

SACE TWO

NUTRITION

WORKBOOK
SEVENTH EDITION

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ADELAIDE
TUITION
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Preface

This workbook has been written for students and educators undertaking Stage 2 Nutrition in 2021. The three topics in the book start with the Science Understandings prescribed in the new SACE Subject Outline, which was last released in July 2020. Each topic also includes a full description of the content the authors have interpreted from the SACE subject outline, exam-style questions, extension activities, informative and coloured diagrams, and a summary test. Key terms have been highlighted in bold and included as a glossary at the end of each section. Other terms are highlighted in a specific colour where their definition (orange), an interesting fact (green) or a reminder (blue) is provided in a separate box on the page.

The questions in the workbook allow students to build their confidence in addressing and applying their knowledge and understanding to a range of questions that target the SACE Performance Standards. A set of review questions have been included at the end of each section, which provide exam style questions that vary in length and difficulty. Each set of review questions equates to 45 marks, which is ideal for a single lesson. Each topic is also supported with a 90 mark summary test, designed to support students with their revision and preparation for timed skills and application tasks and external SACE examinations. These questions ask students to recall, apply and describe their knowledge of the concepts addressed in the topic to real world examples. An extensive set of solutions to all topic and review questions have been included in the back of the book, modelling the expected responses.

The authors have presented the relevant content using real world examples through Science as a Human Endeavour (SHE). The authors have provided several SHE examples (e.g., in blue boxes) throughout each topic to demonstrate the links between science and society. These activities can be used as a strategy to get students familiar with identifying the key elements of science: communication and collaboration between scientists, governments and other agencies, the development of new technologies and theories, the influence of other areas and considerations, and the application and limitations in nutrition. Wherever possible, the authors have presented sources demonstrating nutrition from local and global perspectives.

Science Inquiry Skills have been considered where opportunities for students to analyse data and formulate conclusions have been provided when applicable. Extension activities have also been provided, allowing students to design an investigation and obtain meaningful data.

We hope that you find this resource helpful, and that it demonstrates the significant role of Nutrition in the many aspects of our lives.

The authors and publisher wish you all the best for your studies in Stage 2 Nutrition in 2021.

Vicki Dent

Anastasia Toumpas

Topic 1: Principles of nutrition, physiology, and health

1.1 Energy in Foods

Science understanding

The importance of the macronutrients (protein, carbohydrates and lipids) and water and their respective energy values

- Nutrient energy values per kJ per gram
- Composition of macronutrients in food
 - Recommended proportions of individual macronutrients as a % of the total macronutrients
- Nutrient reference values
 - Estimated Average Requirement (EAR)
 - Recommended Daily Intake (RDI)
 - Adequate Intake (AI)
 - Tolerable Upper Intake Level (UL)
 - EARs for energy through life cycle (Estimated Energy Requirement (EER))

SACE Subject Outline, 2020.

Energy yielding nutrients

In the human body, three nutrients can be used to provide energy: carbohydrates, proteins and lipids. The other nutrients: vitamins, minerals and water do not provide energy to the body, and therefore are not **energy-yielding**. The energy released from carbohydrates, proteins and lipids is measured in **kilojoules** (kJ). However, in countries such as the United States, the term **calories** is still used as the preferred unit of food energy.

Fast fact

1 Calorie is equal to 4.2 kilojoules.

Most foods contain all three energy-yielding nutrients, as well as water, vitamins and minerals. The energy stored within a food item is only released when its bonds are completely broken down in the body during metabolism. This energy is then used to fuel everyday activities, such as sending electrical impulses through the brain and nerves, moving muscles and synthesising body compounds.

The amount of energy provided depends on the quantity of carbohydrates, proteins and lipids a food item contains. Each macronutrient yields a different number of kilojoules per gram. Carbohydrates yield approximately **16.7 kJ** per gram, protein yields **16.7 kJ** per gram and triglycerides yield the greatest amount of **37.7 kJ** per gram (as shown in Table 1.1.1). Therefore, a food item with a greater amount of lipids will provide a greater amount of energy; this food item would be **energy dense**.

Table 1.1.1: Energy provided by energy-yielding macronutrients.

Macronutrient	Energy (kJ/g)	Energy (cal/g)
Carbohydrate	16.7	4
Protein	16.7	4
Lipid	37.7	9

National Health and Medical Research Council, 2006. Nutrient reference values for Australia and New Zealand: Dietary energy, viewed 18 July 2018, <<https://www.nrv.gov.au/dietary-energy>>.

Alcohol contributes 29.3 kilojoules per gram (7 calories per gram). However, it is not considered a nutrient, as, due to its diuretic nature, it depletes the body of its nutrients and interferes with the growth, maintenance and repair of the body. Water provides no kilojoules, contributing 0 kilojoules per gram and serves other benefits in the body (explained further in Topic 1.5: Water and Other Fluids).

Questions

1. Identify how calories can be converted to kilojoules.

(1 mark) (KA4)

2. Complete the following table by rounding the energy values (kJ/g) for Carbohydrates and Protein to the nearest whole number. (Please note: the energy value of lipids used in calculations will be 37kJ/g as used in practice by dietitians, and therefore does not get rounded up as the other macronutrients do).



Reminder

Rounding to the nearest whole number: if the number after the decimal is lower than 5, round down. If the number after the decimal is 5 or greater, round up.

Macronutrient	Energy (kJ/g) as a decimal	Energy (kJ/g) as a whole number
Carbohydrate	16.7	
Protein	16.7	

(2 marks) (KA4)

Calculating the composition of macronutrients in food

To calculate the energy composition from a food product, the quantity (grams) of carbohydrate, protein and lipid is multiplied by the energy provided by one gram of each of these macronutrients. These amounts are then added together. This total is a legal requirement and must be displayed on all nutritional information panels (Figure 1.1.1).

NUTRITION INFORMATION		
Servings per package: 3		
Serving size: 150g		
	Quantity per serving	Quantity per 100 g
Energy	608 kJ	405 kJ
Protein	4.2 g	2.8 g
Fat, total	7.4 g	4.9 g
— saturated	4.5 g	3.0 g
Carbohydrate, total	18.6 g	12.4 g
— sugars	18.6 g	12.4 g
Sodium	90 mg	60 mg
Ingredients: Whole milk, concentrated skim milk, sugar, banana (8%), strawberry (6%), grape (4%), peach (2%), pineapple (2%), gelatine, culture, thickener (1442)		
All quantities above are averages		

Figure 1.1.1: The energy content per serving and per 100 g (or mL) is a legal requirement of all nutritional information panels on food products.

Example

Calculate the total energy provided by a cup of fried rice containing 5 g protein, 30 g carbohydrate and 11 g lipid. Show all your calculations and round your final answer to the nearest whole number.

$$30 \text{ g carbohydrate} \times 17 \text{ kJ/g} = 510 \text{ kJ}$$

$$5 \text{ g protein} \times 17 \text{ kJ/g} = 85 \text{ kJ}$$

$$11 \text{ g lipid} \times 37 \text{ kJ/g} = 407 \text{ kJ}$$

$$\text{Total} = 1002 \text{ kJ}$$

The **energy distribution (%)** of each energy-yielding nutrient can be calculated using the following formula:

$$\text{Energy distribution} = \frac{\text{amount of energy provided per macronutrient}}{\text{total energy provided}} \times 100$$

Example

Calculate the energy distribution of each macronutrient in the fried rice example above. Show all calculations and round your answers to the nearest whole number.

$$\text{Carbohydrate energy distribution} = \frac{510}{1002} \times 100 = 50.9\% \approx 51\%$$

$$\text{Protein energy distribution} = \frac{85}{1002} \times 100 = 8.4\% \approx 8\%$$

$$\text{Lipid energy distribution} = \frac{407}{1002} \times 100 = 40.6\% \approx 41\%$$



Reminder

To confirm your calculations are correct, add up all your percentages. The total should equal 100.

These percentages can then be compared to the acceptable macronutrient distribution ranges (AMDR) (Figure 1.1.2). These are recommendations for optimising the balance of macronutrient intake to reduce the risk of developing diet-related disorders, while also allowing for an adequate intake of nutrients. These ranges are set for healthy individuals who are maintaining their body weight and are not appropriate for weight loss or management of a specific health concern.

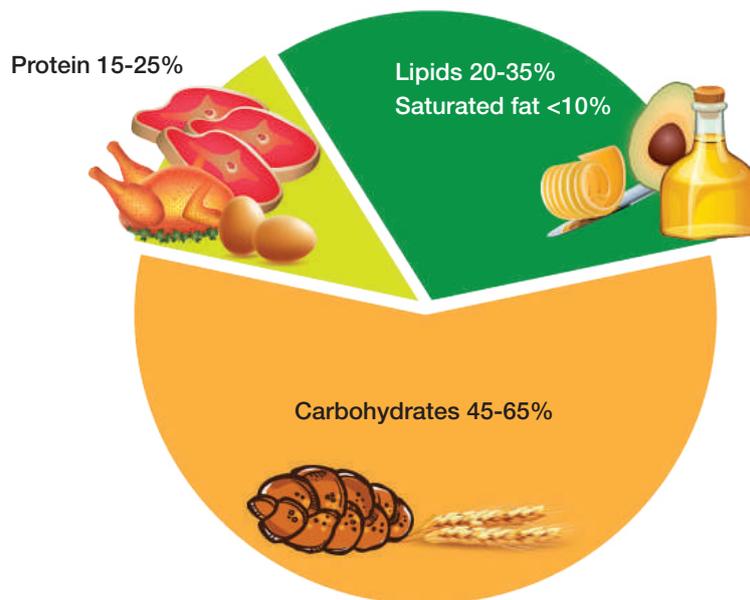


Figure 1.1.2: The acceptable macronutrient distribution ranges of each of the energy-yielding nutrients for individuals.

Example

Compare the energy distribution of each of the macronutrients in the fried rice example with those from the acceptable macronutrient distribution ranges, and make suitable recommendations when necessary to ensure they meet these ranges.

Knowing that the fried rice provides 51% of its kilojoules as carbohydrates tells an individual that this is a suitable carbohydrate selection as it is within the recommended range of 45–65%. On the other hand, only 8% of the kilojoules are provided by protein, which tells an individual they need to make higher protein selections at other times of the day to meet the recommended range of 15–25%. The fried rice provides 41% of its kilojoules as lipids, which suggests that an individual should make lower lipid selections at other times of the day to keep with the recommended range of 20–35%.

Questions

3. (a) An adolescent male has the following energy intake:

170g carbohydrate (120g simple carbohydrates, 50g complex carbohydrates)

75g protein

110g lipid (70g saturated, 20g polyunsaturated, 20g monounsaturated)

Calculate the total energy provided to this male adolescent after consuming the quantities of each macronutrient listed above. Show all your calculations and round your final answer to the nearest whole number.

(4 marks) (KA2, KA4)

(b) Calculate the energy distribution of each macronutrient from the male adolescent's diet from part (a). Show all your calculations and round your answers to the nearest whole number.

(3 marks) (KA2, KA4)

(c) Compare the energy distribution of each macronutrient calculated in part (b) with those from the acceptable macronutrient distribution ranges, and make suitable recommendations.

(3 marks) (IAE3)

4. Australian researchers found that children and adolescents consume more energy from energy dense foods than any other age group, with the average child receiving three packaged snack foods in their lunchbox each day. Parents should aim to provide only one snack food in their child's lunch box each day, and ideally be less than 600kJ.

On the next page, calculate the total energy provided by one serving of each of the following lunch box snacks and make a recommendation to which snack parents should choose to include in their child's lunch box. Show all your calculations and round your final answer to the nearest whole number.

	SNACK A Small packet (20g) of Original Popcorn	SNACK B Fruit & Nut Muesli Bar (45g)	SNACK C Mini Blueberry Muffin (40g)
Protein	1.8g	4.1g	1.7g
Fat, total	5.1g	6.7g	6.2g
Fat, saturated	1.0g	1.1g	1.0g
Carbohydrate, total	8.4g	25.1	17.0g
Carbohydrate, sugars	0.7g	7.8g	9.4g

Questions

1

(4 marks) (KA4, IAE3)

Nutrient Reference Values

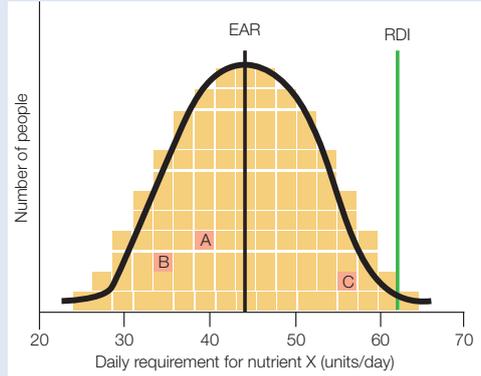
Nutrient reference values (NRVs) are a set of recommendations for nutritional intake based on current available scientific knowledge that best support the health of individuals in Australia and New Zealand. These recommendations apply to healthy people and may not be appropriate for people with diseases that require an increase or decrease in nutrient needs. Each person's body is unique and has its own set of requirements. Men differ from women and needs change as people grow from infancy to old age. This is why nutrient recommendations are based on age, gender and specific life stages. These values provide recommended intakes for energy (kilojoules), protein, carbohydrate, fibre, fats, water, vitamins and minerals. The NRVs are made up of 5 different values (as discussed in Table 1.1.2):

Table 1.1.2: Description of NRVs used in Australia and New Zealand

NRV	Description
Estimated Average Requirement (EAR)	The average amount of a nutrient estimated to meet the nutrient requirements of half of a group of healthy individuals in a specific life stage and gender group.
Recommended Daily Intake (RDI)	The average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (approximately 98%) healthy individuals in a specific life stage and gender group. The RDI is set high enough above the EAR to meet the needs of most healthy people. When people's nutrient intakes are consistently below their daily requirements, they can become deficient, causing their nutrient stores to deplete and leading to poor health and deficiency symptoms. This is why the RDI is set so much higher than the EAR, to ensure this value meets the nutrient needs of as many people as possible.
Adequate Intake (AI)	The AI reflects the average amount of a nutrient that a group of healthy individuals consumes. This NRV is used when an RDI or EAR cannot be determined due to insufficient scientific evidence. Therefore, AI relies heavily on scientific judgement.
Tolerable Upper Intake Level (UL)	The UL is the point in which an individual exceeds the recommended intake and where a nutrient is likely to become toxic. It is recommended that an individual not exceed these recommendations often or by much. The RDI should not be thought of as a minimum amount, and a more accurate view is to see an individual's requirements as a range, with a marginal and danger zone both below and above this range.
Estimated Energy Requirement (EER)	The EER represents the average dietary energy intake (kilojoules consumed per day) that will maintain an energy balance in a person who has a healthy body weight and level of physical activity. These values are determined to sustain a healthy and active life, as too much energy can lead to weight gain and its associated health consequences.

Questions

5. The EAR and RDI of a specific nutrient is shown in the graph on the right. Each square in the graph below represents an individual with unique nutritional requirements, however three different individuals are shown: A, B and C.



(a) With reference to the graph, state the daily requirement for nutrient X for the following individuals:

A: (1 mark) (IAE3)

C: (1 mark) (IAE3)

(b) Suggest one reason why individual C has a higher daily requirement of nutrient X than individual A.

.....

 (1 mark) (KA2)

(c) True or False: An RDI for a nutrient is the amount that everyone needs to consume each day. Provide reasoning to explain your answer.

.....

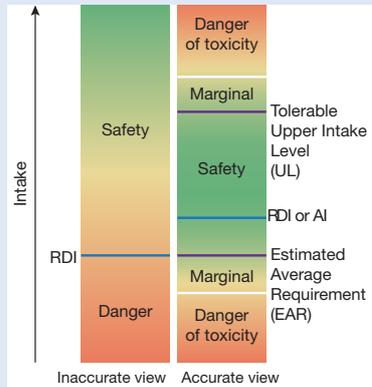
 (2 marks) (KA2)

(d) Explain why the RDI value is much higher than the EAR value on the graph.

.....

 (2 marks) (KA2)

6. The image below demonstrates an inaccurate view vs accurate view of the nutrient intakes of individuals.



(a) With reference to the image above (accurate view), identify when an individual's intake of a nutrient would be inadequate.

.....
 (1 mark) (IAE3)

(b) Explain why the view for nutrient intakes on the right in the image above is regarded as the accurate representation.

.....

 (2 marks) (KA2)

Key terms

Acceptable macronutrient distribution ranges (AMDR)	Estimated Average Requirement (EAR)
Adequate Intake (AI)	Estimated Energy Requirement (EER)
Carbohydrates yield 16.7 kJ/g \approx 17kJ/g	Kilojoule (kJ)
Energy dense nutrient	Lipids yield 37 kJ/g
Energy composition	Nutrient Reference Value (NRV)
Energy distribution	Proteins yield 16.7 kJ/g \approx 17kJ/g
Energy-yielding nutrient	Recommended Dietary Intake (RDI)
	Tolerable Upper Intake Level (UL)

Review questions: 1.1 Energy in foods

- An advertisement for a new 'super protein supplement' claims to contain 20 g protein and provide 50 kJ per serving. Explain if this claim is possible and provide evidence to justify your answer.

(2 marks) (KA4, IAE3)

- Refer to the ingredients list and nutritional information panel for one serving (100 g) of pasta carbonara.

	100 grams	Ingredients
Energy (kJ)		250 g cooked pasta
Protein (g)	14	20 g butter
Carbohydrates – total (g)	29	1 cup thickened cream
Carbohydrates – sugar (g)	4	250 g bacon
Fat – total (g)	14	2 eggs
Fat – polyunsaturated (g)	2	2 egg yolks
Fat – monounsaturated (g)	3	1 cup grated parmesan cheese
Fat – saturated (g)	9	1 tablespoon rosemary
Dietary fibre (g)	1.5	Pinch of salt
Sodium (mg)	200	Pinch of pepper

- (a) Calculate the total energy of one serving (100 grams) of pasta carbonara. Show all your calculations and round your final answer to the nearest whole number.

(4 marks) (KA4, IAE3)

- (b) Calculate the energy distribution of each energy-yielding nutrient and make recommendations in comparison to the acceptable macronutrient distribution ranges for Australians. Show all calculations and round your answers to the nearest whole number.

(6 marks) (KA4, IAE3)

- (c) Suggest three specific modifications to the ingredients for the pasta carbonara recipe that would reduce the meal's energy density and increase its nutrient density.

(3 marks) (KA2)

3. Refer to the following nutritional information panel for a meal made by an elderly female aged 70 years old.

	Per serving
Energy (kJ)	
Protein (g)	15
Carbohydrates – total (g)	58
Carbohydrates – sugar (g)	36
Fat – total (g)	31
Fat – saturated (g)	18
Dietary fibre (g)	3
Sodium (mg)	320

- (a) Calculate the total energy content provided by one serving of this meal. Show all calculations and round to the nearest whole number.

(4 marks) (KA2, KA4)

- (b) The estimated energy requirement (EER) for an elderly female is 7600 kJ. What percentage of that recommended daily energy requirement is provided by this meal? Show all calculations and round your answer to the nearest whole number.

(2 marks) (KA2, KA4)

- (c) Using the NRV calculator on the following website: <https://www.nrv.gov.au/nutrients-energy-calc>, determine the NRVs of the following nutrients for this elderly woman.

	AI	EAR	RDI	UL
Calcium				
Iron				
Vitamin C				
Dietary Fibre				
Water				

(5 marks) (IAE3)

4. Refer to the nutritional information panel of one serving of a mango fruit smoothie.

	Per serving
Energy (kJ)	
Protein (g)	8.4
Carbohydrates – total (g)	89.6
Carbohydrates – sugar (g)	79.5
Fat – total (g)	6
Fat – saturated (g)	2.3
Dietary fibre (g)	3.5
Sodium (mg)	154

- (a) Calculate the quantity of carbohydrates that are not sugars (complex) in this mango fruit smoothie. Show all your calculations.

(1 mark) (KA4)

- (b) Calculate the total energy content provided by one serving of a mango fruit smoothie. Show all your calculations and round your final answer to the nearest whole number.

(4 marks) (KA4, IAE3)

5. Calculate the amount of energy provided by alcohol in a glass of wine containing 520 kJ, 2.6 g carbohydrate and 1 g protein. Show all your calculations and round your final answer to the nearest whole number.

(3 marks) (KA2, KA4)

6. Refer to the following nutrition information panel from a packet of breakfast cereal.

	Per serving	Per 100 g
Protein (g)	2.2	8.8
Fat – total (g)	0.6	2.5
Fat – saturated (g)	0.2	0.8
Carbohydrate – total (g)	21.1	84.5
Carbohydrate – sugars (g)	6.3	25

- (a) Calculate the total energy provided from one 100 g serving of the breakfast cereal. Show all your calculations and round your final answer to the nearest whole number.

(4 marks) (KA2, KA4)

- (b) Using the NRV calculator on the following website: <https://www.nrv.gov.au/nutrients-energy-calc>, determine your estimated energy requirement (EER). Then calculate the proportion (%) of energy that this breakfast cereal would account for, in comparison to your EER. Show all calculation and round your final answer to the nearest whole number.

To calculate your EER, determine your physical activity level (PAL) and then multiply that value by 1000 to get it into kJ.

Your EER:

(2 marks) (KA2, IAE3)

- (c) Using the NRV calculator on the following website: <https://www.nrv.gov.au/nutrients-energy-calc>, determine your NRVs of the following five nutrients.

	AI	EAR	RDI	UL
Calcium				
Iron				
Vitamin C				
Dietary Fibre				
Water				

(5 marks) (IAE3)

Total: ____ / 45 marks

Macronutrients

The macronutrients can be defined as the nutrients humans consume, and need, in the largest quantities. Macro, meaning 'large', alludes to this. Their requirements are prescribed in grams per day, whilst other nutrients have only milli or microgram needs. Not only are macronutrients defined by being needed in large quantities each day, but they also give humans energy. Each macronutrient provides a differing amount of energy. While water does make up a large proportion of what we consume each day, and need, it does not provide any energy and is therefore not considered a true macronutrient. The true macronutrients that are needed in large amounts each day, and provide energy, are carbohydrates, lipids and protein.

1.2 Carbohydrates

Science understanding

Recognition that macro nutrients have a specific function and structure

- The structure and classification of carbohydrates as a nutrient
- Sources of carbohydrates in the diet
- The function and nutritional significance of the following carbohydrates:
 - Polysaccharides
 - Disaccharide
 - Monosaccharide
 - Glucose molecule
 - The effects of different carbohydrates on blood sugar levels
 - The role of soluble and insoluble fibre in the body

SACE Subject Outline, 2020

Structure and Classification of Carbohydrates

Carbohydrates are made from combinations of the elements carbon (C), hydrogen (H) and oxygen (O). You may see carbohydrates referred to as CHO. Atoms of these elements arrange into a variety of structures called saccharides. The carbohydrate saccharides we consume include:

- **monosaccharides** (single unit)
- **disaccharides** (double unit of two joined monosaccharides)
- **oligosaccharides** (small number of joined monosaccharides, typically three to ten)
- **polysaccharides** (long linear or highly branched chains of many joined monosaccharides).

Simple Carbohydrates

The monosaccharides and disaccharides can be collectively termed the **simple carbohydrates (sugars)**. They can be considered 'smaller' based on being only one or two saccharide units in size. Within each saccharide classification of the simple sugars, there are several different types of simple carbohydrates (as shown in table 1.2.1), possessing different structural features. Each monosaccharide contains 6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms, which can be written in shorthand as $C_6H_{12}O_6$.

The monosaccharides include:

- glucose 
- fructose 
- galactose 

The disaccharides include:

- maltose (glucose + glucose) 
- sucrose (glucose + fructose) 
- lactose (glucose + galactose) 



Fast fact

To make a disaccharide, a chemical reaction known as condensation links two monosaccharides together. A hydroxyl (OH) group from one monosaccharide and a hydrogen (H) atom from the other combine to create a molecule of water (H_2O). The two originally separate monosaccharides link together with single oxygen (O).

Table 1.2.1: Classification and structure of simple carbohydrates (Monosaccharides and Disaccharides)

Carbohydrate classification	Examples	Structure
Monosaccharide	Fructose	
	Glucose	
	Galactose	
		*The orientation of the hydroxyl group (OH) around the fourth carbon is the only structural difference between glucose and galactose.
Disaccharides	Lactose	<p>(Galactose + Glucose)</p>
	Sucrose	<p>(Glucose + Fructose)</p>
	Maltose	<p>(Glucose + Glucose)</p>

Extension activity

The World Health Organisation recommends our free (added) sugar consumption should only make up 10% of our total daily energy intake, which equates to approximately 50g or 12 teaspoons a day.

The Australian Health Survey found that in 2011-2012, Australians were consuming an average of 105 grams of total sugars per day, with just over half of this being free sugars (60g each day, or the equivalent of 14 teaspoons of white sugar), with the balance (45 grams) being the naturally occurring sugars.

Research and explain the difference between the following terms: free sugar, naturally occurring sugar and total sugar.

.. .. .

.. .. .

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.. .. .

Look up and state the name of common free sugars that are added to foods in Australia.

.. .. .

.. .. .

.. .. .

The amount of sugar on the Nutritional Information Panel (NIP) of food products includes the naturally occurring sugar, as well as the free sugars. Avoiding sugar completely is not necessary, but to try and avoid large amounts of added sugar look to see if there is more than 15g of sugar per 100g, and then check the ingredients list for added sugar or alternate names that are listed high.

Look up the sugar content per 100g of commonly consumed carbohydrates or perceived “healthy” carbohydrates.

Food	Sugar per 100g	Food	Sugar per 100g

Complex Carbohydrates

The remaining saccharide classifications, namely the oligosaccharides and polysaccharides, can be collectively known as the **complex carbohydrates (sugars)**. They can be considered to be ‘larger’ in size, especially the polysaccharides, which may be composed of several hundred thousand joined glucose molecules! Like the monosaccharides and disaccharides, the saccharides of the complex sugar grouping can further be divided into examples of different sugars, each with a unique structure. The structure of each molecule belonging to the complex sugars, or the oligo- and poly-saccharide classification, is shown in detail in Table 1.2.2.

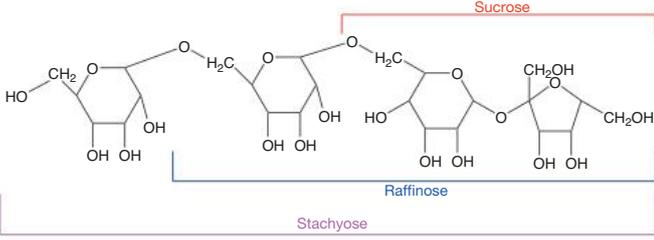
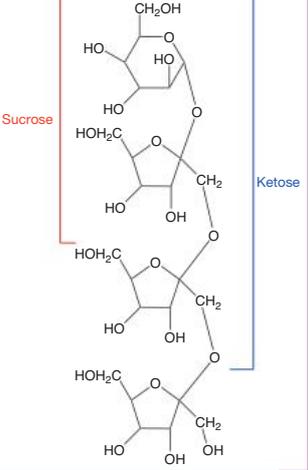
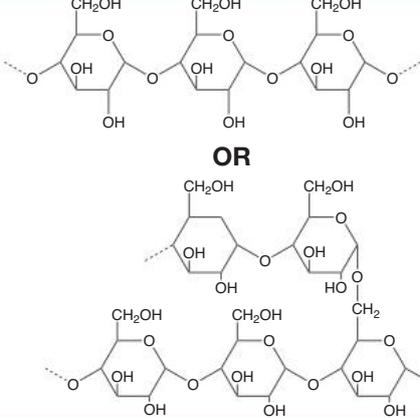
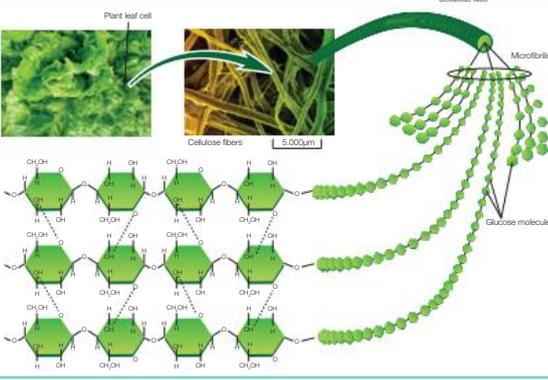
The oligosaccharides include:

- Galacto-oligosaccharides: Raffinose and Stachyose
- Fructo-oligosaccharides: ketose and nystose

The Polysaccharides include:

- Starch
- Resistant Starch
- Glycogen
- Soluble and Insoluble Fibre

Table 1.2.2: Classification and structure of complex carbohydrates (Oligosaccharides and Polysaccharides)

Carbohydrate classification	Examples	Structure
Oligosaccharides	Galacto-oligosaccharides (such as raffinose and stachyose)	 <p style="text-align: center;">(Galactose + Galactose + Glucose + Fructose)</p>
Oligosaccharides	Fructo-oligosaccharides (such as ketose and nystose)	 <p style="text-align: center;">(Glucose + Fructose + Fructose + Fructose)</p>
Polysaccharides	Starch and resistant starch	 <p style="text-align: center;">(Glucose + Glucose + Glucose + etc.)</p>
Polysaccharides	Soluble and insoluble fibre	 <p style="text-align: center;">(Glucose + Glucose + Glucose + etc.)</p>

Carbohydrate classification	Examples	Structure
Glycogen	Glucose + Glucose + Glucose + etc.)	

Questions

1. Using the information presented in Tables 1.2.1 and 1.2.2, rank the following in order of size (number of molecules).

Fructose	Starch	Lactose	Raffinose
----------	--------	---------	-----------

Smallest: ..

.....

.....

..... Largest

(2 marks) (KA2)

Extension activity

Explain the role of Glycogen when excessive simple carbohydrates and starch are consumed.:

..

..

..

..

Sources of Carbohydrates in the Diet

Food and/or beverages that are good sources of each of the examples of saccharides are displayed on the following continuum. The continuum lists the saccharide examples from the most to least sweet, with the sweeter sugars coinciding with those we crave most.

Very sweet

Fructose

Found naturally in honey and sweet fruits, e.g. grapes.

Can be added as high-fructose corn syrup in foods and beverages, such as confectionery and soft drink.

Sucrose

Found naturally in sweet fruits.

Added as granulated sugar (table sugar, e.g. raw sugar) from sugar-cane processing (called **refined sugar**) in many foods, such as cakes and dried fruit.

Glucose

Found naturally in honey and fruit.

Added in foods such as sauces and cereals.

Definition

Sugar added to food is termed refined sugar.

Galactose

Not found naturally in high amounts in its monosaccharide form. When galactose is found in foods, it is usually present in its disaccharide form, i.e. joined to glucose to form lactose.

Maltose

Not found naturally in high amounts in any foods. However, when foods high in starch undergo processing (such as cooking), the starch can end up being broken down into maltose. This may be the case in breads, cereals, sweet potatoes, etc.

Can be added in foods with a malt flavour, e.g. malt milkshake, malt biscuits, confectionery.

Oligosaccharides

Found naturally in the onion group (onions, garlic, etc.) and legumes.

Can be added to foods such as cereals and yoghurts as inulin; its creamy texture is used to replace oils, and its sweet taste is used to replace sucrose.

Lactose

Found naturally in the dairy group (milk, cheese, etc.), making it the only carbohydrate that doesn't come from plants.

Starch

Can be added to bread and bread products.

Found naturally in foods such as oats, rice, legumes, corn and root vegetables. It is used as a primary ingredient in cereals, breads, pasta, etc.

Corn starch/potato starch (called refined starch) can be added as a thickener to many processed foods, such as custard.

Soluble fibre

Found naturally in the pith (flesh) of fruits and the flesh of vegetables, plus in foods such as oats, legumes, and soy products.

Insoluble fibre

Can be added to many fibre-enriched/fortified foods, such as bread.

Found naturally in foods such as bran, nuts, seeds, the skins of fruit and vegetables; also used as an ingredient in wholemeal/whole wheat products, such as wholemeal bread.

Can be added to many fibre-enriched/fortified foods, such as bread.

Least sweet

Questions

2. Using information from the continuum of sweetness, which sugar would be the most addictive?

..... (1 mark) (IAE3)

Simple Carbohydrates

Monosaccharides are already small enough to enter the bloodstream, while disaccharides need only one bond broken between the two joined monosaccharides before they can be absorbed into the bloodstream. Both monosaccharides and disaccharides can therefore enter the bloodstream quickly and are associated with a rapid rise in blood glucose levels and consequential rapid energy release (as shown in Figure 1.2.1). Foods or beverages consumed that produce this blood glucose response are known to have a high **glycaemic index** (high GI).

Definition

Glycaemic Index (GI) is a measure of how a food or beverage will affect blood glucose levels after consumption.

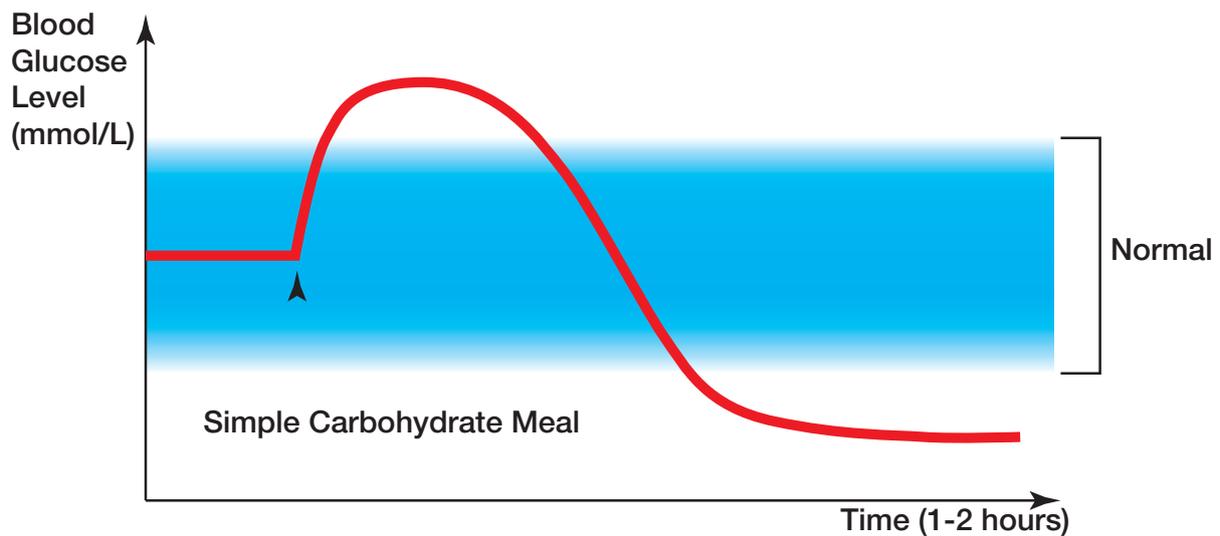


Figure 1.2.1: Effect of simple sugars on blood glucose levels (high GI).

Complex Carbohydrates

Starch, on the other hand, is a much larger molecule, made of hundreds of glucose units bonded together (as shown in Table 1.2.2). Therefore, it breaks down into glucose slowly and takes longer to be absorbed into the bloodstream. This results in a lower and more gradual elevation in blood glucose levels and, consequentially, sustained energy (as shown in Figure 1.2.2). Foods or beverages that produce this blood glucose response are known to have a low glycaemic index (low GI).

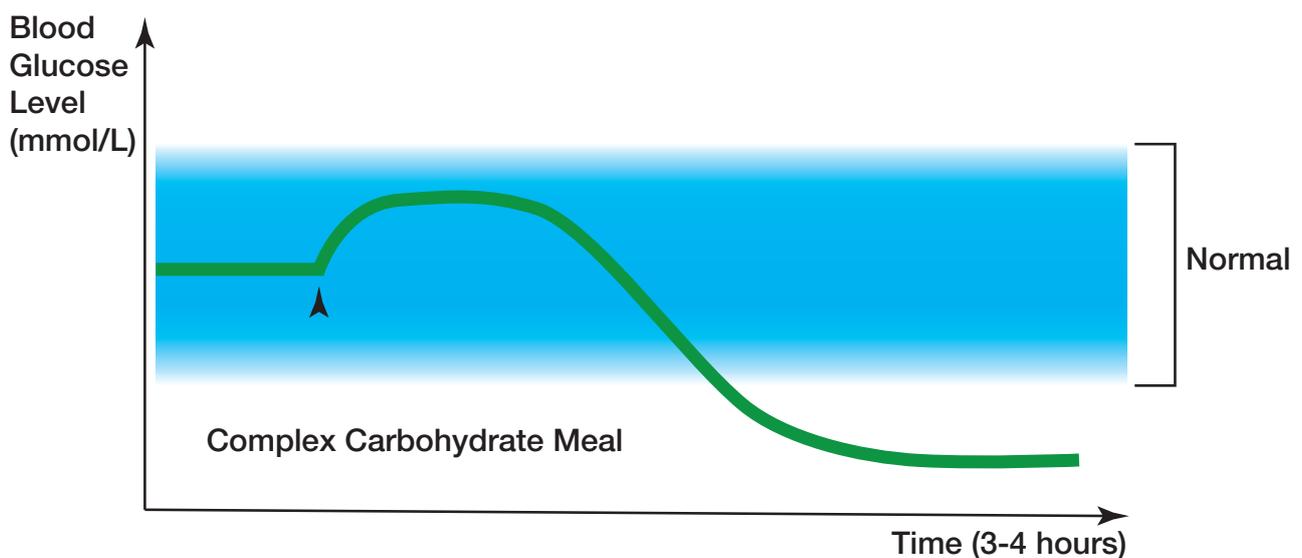


Figure 1.2.2: Effect of starch on blood glucose levels (low GI).

Questions

3. Classify the following carbohydrates as either simple or complex:

Glucose:

Oligosaccharides:

Fructose:

Maltose:

Starch: (5 marks) (KA1)

4. Many foods high in starch, such as white bread, baked potatoes and white rice are processed (e.g. cooked) having had their starch partly broken down into smaller chains including maltose. Explain the effect these foods would have on blood glucose levels, and why.

.....

.....

.....

.....

..... (3 marks) (KA2)

5. Explain the effect of the following carbohydrates on blood glucose levels after consumption.

Glucose:

.....

.....

.....

.....

Starch:

.....

.....

.....

..... (4 marks) (KA2)

A component of the Cell Membrane

Blood glucose can also be used for a structural role, as part of the cell membrane. Glucose molecules will bond together and form short-chain **oligosaccharides** on the exterior of the cell membranes (Figure 1.2.3). The role of these oligosaccharides is in cell recognition: how our body recognises our own cells in contrast to those that are foreign, such as bacteria or viruses.



Reminder

Oligosaccharides are 3 to 10 glucose molecules joined together.

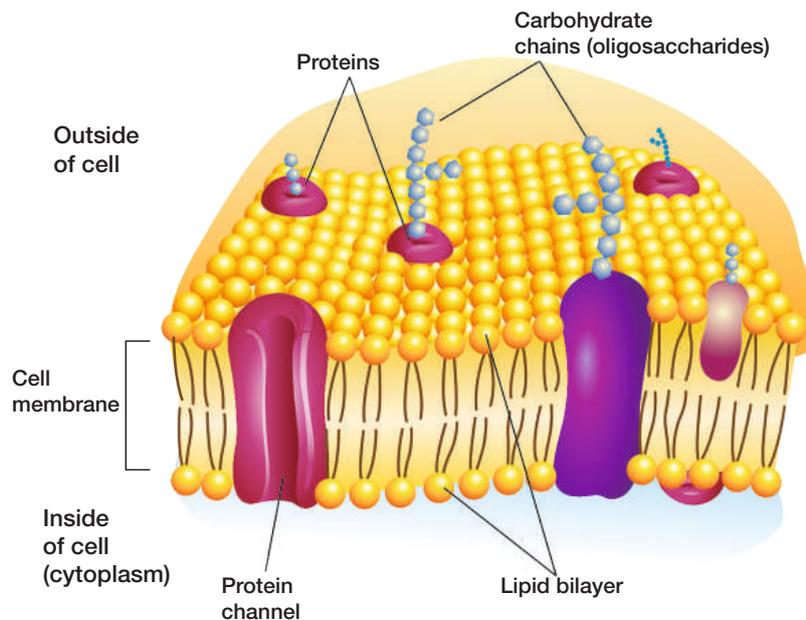


Figure 1.2.3: Oligosaccharides in the cell membrane.

Achieving efficient nutrient absorption and satiety

Oligosaccharides, **resistant starch** and soluble fibre cannot be broken down into glucose and absorbed into the bloodstream. Instead, most of these carbohydrates bind water and partly dissolve to become 'gel-like' in the stomach. The addition of water to the carbohydrate food consumed can also cause expansion of the stomach. The gel-like consistency of the carbohydrate food, plus the increase in volume from the addition of water, causes food to empty from the stomach into the small intestine at a slower rate. The slower rate of stomach emptying has two roles:

1. It slows initial digestion and therefore maximises the absorption of nutrients (including monosaccharides) from the duodenum (the first part of the small intestine).
2. It keeps the body feeling fuller for longer (this feeling is called **satiety**), via two means:
 - i. expansion of the stomach triggers the feeling of satiety
 - ii. slow absorption of monosaccharides gives a gradual blood glucose rise, providing sustained or longer-lasting energy. This can also help to regulate blood glucose levels.

Definitions

Many foods high in starch, particularly when eaten raw, without any processing (for example bananas with some green to them, and beans), will not be completely digested into glucose. The starch that isn't digested is called resistant starch.

Maintaining a healthy digestive tract

The ability of the oligosaccharides, resistant starch and soluble fibre to continue to bind water along the digestive tract helps to produce soft and bulky faeces, allowing easier passage through the large intestine.

Unlike simple sugars and starch, these carbohydrates are mostly indigestible. The human body lacks the enzymes to break them down into monosaccharides, the only size saccharide molecule small enough to be absorbed into the bloodstream from the small intestine. Oligosaccharides, resistant starch and soluble fibre will therefore move onto the large intestine. This is where many **beneficial bacteria** are found.

Definitions

Beneficial or non-harmful bacteria (microorganisms) are termed non-pathogenic; harmful microbes are termed pathogenic.

The bacteria use oligosaccharides, resistant starch and soluble fibre as sources of food and can break them down in a process called fermentation. When these carbohydrates are broken down via fermentation, the products are flatulence-causing gas and short-chain fatty acids, which can even provide some energy to intestinal cells lining the colon (around 8–13 kJ/g, depending on the type of carbohydrate broken down) (as shown in figure 1.2.4). Bacteria that die during the fermentation process then provide additional bulk to stools.

Colon bacteria also aid in our immune system, serving a function of hindering the growth of harmful microorganisms that may enter the large intestine.

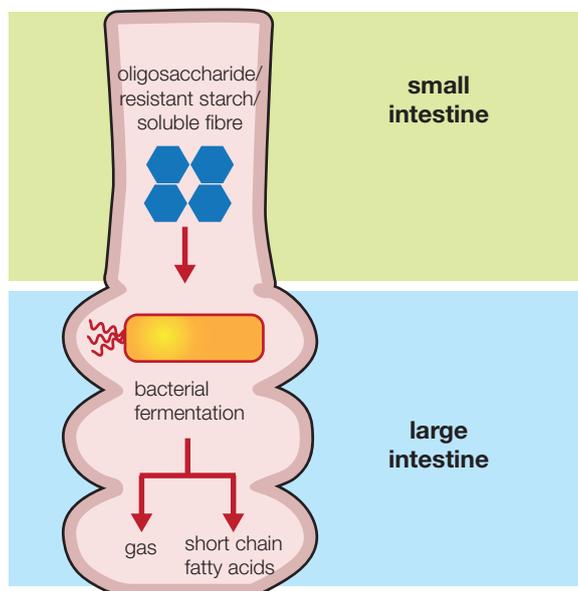


Figure 1.2.4: Bacterial fermentation of oligosaccharides, resistant starch and soluble fibre in the large intestines, producing gas and short chain fatty acids.

Extension activity

Food sources that contain live beneficial bacteria are known as probiotics, whereas a prebiotic is a special type of soluble fibre that encourage the growth and activity of beneficial bacteria in the colon. Research and state some food sources of both probiotics and prebiotics.

Probiotic Food Sources	Prebiotic Food Sources

Extension activity

Explain the impact of consuming excess sugar, which can be found in products such as Kombucha on the health of an individual's teeth.

..

..

..

..

..

Lowering blood cholesterol levels

Soluble fibre is known to reduce cholesterol. It does this by binding to bile acids that are excreted into the small intestine from the liver (Figure 1.2.5). Bile acids are made of cholesterol and will re-enter the bloodstream from the small intestine, potentially raising blood cholesterol levels. However, if soluble fibre binds to the bile acids, it reduces the amount of cholesterol re-entering the bloodstream, because soluble fibre is too large to be absorbed into the bloodstream. Therefore, the bile acids (cholesterol) are transported by soluble fibre along the digestive tract and finally removed from the body as waste (we defecate them as faeces).

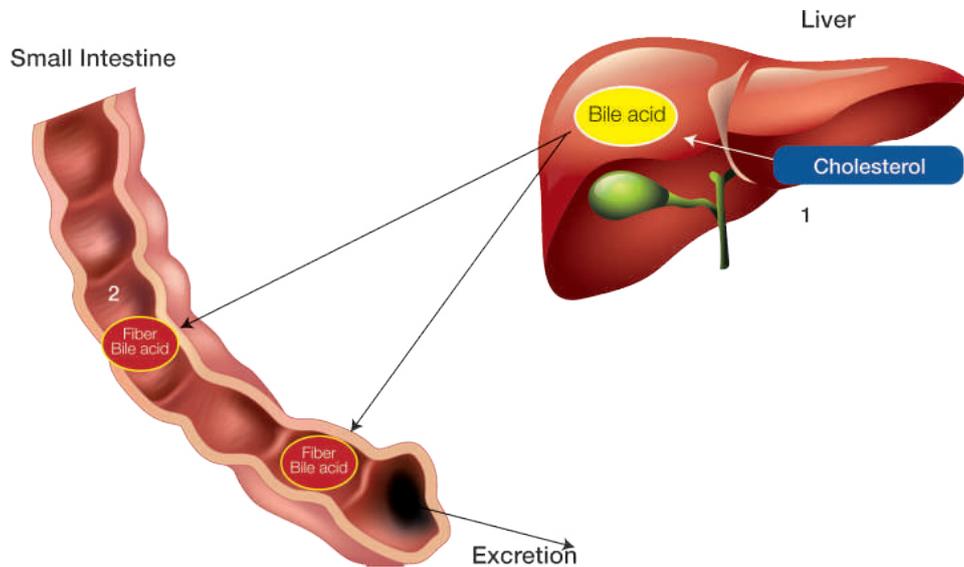


Figure 1.2.5: Soluble fibre binding to bile acids (made of cholesterol), preventing them from entering the bloodstream and causing them to be excreted as waste.

Questions

10. Fill in the empty column of the table below using the following types of carbohydrates (more than one type of carbohydrate can be used for the following functions and may be used more than once).

Simple Carbohydrates (SC) Glucose (G) Starch (S) Resistant Starch (RS)
 Oligosaccharides (O) Soluble Fibre (SF) Insoluble Fibre (IF)

Function	Type of Carbohydrate
Provides bulk to stools due to not being broken down	
Slows stomach emptying	
Binds to water, producing soft and bulky stools	
Foods high in this carbohydrate create a low GI response	
These carbohydrates undergo fermentation in the colon, providing energy and a food source to beneficial bacteria	
Foods high in this carbohydrate create a high GI response	
Assists in the functioning of the immune system	
Carbohydrates that provide the body with energy	
Simple carbohydrates and starch are broken down into this molecule	
Slows down initial digestion, maximizing nutrient absorption	
The only type of carbohydrate the brain can utilize to create energy	
Creates satiety	
Reduces cholesterol levels, by binding to bile acids	
Provides bulk to stools through the bacteria that die during fermentation	

(14 marks) (KA1)

 Key terms

Adenosine triphosphate (ATP)	Glycogen	Polysaccharides
Complex Carbohydrates	High GI	Resistant starch
Disaccharides	Insoluble fibre	Satiety
Fermentation	Low GI	Simple Carbohydrates
Glucose	Monosaccharides	Soluble fibre
Glycaemic index (GI)	Oligosaccharides	Starch

3. Name the following.
 (a) Glucose is part of the structure of several disaccharides. Name two:

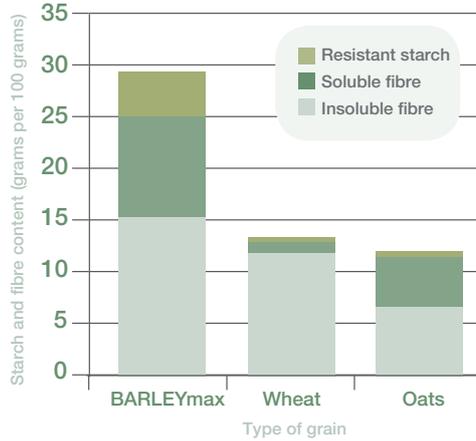
Disaccharide 1:(1 mark) (KA1)

Disaccharide 2:(1 mark) (KA1)

4. A government-funded research team has developed a wholegrain barley, called BARLEYmax, that it claims is higher in fibre than other grains.

Refer to the following graph:

Resistant starch and fibre content in three grains



Source: Adapted from CSIRO and Australian Capital Ventures Ltd, 'The BARLEYmax Better Nutrition Report', July 2009, p.5, viewed 10 July 2015, <http://goodnesssuperfoods.com.au/wp-content/uploads/BARLEYmaxReport.pdf>

- (a) Using information from the graph, compare the differences in the fibre content of the three grains depicted.

.....

(3 marks) (IAE3)

- (b) Determine the amount of soluble fibre in BARLEYmax.

.....grams per 100 grams (1 mark) (IAE3)

- (c) Describe two specific functions of soluble fibre that help to prevent diet-related disorders.

(i)

(2 marks) (KA2)

(ii)

(2 marks) (KA2)

(d) Below is a table listing some of the ingredients in a bowl of cereal. Categorise the foods that are good sources of carbohydrate into their appropriate saccharide grouping (not all ingredients need to be classified; only 4 marks are necessary).

Ingredient	Saccharide grouping
Whole wheat flakes	
Corn flakes	
Raisins	
Apricots	
Almonds	
Raw sugar	
Milk	

(4 marks) (KA2)

5. (a) Explain where and how soluble fibre is broken down in the body.

..

 (2 marks) (KA1)

(b) Explain two ways that soluble fibre can help prevent constipation.

(i) (2 marks) (KA2)

 (ii) (2 marks) (KA2)

(c) Provide two specific examples of foods that are high in soluble fibre.

(i) (1 mark) (KA1)
 (ii) (1 mark) (KA1)

6. The Glycaemic Index (GI) ranks carbohydrates in food according to how their consumption would affect a person's blood glucose levels. Majority of sports drinks have a high GI, explain how this would affect an individual's energy levels for the first few hours after consumption.

..

 (2 marks) (KA2)

7. Explain the structural difference between a monosaccharide and disaccharide.

..

 (2 marks) (KA1)

8. For the foods below, match the carbohydrate to the speed of breakdown and absorption into the bloodstream. Choose between starch, glucose and sucrose.

	Food A	Food B	Food C
Time from consumption to blood glucose peak	18 minutes	90 minutes	20 minutes
Type of carbohydrate			

(3 marks) (IAE3)

9. Refer to the following nutritional information panel, demonstrating the carbohydrate and sugar content of three different food sources.

Content per 100g	Food A	Food B	Food C
Carbohydrate (g)	77	44.3	44.4
Sugar (g)	51.3	2.7	40.5

- (a) With reference to the nutritional information panel above, which food source has the highest carbohydrate content.

..... (1 mark) (IAE3)

- (b) With reference to the nutritional information panel above, which food source has the highest complex carbohydrate content.

..... (1 mark) (IAE3)

- (c) With reference to the nutritional information above, identify the food source which would have the highest glycaemic index. Make sure to justify your response and use data to support your explanation.

.....

 (3 marks) (IAE3)

- (d) Foods can be classified based on their primary nutrient. With reference to the nutritional information above, what type of saccharide would food B be considered as and explain the effect the consumption of this food source would have on blood glucose levels.

.....

 (3 marks) (KA2, IAE3)

Total: _____ / 45 marks

1.3 Lipids

Science understanding

Recognition that macro nutrients have a specific function and structure

- The structure and classification of lipids as a nutrient
 - Saturated vs Unsaturated
 - Monounsaturated
 - Polyunsaturated
 - Trans-fatty acids
 - Cholesterol (type of sterol)
- Sources of lipids in the diet
- The function of lipids (fats) as a nutrient, including:
 - The role of Omega 3 and Omega 6 essential fatty acids
 - Functions of Blood cholesterol

SACE Subject Outline, 2020

Structure and Classification of Lipids

The **lipid** family includes triglycerides (fats and oils), phospholipids and sterols, where triglycerides are the most abundant both in foods and the body. The structure of lipids is similar to carbohydrates in that they consist of carbon (C), hydrogen (H) and oxygen (O).

Triglycerides

Every **triglyceride** is composed of one molecule of **glycerol** and three **fatty acid chains** (basically, chains of carbon atoms) (as shown in Figure 1.3.1). Glycerol acts as a 'backbone' to three attached fatty acids.

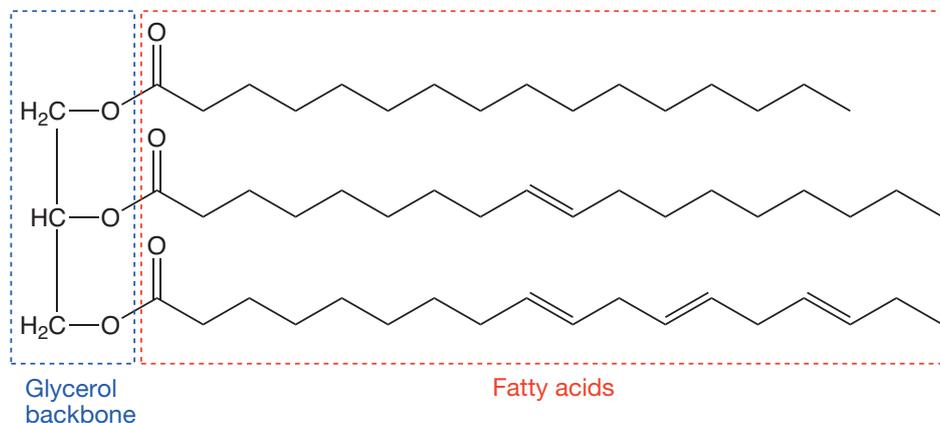


Figure 1.3.1: The Structure of a triglyceride, composed of a glycerol backbone attached to three fatty acid chains.

All fatty acids have the same basic structure – a chain of carbon and hydrogen atoms with an **acid group (COOH)** at one end and a **methyl group (CH₃)** at the other end (as shown in figure 1.3.2 and 1.3.3, which demonstrates a simplified way with each corner on the zigzag line representing a carbon atom with two attached hydrogens). Fatty acids differ from one another, by the length of their carbon chains and in the number and location of their double bonds. Most naturally occurring fatty acids contain even number of carbons in their chains, which may be between 4-24 carbons long. The longer chain (12 to 24 carbons) fatty acids of meats, fish and vegetable oils are most common in the diet. Smaller chain (fewer than 10 carbons) fatty acids are primarily found in dairy products.

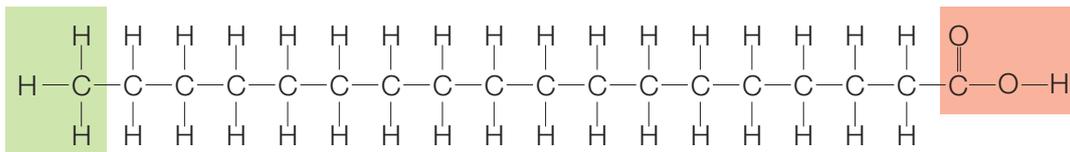


Figure 1.3.2: The structure of stearic acid, an 18-carbon saturated fatty acid

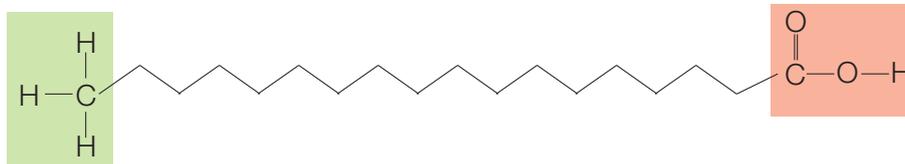


Figure 1.3.3: The structure of stearic acid, an 18-carbon saturated fatty acid (Simplified version).

Fatty acids may be saturated or unsaturated. A **saturated** fatty acid is completely loaded with all its hydrogen atoms and contains only single bonds between its carbon atoms (as shown in Figure 1.3.2). These types of triglycerides are generally solid at room temperature and have a higher melting point. An **unsaturated** fatty acid does not contain the full quota of hydrogen atoms, due to containing at least one double bond between the carbon atoms. An unsaturated fatty acid that contains one double bond between the carbon atoms is a **monounsaturated** fatty acid (as shown in Figure 1.3.4 and 1.3.5), which are generally liquid at room temperature and have a lower melting point than saturated fats. An unsaturated fatty acid that contains more than two double bonds between the carbon atoms is a **polyunsaturated** fatty acid (as shown in Figure 1.3.6 and 1.3.7). These types of triglycerides are also generally liquid at room temperature and have a lower melting point than saturated fats and monounsaturated fats. Although, drawn straight in Figure 1.3.4, 1.3.5, 1.3.6 and 1.3.7, the actual shape of the fatty acids' bend at the double bond, which is regarded as a point of unsaturation as two hydrogen atoms are missing in this part of the carbon chain.

Fast fact

The three types of atoms found in triglycerides: hydrogen (H), oxygen (O) and carbon (C) has a characteristic number of bonds it can form with other atoms, which determines the saturation of hydrogens of each fatty acid. Hydrogen can only form 1 bond; oxygen can only form 2 bonds and carbon can only form 4 bonds.

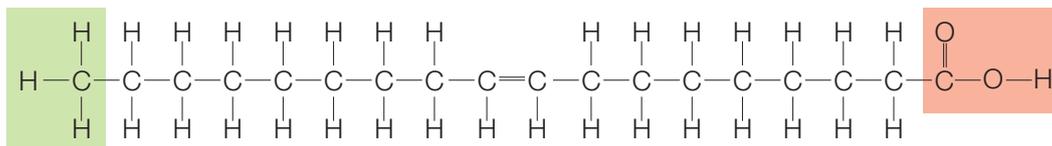


Figure 1.3.4: The structure of oleic acid, an 18-carbon monounsaturated fatty acid containing one double bond between the carbon atoms

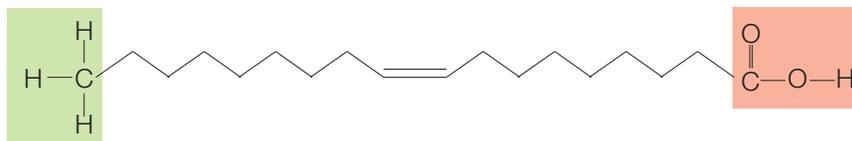


Figure 1.3.5: The structure of oleic acid, an 18-carbon monounsaturated fatty acid (simplified version)

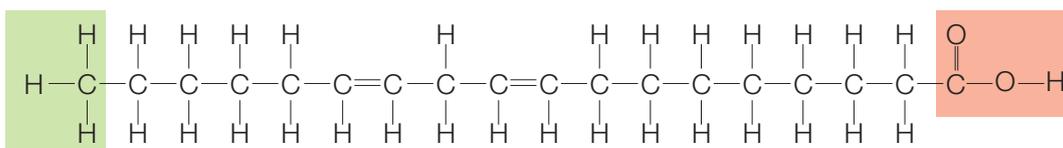


Figure 1.3.6: The structure of Linoleic acid, an 18-carbon polyunsaturated fatty acid containing two double bonds between the carbon atoms.

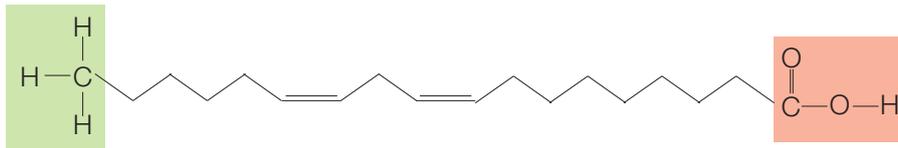
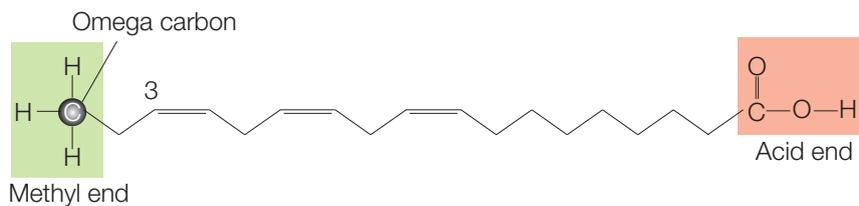


Figure 1.3.7: The structure of Linoleic acid, an 18-carbon polyunsaturated fatty acid (simplified version).

1

Fatty acids also differ in the location of their double bond. Polyunsaturated fatty acids are identified by the position of the double bond in relation to the methyl group (CH₃) end of the carbon chain. This is described by an omega number. A polyunsaturated fatty acid with its first double bond three carbons away from the methyl end is known as **omega-3** fatty acid, whereas a fatty acid with its first double bond six carbons away from the methyl end is known as **omega-6** (as shown in Figure 1.3.8).

Linolenic acid, an omega-3 fatty acid



Linolenic acid, an omega-6 fatty acid

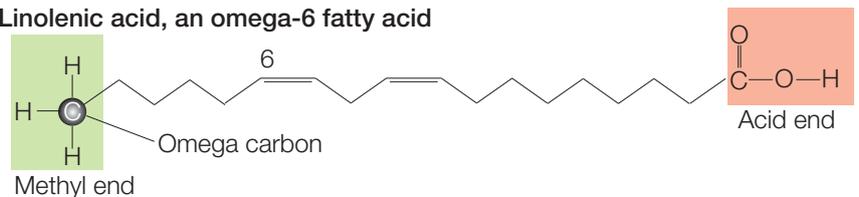
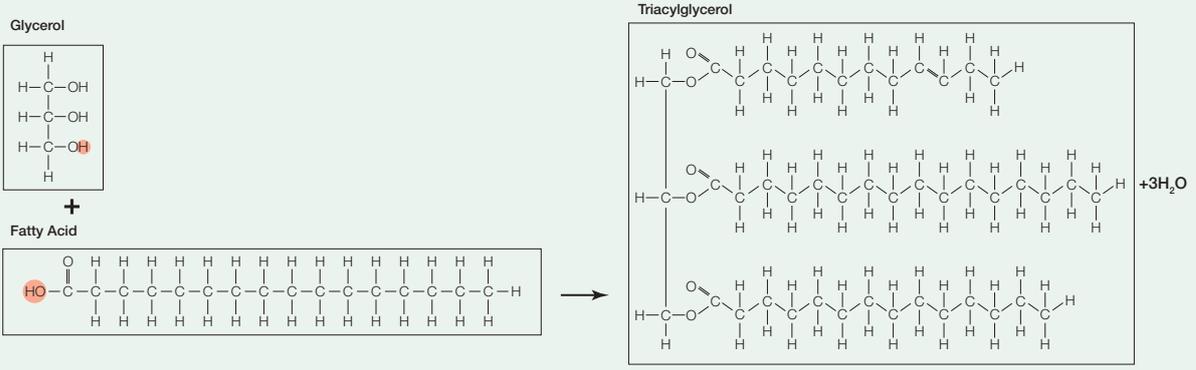
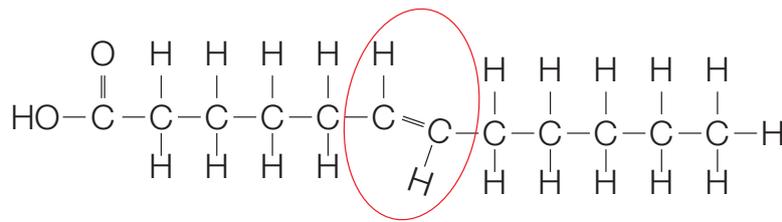


Figure 1.3.8: The omega number of polyunsaturated fatty acids: Omega-3 and Omega-6.

Fast fact

Fatty acids rarely occur free in food or in the body and are most often attached to a glycerol molecule via their acid end, making a triglyceride. To make a triglyceride, a series of condensation reactions combine a hydrogen atom (H) from the glycerol and a hydroxyl group (OH) from a fatty acid, forming a molecule of water (H₂O). A triglyceride may be composed of a mixture of more than one type of fatty acid, as shown below where 2 fatty acids are saturated, and one is monounsaturated.





1

Figure 1.3.10: A naturally occurring *trans*-fatty acid, with its hydrogen atoms at the double bond on the opposite side of the carbon chain.

Fatty acids can be commercially **hydrogenated** where some or all of the points of unsaturation (double bonds) are made saturated by adding hydrogen atoms. Most often, polyunsaturated fatty acids are partially hydrogenated as only some of their double bonds are broken by the addition of hydrogen atoms, creating a *trans*-fatty acid. Therefore, they are partially hydrogenated as not all of their double bonds have been broken. However, the double bonds that remain after processing change their configuration from *cis* to *trans*. The benefit of hydrogenation is it can improve the texture of foods by making them more solid and protects fats against oxidation, which causes these products to turn **rancid**. The process of complete and partial hydrogenation is shown in Figure 1.3.11 below.

Definitions

Rancid refers to foods containing fat or oil, which causes them to smell or taste unpleasant as a result of being old, stale and exposed to oxygen.

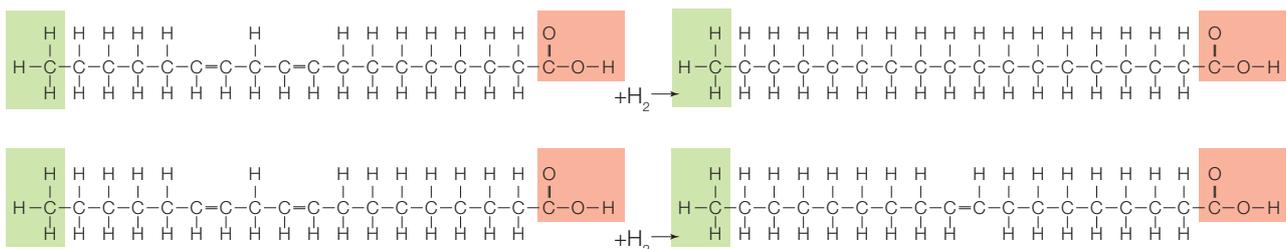


Figure 1.3.11: The process of complete (top) and partial (bottom) hydrogenation, where hydrogen atoms are added to an unsaturated fatty acid to remove all double bonds or where some remain to extend shelf life and improve texture.

Cholesterol

In addition to triglycerides, the lipids also include sterols. The most well-known sterol is **cholesterol**. Cholesterol is also composed of carbon, hydrogen and oxygen. The structure of cholesterol features glycerol and fatty acid chains, similar to that found in triglycerides. However, in cholesterol, the fatty acid chains are fused as rings, giving it a steroid section and its classification as a **sterol** (as shown in Figure 1.3.12).

Cholesterol is a waxy substance that is only very slightly soluble in water and blood, therefore it requires transport with **hydrophilic** proteins in molecules, called **lipoproteins**. This is the same transport requirement that triglycerides have.

Definitions

Hydrophilic molecules have a tendency to mix with and dissolve in water, and therefore can be transported in the blood, which is predominantly composed of water.

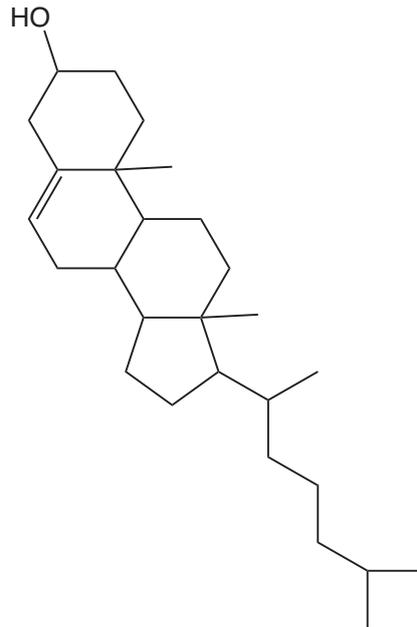


Figure 1.3.12: Structure of cholesterol.

Lipoproteins assist in transporting lipids (triglycerides, phospholipids and cholesterol) throughout the watery bloodstream. The body makes four types of lipoproteins, distinguished by their size and density, which is determined by their composition (as shown in Figure 1.3.13). Each type contains different kinds and amounts of lipids and proteins. The more lipids, the less dense; the more protein, the denser. Therefore, the classifications of cholesterol are based on the proportion of cholesterol, as the cholesterol molecule does not change. The four types are chylomicrons, very-low density lipoprotein (VLDL), low-density lipoprotein (LDL) and high-density lipoprotein (HDL).

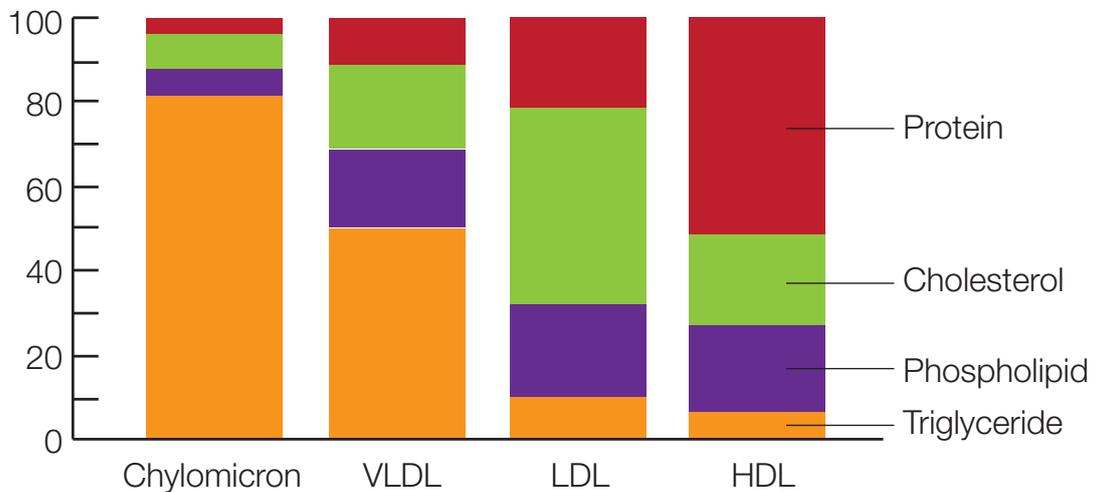


Figure 1.3.13: The composition of Chylomicron, VLDL, LDL and HDL, which determines its size and density.

Chylomicrons

Chylomicrons are the largest and least dense of the lipoproteins. They transport diet-derived lipids (mostly triglycerides), delivering lipids from digestive processes to cells all over the body and becoming smaller and smaller in size as its contents get depleted.

Very-low Density Lipoprotein (VLDL)

The lipids made in the liver and the leftovers collected from chylomicrons are packaged and transported as a **very-low density lipoprotein** (VLDL) and transported to other parts of the body. VLDL is the second least dense of the lipoproteins; however, as it travels throughout the body, cells remove triglycerides, causing VLDL to shrink in size. As a VLDL loses triglycerides, the proportion of lipids shifts, and the lipoprotein density increases. Therefore, the VLDL eventually become a low-density lipoprotein (LDL).

Low-density Lipoprotein (LDL)

A **low-density lipoprotein** (LDL) is composed of greater cholesterol and fewer triglycerides than a VLDL. The LDL circulates throughout the body, making its contents available to the cells.

High-density Lipoprotein (HDL)

The liver makes **high-density lipoprotein** (HDL) to remove excess cholesterol from the cells and carry it back to the liver for recycling and disposal. HDL contains the lowest proportion of lipids, and highest quantity of proteins making it the smallest in size with the greatest density.

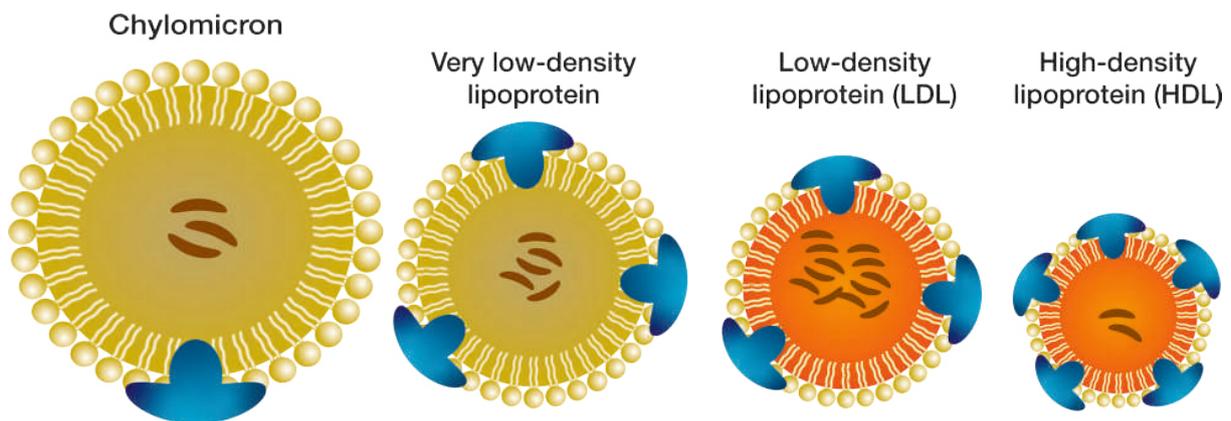


Figure 1.3.14: Comparison of Chylomicron, VLDL, LDL and HDL.

Extension activity

Phospholipids is another form of a lipid. Research and draw the structure of a phospholipid, describing the differences in its structure in comparison to a triglyceride.

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Sources of Lipids in the Diet

Foods high in lipids will typically have proportions of each of the types of fatty acids. Foods sources will differ depending on the classification of fatty acid

Saturated fat

Foods high in saturated fat mostly come from animals (as shown in Figure 1.3.15). Most dairy products – especially cream, cheese and butter – contain a substantial quantity of saturated fats, as do most meats and meat products – for example beef, sausages and pork. The fat from pork, called lard (as shown in Figure 1.3.16), is sometimes used as a **cooking fat in fast food outlets** (turns to oil when heated). Any food deep-fried in lard soaks up the oil and becomes a source of saturated fat.

Fast fact

The trend is shifting to the use of cottonseed oil (primarily polyunsaturated fat) for health and economic reasons.

Non-animal sources of saturated fat include coconut oil, palm oil and cocoa butter (as shown in Figure 1.3.16). Palm oil is commonly used as an ingredient in foods such as ice cream, margarine, instant noodles, chocolate and bread or bread products. Coconut oil is commonly used as a dairy replacement in pastries and desserts. Cocoa butter is a key ingredient in chocolate.

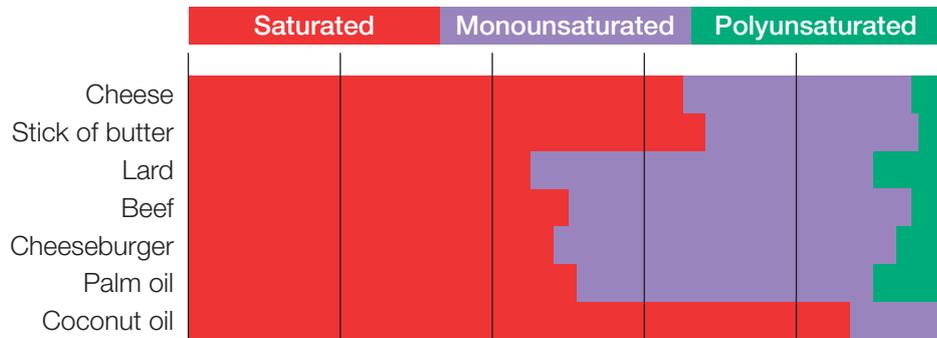


Figure 1.3.15: The percentage of the triglycerides in foods high in saturated fat.



Figure 1.3.16: Common sources of saturated fat (from left to right: lard from pork used in cooking, coconut oil, palm oil from fruit of oil palms and cocoa butter from cocoa beans).

Monounsaturated fats

Monounsaturated fats are found predominantly in foods such as avocados and nuts (for example, macadamias and almonds). Cooking oils including canola (Figure 1.3.17), olive and peanut, also contain high quantities of this fat (as shown in figure 1.3.18).



Figure 1.3.17: Canola Oil, a common source of monosaturated fats

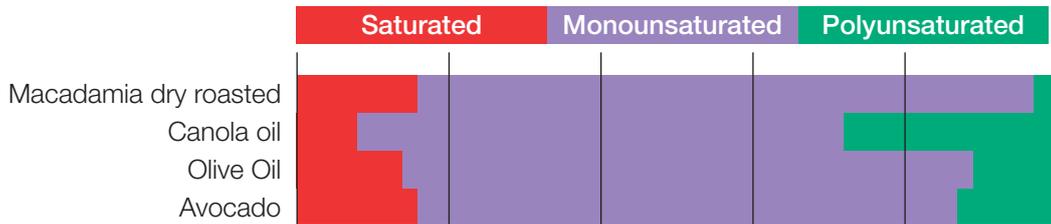


Figure 1.3.18: The estimated percentage of different triglycerides in foods high in monounsaturated fats.

Polyunsaturated fats

Omega 3

A number of foods have their highest fatty acid contribution from polyunsaturated fats (see Figure 1.2.11). Omega 3 is highest in oily fish, for example salmon and sardines. Other good sources include walnuts, chia seeds, and soybean oils and spreads (Figure 1.3.19).



Figure 1.3.19: Common sources of Omega 3, from left to right: Sardines, soybeans, chia seeds in bread and a smoothie.

Omega 6

Walnuts and soybean oils and spreads are high in omega 6 as well as omega 3. Other good sources of omega 6 include a range of seeds (e.g. sunflower seeds and oil, sesame seeds, pumpkin seeds), nuts (e.g. pine nuts, brazil nuts, pecans) and cottonseed oil (Figure 1.3.20).



Figure 1.3.20 Cottonseed oil extracted from seeds of cotton plant, brazil nuts and pumpkin seeds in bread.

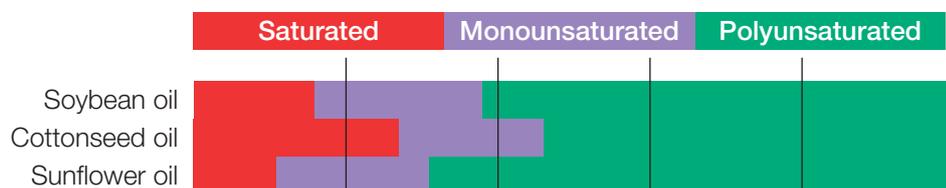


Figure 1.3.21: The estimated percentage of different triglycerides in foods high in polyunsaturated fats.

Questions

5. Rank each type of spread by how easily it would melt as temperature increases.

Sunflower seed margarine Olive oil margarine Butter

Melts first: ..

Melts second: ..

Melts last: ..

(3 marks) (KA2)

Trans-fatty acids

Trans-fatty acids are not found naturally in high quantities in any food. Artificially produced trans fats are used in commercially produced foods such as biscuits, cakes and pastries (Figure 1.3.22). Fast food outlets may also use partially hydrogenated vegetable fats (mostly trans-fat) for deep-frying, thereby rendering any food that soaks up the fat high in trans fats.



Reminder

Trans fats can also be called trans fatty acids or hydrogenated acids

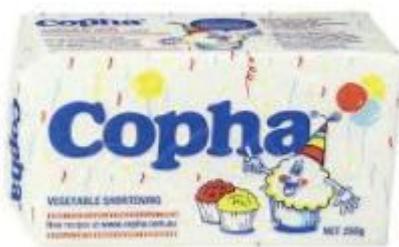


Figure 1.3.22: Copha is a hydrogenated coconut oil used in cooking (for example, in chocolate crackles).

Extension activity

Research foods in which trans-fat are found naturally.

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Questions

6. Most foods containing fat hold a proportion of each type of fat (Figures 1.3.15, 1.3.18 and 1.3.21). It is the fat in the highest proportion that gives the food its fat source classification. For example cheese, being around 65% saturated fat, 30% monounsaturated and a small percentage of polyunsaturated fat is considered a saturated fat food.

Using the figures mentioned above, identify the fat source classification of the following foods.

Macadamia nuts:

Beef:

Avocado:

Walnuts:

Cheeseburger: (5 marks) (IAE3)

7. Look at the following list of ingredients. Suggest three appropriate substitutions which would decrease saturated fat and trans fat, and increase unsaturated fat.

2 tbs hydrogenated vegetable oil

300 g beef mince

50 g grated cheese

50 g bread crumbs

100 g mixed vegetables

Salt and pepper

Substitution 1:

Substitution 2:

Substitution 3: (3 marks) (KA2)

Cholesterol

Cholesterol is only found in animal products, namely meat (for example, beef and poultry), eggs, and dairy (for example, cheese). The body can actually make all the cholesterol it needs; and therefore, dietary sources are not required.



Reminder

Consumers commonly ask which foods contain ‘good cholesterol’ e.g. HDL or ‘bad cholesterol’ e.g. LDL. However, good or bad cholesterol are not types of cholesterol, which is found in foods, but refers to the way the body transports cholesterol in the blood.

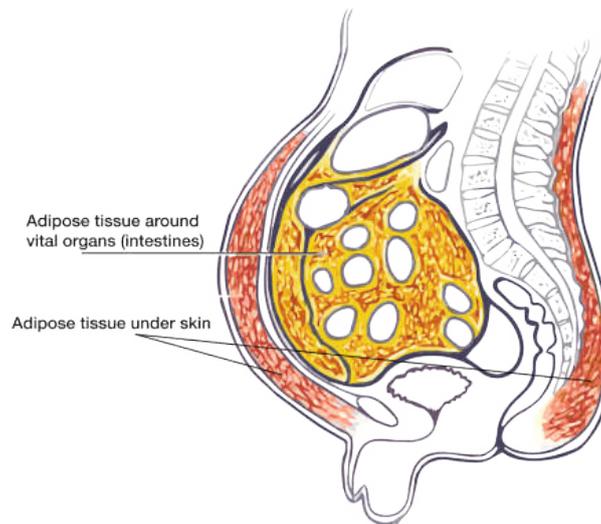


Figure 1.3.23: Adipose tissue providing cushioning for major organs.

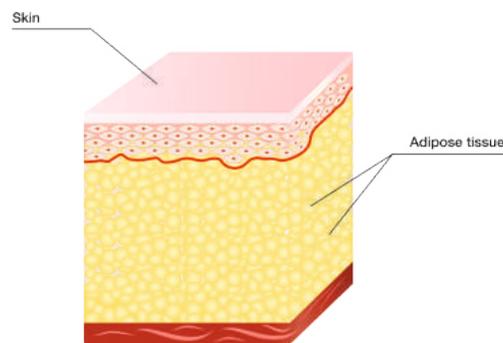


Figure 1.3.24: Adipose tissue layer under the skin for insulation.

Triglycerides – Omega 3 and Omega 6

Assisting the circulatory and immune systems

Omega 3 and 6 are the **essential fatty acids**, which play a part in the successful functioning of circulatory and immune systems. They are polyunsaturated triglycerides that the body cannot synthesise; therefore, they must be consumed from the diet. Functions of omega 3 and 6 are yet to be fully understood.

Omega 3 seems to have roles including: keeping the heart beating regularly, thereby reducing the risk of an abnormal heart beat (arrhythmia) (Figure 1.3.25); 'thinning' the blood, thereby reducing the risk of clotting; and supporting the immune system by reducing inflammation.

Omega 6 has been found to assist in blood-clotting processes.

Both essential fatty acids may be useful in normal fetal/infant brain development and in the reduction of low-density lipoprotein.

Component of the cell membrane

Cholesterol is needed by cells for its structural role in the cell membrane: it creates stability.

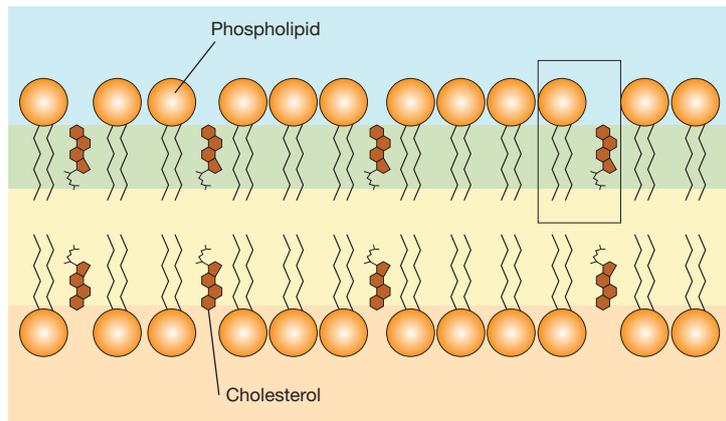


Figure 1.3.26: Cholesterol in the phospholipid bilayer of the cell membrane.

Synthesis of body compounds

Many vitally important body compounds are composed of cholesterol. Among them are bile (see digestion for its role), hormones (including the sex hormones: estrogen and testosterone) and vitamin D (as shown in Figure 1.3.27).

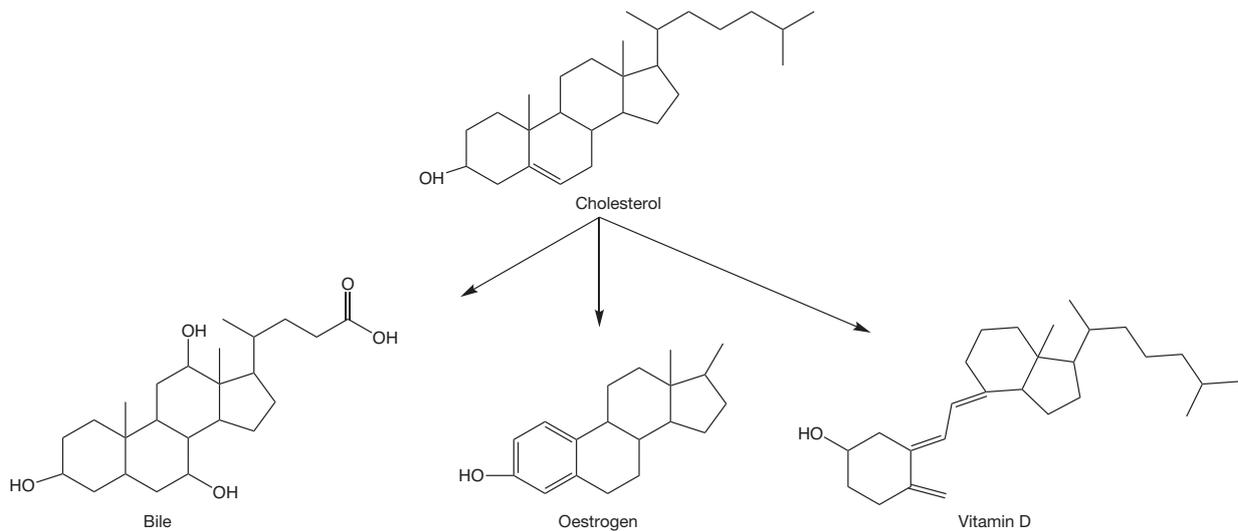


Figure 1.3.27: Cholesterol is used to make bile, sex hormones like estrogen and vitamin D.

Key terms

Adipocytes	Glycerol	Omega-6
Adipose tissue	High-density lipoprotein (HDL)	Saturated
Albumin	Hydrogenation	Sterol
Cholesterol	Lipids	Trans-fatty acid
Chylomicrons	Lipoprotein	Triglyceride
Cis fatty acid	Low density lipoprotein (LDL)	Unsaturated
Essential Fatty acids	Monounsaturated	Very-low density lipoprotein (VLDL),
Fatty Acid	Omega-3	

Review questions: 1.3 Lipids

1. Trans fatty acids can be found naturally in very small amounts in some foods, or they can be created artificially by food manufacturers. The industrial process partially hydrolyses vegetable oils to produce trans fatty acids.
- (a) Describe how trans fatty acid properties are similar to both saturated fat and unsaturated fat.
- (i) Property similar to saturated fat: (1 mark) (KA2)
- (ii) Property similar to unsaturated fat: (1 mark) (KA2)
- (b) Apart from providing and storing energy, list two other functions of trans fats and all other fats in the body:
-
-
- (2 marks) (KA1)
2. Essential fatty acids are an important nutrient in the body.
- (a) State an essential fatty acid.
- (1 mark) (KA1)
- (b) Describe what an essential fatty acid is.
-
-
-
- (2 marks) (KA1)
- (c) State a function of the essential fatty acid identified in part (a).
- (1 mark) (KA1)
3. The following questions are about cholesterol, an insoluble and waxy substance.
- (a) Describe how cholesterol is carried around in the blood.
-
-
-
- (2 marks) (KA1)
- (b) State two functions of cholesterol in the body.
- (i)
- (ii) (2 marks) (KA1)
- (c) Explain why LDL cholesterol is described as 'bad'.
-
-
-
- (2 marks) (KA2)
- (d) List two foods that are likely to increase blood cholesterol levels.
- (i)
- (ii) (2 marks) (KA1)

4. Identify four good sources of monounsaturated and polyunsaturated fats from the following recipe for zucchini, cheese and smoked salmon salad.

Ingredients	Triglyceride category
1 zucchini (about 12–15 cm long)	
2½ tbsp olive oil	
2 tbsp sesame seeds	
4 slices avocado	
1 tbsp finely chopped basil	
200 g cherry tomatoes	
90 g (about 6 slices) smoked salmon	
125 g soy cheese cut into small cubes	

(4 marks) (KA2)

5. Triglycerides provide the most energy of any of the macronutrients.

(a) State the energy value per gram.

..... (1 mark) (KA1)

(b) Describe a concern about the excessive consumption of fat, due to its high kilojoule count.

.....

 (2 marks) (KA2)

(c) Name the two molecules all triglycerides are composed of.

.....
 (2 marks) (KA1)

6. Explain the structural and physical differences between saturated and unsaturated fats.

.....

 (8 marks) (KA2)

7. Unsaturated fats have double bonds between the carbon atoms, explain the difference between a double bond that is cis and trans.

.....

 (2 marks) (KA2)



8. The properties (melting point) of fatty acids are dependent on the carbon length chain and degree of saturation (number of double bonds). The results of this investigation are shown in the table below.

Fatty Acid Name	Carbon Chain Length	Degree of saturation (number of double bonds)	Melting point (°C)
Myristate	14	0	54.4
Palmitoleate	16	1	-0.1
Linoleate	18	2	-5
Arachidonate	20	4	-49

(a) Identify the following fatty acids as saturated, monounsaturated and polyunsaturated.

Myristate:

Palmitoleate:

Linoleate:

Arachidonate: (4 marks) (KA2)

(b) Predict the state of the following fatty acids at room temperature.

Myristate: (1 mark) (IAE3)

(c) Using data from the table above, explain the link between the carbon chain length and the degree of saturation and how this impacts the melting point of fatty acids.

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..... (3 marks) (IAE3)

(d) The following table lists the content of saturated, monounsaturated and polyunsaturated fats in one tablespoon of various oils.

Oil	Total Fat Content (g)	Saturated Fat Content (g)	Monounsaturated Fat Content (g)	Polyunsaturated Fat Content (g)
Flaxseed	14	1	3	10
Coconut	14	12	1	1
Olive	14	2	10	2
Canola	14	1	8	4

Which oil would have a similar melting point to the following fatty acids:

Myristate:

Palmitoleate: (2 marks) (IAE3)

Total: _____ / 45 marks

1.4 Proteins

Science understanding

Recognition that macro nutrients have a specific function and structure

- The general structure of amino acids
- Essential, non-essential and conditional (babies, illness and vegan) amino acids
- Biological value of protein sources including; complete and incomplete proteins
- Plant, animal and novel sources of protein in the diet
- The functional roles of protein as a nutrient

SACE Subject Outline, 2020

Structure of Proteins and Amino Acids

Proteins chemically consist of the same elements as carbohydrates and lipids: carbon (C), hydrogen (H) and oxygen (O); however, proteins also consist of nitrogen (N). Therefore, protein-containing foods are the only source of nitrogen for the body. Carbon, hydrogen, oxygen and nitrogen link together to form different **amino acids**, which are the building blocks of protein chains. 'Amino' means 'contains nitrogen'.

Amino acids have the same structural formula: a central carbon atom bonded to one hydrogen (H) atom, an amino group (NH_2) and a carboxylic acid group (COOH). However, it is the fourth attachment that distinguishes the difference between each amino acid, changing the acid's shape, size, electrical charge or other characteristics. This fourth attachment is known as a side group, which may involve a single atom or group of atoms (as shown Figure 1.4.1). This is why proteins are more complex in structure than the other two macronutrients (carbohydrates and lipids), as each side group varies from one amino acid to the next (Figure 1.4.2 shows examples of different amino acids).

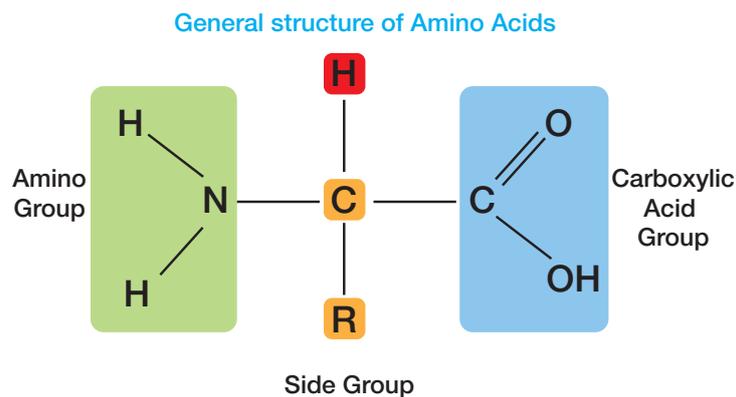


Figure 1.4.1: The general chemical structure of an amino acid.

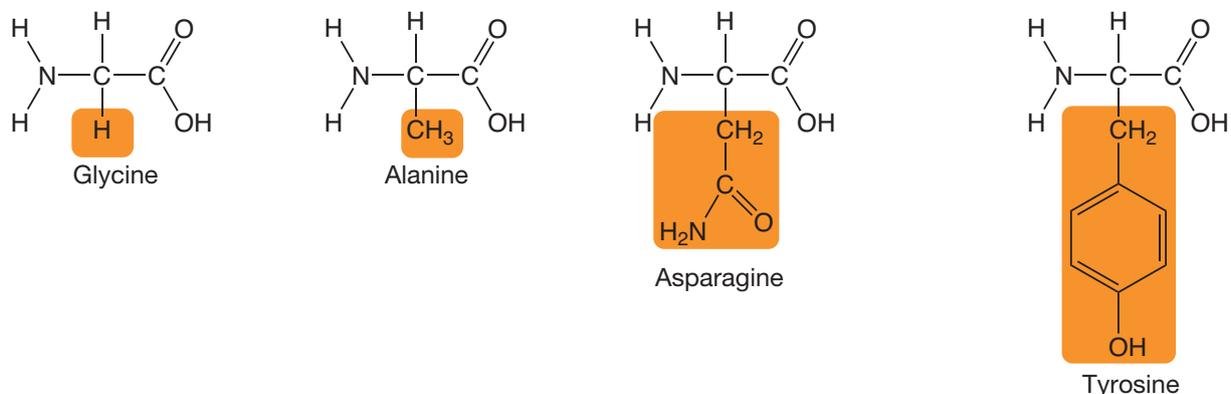


Figure 1.4.2: Different examples of amino acids. Each of them has the same chemical structure, differing only in each fourth attachment – the side group.

Questions

1. Using the information above, arrange the following in order of size: smallest to largest.

amino acid body tissue amino group protein

.....

..... (2 marks) (KA2)

Essential, Non-essential and Conditional Amino Acids

There are 20 amino acids required by the body. These amino acids are categorised as being essential or non-essential (Table 1.4.1). **Essential amino acids** must be provided by the diet, as the body cannot synthesise these at all or cannot produce them in amounts sufficient for meeting the body’s requirements. **Non-essential amino acids** can be synthesised by the body. The amino group in general is formed using nitrogen from the breakdown of excess amino acids, while the remainder of its structure is developed using carbon, hydrogen and oxygen provided by carbohydrates and lipids. Protein food sources contain both these types of amino acids; however, it is not vital to consume non-essential amino acids as these are synthesised by the body.

Table 1.4.1: The 20 different amino acids required by the body, categorised as essential and non-essential. Their abbreviated names are in brackets.

Essential amino acids	Non-essential amino acids
Histidine (His)	Alanine (Ala)
Isoleucine (Ile)	Arginine (Arg)*
Leucine (Leu)	Asparagine (Asn)*
Lysine (Lys)	Aspartic Acid (Asp)
Methionine (Met)	Cysteine (Cys)
Phenylalanine (Phe)	Glutamic Acid (Glu)
Threonine (Thr)	Glutamine (Gln)*
Tryptophan (Trp)	Glycine (Gly)*
Valine (Val)	Proline (Pro)*
	Tyrosine (Tyr)*
	Serine (Ser)*

*Conditionally essential amino acids

Questions

2. State an amino acid that cannot be synthesised by the body, and therefore must be consumed.

..... (1 mark) (KA2)

Non-essential amino acids may become essential under certain circumstances, such as illness, injury, stress or rapid growing stages. In these cases, they are referred to as **conditionally essential** (refer to Table 1.4.1; conditionally essential amino acids are asterisked). For example, in children, arginine is a conditionally essential amino acid for optimal growth and development, and it must therefore be provided by the diet. However, in adults, arginine is a conditionally essential amino acid that is only required in the diet in certain circumstances (such as after trauma, injury, or renal failure).

Extension activity

Research when another non-essential amino acid becomes conditionally essential.

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Biological Value of Proteins

Proteins can be classed as complete, incomplete or complementary. Their classification is determined by the type of amino acids in their structure. A **complete protein** contains all essential amino acids required by the body in the correct proportion; however, they may or may not contain all the non-essential amino acids. These proteins are considered to have a **high biological value**. Proteins that are missing or have a limited supply of one or more essential amino acids are labelled as **incomplete** and having a **low biological value**. Therefore, incomplete proteins cannot support the structural and functional roles of proteins in the body solely. The combination of incomplete proteins to obtain all essential amino acids, produces a **complementary protein**.

Sources of Protein in the Diet

The body is unable to store excess amino acids; therefore dietary protein is vital to consume on a daily basis. Protein food sources are required to provide the essential amino acids and nitrogen, in which is used to build non-essential amino acids and other nitrogen containing compounds the body needs.

Complete Proteins

Generally, foods derived from animal sources, such as meat, fish, poultry, cheese, eggs, yoghurt and milk, are complete proteins (Table 1.4.2). Gelatine is an exception, as it does not contain the essential amino acid tryptophan.

Incomplete Proteins

Foods derived from plant sources, such as nuts, seeds, cereals and legumes are good sources of incomplete proteins. These tend to be lacking one or more essential amino acids (Table 1.4.2). Soy products (e.g. tofu, soybeans), quinoa and chia seeds are an exception, as they have a high biological value containing all essential amino acids.

Table 1.4.2: The essential amino acid composition of beef (a complete protein) and cereals (an incomplete protein).

Essential amino acids	His	Ile	Leu	Lys	Met	Phe	Thr	Trp	Val
Beef	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cereals	✓	✓	✓		✓	✓		✓	✓

Extension activity

Research which essential amino acids are missing from the following incomplete protein food sources.

Incomplete protein food source	Missing essential amino acid(s)
Beans	
Seeds	
Almonds	
Rice	
Peas	
Peanuts	
Wholemeal bread	

A number of people in Australia restrict their consumption of animal products due to religious beliefs, perceived health benefits, personal likes and dislikes, ethical concerns and current trends. Where possible, the general term ‘vegetarian’ should be avoided, as it is a broad term that does not specify the specific limitations of that individual’s diet.

Extension activity

Research the restrictions of the following diets.

Vegan	
Lacto vegetarian	
Lacto-ovo vegetarian	
Pescatarian	
Pollo-tarian	

Complementary Proteins

Generally, proteins derived from plant sources have a lower biological value than animal sources as they offer less protein and are limited in one or more essential amino acids. For these reasons, vegetarians and vegans improve the composition of protein in their diets by combining plant sources that contain different amino acids (Table 1.4.3). It is not necessary to balance amino acids at every meal, as long as an individual obtains every essential amino acid over the course of a day by consuming a variety of wholegrains, legumes, seeds, nuts and vegetables.

Table 1.4.3: Two incomplete proteins combine to produce a complementary protein that provides all essential amino acids.

Essential amino acids	His	Ile	Leu	Lys	Met	Phe	Thr	Trp	Val
Peanut butter	✓	✓	✓	✓		✓	✓	✓	✓
Wholegrain bread	✓	✓	✓		✓	✓	✓	✓	✓
Together	✓	✓	✓	✓	✓	✓	✓	✓	✓

Peanut butter is limited in the essential amino acid Met but has a sufficient supply in Lys. Wholegrain bread has the opposite composition. By consuming them together, a person receives all the essential amino acids.

Questions

3. State the classification of a protein that combines two incomplete proteins to obtain all essential amino acids.

..... (1 mark) (KA1)

4. Identify the following food sources as complete or incomplete.

Chicken: ..
 Chickpeas: ..
 Yoghurt: ..
 Tofu: ..
 Gelatine: ..

(5 marks) (KA1)

Extension activity

Research other sources of complementary proteins that a vegetarian or vegan could consume to obtain all essential amino acids.

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Novel Proteins

Novel protein foods (NPFs) are products based on vegetable protein and micro-organisms and are produced from sources that are widely available but not commonly consumed. A wide variety of vegetarian alternatives are already available on the market, including seitan, tofu, soy meat, tempeh, quorn and meatless based on lupin beans. Some novel protein sources such as insects, algae, duckweed, microbial protein, leaf protein and rapeseed are expected to enter the market as replacements for animal derived protein sources. These sources are being explored due to the increasing demand for protein as the growth of the population continues to increase.

Science as a human endeavour (Application and Limitation)

Considering insects as food

Source: <https://medicalxpress.com/news/2020-02-insects-seaweed-lab-grown-meat-foods.html>

Insects form a significant part of diets across the globe and are increasingly discussed as a sustainable protein source for the future. The largest farm in North America is less than two hours outside of Toronto and produces an array of cricket and mealworm powders and whole-roasted snacks. Insects are a front-runner in the quest for sustainable protein sources, producing the same amount of protein as conventional poultry, beef and pork with far fewer feed requirements. Studies estimate that insects require 25 times less land resources to raise than conventional beef, half the energy and one-third of the water resources. From a nutritional standpoint, numerous species of insects are rich in key proteins, micronutrients and minerals, although nutritional profiles change significantly during the different life stages of various insects.

Questions

5. With reference to the science as a human endeavour on the previous page, identify two benefits to the consumer if insects were widely consumed as a main protein source.

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(2 marks) (KA3)

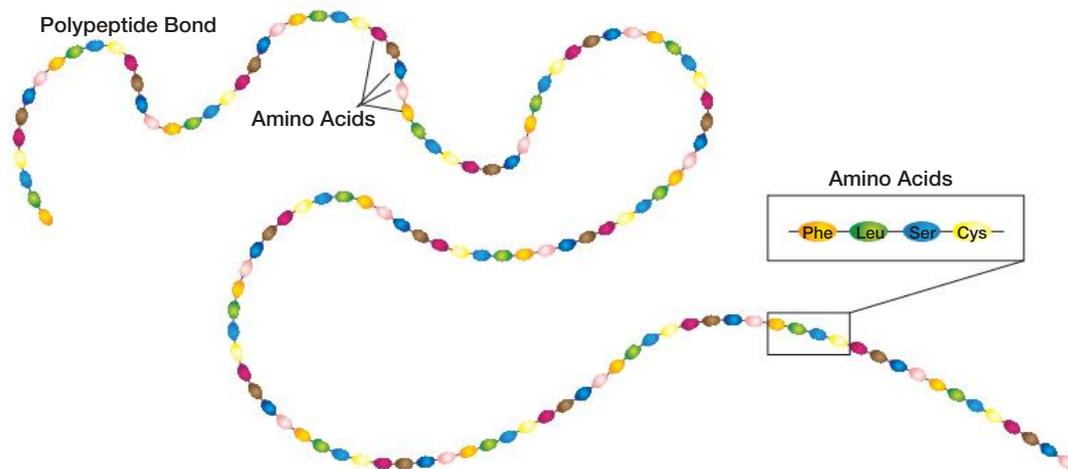
Functional Role of Proteins

Amino acids – whether essential and gained via consumption, or non-essential and synthesised by the body – are linked together in a variety of sequences to make different proteins required by the body. A peptide bond links each amino acid, forming a polypeptide chain (Figure 1.4.3). This is completed through a **condensation** reaction, the same type of reaction that combines monosaccharides to form a disaccharide or polysaccharide and fatty acids and glycerol to form a triglyceride.

Definitions

Condensation is the combination of two molecules to form a larger molecule; by producing water as a by-product.

Proteins can be a few dozen to several hundred amino acids long. The length and sequence of amino acids determines a protein’s unique shape, which enables them to perform their various functions in the body.



Amino Acids

Ala: Alanine	Gln: Glutamine	Leu: Leucine	Ser: Serine
Arg: Arginine	Glu: Glutamic acid	Lys: Lysine	Thr: Threonine
Asn: Asparagine	Gly: Glycine	Met: Methionine	Trp: Tryptophane
Asp: Aspartic acid	His: Histidine	Phe: Phenylalanine	Tyr: Tyrosine
Cys: Cysteine	Ile: Isoleucine	Pro: Proline	Val: Valine

Figure 1.4.3: A sequence of amino acids linked together forming a polypeptide bond.

The sequence of amino acids is determined by **genes** provided to the foetus by the genetic information received at conception. This code of instructions is held in every cell; however, each cell uses a different combination of genes to build the particular protein it needs to perform its specialised functional roles in the body (Figure 1.4.4).

Definitions

A gene is a segment of DNA

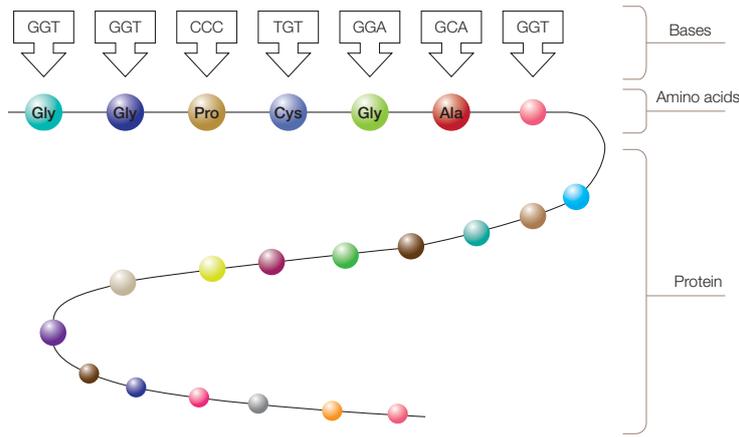


Figure 1.4.4: The creation of proteins in the body to perform its structural and functional roles.

Growing, maintaining and repairing body tissues

From the moment of conception, proteins (e.g. collagen, elastin, and keratin) are the building blocks of the initial matrix of bones, muscles, nerves, blood, glands, skin, hair, fingernails, teeth, ligaments, tendons and artery walls. For example, cells lay down an initial matrix of the protein collagen and then fill it with crystals of calcium, phosphorus and other minerals to produce bones.

Synthesising enzymes

An enzyme is a catalyst that speeds up biochemical reactions in the body (e.g. metabolism). An enzyme is also involved in the breakdown of materials (e.g. digestion), the building of bodily tissues (e.g. bone) and the transformation of substances in the body (e.g. glucose into energy). An enzyme has a specific active site that attracts a particular substance to assist in its breakdown, development or transformation (Figure 1.4.5, which demonstrates the digestion of a disaccharide, sucrose).

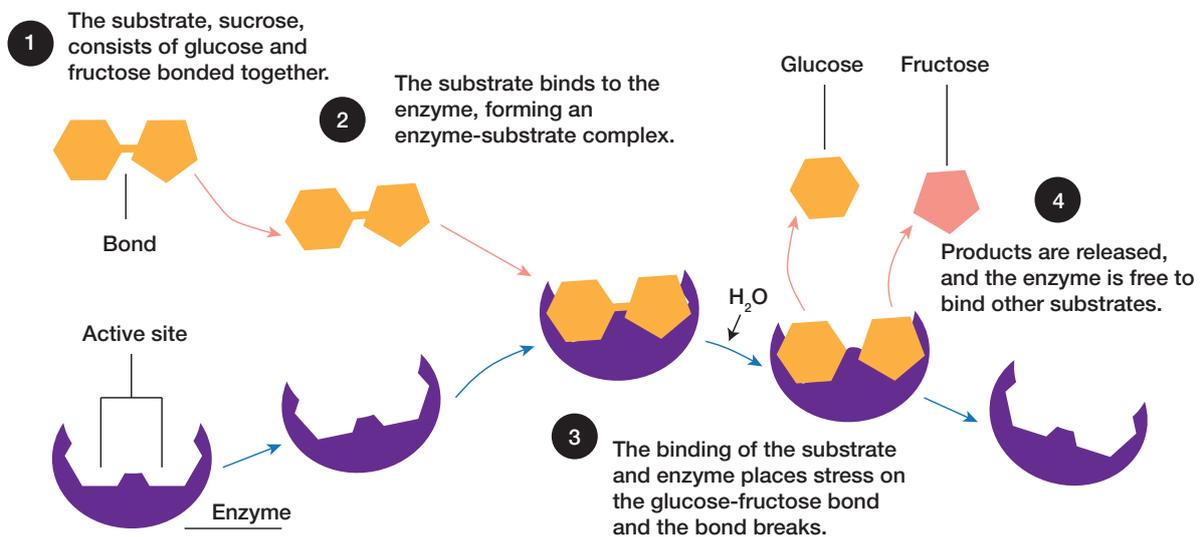


Figure 1.4.5: An enzyme acts on sucrose, breaking it down into its monosaccharides.

Every enzyme in the body facilitates biochemical reactions in the body. The enzyme shown in Figure 1.4.5 assists in the digestion of sucrose (breaking the disaccharide into its monosaccharides) by allowing this substance to bind to its specific active site. The enzyme itself remains unchanged.

Synthesising hormones

Hormones are the body's chemical messengers. They are made by the **endocrine glands**. The endocrine glands release these hormones directly into the bloodstream in response to changes that challenge the body (e.g. heart rate, blood glucose levels, growth and development). The blood carries these hormones to their target site, where

they implement the appropriate response to achieve **homeostasis**. Table 1.4.4 lists examples of hormones and their actions.

Definitions

Homeostasis is the tendency of an organism or cell to maintain a constant internal environment within tolerance limits, in order to restore and maintain normal body conditions.

Fast fact

Some examples of endocrine glands that produce hormones include the pancreas, ovaries, testes, pituitary gland, thyroid gland, hypothalamus and adrenal glands.

Table 1.4.4: Examples of hormones and their functions.

Hormones	Function
Insulin and glucagon	Regulates blood glucose levels
Growth hormone	Stimulates growth and the reproduction of cells
Thyroxine	Regulates body metabolism and protein synthesis
Dopamine	Regulates mood, memory, learning, behaviour and attention

Synthesising antibodies

An **antibody** defends the body against invading antigens that may cause disease or a virus (e.g. flu, smallpox, measles, or the common cold). The body responds to antigens by producing an antibody, which is able to work quickly and efficiently to destroy a specific antigen (Figure 1.4.6). First, the antibody binds to the antigen. This signals other immune cells to kill the unwanted antigen. Once the body has produced a specific antibody in response to a particular invading antigen, the body remembers how to manufacture it. This allows the body to produce the antibody more quickly the next time the same antigen invades the body. This assists the development of the body's immunity.

Fast fact

Pathogen can be another word used for antigen.

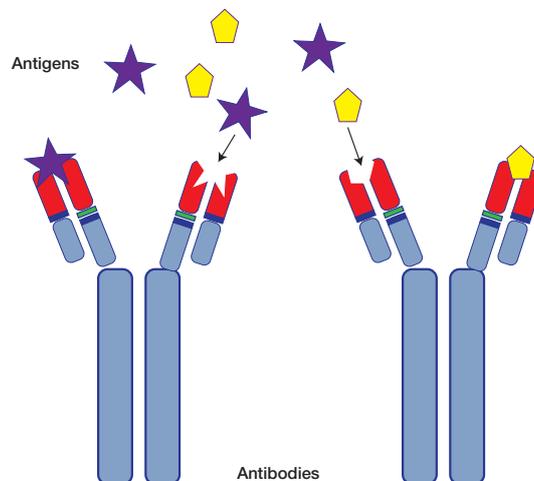


Figure 1.4.6: Each antibody is manufactured to destroy a specific antigen invading the body. The antigen binds to the specific binding site on the antibody.

Regulating fluid and acid–base balance

An important protein, albumin, produced by the liver, maintains **homeostasis** (equilibrium state) in the body by attracting water and controlling the movement of liquids in to and out of the cell.



Fast fact

The liquid in a cell is known as intracellular fluid, whereas the liquid outside of the cell is known as the extracellular fluid

Proteins can also control the acid–base balance in the blood. Proteins can achieve this due to their amino and carboxylic acid groups, which allows them to bind to positively charged hydrogen ions (H^+) or negatively charged hydroxide ions (OH^-) and discharge them from the body if required. This maintains the pH of the blood, preventing it from becoming too acidic or basic.

Assisting in muscle contraction and relaxation

A muscle fibre is composed of two types of proteins – actin (thin) and myosin (thick) filaments – which assist in transforming chemical energy (Adenosine triphosphate – ATP) into mechanical energy. This transformation causes the muscle to contract as the actin and myosin filaments slide past one another (Figure 1.4.7).

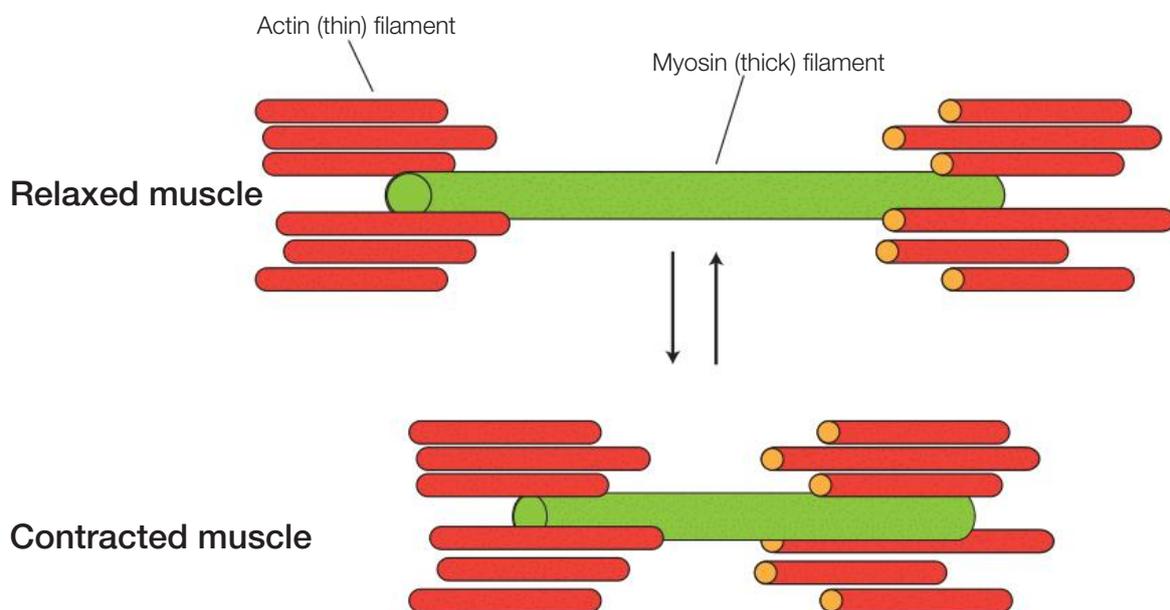


Figure 1.4.7: Sliding proteins (actin filaments and myosin filaments) allow muscle contraction and relaxation to occur.

Acting as transporters

Proteins in the body are hydrophilic and travel throughout bodily fluids, delivering nutrients and other molecules for cellular use. For example, for respiration to occur, the protein haemoglobin in red blood cells carries oxygen from the lungs to the body's cells.



Reminder

Hydrophilic molecules have an affinity to water and tendency to mix with it, whereas hydrophobic molecules tend to repel water and are unable to mix with it.

Other proteins can be found embedded in the cell membrane, such as channel and carrier proteins. These allow specific compounds to enter the cell when required (as shown in Figure 1.4.8).

Each transport protein is specific to a certain nutrient or group of compounds.

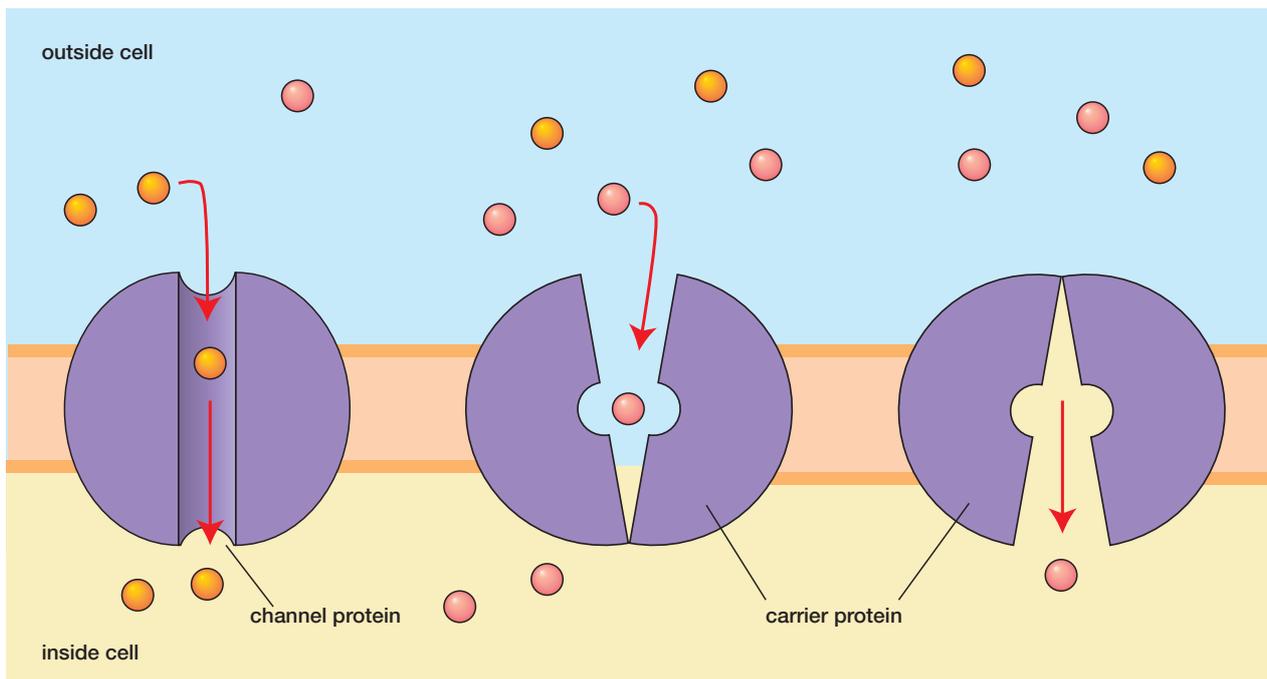


Figure 1.4.8: Channel and carrier proteins can be found in the cell membrane, which allows specific nutrients or compounds to enter the cell when required.

Providing a secondary source of energy

The body requires a constant supply of energy for efficient cell and brain function. Proteins are tasked with specific roles, so they are not designed to be the body's primary supplier of energy. However, during times of starvation and insufficient carbohydrate and lipid consumption, proteins' main functions are sacrificed. The body will break down body tissue proteins to make amino acids that can be converted into glucose (through the process of gluconeogenesis) and used as an energy source. Therefore, blood glucose levels are maintained, but at the expense of muscle and body mass.

Of the energy we consume, it is recommended that 15 to 25 per cent be sourced from protein (refer to Topic 1.1 Energy in foods for further information).



Science as a human endeavour

High protein diets boost artery clogging plaque

The source for this article is <https://www.sciencedaily.com/releases/2020/01/200123152614.htm>

Researchers studied mice fed a high-fat diet to deliberately induce atherosclerosis, or plaque build-up in the arteries. According to Razani, mice must eat a high-fat diet to develop arterial plaque. Therefore, some of the mice received a high-fat diet that was also high in protein. And others were fed a high-fat, low-protein diet for comparison. "A couple of scoops of protein powder in a milkshake or a smoothie adds something like 40 grams of protein — almost equivalent to the daily recommended intake," Razani said. "To see if protein has an effect on cardiovascular health, we tripled the amount of protein that the mice receive in the high-fat, high-protein diet — keeping the fat constant. Protein went from 15% to 46% of calories for these mice." The mice on the high-fat, high-protein diet developed worse atherosclerosis — about 30% more plaque in the arteries — than mice on the high-fat, normal-protein diet, despite the fact that the mice eating more protein did not gain weight, unlike the mice on the high-fat, normal-protein diet.

Questions

6. Explain a consequence to the health of society if protein consumption makes up more than 25% of an individual's energy intake on a regular basis.

.....

.....

.....

.....

(3 marks) (KA3)

 Key terms

Actin and myosin filaments	Enzyme	Novel Protein Foods (NPFs)
Ammonia/urea	Essential amino acid	Peptide bond
Antibody	Homeostasis	Polypeptide chain
Body tissues	Hormone	Secondary source of energy
Complementary protein	Incomplete protein	Transporter proteins
Complete protein	Limiting amino acid	
Conditionally essential amino acid	Non-essential amino acid	

Review questions: 1.4 Proteins

1. (a) Draw the chemical structure of an amino acid. Make sure it is well labelled.

(2 marks) (KA1)

(b) Identify the structural component of an amino acid that distinguishes one amino acid from another.

..... (1 mark) (KA1)

2. Explain the difference between an essential and a non-essential amino acid.

.....

.....

.....

..... (2 marks) (KA1)

3. Explain when an amino acid might be conditionally essential.

..
..
..
..
..... (2 marks) (KA2)

4. Describe what determines the shape and function of a protein.

..
..
..
..
..... (2 marks) (KA2)

5. Describe the difference between an enzyme and a hormone and use an example of each type of protein to support your explanation.

..
..
..
..
..... (4 marks) (KA2)

6. Explain why using protein as the predominant energy source may be concern to an individual's health.

..
..
..
..
..... (2 marks) (KA2)

7. Excess amino acids cannot be stored in the body. Explain how an individual can obtain all essential amino acids.

..
..
..
..
..... (2 marks) (KA2)

8. (a) Name one food that a vegan could consume with a serving of brown rice to improve the protein composition of the meal.

..... (1 mark) (KA2)

(b) Explain how the food item listed in question 8(a) would improve the protein composition of the meal.

..
..
..
..
..... (2 marks) (KA1)

9. Refer to the following table, which demonstrates the recommended daily intake (RDI) of protein for different stages of the human life cycle.

Stage in human life cycle	Protein RDI (grams)
Infancy (0–12 months)	10–14
Childhood (1–8 years)	14–20
Adolescence (13–18 years)	40–65
Adulthood (18–50 years)	45–60
Pregnancy	60

- (a) With reference to the table above, explain the trend in the RDI of protein from the ages 0 to 18 years.

.. .. .

 (2 marks) (IAE3)

- (b) Explain why the RDI of protein is greatest during adolescence.

.. .. .

 (2 marks) (KA2)

10. Nutrient requirements change according to person’s stage of life.

- (a) Explain why an 8-year-old male requires 20g of protein, whereas a 16-year-old male requires 65g of protein.

.. .. .

 (2 marks) (KA2)

- (b) Explain one role of protein in people aged 70 years and older.

.. .. .

 (2 marks) (KA2)

- (c) Describe one economic factor that might influence the protein intake of an older person.

.. .. .

 (2 marks) (KA2)

- (d) Provide an alternative source of protein that may be cheaper and more affordable than animal proteins.

.. .. . (1 mark) (KA1)

11. Vegans can find it difficult to consume all essential amino acids.

(a) Name one food that an adolescent vegan could consume with a serving of baked beans in tomato sauce that would improve the protein composition of the meal.

..... (1 mark) (KA1)

(b) Justify your choice, in part 11 (a).

.....

 (2 marks) (KA2)

12. After finishing a weight training session some athletes often consume a protein shake.

(a) Identify *one* function of protein in relation to sports performance.

..... (1 mark) (KA1)

(b) Explain *one* health implication of consistently consuming protein in levels far exceeding the Recommended Daily Intake (RDI).

.....

 (2 marks) (KA2)

13. Although, a deficiency in protein is not very common in Australia, groups at greater risk may develop the following symptoms in the table below. Explain why the following symptoms may occur in an individual with a **deficiency** in protein.

 **Fast fact**

A deficiency in a nutrient is the opposite of its function.

Symptom of Protein Deficiency	Explanation
Oedema and difficulty with correct fluid balance	
Poor skin, nail and hair development	
Stunted growth in children	
Greater susceptibility to bacterial and viral infections	
Anaemia	
Depletion in muscle mass	
Muscle pain	
Fatigue	

(8 marks) (KA2)

Total: _____ / 45 marks

1.5 Water and Other Fluids

Science understanding

- Sources of Water in the Diet
- Functions of Water
 - Benefits derived from consuming fluids other than water
- The causes and effects of dehydration

SACE Subject Outline, 2020

Sources of Water in the Diet

The recommended daily intake of water is dependent on diet, body size, activity levels, environmental temperatures and humidity; therefore, it is difficult to establish one water requirement value. However, according to the nutrient reference values for Australia and New Zealand, a male should consume 3.4 litres and a female should consume 2.8 litres of total water content a day. The total water content includes not only consuming water but other beverages and food items, which almost all contain some water.

The body's metabolic processes (e.g. digestion) are also sources of water, as they produce approximately 200 to 300 mL of water each day that can then be used by the body for other functions.

Fluid sources

Water is undoubtedly the best drink for hydration, as it contains no kilojoules. However, consumers do not only drink water for hydration. After water, other fluid sources of water include coffee, tea, full fat or reduced fat milk, flavoured milks, fruit juices, cordial, regular or diet soft drinks, energy or sports drinks and alcohol. However, caffeinated beverages (tea, coffee and soft drinks) and alcohol promote greater water loss through urine as they act as a **diuretic** – especially if more than 3 cups are consumed in a day.

Definitions

A diuretic is a source which causes increased urination.

Science as a human endeavour (Application and Limitation)

Which drink is best for hydration? Hint: It isn't Water

Source: <https://edition.cnn.com/2019/09/25/health/best-drinks-for-hydration-wellness/index.html>

Sure, you can always reach for a glass of water — but plain H₂O isn't the most hydrating beverage around, according to a study from Scotland's St. Andrews University that compared the hydration responses of several different drinks. The researchers found that while water — both still and sparkling — does a pretty good job of quickly hydrating the body, beverages with a little bit of sugar, fat or protein do an even better job of keeping us hydrated for longer. The reason has to do with how our bodies respond to beverages, according to Ronald Maughan, a professor at St. Andrews' School of Medicine and the study's author. One factor is the volume of a given drink: The more you drink, the faster the drink empties from your stomach and gets absorbed into the bloodstream, where it can dilute the body's fluids and hydrate you. The other factor affecting how well a beverage hydrates relates to a drink's nutrient composition. For example, milk was found to be even more hydrating than plain water because it contains the sugar lactose, some protein and some fat, all of which help to slow the emptying of fluid from the stomach and keep hydration happening over a longer period of time. Milk also has sodium, which acts like a sponge and holds onto water in the body and results in less urine produced. This study tells us much of what we already knew: Electrolytes — like sodium and potassium — contribute to better hydration, while calories in beverages result in slower gastric emptying and therefore slower release of urination," said Melissa Majumdar, a registered dietitian, personal trainer and spokeswoman for the Academy of Nutrition and Dietetics who was not involved in the study.

Functions of Water

Approximately 60 per cent of the average adult body is composed of water, where it makes up 75 per cent of lean body tissue, 25 per cent of adipose tissue and 90 per cent of blood plasma. The bodily proportion of water is smaller in female, obese and/or elderly people, as they have a lower percentage of lean body tissue. It is essential for an individual to stay well **hydrated** as water is the fluid in which all life processes occur in the body.

Definitions

To stay well hydrated is having absorbed enough water or other liquid to perform its bodily processes.

Carrying nutrients and waste products throughout the body

Water acts as a **solvent**. It dissolves a variety of different nutrients and substances, including minerals, vitamins, amino acids, glucose and many other small molecules, which can participate in metabolic reactions. This allows nutrients to be efficiently transported in blood, which is predominantly made of water. Water, via blood, also carries waste to the kidneys for filtering and finally excretion through urine.

Questions

2. Identify the term given to substances that can mix well with water.

(1 mark) (KA1)

Regulating body temperature

Water allows heat to be released from the body when ambient (air) temperature is higher than body temperature. The body begins to **sweat (perspire)**; this sweat then evaporates from the surface of the skin, cooling the body very efficiently.

Questions

3. Water is required for cooling the body. Identify the nutrient that is required for keeping the body warm and explain how it performs this function.

(2 marks) (KA2)

Supporting digestion

Digestion starts with saliva, the basis of which is water. Saliva moistens food for easy movement throughout the remainder of the digestive tract. Water also produces soft stools, preventing them from drying out and getting stuck in the large intestines. This promotes easy evacuation from the bowels, preventing the risk of constipation.

Questions

4. Identify the nutrient that assists water in producing soft stools.

(1 mark) (KA1)

Moistening air breathed in via the nasal cavity and mouth

As air passes through the nasal cavity and mouth it is warmed, filtered and humidified by mucous secretions containing water. Air entering the mouth is warmed but not filtered. This increases the amount of water vapour in the air entering the lungs, which in turn reduces risks to the respiratory system. Without the moist air, the respiratory system could dry out and cause damage to the delicate tissues.

Maintaining blood volume

Blood volume is determined by the amount of water ingested (along with other factors). The kidneys can adjust blood volume by expelling excess water or conserving water if an individual is dehydrated.

Definitions

Blood volume refers to the total amount of fluid circulating within the arteries, capillaries, veins, venules, and chambers of the heart at any time.

Lubricating and moistening body joints and tissues

Water acts as a **lubricant and shock absorber** for joints, the eyes, the brain, the spinal cord and the fetus during pregnancy. There are names for the different types of lubricating/shock absorbing fluids; for example, amniotic fluid protects the fetus, synovial fluid protects joints. This protects the body's sensitive structures against shock.

The water (synovial fluid) between a knee joint reduces friction and allows for a smooth gliding motion between the bones. This prevents the bones from rubbing against each other, which would cause stiffness and pain during movement (as shown in Figure 1.5.1).

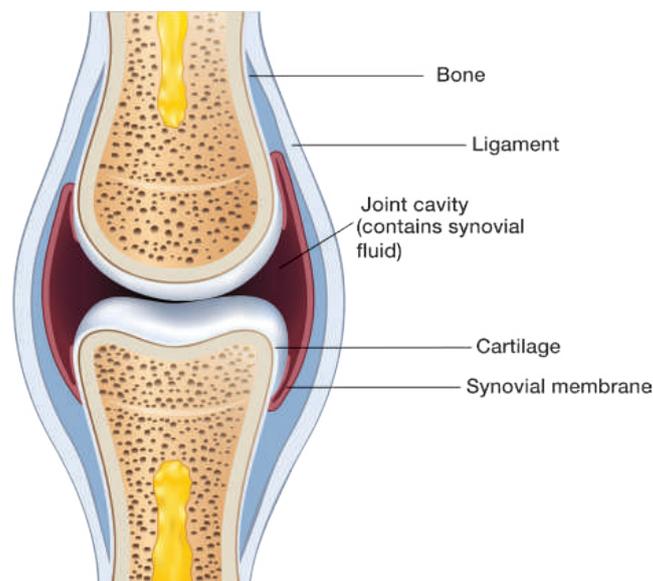


Figure 1.5.1: Fluid cushions joints to protect them from damage.

Extension activity

Water is the best recommended source of water, due to containing no kilojoules or sugar. However, other fluids can be a great source of water and other nutrients which can provide another function in the body. Research two other nutrients that may be provided by these other fluid sources and their benefits in the body.

Fluid Source	Other Nutrients Present and their Benefit
Milk	
Black Coffee and Tea	
Fruit Juice	
Sports or Energy Drink	

The Causes and Effects of Dehydration

The body loses water each day through fluids such as sweat, faeces, urine, breath, blood, vomit and tears. The average amount of water lost from the body is approximately 2.2 litres per day. The greatest loss of water is through urine, which accounts for approximately 0.5 to 1.4 litres per day. Urine helps to excrete the waste products generated by a body's metabolic reactions throughout the day. If an individual consumes more water, the kidneys excrete more urine, which makes it more dilute. On the other hand, if an individual does not consume enough, the kidneys conserve as much water as possible, making urine more concentrated.

The Causes of Dehydration

Dehydration is caused by not consuming enough fluid and losing more than we intake. The amount of water lost from the body can be increased due to hot and humid environmental conditions, illness, the excessive consumption of diuretics and strenuous physical activity. Water loss is important for maintaining a healthy balance, where excretion is equal to intake (as shown in Table 1.5.2).

Table 1.5.2: The amount of water gained from different sources and the amount of water lost via different bodily fluids to maintain a fluid balance in the body.

Water sources	Amount (mL)	Water loss	Amount (mL)
Beverages	550–1500	Kidneys (urine)	500–1400
Food	700–1000	Skin (sweat)	450–900
Metabolic processes	200–300	Lungs (breath)	350
		GI tract (faeces)	150
Total	1450 – 2800	Total	1450 – 2800

Questions

5. Identify three food sources that would contribute a significant amount of water to an individual's daily intake.

.....

.....

.....

..... (3 marks) (KA1)

6. With reference to Table 1.5.2, identify where the greatest amount of water is lost from the body.

..... (1 mark) (IAE3)

7. Identify three conditions which may impact hydration and increase excessive water loss from the body.

.....

.....

..... (3 marks) (KA1)

How do you know if you are drinking enough water?

This can be checked and monitored every few hours and compared to a dehydration urine chart (Figure 1.5.2). If a person’s urine is light in colour, this is an indication that that person is drinking enough. However, if the urine colour is dark, then not enough water is being consumed.



Figure 1.5.2: Urine dehydration chart.

The Effects of Dehydration

Dehydration may develop through water deprivation or excessive **water loss**. Thirst is the first sign of dehydration, causing the mouth to become dry and initiating drinking behaviour. If an individual is not able to replenish bodily fluids, the symptoms of dehydration may progress rapidly from thirst to weakness, fatigue, headaches, fevers, delirium, and kidney damage. Dehydration may even lead to death if bodily fluids are not replenished (refer to Table 1.5.3 for specific symptoms and signs of dehydration).

Table 1.5.3: Signs and symptoms of different stages of dehydration.

Stage of dehydration	Body weight loss (%)	Symptoms
Mild	1–2	Thirst, fatigue, weakness, vague discomfort, loss of appetite, dizziness, dry mouth, dark-coloured urine.
Moderate	3–6	Increased heart rate, decreased sweating and urination, headaches, nausea, difficulty concentrating, irritability, impaired temperature regulation.
Severe	7–10	Muscle spasms, vomiting, seizures, exhaustion, delirium, increased risk of collapsing.

Questions

- State which stage of dehydration an individual is experiencing if they present with the following symptoms and signs: muscle spasms and vomiting.

..... (1 mark) (IAE3)

Extension activity

Although water consumption is vital, drinking too much water can be fatal, causing intoxication. This is rare but can occur if an individual consumes more than the recommended daily intake in a short period of time. Research the amount of water that can be toxic to an individual and explain the impacts of excessive water consumption.

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.....

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Key terms

Blood Volume	Hydrated	Urine
Dehydration	Lubricant & shock absorber	Water loss
Dehydration urine chart	Solvent	Water source
Diuretic	Sweat (perspire)	

Review questions: 1.5 Water

1. Evaluate the following statements as True or False and provide reasoning behind your choice.
 - (a) Muscle tissue contains less water than fat tissue.
 -
 - (b) Bodily water content is dependent on age and body weight.
 -
 - (c) Diarrhoea and vomiting can cause dehydration.
 -
 - (d) Water deficiency will not cause kidney damage.
 -
 - (e) Constipation cannot be prevented by an increased water intake.
 -
 - (f) People who are more active require more water.
 -
 - (g) Water is not necessary for the digestive process.
 -
 - (h) Males generally require more water than females.
 -
 - (i) Water is the vehicle for transportation of nutrients around the body.
 -
 - (j) Water contains 20 kJ per 100 mL.
 -

(20 marks) (KA1)

7. An experiment was conducted investigating the amount of water (L) lost via sweat from athletes in different environmental temperatures. The amount of water lost via sweat was recorded every 15 minutes throughout two different football games and the results are shown in the table below.

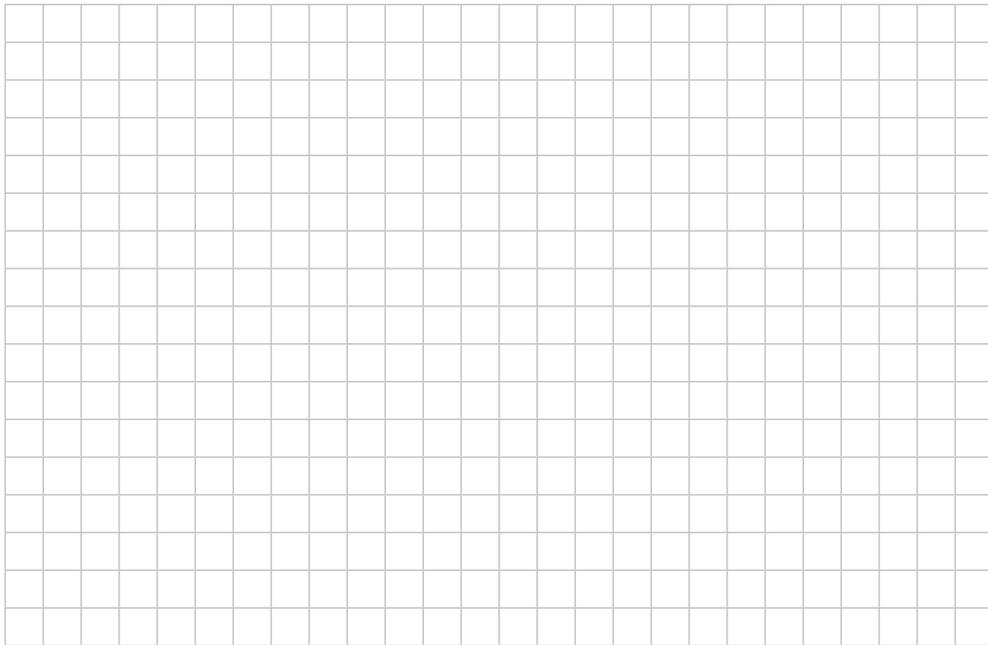
The amount of Water Lost (Litres)									
Temperature (°C)	0min	15min	30min	45min	60min	75min	90min	105min	120min
22	0	0.2	0.3	0.7	1	1.3	1.5	1.8	2.2
31	0	0.5	1.2	1.7	2.4	2.9	3.4	4.0	4.5

- (a) State the dependent variable of this investigation.

..... (1 mark) (IAE1)

- (b) Graph both sets of data from the table above on the same set of axes in the space provided below.

Title: The Effect of Temperature on the Amount of Water Lost via Sweat in Football Athletes



(4 marks) (IAE2)

- (c) Using data from the table or graph, explain why there is a difference in the amount of water lost via sweat in the two football games.

.....

 (2 marks) (IAE3)

- (d) It is almost impossible to achieve full fluid replacement during a game of football due its intensity and length, therefore putting these athletes at risk of dehydration.

- (i) Identify the first sign of dehydration, that may indicate an athlete needs to consume water.

..... (1 mark) (KA2)

- (ii) Suggest how an athlete could avoid becoming significantly dehydrated during a game of football.

..... (1 mark) (KA2)

- (iii) Suggest an ideal source of water that could be consumed after a game to replenish water levels lost from the body.

..... (1 mark) (KA1)

Total: _____ / 45 marks

Micronutrients

The micronutrients can be defined as the nutrients humans consume, and need, in small amounts. Micro, meaning 'extremely small' alludes to this. They tend to have recommended daily intakes of less than 100 milligrams (for many), compared to the macronutrients that have much larger daily demands in grams. The micronutrients include the vitamins and the minerals. Most micronutrients are essential, which means they must be supplied through consumption as the body cannot synthesise them.

1.6 Vitamins

Science understanding

Micronutrients (vitamins and Minerals) are required by the body for good health and the prevention of diet related disorders

- Vitamin Classification and the difference between fat soluble and water-soluble vitamins
- Vitamins: B1, B2, B3, Folate, B12, C and D
 - Sources of Vitamins
 - Function of Vitamins
 - The consequences and health issues associated with a deficiency of Folate, Vitamin B12, Vitamin C and Vitamin D

SACE Subject Outline, 2020

Vitamin Classification

Although most vitamins are essential, some are required more readily in the diet. How frequently they are needed in the diet is somewhat dependent on whether the vitamins are water soluble or fat soluble (see Table 1.6.1).

Table 1.6.1: Characteristics or properties of fat-soluble and water-soluble vitamins.

	Water-soluble vitamins	Fat-soluble vitamins
Transportation in the body	Dissolve in water, therefore transported freely and easily in the blood.	Dissolve in fat/oil, therefore, require transport in the bloodstream via triglycerides in lipoproteins.
Absorption	Move directly into the blood, due to being able to dissolve in water	Enter the lymphatic system with fats, before making their way into the bloodstream
Storage in the body	Body cannot store most of them, therefore any excess quantities of water-soluble vitamins pass out of the body, primarily via urine.	Body has stores of fat-soluble vitamins in adipose tissue and the liver.
Requirements	Required in frequent amounts, up to 1-3 days as they are not stored in the body and frequently excreted.	Not required as frequently, and can be consumed between weeks and months as the body stores these vitamins.
Probability of deficiencies	Deficiencies are possible (hypovitaminosis), while excess is rare, due to the body's inability to store most water-soluble vitamins.	With storage in the body possible, deficiencies are less common. However, fat-soluble vitamins are more likely to accumulate in the body leading to dangerously high levels and toxicity (hypervitaminosis).
Stability	Less stable and can be destroyed through processing (e.g. cooking and exposure to heat) and lost with poor storage (e.g. food left uncovered on a bench top exposed to oxygen and light). These vitamins can also leech into the surrounding water when these food sources are cooked in water, such as in boiling.	More stable and not readily lost through processing and poor storage.

There are 13 essential vitamins in total. Their classification as either water or fat soluble is displayed in Figure 1.6.1. Of the 13 vitamins listed below, the vitamins discussed in this topic are vitamin B₁ (Thiamin), B₂ (Riboflavin) & B₃ (Niacin), B₉ (Folate), B₁₂ (Cobalamin) C (Ascorbic Acid) and D (Calciferol).

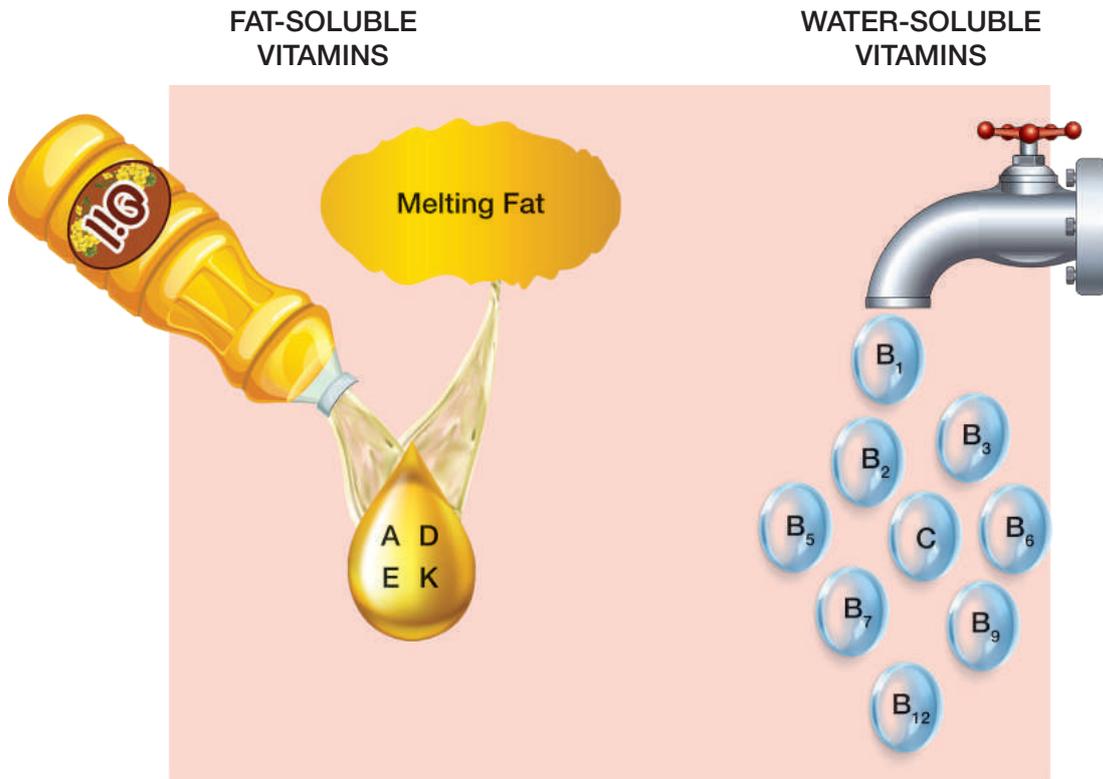


Figure 1.6.1: Vitamins and their groupings as either water or fat soluble.

Questions

1. Complete the following table:

Vitamin characteristic	Fat soluble	Water soluble
Dissolves in		Water
Storage in body	Yes – adipose tissue	
Hypovitaminosis risk	Lower risk	
Hypervitaminosis risk		Lower risk
Stability in food processing	More stable	

(5 marks) (KA1)

Extension activity

Find out the scientific name for each vitamin.

Generic name	Scientific name
Water soluble	
B ₁	
B ₂	
B ₃	
B ₅	
B ₆	
B ₇	
B ₉	
B ₁₂	
C	
Fat soluble	
A	
D	
E	
K	

1

Vitamins B₁, B₂ & B₃ (Thiamin, Riboflavin & Niacin)

Vitamins B₁, B₂ and B₃ are part of the B group of vitamins, which do not provide fuel for energy; however, without these vitamins the body could be lacking in energy as these assist with the release of energy.

Sources of Vitamins B₁, B₂ & B₃

Vitamins B₁, B₂ and B₃ occur in small quantities in many nutritious foods. Wholegrain or fortified bread and cereal products, meat, poultry, legumes, dark green leafy vegetables (such as broccoli, turnip greens, asparagus and spinach), yeast and vegemite (as shown in Figure 1.6.2) are all great sources of these vitamins.

Fast fact

The greatest source of Vitamin B₂ are milk and milk products, which is these products are sold in cardboard or opaque plastic containers as these vitamins are water soluble and sensitive to ultraviolet light.



Figure 1.6.2: Vegemite, a great source of Vitamins B₁, B₂ and B₃.

Functions of Vitamins B₁, B₂ & B₃

Metabolism of Macronutrients

Vitamins B₁, B₂ and B₃ act as a **coenzyme** in the metabolism of macronutrients and release of their energy (as shown in Figure 1.6.3). Vitamin B₁ acts as a coenzyme factor that assist enzymes in the breakdown of glucose, for energy production. Vitamin B₂ specifically acts as a coenzyme involved in the metabolism of carbohydrates, lipids and protein; and thus, the production of energy and ATP. And finally, vitamin B₃ acts as a coenzyme in the catabolism and anabolism of carbohydrates, lipids and protein. Therefore, these vitamins are essential in the production and release of energy from the foods that are consumed.

Definitions

A coenzyme is a non-protein compound that is necessary for the functioning of an enzyme.

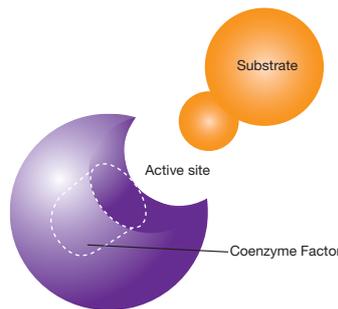


Figure 1.6.3: Vitamins B₁, B₂ and B₃ act as a coenzyme factor, which assists with the production of energy from carbohydrates, lipids and protein – the energy yielding macronutrients.

Vitamin B₉ (Folate)

The chemical names for vitamin B9 are **folate** or **folic acid**. Folic acid is the synthetic form added into foods (or supplements), while folate is the naturally occurring form found in food. This is why you will commonly see vitamin B9 referred to as folate.

Sources of Vitamin B₉

As the vitamin's name suggests foliage, green leafy vegetables (such as broccoli and brussels sprouts) are an excellent source of Folate. Folate is also abundant in legumes (such as chickpeas and lentils), some fruits (including strawberries and citrus fruits), and yeast extracts (such as Vegemite). Its artificial form, folic acid, must be added (fortified) to flour used in making bread and grain products (for example rolls and pizza bases) in Australia.

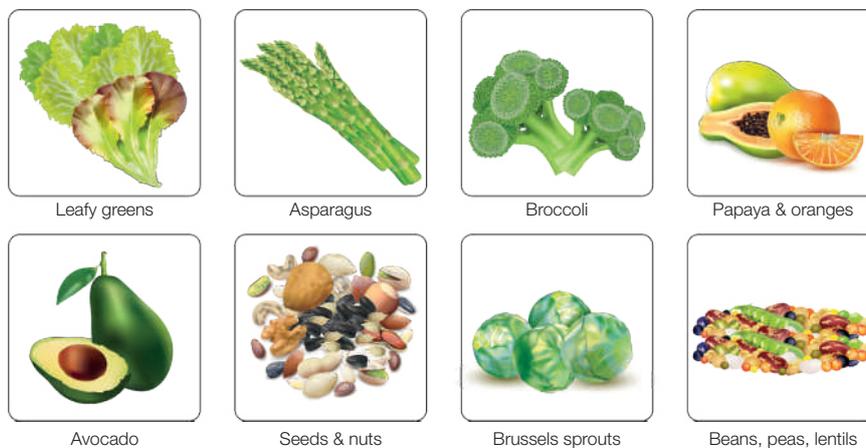


Figure 1.6.4 Sources of folate.

Functions of Vitamin B₉

Acting as a Coenzyme

Like most other water-soluble B vitamins, folate helps metabolise or break down the macronutrients to produce energy. B9 specifically metabolises amino acids (protein) and also works as a coenzyme to carry out this function (as shown in figure 1.6.5). A coenzyme's role is to bind to an enzyme to activate the enzyme, which then catalyses body reactions – in this case, the breakdown of amino acids. Folate also operates as a coenzyme in the synthesis of deoxyribonucleic acid (DNA) required for rapidly growing cells.

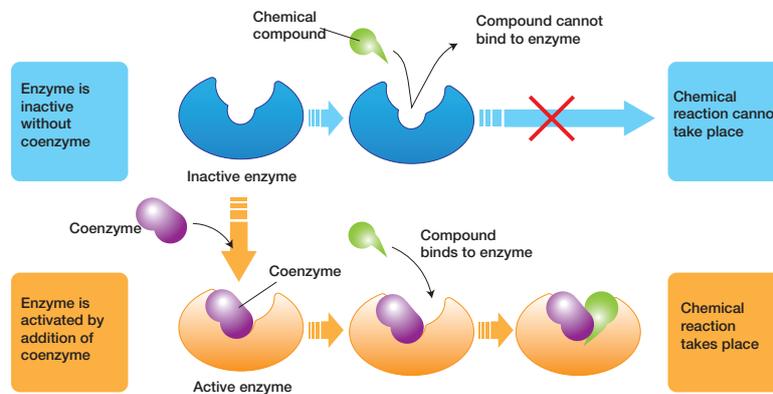


Figure 1.6.5: Coenzyme attachment activating an enzyme to carry out a body reaction.

Development of red blood cells and the neural tube

Folate is required for the formation of red blood cells (RBCs) and is particularly important during pregnancy for the growth and formation of the foetus' **neural tube**. The neural tube becomes the baby's brain and spinal cord (as shown in Figure 1.6.6).

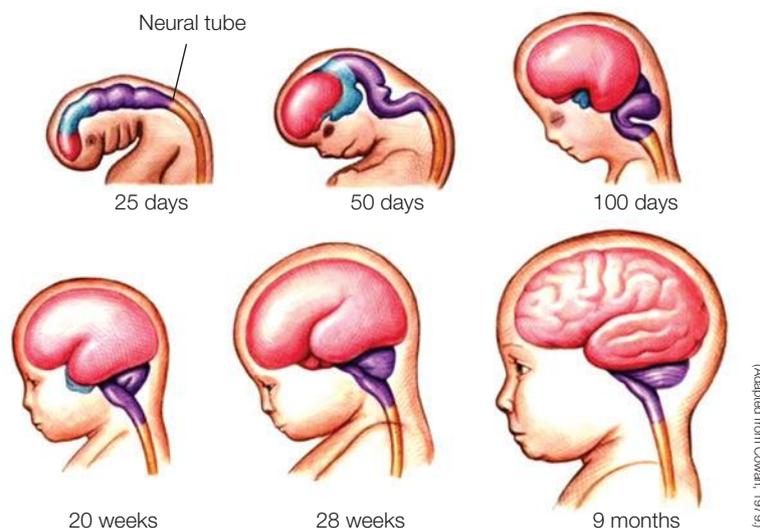


Figure 1.6.6: Neural tube development into the brain and spinal cord.

Deficiency of Vitamin B₉

Megaloblastic Anaemia

Folate deficiency is linked to a type of anaemia called megaloblastic anaemia. The underlying problem is that DNA synthesis, which requires folate as a coenzyme, is disrupted in RBC formation when folate is deficient. Without folate, DNA damage destroys many of the RBCs as they attempt to divide and mature. Therefore, the result is RBCs are characterised as immature and abnormally large (as shown in Figure 1.6.7). This results in fewer, but larger RBCs that are unable to carry efficient oxygen, which is needed to create energy or travel through the capillaries as efficiently as normal red blood cells. Fatigue from lack of energy is the main symptom indicating this condition.

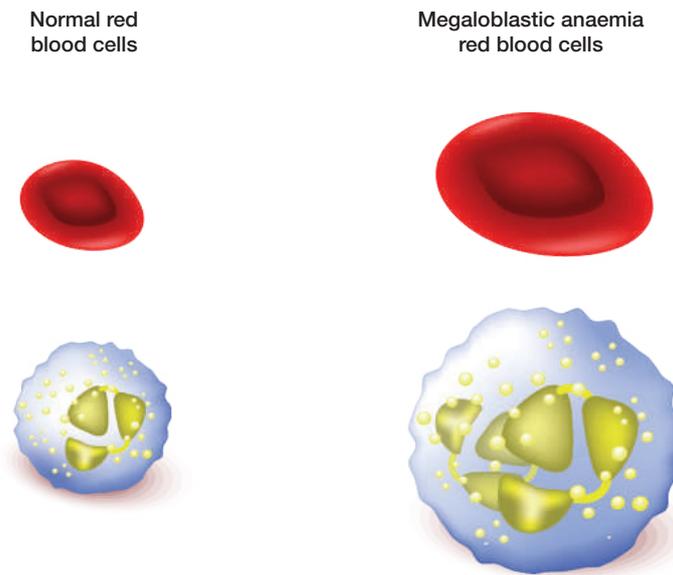


Figure 1.6.7: Normal red blood cell compared to a red blood cell with folate deficiency.

Neural Tube Defects

Folate requirements increase substantially during pregnancy, increasing the risk of deficiency. Inadequate folate a month prior to conception and during pregnancy, especially in the first trimester (first three months) is linked to **neural tube defects**, where the tube doesn't fuse properly. The different types of disabilities are all termed as neural tube defects, with the two most common types being **anencephaly** and **spina bifida**. In anencephaly the neural tube fails to close, resulting in the brain missing or failing to develop. This type of neural tube defect often results in miscarriage or the infant dying shortly after birth. Spina bifida is more common and characterised by the incomplete closure of the spinal cord, where the spinal cord protrudes as a sac (as shown in figure 1.6.8). This sac may rupture and lead to meningitis, a life-threatening infection. Spina bifida can also be accompanied by varying degrees of paralysis and other problems including kidney disorders, curvature of the spine, muscle weakness and motor and sensory losses. There are a number of supposedly causes of neural tube defects, which are still being researched; however, folate supplementation has been confirmed to reduce the risk.

Fast fact

Each year, 300 to 350 pregnancies in Australia are affected by neural tube defects, where approximately 45-50 of every 100,000 newborns are born with a neural tube defect.

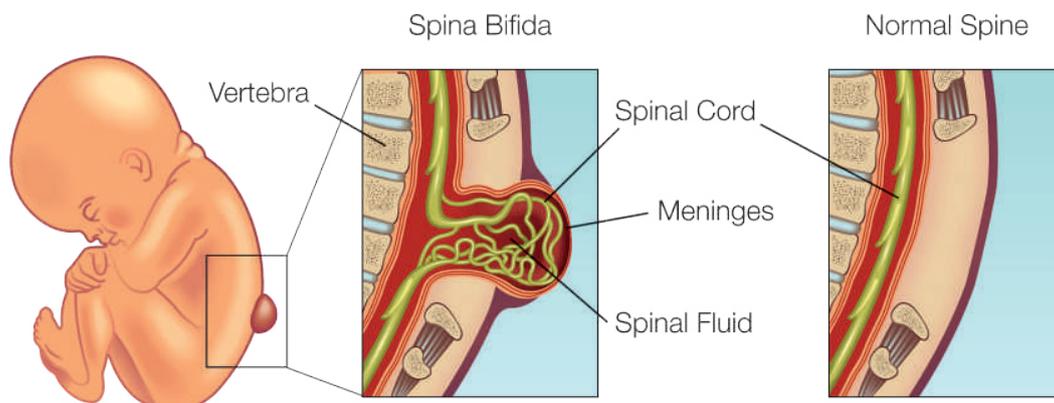


Figure 1.6.8: The spinal cord in Spina bifida, where the neural tube fails to close around the spine leaving it unprotected.



Science as a human endeavour (Influence)

Folate Fortification Reduces Neural Tube Defects

Source: <https://researchimpact.uwa.edu.au/research-impact-stories/folate-fortification-reduces-neural-tube-defects/>

Maternal dietary folate deficiency in the first weeks of life carries a higher risk that the fetus' neural tube will not fuse, leading to the development of either spina bifida or anencephaly. For two decades Bower et al. followed a dedicated pathway to impact by lobbying the Australian Government's Health portfolio's statutory authority, Food Standards Australia New Zealand (FSANZ), to introduce mandatory fortification of wheat flour. In 1995 voluntary fortification was allowed and in 2009 fortification of wheat flour with folate became mandatory. From 2011 to 2016, NTD births dropped, regardless of mother's culture, age, educational attainment or choice of hospital system.

Folate is essential to the healthy development of babies in early pregnancy. Maternal dietary folate deficiency in the first weeks of life carries a higher risk that the fetus' neural tube will not fuse, leading to the development of either spina bifida or anencephaly. Spina bifida results in significant lifelong physical disability and early death. Anencephaly almost always results in death before or within a few days of birth. Both conditions are known as Neural Tube Defects (NTD).

Bower et al identified the importance of folate in the 1980's resulting in widespread promotion of the benefits of folic acid supplements to Western Australian women considering pregnancy. However, campaigns to encourage folic acid supplements were not effective in reducing NTD in the Indigenous population. Other factors such as the mother's age, educational attainment, being pregnant for the first time, and the birthing using the public health system were found to increase risk of NTD, even though heavy promotional campaigning was undertaken. Additionally, the Indigenous population was found to be at higher risk of NTD compared to the non-Indigenous population. While health promotion was moderately successful in reducing the overall risk of NTD, it wasn't effective for Indigenous children, of whom a higher proportion were vulnerable. The result was an increasing disparity in NTD between Indigenous and non-Indigenous children.

A 2016 review by the Australian Institute of Health and Welfare found that since the flour fortification program's introduction, levels of NTDs had dropped by 14.4 per cent. Pre-fortification, the cost of spina bifida was calculated as \$13,535 for the first four years and \$4354 for every year after, up to the age of 43 or 84 years. Children with spina bifida are hospitalised 19.4 times more than the general population and have 2.9 times more outpatient visits. Children with spina bifida have pharmaceutical use that is 3.1 times that of the general population and often require assistive technology. Loss of work productivity in carers of people with spina bifida has been estimated at 9.2 hours a week. People with spina bifida in the workforce lose an average of 10 days due to their disability and have reduced earning capacity (\$21,000 less than the general population). The Commonwealth of Australian Governments Health Council Report estimated that mandatory folic acid fortification resulted in 1) \$350,000 per year more value in terms of a combination of increased productivity and reduced health costs than the alternative of no mandatory fortification; 2) fewer NTD-affected pregnancies, translating into gains of 135 life years and 130 Quality Adjusted Life Years.

Pre-fortification (2007-2009) there were 2.43 cases of spina bifida per 1000 births in the Indigenous population. The disparity in mortality and morbidity between Indigenous and non-Indigenous Australians is a stark example of the inequity that exists in Australia. Mandatory fortification of wheat flour with bread is an example of a research led change in government policy that was designed to address the health needs of less socially privileged members of our society. Post-fortification (2010-2014) rates had dropped to 0.82 cases of spina bifida per 1000 births in the Indigenous population..

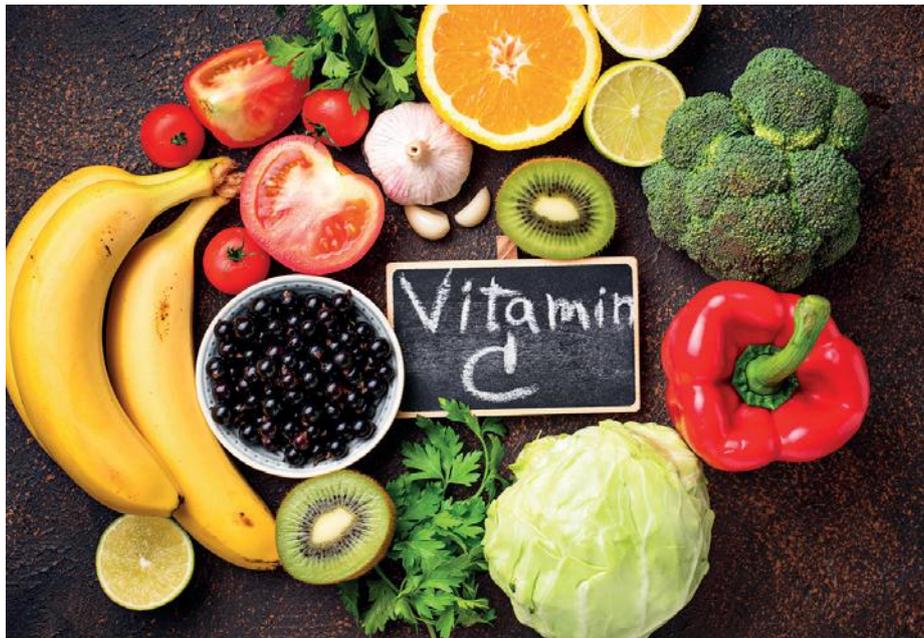


Figure 1.6.10: Common sources of Vitamin C.

Functions of Vitamin C

Synthesis of Collagen

Vitamin C is important in the formation of collagen. Collagen is the main component in **connective tissues** (e.g. tendons, ligaments, skin) and serves as the matrix on which bones and teeth form. It is also abundant in tissues such as blood vessels and capillaries, which must expand and contract with each beat of the heart. Beyond its structural role, collagen has a functional role in the skin of healing wounds. Collagen assists in gluing separated tissues together, forming scars and therefore helping wounds heal.

Definitions

Body tissues such as tendons, ligaments, skin, cartilage, etc. are called connective tissue. The term is derived by its ability to connect, support or separate tissues or organs. For example, tendons connect muscles to bone.

Antioxidant

Vitamin C acts as an antioxidant, which defends against free radicals. A free radical is an unstable atom that can cause **oxidative stress** to cells and body tissues. This oxidative stress can cause damage to cells in the body and accelerate the aging process. By causing damage to cells and their DNA, proteins and cell membranes, this prevents the cell from functioning normally and potentially causing the development of some cancers in the body. However, Vitamin C can react with these free radicals, making them more stable and protecting other substances in the body from their damage.

Definitions

Oxidative stress is when there is an imbalance of free radicals and antioxidants in the body, and when there is a greater number of free radicals than antioxidants.

Absorption of Iron

Another of Vitamin C's many roles is to enhance the absorption of iron from food by protecting this mineral from oxidation by free radicals. When consumed in the same meal, vitamin C will improve the absorption of iron from digested food into the bloodstream, specifically non-haem iron from plant sources (see chapter 1.7 for more information).

Deficiency of Vitamin C

Scurvy

Scurvy is the deficiency disease associated with hypovitaminosis of vitamin C. Initial symptoms include fatigue, inflammation of the gums and generally feeling unwell. If ascorbic acid deficiency progresses, symptoms progress to small red/purple spots/bruising on the skin from broken and bleeding capillary blood vessels, joint pain, swollen bleeding gums and loosening teeth, and many other symptoms (as shown in figure 1.6.11).

These symptoms are directly correlated to impairment of collagen synthesis, as this process is driven by vitamin C. When the collagen synthesis fails, connective tissues become weak. Poor wound-healing can also result, as collagen has a key role in the formation of scar tissue.



Figure 1.6.11: Symptoms of scurvy (red/purple spots and swollen gums, loosening teeth).

Extension activity

Discuss why scurvy was known as a Sailor's (sea explorer's) disease.

.. .. .

.. .. .

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Vitamin D (Calciferol)

Vitamin D is different from all the other nutrients in that the body can synthesise it, with the help of sunlight and from a precursor that the body makes from cholesterol. A series of reactions (via enzymes of the liver and then kidney) turn vitamin D into its active form.

Sources of Vitamin D

Most of the world's population relies on natural exposure to sunlight to maintain adequate vitamin D levels. Therefore, the best source of vitamin D is from its production in the skin from cholesterol. This process is dependent on ultraviolet radiation (UV) from the Sun (Figure 1.6.12). Although, most people don't need to make a special effort to consume Vitamin D from food, it is advised that people who don't spend much time in the sun or live in northern/southern regions of the world consume sources of Vitamin D. Unfortunately, very few foods contain Vitamin D; however great sources include fortified margarines, oily fish (such as salmon, herring and mackerel), liver and eggs. However, it is difficult to get all the required vitamin D from consumption.

Functions of Vitamin D

Absorption of Minerals

Vitamin D is important for increasing the blood concentrations of Calcium and phosphate (phosphorus). Vitamin D increases the blood concentration of these minerals by enhancing their absorption from the small intestines into the blood (as shown in Figure 1.6.13), reducing the amount lost via urine by enhancing their reabsorption by the kidneys and enhancing their movement into the bones. This allows the bones to grow denser and stronger, as they absorb and deposit these minerals.

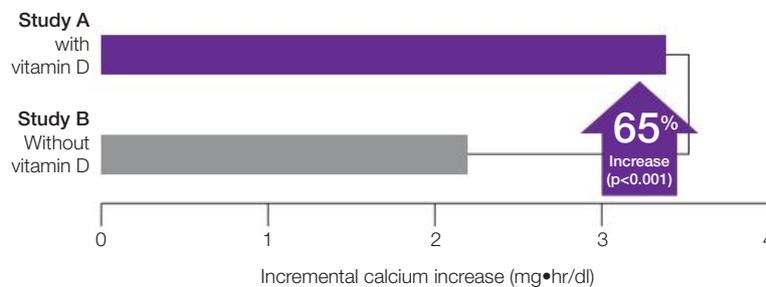


Figure 1.6.13: Absorption of calcium with and without vitamin D in the same meal.

Deficiency of Vitamin D

Rickets and Osteomalacia

As vitamin D has a vital role in the absorption of nutrients responsible for muscle movement and bone development, a person who does not get enough of this vitamin may experience muscle weakness or pain, or bone (joint) pain. Chronic hypovitaminosis impairs calcium and phosphorus absorption. This leads to the failure of the bones to calcify normally, causing the softening of the bones, growth retardation and skeletal abnormalities. The prevalence of this disorder in children is known as **rickets**, where the bones become so weak that they bend when they have to support the body's weight causing bowed legs (as shown in figure 1.6.14). In adults, poor mineralization of bones results in the painful bone disease: **osteomalacia**. The bones become soft, flexible, brittle and deformed.



Fast fact

In Australia, rickets is emerging where approximately 6 children per 100,000 under the age of 15 are diagnosed each year.

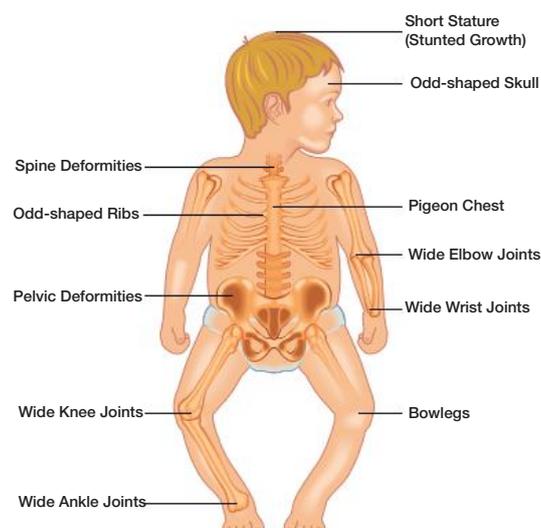


Figure 1.6.14: Skeletal deformities associated with rickets.

2. Breakfast cereals can offer a consumer a wide range of nutrients naturally or through fortification. A lot of cereals are fortified with Vitamin D.

(a) List a nutrient that vitamin D can work in conjunction with.

..... (1 mark) (KA2)

(b) Describe how these nutrients will work in conjunction with each other.

..... (1 mark) (KA2)

(c) Identify if Vitamin D is water or fat soluble.

..... (1 mark) (KA1)

(d) Explain what fortification is and why margarine and some milk products are currently fortified with Vitamin D in Australia.

.....
.....
.....
..... (2 marks) (KA2)

3. Explain what type of vitamin-high foods are required more often in the diet, those containing fat-soluble or water-soluble vitamins?

.....
.....
.....
.....
.....
..... (3 marks) (KA2)

4. Discuss two groups of people who are more at risk of osteomalacia.

.....
.....
.....
.....
.....
.....
..... (4 marks) (KA2)

5. Refer to the following table:

Vitamin	Life stage (years)				
	0 – 1	1 – 12	12 – 18	18+	Pregnancy
Folate RDI (µg)	100	150	200	200	400
Folate actual intake (µg)	100	150	180	170	300
Vitamin C RDI (mg)	20	30	40	30	40
Vitamin C actual intake (mg)	25	35	50	30	450

(a) Discuss the trend in the RDI of Vitamin C across the age groups, excluding pregnancy.

.. ..

 (2 marks) (IAE3)

(b) State a health concern for a foetus and the pregnant female if the actual intake of Folate is consumed, compared to the RDI.

 Foetus: (1 mark) (IAE3)
 Pregnant Female: (1 mark) (IAE3)

6. Vitamin B12 is a micronutrient that is naturally present in some foods and is added to others. It is also available as a dietary supplement and prescription medication.

(a) State whether Vitamin B12 is water-soluble or fat soluble.

.. .. (1 mark) (KA1)

(b) State one function of Vitamin B12 in the body.

.. .. (1 mark) (KA1)

(c) Name one food group that is naturally high in Vitamin B12.

.. .. (1 mark) (KA1)

(d) Vitamin B12 deficiency is a relatively common disorder. Describe the signs and symptoms of Vitamin B12 deficiency.

.. ..

 (2 marks) (KA2)

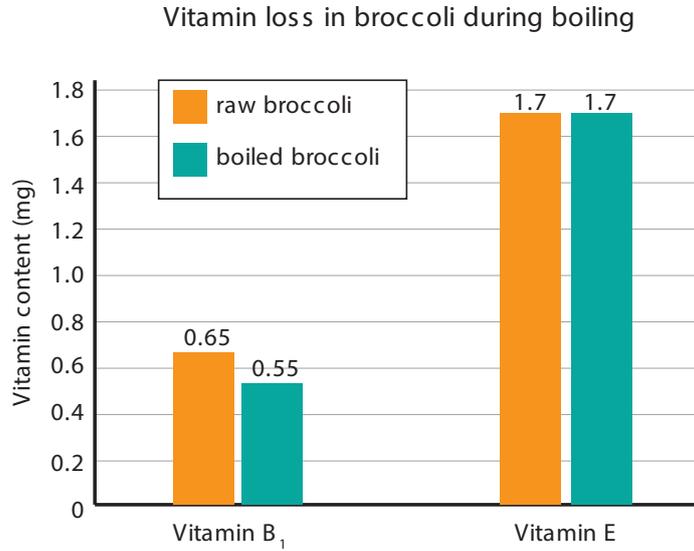
(e) Suggest two reasons why most dietitians state that the best way to obtain the essential vitamins is to consume a variety of foods from each of the food groups in the Australian Guide to Healthy Eating (AGHE) rather than take supplements.

.. ..

 (2 marks) (KA2)

7. Students investigated the effects of boiling vegetables. They compared the vitamin content of raw broccoli with that of the broccoli that was boiled.

Refer to the following graph, which shows the amount of vitamin B1 and vitamin E lost from broccoli during boiling.



- (a) State the dependent variable of this investigation.

.. .. .
 (1 mark) (IAE1)

- (b) Identify two factors that must remain constant during the investigation and explain why.

(i)

 (2 marks) (IAE1)

(ii)

 (2 marks) (IAE1)

- (c) Using data from the graph, state the effect of boiling on the:

(i) Vitamin B1 content of broccoli

 (1 mark) (IAE3)

(ii) Vitamin E content of broccoli

 (1 mark) (IAE3)

- (d) Explain why there is a difference between the amount of Vitamin B1 lost and not the amount of Vitamin E lost from broccoli during boiling.

.. .. .

 (2 marks) (KA2, IAE3)

(e) State how the B vitamins are excreted from the human body.

.....
 (1 mark) (KA1)

(f) (i) State one function of Vitamin B1 in the human body.

.....
 (1 mark) (KA1)

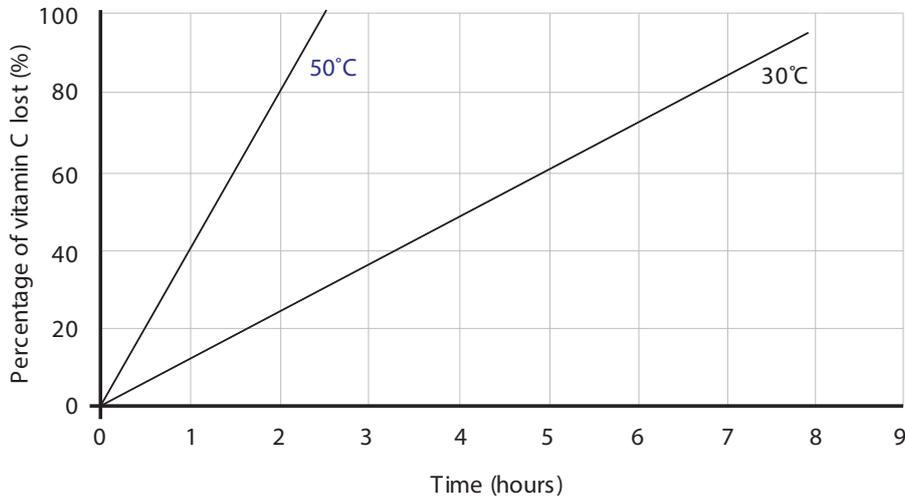
(ii) State one specific food source of Vitamin B1, other than broccoli.

.....
 (1 mark) (KA1)

8. Fresh juice should be stored at 4°C and consumed within 3 days. Students conducted an experiment to investigate the effect of poor storage on the Vitamin C content of orange juice.

Two samples of orange juice were heated at different temperatures, one being heated at 30°C and the other heated at 50°C. The amount of vitamin C lost was measured every hour for 8 hours.

Refer to the following graph, which shows the percentage of vitamin C lost over time in orange juice.



(a) Using data from the graph, compare the percentage of Vitamin C lost after 2 hours of heating the orange juice at 30°C and at 50°C, and explain the result.

.....

 (3 marks) (KA2, IAE3)

Total: _____ / 45 marks

1.7 Minerals

Science understanding

Micronutrients (vitamins and Minerals) are required by the body for good health and the prevention of diet related disorders

- Minerals: Calcium, Iron, Sodium, Potassium
 - Sources of Minerals
 - Function of Minerals
 - Factors affecting the bioavailability and absorption of Calcium and Iron

SACE Subject Outline, 2020

Minerals

Minerals are inorganic compounds that do not contain carbon. They are water soluble and must be obtained from the diet. They retain their chemical structure until excretion from the body. They can be categorised as major or trace (refer to Table 1.7.1). **Major minerals** are required in larger amounts and are found in the body in amounts greater than 5 grams. **Trace minerals** are required in smaller amounts and are found in the body in amounts less than 5 grams. This does not indicate that one group is more important than the other, as all minerals are vital for body function.

Table 1.7.1: Common major and trace minerals required and present in the body

Major minerals	Trace minerals
Calcium	Iron
Phosphorus	Zinc
Sodium	Copper
Potassium	Iodine
Magnesium	Manganese
Sulfur	Selenium
Chloride	Fluoride
	Chromium
	Molybdenum
	Nickel
	Silicon
	Vanadium
	Cobalt
	Boron

Of the minerals listed in Table 1.7.1, those that are most commonly found to be an imbalance in Australian diets are calcium, sodium, potassium and iron. These are therefore of priority and discussed in detail in this topic.

Calcium

Sources of Calcium

Bones act as a calcium bank, offering a source of this mineral to the body if the levels of calcium in the blood drop. This is why recommendations are based on the amount needed to retain as much calcium in the bones as possible (as shown in Table 1.7.2). This allows bones to develop to their fullest potential in size and density. An individual should achieve their peak bone mass by their mid to late twenties.

Table 1.7.2: The recommended daily intake (RDI) of calcium at different ages for males and females.

Age (years)	Calcium RDI (mg)
1 – 3	500
4 – 8	700
9 – 11	1000
12 – 18	1300
19 – 50/70	1000
50+ (women)	1300
70+ (men)	1300

Calcium is found most abundantly in a single food group: dairy products. These include milk, cheese and yoghurt. However, if an individual is unable to consume dairy products due to personal likes and dislikes, religious or ethical beliefs, or malabsorption syndromes, they can include non-dairy sources of calcium to reach their recommended daily intake. Tofu, almonds, sesame seeds, green leafy vegetables, and fortified products (e.g. juices, cereals and soy milk) can supply calcium to a person who doesn't consume dairy products.

Functions of calcium

Calcium has a number of functions; its main role is its involvement in the development of our bone's structure.

Strengthening bones

Calcium plays an integral part in the development of bones, providing a rigid structure that supports the body and serves as an attachment point for muscles, making movement possible. Calcium combines with phosphorus and forms Calcium Phosphate crystals on a matrix of the protein collagen during bone formation. During mineralisation, the crystals become denser providing strength and rigidity to the bones. This process is continuous throughout an individual's life cycle, where bone is constantly being reabsorbed and produced during an ongoing process of **remodelling**. The production of bone is greater in children and adolescents than it is in the elderly. This means older people are more susceptible to osteoporosis, where bones become more fragile and porous (as shown in Figure 1.7.1 and discussed further in Topic 1.10).

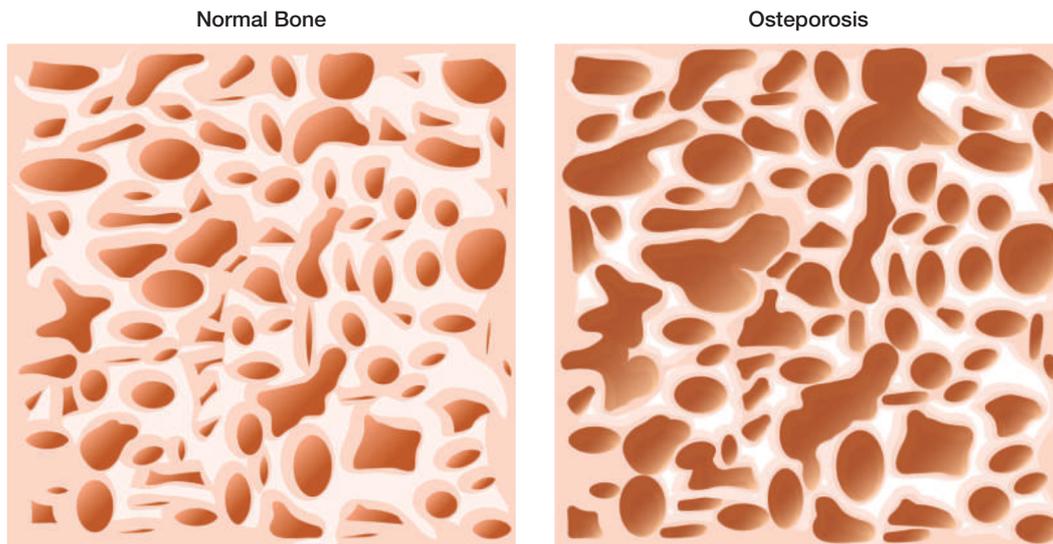


Figure 1.7.1: A comparison between strong, dense bone (left) and fragile, porous osteoporotic bone (right).

Assisting in the transmission of nerve impulses, along with muscle contractions and relaxations

The muscle and nerves work together to use calcium. The nerve tissues use calcium to stimulate nerve impulses to trigger muscle contraction. These contractions produce muscle movement. Since the heart is composed of muscle tissue, calcium also assisting in keeping the heart beating and contracting.

Factors affecting the Bioavailability of Calcium

Some dietary foods and beverages can inhibit the absorption of calcium by binding to the mineral when consumed at the same time, forming insoluble salts. Table 1.7.3 shows dietary sources of components that inhibit (block or reduce) calcium absorption. Excessive sodium, alcohol and caffeine intakes can reduce calcium **bioavailability** by promoting greater calcium urinary excretion. Therefore, consuming a high intake of calcium absorption inhibitors and having conditions that can impair calcium absorption and can contribute to the development of osteoporosis (as discussed in Topic 1.10).

Definitions

Bioavailability is the degree to which a nutrient is absorbed and utilised by the body.

Table 1.7.3: Calcium absorption inhibitor food sources and their responsible components.

Food sources	Component
Processed foods, cured meats, salted nuts, cold cuts, sauces, canned products	Sodium
Soft drinks	Phosphoric Acid
Tea, spinach, kale, nuts, chocolate, strawberries, herbs	Oxalates
Cocoa, coffee, apples, herbal teas, blackberries, raspberries, blueberries	Polyphenols
Walnuts, lentils, wholegrains, cereals, dried beans, almonds, rice	Phytates

Questions

1. Identify a nutrient that can increase the absorption and therefore the bioavailability of Calcium.

.. (1 mark) (KA1)

Iron

Sources of Iron

The average red blood cell has a life span of approximately 115 days (four months), before it is taken apart in preparation for recycling and excretion. The iron component of a red blood cell can be recycled and taken to the bone marrow to be reused in new red blood cells. This is one of the reasons why iron is only required in small amounts, as the body recycles its stores and only a small amount is lost daily through bodily fluids.

Growing children and adolescents have high iron demands due to rapid growth that causes an increase in their blood volume. Menstruating, lactating and pregnant females have the greatest demands for iron, due to the loss of iron to monthly periods, growing fetuses or breastfeeding babies (as shown in Table 1.7.4).

Table 1.7.4: The recommended daily intake (RDI) of iron at different life stages for males and females.

Life stage	Iron RDI (mg)
Children and adolescents	10 – 13
Menstruating females	12 – 18
Lactating females	12 – 18
Pregnant females	22 – 36
Males	8

Iron occurs in two forms: haem iron and non-haem iron. **Haem iron** is only found in flesh of foods derived from animal sources, such as meat, poultry and seafood. **Non-haem iron** is found in food derived from plant sources, such as lentils, beans, tofu, nuts, seeds and grains and animal sources, such as eggs, milk and dairy. Therefore, foods derived from animal sources are a combination of haem and non-haem iron. Haem iron is also better absorbed by the body at a rate of 7–35%, whereas non-haem iron is absorbed at a rate of 2–20%. This is dependent on an individual's dietary factors and the body's iron stores.

Functions of iron

Most of the body's iron is found in two proteins: haemoglobin and myoglobin.

Producing haemoglobin in red blood cells

Iron is a significant component of haemoglobin, which is found in red blood cells. **Haemoglobin** is the component of red blood that picks up oxygen when blood passes through the lungs. This oxygen is then transported throughout the body and delivered to the cells for the process of **aerobic respiration** to occur. Oxygen is one of the requirements of this reaction, in order for ATP (energy) to be produced (as shown by the equation below in Figure 1.7.2). In addition, the red blood cell is able to pick up the waste product, carbon dioxide, some of which is carried by haemoglobin to be exhaled by the lungs. It is also the haemoglobin component that provides the colour of a red blood cell. When haemoglobin is attached to oxygen molecules, this adds a red colour to these cells. However, when oxygen has been delivered to the cells, the red blood cell has a blue-red appearance.



Figure 1.7.2: The aerobic respiration reaction, where glucose obtained from ingested food and oxygen inhaled are requirements to produce ATP (energy) the body requires for bodily processes.

Producing myoglobin

Iron is a component of the oxygen-binding protein myoglobin, which is found in the body's muscle tissue. Myoglobin has a strong affinity for oxygen, which allows it to store oxygen in the muscle efficiently. This is important when the body is lacking oxygen, such as during anaerobic (short-lasting and high-intensity) exercise when the body's demand of oxygen is greater than the supply. This is when myoglobin is able to release its oxygen and make it available to the muscle tissue, preventing it from becoming damaged under these harsh conditions.

Factors affecting the Bioavailability of Iron

A diet low in iron and nutrients that aid in its absorption can reduce the bioavailability and absorption of Iron.

Some components of dietary choices can bind with non-haem iron, inhibiting its absorption. Therefore, a high intake of iron absorption inhibitors (as shown in Table 1.7.5), plus conditions that can impair iron absorption, can also contribute to the development of iron deficiency anaemia (discussed further in Topic 1.10).

Table 1.7.5: Iron absorption inhibitor food sources and their responsible components.

Food sources	Component
Eggs	Phosvitin
Dairy	Calcium
Tea, spinach, kale, nuts, chocolate, strawberries, herbs	Oxalates
Cocoa, coffee, apples, herbal teas, blackberries, raspberries, blueberries	Polyphenols
Walnuts, lentils, wholegrains, cereals, dried beans, almonds, rice	Phytates

Questions

- Identify a nutrient that can act as an Iron absorption enhancer and therefore increase the bioavailability of Iron.

(1 mark) (KA1)

Sodium

Sources of sodium

It is suggested that the upper limit of sodium for adults is 2300 mg per day. Due to their smaller body sizes and more sensitive taste buds, children and infants have lower recommended sodium intakes: infants (0 to 1 year of age) should not exceed 580 mg and children (1 to 7 years of age) should not exceed 1730 mg. According to Food Standards of Australia and New Zealand, approximately one third of Australians consume a greater amount of sodium than the upper limit.

In general, processed foods have a greater amount of sodium present than fresh produce, as sodium is intentionally added as a preservative and flavour enhancer. In fact, a majority of the sodium consumed in people's diets comes from the salt added to foods during manufacturing. The second greatest source is the salt added to cooking and at the table.

Extension activity

Research and list foods that are naturally high in salt and processed foods that have a high salt content. (Challenge: list a food naturally high in salt from every food group.)

Naturally high in salt.

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Processed foods.

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Questions

3. Suggest two dietary and lifestyle strategies that an individual could implement to reduce their salt intake.

(a) Dietary:

Strategy 1:

.....

Strategy 2:

.....

Strategy 1:

.....

Strategy 2:

.....

(4 marks) (KA2)

Functions of sodium

Sodium works in conjunction with potassium to regulate fluid balance and assist in muscle contraction and relaxation.

Regulating the volume of extracellular fluid

Extracellular fluid is the body's fluid that is not contained in the cells, including blood. Sodium has the ability to attract and hold on to water by reducing the kidneys' ability to remove water via urine. Therefore, when an individual consumes foods high in salt, greater water is attracted and held. This increases blood volume and pressure, until sodium is not needed and excreted via urine.

Fast fact

Blood is approximately 90 per cent water.

Assisting with the contraction of muscles and the transmission of nerve impulses

Sodium is required for electrical impulses to travel along nerves. It is also needed for muscle movement. Muscle and nerve cells generate electrical impulses by controlling the flow of electrically charged molecules, including sodium. This is part of the **sodium-potassium pump** found in the membranes of cells. Sodium is pumped out of the cell and potassium is pumped into the cells, which creates an electrical charge that leads to the transmission of impulses along the nerves (as shown in Figure 1.7.3). This same electrical charge stimulates the contraction of muscles.

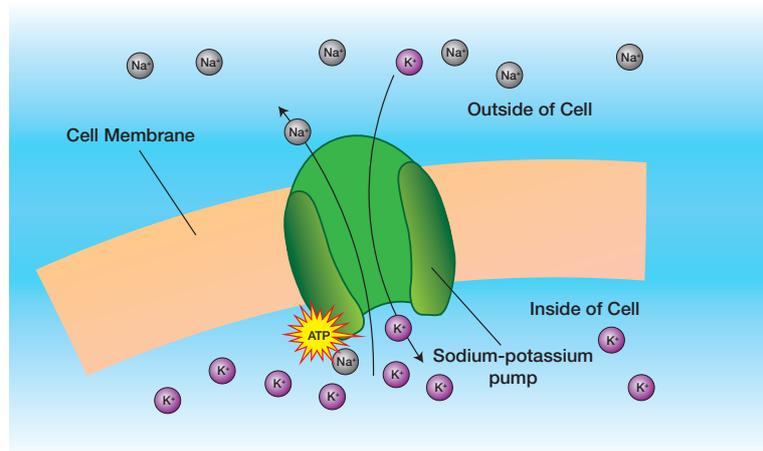


Figure 1.7.3: The sodium-potassium pump found in the membrane of the cell. Sodium is pumped out of and potassium in to the cell, creating an electrical charge which allows for muscle contraction and transmission of messages along the nerve cells.

Questions

4. Identify a nutrient, other than sodium, that assists with the contraction and relaxation of muscles.
 _____ (1 mark) (KA1)
5. State a condition that can cause the body to become deficient in sodium.
 _____ (1 mark) (KA1)
6. Predict what would happen to an individual's blood pressure and fluid levels if an excessive amount of sodium was to be consumed.
 - (a) Blood Pressure: ..

 (2 marks) (KA2)
 - (b) Fluid Levels: ..

 (2 marks) (KA2)

Potassium

Sources of potassium

The richest sources of potassium are fresh fruit and vegetables. The greater processing a fresh product is exposed to, the less potassium will be present and the more sodium it will contain. It is recommended that people increase their intake of fresh produce to meet the recommended daily intake of potassium, which is 3800 mg for males and 2800 mg for females.

Extension activity

Research ten different food sources that are high in potassium.

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..
..

Functions of potassium

Potassium works in conjunction with sodium to regulate fluid balance and assist in muscle contraction and relaxation.

Regulating the volume of extracellular fluid

Potassium regulates the amount of sodium that enters and exits the cell. If there is greater sodium on the outside of the cell, the kidneys will retain more water to maintain the sodium–water ratio in the body.

Assisting the contraction of muscles and the transmission of nerve impulses

In order for electrical impulses to travel along nerves, potassium is required. Potassium is also vital for muscle movement, as it works with sodium to create an electrical charge. This is achieved with the assistance of the sodium–potassium pump in the cell membrane (Figure 1.7.3). This exchange of sodium and potassium across the cell membrane assists in maintaining a steady heartbeat.

Questions

7. Fill in the following table, summarising the minerals covered in this topic.

Mineral	Two food sources	One function
		Production of haemoglobin
	Bananas Spinach	
	Processed food e.g. chips Table salt	

(9 marks) (KA1)

11. Complete the following table by identifying if an individual diagnosed with a deficiency of Iron or Calcium should increase or decrease their intake of the following foods and beverages to assist with the management of their nutrient deficiency.

(a) Iron Deficiency:

Food or beverage source	Increase or decrease intake
Orange juice	
Excessive milk and yoghurt	
English Breakfast Tea	
Lamb	
Fresh salmon	
Eggs	
Fortified cereals	

(b) Calcium Deficiency:

Food or beverage source	Increase or decrease intake
Cow's milk	
Salmon	
Pepsi	
Coffee	
Yoghurt	
Wholegrains	
Processed foods	

(14 marks) (KA2)

Total: _____ / 45 marks

1.8 Digestion and Metabolism of Food

Science understanding

Digestion and Metabolism of food influences the absorption and use of nutrients

- The processes of ingesting and digesting foods/fluids and the absorption of macronutrients through the Gastrointestinal tract:
 - Primary and Secondary organs involved in digestion
 - Chemical digestion of macronutrients and their enzymes
 - Mechanical digestion
 - Absorption of the products of macronutrient digestion in the villi and water absorption in the large intestine
- Microbiome synthesis of nutrients
- Factors that interfere with the absorption of nutrients
- Factors that determine Energy Balance (basal metabolic rates (BMR) and estimated energy expenditure)

SACE Subject Outline, 2020

The gastrointestinal tract

The gastrointestinal tract (GI) tract is a flexible muscular tube that extends from the mouth, through the oesophagus, stomach, small intestine, large intestine (also called the colon) and rectum to the anus (Figure 1.8.1). The salivary gland, pancreas, liver and gallbladder are accessory organs, which release their secretions into the GI tract when required.

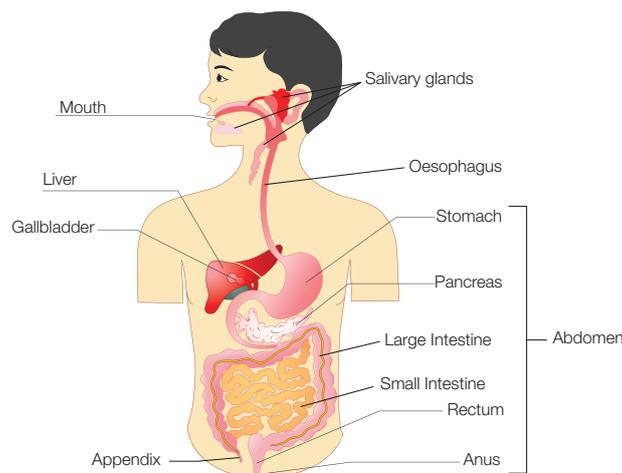


Figure 1.8.1: The gastrointestinal tract organs, starting from the mouth and ending at the rectum and anus.

Fast fact

- The abdomen, also more commonly known as the 'belly', is the part of the body that starts from the stomach and ending at the anus.
- The bowel is another term used to describe the small intestines, large intestines, rectum and anus.

Extension activity

Find out the length of your gastrointestinal tract, by making the following measurements with a piece of string:

Digestive Organ	Instructions on how to Measure	Length (cm)
Mouth	Measure from the corner of your mouth to the midpoint of your ear	
Oesophagus	Measure from the bottom of your chin to the top of your folded arms	
Stomach	Spread the fingers of your hand and measuring the span from the thumb to the little finger	
Small Intestines	Measure your height and then multiply this by 4	
Large Intestines	Measure your height	
Rectum	Spread the fingers of your hand and measuring the span from the thumb to the little finger	
Total Length		

1

Mouth

The process of digestion begins in the mouth or oral cavity. After food enters the mouth, teeth mechanically break down large pieces of food into smaller ones through the process of chewing, also known as **mastication**. This process involves the grinding and chopping action of the teeth, which physically break down ingested food into smaller pieces. This prepares food for swallowing and movement into the oesophagus. This also increases the surface area of ingested food, for efficient chemical digestion further in the gastrointestinal tract.

During mastication, food is mixed with saliva released by the **salivary gland**, which is located behind the tongue. Saliva consists of water, salts, and mucus; it moistens food to allow for easy swallowing into the oesophagus.

Saliva also consists of digestive enzymes, including **salivary amylase** and **lingual lipase**. Salivary amylase initiates the chemical digestion of starch (complex carbohydrates) into shorter polysaccharides and disaccharides, specifically maltose. Lingual lipase initiates the chemical digestion of triglycerides into shorter fatty acid chains. Very little carbohydrate and triglyceride digestion takes place here, due to food spending little time in the oral cavity. Saliva also assists in dissolving the food to allow the taste buds on the tongue to detect any of the five basic sensations: sweet, salty, sour, bitter and **umami**.



Fast fact

Umami corresponds to the flavour of glutamates, especially monosodium glutamate, which is a compound that naturally occurs in the breakdown of proteins.

When a mouthful of food is swallowed, it is then referred to as a bolus. The bolus passes through the **pharynx**, a short tube connecting the oral cavity to the oesophagus. The pharynx also serves the respiratory system as it connects the nasal and oral cavity to the larynx; however, the epiglottis closes off the air passage when swallowing to avoid choking.

Questions

1. Identify the mechanical process that occurs in the mouth.

..... (1 mark) (KA1)

2. State *two* functions of saliva in the mouth.

.....

 (2 marks) (KA1)

3. *Two* macronutrients being their chemical digestion in the mouth. Fill in the following table.

Macronutrient	Digestive enzyme involved	Chemically broken down into

(6 marks) (KA1)

Oesophagus

The oesophagus is a muscular tube connecting the oral cavity to the stomach. Once the bolus enters the oesophagus from the mouth, it takes 5 to 10 seconds for it to reach the stomach. The oesophagus is ringed with circular muscles, which are surrounded by longitudinal muscles. When the rings tighten and the longitudinal muscles relax, the tube is contracted. When the rings relax and the longitudinal muscles tighten, the tube bulges and relaxes. These mechanical actions are known as **peristalsis**, which occur involuntarily and continuously to push the bolus further along the oesophagus in one direction (Figure 1.8.2).

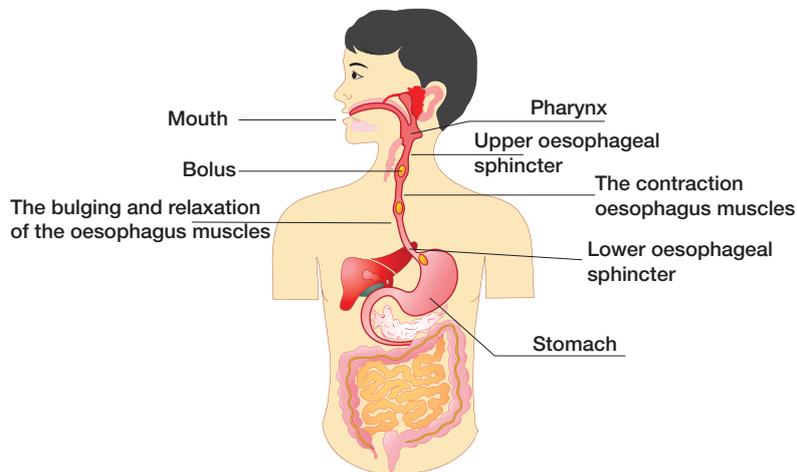


Figure 1.8.2: The involuntary contractions and relaxations (peristalsis) of the oesophagus muscles pushing the bolus along the tube into the stomach.

The oesophagus also has a sphincter muscle at each end (Figure 1.8.2). During swallowing, the **upper oesophageal sphincter** opens, allowing the bolus to enter oesophagus from the pharynx. The bolus is then pushed down the oesophagus, passing through the **lower oesophageal sphincter** into the stomach. Once the bolus enters the upper portion of the stomach, the lower oesophageal sphincter closes (Figure 1.8.3) to prevent the stomach contents and gastric juices from travelling backward.

Fast fact

The lower oesophageal sphincter is also known as the cardiac sphincter.

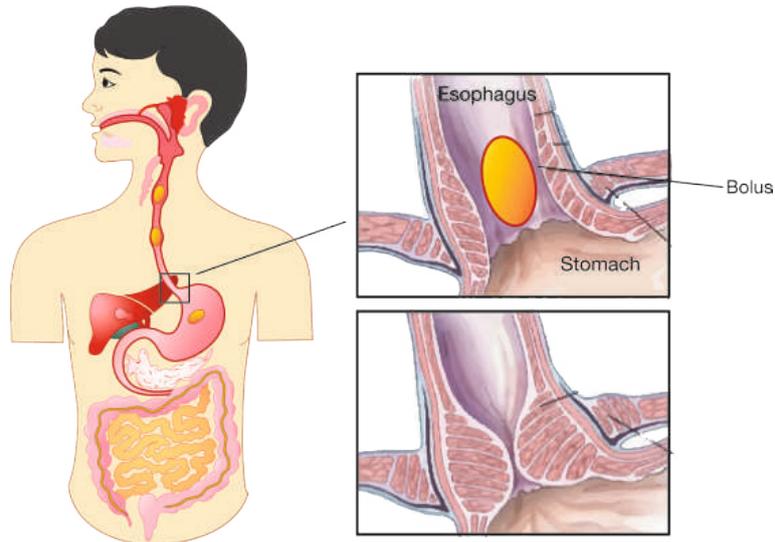


Figure 1.8.3: The lower oesophageal sphincter, which opens to allow the bolus to enter the stomach and closes to prevent the gastric contents from moving backward.

Questions

4. Describe the mechanical digestion that occurs in the oesophagus.

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..... (2 marks) (KA2)

5. Identify the structure that prevents the backward movement of the bolus from the stomach into the oesophagus.

..... (1 mark) (KA1)

Extension activity

Research the cause of heartburn.

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Stomach

The stomach has the thickest and strongest muscles of all the GI tract organs. The stomach has three types of muscles – circular, longitudinal and diagonal – that alternately contract and relax (Figure 1.8.4). These actions assist in the mechanical **mixing and churning** of the bolus with **gastric juices** to produce a semiliquid paste called **chyme**. The gastric glands secrete gastric juices, which are a mixture of water, enzymes and hydrochloric acid, which has a strong acidic pH of 2. The strong acidity of the stomach prevents bacterial growth and kills most bacteria that have been ingested with food consumption. This is the only site in the digestive system that can withstand a strong acidic nature. The cells of the stomach secrete a thick, slippery white mucus that covers and protects them from the acid, enzymes and pathogenic bacteria.

The hydrochloric acid also assists in the chemical digestion of protein. Hydrochloric acid uncoils and **denatures** each protein strand to allow digestive enzymes to break the peptide bonds between the amino acids. The hydrochloric acid converts the inactive form of the enzyme **pepsinogen** into its active form: **pepsin**. Gastric pepsin is then able to break larger polypeptide chains into smaller ones by breaking the peptide bonds between them. The stomach enzymes work most efficiently in the stomach’s strong acidic environment, but the salivary enzymes become inactive, therefore ceasing the breakdown of carbohydrates and lipids. Once the actions of the stomach are complete, the stomach releases a small amount of chyme at a time through the **pyloric sphincter** into the first part of the small intestine: the duodenum.

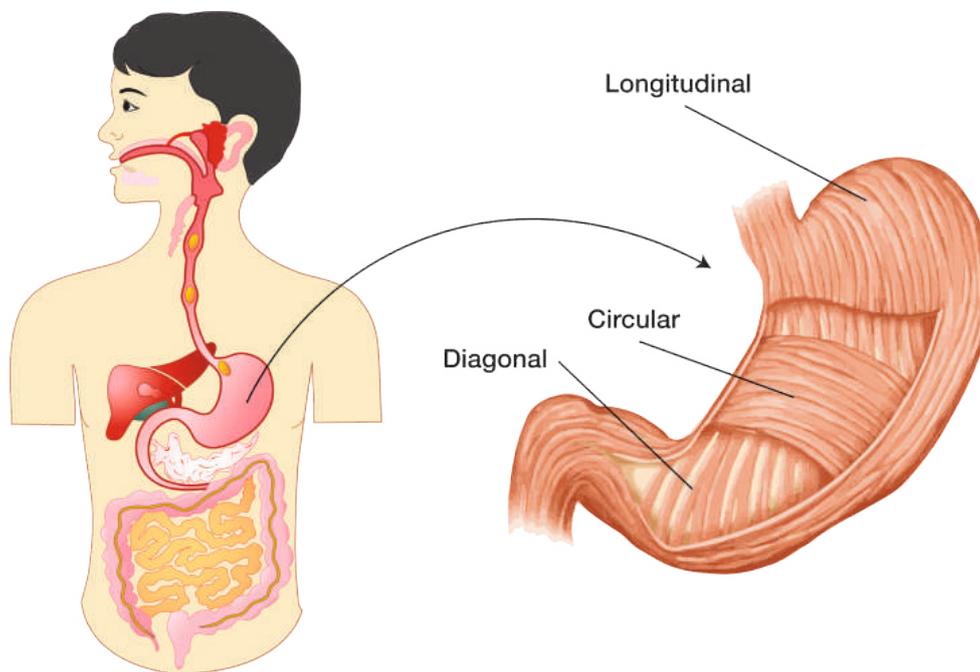


Figure 1.8.4: The circular, longitudinal and diagonal muscles of the stomach, which alternately contract and relax to mix and churn the bolus with gastric juices to make a semiliquid called chyme.

Questions

6. Describe the mechanical process that occurs in the stomach.

.....

.....

.....

..... (2 marks) (KA2)

7. Explain why the chemical digestion of carbohydrates and triglycerides does not occur in the stomach.

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..... (2 marks) (KA2)



Extension activity

Explain why vomit has an acidic nature.

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Small Intestine

The small intestine is made up of three segments: the **duodenum**, the **jejunum**, and the **ileum** (as shown in Figure 1.8.5), which make up approximately 6 metres of tubing coiled up within the abdomen. This is the site where the chemical digestion of macronutrients is completed. Nutrient and water absorption takes place here too.

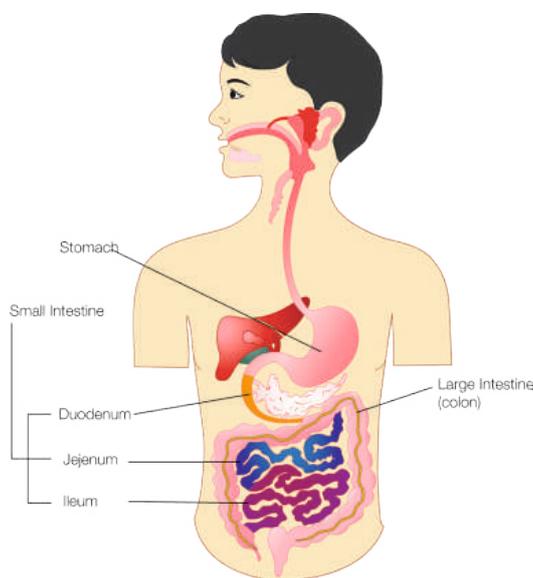


Figure 1.8.5: The three segments of the small intestine: duodenum, jejunum, and ileum.

For chemical digestion to be completed, the pancreas, liver, and gallbladder release their secretions into the small intestines via the common bile duct and pancreatic duct (as shown in Figure 1.8.6). These secretions compose of enzymes, bile, and sodium bicarbonate. The sodium bicarbonate is secreted by the pancreas and is alkaline (the opposite of the gastric contents) and neutralises the acidic nature of the chyme that has come from the stomach. This allows the pancreatic enzymes to efficiently complete the chemical digestion of all macronutrients.

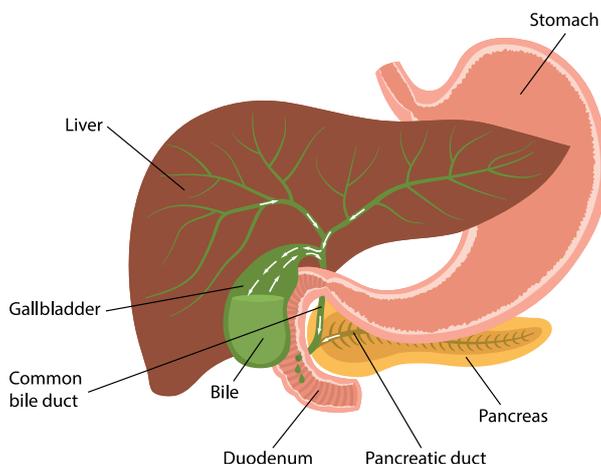


Figure 1.8.6: The common bile and pancreatic duct, which release their secretions into the small intestines.

The mechanical contractions and relaxations of the circular intestinal wall muscles assist with mixing the stomach's chyme with the digestive juices and enzymes involved in the chemical digestion. These actions are known as **segmentation**. This mechanical process also assists with the absorption of nutrients by promoting close contact with intestinal cells and causing the contents to move slowly through the tract for maximum digestion and absorption.

Chemical digestion of carbohydrates

The chemical digestion of carbohydrates continues and is completed in the small intestine. **Pancreatic amylase** enters the small intestine via the pancreatic duct. This enzyme continues to break down polysaccharides (complex carbohydrates) into shorter glucose chains and disaccharides. The final steps are completed by specific enzymes secreted by the intestinal cells, which break down disaccharides into monosaccharides:

- Maltase breaks maltose into two glucose molecules.
- Sucrase breaks sucrose into one glucose and one fructose molecule.
- Lactase breaks lactose into one glucose and one galactose molecule.

At this stage, all polysaccharides and disaccharides have been broken down into monosaccharides, ready for absorption into the bloodstream. Glucose travels throughout the bloodstream ready for cellular use (producing energy during a process of respiration). Fructose and galactose are taken to the liver, where they are converted into other compounds similar to glucose.

Chemical digestion of lipids

The majority of lipid digestion takes place in the small intestine, where it is completed. Once the small intestine detects lipid is present, the gallbladder releases its stores of **bile** via the common bile duct. The liver produces bile, but the gallbladder concentrates, stores and releases it when required.

Bile is composed of bile acids and cholesterol, and it has an affinity for both fat and water. Bile **emulsifies** larger fat molecules and converts them into small fat droplets, allowing them to be immersed in the surrounding water fluid. The emulsification of fat aids in the mechanical digestion of lipids, by increasing the surface area available for **pancreatic lipase** to complete its chemical digestion (Figure 1.8.7).

Pancreatic lipase can either remove each of the triglyceride's outer fatty acids one at a time (leaving a **monoglyceride**) or break apart all three fatty acids (leaving a **free molecule of glycerol**). These are then absorbed and transported through the lymphatic system, before entering the bloodstream near the heart. The blood carries these lipids to the rest of the body for immediate use and storage.

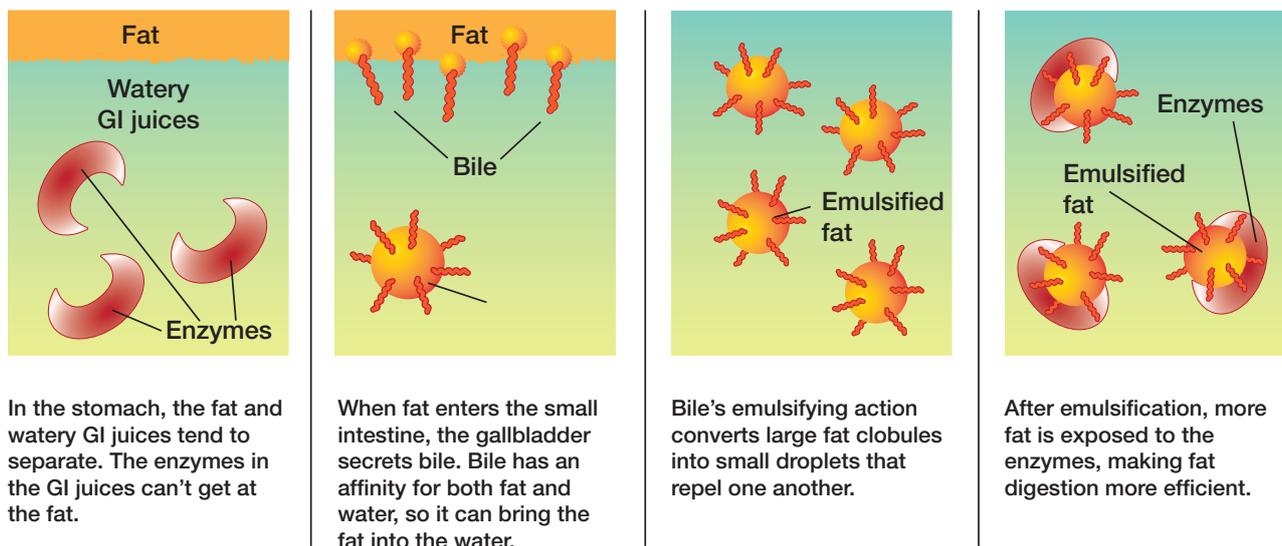


Figure 1.8.7: The emulsification of larger fat molecules produces small fat droplets, which increase the surface area available for pancreatic lipase to efficiently complete the chemical digestion of lipids into fatty acid chains, glycerol and monoglycerides.

Chemical digestion of proteins

The shorter polypeptide chains (produced from the chemical digestion in the stomach) enter the small intestine where their digestion is completed. Several pancreatic and intestinal protease enzymes, including **trypsin** and **chymotrypsin**, break them down into singular amino acids or shorter peptide chains consisting of two or three amino acids. An enzyme found on the surface of the intestinal cells, **peptidase**, completes the digestion of these shorter peptides into singular amino acids. Singular amino acids are then absorbed into the bloodstream ready for their functional and structural roles in the body.

Absorption of macronutrient digestion

Once chemical and mechanical digestion have completed the breakdown of food into molecules small enough, the body absorbs the nutrients and water derived from the food consumed. Almost all ingested food, 80% of micronutrients and 90% of water are absorbed in the small intestines.

The inner surface of the small intestine appears to be smooth; however, when looked at closely, it has a wrinkled appearance and is covered with hundreds of folds. Each fold has thousands of finger-like projections, known as **villi**. Each villus is composed of thousands of cells, which are covered in **microvilli** on their surface (Figure 1.8.8). These villi and microvilli increase the surface area available, maximising the absorption of macronutrients, micronutrients, and water. The cells covering each villus can identify and select the nutrients the body requires. These cells then absorb the nutrients through a process of diffusion, facilitated diffusion or active transport.

The absorption of nutrients occurs throughout the small intestines; however, nutrients that are ready for absorption early are absorbed near the top of the small intestine (duodenum), whereas nutrients that take longer to digest are absorbed further down (in the jejunum and ileum).

Once a nutrient passes through the cell of a villus, it enters the transport systems (the bloodstream or the lymphatic system). Both systems supply vessels to each villus, as shown in Figure 1.8.8. The products of carbohydrate digestion (monosaccharides) and protein digestion (amino acids) are absorbed into the bloodstream. Most triglycerides are absorbed into the lymphatic system before making their way into the bloodstream closer to the heart. Once nutrients have been absorbed, they are transported throughout the body for immediate use and storage or to the liver for further metabolism.

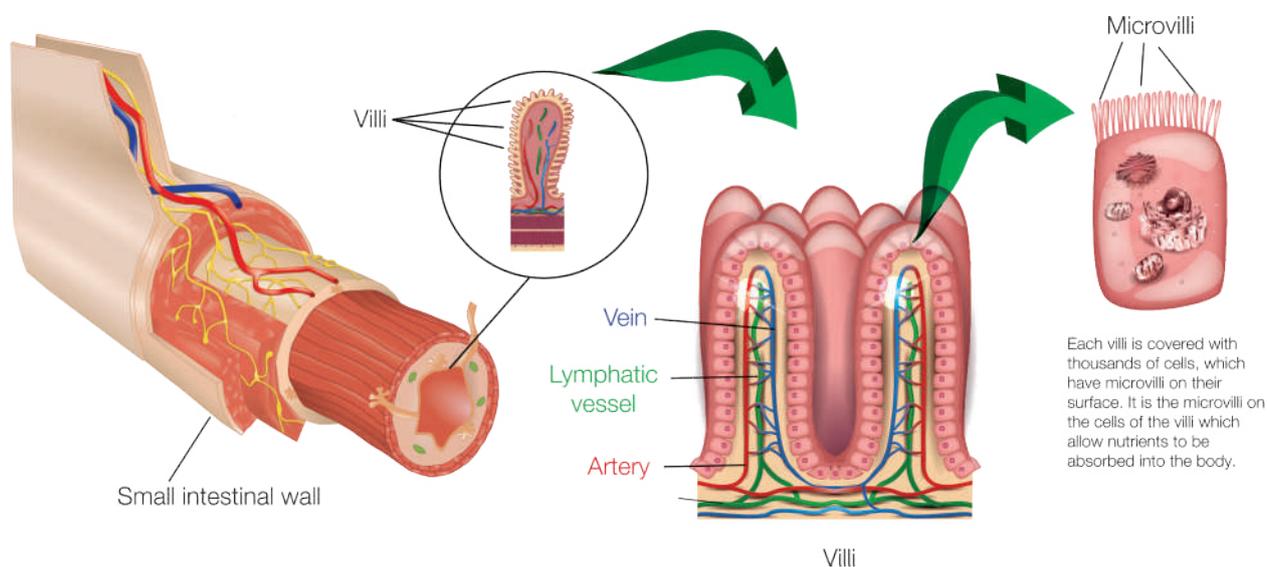


Figure 1.8.8: The small intestinal wall, composed of thousands of villi and microvilli.

Extension activity

Explain what the following transportation methods are:

(a) Diffusion

.....

(b) Facilitated diffusion

.....

(c) Active transport

.....

Questions

8. Explain the chemical digestion of each disaccharide in the small intestines.

.....

(4 marks) (KA2)

9. Explain the role of bile in the chemical digestion of lipids.

.....

(3 marks) (KA2)

10. Identify the *three* enzymes involved in the chemical digestion of proteins in the small intestines.

.....

(1 mark) (KA1)

11. Explain the role of the villi in the small intestines.

.....

(2 marks) (KA2)

Large Intestine

The nutrients that have not been digested or absorbed make their way to one of the final parts of the gastrointestinal tract. The large intestine is four times thicker than the small intestines and is made up of three sections: **ascending colon**, **transverse colon**, and **descending colon** (as shown in Figure 1.8.9). The contents that reach the large intestine are composed of water, a few dissolved salts, excess body secretions, and undigested materials including dietary fibre.

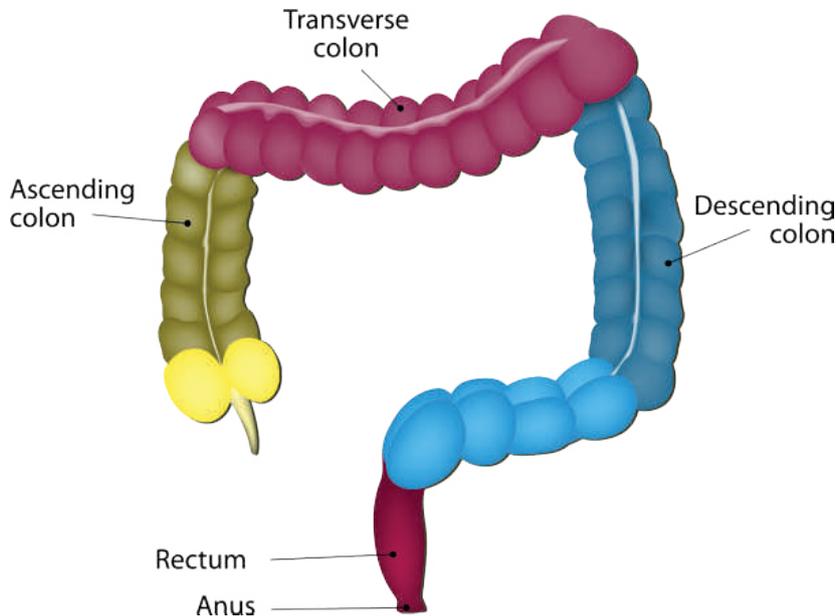


Figure 1.8.9: The sections of the large intestine.

In the large intestine, bacteria **ferment** soluble fibre, producing water and gas. The products of fermentation make stools soft through the addition of water and stimulate movement of the colon, assisting in the excretion of stools. This process can also add bulk to stools through the addition of bacteria that may have died during the fermentation process.

Insoluble fibre passes through the large intestine unchanged, which assists in adding bulk to stools, preventing diarrhoea, and eliminating waste. Finally, all the materials, including water, salts, and minerals (sodium and potassium) that the body can use are reabsorbed, leaving the waste that is actually excreted from the body with little to no nutritional value in it.

Questions

12. Identify the mechanical process which occurs in the large intestines.

..... (1 mark) (KA1)

13. Explain what occurs to soluble and insoluble fibre in the large intestines and the role it plays at this site of the gastrointestinal tract.

.....

..... (4 marks) (KA2)

14. State what occurs to water in the large intestines.

..... (1 mark) (KA1)

Microbiome synthesis of nutrients

A healthy gastrointestinal tract is home to a community of 100 trillion microbes, including bacteria, viruses, fungi, protozoa, and other microorganisms. This is collectively known as the human **microbiome**, which can be found within our gastrointestinal tract, skin, reproductive tract, liver, eyes, mouth, nose and even our belly button; however the microbiome in the large intestine will be the main focus. The balance and diversity of the human microbiome has been proven to reflect the health of an individual and is associated with a greater susceptibility of diseases, including cancer, inflammatory bowel disease, obesity, and asthma. Therefore, the food you eat is the main fuel for your microbiome.

It is essential that foods high in prebiotics, dietary fibre and probiotics are consumed as a way of keeping the microbiome in good shape and maintaining its diversity. Soluble fibre cannot be digested by the human body and therefore, provides a major source of energy for these microbes, fostering their growth. The process of fermentation produces small fatty acid chains, which are then used as energy for the cells of the colon and assist in protecting against disease. Foods that contain soluble fibre and other components are known as **prebiotics**. Inulin is a common prebiotic and it is naturally found in garlic, asparagus, onions, leeks, and artichokes. However, prebiotics are also now added to many foods including breakfast cereals, bread, table spreads, drinks, and yoghurt. Prebiotics encourage the growth and activity of bacteria, as they are an adequate food source. Some foods contain probiotics, which contain live microbes that change the conditions in the gastrointestinal tract. Probiotics assist in maintaining a healthy gut by reducing the number of harmful bacteria, boosting the immune system, alleviating diarrhoea, and constipation, protecting against colon cancer and reducing the symptoms of lactose intolerance and irritable bowel syndrome. Probiotics are generally found in yoghurts and certain fermented foods (refer to Topic 3.1 for further description of fermented foods). Therefore, prebiotics act as a food source for **probiotics**, which are beneficial bacteria for the human microbiome (as shown in figure 1.8.10).

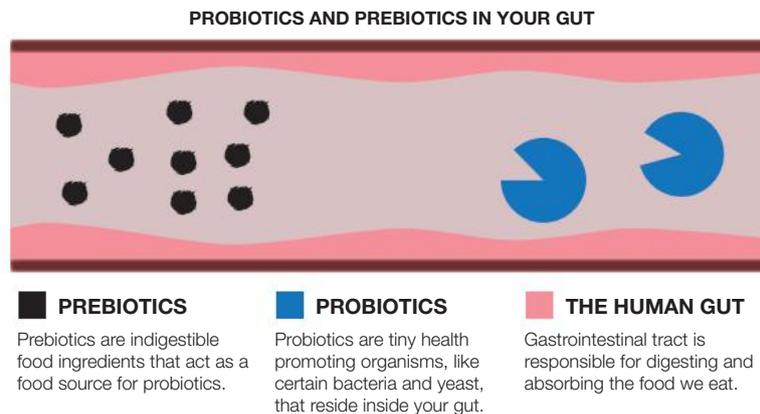


Figure 1.8.10: The role of prebiotics and probiotics in the human gut.

Bacteria in the gastrointestinal tract also produce several vitamins, including vitamin B₁, vitamin B₂, Folate, vitamin B₆, vitamin B₁₂, vitamin H and vitamin K. However, the amount synthesised in this site of the body is insufficient to meet the body's needs, which is why it is essential that these vitamins are provided by the diet also.

Extension activity

Research the functions of vitamin B₆, vitamin H and vitamin K and some common food sources these vitamins can be found in.

Vitamin B₆

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Vitamin H

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Vitamin K

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Science as a human endeavour (Communication & Collaboration)

Gut bacteria transplants could one day be used as a defence against Alzheimer’s disease.

Source: <https://inews.co.uk/news/science/gut-bacteria-transplants-defence-cognitive-decline-alzheimers-disease-675759>

Gut bacteria transplants could one day be used to protect against Alzheimer’s disease after experiments in mice found they had a strong effect on the brain’s cognitive abilities.

Researchers found that transplanting faeces between younger and older mice significantly altered the recipient’s gut microbiome. This, in turn, affected their spatial learning and memory. The researchers hope that transplanting gut bacteria from younger patients to elderly ones could eventually be used to combat cognitive decline.

“Research has shown that the aging process may be linked with age-related changes in our gut microbiota,” said David Vauzour, of the University of East Anglia.

“The existence of two-way communication between the gut and the brain – known as the ‘gut-brain axis’ – has emerged as an important player in shaping aspects of behaviour and cognitive function.”

“The procedure had an impact on the expression of proteins involved in key functions of the hippocampus – an important part of the brain that has a vital role in a variety of functions including memory, learning but also in spatial navigation and emotional behaviour and mood.

Prof Claudio Nicoletti, from the University of Florence, Italy, said: “While it remains to be seen whether transplantation from very young donors can restore cognitive function in aged recipients, the findings demonstrate that age-related shifts in the gut microbiome can alter components of the central nervous system.”

“This work highlights the importance of the gut-brain axis in ageing and provides a strong rationale to devise therapies aiming to restore a young-like microbiota to improve cognitive functions and quality of life in the elderly,” he added.

“Manipulating the microbiome is increasingly being seen as a way of improving or maintaining human health, and these results are an exciting indication of its potential for helping us age healthily” said Prof Arjan Narbad from the Quadram Institute.



Questions

- 15. Discuss how this example above, demonstrates the key concept of Communication and collaboration. Provide two clear examples from the example above.

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(3 marks) (KA3)

Rectum and anus

Once the food reaches the rectum, the digestion and absorption of nutrients is complete, leaving semisolid waste ready to be excreted from the body. The strong muscles of the rectum and anus expand to hold this waste until ready to defecate. Once ready, the muscles of the rectum and the anus relax, opening the passage for waste to be excreted.

Secondary organs of the digestive tract

The breakdown of food into nutrients requires secretions from five different organs: the salivary gland, gastric glands, pancreas, liver, and gallbladder. These secretions enter the GI tract at various points, providing water and different **enzymes** that assist in the chemical breakdown of nutrients. The enzymes involved in digestion facilitate the chemical process of hydrolysis, where the addition of water breaks down larger molecules into smaller ones ready for absorption.



Reminder

An enzyme is a type of protein that speeds up a chemical reaction in the body, including the breakdown of materials during digestion.

Questions

16. Complete the following table, which summarises the secretions of the following organs and glands and the specific actions of their secretions.

Organ or gland	Secretion	Site of release	Action
Salivary gland	Salivary amylase		
		Mouth	Begins the chemical breakdown of lipids into shorter fatty acid chains.
Gastric glands			Gastric juice (hydrochloric acid) is mixed with the bolus, which uncoils proteins and activates gastric pepsin to begin the chemical breakdown of proteins into shorter polypeptide strands.
Pancreas	Pancreatic amylase		
	Pancreatic trypsin and chymotrypsin		
	Pancreatic lipase		
Liver		Gallbladder	
Gallbladder	Concentrated bile	Small intestine	

(14 marks) (KA1)

Overview of the gastrointestinal tract

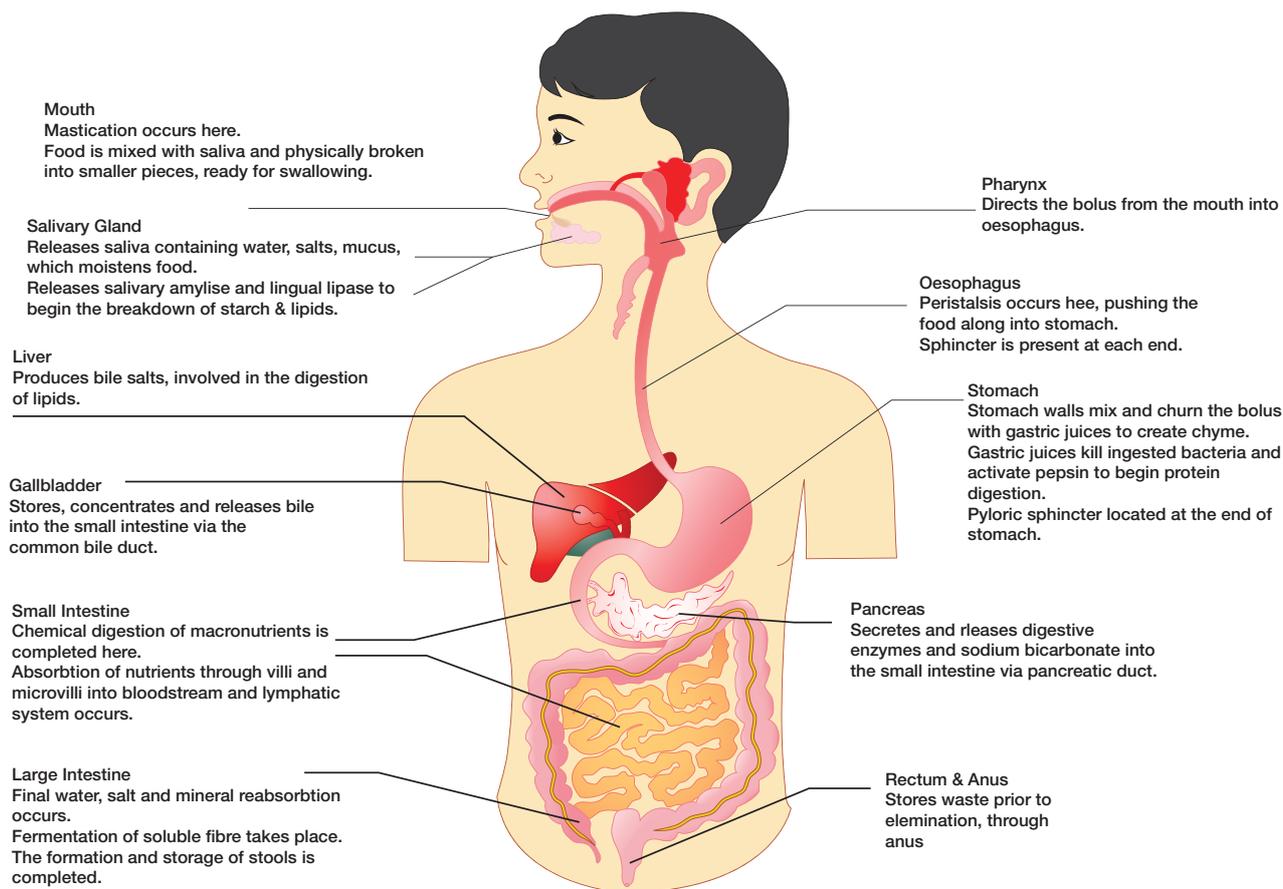


Figure 1.8.11: The functions of primary and secondary organs in the gastrointestinal tract.

Overview of mechanical digestion

In mechanical digestion, food is pushed along and physically broken down into smaller fragments via the acts of mastication in the mouth, peristalsis of the oesophagus, the mixing and churning of the stomach walls, and the segmentation of the intestinal walls.

Questions

17. Complete the following table, explaining each mechanical process that occurs in the gastrointestinal tract.

Mechanical process	Site where it occurs	Definition
Mastication	Mouth	
Peristalsis	Oesophagus	
Mixing and churning	Stomach	
Emulsification of Fats	Small Intestines	
Segmentation	Intestines	

(5 marks) (KA2)

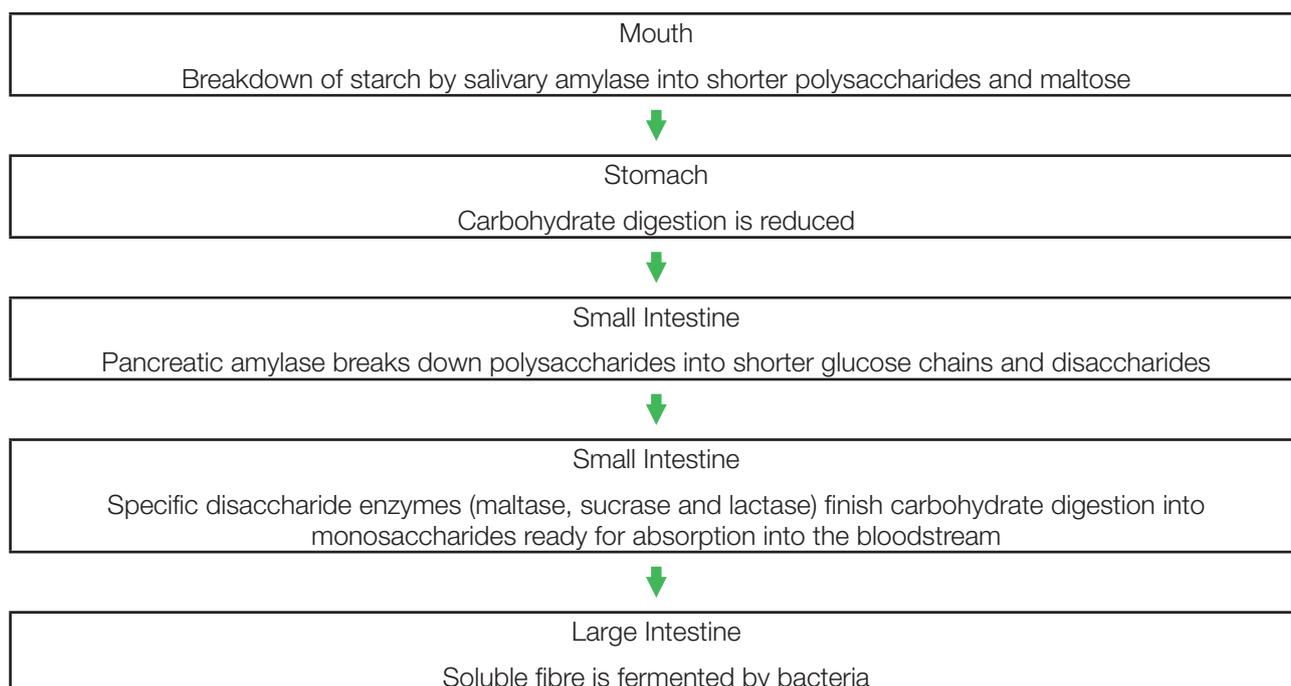
Overview of chemical digestion

Chemical digestion results in the breakdown of all three macronutrients into their basic chemical structures, with the assistance of digestive enzymes and juices. This takes place throughout the gastrointestinal tract; however, it predominantly occurs in the small intestine where this process is completed. The chemical digestion of each macronutrient is summarised in Table 1.8.1 below.

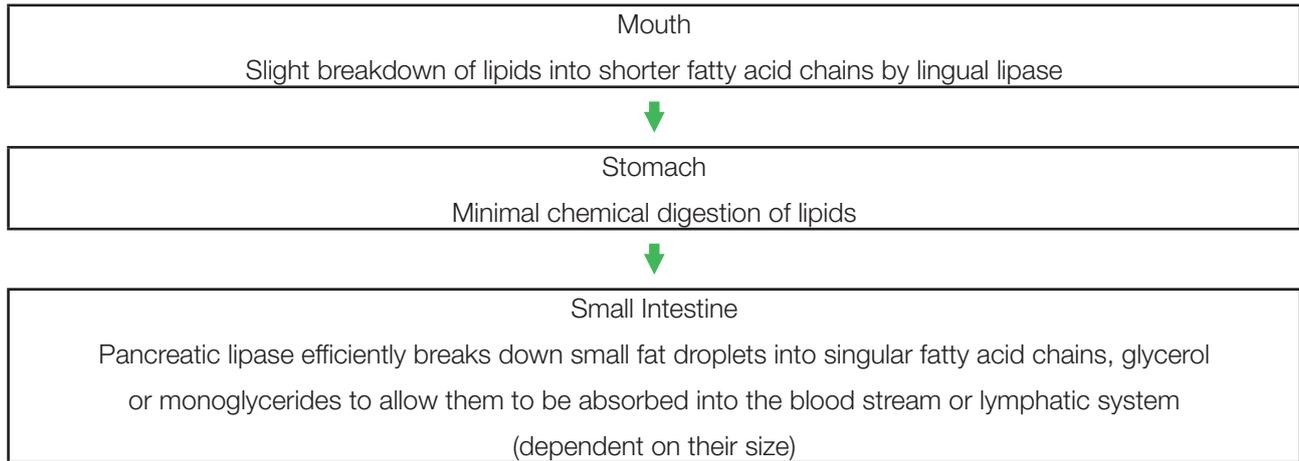
Table 1.8.1: The chemical digestion of each macronutrient

Macronutrient	Site of digestion	Digestive enzymes and juices involved	Products of digestion	Absorbed into
Carbohydrates	Mouth	Salivary amylase	Shorter polysaccharides and disaccharides	N/A
	Small intestine	Pancreatic amylase	Shorter polysaccharides and disaccharides	
		Maltase, sucrase, lactase	Monosaccharides	Bloodstream
Proteins	Stomach	Hydrochloric acid and gastric pepsin	Shorter polypeptide chains	N/A
	Small intestine	Pancreatic trypsin and chymotrypsin	Singular amino acids and short peptide chains	Bloodstream
		Intestinal peptidase	Singular amino acids	
Lipids	Mouth	Lingual lipase	Shorter fatty acid chains	N/A
	Small intestine	Bile	Small fat droplets	N/A
		Pancreatic lipase	Glycerol and short fatty acids	Bloodstream
Monoglycerides and long fatty acids	Lymphatic system			

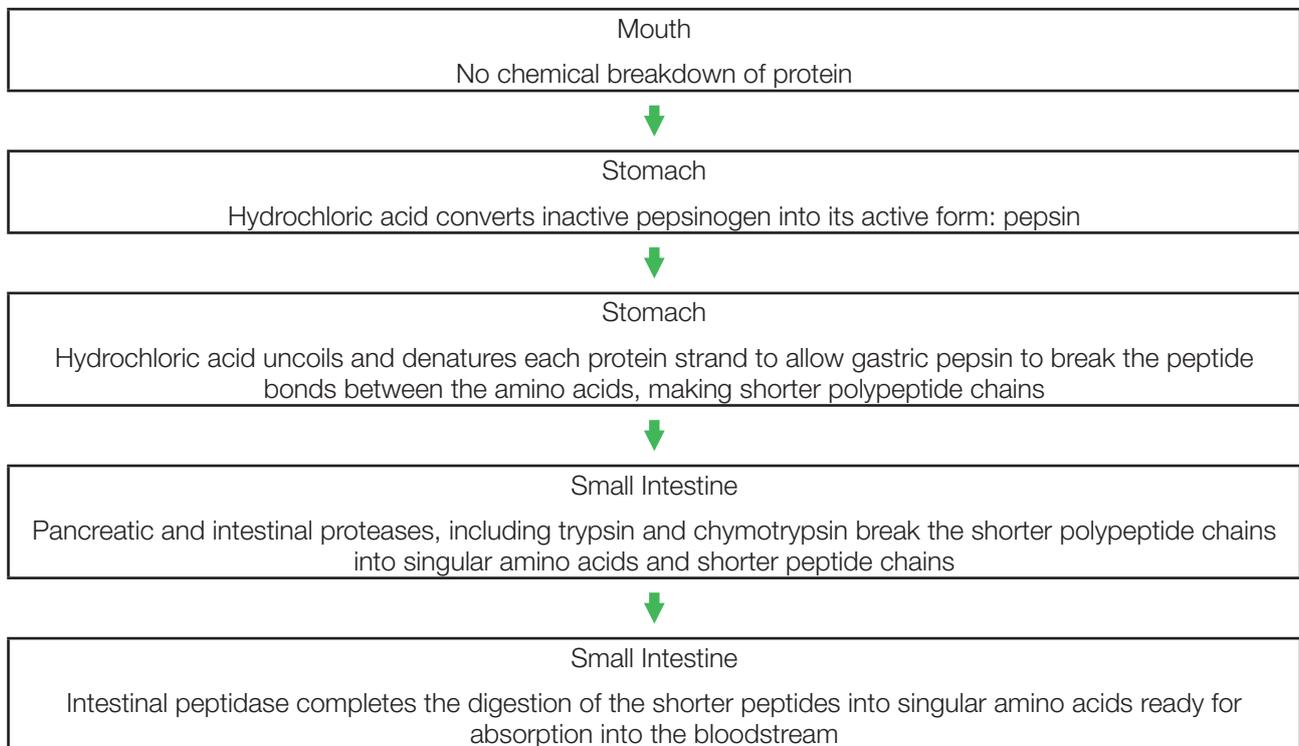
Chemical digestion of carbohydrates



Chemical digestion of lipids



Chemical digestion of proteins



Factors that Interfere with the Absorption of Nutrients

An individual with a **malabsorption syndrome** has difficulty digesting and absorbing specific nutrients due to an autoimmune disease, intolerances, or allergies. This can impair an individual's intake of nutrients, therefore requiring them to modify their diet and lifestyle. Two common malabsorption syndromes include coeliac disease and lactose intolerance.

Coeliac Disease

Coeliac disease affects 1 per cent of the world's population, and 1 in 70 Australians. However, 80 per cent of these Australians remain undiagnosed, and are therefore unaware they have this disease. Coeliac disease is an autoimmune disease characterised by the inflammation of the small intestinal walls. It occurs in response to consumption of foods containing **gluten**.

Gluten is made of two proteins: **gliadin** and **glutenin**. Gliadin is the protein that is toxic to those suffering from coeliac disease. Gluten can be found in products that contain wheat, rye, oats, or barley. In people with coeliac disease, gluten triggers an immune response in the small intestines, which causes inflammation of the walls. This causes the villi to become damaged and flat, reducing the surface area available for nutrient absorption (Figure 1.8.12). This can lead to several nutrient deficiencies.

Nutrient deficiencies including anaemia or osteoporosis are common consequences of this malabsorption syndrome. This is due to a reduction in the absorption of nutrients across the damaged and flattened intestinal walls.



Figure 1.8.12: The villi of a healthy intestinal wall (image on the left) in comparison to the damaged villi (image on the right) of the intestinal wall of an individual suffering from coeliac disease.

Symptoms

The symptoms of coeliac disease can range from severe to minor and may go undetected. The most common symptoms can include bloating, flatulence, diarrhoea, nausea, fatigue, abdominal cramps and weakness. Symptoms can be like that of irritable bowel syndrome, so a biopsy of the intestinal walls is the only way to confirm the diagnosis of this syndrome.

Dietary management

People with coeliac disease remain sensitive to gluten throughout their entire lives, therefore dietary management is essential, as there is no current cure. A strict **gluten-free diet** is currently the only recognised treatment for coeliac disease.



Fast fact

Despite the growing popularity of gluten-free products, there is little evidence to suggest that a gluten-free diet is beneficial for the general population.

The list of foods that should be avoided is extensive; however, all fresh fruit and vegetables, nuts and seeds, meats, poultry, seafood, dairy and some grains and starches (e.g. quinoa, soy) can be consumed. Individuals should look for products labelled as 'gluten free' or displaying the **Coeliac Australia endorsement logo** (Figure 1.8.13). This endorsement logo allows consumers to shop with confidence, as all products are tested to ensure that no gluten is detected. An individual can also read the ingredients panel on a food label as a food product derived from wheat, rye, oats, and barley must be declared. Products with cross-contamination labels, e.g. 'may contain traces of gluten', should also be avoided.

A strict gluten-free diet allows the walls of the small intestine to heal themselves and resolve any related symptoms.



Figure 1.8.13: Coeliac Australia endorsement logo

Lactose Intolerance

Lactose intolerance results in the inability to digest the disaccharide lactose, which is commonly found in dairy products. This is because the intestinal cells do not produce enough of the enzyme **lactase**, which finishes the digestion of this disaccharide into its two monosaccharides (glucose and galactose) in preparation for absorption.

Lactase production commonly decreases with age, with the most dramatic decline occurring during childhood and adolescence. Lactase production is the highest immediately after birth, as an infant's only food source is breast milk or formula for the first few months of its life. Humans are the only animal species that continues consuming milk products into adulthood.

Lactase deficiency may also develop when the intestinal villi are damaged due to disease, medication, prolonged diarrhoea, or malnutrition.

Symptoms

When a greater amount of lactose is consumed than the available lactase can handle, lactose molecules remain in the intestines undigested. This undigested lactose attracts water, causing bloating, abdominal discomfort, and diarrhoea. Once the undigested lactose reaches the large intestines, it becomes a food source for the bacteria present. This causes bacteria multiplication and the production of gas and an irritating acid, further contributing to discomfort and diarrhoea.

Dietary management

An individual with lactose intolerance is required to make some dietary changes but does not need to eliminate all dairy products from their diet. Excluding all dairy products from their diet can put an individual at risk of being deficient in nutrients, including calcium and phosphorus, as they are predominantly found in these food sources. This can have an implication on the health of bones and teeth.

In many cases, individuals with lactose intolerance can still consume products containing up to 6 grams of lactose without experiencing any of the related symptoms. Milk products that have been fermented (e.g. yoghurt and cheese) can also be tolerated, as the bacteria present in these products have consumed the lactose for their own benefit. This further reduces the lactose present in these products.

Alternatively, individuals may consume enzyme tablets with meals containing lactose. This breaks down a significant amount of the lactose present into glucose and galactose and allows for these monosaccharides to be absorbed without any ill effects.

A lactose-free diet can be restrictive and difficult to maintain; an individual needs to read the food labels and avoid products that contain milk, milk solids, whey (milk liquid) and casein (milk protein). An individual must also read the labels of most pharmaceuticals, as lactose is a common ingredient in medicines.

Questions

18. Some dietary foods and beverages can reduce the bioavailability of nutrients, including calcium and iron. Identify two specific food or drink sources and their corresponding component that reduces the absorption of these minerals.

(a) Iron

1.

2.

(b) Calcium

1.

2.

(8 marks) (KA1)

19. Explain how cooking foods for an extended period can reduce the absorption of vitamins.

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(2 marks) (KA2)

20. Explain two ways that chewing food slowly and completely, can enhance the absorption of nutrients.

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(3 marks) (KA2)

21. Explain how consuming soluble fibre with your meals can enhance the absorption of nutrients.

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(2 marks) (KA2)

Extension activity

Research and explain what the following disorders are and how they can interfere with the absorption of nutrients.

Irritable Bowel Syndrome (IBS)

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Crohn's Disease

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Factors that Determine Energy Balance

We continuously expend energy and consume food periodically to refuel. Ideally, an individual's energy intake (energy in) should be equal to their energy expenditure (energy out), to achieve an **energy balance** and maintenance of their weight (as shown in figure 1.8.14). When the balance shifts, **weight can fluctuate**.



Fast fact

A classic rule states that for each 30,000 kilojoules eaten in excess, a kilogram of body fat is stored. Similarly, a kilogram of body fat is lost for each 30,000 kilojoules expended above the amount consumed. Therefore, most diet plans recommend reducing your energy intake by 2000-4000 kilojoules a day to achieve a weight loss of half to one kilogram a week.

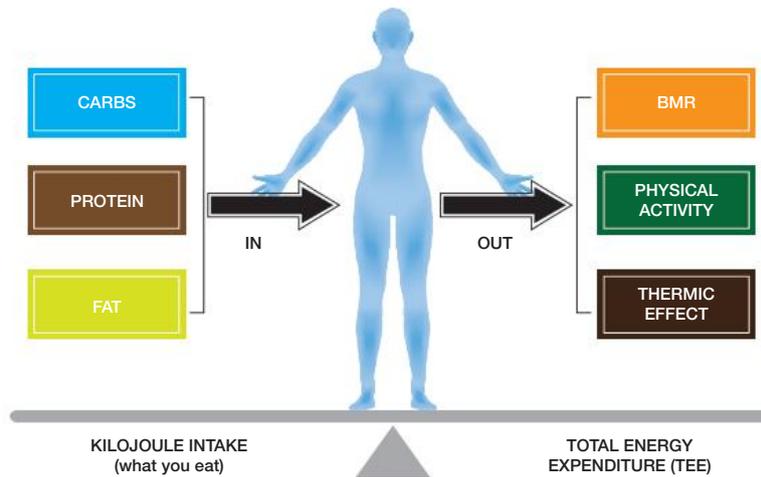


Figure 1.8.14: The energy balance, where the energy in is equal to the energy out.

A **positive energy balance** occurs when energy intake is greater than energy expenditure. That is, a person has consumed more kilojoules than the body needs. This leads to excess energy being stored as body fat, resulting in weight gain. Weight loss results from a **negative energy balance** when energy intake is less than energy used (as shown in Figure 1.8.15).

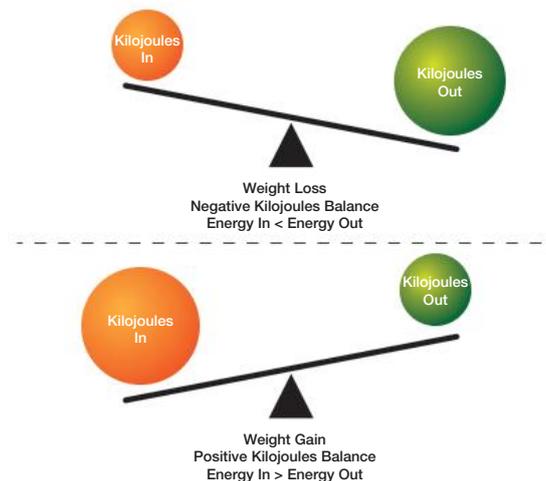


Figure 1.8.15: Positive and negative Energy Balance

Energy Intake (Energy In)

The consumption of food and beverages contributes to an individual's **energy intake**, which is dependent on the composition of food (number of kilojoules) and the amount that is eaten. The amount of food consumed must meet the nutritional needs without taking in too much or too little energy; however, a person's appetite prompts how much and how often to eat.

Extension activity

The number of kilojoules (composition) that food provides can be determined by burning food in a calorimeter (as shown in Figure 1.8.16).

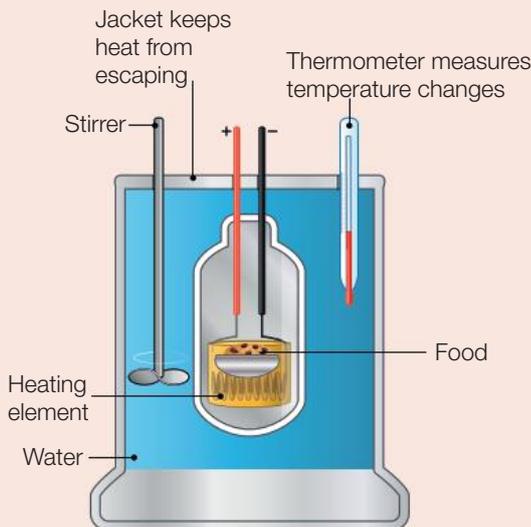


Figure 1.8.16: An example of burning of food in a calorimeter

When the food burns, the chemical bonds break, and energy is released in the form of heat. The amount of heat given off provides an indication of the food’s energy value and can be calculated using the following formula:

$$\text{Energy per 100 g} = \frac{(m_{\text{water(g)}} \times (\text{Change in Temperature} \times \text{Heat Capacity (Cp} = 4.185)))}{[\text{mass of food sample combusted (g)} \times 10]}$$

Design an experiment investigating the amount of heat given off when burning different foods to determine their energy value.

(a) Propose a testable hypothesis or inquiry question

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(b) Identify the independent variable (IV) and dependent variable (DV). Make sure to include how the independent variable is going to be manipulated and how the dependent variable is going to be measured, including how many times.

IV:

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DV:

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Extension activity

- (f) Identify ethical and/or safety considerations and explain how these are going to be managed.

Ethical and/or Safety Considerations	How they are going to be managed

- (g) Construct an appropriate table, that is labelled and includes the correct SI units to collect raw data if this experiment were to be conducted. Make sure to consider the factors required to calculate the energy with reference to the formula and the number of trials that would be conducted for every food item selected.

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1

Energy Expenditure (Energy Out)

People expend energy when they are physically active, but they also expend energy when they are resting quietly. An individual's **energy expenditure** is determined by three main categories (as outlined below and shown in figure 1.8.17):

- Energy expended for basal metabolism (BMR)
- Energy expended for physical activities
- Energy expended for food digestion (thermic effect of food)

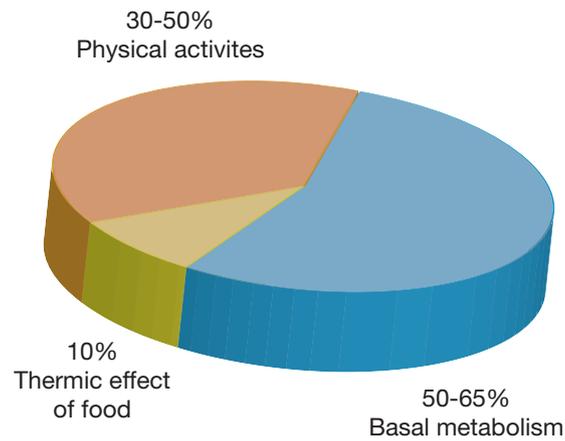


Figure 1.8.17: Components of energy expenditure

Basal Metabolic Rate (BMR)

Basal metabolic rate (BMR) can be defined as the rate at which the body expends energy for basal metabolic activities, which support all basic processes of life. Basal metabolic activities maintain the body temperature, keep the lungs inhaling and exhaling air, allows the bone marrow to continue producing red blood cells, keeps the heart beating 100,000 times a day and keeps the kidneys filtering the blood and removing wastes. Approximately two thirds of the energy an average person expends in a day supports these basal metabolic processes. However, the rate at which an individual expends this energy for these activities varies from person to person and may vary for the same individual with a change in circumstances of physical conditions (as shown in table 1.8.2)

Table 1.8.2: Factors that influence an individual's BMR (the rate at which they expend energy)

Factor	Influence on BMR
Age	Lean body mass diminishes, and physical activity declines with age, which slows BMR.
Body Size	Larger body sizes (including greater height) have greater metabolising tissue and larger surface area, increasing their BMR.
Growth	During childhood, adolescence and pregnancy energy demands are greater due to the growth experienced, increasing their BMR.
Body Composition	A larger amount of lean body tissue increases BMR. This is because muscle tissue is a faster metabolising tissue (burns more kilojoules) than sluggish adipose tissue.
Gender	Males generally have a higher BMR as their body is composed of greater lean body tissue than females. Males also expend more calories per kilogram per hour than females, where males burn 1.0 calorie and females burn 0.9.
Amount of Physical Activity	Regular physical activity increases lean body tissue, increasing BMR as muscle tissue burns more kilojoules than adipose tissue even at rest.
Fever, Infection, and Illness	The body must work harder to build new tissues, develop an immune response, and maintain normal body temperature, which increases BMR.
Environmental Temperature	High and low environmental temperatures increase BMR, as the body must work harder to maintain normal body temperature.
Fasting, Starving, Malnutrition and Crash Dieting	Consuming fewer kilojoules than the body expends, reduces BMR. This is because the body's basal metabolism slows down to conserve energy. BMR can drop up to 15%, and even further if lean body tissue is lost also.
Drugs	Drugs can increase or decrease an individual's BMR. For example, nicotine in smoking and caffeine can increase BMR; whilst some antidepressants and steroids can decrease BMR.
Genetics, Hormonal balance	Genetics and hormone levels can increase or decrease BMR, due to their influence on the rate at which the body expends energy.

Questions

22. Allocate each of the factors in *Table 1.8.2*, by identifying how they influence BMR and entering them into the table below (some factors may be placed in both columns).

Factors increasing BMR	Factors decreasing BMR

(11 marks) (KA1)

There are several ways to calculate the BMR of an individual, however a simple method commonly used is to multiply the weight (kg) of an individual by 1.0 calorie per kilogram per hour for adult males and 0.9 calories per kilogram per hour for adult females. This is then multiplied by 24 to determine the kilojoules used for basal metabolic processes in a day, and finally multiplied by 4.2 to convert this value into kilojoules, which is the preferred energy unit used in Australia (as shown by the equations and example below).

Male

$$\text{BMR} = \text{Bodyweight (kg)} \times 1 \text{ (calories)} \times 24 \text{ (hours)} \times 4.2 \text{ (kilojoules)}$$

$$\text{BMR} = \dots\dots\dots \text{kJ/day}$$

Female

$$\text{BMR} = \text{Bodyweight (kg)} \times 0.9 \text{ (calories)} \times 24 \text{ (hours)} \times 4.2 \text{ (kilojoules)}$$

$$\text{BMR} = \dots\dots\dots \text{kJ/day}$$

Example

Calculate the BMR for a 31-year-old female who weighs 73kg and is 165cm tall. Show all your calculations and round your final answer to the nearest whole number.

$$\text{BMR} = 73 \times 0.9 \times 24 \times 4.2$$

$$\text{BMR} = 6622.56 \approx 6623 \text{ kJ/day}$$

Questions

23. Calculate the BMR for a 47-year-old male who weighs 88 kg and is 166 cm tall. Show all your calculations and round your final answer to the nearest whole number.

.....

.....

.....

kJ/day (2 marks) (KA4)

Physical Activity

Another component of an individual's energy expenditure is **physical activity**. This component is the most changeable, however, its influence on both weight gain and weight loss can be significant. During physical activity, the muscles require greater energy to move and the heart and lungs need additional energy to deliver nutrients and oxygen and dispose of wastes. The amount of energy needed for any activity, depends on muscle mass, body weight and activity. The larger the muscle mass and the heavier the body part being moved, the more energy that is expended. The activity's duration, frequency and intensity also influence energy expenditure. The longer, more frequent, and more intense the activity, the more kilojoules expended (as shown in table 1.8.3).

Table 1.8.3: Energy expended on various physical activities.

Activity	kJ/kg/min
Aerobics (vigorous)	0.571
Basketball (vigorous and full court)	0.895
Bicycling (21km/h)	0.416
Rowing (vigorous)	0.895
Running (12km/h)	0.869
Walking (6km/h)	0.345
Soccer (vigorous)	0.895
Swimming (20m/min)	0.322
Table Tennis (skilled)	0.416
Tennis (beginner)	0.294
Gardening	0.416
Vacuuming and other household tasks	0.277
Studying	0.100

Extension activity

Write the name of a food or beverage item recently consumed, and then draw the item in the box below (or find a picture). Find the nutrient content of that food item and record below, and then calculate the **amount of physical activity** (using Table 1.8.3) needed to be completed to use the energy consumed from this food or beverage item.

Fast fact

To calculate the kilojoules spent per minute of activity for your own body weight, multiply the kJ/kg/min by your weight and then multiply that number by the number of minutes spent in the activity.

Food or beverage item:

picture or drawing	Your Serving Size (g or ml)	
	Energy (kJ)	
	Protein (g)	
	Fat, total (g)	
	Fat, saturated (g)	
	Carbohydrates (g)	
	Sugars (g)	

One serving of which contains kilojoules per serving is equivalent to minutes of

Thermic Effect of Food

The **thermic effect of food** refers to the energy required and the heat produced following the consumption of food. The additional energy required and the heat produced is due to the increase in the contractions of the gastrointestinal tract, the manufacture and secretion of digestive juices and enzymes by different cells in the body and the active transport processes which absorb some nutrients. Therefore, the thermic effect of food can be defined as the energy required to eat and digest food, absorb nutrients, and move food through the gastrointestinal tract.

The thermic effect of food is proportional to the food energy consumed and is estimated at 10 percent of the energy intake. The proportions vary for different foods, as the thermic effect is greater for high protein foods than for high fat and carbohydrate foods. For example, lipids and carbohydrates, which are relatively easy to digest, raise energy needs by around 0-5% and 5-10% respectively, while proteins, which are more difficult to break down in digestion, require 20-30% of the energy consumed. The thermic effect can also be influenced by the meal size and frequency, as it is greater for a larger meal eaten at once rather than spread out over a couple of hours. However, with such a large variance in foods and their thermic effects, a figure of 10% of kilojoules consumed can be used to calculate energy needs required for the digestion of food (as shown in the example below).

Example

Calculate the thermic effect of energy intake when a female's daily energy consumption is 8500kJ. Show all your calculations using: $0.10 \times \dots \dots \dots$ kJ consumed/day.

$$0.10 \times 8500\text{kJ consumed/day} = 850\text{kJ}$$

Questions

24. Calculate the thermic effect for a daily consumption of 13,500 kJ.

..... (1 mark) (KA4)

25. Fred consumes 8990 kJ in day. Calculate how much energy will be left for body functioning after energy used by the thermic effect is considered.

..... (2 marks) (KA4)

Calculating Total Daily Energy Expenditure

The total energy expenditure (TEE) for a day can be simply calculated by adding an individual's BMR, the energy expended on physical activity that day and their thermic effect of food (as shown by the formula and example below).

$$\text{Total Energy Expenditure} = \text{BMR} + \text{Energy Expended on Physical Activity} + \text{Thermic Effect of Food}$$

Example

Calculate the total energy expenditure for a female who has a BMR of 6623kJ/day, expends 1806kJ on physical activity (cycling and walking) and a thermic effect of 850kJ. Show all your calculations and round your final answer to the nearest whole number.

$$\text{Total Energy Expenditure} = 6623 + 1806 + 850$$

$$\text{Total Energy Expenditure} = 9279 \text{ kJ/day is expended}$$

Questions

26. Calculate the total energy expenditure of a 65 kg male who expends 450 kJ exercising and consumes 8200 kJ. Show all working and round to the nearest whole number.

(4 marks) (KA4)

Extension activity

There are also several ways to estimate an individual's total energy expenditure for the day. The Schofield method used to calculate an individual's BMR, can also be used to determine the number of kilojoules expended in a day. This is determined by multiplying their BMR using the Schofield equation with an estimate of physical activity levels (PAL) from the table below (as shown by the following equation).

$$\text{Total Energy Expenditure} = \text{BMR (using Schofield equation)} \times \text{PAL}$$

Description of Lifestyle	Examples of Occupations / Individuals	Physical Activity Levels (PAL)
At rest, exclusively sedentary or lying (chair-bound or bed-bound).	Old individuals. Unable to move around freely or earn a living.	1.2
Very sedentary with seated work with little or no strenuous leisure activity	Office employees, precision mechanics	1.4-1.5*
Light active with seated work with some requirement for occasional walking and standing but little or no strenuous leisure activity	Laboratory assistants, drivers, students, assembly line workers	1.6-1.7*
Moderately active with predominantly standing or walking work	Domestic duties, salespersons, waiters, mechanics, traders	1.8-1.9*
Heavy to vigorously active with heavy occupational work or highly active leisure	Construction workers, farmers, forest workers, miners, high performance athletes	2.0-2.4

*Significant amounts of strenuous leisure activities (30-60 minutes, 4-5 times a week) should add 0.3 PAL units per day.

Calculate the total energy expenditure of a 55-year-old male who weighs 90 kg and works in an office environment and performs no strenuous leisure activity. Use the Schofield equation given below to calculate his BMR and then determine his total energy expenditure by using the PAL units in the table above.

$$\text{BMR} = 48 \times \text{weight in kg} + 3653$$

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Calculating Energy Balance

An individual's energy balance can be calculated by subtracting their total energy expenditure for a day from their energy intake from the foods and beverages consumed in that same day (as shown in the equation and example below).

$$\text{Energy Balance} = \text{Energy Intake} - \text{Total Energy Expenditure}$$

Energy balance is defined as the state achieved when energy intake is equal to energy expenditure. When the body is in energy balance, body mass is maintained. Differences in energy balance can cause changes in the body's mass. A positive energy balance will result when the energy balance is a positive value, due to the energy intake exceeding the total energy expenditure. This will result in weight gain if this pattern continues over a longer period. Whereas, a negative energy balance will result when the energy balance is a negative value, due to the total energy expenditure exceeding the energy intake. This will result in weight loss if this pattern continues over a longer period. The rate at which weight is gained or lost is determined by the magnitude of the difference between an individual's energy intake and their total energy expenditure. The different types of energy balance can be summarised as:

Energy Balance (maintenance of weight): Energy Intake = Energy Expenditure

Positive Energy Balance (weight gain): Energy Intake > Energy Expenditure

Negative Energy Balance (weight loss): Energy Intake < Energy Expenditure

Example

Calculate the energy balance of a female who consumes 8500kJ a day and has a total daily energy expenditure of 9279kJ. Show all your calculations and explain the impact this balance will have on her weight if this pattern continues.

$$\text{Energy Balance} = 8500 - 9279$$

$$\text{Energy Balance} = -779\text{kJ}$$

This female's energy expenditure is greater than her energy intake, resulting in a negative energy balance (indicated by the minus sign). If this pattern were to continue, she would experience weight loss.

Questions

27. The number of kilojoules in food consumed is less than the amount of energy burned in activity. Identify this situation's type of energy balance.

..... (1 mark) (KA1)

28. Calculate the energy balance of a male who consumes 8200kJ a day and has a total daily energy expenditure of 7822kJ. Show all your calculations and identify the type of energy balance and the impact this will have on his weight if this pattern continues.

..... (4 marks) (KA1, KA4)



Key terms

Basal Metabolic Rate (BMR)	Gastrointestinal (GI) tract	Pancreatic lipase
Bile	Gliadin	Peristalsis
Bolus	Gluten	Pharynx
Chemical digestion	Glutenin	Physical activity
Coeliac Australia Endorsement Logo	Lactose Intolerance	Positive energy balance
Coeliac Disease	Lingual lipase	Prebiotics
Chyme	Lower oesophageal sphincter	Probiotics
Digestion	Malabsorption syndrome	Pyloric sphincter
Duodenum, jejunum, ileum	Maltase, sucrase and lactase	Salivary amylase
Emulsification	Mastication	Salivary gland
Energy Balance	Mechanical digestion	Segmentation
Energy Expenditure	Microbiome	Thermic effect of food
Energy Intake	Mixing and churning	Trypsin and chymotrypsin, peptidase
Fermentation	Negative energy balance	Upper oesophageal sphincter
Gastric juices	Pancreatic amylase	Villi, microvilli
Gastric pepsin		

Review questions: 1.8 Digestion and Metabolism of Food

- Explain the difference between mechanical and chemical digestion.

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..... (2 marks) (KA2)
- Describe how coeliac disease impacts the absorption of nutrients in the small intestines.

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..... (2 marks) (KA2)
- The stomach has the strongest muscles and the most acidic nature of the entire gastrointestinal tract.
 - State a function of hydrochloric acid in the stomach.

.....

..... (1 mark) (KA1)
 - Explain how the entry and exit of food is controlled in the stomach.

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..... (2 marks) (KA2)

1.9 Imbalance of Nutrient Intake – Over Nutrition Disorders

Science understanding

Imbalance of nutrient intake is likely to cause diet related disorders. Diet related health disorders include:

- The consequences of over nutrition:
 - Obesity
 - Type 2 Diabetes
 - Atherosclerosis & Cardiovascular Disease
 - Hypertension
- The role of diet and lifestyle in the prevention and management of such disorders

SACE Subject Outline, 2020.

Obesity

Obesity and being overweight are defined as abnormal or excessive fat accumulation that presents risk to an individual's health. An individual can be categorised as being overweight if they have a **Body Mass Index (BMI)** equal to or greater than 25. An individual with a BMI greater than 30 is considered obese, and a BMI greater than 35 is considered morbidly obese.

Definition

Glycaemic Index (GI) is a measure of how a food or beverage will affect blood glucose levels after consumption. Body Mass Index (BMI) is a diagnostic tool used to assess an individual's weight category, which is calculated by dividing their weight in kilograms by the square of their height in metres.

The prevalence of individuals who are classified as being overweight or obese in all parts of the world is increasing at an alarming rate (as shown in Figure 1.9.1). The proportion of Australians who are classified as being overweight or obese has significantly increased over the last two decades, where obesity is becoming an epidemic.

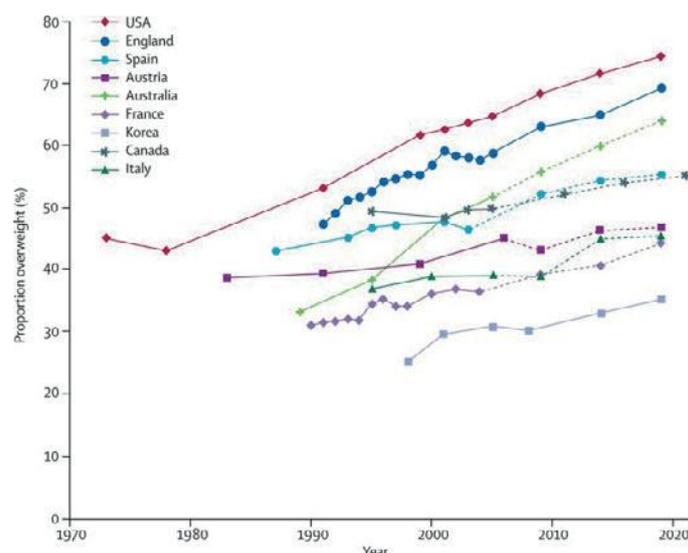


Figure 1.9.1: The escalation of obesity rates worldwide and projected future trends, according to Wang C. et al. (2011), *Health and economic burden of the projected obesity trends in the USA and the UK*, *The Lancet*, vol. 378, issue 9793.

Fast fact

In 2014/2015 two in three adult Australians, and one in four children, were classed as overweight or obese. Approximately 28 per cent of Australians are obese, which is an increase from 19 per cent in 1995.

Questions

1. Refer to Figure 1.9.1 to answer the following questions.

(a) Identify which country currently has the greatest and lowest proportion of obesity.

..... (1 mark) (IAE3)

(b) Identify the predicted proportion of overweight Australians in 2020.

..... (1 mark) (IAE3)

2. Using the formula below, calculate the BMI of an individual who weighs 93 kilograms and is 1.6 metres tall. Show all your working out, round your final answer to the nearest whole number and identify what BMI category this individual would be considered as.

$$\text{Body Mass Index} = \frac{\text{weight (kg)}}{\text{height (m)}^2}$$

(3 marks) (IAE3, KA4)

Signs & Symptoms

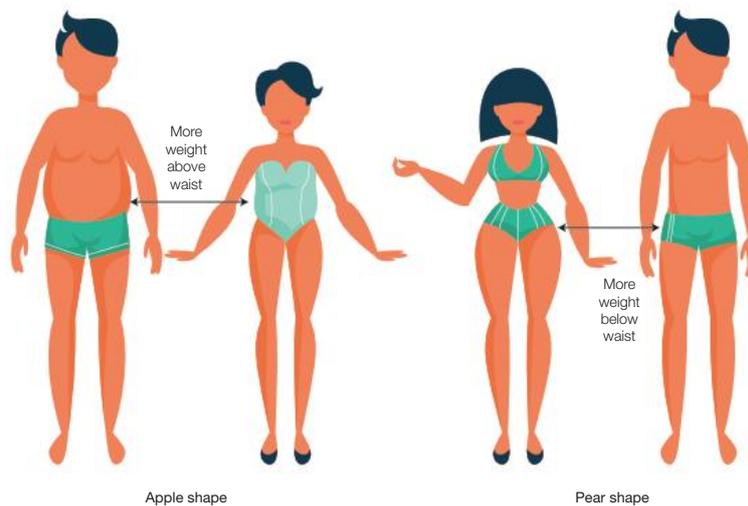


Figure 1.9.2: The different body shapes, which can result from excessive fat accumulation.

The more obese an individual is, the more likely they are to experience symptoms related to obesity. The most prevalent symptom experienced by individuals is visible fat accumulation. Fat can be stored in different areas around the body. In an android body shape, the individual will store the fat around his or her abdominal region. This type of body shape will have greater amounts of visceral fat, which is located between the organs, contributing to 'belly' fat. These individuals are labelled as having an apple-shaped body shape (as shown in Figure 1.9.2). In a gynoid body shape, excess fat is deposited around the hip and thigh regions of the body. This body shape is labelled as being pear shaped (as shown in Figure 1.9.2).

Questions

3. State which body shape each gender is likely to develop if excess fat accumulation occurs.

Male:

Female:

(2 marks) (KA1)

Other symptoms that an individual who is classified as being obese may experience include fatigue, joint pain and shortness of breath. These symptoms can also lead to physical, economic, social and psychological consequences.

Extension activity

Identify two physical, economic and social consequences that an obese individual may experience.

Physical	Economic	Social & Psychological

Extension activity

Research and explain the difference between the two types of fat that the body stores: subcutaneous and visceral.

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Nutrition Related Risk Factors

The most significant causes of obesity are dietary factors when energy intake exceeds energy expenditure over a considerable amount of time. The consumption of alcohol which is high in kilojoules and processed foods which are high in fat and sugar and low in dietary fibre can also accelerate the development of this overnutrition disorder.

Energy intake exceeds energy expenditure

When more energy is consumed than expended, much of the excess energy from each macronutrient is stored in the fat cells of adipose tissue as triglycerides. The fat cells accumulate triglycerides and expand in size. When the cells enlarge, they stimulate cell reproduction, so their numbers increase also. Therefore, obesity is a result of increases in the size of fat cells in adipose tissue, as well as increases in the number of fat cells when energy-yielding nutrients are consumed in excess (as shown in Figure 1.9.3).

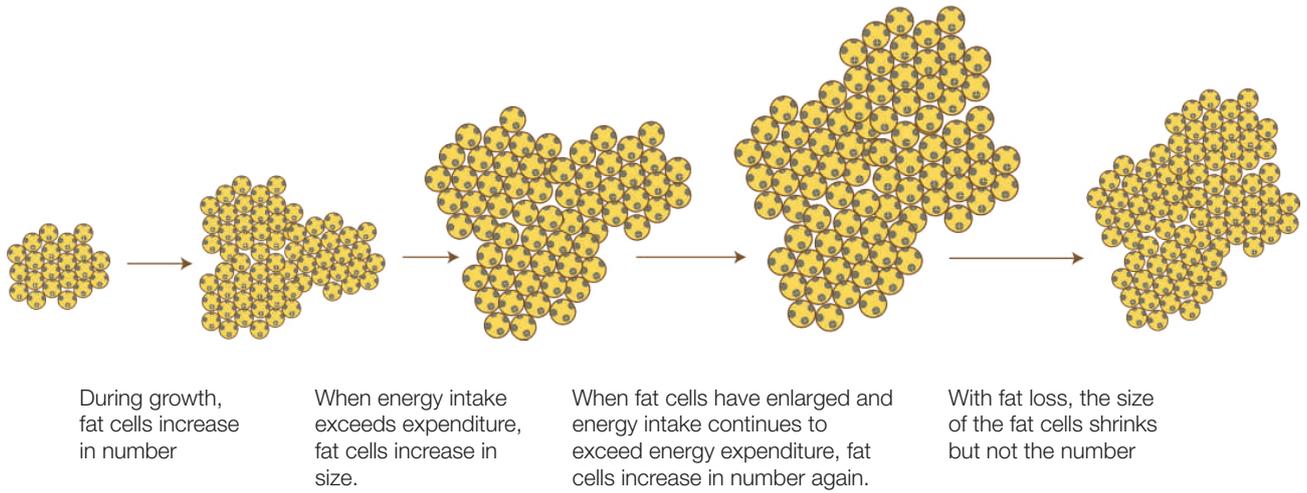


Figure 1.9.3: The development of fat cells when energy intake exceeds energy expenditure.

Fast fact

When energy expenditure exceeds energy intake, the size of the fat cells decreases, but not their number. Therefore, people with an average number of fat cells are more successful in losing weight.

Questions

4. Identify which nutrients are energy yielding, and how much energy they provide per gram.

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..... (3 marks) (KA1)
5. If an obese individual was wanting to lose weight, identify what their energy intake be in comparison to their energy expenditure.

..... (1 mark) (KA2)
6. Explain how a diet low in soluble fibre can contribute to the development of obesity.

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..... (3 marks) (KA2)

Extension activity

Describe the storage pathways of an excessive intake of each macronutrient: carbohydrates, lipids and protein and explain how they can contribute to the development of obesity.

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Portion Sizes

One cultural practice that is commonly observed is the expectation that people will “clean their plates”, that is, eat everything served in a meal. The quantity of food on an individual’s plate has become an indication of the amount needing to be consumed, rather than a person’s hunger and satiety levels. Portion sizes have **increased** over time, causing Australians to overeat and consume unwanted kilojoules, ultimately leading to weight gain. As well as this, Australians now consume foods with a greater energy density rather than nutrient density. Foods that are energy dense are generally high in kilojoules (energy) and low in beneficial nutrients, including fibre, vitamins, minerals and protein.

Fast fact

The average home dinner plate has increased in size from a diameter of 25 cm in the late 1970s to up to 31 cm today.

Question

7. Determine which muesli bar is more energy dense by calculating the number of kilojoules per gram, that a serving (one bar) will provide. Make sure to show all your working out and round your answer to the nearest whole number.

Chewy Chocolate Chip Muesli Bar		Almond, Cashew & Cranberry Muesli Bar	
Serving size (g)	31.3	Serving size (g)	35
Energy per serving (kJ)	510	Energy per serving (kJ)	692

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(5 marks) (IAE3, KA4)

The Role of Diet in Prevention and Management

The aim of weight loss is to ensure that the diet provides less energy than the body needs to maintain current body weight. It is essential that an individual's energy intake provides nutritional adequacy without excess. It is suggested that an individual reduces their energy intake by 2000–4000 kilojoules per day, producing a weight loss of up to 0.4–0.8 kilograms per week.

Diets

A successful and well-balanced diet encourages the consumption of fruits, vegetables, wholegrains, lean meats and low-fat milk products. A plan that provides adequate nutrition supports healthier and more successful weight loss compared to restrictive fad diets that create feelings of starvation and deprivation. These fad diets can lead to irresistible urges to binge and desires to resort to old eating habits.



Fast fact

An adequate diet is difficult to achieve on less than 5000 kilojoules a day.

Question

8. A high-quality diet will ask an individual to reduce their energy intake by decreasing their portion size or intake of energy-dense foods. Suggest two ways an individual could reduce their portion sizes of energy-dense foods.

1.
2.

(2 marks) (KA2)

Extension activity

Research and explain the term 'fad' diet, and outline two key features of these diets.

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Research an example of a fad diet, and state what it claims to achieve and which nutrients it promotes for consumption.

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Question

14. Identify the types of carbohydrates that are metabolised and digested into glucose.

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 (2 marks) (KA1)

15. If insulin is ineffective, state what would happen to blood glucose levels and predict the impact this would have on the body's cells.

.....

 (2 marks) (KA2)

Type 1 Diabetes

Type 1 diabetes, the less common type of diabetes, represents around 10 per cent of all cases of diabetes in Australia. Type 1 diabetes is an autoimmune disorder in which the immune system mistakenly attacks and destroys the beta cells in the pancreas, which produce the hormone insulin. Therefore, the pancreas loses its ability to produce insulin, causing blood glucose levels to continue to rise (as shown in Figure 1.9.7). In most cases, type 1 diabetes is inherited and commonly occurs in childhood and adolescence, but can be diagnosed at any age.

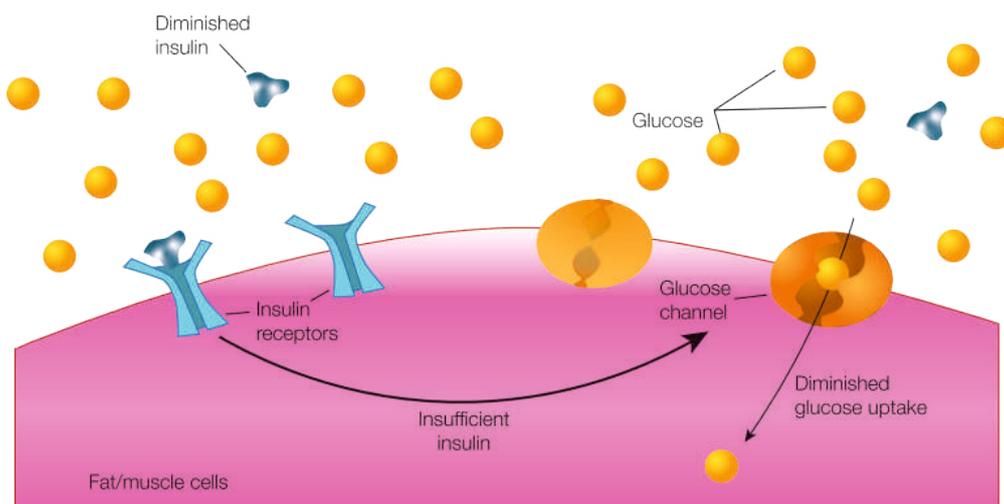


Figure 1.9.7: The effect of type 1 diabetes on blood glucose levels, due to insufficient insulin.

Type 2 Diabetes

Type 2 diabetes is the most prevalent form of diabetes, accounting for 85–90 percent of cases in Australia. Type 2 diabetes is a progressive condition in which the body's cells do not respond to insulin effectively. This is also known as **insulin resistance** (Figure 1.9.8). To compensate, the pancreas secretes larger amounts of insulin to assist in managing blood glucose levels. However, over time the pancreas loses its capacity to compensate for the cell's insulin resistance, exhausting the beta cells of the pancreas and leading to a reduction in insulin production. Therefore, Type 2 diabetes is associated with insulin resistance and insufficient insulin. Although the cause of Type 2 diabetes is unknown, the risk of developing this disorder is increased by specific diet and lifestyle factors (which is why Type 2 diabetes will be the focus of this section). In most cases, Type 2 diabetes is diagnosed in adults over the age of 45 years but is increasingly occurring in younger age groups including children, adolescents, and young adults.

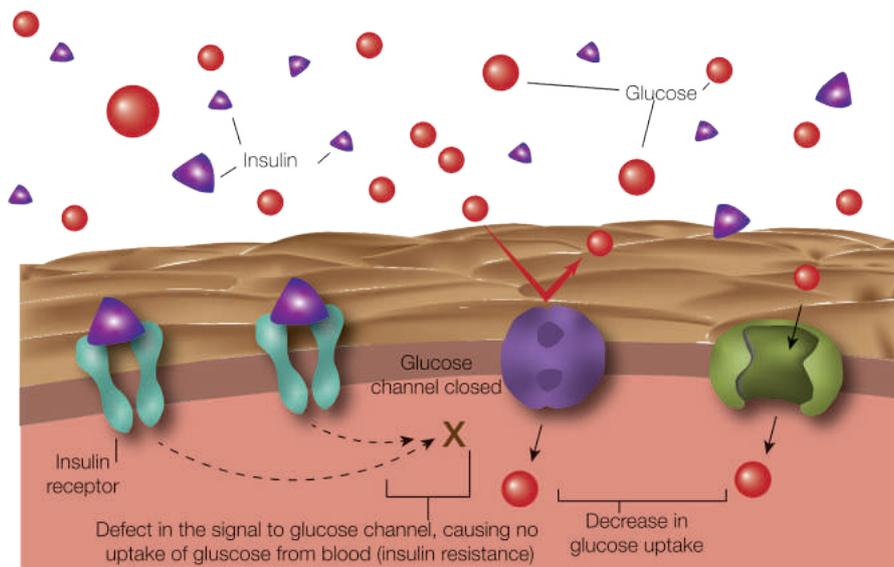


Figure 1.9.8: The effect of type 2 diabetes on blood glucose levels, due to insulin resistance and insufficient insulin.

Question

16. Complete the following table, comparing the differences between type 1 and type 2 diabetes.

	Type 1 diabetes	Type 2 diabetes
Prevalence in Australia (%)		
Age of onset		
Risk factor (main cause)		
Progression		
Insulin production in the pancreas		

(5 marks) (KA1)

Extension activity

Another form of diabetes is gestational diabetes, which occurs in pregnant females and Type 1.5 diabetes which is diagnosed during adulthood. Research and describe both forms of diabetes and explain their cause.

Gestational Diabetes

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Type 1.5 Diabetes.

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Signs & Symptoms

In type 2 diabetes, glucose slowly enters and/or fails to enter the body's cells and consequently accumulates in the blood. This causes blood glucose levels to rise, which is known as **hyperglycaemia**. When glucose fails to enter the body's cells, this deprives them of energy, as glucose is a vital component in **cell respiration**. This leaves the body feeling fatigued, causing an increase in a diabetic's hunger levels. This hunger can then lead to excessive eating and weight gain.

Definition

Cell respiration is a metabolic process which converts oxygen and glucose into ATP (energy) and waste products.

Question

17. If glucose cannot be used as the body's predominant energy source, identify where the body will obtain its energy from.

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(2 marks) (KA2)

As blood glucose levels continue to rise, the excess glucose must go somewhere. The kidneys filter our blood and produce urine. Glucose is normally reabsorbed into the blood at this point. However, a type 2 diabetics' unusually high blood glucose levels means not all glucose can be absorbed. The excess ends up in urine. This process results in unusually large volumes of urine, which require more water. This frequent urination can lead to dehydration and excessive thirst (as shown in Figure 1.9.9).



Figure 1.9.9: The development of frequent urination, dehydration and excessive thirst in a type 2 diabetic.

Question

18. Identify one nutrient a type 2 diabetic may be deficient in due to their frequent urination.

..... (2 marks) (KA1)

Type 2 diabetes, that is not managed appropriately can also cause damage to the eyes. When blood glucose levels are high over a long period of time, fluid is drawn into the eye causing it to swell. This can cause blurred vision and can take up to six weeks for the swelling to reduce once blood glucose levels are managed. High blood glucose levels can also cause damage to the blood vessels behind the retina at the back of the eye. The walls of the blood vessels can become very thin and weak, causing blood, proteins and fluids to leak into the eye, leading to further swelling and damage (as shown in Figure 1.9.10). This damage is known as retinopathy and can lead to permanent vision impairment, including blindness.

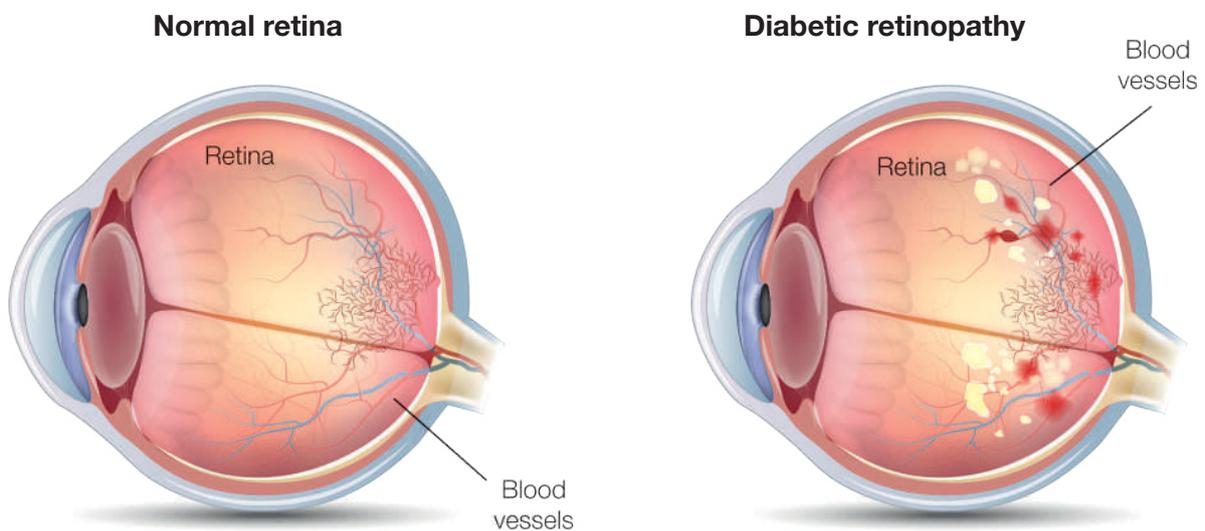


Figure 1.9.10: The effects of type 2 diabetes on the retina, causing the blood vessel walls behind the eye to become thin and weak allowing fluid, proteins and blood to leak in.

The structures of blood vessels and nerves can also become damaged due high blood glucose levels and the pressure this places against the nerves and blood vessel walls. This can lead to the loss of circulation and nerve function, which can be expressed as a painful prickling sensation followed by a loss of feeling in the hands and feet. Therefore, a type 2 diabetic is more prone to infection due to poor circulation and glucose-rich blood. Therefore, a diabetic must be cautious of hygiene, as undetected infections can lead to **gangrene**, which can require the amputation of the limbs (most commonly legs and feet).

Definition

Gangrene is the death of tissue due to insufficient blood supply.

Question

19. Complete the following table, identifying four short-term/immediate and four long-term/chronic symptoms that may be experienced by a type 2 diabetic who doesn't manage their blood glucose levels effectively.

Short-term/immediate symptoms	Long-term/chronic symptoms

(8 marks) (KA1)

Nutrition Related Risk Factors

Due to its effect on blood glucose levels, diet is an important contributing factor in the development of type 2 diabetes.

Carbohydrates – simple sugars

Simple sugars have been found to have direct and indirect links to the development of type 2 diabetes. Simple sugars require little to no breakdown after they have been consumed; therefore, they move into the blood stream very rapidly. This causes a rapid rise in blood glucose levels and a consequential rapid energy release. Carbohydrates that produce this response are known to have a high **glycaemic index** (GI) (Figure 1.9.11). If a large portion of simple sugars are consumed at one time, this can elevate blood glucose levels significantly, stressing the already compromised beta cells of the pancreas. As well as this stress, an excessive consumption of simple sugars can contribute to the development of obesity, which is also a risk factor for this disorder.

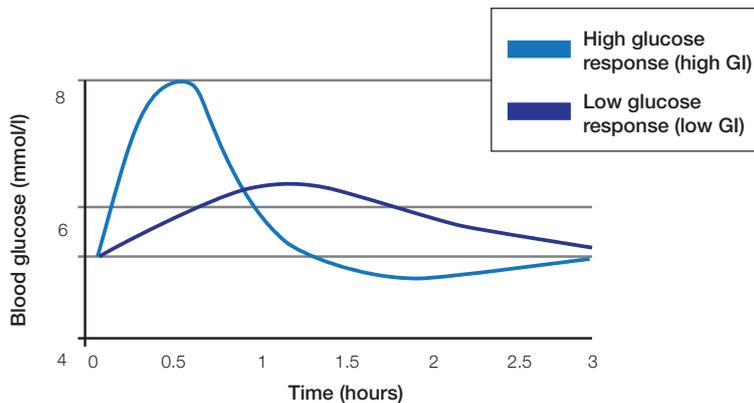


Figure 1.9.11: The effect of the glycaemic index (GI) of carbohydrate-containing foods on blood glucose levels over time.

Question

20. Explain how an excessive consumption of simple sugars can contribute to the development of obesity.

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(2 marks) (KA2)

Dietary Fat

A high consumption of dietary fat has been found to have a role in the development of type 2 diabetes. Foods that have a high fat content are energy dense (have a high kilojoule content). This increases the risk of fat accumulation in adipose tissue and can contribute to the development of an android body shape. This can put pressure on the pancreas, further compromising its ability to produce insulin. However, a high fat content in the bloodstream can also build up inside cells and can block the process whereby insulin signals for a cell's glucose channels to open and allow glucose to enter the cell. This increases insulin resistance and causes blood glucose levels to continue to rise

Question

21. Identify the type of body fat that is associated with an android body shape.

(1 mark) (KA1)

The Role of Diet in Prevention and Management

Insulin resistance can be regressed at any stage, which is why dietary management is important for managing type 2 diabetes.

Carbohydrates

Carbohydrates have the biggest impact on blood glucose levels. The effect of carbohydrates depends on the amount and type of carbohydrate consumed. It is recommended that a type 2 diabetic spreads their intake of carbohydrates throughout the day to avoid causing large rises in blood glucose levels. It is also recommended that, if high GI carbohydrates are consumed, they are best consumed with moderate amounts of high fibre, low GI carbohydrates.

GI ratings are becoming less relied on; it is the **glycaemic load** (GL) of food that is considered more valuable in predicting a food's effect on blood glucose levels. The GL considers the amount of carbohydrate in a particular food as well as the GI rating of that food. It is calculated by taking the number of grams of carbohydrate in a serving of food, multiplied by the GI of that food, and then divided by 100 (as shown in figure 1.9.12).

$$\frac{\text{carbohydrate content (g)} \times \text{GI rating}}{100}$$

Figure 1.9.12: The formula used to calculate the GL of a food source.

Example

if a potato weighting 100g held 16g of carbohydrate, with a known GI rating of 90, its GL would be:

$$\begin{aligned} & \frac{\text{carbohydrate content (g)} \times \text{GI rating}}{100} \\ &= \frac{16 \times 90}{100} \\ &= 14 \end{aligned}$$

The GI only provides insight into how rapidly the carbohydrate can be broken down into glucose to affect blood glucose levels (its quality), but not how much of that carbohydrate is in a food serving (its quantity). Therefore, the GL gives a more accurate account of the overall affect the carbohydrate food has on blood glucose levels as it considers both quality and quantity. The GL rankings (as shown in Figure 1.9.13) will give similar blood glucose responses to the GI index: low GL will initiate low and sustained blood glucose levels (Figure 1.9.11), and high GL rankings will mirror the rapid and high blood glucose response (displayed in Figure 1.9.11).

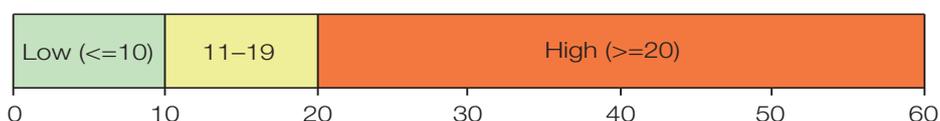


Figure 1.9.13: The Glycaemic Load Rankings.

Question

22. (a) Calculate the GL of a piece of watermelon that weighs 150 g, but holds 12 g of that weight as carbohydrate, and has a GI of 70. State the formula and show all working and round to the nearest whole number.

(3 marks) (KA4)

(b) With reference to figure 1.9.13, rank the GL of the watermelon.

(1 mark) (IAE3)

Nutrition related risk factor	Dietary management
Simple sugars	<p>Consume sparingly foods that are high in added sugars and are poor sources of other nutrients. These include sweets, lollies, standard soft drinks, sugary drinks, cakes, muffins, biscuits, chocolate, potato chips, pastries, ice cream and hot chips.</p> <p>Consume low GI/GL foods at every meal, such as traditional rolled oats, dense wholegrain breads, lentils and legumes, sweet potato, milk, yoghurt, pasta and most types of fresh fruit.</p> <p>Look for foods marked as Low GI (Figure 1.9.14).</p> <div style="text-align: center;">  </div> <p style="text-align: center;"><i>Figure 1.9.14 Glycaemic Index (GI) Foundation symbol.</i></p> <p>Use sweeteners such as Equal, Stevia, Sugarine and Splenda (Figure 1.9.15) in place of sugar, especially if they are replacing large amounts of sugar.</p> <div style="text-align: center;">  </div> <p style="text-align: center;"><i>Figure 1.9.15: Artificial sweeteners which can be used in place of sugar.</i></p>

Question

23. Explain why it is recommended that high fibre, low GI carbohydrates are to be consumed with high GI carbohydrates.

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(2 marks) (KA2)

Question

24. Complete the following table on the role of different types of carbohydrates in the development or prevention of type 2 diabetes. Provide two examples of food sources.

Type of carbohydrate	Role in the development or prevention of type 2 diabetes	Examples of two food sources
Simple, e.g. monosaccharides and disaccharides		
Complex, e.g. polysaccharides		

Dietary Fat

Fats provide the greatest energy (kilojoules), which is why it is important to limit fat consumption, as they can increase a person’s risk of gaining weight. This makes it difficult to manage blood glucose levels.

Nutrition related risk factor	Dietary management
Dietary fat	<p>Choose reduced or low-fat milk, yoghurt, cheese, ice-cream and custard. Choose lean meat and trim any fat off before cooking.</p> <p>Remove the skin from chicken, duck and other poultry (where possible, before cooking).</p> <p>Avoid using butter, lard, dripping, cream, sour cream, copha, coconut milk, coconut cream and hard cooking margarines.</p> <p>Limit pastries, cakes, puddings, chocolate and cream biscuits to special occasions.</p> <p>Limit pre-packaged biscuits, savoury packet snacks, cakes, frozen and convenience meals.</p> <p>Limit the use of processed deli meats (fritz/devon/polony/luncheon meat, chicken loaf, salami etc.) and sausages.</p> <p>Avoid fried takeaway foods such as chips, fried chicken and battered fish. Choose BBQ chicken (without the skin) and grilled fish instead.</p> <p>Avoid pies, sausage rolls and pastries.</p> <p>Rather than creamy sauces or dressings, choose those that are based on tomato, soy or other low-fat ingredients.</p> <p>Limit creamy style soups.</p> <p>Eat small amounts of polyunsaturated and monounsaturated fats to help ensure you obtain the essential fatty acids and vitamins the body needs. These include sunflower, safflower, soybean, corn, cottonseed, grapeseed, olive, canola and sesame oils, oily fish such as herring, mackerel, sardine, salmon and tuna, and avocado.</p>



Science as a human endeavour (Development, Influence and Communication & Collaboration)

1

Israeli firm develops bio-artificial pancreas that can cure diabetes

Source: <https://www.itwire.com/health/israeli-firm-develops-bio-artificial-pancreas-that-can-cure-diabetes.html>

An Israeli company named Betalin Therapeutics has developed a bio-artificial pancreas that it says can replace the functions of the human pancreas and cure patients who have type 1 and type 2 diabetes and are insulin-dependent.

The artificial organ is made of pig’s lung tissue and insulin secreting cells. The bio-artificial pancreas will be implanted under the skin during an outpatient procedure using local anaesthesia. It can be implanted in the human body and can then connect with his or her blood vessels. It would then be able to measure the body’s sugar level and secrete an optimal amount of insulin needed to balance blood sugar.

Dr Nikolai Kunicher, chief executive of the Jerusalem-based company, said in a statement that human trials were expected to begin by January 2021.

Betalin, which has been in business for five years, has raised US\$3.5 million (A\$4.89 million) and is looking to raise another US\$5 million before human trials begin. It is expected that the biological pancreas will cost around US\$50,000 per patient.

“This is a new way to treat diabetes,” he said. “Today, you only have ways to manage the disease. This is a cure. The diabetic pancreas has lost the function of secreting insulin and we give it back. The patient should never have to inject insulin into his body again.”

There are about 500 million diabetics around the world and of them, Dr Kunicher said, about 160 million were insulin-dependent.

Professor Aryeh Warshel, also a Nobel Prize winner (2013 in Chemistry), is a member of the company’s scientific advisory board.

Question

27. Discuss how this example above, demonstrates the key concept of development, influence and communication & collaboration. Provide one clear example from the article above to demonstrate each of the key concepts.

Development:

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Influence:

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Communication & Collaboration

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(6 marks) (KA3)

Atherosclerosis & Cardiovascular Disease

The leading cause of **death and disease burden** around the world today are diseases of the heart and blood vessels, collectively known as cardiovascular disease (CVD). The different forms of CVD are usually caused by Atherosclerosis, which is characterised by the accumulation of lipids and other materials along the inner walls of the arteries.

Fast fact

According to the Australian Institute of Health and Welfare National Mortality Database, CVD was the underlying cause of 41,800 deaths in 2018 (26% of all deaths), where CVD kills one Australian every 12 minutes and affects one in six Australians.

Atherosclerosis

Atherosclerosis or 'hardening of the arteries' is a precursor to hypertension and cardiovascular disease. It is the deposition of plaque along arteries anywhere around the body, especially at branch points. Arteries are the blood vessels that carry oxygenated blood from the heart to the body and to the heart itself from the lungs. Normally they are lined by a thin inner layer of cells called the **endothelium** (see Figure 1.9.16). The endothelium keeps the inside or lumen of arteries smooth, allowing for the easy passage of blood. A build-up of plaque narrows and hardens the arteries.

Definition

The endothelium can also be called the endothelial cell layer

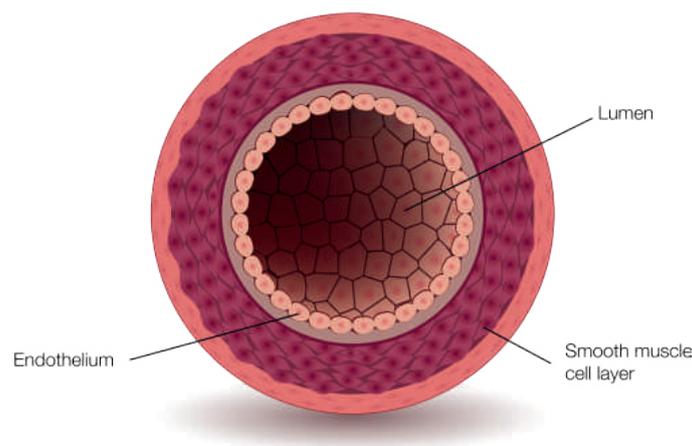


Figure 1.9.16: Endothelial lining of artery.

Question

28. Plaque deposits hold cholesterol. Recall which cholesterol-carrier removes cholesterol from plaque deposits.

..... (1 mark) (KA1)

The exact cause of atherosclerosis is not yet completely understood. It is thought to begin when the endothelium lining is damaged by certain dietary and/or lifestyle risk factors, including high LDL cholesterol, hypertension or toxins from cigarette smoking. Once damaged, the initial stage of atherosclerosis development is **low-density lipoprotein (LDL)** depositing into the artery walls and becoming entrapped. LDL entrapment in the artery walls may then trigger an inflammatory response, which activates the immune system. The immune system sends a type of white blood cell called a **monocyte** to 'clean up' the LDL cholesterol. The monocyte will convert into a white blood cell called a macrophage once it enters the endothelial cells. The macrophage will engulf the trapped LDL and become what is termed as a **foam cell**. These swell with large quantities of LDL cholesterol becoming trapped, and eventually become the cells of the plaque (see Figure 1.9.17). Foam cells congregating together is what gives this early stage of atherosclerosis its appearance (under a microscope) as '**fatty streaks**' (see Figure 1.9.17).

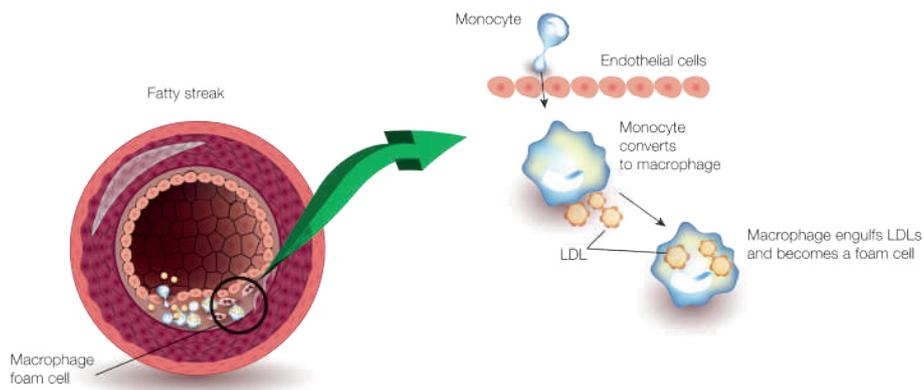


Figure 1.9.17: Fatty streak (foam cells) under artery endothelium lining (left) and foam cell formation (right).

Over many years, LDL cholesterol continues to embed in artery walls, causing foam cells to accumulate into larger deposits known as a **plaque** or atheroma. The smooth muscle cells of the artery walls (as shown in figure 1.9.18) will move and stretch to allow for the growth of the plaque within the layers of the artery wall. This ensures the plaque does not impose on the inside (lumen) of the artery, allowing blood to remain flowing freely through the blood vessels. The muscle cells will also move and stretch to provide a protective thick layer called a **fibrous capsule**, which forms between the LDL cholesterol deposits and the artery lumen lining (Figure 1.9.18). The fibrous capsule may remain thick and protect the lumen opening of the artery, becoming what is known as a stabilised plaque (Figure 1.9.18). This, however, is not always the case, and further plaque build-up may continue.

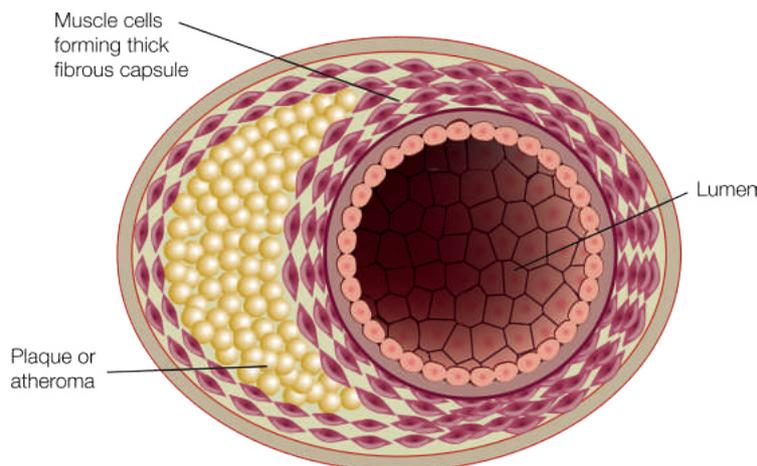


Figure 1.9.18: The formation of a stabilised plaque in the muscle cells of the artery.

Fast fact

No one is free of the fatty streaks, which may become the plaques of atherosclerosis. For most adults, the question is not whether you have plaques, but how advanced they are and what you can do to slow or reverse their progression. Most people have well developed plaques by the age of 30.

Plaque deposits can continue to build, again over many years, until the smooth muscle layer of the artery walls is distended to such an extent it begins to stiffen, unable to stretch further. Plaque growth will then begin to bulge into the lumen instead, imposing on the passage where blood flows through, and thereby **narrowing the artery** (Figure 1.9.19). Calcium flowing through the bloodstream may also deposit in the plaque and calcify or harden, further causing the arteries to stiffen, or lose flexibility and stretching ability. The growth of plaque into the inner artery also thins the protective fibrous capsule (Figure 1.9.19), leaving the atheroma or plaque vulnerable to rupture.

Definition

Narrowing of the arteries can be called stenosis.

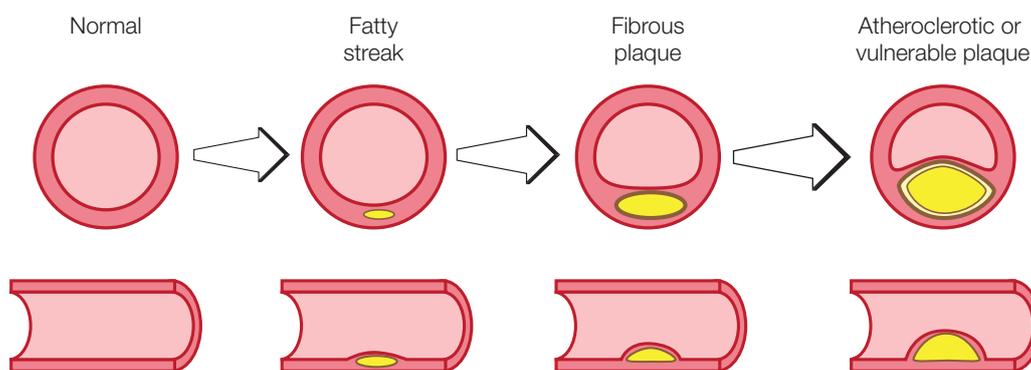


Figure 1.9.20: Summary of atherosclerosis development.

Cardiovascular Disease (CVD)

Cardiovascular disease (CVD) occurs when a vulnerable plaque (a shown in figure 1.9.19), found in the later stages of atherosclerosis, ruptures. When a plaque ruptures, a blood clot (or **thrombus**) will form over the ruptured area. This can result in a blockage of blood flow (see Figure 1.9.21). Atherosclerosis can also result in an **aneurysm** by weakening and damaging the blood vessels. An aneurysm is a bulge in a blood vessel that can burst and lead to internal bleeding (see Figure 1.9.22). As the blood supplies nutrients, oxygen and, therefore, energy, and removes waste products away from the tissues, a blockage or ruptured aneurysm can result in malfunctioning and death of the region of the body the artery was supplying blood to.

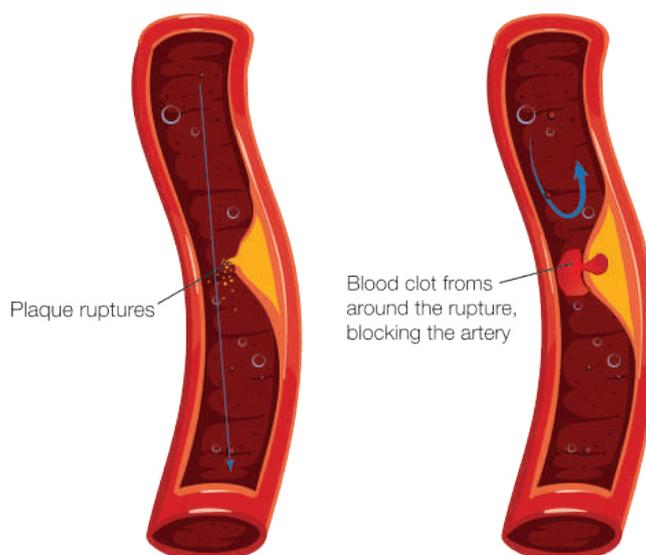


Figure 1.9.21: Vulnerable plaque rupturing (left) and clot formation (right).

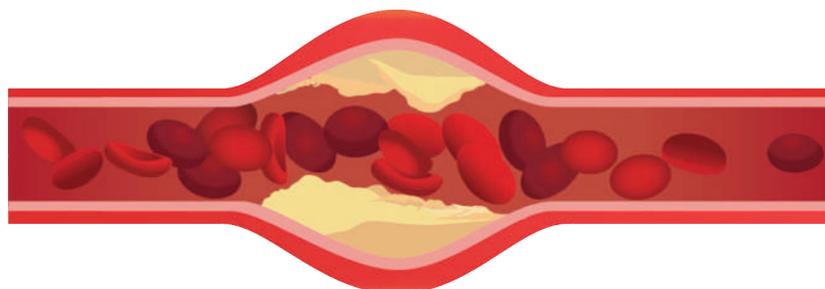


Figure 1.9.22: Weakened, bulging artery wall (aneurysm) from atherosclerosis.

Signs & Symptoms

Atherosclerosis does not have symptoms for many years because the arteries will stretch where plaque deposits occur, ensuring there is no effect on blood flow. It is only when severe narrowing or blockage impedes blood flow that **symptoms** are felt. At this stage, the narrowing or blockage is typically because a cardiovascular disorder has occurred.



Fast fact

Symptoms (which belong to CVD episodes) typically do not begin until around 40 years for men and 50 years for women.

Most of the symptoms associated with each type of CVD indicate that a cardiovascular event is happening. These warning signs should be taken seriously and in many instances an ambulance should be called.

Stroke

When part of the brain dies due to a stroke, it can lead to a sudden impairment in one or more capabilities such as speaking or movement. The symptoms that emerge when a stroke is happening may involve:

- drooping or numbing of the face, particularly on one side
- poor mobility or weakness of arms, uncoordinated movement, or even paralysis of limbs
- slurred speech
- loss of vision or blurred vision
- sudden severe headache.

Coronary heart disease (CHD)

Angina will appear as temporary chest pain during periods of exertion that require additional blood to be pumped to the heart, such as during exercise. The symptoms of a heart attack typically appear when it is occurring and include:

- chest pain and further upper body pain, e.g. the shoulders and neck
- feeling faint and short of breath
- feeling nauseous
- having cold sweats.

Peripheral vascular disease (PVD)

The symptoms of PVD are dependent on the region of the body affected. When the renal arteries that supply the kidney suffer a blockage, chronic kidney disease (CKD) can be the result. Similar to most other types of CVD, kidney disease will have few to no symptoms until the kidneys lose most of their functioning ability. The symptoms that may be experienced include:

- changes in urination frequency or pain/blood with urination
- swollen ankles
- back pain (around the kidney area).

If an artery supplying blood to the extremities (typically the legs) is blocked, gangrene can result (see Figure 1.9.24). Before gangrene (tissue death) sets in as a sign of PVD, symptoms that can emerge are:

- pins and needles and/or numbness
- intermittent pain called **claudication**
- poor wound healing of the affected region.



Definition

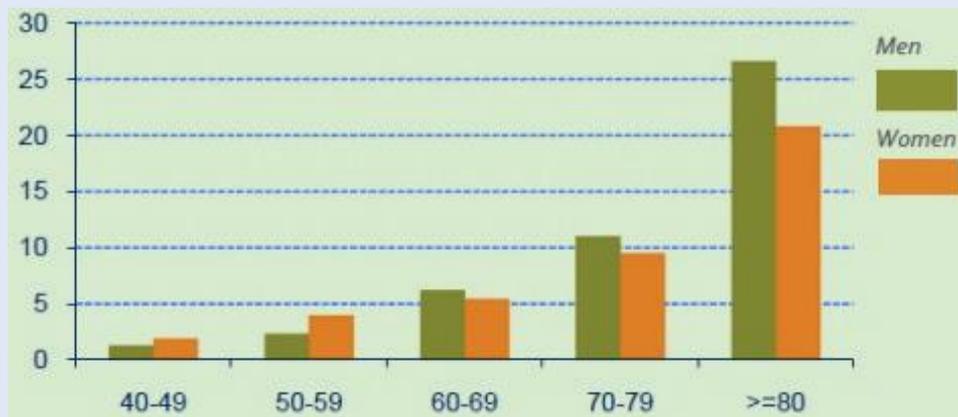
Claudication is cramp-like pain or heaviness in the limbs that is more noticeable during exercise.



Figure 1.9.24: Gangrene is seen when there is death of the tissues of the extremities.

Question

31. The following questions refer to the graph below.



(Source: https://www.cdc.gov/dhdsp/data_statistics/fact_sheets/fs_pad.htm)

- (a) The graph above is missing some features required at Stage 2 Nutrition when presenting graphs. Add these missing features to the graph above. (3 marks) (KA4)
- (b) Using data from the graph above, identify a conclusion that can be made about the prevalence of PVD in males.

.....

.....

.....

(2 marks) (IAE3)

- (c) With reference to the graph above, state which gender is more likely to suffer from gangrene when aged:

55: (1 mark) (IAE3)

75: (1 mark) (IAE3)

Question

32. Match the following definitions and symptoms with their relevant disease.

Cardiovascular disease Heart attack Stroke Peripheral vascular disease

Type of cardiovascular disease	Definition or symptom
	Involves a blockage of blood supply to the brain
	Poor balance when walking and slurred speech
	Chest pain with exercise that reduces once exercise ceased
	Collective term for diseases of the heart and blood vessels
	Collective term for diseases of the heart
	Sudden chest pain that radiates across the shoulders
	Frequently going to the toilet to urinate during the night
	Involves a blockage of blood supply to the legs and/or kidneys
	Involves a blockage of the blood supply to the heart
	Ongoing toe numbness and pain

(10 marks) (KA1)

Nutrition Related Risk Factors

The risk factors that may damage the artery endothelial lining, thereby permitting LDL to deposit and atherosclerosis to develop, can be categorised as either nutrition or lifestyle related risk factors. There are a number of nutrition related causes of atherosclerosis, which are the same for CVD due to it being a precursor to this diet related disorder.

Cholesterol

Cholesterol from the diet are transported by lipoproteins due to being very slightly soluble in water and blood (see Cholesterol in Topic 1.3). Any LDL cholesterol that remains in the blood after the body’s cells take up the amount they need, becomes vulnerable to depositing in the artery walls at damaged sites. Therefore, **high LDL and low HDL** correlate directly with atherosclerosis, whereas low LDL and high HDL reduce the risk of this development of this disease.

Fast fact

Total blood cholesterol levels should not exceed 5.5mmol/L for the general population, and 4mmol/L for individuals at high risk. The proportion of LDL cholesterol should be less than 1.8mmol/L and HDL should be greater than 1mmol/L. These levels can be determined with a blood test.

However, cholesterol in food has only a small effect on LDL in blood. Saturated fat and trans-fat pose much greater risks to elevated blood cholesterol (LDL) levels.

Saturated Fat

Consumption of foods that are high in saturated fat significantly increases the liver’s production of very low-density lipoprotein (VLDL), the precursor to LDL. This increase in VLDL will therefore end up raising LDL cholesterol in the blood, a risk for atherosclerosis.

Question

33. Australians typically consume too much saturated fat. Consider a person’s recommended daily energy intake. What percentage of that intake should come from saturated fat?

..... (1 mark) (KA1)

Trans-fat

By a similar means to saturated fat, a diet high in trans fats will markedly elevate LDL blood cholesterol levels, increasing the chance of LDL becoming plaque deposits. Furthermore, trans fats can lower high-density lipoprotein (HDL). Therefore, trans fat can reduce the amount of LDL cholesterol cleared by HDL.

Extension activity

Australians tend to consume less than the recommended ‘no more than 1% of the daily energy intake’ from hydrogenated fats. What makes Australia successful in ensuring trans fat consumption is kept low?

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Unsaturated Fat

Fat consumption should be limited to no more than 30 per cent of the RDI. Of this percentage, most should come from mono- and poly-unsaturated fats. When a higher proportion of overall fat is unsaturated fat, saturated fats’ effect on the liver’s ‘bad’ cholesterol production is limited, thereby LDL levels drop. A higher proportion of unsaturated fats (particularly a good balance of omega 3 and 6), has also been found by some studies to help raise HDL. Therefore, a diet low in monounsaturated and polyunsaturated fat is a dietary risk of atherosclerosis.

Triglycerides

Fat consumption beyond the recommended 30 per cent, results in high blood triglycerides, which is called **hypertriglyceridemia**. Recent studies are finding that lipoproteins carrying triglycerides can also be found in plaque deposits, therefore hypertriglyceridemia is, like LDL, a direct cause of atherosclerosis. Hypertriglyceridemia has also been found to promote foam cell formation and therefore plaque development.

Simple Sugars

Consuming foods with high GI and GL (see Topic 1.2 for GI and GL definitions), especially foods high in **refined sugar**, have been found to increase LDL by promoting liver VLDL production. Fructose, a monosaccharide composing refined sugar and a constituent of many foods with high GI/GL, has been linked strongly with this finding, as it requires metabolism in the liver, the organ that produces VLDL. High GI/GL foods have also been found to decrease HDL.

Definition

When foods have added table sugar (sucrose), for example, cake, the sugar is referred to as refined sugar.

Soluble Fibre

Along the digestive tract, soluble fibre can bind to cholesterol (from food consumed or from bile) and dispose of it through defecation. This can contribute to less cholesterol entering the bloodstream, therefore lowering LDL. Soluble fibre is also associated with slowing initial digestion (stomach emptying into the duodenum), allowing for slower absorption of monosaccharides (including glucose) into the bloodstream (see Topic 1.2 for soluble fibre functions). Soluble fibre can therefore lower the GI or the blood glucose effect of foods high in simple sugars.

Reminder

Bile is made in the liver from cholesterol taken from either LDL or HDL.
 Cholesterol from the diet or unused bile will become the cholesterol in LDL.

Question

34. Fill in the blanks for the following table.

Nutrient balance	Effect on LDL production	Effect on HDL production
Excess cholesterol		-----
High saturated fat		-----
High Trans fat		
Low monounsaturated fat: high sat fat balance	Increases	
High polyunsaturated fat: low saturated fat balance		
Soluble fibre		-----

(8 marks) (KA1)

35. Recall two specific foods and/or beverages that are good sources of each of the nutrients linked to atherosclerosis. List foods from different food groups and alternately from plant or animal sources, where possible.

Saturated fat: ..
 ..
 ..

Monounsaturated fat: ..
 ..
 ..

Omega 3: ..
 ..
 ..

High GI and GL foods: ..
 ..
 ..

Soluble fibre: ..
 ..
 ..

(10 marks) (KA1)

The Role of Diet in Prevention and Management

Plaque development can be regressed at any stage, even when plaque has become calcified in its later stages. Dietary management is therefore of importance in managing atherosclerosis and preventing CVD.

Table 1.9.1: Dietary management recommendations for regressing plaque development.

Nutrition related risk factor	Dietary management
High cholesterol	Include garlic in the diet; garlic has been shown to lower blood cholesterol, Use margarines that contain plant sterols (as shown on the labelling); plant sterols disallow cholesterol to be absorbed into the bloodstream, Consume foods high in soluble fibre (see last row of this table),
High saturated fat and/or high trans fat proportion compared to low monounsaturated fat and/or low polyunsaturated fat (Omega 3 & Omega 6)	Replace some meat with fat on it with oily fish, e.g. salmon; plus trim the fat off meat, Cook with vegetable oils, e.g. olive and sunflower oils instead of butter, Replace some energy-dense snacks like hot chips, ice-cream, and cheese with nuts and seeds, Replace full-cream milk with alternatives such as skim, almond, and soy milk, Replace butter with margarine, Replace highly processed meats used in sandwiches with avocado, tahini spread (see Figure 2.3.6), vegan cheese (soy), etc.
High triglycerides	The correct balance of more unsaturated fats vs saturated fat can actually decrease blood triglyceride levels (see above) Avoid deep-fried foods.
Low fibre (specifically soluble fibre)	Replace processed snacks, e.g. potato chips, with more fruit and vegetables. Replace heavily processed cereals, e.g. Froot Loops, with wholegrain cereals, oats. Add legumes into the diet.
High simple sugars (high GI/GL)	Replace energy-dense snacks like confectionery and biscuits, and heavily processed foods like cereals and cereal bars (that aren't made with wholegrain) with high fibre sources. Look for foods marketed as low GI (see Figure 1.9.25). <div style="text-align: center;">  </div>

Figure 1.9.25: Glycaemic Index foundation Low GI symbol

Lifestyle & Physiological Related Risk Factors & Management

With atherosclerosis being the precursor to CVD, the lifestyle and physiological risk factors, and management are the same. Many of these risk factors can be modified (see Table 1.9.2), making atherosclerosis a disease precursor that should not be as predominant as it is.

Extension activity

It was stated that most of the lifestyle risk factors for atherosclerosis can be modified. Modifying the risk factors and making better lifestyle choices is important in preventing atherosclerosis and the diseases it is associated with (hypertension and CVD). In Table 1.9.2, identify each risk factor as being modifiable or not and suggest how they could be modified if they can be.

Table 1.9.2: Lifestyle or physiological risk factors of atherosclerosis and CVD

Risk factor	Explanation	Modifiable risk factor? Y/N
Overweight/obesity	The excessive storage of visceral fat is linked to high blood triglyceride levels (hypertriglyceridemia), high LDL levels and insulin resistance. Obese people also tend to have lower levels of HDL and are at further risk of type 2 diabetes.	
 Reminder		
Visceral body fat is stored within the abdominal cavity (giving android body shape).		
Lack of exercise	A sedentary lifestyle can contribute to the development of atherosclerosis in several ways. A lack of exercise can result in a positive energy balance, with excess kilojoules being stored and leading to weight gain, therefore, increasing the risk of obesity. A lack of exercise can also result in higher blood triglyceride levels (hypertriglyceridemia), as well as lower levels of HDL and higher levels of LDL. Individuals who live a sedentary lifestyle may also have poor blood glucose control and insulin resistance, increasing risk of type 2 diabetes and high blood pressure.	
Hypertension	High blood pressure injures the artery endothelium via the sheer force of blood pushing through the arteries. This accelerates plaque formation, thus initiating or worsening the progression of atherosclerosis. The formation of plaque, narrowing of arteries causing reduced blood flow can further elevate blood pressure.	
Type 2 diabetes	Ineffective movement of blood glucose into cells, due to insulin resistance or poor insulin production, leaves glucose and insulin levels high in the blood. Both high blood glucose and insulin levels can elevate blood pressure, causing damage to the artery endothelial layer thereby promoting LDL deposition. Diabetes can also cause damage to the nerves that control the heart and blood vessels.	
Smoking	Cigarette smoking is a significant risk factor that increases the more a person smokes and is the same for men and women. Drugs in cigarettes can damage the endothelial lining of arteries and cause plaque deposits to grow larger and faster. Cigarettes contain nicotine, which increases blood pressure causing the heart to work harder. As well as this, cigarettes contain carbon monoxide, which is a gas and replaces the oxygen needed by the heart and body for aerobic respiration. When people quit smoking, their risk of atherosclerosis and CVD declines within a few months.	

Fast fact

Smoking increases the risk of heart attack by two times, stroke by three times, and PVD (leading to gangrene) by more than five times!

Source: <https://www.betterhealth.vic.gov.au/health/HealthyLiving/smoking-and-heart-disease>



Science as a human endeavour (Influence and Communication & Collaboration)

Plaques Causing Heart Attacks – Can Nanoparticles Help?

Source: <https://www.azonano.com/article.aspx?ArticleID=5451>

In January 2020, a team of scientists from Michigan State University and Stanford University announced the creation of a nanoparticle that can destroy heart-attack-causing plaques efficiently – from the inside out.

Dubbed the ‘Trojan Horse’ nanoparticle, it has proven itself effective at reducing and stabilizing plaque, as well as clearing debris. Scientists believe the particle will be vital in developing future treatments for one of the leading causes of death in the US: atherosclerosis.

Approximately half of all deaths in the Western world are caused by atherosclerosis, a chronic inflammatory disease where plaque accumulates in the arteries, preventing the transportation of oxygen-rich blood from the heart to the body’s tissues and organs. It is the primary cause of atherosclerotic cardiovascular disease (ASCVD), which leads to heart attacks, peripheral arterial disease, and stroke.

Approximately 25% of deaths in the US are a result of heart disease, amounting to 610,000 people each year, and approximately 735,000 Americans suffer from heart attacks annually. Targeting the root cause, atherosclerosis, is a key focus on research into establishing new methods of treatment and prevention.

In a paper published last month in *Nature Nanotechnology*, the Michigan State and Stanford team explains that the Trojan Horse nanoparticle is effective at targeting atherosclerotic plaque because of its high selectivity to monocytes and macrophages, two types of human immune cell.

It works by entering into the macrophages of plaques to deliver a drug that initiates processes that result in the engulfing and consumption of cellular debris. In essence, the nanoparticles stimulate the reinvigoration of the macrophages, which work to reduce and stabilize the plaque while also clearing the dead cells in the plaque core.

Previously, studies focused on exploring systems that target the cell’s surface, although success was limited. This new method of working intracellularly has shown promise in its ability to stimulate the macrophages.

Clinical trials are planned to investigate the nanoparticle’s effectiveness in reducing the risk of heart attacks. Trials will also ensure the nanoparticle does not have unwanted side effects.

Presently, the findings are positive. Data shows the nanoparticle is effective in its ability to stimulate the body’s macrophages to selectively attack and clear dying cells, which are the first stage of developing atherosclerosis. Scientists believe the new method is an improvement on the techniques that are currently used.

Scientists working on the project believe that the nanoparticle will have applications outside of atherosclerosis. However, more research is needed.

Question

38. Discuss how this example above, demonstrates the key concept of influence and communication & collaboration. Provide one clear example from the article above to demonstrate each of the key concepts.

Influence

.....

.....

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Communication & Collaboration

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.....

(4 marks) (KA3)

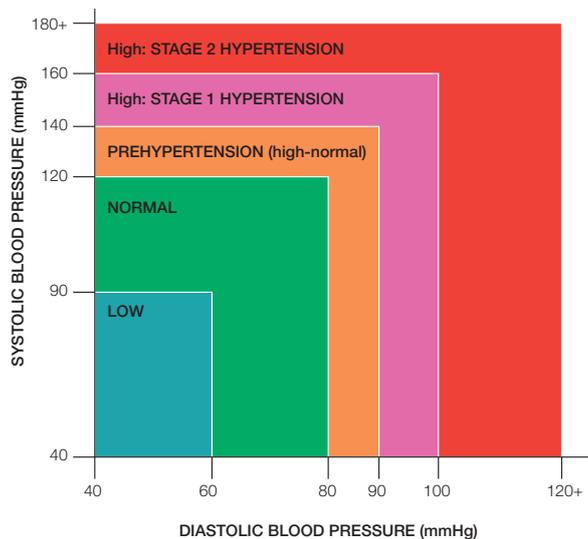


Figure 1.9.27: Blood pressure chart.

Question

39. Refer to Figure 1.9.27 to answer the following questions.

(a) Determine the systolic blood pressure range of a person who has stage 1 hypertension.

..... (1 mark) (IAE3)

(b) Determine the diastolic blood pressure range of a person who has stage 1 hypertension.

..... (1 mark) (IAE3)

(c) The blood pressure readings of a 32-year-old male were consistently systolic 95 and diastolic 65. Determine the male's blood pressure classification.

..... (1 mark) (IAE3)

Signs & Symptoms

Most people with high blood pressure have no symptoms. A few people with very high blood pressure may experience symptoms such as headaches, dizziness or facial flushing. For most people, it is only when the effects of hypertension lead to a cardiovascular event, such as a heart attack, that symptoms are felt (see Atherosclerosis and CVD symptoms section).

Nutrition Related Risk Factors & Management

The dietary risk factors for hypertension involve the imbalance of nutrients associated with atherosclerosis as well as excess sodium or salt. The main reason for blood not flowing easily through the arteries, leading to heightened blood pressure, is atherosclerosis. Therefore, all nutrition related risk factors and management of atherosclerosis previously mentioned are also behind the development of hypertension occurring and its prevention.

Sodium

Blood pressure is dependent on the amount of blood being pumped through the arteries. When blood volume increases, blood pressure increases. Therefore, dietary factors that increase blood volume, namely eating too much salt, pose additional risks for high blood pressure. Excess salt in the diet raises the amount of sodium in the bloodstream. Elevated sodium in the bloodstream can then increase blood volume by causing water retention in the blood vessels. This causes an increase in blood volume, resulting in higher blood pressure. Should salt be continually high in the diet, the artery walls will become stronger and thicker to cope with the extra strain of pushing a higher blood volume through the arteries. A consequence of the artery walls becoming thicker is that the opening (lumen) of the artery will narrow over time. Another consequence is hypertension, which can lead to atherosclerosis due to the damage this higher blood pressure can cause to the endothelium of the artery walls.

Fast fact

Most Australian adults have a daily salt intake of around 10 grams – twice the suggested target of 5 grams!
 Advice from *The National Health and Medical Research Council (NHMRC)*

Extension activity

Research and State the difference between salt and sodium.

.....

.....

.....

.....

Question

40. Most Australians consume too much salt. Identify two foods potentially high in salt from the following shopping list.

- | | |
|--------------|--------|
| Vegemite | Cereal |
| Bread | Apples |
| Orange juice | Ham |
| Milk | |

Foods high in salt: (2 marks) (KA1)

41. Although it is important to lower salt intake to reduce the risk of high blood pressure, list a reason why Australians require sodium (apart from its role in water balance in the body):

.....

..... (1 mark) (KA1)

Lifestyle & Physiological Related Risk Factors & Management

With atherosclerosis being a cause of hypertension, the lifestyle risk factors, and management covered earlier are valid for high blood pressure as well. Additional lifestyle management methods include ways to reduce salt in the diet.

Smoking is a major risk factor, as some of the drugs in cigarettes contribute to the narrowing of blood vessels. **Narrowing of the blood vessels** increases the pressure the blood exerts against the arterial walls; therefore increasing blood pressure.

Definition

The narrowing of blood vessels is called vasoconstriction.

Extension activity

Mental stress can elevate blood pressure due to its effect as a vasoconstrictor. Examinations can be quite stressful situations. Research some stress-relieving activities that could be performed prior to examinations to reduce stress.

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Key terms

Android Body Shape	Foam cell	Nutrient density
Aneurysm	Gangrene	Obesity
Atherosclerosis	Glycaemic index	Pancreas
Beta cells	Glycaemic load	Peripheral vascular disease
Body Mass Index	Gynoid Body Shape	Plaque
Cardiovascular disease	High density lipoprotein (HDL)	Retinopathy
Cell respiration	Hyperglycemia	Stroke
Coronary heart disease	Hypertension	Systolic blood pressure
Diabetes mellitus	Hypertriglyceridemia	Thrombus
Diastolic blood pressure	Insulin	Type 2 diabetes
Endothelium	Insulin resistance	Vasoconstriction
Energy density	Low density lipoprotein (LDL)	Visceral Fat
Fatty streak	Macrophage	
Fibrous capsule	Monocyte	

Review questions: 1.9 Imbalance of Nutrient Intake – Over Nutrition Disorders

- Explain which type of fat storage increases an individual's health risks the most.

..

..

..

..

..... (2 marks) (KA2)
- Explain the term 'insulin resistance'.

..

..

..

..... (2 marks) (KA2)
- Describe the difference between energy-dense foods and nutrient-dense foods.

..

..

..

..... (2 marks) (KA2)

8. Andrew is a sedentary 65-year-old man who has recently been diagnosed with type 2 diabetes. He lives alone and lacks the motivation to cook, relying on convenience microwave meals and takeaway.

(a) Discuss how Andrew’s type 2 diabetes diagnosis can increase the risk of atherosclerosis development.

.....

 (2 marks) (KA2)

(b) Name a non-modifiable risk factor of atherosclerosis that Andrew possesses.
 (1 mark) (KA1)

(c) Using data from the nutrition information panel displayed below, discuss which of Andrew’s microwave meals options would be best for reducing the risk of atherosclerosis.

Nutrient	Meal A	Meal B
Energy (kJ)	1089	1549
Total fat (g)	7	4
– Saturated fat (g)	2	3
Total carbohydrates (g)	40	60
– Fibre (g)	10	2
– Sugars (g)	1	10
Protein (g)	9	16
Sodium (mg)	630	561

.....

 (3 marks) (IAE3, KA2)

(d) Describe one way how exercise can slow Andrew’s development of atherosclerosis.

 (2 marks) (KA2)

9. Tania is a manager in a stressful workplace who smokes cigarettes as a way to manage the stress. She has recently had a blood test, which has shown high blood cholesterol levels and been diagnosed with hypertension.

(a) Explain how smoking can contribute to hypertension.

 (2 marks) (KA2)

(b) Explain how high blood cholesterol can lead to the development of hypertension and how hypertension can accelerate the development of atherosclerosis.

 (4 marks) (KA2)

10. George is a 58-year-old male who was diagnosed with type 2 diabetes following a test that measured his blood glucose levels after eating a meal. His blood glucose levels were compared with those of Paul — a 58-year-old male who does not have diabetes — as shown in the following graph.



- (a) Using data from the graph, describe the blood glucose levels of the two individuals between 0 and 2 hours after eating a meal.

.....

 (2 marks) (IAE3)

- (b) Identify a symptom that George may be experiencing and describe how it was caused due to his type 2 diabetes.

.....

 (2 marks) (KA2)

- (c) George consulted a dietitian to learn how best to manage his type 2 diabetes. Refer to the following consultation notes made by the dietitian:

Date: 29/05/2018 **Time:** 1:30 pm
Age: 58 years old
Weight: 115 kg **Height:** 167 cm
Occupation: Cafe owner
Blood glucose level: 16.0 mmol/L (high) 2 hours after eating
Exercise: 1-3 hours of light exercise per week
Smoker status: Non-smoker
Alcohol intake: 3-5 glasses a week
Current diet habits: Regularly consumes pre-packaged and convenience foods, or eats at work. Doesn't like the taste of most vegetables.
Client goals: Lose weight and modify diet and lifestyle habits to manage his type 2 diabetes.

- (i) Discuss one diet modification that would help George to manage his type 2 diabetes.

.....

 (2 marks) (IAE3, KA2)

(ii) Identify two strategies that George could implement to make lifestyle changes that will help him to manage his type 2 diabetes.

- 1.
- 2. (2 marks) (KA2)

11. Refer to the following information:

A 50-year-old male who lives a sedentary lifestyle is trying to change his diet and lifestyle habits to achieve a healthier weight.

He is 1.78 metres tall and weighs 120 kilograms. He lives alone and he relies on packaged convenience meals and takeaway food. John is a supervisor in a stressful environment where he works 60 hours a week in five 12-hour shifts. John usually drinks beer with his friends after work.

(a) Suggest a specific dietary modification this male should make.

.....
 (1 mark) (KA2)

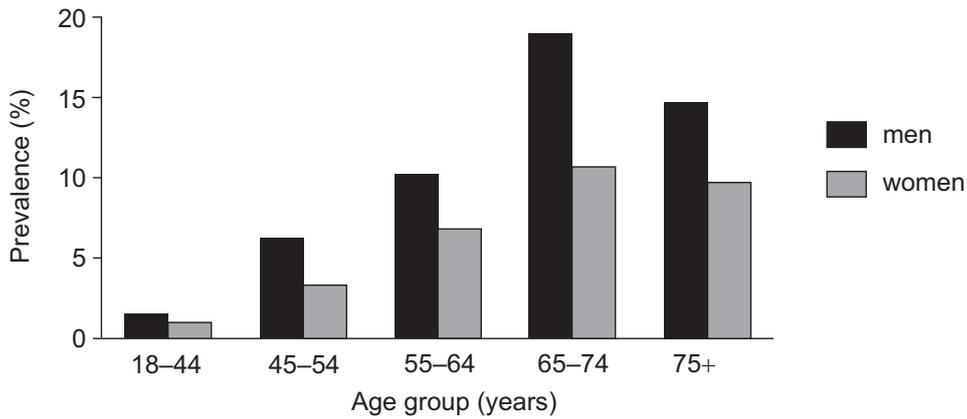
(b) Explain a lifestyle modification this male could make to achieve a healthier weight.

.....

 (2 marks) (KA2)

12. Refer to the following graph:

Prevalence of diabetes, by age and gender, 2011–12



(a) Using data from the graph above, discuss the prevalence of diabetes in adults aged up to 74 years old.

.....

 (2 marks) (IAE3)

(b) Explain one reason why the prevalence of diabetes in males is different to the prevalence in females.

.....

 (2 marks) (KA2)

13. Suggest two modifications to the following homemade pie recipe to make it more suitable for someone with CVD.

1 tbs butter	¾ cup tomato sauce
1 large brown onion, diced	1 tbs Worcestershire sauce
500g beef mince	2 sheets frozen short crust pastry
1 tbs flour	2 sheets frozen puff pastry
¾ cup beef stock	1 egg, beaten

Modification 1:

 Modification 2:
 (2 marks) (KA2)

Total: _____ / 45 marks

1.10 Imbalance of Nutrient Intake – Under Nutrition Disorders

Science understanding

Imbalance of nutrient intake is likely to cause diet related disorders. Diet related health disorders include:

- The consequences of under nutrition:
 - Constipation/Diverticular Disease
 - Iron Deficient Anaemia
 - Osteoporosis
- The role of diet and lifestyle in the prevention and management of such disorders

SACE Subject Outline, 2020.

Constipation & Diverticular Disease

Each individual's digestive tract has its own cycle of waste elimination, which depends on the person's health, the type of food eaten, when it was eaten and when the person takes time to **defecate**. The normal amount of times to defecate is different for every individual; however, what is considered normal is between a range from several times daily to three times a week. Therefore, constipation is defined as having difficulty passing stools as often or easily as they are used to and fewer times than three times a week due to being dry and hard. Constipation is considered a pre-cursor to diverticular disease.

Definition

To defecate is the excretion of faeces/stools from the body.

Diverticular disease includes both diverticulosis and diverticulitis. Diverticulosis is a condition where small pockets or pouches develop along the inner lining of the colon, most commonly the **sigmoid colon** (the segment of the colon before the rectum). The pouches (diverticula) push outwards through areas where muscles of the intestinal wall are weakened. Diverticulitis is a condition where the diverticula become infected or inflamed when faeces becomes trapped, encouraging bacterial growth within a pouch (Figure 1.10.1).

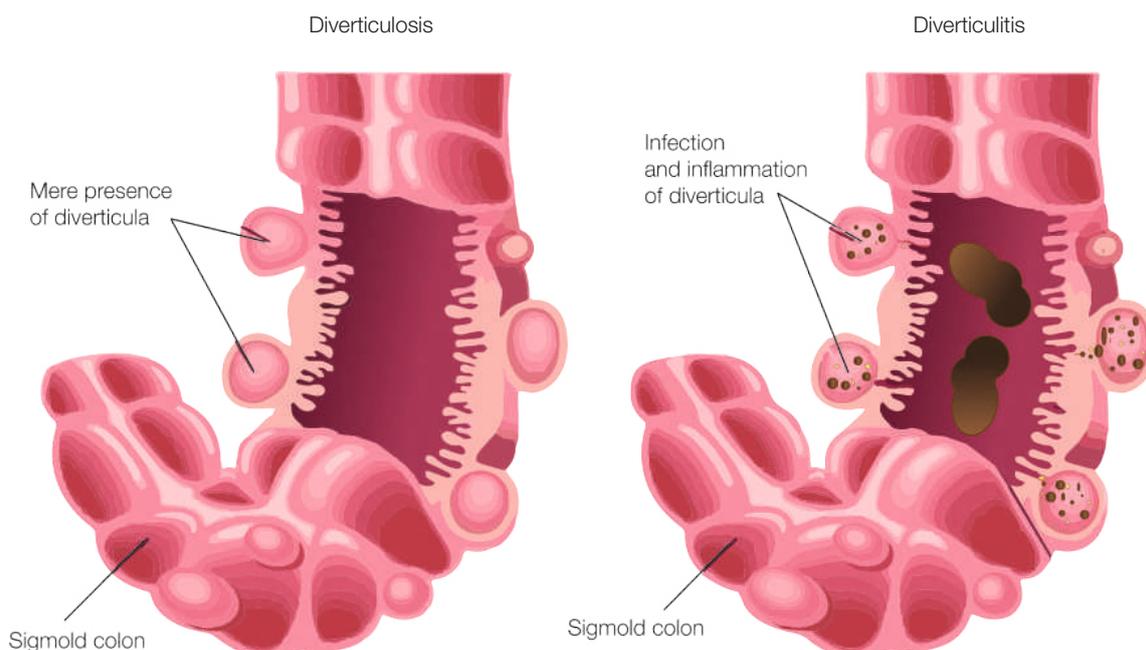


Figure 1.10.1: The development of Diverticulosis (left) and Diverticulitis (right) in the Sigmoid Colon.

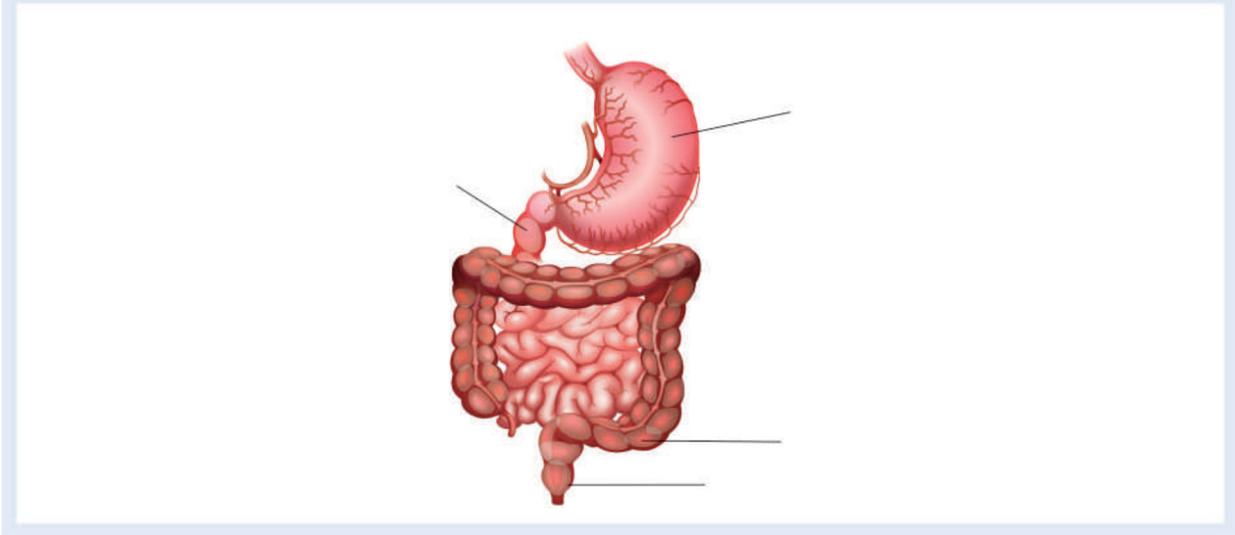
Fast fact

Diverticular disease is very common. While it is rare before the age of 35, the incidence increases with age. One third of Australians over 45 years of age, and two thirds over 85 years have some diverticular disease. Many are unaware they have it.

Question

1. Label the stomach, duodenum, sigmoid section of the colon, and rectum.

(4 marks) (KA1)



Signs & Symptoms

A sudden change in an individual's bowel movements and the number of times they defecate, can be a reason for concern. The consistency, colour and density can be a sign of the health of your large intestines. Lumpy stools (as shown as type 1 and type 2 below in figure 1.10.2) could be an indication of diverticular disease, where pockets may have developed in the large intestines.

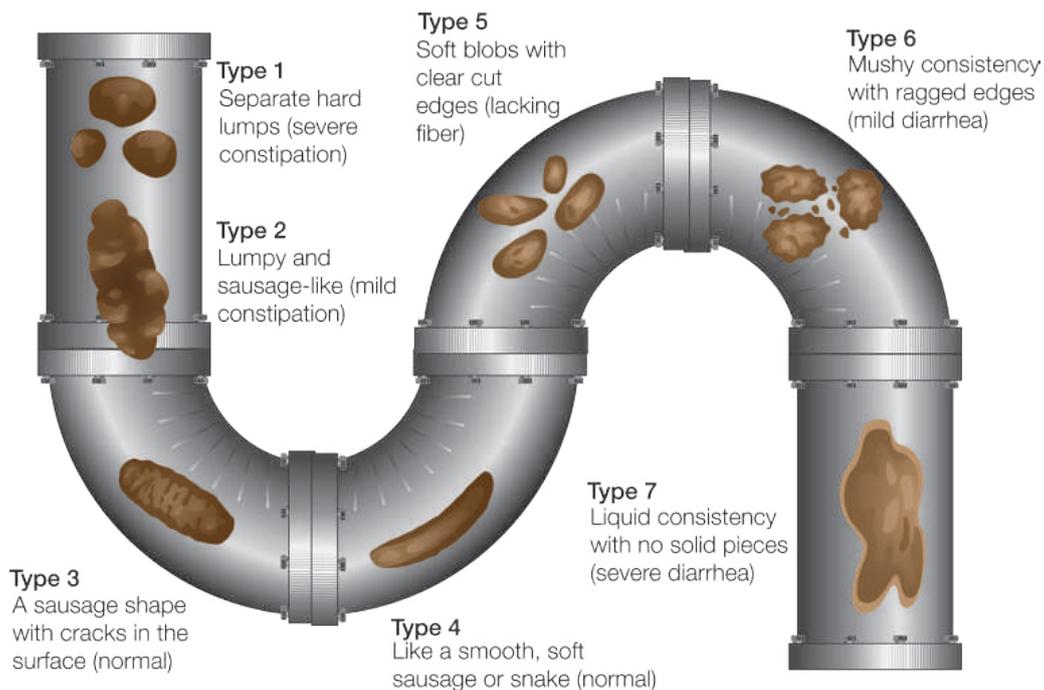


Figure 1.10.2: The consistency and colour of your stools, which can indicate the health of your large intestines.



Extension activity

Research and explain what the colour and density of your stools may tell you about the health.

Colour:

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.. ..
.. ..
.. ..
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.. ..

Density:

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.. ..
.. ..
.. ..
.. ..
.. ..

Diverticulosis usually has no symptoms, unless numerous diverticula (pouches) are present. When there are many diverticula present, the normal functioning of the intestines can be affected and lead to symptoms such as:

- abdominal pain and bloating
- excessive flatulence
- bowel movements alternating between constipation and diarrhoea
- blood in the faeces (usually minor, only heavy if a diverticulum pushes through the intestinal wall near a blood vessel).

For those who develop diverticulosis, there is a chance it may progress to diverticulitis at some stage. It is uncommon for a person to suffer from diverticulitis more than once in their lifetime, however symptoms of diverticulitis tend to be more distressing, including:

- sharp abdominal pain (most commonly from the lower left side of the abdomen)
- distention (bloating) of the abdomen
- Infection may cause nausea, fever and vomiting
- blood in the faeces (occasional and rare symptom).
-

Extension activity

Diverticular disease can also lead to further complications. Discuss three complications that may arise from having diverticular disease..

.. ..
.. ..
.. ..
.. ..
.. ..
.. ..

Nutrition Related Risk Factors

The exact cause of diverticulosis, or pouches forming, is unclear. However, a diet low in fibre and water increases the chances of developing diverticular disease via becoming constipated over a long period of time. Constipation and subsequent straining to pass hard/dry faeces (or stools), can increase pressure in the intestines or colon. A higher pressure needs to be generated to push hard/dry stools through the gastrointestinal tract. This high pressure can force the lining of the intestines to pocket outwards, through the muscle layer where weaknesses occur, leading to the formation of pouches and diverticulosis. Diverticulitis may then be caused by small fragments of faeces becoming trapped in these pouches, encouraging bacterial growth and causing infection and inflammation

Question

2. Describe how an inadequate intake of the following nutrition related factors can lead to constipation.

(a) Insoluble Fibre

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(b) Soluble Fibre

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.....

(c) Water

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.....

.....

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(6 marks) (KA2)

The Role of Diet in Prevention and Management

To reduce the chance of diverticular disease, a gradual increase in the consumption of dietary fibre and fluids is needed in the diet. A daily intake of 30 grams of fibre is recommended to make stools softer and help prevent constipation. A high fibre diet may also prevent further diverticula forming. Adequate water intake can also help keep stools soft, making them pass easier through the intestines.

Question

3. Name two specific foods that are good sources of soluble fibre, insoluble fibre and water.

Soluble Fibre: ..

.....

Insoluble Fibre: ..

.....

Water: ..

.....

(6 marks) (KA1)

4. Discuss a situation that would require additional water intake above the RDI.

.....

.....

.....

.....

(2 marks) (KA2)

Lifestyle & Physiological Risk Factors & Management

Diverticulosis is quite common in the elderly, for both genders. Its progression takes considerable time which explains why age is a risk factor. However, regular exercise is a lifestyle management that is key in protecting against diverticular disease. Exercise can improve gut motility. Gut motility is the speed at which the intestinal muscles contract to move food/faeces through the digestive tract. Exercise directs more blood flow to the digestive muscles, allowing them to contract quicker and more efficiently. This speeds up the movement of faeces through the colon, thereby reducing the risk of constipation.

Extension activity

Diverticulosis is generally diagnosed during routine screening for colorectal cancer or during other tests for other intestinal problems. Diverticulitis is usually diagnosed on clinical examination during an acute attack of symptoms and confirmed with a CT scan of the abdomen.

Research and explain the treatment of acute and severe Diverticulitis, to prevent further complications.

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Iron Deficient Anaemia

Anaemia is a condition with lower than normal concentrations of haemoglobin or a lower number of quality red blood cells. There are different types of anaemia, but iron deficiency anaemia is the most common and widespread nutrient deficiency in the world.

Red blood cells are the most abundant cell type in the blood. Their primary function is to transport oxygen to the body’s muscles and tissues and deliver carbon dioxide to the lungs. A **healthy red blood cell** has a concave shape on both sides (biconcave), where its surface curves inwards (as shown in Figure 1.10.3). Its flexible disc shape increases its surface area to volume ratio, allowing for oxygen and carbon dioxide to be exchanged more readily. Its shape is also essential for its ability to move through tiny blood vessels to reach all tissues in the body.

Fast fact

A healthy red blood cell begins its production in the bone marrow and will remain in blood circulation for approximately 115 days, at which point they are recycled and excreted.

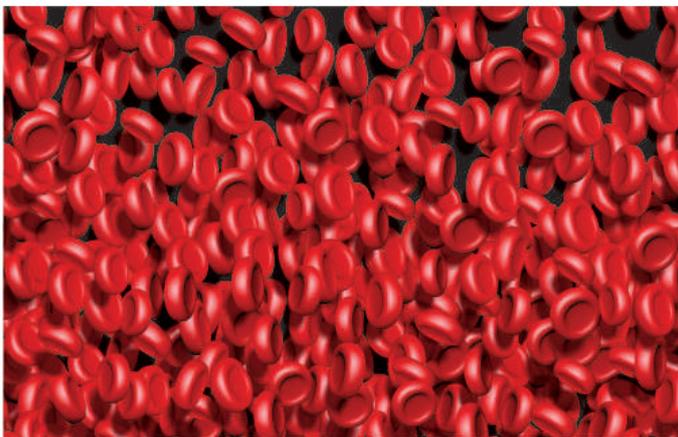


Figure 1.10.3: The biconcave shape of red blood cells allows for efficient gas exchange and movement throughout the body’s blood vessels.

Red blood cells contain enormous amounts of a protein known as **haemoglobin**, which binds to oxygen when the blood passes through the lungs (as shown in Figure 1.10.4). Haemoglobin also provides the characteristic red colour of blood, when it has attached to an oxygen molecule.



Reminder

Iron is a significant component of haemoglobin and assists in its production.

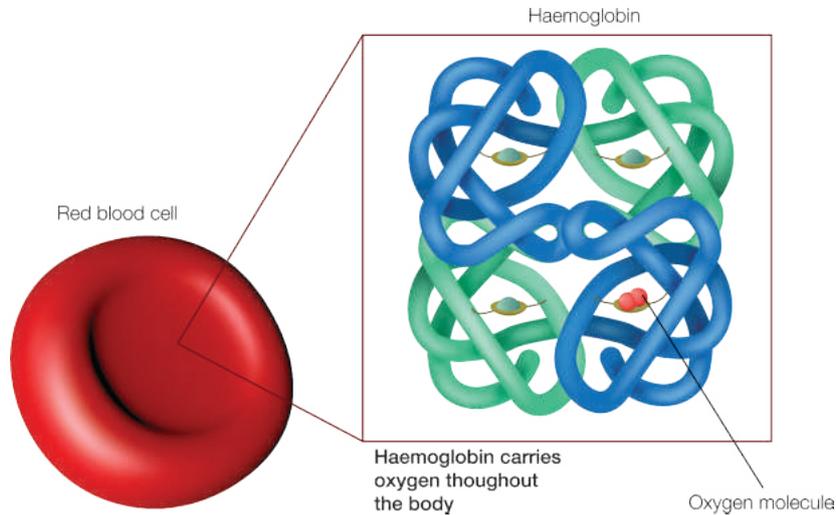


Figure 1.10.4: Red blood cells contain haemoglobin, which is the oxygen-binding component of a red blood cell.

Question

5. Explain why oxygen is an essential requirement of the body's tissues and organs.

.....

(2 marks) (KA2)

6. In an individual with iron deficiency anaemia, the red blood cells appear abnormal and are unusually **small and pale** in colour (as shown in Figure 1.10.5). Explain how this would impact the delivery of oxygen to the body's tissues and organs.

.....

(2 marks) (KA2)



Fast fact

Small red blood cells are known as microcytic; pale ones are known as hypochromic.

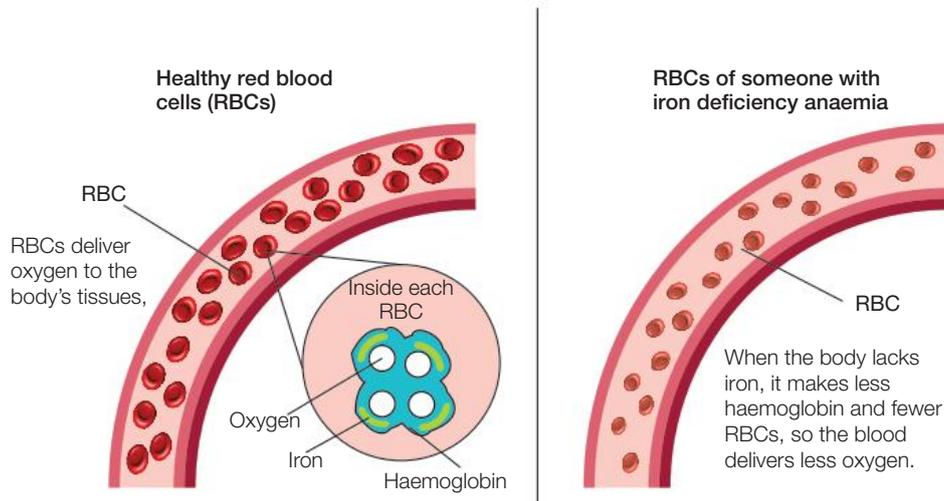


Figure 1.10.5: A comparison of the number and quality of red blood cells in a healthy individual (left) and a person with iron deficiency anaemia (right).

Signs & Symptoms

The red blood cells of people with iron deficiency anaemia have a reduced amount of haemoglobin, which reduces the amount of oxygen supplied to tissues. A lack of oxygen over a long period of time can cause the following signs and symptoms:

- fatigue
- pale skin
- fast heartbeat
- chest pain
- headaches and dizziness
- difficulty with concentration and memory
- cravings for unusual objects, e.g. dirt.

Question

7. Explain why the following symptoms may develop and be experienced by an individual with iron deficiency anaemia.

(a) Fatigue:

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.....

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..... (2 marks) (KA2)

(b) Pale Skin:

.....

.....

.....

..... (2 marks) (KA2)

(c) Fast Heartbeat:

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..... (2 marks) (KA2)

In mild cases of iron deficiency anaemia, a person is unlikely to experience more than the symptoms listed above. However, if anaemia is left unmanaged, additional complications can occur. Possible complications may include:

- slow growth and development delays in infants and children
- heart failure due to how it compensates for a lack of oxygen
- pregnancy complications, including low birth weight or premature birth.

Nutrition Related Risk Factors

A diet low in iron and nutrients that aid in its absorption can contribute to the development of iron deficiency anaemia.

Some components of dietary choices can bind with non-haem iron, inhibiting its absorption. Therefore, a high intake of iron absorption inhibitors (as shown in Table 1.10.1), plus conditions that can impair iron absorption, can also contribute to the development of iron deficiency anaemia

Table 1.10.1: Iron absorption inhibitor food sources and their responsible components.

Food sources	Component
Eggs	Phosvitin
Dairy	Calcium
Tea, spinach, kale, nuts, chocolate, strawberries, herbs	Oxalates
Cocoa, coffee, apples, herbal teas, blackberries, raspberries, blueberries	Polyphenols
Walnuts, lentils, wholegrains, cereals, dried beans, almonds, rice	Phytates

Question

8. Explain how a diet low in iron can lead to the development of iron deficient anaemia.

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.....

(3 marks) (KA2)

9. A diet low in meat, poultry and fish can contribute to the development of iron deficiency anaemia.

(a) State which type of iron these food sources would be high in.

..... (1 mark) (KA1)

(b) Identify a group of people who would be at risk of developing iron deficiency anaemia, as they do not consume these foods.

..... (1 mark) (KA2)

10. Identify a vitamin that can assist with the absorption of iron from plant based foods when coupled in the same meal.

..... (1 mark) (KA1)

Question

15. Complete the following table by identifying if an individual diagnosed with iron deficiency anaemia should increase or decrease their intake of the following foods and beverages to assist with the management of their disorder.

Food or beverage source	Increase or decrease intake
Oranges	
Excessive milk and yoghurt	
English Breakfast Tea	
Lamb	
Fresh salmon	
Eggs	
Fortified cereals	
Broccoli with orange juice	

(8 marks) (KA2)

Lifestyle & Physiological Risk Factors & Management

Different groups in Australia are at greater risk of developing iron deficiency anaemia due to a number of lifestyle and physiological risk factors.

Periods of Rapid Growth

Life stages, including puberty and pregnancy, can result in a rapid increase in blood volume. This increases a person's recommended daily intake of iron to provide an adequate amount of haemoglobin for the increase in red blood cell production. This compensates for the increase in blood volume and, in the case of pregnant women, supports the needs of a developing foetus.

Question

16. Identify two life stages at which people would be at greater risk of iron deficiency anaemia due to rapid growth in their blood volume.

1.
 2. (2 marks) (KA2)

High energy demands

Endurance athletes, especially female athletes, are at risk of iron deficiency anaemia due to increased demands for iron. Iron is essential for athletic performance due to its role in haemoglobin production, which is responsible for the transportation of oxygen to the muscle cells in preparation for aerobic respiration. High energy demands stimulate an increase in red blood cell production, thus require an increased iron intake.



Fast fact

Endurance athletes can damage the red blood cells in their feet as a result of the way the foot lands while running on hard surfaces. This can further cause a loss of blood.

Question

17. State one reason why female endurance athletes are at greater risk of anaemia than male athletes.
 (1 mark) (KA2)
18. Suggest another possible reason (which has not been discussed above) why athletes are at risk of iron deficiency anaemia, due to the loss of iron stores from the body.

 (2 marks) (KA2)

Vegetarian and Vegan Lifestyle

Individuals who are **vegetarian or vegan** can be at greater risk of iron deficiency anaemia if proper care is not taken when selecting foods. Foods derived from animal sources provide both haem and non-haem iron, whereas plant sources only provide non-haem iron (as shown in Figure 1.10.6). Therefore, if an individual does not consume the flesh of animal products, only non-haem iron is consumed. This is not absorbed as readily as haem iron is.

Fast fact

The recommended intake of iron for vegetarians and vegans is usually 1.8 times greater than for people who consume animal products.

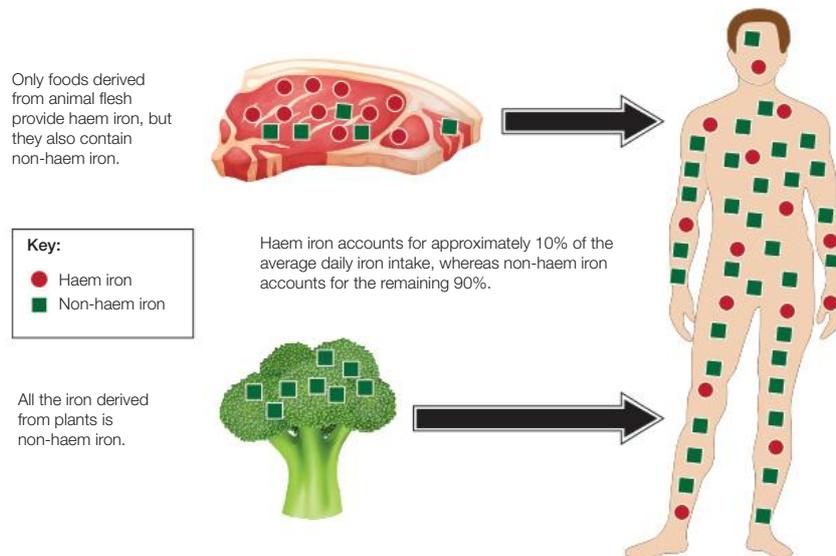


Figure 1.10.6: The composition of animal and plant iron sources.

Question

19. State the rates at which haem iron and non-haem iron are absorbed by the body.
 (2 marks) (KA1)

Significant blood loss

Blood carries iron stored in red blood cells, therefore people who lose blood from the body will lose their iron stores. A significant amount of blood loss can occur from injury, surgery, heavy menstrual bleeding, conditions that cause internal bleeding or the overuse of pain medications (which causes digestive bleeding).

Bone marrow disorders

Bone marrow is a soft, spongy tissue found in the centre of bones. Bone marrow produces stem cells, which then develop into red blood cells, white blood cells and platelets. However, a number of diseases can affect the function of bone marrow, including some cancers. This disrupts the production of red blood cells, decreasing the number of healthy blood cells circulating in the blood stream.

Autoimmune disorders and infections

Autoimmune disorders (such as haemolytic anaemia) and infections (including malaria and septicaemia) can reduce the life span of a red blood cell. These conditions can cause premature rupturing of healthy red blood cells, decrease RBC production or cause the body’s immune system to attack RBCs as if they were substances foreign to the body. This increases the demand for RBCs from the bone marrow.

Extension activity

Research and explain how inherited disorders such as thalassaemia and sickle cell disease can put an individual at greater risk of iron deficiency anaemia.

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Question

20. State the reason why the following individuals would be at risk of iron deficiency:

Individual at risk of iron deficiency anaemia	Reason
Child aged between 5 and 12 years old	
Individual with a serious injury to the skin	
Male marathon runner	
16-year-old adolescent female	
Four-months pregnant female	
Individual with coeliac disease	
Chronic coffee consumer	
Leukaemia patient	
Vegan	
Haemolytic anaemic	

(10 marks) (KA2)

Osteoporosis

Osteoporosis is one of the most prevalent diseases within the ageing population, affecting more than 1.9 million Australians. Osteoporosis is a disorder characterised by low bone density and the **structural deterioration of bone tissue**, which becomes more porous and fragile (as shown in Figure 1.10.7). This leads to weakened bones, which are compressible like a sponge, thus increasing the risk of fractures in the bones.

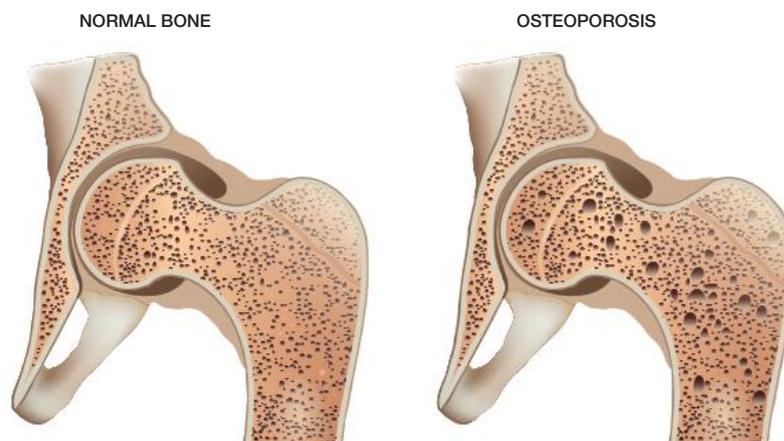


Figure 1.10.7: A comparison between healthy bone (left) and osteoporotic bone (right).

Fast fact

When viewed under a microscope, healthy bones appear like honeycomb, where the spaces are small and densely packed. When osteoporosis occurs, the holes and spaces in the honeycomb are much larger.

Bones are a living tissue that are constantly growing, rebuilding, repairing and replacing. There are 206 connected bones in the adult body. Bones provide a frame to support the body, protect vital organs and enable movement. Bones are attachment points for muscles, tendons and ligaments. Bone tissue is a dense connective tissue, which is composed of a protein, collagen, and a mineral, calcium phosphate. The combination of collagen and calcium phosphate make bones strong and flexible enough to withstand stress.

Throughout an individual's lifetime, a process of bone remodelling is constantly taking place: mature bone is removed (known as bone resorption) and replaced with new bone (known as bone ossification or bone formation, as shown in Figure 1.10.8). It is a process that continues throughout life and is important for healing fractures and changing bone density in response to mechanical stress.

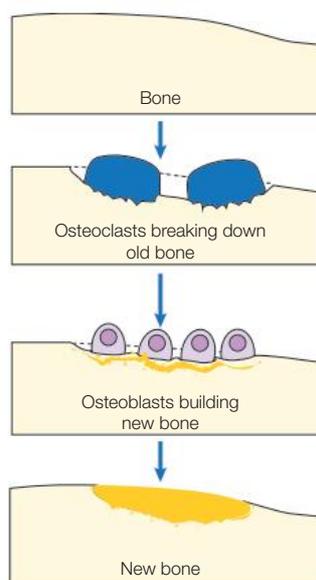


Figure 1.10.8: The continuous process of bone remodelling throughout life, where bone resorption – performed by osteoclasts – removes mature bone and bone formation – performed by osteoblasts – replaces it with new bone.

During childhood and adolescence, the process of bone formation is greater than bone resorption, resulting in larger, heavier and denser bones. Bone formation continues to exceed the rate of bone resorption until an individual reaches their early to mid-twenties, which is when they reach their peak bone mass. An individual's peak bone mass is the greatest amount of bone they will attain in their lifetime and is therefore when they are at their strongest. After peak bone mass is achieved, the rate of bone resorption is equal to the rate of bone formation until an individual reaches the age of approximately 40. After this age, the rate of bone resorption becomes greater than the rate of bone formation leading to bone loss. Therefore, osteoporosis is an imbalance in the turnover of bone, where bone resorption significantly exceeds bone formation (as shown in Figure 1.10.9).

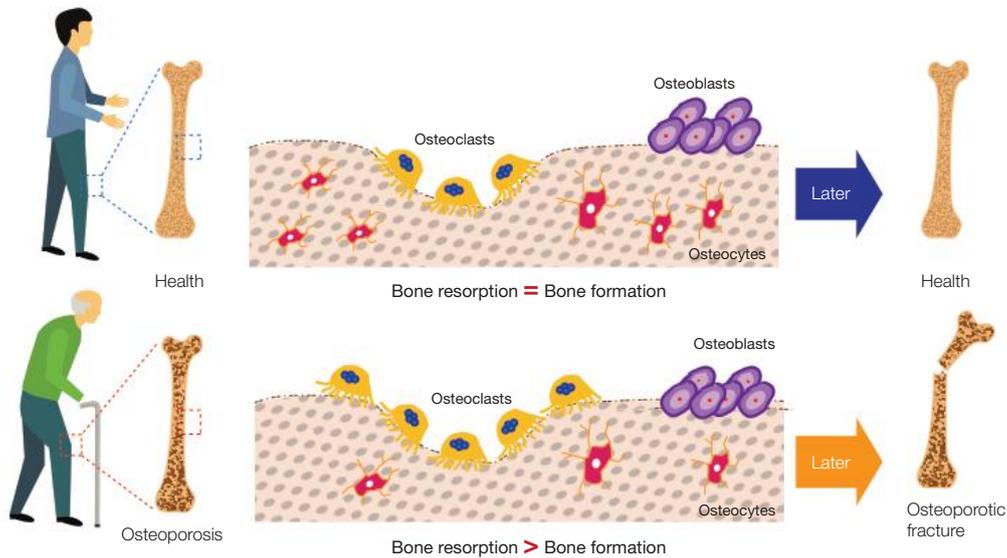


Figure 1.10.9: The process of bone remodeling throughout different life stages.

Question

21. State two functions of bones in the body.

- 1. _____
- 2. _____ (2 marks) (KA1)

22. Predict if an individual with a low peak bone mass will have a reduced or greater risk of developing osteoporosis later in life.

_____ (1 mark) (KA2)

23. Complete the following table by outlining when bone formation is greater (>), equal (=) to, or less (<) than bone resorption.

Age (years)	Bone formation in comparison to bone resorption
0 – 25	
25 – 40	
> 40	

(3 marks) (KA2)

Signs & Symptoms

Osteoporosis generally has no symptoms until a fracture occurs, which is why it is known as a silent and progressive condition. As bones become more brittle and fragile, even a minor bump, fall, cough or sneeze can cause a **fracture** (as shown in Figure 1.10.10). The symptom associated with an osteoporotic fracture is usually chronic pain.

Definition

A fracture is a complete or partial break in a bone.



Figure 1.10.10: The complete fracture of the hip bones is highlighted in red.

Any bone can be affected by osteoporosis, but the **most common sites** include the hip, spine and wrist (as shown in Figure 1.10.11). A small fracture in the spine can result in height loss or a stooped posture, due to the collapse of the vertebrae. This collapse gives individuals a hunched appearance of the upper back, often called a 'dowager hump' because it is commonly seen in the elderly (Figure 1.10.11). Changes to an individual's posture can also increase the risk of a fall or difficulties breathing or digesting. A hip fracture is generally a result of trivial slip and fall accidents. A fracture that occurs during normal activity (e.g. while walking or stepping onto a curb) is known as a stress fracture. A fractured bone can be serious and lead to long term disability, including reduced mobility.

Fast fact

In Australia, of all osteoporotic fractures 46% are spine, 16% are hip, and 16% are wrist.

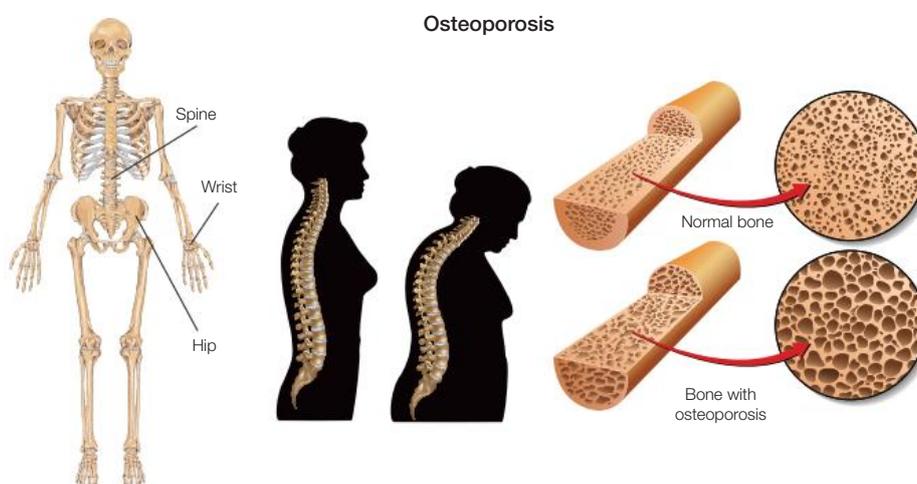


Figure 1.10.11: The common sites of osteoporotic fractures (left), and the development of the 'dowager hump' due to osteoporotic fractures (right).

Osteoporotic fractures are responsible for significant pain, decreased quality of life, lost workdays and disability. Elderly patients can develop possible consequences, including pneumonia and blood clots in the legs that can travel to the lungs, due to prolonged bed rest after a hip fracture. In addition, once an individual has experienced a fracture due to osteoporosis, he or she is very likely to suffer from another fracture in the near future.

Nutrition Related Risk Factors

Osteoporosis can be caused by poor nutrition, where the diet is insufficient in calcium, phosphorus and nutrients that can assist in their absorption.

The main role of calcium and phosphorus is in the development of the bone's structure. These two minerals combine to make the bone matrix denser, which provides strength and rigidity to the bones. The majority of the body's calcium is stored in the bones, which act as a calcium bank. Therefore, if the diet is low in calcium, the body will absorb calcium from the bones, making them more porous and fragile over time. As phosphorus is found in most foods, a deficiency of phosphorus is not common.



Fast fact

More than 99 per cent of the body's stores of calcium are found in bones and teeth, with the remaining 1 per cent found in blood.

Question

24. State the compound that is formed when calcium and phosphorus combine.

..... (1 mark) (KA1)

25. Explain how calcium and phosphorus contribute to denser bones, making them stronger and more rigid.

.....

 (2 marks) (KA2)

26. Identify a vitamin that is essential for the intestinal absorption of calcium and phosphorus from the blood.

..... (1 mark) (KA1)

Some dietary foods and beverages can inhibit the absorption of calcium by binding to the mineral when consumed at the same time, forming insoluble salts. Table 1.10.2 shows dietary sources of components that inhibit (block or reduce) calcium absorption. Excessive sodium, alcohol and caffeine intakes can reduce calcium **bioavailability** by promoting greater calcium urinary excretion. Therefore, consuming a high intake of **calcium absorption inhibitors** and having conditions that can impair calcium absorption can contribute to the development of osteoporosis.



Definition

Bioavailability is the degree to which a nutrient is absorbed and utilised by the body.

Table 1.10.2: Calcium absorption inhibitor food sources and their responsible components.

Food sources	Component
Processed foods, cured meats, salted nuts, cold cuts, sauces, canned products	Sodium
Soft drinks	Phosphoric Acid
Tea, spinach, kale, nuts, chocolate, strawberries, herbs	Oxalates
Cocoa, coffee, apples, herbal teas, blackberries, raspberries, blueberries	Polyphenols
Walnuts, lentils, wholegrains, cereals, dried beans, almonds, rice	Phytates

Reminder
 Excessive consumption of these food sources causes their effects on calcium absorption inhibition.

The Role of Diet in Prevention and Management

To reach optimal peak bone mass and continue building new bone, a number of dietary modifications can be implemented, including an increase in food sources high in calcium, phosphorus and vitamin D. An increase in the consumption of calcium absorption enhancers and a decrease in the consumption of calcium absorption inhibitors can also reduce the risk of an individual developing osteoporosis later in life or prevent their condition from progressing.

Question

27. State two specific food sources of the following micronutrients, making sure one is suitable for a vegan.

- (a) Calcium:
 - 1.
 - 2.
- (b) Phosphorus:
 - 1.
 - 2.
- (c) Vitamin D:
 - 1.
 - 2. (6 marks) (KA1)

28. Identify if an elderly person diagnosed with osteoporosis should increase or decrease their intake of the following foods and beverages to assist with the management of their disorder.

Food or beverage source	Increase or decrease intake
Cow's milk	
Salmon	
Pepsi	
Coffee	
Yoghurt	
Wholegrains	
Processed foods	
Fortified orange juice	

(8 marks) (KA2)

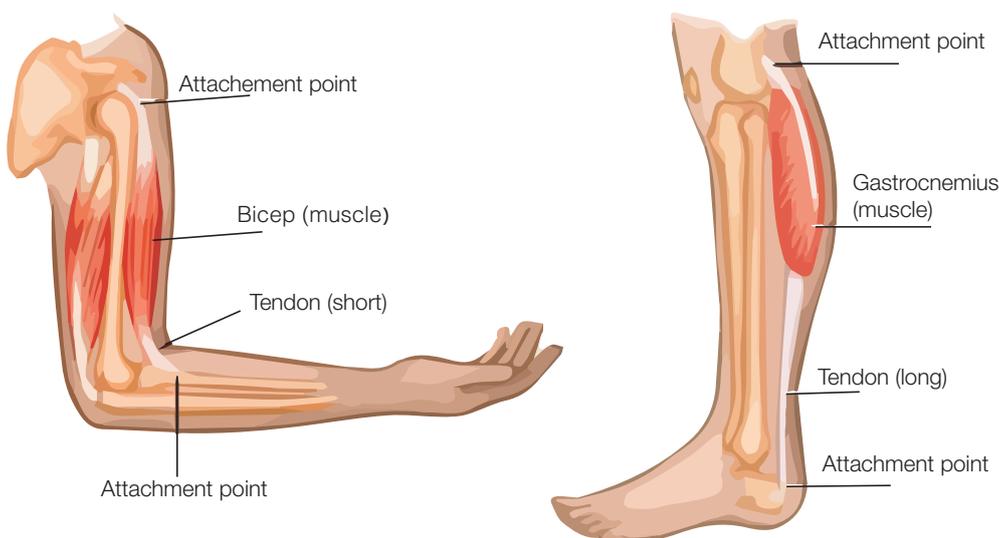


Figure 1.10.12: The attachment of the muscles to bones by a tendon on each end.

Question

31. State two examples of a weight-bearing or resistance exercise, which can delay or manage osteoporosis.

- 1. (2 marks) (KA1)
- 2. (2 marks) (KA1)

32. State the benefit of performing weight-bearing exercises or resistance training in the following age groups and the effect this would have on the development of osteoporosis.

(a) Adolescents (13–17 years old)
 (2 marks) (KA2)

(b) Adults (18–50 years old)
 (2 marks) (KA2)

(c) Elderly people (>65 years old)
 (2 marks) (KA2)

Menopause

Females have a greater prevalence and earlier onset of osteoporosis than males because they experience **menopause** at approximately 50 years of age. For the first 10 years following menopause, there is a significant decline in the amount of the hormone oestrogen in a woman’s body. In menopause, oestrogen deficiency decreases the efficiency of calcium absorption in the intestines and increases the rate of bone resorption decreasing bone density and strength. During this time, women may lose 2 to 4 per cent of their bone density each year.

Definition

Menopause is a change that a female goes through, either just before or just after she stops menstruating, marking the end of her reproductive period.

Extension activity

Hormone replacement therapy (HRT) has been used successfully to relieve the symptoms of menopause, especially in women who experience early menopause before 45 years of age. Explain how this treatment can be used to manage the symptoms of osteoporosis.

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Excessive alcohol consumption

Excess alcohol consumption can interfere with calcium balance in the body by disrupting the production of vitamin D in the liver, which is essential for calcium absorption. Chronic alcohol consumption can also cause hormonal imbalances responsible for managing the bone remodeling process.



Reminder

Exposing hands, face and arms on a clear summer day for five-ten minutes during the peak UV periods 10am and 2pm on most days of the week should be sufficient to achieve adequate Vitamin D levels.

Question

33. It is difficult to obtain all recommended vitamin D from the diet, but it can be produced in the skin from cholesterol. Identify what the skin needs exposure to, to complete vitamin D production.

..... (1 mark) (KA1)

34. Explain how the diuretic nature of alcohol can also affect calcium absorption.

.....

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..... (2 marks) (KA2)

Being underweight

Being underweight can be characterised by having a low BMI and is a result of an individual's energy expenditure exceeding their intake over a considerable amount of time. A low BMI is often associated with poor nutrition, which can affect bone health, especially if the diet is insufficient calcium. A low-calcium diet can contribute to diminished bone density and increased risk of fractures.

Question

35. Using body mass index (BMI) is a good indication if an individual is underweight. State the BMI of an underweight individual.

..... (1 mark) (KA1)

36. If calcium intake is low, state where the body will source calcium from.

..... (1 mark) (KA1)

Limited exposure to sunlight

The best source of vitamin D (which assists with calcium absorption, and thus can prevent or manage osteoporosis) is from its production in the skin from cholesterol. This process is dependent on ultraviolet radiation (UV) from the sun.

Question

37. State the impact of reduced UV exposure on the production of vitamin D, and therefore the effect on calcium stores in the body.

.....

 (2 marks) (KA1)

Extension activity

Ethnicity can also be a physiological risk factor. Research what ethnicities have a greater risk of developing osteoporosis.

.....

Key terms

Bone Formation/Ossification	Diverticular Disease	Osteoblasts
Bone Remodeling	Diverticulitis	Osteoclasts
Bone Resorption	Diverticulosis	Osteoporosis
Calcium Absorption Enhancer	Fractures	Peak bone mass
Calcium Absorption Inhibitor	Gut motility	Porous
Calcium Phosphate	Haemoglobin	Red blood cell
Collagen	Iron Absorption Enhancer	Resistance Training
Constipation	Iron Absorption inhibitors	Sigmoid Colon
Defecate	Iron Deficient Anaemia	Vitamin D
Diverticula	Menopause	Weight-bearing Exercise

Review questions: 1.10 Imbalance of Nutrient Intake – Under Nutrition Disorders

1. Fred is a retired 78-year-old man who does little exercise. Living alone, he lacks motivation to cook for himself and eats mostly processed energy-dense foods.
 - (a) List a dietary risk factor that may lead to Fred developing diverticular disease and discuss how this risk factor may cause this condition.

.....

 (3 marks) (KA2)

(b) List and describe a lifestyle management strategy Fred should adopt to reduce his chance of developing diverticular disease.

.....

 (2 marks) (KA2)

(c) Name the digestive organ where diverticula pouches would develop.
 (1 mark) (KA1)

(d) Describe the cause of one symptom Fred could suffer from if he develops diverticular disease.

 (2 marks) (KA2)

2. According to recent statistics, iron deficiency affects the health of 25 per cent of Australian women and 10 per cent of men in Australia.

(a) There are two forms of iron. State the two forms of iron.
 1.
 2. (2 marks) (KA1)

(b) The following table provides the iron content of different foods:

Food	Iron content (mg per 100 g)
Broccoli	1.0
Canned steak and vegetables	0.8
Dried rice cereal	34.0
Lamb chop	1.7
Salami	2.4

(i) With reference to the table above, state the food source which might contribute to the development of iron deficient anaemia.
 (1 mark) (IAE3)

(ii) State a micronutrient and provide a specific food source that could be consumed with broccoli to increase the absorption of iron.
 Micronutrient:
 Food source: (2 marks) (KA1)

(c) Describe one function of iron that can affect the quality of red blood cells.

 (2 marks) (KA2)

(d) Explain the importance of the shape of a healthy red blood cell and how this changes in an individual with iron deficiency anaemia.

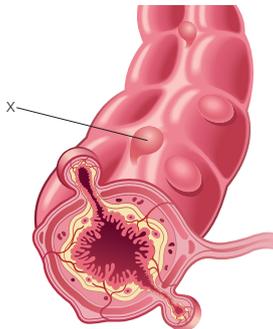
 (3 marks) (KA2)



(e) Identify two groups of individuals who are at greater risk of developing anaemia.

1.
2. (2 marks) (KA1)

3. Refer to the image below:



(a) Name the structure labelled X in the image above.

.. . . . (1 mark) (KA1)

(b) Name the specific type of diverticular disease shown in this image above, which shows empty sacs.

.. . . . (1 mark) (KA1)

4. Discuss two differences between diverticulosis and diverticulitis.

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.. . . . (2 marks) (KA2)

5. Refer to the following table, which shows the recommended daily intake (RDI) of calcium for different age groups and genders.

Males		Females	
Age (years)	RDI calcium (mg/day)	Age (years)	RDI calcium (mg/day)
1–3	500	1–3	500
4–8	700	4–8	700
9–11	1000	9–11	1000
12–18	1300	12–18	1300
19–70	1000	19–50	1000
>70	1300	>50	1300

Source: National Health and Medical Research Council (NHMRC), Nutrient Reference Values for Australia and New Zealand, Department of Health and Ageing, Canberra, 2006, pp.157–8.

(a) Suggest a reason why the RDI of calcium for males and females' peaks at 12–18 years of age.

.. . . . (1 mark) (KA2)

(b) Explain one reason why the RDI of calcium increases at 50 years of age for females, but not until 70 years of age for males.

.....

 (2 marks) (KA2)

(c) Suggest a drink that would assist a lactose-intolerant individual to consume his or her RDI of calcium, regardless of age and gender.

..... (1 mark) (KA1)

(d) Refer to the following list, which shows the ingredients for a sugar-sweetened soft drink:

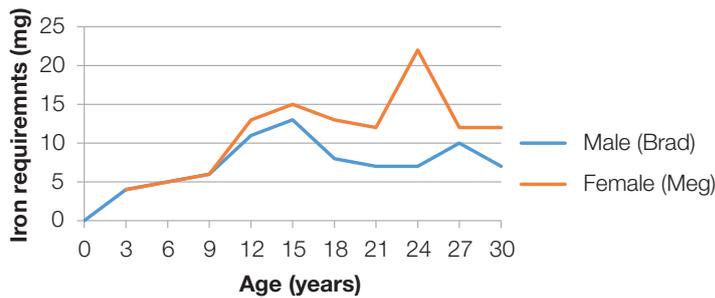
- Carbonated water
- Caramel colour
- Phosphoric acid
- Natural flavours
- Caffeine
- Fructose corn syrup

Identify one ingredient in the soft drink that could reduce bone mineral density if consumed regularly.

..... (1 mark) (KA1)

6. The following graph shows changes in iron requirements for two people of different genders over part of their life spans. Refer to the following graph to answer the following questions.

Graph of iron requirements for Brad and Meg over part of their lifespan



(a) State at what age Brad has his greatest iron requirement.

..... (1 mark) (IAE3)

(b) Using data from the graph, explain the trend in the iron requirements for Brad from ages 3 to 15 years.

.....

 (2 marks) (IAE3)

(c) State a reason why Meg has greater iron requirements between the ages of 12 and 30 years.

..... (1 mark) (KA2)

(d) Suggest a possible reason for the significant increase in Meg's iron requirements at the age of 24 years.

..... (1 mark) (KA2)

(e) State a food or beverage source that could reduce Brad's iron absorption at the age of 27 years, putting him at risk of developing a nutrient deficiency.

..... (1 mark) (KA2)

1.11 Nutrition through the Life Cycle

Science understanding

Changes to the specific nutrition needs and energy requirements are determined by an individual's physiological needs (age, gender, body size and activity level), which can be explored through different stages of the life cycle:

- Infancy
- Childhood
- Adolescence
- Adulthood
- Elderly
- Pregnancy and Lactation

SACE Subject Outline, 2020.

Nutritional Needs and Energy Requirements

The nutritional requirements of the human body change as our physiological features develop through different life stages. The Nutrient Reference Values (NRVs) specify the nutritional needs at various stages of life. Physiological factors also influence metabolic rate and the number of kilojoules needed. During the lifecycle, major physiological changes allow humans to be grouped as infants, children, adolescents, adults, and the elderly. Life stages of pregnancy and lactation also bring large changes in physiological factors and therefore nutritional and energy needs.

Infancy

Infancy is the first stage of the human lifecycle (as shown in Figure 1.11.1). This 12-month life stage includes the newborn period from 0-3 months.



Figure 1.11.1: The first stage of the human lifecycle: infancy.

Physiological characteristics

- Aged between 0 and 12 months
- Rapid growth rate, where infant's length increases approximately 25 centimetres from birth to one year (as shown in Figure 1.11.2) and triple their weight by one year, typically reaching 9.5 to 10 kilograms (as shown in Figure 1.11.3)
- Not very active – by five months many babies can roll, by 8-9 months most can crawl and pull up to stand, and by 12 months some infants will be walking.

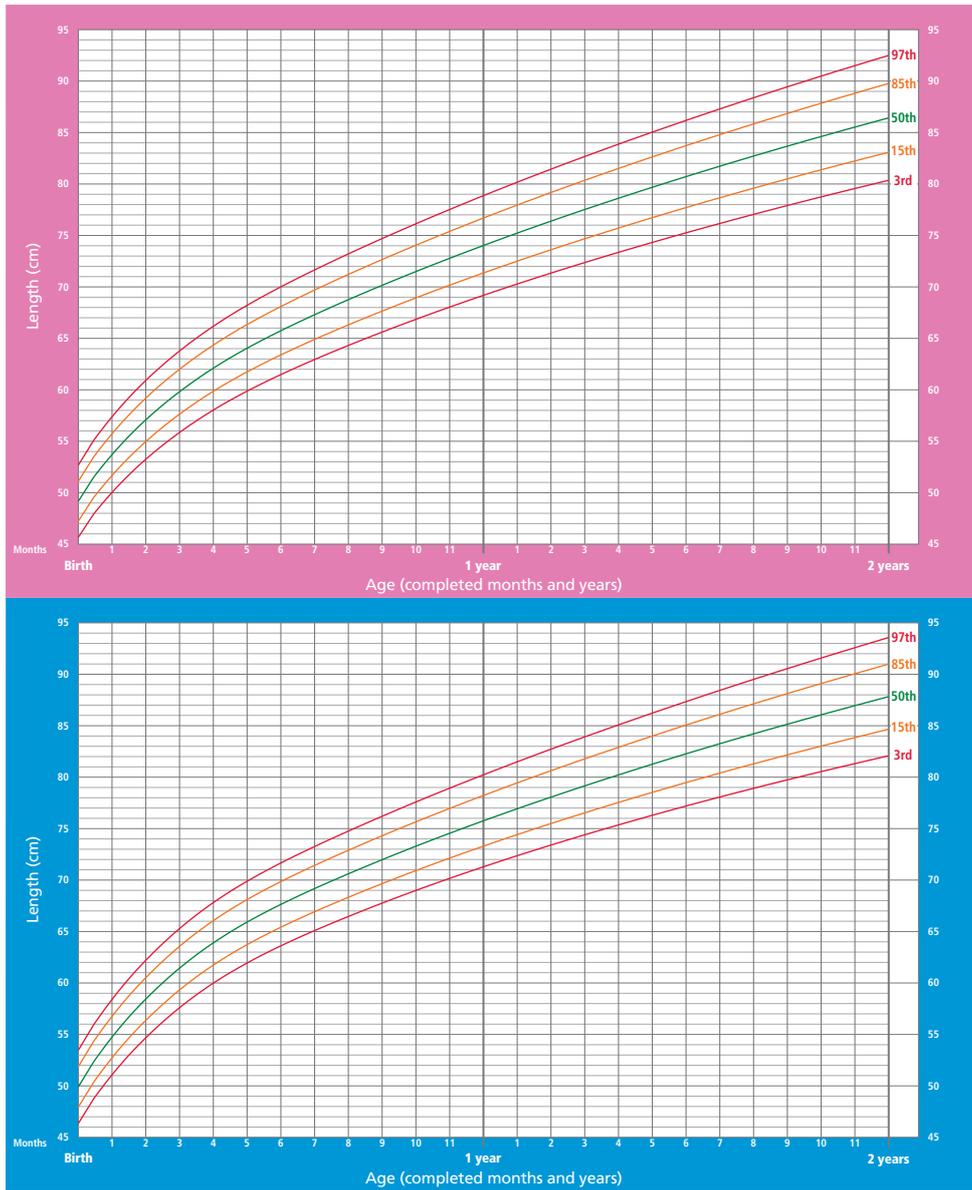


Figure 1.11.2: The growth chart for Girls (top) and Boys (bottom) between 0-2 years for length
 Source: The Royal Children’s Hospital Melbourne

Question

1. With reference to Figure 1.11.2, determine the percentile the following infants would be categorised in at the following age and length:

(a) 7-month old girl who is 67cm long

..... (1 mark) (IAE3)

(b) 11-month old boy who is 78cm long

..... (1 mark) (IAE3)

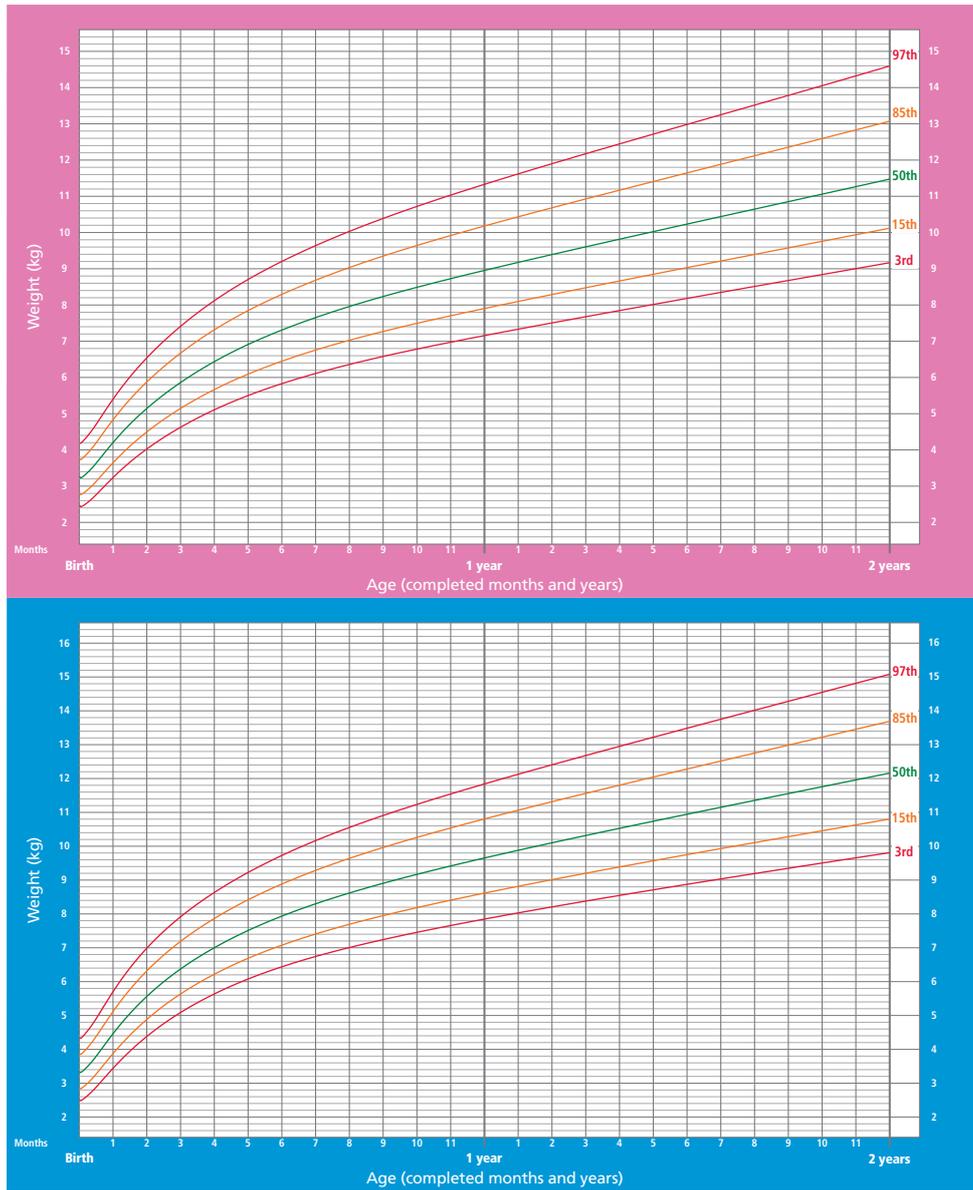


Figure 1.11.3: The growth chart for Girls (top) and Boys (bottom) between 0-2 years for weight
 Source: The Royal Children’s Hospital Melbourne

Question

2. With reference to Figure 1.11.3, determine the percentile the following infants would be categorised in at the following age and weight:

(a) 12-month old girl who weighs 9kg

..... (1 mark) (IAE3)

(b) Newborn born (0 months) girl weighing 4.2kg

..... (1 mark) (IAE3)

(c) 5-month old boy weighing 6kg

..... (1 mark) (IAE3)

Nutritional Needs

Although NRVs may show smaller quantities of each nutrient during this life stage, the intake of most is higher relative to the body size compared to adults (as shown in Figure 1.11.4).

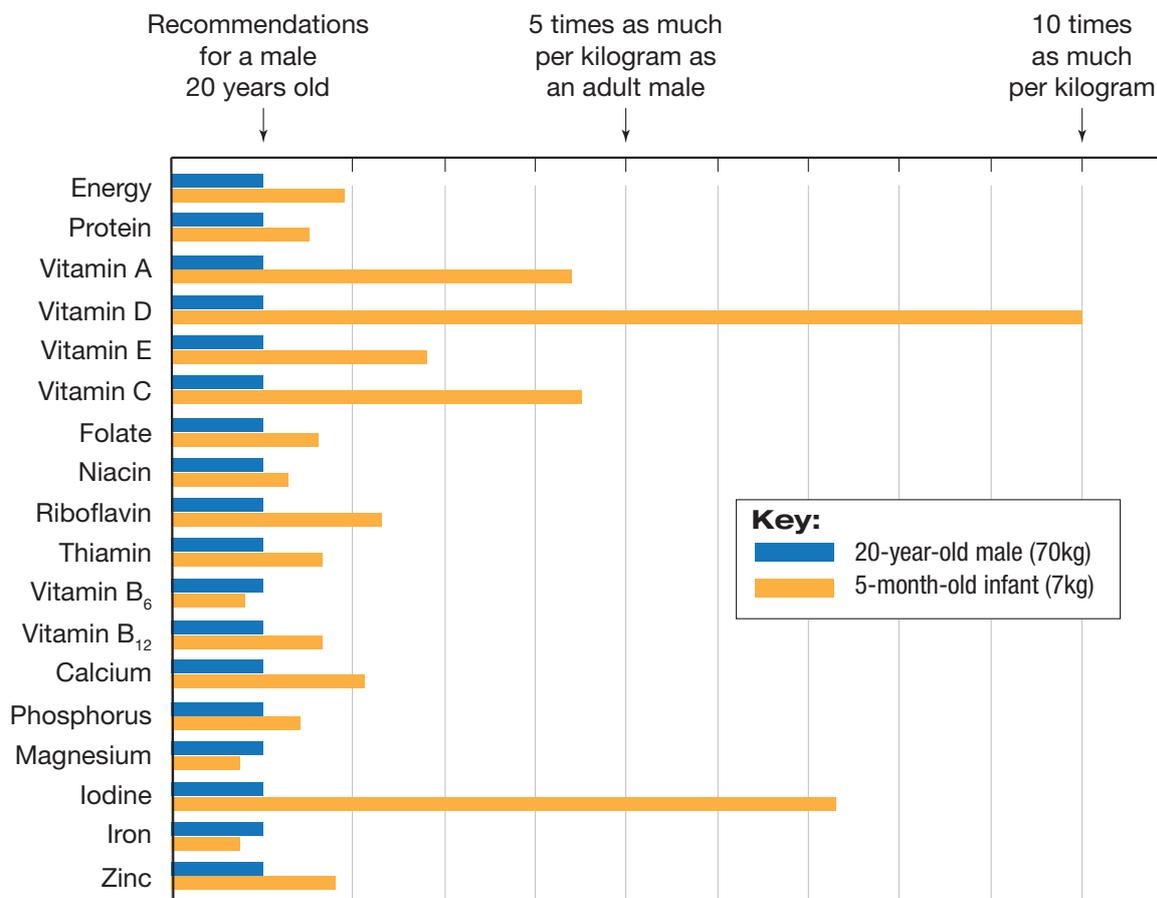


Figure 1.11.4: The recommended intakes of an infant and an adult, relative to body size.

Question

3. With reference to Figure 1.11.4, identify two nutrients where a five-month old infant requires between 5-10 times more per kilogram than an adult male.

.....
 (2 marks) (IAE3)

4. With reference to Figure 1.11.4, identify two nutrients where a 20-year old male would require more per kilogram than a five-month old infant.

.....
 (2 marks) (IAE3)

The two dietary practices that have the most significant effect on an infant's nutrition are the type of milk the infant receives and the age at which solid foods are introduced. **Breast** milk is recommended for healthy full-term infants where possible until at least six months of age. Breast milk excels as source of nutrients for an infant, where it supplies the required amounts of energy, macronutrients, micronutrients and water. Its protective **immunological factors** promote optimal development of the baby's immune system throughout the first year of life. If breastfeeding isn't possible, then an appropriate infant formula that imitates the nutrient composition of breast milk is an acceptable alternative.

Definition

Immunological factors are substances that play a role in the functioning of the immune system, for example, antibodies and white blood cells which are present in high amounts in colostrum, which is the first milk that comes out of the breasts after birth. There are antibodies in breastmilk the entire time a mother continues to nurse also.

Extension activity

Research and suggest at least five benefits of breastfeeding infants over bottle-feeding, and then five benefits of bottle-feeding infants over breastfeeding.

Benefits of Breastfeeding	Benefits of Bottle Feeding

From six months, solid foods should be introduced and given to the infant in conjunction with breast milk until 12 months. The purpose of introducing solid foods is to provide the needed nutrients that are no longer supplied adequately by breast milk or formula. The addition of solid foods should consider the infant’s nutritional needs, the infant’s physical readiness to chew and swallow different foods and the need to detect allergic reactions. If there is family history of allergic reactions, it is recommended that foods should be introduced individually and in small portions over a few days to identify any food allergies. It is also strongly recommended that infants should not be given foods high in sugar or salt, due to the sensitivity of their taste buds, which can potentially set them up for negative habits and promote obesity later in life. Full fat products should also be given, rather than low or reduced fat products also, as fat provides the energy and essential nutrients for growth and physical activity.

Extension activity

Infants and even young children cannot safely chew and swallow many foods, research some foods that should be avoided as they can easily choke on these foods.

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Science as a human endeavour (Development & Influence)

Formula – while “a safe, relatively affordable, thoughtfully designed, rigorously tested, and continually improving” alternative, according to paediatrician Dr. Kelly Fradin – cannot replicate all those benefits since it’s not made from human-made. Instead, it comes from cows, plants, or both. Plus, formula can be harder for the baby to digest and doesn’t adapt to the infant’s changing needs like breastmilk, according to the US Department of Health and Human Service’s Office on Women’s Health.

The founders don’t claim their future product will be identical to breast milk in every way – it won’t morph to a specific baby’s needs or offer the same protections for a baby’s immune system – but they do expect it to produce all 2,500-some components of human breast milk since a single cell, the human mammary epithelial cell, produces them all.

It could especially come in handy for dads, non-biological parents, or parents whose babies have food allergies and can’t tolerate breast milk after their birthing parent has eaten that allergen. She wouldn’t choose it over human breastmilk, though, due to its inability to transmit antibodies and build up the baby’s immune system.

Heather Guith, a Washington, DC, mum to a 1-and-a-half-year-old for whom nursing “mostly worked out,” told Insider she’s sceptical it will be even that. She said she would only choose it if it were priced similarly to formula – which Egger says it will be, at least eventually – or if her baby had a condition that didn’t allow them to digest formulas.

“Otherwise, I think it’s marketing itself as something it’s not and making really great parents feel bad about using formula because there might be a ‘better’ option.” Instead, they want to introduce another option into a decision that has thus far been mostly binary: breastfeed or use infant formula. A third option, using donor milk, is expensive and limited when accessed via a doctor’s prescription, and unregulated when accessed via a black market.

“We have had the same two solutions for like a hundred years now... and breastfeeding is wonderful, but it’s not always the best option for everyone. And mums deserve better mums and families deserve better,” Egger said.

“I think pretty much everyone is in agreement that the most important thing is to get fundamental nutrition right for an infant,” she said. “And if we have a new tool in our toolbelt that’s able to get us there faster or better than the existing options that are sold in the market today, then everyone should be wholeheartedly excited about it.”

Question

- 5. Discuss how this example above, demonstrates the key concept of Development and Influence. Provide two clear examples from the article above to demonstrate each key concept.

Development:

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Influence:

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(6 marks) (KA3)

Energy Requirements

An infant's energy requirements are remarkably high – approximately twice that of an adult, based on body weight. A newborn baby requires 1800-2000 kilojoules per day, which calculates to 420-450 kilojoules per kilogram of body weight per day. However, after six months, the infant's energy needs decline as growth rate slows. Some of the energy saved by slower growth is spent in increased activity.



Fast fact

Most adults require 8500 kilojoules per day, calculating to fewer than 170 kilojoules per kilogram of body weight. If an infant's energy needs were applied to an adult, a 70kg adult would require over 30,000 kilojoules a day.

Carbohydrates, fat, and protein are energy yielding and therefore are recommended based on the average intakes of healthy full-term infants fed breast milk in the first six months. During the second six months of life, recommendations are based on the typical intake from solid foods, as well as breast milk. Carbohydrates provide energy to all the cells of the body, especially those in the brain which predominantly rely on glucose as its fuel. An infant's brain is larger, relative to its body's size and therefore uses 60% of the total daily energy intake. Fat is energy dense and provides most of the energy in breast milk and standard infant formula, which supports the rapid growth of early infancy. Protein acts as a secondary energy source and should not be relied on due to its essential role acting as a basic building block of the body's tissues which are growing rapidly.

Childhood

After infancy is childhood (as shown in Figure 1.11.5), which includes toddlers, preschoolers and primary school-aged children.



Figure 1.11.5: The second stage of human lifecycle: childhood.

Physiological characteristics

- Aged between 1 and 12
- Steady, consistent growth (with intermittent mini growth spurts) until rapid growth with puberty, which starts around 10 years for females and 11 for boys
- Bones and muscles increase in mass and density
- Activity levels increase due to learning how to walk, run, talk, concentrate, jump and climb
- Hormone levels start to increase due to the onset of puberty, which varies for each individual. Puberty for girls usually begins between 10 and 11 years old and begins usually around 11 or 13 for boys

Nutritional Needs

During this stage of life, toddlers adjust from a diet of breastmilk or infant formula to a diet of adult foods. The nutrient needs of children increase with age, where a balanced diet is required to meet the needs of these nutrients. Growth and higher activity levels require extra energy, protein, low GI carbohydrates, fat (low-fat products are inappropriate for children under two years of age), calcium, vitamin D and iron. Ideally, children should be accumulating their stores of these nutrients and body fat in preparation for puberty by eating a wide range of foods. It is also essential as in infancy, that fruit juices, sugar-sweetened fluids, sugar, salt, and saturated fat are limited to prevent the development of childhood obesity. In addition, some children become fussy about the foods they eat, which can interfere with critical brain growth and development during this time. It is essential that parents promote nutritious choices and healthful habits by providing access to nutrient dense and delicious foods. This ensures that good habits are established at a young age to prevent the development of bad habits and potentially diet related disorders later in life.

Energy Requirements

Children's appetite begins to decline after the age of one, which is consistent with their slowing growth. A child's energy intake varies, depending on their growth and physical activity. Therefore, their required energy intake does increase slightly with age but declines gradually per kilogram of body weight.

Adolescence

Adolescence (as shown in Figure 1.11.6) is the life stage between childhood and adulthood.



Figure 1.11.6: The adolescent stage of the human lifecycle.

Physiological characteristics

- Aged between 13 and 18 years.
- The steady growth of weight and height in childhood speeds up abruptly and dramatically, which lasts for approximately two and a half years. On average, males grow 20cms taller and females grown 15cms taller. Males gain approximately 20kgs and females gain approximately 16kgs.
- During the adolescent growth spurt, differences between males and females become apparent in the skeletal system, lean body mass and fat stores, where fat accounts for a larger percentage of the total body weight in females and lean body mass (muscle and bones) increases much more in males than females.
- Hormone levels continue to increase due to puberty (which generally starts at the end of childhood). This determines the growth spurt of an adolescent, affecting the shape of their body and every organ in their body (including the brain).
- Blood volume increases due to rapid growth spurt in height
- Muscles can increase in strength and size with puberty (dependent on physical activity)

Question

8. Identify by circling, which of the following situations in each row in the table below would require greater energy requirements in an adolescent.

Situation 1	Situation 2
Increase in physical Activity	Living a sedentary lifestyle
Being a 10-year-old female	Being a 10-year-old male
Developing greater adipose tissue	Developing greater lean body tissue
Being a 16-year-old female	Being a 16-year-old male
The onset of puberty	The completion of puberty

(5 marks) (KA2)

Adulthood

Adulthood (as shown in Figure 1.11.7) follows adolescence and is the longest of the life stages.



Figure 1.11.7: The longest stage of the human lifecycle: adulthood.

Physiological characteristics

- Ages 18 to 65 years.
- Growth ceases (most females have already stopped growing by adulthood, and most males stop around age 20).
- Activity levels decrease.
- Lean muscle mass and bone density slowly decrease after approximately 30 years of age, while body fat steadily increases.

Nutritional Needs

The slowing down of physiological changes in this life stage results in lower nutritional requirements per kilogram. However, during this stage an increased prevalence of overnutrition and undernutrition diseases occurs, therefore foods rich in fibre, iron and calcium should be included while saturated fats, sugar and salt should be reduced, including alcohol. It is recommended by the Australian Guide to Healthy Eating that a wide variety of nutritious foods from the five food groups should be consumed daily.

Energy Requirements

The average adult requires 8700kJ daily to maintain a healthy weight and to ensure the intake of all recommended nutrients are consumed. However, this is dependent on body composition, physical activity, and gender.

Elderly

Following adulthood is being elderly (as shown in Figure 1.11.8), the final stage of the human lifecycle.



Figure 1.11.8: The final stage of the human lifecycle: being elderly.

Physiological characteristics

- Ages 65 years and above.
- Activity levels continue to decrease, leading to a decline in lean muscle mass and bone density, while body fat continues to increase. This can lead to joint pain, arthritis, muscle weakness, limited mobility and increase the chance of falls and fractures.
- Bone resorption is greater than bone formation, further leading to a decline in bone density.
- Functioning of the immune system declines with age and can become compromised further with nutrient deficiencies; therefore, increasing the risk of illness and chronic disease.
- GI tract loses strength and elasticity with age, slowing its motility and making constipation more common.
- Appetite diminishes due to hormonal changes, leading a decreased energy intake and weight loss.
- Tooth loss and gum disease are common in old age, making chewing of hard foods (e.g. red meat) difficult and painful. Dentures may be fit; however, these are still less effective than natural teeth.
- Sensory losses, such as failing eyesight and diminishing of taste buds.
- Psychological changes, including dementia, depression, loss of motivation.

Fast fact

The population of Australia is growing older, and the ratio of elderly people to younger people is increasing. In 2014, approximately 14.7% of Australians were elderly, however projections for 2050 indicate that one in four Australians will be over the age of 65. Since 1950, the population of those over 65 has almost tripled.

Extension activity

Suggest two reasons why this life stage is the fastest growing group in Australia, caused by the lengthening of life expectancy.

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Nutritional Needs

Nutritional needs of elderly are difficult to determine due to individual differences, such as genetics, chronic diseases, and the administration of various medicines. However, nutrients of greatest concern include, water, protein, carbohydrates, fibre, fat, vitamin D, calcium, and iron.

Dehydration is a risk for older people, as they do not seem to feel thirsty or notice a dry mouth and their total body water decreases with age. Therefore, to prevent dehydration, older people need to drink at least six glasses of fluid a day. Protein is essential to obtain from high quality sources, including lean meats, poultry, fish and eggs, legumes, and low-fat dairy products. This macronutrient is important to support a healthy immune system, prevent muscle wasting and optimise bone mass. However, high quality protein sources can be difficult to chew due to poor dental health leading to a reduced intake of these foods causing a deficiency. Carbohydrates are needed to protect protein from being used as a secondary source of energy. Sources of complex carbohydrates include legumes, vegetables, whole grains, and fruits, which are also good sources of fibre. The consumption of fibre and water is essential to alleviate constipation. Fat intake needs to be moderate, enough to provide for its important roles in the body and prevent significant weight loss, but not so much to increase the risk of obesity and atherosclerosis. Vitamin D deficiency can be a problem in elderly as they are often less exposed to sunlight and the ability to produce vitamin D and convert it into its active form is reduced with age. As well as this, calcium intakes of older people are below the recommendations as dairy products can be avoided because they are disliked or cause stomach discomfort. However, an increase in the intake of vitamin D and calcium are essential to improve bone strength and reduce the severity of osteoporosis. Iron deficient anaemia is less common in elderly than in younger people, especially females as menstruation ceases. However, iron deficiency may develop in older people if their energy intake is low, they experience chronic blood loss from diseases or suffer from poor iron absorption. Therefore, it is important for older people to take iron supplements, consume haem iron sources and include vitamin c rich foods in their diet.

Energy Requirements

The energy requirements decline an estimated 5% per decade beyond the age of 50. The main reason for this is because people usually reduce their physical activity as they age. Another reason is that their basal metabolic rate declines 1 to 2 percent per decade, due to lean body mass diminishes. Therefore, with limited energy allowances, it is essential that older individuals consume mostly nutrient dense foods rather than foods with added sugars and high in saturated fat.

Pregnancy & Lactation

Pregnancy can be broken into three trimesters: trimester one is the first three months (or weeks one to 12), trimester two is from three to six months, (weeks 13 to 27) and trimester three, the last trimester, is from six to nine months (weeks 27 to 40, the average duration of pregnancy). A female can become pregnant during her menstruating years (as shown in Figure 1.11.9). Lactation, also known as breastfeeding, is the life stage that follows the birth of a child. It describes the period where a mother secretes milk from the mammary glands in her breasts to feed her infant. The mammary glands develop during puberty but remain fairly inactive until pregnancy.

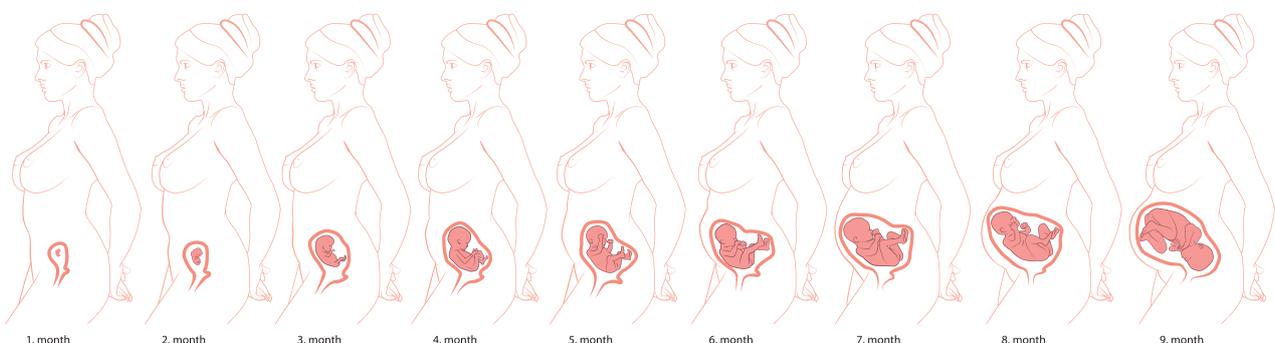


Figure 1.11.9: The stages of pregnancy and changes that occur in a female's body.

Physiological characteristics

- Weight gain of around 10 to 13 kg during pregnancy (dependent on pre-pregnancy weight).

Fast fact

When a baby is born, it typically weighs between 2.5 and 4 kg. The remainder of pregnancy weight gain is from uterus, blood volume and breast-size increases, plus the placenta, amniotic fluid surrounding the fetus in the womb, body fluid, and body fat.

- Morning sickness (nausea and vomiting), especially during the first trimester.
- Activity levels tend to decrease, particularly in trimesters two and three, although recommendations are to continue pre-pregnancy exercise, or begin regular exercise if sedentary, taking precautions as to exercise type and intensity
- Times of intense development and rapid cell division are commonly in the first 12 weeks (as shown in Figure 1.11.10).
- Postpartum (period after childbirth) physiological changes, e.g. uterus reducing in size, return the mother to pre-pregnancy characteristics.
- Generally, a reduction in the body fat gained during pregnancy is experienced during lactation.

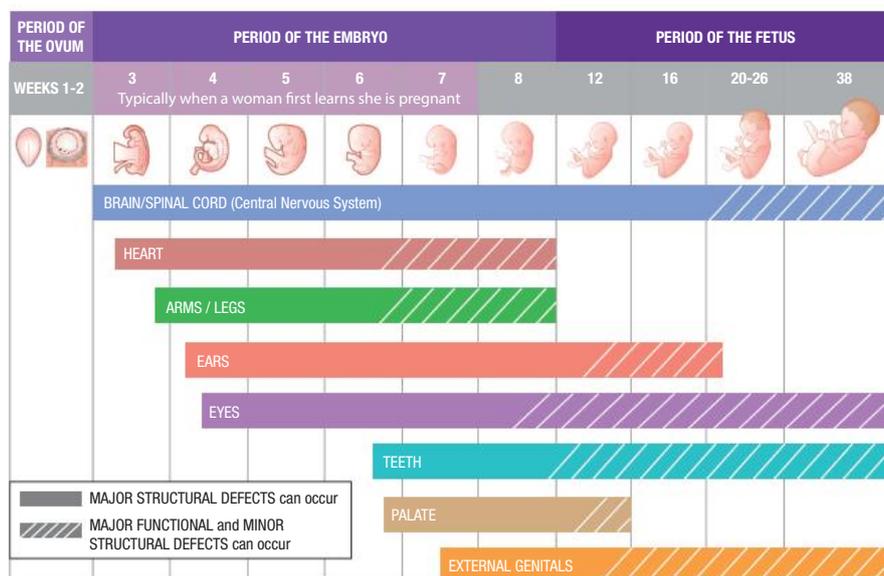


Figure 1.11.10: The critical periods of development, where deficiencies can cause major structural defects that are irreversible and in the later stages of development nutrient deficiencies can be less critical and relatively minor or reversible.

Nutritional Needs

From conception to birth, all parts of the infant's bones, muscles, organs, blood cells, skin and other tissues are made from the nutrients in the food that the mother consumes. For most women, nutrient needs during pregnancy and lactation are the highest than at any other time. It is crucial for a woman to make careful food choices to ensure she meets these higher nutrient requirements (as shown in Figure 1.11.11); however, her body will also assist in maximising nutrient absorption and minimising losses.

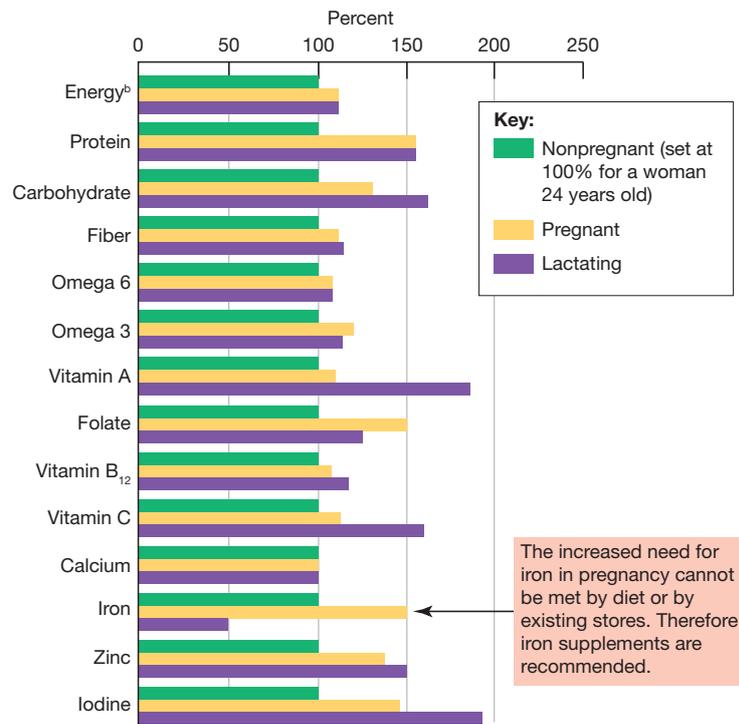


Figure 1.11.11: Comparison of nutrient recommendations for non-pregnant, pregnant and lactating females.

Pregnant women need to increase their consumption of carbohydrates to ensure adequate fuel is provided for the growth and development of the foetus. Essential fatty acids are important for the growth, function, and structure of the foetus' brain as it is largely made of lipid material. Folate, Vitamin B₁₂, Iron and Zinc play a key role in the synthesis of DNA and new cells and to support a female's enlarged blood volume. Iodine regulates the thyroid gland which maintains metabolic processes, including growth and energy use. An insufficient intake of vitamin D, calcium, phosphorus, magnesium, and fluoride may produce abnormal foetal teeth and bones. Pregnant women who make wise food choices can meet most of their nutrient needs, with the possible exception of iron, calcium, and folate.

Lactating females require additional intake of most nutrients also; however, if she fails to get enough in her diet, the quantity of her breast milk may reduce but not the quality. The quality of breast milk is maintained at the expense of the mother's nutrient stores. Therefore, women can still produce high quality breast milk with an inadequate intake of protein, carbohydrates, fat, most minerals, and Folate. However, the female may experience symptoms of these nutrient deficiencies. The nutrients in breast milk that are most likely to decline in response to long term inadequate intake includes vitamins A, D and B₁₂ especially. However, most women can obtain all nutrients they need from a well-balanced diet and some supplementation to refill their depleted stores. As well as this, lactating mothers need to consume an additional 500ml of water each day to compensate the water lost through her breast milk.

Energy Requirements

The enhanced work of pregnancy and lactation increases the female's basal metabolic rate and requires additional energy. An additional 1400kJ per day are required during the second trimester and an additional 1900kJ per day are required in the third trimester. A woman should choose to consume more nutrient dense foods to supply these extra kilojoules, rather than consuming energy dense foods. This not only ensures that energy requirements are met, but also nutrient requirements. Foods such as wholegrain breads and cereals, legumes, dark green leafy vegetable, citrus fruits, low-fat milk and milk products, lean meats, fish, poultry, and eggs should be chosen.

A nursing mother produces approximately 750ml of milk per day, which can vary from woman to woman and in the same woman from time to time. To produce an adequate supply of milk, a woman requires an additional 2000kJ a day above her regular needs. Women lactating require the same intake of protein and fat than they did during pregnancy; however, additional carbohydrates are recommended. An increase in carbohydrate intake is needed to replace the glucose used to make the lactose in breast milk.



Extension activity

Physical activity demands carbohydrates and fat for fuel, protein to build and repair lean body tissues, vitamins and minerals to support both energy metabolism and tissue building, and finally, water to assist with the distribution of fuels and to disperse the resulting heat and wastes.

Research and suggest what nutrients are crucial for an athlete involved in endurance sports and high intensity training should consume, before, during and after their physical activity. Provide reasons for the suggested nutrients and recommend a meal that caters for your suggestions also.

Endurance Athlete:

	NUTRIENT/S	REASONS	POSSIBLE MEAL
BEFORE			
DURING			
AFTER			

High Intensity Athlete:

	NUTRIENT/S	REASONS	POSSIBLE MEAL
BEFORE			
DURING			
AFTER			

(b) With reference to the graph, outline the implications of introducing cow’s milk to an infant within the first 12 months in replacement of human breast milk.

..
..
..
.. (2 marks) (KA2)

3. Explain why a lactating female is at greater risk of developing a diet related deficiency, than a female who feeds their baby formula. Use a nutrient as an example in your response.

..
..
..
..
..
.. (3 marks) (KA2)

4. Elenor is a 75-year old, recently widowed woman who has a limited income. She lives alone and does not have any family nearby. Elenor is slightly underweight and severe osteoporosis, which limits her mobility.

Identify three barriers to Elenor meeting her nutritional needs and describe a strategy that will assist her to overcome each of these barriers.

Barrier:
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Strategy:
.
.
.. (3 marks) (KA2)

Barrier:
.
Strategy:
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.
.. (3 marks) (KA2)

Barrier:
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Strategy:
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.. (3 marks) (KA2)

7. Explain why older people are at greater risk of the following diet related disorders, in relation to their age and physiological characteristics.

(a) Constipation

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..
..
.. (2 marks) (KA2)

(b) Iron deficient anaemia

..
..
..
.. (2 marks) (KA2)

(c) Osteoporosis

..
..
..
.. (2 marks) (KA2)

8. A breastfed baby presents as being underdeveloped at its 3-month checkup due to having an intolerance to cow's milk. Explain what changes would need to be made to the baby's diet and how this could impact the mother's health.

..
..
..
.. (2 marks) (KA2)

Total: _____ / 45 marks

Topic One Test

1. Refer to the following table.

	Daily intake (grams)	Daily recommended intake (percentage)
Carbohydrates	350	45-65
Protein	85	15-25
Lipids	120	20-30

(a) Calculate the total energy supplied by daily intake of macronutrients. Show all calculations and round off to nearest round number.

Total Energy provided: (4 marks) (KA4, IAE3)

(b) Calculate the percentage of energy provided by protein in the daily diet in the table above. Show all calculations and round to a whole number.

.....% energy provided by protein (2 marks) (KA4, IAE3)

(c) Using the data compare the actual protein intake with the recommended protein intake and formulate a conclusion about the suitability of this dietary intake if the diet was for a 10-year-old.

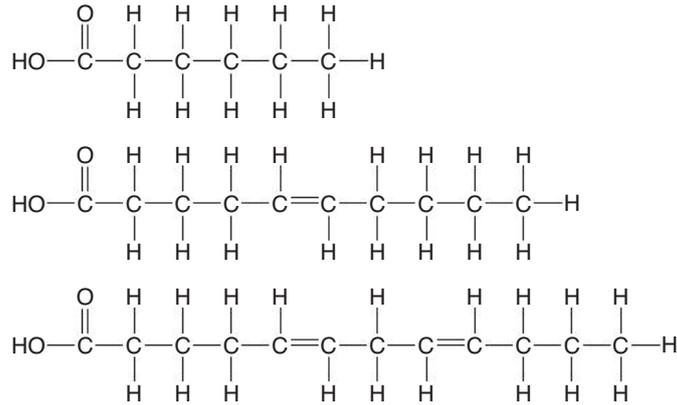
.....

 (2 marks) (IAE3)

2. State the type of saccharide the following carbohydrates are classified as:

Lactose: ..
 Fructose: ..
 Soluble Fibre: ..
 Galactose: .. (4 marks) (KA1)

3. Illustrated below are three different fatty acid chains. Name each fatty acid chain.



(3 marks) (KA1)

4. Samuel, a 40-year-old man with a sedentary lifestyle, weighs 125 kilograms and has a body mass index (BMI) of 40.

(a) Using the following information, calculate Samuel's total daily energy expenditure.

- Daily energy intake: 15,870 kJ
- Basal metabolic rate (BMR): 12,600 kJ
- Energy expenditure from daily activity: 580 kJ
- Thermic effect of food: 10% of daily energy intake

Total Daily Expenditure: (2 marks) (KA4)

(b) Calculate the difference between Samuel's daily energy intake and his total daily energy expenditure. State if it is a positive or negative energy balance, and the impact this will have on Samuel's weight in the long term if this pattern continues.

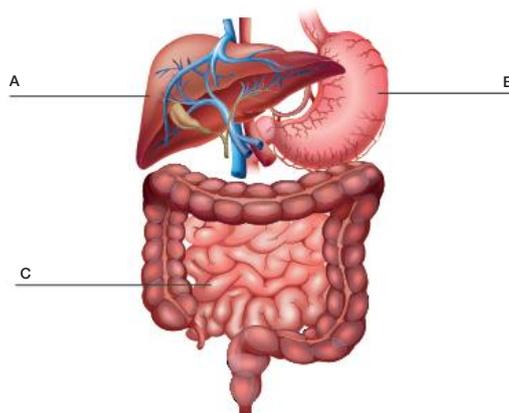
Energy Difference:

Energy Balance:

..... (3 marks) (KA4, IAE3)

5. Food must be digested in order for people to obtain essential macronutrients and micronutrients.

(a) Label the organs required for digestion as indicated on the image below.



(3 marks) (KA1)

(b) Explain the mechanical digestion of food in the mouth.

.....

.....

.....

(2 marks) (KA2)

(c) Explain the chemical digestion of one macronutrient in the mouth.

.. .. .

 (2 marks) (KA2)

6. Approximately 280 Australians develop type 2 diabetes every single year – this is one person every five minutes.

(a) Explain what type 2 diabetes is and explain its link to high sugar consumption.

.. .. .

 (2 marks) (KA2)

(b) Explain how the following symptoms may develop in a type 2 diabetic who does not manage their condition appropriately.

(i) Blurred vision

.. .. .

 (2 marks) (KA2)

(ii) Frequent urination and excessive thirst

.. .. .

 (2 marks) (KA2)

(iii) Fatigue

.. .. .

 (2 marks) (KA2)

(c) Explain how the glycaemic index and/or glycaemic load of foods containing carbohydrates can assist a type 2 diabetic in managing their blood glucose levels.

.. .. .

 (3 marks) (KA2)

7. Iron deficiency is the most common deficiency in the world.

(a) Explain the importance of iron in the human body and its role in the prevention of iron deficient anaemia.

.. .. .

 (3 marks) (KA2)

(b) Identify one symptom that an individual with anaemia may experience and explain why these symptoms may develop.

..
..
..
.. (2 marks) (KA2)

8. Arthur frequently experiences constipation, which causes severe abdominal cramps and bloating.

(a) Which diet-related disorder is Arthur likely to be suffering from? (1 mark) (KA1)

(b) Increased consumption of soluble fibre can assist in the management and prevention of the diet-related disorder identified in 10(a).

(i) Explain how and where soluble fibre is broken down in the body. (2 marks) (KA2)

(ii) Explain one way that soluble fibre can help prevent constipation. (2 marks) (KA2)

(iii) Provide two specific examples of foods that are high in soluble fibre.
(1)
(2) .. (2 marks) (KA1)

9. Smoking and alcohol are two risk factors for the development of hypertension. Choose one of these risk factors and explain how it might contribute to hypertension.

Risk Factor:
Explanation:
.. (2 marks) (KA2)

10. The ingredients of banana bread are listed below:

- self-raising flour • brown sugar • cinnamon
- plain flour • rolled oats • bananas
- eggs • skim milk • butter

(a) Several of the ingredients are a concern for a person who has coeliac disease. Identify one of these ingredients and explain why it is a concern. (2 marks) (KA2)

(b) Explain why a person who has coeliac disease is at risk of developing nutrient deficiencies. (2 marks) (KA2)

11. Refer to the following recipe for lasagne served with chips:

Lasagne

Ingredients

- 2 tablespoons olive oil
- 300 g button mushrooms
- 350 g pork and veal mince
- 500 g Napoletana sauce (see below)
- 4 lasagne sheets
- 530 g Béchamel sauce (see below)
- $\frac{2}{3}$ cup grated pizza cheese

Method

- Prepare according to recipe instructions.
- Bake at 200°C in a greased baking dish 17 × 28 centimetres and 5 centimetres deep for 45 minutes until golden brown.

Napoletana sauce

Ingredients

- 2 tablespoons olive oil
- 1 onion
- 3 cloves of garlic
- 1.5 kg tomatoes
- 1 tablespoon tomato paste
- 1 teaspoon sugar
- 2 bay leaves

- Prepare according to recipe instructions.

Béchamel sauce

Ingredients

- 60 g butter
- $\frac{1}{3}$ cup plain flour
- 4½ cups full-cream milk
- 75 g Parmesan cheese
- $\frac{1}{4}$ teaspoon salt
- pinch of ground nutmeg

- Prepare according to recipe instructions.

Potato chips

Ingredients

- 2 medium potatoes
- vegetable oil for deep-frying
- 2 teaspoons salt
- 1 teaspoon cracked pepper

- Peel potatoes and cut into thin shoestring fries.
- Deep-fry in hot oil until crisp and golden.
- Sprinkle with salt and pepper.

(a) Recommend two substitutions to the ingredients that would improve the lasagne recipe for a person with cardiovascular disease (CVD).

(1).. .. . (2 marks) (KA2)

(2).. .. .

(b) Describe one modification to the method that would make the recipe for potato chips more suitable for a person with CVD.

.. .. .

.. .. .

.. .. .

.. .. . (2 marks) (KA2)

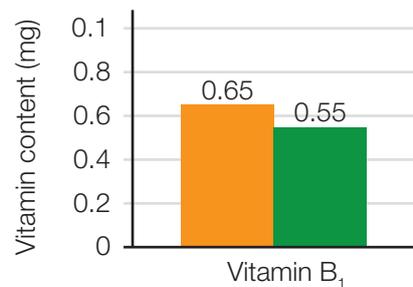
12. Students investigated the effect of boiling vegetables.

They compared the vitamin content of raw broccoli with that of the broccoli after it was boiled.

Refer to the following graph, which shows the amount of vitamin B1 and vitamin E lost from broccoli during boiling:

Vitamin loss in broccoli during boiling

■ raw broccoli ■ cooked broccoli



(a) State the dependent variable.

.. .. . (1 mark) (IAE3)

(b) Identify one factor that must remain constant during this investigation and explain why.

..
..
..
.. (2 marks) (IAE3)

(c) Using data from the graph, state the effect of boiling on the Vitamin B1 content of the broccoli and explain why this effect has occurred when boiling broccoli.

..
..
..
.. (2 marks) (IAE3)

(d) State how vitamin B is excreted from the human body.

.. (1 mark) (IAE3)

(e) State one function in the human body and specific food source of vitamin B₁.

Function:
Food Source: (2 marks) (KA1)

13. Read the following case notes of different patients that present to you, their dietitian, and answer the corresponding questions.

(a) A 55-year-old male describes his symptoms: he always has a headache and feels fatigued; yesterday, he found blood in his urine. You take his blood pressure reading and find it is 150/90.

(i) Identify what diet-related disorder you think this male may have.

.. (1 mark) (KA2)

(ii) State what his blood pressure reading should be and explain what each value of his blood pressure reading represents.

..
..
..
.. (3 marks) (KA2)

(iii) Identify one possible consequence that could develop if he fails to manage his condition.

.. (1 mark) (KA2)

(b) A 59-year-old female has suffered a heart attack and has been fortunate to survive and suffer minimal side effects. She explains that prior to her heart attack she experienced some chest pain and difficulty sleeping. She also explains that her diet consisted mainly of foods high in fat and sugar. She rarely exercised, as she lacked time due to her stressful work demands. After your consultation with her, you have identified her as overweight and at risk of becoming obese if she continues her eating and lifestyle patterns.

(i) Identify the type of cardiovascular disease she experienced.

.. (1 mark) (KA2)

(ii) Explain how her diet high in saturated fat could have contributed to the development of this type of cardiovascular disease.

..
..
..
.. (2 marks) (KA2)

(iii) Identify two contributing lifestyle risk factors.

- (1)
- (2) (2 marks) (KA1)

(c) An 85-year-old female knocks into something and breaks her hip. She is confused why her injury is so severe after such a simple knock.

(i) Identify what diet-related disorder you think this elderly female may have.
 (1 mark) (KA2)

(ii) Explain why her age is a risk factor for the development of this diet-related disorder.

 (2 marks) (KA2)

(iii) Identify one mineral she should increase her intake of to reduce the severity of this diet-related disorder.
 (1 mark) (KA1)

(iv) Suggest one specific food or beverage source that this female should increase her consumption of to assist in the management of her condition. Suggest a food or beverage source she should decrease consumption of.
 Increase: ..
 Decrease: (2 marks) (KA1)

(d) A 57-year-old male is 161 cm tall and weighs 115 kg. He is a smoker and does not like to exercise; however, he does have a slightly active job. His diet consists of a lot of processed foods and takeaway. The average reading of his blood glucose levels is 10.2 mol/L and his blood pressure reading is 148/89.

(i) (i) Identify two diet-related disorders this male is at risk of developing or may already have.

 (2 marks) (KA2)

(ii) Suggest one diet and one lifestyle modification that would be recommended for this male to improve his habits.
 Diet: ..
 Lifestyle: (2 marks) (KA1)

(iii) Explain why this male may experience a stroke, due to his diet and lifestyle habits and the symptoms he is currently exhibiting.

 (2 marks) (KA2)

Total: _____ / 90 marks

Topic 2: Health promotion and emerging trends

2.1 Diagnostic tools

Science understanding

Diagnostic tools assist individuals and health professionals in evaluating health and diet:

- Body mass index (BMI)
- The limitations, advantages and disadvantages of using the BMI compared to one of the following: waist circumference, waist-to-hip ratio, weight for height tables, blood analysis, Nutrient Reference Values (NRV's).

SACE Subject Outline, 2020.

2

Anthropometry Diagnostic Tools

A **diagnostic tool** or test is a measure to help determine whether someone is at risk of a particular health condition. **Anthropometry** refers to measurements of the human body. Anthropometric measurements are used to assess size (e.g. height), shape and body composition (e.g. percent body fat). They can also be used on children to assess growth. Anthropometry can be used for diagnosing malnutrition, overweight or obesity and when there is an increased risk of **over-nutrition diseases associated with obesity**. Common measurements include BMI (body mass index), waist circumference and waist-to-hip ratio.

Definition

Overnutrition diseases associated with obesity can also be termed weight-related or obesity-related diseases or chronic nutritional diseases.

Question

1. Name the typical body shape of a female and male when obese:

Male: (1 mark) (KA1)

Female: (1 mark) (KA1)

Body Mass Index (BMI)

BMI offers a way to assess whether an adult's weight is in a healthy range for their height. It is calculated by dividing body weight (in kilograms) by height (in meters squared) and is expressed in units of kg/m².

$$\text{Body Mass Index} = \frac{\text{weight (kg)}}{\text{height (m}^2\text{)}}$$

The result of the calculation is used to indicate whether someone is underweight, healthy weight, overweight or obese (see Figure 2.1.1):



Figure 2.1.1: BMI classifications

BMI/weight classification can then be used to assess the risk of obesity-related diseases such as CVD and Type 2 Diabetes (normally in conjunction with further assessments).

Extension activity

The continuum on the previous page shows BMI/weight categories as per recommendations of the Heart Foundation of Australia. Other countries may categorise each BMI range further. List some additional categories and their BMI ranges.

.....

.....

.....

Questions

2. (a) Calculate the BMI of a 38-year-old female with a body mass of 59kg and height of 1.68m. Show the formula and round the answer to the nearest whole number:

Formula = (1 mark) (KA1)

BMI = kg/m² (1 mark) (KA2)

(b) State the BMI/weight classification of the female using Figure 2.1.1.

(1 mark) (IAE3)

3. (a) Calculate the BMI of a 55-year-old male with a body mass of 99kg and height of 172cm. Show working and round the answer to the nearest whole number:

BMI = kg/m² (2 marks) (KA2)

(b) State the BMI/weight classification of the male using Figure 2.1.1.

(1 mark) (IAE3)

Although BMI is widely used in Australia, it has a number of disadvantages and limitations along with its advantages.

Advantages	Disadvantages	Limitations	Extension Activity
<ul style="list-style-type: none"> • inexpensive • non invasive • equipment is easy and straight forward to use • not very time consuming 	<ul style="list-style-type: none"> • BMI is only an estimate (it doesn't take into account age, ethnicity, gender and body composition; see limitations) • requires a calculation • recording of height and weight can be inaccurate and misleading if the equipment is poor or if improper techniques are used, for example weighing someone on an uneven surface 	<ul style="list-style-type: none"> • pregnant women • the elderly • people with a physical disability • people under 18 years • BMI does not distinguish between the fat or muscle when looking at body weight. It is therefore less accurate in certain groups who may genetically have a different body shape/muscle fat balance, including: <ul style="list-style-type: none"> > Torres Strait Islander people, Maoris, Aboriginals, and Asian populations > body builders > some high performance athletes 	

Definition

A non-invasive diagnostic test means that it does not cut the skin or enter the body

Extension activity

Alongside each group that BMI is not as accurate for (see limitations above), state if BMI ranges are accepted as being slightly higher, lower or NA (not applicable - not able to calculate BMI, or compare to the norms for the group).

Questions

5. (a) State the BMI category for a 30-year-old female who weighs 40kg and is 1.60m tall, using Figure 2.1.2.

..... (1 mark) (IAE3)

(b) State the BMI category for a 25-year-old male with a height of 5'9" and body mass of 80kg, using Figure 2.1.2.

..... (1 mark) (IAE3)

Weight-for-height charts also exist for children and infants and BMI classifications for the obese category are available for children. However, it is not always easy to tell if a child is a healthy weight for their age and height due to growth rates differing for individuals.

Extension activity

Have a look at some stature/height-for-age and weight-for-age percentile charts for children and infants used to monitor growth and explore how to interpret them.

Extension activity

The advantages, disadvantages and limitations of using BMI and weight-for-height tables/charts have many similarities. Transfer those that are applicable from the BMI section to the diagram below.

Advantages	Disadvantages	Limitations

Waist circumference

Measuring **waist circumference** is used to check if someone is carrying **excess body fat around the abdomen**.

Reminder

Excess body fat around the abdomen is called visceral fat

It is found by measuring around the waist, half way between the lower rib and top of the hipbone (or roughly in line with the belly button), after breathing out normally. For men, a waist circumference of 94cm or greater indicates an increased risk of weight-related overnutrition diseases, while 102cm or greater is a highly increased risk. For women, 80cm or more is an increased risk and 88cm and over is a greatly increased risk (see Figure 2.1.3).

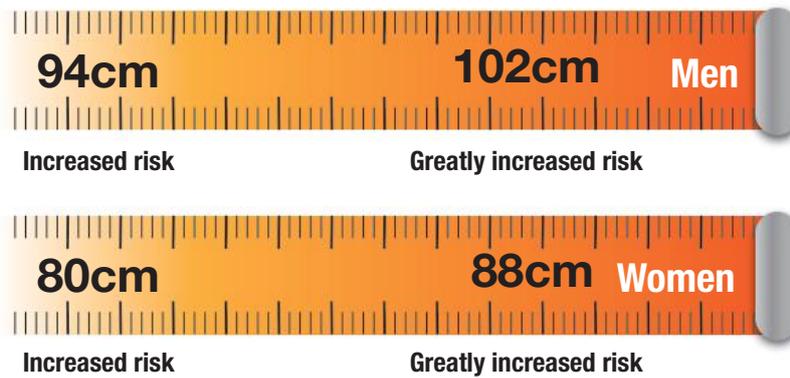


Figure 2.1.3: Waist circumference risk classifications.

2

For most adults, measuring 94cm and above for males and 80cm and above for females, is an indication that the level of visceral body fat deposits coating the heart, kidneys, liver, digestive organs and pancreas is too high. Excess visceral fat increases the risk of weight-related diseases. The larger the waist circumference, the higher the risk of developing nutritional diseases like CVD and Type 2 Diabetes.

Waist circumference is therefore another diagnostic tool that is useful in determining whether someone is at risk of an obesity-related overnutrition disease. However, it also comes with a number of limitations and disadvantages (see below).

Advantages	Disadvantages	Limitations
<ul style="list-style-type: none"> • inexpensive • non invasive • minimal equipment • simple to perform 	<ul style="list-style-type: none"> • measuring waist circumference can be inaccurate and misleading if improper techniques are used (a high level of training is required to achieve accurate measurements) 	<ul style="list-style-type: none"> • pregnant women • people under 18years • certain groups of people who may genetically have a different body shape, such as Aboriginal and Torres Strait islanders and Japanese adults

Fast fact

Measuring waist circumference requires a specialist to be accurate, even general practitioners (doctors) measure inaccurately, especially with overweight and obese patients when the halfway measurement (between top of the hip bone and lower rib) is difficult to find.

Question

6. List an advantage of using waist circumference in comparison to BMI to diagnose an increased chance of an overnutrition disease:

.....
 (1 mark) (KA2)

7. A medical student takes waist measurements of 10 patients with a BMI of 32 to find an average waist circumference for the obese category. State two possible sources of random error when taking the measurements and discuss how the error could impact upon the measurement:

Error one:
 (2 marks) (IAE4)

Error two:
 (2 marks) (IAE4)

Waist-to-hip ratio (WHR)

Using **waist-to-hip ratio** is another diagnostic tool to check if someone is carrying excess body fat around the abdomen and is therefore at risk of overnutrition diseases.

The WHR assesses whether the waist is wider than the hips (apple/android shape), or smaller than the hips (pear/gynoid shape). Waist circumference (W) is measured in cm (see waist circumference for measuring technique) and then divided by hip circumference (H) in cm ($W \div H$). Hip circumference is found by measuring around the point where the buttocks are the widest (see Figure 2.1.4).



Figure 2.1.4: Measurement of hip circumference.

Excess visceral fat and an increased risk for weight-related diseases is indicated by a WHR greater than:

- 0.9 for males
- 0.8 for females

Question

8. (a) (i) A female has a waist circumference of 61cm and a hip circumference of 78cm. Calculate her WHR:
 (1 mark)(KA2)
- (ii) Identify if the female is at risk of a chronic nutritional disease:
 (1 mark) (IAE3)
- (b) (i) A male has a hip circumference of 84cm and a waist circumference of 99cm. Calculate his WHR:
 (1 mark) (KA2)
- (ii) Identify if the male is at risk of a chronic nutritional disease:
 (1 mark) (IAE3)

Extension activity

The advantages, disadvantages and limitations of using the WHR are quite similar to using waist circumference as a diagnostic tool. Transfer those that are applicable from the waist circumference section to the diagram below.

Advantages	Disadvantages	Limitations

Extension activity

Name and discuss the purpose of some further anthropometric measurements.

.....

.....

.....

.....

Nutrient Reference Values (NRVs)

The NRVs (see Topic 1.1 for details of each of the NRVs) can be used by dietitians, nutritionists and other health professionals to assess the dietary needs of individuals and groups (for example residents of a nursing home). Although the values of NRVs are expressed daily, patients are typically assessed over 3 or more days, collecting information about what they eat and physical activity performed. Most health professionals in Australia utilise nutritional analysis computer software such as FoodWorks to analyse the information collected by patients in food dairies. Such software can generate actual intake of nutrients compared to the NRVs, with values lower than EAR useful in diagnosing deficiency diseases and higher than UL useful in diagnosing health concerns. RDIs tend to be the most commonly used value to correct nutritional intake of patients, giving a value to aim for.

For example, the RDI for iron for a woman aged 19-50 years is 18mg/day. The EAR is 8mg/day and the UL is 45mg/day. This can be interpreted as 8mg is the minimum a woman needs, 18mg is the average daily intake that should be aimed for and iron intake should remain below 45mg to avoid iron overload. Use this data to answer the following questions:

 **Reminder**
 EAR = Estimated Average Requirement; RDI = Recommended Daily Intake; UL = Upper Limit

Question

9. (a) List the Recommended Daily Intake (RDI) for fibre:
 (1 mark) (KA1)

(b) List the RDI for carbohydrate:
 (1 mark) (KA1)

Extension activity

Although FoodWorks is not available without subscription/payment, an alternate for personal use is FoodChoices (windows compatible only). Download from <http://www.foodchoices.com.au/> and explore how working with NRVs as a diagnostic tool works. Please note – this program is only available for personal use. School/class use requires subscription. Simpler versions of working with NRVs and food dairies are available from websites/apps such as MyFitnessPal, Cron-o-meter and Lose it.

Question

10. (a) Describe the suitability of a diet for a 33-year-old female with an iron intake averaging 6mg/day:

 (2 marks) (IAE3)
- (b) Diagnose a health concern that may develop should the female continue this diet:
 (1 mark) (KA2)
- (c) List two foods, from different food groups, that should be added to the diet of the female to increase the iron she consumes:
 (2 marks) (KA2)
- (d) The RDI of a woman aged 51+ drops to 8mg/day. Identify a reason for lower iron needs at this age:
 (1 mark) (KA2)

Unlike the anthropometry diagnostic tools, there are no limitations for collecting food diaries and analysing nutrient intake to diagnose potential deficiencies and excesses. There are however, a number of advantages and disadvantages:

Advantages	Disadvantages	Limitations
<ul style="list-style-type: none"> • Can test for a range of both nutrient deficiencies and excesses • Non-invasive 	<ul style="list-style-type: none"> • Nutrient analysis software may not be updated timely enough as NRVs are updated and new foods enter the market • Time consuming and costs may be involved (dietician/nutritionist) • NRVs for each age, gender and life stage are based on an average body weight • Quality of results is dependent on participant's accuracy in recording food intake and physical activity 	<ul style="list-style-type: none"> • Can be utilised by people of all ages, gender and life stages

Nutrient blood analysis

A blood test typically involves a small amount of blood being taken from a **vein in the arm using a hypodermic needle** (**finger prick** may be used in patients where it can be more difficult to draw blood; for example, infants) (see Figure 2.1.5). The blood is analysed in a laboratory with a purpose to uncover a nutrient deficiency or excess and then diagnose any associated health risks (using patient history and symptoms to assist the diagnosis). Beyond nutrient analysis, blood collection can also be used for a number of other roles, such as evaluating how well organs are functioning, detecting drug abuse or performing blood cell counts to diagnose immune system disorders.



Fast fact

The person collecting your blood is technically called a phlebotomist



Figure 2.1.5: Hypodermic needle being used to take a blood sample.

Question

11. Match the following blood analysis results to their associated health risk: (4 marks) (KA1)

Blood analysis result	Health concern
High LDL and triglyceride levels	Osteomalacia
Low Vitamin D	Type 2 Diabetes
Low folate	Coronary heart disease
Sustained elevated blood glucose after consumption of sugary beverage	Megaloblastic anaemia

Similar to the use of NRVs with dietary comparison, a wide range of nutrient imbalances can be uncovered and there are no limitations to who can undertake blood analysis. There are however, a number of advantages and disadvantages of nutrient blood testing:

Advantages	Disadvantages	Limitations
<ul style="list-style-type: none"> • Can test for a range of both nutrient deficiencies and excesses • Generally accurate, although 'false positives' (results suggest something is abnormal when it is not) and 'false negatives' (results return normal findings despite them actually being too high or too low) can occasionally occur. 	<ul style="list-style-type: none"> • Time consuming and costs may be involved (Doctor/Pathology laboratories) • Discomfort: some blood tests require fasting; pain, bleeding and bruising can occur at the site where blood is taken; some people can feel anxious/dizzy/faint prior to, during or after a blood test 	<ul style="list-style-type: none"> • Can be utilised by people of all ages, gender and life stages i.e. no limitations

Question

12. List a disadvantage of using the BMI rather than a blood analysis to diagnose an increased chance of an overnutrition disease:

(1 mark) (KA2)

Extension activity

List some factors that may cause false positive or false negative blood test results.

.....

.....

.....

.....

Extension activity

Extension activity: Discuss some further diagnostic tests doctors may perform to diagnose over or under nutrition diseases, such as urine tests.

.....

.....

.....

.....

.....

.....

.....

Summary

Utilising information about each diagnostic tool, it is possible to compare the limitations, advantages and disadvantages of using the BMI to each alternate diagnostic method. This comparison is presented in Table 2.1.1 on the following page.

Table 2.1.1: Advantages, disadvantages and limitations of using BMI compared to alternate diagnostic tools.

Diagnostic tool	Advantages compared to BMI	Disadvantages compared to BMI	Limitations compared to BMI
Height-for-weight charts	<ul style="list-style-type: none"> • Calculation not required 	–	–
Waist circumference	<ul style="list-style-type: none"> • Calculation not required • Fewer measurements needed (one vs two) • More accurate diagnostic tool for overnutrition disease risk for those with a higher muscle mass e.g. athletes, or the elderly with a reduced muscle mass with age (see limitations) • Less equipment required (no weight scales) 	<ul style="list-style-type: none"> • Higher likelihood of measuring waist circumference inaccurately compared to familiar height or weight measures (at home) 	<ul style="list-style-type: none"> • Limitation of lean muscle mass not being distinguished is removed due to this measure focusing on body fat distribution, not weight
Waist-to-hip ratio	<ul style="list-style-type: none"> • More accurate diagnostic tool for overnutrition disease risk for those with a higher muscle mass e.g. athletes, or the elderly with a reduced muscle mass with age (see limitations) • Less equipment required (no weight scales) 	<ul style="list-style-type: none"> • Higher likelihood of measuring waist and hip circumference inaccurately compared to familiar height or weight measures (at home) 	<ul style="list-style-type: none"> • Limitation of lean muscle mass not being distinguished is reduced due to this measure focusing on body fat distribution, not weight
NRVs	<ul style="list-style-type: none"> • More accurate • Range of nutrient levels could be looked at to confirm specific overnutrition diseases vs the general 'at risk' diagnosis from using BMI e.g. kJ balance, fat intake for obesity or types of each triglyceride and sodium for hypertension • Able to diagnose nutrient deficiencies and associated health concerns as well 	<ul style="list-style-type: none"> • Time consuming • More complex to obtain a diagnosis (recorded food intake for a few days vs some simple measurements/calculation) • Costly (if run via Dietician) 	<ul style="list-style-type: none"> • Unlike BMI, no limitations (food diaries can be completed at any age, gender, etc)
Blood analysis	<ul style="list-style-type: none"> • More accurate • Range of nutrient levels could be looked at to confirm specific overnutrition diseases vs the general 'at risk' diagnosis from using BMI e.g. total LDL & HDL cholesterol levels for CVD risk • Able to diagnose nutrient deficiencies and associated health concerns as well 	<ul style="list-style-type: none"> • Time consuming • More complex to obtain a diagnosis (recorded food intake for a few days vs some simple measurements/calculation) • Costly (if run via Dietician) • May involve discomfort in regards to needle/blood 	<ul style="list-style-type: none"> • Unlike BMI, no limitations

Key terms

Anthropometry	Nutrient Reference Values (NRVs)
Body Mass Index (BMI)	Weight-for-height charts
Diagnostic tool	Waist circumference
Nutrient blood analysis	Waist -to-hip ratio (WHR)

Review questions: 2.1 Diagnostic tools

1. (a) A 20-year-old male is 1.75m and 60kg. Identify his weight/BMI classification using Figure 2.11.2:
 ..
 .. (1 mark) (IAE3)
- (b) A 20-year-old female is 195cm tall. Using Figure 2.11.2, state the weight range for her to be classified as healthy.
 ..
 .. (1 mark) (IAE3)
- (c) List an advantage of using the height-for-weight chart of figure 2.1.2 instead of using BMI as a diagnostic tool.
 ..
 .. (1 mark) (KA1)
2. (a) Define body mass index (BMI):
 ..
 ..
 ..
 .. (2 marks) (KA1)
- (b) List two advantages, disadvantages and limitations of using the BMI as a diagnostic tool:
 Advantages: .. (2 marks) (KA1)
 Disadvantages: .. (2 marks) (KA1)
 Limitations: .. (2 marks) (KA1)
- (c) An experiment is performed on twenty 50-year-old men to find out the average BMI. To calculate BMI, scales should be used on a hard level surface, with a subject wearing light clothing and standing on the centre of the scales. The tape measure for height should be vertically taped to a hard wall with the subject standing straight with feet together and back to the wall. A ruler should be used to parallel on top of the head to find the height.
 - (i) Identify a possible source of systematic error in this experiment and discuss how it may affect the results:
 ..
 ..
 .. (2 marks) (IAE4)
 - (ii) Identify a possible source of random error and an improvement to reduce the impact of this error:
 ..
 ..
 .. (2 marks) (IAE4)

3. The following questions utilise the weight category tables as seen below:

Weight Categories	BMI (kg/m ²)
Underweight	< 18.5
Healthy Weight	18.5-24.9
Overweight	25-29.9
Obese	30-34.9
Severely Obese	35-39.9
Morbidly Obese	≥40

(a) Veronica is a 32-year-old female who weighs 88kg and is 154cm tall.

(i) Show the formula used to calculate BMI:

(1 mark) (KA1)

(ii) Calculate Veronica's BMI (round to the nearest whole number):

BMI = kg/m²

(1 mark) (KA2)

(iii) Identify Veronica's BMI/weight classification using the table above:

..... (1 mark) (IAE3)

(b) Veronica's mother weighs 90kg and is slightly shorter at 1.51m.

(i) Calculate her BMI and round to the nearest whole number:

BMI = kg/m²

(1 mark) (KA2)

(ii) Identify Veronica's mothers BMI/weight classification using the table above:

..... (1 mark) (IAE3)

4. George has a waist circumference of 104cm. Explain how this puts him at risk of developing either CVD or Type 2 Diabetes:

.....

 (2 marks) (KA2)

5. Waist circumference is a diagnostic tool used to determine if someone has excess visceral fat. Name a group of people who may find the accuracy of using waist circumference better in comparison to using the BMI:

..... (1 mark) (KA2)

6. (a) State the formula for WHR:
 (1 mark) (KA1)
- (b) (i) Calculate the WHR for a Susie who has a waist circumference of 61cm and a hip circumference of 79cm (round to two decimal places):
 (1 mark) (KA2)
- (ii) Identify whether Susie is at risk of CVD based on her WHR:
 (1 mark) (IAE3)
- (c) (i) Calculate the WHR for a Wayne who has a waist circumference of 112cm and a hip circumference of 88cm (round to two decimal places):
 (1 mark) (KA2)
- (ii) Identify whether Wayne is at risk of Type 2 Diabetes based on his WHR:
 (1 mark) (IAE3)
- (d) Describe a disadvantage of using the WHR instead of the BMI in diagnosing obesity :
 (2 marks) (KA2)

	Age	EAR	RDI	UL
Men	19-30 years	840 mg/day	1,000 mg/day	2,500 mg/day
	31-50 years	840 mg/day	1,000 mg/day	2,500 mg/day
	51-70 years	840 mg/day	1,000 mg/day	2,500 mg/day
	>70 years	1,100 mg/day	1,300 mg/day	2,500 mg/day
Women	19-30 years	840 mg/day	1,000 mg/day	2,500 mg/day
	31-50 years	840 mg/day	1,000 mg/day	2,500 mg/day
	51-70 years	1,100 mg/day	1,300 mg/day	2,500 mg/day
	>70 years	1,100 mg/day	1,300 mg/day	2,500 mg/day

Table 2.1.2: NRVs for calcium in adulthood

Refer to Table 2.1.2 to answer the following questions:

7. (a) Explain why calcium EAR and RDI increases at 51-70 for female compared to at 70+ for men:
 (3 marks) (KA2)
- (b) (i) A 32-year old vegan woman is consuming an average of 700mg of calcium a day. Using data from the table above, discuss the suitability of her diet:
 (2 marks) (IAE3)

- (ii) Diagnose a condition that may result should this calcium intake continue for an extended period of time:

..... (1 mark) (KA2)

8. A doctor ordered lipoprotein blood tests for a 72-year-old man presenting with chest pain upon getting up in the morning or when out walking the dog. Pathology results returned a total cholesterol level of 212 mg/dL, HDL 59mg/dL and LDL of 187mg/dL. The doctor compared the man’s pathology results with the following table :

Total cholesterol level	Total Cholesterol Category	LDL Cholesterol Level	LDL Cholesterol Category	HDL Cholesterol Level	HDL Cholesterol Category
Less than 200 mg/dL	Desirable	Less than 100 mg/dL	Optimal	60 mg/dL and above	Considered protective against heart disease
		100–129 mg/dL	Near optimal/above optimal	40–59 mg/dL	Above optimal
200–239 mg/dL	Borderline high	130–159 mg/dL	Borderline high		
240 mg/dL and above	High	160–189 mg/dL	High	Less than 40 mg/dL	A major risk factor for heart disease
		190 mg/dL and above	Very high		

(a) Identify the cholesterol categories of the patient using the table above:

Total cholesterol category: (1 mark) (IAE3)

HDL cholesterol category: (1 mark) (IAE3)

LDL cholesterol category: (1 mark) (IAE3)

(b) Discuss the suitability of the patient’s total cholesterol levels using data from the table above:

..... (2 marks) (IAE3)

(c) Name a disease that the doctor would diagnose based on the blood test results and symptoms presented by the 72 year-old man:

..... (1 mark) (KA2)

(d) The patient could have done a BMI test at home to diagnose his risk for overnutrition disease, instead of the blood tests.

(i) List an advantage and limitation that is applicable to the patient for using the BMI as a diagnostic tool instead of getting blood tests:

..... (2 marks) (KA2)

(ii) List an advantage of going to the doctors to have blood tests instead of calculating one’s BMI:

..... (1 mark) (KA2)

Total: _____ / 45 marks

2.2 Educational aids for food selection

Science understanding

Educational aids are available to help improve individuals dietary patterns and health

- importance of government dietary guidelines such as the Australian Dietary Guidelines and the Australian Guide to Healthy eating
- social marketing campaigns and programs about adopting healthy nutrition behaviour
- food models (e.g. Canadian model compared to the Australian Guide to Healthy Eating or the Aboriginal and Torres Strait Islander Guide to Healthy Eating)

SACE Subject Outline, 2020.

Australian Dietary Guidelines

The [Australian Dietary Guidelines \(ADGs\)](#) are aimed to provide dietary patterns that will enable people to get sufficient amounts of the essential nutrients for good health and help reduce the risk of over-nutrition diseases such as obesity, CVD and Type 2 Diabetes. The ADGs can help adults choose wisely from the wide variety of foods and drinks available in Australia. The current ADGs are:



Fast fact

The Australian Dietary Guidelines (ADGs) were developed based on the NRVs

Guideline 1:

To achieve and maintain a healthy weight, be physically active and choose amounts of nutritious food and drinks to meet your energy needs.



Fast fact

Although the guidelines are numbered 1 to 5, this numbering does not indicate importance, the guidelines are equally as important as each other.

Question

1. The energy needs for a typical 25-year-old man are around 8700 kJ. Identify the type of energy balance should 10000 kJ of energy be consumed in a day.

(1 mark) (KA2)

Guideline 2:

Enjoy a wide variety of nutritious foods from these five food groups every day:

- Plenty of vegetables of different types and colours, and legumes/beans
- Fruit
- Grain (cereal) foods, mostly wholegrain and/or high cereal fibre varieties, such as breads, cereals, rice, pasta, noodles, polenta, couscous, oats, quinoa and barley
- Lean meats and poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans
- Milk, yoghurt, cheese and/or their alternatives, mostly reduced fat.

And drink plenty of water.



Science as a human endeavour (Application and Limitation)

Is an update of the Infant feeding guidelines needed?

The ADGs can't be applied to babies. Its creators, the National Health and Medical Research Council (NHMRC) have therefore also developed the Infant Feeding Guidelines (IFG). The guidelines specify solid foods to be introduced from around 6 months (see: <https://www.nhmrc.gov.au/about-us/publications/infant-feeding-guidelines-information-health-workers> and download the summary document). There has been public debate however, over whether this recommendation should be reduced to around 4 months of age or remain at 6 months. Scientific literature exists supporting both age options.

Questions

7. Complete the table by presenting information that supports either side of the public debate: introducing solid foods at 4 months vs 6 months. Use the articles of the websites listed below to research and make arguments in regard to allergic reactions, nutrient levels, risk of illness and other other findings you may come across of interest.

Factor	Arguments pro 4 months	Arguments pro 6 months
Allergic reactions		
Nutrient levels		
Risk of illness		
Other		

(8 marks) (KA3)



Helpful online resources

<https://theconversation.com/introduce-eggs-and-peanuts-early-in-infants-diets-to-reduce-the-risk-of-allergies-65564>



<https://www.breastfeeding.asn.au/bf-info/weaning-and-introducing-solids/solidsconfusion>



Australian Guide to Healthy Eating (AGHE)

The AGHE is an extension of the ADGs. It summaries the guidelines visually (see Figure 2.2.1), particularly guideline 2 which describes the five food groups. These food groups are represented as a plate, in the proportions recommended for consumption each day. Foods are split into the **five predominant food groups** (and into the groups outside the plate) based on their type and their contribution of nutrients to the Australian diet. The food groups included in the plate are: grain cereal foods; vegetables and legumes/beans; fruits; lean meats and poultry, fish, eggs, tofu, nuts and seeds; and reduced fat dairy products and/or alternatives. Food and drinks which are not part of the five food groups are shown outside the central plate (or main circle). Alcohol and highly processed foods (high in kJ, sugar, fat and sodium), or **discretionary foods**, appear at the bottom right of the AGHE. They are only to be consumed sometimes and in small amounts. Outside of the plate there is the also advice to drink plenty of water and a recommendation to use spreads/oils in small amounts.

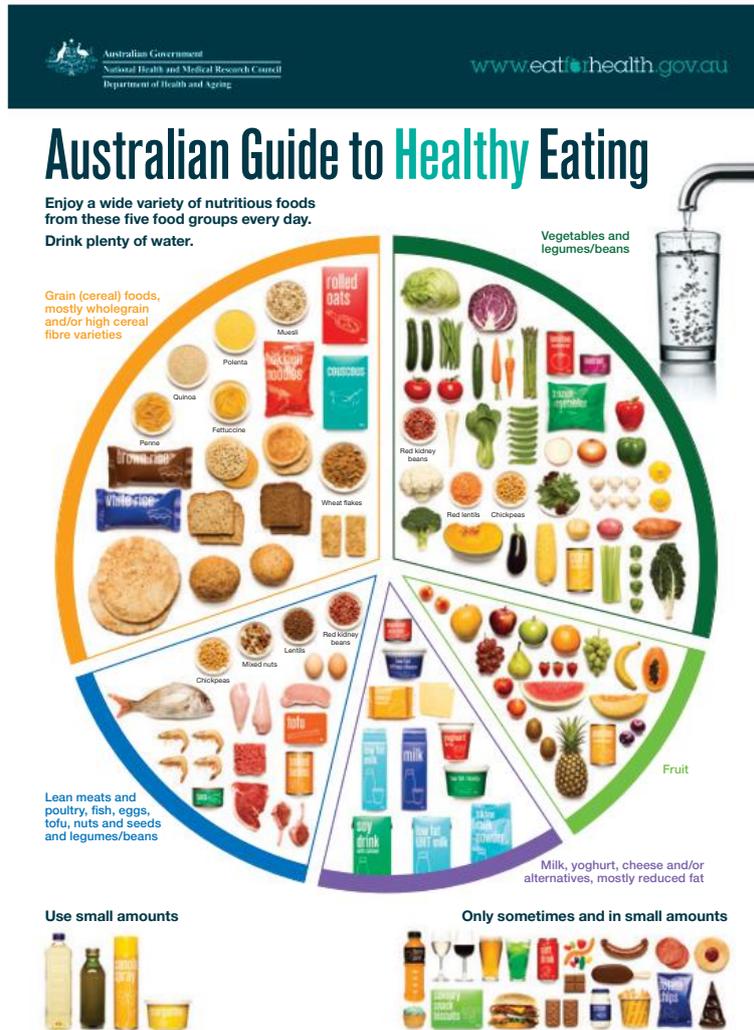


Figure 2.2.1: The Australian Guide to Healthy Eating.

Question

8. (a) Identify the triglyceride classification (s) of the spreads and oils that appear in the bottom left-hand corner of the AGHE:

..... (1 mark) (KA1)

(b) Name a health benefit of consuming small amounts of the spreads/oils (instead of butter):

..... (1 mark) (KA2)

Grain (cereal) foods, mostly wholegrain and/or high cereal fibre varieties

Grain (cereal) foods are made from grains such as wheat, oats, rice, rye, barley, millet, quinoa and corn. The different grains can be cooked and eaten whole, or ground into flour to make a variety of cereal foods. The grain (cereal) food group includes breads, breakfast cereals, rice, pasta, noodles, polenta, couscous, bulgur, oats, quinoa and barley. Wholemeal or wholegrain varieties are preferable because they provide more dietary fibre, as well as vitamins such as niacin, riboflavin, thiamine, folate and minerals such as iron.

Question

9. Name the macronutrient that is in very high quantities in grain (cereal) foods, whether they are wholemeal or not.

(1 mark) (KA1)

Extension activity

Wholegrain cereals are also a good source of antioxidants and phytochemicals/phytonutrients. Discuss what these substances are and what role they have in the body.

.....

.....

.....

.....

.....

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.....

Vegetables and legumes/beans

Different **vegetables** and legumes/beans supply various micronutrients that are needed by the body for different functions. Hence this food group includes a variety of coloured vegetables: green (such as broccoli and spinach), orange/yellow (for example pumpkin and carrot) and red (such as capsicum and tomato). It also displays different types of vegetables, for example from the leaves and roots of plants, as well as legumes such as beans, lentils and chickpeas. Canned and frozen vegetables are also included in this food group, if they have no added salt.



Fast fact

Most Australians eat only around half the recommended quantity of vegetables per day!

Source: <https://www.eatforhealth.gov.au/food-essentials/five-food-groups/vegetables-and-legumes-beans>

Question

10. Vegetables provide a good range of micronutrients and fibre. State which vitamins are commonly found in high quantities in each of the coloured varieties:

Green: .. (1 mark) (KA1)

Red: .. (1 mark) (KA1)

11. List two micronutrients and one macronutrient that legumes provide a good source of:

Micronutrients: ..

Macronutrient: .. (3 marks) (KA1)

Fruit

A wide variety of fruit is grown and available in Australia. Like the vegetables, choosing different coloured and types of fruits increases the variety of nutrients consumed. Canned or frozen fruit is also a suitable option, if found in natural juice (without added sugars), not syrup. Fruit is typically a good source of fibre, water and abundant in micronutrients such as potassium, vitamin A (as beta-carotene) and vitamin C.

Extension activity

Fruit can be placed into different categories. List some examples of fruit in the following categories.

Pome fruits ..

Citrus fruits ..

Stone fruits ..

Tropical fruits ..

2

Milk, yoghurt, cheese and / or their alternatives (mostly reduced fat)

Low or reduced fat milk, yoghurt and cheese choices are recommended for most people two years and over. A wide range of milk and milk products are available with varying amounts of fat. For example, milk can be fresh, evaporated or UHT (long life) and is able to be purchased as full fat, low fat, fat free and more!

Milk, cheese and yoghurt are important in the diet because they provide nutrients including calcium, potassium, vitamin A, vitamin D and vitamin B12.

Extension activity

Name some varieties of cheese that are lower in fat compared to cheddar cheese.

..

..

Question

12. Name the macronutrient found in high quantities in reduced fat milk/milk products:

..... (1 mark) (KA1)

Lean meat and poultry, fish, eggs, tofu, nuts and seeds and legumes/beans

Red meats tend to be consumed too often in the Australian diet (mostly by adult males), forming the main part of dinner meals. Variety is therefore key within this food group and frozen/canned options are suitable if low in salt and saturated fat. All foods within this food group are rich in protein as well as providing a wide range of nutrients such as essential fatty acids, iron and vitamin B12. Legumes/beans provide some similar nutrients to those in lean meat, poultry, fish (and other seafood), which is why they are included in an additional food group.

Question

13. (a) Name an essential fatty acid:

..... (1 mark) (KA1)

(b) Discuss what it means to be termed as essential fatty acid:

..... (2 marks) (KA1)

Extension activity

Foods from this food group fall into 6 categories. Match the examples of protein foods into their correct categories.

Beef, tofu, duck eggs, veal, prawns, macadamias, turkey, lentils, almonds, emu, kangaroo, mussels.

Lean meats ..

Poultry ..

Fish and seafood ..

Eggs ..

Nuts and seeds ..

Legumes/beans ..

ADGs and AGHE resources

To assist further in selecting nutrient-dense foods in appropriate amounts, the ADG and AGHE are presented in one key document that gives suggested dietary patterns for all ages/genders. See Figure 2.2.2 for an example of food patterns for children and adolescents.

Recommended average daily number of serves from each of the Five Food Groups*							Additional serves for more active, taller or older children and adolescents
	Age	Vegetables and legumes/beans	Fruit	Grain (cereal) foods, mostly wholegrain and/or high fibre cereal varieties	Lean meats and poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans	Milk, yoghurt, cheese and/or alternatives, mostly reduced fat	Approx. number of additional serves from the Five Food Groups or unsaturated spreads and oils or discretionary choices
Boys	2-3	2½	1	4	1	1½	0-1
	4-8	4½	1½	4	1½	2	0-2½
	9-11	5	2	5	2½	2½	0-3
	12-13	5½	2	6	2½	3½	0-3
	14-18	5½	2	7	2½	3½	0-5
Girls	2-3	2½	1	4	1	1½	0-1
	4-8	4½	1½	4	1½	1½	0-1
	9-11	5	2	4	2½	3	0-3
	12-13	5	2	5	2½	3½	0-2½
	14-18	5	2	7	2½	3½	0-2½

* Includes an allowance for unsaturated spreads or oils and nuts or seeds: ½ serve [4–5g] per day for children 2–3 years of age, 1 serve [7–10g] per day for children 3–12 years of age, 1½ serves [11–15g] per day for children 12–13 years of age, and 2 serves [14–20g] per day for adolescents 14–18 years of age and for pregnant and breastfeeding girls.

Figure 2.2.2: Suggested daily food patterns for children and adolescents.

Recommended serving sizes for each food group are also included in the document for the ADGs/AGHE. See Figure 2.2.3 below for an example of recommended serving sizes of the lean meat and poultry, fish, eggs, tofu, nuts and seeds and legumes/beans food group.

How much is a serve of lean meat and poultry, fish, eggs, nuts and seeds, and legumes/beans?

A standard serve is (500–600kJ):

65g	cooked lean red meats such as beef, lamb, veal, pork, goat or kangaroo (about 90-100g raw)
80g	cooked lean poultry such as chicken or turkey (100g raw)
100g	cooked fish fillet (about 115g raw) or one small can of fish
2 large (120g)	eggs
1 cup (150g)	cooked or canned legumes/beans such as lentils, chick peas or split peas (preferably with no added salt)
170g	tofu
30g	nuts, seeds, peanut or almond butter or tahini or other nut or seed paste (no added salt)*



*Only to be used occasionally as a substitute for other foods in the group

Figure 2.2.3: Recommended serving sizes for lean meat and poultry, fish, eggs, tofu, nuts and seeds and legumes/beans food group.

The target audience of Go for 2&5 was primarily parents/carers (the grocery buyer and meal preparer!) of children and adolescents (0-17), with the campaign hoping to help parents encourage their children to eat fruit and vegetables. Children and adolescents were therefore an additional secondary targeted audience.

Question

16. Refer to Figure 2.2.7 to answer the following questions:

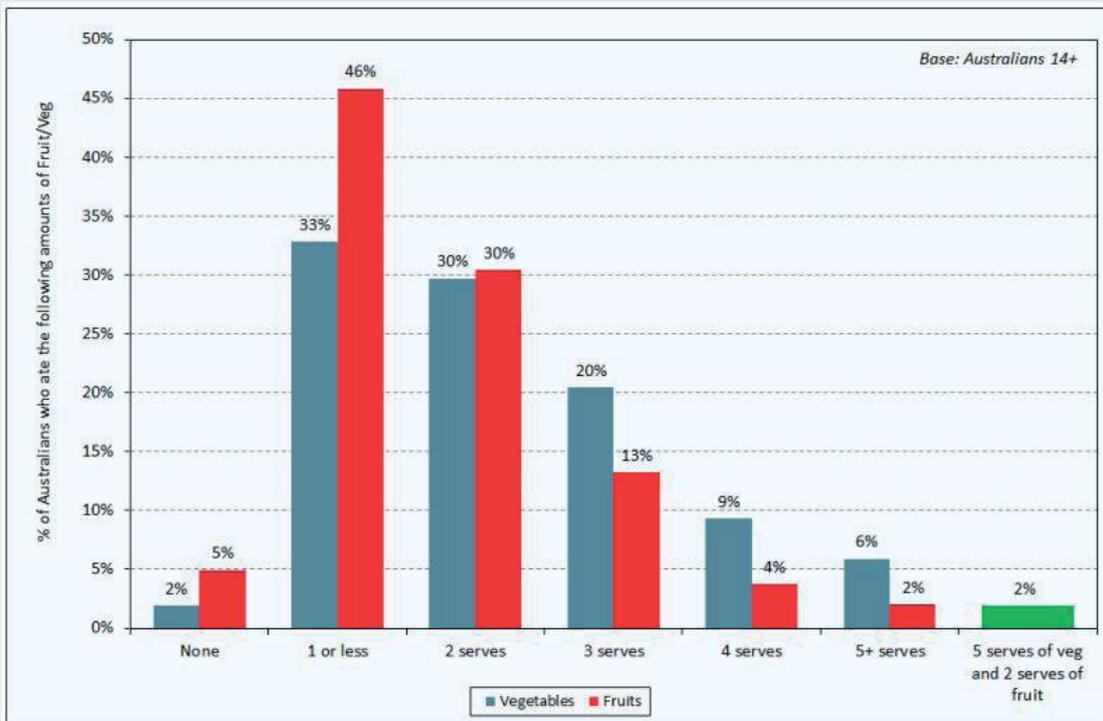


Figure 2.2.7: Serves of fruit and vegetables eaten each day for Australians aged 14+

Source: <http://www.roymorgan.com/findings/6003-most-of-us-dont-eat-enough-fruit-veg-201501062212>.

(a) State the percentage of Australians (aged 14 and older) meeting The Go for 2&5 campaign goals for fruit consumption:

..... (1 mark) (IAE3)

(b) State the percentage of Australians meeting The Go for 2&5 campaigns aims for vegetable consumption:

..... (1 mark) (IAE3)

(c) Identify the proportion of Australians (14+) who are not consuming any vegetables at all:

..... (1 mark) (IAE3)

(d) Identify how many Australians, aged 14 and above, are not getting the recommended serves of 5 vegetables and 2 fruits:

..... (1 mark) (IAE3)

The impact of the Go for 2&5 social marketing campaign was an increase of 0.8 serves of fruit and vegetables per day for the entire population. The greatest increase of fruit and vegetable consumption was amongst males who had a low consumption rate before the campaign ran.

Extension activity

Find some current statistics about the proportion of Australians (both adults and children, male and female) who are obese.

.. .. .

.. .. .

.. .. .

Following the ‘Swap it, don’t stop it’ campaign, the Australian Government launched the ‘Shape Up’ initiative (see logo Figure 2.2.10), a campaign without media commercials, comprising only online features similar to Swap it, don’t stop it. It was aimed at addressing Australia’s growing obesity epidemic and ran for 2 years until 2015. A similar online tool, “Healthy weight guide” has since replaced the Shape Up initiative and continues to be active.

Extension activity

Navigate and become familiar with the Healthy Weight Guide website: <http://healthyweight.health.gov.au>



Figure 2.2.10: Logo brand of the Shape Up Australia initiative.

Programs encouraging healthy nutrition behaviour

Although there is currently no active national social marketing campaign screening on our TVs, the federal government is making a concerted effort to battle our obesity epidemic and prevalence of diet-related diseases associated with obesity via a variety of methods including the implementation of a policy called the “Healthy food partnership” and the “Health star rating system” for food labelling (see Topic 2.5)

Extension activity

Describe what the ‘Healthy food partnership’ policy is, some of the food manufacturers involved and what demographic might benefit from this partnership.

.. .. .

.. .. .

.. .. .

.. .. .

.. .. .

.. .. .

Within the schooling setting, the main Government endorsed program implemented across Australia to encourage healthy nutrition behaviour stems from the **National Healthy School Canteens (NHSC) project**. The NHSC project offers resources such as canteen posters, canteen staff training manuals and of most importance: a set of guidelines, based on the AGHE and ADGs (for children and adolescents). The guidelines document is aimed to assist those running school canteens to select food and drinks to sell that encourage and promote a healthy eating pattern. The NHSC guidelines center around a healthy eating message that is conveyed by use of a traffic lights food categorization system (see Figure 2.2.11 & Table 2.2.1).

Fast fact

Materials and resources of the NHSC have been developed by Flinders University, South Australia, in collaboration with a state and territory reference group, nutrition experts and the Department of Health

Helpful online resources

For all resources of the NHSC project visit:

[https://www1.health.gov.au/internet/main/publishing.nsf/content/5FFB6A30ECEE9321CA257BF001DAB17/\\$File/Canteen%20guidelines.pdf](https://www1.health.gov.au/internet/main/publishing.nsf/content/5FFB6A30ECEE9321CA257BF001DAB17/$File/Canteen%20guidelines.pdf)



National
Healthy School Canteens

Australian Government
Department of Health and Ageing

Healthy kids need healthy canteens!

ALWAYS ON THE CANTEEN MENU

Encourage and promote these foods and drinks

These foods and drinks:

- are the best choices for a healthy school canteen
- should be available every day and be the main choices on the canteen menu
- contain a wide range of nutrients
- are generally low in saturated fat and/or sugar and/or sodium (salt).

SELECT CAREFULLY

Do not let these foods and drinks take over the menu and keep serve sizes small

These foods and drinks:

- contain some valuable nutrients
- contain moderate amounts of saturated fat and/or sugar and/or sodium (salt)
- if eaten in large amounts, may increase the amount of energy (kilojoules) being consumed.

NOT RECOMMENDED ON THE CANTEEN MENU

These foods and drinks should not be sold in a healthy school canteen

These foods and drinks:

- may contain excess energy (kilojoules) and/or
- saturated fat and/or sodium (salt) and/or sugar are low in nutritional value.

Figure 2.2.11: Traffic light system of the NHSC

Each traffic light zone: green, amber and red, is expanded upon in the NHSC guideline document, listing many foods that belong to each category. Examples of some of those food categories are displayed in Table 2.2.1 on the following page.

Table 2.2.1: A sample of foods and drinks categorised as green, amber and red

Food	Green	Amber	Red
Drinks	<ul style="list-style-type: none"> • Low or reduced-fat milk and soy drinks, plain and flavoured • Water 	<ul style="list-style-type: none"> • Full fat milk and soy drinks (e.g. so milk), plain and flavoured • Fruit/vegetable juice with at least 99% fruit/vegetable juice, including sparkling varieties, no added sugar (max 250mL serve size) 	<ul style="list-style-type: none"> • Soft drinks, iced tea, cordial, sports waters, sports drinks, flavoured mineral water, energy drinks, sweetened waters. • Fruit/vegetable juice with less than 99% juice and/or added sugar and/or greater than 250mL serve size.
Fruit	<ul style="list-style-type: none"> • Fresh, in-season is the best choice. Frozen, pureed or canned in natural juice (does not include dried fruit). 	<ul style="list-style-type: none"> • Dried fruit or fruit leathers (leathers must be 100% fruit) and keep the serve size small. 	—
Fats and oils	—	<ul style="list-style-type: none"> • Choose polyunsaturated and monounsaturated oils and spreads and use sparingly (for example: sunflower, safflower, corn, soya bean, olive, canola). 	<ul style="list-style-type: none"> • Cream, coconut cream, coconut milk, butter, cophera, ghee, lard.

Question

20. The following questions relate to Table 2.2.1 above:

(a) Dried fruit is classified as amber. Provide reasoning for its classification:

.....

 (2 marks) (KA2)

(b) A small amount of sunflower oil can be used sparingly in making canteen sandwiches (amber), but butter is not allowed (red). Outline the reasoning behind this canteen recommendation:

.....
 (1 mark) (KA2)

(c) A sandwich has been classified as ‘amber’. Suggest how you could move it into the green category:

..... (1 mark) (KA2)

It can often be easier to distinguish red and green foods, with amber foods offering some uncertainty. The NHSC guidelines therefore offer two nutrient criteria tables to assess a foods eligibility as an amber food (see Figure 2.2.12). When a food item is assessed as having less than (or equal to) the specified energy, saturated fat and sodium amount, or more than (or equal to) the specified fibre quantity, it is able to be sold in canteens as an amber food. If the food item is found to be over the threshold for energy, saturated fat or sodium or under the quantity needed for fibre, the food is categorised as red and unable to be sold in canteens.

Table 1: Hot food items and processed meats assessed per 100g			
Category	Nutrient Criteria		
	Energy (kJ) per 100g	Saturated fat (g) per 100g	Sodium (mg) per 100g
Savoury pastries, filled breads, pasta dishes, pizzas, oven-baked potato products, dim sims, spring rolls, rice and noodle dishes	1000kJ or less	5g or less	400mg or less
Meat products and alternatives crumbed and not-crumbed (burgers, patties, strips, balls or nuggets), sausages, frankfurts and saveloys, stews, casseroles and curries	1000kJ or less	5g or less	450mg or less
Processed luncheon meats (fritz, devon, chicken loaf, free flow chicken products) and cured meats (for example: ham, bacon)	1000kJ or less	3g or less	750mg or less

Figure 2.2.12: Nutrient criteria table one (of two) to determine amber or red food classification of canteen foods (take note that fibre is not applicable to this table as it contains foods that do not typically contain fibre).

Question

21. (a) Per 100g, a quiche has 1200kJ, 5.5g saturated fat and 250mg of sodium. Using Figure 2.2.12, identify the traffic light classification of the quiche.

..... (1 mark) (IAE3)

(b) Per serve (50g), a sausage contains 450kJ, 2.5g saturated fat and 200mg sodium. Using figure 2.2.12, identify the traffic light classification of the quiche

..... (1 mark) (IAE3)

Implementation of the NHSC project has been at the discretion of each state and territory government. Some have implemented the NHSC in full, while others have used components of the guidelines to create their own nutritional policies. Although the NHSC project is no longer running, the main principals of the traffic light system have been implemented as the **Rite Bite policy** in South Australia (see Figure 2.2.13) and the **School Nutrition and Healthy eating policy and guidelines** in the Northern Territory, both of which are still active. These programs are compulsory in all department or public schools, both primary and secondary, with independent and catholic school strongly encouraged to adopt them.



Figure 2.2.13: Rite Bite strategy symbol

Extension activity

Some of Australia's other state governments have taken a different approach in translating the NHSC guidelines into their school canteen policies. Discuss the concept used in NSW schools.

.....

.....

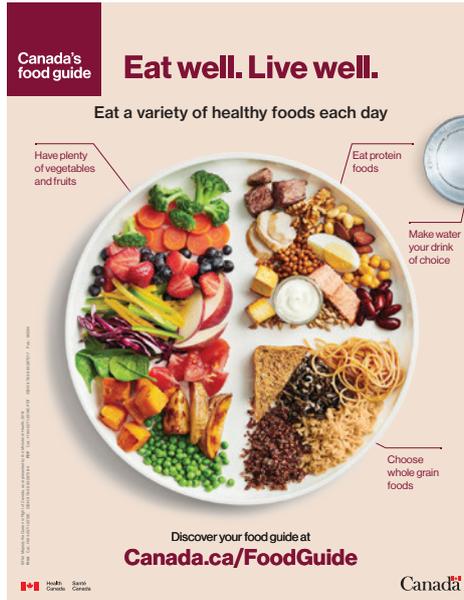
.....

Extension activity

Extension activity - Apart from the NHSC project, there are many other programs run on a smaller scale, that centre around encouraging healthy nutrition behaviour. In class groups, present information about each of the following programs such as: age of cliental aimed at and key principals of the program. It is important to note that some programs that have been included in the table below are no longer active, but their principals have become embedded in schools or communities and therefore in essence they are still active!

Program	Details
Stephanie Alexander Kitchen Garden Foundation	
OPAL (Obesity Prevention and Lifestyle program for children)	
Get Healthy program: Information and Coaching services	
Crunch & Sip	
Eat Well Be Active Primary School or Community program	
Eat a rainbow	

8. The Canadian food guide is another food selection model. State two similarities and two differences between the healthy eating pyramid and the AGHE:



Similarities: ..

..

..

..

Differences: ..

..

..

..

..

.....

 (2 marks) (KA2)

.....

 (2 marks) (KA2)

9. In one day, Matty, a 15-year old adolescent, eats the following foods:

- 2 slices bacon with 2 large eggs
- 2 pancakes with maple syrup
- Sandwich with 50g cheese and 65g sliced beef
- 30g handful of nuts
- Around 160g chicken breast in honey mustard sauce on rice
- Apple
- Ice cream with chocolate topping

A standard serve is (500–600kJ):	
65g	cooked lean red meats such as beef, lamb, veal, pork, goat or kangaroo (about 90-100g raw)
80g	cooked lean poultry such as chicken or turkey (100g raw)
100g	cooked fish fillet (about 115g raw) or one small can of fish
2 large	(120g) eggs
1 cup	(150g) cooked or canned legumes/beans such as lentils, chick peas or split peas (preferably with no added salt)
170g	tofu
30g	nuts, seeds, peanut or almond butter or tahini or other nut or seed paste (no added salt)*

(a) Utilising the adolescent standard serving size information above, calculate how many serves Matty has in a day from the lean meat and poultry, fish, eggs, nuts and seeds, and legumes/beans food group. Show all working:

(4 marks) (IAE3)

Recommended average daily number of serves from each of the Five Food Groups*							Additional serves for more active, taller or older children and adolescents
	Age	Vegetables and legumes/beans	Fruit	Grain (cereal) foods, mostly wholegrain and/or high fibre cereal varieties	Lean meats and poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans	Milk, yoghurt, cheese and/or alternatives, mostly reduced fat	Approx. number of additional serves from the Five Food Groups or unsaturated spreads and oils or discretionary choices
Boys	2-3	2½	1	4	1	1½	0-1
	4-8	4½	1½	4	1½	2	0-2½
	9-11	5	2	5	2½	2½	0-3
	12-13	5½	2	6	2½	3½	0-3
	14-18	5½	2	7	2½	3½	0-5
Girls	2-3	2½	1	4	1	1½	0-1
	4-8	4½	1½	4	1½	1½	0-1
	9-11	5	2	4	2½	3	0-3
	12-13	5	2	5	2½	3½	0-2½
	14-18	5	2	7	2½	3½	0-2½



(b) Give a concluding statement in regard to Matty’s lean meat and poultry (etc) serves calculated from 9(a), in comparison to the daily recommended serves for his age, using data from the table above:

..
 ..
 ..
 ..
 .. (2 marks) (IAE3)

(c) Discuss a health concern that may develop should Matty continue to eat this daily quantity from the lean meat and poultry (etc) food group:

..
 ..
 .. (2 marks) (KA2)

10. All government social marketing campaigns have aimed to reduce obesity rates in Australia. Name a chronic disease associated with obesity:

.. (1 mark) (KA1)

11. (a) Discuss why adults with children have been a target audience of social marketing campaigns:

..
 ..
 .. (2 marks) (KA2)

(b) Identify why children have been a target audience of social marketing campaigns:

.. (1 mark) (KA2)

12. (a) Apart from Swap it, don’t stop it, name a national social marketing campaign:

.. (1 mark) (KA1)

(b) Name the schools canteen program in South Australia that supports the aims of national social marketing campaigns:

.. (1 mark) (KA1)

13. Refer to some of the swapping tips from the Swap it, don't swap it campaign (see below):



- Swap fried food for fresh
- Swap take-away for home-made
- Swap fizzy drink for water
- Eat less 'sometimes' food

(a) Explain why swapping fizzy drink for water is recommended:

..

..

..

..

..

..... (2 marks) (KA2)

(b) Explain why eating less 'sometimes' food is recommended:

..

..

..

..

..

..

..

..... (4 marks) (KA2)

Total: _____ / 45 marks

2.3 Food sociology

Science understanding

Food sociology is understanding factors impacting on food selection by individuals.

- sensory reactions to food effect food selection
- psychological influences effect food selection
- social and environmental factors effect food selection
 - social influences effect food selection
 - food regulation, marketing and advertising including social media and celebrity endorsements
 - food affordability and food availability impacts on the nutrition status of individuals

SACE Subject Outline, 2020.

2

Sensory factors affecting food choices

The basic biology underlying food intake is that it is closely linked to pleasure. Our senses are stimulated by sensory factors including the appearance, flavour, smell, texture and sound of food. These sensory factors, can increase (or decrease) our appetite or desire to consume the product, making them predominately **internal factors influencing food choices**. One of the most important goals of the food industry is to determine how food products affect a consumer's senses. Sensory factors can also be a primary concern for nutritionists and dietitians when modifying recipes to make them healthier. As our senses act as the determinant of food consumption, consumer reaction is considered a vital measure of food development. As no apparatus or equipment can substitute the five senses of a human response to food, individuals are used as test subjects in sensory evaluations. These type of tests are becoming more prevalent, despite their limitations and the potential biases of humans.



Fast fact

Physiological changes such as growth, which can increase appetite, is another example of an internal factor influencing food choice (see Topic 1.1 for more information)

Sensory characteristics

The characteristics and quality of food are perceived by the five senses: sight, taste, smell, touch and sound, which can be used to judge a food product's appearance, flavour, smell, texture and sound (common descriptive words used to describe these characteristics are shown in Table 2.3.1). These senses are used to determine a human's response to a food product.

Table 2.3.1: A tasting test word bank, which can be used to describe specific characteristics of food products.

Appearance	Flavour	Smell	Texture	Sound
Appetising	Acidic	Aromatic	Adhesive	Bubbling
Attractive	Bitter	Astringent	Airy	Crackly
Brittle	Bland	Burnt	Brittle	Crunchy
Burnt	Burnt	Coffee	Bubbly	Grating
Cellular	Buttery	Fermented	Chewy	Fizzy
Clear	Creamy	Floral	Coarse	Percolating
Cloudy	Fatty	Fresh	Cohesive	Sizzling
Cold	Herby	Fruity	Cold	Snapping
Colourful	Hot	Musty	Crisp	
Colourless	Musty	Pungent	Crumbly	
Creamy	Piquant	Rancid	Crunchy	
Crumbly	Salty	Roasted	Crystalline	
Dark	Sharp	Smokey	Dry	
Dry	Smokey	Sour	Effervescent	
Foamy	Sour	Spicy	Elastic	
Fresh	Spicy	Stale	Fibrous	
Grained	Stale		Fine	
Greasy	Sweet		Firm	
Healthy	Tangy		Fizzy	
Moist	Tart		Flaky	
Mottled	Tasty		Flat	
Opaque	Tasteless		Foamy	
Pale	Undercooked		Grainy	
Powdery	Watery		Greasy	
Shiny			Gritty	
Slimy			Hard	
Smooth			Juicy	
Soggy			Lumpy	
Sticky			Moist	
Thick			Mushy	
Translucent			Powdery	
Watery			Rubbery	
			Slimy	
			Smooth	
			Soft	
			Spongy	
			Sticky	
			Tender	
			Tough	
			Watery	

Appearance

The eyes perceive the initial appearance of the food, which includes colour, size, shape, transparency, dullness and gloss. The colour of food may accurately indicate ripeness, strength of dilution, or the degree to which the food has been cooked or reheated. The colour is used to evaluate a food's desirability and acceptability. Green bananas, burnt meat or dark brown avocado can send a visual signal which changes a person's food choice. The shape, size and surface appearance, such as width, length, thickness, distribution of pieces, dullness, shininess, smoothness or roughness, can also influence consumers and provide information about food quality.

Flavour

Taste is the most influential factor in a person's selection of a particular food. Taste is perceived by the tastebuds on the surface of the tongue (shown in Figure 2.3.1) and in areas of the throat. The tongue is able to detect five different tastes, including sweet, salty, sour, bitter and umami. Taste relies on the sensation produced through the stimulation of the tastebuds on the tongue, whereas flavour is a combined sense of taste, aroma and mouthfeel. Aroma is especially important as it contributes approximately 75 per cent of a food product's flavour.



Fast fact

The human tongue has on average between 2000 and 8000 tastebuds, though this number decreases with age. This is why older people seek more spices, sugar and salt in their food.

Definition

Mouthfeel is the way an item of food or beverage feels in the mouth.



Figure 2.3.1: The tastebuds on a human tongue, which are used to detect the taste and flavour of a food product.

Question

1. Describe what the recently discovered taste, umami, is and what foods it can be found in.

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 (2 marks) (KA1)

Extension activity

To experience the influence of aroma, pinch your nose the next time you're eating a flavoured food item and explain what happens to its flavour.

Science as a human endeavour (Application and Limitation)

Can you change your sensory appeal and adapt to bitter tastes?

Question

2. Read through the following article and discuss the application and possible impact of this study's findings.

Helpful online resources

<https://www.sciencealert.com/you-can-modify-your-saliva-to-make-things-taste-better-study-shows>



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 (4 marks) (KA3)

Smell

The odour or aroma of a product can be detected directly through the nose or by entering the mouth and flowing to the back of the throat and up into the nasal cavity. The strength of odours is related to temperature, which is why it is easier to smell hot foods than cold ones. For example, hot tea is much easier to detect than iced tea; another example, the aroma of a baked item is more intense than that of ice cream. Human subjects have varying sensitivities to odours, depending on hunger, satiety, mood, concentration, presence or absence of respiratory infections, and gender. As people perceive odours differently, identifying a new aroma from a food product requires a large panel of testers to ensure a valid result is obtained.

Extension activity

Research and discuss how each of the following factors may affect an individual's ability to detect odours.

Hunger: ..

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Satiety: ..

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Mood: ..

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Concentration: ..

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Presence of a respiratory infection: ..

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Gender: ..

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Texture

The sense of touch provides impressions of a food's texture through oral sensations or the skin. Texture of a food product can be complex, as it is determined by an individual's visual perception, touch through the fingers or eating utensils, and finally the feeling in the mouth (mouthfeel) as detected by the teeth and nerves on the tongue.

Sound

Sound is another sense used in evaluating food quality. Sounds such as sizzling, crunching, popping, bubbling, squeaking, dripping, exploding and crackling can communicate much about a food. A majority of these sounds are impacted by the food's water content, therefore the presence of these sounds indicates a product's freshness and ripeness.

Sensory evaluation

A sensory evaluation is defined as a scientific discipline used to invoke, measure, analyse and interpret reactions to specific characteristics of foods, which are perceived by the five senses: sight, smell, taste, touch and sound. A sensory evaluation uses collected numerical data to determine the relationship between specific characteristics and human perceptions, which is a necessary part of both product development and quality control. Food manufacturers and retailers may use this type of testing during various stages of the food production process, which may include testing raw ingredients, reviewing newly developed dishes, analysing food samples for improvements, gauging responses to dishes to determine if they are acceptable or unacceptable, or testing the products after they have been stored. In order to ensure that the sensory testing is fair and not biased, it is important that conditions are carefully controlled. This involves:

- swirling and sipping water in between each sample to remove the taste and debris of any previous food.
- using separate testing areas so that testers are not influenced by others.
- not allowing communication between members on the panel.
- conducting testing between 10am and 12 noon, or 3pm and 5pm.
- labelling samples with numbers or letters to keep the products anonymous – this way the testers will not recognise brand names (e.g. could use a random three-digit code).
- having a well-lit room with few distractions, including colours on the walls, noises and smells.
- using clean cutlery and utensils for each sample.
- using blindfolds (blind testing) so that the tester is not influenced by the appearance of the food.
- making each sample of food the same size and temperature.
- allocating samples randomly to testers.
- completing odour observations prior to tasting.
- making sure scorecards are typed, simple and clear.
- having at least six testers.



Testers must not be:

- suffering from a condition, that could affect their sense of taste (e.g. they should not be a heavy smoker, an individual with a cold, or a person taking strong medication).
- allergic to the food or ingredients.

Question

3. Explain why a sensory evaluation test should be conducted between 10am and 12 noon or 3pm and 5pm.

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(2 marks) (KA2)

A significant limitation of this type of scientific testing is that data is generated from human responses, which can be highly variable. Therefore, this is a subjective method. For example, one consumer may describe a sample as unpalatable while another consumer may consider the same sample acceptable. These differences are common in a sensory evaluation, and can be explained by an individual's past experiences, values, beliefs, family habits, attitudes and personal preferences.

Common sensory evaluation tests that can be used to measure an individual's response to a food product can include a star profile, ranking test, rating test or a triangle test.

Star profile

A star profile can be used to test a single food product or a range of food products. This type of sensory evaluation test can be used to evaluate differences in similar products, analyse specific characteristics, compare similarities in a range of products or show new opportunities for product development. A star with between five and eight points is then labelled with words that describe different sensory characteristics of the tested product (see example characteristics in Table 2.3.1). A member on the panel is then asked to place the food sample on a scale from one to five for each characteristic, where the highest number represents the greatest the intensity. These results are then plotted onto the star profile (also known as a radar graph, an example of which can be seen in Figure 2.3.2). It is possible to compare similar products (e.g. two types of biscuits) by plotting them on the same star profile.

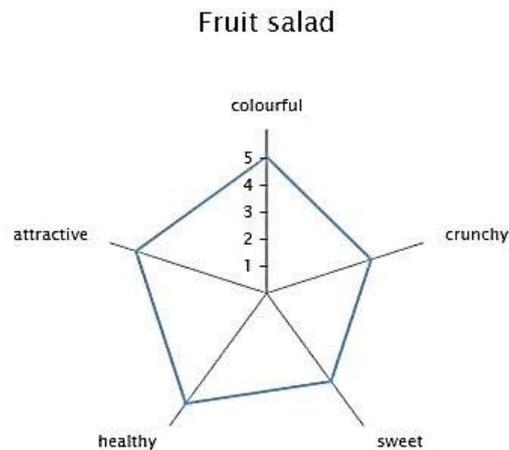
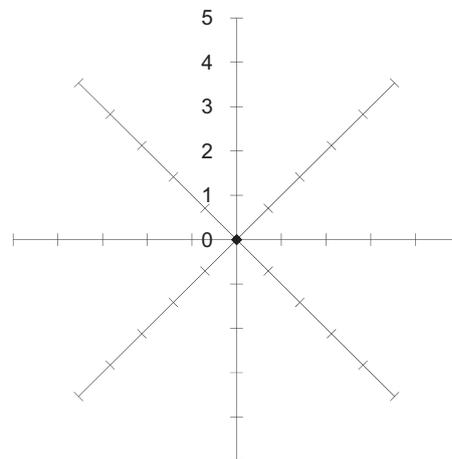


Figure 2.3.2: An example of a star profile analysing the specific characteristics of a fruit salad.

Question

4. Select eight words to describe the specific characteristics of an apple pie that can be used in a star profile sensory evaluation. Place these words on the star profile below.



(4 marks) (IAE2)

Ranking test

A ranking test is a quick, simple and useful tool to assess the differences in preference or intensity of sensory attributes of multiple products (usually between 3 to 5 samples). Panelists are given coded products and asked to put them in order against a specific sensory attribute (e.g. most to least sweet) or in order of preference. An example of a ranking test can include four different samples of apple juice with assorted amounts of citric acid added to them. Panelists are then asked to sample them in any order and rank them from most sour to least sour, to determine which amount of citric acid is most preferred. An example of a scorecard given to testers is shown in Table 2.3.2.

Table 2.3.2: An example of a scorecard given to each tester on a panel of a ranking test where panelists are asked to rank a food product based on its sweetness.

Date:	Name:				
Panelist Number:	Product:				
Sample	Ranking of samples				
	1st	2nd	3rd	4th	Comments

Rating test

A rating test asks testers to rate a product using either a five-, seven- or nine-point scale. A rating test may be useful if a baker has produced for example, a new low-fat cake in which butter has been replaced with applesauce. The test would try to determine which recipe produces the same moistness as the original, but with a lower fat content. The baker would make four samples with four levels of applesauce substitution (0%, 33%, 66% and 100%); he would select moistness as the most suitable sensory characteristic to measure. Testers would then be asked to evaluate the moistness of the cake using a rating scale from 1 to 9 (as shown in Figure 2.3.3).

Sample code: _____

1. Extremely wet
2. Very wet
3. Moderately wet
4. Slightly wet
5. Neither wet or dry
6. Slightly dry
7. Moderately dry
8. Very dry
9. Extremely dry

Figure 2.3.3: An example of a rating test scorecard used to assess the moistness of a modified cake.

Triangle test

In a triangle test, testers are presented with three coded samples, but two of them are identical or alike. The members on the panel should be presented with all three samples at once and instructed to taste them from left to right. The combinations given to each tester should be randomised, as shown in Table 2.3.3.

Table 2.3.3: An example of the random allocation of two samples (A and B) to each tester in a triangle test.

Tester	Sample 1	Sample 2	Sample 3
1	A	A	B
2	A	B	A
3	B	A	A
4	B	B	A
5	B	A	B
6	A	B	B

The testers are asked to identify the 'odd one out' by placing an X on the scorecard and any comments describing what is different about the identified sample. An example of a triangle test scorecard is shown in Table 2.3.4. This test is useful for comparing different brands of the same product or for ensuring that all batches from production are identical. A triangle test can also be used to determine if there is a sensory difference between two products. For example, a food manufacturer may want to see if changing one ingredient in a recipe to make a certain food product will alter the final taste. The testers have a 33% chance of simply guessing correctly, however fatigue is a factor, which requires panelists to re-taste the samples several times. An example of a triangle test could include a manufacturer wanting to confirm if there is a significant sensory difference between a canned product and a paper carton product, as they are considering changing to cartons due to the desire for more sustainable packaging by consumers.

Table 2.3.4: An example of a triangle test scorecard given to each tester on the panel.

Name:	Product:
Panelist Number:	Date:
Instructions: You are presented with three coded samples of _____. Two of these samples are identical or alike, while the third is different or odd. Taste and smell each sample, and then place an X in the second column next to the sample code that you identify as being odd. Write any comments below describing what is different about the sample. You may test each sample several times if required.	
SAMPLE CODE	ODD SAMPLE
Comments:	

Further values gaining popularity and awareness are the support for environmental sustainability and animal rights. Vegetarianism and selecting organic produce are often reflections of these values. Organic foods are those farmed without the use of synthetic chemicals (or genetically modified components) which have known consequences on the environment. The animals are also raised humanely and with respect. For example, chickens are free range and not kept in cages (see Topic 3 for more information). Some people regard animals' rights to freedom so highly that they abstain from all animal products, called veganism. The three main types of vegetarianism are:

1. **Lacto-ovo vegetarians** – people who do not eat any meat and seafood, but include dairy foods, eggs (typically free-range) and plant foods.
2. **Lacto-vegetarians** – people who avoid meat, seafood and eggs, but include dairy foods and plant foods.
3. **Vegans** – people who consume only plant foods.

Human welfare is another value which can drive food choices towards selecting fair-trade produce. Foods with the fair-trade logo ensure more of the profit is returned to small-scale (not larger, dominant and often wealthy corporations) farmers and workers in developing countries so that the producers can improve their social, economic and environmental conditions; i.e. lift themselves out of poverty. In addition, the Fairtrade premium provides extra money as a communal fund which can be put towards community needs; for example, better healthcare for children.

Question

7. (a) Name the food group from the Australian Guide to Healthy Eating (AGHE) that is under-represented in a lacto-vegetarian diet.
 (1 mark) (KA2)
- (b) Describe a possible health disadvantage of being vegan.

 (2 marks) (KA2)

Science as a human endeavour (Influence)

Will dairy cows be replaced by cultured yeast as veganism popularity surges?

Question

8. Read through the following articles and discuss how this new method of milk production has been influenced by other areas of science and technology, as well as social, economic, cultural and ethical considerations.

Helpful online resources

<https://www.nationalgeographic.com/news/2014/10/141022-lab-grown-milk-biotechnology-gmo-food-climate/>



<https://newatlas.com/muufri-synthetic-milk/34415/>



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Buddhism

The Buddhist religion doesn't specifically restrict any particular food or food group. However, its beliefs, which centre on the cessation of suffering, or doing no harm, are expressed through practicing a vegetarian diet. Lacto-vegetarianism is the most common type of vegetarianism among Buddhists. Many are also vegans.

Question

10. Describe a difference and a similarity between a vegan diet and a lacto-vegetarian diet.

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..... (3 marks) (KA2)

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Extension activity

Buddhism and Islam are popular religions in Australia. Around the rest of the globe, some other popular religions with food restrictions are Hinduism, Judaism, Jainism, Mormonism and Rastafarianism. Working in groups, describe food restrictions of one religion and share your findings with your class.

Religion	Dietary restrictions
Hinduism	
Judasim	
Jainism	
Mormonism	
Rastafarianism	

Other beliefs

Some social groups and cultures around the world have specific, and unusual, beliefs about food. A certain food tends to be prohibited, creating what is called a **food taboo**. Food taboos are most common in areas where educational levels are poor, and often remove an important food source from the diet. For example:

- In the mid-west state of Nigeria, meat and eggs are not usually given to children because parents believe it will make the children steal; coconut milk is taboo for children as well, as it is believed that it will render children unintelligent.
- In some Papua New Guinean tribes, women are thought to be 'sickly' because of recurring menstruations and are not allowed fresh meat, juicy bananas and all fruits of the forest of a red colour.
- Some people in remote areas of south-east Asia avoid eggs because they are believed to destroy human fertility

Definition

The word taboo means 'forbidden'; a food taboo is a certain food that is prohibited or forbidden.

Question

11. If a food taboo exists that cow's milk is avoided in belief that it is a repulsive body secretion similar to urine, discuss how this food taboo can negatively affect health.

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..... (3 marks) (KA2)

Past experiences

Past experiences can influence food choices. Foods eaten habitually with family and friends often remain firm regulars in the diet. A powerful negative experience with a food, however, can result in aversion to or avoidance of that food for a lasting period of time (sometimes as long as the unpleasant memory of the food endures). The most well-known reason for food aversion is because the food has made the consumer sick. Presentation of that same food can bring nauseating sensations and feelings of disgust. It is an innate rejection of food to protect us from potential toxins or poisoning. Food poisoning and toxins are known to elicit vomiting. Therefore, our bodies are protecting us from a food that on one occasion, or past experience, caused vomiting.

Extension activity

Someone who is more likely to have food aversions to bitter foods is a 'supertaster'. Discuss what a supertaster is and how it may affect a person's food choices.

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Attitudes (Likes and Dislikes)

An attitude is the way in which a person views something and behaves towards it. In relation to food, attitude is our likes and dislikes (see Figure 2.3.6). Whether we evaluate a food positively (like) or negatively (dislike) affects food selection. Food attitude, our likes and dislikes, are shaped by many factors, including cultural and family traditions, our beliefs, sensory preferences, health and safety perception of the food, past experiences with food and the emotions experienced with consumption of the food, e.g. guilt, comfort, etc. Even perceived status and cost of the food can influence food attitude. For example, lobster and truffles tend to have a higher status (and cost!). This could create a negative attitude towards the food for those of lower socioeconomic status.



Figure 2.3.6: Food attitude, our likes and dislikes.

Of interest, just because an individual has a positive attitude towards a food does not necessarily mean they will regularly eat the food. For example, someone who places value on health may view tofu positively, but they may only consume it when they are dining in certain restaurants with tofu dishes.

Habits

Habits are routines that are performed without really thinking about them. Many of the food choices people make are routine and, like all habits, can be difficult to break. They are influenced by many factors, including cultural traditions, socioenvironmental factors and food attitudes. Food habits can be foods eaten at a particular time of day or in a certain situation; they can be good or bad for health. Some examples of food habits are:

- eating cereal for breakfast.
- sprinkling salt on meals before tasting it.
- eating a snack immediately after getting home from school/work.
- eating dessert after dinner.
- eating cake for birthdays.

Extension activity

Think back to a time where an emotion and a past experience influenced the foods you chose to eat. Record these experiences. How do attitudes affect your food choices? List a food you like and dislike. State some of your habits that affect your eating patterns and selections.

Emotion: ..

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Past experience: ..

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Attitude: ..

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Habits: ..

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Self-image

Self-image (or body image) is the way a person views their appearance (and abilities and personality), or it's how someone sees themselves. It is also how you believe others see you. Self-image does not always coincide with reality. More often than not, the way we view ourselves is distorted and unrealistic (see Figure 2.3.7). Humans can be very critical of themselves and their abilities. Dissatisfaction with body image tends to increase from around the age of puberty until the mid 20s, especially in females.



Figure 2.3.7: Distorted (or negative) self-image.

Question

13. Identify a physiological characteristic, specifically the life cycle age group name, where puberty occurs: .. (1 mark) (KA1)

Many individuals have a desire to lose weight and improve their body image. This can lead to food choices that restrict kilojoules. Many turn to 'fad diets'. Unfortunately, problems can arise with fad dieting used in attempts to lose weight and when dieting and/or exercising is taken to the extremes. These extremes are often seen in disordered eating conditions: anorexia nervosa and bulimia nervosa.

Fad dieting

A fad diet is a short-term or temporary eating plan that often promises rapid weight loss but is not based on sound science. Fad diets are often highly restrictive, either on kilojoules, foods and/or nutrients, and, in some cases, eliminate entire food groups! Unfortunately, fad diets are frequently undertaken in Australia. Common fad diets include those that recommend cutting out sugar, drinking meal replacement shakes, following a low carbohydrate diet, detox diets, fat-free diets, and more!

Fad diets can provide short-term results of weight loss. Unfortunately, most of the weight lost is water and lean muscle mass, not fat. Loss of muscle mass will reduce a person's **basal metabolic rate (BMR)**. Adding to this, severe restriction of kilojoules for a weight loss fad diet will also cause the body to respond by slowing its metabolism. A slower metabolism and reduced muscle mass (the kJ burners) result in the body using kilojoules less efficiently, therefore, once the fad diet is completed and the dieter returns to their usual diet, weight can be more easily put back on.



Reminder

BMR is the minimal energy used to keep the body functioning, e.g. breathing, maintaining muscle tone, maintaining a heart rate.

Not only can fad diets lead to a decreased metabolism, the fact that they restrict certain nutrients, or food, or entire food groups can lead to many other problems, such as:

- dehydration.
- weakness and fatigue.
- nausea and headaches.
- constipation (or diarrhoea).
- inadequate vitamin and mineral intake can increase the chances of undernutrition conditions; for example, restricting the dairy group can lower calcium intake, resulting in lower bone density and increasing the risk of osteoporosis later in life.
- insomnia.
- constant feelings of hunger, leading to cravings and increased appetite, which can lead to yo-yo dieting and disordered eating.

Extension activity

Define what yo-yo dieting is.

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Disordered eating

Eating disorders are mental health conditions that involve an unhealthy relationship with food and eating (or result in extreme and dangerous eating behaviours). There are a few different types of eating disorders, including bulimia nervosa and anorexia nervosa. **Bulimia** is characterised by regular episodes of a loss of self-control, which leads a person to eat large amounts of food at one time (called bingeing). They then try to get rid of the food and potential weight gain by throwing up or taking laxatives (called purging), or by fasting or doing excessive exercise. Bulimia can be difficult to identify because the related behaviours tend to be performed in secrecy and someone with bulimia may present with normal weight. **Anorexia**, on the other hand, is easier to diagnose visually, as the individual appears dangerously thin. It is an eating disorder characterised by severe restriction of kilojoules and food, often coupled with too much exercise. Disordered eating conditions can also lead to the symptoms and complications associated with fad dieting (as well as additional health concerns, see next extension activity).

Food availability

Food security can be defined as follows: when all people, at all times, have physical and economical access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle. A person's ability to acquire appropriate and nutritious food on a regular basis is determined by the availability of food and that person's capacity and resources to access that food.

Geographic location affects the price, quality and availability of foods, and therefore significantly impacts one's ability to access, choose and consume healthy foods. The cost of healthier and nutritious foods is approximately 30 per cent higher in rural and remote areas compared to urban areas. This is because prices are associated with transport, storage and handling. In remote areas, these factors are compounded by a lack of demand and competition from other marketplaces. Fresh foods – such as fish, lean meats, fruit and vegetables – are also limited in rural and remote areas of Australia, restricting food choices further. These price and availability differences make it harder for people in rural communities to purchase nutritional foods and achieve a secure food supply. In contrast, people living in urban areas are generally closer to supermarkets and fruit and vegetables stores. This proximity means these individuals have greater food access, choice and ability to consume healthy foods. Therefore, in summary, the more remote an area is, the higher the cost of food, the more limited the availability, and generally, the lower the quality of fresh produce. This limits people's food choices and food security and increases the risk that those people will develop diet-related disorders.

Key Definition

A marketplace is a place where consumers purchase food, which may include the corner store, small local supermarket or an urban shopping centre.

Question

16. As shown in the image below, peaches in an urban city were priced at \$3.99/kg and peaches in a remote community were priced at \$21.89/kg. Explain one reason why there is a significant price difference between these food items.



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..... (2 marks) (KA2)

17. Explain why the prevalence of diet-related disorders (including obesity, type 2 diabetes and cardiovascular disease) is greater in remote and rural communities than urban cities.

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..... (2 marks) (KA2)

Extension activities

Suggest two strategies that can be implemented by the government to close the gap in health outcomes between remote, rural and urban Australians.

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Food affordability

The cost of food is a primary determinant of food choice. Therefore, food access, choice, purchases and consumption depend on an individual's **socioeconomic status**. Socioeconomic status refers to the social and economic position of an individual or group of individuals within society. Evidence shows that people living under financial constraints tend to preferentially choose high-energy, nutrient-poor food, to maximise their energy intake value for money. For example, foods such as rice, pasta and sweets are high in energy and are relatively cheap. Fresh fruit and vegetables have high nutrient value but they cost much more for the energy they provide. Therefore, low socioeconomic groups have a tendency to consume unbalanced diets, which can lead to the development of both undernutrition and overnutrition disorders.

People eat foods that are not only within their financial means but that are accessible, quick and easy. Today's consumers value convenience and are willing to spend more than half of their food budget on meals that require little, if any, further preparation. They frequently eat out, bring home ready-to-eat meals or have food delivered. This is because households may be lacking in resources, including cooking equipment, transportation and time to prepare healthy meals. These economic factors are affected by an individual's occupation, earnings, labour force participation, knowledge and skills, socioeconomic status, and the number of children in the household. For example, having multiple jobs, inflexible hours and night shifts can limit the amount of time available to choose and prepare healthy meals. Elderly people can also have limited access to foods, as they may be retired and on the pension and therefore under financial constraints. These individuals may skip meals, consume takeaway meals, eat out more often or use premade ingredients when cooking. Not surprising, households with the highest incomes and resources available have a greater average weekly expenditure on food and beverages than the lowest income households (as shown in Figure 2.3.8).

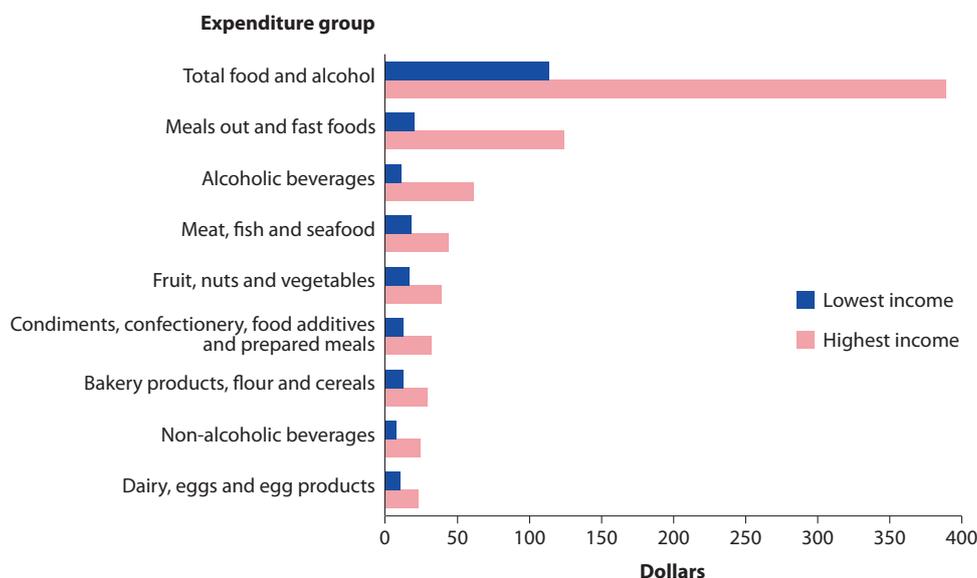


Figure 2.3.8: The average weekly expenditure on food and beverages by selected food items and household income (ABS, 2011).

Socioeconomically disadvantaged groups or lower income households can adopt methods to reduce their food bills to increase the affordability of healthier foods. **Methods for reducing food bills can include:**

- planning the meals for the week.
- writing a list of the items needed prior to grocery shopping to avoid buying additional unnecessary items.
- buying fresh produce in season and/or at local markets.
- looking out for supermarket specials.
- buying non-organic.
- buying in bulk when possible.
- storing leftovers appropriately.
- buying homebrand (generic) products when possible.
- not shopping when hungry.
- consuming less animal protein and swapping meat with plant-based protein sources.
- buying individual ingredients and not pre-packaged meals such as salads.
- growing vegetables and herbs.
- shopping online.

Level of education

Education is an important determinant of food access, choice and eating behaviours. Education provides the fundamental food and nutrition-related knowledge required to make informed food choices. Therefore, an individual with a high level of education generally has increased opportunities for food access, choice and consumption of healthier foods. In contrast, a lack of nutritional knowledge – as well as a lack of knowledge and skills required to successfully budget, plan, and cook healthy meals – predisposes people with low levels of education to eat poor-quality meals that do not meet nutritional requirements. Individuals with higher education levels tend to also have better employment outcomes with higher incomes, which in turn improves health habits.

Question

20. Suggest two strategies that can be implemented by the government to increase education levels of Australians and enhance their food knowledge, skills and abilities..

1.

2.

(2 marks) (KA2)

Extension activity

Suggest two strategies that can be implemented by the government to increase levels of Australians and enhance their food knowledge, skills and abilities.

.

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Key terms

- | | | |
|---|------------------------------|----------------------------------|
| Anorexia nervosa | Food security | Sensory evaluation |
| Appearance | Islam religion | Smell |
| Belief | Lacto-ovo vegetarian | Social and environmental factors |
| Buddhism religion | Lacto-vegetarian | Socioeconomic status |
| Bulimia nervosa | Level of education | Sound |
| Comfort eating | Media | Star profile |
| Emotion Fad diet | Methods to reduce food bills | Taste and flavour |
| Five human senses: sight, taste, smell, touch and sound | Mouthfeel | Touch and texture |
| Food attitude | Peer pressure | Triangle test |
| Food availability | Ranking test | Value |
| Food habits | Rating test | Vegan |
| | Self-image | |

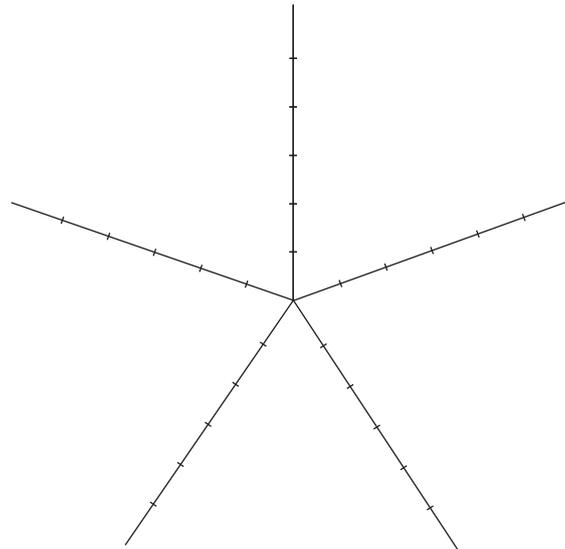


Review questions: 2.3 Food sociology

1. Refer to the following table, which shows some sensory characteristics of three types of lactose-free milk:

Sensory characteristics	Type of milk		
	X	Y	Z
Packaging (1 – unappealing, 5 – attractive)	4	2	3
Texture (1 – watery, 5 – thick)	4	2	2
Aroma (1 – unpleasant odour, 5 – neutral odour)	2	5	4
Colour (1 – grey, 5 – bright white)	5	3	4
Sweetness (1 – sour, 5 – sweet)	4	2	4

(a) Graph the sensory characteristics of each milk onto the axes of the star profile below.



(4 marks) (IAE2)

(b) Identify one factor that needs to be held constant during sensory testing in order to ensure the reliability of results.

.....
 (1 mark) (IAE1)

(c) Using the data in the table and/or graph above, determine which milk is likely to be the most popular.

.....
 (1 mark) (IAE3)

2. In a recent survey, four consumers were asked to evaluate the physical and sensory characteristics of a ham and pineapple pizza from a local pizza store and those of a similar reheated frozen pizza from a supermarket.

(a) Suggest one physical characteristic that could differ between fresh pizza and reheated frozen pizza.

.....
 (1 mark) (KA2)

(b) Identify two factors that should be held constant when this physical characteristic of the fresh pizza and the reheated frozen pizza is evaluated.

- (i)
-
- (ii)
-

(2 marks) (IAE1)

3. Childhood is a stage of the lifecycle where the diet is primarily parent controlled. Discuss how a child may gain some of their own food choice preferences (typically for energy-dense foods) during this life stage.

.....
 (2 marks) (KA2)

4. Match the following psychological factors that influence food choices to their definitions.

Value	A mental state associated with thoughts, feelings and behavioural responses caused by one’s circumstances, mood or the people you are with.
Belief	Our likes and dislikes.
Food taboo	Strong personal feeling about what is important to you.
Emotions	An unusual belief about certain food that usually results in it being prohibited.
Food attitude	Meal routines that are performed without really thinking about them.
Food habits	A short-term or temporary eating plan that often promises rapid weight loss but is not based on sound science.
Self-image	Thinking that something exists or is true. without the need for scientific proof.
Fad diet	The way a person views their appearance (and abilities and personality).

(8 marks) (KA1)

5. Refer to the following daily foods of an Australian adult named Justin.

Breakfast: Vegemite on toast, coffee

Lunch: Sushi

Dinner: Salt and pepper crocodile with chips

Snacks: Apple, nuts, biscuits, yoghurt

(a) Identify a food that has most likely been influenced by Indigenous culture, one that is distinctly Australian and another that has been influenced by the diversity of cultures in Australia.

Indigenous influence:..... (1 mark) (KA1)

Distinctly Australian:..... (1 mark) (KA1)

Multicultural influence:..... (1 mark) (KA1)

(b) Justin eats Vegemite on toast for breakfast every morning. Name the psychological factor behind this food choice.

..... (1 mark) (KA2)

(c) Justin refuses to use Marmite (a powerfully salty spread somewhat similar to Vegemite), claiming he hates it. Name the psychological factor behind this food choice.

..... (1 mark) (KA2)

(d) Justin did not realise that the sushi had been prepared 8 hours earlier and a few hours after eating it, he found himself vomiting. Now he won’t eat sushi again and feels nauseous at the thought of sushi. Discuss the psychological reasoning behind the nauseated feeling.

.....
 (2 marks) (KA2)

6. Make two modifications to the following meal plan to accommodate for a follower of Islam.

Breakfast – Bacon, cheese and egg muffin with orange juice

Lunch – Beef and salad sandwich

Dinner – Beef stir-fry and a glass of wine

Modification one:..... (1 mark) (KA2)

Modification two:..... (1 mark) (KA2)

7. Identify two groups of people in Australia who experience food insecurity. Explain why they experience it.

1.. .. .

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2.. .. .

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.. .. . (4 marks) (KA2)

8. Describe one economic factor that might influence the protein intake of elderly people, and suggest one way they can ensure they meet their protein requirements.

.. .. .

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.. .. .

.. .. . (3 marks) (KA2)

9. Discuss the effect of one social or environmental factor on the food choices of children aged 4–8 years.

.. .. .

.. .. .

.. .. .

.. .. . (2 marks) (KA2)

10. People’s levels of education and income can impact their health habits, ultimately determining what weight range they fit into.

(a) Refer to the following table, which shows the percentages of the South Australian population in the normal weight, overweight and obese weight ranges in relation to their maximum level of education.

Maximum level of education	Percentage of population in weight range		
	Normal weight	Overweight	Obese
Year 12	41.1	35.6	20.5
Tertiary	49.2	34.9	13.0

With reference to the table, state one conclusion that you can draw about the relationship between the maximum levels of education and the percentage of the population that is obese.

.. .. .

.. .. . (2 marks) (IAE3)

- (b) Refer to the following table, which shows the percentages of South Australians in the normal weight, overweight and obese weight ranges in relation to their level of income.

Level of income	Percentage of population in weight range		
	Normal weight	Overweight	Obese
Low	40.0	34.5	22.4
Middle	43.8	35.8	17.4
High	49.6	34.8	12.9

With reference to the table, state one conclusion that you can draw about the relationship between the levels of income and the percentage of the population that is in the normal weight range.

.....
 (2 marks) (IAE3)

- (c) Explain how an individual's geographic location may impact their dietary intake influencing the weight range they fit into.

.....

 (2 marks) (KA2)

- (d) Suggest two strategies that an adolescent living independently could use to reduce food costs and still maintain a nutritionally balanced diet.

1.

 2.

 (2 marks) (KA2)

Total: _____ / 45 marks



2.4 Safe food: contamination and its prevention

Science understanding

In Australia, the sale of food is regulated and the consumers are protected, by government policy regulation.

- the process of food contamination from food borne illnesses (e.g. botulism, listeria, E. coli and salmonella) and its prevention

SACE Subject Outline, 2020.

Food contamination

Humans with poor hygiene standards or **sanitisation** practices, particularly those who produce, process or serve food, pose the strongest threat to food safety, through the risk of food contamination and its consequences. If the microbes that contaminate food are given favourable conditions in which to multiply, the consequences of contamination can result in food spoilage (which leads to food wastage) or food poisoning.

Types of food contamination

At each stage of food processing, it is possible for food to be **contaminated**. **Food contamination** occurs when foods have been tainted because they contain substances such as microorganisms or toxins that make them unfit for consumption. Contaminants can be classified as biological, chemical or physical.



Fast fact

Intentional contamination of food via the deliberate addition of a harmful or poisonous substance to a food product is a criminal act known as **food fraud**. Note that intentional contamination is just one kind of many types of food fraud.

Extension activity

Foods contaminated with antibiotic-resistant bacteria (ARB) could be the major food safety issue in the future. Discuss how ARB in food may be possible.

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Physical contaminants

Physical contamination

refers to any foreign object found in food such as pieces of plastic, glass, hair, fingernails and band-aids (see Figure 2.4.1 for further sources of physical contamination). This could happen at any stage of the food production process. The added risk of physical contamination is that the foreign object could also be a source of biological contamination.



Figure 2.4.1: Physical contaminants.

Biological contaminants

Biological contamination is the most common source of contamination. It includes the **microorganisms**: **bacteria** (plus the toxins they may produce), **viruses** and **fungi** (mould and yeast). Bacteria – particularly *Salmonella*, *Escherichia coli* (*E. coli*) and *listeria* – and viruses – namely *norovirus* – are the most well-known causes of biological contamination. They often enter foods transferred via poor human hygiene, such as unclean hands or unsanitary food-handling equipment (see Figure 2.4.2 for further methods of biological food contamination).



Figure 2.4.2: Typical means of biological contamination (transfer of microbes from humans, waste bins, insects, cross-contamination of raw meat, unwashed fruit and vegetables, and more.)

Chemical contaminants

Chemical food contaminants

that can enter the food supply chain include cleaning agents, pesticides, natural food toxins and heavy metals (see Figure 2.4.3 for further chemical contaminants). Pesticides may reside on unwashed fruit/vegetables or be transferred from the soil in which the food was grown. Cleaning agents can enter foods during manufacturing processes. Toxic metals – including lead, cadmium, arsenic and mercury – can pass to food through soil/water or via processing, preparation or cooking.



Figure 2.4.3: Chemical contaminants.

Contaminated food

Definition

Microbe(s) or microbial (relating to microbes) are terms that can be used interchangeably with microorganism(s).

Extension activity

Research:

- how mercury enters the human food supply
- which foods are typically found with high levels of mercury
- what effect mercury can have on humans/fetuses
- how much of these mercury-laden foods people can consume during pregnancy.

Question

1. Identify the following contaminants as either physical, biological, chemical or a combination by ticking the boxes that are applicable (an example has been completed). (6 marks) (KA1)

Contaminant	Physical	Biological	Chemical
Lead	x	x	✓
Rat poo			
Pesticide			
Salmonella			
Norovirus			
Metal debris			
Hand sanitiser			

Factors favouring microbial growth

Once contaminants enter food, they can make the food unfit for consumption. Biological contamination generally has minimal repercussions unless the microbes are given favourable conditions in which to multiply to dangerous numbers in the food. These favourable conditions include optimal temperature, optimal pH, nutrients, water, air and time. In comparison, viruses will not multiply in food; instead, they travel with food and transfer to a host (e.g. a human) when consumed. Viruses will then use host cells to replicate. For this reason, only the microbes bacteria and fungi are discussed below.

Optimal temperature

Most bacteria multiply in temperatures ranging between around 5°C and 60°C, with their ideal temperature being human body temperature, i.e. around 37°C. At this temperature bacteria are at their most active, as their enzymes are catalysing reactions needed for functioning well. Fungi prefer a smaller range of temperatures to function best, from about 10°C to 35°C. See Figure 2.4.4 for the preferred temperature ranges of a range of microbes.



Reminder

Fungi is the generic term for mould and yeast.



Definition

Temperatures that allow for microbe growth are referred to as the 'danger zone'.

Extension activity

Some individual bacterial species have grown to prefer different levels of temperature. Based on their preferred temperature for growth, bacteria have been grouped as psychrophiles, mesophiles and thermophiles. Identify the optimal temperature ranges for each category of bacteria.

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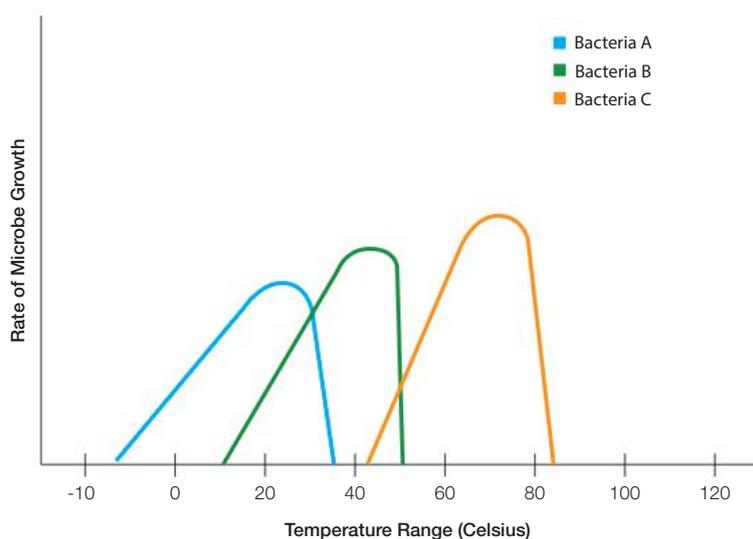


Figure 2.4.4: Preferred temperature ranges of a variety of microbes.

Question

2. Refer to Figure 2.4.4 to answer the following questions.

(a) Identify the temperature at which Bacteria C grows best

..... (1 mark) (IAE3)

(b) Identify the temperature range preferred by Bacteria B.

..... (1 mark) (IAE3)

Optimal pH

pH is measured on a scale of 0 (acidic) to 14 (alkaline), with seven being neutral (see Figure 2.4.5). If the pH value of a food or beverage is below 7, it is considered to be acidic. If it is above 7, it is considered alkaline. How acidic or alkaline a food or beverage is, is an important factor affecting microbial growth. Bacteria tends to multiply best around a neutral pH of 7 (but can still reproduce within a range of around 4.5 to 10), compared to fungi, which multiplies best at a slightly more acidic pH of 5 to 6 (but may still survive from around 2.5 to 8). Just as with temperature, these optimal pH levels are where their enzymes function best.

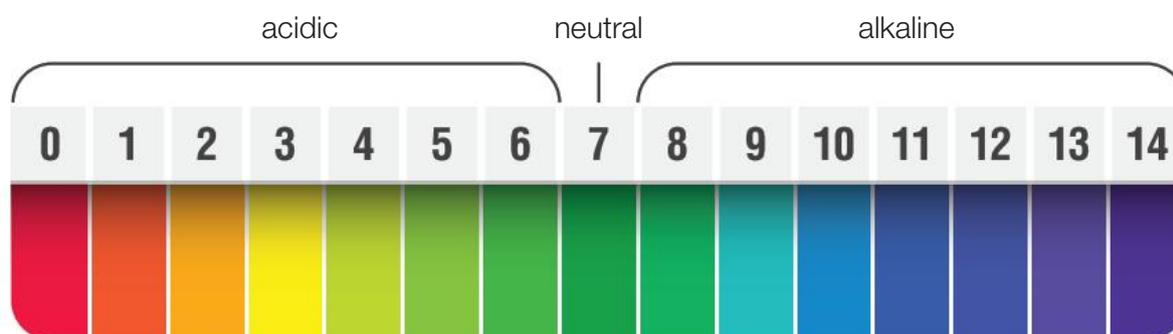


Figure 2.4.5: pH scale.

Question

3. Refer to Figure 2.4.6 to answer the following questions.



Figure 2.4.6: pH of various foods along pH spectrum.

- (a) *Listeria* is a bacterium with a preferred pH of 7 to 8. List two foods *Listeria* may commonly be found to contaminate.

..... (1 mark) (IAE3)

- (b) *Listeria* is known to survive within a pH range of about 4.5 to 9. List a food and beverage *Listeria* may not commonly utilise as a nutrient source.

..... (2 marks) (IAE3)

- (c) The juices of many fruits are typically quite acidic. State whether this pH is more suitable to bacteria or yeast.

..... (1 mark) (IAE3)

- (d) Foods like meat and seafood have a pH around neutral. State whether this pH is more suitable to bacteria or yeast.

..... (1 mark) (IAE3)

Nutrients

Most foods and/or beverages provide a sufficient nutrient source for microbes to flourish. A primary nutrient needed by bacteria is protein, therefore high-protein foods such as meats are particularly vulnerable to bacterial biological contamination. Other energy sources bacteria can use to function and replicate are sugars, starch and fats. Fungi, on the other hand, although able to use protein, prefer carbohydrates, and are able to readily absorb a variety of soluble sugars such as [glucose](#), [fructose](#) and [sucrose](#).



Reminder

These sugars belong to the simple sugars grouping (glucose and fructose are monosaccharides, while sucrose is a disaccharide).

Extension activity

Discuss how bacteria and fungi obtain energy and nutrients from food.

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Water

Water is essential to microbes; their cells require it for exchanging substances, dissolving the food they use for energy and growth, and running their metabolic processes or microbial reactions. Generally, the more water in the food/beverage, the better! This water, however, needs to be 'free' water, meaning the water within the food needs to be useable, and not bound to molecules such as **sodium**, which makes the water inaccessible to microbes.

Water activity (a_w) is the measure of the available or useable water in food. The water activity scale runs from 0.0 to 1.0, with pure water being 1.0 (therefore all foods and beverages fall below this value). The lower the a_w , the less water is available in a form that can be used by microbes. Most bacteria require a water activity of around 0.90 or higher to be able to function, while fungi can survive in a slightly lower a_w of around 0.88 for yeast and 0.80 for mould.



Definition

Sodium is defined as an electrolyte, meaning it attracts and binds water.

Question

4. The data for the bacteria (below left) displays the minimum water activity needed for the bacteria to survive. Compare the minimum water activity needed by the bacteria with the water activity of a variety of foods to make conclusions.

Bacteria	Minimum a_w	Food	Minimum a_w
Botulism	0.97	Raw meat/fish	0.98
E. coli	0.96	Bread	0.95
Staphylococcus	0.86	Dried fruit	0.6

- (a) Name the bacteria able to survive in raw meat/fish.

..... (1 mark) (AE1)

- (b) Name the bacteria able to survive in bread.

..... (1 mark) (AE1)

- (c) True or false? None of the listed bacteria are able to flourish in dried fruit.

..... (1 mark) (AE1)

Extension activity

Discuss the features of bacteria that allow them to move and adhere where favourable conditions lie.

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Air

Most microbes require air, specifically the oxygen in air, to survive. Those that utilise oxygen (to make energy via aerobic respiration) are called **aerobic microorganisms**. Some microorganisms, however, called **anaerobes**, can create energy without oxygen, and others can even **shift between being aerobic or anerobic** depending on environmental conditions.

Definition

Microbes that can respire with (aerobic) or without oxygen (anerobic) are called **facultative anaerobes**.

Time

In ideal conditions, bacteria grow exponentially, with some bacteria able to double in as little as 20 minutes; this can equate to two million in seven hours! Bacteria reproduce by **binary fission** (see Figure 2.4.7), a process in which their DNA duplicates within a cell, which then divides into two new bacterial cells.

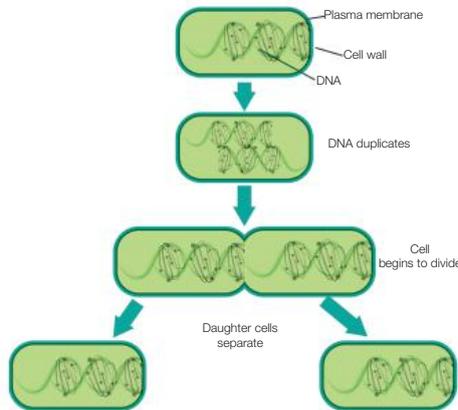


Figure 2.4.7: Stages of binary fission for bacterial reproduction.

Question

5. Explain why cuts or wounds that discharge blood can be easily infected by bacteria should the cut/wound not be well cared for (e.g. not disinfected and then covered with a bandaid).

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.....

(4 marks) (KA2)

Food poisoning and spoilage

Contamination of food will typically result in either food poisoning or food wastage (food spoilage).

Food poisoning

Foodborne illness or food poisoning is defined as illness, generally seen as **gastroenteritis**, resulting from eating contaminated food and/or beverages. Whether the consequence is food wastage, food poisoning, or neither, can depend on the type of contaminant (biological, chemical or physical).

Definition

Gastroenteritis is a condition with symptoms of diarrhoea and vomiting.

Physical contaminants tend to be noticed in food and the food gets discarded (and therefore adds to food wastage). If they are ingested, they may cause harm such as lacerations of the digestive organs.

Question

6. List two examples of physical contaminants that may cause lacerations of the digestive organs if consumed.

.....

..... (2 marks) (KA2)

The consumption of food with chemical contaminants can result in concerns ranging from mild gastroenteritis to fatal cases of kidney or neurological problems. These results may be immediate, such as with some natural toxins in plants, or may only be apparent after many years of accumulation, such as with some of the heavy metals, like mercury. Because chemical contaminants can cause gastroenteritis (or worse), they are known to cause food poisoning, or foodborne illness.

Extension activity

Name a few different plant toxins and discuss their health implications.

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When biological contaminants are exposed to favourable conditions, they can multiply rapidly. Once high numbers of these contaminants are present, they can cause food poisoning or food spoilage.

Food poisoning is typically caused by **pathogenic** bacteria (see Figure 2.4.8) or viruses. Biological contamination leading to **food poisoning is more common** than that of chemical contamination, because bacteria and viruses tend to be odourless, flavourless and invisible to the naked eye, and thus get consumed. Some bacteria can produce toxins that can be heat-resistant and persist in food even after heating. These toxins can also cause food poisoning when eaten. When food with pathogenic bacteria or their toxins are consumed, the typical results are gastroenteritis symptoms of vomiting and diarrhoea, particularly for those with weakened immune systems, such as infants, pregnant females, the elderly and those who are immunocompromised.

Definition

A **pathogenic** bacterium is one that is harmful to health.

Fast fact

An estimated 4.1 million Australians are affected by food poisoning each year.

Source: <http://www.foodauthority.nsw.gov.au/fp/food-poisoning>

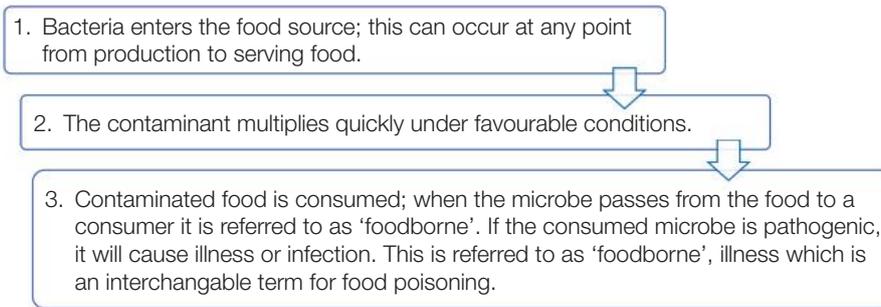


Figure 2.4.8: Process leading to bacterial food poisoning.

Extension activity

Define 'immunocompromised' and give some examples of people who would be classified this way.



Science as a human endeavour (Influence, Application and Limitation)

A bacterial mechanism causing food poisoning uncovered

The following article has been condensed from the following source:

<https://phys.org/news/2018-12-food-poisoning.html>

Food poisoning is estimated to affect 4.1 million Australians each year and *Bacillus cereus*—one of the most common types of stomach bug—is responsible for producing toxins that cause vomiting and diarrhoea. It may not be a household name, but *Bacillus cereus* can be found in vegetables, meat, fish, rice and pasta, and will grow in these foods if they are not stored properly.

Lead researcher Ms Anukriti Mathur, from the The Australian National University (ANU), has found how the bacteria works and how to combat it. «We knew the toxin would have to attack the cells, triggering an immune reaction, but we now know how it does it,» said Ms Mathur. «We discovered the toxin directly binds to the cell and punches holes to kill the cell, the immune system responds to the infection and has a reaction.

“Because we now know how the bacteria and the toxins work, we can fight it and find ways to use the immune system against it. “Researchers say the discovery will be vital in understanding and treating serious cases of food poisoning. “This research could help patients with a compromised immune system,” said Ms Mathur. “We might be able to save patients by weakening the toxin, or in the case of sepsis, dampening inflammatory responses. “It also means we have therapeutic drug options to further support antibiotic therapies, especially in the face of rising antibiotic resistance.”

Question

7. Highlight sections of the article that may be useful to a SHE task background information section as well as text that relates to SHE components Influence, Application & Limitation.

(4 marks) (KA3)

Food spoilage

Food spoilage can be defined as changes in food and/or beverages that render the product undesirable for consumption, leading to its disposal; i.e. food wastage. **Food wastage** is when food is not consumed but thrown away as rubbish somewhere along the food supply chain. Signs of food spoilage can be unusual texture, odour, taste, and appearance, and there a variety of factors that can cause it, including those seen in Figure 2.4.9.

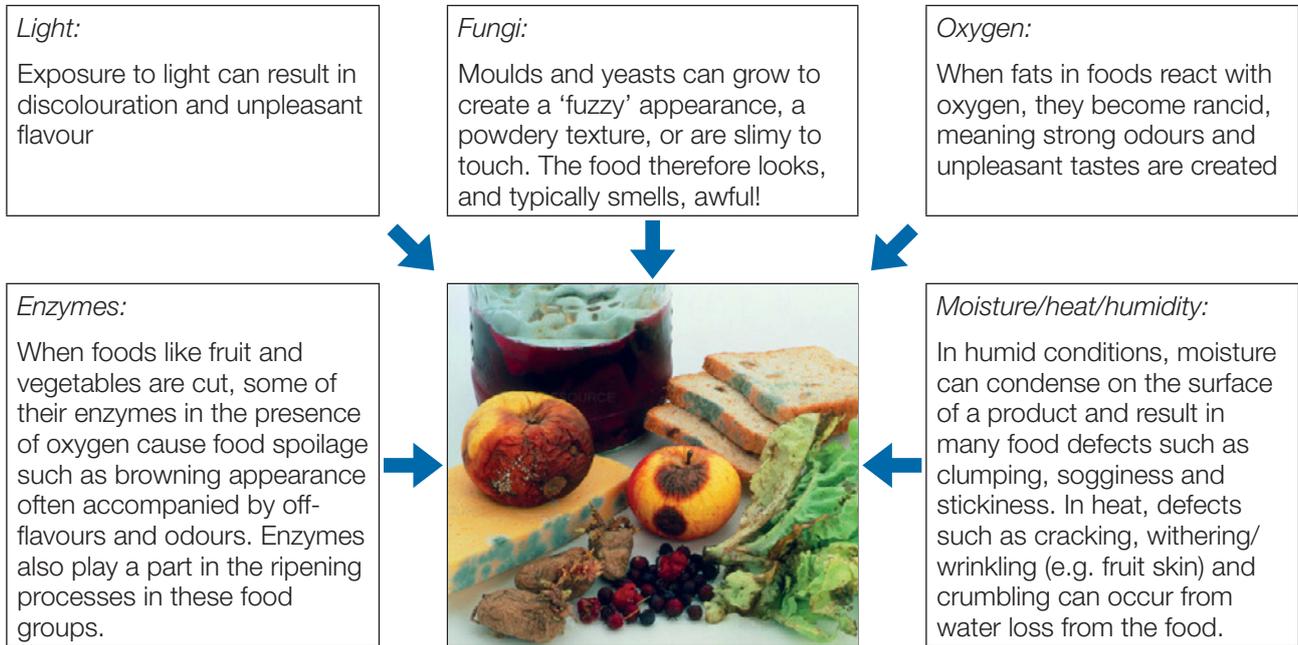


Figure 2.4.9: Food spoilage appearance and causes.

Question

8. Identify each of the causes of food spoilage as microbial (M) or environmental/natural decaying processes (E). (5 marks) (KA1)

	Factor enhancing food spoilage				
	Enzymes	Light	Fungi	Oxygen	Humidity
Microbial (M) or natural decay/ environmental (E)					

Extension activity

Some bacteria can be associated with food spoilage. Name the bacteria responsible for meat/poultry and milk/cream spoilage and outline how the spoilage is detected.

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Question

10. Define biological contamination.

(2 marks) (KA1)

Table 2.4.1: Common sources of cross-contamination

Source of contaminant	Method to reduce cross-contamination
Dirty hands used in food preparation; for example, not washing hands with soap after going to the toilet	
Dirty clothes; for example, a T-shirt with pasta sauce on it from lunch worn to prepare dinner	
Used utensils; for example, the same chopping board and knife are used to prepare raw chicken followed by a roast chicken	
Poor personal hygiene; for example, coughing/sneezing over food or even licking fingers and scratching one's head before handling food	
Pests; for example, flies, mice and cockroaches can carry pathogenic bacteria or leave their faeces harboring bacteria	

Extension activity

Complete Table 2.4.1 above by giving a number of methods to eliminate or reduce the chance of each source of cross-contamination occurring. Extend the table by adding an additional two common sources of cross-contamination.

Question

11. Soap is commonly used to wash hands, having a pH of around 9-10. Explain why soap is used to wash hands.

(3 marks) (KA2)

Questions

13. State the temperature range of the danger zone.

..... (1 mark) (KA1)

14. Identify the term for microbe transfer when a service staff member uses the same gloves to handle food and money, thereby transferring bacteria from money onto the food.

..... (1 mark) (KA1)

Apart from applying good hygiene and food handling practices, there are a number of additional tips to reduce the occurrence of food poisoning when preparing and/or cooking foods:

- Avoid thawing frozen food in the temperature danger zone where bacteria can grow or cook immediately after defrosting if using a microwave/oven's defrosting settings to defrost.
- Do not allow prepared foods to remain at room temperature for more than two hours before eating (see section on food storage.)
- Make sure that cooked food reaches a temperature of at least 75°C.
- Cook white fish until it flakes easily with a fork.
- Cook poultry until all the meat is white (check by slicing at thickest section) and the juices run clear.
- Cook hamburgers, minced meat, sausages and rolled roasts right through (no red) until the juices are clear
- When reheating meals, make sure to heat thoroughly as per cooking instructions (at least 75C) or steaming hot throughout

Questions

15. Undercooked chicken is considered a 'high risk' food in regard to food poisoning. Discuss reasons for raw chicken being categorised this way.

.....

 (2 marks) (KA2)

16. A beef steak can be served to be eaten with red to the middle, yet a minced beef hamburger patty should be cooked through with no red to the middle. Explain why these meat products, despite both being beef, have different cooking requirements.

.....

 (2 marks) (KA2)

Extension activity

Microwaves provide a quick and convenient way to cook food. However, if they are not used correctly, they can cook food unevenly. This may leave food partially cooked or below a uniform temperature of 75°C. Provide some recommendations for microwave cooking to ensure food is evenly cooked and reaches an appropriate temperature.

.....

Food storage

For food to be stored safely, the following precautions should be observed.

- Separate raw and cooked food, storing raw food at the bottom of the fridge to avoid juices dripping onto other foods. Always store raw food in sealed or covered containers.
- Under ideal conditions, cooked food can be stored in the fridge for a few days. If you want to keep cooked food longer, freeze the food immediately after cooling in the fridge.
- Ensure fridge temperature is below 5°C (4°C) and freezer below -15°C (-18°C) (see Topic 3 food processing section for further explanation)
- Allow cooked foods to cool quickly (less than two hours) to around room temperature (no steam rising off the food; the food should not be very hot to the touch) before storing in the fridge; cool food quicker by separating it into smaller containers. This tip follows the 2-hour/4-hour food safety guide displayed in Table 2.4.2. The 2-hour/4-hour guide is substantiated on food poisoning bacteria generally taking more than four hours to reach dangerous numbers in ready-to-eat food. It is important to note that the times refer to total time the food has been in the danger zone – including before and after cooking.
- Avoid re-freezing any food that has been thawed.

Table 2.4.2: 2-hour/4-hour food safety guide.

Total time limit between 5°C and 60°C	Action
Less than 2 hours	Refrigerate or use immediately
Between 2 and 4 hours	Use immediately or discard
More than 4 hours	Discard

Questions

17. Explain why food is allowed to reach room temperature quickly before being stored in the fridge.

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.....

..... (2 marks) (KA2)

18. Apart from cooling quickly, outline another benefit of storing leftovers in smaller, single serving-sized containers.

.....

..... (1 mark) (KA2)

Extension activity

Leftover food should not be stored in opened tin cans but transferred into sealed containers. Discuss the rationale behind this recommendation.

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Key terms

2-hour/4-hour rule	Danger zone	Hygiene/sanitisation
Aerobic microorganisms	Facultative microorganisms	Microorganism/microbe
Anaerobic microorganisms	Food contamination	Pathogenic
Bacteria	Food poisoning/foodborne illness	Physical contaminant
Binary fission	Food spoilage	Virus
Biological contaminant	Food wastage	Water activity
Chemical contaminant	Fungi	
Cross-contamination	Gastroenteritis	

Review questions: 2.4 Safe food: contamination and its prevention

1. 28-year-old Val left his food shopping (bread rolls, milk, tomatoes and roast chicken) in the car for five hours at 40°C. Upon retrieving it, he noticed some of the foods had begun to spoil.

(a) State what Val may have noticed to indicate his food had begun to spoil.

.....
 (2 marks) (KA2)

(b) Discuss three conditions that would have allowed the food spoilage to occur.

Condition one:

.....
 (2 marks) (KA2)

Condition two:

.....
 (2 marks) (KA2)

Condition three:

.....
 (2 marks) (KA2)

(c) Select a food and name a pathogenic microbe that may now be present in dangerous numbers in Val's groceries.

..... (1 mark) (KA2)

(d) Val decides to risk eating his chicken, but he firstly reheats it above 80°C to ensure any bacteria that may be present are completely killed. Discuss why this process is not sufficient for eliminating the food-poisoning potential of this chicken.

.....
 (2 marks) (KA2)

(e) Val is quite lucky, he does not get any gastroenteritis from consuming the reheated chicken. Name a group of people who have a greater risk of food poisoning and provide reasons why they are at a greater risk.

.....
 (2 marks) (KA1)

2. Identify the following examples of contaminants as either physical, chemical or biological. (4 marks) (KA1)

Contaminant	Classification
Pesticides	
Green potato (contains plant toxin)	
Human nail clipping	
Norovirus	

3. Complete the table by filling in the optimal conditions for bacteria. (4 marks) (KA1)

Factor allowing bacterial growth	Optimal conditions preferred by most bacteria
pH	
Temperature	
Nutrient	
Water activity	

4. Microbes can be grouped as acidophiles, neutrophiles or alkaliphiles based on the range of pHs they survive in. The following questions use the data from Figure A.

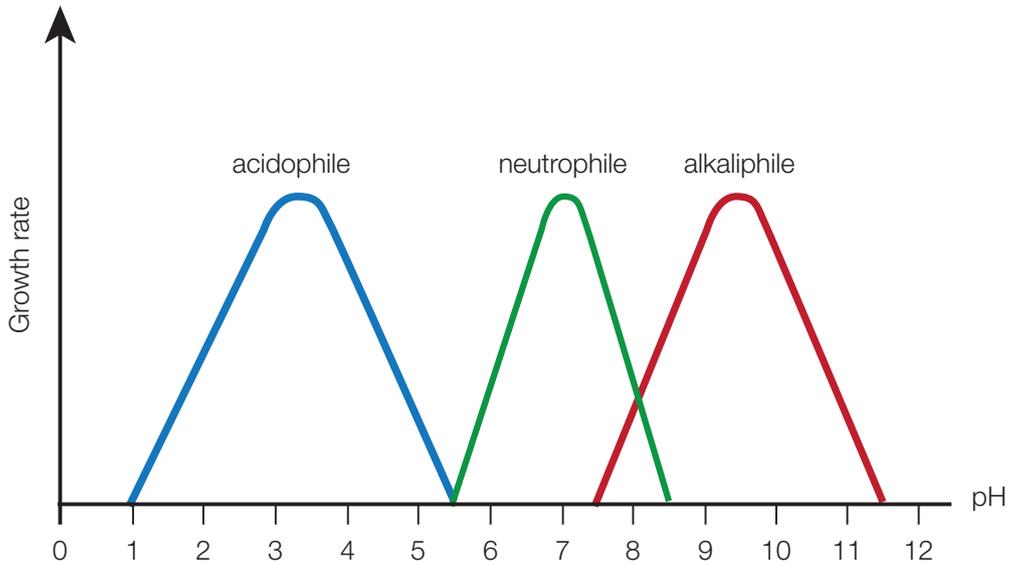


Figure A: pH range for acidophiles, neutrophiles and alkaliphiles.

- (a) Name the type of microbe that thrives best in foods with a neutral pH.
 .. (1 mark) (IAE3)
- (b) Identify the type of microbe with the largest pH range, using data to justify your response.
 .. (2 marks) (IAE3)
- (c) State whether acidophiles would most likely be bacteria or fungi.
 .. (1 mark) (IAE3)

5. David washes his hands with soap after going to the toilet and dries them on the kitchen tea towel, which is washed weekly, before preparing his lunch. He takes his lunch out of the fridge – leftover pizza, some cheese slices that have been stored directly under a packet of steak, plus some lettuce he has kept in the crisper section. He decides he'll also eat the scrambled eggs leftover from breakfast sitting in the frying pan. David scratches his head while considering what to do first. He reheats his pizza. While this is reheating, he cuts the fat off the steak on a chopping board. He passes the trimmings to his cat, which is sitting on the kitchen bench waiting for scraps. He then slices up the lettuce on the chopping board. His pizza has gone cold while he has been preparing his other food, so he reheats his pizza and then eats it.

List three unsafe food practices undertaken by David. Describe why each food handling method is an unsafe practice and give a recommendation to improve David's food safety.

Unsafe practice:

Description:

..

Recommendation:

.. (3 marks) (KA2)

Unsafe practice:

Description:

..

Recommendation:

.. (3 marks) (KA2)

Unsafe practice:

Description:

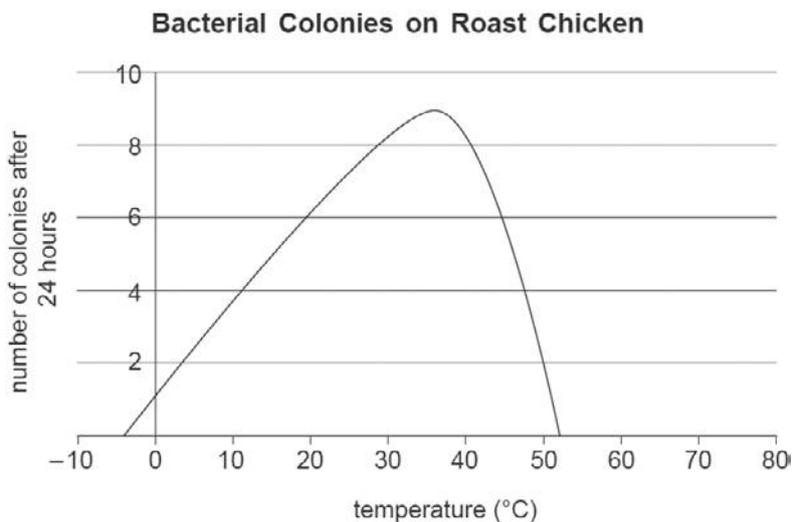
..

Recommendation:

.. (3 marks) (KA2)

6. Chicken is a common source of food poisoning. Laboratory staff counted the number of bacterial colonies on roast chicken after 24 hours at different temperatures.

Refer to the following graph, which shows the results of laboratory testing.



- (a) State the independent variable.
 (1 mark) (IAE1)
- (b) State two variables that the laboratory staff will need to keep constant so that the results can be compared.
 (2 marks) (IAE1)

(c) Using data from the graph above, describe the effect of temperature on the number of bacterial colonies on the roast chicken over the 24-hour period.

.....
.....
..... (2 marks) (IAE3)

(d) Explain why there was a change in the trend of bacteria growth on the roast chicken at 37°C.

.....
.....
..... (2 marks) (IAE3)

(e) A number of people became severely ill 24 hours after eating roast chicken from a catering company for lunch. The roast chicken was prepared as follows:

1. The raw chickens were roasted in the oven on the morning they were used
2. The roast chicken was removed from the oven and left on a bench at room temperature until it was served at lunch. After lunch, left over chicken was supplied to diners in takeaway food containers.

Use this information to make a recommendation to the catering company about how to improve their food preparation procedures in order to minimise the risk to consumers. Justify this recommendation.

.....
.....
..... (2 marks) (KA2)

7. Describe the best way of cooling five litres of soup and storing it for four weeks to limit the amount of bacterial contamination that occurs.

.....
.....
..... (2 marks) (KA2)

Total: _____ / 45 marks

2.5 Safe food: government regulation

Science understanding

In Australia, the sale of food is regulated and the consumers are protected, by government policy regulation.

- the role of FSANZ in
 - regulation of food production and consumer safety
 - using additives including emulsifiers, antioxidants, artificial colours and sweeteners
 - mandatory fortification (specifics- folate, thiamine, iodine, vitamin D)
 - mandatory food labelling requirements
 - nutrition value per 100 grams
 - composition of food using nutrition tables or programs

SACE Subject Outline, 2020.

FSANZ food standards code

FSANZ, a government authority, developed a food standards code that covers many food legislations, or standards, in the areas of primary production (or agriculture/farming), composition of food, food processing, food labelling, food safety and food handling. The standards of the code place responsibilities on **food businesses** to produce food that is safe and suitable to eat all in an effort to lower the incidence of foodborne illness. The food standards code enforcement is the responsibility of state and local governments. It is an offence to sell food not compliant with the FSANZ food standards code.

Definition

A **food business** could be a food manufacturer or any business like a restaurant that involves the handling of food for sale. It does not include temporary or home-based businesses.

Question

1. Name a group of people more likely to be gravely affected by foodborne illness in Australia.

(1 mark) (KA1)

Helpful online resources

<http://www.foodstandards.gov.au/code/Pages/default.aspx>



Amongst all the food legislations set out by many standards of the 'food standards code' (see all 4 chapters and schedules via <http://www.foodstandards.gov.au/code/Pages/default.aspx>), some of the standards with relevance to Nutrition studies are summarised below:

- Food additives (see later section on additives) used by manufacturers must be rigorously assessed for safety, approved by FSANZ, used in the lowest quantity possible to perform their function and appear in the ingredients list
- All packaged foods sold in Australia must comply with the mandatory (or compulsory) labelling requirements prescribed by FSANZ (see later section on food labelling); country of origin labelling, however, is overseen by Australian consumer laws
- Packaging regulations set by FSANZ maintain that packaging is 'safe'; for example, food businesses can only use materials that will likely not contaminate (metal, chemical, etc) the food (see 'Packaging' in Topic 3 for further details)
- Food manufacturers must follow stringent requirements for making 'gluten free' or 'low gluten' claims about their food

- Nutritional and health claims made on food labels (see later section voluntary food labelling) are regulated by FSANZ; the food standards code specifies many definitions for claims food manufacturers can use such as:
 - ‘reduced fat or salt’ claim – products should have at least 25% less fat/salt compared to the original product
 - ‘fat free’ claim – food products must be less than 0.15% fat
 - ‘good source of...’ – the food must contain no less than 25% of the RDI for that micronutrient
- The food standards code regulates the use of added vitamins and minerals to food, called food fortification.

Beyond the food standards code, FSANZ also has many other roles in Australia including coordinating food surveillance (monitoring food for safety and ensuring it complies with standards such as those for microbiological contaminants, pesticide residue and chemical contamination), offering food recall systems (recall webpage displaying foods and alert feeds possible with subscription) and providing a Nutrition panel calculator to help food manufacturers prepare a Nutrition Information Panel (NIP) (see later section food labelling) for their products.

Questions

2. FSANZ aims to reduce the incidence of food poisoning by carrying out a number of roles. Indicate which of the following are (or aren't) roles of FSANZ. (6 marks) (AE1)

Role	Indicate if each is a role of FSANZ with a 'yes' or 'no'
Provides food standard codes for fortification	
Regulates food additive use	
Provides food standards for hygiene for food handlings	
Enforces the food standards code and fines manufacturers not compiling	
Provides food standards for fundraising events selling foods	
Regulates food labelling laws	

3. Looking at Figure 2.5.1, identify which breakfast cereal could make a claim ‘good source of calcium’, using data to support your answer

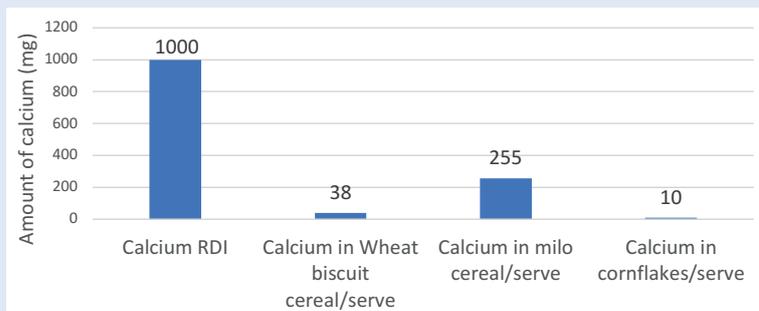


Figure 2.5.1: Amount of calcium (mg) in some breakfast cereals compared to the RDI.

.....

..... (2 marks) (IAE3)

Food fortification

Food fortification is when a micronutrient is added to a food in amounts above the quantity found naturally or originally in that food. FSANZ only permit certain nutrient fortifications and quantities, so long as they are in an effort to improve the nutritional quality of the food supply and/or provide a public health benefit with minimal risk to health. Some of these fortifications are mandatory (compulsory), while others are voluntary and food manufacturers may choose to fortify:

Definition

Food fortification that refers to the addition of micronutrients that are lost during food processing is called **enrichment**

- **Mandatory fortification** – FSANZ stipulates food manufacturers must add vitamin D to oil spreads such as margarine, iodised salt (salt that has had the mineral iodine added to it) to bread, and vitamin B1 (thiamine) and **folic acid** must be added to wheat flour also used in making bread
- **Voluntary fortification** – Micronutrients commonly chosen to be added to foods by food manufacturers include iron and calcium; when fortified voluntarily, these nutrients must appear on nutrition information panel (NIPs) (see later section).

Reminder

Folic acid is the synthetic version of folate (B₉).

Questions

4. FSANZ mandate folic acid to be fortified in wheat flour used to make bread, and vitamin D in oily spreads like margarine. Name the health concern that these mandates may be aimed at alleviating.

Folic acid fortification: (1 mark) (KA1)

Vitamin D fortification: (1 mark) (KA1)

Extension activity

Voluntary fortification can pack nutrients into a food to create a 'superfood'. A naturally occurring 'superfood' is one with a very high nutritional density and often additional compounds offering health benefits. Name some superfoods, list the range of nutrients they hold and discuss their 'disease-fighting compounds' utilising the table below:

Superfood	Range of nutrients	Compound with health benefits

*Note that scientists, dieticians (etc) resist use of the term 'superfood' due to it being used as a marketing ploy, often inappropriately!



Science as a human endeavour (Communication & Collaboration; Development; Influence; Application & Limitation).

Broccoli – can it be made ‘more super’?

The article below has been condensed from the following source:

<https://www.sciencealert.com/powdered-broccoli-coffee-emerging-new-food-trend>

A new way of processing broccoli could help you get your servings of vegetables, while dealing with the wastage of “unsightly” food. We’re talking dried, ground to fine powder, and stirred into your coffee. But coffee isn’t the only potential application for the powdered brassica. The CSIRO has also added it to extruded snacks, and it could also work as an ingredient for smoothies, muffins, and soup.

Approximately two tablespoons of the powder is equivalent to one serve of vegetables, as per the Australian government’s recommended five to seven daily serves. “Research shows the average Australian is still not eating the recommended daily intake of vegetables a day, and options such as broccoli powder will help address this,” said Hort Innovation’s John Lloyd.

A lot of produce is wasted before it even gets to the store shelves because it’s «ugly». Some of these ugly fruits and vegetables can be used for juicing, and «superfood» powders made from vegetables such as chia and kale have been around for a while. In the case of the new broccoli powder, it uses the whole broccoli - florets and stems. No wasted chunks thrown in the bin like in your typical cooking process.

To make broccoli coffee, the powder is added to the cup after the espresso shot has been pulled. Steamed milk is added, and more broccoli powder is sprinkled on top. It sounds... rather more broccoli-flavoured than many might usually prefer their coffee to be, and doesn’t take into account drinkers who prefer their brew without milk.

The next step, however, is to investigate bringing powdered broccoli to the consumer market, so you might soon have a chance to try it out yourself at home. “I see this project as the emerging new food trend,” said John Said of broccoli producer Fresh Select. «Australians don’t eat enough vegetables and farmers across Australia will have access to an alternative market whilst improving farm yields and sustainability. They will also be contributing to healthier lifestyles!»

We’re not entirely sure it’s going to catch on as a coffee additive, but, as the blue algae latte shows, stranger things have happened!

Question

5. Highlight sections of the article that are relevant to Communication and collaboration, development, influence, and application and limitation. (4 marks) (KA3)

Food labelling

Food labels carry essential information to allow consumers to make informed choices before purchasing foods. A number of these labels act to reduce the chance of microbes flourishing and causing spoilage or poisoning. Many of the food labels seen on products are **mandatory** (or compulsory), although food manufacturers may include a number of FSANZ approved voluntary food labels.

Mandatory food labelling

Mandatory food labels in Australia are detailed in Figure 2.5.2 Apart from labelling requirements, there are also legibility requirements. Label information must be legible (for example, warning statements must be at least 3 mm high for most packaging types), prominent (distinct from the background) and in English. Should the label be in another language, the essential information must also be given in English.

Use-by date:

Food that has potential to cause food poisoning or other health concerns must have a use-by-date to indicate when the food needs to be consumed by, to reduce this risk.

Best-before date:

Products with a shelf-life of less than two years that don't pose these health risks if eaten after its date marking (but may have lost quality), must be labelled with a best before date.

Nutrition information panel (NIP):

The NIP must list energy (kJ) and key nutrients: protein, total fat and the quantity that comes from saturated fat, total carbohydrate and the quantity that comes from sugars, plus sodium. If the product has a nutrient claim displayed anywhere on the label such as 'high in fibre', this must also appear in the NIP, to substantiate the claim.

The quantities of the nutrients are given per serving (and sometimes also displayed as % daily intake), to allow the consumer to keep track of what they are eating, and per 100g (or 100 mL if liquid), to allow comparison to similar products.

List of ingredients:

The ingredients of the food are listed in order from the one contributing the highest quantity first through to the least (according to weight). **Individual ingredients that make up a compound or composite ingredient of significant contribution to the food (>5%),** and any added water, must also be listed. If an ingredient (other than an additive or known allergen) is less than 5%, it does not have to be listed.

Percentage labelling:

The key/characterising ingredients (or the ingredient the manufacturer advertises/claims the product to contain) must be presented with the percentage of it in the food to allow comparisons to similar products

Food additives:

Food additives are listed in the ingredients list, displayed according to their type or class, followed by their chemical name or number, e.g. colour (tartrazine) or colour (102).

Name and/or description of the food/beverage:

The name/description of the food needs to indicate the true nature of the food. For example, 'Strawberry Yoghurt' should contain strawberries while 'strawberry-flavoured yoghurt' would need to taste like strawberries but not contain them. It should not misinform consumers through false, misleading or deceptive representations.

Net weight:

Manufacturers must label food products with accurate weights and/or measures (quantities of servings contained in a package).

Warning and advisory statements:

If the food contains any known **allergens** such as nuts, milk, shellfish, eggs and **gluten**, that may have severe health effects, or the preservative sulphite in quantities that may trigger asthma, they must be declared in the ingredients list (typically found in bold print or brackets). Allergens can also appear as a separate warning statement found near the ingredients list. Some food manufacturers also choose to use a 'may contain' statement should processing equipment of their foods be used for other foods with known allergens.

Advisory statements appear under the ingredients list when the food contains ingredients that may pose a health risk to some consumers, such as 'contains caffeine'.

Food recall information:

Name and address (PO box not sufficient) of the food supplier plus identification of the 'lot' number is listed (allows for effective recall of batches of food that may have a potential contaminant).

Country of origin:

All packaged food and some unpackaged food such as meat, fruit and vegetables, must be identified as being made from imported or local ingredients (or a mixture of both). Country of origin labelling can indicate where the food was grown, produced, made/ manufactured or packaged (see Figure 2.5.3 for additional country of origin labelling types).

Storage instructions:

If a product poses a risk of microbial growth or deterioration, instructions on how to specifically store the food to maintain its quality and safety until its date mark need to be included. Manufacturers also have to provide preparation directions for any products that are unsafe to eat unless prepared as directed.

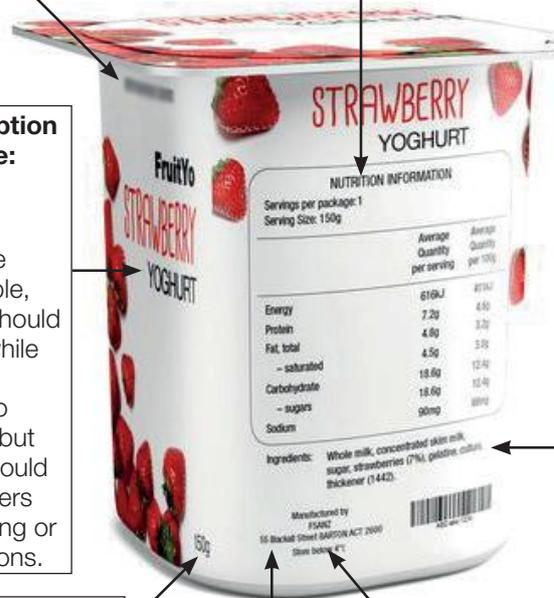


Figure 2.5.2: Food labelling requirements in Australia.

Question

9. Referring to Figure 2.5.4, list three mandatory labelling requirements missing from the preserved mangoes.



Figure 2.5.4: Labeling on a can of preserved mango.

(3 marks) (KA2)



Science as a human endeavour (Development)

Laboratory testing to confirm NIPs

Question

10. (a) Routine and accurate measurement of the nutrients in food is necessary to ensure that products are in compliance with their NIPs. Total fat is commonly found using a standard solvent extraction/acid hydrolysis method (called the Soxhlet or wet chemistry method). Nuclear magnetic resonance (NMR) offers an alternate method to test for fat content in foods but is not yet widely used. Discuss how this newer technology can improve the efficiency of scientific procedures, data collection and analysis, using the following websites:



Helpful online resources

<https://nmr.oxinst.com/assets/uploads/documents/Determination-of-Fat-and-Oil-Content-in-Foodstuffs.pdf>



<https://nmr.oxinst.com/assets/uploads/documents/Using-Nuclear-Magnetic-Resonance-to-Test-Fat-Content-in-Foods.pdf>



(4 marks) (KA3)



Science as a human endeavour (Development)

- (b) NMR does not only hold the potential to improve the efficiency of testing for fats and oils in foods. Identify other processes that could be replaced by a more efficient NMR method utilising the following website:



Helpful online resources

<https://www.theresonance.com/nmr-for-foods-and-beverages/>



(2 marks) (KA3)

Voluntary food labelling

Food manufacturers may choose to add nutrition content claims and health claims, typically in an effect to make their product more appealing to the customer.

- **Nutrition content claims** are about the quantity of a certain nutrient in the food, such as being 'low in fat' or 'high in calcium'.
- **General-level health claims** refer to the relationship of the nutrient quantities (or substance in a food) to its effect on a health function; for example, 'calcium helps healthy bones'.
- **High-level health claims** relate the nutrient level in the food (or substance in a food) to a disease; for example, 'diets high in calcium may reduce the risk of osteoporosis'.

These claims are not permitted on foods high in saturated fat, sugar or salt.



Reminder

The nutrient the claim is made about must be added to the NIP to allow a customer to verify the claim.

Question

11. Suggest one reason why health claims are not permitted on foods high in saturated fat, sugar or salt.

(2 marks) (KA2)

Other claims manufacturers include to appeal to customers can be deceiving. For example:

- 'Light/lite' – may not be referring to the fat or energy level, but the texture/colour/taste of the food!
- 'No/low cholesterol' on plant foods – these foods naturally have virtually no cholesterol!
- '93% fat free' – it still has 7% fat but sounds better saying the opposite!
- 'Baked not fried' – but it may still contain the same levels of fat!

Therefore, always read the nutrition information panel when these claims are made.

A newer voluntary innovation that may soon become mandatory is the **health star rating** (HSR) system. The HSR is a nutrition information label for the front of packaged foods that rates the product from 0.5 to 5 stars (5 being the best, or healthiest) (see Figure 2.5.5). The star rating offers a nutritional profile of the food that complements the NIP, but aims to be more convenient and readily understood, to assist customers in making informed and healthier eating choices.



Figure 2.5.5 Health star rating (left) and HSR with individual nutrients contributing to rating (right).

Extension activity

Hold a classroom discussion around the limitations and credibility of the HSR, especially considering food manufacturers can manipulate the serving size that determines a food's star rating. Compare the serving size and star rating of a number of similar foods (for example, muesli bars). Investigate how a substance like Milo can receive a high star rating.

There are a range of other labelling types and production methods, such as free range and organic, that can also be declared voluntarily on a food product. However, to include this declaration on a food label, manufacturers must follow stringent rules typically regulated by FSANZ. For example, if genetically modified foods/ingredients are chosen to be added to a produce, FSANZ then requires one that manufacturers label the product as containing genetically modified ingredients.

Extension activity

Complete the table for the following voluntary types of labelling.

Type of labelling	Illustration of the labelling	Description	Examples of foods that commonly use this labelling	Requirements to obtain the labelling
Organic				
Halal				
Heart foundation tick				
Fair trade				

Food not requiring labelling

Food that is exempt from any labelling includes:

- unpackaged food or food packaged at its point of sale, such as from a bakery, butcher, fast food outlets and restaurants
- smaller individual packets held within larger labelled packaging
- single-ingredient foods, such as fresh fruit and vegetables
- foods sold at fundraising events
- very small packaged foods and foods without significant nutritional value, such as herbs, spices and coffee.

However, the retailer must be able to provide labelling information for these foods if asked, such as allergens, storage instructions, country of origin, etc.

Food additives

Food additives are chemicals added to processed foods (either put into their ingredients or coated over the food) to improve them. There are many food additives, each with a specific role, ranging from increasing the shelf life of food to enhancing the texture, taste and/or appearance. Although labelled as chemicals and added artificially into foods, many food additives actually occur naturally in the foods **that people eat every day**. A number of food additives are included in Table 2.5.1 (on the next page).

Fast fact

For most people, food additives are safe to consume. However, some people can be sensitive to food additives, particularly the flavour enhancer MSG, food colourings, preservatives and the sweetener aspartame. These food additives have known to cause allergic reaction responses including diarrhoea, insomnia, asthma, or hives. Symptoms, however, may be due to an underlying illness and medical diagnosis is important.

Table 2.5.1: Food additives and their uses.

Food additive	Purpose	Foods commonly added to
Colourings	Add or restore colour to many processed foods	Confectionery, cereals, jams
Sweeteners	Replace the sweetness normally provided by sugars in food without significant contribution to the kJs of the food	'Diet' options of soft drink, baked goods like biscuits
Emulsifiers	Prevent water and oil from separating into different layers	Mayonnaise, margarine (see Figure 2.5.6).
Anti-oxidants	Prevent foods, particularly those with a high fat content, from oxidising and going rancid ; antioxidants can also discourage the loss of vitamins that are easily destroyed from oxygen exposure.	Cooking oils, oil spreads like peanut butter

Definition

Rancidity is the development of unpleasant flavours and odours.



Figure 2.5.6: Mayonnaise with and without emulsifiers.

Extension activity

Discuss the use of the following additional food additives.

Food additive	Purpose	Foods commonly added to
Anti-caking agents		
Food acids		
Foaming agents		
Mineral salts		
Stabilisers and firming agents		
Flour treatment		
Gelling agents		
Propellants		
Bulking agents		
Flavour enhancers, such as monosodium glutamate (MSG)		
Flavours (vs flavour enhancers), such as vanilla		
Thickeners		
Preservatives		
Humectants		
Glazing agents, such as beeswax		
Raising agents		

Question

12. A supermarket stocks a 'diet' muffin. Describe two food additives that may be present in the ingredients list of this food.

.....

.....

.....

(4 marks) (KA2)

Cereals (44%) (Whole Oats, Whole Wheat, Rice, Wheat Flour), Glucose Syrup, Raisins (9%), Sweetened Cranberries (6%) (Sugar, Cranberries), Apple Juice Concentrate, Humectant: Glycerol, Sunflower Oil, Sugar, Skimmed Milk Powder, Sweetened Blackcurrants (1%) (Blackcurrants, Apple Juice Concentrate, Lemon Juice Concentrate), Milk Whey Powder, Sweetened Blueberries (1%) (Blueberries, Apple Juice Concentrate, Lemon Juice Concentrate), Malted Wheat Extract, Malted Barley Extract, Emulsifiers (Soya Lecithin, Rapeseed Lecithin), Citric Acid, Salt, Raising Agent: Sodium Bicarbonate, Flavouring.

13. Refer to the ingredients list of a cereal bar (included above) to answer this question. Identify two food additives used in this cereal bar, and explain why they have been used.

.....

.....

.....

(4 marks) (KA2)

Extension activity

Discuss the effects that the consumption of food additives may have on children (be mindful, as findings are controversial).

.....

.....

.....

.....

.....

Key terms

Allergen	FSANZ	Percentage labelling
Best-before date	Health star rating	Use-by date
Country of origin	Ingredients list	Voluntary food fortification
Enrichment	Mandatory food fortification	Voluntary food labelling
Food additives	Mandatory food labelling	Warning and advisory statements
Food business	Nutrient content claim	
Food fortification	Nutrition Information Panel (NIP)	

Review questions: 2.5 Safe food: Government regulation

1. (a) Name the government organisation that produced the food standards code.

..... (1 mark) (KA1)

- (b) Describe three additional roles of this consumer protection authority.

.....

 (3 marks) (KA1)

2. Identify two nutrients that have mandatory food fortification specifications and list a food it would be found in.

Nutrient one:..... Food:.....

Nutrient two:..... Food:.....

(4 marks) (KA1)

3. The following questions revolve around food labelling.

- (a) Match the mandatory labelling law with its description:

(8 marks) (KA1)

Percentage labelling	For food with a shelf life of less than two years
Name/description	Needs to indicate the true composition of the food
NIP	Allows recall of potential batches of food that could be contaminated
Date marking	Provides quantities of nutrients per serve and per 100 g
Ingredients list	Allows the characterising ingredient to be compared to alike products
Recall information	Where allergens and food additives are found
Food additives	Must be provided if food poses gastroenteritis risk after opening
Storage instructions	Must be listed in ingredients, even if in small amounts <5%

- (b) Describe a food that does not need to be labelled.

.....
 (2 marks) (KA2)

4. Explain why sodium quantity is required on NIPs.

.....
 (2 marks) (KA2)

5. Identify whether buying 'Product of Australia' or 'Made in Australia' would support the Australian economy the best and justify your response.

.....

 (2 marks) (KA2)

6. A nutritional claim on a rice cereal states that it is 'low in cholesterol'. Outline how this claim can be considered misleading.

..... (1 mark) (KA2)

7. (a) Complete the following table of information related to food additives. (5 marks) (KA1)

Type of additive	Foods/beverages used in	Benefit to consumer
Sweetener	Soft drinks Confectionery	
	Margarine Chocolate	Stop rancidity in foods that contain fats
Food colouring	Confectionery, cereals, jams	
Emulsifiers		

(b) List a reason why food manufacturers would add emulsifiers to their oily spreads.

..... (1 mark) (KA2)

8. Refer to the following food label to answer the following questions.

Preparation instructions



Stove-top cooking:

- Spoon baked beans into a small saucepan.
- Heat until almost boiling, occasionally stirring. Do NOT boil.
- Remove from heat and serve.



Microwave cooking:

- Spoon baked beans into a microwave-safe dish.
- Cover and cook for 90 seconds on high. Stir halfway through cooking time.

Information:
Made in Australia from imported and local ingredients.

 Please recycle

No Brand

Low in Fat

Baked Beans
in tomato sauce



420 g

HIGH IN PROTEIN
HIGH IN DIETARY FIBRE

NUTRITION INFORMATION

Servings per package: 3
Serving size: 140 g

	Quantity per serving	Quantity per 100 g
Energy	508 kJ	363 kJ
Protein	6.4 g	4.6 g
Fat total	0.8 g	0.6 g
– saturated	0.3 g	0.2 g
Carbohydrate	25.1 g	17.9 g
– sugars	6.6 g	4.7 g
Sodium	364 mg	260 mg

Ingredients: navy beans (50%), tomato puree, water, sugar, thickener (1422), mineral salt (509), acidity regulators (acetic acid, citric acid), colour (paprika oleoresin), flavour, onion. May contain traces of nuts.

Storage: Store in a cool place out of direct sunlight. Refrigerate unused contents in a non-metallic container. Consume within 3 days.

Best before: See end of can.

Low GI: 38

(a) Name two food additive groups that are used in the can of baked beans in tomato sauce and outline their function in this particular food.

Additive group 1: ..
 Function: ..
 .. (2 marks) (KA2)

Additive group 2: ..
 Function: ..
 .. (2 marks) (KA2)

(b) Identify two areas of the food label shown on the previous page that are in breach of the FSANZ labelling requirements and explain how this could affect consumers.

Breach: ..
 Explanation: ..
 ..
 .. (3 marks) (KA2)

Breach: ..
 Explanation: ..
 ..
 .. (3 marks) (KA2)

(c) Discuss two aspects of the food label shown that can ensure consumer protection or safety.

1..
 ..
 .. (2marks) (KA2)

2..
 ..
 .. (2marks) (KA2)

9. Reduced salt products should have at least 25% less salt compared to the original product in order to claim they are low in salt. State whether FSANZ would allow the product on the right to label their tomato sauce as reduced salt. Show all calculations to justify your response.

Nutritional information	Original Sauce	Reduced Salt tomato sauce
	Avg Qty Per 100mL	Avg Qty Per 100g
Energy	530kJ	305kJ
Protein	1.5g	1.7g
Fat, total	0.2g	0.2g
—saturated	0.1g	0.1g
Carbohydrate	27.0g	14.9g
—sugars	24.9g	11.6g
Sodium	1220mg	490mg

..
 ..
 ..
 .. (2 marks) (KA4)

Total: _____ / 45 marks



Topic Two Test

1. (a) Define what a diagnostic tool is.

.....
 .. (1 mark) (KA1)

(b) Calculate the body mass index (BMI) of an individual with a height of 153 centimetres and weight of 76 kilograms. Make sure to state the formula, show all your working out and round your final answer to the nearest whole number.

(2 marks) (KA2)

(c) Categorise the weight classification of this individual:

..... (1 mark) (KA1)

(d) The BMI of an athlete is classified as obese, yet when this same athlete performs the waist-circumference, his classification is normal (not obese or at risk of overnutrition disease). Provide reasoning for this anomaly in findings.

..... (1 mark) (KA2)

(e) Identify an advantage of using the BMI instead of the waist circumference as a diagnostic tool in the home:

..... (1 mark) (KA1)

(f) Identify a further diagnostic tool often used by doctors or dieticians, not involving anthropometry measurements:

..... (1 mark) (KA2)

(g) Identify a disadvantage of using the BMI as a diagnostic tool for obesity in comparison to the selection above (f):

..... (1 mark) (KA1)

2. Most SA school canteens use the Right Bite policy to classify foods and drinks according to their nutritional value.

Right Bite food and drink spectrum

RED	<p>These foods and drinks are banned from sale in SA school canteens and preschools ...</p> <p>They:</p> <ul style="list-style-type: none"> • lack adequate nutritional value • are high in saturated fat and/or sugar and/or salt • can contribute to excess energy (kilojoules or calories)
------------	--

Source: Adapted from DECD 2015, 'Right Bite food and drink spectrum', *Right Bite, easy guide to healthy food and drink supply for South Australian schools and preschools*, Department for Education and Child Development, viewed 23 April 2018, education.sa.gov.au

(a) Discuss the importance of healthy-eating initiatives, like Right Bite, for children aged 5 to 12 years.

..... (2 marks) (KA2)

(b) The Australian Guide to Healthy Eating (AGHE) (NHMRC 2017) separates discretionary food choices from the five food groups recommended for daily consumption. These discretionary foods are the red food in the Right Bite policy. Explain one nutritional reason why parents should limit discretionary or 'red' food choices for children aged 4 to 8 years.

..... (2 marks) (KA2)

- (c) Canteen staff need to determine the traffic light colouring of their foods when following the SA Rite Bite policy. When a food item is assessed as having less than (or equal to) the specified energy, saturated fat and sodium amount, or more than (or equal to) the specified fibre quantity, it is able to be sold in canteens as an amber food. If the food item is found to be over the threshold for energy, saturated fat or sodium or under the quantity needed for fibre, the food is categorised as red and unable to be sold in canteens (see table below for nutrient amounts used to categorise foods).

Table 2: Snack food items assessed per serve

Category	Nutrient Criteria			
	Energy (kJ) per serve	Saturated fat (g) per serve	Sodium (mg) per serve	Fibre (g) per serve
Sweet snack food, bars and biscuits	600kJ or less	3g or less	–	1g or more
Savoury snack food, biscuits, crispbreads and crisps	600kJ or less	2g or less	200mg or less	–
	-- (Energy must be 1800kJ or less per 100g) --			
Ice creams, milk-based ices and dairy desserts	600kJ or less	3g or less	–	–
	-- (Milk must be listed as first ingredient) --			
Un-iced cakes, muffins and sweet pastries	900kJ or less	3g or less	–	1.5g or more

- (i) Per 40g serving, a muesli or granola bar has 773 kJ, 6.2g saturated fat and 2.6g fibre. Using the table and information above, identify the traffic light classification of the bar:
 (1 mark) (IAE3)
- (ii) Per 35g serving, a nut bar has 581 kJ, 1.4g saturated fat and 3.1g fibre. Using the table and information above, identify the traffic light classification of the bar:
 (1 mark) (IAE3)

3. The nutritional information panel (NIP), ingredients and warning statements from two different cereals are shown below (Food A left, Food B right):

Cereal A

Nutrition Information (AVERAGE)

Servings per package: 9
 Serving size: 30g (3/4 metric cup)

	quantity per serving	% daily intake per serving	per serve with 1/2 cup reduced fat milk	quantity per 100g
ENERGY	510 kJ	6%	790 kJ	1690 kJ
PROTEIN	1.6 g	3%	6.8 g	5.3 g
FAT, TOTAL	1.2 g	2%	3.3 g	4.1 g
- SATURATED	0.4 g	2%	1.7 g	1.4 g
CARBOHYDRATE	25.2 g	8%	32.2 g	83.9 g
- SUGARS	10.5 g	12%	17.5 g	35.0 g
DIETARY FIBRE	0.7 g	2%	0.7 g	2.4 g
SODIUM	102 mg	4%	170 mg	340 mg

	quantity	% RDI*	quantity
RIBOFLAVIN (VIT B2)	0.42 mg	25%	0.66 mg 1.42 mg
NIACIN	2.5 mg	25%	3.7 mg 8.3 mg
VITAMIN B6	0.4 mg	25%	0.4 mg 1.3 mg
FOLATE	50 µg	25%	58 µg 166 µg
IRON	3.0 mg	25%	3.0 mg 10.0 mg
ZINC	1.8 mg	15%	2.3 mg 6.0 mg

Ingredients

Cereals (55%)(maize flour, wheat flour, oat flour), sugar, natural colours (carmine, paprika, vegetable carbon, turmeric, copper chlorophyll), vegetable oil, salt, dextrose, minerals (iron, zinc oxide), vitamins (niacin, vitamin B6, riboflavin, folate), natural flavours (orange, lemon, lime).

CONTAINS CEREALS CONTAINING GLUTEN.
MAY CONTAIN TRACES OF PEANUTS AND/OR TREE NUTS.

Cereal B

Serving size: 45g (1/2 metric cup)

	quantity per serving	% daily intake per serving	per serve with 1/2 cup skim milk	quantity per 100g
ENERGY	620 kJ	7%	820 kJ	1380 kJ
PROTEIN	6.3 g	13%	10.9 g	13.9 g
FAT, TOTAL	1.2 g	2%	1.3 g	2.7 g
- SATURATED	0.2 g	0.9%	0.4 g	0.5 g
CARBOHYDRATE	21.7 g	7%	28.2 g	48.3 g
- SUGARS	7.5 g	8%	14.0 g	16.7 g
DIETARY FIBRE	12.6 g	42%	12.6 g	28.0 g
- SOLUBLE	2.1 g	-	2.1 g	4.7 g
- INSOLUBLE	10.5 g	-	10.5 g	23.3 g
SODIUM	162 mg	7%	218 mg	360 mg

	quantity	% RDI*	quantity
RIBOFLAVIN (VIT B2)	0.42 mg	25%	0.68 mg 0.94 mg
NIACIN	2.5 mg	25%	2.6 mg 5.6 mg
VITAMIN B6	0.4 mg	25%	0.4 mg 0.9 mg
FOLATE	50 µg	25%	56 µg 111 µg
IRON	3.0 mg	25%	3.1 mg 6.7 mg
MAGNESIUM	108 mg	34%	124 mg 241 mg
ZINC	1.8 mg	15%	2.3 mg 4.0 mg

Ingredients

Wheat bran (85%), sugar, barley malt extract, salt, minerals (iron, zinc oxide), vitamins (niacin, vitamin B6, riboflavin, folate). (Natural source of magnesium).

CONTAINS CEREALS CONTAINING GLUTEN.
MAY CONTAIN TRACES OF PEANUTS AND/OR TREE NUTS.

(a) Identify the food that meets the ADGs the best, and provide reasoning for your response:

..
..
..
..
.. (3 marks) (KA2)

(b) Identify a fortified nutrient in both cereals:

.. (1 mark) (KA2)

(c) The NIP, ingredients and warning statement (pictured on the previous page) are found on the cereal packaging. Name another label that must be included on the packaging of the cereal as per FSANZ requirements.

.. (1 mark) (KA1)

(d) The health star rating (HHR) is found on both cereal boxes. Identify whether the HSR is mandatory or voluntary food label.

.. (1 mark) (KA1)

(e) Provide reasoning for nutrient levels being provided in amounts/serves and amounts/100g.

..
..
.. (2 marks) (KA1)

4. Name one social marketing campaign that encourages people to eat the recommended number of serves of vegetables each day and discuss how it does this.

Advertising campaign: .. (1 mark) (KA1)

Discussion: ..
.
.. (2 marks) (KA2)

5. (a) Outline a characteristic of a fad diet.

..
.. (1 mark) (KA1)

(b) Discuss one health consequences of partaking in a fad diet.

..
..
..
..
.. (2 marks) (KA1)

6. Discuss how placing value over animal rights may affect food choices in relation to the AGHE.

..
..
..
..
.. (2 marks) (KA2)

12. Define emotional (comfort) eating and describe how it can be recognised.

.....

 (2 marks) (KA1)

13. Giuseppe is a student who works part time in a restaurant. He often brings home leftover food. He takes this food with him to university to eat between lectures and reheats it in a microwave. Describe a food safety issue that could arise when reheating and consuming his leftover meal the next day between lectures.

.....
 (2 marks) (KA2)

14. Distinguish between food spoilage and food poisoning.

.....

 (2 marks) (KA2)

15. Contaminants such as microorganisms, toxins and pesticides affect the quality of food and beverages. Outline three conditions needed for most food-poisoning bacteria to multiply.

- 1.
- 2.
- 3. (3 marks) (KA1)

16. Explain why it is a good practice when preparing food on a chopping board to cut cooked meat first and then to cut raw meat.

.....

 (2 marks) (KA2)

17. Refer to the table below to answer the following questions.

*Food Poisoning Outbreaks, by City and Year
 Number of reported cases, 2003-05*

Year	City A	City B	City C
2003	2300	7900	3600
2004	2690	5900	3820
2005	2450	5910	4040

(a) Suggest one possible reason for the change in the number of reported cases of food poisoning in City B between 2003 and 2004.

..... (1 mark) (IAE3)

(b) Name one group of people who are at high risk of developing food poisoning and explain why they are at high risk.

Group:
 Explanation:
 (2 marks) (KA1)

Topic 3: Sustainable food systems

3.1 Food Processing

Science understanding

Food processing techniques enable consumer convenience and safety

- Food processing techniques: freezing (temperature reduction), canning or pasteurisation (heat treatment) and their impact on the nutrition content or shelf life of food
- Food packaging techniques and medium; canning, plastic, paper, glass, and active packaging and their impact on the nutrition content or shelf life of food

SACE Subject Outline, 2020.

Food processing involves any method that turns fresh or raw agricultural products into foods suitable for consumption, cooking, or storage i.e., any process that changes the food's original form. Almost all food is processed in some way before it is eaten. The main reasons to process foods are to eliminate microorganisms and to extend the shelf life, although it is often used by manufacturers to create attractive and marketable food products (see Figure 3.1.1 for further impacts of food processing). Food can be processed in many ways, with food preservation methods being commonly used to maintain the quality of foods which are freshest and at optimal quality at the time of their harvest or slaughter. Preservation can, however, alter the nutrient content of food products. After preservation, food is presented to consumers in varying packaging types. Packaging serves a variety of purposes such as reducing damage to the product inside; however, its protective potential is dependent on the packaging material used of which there are many, including newer advances in active packaging forms.



Figure 3.1.1: Impacts of food processing.

Food Preservation

Food preservation methods are an example of food processing, which are used to extend the **shelf life** of food products and prevent deterioration, spoilage, and potential food poisoning. The aim is to maintain conditions that discourage or stop microorganism growth and to prevent microorganisms from reaching the food. Food preservation methods can ensure a continuous and plentiful supply of food by:

- extending the shelf life of food products
- making food safe for consumption
- increasing the range of food available
- reducing the shopping frequency
- reducing the cost of food
- saving time preparing food at home.

Definition

The shelf life of a product is the time it takes a product to decline to an unacceptable level, resulting in a loss of sensory properties and nutritional quality. At the end of its shelf life, a food is no longer safe to consume.

Common food preservation methods reverse the favourable conditions required by pathogenic microorganisms by reducing temperature, applying heat treatment, controlling water activity, reducing pH and/or reducing available oxygen. They include methods such as freezing, pasteurisation and canning.

Temperature Reduction

The shelf life of many foods can be extended by storing foods at temperatures below 5°C, in the **refrigerator** or **freezer**. **Refrigeration** slows enzymatic changes within the food and slows microbial growth, while **freezing** delays enzymatic activity that can cause spoilage, and keeps food safe by inhibiting microorganism growth, as at very low temperatures microbes are essentially inactive (known as **dormant**). This is because during the freezing process water molecules are converted into ice, making it unavailable to microorganisms which require it for growth. Therefore, reducing the temperature does not kill microorganisms; when food is defrosted and exposed to a temperature in the danger zone, they are able to multiply to dangerous levels once again. Therefore, foods must be handled safely prior to freezing and while being defrosted. When cooling foods, the temperature should fall from 60°C to 21°C in the first two hours, and then be reduced to 5°C or colder in the next couple of hours (refer to Topic 2.4 for further detail). It is important to remember that refrigerators or freezers do not work properly when they are overloaded or when food is packed tightly, because the cold air cannot circulate.

Fast fact

The ideal temperature of a refrigerator is 3°C and a freezer should be set between -18°C and -20°C.

The Effect of Freezing on Nutrients

Freezing is generally regarded as the best method of long-term food preservation when based on the retention of sensory attributes and nutrients. Refrigeration is essential because it increases the shelf life of perishable foods like fruits and vegetables, however the longer the food stays in the fridge, the more it loses its freshness, taste, colour, aroma and nutrient content. This is dependent on the food source, as highly perishable foods can be stored for eight to 10 days in a refrigerator, whereas less perishable products can be stored for eight to ten weeks. Freezing foods can cause the loss of some of the flavour; however, most of the nutritional quality is maintained. A concern with nutrient loss associated with freezing seems to be related to the exposure to high temperatures and oxygen that often occurs when handling and preparing food prior to being frozen. Freezing assists in retaining the nutrient content of most foods. However, some nutrients begin to break down when frozen produce is stored for more than a year, which is why the frozen storage recommendation of foods does not usually surpass 12 months.

Questions

- It can be difficult to cool food within a short time frame. Suggest a storage strategy that could speed up the cooling down process of food.
..... (1 mark) (KA1)
- If you are running out of room in your refrigerator, foods that are not potentially hazardous, such as unopened drinks, should be removed to make room for foods that critically need to be kept cool. State two foods that are potentially hazardous and require storage in the refrigerator or freezer.
 -
 - (2 marks) (KA1)
- Outline why foods need to be cooled and reduced to a temperature of 4°C or colder in the first four hours of storage.
.....
..... (3 marks) (KA2)
- Explain why it is recommended to avoid freezing food a second time that has already been defrosted.
.....
.....
..... (2 marks) (KA2)

Heat Treatment

Heat treatment (or thermal processing) is a combination of time and high temperatures to kill microorganisms or denature enzymes from food. **High-risk foods** must be reheated or exposed to a temperature of at least 75°C to reduce the number of bacteria to a safe level for consumption. The specific amount of time required depends upon the specific food, as exposure to heat can alter the nutritional content and texture. There are several types of heat treatments that are used in the food industry, including pasteurisation (high temperature short time, HTST) and canning.

Definition

High-risk foods support the growth of bacteria, where their reproduction can occur more rapidly. High-risk foods can include dairy products, eggs, meat products, poultry, and seafood.

Pasteurisation

Pasteurisation is a type of heat treatment where low heat is applied to food and beverages to kill pathogens and inactivate spoilage enzymes. In Australia, the minimum thermal process for pasteurisation requires a holding time and temperature of 72°C for 15 seconds. This heat treatment extends the shelf life of foods by days or weeks and is commonly used for milk, eggs, fruit juices, beer, canned food.

Canning

Canning is another type of heat treatment often used in preserving fruit, vegetables, meat products and other miscellaneous processed foods. Food products are placed into cans, with an accompanying liquid to replace as much air as possible, and then exposed to elevated temperatures. High-acid foods (for example, some fruit) require temperatures of around 100°C, while most foods need to be pressure canned at higher temperatures of 121°C for around 3 to 15 minutes, dependent on the foods ability to transfer heat. For example, tomatoes require less heating time than pumpkin. The application of heat can also **expand** the food, which expels any remaining air; therefore, after sealing and cooling, the contraction of the contents and lid produces a partial vacuum within the container (see figure 3.1.2). The can is then exposed to high temperatures again after being sealed to destroy any microorganisms that may still be present. The result of canning is a product with an extended shelf life of up to two years or more.

Definition

Cans are 'exhausted' is the term given when heat expands the food and expels air.

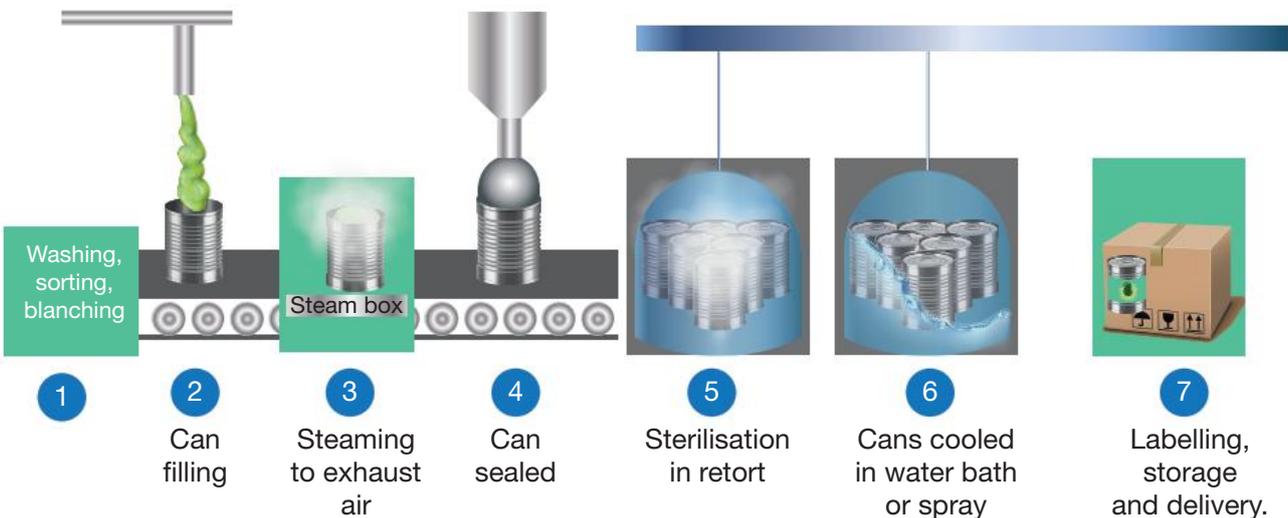


Figure 3.1.2: Exhaust box used in canning (top) and canning process within the exhaust box (bottom).

Vacuum sealing

In addition to the partial vacuum seal provided via the cooling process, many cans are mechanically manipulated to expel the air after heating and vacuum-sealed using industrial machinery (see step 4 of figure 3.1.2). The purpose of the expulsion of air is to reduce oxygen, which is required by pathogenic aerobic microorganisms for functioning. It also preserves against the oxygen degradation to food. Oxygen degradation involves the rancidity of fats (see section on food additives), darkening of fresh meat and the browning of fruit and vegetables. Reducing oxygen is therefore essential to improve the shelf life of food and customer acceptability of the products appearance and other sensory characteristics.

Liquid fill

Foods containing high concentrations of water are generally more favourable to microorganism reproduction. Therefore, the addition of the liquid fill used in canning often aims to reduce water activity by adding solutes. Common solutes added to food can include **sugar** and **salt**, which dissolve in water and bind to free water molecules making them unavailable for microorganisms to use. These methods prevent the growth of microorganisms and slow the action of enzymes.

Definition

Brine is the term given to salty water used in preservation, while sugar syrup is the name given to the sugary water often used to can fruits.

An alternate or additional liquid fill involves the preservation method of pH manipulation. As the pH is lowered below 7 (neutral) the food becomes more acidic. A food product with a pH of 4.5 or lower will not support the growth of pathogenic bacteria or the production of their toxins, therefore requiring less severe heat treatment to extend their shelf life and make them safe for consumption. Therefore, the addition of acids as liquid fill, such as vinegar or citric acid is a common preservation method used to reduce the pH to below 4.5.

Definition

The addition of an acid to a food product is known as acidification, resulting in acidified foods (also referred to as pickled foods).

The Effect of Heat Treatment on Nutrients

Thermal processing methods, such as pasteurisation and canning have a detrimental effect on the nutrients present in food due to their exposure to high temperatures. When foods are cooked at high temperatures or for long periods of time, heat-sensitive nutrients, including B vitamins and vitamin C are denatured and destroyed. Nutrients that are water soluble can also leech out of foods when water is involved in the cooking process. For example, boiling broccoli can cause much of the broccoli's water-soluble vitamins to migrate to the boiling water. However, you can still benefit from these nutrients if the liquid is consumed. Fat-soluble vitamins (A, D, E and K) can also leech into cooking oils if used in the process. Heat treatments have minimal impact on the mineral content, as these nutrients tend to remain stable when exposed to high temperatures. Therefore, it can be concluded the higher the temperature, the greater the volume of water/oil present and the longer the cooking time, the greater loss of nutrients from the food source. Higher temperatures for sustained periods of time are also associated with greater changes to the foods natural flavour, texture and appearance.

Extension activity

Research and describe the differences in the processing methods of pasteurisation (with high temperature, short time (HTST)) and ultra-high temperature (UHT).

.....

.....

.....

.....

.....

.....

.....

Questions

5. Explain how freezing can reduce water availability in foods, therefore inhibiting microorganism growth.

.....

.....

.....

.....

..... (2 marks) (KA2)

6. State the water activity that is necessary for the growth of most bacterial species.

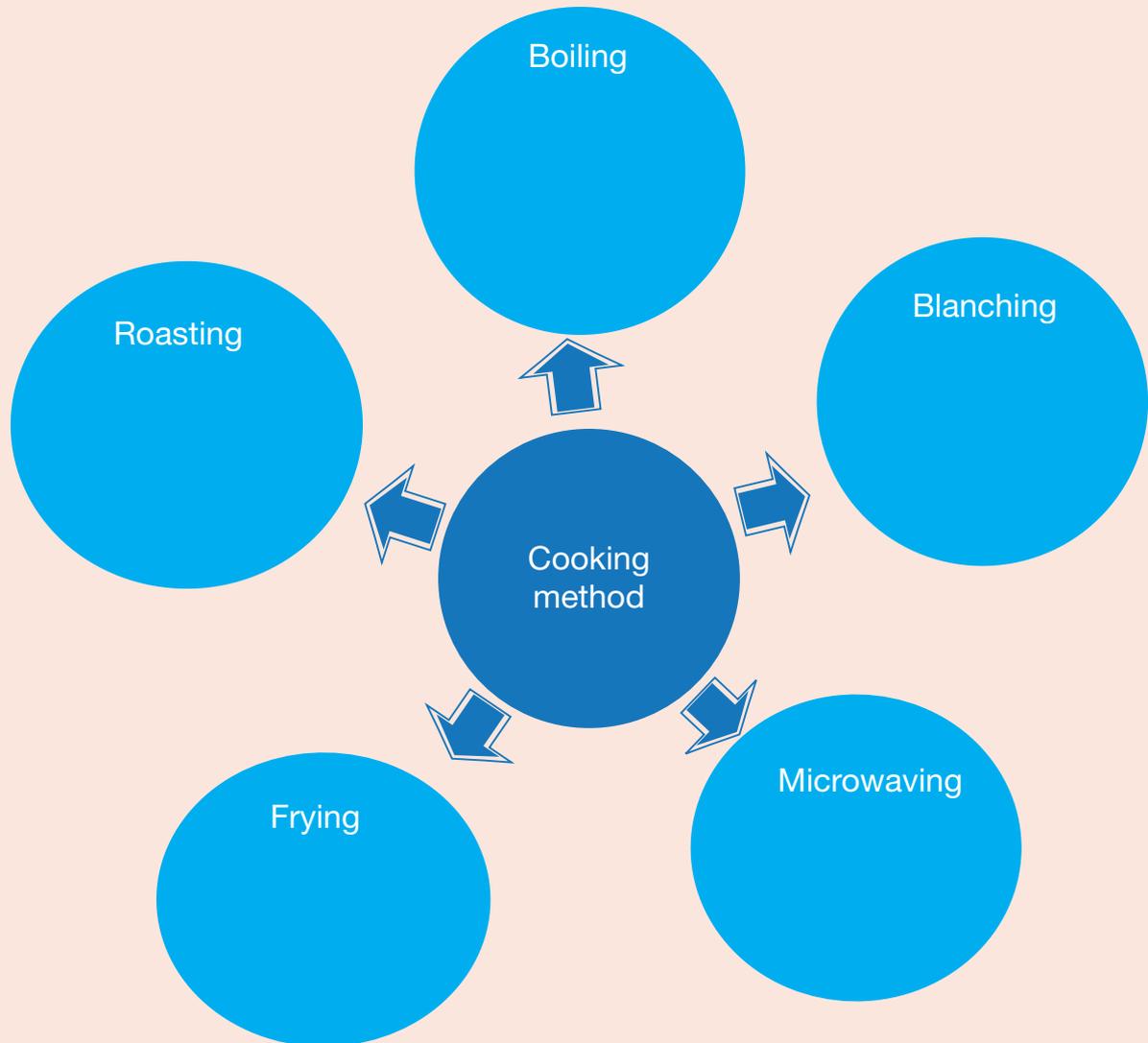
..... (1 mark) (KA1)

7. State the pH range in which bacteria can reproduce.

..... (1 mark) (KA1)

Extension activity

Canned and frozen foods are often cooked prior to being packaged. Cooking is also the predominant processing technique used in the home to make food suitable and safe for consumption. Complete the following brainstorm about the various cooking methods: you may like to define the method, list foods commonly cooked via each method, discuss their impact on nutrient retention, or add any information of interest!



3

Extension activity

Complete the following table by researching and explaining how the following processing methods can be used to extend the shelf life of food products by making them safe for consumption. Research which foods these processing methods can be applied to and how they might impact the nutritional content.

Processing Method	How it extends the Shelf Life	Examples of foods that this method is used for	Impact on Nutritional Content
Removal of Moisture			
Oxygen Reduction			
Changes to pH			
Food Irradiation			

Extension activity

Design an experiment investigating the effectiveness of a food processing method on keeping consumers safe by extending the shelf life of chosen food product.

(a) Propose a testable hypothesis or inquiry question.

.....

.....

.....

(b) Identify the independent variable (IV) and dependent variable (DV). Make sure to include how the independent variable is going to be manipulated and how the dependent variable is going to be measured, including how many times.

IV: ..

.....

.....

.....

.....

.....

DV: ..

.....

.....

.....

.....

.....

(c) Identify at least three factors that are held constant and explain how and why they are controlled.

Factors held constant	How the factor will be kept constant	Why the factor needs to be kept constant



Extension activity

(d) Include a list of materials required.

•	•
•	•
•	•
•	•
•	•
•	•
•	•
•	•

(e) Identify and ethical and/or safety considerations and explain how these are going to be managed.

Ethical and/or Safety Considerations	How they are going to be managed

(f) Record your results in a well organised way to allow them to be interpreted. Ensure your results are represented using appropriate conventions (e.g., SI units, even scales, labels).

Food packaging

Food packaging is another method of food processing, which is any container or wrapper that food for sale is wholly or partly encased, covered, enclosed, or packaged. Manufacturers, consumers, and businesses use three kinds of packaging: primary, secondary, and tertiary (as shown in Figure 3.1.3). Primary packaging is the immediate layer that is in direct contact with the product, while secondary packaging assembles primary packaging that assists in displaying, storing, shipping, and protecting products. Additionally, tertiary packaging is the combining of products for storage and transportation.



Figure 3.1.3: The primary, secondary and tertiary packaging of a chocolate bar.

Any form of packaging that encounters the food must be safe. It is important that the materials used to package food are **food grade**, which is outlined on most packaging (as shown in Figure 3.1.4). Regulations for food packaging in Australia mandate that all food packaging must be designed and selected in a way that does not have any adverse interactions between it and the food, is fit for its intended purpose and is not likely to cause food contamination. Regulations also state that any packaging and material in the packaging or in contact with the food must not be capable of being swallowed or obstructing any respiratory passage, or otherwise cause bodily harm, distress, or discomfort. Food manufacturers must ensure that packages used in contact with food do not cause the food to exceed the permitted levels of metals (e.g. tin in canned foods), non-metal contaminants (e.g. acrylonitrile, vinyl chloride used in plastics) or natural toxicants (e.g. erucic acid). Therefore, any substance used in packaging must not impact the safety and suitability of the contacted food and present any known hazards to the consumer even if chemicals used potentially migrate to the food source. Finally, recycled, and reused materials may be used for food packaging applications, provided they are suitable for the intended use and will not contaminate food. These regulations also apply to food that is imported in the packaging in which is intended to be sold.

🔑 Definition

Food-grade packaging is produced and handled in such a way that the packaging will not contaminate the food in any way.

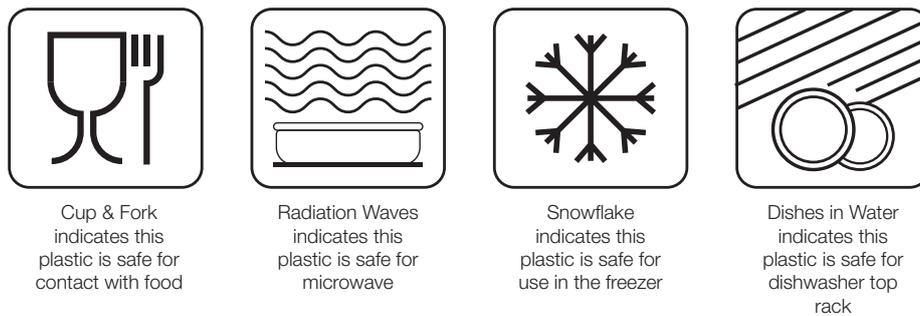


Figure 3.1.4: The labels on packaging to outline if it is food-grade, and suitable for microwaving, freezing or exposure to hot water.

The Functions of Packaging

Up until the 20th century most food was sold loose, however, most of the packaging produced today is for food products. Food was weighed and measured out and then placed into bags or directly into the shopper's bag to carry home. Today packaging is a massive and lucrative industry and is one of the contributing factors that persuades the consumer into purchasing the product. Therefore, it serves an important role in maintaining several functions, which include:

- **Protection:** protecting the food from biological contamination agents (such as rodents, insects and bacteria), mechanical damage (such as abrasion, fracture and/or crushing), and chemical or environmental degradation (such as oxidation, high temperatures, moisture transfer and exposure to ultraviolet light).
- **Convenience:** is important to consumers for optimum functionality, therefore packaging must come in a range of sizes, be easy to handle, open and dispense, and is often able to be resealed. Packaging should also be designed to make it easy to transport, move, lift, stack, and store.
- **Communication:** providing a surface that allows a label to be printed on or attached, for legal and marketing purposes. This allows consumers to identify the product and make an informed decision about the product and if it is suitable for them. Graphics and claims may also be included to communicate product quality, and thus increase sales.

Questions

- Identify the government authority that develops the regulations for food packaging.
..... (1 mark) (KA1)
- Suggest two ways that food packaging could contaminate food, making it unsafe for consumption.
 -
 - (2 marks) (KA2)
- Identify a feature of packaging that makes it convenient for consumers.
..... (1 mark) (KA1)

Types of Packaging Materials

The packaging materials that are primarily used in the food industry in Australia are passive, acting as a barrier between the food and the atmosphere surrounding the food and the external environment. The most common passive packaging materials used include aluminium or tin for canning, plastic, cardboard/paper, and glass (Table 3.1.1).

Table 3.1.1: Advantages and disadvantages of common/traditional food packaging materials.

Food packaging material	Examples of use	Advantages	Disadvantages
Aluminium	<ul style="list-style-type: none"> • Drink cans • Foil • Foil Trays • Pull tabs • Tea • Fruit Juices • Sweets 	<ul style="list-style-type: none"> • Inexpensive to produce • Can continually be recycled • Impermeable to light, moisture, oils and fats, oxygen and micro-organisms • Lightweight • Does not rust when exposed to moisture 	<ul style="list-style-type: none"> • Not suitable for reuse • Some need to be cut open on one end • The product inside is not visible • Production uses non-renewable resources and releases greenhouse gas emissions • Cannot be microwaved • Can corrode when exposed to acidic foods
Tin	<ul style="list-style-type: none"> • Coating steel cans • Candy bars • Olive oils • Vegetables • Meat • Pet food • Fruit 	<ul style="list-style-type: none"> • Inexpensive to produce • Recyclable • Impermeable to light, moisture, oils and fats, oxygen and microorganisms • Does not react with oxygen, therefore doesn't rust • Highly resistant to corrosion by acidic substances • Safely holds food for a longer period of time without contaminating it 	<ul style="list-style-type: none"> • Not suitable for reuse • Some need to be cut open on one end • The product inside is not visible • Production uses non-renewable resources and releases greenhouse gas emissions • Cannot be microwaved • Heavier than aluminium
Plastic	<ul style="list-style-type: none"> • Sauces • Water • Soft drinks • Takeaway containers • Cling wrap • Spreads • Yoghurt • Bags in breakfast cereal boxes • Plastic cutlery 	<ul style="list-style-type: none"> • Can be moulded into any shape • Easy to handle and open • Lightweight • Inexpensive to produce • Resistant to breaking • Impermeable to oxygen, moisture, light. 	<ul style="list-style-type: none"> • Produced from hydrocarbons sourced from non-renewable resources • Causes greenhouse gas emissions from production • Contributes to landfill, and pollutes ecosystems • Not biodegradable • Not always resealable • Potential of chemical migration into food • Exposure to extreme heat can cause it to melt or deform
Cardboard/ Paper	<ul style="list-style-type: none"> • Breakfast cereals • Pizza • Fast food • Coffee • Popcorn • Fruit juices • Milk 	<ul style="list-style-type: none"> • Cheap • Lightweight • Excellent printing capacity for labelling • Recyclable and can be biodegradable • Made from renewable resources 	<ul style="list-style-type: none"> • Permeable to moisture • Can be crushed from mechanical pressure • Not applicable for products that require freezing • Weak when wet
Glass	<ul style="list-style-type: none"> • Jams • Mustard • Instant coffee • Processed baby foods • Spreads • Wine • Mineral water 	<ul style="list-style-type: none"> • Strong and durable • Highly recyclable • Chemically resistant • Inert • Transparent; product is visible to consumer • Can be reused and resealed • Impermeable to oxygen and moisture 	<ul style="list-style-type: none"> • Fragile • Can be a safety hazard • Allows light exposure • Emits greenhouse gases during production • Production is energy- and resource-intensive • Heavier than alternatives, which increases transport costs

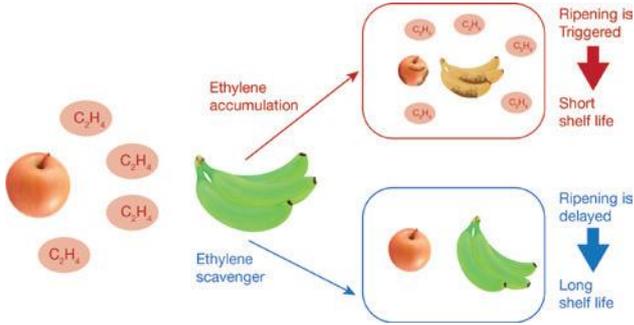
However, it is anticipated that there will be a shift towards **active packaging** due to consumer concerns about safety and additive content. Active packaging performs a role other than providing an inert barrier to external conditions. These types of packaging are intended to extend the shelf-life or to maintain or improve the condition of packaged food by interacting with food and the environment. These packaging technologies eliminate unwanted components from the packaging **headspace** and/or from the food itself by absorbing active components into the food or its surroundings. The main applications focus on delaying oxidation, controlling moisture migration, microorganism growth and volatile flavours and aromas. Common types of active packaging technologies are further explained in Table 3.1.2.

Definition

The inside (volume) of packaging that is not occupied by the food product itself is referred to as headspace. The atmosphere within this space is referred to as the headspace gas.

Table 3.1.2: Examples of active packaging technologies that reduce oxygen exposure.

Types of Active packaging	Description	Examples of use
Modified atmosphere packaging (MAP)	MAP provides an optimum balance of environmental gases: oxygen, carbon dioxide and nitrogen inside the packaging. Carbon dioxide inhibits the growth of most aerobic bacteria and mould but can cause flavour tainting if excess levels are present. Nitrogen is an inert gas and used as a filler gas to expel oxygen, preventing the collapse of packaging and oxidative rancidity. Although oxygen causes the deterioration of foods and growth of aerobic microorganisms, some oxygen is required to maintain colour and the respiration of fruit and vegetables. This type of active packaging may use oxygen absorbers and carbon dioxide emitters.	Meat, dairy products, fish and seafood, fruit, vegetables
Vacuum packaging	Vacuum packaging is airtight, where the oxygen has been evacuated prior to sealing. This reduces the oxygen levels in the packaging, reducing the growth of bacteria and the rate of spoilage due to oxidation. It is not possible to withdraw all oxygen, therefore a small amount of air will remain. A limitation of vacuum packaging is that it causes the packaging material to collapse forming tightly around the food product. This can distort and deform the appearance of the products, which is why this product cannot be used for all food types.	Meat, fruit, vegetables, seafood
Oxygen absorbers or scavengers	Oxygen absorbers are little parcels that are filled with iron powder and placed inside packaging. The iron absorbs 99% of the oxygen that is present when placed in a sealed environment. The iron powder reacts with the oxygen in the air causing the iron powder to rust. When all the iron powder has oxidised, the oxygen absorbers are loaded and the absorbing action stops, leaving only nitrogen left in the container.	Dry Foods e.g. taco shells
Moisture Scavenger	Moisture scavengers are an effective way of controlling excess water accumulation in a food package, thereby inhibiting spoilage and microorganism growth. Moisture scavengers can come in the form of a pad or sheet that absorbs and holds moisture or as a regulator which sustains a state of dryness by absorbing moisture from the air and controlling humidity in the headspace of the package. These regulators can come in the form of a sachet and contain calcium chloride, which is an example of a compound that can effectively absorb moisture from the air.	Cereals, nuts, snack foods, fresh fish, meat
Carbon Dioxide (CO ₂) Emitter	CO ₂ emitter actively produces and releases this gas within the package to inhibit spoilage and control harmful microorganism growth. This preserves the quality of the food and extends the shelf life of food products. These technologies can also be used with oxygen scavengers, whereby oxygen is absorbed and replaced with CO ₂ .	Snack foods, nuts, bakery items, dried and fresh meats, fish

Types of Active packaging	Description	Examples of use
Ethylene Scavenger	<p>Ethylene (C_2H_4) accelerates the ripening and spoilage of packaged products if not properly controlled. Ethylene scavengers are used to control the ripening process in packaged fruits and vegetables by absorbing ethylene from the environment and holding it. This prevents deterioration and increases the shelf life of these products by delaying their spoilage (as shown in Figure 3.1.5). The most common ethylene scavenger is potassium permanganate, which is generally embedded in a silica gel sachet or zeolite clay, which is embedded into food grade packaging.</p>  <p style="text-align: center;"><i>Figure 3.1.5: The effectiveness of Ethylene Scavengers in the increase in the shelf life of fruit.</i></p>	Packaged fruits and vegetables



Questions

11. Active packaging can be divided into two systems: active scavenging systems (absorbers) or active release systems (emitters). Identify the following active packaging technologies as scavengers or emitters and identify the component they release or absorb.

Type of active packaging	Scavenger or Emitter	Component Released or Absorbed
Modified Atmosphere Packaging		
Vacuum packaging		
Oxygen Absorber		
Moisture Scavenger		
Carbon Dioxide Emitter		
Ethylene Scavenger		

(6 marks) (KA1)

The effect of Packaging on Nutrients

Almost all food processing methods reduce the amount of nutrients present in food, after harvest or slaughter. Once foods, especially fruits and vegetables, are separated from their source of nutrients (tree, plant, or vine), they undergo higher rates of respiration, resulting in moisture loss, quality and nutrient degradation, and the growth of pathogenic bacteria. Packaging materials that expose foods to high levels of light, water and/or oxygen cause the greatest nutrient loss, especially sensitive water-soluble vitamins. For example, packaging materials such as glass and transparent plastic results in greater nutrient loss than translucent and opaque materials due to allowing light to pass through.

Key terms

Active packaging	Food packaging	Heat Treatment
Canning	Food Processing	Pasteurisation
Dormant	Freezing	Refrigeration

Review questions: 3.1 Food Processing

1. A remote community produces excess fresh herbs (thyme, rosemary, and sage), tomatoes and apricots, which need to be preserved to extend their shelf life and reduce wastage.

(a) State two aims of food processing.

1.
2. (2 marks) (KA1)

(b) For each of the following foods, name a different method of preservation that is suitable for use in the home and describe how the identified method preserve the food.

(i) Chicken

Method of Preservation:

How the method preserves the food:

..... (3 marks) (KA2)

(ii) Milk

Method of Preservation:

How the method preserves the food:

..... (3 marks) (KA2)

(iii) Tomatoes

Method of Preservation:

How the method preserves the food:

..... (3 marks) (KA2)

2. The value of packaging produced in Australia is estimated to be approximately \$10 billion. The food and beverage sector uses almost 70 per cent of all Australian-produced packaging. Suggest and explain a reason why the packaging industry in Australia continues to grow.

.....

.....

.....

..... (2 marks) (KA2)

3. One method of preserving food is canning. Explain two principles of the canning process that provide canned food with a longer shelf life than fresh food.

Principle 1: ..
 ..
 ..
 ..

Principle 2: ..
 ..
 ..
 .. (4 marks) (KA2)

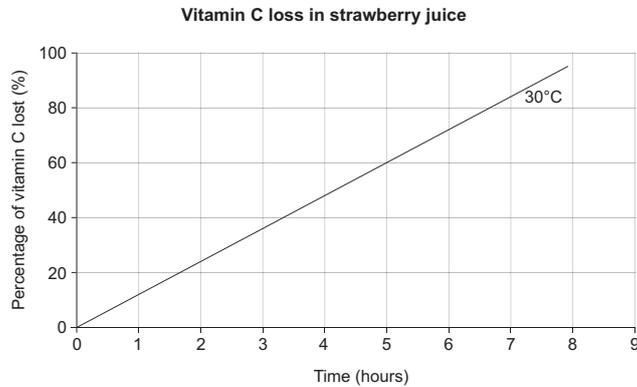
4. Give two reasons why milk is no longer routinely packaged in glass bottles.

Reason 1: ..
 ..
 ..
 ..

Reason 2: ..
 ..
 ..
 .. (4 marks) (KA2)

5. Fresh fruit juice should be stored at 4°C and consumed within three days. Students conducted an experiment to investigate the effect of poor storage on the vitamin C content of strawberry juice. The strawberry juice was heated to 30°C and the amount of vitamin C was measured every hour for eight hours.

Refer to the following graph, which shows the percentage of vitamin C lost over time.



(a) From the graph, identify the time taken to lose 40 per cent of the vitamin C.
 .. (1 mark) (IAE3)

(b) State one conclusion that could be drawn from the graph.
 .. (1 mark) (IAE3)

(c) Identify one variable that must remain constant during the experiment and explain why it must remain consistent throughout.
 .. (2 marks) (IAE3)



6. Describe two disadvantages of using aluminium cans to package food.

Disadvantage 1: ..
 ..
 ..
 ..
 Disadvantage 2: ..
 ..
 ..
 ..
 .. (4 marks) (KA2)

7. A frozen meal of chicken satay with rice was packaged in plastic.

(a) Describe one advantage for the consumer of using plastic as a packaging material.

..
 ..
 ..
 .. (2 marks) (KA2)

(b) Describe one environmental disadvantage of using plastic as a packaging material.

..
 ..
 ..
 .. (2 marks) (KA2)

8. Packaging protects food from damage, spoilage, or contamination that would reduce its quality. For each of the foods listed below:

- identify one risk factor that could reduce the quality of the product
- suggest a packaging material that manufacturers could use to reduce this risk factor
- explain how the suggested packaging material reduces the risk factor.

(a) Breakfast cereal

Risk factor: ..
 Packaging material: ..
 Explanation: ..
 ..
 ..
 .. (4 marks) (KA2)

(b) Fresh Eggs

Risk factor: ..
 Packaging material: ..
 Explanation: ..
 ..
 ..
 .. (4 marks) (KA2)

(c) Orange juice

Risk factor: ..
 Packaging material: ..
 Explanation: ..
 ..
 ..
 .. (4 marks) (KA2)

Total: _____ / 45 marks

3.2 Food systems and their impact on the environment

Science understanding

The food system involves the stages of production, processing, distribution, consumption and research and development. Each stage impacts on the nutrition quality and accessibility of the food product.

Production and distribution:

- the impact of food production on the environment and health of individuals in relation to: soil quality, land availability, water quality/ availability, biodiversity, nutrition issues.
- food availability and distribution has implications to food miles for local, regional, national and global production.

Processing:

- food processing and packaging materials may have an environmental impact.

Food waste:

- Within all food systems the principles of sustainability, waste management and protection of food supplies need to be addressed.
- strategies to reduce food waste at the local and global level.

SACE Subject Outline, 2020.

3

Production

A food system includes all processes and **infrastructure** involved in providing food for our population. Processes include: growing, harvesting, processing, packaging, transporting, retail, consumption, disposal of food and food-related items.

Definition

Infrastructure within food systems refers to all the structures and facilities needed to provide food to communities e.g. storage buildings, refrigerated transport vehicles and harvesting machinery.

The first stage of our modern food systems, food production (specifically primary food production) or **agriculture**, is the growing or cultivation of plants for human or livestock consumption, the raising, collecting or catching of animals or animal products used as food sources, and the picking or harvesting of produce. There are a multitude of food production methods, with varying magnitudes of health effects on individuals and environment damage. Environmental damage is due to agricultural use of the resources: land, chemicals, water and energy. However, the degree of dependence on each resource differs for each agricultural method, and therefore its degree of environmental impact differs. For each type of resource used, a food production method strongly associated with its dependence or avoidance is outlined. However, it is important to note that each and every type of primary production method has an impact on the environment as they all require land, chemicals, water and energy to be viable or successful.

Definition

Agriculture is known more simply as farming; edible plants grown for human consumption are known as **crops**; plants grown for livestock grazing are referred to as **pastures**.

Issues surrounding land use by primary production: Land availability

Australia's early pioneers settled near good farming land, with fertile soils rich in nutrients and areas with plentiful rainfall, and cities began from there. However, as populations have grown and cities have expanded, some farmland areas have been pushed into areas that are not as **arable**. Moving to areas of poorer soil quality (or less fertile soil) and lower rainfall patterns, in conjunction with Australia's continual growth in population size to feed, means farms are increasing in size to stay economically viable. Whether that results in further land cleared for crops, or the raising of livestock increasing competition over native grazing plants (see Figure 3.2.1), Australian's population and variety of plants and animals or **biodiversity**, and their interwoven food chains and habitats suffer. Deforestation or clearing land for farming also removes the Earth's ability to utilise carbon dioxide. Trees are particularly useful in absorbing carbon dioxide from the atmosphere as they grow. They convert carbon dioxide into carbon and store it in branches, leaves, trunks, roots and in the soil. Removal of trees and other plants therefore leaves once absorbed carbon dioxide in the atmosphere and stored carbon is released into the atmosphere as carbon dioxide as well. This contributes to increased atmospheric carbon dioxide levels and climate change (see later section). Also of concern, is that Australia is a country with **limited quality farming land**, and **urbanisation** expansion in arable regions pushing farming areas into regions that would result in lower yields, is raising questions about **food security** or future food availability and accessibility.

Definition

Land that is able to support farming is called arable land, while land that is difficult to farm on due to factors such as high temperatures, low rainfall and poor soil quality, is called arid land.

Urbanisation is the process by which large numbers of people concentrate in relatively small areas forming cities.

Reminder

Food security refers to populations having access to enough food to meet their dietary needs.

Fast fact

Around only 5-10% of Australia's land is arable or quality farming land. Farming areas therefore need to be larger in size to produce sufficient yields and this accounts for just under 50% of Australia's land being used in agriculture!

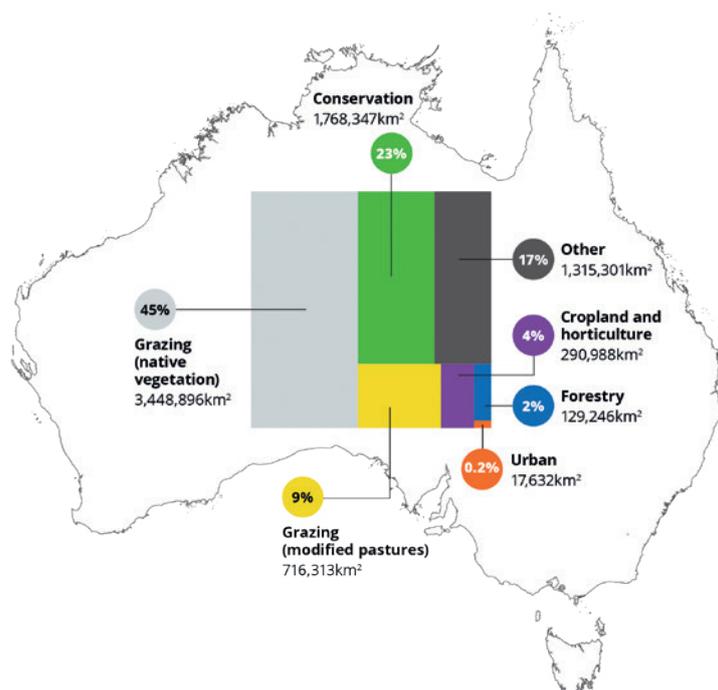


Figure 3.2.1: Australia's land use.

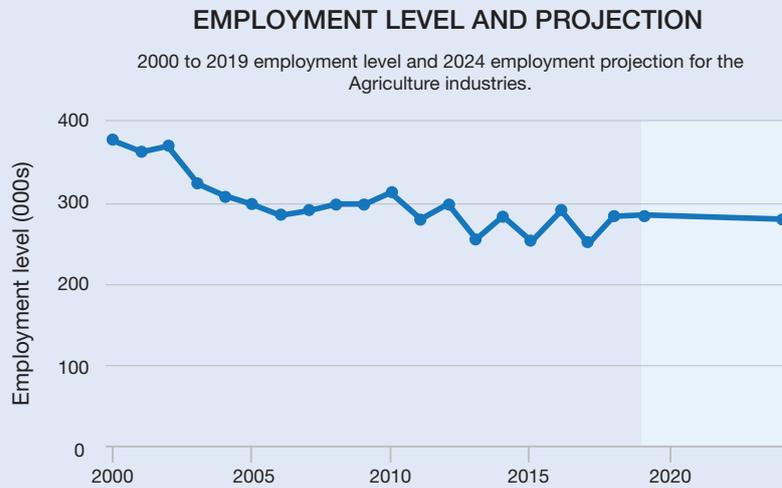
A further consequence of agriculture occupying rural areas away from urbanisation, particularly concerning livestock farmers using native vegetation, is upon individual health, namely mental health. Living rurally can mean living quite isolated, with limited access to leisure, medical assistance and other services, support organisations and socialisation opportunities. As well as this, hardship can present during natural disasters such as bushfires and drought. It is therefore understandable that stress and depression are often experienced in farming communities. Isolation and poor mental health, plus a heavily labor-intensive role on farms may also relate to the appeal of farming fading over the decades. The compounding issue of depletion of farmers and therefore farms is again having a negative impact on Australia's future food security.

Fast fact

Over the 30 years to 2011, the number of farmers declined by 106,200 (40%)(source: <https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4102.0Main+Features10Dec+2012>). Employment in agriculture is expected to decline further into the future (source: <https://nationalindustryinsights.aisc.net.au/industries/agriculture>).

Questions

2. Refer to the following graph to answer the questions below.



Source: <https://nationalindustryinsights.aisc.net.au/industries/agriculture>

(a) Using data from the graph above, describe the trend in agricultural employment from 2000-2019:

.....

 (2 marks) (IAE3)

(b) Suggest a reason for the trend in agricultural employment:

.....
 (1 mark) (KA2)

A closer look: Beef cattle farming in Australia

Primary production issues surrounding land availability and the need to expand farms when pushed to less arable land, is an issue particularly relevant to Australia's cattle or beef meat industry. Beef cattle farming refers to the rearing, or breeding and raising until of market age, of cattle for their meat (the meat is known as beef). In beef production there are 3 main stages:

1. Cow-calf stage – a bull (or some farmers may use **artificial insemination**) is released into a cow herd for breeding purposes each year, to produce offspring or calves; after weaning off their mother's milk at around 8-10 months of age, calves move into the backgrounding stage.
2. Backgrounding – is an intermediate stage where cattle tend to forage or graze for food and increase in size and weight before moving into feedlots
3. Feedlots – are the final stage for most cattle, where they are supplement fed grains by farmers (see Figure 3.2.2) for final muscle or weight gain to provide more meat.

Definition

Artificial insemination is the process of collecting sperm from a male animal and manually depositing it into the reproductive tract of a female. Farmers may prefer this to natural breeding for a number of reasons including a larger number of cows can be impregnated and bull sperm can be selected for desirable traits such as large muscle mass.



Figure 3.2.2: Cattle feedlot.

Although supplement feeding produces better meat yields, feedlots tend to only be used in the final stages of beef cattle rearing before it is slaughtered for its meat. This is because of the **large amounts of feed** it takes to rear cattle and the limited land to grow grains for supplement feeding of livestock. Rearing cattle has to be expanded from small confined feedlots to larger areas of land where cattle are left to forage or graze for food during the backgrounding stage. Foraging for food can be upon native land and grasses or upon pastures. When upon pastures, biodiversity is harmed and carbon dioxide levels increase in the atmosphere because land must first be cleared or deforestation must occur in order to plant pastures. Despite this, farmers have a preference for cattle foraging or grazing to be via pastures because plants grown in pastures are of high yield and this allows for a greater number of cattle and therefore better meat yield. However, pastures tend to only grow well in the southern states and south-east Queensland due to their cooler climates and more arable land. These pastures are primarily used by dairy cows and further pasture land for beef cattle is limited due to the arable land also being taken by crops, forest and conservation, and urbanisation. The result is that most beef cattle farming gets pushed into the northern states and middle of Australia (see Figure 3.2.3 left) where weather patterns tend to be hotter and dryer and land is less arable. Pastures don't fare well in these conditions, so farmers rely on resilient native grasses found across these regions. Native grasses do not tend to grow densely or give high yields like pastures, they can be quite sparse. This results in expansion of farming areas over vast amounts of land to support the large daily food needs of cattle. Across Australia there are around 20 million beef cattle being reared and yet a massive 200 million acres are used to feed them (see Figure 3.2.3)! Beef cattle farming in the northern states also has a large impact upon biodiversity due to cattle competing with wildlife such as kangaroos for native grasses as feed. The arid land of northern beef cattle farms is also typically far from arable coastal areas of urbanisation; hence cattle beef farming communities tend to be the hardest hit by mental health concerns. In addition, should poor cattle farming methods be used, or cattle not be monitored regularly due to being spread over vast areas of land not easily reached by farmers, farmers can leave cattle to overgraze regions. Overgrazing means cattle consume plants to the point the land is bare and its difficult for the plants to regenerate or grow quickly. This results in even further farming land expansion needed!

Fast fact

Cattle can consume anywhere from around 10 to 20kg of grass alone per day!

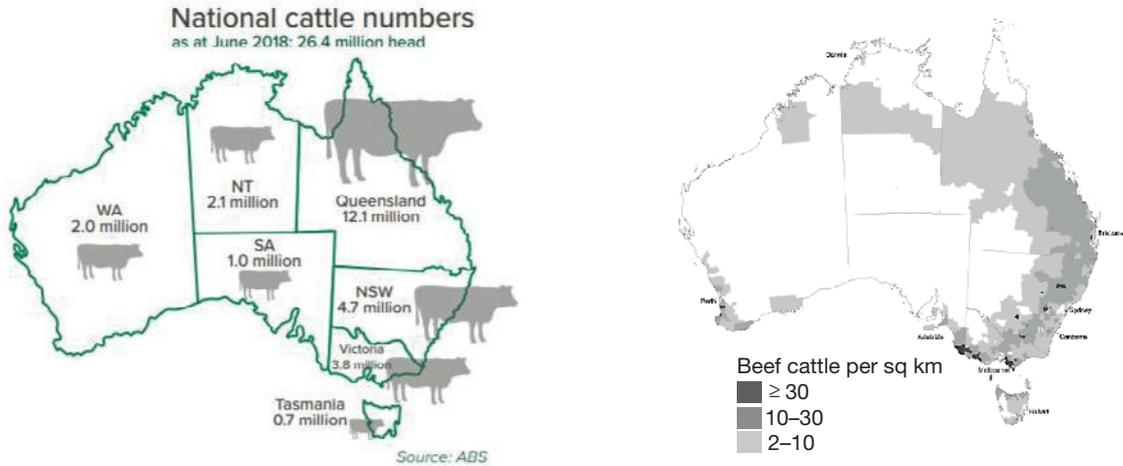


Figure 3.2.3: Number of cattle being reared per State across Australia (left) and cattle density per state (right).

Questions

- State a mental health concern for a northern states farmer in the cattle meat industry and outline a reason for the mental health concern.

.....

.....

..... (2 marks) (KA2)

Apart from issues surrounding land use, the number of cattle in Australia is implicated in a number of other environmental and individual health issues including cows releasing a greenhouse gas called methane, their weight compacting soils which heightens erosion, their manure reaching water ways causing eutrophication, water-scarcity due to their high water needs, and antibiotic residue dangers (see further sections for details of each issue).

Issues surrounding land use by primary production: Dryland salinity and soil erosion

Primary production requires the clearing or deforestation of native vegetation for crops or pastures. Deforestation plus harvesting crops can lead to environmental concerns in relation to soil quality: namely salinity and soil erosion.

Dryland salinity

Dryland salinity refers to an increase in the salinity or saltiness of the land. This occurs when the water table or groundwater (which refers to soils saturated with water) rises from its usual location deep below the soil surface. It rises when rainwater penetrates or leaks down through the soil and adds to the water table. As it rises, the groundwater dissolves naturally occurring salts in the soil, in particular sodium chloride, thereby increasing the salinity or saltiness of the water and land as it reaches the Earth's surface. Ordinarily, minimal rainwater will penetrate the soil to reach the water table because large, sparse tree roots utilise the water before it can reach the water table (see Figure 3.2.4 A). However, agricultural practices which replace native vegetation, particularly trees, with shallow-rooted crops and pastures means rainwater is left to penetrate down to the water table and groundwater levels begin to rise (see Figure 3.2.4 B).

Fast fact

In 2000, 5.7 million hectares of Australia were assessed as having a high potential to develop salinity. Predictions indicate that unless effective solutions are implemented, the area affected could increase to 17 million hectares by 2050, most of which is agricultural land (more than 11 million hectares).

Source: [https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1370.0~2010~Chapter~Salinity%20\(6.2.4.4\)](https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1370.0~2010~Chapter~Salinity%20(6.2.4.4))

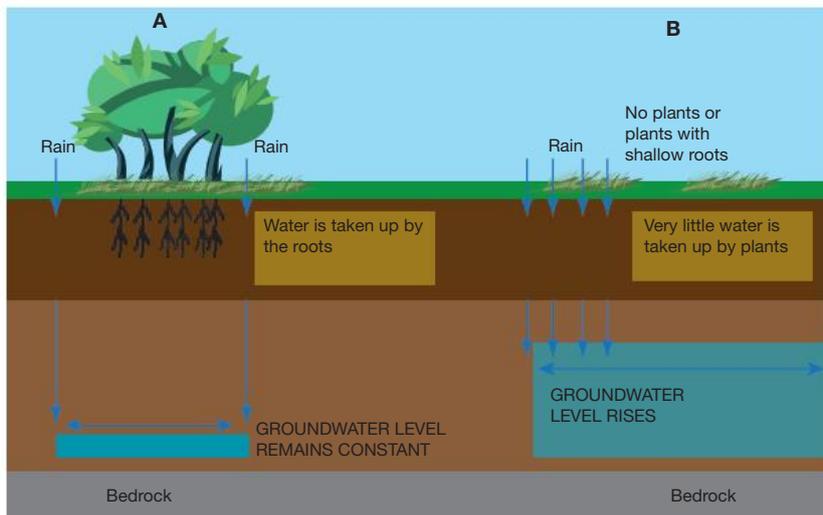


Figure 3.2.4: The process of dryland salinity – ‘A’ is before land is cleared showing minimal rainwater leakage and the water table remaining deep below the Earth’s surface; ‘B’ is after clearing of native vegetation and trees for crops/pastures, showing substantial rainwater leakage to the water table and the water table rising.

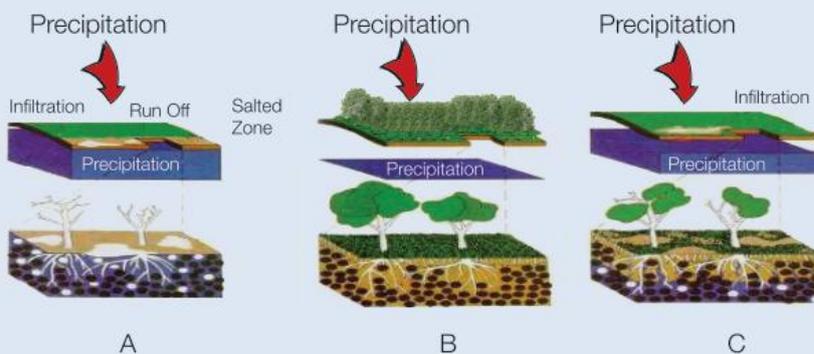
Once saline waters reach the surface, it can pass directly into our wetlands, streams and river systems, making these bodies of water too salty to provide hydration for native flora and fauna and too salty for agricultural use. The salt will also be transported to the root-zones of natural vegetation, crops and pastures, often killing them. In summary, the result of saline water and land is a reduction in biodiversity, crops and pastures and therefore a decline in Australia’s food security.

Definition

Flora refers to plant life while fauna is the corresponding term for animals.

Questions

4. Refer to the images below to answer the following questions.



(a) Identify A, B & C as ‘before clearing’, ‘after clearing’ and ‘land with dryland salinity’.

A = _____
 B = _____
 C = _____ (3 marks) (KA2)



Figure 3.2.6: Enlargement of the thyroid gland seen in Goitre.

Questions

5. To help ensure Goitre is not a prevalent condition, iodine has mandatory fortification.

(a) Name the food iodine must be added to in Australia:

..... (1 mark) (KA1)

(b) Name the government authority body that specifies this mandatory fortification:

..... (1 mark) (KA1)

6. Food crop farmers are encouraged by environmentalists to surround their fields with corridors. A corridor is typically a strip of natural vegetation, often a strip of native plants including Eucalypt trees.

(a) Discuss two ways adding a corridor with Eucalypt trees around shallow-rooted crops can improve soil quality or land degradation issues.

.....

 (4 marks) (KA2)

(b) Describe a further environmental benefit of adding corridors of native habitat to farming areas.

.....

 (2 marks) (KA2)

A closer look: Monoculture cropping

The issues of soil erosion and dryland salinity are particularly relevant to an agricultural practice called monoculture. In terms of growing plants for human consumption, monoculture refers to growing a single plant or crop across all fields at the same time. Monoculture is used widely across Australia in conventional farming for reasons such as better efficiency and lower costs in planting or sowing seeds, providing pest care and ongoing needs like water and nutrients (through fertilisers), and harvesting fields, all of which can be done simultaneously across a farm. Allowing farmers to specialise and care for only one crop type allows for higher yields and better food security. Their higher yields can also equate to less land being needed to be cleared to meet consumer demands for food crops.

However, production of one crop only, season after season can allow pests of that crop to flourish. Should a plant be susceptible to a particular pathogen and it reaches the monoculture crop, the disease spread from that pathogen can quickly move through uniform monoculture fields. Both of these factors jeopardise yields and food security and are reasons for monoculture farmers to rely heavily on pesticide use (see next section).

Extension activity

Investigate Panama disease, a disease threatening Australia's monoculture banana industry.



Helpful online resources

Either view the video or read the article from the following website: <https://www.brisbanetimes.com.au/national/queensland/queensland-banana-disease-scare-could-increase-growers-costs-20150305-13w3fb.html>



In regard to dryland salinity and soil erosion issues, monoculture crops are typically shallow-rooted (see 'Clearing for crops/pastures' (see 'B' of of Figure 3.2.4). During and after periods of rainfall, shallow-rooted crops are unable to utilise a majority of rainwater and it seeps through the soil to add to the water table, resulting in dryland salinity (see Figure 3.2.4). Their inability to capture rainfall well means their water needs from reserves like dams and lakes are high, and this is linked to problems with water scarcity and irrigational salinity (see later sections).

The efficiency and lower costs of monoculture planted fields being able to be harvested simultaneously comes at the cost of erosion. After harvesting, fields of land can be left bare or uncovered (see Figure 3.2.7), with the topsoil able to be washed away by rain or blown away by the wind. The resulting loss of the fertile topsoil in addition to the one crop being planted time after time over the same fields and depleting the same nutrients, means monoculture farmers can also depend heavily on chemical fertilisers (see next section).



Figure 3.2.7: Bare land being left as soybeans are harvested across a monoculture farm.

Extension activity

The next time you take a drive outside of Adelaide Metropolitan, especially over the Christmas school holiday, take note of bare fields after farming harvest to see the environmental impact of monoculture (and other human activity) in action!

Issues surrounding chemical use by primary production

The **chemicals commonly used** in agriculture are known as agrichemicals. Agrichemicals include veterinary substances, fertilisers and pesticides. Pesticides can be further categorised into groups including insecticides (to eradicate insects), herbicides (to eliminate weeds) and fungicides (to stop plant fungal diseases).

Fast fact

For example, an estimated 5 million tonnes of fertiliser over a total of 50 million hectares of agricultural land was used across Australia in 2016-17

(Source: <https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4627.0main%20features82016-17>)

Fertilisers

To overcome issues of infertile soils, fertilisers are often applied. A **fertiliser** is a chemical that adds nutrients to the soil that are essential to plant growth, thereby producing better yielding crops. Nitrogen, phosphorus and potassium are always present in fertilisers as they are the main nutrients required for plant growth. Although fertilisers are beneficial to crop yield and therefore food availability, they have negative impacts upon the environment including soil acidification, eutrophication and groundwater pollution.

Eutrophication

Fertiliser application can either be upon the soil or sprayed from the air above the crops (aerial spraying). No matter the application style, the fertiliser is not always absorbed well into the soil. Fertiliser not absorbed into the soil can be washed away with rain or with excess water from irrigating or watering farming fields. It will run-off into and accumulate in nearby rivers, lakes, or other bodies of water. This results in **eutrophication**: an increase in the concentration of nutrients in a body of water. Run-off from cleaning feeding areas plus urine and faeces from dairy and cattle farms can also add to this issue as they all contain nutrients. The increased nutrient concentration provides excellent conditions for blue-green algal growth, especially if the water is stagnant or only flowing slowly. Blue-green algae grows rapidly using the nutrients and oxygen in the water until an intensive area of growth, called algal bloom results (see Figure 3.2.8). The algal bloom at the water's surface can block sunlight needed for photosynthesis and functioning and growth by water plants, which results in their death. Algal blooms can also leave the water with inadequate oxygen to support animal and plant respiration resulting in the death of organisms in the water, and hence, a decrease in biodiversity.



Figure 3.2.8: Close-up of an algal bloom across a body of water.

In addition, blue-green algae can produce toxins which are poisonous to animals, including humans, rendering the body of water useless, thereby reducing water availability. The toxins can also have ill-health effects including causing skin and eye irritation with direct contact. If the toxins are inhaled during recreational activities like swimming, water-sports and boating, mild respiratory symptoms similar to hay fever may be experienced. If toxins are consumed, either by drinking algal-affected water or consuming shellfish or fish containing toxins, gastroenteritis can occur. The toxins have also been known to affect our liver or nervous system.

Groundwater pollution

Some fertiliser nutrients can even leach far down through the soil, especially through permeable sandy soils and enter the water table, reducing water quality. Should this groundwater be a source of domestic water, the nitrogen of fertilisers (which become nitrates) can be a serious health hazard. Excess nitrates in drinking water can cause health risks such as depleting oxygen levels because they disrupt the functioning of haemoglobin. Nitrates have also been shown to combine with food to make cancer-forming compounds which has been linked to the increased incidence of many types of cancer.

Questions

8. (a) Name the mineral in haemoglobin that picks up the oxygen:
 (1 mark) (KA1)
- (b) State a symptom that may emerge when oxygen levels are low in the human body:
 (1 mark) (KA1)

Extension activity

Collect soil samples such as sandy and clay soils from different areas around Adelaide (a decent 'handful'). Using some of the soil, mix with water in a test tube to test pH and decide which soils are suspect to acidification issues (see steps and illustrations below).

Step 1: Mix a teaspoon of both water and soil in a test tube and dip indicator paper into soil mixture (bottom left).

Step 2: Determine the pH of the soil using a pH indicator chart (bottom right).



Using the remaining soil, place indicator paper in the bottom of a test tube, then place soil over it and fill to the top. Push soil down gently during filling. Following safety precautions, add a similar amount (5-10mL dependent on size of test tube and amount of soil) of dilute acid which simulates fertiliser application to each test tube and time how long it takes for the acid to leach through the soil to reach the indicator paper and change its colour. Identify which soils would be suspect to fertiliser run-off or groundwater pollution based on findings.

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You may wish to then test low pH soils with methods to reduce acidification found in the previous extension activity with science laboratory safety assistance.

Extension activity

Research and list additional roles carried out by the EPA in relation to farming sustainability towards the environment:

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Science as a human endeavour (Influence, Application & Limitation)

Where does Australia stand on use of neonicotinoid insecticides?

The following article has been condensed and combined from the following two sources:

<https://www.pum.com.au/blog/where-does-australia-stand-on-neonicotinoid-insecticides/>

<https://www.sciencealert.com/the-world-s-pollinators-are-dying-out-and-all-our-favourite-foods-could-go-with-them>

Neonicotinoids (neonics) were designed to be less harmful to humans and other mammals. Still, however, there is a large body of scientific research that links neonics to pollinator health and shrinking bee populations.

In Europe, the threat posed by neonics has been compelling enough for the EU to propose a ban of these popular insecticides across the continent. Certain neonic insecticides have been implicated more than others, leading to bans all around the world, but not as yet in Australia.

Although controversial, many farmers and growers, stand by the use of neonics, making them widely used by Australian crop growers. After all, they are some of the most effective pesticides for controlling pests like aphids, flies, hopping insects, and beetle pests, allowing farmers to keep their plants healthy. Neonics are also incredibly versatile. They can protect plants throughout the duration of the growing season without requiring respray because they are not prone to washing off during watering and can stand up to UV light degradation. According to the Australian Pesticides and Veterinary Medicines Authority (APVMA), “when compared with [older insecticides], neonicotinoids pose lower risks to humans and other mammals.” Further, they leave very little residue on the surface of plants, making them less harmful to farmers. Their use is tightly regulated in Australia where bee populations have not been found to be declining.

However, in a two-year study by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), scientists warn that unless action is taken to curb human activity affecting thousands of species of pollinators, food as we know it is at risk. «Without pollinators, many of us would no longer be able to enjoy coffee, chocolate, and apples, among many other foods that are part of our daily lives,» said Simon Potts, a biodiversity and ecosystems scientist from the University of Reading in the UK. While people are probably mostly familiar with pollination in the context of bees, the natural process goes far beyond honey production. Over three-quarters of the world’s food crops depend at least in part on pollination by insects and other animals.

The researchers say sustainable agriculture, including practices based on indigenous and local knowledge, would help to ensure more pollinator species don’t go extinct. To achieve this, they recommend maintaining a greater diversity of pollinator habitats; supporting traditional practices that manage habitat patchiness, such as crop rotation; decreasing the use of pesticides; changes to bee husbandry and commercial pollination practices; and public education and awareness campaigns.

A closer look: Organic farming

The issues surrounding primary production's use of chemicals are significantly reduced for the agricultural practice called **organic farming**. This is because organic produce is grown or raised without using synthetic or artificial chemicals, for example pesticides and fertilisers for crops and pastures; and without dependence on chemicals such as antibiotics for animal health (animals can be treated with vaccines to prevent disease).

Questions

12. Complete the following table on synthetic chemicals, by identifying the specific chemical and an advantage and disadvantage of their use.

Chemical	Purpose	Advantage	Disadvantage
	Kill pests (insects, weeds, fungi) consuming crops/pastures		
Fertilisers			
	To kill bacterial infections in animals		

(9 marks) (KA1)

In addition, organic foods will not use genetic modification (see Topic 3.3) or food irradiation (see Topic 3.1). Organic farming aims to protect the natural environment, often leaving areas of natural vegetation within and around a farm to maintain biodiversity. This aim also includes conserving water and soil and reducing energy use by focusing on reliance on renewable resources. To meet organic farming aims and principals, a number of agricultural methods and practices are used (as shown in Table 3.2.1).

Table 3.2.1: Organic production systems and practices.

Agricultural method or practice	Advantages
<p>Crop rotation: Involves planting alternate and rotating crops on the same field (see Figure 3.2.11).</p> <p>For example: A simple crop rotation that begins by planting corn which uses a lot of nitrogen to grow. After it is harvested, the field is then planted with soybeans that return nitrogen to the soil. NB.> Farmers can rotate through varied numbers of different crops.</p> 	<ul style="list-style-type: none"> • Prevents nutrient depletion in soil and therefore minimises the negative impacts of fertilisers e.g. soil acidification. • Manages pests by taking away their food source for substantial periods of time. • Crop rotation also ensures a field is not left bare and able to be overgrown by weeds. This minimises the negative effects of needing pesticides on biodiversity.

Figure 3.2.11: Crop rotation of corn followed by soybeans.

Agricultural method or practice	Advantages
<p>Intercropping: Is the agricultural practice of growing two or more crops in the same field at the same time (see Figure 3.2.12).</p>  <p><i>Figure 3.2.12: Intercropping of sugar cane and cabbage being grown in alternate rows during the same season.</i></p>	<ul style="list-style-type: none"> • Pest numbers tend to be lower with a variety in crops growing as there is a limited food supply for each type of pest which hinders breeding habits. This minimises pesticide needs. • Growing different types of crops is beneficial to food security should a disease destroy one type of plant. • Soil fertility can benefit due to different plants requiring and returning different nutrients to and from the soil.
<p>Free range: Refers to animals not kept in cages or pens or feedlots. Animals can be fed using rotational grazing of mixed pastures for livestock or an organic farmer may use mixed farming practices. Mixed farming involves rearing livestock and crops on the same farm, often feeding livestock on weeds or crop remnants left after harvest (see Figure 3.2.13).</p>  <p><i>Figure 3.2.13: Sheep grazing on remaining wheat stubble after its harvest.</i></p>	<ul style="list-style-type: none"> • Better animal welfare and variety in diet can aid in animal health. • Can reduce soil erosion issues from over-grazing if rotational grazing is used. • Reduced chance of disease spread from confinement. • Mixed farming offers: <ul style="list-style-type: none"> ◦ A source of natural fertiliser through animal manure and therefore reduced fertiliser needs. ◦ Animals can assist with weed management resulting in reduced herbicide needs.
<p>Natural pest control: Substances extracted from plants or animals can be used to repel or attract insects or deter weeds (see Figure 3.2.14).</p> <p>For example, pheromones which are substance secreted by an animal that can disturb pest mating cycles, can be used in traps to attract insects (see below).</p>  <p><i>Figure 3.2.14: Pheremone trap.</i></p>	<ul style="list-style-type: none"> • Reduced air, land and water pollution (and associated impacts on biodiversity).

Agricultural method or practice	Advantages
<p>In addition, farmers can encourage populations of natural predators and beneficial insects (called biological control – see Figure 3.2.15).</p>  <p><i>Figure 3.2.15: Ladybug as a natural predator of crop-consuming aphids.</i></p>	
<p>Human labor: Agricultural workers can run tasks normally performed by chemicals or machinery (see Figure 3.2.16).</p>  <p><i>Figure 3.2.16: Farmer using a hoe to remove weeds instead of machinery in preparing a field to plant a crop.</i></p>	<ul style="list-style-type: none"> • Reduces herbicide needs and its associated environmental damage. • Reduces greenhouse gas emissions from machinery.

Questions

13. Match the following organic practices to their appropriate description, example, or benefit.

Human labor		Prevents soil nutrient depletion and reduces weed and insect invasion of crops
Natural pesticides		Braconid wasps encouraged around lettuce crops for the purpose of their larvae being a parasite to the caterpillars that consume lettuce
Biological control		Workers hand-picking potatoes using a hoe to dig them up
Mixed farming (form of free range farming)		Pyrethrin, a compound extracted from the chrysanthemum flower can be sprayed on crops as an organic insecticide
Crop rotation		Can improve soil fertility by adding nutrients through manure
Intercropping		Field planted with rows of lettuce, spinach and carrots

(5 marks) (KA1)

Climate change

Burning fossil fuels for energy leads to the production of **greenhouse gases**. The major greenhouse gases released in farming are carbon dioxide (CO₂), **methane (CH₄)** and nitrous oxide (N₂O). Considering the agricultural sector is the fourth most energy-intensive industry in Australia, it is also a large contributor to greenhouse gases and their increase in the atmosphere (see Figure 3.2.18).

Fast fact

Raising cattle contributes to methane production as well; a single cow on average produces between 70 and 120 kg of methane per year (Source: <https://www.adelaide.edu.au/news/news107762.html>)

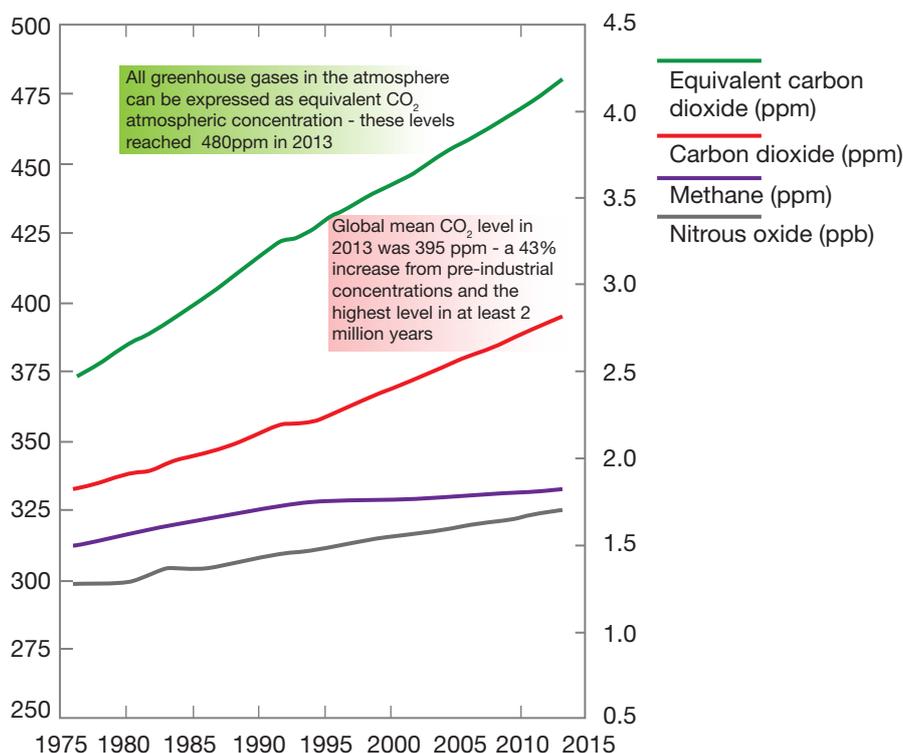


Figure 3.2.18: Increasing greenhouse gases in Australia.

Questions

15. Describe how deforestation also contributes to an increase in greenhouse gases in the atmosphere.

(2 marks) (KA1)

Greenhouse gases have an ability to trap heat radiation from the sun and keep the earth warm (much like a greenhouse, hence their name). Climbing levels of greenhouse gases can therefore result in greater heat retention, meaning the Earth has, and is, **becoming warmer** (see Figure 3.2.19). This is known as the ‘Greenhouse effect’ or ‘**Global warming**’. Global warming is contributing to the world’s weather patterns being more extreme and unpredictable. For example, in Australia this can mean increased prevalence of drought or floods. These weather events can have dire consequences on farming areas and food security, biodiversity and human health.

Fast fact

Australia’s climate has warmed by just over 1.0°C since 1910, with projections for Australia developed by CSIRO suggesting that annual average temperatures will increase between 0.4 C and 2 C by 2030! (Source: <https://www.betterhealth.vic.gov.au/>)

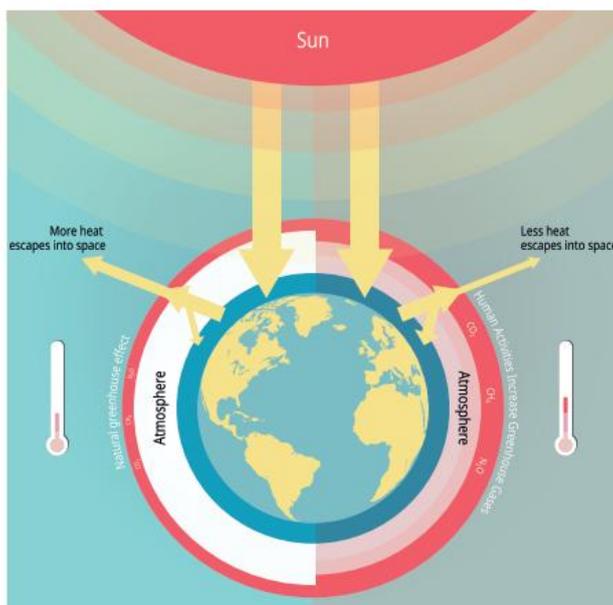


Figure 3.2.19: Natural greenhouse effect (left) and global warming (right).

Extension activity

Using the image below as a stimulus, research and discuss some of the consequences and impacts of global warming on society. For example, a decrease in global ocean oxygen would create greater no-go zones for aquatic life leaving them with fewer areas to eat and reproduce.



Area for student response with horizontal dotted lines.

In the past, a majority of water from the Murray-Darling river system has been allocated to farming (under government water delivery schemes). Water is now however, being re-allocated to the environment to strengthen the ecological functioning of the river systems and undo damage to biodiversity caused by prior water allocation concentrating on human farming use.

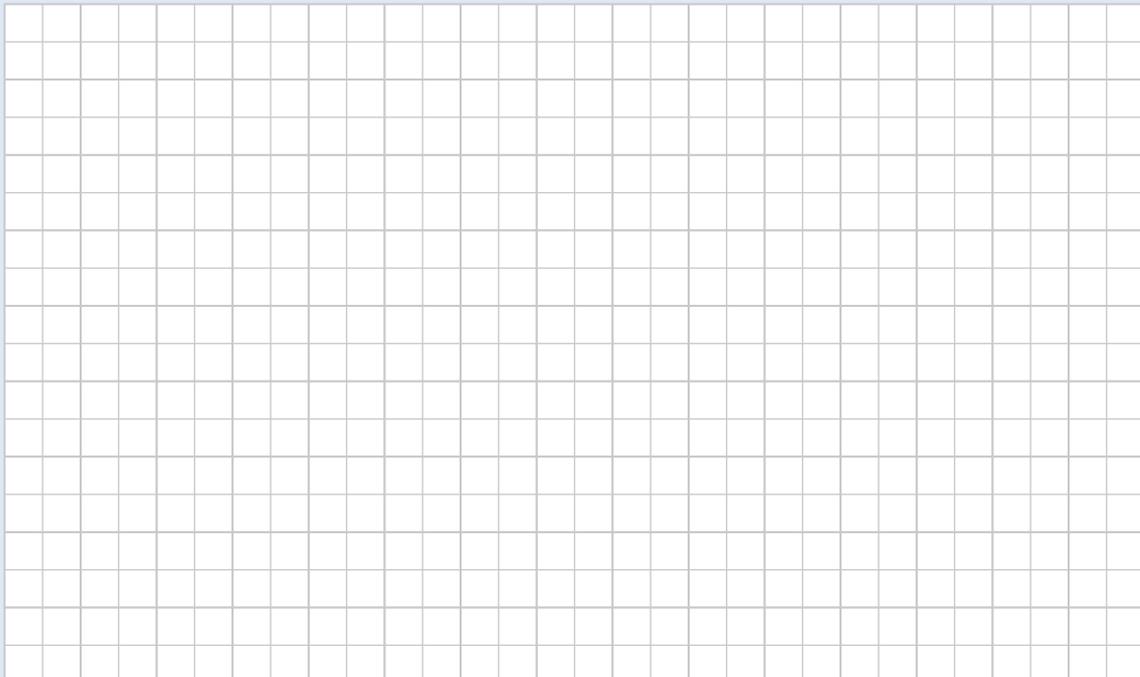
Questions

17. The following questions relate to the information presented below about agriculture’s water-scarcity footprint (adapted from the scientific journal ‘Nutrients’ 2019: <https://www.mdpi.com/2072-6643/11/8/1846/htm>).

The water-scarcity footprint consists of the litres of water used to create the final food product in combination with its weighting and the amount of readily water available to produce it.

- In 9,000 Australian diets studied, 25% of the water scarcity footprint came from discretionary foods and beverages such as cakes, biscuits, sugar-sweetened drinks and alcohol.
- Fruit contributed 19%. This includes whole fruit and fresh (not sugar-sweetened) juices.
- Dairy products and alternatives (including non-dairy beverages made from soy, rice and nuts), collectively contributed around 16% to the water-scarcity footprint.
- Breads and cereals contributed to around 13%.
- Fresh meats (i.e., meats that have not undergone any preserving process) and alternatives (such as eggs, tofu and other vegetarian and vegan substitutes) contributed around 10%.

(a) Graphically present the percentages contributing to the water-scarcity footprint from each food group



(4 marks) (IAE2)

(b) (i) With reference to the graph above, identify the predominant food group that should be reduced in our diets to reduce water usage. Provide data to justify your response.

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(2 marks) (IAE3)

(ii) Discuss another reason for this food group to be reduced in our diets, relevant to nutritional health:

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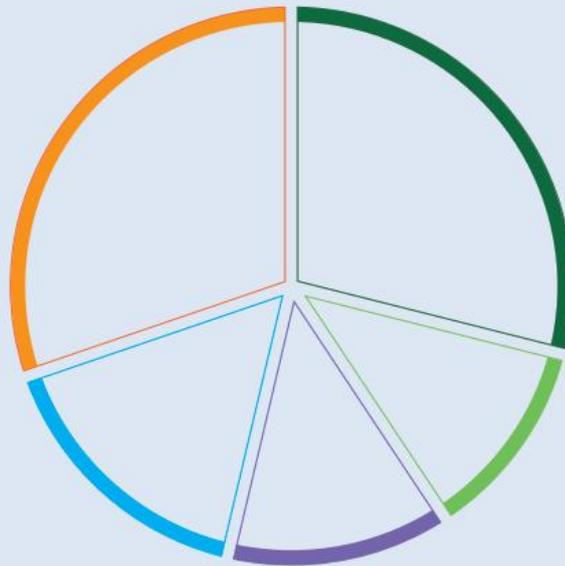
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(2 marks) (KA2)

Questions

- (c) Identify and place the 'fruit' food group and 'meats and alternatives (such as eggs, tofu and other vegetarian and vegan substitutes)' group into their equivalent location on the following outline of the AGHE: (2 marks) (KA2)



Irrigation salinity

Irrigation salinity arises via similar processes of dryland salinity, whereby water seeps through the soil adding to the water table so that it rises, bringing dissolved salts with it to the surface (refer back to Figure 3.2.4). The difference with irrigation salinity is that the water that leaks down through the soil is not from rainwater like it is in dryland salinity, but from large quantities of water that are irrigated or watered over crops and pastures to maximise their growth.

Questions

- 18. Describe a consequence of topsoil with a high salinity content.

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(2 marks) (KA2)

Extension activity

Irrigating or watering crops is strongly linked to water-scarcity and irrigation salinity issues in primary production. Describe an alternate method of growing crops called hydroponics and discuss how this method can reduce these environmental issues.

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A closer look: Aquaculture

Aquaculture is an agricultural practice requiring significant bodies of water, thereby making it a practice that is well-associated with primary productions' water-scarcity issue. **Aquaculture**, or fish farming, is rearing aquatic organisms including fish, molluscs (e.g. mussels, octopus), crustaceans (e.g. crabs and prawns) and aquatic plants, in a defined marine (saltwater), estuary (mix of salt/fresh) or freshwater area. Although **around for hundreds of years**, it has become an increasingly popular agricultural fishing practice in comparison to traditional wild fishing. This is because aquaculture is an answer to the issue of overfishing native fish and it enhances yield through controlled feeding and protection from predators. Fish farms are protected because they barricade off portions of natural bodies of water to rear marine life intensively (see Figure 3.2.22).

Fast fact

Aboriginals have practiced (and still continue to practice) small-scale aquaculture methods utilising fish traps to capture and hold aquatic life for food.



Figure 3.2.22: Marine aquaculture utilising ocean areas (left) and an underwater view of the intensive rearing of aquaculture fish (right).

A consequence of taking over portions of natural bodies of water is a reduction in biodiversity. Even if the fish farms don't section off water in natural water bodies and instead build ponds or tanks or large aquariums, water is required to fill and maintain these artificial habitats, adding to water scarcity and the land to create artificial habitats again means biodiversity can suffer. An additional concern upon biodiversity is that high-protein feed pellets fed to larger aquaculture fish are sourced from smaller wild fish populations. Being intensively raised runs further risks of uneaten food pellets, aquatic waste and chemicals used such as antibiotics causing water pollution and/or eutrophication. Close proximity of fish farming organisms can also amplify disease and parasite spread, including to wild populations sharing the same bodies of water.

Questions

19. Define eutrophication.

(1 mark) (KA1)

Extension activity

Define wild fishing and discuss some methods that are used to capture fish, then complete the following table comparing wild fishing and aquaculture.

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Agricultural method	Disadvantages	Advantages
Aquaculture		
Wild fishing (bottom trawler)		

Distribution and processing

After harvest, collection or slaughter, raw products from primary production can be transported to food manufacturing plants for food processing and/or distributed to places of sale.

Food miles

Transport of raw or processed food products is called **food miles**. It is a measure of the distance food travels between production and consumption. Australian domestic food products require distribution across the country while imported or international products need to be firstly transported over air or water before distribution across Australia. Whether international imports or domestically sourced foods, food can **travel over vast distances** to reach consumers, particularly those in remote populations. Vast distances equate to high petroleum or petrol needs. Petroleum combustion means large amounts of motor vehicle exhaust, which contribute to greenhouse gas emissions, global warming and climate change. Additional air pollutants also arise from fuel combustion from motor vehicles, including carbon monoxide (CO), nitrogen dioxide (NO₂) and sulphur dioxide (SO₂). Upon emission, sunlight can interact with some exhaust air pollutants to form ozone gas. Ozone has a role in the upper atmosphere to protect the earth from UV radiation, but breathing ozone at ground level, or the other pollutants, can be hazardous to human health:

- CO – reduces the ability of the blood to carry oxygen, leading to respiration difficulties
- NO₂, SO₂ & Ozone gas – can aggravate asthma and other respiratory disorders

Fast fact

Our shopping basket has travelled an average of 21 073km, almost the whole way around Australia's coastline. Should four imported items be added to the shopping basket, this equates to approximately an additional 50 000km! The resulting fossil fuel use for all food transporting trucks carrying one shopping basket of 25 items on any given day is the equivalent of 2,830 cars driving for a whole year (Community Environment Park's Food Miles Report, 2008)

Questions

20. Country of origin labelling types include 'Made in Australia' and 'Product of Australia'. State which country of origin labelling type should be chosen to ensure lower food miles and justify your response.

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..... (2 marks) (KA1)

An obvious solution to reducing food miles is to consume domestic foods grown and produced in Australia. However, farms are becoming more specialised worldwide and Australia does depend on foods from some of these specialised farms and their global food trade. Food imported from overseas is important to ensure Australians have enough food or good food security and to ensure there is variety in our diets. The **overwhelming majority** of food sold in Australia is grown and supplied by Australian farmers. Of the foods imported into Australia, a substantial proportion is highly processed foods, but also includes seafood and some vegetables. Whilst still meeting domestic needs, Australia is able to export more than half of all agricultural produce to help meet global food needs worldwide.



Fast fact

More than 90% of fresh fruit and vegetables, meat, milk and eggs sold in our supermarkets are domestically produced (by Australian farmers).

Food processing

Food processing factories or manufacturing plants convert raw or whole foods in a number of ways (see Topic 3.1) into the food products we purchase from places like supermarkets. The conversion of raw foods into food products in manufacturing plants relies on resources like water, requires a lot of energy and generates greenhouse gases that contribute to climate change.

The modern food system can also give consumers the convenience of being able to purchase fruit and vegetables out of season; for example, tomatoes in winter (tomatoes perish in cold weather). This convenience requires production in enclosed areas like greenhouses and processing in the form of refrigerated transportation and/or cold storage, all of which are a further burden on climate change due to extra energy being needed.

Questions

21. List two strategies that can be used by consumers to reduce the environmental impact of food distribution and the production and processing of foods out of season.

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..... (2 marks) (KA2)

Environmental impacts of food packaging

Food processing also involves the packaging of the food. Production of the packaging materials takes a lot of natural resources to produce. Over the past few decades the amount of natural resources Australians use: including aluminium/tin/steel (for cans for example), sand (for glass) and trees (for paper/cardboard), has doubled! Sourcing these resources therefore comes with environmental concerns from mining land and deforestation. Similar to processing foods, processing the packaging materials requires resources like water, consumes a lot of energy and generates greenhouse gases that contribute to climate change.

Another problem that stems from the packaging of food is that a majority of the packaging ends up in **landfill** (see Figure 3.2.23) which can take hundreds of years to decompose completely, if at all (as shown in Table 3.2.2). For some packaging materials that can decompose, greenhouse gases can be released into the atmosphere and chemicals from packaging materials such as labelling inks and dyes can also leach into groundwater and soil. Landfill sites also require deforestation to occur.

 **Definition**

Packaging waste that makes its way into the environment via water ways or wind is called litter.

**Science as a human endeavour
(Communication & Collaboration, Application & Limitation)**

The article has been adapted from the following source:

<https://www.sciencealert.com/humans-consume-over-74-000-microplastic-particles-each-year-without-knowing-it>

Questions

23. In different colours, highlight sections of the article that are relevant to Communication & collaboration or to the following segment of the Application and Limitation key concept that focuses on Limitations: 'there may be complex, unanticipated variables or insufficient data that may limit possible conclusions'. (KA3)

We're increasingly aware of how plastic is polluting our environment. Plastic debris is gradually broken down into smaller and smaller fragments in the ocean, until it forms particles smaller than 5 mm, known as microplastics, which will likely never biodegrade!

From what little we know about microplastics in air, food and water, Canadian researchers have now estimated that the average person consumes more than 74,000 particles of plastic each year. In all likelihood, the authors admit, this undervalues the reality. Due to a lack of data, the research was limited to only a few categories, including fish, shellfish, added sugars, salts, alcohol, tap or bottled water, and—of course—the air we breathe. Based on a thorough review of the literature, including 26 peer-reviewed studies, the team created a microplastics database which they then compared to US dietary data. Depending on a person's age and sex, the number of particles consumed yearly sat somewhere between 74,000 and 121,000 particles. Of all the items in the database, air, bottled water, and seafood accounted for most of the microplastic intake, although these also had the most variation depending on your location and food intake.

While the results might sound scary at first, the authors themselves admit that there's a lot of variation in the underlying data. They also remind readers that their estimates are based solely on the average American's daily food consumption, and only 14 percent of the caloric intake at that. "Extrapolating the number of microplastics consumed with the remaining 85 percent of calories is not possible," the authors write, "however, if our findings are remotely representative, annual microplastic consumption could exceed several hundred thousand."

Without including cultural differences in diet, or staples like meat, dairy, grains, and vegetables (data which does not yet exist), these results are more of a ballpark figure. What's more, the research says nothing about the costs, if any, to human health. Today, the effects of consuming microplastics are largely unknown, and yet there's little doubt that it's going on right now at unprecedented volumes. The potential pathways for harm are many, and scientists have only proposed a few. Once microplastics enter the gut, they could release toxic substances causing oxidative stress or even cancer, according to the researchers. Particles small enough could be taken up by cells in the lungs and gut; while larger ones might be absorbed in the digestive tract. What happens from here is anyone's guess. Many questions for the scientist to try to answer in a short period of time because this is urgent."

If the goal in the meantime is to avoid microplastic ingestion, the authors suggest quitting bottled water first. In their findings, microplastic consumption in water changed considerably depending on whether it came from a bottle or the tap. Compared to water from a pipe, for instance, the authors found bottled water contained 90 more microplastic particles per litre.

Still, in all likelihood, avoiding bottled water is just a drop in the bucket. While more direct research needs to be done, the trend so far suggests that microplastics will continue to be found in many, if not all, items intended for human consumption. "If the precautionary principle were to be followed, the most effective way to reduce human consumption of microplastics will likely be to reduce the production and use of plastics," the authors conclude.

Extension activity

List a number of ways your household could reduce your packaging environmental impact

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As can be seen in Figure 3.2.23 earlier, plastic is a predominant packaging material contributing to landfill, with it being so heavily used in the food industry. Plastic is also a common packaging material that ends up as litter in the environment. In response to this, there are a number of initiatives across Australia aiming to reduce the environmental impact of packaging and ban single-use plastic. For example, the World Wildlife Fund (WWF) run a plastic free July challenge that includes signing a petition sent to government bodies requesting the banning of single use plastic, and Plant Ark and APCO (Australian Packaging Covenant Organisation) created the Australasian recycling label, to make recycling easier (see Figure 3.2.24).

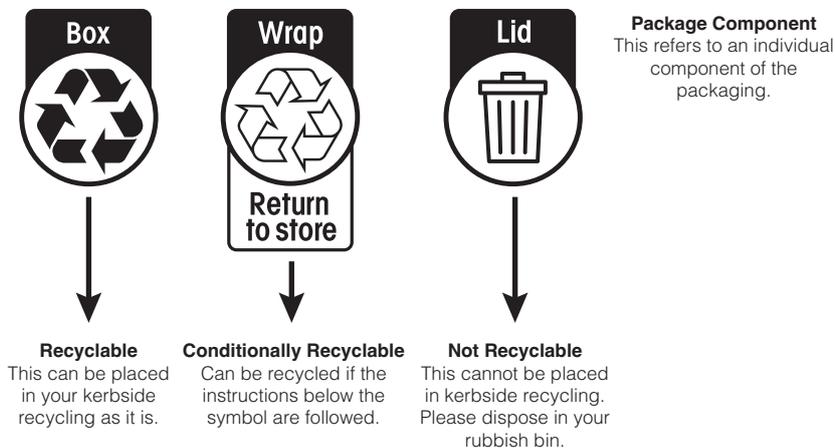


Figure 3.2.24: The three variations of the Australasian recycling label.

In answer to known environmental impacts, pressure from environmentalists and initiatives like those mentioned, most state and territory governments have banned single-use lightweight plastic bags and have been supported by Australia’s major supermarkets. South Australia has gone as far as banning single-use plastics including cutlery, straws and polystyrene cups and plates, the first state to do so (from 2021)! Australian governments have also endorsed the Australasian recycling label and states and territories are implementing legislation and container deposit schemes that specifically address packaging litter issues. An incentive of money for returning containers to be recycled is helping to keep plastic out of the environment and landfill.

Questions

24. Identify the most appropriate SHE key concept at play when SA government brought in single-use cutlery banned in response to pressure from environmentalists
 (1 mark) (KA3)

However, it should be noted that simply banning and reducing packaging in an effort to counteract the mentioned environmental impacts, is a complex issue because packaging has a role in reducing food waste. If packaging is removed, food waste and its associated environmental impacts increase (see next section).

Food waste

The final step of the modern food system is food waste management. Of the food that is produced globally, one third of it is **lost or discarded**, and this increases up to approximately half when considering only fruit and vegetables. If just a quarter of this food could be saved, it could feed over 800 million people who face food insecurity around the globe!

Definition

Food loss is defined as the decrease in quality of food to the point it loses nutritional and/or economic value and then may not be eaten, instead being discarded. An important part of food loss is **food waste**, which refers to when the food is discarded as it is no longer fit for consumption. This includes edible and inedible parts of the food (such as seeds, bones, peels, etc).

In Australia, we also discard a lot of food every year: around 300kg per person, equivalent to one out of every five bags of groceries! Food waste is not however, only food discarded from households; it also includes food that does not reach the consumer, discarded along the food systems pathway for a variety of reasons (see Figure 3.2.25).

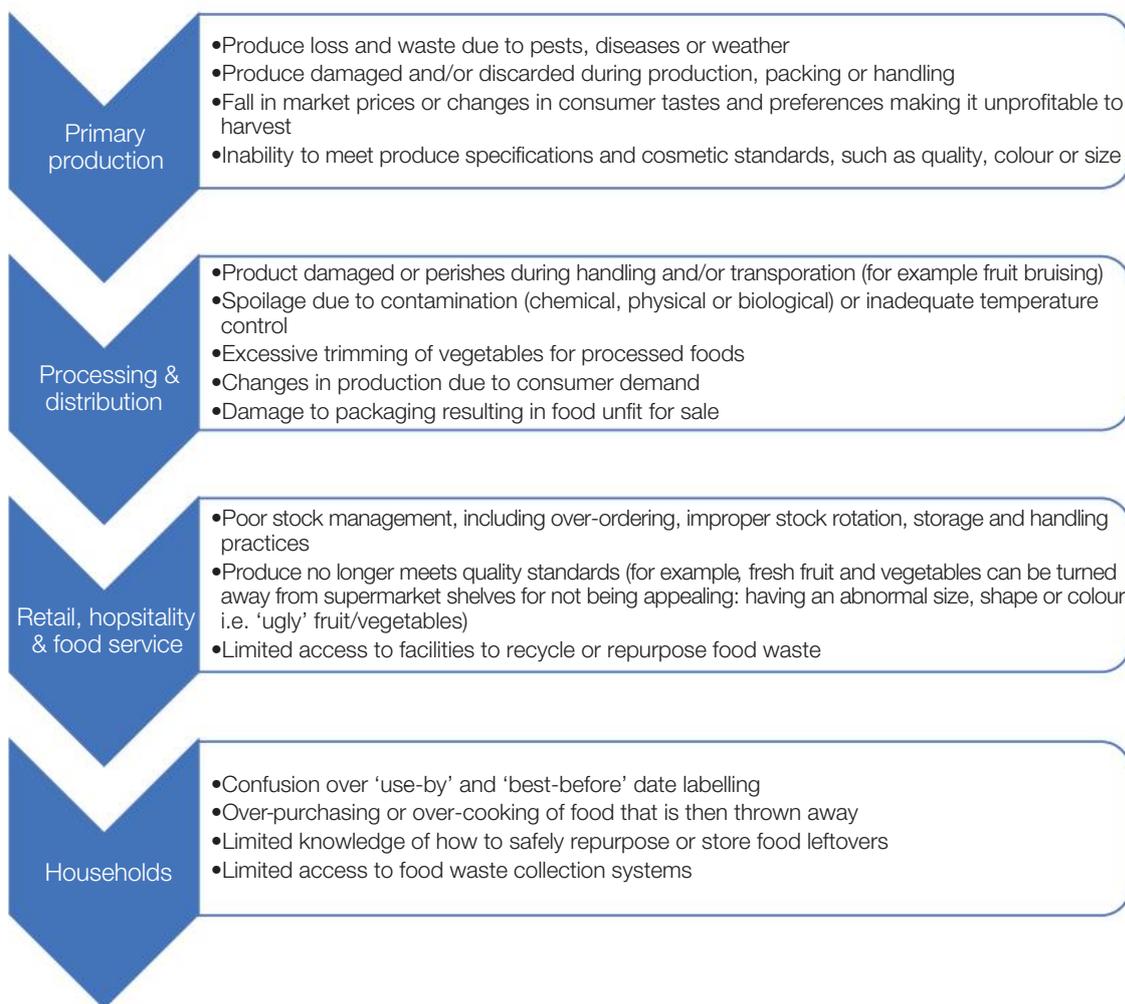


Figure 3.2.25: Examples of how food waste can occur along the modern food systems.

Questions

25. Foods with a best-before date can be consumed after their date marking. State why foods with a use-by-date cannot:

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.....

(1 mark) (KA1)

Throwing away food is a waste of the fuel, water, nutrients, farming labour and other resources that were invested in its production, not to mention the associated futile impacts on the environment! Furthermore, discarded food is sent to landfill where it rots and releases methane gas. Methane gas is more potent in comparison to other greenhouse gases and is therefore strongly linked to climate change.

Fast facts

- Throwing out one burger wastes the same amount of water as a 90-minute shower! (Source: <https://www.environment.gov.au/protection/waste-resource-recovery/food-waste#:~:text=Food%20waste%20is%20also%20a,in%20five%20bags%20of%20groceries.>)
- Over 5 million tonnes of food ends up as landfill (from households and commercial and industrial sectors), enough to fill over 9000 Olympic-sized swimming pools (Source: OzHarvest)

Questions

26. Other than methane, list a greenhouse gas and discuss how it contributes to climate change.

.....

.....

.....

.....

(3 marks) (KA1)

Strategies to reduce food waste

Global level

Reducing food waste (and improving distribution) is critical to reducing global hunger and greenhouse gas emissions. Recognition that global food waste is an issue that needs to be tackled and reduced worldwide, is conveyed by the United Nation’s (UN) Sustainable Development Goal 12.3: an aim by 2030 to halve global food waste at the retail and consumer levels and reduce food losses along production and supply chains. The United Nations is an international organisation that has numerous sustainable goals that are a call for action by all countries, whether poor or wealthy, to promote prosperity and protect the Earth from environmental harm. The goals aim to achieve a better and more sustainable future for all people around the world and urge developed countries to take the lead. The UN food waste goal has prompted a number of initiatives across the world including those in the figure below (3.2.26).



Figure 3.2.26: World initiatives in response to addressing the issue of food waste.

In late 2017, the Australian Government responded to the call to action by committing to a National Food Waste Strategy that aims to halve Australia’s food waste by 2030, aligning with the UN Sustainable Goal on food waste. Some of the plans to be undertaken to reduce food waste from the National Food Waste Strategy are:

- Developing a voluntary commitment program from food industry organisations to identify solutions to reduce food waste
- Diverting more surplus food to the food rescue sector (organisations like Ozharvest & SecondBite) so that it can be redistributed
- Supporting educational campaigns around food waste (increasing public awareness about the magnitude of the food waste problem and its negative impacts)
- Investment into research and technological improvements
- Investment into agricultural efficiency and waste treatment infrastructure (for example funding for projects that encourage composting).

The effective management of food waste to meet the 2030 goal will require actions such as:

- assessment of food ordering, transport and storage practices
- partnerships between food and grocery retailers and charitable organisations
- incentives for alternatives to landfill disposal
- creating value from food waste (for example providing funding to projects that focus on capturing methane from landfills to produce electricity)
- standardisation of data for the measurement of food waste and tracking of waste reduction (this data means that governments and the public are able to see changes in Australia's food waste generation).

To ensure the introduction and success of these actions, national government bodies need to provide guidance and plans to reduce food waste that both support and encourage state, territory and local government initiatives on food waste programs and initiatives.

Local level

Local government

Local governments operate in accordance with federal and state/territory governments regulations and organise waste collection and disposal from households and businesses in their local area. Our local governments were responsible for the roll-out of the kerbside green organic bins. Many local governments are also taking steps to reduce food waste through a range of programs, such as:

- community information sessions and demonstrations on appropriate food storage and composting at home
- grants and rebates for households to purchase compost bins and worm farms
- trialling and running programs for restaurants and cafes to assess their food waste practices and reduce the amount of food they send to landfill
- supporting local businesses to collect food waste and turn it into valuable products like compost and fertiliser.

Halving Australia's food waste will not be successful venture if governments work alone. It will require an integrated approach where governments, food industries and businesses, food charity sectors, and the community work together.

Food industries and businesses

The food processing industry's lead organisation, the Australian Food and Grocery Council runs award schemes to promote the reduction of food waste, providing incentives for food manufacturers should less food go to waste. Food industries and businesses are playing their part in reducing food waste by:

- composting organic materials in an effort for food waste to then be converted into energy sources (this could see investing in facilities to allow on-site processing of food waste)
- developing solutions to convert food waste into animal food
- exploring and experimenting how different types of packaging can reduce food waste
- marketing aesthetically imperfect produce, discounting product that is near expiry date, and forecasting and planning to avoid over-ordering
- partnering with food rescue organisations to donate food that would otherwise be wasted
- developing web-based wholesale marketplaces for surplus food and ingredients

Food charity sectors

A substantial amount of food is diverted from landfill through a number of food recovery services or charities including: Foodbank, OzHarvest and SecondBite (see Figure 3.2.27). Grocery retailers Coles and Woolworths, who hold the majority of the supermarket sector in Australia, have partnered with food recovery organisations and donate their surplus foods. Food recovery charities redirect surplus food to community food programs for the those with food insecurity, such as the homeless. Donating surplus food to organisations like these means that

food can be redistributed to people who need it, instead of going to landfill. Some food charity organisations also work with farmers so that food waste is being reduced along the entire food systems pathway.



Figure 3.2.27: Logos of food recovery charities in Australia.

Households

To reduce food waste in the home, you can:

- Make and use your own compost bin
- Store food correctly
- Be open to purchasing and consuming ‘ugly’ or imperfect fruit and vegetables (see Figure 3.2.28)
- Check food labels date markings and know that food can be consumed after its best before date (as long as the food has not been opened)
- Freeze food you know you won’t get a chance to eat before it passes its use-by date.
- Check the fridge before shopping, don’t go hungry and write shopping lists so that you stick to buying only the food you need
- Plan meals so that you only buy what is needed and don’t cook too much food
- Should you buy additional take-away food for convenience, leaving food planned to be cooked sitting in the fridge, rather than leave it to spoil: cook and store safely for an alternate day.
- Use left-overs
- Donate unwanted food.



Figure 3.2.28: Shopping bag of imperfect fruit and vegetables.

3

Questions

27. Provide four tips in order to ‘cook and store food safely for an alternate day’.

1.

2.

3.

4.

..... (4 marks) (KA1)

Extension activity

Make your own compost bin as outlined by many youtube videos (select the one to suit your material, skill set and household needs).

Helpful online resources

A simple small scale option can be found at: <https://www.younghouselove.com/younghouselovedotcompost/>



Key terms

Antibiotics	Fertiliser	Irrigation salinity
Aquaculture	Food miles	Monoculture
Biodiversity	Food security	Organic farming
Climate change	Food waste	Pastures
Crop rotation	Fossil fuels	Pesticides
Crops	Global warming	Primary food production (agriculture)
Dryland salinity	Greenhouse gases	Soil acidification
Eutrophication	Intercropping	Soil erosion

Review questions: 3.2 – Food systems and their impact on the environment

1. The following questions focus on crop rotation.

(a) Describe the difference between intercropping and crop rotation.

.....

 (2 marks) (KA2)

(b) Explain how crop rotation can reduce soil acidification

.....

 (3 marks) (KA2)

(c) Crop rotation and intercropping are practices used in organic farming. List another type of practice used organic farming.

..... (1 mark) (KA1)

2. Complete the following table that compares growing crops using organic farming and monoculture. Place a tick or cross under each type of farming.

Practice	Organic Farming	Monoculture
Using synthetic pesticides		
Typically produces higher yields		
Uses manure as fertiliser		
Conserves energy by using human labour where possible		

(4 marks) (KA1)

3. Describe three human health concerns stemming from primary production practices.

Health concern one: ..

.. (2 marks) (KA2)
 Heath concern two: ..

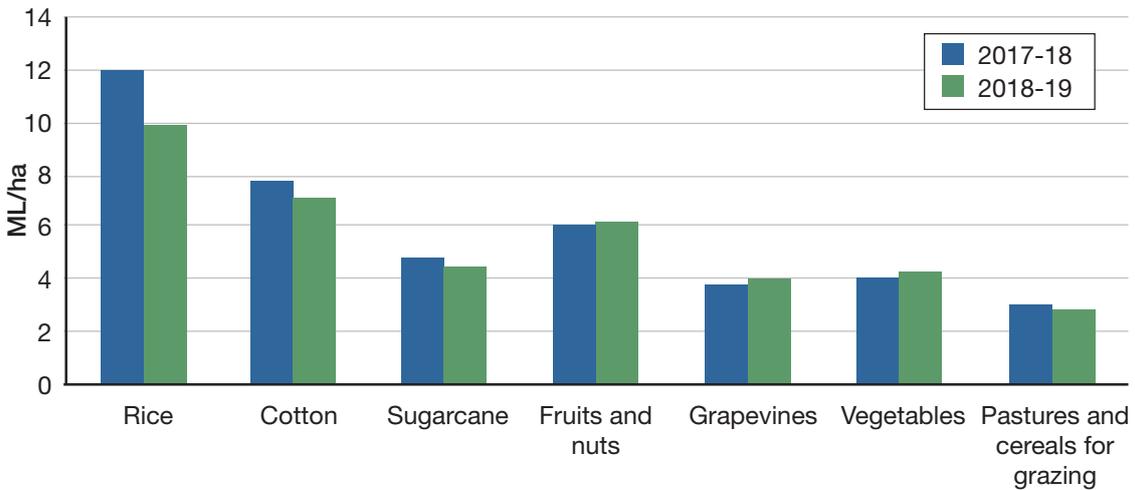
..
 .. (2 marks) (KA2)

Heath concern three: ..

..
 .. (2 marks) (KA2)

4. The following questions refer to the water application rate on various crops over 2017-2019.

Water application rate for selected crops and pastures



(a) List a crop that reduced its water use over the 2018-19 period:
 .. (1 mark) (IAE3)

(b) Identify the crop contributing most to Australia's water scarcity issue:
 .. (1 mark) (IAE3)

(c) Vegetables received greater water application rates than necessary in 2018-19. Explain how this may impact upon food security negatively.
 ..
 ..
 ..
 ..
 .. (3 marks) (KA2)

5. Provide one reason for food waste in the following sectors in the food production system.

Agriculture: ..

Processing and distribution: ..

Retail and food service: ..

Households: .. (4 marks) (KA1)

3.3 Research and development

Science understanding

Research and Development

- are pinnacle to nutrition health
- new food innovations are the necessity of consumer demands or environmental impact
- applied research in scientific or technological fields facilitate future product development
- new food products including GMO and entomophagy

SACE Subject Outline, 2020.

Future farming innovations

Consumer trends over food choices are moving towards produce whose primary production places significance on animal welfare and environmental sustainability. Organic farming does just this and as a result, there has been and continues to be an **increase in organic produce**. However, without the help of artificial chemicals such as pesticides, it is disputed as to whether current organic methods can produce the required yields to support a growing consumer demand for food as our population expands. It is also disputed as to whether commonly used current farming methods such as monoculture can support consumer demand for food due to its negative impact on the environment. Humanity will be challenged worldwide to feed the rapidly growing human population, which is predicted to reach around 9.7 billion by 2050. Farming methods will need to expand to meet consumer food demands of the growing population. However, expansion of either organic or conventional farming methods is questionable, considering most land suitable for farming (called arable land), is already being farmed! If farms are unable to increase in size to match food demands, yields will need to increase. To go beyond current yields, research and development is integral to finding solutions. Applied research into technological fields needs to look at how agriculture can be immersed with technology to improve current food production methods (see digital farming section). In addition, research and development needs to explore innovative blending of organic and conventional agricultural methods with technological advances. An example of this is vertical farming. Beyond adapting and improving food production methods that are already predominately being used in agriculture, research and development needs to explore entirely new food production innovations that have potential to meet consumer demands and decrease environmental damage. Food produced via new means are called **novel foods**. This includes 3D printing of food, cellular agriculture, entomophagy and the genetic modification of new foods. Of importance, for any new food production method or current method with added technological advancements to be successful in facilitating future food product development, it must actively find ways to reduce food waste and reduce or replace food packaging with environmentally friendly options. It must also incorporate the use of alternate or reduced energy and water sources to ensure environmental sustainability.

3

Fast fact

Consumer demand for organic produce is growing at a rate of 20-30% per year in Australia.

Definition

Novel foods are those that are produced by a method that has not previously been used for food by humans and must be approved by FSANZ before being marketable.

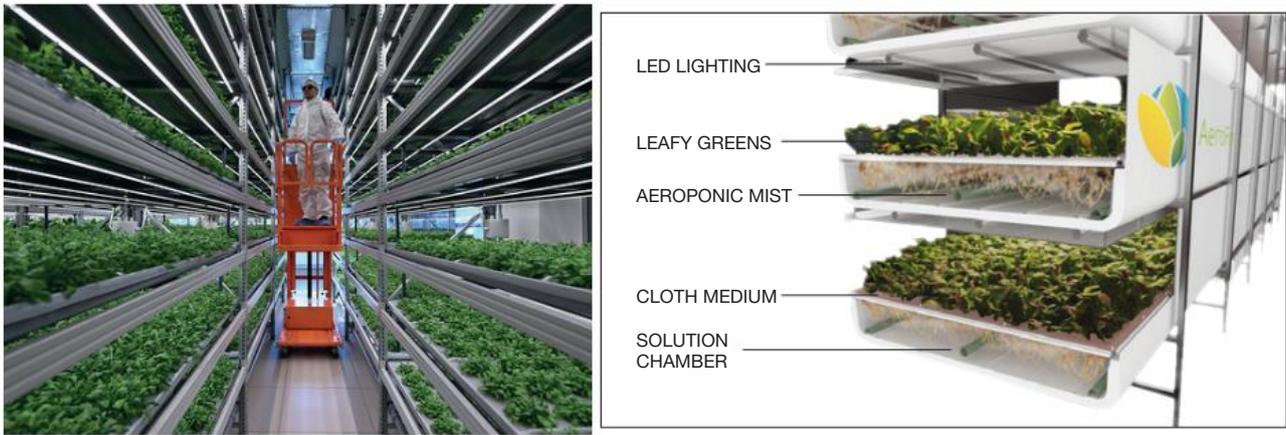


Figure 3.3.4: Vertical farming with hydroponics (left) and aeroponics (right).

Vertical farms are often started-up in urban areas or cities, in climate-controlled indoor areas (often in buildings, which some farmers term as plant-scrappers!). Vertical farms can function all-year around due to environmental conditions like light (often LED light for energy-saving purposes), temperature and water, being controlled.

Vertical farming is an emerging food production innovation in answer to traditional farming land and [water usage issues](#). The benefits of growing crops via vertical farming principals include:

- Vertical farms can grow in urban or city areas, which reduces the issues of urbanisation pushing farming areas out to less arable regions (see land use in Topic 3.2). It can also mean a heavy reduction in [food miles](#) before produce reaches consumers.
- Water not trapped by plant roots is able to be reused rather than leaching through the soil to the water table as it does in conventional farming on land.
- Growing crops vertically means limited land usage which is a favourable aspect to biodiversity conservation.
- Farms being indoors allows them to grow in challenging weather such as drought. Therefore, vertical farming could also be considered an innovative food production method in answer to climate change and its associated changes in weather patterns.
- Vertical crop yields have been found to result in higher yields in comparison to crops on traditional fields and therefore could also be a solution to growing consumer demands for food as our population expands.
- The ability to cultivate or grow a larger variety of crops at once because plants are not sharing the same plot of land, is another reason for the occurrence of vertical farms increasing. A variety of crop plants growing ensures food security if disease was to affect one crop.
- There has also been some scientific evidence of better nutrient absorption by crops grown using aeroponics. This could be pinnacle in producing more nutrient-dense foods that can improve nutritional health.

Fast fact

Vertical farming uses approximately 50-90% less water (dependent on the type of vertical farming and plants grown) than traditional farming fields!

Reminders

Food miles is the distance food travels between production and consumption.

Questions

3. Describe how urbanisation pushing farming areas to less arable regions of Australia affects food availability.

.....

.....

.....

..... (2 marks) (KA2)

4. Describe an additional benefit of growing plants in enclosures in comparison to fields that rely on chemical use.

.....

.....

.....

..... (2 marks) (KA2)

A closer look: Aquaponics

In a modern context, aquaponics emerged from the aquaculture industry as fish farmers and scientists in research and future food product development were exploring methods of raising fish while trying to decrease their dependency on land, water and other resources. In aquaculture, aquatic animal waste can accumulate in the water. In aquaponics, water with wastes from the aquaculture system is recycled and used in the hydroponic water system. Beneficial bacteria, called nitrifying bacteria within the hydroponics system that are gathered around the plant roots, are able to convert fish farming wastes into nutrients used by the plants for growth. Conversion of wastes also acts to 'clean' the water, allowing it to be recirculated back to the aquaculture system (see Figure 3.3.5). Edible freshwater fish that tolerate crowding in tanks are the most common aquatic animals raised in aquaponics. For example, barramundi and silver perch, to name a few. Many different plants typically found in salads and stir-fry's grow well in aquaponics, while green leafy vegetables with low nutrient requirements, for example spinach and lettuce, grow best.

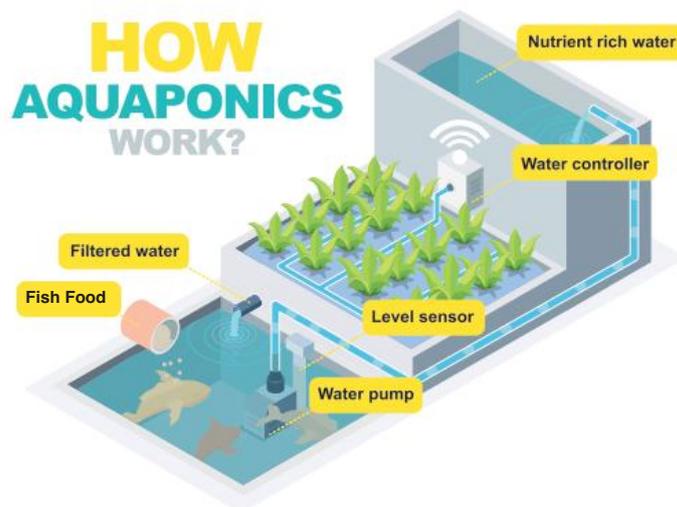


Figure 3.3.5: Aquaponics system components*

*this image does not display the aquaponic components as they would vertically, so that each level can be viewed easily.

Questions

7. (a) Sugar beets are a good source of sucrose. Name this sugars saccharide classification:

..... (1 mark) (KA1)

(b) Soy products are high in a number of nutrients. Name two – one specific macronutrient, the other a specific micronutrient.

Macronutrient: (1 mark) (KA1)

Micronutrient: (1 mark) (KA1)

Extension activity

Research types of foods that include the ingredients outlined in the table below:

International GM crop	Australian foods found in (as an ingredient)
Soy	
Corn (maize)	
Sugar beet	

Most existing foods with GM are from plants that have been engineered to be more tolerant to disease or herbicides, in order to improve yield. In future, new foods plus foods derived from GM microorganisms and GM animals, could be introduced into our food market. The purpose of creating new GM foods includes:

- Reducing a food’s allergen potential.
- Improving the efficiency of the modern food systems to match a growing population and consumer demands
- A focus on sustainability and reducing the food systems environmental damage.
- Improving yield in weather extremes that can be brought on more frequently by climate change, for example drought.
- Creating **functional foods**, which are foods with an improved nutritional content to better nutritional health and/or alleviate prevalent nutritional diseases.

For example, wheat could be engineered to have improved nutrition with a higher protein and soluble fibre content. CSIRO researchers are working on a wheat that might improve nutritional properties such as the [glycaemic index \(GI\)](#). Wheat could also be genetically manipulated to be resistant to salinity or more efficient at utilising soil nitrogen, therefore potentially decreasing the need for added fertilisers. Black tiger prawns (or other aquaculture species) could have their conventional breeding time sped up and chickpeas are being trialed to tolerate drought conditions thanks to some biotechnological changes. With such a vast array of technical advances possible, GM could be the solution to meeting consumer demands and decreasing environmental damage, whilst also being pinnacle to nutritional health.

 **Reminder**

Glycaemic index is a measure of the effect of a food on one’s blood glucose levels.

Questions

8. (a) Discuss how creating a wheat variety with higher levels of soluble fibre in comparison to their conventional counterpart could improve GI:

.....

 (2 marks) (KA2)

(b) Identify a nutritional disorder that this new wheat variety could be used as dietary management.

..... (1 mark) (KA2)

GM foods on the market, including products containing GM ingredients must comply with FSANZ codes. All GM foods are considered novel foods and are therefore safety assessed by FSANZ before being allowed on the market to be consumed. Assessment investigates aspects such as toxicity, tendency to provoke allergic reactions, unintended effects of the gene insertion and stability of the inserted genetic material. A GM food will only be approved for sale if it is assessed as safe and as nutritious as its conventional counterpart.

Questions

10. State another two roles of FSANZ:

(2 marks) (KA1)

Extension activity

Run a class debate on the benefits and concerns of introducing further GM foods into Australia.

Entomophagy

Entomophagy is the consumption of insects (see Figure 3.3.7). There are around 1900-2000 edible insects known to exist. Entomophagy occurs in many countries around the world (predominantly in continents such as Asia and Africa) as well as within Australia by Indigenous Australians as **bush tucker foods**. Insects, however, are not traditionally part of our Westernised diets and can therefore be considered a **novel food** in Australia. Risk assessment and approval by FSANZ is mandatory as allergic reactions to insects may be possible in those allergic to crustaceans. For populations around the world where insects have not been a traditional part of the diet, the thought of eating insects can be unappealing or unappetizing, with this view possibly being influenced by media, where people display disgust at their consumption, for example on the TV show 'Celebrity get me out of here'. There is also a common misconception that insects are only consumed in dire survival circumstances. Therefore, the future of entomophagy could be in the form of crushed insects or powdered insect flours incorporated into new food innovations like biscuits and pasta (see Figure 3.3.8). Entomophagy's future may also expand into alternate 'bush tucker' protein sources, especially considering they have fed populations or indigenous communities in the past and would be well-adapted to Australian climates.

Definitions

- Bush tucker foods refers to any wild animal, insect, plant or plant extraction traditionally used by native Australians.
- The definition for novel foods also extends to foods that have not been consumed to a significant degree in the past.



Figure 3.3.7: Traditional entomophagy dishes – crispy salted crickets.

Extension activity

Research and list some of the insects consumed by aboriginals as bush tucker foods.

.....

.....

Entomophagy has captured media attention and been an area of research and development due to their nutritional composition, ability to meet consumer demands and their potentially lower environmental footprint. The benefits of entomophagy include:

- Nutritional composition of insects can vary widely based on the species and life stage consumed, but in general, insects have similar energy and quantities of protein to meat and fish. They are also a good source of fibre and micronutrients such as iron. Many insect species can also be a good source of unsaturated fats. It should be noted that nutritional composition data (currently limited) and the **bioavailability** of these nutrients to humans still requires applied scientific research to facilitate the future of insect farming production.
- Traditional sources of protein, particularly meat and dairy products, are recognised as having a large environmental footprint (see Topic 3.2). Insects are reported to **emit fewer greenhouse gases** than cattle.
- Due to their ability to **convert the food they eat into body growth and weight effectively**, reproduce rapidly and grow quickly, insects could be a solution to meeting consumer demands as our human population expands. These abilities also mean they require significantly less water and land for feed resources in comparison to rearing livestock (see Figure 3.3.9). Food sources can also be organic food wastes, which additionally lowers entomophagy’s environmental footprint.



Reminder

Bioavailability refers to how much of the nutrient is able to be absorbed into the human body for use.



Fast fact

As an example, pigs produce 10–100 times more greenhouse gases per kg of weight than mealworms.

On average, insects can convert 2 kg of feed into 1 kg of insect mass, whereas cattle require 8 kg of feed to produce 1 kg of body weight gain.

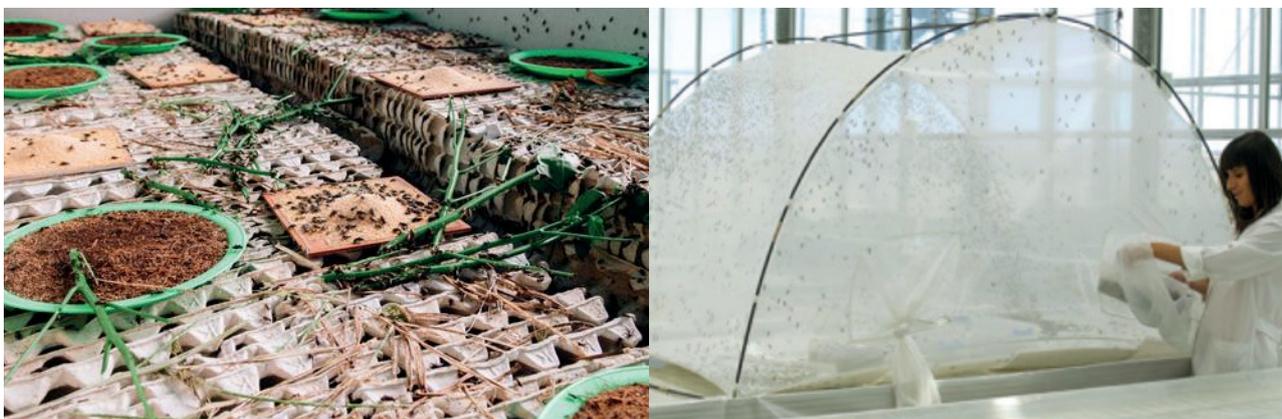


Figure 3.3.9: Cricket farming enclosure with egg carton homing occupying small areas of land in Thailand (left) and fly rearing in Spain (right).

Questions

12. Name a category of triglycerides that fall under the collective term of unsaturated fats.

..... (1 mark) (KA1)

13. Apart from being high in protein, describe how an energy bar made from cricket flour in comparison to plain flour could be considered nutrient-dense.

..... (2 marks) (KA2)

Cellular agriculture

Cellular agriculture is the production of novel foods from cell cultures and a cell culture is the name given to the process of growing a collection of cells. Primary research and development has focused on using cell cultures to grow cultured meat (also called lab-grown meat) as an alternate to livestock farming. In this new and innovative method of food production, muscle cells are taken from a living animal in a relatively painless procedure due to it being performed under anesthetic. The muscle cells taken are the stem cells of muscles, called myosatellite cells. The myosatellite cells are placed into labware containing a medium or mixture of substances such as nutrients and naturally-occurring growth factors. Myosatellite cells function in animals to create new muscle tissue when an animal's muscle is injured. Under favourably controlled laboratory conditions, the muscle stem cells perform the same functions they do in injured animal muscles and they create new muscle cells. Myosatellite cells are left to multiply and create new cells until there are trillions of cells. Growth factor is then no longer given to the myosatellites and the cells naturally form muscle fibres (called myotubes) and then muscle tissue. Muscle fibres or tissues are then combined to create a **piece of meat** (see Figure 3.3.10). The meat tissue from cell culture is biologically exactly the same as meat tissue that comes from the animal!

Fast fact

One sample of muscle cells taken from a cow can produce 800 million strands of muscle tissue, equivalent to around 80 000 hamburger patties!

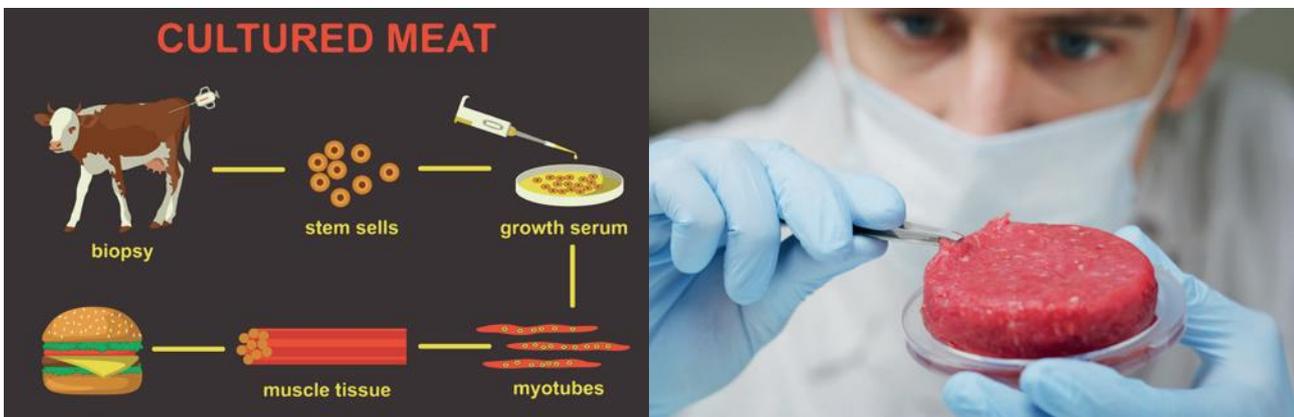


Figure 3.3.10: Process of creating cultured meat (left) and the final cultured meat product (right).

Questions

14. If cultured meat is exactly the same as lean meat, name a macronutrient and micronutrient that would have similar quantities in each.

Macronutrient: _____ (1 mark) (KA2)

Micronutrient: _____ (1 mark) (KA2)

Cellular agriculture of produce from livestock, for example, milk and eggs, has also been a focus for research and development. It uses **acellular agriculture**, a type of cellular agriculture that involves production of foods without plants or animals, by using microbes like yeast or bacteria. The foods created don't contain cellular tissues like cultured meat does, they are a mixture of nutrients like protein and fats. An example of this is milk production from yeast. To grow casein, which is a key protein in milk, a copy of the casein gene from a cow is inserted into yeast. The yeast will make many copies of the casein protein. When casein is mixed with other proteins and components of milk, cow's milk is made, without the need of a cow!.

Questions

15. Name the innovative technological method acellular agriculture is utilising.

..... (1 mark) (KA2)

16. Describe the procedural difference between meat culturing in cellular agriculture and milk production in acellular agriculture.

.....

 (2 marks) (KA2)

Being an alternate to livestock farming, cellular agriculture has similar benefits to the environment as entomophagy (but to a larger degree particularly in regard to needing minimal land). Being capable of manufacturing large amounts of produce from a small cell sample from an animal or from rapidly reproducing microbes, also makes this innovative food production method a promising solution to increasing demand for food in the future.

3D food printing

3D food printing is the process of manufacturing a food from syringes that hold food pastes. The food pastes are deposited or pushed through a nozzle, layer by layer, following software/computer program instructions (aliked to a recipe), to create a food or even meal! The novel food that is made can be in a range of shapes, colours, textures and flavours (see Figure 3.3.11). The food pastes need to be soft enough to pass through a syringe and nozzle yet possess a thick viscosity to hold their shape. For example, purees of vegetable, fruit, and legumes. Powdered ingredients can be used to thicken liquids or increase viscosity. For example, flour could be mixed with milk to create a paste. Food pastes can also be created from melted solid ingredients such as cheese and chocolate.

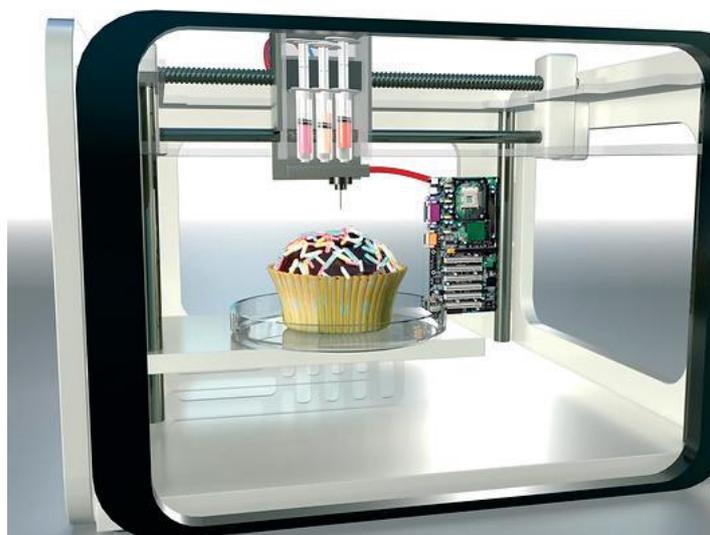


Figure 3.3.11: 3D printed cupcake.

The benefits of creating new foods from 3D printing include:

- The food can be customised in nutrition, or the amount of each nutrient such as protein, sugar, vitamins and minerals can be controlled (by adding them to pastes). This can be done at an individual level, based on one's health and nutritional needs, making 3D food production a pinnacle move towards optimal nutritional health and prevention of dietary diseases. This is an especially applicable way to produce aesthetically pleasing nutritious food for fussy children, or for the elderly who require softer foods.
- In conjunction with entomophagy, 3D printing using cricket flour to make pastes, offers an environmentally sustainable solution to meet growing consumer demands for food. It also offers a way insects can be presented so they don't resemble insects, to improve appeal.
- Livestock farming, especially raising cattle, is associated with environmental concerns such as greenhouse gas emissions and land degradation. Offering a solution to this, in conjunction with muscle cells from cultured meat (see earlier section), is 3D printing called meat bioprinting. **Meat bioprinting** takes the mixture of

muscle stem cells and growth factors and 3D prints it into a layered structure which becomes the piece of muscle tissue or meat replica (see Figure 3.3.12).

- 3D printing called ‘**meat analogue**’ can print plant-based steaks that mimic the texture and appearance of meat. The potential benefit of this is on the environment considering growing crops is known to be less taxing on the environment than raising livestock.
- 3D printing can use foods or parts of foods typically ending up as food waste. For example, ‘ugly’ fruit and vegetables and meat off-cuts can be turned into purees and used to create new foods.
- Although not a food, 3D printing is also able to print edible utensils such as straws and cutlery. This could help combat environmental issues surrounding single-use food packaging (see Topic 3.2).

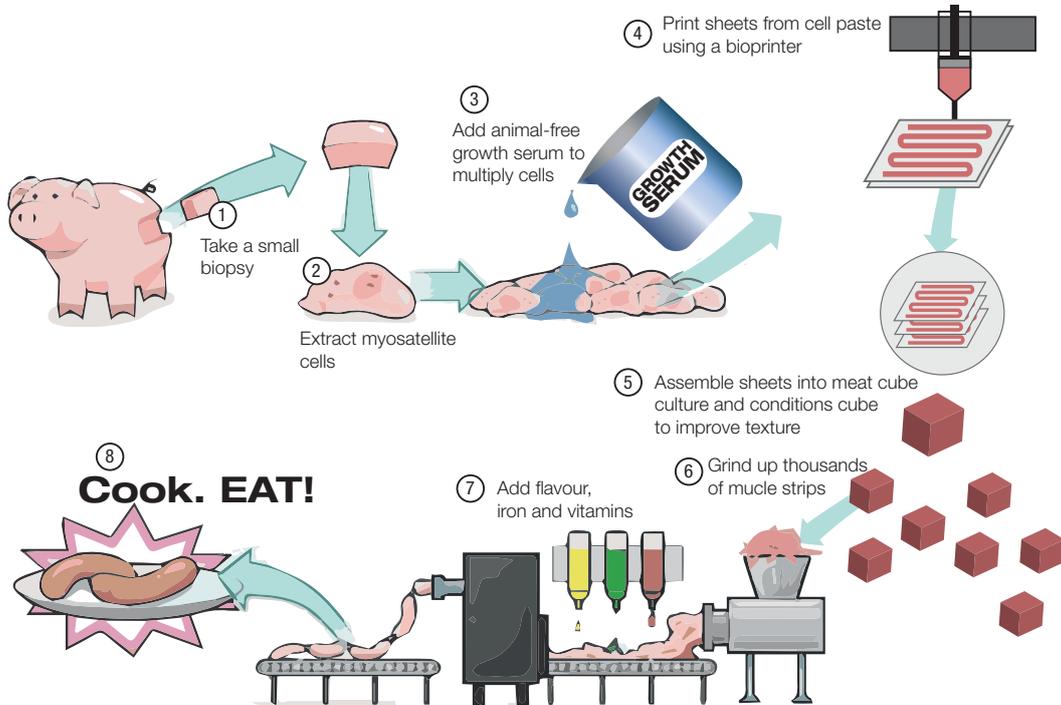


Figure 3.3.12: Cultured meat process (steps 1-3) followed by 3D printing (step 4) and further traditional processing steps can also be added to the meat production (steps 6-8).

Questions

17. ‘Entomophagy offers an environmentally sustainable solution’. List two environmental resources positively affected by entomophagy that relate to this statement being made.

.....

 (2 marks) (KA2)

18. Cattle are associated with land degradation. Explain this statement.

.....

 (3 marks) (KA2)

19. Name two environmental issues surrounding single-use food packaging.

.....
 (2 marks) (KA1)



(b) The scatter of the data between the years 1965 to 1970 differs from the years between 1985 to 1990. Compare the scatter in data between 1965-1970 to 1985-1990 and discuss possible reasons for the differences in data and how this affects reliability and/or accuracy.

..
..
..
..
..
..
..
..
..
..... (4 marks) (IAE3)

(c) Increased cattle grazing to increase demand for protein-rich food sources has been found to be a leading cause in the decline of available farming land.

(i) Identify an alternate animal that could be farmed as a source of protein-rich animal foods that would reducing farming land needs.

..... (1 mark) (KA1)

(ii) Describe an environmental benefit of rearing the animal identified at (i) in comparison to rearing cattle.

.....
.....
..... (2 marks) (KA2)

(iii) Describe one nutritional benefit of rearing the animal identified at (i) in comparison to rearing cattle.

.....
.....
..... (2 marks) (KA2)

(iv) Outline a disadvantage of rearing the animal identified at (i) in comparison to rearing cattle.

.....
..... (1 mark) (KA2)

(v) Describe another innovative food production method of animal-sourced protein foods to address the issue of cattle needing large areas of farming land.

.....
.....
..... (2 marks) (KA2)

6. Name an innovative food production method for growing crops and discuss how it addresses food mileage issues.

.....
.....
..... (2 marks) (KA2)

7. The following questions refer to the following passage of information on dysphagia:

Dysphagia is a swallowing disorder affecting just under 10% of the world's population. It is a disorder that can develop in a number of conditions such as throat cancer or dementia. The main symptom of this disorder, finding swallowing difficult, can affect quality of life including mental health. It can also impact quite drastically on nutritional health. It's often recommend that those suffering from dysphagia eat texture-modified foods, which include soft, bite-sized, minced, and liquified foods. It's also generally advised that those suffering from dysphagia avoid any food that can be stringy, chewy, crunchy or solid. The problem with these modified meals is that they are often considered to be mushy and unappealing, which leads to food refusal and poor nutrition. Loss of control over one's meal choices can also result in anger and depression.

(a) Identify the stage of the lifecycle most at risk of dysphagia and provide reasoning for your response:

..
..
..
.. (2 marks) (KA2)

(b) To make food softer, it often requires cooking. Explain how this can impact upon the food's nutritional levels.

..
..
..
.. (2 marks) (KA2)

(c) Identify an innovative food production method that could be of assistance to someone with dysphagia and outline how the food produced is suitable.

..
.. (2 marks) (KA2)

(d) Describe in detail the application of the innovative food production method selected in the answer above (c) on mental health.

..
..
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..
..
.. (4 marks) (KA3)

Total: _____ / 45 marks



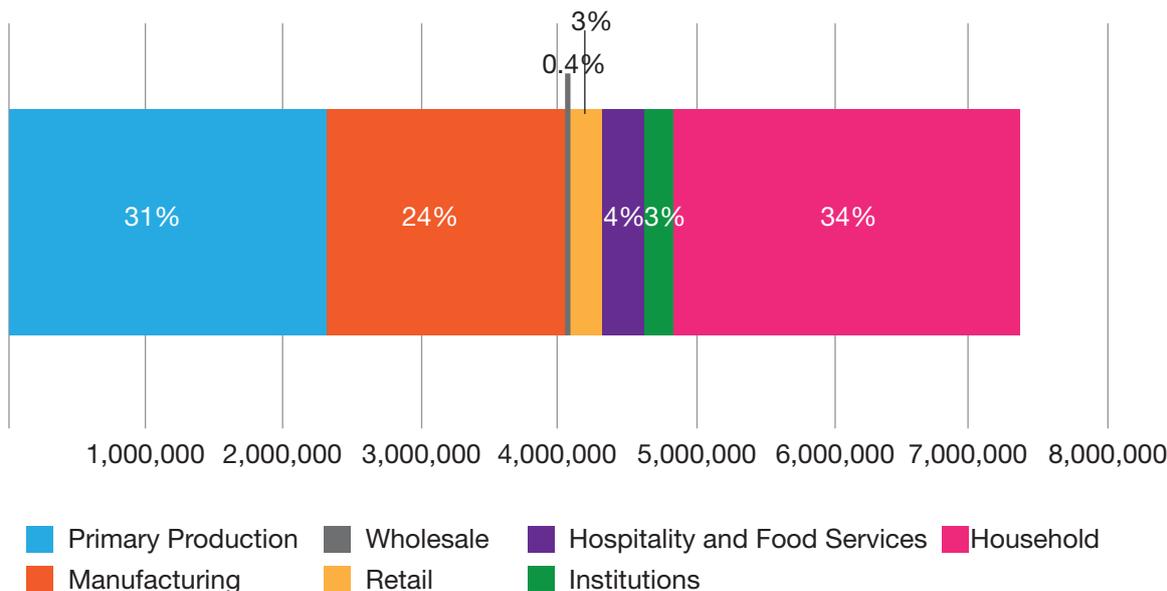
5. Discuss how reducing (or removing) red meat from one’s diet can help lower agricultures’ environmental footprint.

.....

 (4 marks) (KA2)

6. In Australia, 7.3 million tonnes of food is lost or wasted per year! The following figure demonstrates the National food waste generation by sector for 2016 and 2017.

Food Waste Generated 2016-17 (tonnes per annum)



(a) Refer to the graph above to answer the following questions.

(i) Identify which sector wasted the most food over the 2016-17 period.

..... (1 mark) (IAE3)

(ii) Provide two reasons why this sector (identified at (i)) wastes so much food:

.....

 (2 marks) (KA2)

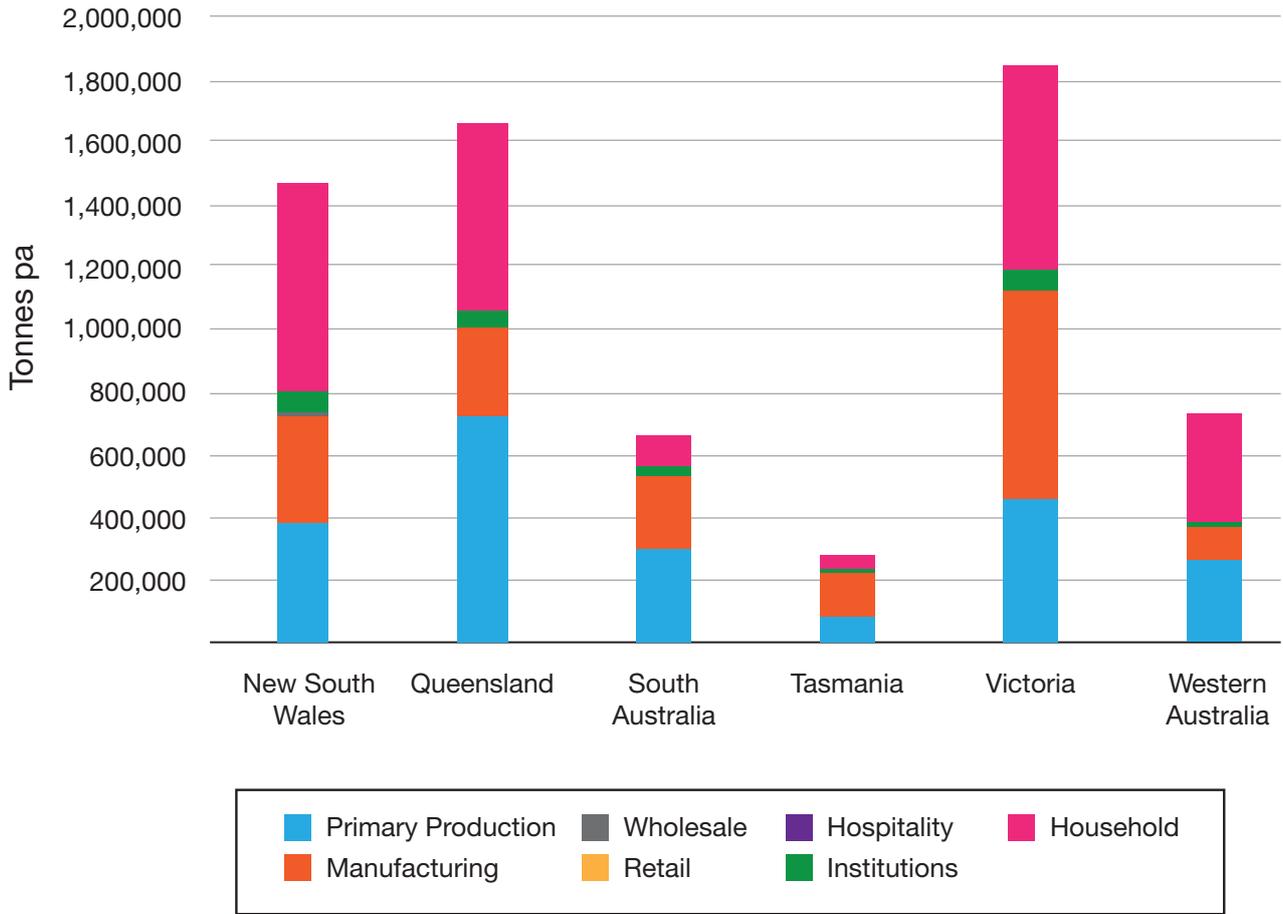
(iii) Give a concluding statement about sector contributions to food waste, using data from the graph above.

.....

 (2 marks) (IAE3)



(b) Refer to the graph below, which demonstrates the food waste contributions by sector and state for 2016 and 2017, to answer the following questions:



(i) Identify the state whose agricultural sector contributes the least food waste.

..... (1 mark) (IAE3)

(ii) Suggest two government initiatives running in this state that may account for it having the least food waste from agriculture.

.....

 (2 marks) (KA2)

7. Explain how the preservation method of canning reduces the oxygen availability, extending its shelf life.

.....

 (4 marks) (KA2)

8. Explain how packaging can reduce the changes to the nutritional value of food.

.....

 (2 marks) (KA2)

9. On average, food travels approximately 4,000 km every time that it is delivered to the consumer.

(a) Define food miles.

.....
..... (1 mark) (KA1)

(b) Give detailed reasoning to support the following statement: 'Foods with lower food miles do not necessarily have a lower environmental footprint'.

.....
.....
.....
.....
.....
..... (4 marks) (KA2)

10. Aeroponics development

The following article has been condensed from: <https://interestingengineering.com/13-vertical-farming-innovations-that-could-revolutionize-agriculture>

The innovation of Aeroponics in the field of vertical farming was made by 'The National Aeronautical and Space Administration' (NASA). This sustainable growing technique was invented by NASA in the 1990s when it was looking for efficient techniques to grow plants in space. This technique was then coined *Aeroponics* and involves growing plants without soil and with very little water.

It is undoubtedly the most efficient way in vertical farming as it uses a staggering 90% less amount of water than the most efficient hydroponics systems too. It has also been observed that the plants that are grown with the aeroponics system uptake more vitamins and minerals, thus making the plants potentially healthier and more nutritious.

(a) Describe the development of aeroponics in vertical farming.

.....
.....
.....
.....
..... (4 marks) (KA3)

(b) Describe a difference between aeroponics and hydroponics when utilised as vertical farming methods, apart from those given in the article above.

.....
..... (2 marks) (KA2)

(c) Describe two similarities between aeroponics and hydroponics when utilised as vertical farming methods.

.....
.....
..... (4 marks) (KA2)



11. CSIRO is undertaking a series of projects designed to kick-start an Australian insect industry:

The following article has been condensed from: <https://www.sustainabilitymatters.net.au/content/sustainability/article/csiro-developing-nation-s-insect-industry-472464035>

Boosting libido in flies

One project involves the development of a recipe to get Black Soldier Flies in the mood to mate in order to tackle Australia’s food waste crisis.

Partnering with Canberra-based start-up Goterra (a food waste industry), farming experts from CSIRO have been searching for the perfect combination of conditions that will encourage flies to mate — testing lighting, temperature, moisture, surface texture and diet. Boosting egg laying will enable Goterra to breed more insects to eat through food waste and turn it into compost, a strategy that will reduce landfill and emissions from transporting food to landfill, and enrich soil with nutrient-rich fertiliser.

Farming insects for food

Sustainable insect farming requires less land and water than raising cattle or pigs, while still producing a high-protein end product for consumption. Working alongside the University of Adelaide, CSIRO is expanding its partnership with Goterra to investigate which native Australian insects are the best nutritional options for human consumption. The agency’s Australian National Insect Collection will help identify native species of insects that are potential candidates for Australia’s edible insect industry. The organisation is also working with local Aboriginal communities to understand traditions around witjuti grubs, bogong moths and green tree ants, which are known for their zesty citrus-tasting abdomens.

To get the industry roadmap underway, CSIRO is hosting an international conference on edible insects — Developing Australia’s edible insect research and industry to improve environmental, health and cultural outcomes — on 28–30 August in Brisbane, to help guide the development of the insect industry in Australia.

(a) Using the information provided and two of the key concepts of Science as a Human Endeavour (SHE), explain how this study highlights the interaction between science and society.

SHE concept one:

.....

.....

.....

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.....

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..... (4 marks) (KA3)

SHE concept two:

.....

.....

.....

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.....

..... (4 marks) (KA3)

(b) If flies can be encouraged to mate, they will produce eggs and therefore larvae at a more frequent rate. Larvae utilise the food waste, converting it into compost. To determine the best conditions that will encourage flies to mate, researchers manipulated the temperature of 4 different aquarium-style containers. The following results were recorded after one week.

Temperature	20°C	25°C	30°C	35°C
Food waste consumed (g)	346g	442g	488g	435g

(i) Identify the independent variable in this experiment.
 (1 mark) (IAE1)

(ii) Identify the dependent variable in this experiment.
 (1 mark) (IAE1)

- (b) In comparison to cattle farming, explain how it is possible for cultured meat to provide a solution to increased consumer demands for plant-based foods.

..

 (2 marks) (KA2)

- (c) Using the information provided below and two of the key concepts of Science as a Human Endeavour (SHE), explain how this information highlights the interaction between science and society.

Cultured meat is produced using many of the same tissue engineering techniques originally used in regenerative medicine. Regenerative medicine involves the process of growing and replacing ineffective human cells, tissues or organs to establish normal body functioning. The concept of cultured meat was popularised by Jason Matheny in the early 2000s after co-authoring a scientific paper on cultured meat production and creating New Harvest, the world’s first non-profit organisation dedicated to supporting cultured meat research.

SHE concept one:

..

 (2 marks) (KA3)

SHE concept two:

..

 (2 marks) (KA3)

14. Takeaway foods are generally delivered using cardboard.

- (a) Explain one advantage of purchasing food that has been packaged in cardboard to the consumer.

..

 (2 marks) (KA2)

- (b) Explain one advantage to a manufacturer of producing food packing made from cardboard.

..

 (2 marks) (KA2)

- (c) Cardboard can be permeable to moisture and oxygen, identify and explain a type of active packaging that could be added as a sachet to reduce the presence of one of these factors which can reduce the shelf life of these foods.

..

 (2 marks) (KA2)

15. Science as a Human Endeavour (SHE) – Biotechnology to help soil and crops

Refer to the following article to answer questions (a) to (c) below, which has been adapted and condensed from: <https://www.economist.com/technology-quarterly/2016-06-09/factory-fresh>

Understanding and exploiting microbes for farming is a rapidly developing part of agricultural biotechnology. Of particular interest is the symbiotic relationship microbes can form with plants. For example, the natural partnerships formed with nitrogen-fixing bacteria by legumes such as soya beans. In legumes, the plants' roots grow special nodules that become homes for the bacteria. The bacteria fix nitrogen from the air into soluble nitrates that act as natural fertiliser. The big prize, however, would be to persuade the roots of crops such as wheat to form partnerships with nitrogen-fixing soil bacteria. If wheat rhizomes could be persuaded, by genomic breeding or genome editing, to behave likewise, everyone except fertiliser companies would reap enormous benefits.

Another start-up company is Adaptive Symbiotic Technologies, of Seattle. The scientists who formed this firm study fungi that live symbiotically within plants. They believe they have found one, whose natural partner is panic grass, a coastal species, which gives salinity-resistance when transferred to crops such as rice.

(a) Explain why 'everyone except fertiliser companies would reap enormous benefits' in relation to the application of the symbiotic relationship between nitrogen-fixing bacteria and wheat crops.

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..... (4 marks) (KA3)

(b) Discuss the application of scientific knowledge or understanding that could be driving scientists to develop sustainable cropping solutions such as salinity-resistance in crops like rice.

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..... (2 marks) (KA3)

(c) Discuss how society may be influencing the research into symbiotic microbial agricultural biotechnology.

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..... (2 marks) (KA3)

Total: _____ / 90 marks



1.1: Energy In Foods

Topic Solutions

1. Calories are multiplied by 4.2 to be converted into kilojoules.

2.

Macronutrient	Energy (kJ/g) as a decimal	Energy (kJ/g) as a whole number
Carbohydrate	16.7	17
Protein	16.7	17

3. (a) Carbohydrates: $170\text{g} \times 17\text{kJ/g} = 2890\text{kJ}$

$$\text{Protein: } 75\text{g} \times 17\text{kJ/g} = 1275\text{kJ}$$

$$\text{Lipids: } 110\text{g} \times 37\text{kJ/g} = 4070\text{kJ}$$

$$\text{Total: } 2890 + 1275 + 4070 = 8235\text{kJ}$$

(b) Carbohydrate energy distribution = $\frac{2890}{8235} \times 100 = 35.09\% \approx 35\%$

$$\text{Protein energy distribution} = \frac{1275}{8235} \times 100 = 15.5\% \approx 16\%$$

$$\text{Lipid energy distribution} = \frac{4070}{8235} \times 100 = 49.4\% \approx 49\%$$

- (c) A majority (49%) of this adolescent's energy intake is being provided by the macronutrient: lipids. This alerts an individual to the need to make lower lipid selections during the day to meet the recommended range of 20-35%. On the other hand, only 35% and 16% of the kilojoules are being provided by carbohydrates and protein respectively. Therefore, this alerts an individual to make higher carbohydrate and protein selections during the day to fall within the recommended ranges of 45-65% and 15-25% respectively.

4. Snack A: Small packet (20g) of Original Popcorn

$$\text{Carbohydrates: } 8.4\text{g} \times 17\text{kJ/g} = 142.8\text{kJ}$$

$$\text{Protein: } 1.8\text{g} \times 17\text{kJ/g} = 30.6\text{kJ}$$

$$\text{Lipids: } 5.1\text{g} \times 37\text{kJ/g} = 188.7\text{kJ}$$

$$\text{Total} = 362.1\text{kJ} \approx 362\text{kJ}$$

- Snack B: Fruit & Nut Muesli Bar (45g)

$$\text{Carbohydrates: } 25.1\text{g} \times 17\text{kJ/g} = 426.7\text{kJ}$$

$$\text{Protein: } 4.1\text{g} \times 17\text{kJ/g} = 69.7\text{kJ}$$

$$\text{Lipids: } 6.7\text{g} \times 37\text{kJ/g} = 247.9\text{kJ}$$

$$\text{Total} = 744.3\text{kJ} \approx 744\text{kJ}$$

- Snack C: Mini Blueberry Muffin (40g)

$$\text{Carbohydrates: } 17\text{g} \times 17\text{kJ/g} = 289\text{kJ}$$

$$\text{Protein: } 1.7\text{g} \times 17\text{kJ/g} = 28.9\text{kJ}$$

$$\text{Lipids: } 6.2\text{g} \times 37\text{kJ/g} = 229.4\text{kJ}$$

$$\text{Total} = 547.3\text{kJ} \approx 547\text{kJ}$$

Based on the recommendation that snacks in children's lunchbox should be below 600kJ per serving, Snack A: Small packet of Original Popcorn would be the most suitable snack as it provides the lowest kilojoules per serve.

5. (a) A: 38-41 units per day, C: 55-58 units per day
- (b) Individual C may require higher units of nutrient X each day due:
- To being malnourished
 - To having a medical problem/chronic disease
 - To being pregnant
 - To experiencing rapid growth
- (c) False. An RDI is set at the level of meeting the needs of 98% of the population it is targeting. Most people require less than this, but a small number require more.
- (d) The EAR value is established to meet the nutritional needs of at least half of the population of healthy individuals, whereas the RDI is set higher than this value to meet the requirements of approximately 98% of the population.
6. (a) An individual's intake of a nutrient would be inadequate if consuming below the EAR or consuming above the UI.
- (b) Individual's nutrient requirements vary and fall within a range, where toxicity and deficiency can occur if a specific nutrient is consumed in excess or below this range. It is inaccurate to think a nutrient requirement is only one set value for everyone, and not consuming this specific amount will result in toxicity or deficiency symptoms.

Review Solutions

1. Protein: $20\text{g} \times 17\text{kJ/g} = 340\text{kJ}$

This claim is impossible as one serve contains 20g of protein, which would provide more than 50 kilojoules (340 kilojoules).

2. (a) Carbohydrates: $29\text{g} \times 17\text{kJ/g} = 493\text{kJ}$

$$\text{Protein: } 14\text{g} \times 17\text{kJ/g} = 238\text{kJ}$$

$$\text{Lipids: } 14\text{g} \times 37\text{kJ/g} = 518\text{kJ}$$

$$\text{Total: } 493 + 238 + 518 = 1249\text{kJ}$$

- (b) Carbohydrate energy distribution = $\frac{493}{1249} \times 100 = 39.5\% \approx 40\%$

$$\text{Protein energy distribution} = \frac{238}{1249} \times 100 = 19.1\% \approx 19\%$$

$$\text{Lipid energy distribution} = \frac{518}{1249} \times 100 = 41.4\% \approx 41\%$$

A majority (41%) of the energy provided by this meal is being provided by the macronutrient: lipids. This alerts the manufacturer to reduce the lipid content to meet the recommended range of 20-35%. On the other hand, only 45% of the kilojoules are being provided by carbohydrates. Therefore, this alerts the manufacturer to increase the content of carbohydrates in this meal to fall within the recommended range of 45-65%. The energy provided by protein in this pasta meal (19%) falls within the recommended range of 15-25%, therefore is suitable.

- (c) To reduce the lipid content: using low fat cheese, low fat cream, egg whites only or low fat butter will ensure the energy provided by lipids falls within the recommended range of 20-35%. As well as this, vegetables (e.g. spinach) can be added to the pasta recipe to increase the amount of energy provided by carbohydrates to ensure it is within the recommended range of 45-65%.

3. (a) Carbohydrates: $58\text{g} \times 17\text{kJ/g} = 986\text{kJ}$

$$\text{Protein: } 15\text{g} \times 17\text{kJ/g} = 255\text{kJ}$$

$$\text{Lipids: } 31\text{g} \times 37\text{kJ/g} = 1147\text{kJ}$$

$$\text{Total: } 986 + 255 + 1147 = 2388\text{kJ}$$



(b) $\frac{2388}{7600} \times 100 = 31.4\% \approx 31\%$

This meal would provide approximately 31% of an elderly female's estimated energy requirements for the day.

(c)

	AI	EAR	RDI	UL
Calcium		1100mg	1300mg	2500mg
Iron		5mg	8mg	45mg
Vitamin C		30mg	45mg	
Dietary Fibre	25g			
Water	2.8L			

4. (a) Complex carbohydrates: $89.6 - 79.5 = 10.1$ grams of carbohydrates are complex.

(b) Carbohydrates: $89.6\text{g} \times 17\text{kJ/g} = 1523.2\text{kJ}$

Protein: $8.4\text{g} \times 17\text{kJ/g} = 142.8\text{kJ}$

Lipids: $6\text{g} \times 37\text{kJ/g} = 222\text{kJ}$

Total: $1523.2 + 142.8 + 222 = 1888\text{kJ}$

5. Carbohydrates: $2.6\text{g} \times 17\text{kJ/g} = 44.2\text{kJ}$

Protein: $1\text{g} \times 17\text{kJ/g} = 17\text{kJ}$

Total: $44.2 + 17 = 61.2\text{kJ}$

Alcohol: $520 - 61.2 = 458.8\text{kJ}$

Alcohol provides 459kJ of energy in a glass of wine.

6. (a) Carbohydrates: $84.5\text{g} \times 17\text{kJ/g} = 1436.5\text{kJ}$

Protein: $8.8\text{g} \times 17\text{kJ/g} = 149.6\text{kJ}$

Lipids: $2.5\text{g} \times 37\text{kJ/g} = 92.5\text{kJ}$

Total: $1436.5 + 149.6 + 92.5 = 1678.6\text{kJ} = 1679\text{kJ}$ from one 100 serving

(b) dependent on student.

(c) dependent on student.

1.2: Carbohydrates

Topic Solutions

1. (Smallest) Fructose, Lactose, Raffinose, Starch (largest)

2. Fructose

3. Glucose: Simple

Oligosaccharides: Complex

Fructose: Simple

Maltose: Simple

Starch: Complex

4. When these starchy processed foods are consumed, they become easier to break down into glucose as their starch is partly broken down into maltose, a disaccharide. As maltose requires little digestion due to being made of only 2 sugar units, this sugar enters the bloodstream quickly, producing a similar rapid surge in blood glucose as simple carbohydrates.

5. Glucose is a monosaccharide and therefore already small enough to enter the bloodstream. Glucose would then enter the bloodstream quickly and is associated with a rapid spike in blood glucose levels and a rapid energy release.

Starch is a polysaccharide and a larger molecule made of hundreds of glucose units bonded together. Therefore, it breaks down slowly and takes longer to be absorbed into the bloodstream, resulting in a lower and more gradual blood glucose levels, consequentially sustained energy.

6. Food sources such as Kombucha contain live beneficial bacteria which can enhance gut health by controlling harmful bacteria, protecting against colon cancer, enhancing immune function and alleviating diarrhea and constipation by allowing an easy passage for waste.
7. Simple carbohydrates and starch are able to be broken down into monosaccharides and enter the bloodstream, therefore providing energy and cellular recognition. Whereas, fibre, resistant starch and oligosaccharides are unable to be broken down to enter the bloodstream, therefore its functions are restricted to within the gastrointestinal tract, specifically the colon.
8. Soluble fibre is able to partly dissolve in water and become gel-like i.e. it's partly soluble; while insoluble fibre remains undigested and not dissolvable in water i.e. it is insoluble.
9. (a) Simple carbohydrates and starch are broken down into monosaccharides (in particular glucose), which are then transported to cells to be broken down further to create energy in the form of ATP.
- (b) Low quantities of fibre, resistant starch and oligosaccharides can lead to constipation, as these carbohydrates assist in producing soft and bulky stools. These carbohydrates do so by binding to water and contributing dead bacteria from fermentation (soluble fibre, resistant starch and oligosaccharides). Insoluble fibre assists in producing bulk to stools as it cannot be broken down and therefore increases stool weight. Producing soft and bulky stools allows for easier passage, therefore reducing constipation.

Function	Type of Carbohydrate
Provides bulk to stools due to not being broken down	Insoluble Fibre (IF)
Slows stomach emptying	Soluble Fibre (SF), Oligosaccharides (O), Resistant Starch (RS)
Binds to water, producing soft and bulky stools	Soluble Fibre (SF), Oligosaccharides (O), Resistant Starch (RS)
Foods high in this carbohydrate create a low GI response	Starch (S)
These carbohydrates undergo fermentation in the colon, providing energy and a food source to beneficial bacteria	Soluble Fibre (SF), Oligosaccharides (O), Resistant Starch (RS)
Foods high in this carbohydrate create a high GI response	Simple Carbohydrates (SC), Glucose (G)
Assists in the functioning of the immune system	Soluble Fibre (SF), Oligosaccharides (O), Resistant Starch (RS)
Carbohydrates that provide the body with energy	Simple Carbohydrates, (SC), Glucose (G), Starch (S)
Simple carbohydrates and starch are broken down into this molecule	Glucose (G)
Slows down initial digestion, maximizing nutrient absorption	Soluble Fibre (SF), Oligosaccharides (O), Resistant Starch (RS)
The only type of carbohydrate the brain can utilize to create energy	Glucose (G)
Creates satiety	Soluble Fibre (SF), Oligosaccharides (O), Resistant Starch (RS)
Reduces cholesterol levels, by binding to bile acids	Soluble Fibre (SF)
Provides bulk to stools through the bacteria that die during fermentation	Soluble Fibre (SF), Oligosaccharides (O), Resistant Starch (RS)



Review Solutions

1. (a) 5 mmol/L
(b) 1.8 mmol/L
(c) Pancakes with syrup hold more simple sugars, which are quick to break down and enter the bloodstream causing high/rapid peaks in blood glucose that don't give sustained energy, resulting in hunger earlier (about 2.5h). Bran cereal is higher in starch that are slow to breakdown and enter the bloodstream, causing a low/sustained peak in blood glucose and sustained energy that reduces hunger. Bran cereal would also be higher in soluble fibre, which extends the stomach and creates satiety. It also slows initial absorption and therefore glucose entrance into the blood, ensuring longer-lasting energy supply that would reduce chances of over-eating.
2. (a) Polysaccharide
(b) Monosaccharide
3. Sucrose, lactose or maltose
4. (a) BARLEYmax has the greatest content of resistant starch (4g), soluble fibre (9g) and insoluble fibre (15g); overall the total fibre content of BARLEYmax is the most (29g/100g). Whereas, wheat has approximately 13g of fibre per 100g, and a higher content of insoluble fibre than oats. Oats has a fibre content of 12g per 100g and has a greater content of soluble fibre and resistant starch.

(b) 9g/100g

(c) Any one of the following:

Diabetes Type II – Soluble fibre slows the emptying process of stomach into the duodenum. Therefore, it slows the rate of glucose absorption into the blood.

CVD – helps reduce blood cholesterol levels. Soluble fibre binds with the bile (made of cholesterol) and removes them as waste.

Obesity – satiety level. Binds water and expands the stomach to create feeling of fullness

Diverticular – water adds weight to the faeces allowing easy passage of wastes through GIT

Forms a gel like substance that slows down initial digestion; Allows more time for absorption in the duodenum reduces risk of becoming deficient in micro/ macronutrients and name one specific one e.g. anaemia

(d)

Ingredient	Saccharide grouping
Whole wheat flakes	Polysaccharide
Corn flakes	Poly (processing = mono/di as well)
Raisins	Monosaccharide
Apricots	Monosaccharide
Almonds	–
Raw sugar	Disaccharide
Milk	Disaccharide

5. (a) Soluble fibre is broken down in the large intestines by bacteria through a process of fermentation.
- (b) Soluble fibre can prevent constipation:
 - As it binds to water, which produces soft bulky stools which are easy to expel from the body
 - As bacteria die during the fermentation process, which produces bulky stools which allows an easy passage through the large intestine
 - By increases the transit time of stools through the intestine preventing constipation/diverticular disease/bowel cancer/haemorrhoids/varicose veins

- (c) Any two of the following, but make sure to provide a food source from different food groups to demonstrate your extensive knowledge and avoid double dipping:
- Wheat bread
 - Whole wheat/grain pasta
 - Whole grain cereals
 - Oatmeal
 - Brown rice
 - Broccoli
 - Carrots
 - Banana
 - Apple
 - Pear
 - Strawberries
 - Nuts
 - Beans
 - Green leafy vegetables
 - Flesh of the vegetables
 - Linseed
 - Legumes
 - Seeds

6. As most sports drinks have a high GI, energy levels would rapidly increase followed by a rapid decrease as energy levels would not be sustained for the first few hours after consumption.
7. Monosaccharides are composed of a single sugar unit (either glucose, fructose or galactose) and a disaccharide is made of two monosaccharide units, which are bonded together through a condensation reaction.

8.

	Food A	Food B	Food C
Time from consumption to blood glucose peak	18 minutes	90 minutes	20 minutes
Type of carbohydrate	Glucose	Starch	Sucrose

9. (a) Food A
- (b) Food B
- (c) Food C would have the highest glycaemic index, as it is predominantly composed of simple sugars. Food C contains 40.5g of simple sugars and only contains 3.9g of complex carbohydrates; therefore approximately 91% of this food source are simple sugars and would enter the bloodstream rapidly, resulting in a high glycaemic index response. Simple sugars account for approximately 67% of Food A and 6% of
- (d) Food B would be classified as a polysaccharide as it is made up of a majority of complex carbohydrates (approximately 41.6g of a total carbohydrate content of 44.3g). Consuming this food source would therefore cause blood glucose levels to gradually and slowly rise due to taking longer to break down.

1.3: Lipids

Topic Solutions

1.

Triglyceride classification	Structural property	Physical property
Monounsaturated	One double bond between carbon atoms	Liquid at room temperature
Polyunsaturated	More than one double bond between carbon atoms	Liquid at room temperature
Saturated	No Double bonds between carbon atoms	Solid at room temperature

2. (a) The fatty acid would be monounsaturated as it only contains one double bond between the carbon atoms.
- (b) The omega number would be 9, as the first double bond is 9 carbons away from the methyl end.

3. This example demonstrates the key concept of communication and collaboration, as it shows the collaboration between scientists, dietitians and different dietary associations in researching if coconut oil is healthy or unhealthy for consumption. Examples from the source include:
 - Major health heavyweights, including the Dietitians Association of Australia, the Heart Foundation, the World Health Organisation and the American Heart Association aren't so enthusiastic, advising that we only use the saturated-fat laden oil occasionally
 - Professor Barbara Meyer, director of the University of Wollongong's Lipid Research Centre states there is not enough scientific evidence to state categorically that coconut oil is good for us, nor bad for us.
 - Melanie McGrice, accredited practising dietitian and spokesperson for the Dietitians Association of Australia, agrees. "I don't think there's enough research yet
 - Peter Clifton, a professor of nutrition at the University of South Australia, there's no doubt that LDL cholesterol is a heart risk.
 - Dr Yutang Wang, senior lecturer in biomedical science at Federation University suspects that we may not have a black and white answer as to whether coconut oil is good or bad for us, we don't need to avoid it entirely now.
 - It probably doesn't hurt to include a bit of coconut oil, maybe once a week or fortnight," advises McGrice.
 - According to Clifton, coconut oil only really becomes a concern, cholesterol-wise, if you're consuming it regularly.
 - Wang recommends choosing virgin coconut oil, as the hydrogenation process that other oils go through can generate harmful trans fats.
4. Hydrogenation adds Hydrogen atoms to an unsaturated fat (mono or poly), where some or all of the double bonds are made saturated (broken). If any of the double bonds remain after hydrogenation, the configuration changes from cis to trans, producing a trans-fatty acid.
5. Melts first: Sunflower seed margarine
Melts second: Olive oil margarine
Melts last: Butter
6. Macadamia nuts: Monounsaturated fat
Beef: Saturated fat
Avocado: Monounsaturated
Walnuts: Polyunsaturated fat (Omega 3)
Cheeseburger: Saturated fat
7. Any of the following:
Plant oil e.g. peanut, sunflower, etc instead of hydrogenated vegetable oil; vegetables/tofu/legumes/lentils/ etc instead of beef mince; vegan cheese (soy)/or as per last suggestion instead of cheese; As per last suggestion or flour instead of breadcrumbs (could contain palm oil)
8. Triglycerides travel from the small intestine to the adipose tissue in a complex called a lipoprotein where they are stored as an energy reserve. While the fatty acids of the triglycerides travel to cells via the protein albumin when they are required for body functions, such as a source of energy.
9. Hydrophobic means 'water-hating' e.g. Lipids/triglycerides/cholesterol will aggregate in water/blood. Hydrophilic means 'water-loving' and are able to mix well/dissolve in water e.g. proteins .
10. Vitamins A D E K
11. Adipose tissue forms a layer under the skin around the body; which acts as insulation, keeping the body warm. Adipose tissue layer can generate heat and not conduct heat to allow less to be lost to the environment, therefore acting as an insulator.
12. Both essential fatty acids may be useful in foetal/infant brain development and functioning; and in the reduction of LDL.

Review Solutions

1. (a) (i) solid at room temperature
(ii) double bond can be present between carbon atoms
(b) Any one of the following:
 - Cushioning/protection of vital organs
 - insulation/thermoregulation
 - transport and storage of the fat-soluble vitamins
 - forms hormones
 - part of the cell membrane
 - provides satiety (feeling of fullness)NB. Must be functions in the body vs in food such as improves taste.
2. (a) Omega 3 or Omega 6
(b) An essential fatty acid cannot be synthesised in the body, and therefore must be consumed from the diet.
(c) Any one of the following:
Omega 3:
 - reducing the risk of an abnormal heart rate
 - reducing the risk of blood clotting, by thinning the blood
 - reduces inflammation, supporting the immune system
 - reduces LDL cholesterol
 - assists in the development and functioning of the brain in a fetus and infantOmega 6:
 - assists in the blood clotting process
 - reduces LDL cholesterol
 - assists in the development and functioning of the brain in a fetus and infant
3. (a) Cholesterol is transported in lipoproteins dissolved with triglycerides. It is carried in the blood by lipoproteins (low-density) from the liver to sites of function, or back to the liver when in excess via high-density lipoprotein.
(b) Any one of the following:
 - part of the cell membrane
 - produces bile, hormones and vitamin D
(c) Low density low protein (LDL) carries cholesterol from the liver to cells around the body. However, when cholesterol levels are high LDL is left carrying cholesterol throughout the blood, increasing the risk of this excess cholesterol depositing on the walls of the arteries, contributing to Atherosclerosis (which is discussed further in topic 1.9).
(d) Cholesterol, saturated fat and trans-fats are known to increase blood cholesterol levels. Therefore, any one of the following:
 - Fatty meats
 - Dairy products like cheese
 - Deep-fried foods
 - Eggs
 - Coconut oil
 - Cocoa butter
 - Palm oil e.g. biscuits, cakes, chocolate, margarine



4.

Ingredients	Triglyceride category
1 zucchini (about 12–15 cm long)	
2½ tbsp olive oil	Mono
2 tbsp sesame seeds	Poly
4 slices avocado	Mono
1 tbsp finely chopped basil	
200 g cherry tomatoes	
90 g (about 6 slices) smoked salmon	Poly
125 g soy cheese cut into small cubes	poly

5. (a) 37kJ/g
- (b) As lipids are high in kilojoules, when excess consumption of these nutrients are consumed; triglycerides are stored in adipose tissue. Therefore, continual consumption leads to an increase in adipose tissue contributing to weight gain and the cause of obesity
- (c) Triglycerides are composed of Glycerol and three fatty acid chains.
6. A saturated fatty acid is completely loaded with all its hydrogen atoms and contains only single bonds between its carbon atoms. These types of triglycerides are physically solid at room temperature and have a higher melting point. An unsaturated fatty acid does not contain the full quota of hydrogen atoms, due to containing at least one double bond between the carbon atoms. Unsaturated fatty acids are generally liquid at room temperature and have lower melting points than saturated fats.
7. A fatty acid with a *cis* double bond is where the hydrogen atoms attached to the carbon atoms with a double bond are on the same side of the carbon chain. Whereas, a fatty acid with a *trans* double bond are where the hydrogens attached to the carbon atoms part of the double bond are on opposite sides of the carbon chain.
8. (a) Myristate: Saturated
 Palmitoleate: Monounsaturated
 Linoleate: Polyunsaturated
 Arachidonate: Polyunsaturated
- (b) Myristate: Solid
- (c) As the chain increases from 14 to 20 carbons long, and the number of double bonds increases from 0 to 4, the melting point decreases from 54.4 to -49 .
- (d) Myristate: Coconut
 Palmitoleate: Olive or Canola

1.4: Proteins

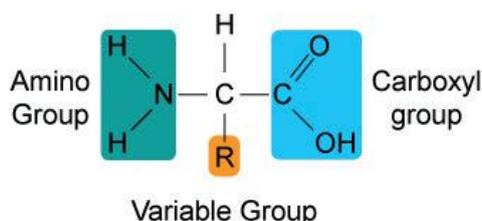
Topic Solutions

- Amino group, Amino Acid, Protein, Body Tissue
- Any of the following: Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, Valine.
- Complimentary Protein
- Chicken: Incomplete
 Chickpeas: Incomplete
 Yoghurt: Complete
 Tofu: Complete
 Gelatine: Incomplete

5. *Two benefits to the consumer:*
- Receive the same amount of protein as conventional poultry, beef and pork
 - Insects may be a cheaper protein source due to requiring less land and resources to produce
 - Provide a high source of micronutrients and minerals
6. Excess protein can increase an individual's development of atherosclerosis and the formation of plaque on artery walls. If this plaque continues to build, it can cause it to become unstable and rupture forming a blood clot. This can then lead to Cardiovascular Disease, where a heart attack, stroke or peripheral vascular result may result dependent on the site of this blockage.

Review Solutions

1. (a) Amino acids have the same structural formula: a central carbon atom bonded to one hydrogen (H) atom, an amino group (NH₂), a carboxylic acid group (COOH) and a side group.



- (b) The fourth group: the side group distinguishes the difference between each amino acid.
2. Essential amino acids must be provided by the diet as the body cannot synthesise these at all or cannot produce in sufficient amounts to meet the body's requirements. Non-essential amino acids can be synthesised by the body.
3. A non-essential amino acid may become essential under certain conditions, such as illness, injury, stress or rapid growing stages. In these cases, they are referred to as conditionally essential as they need to be provided by the diet as the body cannot make enough to supply the body.
4. The sequence of amino acids, which are determined by genes provided by our genetic information determine the type of protein is produced. Each protein has a different shape and function, therefore it is our genes which determine this.
5. An enzyme is a catalyst, which speeds up a biochemical reaction in the body. An example of an enzyme is salivary amylase, lingual lipase or pepsin (*other examples are accepted if suitable*). A hormone is the body's chemical messenger to implement an appropriate response to restore and maintain body conditions. An example of a hormone is insulin, glucagon, growth hormone, thyroxine, dopamine (*other examples are accepted if suitable*).
6. Protein acts a secondary source of energy and is only used during times of starvation and insufficient carbohydrate and lipid consumption. However, if protein is relied on as the predominant energy source the body will break down tissue proteins to make amino acids available to be converted into glucose and then used as an energy source. Therefore, blood glucose levels are maintained, but at the expenses of losing muscle and lean body mass.
7. The body can obtain all essential amino acids from complete proteins, which are derived from animal sources, such as meat, fish, poultry, cheese, eggs, yoghurt, milk and soy products (being the exception).
8. (a) Legumes (e.g. beans, chickpeas, lentils) or vegetables (e.g. spinach, broccoli, sweet potato, Brussel sprouts). *Possible answers are not limited to the options provided.*
- (b) Consuming the food source identified in part (a) with brown rice improves the composition of the protein in this meal by providing different essential amino acids that the brown rice is missing (low in lysine). Therefore, the combination of two plant sources provides a complimentary protein.
9. (a) As an individual increases in age from 0 to 18 years old, their protein RDI also increases from 10-14g to 40-65g.
- (b) Adolescents have the greatest protein RDI due to experiencing puberty, which causes an increase in hormone levels, rapid growth of body tissues (e.g. skeleton, blood volume, muscles).

- (a) *Any of the following:*
- A 16-year-old male may require a higher intake of protein (65g) as they are experiencing a significant growth spurt due to going through puberty. Therefore, they need a greater amount of protein to assist in the growth of their body tissues.
 - A 16-year-old male may require a higher intake of protein (65g) as they are going through puberty and need protein to assist with the synthesis of hormones, as they require greater amounts of testosterone which causes the changes during this time.
- (b) *Any one of the following roles of Protein in an individual who is 70 years and older:*
- stimulates protein synthesis, for the maintenance and repair of body tissues including bones, muscles, nerves, blood, glands, skin, hair, fingernails, teeth, ligaments, tendons and artery walls.
 - Stimulates protein synthesis, for the transportation of nutrients in the body in order for cells to function appropriately.
 - Production of enzymes to speeds up biochemical reactions in the body (e.g. metabolism or digestion).
 - Production of hormones to send chemical messages to regulate heart rate, blood glucose levels and metabolism.
 - production of antibodies to defend the body against invading antigens that may cause disease or a virus. This assists in their immune system.
 - Provides a source of energy in times of starvation and insufficient carbohydrate and lipid intake. This will ensure enough energy for cell and brain function.
 - enabling muscle contraction and movement, assisting in transforming chemical energy into mechanical energy. This assists in the mobility of an elderly individual.
- (c) Older people could be on the pension or have a limited income, therefore their budget may not allow for protein to be purchased as these are generally more expensive to purchase due to the being more expensive to produce.
- (d) *Any one of the following would be accepted:* Legumes (e.g. beans, chickpeas, lentils) or vegetables (e.g. spinach, broccoli, sweet potato, Brussel sprouts). *Possible answers are not limited to the options provided.*
10. (a) *Any one of the following:* pita bread, corn, corn chips, hummus dip, rice, couscous, quinoa, rye bread, tofu, wholemeal bread.
- (b) It is essential for a vegan to consume all essential amino acids, which can be achieved by consuming a complementary protein. A complementary protein improves the composition of protein in their diets by combining plant sources (incomplete protein) that contain different amino acids.
11. (a) *Any one of the following:*
- Protein is needed for the formation and growth of body tissues especially muscle tissues
 - It is also used for repair and recovery of damaged tissue such as muscle tissue
 - Production of red blood cells hormones and anti-bodies and enzymes
 - Provision of emergency fuel when other fuels are depleted
 - Synthesising hormones for growth
 - Enabling muscle contraction and movement
 - Transporting oxygen from lungs to other tissues
- (b) If protein intake exceeds the RDI, increases the risk of diet-related disorders such as obesity, atherosclerosis, as animal proteins are high in saturated fats and increase the production of LDL cholesterol in the body promoting its accumulation along artery walls. As well as this, excess protein is converted to triglycerides and stored in adipose tissue, contributing to the development of obesity.
12. (a) *Any one of the following:*
- Protein is needed for the formation and growth of body tissues especially muscle tissues.
 - It is also used for repair and recovery of damaged tissue such as muscle tissue.
 - Production of red blood cells hormones and anti-bodies and enzymes.
 - Provision of emergency fuel when other fuels are depleted.
 - Synthesising hormones for growth.
 - Enabling muscle contraction and movement.
 - Transporting oxygen from lungs to other tissues.

- (b) If protein intake exceeds the RDI, increases the risk of diet-related disorders such as obesity, atherosclerosis, as animal proteins are high in saturated fats and increase the production of LDL cholesterol in the body promoting its accumulation along artery walls. As well as this, excess protein is converted to triglycerides and stored in adipose tissue, contributing to the development of obesity.

13.

Symptom of Protein Deficiency	Explanation
Oedema and difficulty with correct fluid balance	A protein known as albumin attracts water, which controls the movement of fluids into and out of the cell. Without sufficient quantities of this protein, water remains outside of the cell causing oedema (fluid retention).
Poor skin, nail and hair development	Protein is the building block of the initial matrix of body tissues, including skin, nails and hair. Without sufficient protein these bodily tissues do not develop efficiently.
Stunted growth in children	Protein is the building block of the initial matrix of bones. Cells lay down a protein, known as collagen, which is then filled with crystals of calcium and phosphorus to produce a strong bone matrix. Without the initial laying of collagen, bones can become soft and underdeveloped causing a stunted growth in children. This can also be caused by the underdevelopment of other bodily tissues also.
Greater susceptibility to bacterial and viral infections	Without sufficient protein, the body is unable to produce the required amount of a specific antibody to resist an invading infectious disease. This can increase the prevalence of bacterial and viral infections.
Anaemia	Red blood cells contain a protein known as haemoglobin, which is responsible for transporting oxygen throughout the body. Without sufficient haemoglobin, the quality of red blood cells is compromised leading to the development of Anaemia.
Depletion in muscle mass	If insufficient protein is consumed, protein will be taken from the muscle to be used as energy or to support other bodily functions. This will deplete the muscle mass.
Muscle pain	A muscle fibre is composed of two types of protein: actin and myosin which assist in the contraction and relaxation of this body tissue. Without these types of protein, the muscle cannot contract and relax successfully resulting in pain. As well as this, protein assists in the repair of the muscle after exercise, reducing the pain experienced.
Fatigue	Haemoglobin (a type of protein) in red blood cells delivers oxygen to the body's cells for respiration to occur. Respiration produces ATP, which is the body's source of energy. Therefore, a lack of energy produced can result in fatigue. Protein can also be used as a secondary source of energy during times of starvation or limited carbohydrate and lipid consumption.

A

1.5: Water

Topic Solutions

- The findings in this recent study may suggest that beverages with a small content of sugar, fat and protein (e.g. milk) may be more beneficial for an athlete to consume prior to a marathon event as they slow down the emptying of the stomach and absorption into the bloodstream, keeping individuals hydrated for a longer period of time. However, it would be recommended to consume water after a marathon event to allow for a quick release of water into the bloodstream to increase hydration levels as quickly as possible.
- Hydrophilic
- Triglycerides (fat) are stored in fat cells in adipose tissue. This adipose tissue is involved in thermoregulation, specifically insulation. Adipose tissue generates heat and prevent heat loss, which keeps the body warm.
- Dietary Fibre, specifically soluble fibre.
- Milk, fruit, vegetables. Make reference to the table in water sources section.
- The greatest amount of water is lost by the kidneys, as urine.

7. *Any one of the following:*

- Illness
- Hot or humid temperatures
- Strenuous activities
- Excessive consumption of caffeine and alcohol (diuretics)
- Fever
- Excessive vomiting
- Excessive crying
- Excessive bleeding
- Diarrhoea
- Wearing too many layers of clothing

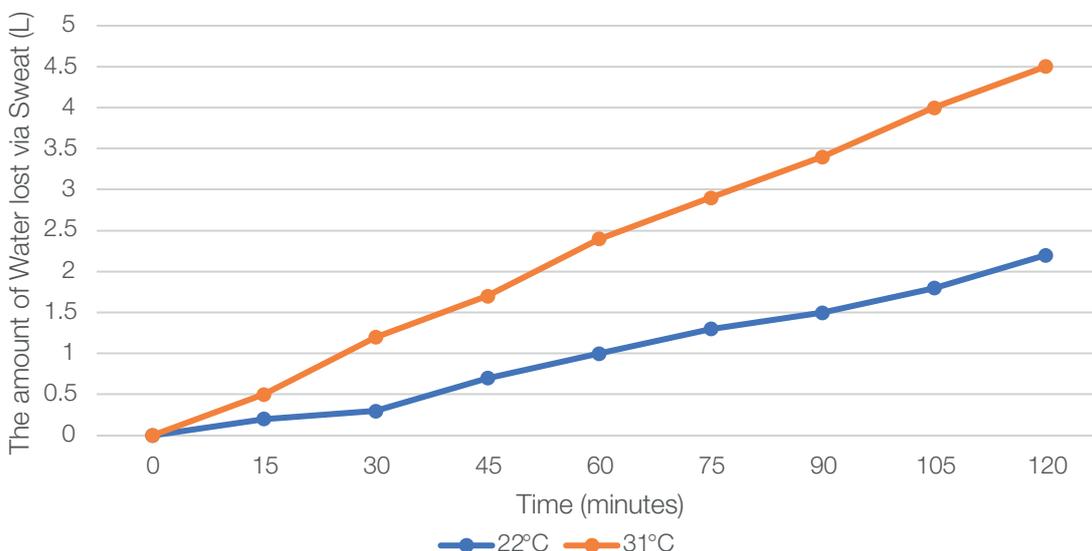
8. Severe

Review Solutions

1. (a) False—Water makes up 75 per cent of lean body tissue and 25 per cent of adipose tissue.
- (b) True – As we age and grow in body size, we require more water as approximately 60% of the body is composed of water.
- (c) True – Water can be lost from the body via vomiting and diarrhoea; therefore causing dehydration.
- (d) False – Frequent dehydration may cause permanent kidney, which can cause a build up of wastes in the body due to less urination.
- (e) False – Water softens stools, allowing easier evacuation from the large intestines and preventing constipation.
- (f) True – people who are active tend to sweat and lose water via this perspiration.
- (g) False – Water softens food and assists with easier movement of food throughout the digestive tract.
- (h) True – Males generally require more water than females because they have a larger body size.
- (i) True – Water acts as a solvent, allowing nutrients to be transported throughout the bloodstream.
- (j) False – Water contains no kilojoules (0kJ).
2. Males require greater amounts of water daily due to having a higher percentage of lean body tissue than females. Three quarters of lean body tissue is composed of water, which is why males require 3.4 litres a day.
3. *Any one of the following as long as from different food groups:* milk, watermelon, strawberries, lettuce, cabbage, celery, spinach, fruit juice, yoghurt, apples, grapes, oranges, carrots, broccoli, pears, pineapple, bananas, avocado, cottage cheese, ricotta cheese, corn prawns, baked potato, pasta, legumes, salmon, ice cream etc.
4. *Any two of the following:*
 - Diet: Low consumption of foods with a high water content, will require more water to be consumed.
 - Body size: an individual with a greater body size will have higher water requirements as 60% of the body is composed of water.
 - Activity levels: an individual who is active will have higher water requirements due to the loss of water from sweating.
 - Environmental temperatures and humidity: an individual living or in a hot/humid environment will have higher water requirements due to a greater loss of water from sweating and evaporation in an attempt to cool the body.
 - Illness/Blood loss: an individual who is ill will have higher water requirements due to greater loss of water from vomiting, diarrhoea, sweating (due to having a high temperature) or blood loss.
5. *Any two of the following:*
 - Water produces soft stools, preventing them from drying out and getting stuck in the large intestines. This promotes evacuation from the bowels, preventing the risk of constipation.
 - Air entering the mouth is warmed. This increases the amount of water vapour the air entering the lungs contains, reducing the risk of the respiratory system from drying out and causing damage to the delicate tissues.
 - One of the factors that determines the blood volume is the amount of water ingested. The kidneys will expel more water in urine as the individual is hydrated.
 - An adequate water intake can act as a lubricant and shock absorber for joints, the eyes, around the brain, spinal cord and foetus through amniotic fluid. This protects the body's sensitive structures against shock and allows for smooth movement of the joints.

6. The least amount of water (150ml) is lost from the GI tract in comparison to the kidneys, skin and lungs, as this is a site where water is reabsorbed back into the body (refer to digestion topic for more information on this).
7. (a) The dependent variable is the amount of water (L) lost via sweat during both games of football.
(b)

The Effect of Temperature on the Amount of Water Lost via Sweat in Football Athletes



(Marks allocated for labelled axes including units, even scale, plotted correctly and legend)

- (c) The amount of fluid lost from the body was greater at a higher environmental temperature (31°C) where this athlete lost a total of 4.5L after 120minutes of football, in comparison to 2.2L of fluid lost at 22°C. This difference could be due to greater perspiration being evaporated from the surface of the skin, cooling the body due to higher ambient temperature.
- (d) (i) Thirst is the first sign of dehydration and would indicate the need for water.
(ii) It would be beneficial for an athlete to drink at least every 15minutes to ensure water is continually absorbed into the bloodstream and replaces the water lost from the body via sweat.
(iii) Sports Drink (low in sugars) or Water.

1.6: Vitamins

Topic Solutions

1.

Vitamin characteristic	Fat soluble	Water soluble
Dissolves in	Fat/oil	Water
Storage in body	Yes – adipose tissue	No (most cannot be stored)
Hypovitaminosis risk	Lower risk	Higher risk
Hypervitaminosis risk	Higher risk	Lower risk
Stability in food processing	More stable	Less stable

2. This example demonstrates the key concept of Influence, as it explains the acceptance of mandatory folate fortification was influenced by social, cultural and economic considerations. These considerations are evident in the article through the following examples:

Social:

- Maternal dietary folate deficiency in the first weeks of life carries a higher risk that the fetus' neural tube will not fuse, leading to the development of either spina bifida or anencephaly
- Spina bifida results in significant lifelong physical disability and early death.
- Anencephaly almost always results in death before or within a few days of birth.

Cultural:

- Campaigns to encourage folic acid supplements were not effective in reducing NTD in the Indigenous population
- The Indigenous population was found to be at higher risk of NTD compared to the non-Indigenous population
- While health promotion was moderately successful in reducing the overall risk of NTD, it wasn't effective for Indigenous children, of whom a higher proportion were vulnerable
- Pre-fortification (2007-2009) there were 2.43 cases of spina bifida per 1000 births in the Indigenous population

Economic:

- Pre-fortification, the cost of spina bifida was calculated as \$13,535 for the first four years and \$4354 for every year after, up to the age of 43 or 84 years
- Children with spina bifida are hospitalised 19.4 times more than the general population and have 2.9 times more outpatient visits – therefore costs associated with medical fees and time taken off work to accompany these children
- Children with spina bifida have pharmaceutical use that is 3.1 times that of the general population and often require assistive technology
- Loss of work productivity in carers of people with spina bifida has been estimated at 9.2 hours a week
- People with spina bifida in the workforce lose an average of 10 days due to their disability and have reduced earning capacity (\$21,000 less than the general population)

3. Pernicious Anaemia is a type of megaloblastic anaemia, which is caused when Vitamin B₁₂ is not absorbed efficiently in the small intestines into the bloodstream – not from an inadequate intake. Whereas, megaloblastic anaemia is caused by inadequate intake of Vitamin B₁₂, which may be caused from a vegan diet. Both forms of anaemia result in abnormally large and immature red blood cells.
4. A vegan diet may put an individual at risk as this type of lifestyle does not consume any animal products, which are a great source of Vitamin B₁₂. An individual who follows a vegan lifestyle can consume fortified products, such as soymilk and cereals to obtain Vitamin B₁₂.
5. Any one of the following:
- part of the cell membrane
 - produces bile and hormones
6. (a) Calcium is a mineral and water soluble; therefore, can be excreted via urine.
- (b) There is a greater risk of hypervitaminosis with Vitamin D, as it is a fat-soluble vitamin. Fat soluble vitamins can be stored in adipose tissue and are at risk of accumulating in the body, possibly leading to toxicity.

Review Solutions

1. 1 = d 2 = a 3 = b 4 = c 5 = e
2. (a) Calcium or Phosphorus
- (b) Vitamin D assists with the absorption of Calcium and/or phosphorus.
- (c) Fat soluble
- (d) Food fortification (also known as food enrichment) is when nutrients are added to food at higher levels than what the original food provides. Products, such as margarine and milk products are being fortified with Vitamin D as Australians are becoming deficient in this vitamin due to limited exposure to sunlight and not being active outside.

3. Water soluble vitamins are required to be consumed more frequently. Water-soluble vitamins are not stored in the body, whereas the fat-soluble vitamins are in the body's adipose tissue. Excess water-soluble vitamins are excreted via mostly urine. As well as this, if the foods are cooked or processed, they have typically lost some of the water-soluble vitamins making them more important to continually have in the diet.
4. *Any one of the following:*
- People who work indoors, as they have limited exposure to sunlight, which assists the body in producing Vitamin D
 - Religions that cover all body parts; as they have limited exposure to sunlight, which assists the body in producing Vitamin D
 - Vegans, as they don't obtain vitamin D from oily fish e.g. salmon, liver, or eggs
 - Pregnant females; require more vitamin D to support foetus growth
5. (a) Vitamin C RDI doubles from 1-18 years and decreases by 10mg from 18 to ages beyond 18 years.
(b) Foetus: Spina Bifida
Pregnant Female: Megaloblastic Anaemia
6. (a) Water-soluble.
(b) *Any one of the following:*
- Works as a coenzyme in DNA synthesis for RBC formation
 - Assists in the metabolism of macronutrients to release energy
 - Activates Folate, to allow it to perform its functions
- (c) Lean meats and poultry, fish, eggs or Milk, Yoghurt, Cheese, Meat & alternatives, Dairy.
(d) Pernicious and Megaloblastic Anaemia can lead to Fatigue. This is because there is a reduced number of healthy red blood cells as they are abnormally large and carry less oxygen to the cells around the body, which is required for energy production. *This is the main sign and symptom, however, further signs and symptoms are explained in Topic 1.10.*
(e) *Any one of the following:*
- There is a greater risk of toxicity with supplements
 - Vitamins are more balanced in whole foods
 - Vitamins in whole food are more readily absorbed by the body as they are in a natural form
 - Obtaining vitamins from whole foods is more cost effective
 - Whole foods can provide more than the one benefit than a supplement can
7. (a) The dependent variable is the vitamin (Vitamin B₁ and E) content (mg) in raw and boiled broccoli.
(b) *Any two of the following:*
- Amount/quantity/surface area of broccoli, as a smaller size of broccoli will lose its vitamin content faster as it has less to start with
 - Volume of water broccoli is boiled in, as a greater volume of water may cause more vitamin loss due to leeching
 - Age of broccoli, as older broccoli may have a lower vitamin content to begin with due to an increased risk of being exposed to light and oxygen which can denature water soluble vitamins especially
 - Temperature of the boiling water, as a greater temperature may cause greater vitamin loss as heat can denature heat sensitive vitamins
 - Parts of the broccoli e.g. stem or floret, as the stem may not be as susceptible to vitamin loss as it requires greater cooking time
- (c) (i) Broccoli loses 0.1mg of Vitamin B₁ after being boiled.
(ii) Broccoli loses no Vitamin E after being boiled.
(d) Vitamin B₁ is water soluble, and therefore, sensitive to heat and water using in the cooking process. Therefore, vitamin B₁ will leech into the surrounding water; whereas vitamin E is fat soluble and therefore not as sensitive to heat or susceptible to leeching into the surrounding water.

- (e) *Any fluid lost from the body, such as one of the following:*
- Urine
 - Faeces
 - Perspiration (sweat)
 - Tears
 - Blood
 - Vomit
- (f) (i) Vitamin B₁ acts as a coenzyme in the metabolism of macronutrients, especially in the breakdown of glucose for energy production.
- (ii) *Any one of the following sources:*
- Wholegrain or fortified bread and cereal products
 - Meat
 - Poultry
 - Legumes
 - dark green leafy vegetables (such as broccoli, turnip greens, asparagus and spinach)
 - yeast
 - vegemite
8. After 2 hours, heating the orange juice at 50°C resulted in an 80% loss of vitamin C; whereas the orange juice heated at 30°C resulted in only 22% loss of vitamin C. This is because vitamin C is water soluble and sensitive to heat, causing it to denature.

1.7: Minerals

Topic Solutions

1. Vitamin D
2. Vitamin C
3. *Any of the following suggestions are acceptable:*

Dietary: Avoid adding salt to cooking, avoid foods naturally high in salt, and avoid adding salt to food at the dinner table.

Lifestyle: Avoid placing the salt shaker at the table to reduce the urge of adding salt to food, creating time to make more homemade meals to reduce the intake of processed and takeaway foods as these are generally high in salt.
4. *Any of the following:* Protein, Calcium or Potassium.
5. *Any one of the following:* excessive fluid intake or excessive sweating due to physical activity of high ambient temperatures.
6. (a) An individual's blood pressure would increase, as a greater consumption of sodium would attract and hold onto more water increase their blood volume; and therefore increasing the pressure against arterial walls.
(b) An individual would retain more fluid, causing fluid retention (oedema) as sodium has the ability to attract and hold on to water by reducing the kidneys' ability to remove water via urine.

7.

Mineral	Two Food Sources*	One Function
Iron	Fish Lentils	Production of Haemoglobin
Potassium	Bananas Spinach	Regulates the volume of extracellular fluid Assists with the contraction of muscles
Calcium	Cheese Green Leafy Vegetables	Development of Strong Bones Assists in blood clotting Assists with the contraction of muscles
Sodium	Processed Food Table Salt	Regulates the volume of extracellular fluid Assists with the contraction of muscles

*Solutions are not limited to the food sources included in this table.

Review Solutions

- Major minerals are required in larger amounts and are found in the body in amounts greater than 5 grams. Whereas, trace minerals are required in smaller amounts and are found in the body in amounts less than 5 grams. They both just as important as each other though.
- Minerals are water soluble; therefore can be lost via fluids excreted from the body. This can include via tears, urine, sweat, blood and faeces.
- Calcium crystals form on a matrix of collagen during bone formation, providing a rigid bone structure. This process is continuous throughout an individual's life cycle where old bone is constantly being reabsorbed and new bone is being produced. A low calcium intake during the key growth and development stages, including infancy, childhood and adolescence can limit the bone's ability to reach its optimal mass and density by their late twenties. Therefore, an individual is at greater risk of age related bone loss, fracture and osteoporosis later in life.
- Phosphorus works closely with calcium to develop a strong bone structure. These two minerals combine to form calcium phosphate, which is the predominant mineral in bones.
- Both sodium and potassium regulate the volume of extracellular fluid in the body and assists with the contraction and relaxation of muscles, which leads to the transmission of impulses along the nerves.
- The kidneys filter the blood to hold onto what the body needs. If an individual consumes foods high in salt, the kidneys will hold onto more water to dilute its concentration in the body. This increases the blood volume in the body, causing greater work of the heart and increasing the pressure against the arterial walls. This increases the risk of severe hypertension. *This is further explained in Topic 1.10.*
- The sodium-potassium pump found in the membrane of cells, pumps sodium out of the cell and pumps potassium into the cell. This creates an electrical charge. This electrical charge stimulates the contraction of muscles.
- Haem iron is only found in foods derived from flesh of animal sources, such as meat, poultry and fish. Whereas, non-haem iron is found in foods derived from plant sources, such as lentils, beans, tofu, nuts, seeds and grains and animal sources including eggs and dairy. Haem iron is also better absorbed by the body at a rate of 7-35%, whereas non-haem iron is absorbed at a rate of 2-20%.
- Any two of the following:*
 - Fatigue: reduced iron intake will lead to reduced haemoglobin production, reducing the quality of red blood cells produced. Therefore, less red blood cells in circulation will reduce the transportation and delivery of oxygen to tissues and organs for cell respiration.
 - Paleness: The red blood cells in iron deficient anaemia have a reduced amount of the protein haemoglobin, which is responsible for binding to oxygen molecules. When haemoglobin is attached to oxygen molecules, it provides the characteristic red colour to these cells. Therefore, if there is a lack of haemoglobin in the red blood cell, this will reduce the amount of oxygen attached, reducing its red colour.
 - Fast Heart Rate: As there is a lower concentration of quality red blood cells in circulation, the heart has to pump harder to get oxygen around the body and to all tissues and organs.

These are further explained in Topic 2.

10. (a) Sodium assists in the contraction and relaxation of muscles, by controlling the movement of sodium and potassium in and out of cell. This generates an electrical charge, which stimulate muscle contraction. Therefore, a deficiency in sodium may also cause muscle spasms and cramps.
- (b) Athletes.
11. (a) Iron Deficiency:

Food or Beverage Source	Increase or Decrease intake
Orange juice	Increase
Excessive milk and yoghurt	Decrease
English Breakfast Tea	Decrease
Lamb	Increase
Fresh Salmon	Increase
Eggs	Decrease
Fortified cereals	Increase

- (b) Calcium Deficiency:

Food or Beverage Source	Increase or Decrease intake
Cow's Milk	Increase
Salmon	Increase
Pepsi	Decrease
Coffee	Decrease
Yoghurt	Increase
Wholegrains	Decrease
Processed Foods	Decrease

1.8 Digestion and metabolism

Topic Solutions

- Mastication
- Saliva in the mouth moistens food to allow for easy swallowing into the oesophagus and provides digestive enzymes: salivary amylase and lingual lipase to begin the chemical digestion of carbohydrates and lipids respectively.
- | Macronutrient | Digestive enzyme involved | Chemically broken down into |
|-----------------------|---------------------------|--|
| Complex Carbohydrates | Salivary Amylase | Shorter polysaccharides and disaccharides, specifically maltose. |
| Triglycerides | Lingual Lipase | Shorter Fatty Acids |
- The mechanical digestion that occurs in the oesophagus is known as peristalsis. Peristalsis is the involuntary contractions and relaxations of the circular and longitudinal muscles of the oesophageal walls that pushes the bolus unidirectionally along the oesophagus into the stomach.
- Lower oesophageal sphincter (also known as the cardiac sphincter).

6. The mechanical process in the stomach involves the contractions and relaxations of the stomach walls, which mix and churn the stomach contents producing chyme.
7. The salivary enzymes become inactive due to the highly acidic nature of the stomach, ceasing the chemical breakdown of carbohydrates and triglycerides.
8. Disaccharides are chemically broken down into monosaccharides by specific enzymes secreted by intestinal cells. Maltase breaks maltose into two glucose molecules, Sucrase breaks sucrose into one glucose and one fructose molecule and Lactase breaks lactose into one glucose and one galactose molecule.
9. Bile emulsifies larger fat molecules and mechanically converts them into small fat droplets, allowing them to immerse into the surrounding water fluid. The emulsification of fat increases the surface area available for then pancreatic lipase to complete the chemical digestion of lipids.
10. Trypsin, chymotrypsin and peptidase.
11. The villi increases the surface area available, to maximise nutrient absorption.
12. Segmentation
13. In the large intestine, bacteria ferment soluble fibre producing water, gas and small fatty acid chains, which are then used as energy for the cells of the colon and assist in protecting against disease. Insoluble fibre passes through the large intestine unchanged, which assists in adding bulk to stools, preventing diarrhoea and eliminating waste.
14. Water is reabsorbed.
15. This example demonstrates the key concept of communication and collaboration, as it shows the collaboration between researchers and professors from different universities and institutes in sharing their findings about how the transplant of gut bacteria from young mice to elderly mice could protect against Alzheimer's disease. Examples from the source include:
 - "Research has shown that the aging process may be linked with age-related changes in our gut microbiota," said David Vauzour, of the University of East Anglia
 - Prof Claudio Nicoletti, from the University of Florence, Italy, said: "While it remains to be seen whether transplantation from very young donors can restore cognitive function in aged recipients, the findings demonstrate that age-related shifts in the gut microbiome can alter components of the central nervous system."
 - "Manipulating the microbiome is increasingly being seen as a way of improving or maintaining human health, and these results are an exciting indication of its potential for helping us age healthily" said Prof Arjan Narbad from the Quadram Institute.

16.

Organ or gland	Secretion	Site of release	Action
Salivary gland	Salivary amylase	Mouth	Begins the chemical break down of starch into shorter polysaccharides and disaccharides, specifically maltose.
	Lingual Lipase	Mouth	Begins the chemical breakdown of lipids into shorter fatty acid chains.
Gastric glands	Gastric Juice	Stomach	Gastric juice (hydrochloric acid) is mixed with the bolus, which uncoils proteins and activates gastric pepsin to begin the chemical breakdown of proteins into shorter polypeptide strands.
Pancreas	Pancreatic amylase	Small Intestine	Breaks down polysaccharides into shorter glucose chains and disaccharides.
	Pancreatic trypsin and chymotrypsin	Small Intestine	Breaks shorter polypeptide strands into shorter peptide chains or singular amino acids.
	Pancreatic lipase	Small Intestine	Breaks small fat droplets into singular fatty acid chains, glycerol or monoglycerides.
Liver	Bile	Gallbladder	Produces bile, which is concentrated, stored and released by the gallbladder.
Gallbladder	Concentrated bile	Small intestine	Emulsifies larger fat molecules, breaking them down into small fat droplets.

17.

Mechanical process	Site where it occurs	Definition
Mastication	Mouth	Mastication is the grinding and chewing action by teeth in the mouth, which physically break down ingested food into smaller pieces.
Peristalsis	Oesophagus	Peristalsis is the alternate and involuntary contractions and relaxations of the circular and longitudinal muscles of the oesophageal walls.
Mixing and churning	Stomach	The circular, longitudinal and diagonal muscles of the stomach walls contract and relax, mixing and churning the bolus with gastric juices to produce a semifluid paste called chyme.
Emulsification of Fats	Small Intestines	Bile emulsifies larger fat molecules and physically breaks them into small fat droplets, allowing them to be immersed in the surrounding water fluid and increasing the surface area available for the chemical digestion to be completed.
Segmentation	Intestines	Segmentation involves the contractions and relaxations of the circular muscles of the intestinal walls.

18. Any two of the following food and drink sources with their corresponding component:

(a) Iron:

- Eggs – Phosvitin
- Dairy e.g. milk, yoghurt, cheese – Calcium
- Tea, spinach, kale, nuts, chocolate, strawberries, herbs – Oxalates
- Cocoa, coffee, apples, herbal teas, blackberries, raspberries, blueberries – Polyphenols
- Walnuts, lentils, wholegrains, cereals, dried beans, almonds, rice–Phytates

(b) Calcium:

- Processed foods, cured meats, salted nuts, cold cuts, sauces, canned products–sodium
- Soft drinks – phosphoric acid
- Tea, spinach, kale, nuts, chocolate, strawberries, herbs – Oxalates
- Cocoa, coffee, apples, herbal teas, blackberries, raspberries, blueberries – Polyphenols
- Walnuts, lentils, wholegrains, cereals, dried beans, almonds, rice–Phytates

19. Cooking foods for extended period exposes foods to heat, causing water vitamins especially to be destroyed. Therefore, this would reduce the bioavailability of vitamins in the food, reducing their absorption in the small intestines.

20. Chewing food slowly and completely can mechanically break down large pieces of food into smaller ones, increasing their surface area for enzymes to efficiently complete the chemical digestion. As well as this, during chewing, food is mixed with saliva which contains digestive enzymes that begins the breakdown of lipids and carbohydrates. Therefore, the more time food spends in the mouth, the more mechanical and chemical digestion that takes place and reducing the amount of digestion that may need to take place further along the gastrointestinal tract and increasing the absorption of nutrients.

21. Soluble fibre binds to water becoming gel-like in the stomach, causing food to empty the stomach and enter the small intestines at a slower rate. This slows down initial digestion, maximising nutrient absorption in the small intestines.

Factors increasing BMR	Factors decreasing BMR
Larger Body Size	Increasing Age
Growing life stages	Fasting, Starving, Malnutrition, Crash dieting
Larger amount of lean body tissue	Drugs
Male	Genetics, Hormonal Balance
Physical Activity	
Fever, infection, illness	
High and low environmental temperatures	
Drugs	
Genetics, Hormonal Balance	

23. $BMR = 88 \times 1.0 \times 24 \times 4.2$

$BMR = 8870.4 \approx 8870 \text{ kJ/day}$

24. $0.10 \times 13500 \text{ kJ} = 1350 \text{ kJ}$

25. $0.10 \times 8990 \text{ kJ} = 899 \text{ kJ}$

Therefore, leaving 8,091 kJ (8990 – 899) for body functioning.

26. $BMR = 65 \times 1.0 \times 24 \times 4.2 = 6552 \text{ kJ/day}$

Thermic Effect = $0.10 \times 8200 \text{ kJ} = 820 \text{ kJ}$

Total Energy Expenditure = $6552 + 450 + 820$

Total Energy Expenditure = 7822 kJ/day is expended

27. Negative Energy Balance.

28. Energy Balance = $8200 - 7822 = +378 \text{ kJ}$

Therefore, this is a positive energy balance and if these eating patterns continue this male would be at risk of gaining weight.

Review Solutions

- In mechanical digestion, food is pushed along and physically broken down into smaller fragments, whereas chemical digestion results in the breakdown of all three macronutrients into their basic chemical structures, with the assistance of digestive enzymes and juices.
- In people with coeliac disease, gluten triggers an immune response in the small intestines, which causes inflammation of the walls. This causes the villi to become damaged and flatten, reducing the surface area available for nutrient absorption.
- (a) *Any one of the following:*
 - Prevents bacterial growth and kills most bacteria that may have been ingested with food consumption.
 - Uncoils and denatures each protein strand to allow digestive enzymes to break the peptide bonds between the amino acids.
 - Converts the inactive form of pepsinogen into its active form: pepsin
- (b) The entry and exit of food is controlled by sphincters on each end of the stomach. The lower oesophageal sphincter (cardiac sphincter) controls the entry of the bolus from the oesophagus into the upper portion of the stomach. The pyloric sphincter controls the release of chyme into the first part of the small intestine: the duodenum.
- (c) The muscles of the stomach alternately contract and relax, which assist in the mechanical mixing and churning of the bolus with gastric juices (a mixture of water, enzymes, and hydrochloric acid) to produce a semiliquid paste called chyme. Whereas, hydrochloric acid activates pepsin, which breaks larger polypeptide chains into smaller ones by breaking the peptide bonds between them. The chemical breakdown of carbohydrates and lipids is stopped as the salivary enzymes become inactive due to the stomach's strong acidic nature, therefore only the chemical digestion of proteins take place at this site.
- In an individual with coeliac disease or lactose intolerance, they experience a reduction in the absorption of nutrients (including glucose). This is due to the damaged and flattened intestinal walls in an individual with coeliac disease or due to the incomplete digestion of lactose in lactose intolerance. Therefore, both malabsorption syndromes can result in fatigue due to a reduced availability of glucose in the blood stream, which is used in cellular respiration to produce ATP (energy).
- (a) Total Energy Expenditure = $6600 + 4748 (793 + 1455 + 2500) + 970 (9700 \times 0.1)$
Total Energy Expenditure = 12318 kJ/day is expended
- (b) Therefore, this is a negative energy balance and this male is expected to lose weight if this pattern continues.
- An individual with lactose intolerance doesn't produce enough of the enzyme: lactase. This enzyme finishes the digestion of lactose into its two monosaccharides: glucose and galactose in preparation for their absorption into the bloodstream. Therefore, lactose intolerance can reduce the absorption of carbohydrates containing lactose.



7. The chemical digestion of lipids begins in the mouth by lingual lipase, which is released by the salivary glands. Lingual lipase breaks down triglycerides into shorter fatty acid chains. The majority of lipid digestion takes place in the small intestine though. Once the small intestine detects lipid is present, the gallbladder releases its stores of bile via the common bile duct. Bile emulsifies larger fat molecules and converts them into small fat droplets, increasing the surface area available for pancreatic lipase to complete their digestion. Pancreatic Lipase either removes each triglycerides fatty acids, leaving a monoglyceride or breaks apart all three fatty acids leaving a free molecule of glycerol. These are then absorbed into the lymphatic system before entering the bloodstream near the heart.
8. An individual who has undergone gastric bypass has a reduced energy intake due to the reduction of the contents of the stomach. This therefore reduces the amount of nutrients absorbed, due to a lower availability. The amount of nutrients absorbed are further reduced due to part of the small intestine being skipped. Therefore, the chemical digestion of ingested macronutrients is not completed to their monomers, preventing their absorption via the villi on the surface of the intestinal walls. Hence, the implications of this surgery is a reduced intake of nutrients and absorption via the villi.
9. (a) Male (Aaron)
- (b) *Any one of the following reasons:*
- Males body composition is composed of greater lean body tissue (muscle), which is a faster metabolising tissue than adipose tissue.
 - Males expend more calories per kilogram per hour than females, where males burn 1.0 calorie and females burn 0.9.
- (c) (i) 10%
- (ii) $BMR = 77 \times 1.0 \times 24 \times 4.2$
 $BMR = 7761.6 \approx 7762 \text{ kJ/day}$
- (iii) Total Energy Expenditure = $7762 + 2210 + 1230$
 Total Energy Expenditure = 11202kJ/day is expended
- (iv) Energy Balance = $12300 - 11202 = +1098\text{kJ}$
 Therefore, this is a positive energy balance.
- (v) If these eating patterns continued for a long time, Aaron would gain weight. This would put him at risk of developing obesity, and some of its associated health related consequences, including type II diabetes, cardiovascular disease and hypertension.
10. A gallstone blocking the common bile duct, would prevent the release of bile into the small intestines when lipid was present and pancreatic lipase. This would prevent the emulsification of lipids and their conversion into smaller fat droplets, which have an increased surface area. The chemical digestion of lipids by pancreatic lipase would then not occur, reducing their absorption and use of lipids in the body.

1.9 Imbalance of nutrient intake – over nutrition disorders

Topic Solutions

1. (a) USA has the greatest proportion, and Korea has the smallest proportion.
 (b) Approximately 45%
2. $\frac{\text{weight (kg)}}{\text{height (m}^2)} = \frac{93}{1.6^2} = 36.3 = 36$
 Therefore, this individual would be classified as morbidly obese.
3. Male: Android Female: Gynoid
4. Carbohydrates (17kJ/g), Lipids (37kJ/g), Protein (17kJ/g)
5. Energy Intake should be lower than their Energy Expenditure.
6. Soluble fibre is not able to be broken down into glucose and absorbed into the bloodstream. Instead, it binds to water and partly dissolves to become 'gel-like' in the stomach. The gel-like consistency of the

carbohydrate food and the increase in volume by the addition of water results in a feeling of fullness (known as satiety). This prevents individuals from overeating, ensuring their energy intake does not significantly exceed their energy expenditure.

7. Chewy Chocolate Chip Muesli Bar

$$\text{Energy density} = \frac{\text{Kilojoules (kJ)}}{\text{Serving size (g)}}$$

$$\text{Energy density} = \frac{510}{31.3}$$

$$\text{Energy density} = 16.3 = 16\text{kJ per gram}$$

Almond, Cashew & Cranberry Muesli Bar

$$\text{Energy density} = \frac{\text{Kilojoules (kJ)}}{\text{Serving size (g)}}$$

$$\text{Energy density} = \frac{692}{35}$$

$$\text{Energy density} = 19.8 = 20\text{kJ per gram}$$

A serving (one bar) of the almond, cashew and cranberry muesli bar has a greater energy density, as it contributes more kilojoules per gram than one serving of a chewy chocolate chip muesli bar. Further analysis of the protein, fibre, vitamin and mineral (nutrient content) of each of these muesli bars would need to be evaluated to make a valid conclusion about their density though.

8. *Any of the following strategies could be suggested:*

- Eat slowly
- Use a smaller plate
- Fill half your plate with vegetables or salad (nutrient dense foods)
- Avoid eating from a large packet of energy dense foods (encourage over eating)
- Avoid buying foods that are energy dense (to remove the temptation)
- Reduce your consumption of alcohol which is energy dense (29kJ/g)
- Consume soluble fibre with your meal

9. Basal Metabolic Rate can be defined as the rate of metabolism, or the energy used, when the body is in a state of rest. It is considered the minimum number of kilojoules your body needs to maintain necessary bodily functions such as breathing, keeping the heart beating, maintaining normal body temperature, and maintaining muscle tone.

10. A positive energy balance occurs when energy intake is greater than energy expenditure. That is, eating more kilojoules than the body needs.

11. *Any three of the following would be accepted:*

- The consumption of alcohol in social settings
- Emotional eating e.g. eating because of boredom
- The size of serving containers
- Greater reliance on processed and convenience foods due to limited time available to cook and prepare home cooked meals
- People eating out more
- Greater access to fast foods and take away options

12. This example demonstrates the key concept of Influence, as it explains the acceptance of New National Obesity Initiatives was influenced by social and economic considerations. These considerations are evident in the article through the following examples:

Social:

- If you are an adult in Australia, odds are you're overweight or obese. At last count, two in three of us over the age of 18 are.
- According to VU's Australian Health Tracker, obesity rates across Australia are hugely dependent on where people live, and vary between regions by as much as 300 per cent
- The proportion of people who are obese has risen 27 per cent in 10 years
- If you're a single parent with several children, it's going to be easier to feed your family a large serving of chips than it is to go and do a meal with vegetables and meat



Economic:

- We cannot ignore the influence of where people live — and where people live has a lot to do with their socio-economic status
- Wealthy city suburbs typically have the lowest rates of obesity because they are the most well-resourced
- According to the ABC's Australia Talks national survey, nearly a third of Australians have trouble making ends meet. For Australians living on a low income, or in poverty, fast food is often the cheapest, most feasible food option
- Your choices are driven by your resources
- It's not easy when you've got plenty of resources and are well educated," Ms Martin said, "it's a lot harder when you don't have the resources, money or skills
- We have children entering schools in parts of Australia that don't know what an apple is until they go to school

13. Any three of the following would be accepted:

- Wealthy suburbs are better resourced
- Wealthy suburbs are usually green and leafy, with more space dedicated to parks, gardens and recreational facilities (to promote physical activity)
- Wealthy suburbs often are well serviced by public transport, bike paths and are relatively close to where people work, which enables people to be physically active in their commute to work, rather than rely on the car (therefore, individuals have more time to participate and complete physical activity)
- A greater density of shops selling fresh fruit and vegetables and fewer fast food outlets also means accessing healthy food is easier (greater accessibility and supply may mean these foods are cheaper)
- People in our wealthier suburbs tend to have better access to information about healthy diet and the financial means to access healthy food options (better educated and more money available to spend on healthier options)
- Low income suburbs are highly dependent on cars, because of usually much less public transport
- Low income suburbs have a much higher rate of fast food outlets, much lower access to speciality fresh food outlets (fast food is a lot cheaper, therefore more accessible)
- Highest rates of obesity also had higher rates of smoking, physical inactivity and chronic illness, and were largely low-socioeconomic communities

14. Simple sugars (Monosaccharides and Disaccharides) and Starch.

15. Insulin will not fit in its receptor and unlock the glucose channel, causing blood glucose levels to elevate and cause the body's cells to be deprived of energy.

16.

	Type I Diabetes	Type II Diabetes
Prevalence in Australia (%)	10	85-90
General Age of Onset	Children and Adolescence	Adults over the age of 45
Risk Factor (main cause)	Inherited (autoimmune)	Diet and Lifestyle factors
Progression	Sudden	Gradual
Insulin production in the pancreas	Insufficient insulin production due to destroyed beta cells in the pancreas	Ineffective and insufficient insulin production due to beta cells being overworked

17. The body will break down triglycerides stored in adipose tissue and protein stored in body tissues, such as muscles.

18. Any one of the following: Water soluble nutrients, including vitamins (B₁, B₂, B₃, B₉, B12, C) and minerals (iron, calcium, phosphorus, sodium, potassium). Other possible answers too.

19.	Short Term/Immediate Symptoms	Long Term/Chronic Symptoms
	<ul style="list-style-type: none"> Fainting Fatigue Hunger & Excessive eating Frequent urination Dehydration Excessive thirst Blurred vision Poor circulation Nerve damage—tingling and numbness in hands and feet 	<ul style="list-style-type: none"> Hyperglycaemia Weight gain Retinopathy Blindness Infections Gangrene Death

20. Once energy needs and reserves have been met, simple sugars are converted into triglycerides and stored in adipose tissue. This contributes to fat accumulation and the development of obesity.

21. Visceral Fat

22. (a)
$$\frac{\text{carbohydrate content (g)} \times \text{GI rating}}{100}$$

$$= \frac{12 \times 70}{100}$$

$$= 8.4 = 8$$

(b) Therefore, watermelon has a low GL.

23. Low GI carbohydrate foods enter the blood stream slowly and have less of an impact on blood glucose levels. As well as this, fibre assists in slowing down the absorption of glucose into the bloodstream avoid high spikes in blood glucose levels.

24.

Type of Carbohydrate	Role in the development or prevention of type II diabetes	Examples of two food sources
Simple e.g. Monosaccharides and Disaccharides	Provides a rapid spike in blood glucose levels, putting pressure on the pancreas to produce insulin to maintain these levels. These carbohydrates also provide empty kilojoules, which can contribute to weight gain.	Sweets, lollies, standard soft drinks, sugary drinks, cakes, muffins, biscuits, chocolate, potato chips, pastries, ice cream, hot chips
Complex e.g. Polysaccharides (starch and soluble fibre)	Provides a slow release of energy, slowly raising blood glucose levels. This allows the pancreas to maintain these levels. The carbohydrates also satisfy hunger and prevent overeating, due to their high fibre content.	Rolled oats, dense wholegrain breads, lentils and legumes, sweet potato, milk, yoghurt, pasta and most types of fresh fruit

25. Being overweight or obese can place pressure on the already compromised pancreas, which can further contribute to it losing its ability to produce effective insulin. This can decrease the cell's sensitivity to insulin, contributing to greater insulin resistance.

26. Regular exercise can result in a negative energy balance, which would promote the loss of fat and weight. This would reduce the pressure placed on the pancreas. As well as this, regular exercise can encourage the muscle cells to absorb and use glucose from the blood for cell respiration (production of energy). This assists in managing blood glucose levels and preventing them from spiking.

27. This example demonstrates the key concept of Influence, as it explains the acceptance of artificial pancreas was influenced by social considerations which consider the rising prevalence of diabetes around the world. These considerations are evident in the article through the following examples:

- Cure patients who have type 1 and type 2 diabetes and are insulin-dependent
- Today, you only have ways to manage the disease. This is a cure
- The patient should never have to inject insulin into his body again
- There are about 500 million diabetics around the world and of them, Dr Kunicher said, about 160 million were insulin-dependent



This example demonstrates the key concept of communication and collaboration, as it shows the collaboration between professors, doctors and companies researching the development of an artificial pancreas and the success in curing diabetes. Examples from the source include:

- An Israeli company named Betalin Therapeutics has developed a bio-artificial pancreas
- Dr Nikolai Kunicher, chief executive of the Jerusalem-based company, said in a statement that human trials were expected to begin by January 2021
- Professor Aryeh Warshel, also a Nobel Prize winner (2013 in Chemistry), is a member of the company's scientific advisory board.

This example demonstrates the key concept of development, as it explains the development of a new technology to improve the efficiency of the treatment of diabetics compromised pancreas. It also explains that data will be collected analysed through human trials.

- The artificial organ is made of pig's lung tissue and insulin secreting cells
- It would then be able to measure the body's sugar level and secrete an optimal amount of insulin needed to balance blood sugar
- Human trials were expected to begin by January 2021

28. high-density lipoprotein (HDL)

29. *The steps of the development of Atherosclerosis can be summarised as:*

1. The endothelium lining is damaged by certain dietary and/or lifestyle factors, including high LDL cholesterol, hypertension or toxins from cigarette smoking.
2. LDL deposits at these damaged sites becoming entrapped.
3. An inflammatory response is triggered, activating the immune system and sending a monocyte to the area for 'clean up'.
4. The monocyte converts to a macrophage once it enters the endothelium cells.
5. The macrophage will engulf the trapped LDL and become a foam cell.
6. Foam cells continue to swell (due to the engulfing of the LDL) and congregate together, which appear like fatty streaks and become the cells of plaque.
7. Foam cells continue to congregate together, as more LDL cholesterol becomes entrapped over many years.
8. The smooth muscle cells of the artery walls will move and stretch to allow for the growth of the plaque, and provide a protective layer known as a fibrous capsule and stabilising the plaque.
9. Plaque continues to build up until the artery walls begin to stiffen and are unable to stretch further.
10. The plaque will begin to then bulge into the lumen, narrowing the artery and reducing blood flow. This causes the fibrous capsule to thin and putting it at risk of rupturing.

30. The rupture of an aneurysm occurs from an area of an artery that has weakened and bulged from atherosclerotic damage, whereas a plaque rupture occurs from the narrowing region of the atherosclerosis plaque into the blood stream. An aneurysm will cause internal bleeding, whereas a ruptured plaque will cause a clot to form over the plaque, blocking blood flow.

31. (a) the graph must include:

- Labelled axes: Vertical axis = Percentage of people with PVD (%) and Horizontal axis = Age group (years)
- Title: The prevalence of PVD (%) by Age Groups (years)

(b) The prevalence of PVD increases by approximately 25% from 40 years of age to the over 80 age group. Also, the prevalence of PVD is more common in males than females over the age of 60, and less common under 60.

(c) 55: Females; 75: Males

32.

Type of Cardiovascular disease	Definition or symptom
Stroke	Involves a blockage of blood supply to the brain
Stroke	Poor balance when walking and slurred speech
Angina (Type of CHD)	Chest pain with exercise that reduces once exercise ceased
Cardiovascular disease	Collective term for diseases of the heart and blood vessels
Coronary heart disease	Collective term for diseases of the heart
Heart attack	Sudden chest pain that radiates across the shoulders
Chronic kidney disease (type of PVD)	Frequently going to the toilet to urinate during the night
Peripheral vascular disease	Involves a blockage of blood supply to the legs and/or kidneys
Heart attack (type of CHD)	Involves a blockage of the blood supply to the heart
Peripheral vascular disease	Ongoing toe numbness and pain

33. 10%

34.

Nutrient balance	Effect on LDL production	Effect on HDL production
Excess cholesterol	Increases	—————
High saturated fat	Increases	—————
High Trans fat	Increases	Decreases
Low monounsaturated fat: high sat fat balance	Increases	Decreases
High polyunsaturated fat: low saturated fat balance	Decreases	Increases
Soluble fibre	Decreases	—————

35. *Food sources may include, but are not limited to:*

Saturated fat: Meat e.g. beef, chicken with fat, meat products e.g. sausages, dairy e.g. cheese, deep-fried foods e.g. hot chips, foods made with palm oil e.g. Ice cream, foods made with cocoa butter e.g. chocolate, foods made with coconut oil e.g. pastries.

Monounsaturated fat: avocado, most nuts, canola oil.

Omega 3: oily fish e.g. salmon, soybean oil/spread, chia seeds.

High GI and GL foods: list is extensive; examples are confectionary, cake, biscuits.

Soluble fibre: fruit (pith), vegetables (pith), oats, legumes e.g. chickpeas and soy products e.g. tofu

36. *Some alternatives may include:*

Chocolate crackle ingredients:	
250 g copha	250g plant oil e.g. sunflower
4 cups of rice bubbles	4 cups whole grain cereal e.g. milo cereal
1 cup icing sugar	1 cup low GI icing sugar
150g melted chocolate	150g reduced sugar/fat chocolate
Vanilla ice-cream ingredients	
1.5 cups thickened cream	1.5 cups low fat cream/almond; or home-made almond/soy cream
125g condensed milk	125g reduced sugar/fat condensed milk



37. Modifications:

1. Lean meat alternative e.g. turkey or pork mince to sausage meat
2. Fish e.g. tuna or vegan/vegetarian e.g. tofu/eggplant/legume replacement of sausage meat.
3. Substitute garlic for salt
4. Add any appropriate vegetable e.g. carrot
5. Use egg whites instead of the whole egg
6. Substitute breadcrumbs for wholemeal breadcrumbs
7. Substitute puff pastry for reduced fat puff pastry

Justifications:

- Modification 1, 2, 7: Reduces triglycerides, which can deposit in arteries leading to plaque formation and atherosclerosis and therefore CVD
- Modification: 1, 2, 3, 7: Reduces saturated fat, trans-fat, cholesterol, which raises LDL levels that deposit at damaged sites along the arteries leading to the formation of plaque and atherosclerosis and therefore CVD.
- Modification 2: provides the diet a better balance of unsaturated fats, which can decrease LDL and increase HDL, thereby reducing the formation of plaque and atherosclerosis/CVD risk
- Modification 4, 6: can increase soluble fibre, which can remove cholesterol as waste thereby reducing potential LDL in blood and plaque formation and therefore reducing the risk of atherosclerosis/CVD.
- Modification 3: Excess salt is a dietary cause of hypertension; the high blood pressure can result in arterial damage that promotes LDL deposition and CVD risk and garlic lowers blood cholesterol.

38. This example demonstrates the key concept of Influence, as it explains the acceptance of nanoparticles in preventing the formation of plaque in the arteries was influenced by social considerations which consider the rising prevalence of cardiovascular disease around the world but especially in the US. This new technology has also been influenced by the limited success of previous systems used to treat this diet related disorder. These considerations are evident in the article through the following examples:

- Scientists believe the particle will be vital in developing future treatments for one of the leading causes of death in the US: atherosclerosis
- Approximately half of all deaths in the Western world are caused by atherosclerosis
- It is the primary cause of atherosclerotic cardiovascular disease (ASCVD), which leads to heart attacks, peripheral arterial disease, and stroke.
- Approximately 25% of deaths in the US are a result of heart disease, amounting to 610,000 people each year, and approximately 735,000 Americans suffer from heart attacks annually
- Exploring systems that target the cell's surface, although success was limited

This example demonstrates the key concept of communication and collaboration, as it shows the collaboration between different scientists researching the development and success of nanoparticles in preventing atherosclerosis and therefore CVD. Examples from the source include:

- In January 2020, a team of scientists from Michigan State University and Stanford University announced the creation of a nanoparticle that can destroy heart-attack-causing plaques efficiently
- In a paper published last month in *Nature Nanotechnology*, the Michigan State and Stanford team explains that the Trojan Horse nanoparticle is effective at targeting atherosclerotic plaque
- Scientists working on the project believe that the nanoparticle will have applications outside of atherosclerosis. However, more research is needed.

39. (a) 140-160 mmHg

(b) 90-100 mmHg

(c) Normal

40. Vegemite, bread, cereal, ham.

41. For Muscle contractions and relaxations.

42. Any two of the following lifestyle changes can reduce the intake of salt.
- Make home cooked meals; home cooked meals tend to use fresher/less processed ingredients that have less hidden sodium.
 - Grocery shop for healthier alternatives; selecting items with claims of being low sodium or with high star rating (for low sodium) or avoid purchasing processed food may help reduce sodium level in diet.
 - Improve education/study nutrition; higher education in nutrition would ensure better knowledge of foods high in sodium so that they could be avoided.
 - Avoid having a saltshaker at the table and change this habit to ensure no additional salt is added to food after it being cooked and prepared.
43. Diuretics promote the excretion of water via the kidneys as urine. This directly reflects the additional water that is held in the blood due to excess sodium and its ability to retain fluid in the body. By excreting additional water, blood volume will reduce and therefore cause blood pressure to decrease.

However, diuretics can dehydrate people and therefore is not preferred as a first line drug for hypertension. Dietary changes are advised as the primary management, followed by the administration of ACE inhibitors, which acts as a vasodilator and widens blood vessels allowing blood to flow easier and therefore reducing blood pressure.

Review Solutions

1. Visceral fat is more dangerous than subcutaneous, as it surrounds vital organs, such as the heart, lungs, liver and pancreas. This increases the risk of cardiovascular disease, high blood pressure, insulin resistance, fatty liver disease, type 2 diabetes and other obesity related diseases.
2. Insulin resistance is a condition where the body's cells do not respond to insulin, thus not allowing glucose to enter the cell from the blood for energy production and/or storage.
3. Energy dense foods are lower in beneficial nutrients, including fibre, vitamins, minerals and protein and high in kilojoules per gram (energy). Whereas, nutrient dense nutrients are high in these beneficial nutrients and lower in kilojoules (energy).
4. The level of LDL declined across the 12-month period from 4.2mmol/L to 3.2mmol/L, whereas the level of HDL increased from 0.9mmol/L to 1.3mmol/L. This is because as HDL levels increased, excess LDL was removed from the artery walls for removal as waste.
5. Android Body Type
6. Excess salt in the diet will eventuate in heightened sodium levels in the blood, which will attract and hold water in the bloodstream thereby increasing blood volume. A larger volume of water moving through the arteries will increase blood pressure, as it will require the muscles of the artery walls to work harder to push through more blood.
7. Possible groups at risk of developing type II diabetes:
 - Individuals from a low socioeconomic area are more likely to consume processed foods, which are higher in sugar, saturated fat and low in fibre are more affordable. These individuals may lack the education or knowledge about the impact of these foods on the development of this disorder.
 - Those who have family members with type II diabetes – this increases their risk due to genetic factors, which can influence the production of insulin and its effectiveness.
 - Geographic isolation – people in rural or remote communities may have to rely to processed foods or do not have access to fresh produce, which are high in fibre, vitamins, minerals and lack added sugars.
 - Overweight or obese people – this increases the pressure on the pancreas and insulin resistance. They may also struggle losing weight and becoming active.
 - Alcohol dependent people – alcohol can be high in simple sugars, which can elevate blood glucose levels putting further stress on the pancreas to produce insulin. Alcohol can also make symptoms and complications of diabetes more severe.
8. (a) Andrew's type 2 diabetes causes ineffective movement of blood glucose into the cells due to insulin resistance, leaving blood glucose levels high. Both high blood glucose levels and insulin levels can damage artery walls, therefore promoting the depositing of LDL cholesterol at these sites.

(b) Age or Gender (male)



(c) *Need to use data in your response and justify why.*

Meal A would be more suitable, as it is lower in the nutrients that can increase the levels of blood LDL (contains 1g less saturated fat and 9g less of simple sugars). Meal A is also higher in dietary fibre (containing 8g more), which can decrease the amount of LDL in the blood. Meal A is also lower in kilojoules (contains 460kJ less), reducing the risk of excess kilojoules being stored in adipose tissue and developing obesity.

However, Meal B may be considered also more suitable due to containing less total fat (3g less), which would reduce overall blood triglyceride levels that can deposit in plaque. As well as this, Meal B is lower in sodium (69mg less) which reduces the risk of developing hypertension that can cause damage to the endothelium of the artery walls.

(d) *Any of the following ways:*

- Exercise can increase HDL levels, which remove LDL as waste and therefore reduce plaque deposits of atherosclerosis.
- Exercise can utilise blood triglycerides, reducing them depositing in arteries walls.
- Exercise improves blood glucose and insulin control, reducing potential damage to artery walls via the development of type 2 diabetes and high blood pressure and therefore reducing likelihood of LDL deposition and atherosclerosis.
- Exercise can burn kJs, reducing the chance of obesity which is linked to lower HDL levels which assist in removing excess LDL as waste.

9. (a) *Smoking can lead to hypertension in a number of ways:*

- The chemicals in cigarettes can damage the artery lining (endothelium) thereby promoting LDL deposition, which leads to the formation of plaque at the sites. This can cause an enlargement of plaque into the lumen (artery space) of the artery, narrowing the artery and causing blood pressure to increase.
- The drugs in cigarettes can also cause artery walls to vasoconstrict, therefore blood is forced to pass through a smaller artery space, and this results in an increased blood pressure.

(b) Chronic hypertension can cause damage to the endothelium lining of the artery walls, which promotes the depositing of excess LDL cholesterol at these sites. This can then lead to the formation of plaque, and the hardening and narrowing of arteries – atherosclerosis. Whereas, atherosclerosis can cause the growth of plaque to bulge into the lumen of the artery, narrowing its diameter. This forces blood to place more pressure against the arterial walls, increasing blood pressure.

10. (a) George had a rapid spike in blood glucose levels from 5.8-16mmol/L (approx.) whereas Paul remained steady and low at approximately 6mmol/L for the first 2 hours.

(b) Symptoms may include:

- Frequent urination – increase fluid consumption due to increased thirst and excretion of excess glucose in urine
- Increased thirst – increased urination
- Blurred vision – pressure behind the eye causes the swelling of the lens
- Tiredness – glucose not entering the cell, low glycogen stores, due to fluctuating blood glucose levels
- Tingling and numbness in the limbs – damage to nerve endings
- Poor circulation – due to excess glucose in the blood
- UTI – too much glucose in urine and microorganisms found in the urinary tract require glucose
- Hyper-glycaemia/hypo – low or high glucose levels that can cause fainting

(c) (i) Possible diet Modifications:

- Reduce intake of Takeaway foods and processed foods–High in sugar (increases BGL) and saturated fat (increases adipose tissue)
- Increase consumption of fruit and veg, low GI foods, soluble fibre – slow release of glucose, increases satiety, wide variety of nutrients especially complex carbohydrates

(ii) Possible lifestyle Modifications:

- Attend weight loss support groups
- Continue seeing a dietitian
- Learn to cook vegetables in an appealing way
- Make homemade meals
- Join a gym
- Get family support
- Have healthy options at the café
- Limit social events that consume alcohol
- See a personal trainer
- Variety of exercises and foods to keep motivation and engagement
- Exercise with friends
- Exercise with music
- Set achievable goals
- Set rewards
- Parking further away from work
- Reduce Alcohol Intake—High in sugar, increases blood glucose levels

11. (a) *any of the following dietary modifications:*

- Decrease his consumption of packaged, convenience meals and takeaway food, which are high in saturated fat, sugar and salt
- Increase his consumption of nutrient dense foods, which are high in vitamins, minerals, fibre and protein

(b) *Any of the following lifestyle modifications:*

Increase physical activity, which would increase his energy expenditure and reduce the risk of fat accumulation in adipose tissue. Physical activity also would increase his metabolism due to the increase in lean muscle tissue.

Limit alcohol consumption in a social setting, as it is high in simple sugars and kilojoules (29kJ/g). This will reduce fat accumulation.

Changing unhealthy eating habits and preparing home cooked meals rather than relying on packaged, convenience meals and takeaway food, which are high in fat, sugar and salt and low in fibre.

Keep a positive mental attitude (as negative attitudes can lead to negative food choices) and seek advice and help to limit the stressful environment he works in. He could look at reducing his work hours also, which will give him more time to purchase and cook ingredients/meals at home.

12. (a) The prevalence of diabetes from 18 to 74 years increases for all four age groups and gender. The prevalence in females increases from 1.5% to 10-12%, and in males increases from 2% to 18%. Males have a greater prevalence of diabetes at each age group than females, where the largest increase for males is from 55- 74 with an 18-20% increase.

(b) Males have a greater prevalence of diabetes in each age group, which can be due to their distribution of fat around the body. Males tend to store their weight around the abdomen, putting pressure on vital organs including the pancreas. This type of fat is known as visceral. Whereas, females have greater amounts of subcutaneous fat which is stored on the thighs and hips.

13. *Any of the following modifications can be suitable:*

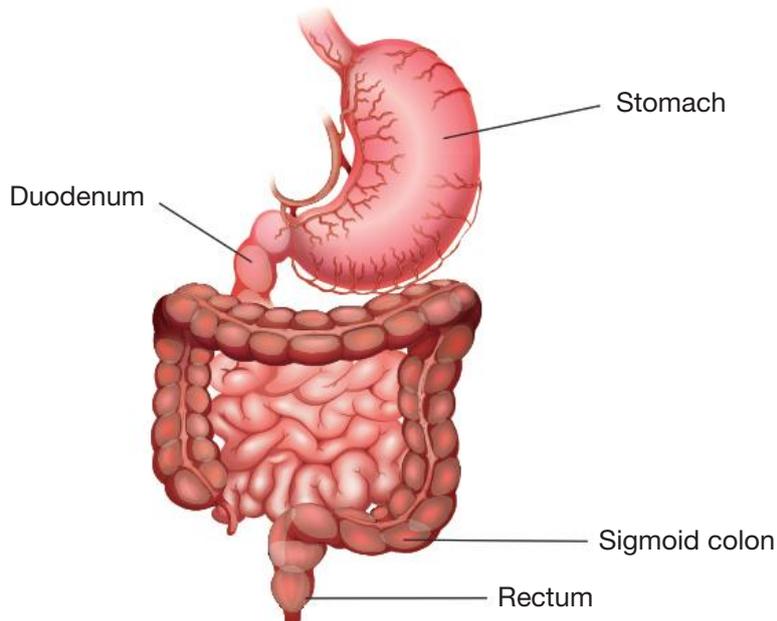
- Replace whole egg with egg white
- Replace beef mince with leaner mince e.g. turkey or pork or tofu or suitable vegetable
- Replace butter with margarine from plant sterols
- Replace tomato sauce for fresh tomatoes or low salt/sugar alternatives
- Replace Worcestershire sauce for miso paste and water
- Replace short crust and puff pastry for Filo or whole meal pastry



1.10: Imbalance of nutrient intake – under nutrition disorders

Topic Solutions

1.



2. (a) Insoluble fibre adds bulk and weight to faeces as it does not get broken down; helping them to move through the digestive tract, which reduces the chance of constipation
- (b) Soluble fibre attracts and binds to water. This water allows for softer stools that are easier to pass, whereas constipation is associated with hard stools lacking in water.

Or

Soluble fibre adds bulk and weight to faeces as bacteria die during the fermentation process (breakdown of soluble fibre by bacteria). This helps to move faeces through the digestive tract, which reduces the chance of constipation.

- (c) Water produces soft stools, preventing them from drying out and getting stuck in the large intestines. This promotes easy evacuation from the colon, preventing the risk of constipation.
3. Soluble Fibre: any fruit or vegetable (particularly flesh) e.g. apple, pumpkin; legumes, oats, soy products e.g. tofu, etc.

Insoluble fibre: any fruit or vegetable e.g. pear, spinach (particularly skin); wholegrain products e.g. wholegrain cereal, etc.

Water: Any fruit e.g. watermelon; any vegetable e.g. cabbage; yoghurt; meat e.g. prawn; any food that soaks up water as it cooks e.g. pasta; etc.

4. *Any one of the following:*

- Excessive exercise, causing additional perspiration or loss of water via sweat (or respiration) would increase water needs.
- Hot climate or humid conditions, causing additional perspiration or loss of water via sweat (or respiration) would increase water needs.
- Fever, causing additional perspiration or loss of water via sweat (or respiration) would increase water needs.
- Consumption of alcohol, caffeine, excess sodium or protein; these factors can increase urination levels, therefore additional water is required to replace that lost in urine.
- Excess fibre/food poisoning/illness; can lead to diarrhoea (and vomiting for food poisoning/illness) and additional water loss.

5. Oxygen is an essential requirement for aerobic respiration to occur in the body's tissues and organs. Aerobic respiration uses oxygen and glucose to produce water, carbon dioxide (waste product) and ATP (energy).

6. The unusual shape and small size of the red blood cells in iron deficiency anaemia would reduce the amount of oxygen transported and delivered to the body's tissues and organs. The unusual shape can also reduce the surface area to volume ratio, which would reduce the exchange of oxygen and carbon dioxide in the lungs and body tissues. This would deprive cells of oxygen, preventing them from producing an adequate amount of ATP (energy).
7. (a) Iron deficient anaemia is a reduced number of quality red blood cells to carry an adequate amount of oxygen to the body's tissues and cells. This deprives cells of oxygen, reducing the amount of ATP (energy) produced through aerobic respiration, causing fatigue.
- (b) The red blood cells in iron deficient anaemia have a reduced amount of the protein haemoglobin, which is responsible for binding to oxygen molecules. When haemoglobin is attached to oxygen molecules, it provides the characteristic red colour to these cells. Therefore, if there is a lack of haemoglobin in the red blood cell, this will reduce the amount of oxygen attached, reducing its red colour.
- (c) As there is a lower concentration of quality red blood cells in circulation, the heart has to pump harder to get oxygen around the body and to all tissues and organs.
8. A diet low in iron can lead to iron deficiency anaemia, leading to a severe depletion of iron stores in the body. This causes a decrease in haemoglobin production and resulting in a low concentration of this protein in red blood cells. This leaves red blood cells pale in colour and small in size, compromising their quality.
9. (a) Haem Iron
- (b) *Any of the following groups:*
- Vegans or Vegetarians due to beliefs
 - Low socioeconomic status due to animal proteins being more expensive
 - Elderly as red meat can be difficult to chew
10. Vitamin C
11. Folate (Vitamin B9) and Vitamin B12. The role of both of these vitamins is to act as a coenzyme in DNA synthesis in red blood cell production. Therefore, a low intake of these vitamins results in the production of abnormal and impaired red blood cells.
12. Coeliac Disease or surgeries which have removed/skips a segment of the small intestine e.g. gastric bypass.
13. Male: 8mg Female: 18mg
14. (a) Haem Iron: Meat, chicken, fish
- (b) Non-haem: lentils, beans, tofu, nuts, seeds, grains, eggs and dairy products.
- (c) Vitamin C: Citrus fruits such as oranges and limes, plus kiwifruit and strawberries, green leafy vegetables including Brussels sprouts, spinach and broccoli.

15.

Food or Beverage Source	Increase or Decrease intake
Oranges	Increase
Excessive milk and yoghurt	Decrease
English Breakfast Tea	Decrease
Lamb	Increase
Fresh Salmon	Increase
Eggs	Decrease
Fortified cereals	Increase
Broccoli with orange juice	Increase

16. *Any one of the following:* Infants, Children, Adolescents, Pregnant females
17. Menstrual cycles where a significant amount of blood is lost each month.
18. Athletes can heavily sweat; therefore, losing iron stores from the body as it is a water soluble mineral.
19. Haem iron is better absorbed by the body at a rate of 7-35%, whereas non-haem iron is absorbed at a rate of 2-20%. This is dependent on an individual's dietary factors and the body's iron stores.

20.

Individual at risk of iron deficient anaemia	Reason
Child aged between 5-12 years old	Rapid growth and increase in blood volume
Individual with a serious injury to the skin	Rapid loss of excessive blood causing a loss of red blood cells and iron stores
Male Marathon runner	High energy demands Significant loss of Iron via sweat
Adolescent female aged 16 years old	Puberty causing an increase in blood volume Blood Loss – menstrual cycle
4 month pregnant female	Rapid growth and increase in blood volume Loss of Iron to the foetus
Individual with Coeliac Disease	Impaired absorption of Iron due to damaged villi
Chronic Coffee Consumer	Impaired absorption of Iron
Leukaemia Patient	Disrupts the production of red blood cells
Vegan	Does not consume animal products, which contain haem iron and are more readily absorbed
Haemolytic Anaemic	Reduces the life span of red blood cells, increasing the demand from the bone marrow

21. *Any two of the following:* keep the body supported, protect vital organs, enable movement and are attachment points for muscles, tendons and ligaments

22. Greater risk of developing osteoporosis later in life.

23.

Age (years)	Bone Formation in comparison to Bone Resorption
0 – 25	Bone formation is greater than (>) bone resorption
25 – 40	Bone formation is equal (=) to bone resorption
> 40	Bone formation is less than (<) bone resorption

24. Calcium Phosphate

25. Calcium and phosphorus combine to form calcium phosphate, which form on a matrix of the protein collagen during bone formation. During mineralisation, the crystals become denser providing strength and rigidity to the bones.

26. Vitamin D

27. (a) Calcium: Dairy products, including milk, cheese and yoghurt. Vegan food sources: tofu, almonds, sesame seeds, green leafy vegetables, and fortified products (e.g. soy milks, juices and cereals).

(b) Phosphorus: commonly found in all foods, foods rich in proteins are a great source.

(c) Vitamin D: Oily fish, liver and eggs, fortified foods such as milk, orange juice, oily spreads (e.g. margarine) and cereals.

28.

Food or Beverage Source	Increase or Decrease intake
Cow's Milk	Increase
Salmon	Increase
Pepsi	Decrease
Coffee	Decrease
Yoghurt	Increase
Wholegrains	Decrease
Processed Foods	Decrease
Fortified Orange Juice	Increase

29. As an individual ages, the rate of bone resorption becomes greater than bone formation. Therefore, this causes bone loss, reducing the density and strength of the bone matrix.
30. *Any one of the following:* High alcohol consumption, Low BMI, poor diet (low in calcium, phosphorus and vitamin D), lack of weight-bearing exercise or resistance training.
31. Examples of weight-bearing exercises include walking, aerobics, running, jumping, hiking, jogging, climbing stairs, playing tennis, and dancing. Resistance exercises include lifting weights, using elastic exercise bands, lifting own body weight and using weight training machines.
32. (a) Increase in bone density, achieving an optimal peak bone mass and therefore reducing the risk/delaying the onset of osteoporosis later in life.
 (b) Minimises the loss of bone density, reducing the risk/delaying the onset of osteoporosis later in life.
 (c) Minimises the loss of bone density, assisting in managing osteoporosis.
33. Ultraviolet radiation (UV) from the sun.
34. Diuretics increase urine production and the loss of water from the body. This increases the amount of calcium excreted from the blood, as it is a water-soluble nutrient.
35. Below 18.5
36. The body will absorb calcium from the bones.
37. Vitamin D production will be reduced, reducing calcium absorption.

Review Solutions

1. (a) Eating processed/energy-dense foods, these foods can be low in fibre/water leading to constipation which requires higher pressure within the GIT to remove the hard/dry faeces, increasing the chances of diverticular disease developing
- (b) *Any of the following would be acceptable:*
- Exercise assists the movement of the faeces through the intestines by improving gut motility, as the intestinal walls contract pushing food and faeces through.
 - Live with family/flatmate, to increase motivation to cook nutrient-dense meals that are higher in water/fibre
 - Avoid straining and holding faeces in the large intestines as water is reabsorbed at this site, which makes stools hard.
 - Avoid the overuse of laxatives, as this can cause damage to the nerves in the large intestines and can weaken the muscles of the large intestines preventing them from being able to contract and push the faecal matter out.
- (c) Large intestines (sigmoid colon) or colon are where small pouches or pockets generally develop.
- (d) *Any of the following symptoms:*
- Blood in faeces caused by the pouches pushing through GIT lining, harming a blood vessel
 - Abdominal pain/bloating caused from pouches pushing through GIT or becoming infected/inflamed
 - Fever, from pouches becoming infected due to faeces becoming trapped in pouches allowing bacterial growth
2. (a) Haem and non-Haem iron
- (b) (i) Canned steak and vegetables
 (ii) Micronutrient: Vitamin C
 Food Sources: Citrus fruits such as oranges and limes, plus kiwifruit and strawberries, green leafy vegetables including Brussel sprouts, spinach and broccoli.
- (c) Iron assists in the production of haemoglobin, which is a significant component of red blood cells. Without haemoglobin, the quality of red blood cells is compromised as this is the component that provides the red colour to these cells and attaches to oxygen, which is carried to the body's tissues and organs for aerobic respiration.
- (d) A healthy red blood cell has a concave shape on both sides, where its surface curves inwards. Its flexible disc shape increases its surface area to volume ratio, allowing for oxygen and carbon dioxide to be exchanged more readily. Its shape is also essential in its ability to move through tiny blood cells to reach



all tissues in the body. In an individual with Iron Deficient Anaemia, the red blood cells appear abnormal and are unusually small (microcytic) and pale (hypochromic) in colour.

(e) *Any two of the following:* Infants and children, adolescents, pregnant females, menstruating females, Cancer patients, vegans and vegetarians, individuals who rapidly lose a significant amount of blood, individuals with infections or an autoimmune disorder, endurance athletes.

3. (a) Diverticulum (diverticula)

(b) Diverticulosis

4. *Any of the following differences:*

- Diverticulosis is where small pouches push through the lining of the GIT, whereas diverticulitis is where these pouches become infected/inflamed
- Diverticulosis has a symptom of abdominal pain/bloating (and symptoms of excessive flatulence, fluctuations between diarrhoea/constipation, blood in faeces) while this symptom is more severe in diverticulitis (and has differing symptoms of fever and nausea/vomiting)
- Diverticulosis requires the gradual addition of fibre supplements, water and probiotics for treatment, while diverticulitis needs antibiotics, a liquid diet and potentially surgery to remove the infected part of the colon prior to it spreading to other parts in the body.

5. (a) Males and females go through puberty during this age and therefore a growth spurt including in their skeleton and bone mass.

(b) The RDI for females is greater at the age of 50, as this is the approximate age menopause is experienced. Menopause promotes greater bone resorption; therefore greater calcium is required to be consumed to increase the rate of bone formation.

(c) Fortified soy/almond milk, fortified orange juice

(d) Phosphoric acid or caffeine (both reduce calcium absorption and/or bioavailability)

6. (a) 15 years old

(b) His iron requirements increase by around 9mg in total, where they increase 1mg/year for 3 years and then suddenly increase of 5mg for a year, followed by smaller increases of 2mg/year for the next year.

(c) Menstruation – monthly loss of blood

(d) Pregnancy or participation in a high-intensity/contact sport for the year

(e) *Any of the following:* Spinach/rhubarb (oxalic acid); caffeinated or alcoholic drinks (diuretics); bran or wholegrain (phytic acid); tea (tannins)

(f) *Any one of the following:*

Fatigue: reduced iron intake will lead to reduced haemoglobin production, reducing the quality of red blood cells produced. Therefore, less red blood cells in circulation will reduce the transportation and delivery of oxygen to tissues and organs for cell respiration.

Paleness: The red blood cells in iron deficient anaemia have a reduced amount of the protein haemoglobin, which is responsible for binding to oxygen molecules. When haemoglobin is attached to oxygen molecules, it provides the characteristic red colour to these cells. Therefore, if there is a lack of haemoglobin in the red blood cell, this will reduce the amount of oxygen attached, reducing its red colour.

Fast Heart Rate: As there is a lower concentration of quality red blood cells in circulation, the heart has to pump harder to get oxygen around the body and to all tissues and organs.

7. (a) Vitamin D

(b) *Any two of the following:* *Any two of the following:* increase weight-bearing exercise and resistance training, reduce alcohol consumption, stop smoking, reduce caffeine consumption and/or increase sunlight exposure.

(c) 1. Females experience menopause, which causes a decline in the hormone oestrogen. This increases the rate of bone resorption decreasing bone density and strength.

2. Males generally have greater muscle mass than women. Therefore, when these muscle tissues are activated, they place stress on the bones, encouraging osteoblasts to migrate to these stressed areas to begin laying down new bone. This increases bone strength in these areas, as a greater amount of calcium phosphate is deposited.

Topic 1.11: Nutrition through the life cycle

Topic Solutions

- 50th percentile
 - Between the 85th and 97th percentile
- 50th percentile
 - 97th percentile
 - 3rd percentile
- Iodine and Vitamin D.
- Vitamin B₆, Magnesium or Iron.
- This example demonstrates the key concept of Influence, as it explains the acceptance of lab made human breast milk was influenced by social, economic and ethical considerations which consider the importance of infant nutrition and the rising prevalence of new mothers that are unable to produce enough breastmilk or have issues with latching or mastitis. These considerations are evident in the article through the following examples:

Social:

- A new mother gave birth to her son early, who had trouble latching, and she struggled to stimulate enough milk.
- She ended up “pumping constantly” and felt beat down by messaging that if breastfeeding didn’t come easily, she just had to try harder.
- It affected how I felt about myself as a woman and as a mother.
- Babies need to eat, and infant nutrition is still going to be fundamentally important for generations to come.
- The American Academy of Paediatrics and the World Health Organisation recommend babies exclusively breastfeed for the first six months of life. The guidance is based on extensive research showing that breastfeeding is linked to a host of physical and mental health benefits for both the birthing parent and baby.
- Breast milk helps protect babies from issues like childhood leukemia and obesity, and is associated with a lower risk of type 2 diabetes and certain cancers in the birthing parent.
- Breastfeeding can help a new parent heal from childbirth and encourage bonding between the parent and infant.
- Formula can be harder for the baby to digest and doesn’t adapt to the infant’s changing needs like breastmilk. And formula can’t replicate all of those benefits since it’s not made from human-made. Instead, it comes from cows, plants, or both.
- It can come in handy for dads, non-biological parents, or parents whose babies have food allergies and can’t tolerate breast milk after their birthing parent has eaten that allergen.
- The important thing is to get fundamental nutrition right for an infant, and this is a new tool in our toolbelt that’s able to get us there faster or better than the existing options that are sold in the market today.
- She wouldn’t choose it over human breastmilk, though, due to its inability to transmit antibodies and build up the baby’s immune system.

Economic:

- Formula – while “a safe, relatively affordable, thoughtfully designed, rigorously tested, and continually improving” alternative to breast milk.
- Heather Guith, a Washington, DC, mum to an 1-and-a-half-year-old for whom nursing, said she’d only choose it if it were priced similarly to formula.
- A third option, using donor milk, is expensive

Ethical

- I think its marketing itself as something it is not and making really great parents feel bad about using formula because there might be a ‘better’ option.
- Donor milk can be unregulated when accessed via a black market.



This example demonstrates the key concept of development, as it explains the development of lab made human breast milk which is better than formula and can provide adequate nutrition to infants in the crucial first six months of their life. This key concept is evident in the article through the following examples:

- Strickland and Egger say they have created the two main components in breast milk.
 - In February, they announced they had reached a pivotal step in achieving their goal of creating a cultured breast milk that's "nutritionally equivalent" to the real thing.
 - Their lab-grown mammary cells made the two key components of breast milk: lactose and casein.
 - We are the first company to produce vital components of milk together within the same system using a process that is sterile from start to finish and free of all contamination.
 - This innovation allows us to create the full constellation of complex components in perfect proportion.
 - They do expect it to produce all 2,500-some components of human breast milk since a single cell, the human mammary epithelial cell, produces them all.
6. Iron is a significant component of haemoglobin, which is found in red blood cells. An increase in blood volume, would require an increase in red blood cell production, which would therefore require an increase in iron requirements.
 7. Iron is a component of the oxygen-binding protein myoglobin, which is found in the body's lean body mass (e.g. muscles). As this component of the body develops, an increase in myoglobin would be required as it allows oxygen to be stored for muscles efficiency.
 8. The situation which would cause an adolescent's energy requirements to be greater are in bold.

Situation 1	Situation 2
Increase in physical activity	Living a sedentary lifestyle
Being a 10-year-old female	Being a 10-year-old male
Developing greater adipose tissue	Developing greater lean body tissue
Being a 16-year-old female	Being a 16-year-old male
The onset of puberty	The completion of puberty

Review Questions

1.

Life stage name	Physiological characteristic
Adulthood	Growth ceases
Childhood	Aged between 1-12
Elderly	Activity levels can decrease due to joint/muscle pain
Infancy	Very fast growth rate (can double in height in one year)
Childhood	Puberty begins
Adolescence	Very rapid growth rate, but exercise may cease for some
Adulthood	Lean muscle mass and bone density begin to decline
Elderly	Immune system function declines
2.
 - (a) The proportion of fat is the highest in all three fluids, where it is the highest in human breast milk (55%) compared to infant formula (49%) and cow's milk (51%). The proportion of carbohydrates is the second highest macronutrient provided by these fluids, where infant formula provides the highest percentage (42%) in comparison to human breast milk (39%) and cow's milk (29%). Protein represents the smallest proportion of all three macronutrients, where cow's milk provides the greatest proportion (20%) in comparison to human breast milk (6%) and infant formula (9%).
 - (b) The implications of introducing cow's milk during the first 12 months in replacement of breastmilk, may not provide adequate fat (only 51%) and too much protein (20%). Fat is required as an energy source and provides more energy than protein (37kJ/g rather than 17kJ/g), which is required for growth. Also, a higher protein concentration can also stress the infant's kidneys (which is responsible for the removal of excess protein).

3. A lactating female is at greater risk of a diet related deficiency as her nutrient intake is provided to the baby through her breastmilk. The quality of breast milk is maintained at the expense of the mother’s nutrient stores. Whereas, the nutrients are provided in the infant formula provided and not at the expense of the mother. If a lactating female fails to get enough of a specific nutrient in her diet, she may experience symptoms of nutrient deficiencies, including reduced bone density from a lack of calcium. *Other examples may be accepted if appropriate.*
4. *Identifying a barrier (1 mark) and describing a strategy to overcome the barrier is 2 marks.*

Barrier	Strategy
Economic: Limited Income—to purchase food	<ul style="list-style-type: none"> Using senior card for discounts at supermarkets Applying for senior services through council for transport to shops, home cleaning, exercise classes, organized elderly activities of lunch and games Purchase foods on special, in season, canned or frozen foods, generic brands, grow own vegetables and fruits, plant-based protein Buy in bulk and therefore prepare meals with similar ingredients Buy in season and go to farmers markets or similar (online e.g. Farmers Direct). Grow own food, cheaper meals, available
Psychological: Loneliness—no family and grieving, lack of desire to cook and eat alone Lack of Education—loss of husband who was educated in cooking/ income management	<ul style="list-style-type: none"> Use council services which promote and assist in social activities to attend supermarkets and lunches, apply for meals on wheels in which food is delivered and social interaction provided Prepare meals with foods she desired which promote happy memories Join social groups to find friends and social interaction
Physiological: Reduced function e.g. mobility, unable to use equipment etc due to—osteoporosis	<ul style="list-style-type: none"> Apply for medication and use of medical allotments of physio and exercise classes to help with pain management Meals on wheels to deliver food Purchase semi-prepared or fully cooked ready to reheat meals online to limit the physical pain of cooking from scratch Use kitchen tools which make food prep easier e.g. electric can opener Look for easy to use packaging such as pull lid cans

5. Modification one: The following modifications could be made as the food sources identified may be too hard and cause choking, or the infant may not have sufficient teeth to chew these foods.
- Apple to apple puree (or cooked apple) or a softer fruit e.g. banana
 - nuts to peanut butter paste (without added sugar/salt) or softer fruit
- Modification two: The following modification could be made as sugar is high in sugar, which can cause tooth decay or develop bad habits which can lead to the development of diet related disorders.
- juice to water/yoghurt to natural or pot set yoghurt or reduced sugar alternate
- Modification three: The following modification could be made to increase iron stores in infants, which are generally low.
- replace any of the snacks for puree meat/iron-fortified cereal
6. (a) Calcium, Vitamin D and phosphorus are the key nutrients required to assist in the growth in length and width of the skeleton. Calcium combines with phosphorus and forms Calcium Phosphate crystals on a matrix of the protein collagen during bone formation, which become denser providing strength and rigidity to the bones. Vitamin D is important for increasing the blood concentrations of Calcium and phosphate (phosphorus).
- (b) Protein is the key nutrient during puberty where the development of secondary sexual characteristics occurs. Protein synthesises hormones, which increase during puberty (e.g. testosterone in males and oestrogen and progesterone in females).

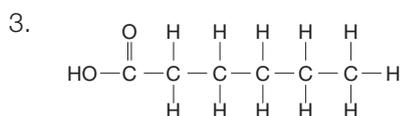


- (c) Protein is the key nutrient required when muscle mass and body weight is increased during adolescence. Protein is the building blocks of all body tissues, including muscles, bones, skin, artery walls, ligaments and tendons which would all increase with body weight.
- (d) Iron is the key nutrient required to compensate with an increase in blood volume. Iron is a significant component of haemoglobin, which is found in red blood cells and responsible for transporting oxygen.
7. (a) Elderly are at greater risk of constipation due to their GI tract losing strength and elasticity, causing food and faecal matter to remain in the digestive tract instead of being excreted. Elderly also have reduced activity levels, which can reduce gut motility and preventing food and waste to be pushed out of the GI tract.
- (b) Iron deficient anaemia is common in elderly individuals due to commonly experiencing tooth loss and gum disease, which makes chewing hard foods difficult. Therefore, older individuals may avoid consuming red meat due to the difficulty in chewing it, reducing their intake of haem iron which is more readily absorbed by the body.
- (c) Osteoporosis is common in elderly, especially females as bone resorption is greater than bone formation as age progresses. This causes a decline in bone density, increasing the risk of fractures.
8. The mother would need to stop consuming cow's milk and switch to alternatives, including almond milk to ensure her breastmilk is able to be consumed by the infant. However, the mother would need to ensure she is consuming enough calcium for herself and the baby, to avoid calcium being lost from her bones and developing osteoporosis earlier in life.

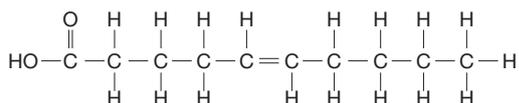
The mother may stop breastfeeding and turn to infant formula. However, this may increase the risk of breast cancer as breastfeeding can decrease the risk.

Topic One Test Solutions

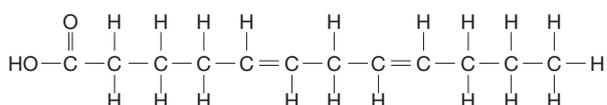
1. (a) $(350 \times 17) + (85 \times 17) + (120 \times 37)$
 $5950 + 1445 + 4440$
 Total Energy provided: 11835 kJ
- (b) $= 1445 (85 \times 17) / 11835 \times 100\%$
 $= 12.21 = 12 \% \text{ energy provided by protein}$
- (c) The actual protein intake was 12%, however the recommended intake of protein is 15-25%, and therefore the actual intake was under by a minimum of 3%. I conclude that the diet is not suitable in the long term for a 10-year-old, as they will consume an inadequate intake of protein.
2. Lactose: Disaccharide
 Fructose: Monosaccharide
 Soluble Fibre: Polysaccharide
 Galactose: Monosaccharide



Saturated Fatty Acid



Monounsaturated Fatty Acid



Polyunsaturated Fatty Acid

4. (a) Total Daily expenditure = BMR + thermic effect of food + exercise
= 12600 + (15870 × 0.1) + 580
= 14,767 kJ
- (b) Difference = Energy intake – energy expenditure
= 15870 – 14767
Difference = 1,103kJ
Therefore, Samuel's energy balance is positive which will cause him to gain weight in the long term if this pattern continues.
5. (a) A = Liver
B = Stomach
C = Small intestines
- (b) Teeth masticate the food into smaller pieces allowing for easier swallowing or to increase surface area and allow salivary enzymes to start the chemical digestion of food consumed.
- (c) *Any of the following would be suitable:*
- Carbohydrates (cooked starch) are broken down by salivary amylase into glucose (monosaccharide)
 - Lingual lipase starts the breakdown of lipids into shorter fatty acid chains
6. (a) Type II Diabetes is a progressive condition in which the levels of glucose in the blood are too high, as the pancreas produces little or ineffective insulin (insulin resistance). Insulin enables glucose to enter the body's cells, where it is used during respiration to produce ATP (energy). A high consumption of sugar can put stress on the beta cells in the pancreas, which can increase the amount of ineffective insulin produced.
- (b) (i) When blood glucose levels are high over a long period of time, fluid is drawn into the eye causing it to swell. This can cause blurred vision
- (ii) As blood glucose levels continue to rise, excess glucose spills into the urine. The kidneys filter the blood when producing urine, where all glucose is normally reabsorbed into the blood. However, in a type II diabetic blood glucose levels are abnormally high, where not all sugar can be reabsorbed: thus, ending up in urine. This results in unusually large volumes of urine, which draws more water. Therefore, this frequent urination can lead to dehydration and excessive thirst also
- (iii) When glucose fails to enter the body's cells, this deprives them of energy as glucose is a vital component in cell respiration. This leaves the body feeling fatigued.
- (c) The glycaemic index (GI) ranks carbohydrates according to their effect on blood glucose levels. Slow absorption (Low GI) leads to a moderate rise in blood glucose levels and a smooth return to normal, which is easier for a diabetic to manage. Fast absorption (High GI foods) results in a rapid spike in blood glucose levels, which cannot be managed. This is why it is recommended for a diabetic to consume high GI in combination with low GI carbohydrates to slow down the release of glucose into the blood. Glycaemic load takes into account the effect of carbohydrates on blood glucose levels as well as the amount of carbohydrates in a meal therefore it can be more beneficial for a diabetic.
7. (a) Iron assists in producing two important proteins in the body: haemoglobin and myoglobin. Haemoglobin is a significant component of red blood cells, which binds to oxygen molecules allowing for it to be transported throughout the body and delivered to tissues and organs. Therefore, iron enhances the quality of red blood cells in the body, preventing the development of iron deficient anaemia.
- (b) Haemoglobin is the component of red blood cells, which carries oxygen throughout the body and provides the red pigmentation of this cell. Therefore, paleness and fatigue are common symptoms due to a deficiency in the number and quality of red blood cells. Oxygen is required by the body's cells for aerobic respiration to occur, which produces ATP (energy) for the body to use to fuel its bodily processes.

8. (a) Diverticular Disease
- (b) (i) Soluble fibre is broken down in the large intestines by bacteria via a process known as fermentation.
- (ii) One way that soluble fibre can prevent constipation can include:
- Soluble fibre produces soft stools due to its water attracting abilities, allowing for easier excretion from the body.
 - Soluble fibre also makes stools bulky, due to the addition of dead bacteria that die during the fermentation process. This also allows for their easy excretion from the body.
- (iii) Soluble fibre food sources may include:
- Wheat/wholegrain bread
 - Wholegrain pasta
 - Wholegrain cereals
 - Oatmeal
 - Brown rice

Other options available also.

9. Smoking: can cause damage to the endothelial lining of the artery wall making it less elastic, causing plaque deposits to grow faster and larger. This causes the heart to work harder to pump blood, elevating blood pressure.

Alcohol: alcohol is high in sugar and kilojoules; therefore, an overconsumption of alcohol can contribute to the accumulation of adipose tissue; leading to the development of obesity. This is a risk factor of hypertension. Excessive consumption of alcohol over a sustained period, can increase blood pressure also due to its vaso-constrictive properties.

10. (a) Any one of the following ingredients: Self-raising flour, oats, plain flour
- These ingredients contain the protein gluten which the immune systems react abnormally to, causing inflammation of the villi.
- (b) Gluten found in ingredients can damage or flatten villi/microvilli in small intestine. This decreases the surface area and reduces the absorption of nutrients, increasing the risk of developing nutrient deficiencies.
11. (a) *Any of the following substitutions would be suitable:*
- Pork and veal Mince → lentils, beans, chargrilled vegetables, soya beans
 - Grated Pizza Cheese / Parmesan Cheese → low fat cheese, vegan cheese
 - Butter → polyunsaturated margarine
 - Full cream milk → low fat milk, almond milk, soy milk
- (b) The following modifications could be made to the recipe for the potato chips:
- Oven bake the wedges instead of deep frying to reduce the amount of absorption of vegetable oil (saturated fat).
 - Avoid adding salt to the wedges and replace with oregano (herbs).
 - Cut fries into thicker pieces rather than shoestring fries, to reduce the amount of vegetable oil (saturated fat) absorbed by each potato.

12. (a) Vitamin B₁ content in the broccoli during boiling (mg)
- (b) *Any of the following:*
- Amount / thickness of broccoli = Smaller pieces/amount will lose vitamin content faster
 - Volume of water broccoli is boiled in = not enough water may reduce vitamin loss due to leaching
 - Age of broccoli = older broccoli may have lower vitamin content to begin with due to vitamin content denaturing due to exposure to oxygen and light
 - Type of broccoli = different types may have differing amounts of vitamins to begin with
 - Temperature of boiling water = hotter temperature will result in greater vitamin loss
 - Broccoli samples come from the same part of the broccoli (e.g. stem) = different parts of the broccoli may have differing amounts of vitamins to begin with or may be effected by temperature differently
- (c) Boiled broccoli loses 0.1mg of Vitamin B₁, as this vitamin is water soluble and will leech out into the surrounding water that is used to boil the broccoli.

(d) *Any one of the following:*

- Urine
- Faeces
- Perspiration
- Tears
- Blood

(e) Function: acts as a coenzyme in the metabolism of macronutrients, which assists in the release of their energy. However, vitamin B₁ specifically acts as a coenzyme that assists enzymes in the breakdown of glucose, for energy production.

Food Sources: Wholegrain or fortified bread and cereal products, meat, poultry, legumes, dark green leafy vegetables (such as broccoli, turnip greens, asparagus and spinach), yeast and vegemite.

13. (a) (i) Hypertension (high blood pressure)
- (ii) His blood pressure should be 120/80, where the first value represents when the heart muscle is contracting and pushing blood through the arteries to the body (systolic blood pressure). The second value represent between heart beats, when the heart muscle is relaxing and filling with blood, (diastolic pressure).
- (iii) Atherosclerosis, Heart Attack, PVD or Stroke.
- (b) (i) Coronary Heart Disease
- (ii) Consumption of foods that are *high* in saturated fat significantly increases the livers production of very low-density lipoprotein (VLDL), the pre-cursor to LDL. This results in raising LDL cholesterol in the blood, which can accumulate at damaged sites along the endothelium lining of the artery wall. This was likely to occur in blood vessels supplying the heart.
- (iii) *Any of the following:*
- Stressful working environment
 - Lack of exercise
 - Being classified as overweight
- (c) (i) Osteoporosis.
- (ii) Her increasing age is a risk factor for the development of osteoporosis, as bone loss increases with age. This is because bone resorption (loss) is greater than bone ossification (formation).
- (iii) Calcium and Phosphorus
- (iv) *Some sources may include:*
- Increase:
- Calcium: milk, cheese, yoghurt, tofu, almonds, sesame seeds, green leafy vegetables, fortified products
- Vitamin D: oily fish, liver, eggs.
- Decrease: coffee (diuretic), tea (oxalic acid), whole bran products (insoluble fibre), soft drinks (phosphoric acid), alcohol (diuretic), spinach (oxalic acid).
- (d) (i) This male may have:
- Obesity (due to his morbidly obese BMI category)
 - Type II Diabetes (due to high blood glucose levels)
 - Hypertension (due to high blood pressure reading)
 - Atherosclerosis/Cardiovascular disease (due to high blood pressure and obesity being a risk factor for this disease)
- (ii) Diet: reduce his intake of take away and processed foods, reduce his intake of sodium, reduce his intake of high GI carbohydrates and replace with low GI carbohydrates, ensure his energy intake is less than his expenditure.
- Lifestyle: Quit smoking, increase exercise performed, Lose weight.
- (iii) This male has high blood pressure and is a smoker, which can damage the endothelium lining of the artery wall promoting the accumulation of LDL cholesterol. He would have high levels of LDL cholesterol in his blood due to his high consumption of processed and takeaway foods that are high in saturated fat. The accumulation of LDL cholesterol must have occurred in a blood vessel supplying blood to the brain, therefore causing a stroke.

Topic 2.1: Diagnostic Tools

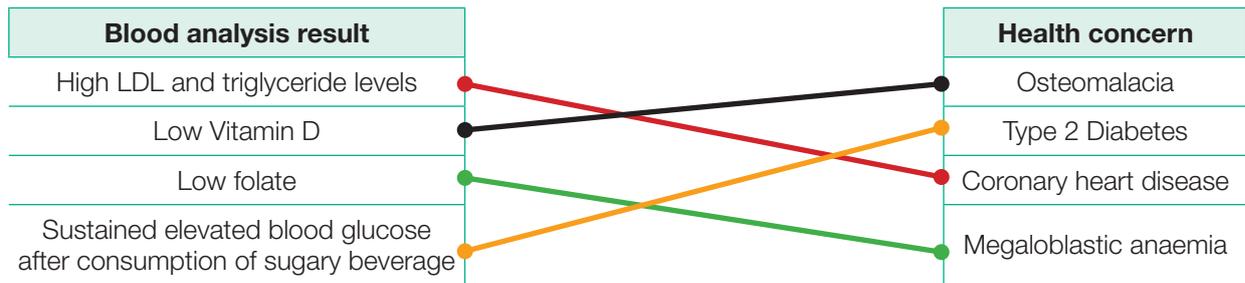
Topic Solutions

1. Male = android (apple) Female = gynoid (pear)
2. (a) Formula = weight (kg)/height (m)²
= $59/1.68^2$
= 20.90
BMI = 21 kg/m²
(b) Healthy
3. (a) BMI = $99/1.722^2$
= 33.46
= 33 kg/m²
(b) Obese
4. Compared to BMI, calculations of RPM are more accurate or closer to their true value (which can be found by dual energy X-ray absorptiometry (DXA)). It also tended to account for limiting factors of the BMI including race, gender and muscle mass to a larger extent, indicated by fewer false obesity results; for example, obese classification for an athlete who has a high muscle mass. Fewer false results improves the reliability of data analysis and reduces misclassification of obesity.
5. (a) Underweight
(b) Overweight
6. Less equipment required; no calculation needed; able to be used by the elderly or athletes more accurately due to waist circumference focusing on visceral fat deposition (not weight).
7. Error one: measuring patients with different amounts of clothing layering/thickness, thicker layer of clothing/ more clothing on would increase the waist circumference.

Error two: measuring above or below the halfway line, lower or higher waist measurements could reduce/ or increase (dependent on body shape) the waist circumference.

Taking the measurement when breathing in, would increase the waist circumference; Pulling the tape too tight/loose, would decrease/increase the waist circumference.
8. (a) (i) $61/78 = 0.78$
(ii) No increased risk
(b) (i) $99/84 = 1.18$
(ii) Increased risk
9. (a) 25-30g
(b) 45-65%
10. (a) Not suitable/too low; the iron intake is 2mg/day lower than the EAR (minimum recommended)/12mg lower than the RDI.
(b) Anaemia
(c) Any meat/legume/nut/seed; any wholegrain product; legumes/green vegetables like broccoli/ spinach
(d) Loss of menstrual cycle/post-menopausal life stage

11. Match the following blood analysis results to their associated health risk:



12. Not as accurate; can't be used by quite a number of people e.g. pregnant, elderly, children, etc.

Review Solutions

- Healthy weight range
 - Approximately 70-95kg
 - Calculation not required (easier).
- BMI is a measure of weight divided by height (squared) in order to classify someone into weight categories of underweight, through to obese.
 - Advantage: inexpensive; non-invasive; equipment is easy and straight-forward to use; not very time consuming.

Disadvantage: requires a calculation; is not entirely accurate/is an estimate; recording of height/weight can be inaccurate/misleading.

Limitation: doesn't consider age (children), ethnicity (e.g. Asians, Torres Strait islanders), gender and body composition; pregnancy; those with physical disability; athletes/body builders with high lean muscle mass.
 - Scales not calibrated all participants may be given a weight over their actual/true weight, giving elevated BMIs.

Scales may not be used on a flat surface, all participants measured weight would be skewed away from their true value.

Measuring tape may be crooked/taped with bends in it, all participants would get a higher height than their actual height, reducing accuracy.
 - Different weights of clothing for each participant, participants instructed to change into the same provided light clothes (same weight) before being weighed.

Subjects alternately standing too low/high/to one side on scales, have participants stand into pre-drawn foot area.

Subjects posture different, have participant barefoot with light clothing to feel feet, calves, buttocks and back against the wall to stand straight

Ruler not parallel, use a level to ensure measuring height parallel from head to measuring tape.
- Formula = weight (kg)/height (m)²
 - $88/1.54^2$
 = 37.11
 = 37 kg/m²
 - Severely obese
 - $90/1.51^2$
 = 39.47
 = 39 kg/m²
 - Severely obese

4. This waist size has a greatly increased risk of chronic disease as it indicates excess visceral fat. Excess visceral fat can increase the level of LDL/blood triglycerides and therefore increase risk of CVD. Excess visceral fat can deposit around the pancreas leading to increased insulin resistance and elevate Type 2 Diabetes risk.
5. Elderly/athletes/body builders (any group of people where muscle mass proportion can affect results).
6. (a) Waist (cm)/Height (cm)
 - (b) (i) $61/79 = 0.77$
 - (ii) No increased risk of CVD (WHR below 0.8)
 - (c) (i) $112/88 = 1.27$
 - (ii) Yes increased risk of Type 2 Diabetes (WHR above 0.9)
 - (d) The line that is halfway between the lower rib/top hipbone can be difficult to find/measure, especially when obese and carrying additional abdomen body fat, therefore the measurement can be inaccurate.
7. (a) 51-70 includes the age where menopause occurs. Menopause causes a reduction in oestrogen and calcium absorption, hence the EAR and RDI increase. Men do not have this hormonal change. At 70, both ages lose bone mass so additional calcium is required.
 - (b) (i) Not/poor suitability as her intake is 140mg/day below the minimal level/EAR or 300mg/day below the recommended amount/RDI
 - (ii) Osteoporosis/muscle cramps.
8. (a) Total cholesterol category: borderline high
HDL cholesterol category: above optimal
LDL cholesterol category: high
 - (b) Not suitable; the test results are 13mg/dL above the desirable range for total cholesterol; the test results are closer to the lower margin of the borderline high values of 200-239mg/dL; 12mg/dL above the lower margin of the borderline high values; or 27mg/dL from the higher margin of the borderline high range
 - (c) Angina; CVD; CHD
 - (d) (i) Advantages = easy; inexpensive; non-invasive; doesn't require a lot of time/equipment
Limitations = not as accurate for the elderly (doesn't consider loss of muscle mass with age)
 - (ii) More accurate; can be used for elderly.

2.2: Educational Aids for Food Selection

Topic Solutions

1. Positive energy balance (weight gain)
2. Different types and colours of vegetables will provide a range of macro and micronutrients (vitamins/minerals) and reduce the chance of developing deficiency diseases/help in optimal body functioning. For example, green leafy vegetables contain calcium to prevent osteoporosis. Those that can be eaten with the skin e.g. roast pumpkin, can provide insoluble fibre to reduce the chance of diverticular disease/help movement of faeces through the digestive system. Green leafy vegetables such as broccoli hold high amounts of folate which is needed to produce normal RBCs/reduce chance of anaemia; or vitamin C for collagen formation/reduced chance of scurvy. Etc.
3. To reduce fat/kJ and therefore chance of weight gain/obesity or diseases a risk of e.g. CVD; to reduce saturated fat and chance of CVD
4. Beverage: dairy milk, coconut milk
Food: biscuits, cakes, pastries, pies, processed meats, sausages, pizza, fried foods, potato chips, etc.
5. (a) Processed meats, cereals/muesli bars, cheese, canned vegetables/fish, etc.
(b) Hypertension or CVD
6. Sugar is a food source for bacteria, bacteria produce acid that can break down tooth enamel/cause tooth decay

7.

Factor	Arguments pro 4 months	Arguments pro 6 months
Allergic reactions	<ul style="list-style-type: none"> Food allergy was rare before the introduction of the guideline moving solid introduction to a later age of 6 months (it was previously earlier) Anaphylaxis from allergic reactions has also increased since the age of solid introduction was increased to 6 months Early introduction of egg and peanuts has been linked to lower rates of allergy 	<ul style="list-style-type: none"> Lack of evidence of greater incidence of allergies in babies starting solids at 6 months compared to 4 months
Nutrient levels	<ul style="list-style-type: none"> Iron levels are low and insufficient levels in breastmilk/formula 	<ul style="list-style-type: none"> A baby has iron stores sufficient to around 6 months of age (iron is stored in infants' body from when in the womb) Breastmilk (or formula) provides all nutrients a baby needs for 6 months and risk of a child receiving too little breastmilk (due to replacement with solids) should be considered
Risk of illness	<ul style="list-style-type: none"> The risk of gastroenteritis (food poisoning) appears to relate to the introduction of complementary feeding with infant formula, rather than solids Risk of contamination (food poisoning) with introduction of solids is primarily an issue in underdeveloped countries 	<ul style="list-style-type: none"> Exclusively breastfeeding until 6 months of age has been linked to lower incidence of gastroenteritis and lower respiratory tract infections (breastmilk provides antibodies) Many studies show that breastfeeding protects babies from gastroenteritis in Western countries as well
Other	<ul style="list-style-type: none"> Early introduction of gluten may decrease the chance of coeliac disease Early introduction of solids has been linked to fewer serious sleep issues in babies (and sleeping longer with less frequent waking) 	<ul style="list-style-type: none"> Younger infants are not coordinated enough to move solid food from the front of the mouth to the back for swallowing (food is therefore only pushed out and poses a choking hazard) Babies are born with immature digestive systems equipped to digest breastmilk and early introduction of solids may alter the child's gut microbiome leading to further complications

8. (a) Monounsaturated/polyunsaturated
 (b) Lowers LDL deposits/atherosclerosis/CVD/hypertension risk
9. Carbohydrates
10. Green: folate, vitamin C
 Red: Vitamin C
11. Micronutrients: iron, folate, calcium.
 Macronutrient: Protein; carbohydrate (starch, fibre).
12. Protein
13. (a) Omega 3/6
 (b) An essential fatty acid cannot be synthesised in the body, it must be consumed.
14. Similarities: Same main 5 food groups; main food groups in the same proportions; both encourage water consumption; both allow small amounts of mono/poly oils; both specify discretionary foods to be in small amounts and sometimes only; both developed by the Australian government
 Differences: Aboriginal & Torres Strait food model focuses on Australian products while the AGHE has more foods with a multi-cultural influence (particularly in the grain food group); the AGHE lean meats and poultry, etc. group has produce that would mostly be obtained from a supermarket, whereas the Aboriginal model includes native animals that could be hunted for food e.g. goanna.
15. Being sedentary does not utilise many kJs, extra kJs are converted to adipose tissue leading to weight gain/obesity. Obesity increases the risk of Diabetes Type 2/Hypertension/ Cardiovascular disease, all of which can lead to death, hence why it can be considered a risky behaviour.

Being sedentary is associated with lower levels of HDL, therefore higher levels of LDL build up along the arteries. This can lead to atherosclerosis/CVD.

16. (a) 30%
 (b) 6%
 (c) 2%
 (d) 98%
17. Stroke, blocks oxygen to brain and causes tissue death and possible death.
 Heart attack, blocks oxygen to the heart and heart tissue dies causing possible death Chronic kidney disease, blocks oxygen needed to keep kidney and therefore body functioning.
18. (a) As time progressed for the running of the Measure Up campaign, it maintained its effectiveness. For example, the impact on vegetable consumption increasing only decreased by 1% for example, the impact on increasing exercise actually increased slightly by 1% from waves 2 to 3; or there was only a minimal decrease in the campaigns effectiveness, for example, those who measured waist circumference dropped by only 2% from April 2009 (Wave 2) to May 2010 (wave 4)
 (b) Increasing the amount of exercise.
 (c) A larger waist measurement indicates excess visceral fat which can increase the levels of LDL and therefore CVD/hypertension risk or can increase insulin resistance/Diabetes Type 2 risk; or a larger waist measurement can indicate obesity which is a risk factor for Diabetes Type 2/CVD/hypertension.
19. This is an age group that is likely to have been diagnosed with an over-nutrition disease or have a larger waistline and therefore be influenced by the campaign into making lifestyle changes, for example walking part of the way to work instead of driving/bus; this age group may also be becoming less active and therefore more likely to develop an over-nutrition disease.
20. (a) Dried fruit contains some valuable nutrients (e.g. vitamin C) (moves the food towards green classification) but can have moderate amounts of added sugar (moves the food towards the red classification).
 (b) Butter provides saturated fat (or oil is a source of unsaturated fat).
 (c) Bread to be whole meal; additional vegetables in sandwich; remove high energy processed products e.g. salami; etc.
21. (a) red
 (b) amber (note = double the values as its 50g).

Review Solutions

1. (a) Substitution one: Replace bacon/ham/cheese/pizza topping with mushrooms/salad/onion/ tomato/ spinach/ etc. to make sure getting a variety (different types and colours) of vegetables.
 Substitution two: Replace apple with mango/rock melon/pear/etc. to ensure getting some variety in fruit.
 Replace toast/roll/pizza base with wholegrain/whole meal to ensure grains consumed are mostly whole meal.
 Replace bacon with beef deli slices – fat trimmed/etc. or beans to ensure protein consumption are from lean meats as advocated by ADG #2.
 Replace milk with skim milk/cheese with ricotta cheese/etc. to support the guideline specifying most milk, yogurt, etc. should be reduced fat.
- (b) Substitution one: Replace butter with margarine; replace bacon with mushroom/tomato/etc.; replace cheese with salad/etc. (to reduce saturated fat)
 Substitution two: Replace bacon with mushroom/tomato/etc.; ham with salad/etc.; cheese with salad/ etc. (to reduce foods high in added salt).
2. Food A; it is lower in saturated fat, sugars and sodium which matches ADG #3.
3. Vegetables, beans/legumes and fruit are relatively low in kJ and hold substantial amount of the micronutrients.
 (1) For example, folate. They are also high in fibre.
4. Care for your food; prepare and store it safely.

5. Any vegetable; any fruit; milk/yoghurt; any meat.

Any grain (cereal) food that soaks water up when cooked e.g. pasta.

6. Oily fish; margarine.

7. Similarities: The 5 predominant food groups of pyramid and AGHE are the same; both encourage to eat variety both encourage drinking water.

Differences: Healthy fats are part of the pyramid/main shape vs they are outside the main shape for the AGHE; discretionary foods do not appear in healthy eating pyramid while they appear outside the main shape in the AGHE; salt and sugar being discouraged from being added to food is shown outside the pyramid, this doesn't appear in AGHE; pyramid encourages activity as well while AGHE doesn't; pyramid suggests addition of herbs/spices to food while AGHE does not

8. Similarities: both food models encourage a variety of foods to be consumed (written words and illustrations); both encourage drinking water; grain food groups are both predominantly wholegrain varieties; grains/vegetables/fruit are larger portion of the plate.

Differences: the Canadian food model combines the vegetables and fruits whereas the AGHE has them as separate food groups; it also combines the milk, yoghurt (etc.) group with the lean meat, poultry, fish (etc.) group while the AGHE has them separated; vegetable/fruit groups are larger portions combined in Canadian model; grain group is a smaller plate portion in the Canadian model in comparison to the AGHE; Canadian model doesn't mention what foods to avoid/have in small amounts (these appear separately, not given in this question).

9. (a) 5 serves: 2 eggs = 1 serve; 65g beef = 1 serve; nuts = 1 serve; chicken = 2 serves;

(b) Matty's consumption of the lean meat, etc. food group is too high; he consumes double the recommended/2.5 additional serves over the recommended.

(c) Excess protein consumption can result in dehydration/water loss from frequent urination or kidney/liver complications; protein provides kJ which can be converted to adipose tissue/weight gain/obesity.

10. CVD, Type 2 Diabetes, Hypertension, (cancer).

11. (a) They wish to live longer to see their children grow up and therefore care about their health; they can influence their children; parents are role models for their children; parents are in control of buying the groceries/preparing meals.

(b) Children can be easily influenced; healthy eating habits can be formed in childhood.

12. (a) Go for 2&5; Measure Up (to a lesser extent as no TV commercials = Shape Up; Healthy Weight Guide).

(b) SA Rite bite.

13. (a) Soft drink is high in simple sugars and too many simple sugars can increase insulin resistance and lead to Type 2 Diabetes; too many simple sugars can also increase LDL/decrease HDL and increase the risk of atherosclerosis/CVD; water is recommended as a replacement due to being needed in large amounts daily for functions such as aiding in digestion/circulation of oxygen and nutrients/waste removal/etc..

(b) Discretionary foods are high in kJs, and excess kJs can be stored as adipose tissue leading to obesity, obesity is a risk factor for CVD/Hypertension/Diabetes Type 2.

Discretionary foods can be high in sodium which can lead to an increased chance of hypertension which then increases the risk of CVD. Excess sodium can also cause increased urination and therefore loss of water and dehydration or could go into loss of water-soluble nutrients and under-nutrition diseases.

Discretionary foods tend to be high in saturated fat which increases LDL production thereby increasing risk of atherosclerosis/CVD/hypertension.

Simple sugars as per part (a) can also be accepted so long as no double-dipping.



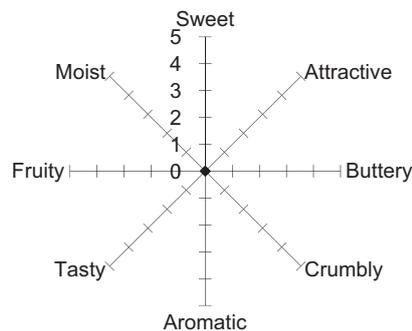
2.3: Food Sociology

Topic Solutions

- Umami corresponds to the flavour of glutamates, especially monosodium glutamate, which is a compound that naturally occurs meats, soy sauce, cheese, mushrooms and fish sauces.
- Scientists have found that proteins in saliva can change based on the food repetitively given. Specifically, avoided bitter foods, if continued in the diet, can become a food one can withstand more of, as salivary proteins will alter to allow taste perception to change. If scientists can apply this finding to change the expression of these proteins in humans, bitterness and other disliked tastes could be weakened. This finding could also allow for innovation in food creation: by adding the salivary proteins, to nutrient-dense foods with less palatable tastes, as a food additive.

This could mean that it could become easier to get children to enjoy the taste of vegetables, even brussel sprouts; in fact, any food that can be considered 'disgusting' by children. For adults, these applications could be key to making healthy foods taste better, which in turn could modify dietary choices for the better. A further positive impact of this could be a reduction in dietary diseases such as cardiovascular disease, Diabetes Type 2 and diverticular disease. While in children it could see reduced micronutrient imbalances and less incidence of obesity. Note – impact has been shortened to two sentences in this answer for simplicity; it would be expanded on for production of a SHE assignment.

- The best time to conduct a sensory evaluation is prior to lunch or dinner, when a tester's hunger levels are high and therefore the sense organs are optimum. If an individual participates in a sensory evaluation after these times, the food source may not be desirable due to being full or a flavour consumed prior may interfere with the true flavours represented, and therefore not a true indication of the consumer's approval of the food product.
- The Sensory Evaluation of Apple Pie (other options can be considered, the characteristics of apple pie are not limited to the ones selected).



- Energy-dense foods are high in kJs, excess kJs will be converted to body fat, additional body fat can lead to weight gain/obesity; energy-dense foods are low in micronutrients, this can be linked to under nutritional diseases for example low intake of iron can lead to anaemia or further examples; energy-dense fast foods are often high in saturated fat or cholesterol, which can increase LDL levels, LDL build-up can progress to atherosclerosis which is a pre-cursor to CVD; energy-dense foods are high in simple sugars and same progression as saturated fat, or, decrease HDL production or they can result in insulin resistance and therefore Type 2 Diabetes; fast food outlets often use excess salt which is associated with increased risk of hypertension which can increase the risk of CVD.
- Alcohol is quite high in kJs (29kJ/g), therefore it is linked to excess kJs that are converted to body fat increasing risk of obesity; alcoholic drinks are often mixed with soft drinks which are high in simple sugars, see previous answer; alcohol is a diuretic, increasing urination and the risk of dehydration; or increasing micronutrient loss via urine and the risk of an undernutrition disease e.g. vitamin C and scurvy; or any water-soluble nutrient and its associate undernutrition disease.
- Lean meats and poultry, fish, eggs, tofu, nuts, seeds and legumes/beans.
 - Decreased haem iron due to meat/seafood, could increase chance of anaemia; decreased vit D in oily fish, could increase chance of rickets/osteomalacia or could result in poorer calcium absorption and osteoporosis risk; decreased complete protein from meat, dairy, eggs could result in muscle weakness, poorer immunity, poorer growth, etc., decreased vitamins B12 deficiency due to only being obtained in animal products can increase the risk of anaemia and nerve damage.

8. The creation of milk from genetically engineered yeast has been influenced by the growing concern over animal welfare, particularly dairy cows and their male calves, and therefore increasing popularity of the vegan diet. Swapping one’s diet to veganism has also gained momentum due to value being placed on the environment. This has been another influence over the creation of a milk that produces a smaller carbon footprint (compared to dairy cows producing methane that impacts the environment via greenhouse emissions). Finally, the yeast milk’s creation is also in response to dairy milk’s growing consumption rate and concerns over its agricultural sustainability: if the continuing trend in consumption vs dairy milk production can sustain the populations needs.

Beyond these environmental, ethical and social influences, the creators of the yeast cultured milk were further influenced by advances in science and technology used in forging many other plant-based alternatives such as meat (sausages, patties, etc.) and cheese. Bioengineering advances were another influence over the cultured milk creation, in order to make a milk product that was unlike other plant-based alternatives such as almond milk.

9.

Food	Yes or No
Bacon	No
Bread	Yes
Prawns	No
Rice	Yes

10. A vegan will abstain from all animal products, whereas a lacto-vegetarian will allow dairy products in their diet. Both types of vegetarian consume plants products (for example, breads, fruit and vegetables).
11. Milk is a good source of calcium, therefore reduced levels may lead to muscle weakness/spasms or decreased bone density/increased risk of osteoporosis later in life
- Good source of protein, reduced levels can result in higher risk of illness/infection, reduced growth, etc. Good source of phosphorus, reduced levels may decrease bone strength
- Good source of B12, reduced levels can lead to anaemia
- Good source of fat which is needed to reduce feeling cold (insulation), provide energy (feel fatigued), etc.
12. Energy-dense foods are high in kilojoules, but low in micronutrients, water and fibre.
13. Childhood (puberty begins in late childhood) or adolescence.
14. Beliefs about what other people think of a particular behaviour can influence food preferences and choices in a social setting. For example, an adolescent who follows the Islam religion may choose to consume certain foods that are prohibited (e.g. pork and pork products, crustaceans, alcohol and non-halal derived animal ingredients such as gelatine) as they fear appearing weird or different to their friends.
15. Children and adolescents are consumers in the making, and during these life stages they are developing habits and attitudes towards food choices, which they may carry throughout life. This is why it is important to educate these groups about the risks associated with their dietary and lifestyle choices from this age.
16. Fresh peaches are more expensive in rural and remote parts of Australia due to the costs associated with refrigerated transportation or careful storage which is required as peaches are a perishable item.
- Fewer marketplaces selling peaches, therefore the lack of competition in these areas can drive the price of these foods further up.
- Additional handling of peaches for them to be transported further (further wages) would also increase prices.
17. Fresh foods, such as fish, lean meats, fruit and vegetables are limited in rural and remote areas of Australia due to the cost of their transportation, storage and handling. Therefore, consumers in rural and remote areas have limited access to fresh foods and rely on processed foods. These food items are lower in price but high in sugar, salt and saturated fat which are risk factors for diet related disorders including obesity, type II diabetes and cardiovascular disease. Individuals in remote and rural communities may lack access to proper health care also.



18. Any two of the following:
- (a) Grow own vegetables, fruits and herbs.
 - (b) Buy in bulk when visiting larger supermarkets in larger cities.
 - (c) Buy fresh produce in season.
 - (d) Look for specials in the community or when visiting larger supermarkets.
 - (e) Buy non-organic products.
 - (f) Store leftovers appropriately to reduce food wastage.
 - (g) Buy fresh foods and freeze them to extend their shelf life.
 - (h) Buy home brand products when possible.
 - (i) Purchase more plant-based protein sources instead of animal-based proteins.
 - (j) Buy individual ingredients and not pre-packaged meals e.g. salads.
19. The hypothesis that 'feeling inferior in social status has a link to obesity (via higher calorie intake)' was proposed after similar findings resulted from a number of different studies.

In one study, when given a dinner buffet and choice over how much and which foods they consumed, people who considered themselves as having a lower socioeconomic background selected a larger quantity of food, with a higher proportion being energy-dense foods. Less economically well-off people consuming larger quantities of food was then replicated in a different experiment when all subjects were given a large bowl of noodles to consume until reaching a comfortable level of satiety. Again, it was those of lower economic standing who consumed larger amounts of food. In support of the first study also finding those who considered themselves to have lower economic ranks tended to select energy-dense foods, another report found given the choice over a number of snacks, lower social ranking people chose higher kilojoule options.

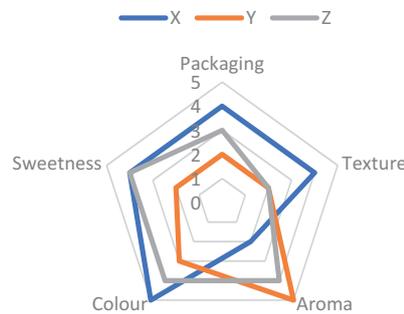
A final study found energy-dense foods to be assigned more positive emotional descriptors by those who thought they had a lower socio-economic standing. With a few studies finding feeling inferior in socioeconomic status led to eating more food, and other studies uncovering food selected tended to be more energy dense. The combined evidence was used to develop the hypothesis that there is a psychological link to a higher kilojoule intake and therefore obesity when having a mindset of financial deprivation.

20. Any two of the following:
- (a) Increase the affordability of healthy foods.
 - (b) Better access to resources e.g. gym memberships.
 - (c) Greater access to resources to make cooking at home easier e.g. cooking equipment.
 - (d) Increases access to healthcare.
 - (e) Reduction in income related stress, which can discourage people from engaging in a healthy lifestyle.
 - (f) May have healthier peers, which encourage healthier behaviours.

Review Solutions

1. (a)

The Average Sensory Scores of Different Types of Lactose Free Milks



(Marks allocated for title, labelling of axes, even scale on axes, legend and correct plotting).

(b) Constant factors may include:

- Amount of milk sampled
- Temperature of milk sampled
- Number of taste testers
- Time of testing

(c) Milk X

2. (a) Any one of the following:

- Frozen pizza could have soggy crust or fresh pizza could have crunchier crust.
- Pineapple could be soggy on frozen pizza (due to be frozen and ice damaged).
- Fresh pizza could be more colourful due to ingredients being fresher.
- Fresh pizza could be hotter in temperature.

(b) Any two of the following:

- Temperature of the pizza when served.
- Number of tasters.
- Sample size of pizza tested.
- Same amount of toppings on each pizza.
- Same toppings on each pizza.
- Time of testing.
- Cooked using the same method (e.g. oven or wood oven).
- Same recipe used for base.

3. A child may gain food preferences by pester power/tantrum/food refusal; food a child may prefer in taste can be learned from friends/media/etc. and a child can protest until a parent caves and allows the child to eat the food they prefer.

4. Value	Strong personal feeling about what is important to you.
Belief	opinion that something exists or is true, without the need for scientific proof
Food taboo	An unusual belief about certain food that usually results in it being prohibited
Emotions	A mental state associated with thoughts, feelings and behavioural responses caused by one's circumstances, mood or the people you are with
Food attitude	Our likes and dislikes
Food habits	Meal routines that are performed without really thinking about them
Self-image	Is the way a person views their appearance (and abilities and personality)
Fad diet	A short-term or temporary eating plan that often promises rapid weight loss but is not based on sound science

5. (a) Indigenous influence: Crocodile Distinctly Australian: Vegemite on toast Multicultural influence: Sushi; coffee
 (b) Food habits
 (c) Food attitude
 (d) Past experiences, negative experiences with a food, especially those that cause food poisoning can be remembered and when presented again will produce the response Justin had, as the bodies way of protecting from toxin/poisoning.
6. Replace bacon/beef with Halal meat/tomato/mushroom/etc. Replace cheese with rennet-free cheese/tomato/etc. Replace wine with water/juice/milk/etc.
7. Remote and Rural Communities: have limited access to healthier foods due to their increased price, poorer quality and reduced availability.
 Lower income families: have limited access to healthier foods due to reduced affordability, which is why these groups rely on high-energy, nutrient-poor food, to maximise their energy intake value for money.
8. Older people may be on the pension; therefore, their budget may not allow for expensive food items. Animal proteins are expensive to purchase due to the costs associated with its production, storage and handling. Therefore, an elderly may not be able to afford meat, and have to rely on plant-based protein sources e.g. legumes as a substitute as these are cheaper.
9. Any one of the following:
 Peer pressure:
- Children will model behaviours such as manners and replicate the habits observed from parents and siblings e.g. sitting at the table, trying new foods, eating in front of the TV, eating out and 'mindless eating'
 - Parents/carers are responsible for the meals cooked and the foods purchased and therefore their autonomy is restricted.
 - Peer influence (lunch-box envy).
- Media and Advertising:
- Social/Environment of the prevalence of fast food outlets and the convenience of these foods can increase food choice for 'discretionary foods' and children need to not choose these options.
 - TV ads and Social Media, popular TV shows may be used as marketing ploys for food products.
 - Brain food at primary school.
 - Pester Power: the ability of children to pressurise their parents into buying them products, especially items advertised in the media.
10. (a) The greater the level of education, the lower the percentage of South Australians who are obese. There is 7.5% greater prevalence of obesity in people without tertiary education.
 (b) The greater the level of income, the greater the percentage of South Australians who are in the normal weight range. Higher income earners were 9.5% less obese than low income earners.
 (c) Individuals in remote and rural communities may have limited access to fresh produce due to the difficulties in transporting and storing them appropriately; therefore rely on processed foods which are available but high in sugar, salt and saturated fat putting these individuals at risk of developing an overnutrition disease, for example obesity.
 (d) Any two of the following:
- Plan the meals for the week, using ingredients that are in the fridge and pantry already.
 - Write a list of the items needed to avoid purchasing additional ingredients.
 - Buy fruits and vegetables in season.
 - Look out for supermarket specials.
 - Buy non-organic products.
 - Buy in bulk when possible.
 - Buy home brand products when possible.
 - Don't shop when hungry to avoid buying unnecessary foods.
 - Purchase more plant-based protein sources instead of animal proteins.
 - Buy individual ingredients to make salads and not pre-packaged meals e.g. salads.
 - Grow your own vegetables and herbs.

2.4: Safe food: contamination and its prevention

Topic Solutions

Contaminant	Physical	Biological	Chemical
Lead	x	x	✓
Rat poo	✓	✓	x
Pesticide	x	x	✓
Salmonella	x	✓	x
Norovirus	x	✓	x
Metal debris	✓	x	x
Hand sanitiser	x	x	✓

- around 72°C (or a few degrees above/below).
 - about 10-50°C
- pineapple, radish, apple, banana, corn, rockmelon, etc.
 - asparagus, broccoli, etc; wine, soft drink, cider, etc
 - yeast
 - bacteria
- Botulism or E.Coli
 - Staphylococcus
 - True
- Cut/wound would be around 37°C which is within the danger zone; blood provides nutrients (for example blood glucose) that bacteria can utilise as energy; pH of blood of humans and other livestock is around neutral which matches pH of 5-8 bacteria where their enzymes are most active; cut is exposed to air with oxygen and most bacteria aerobically respire blood is also primarily water therefore giving means for bacteria to dissolve their nutrients and cuts/wounds take time to heal allowing bacteria to grow; all these factors support bacterial growth which may grow to sufficient numbers to cause an infection.
- glass, metal, wood, plastic, etc.
- Food poisoning is estimated to affect 4.1 million Australians each year and *Bacillus cereus*—one of the most common types of stomach bug—is responsible for producing toxins that cause vomiting and diarrhoea. It may not be a household name, but *Bacillus cereus* can be found in vegetables, meat, fish, rice and pasta, and will grow in these foods if they are not stored properly.

Lead researcher Ms Anukriti Mathur, from the The Australian National University (ANU), has found how the bacteria works and how to combat it. “We knew the toxin would have to attack the cells, triggering an immune reaction, but we now know how it does it,” said Ms Mathur. “We discovered the toxin directly binds to the cell and punches holes to kill the cell, the immune system responds to the infection and has a reaction.”

“Because we now know how the bacteria and the toxins work, we can fight it and find ways to use the immune system against it. “Researchers say the discovery will be vital in understanding and treating serious cases of food poisoning. “This research could help patients with a compromised immune system,” said Ms Mathur. “We might be able to save patients by weakening the toxin, or in the case of sepsis, dampening inflammatory responses. “It also means we have therapeutic drug options to further support antibiotic therapies, especially in the face of rising antibiotic resistance.”

Key = background; influence; application & limitation

- Factor enhancing food spoilage

	Enzymes	Light	Fungi	Oxygen	Humidity
Microbial (M) or natural decay/ environmental (E)	E	E	M	E	E

9. Spoilage and poisoning can both be caused by microbes; both can be caused by poor sanitization, hygiene, improper cooking, improper storage, etc (anything that would contaminate the food biologically; while food spoilage is typically detected (unusual appearance, smell, taste, texture) but food with poisoning potential is not; spoilage normally results in food wastage whereas poisoning is because the food is eaten and gives gastroenteritis symptoms (or worse)
10. Source of contamination is a microbe/bacteria/fungi/virus
11. Bacteria prefers a pH around 7/fungi 5-6, their enzymes do not function efficiently in alkaline conditions/ high pH, even killing them. Washing the hands with soap will therefore reduce the chance of cross- contamination of the bacteria on hands into food and potential of food poisoning
12. One study from 2013, conducted by researchers at Michigan State University in USA, observed that only 5% of people (from a study of 3749 people) washed their hands for the correct amount of time after using the restroom. Most people washed their hands for around 6 seconds (while 10% didn't wash their hands at all!). Their results were communicated in the Journal of Environmental Health to allow for replication and verification. N.B. – The recommended time was at least 15 seconds before this study, CDC updated this recommendation to at least 20 seconds at a later stage after collaboration with scientists (and their findings). Verification of our poor hand washing hygiene was found in a more recent study from 2018 by US Department of Agriculture (USDA), that observed only 3% of people (out of 383 people) washed their hands for long enough before preparing food! Details of the study were published on the US government website for USDA as a press release to allow scientists access to the findings, with findings again indicating CDC recommendations for hand washing were not being met.
13. 5-60°C
14. Cross-contamination
15. It has not been heated above 60-75 degrees to kill bacteria/toxins; chicken has many favourable conditions bacteria flourish in such as pH near neutral, exposure to oxygen, source of protein/nutrients, etc (any of these for the other).
16. Bacterial presence from cross-contamination from poor handling and hygiene practices would be present on the outside of the meat which cooking should destroy (heat contact). However, when meat is minced, the bacteria from the outside is moved throughout the meat, therefore all the meat requires cooking
17. If food is placed into the fridge warm, it could increase the fridge temperature above 4°C-5°C, entering the danger zone where microbes could grow to dangerous numbers in all fridge foods resulting in food spoilage/ poisoning
18. You can thaw out the amount that is needed, which could result in less wastage.

Review Solutions

1. (a) An unpleasant smell, texture e.g. bread hard/dry and tomato soft, taste e.g. milk sour, or appearance e.g. bananas browning.
- (b) Condition one: danger zone temperature, the car at 40 degrees is in the danger zone where bacteria can multiply quickly.
Condition two: optimal pH, many of the foods, for example the milk, are around neutral pH where bacteria grow best.
Condition three: nutrients, the groceries provide plenty of nutrients, particularly the chicken which is high in protein.
Additional: Water, most foods and especially the milk hold a high water activity allowing microbes to flourish; oxygen, because the food was not stored correctly, sufficient air was provided around the packaging of the foods for microbes to make energy; time, because bacteria can grow quickly, 5 hours provided more than sufficient time for microbes to grow to large numbers.
- (c) milk – listeria; chicken – E. coli/salmonella.
- (d) Toxins may remain, toxins produced by bacteria can be heat-resistant and can cause food poisoning.
- (e) Infants/elderly/cancer patients/pregnancy, having an under-developed/less efficient/weakened immune system, respectively.

- 2.
- | Contaminant | Classification |
|-------------------------------------|--------------------------|
| Pesticides | Chemical |
| Green potato (contains plant toxin) | Chemical |
| Human nail clipping | Physical (or biological) |
| Norovirus | Biological |
- 3.
- | Factor allowing bacterial growth | Optimal conditions preferred by most bacteria |
|----------------------------------|---|
| pH | 5-8 |
| Temperature | 37°C (5-60°C) |
| Nutrient | Protein |
| Water activity | Greater than or equal to 0.90 |
4. (a) neutrophile
- (b) Acidophile; its range is 5.5 (from 1 to 5.5) while alkaliphiles range 4 pH ranks (7.5-11.5) or neutrophiles range across 3 pHs (5.5-8.5)
- (c) fungi
5. Unsafe practice: Washing hands with used kitchen tea towel/scratching head while preparing food/pet in kitchen/use of same chopping board.
- Description: Microbes from the tea towel/head/animal could be transferred to the hands and then food (cross-contamination); pet hair source of physical and biological contamination; chopping board a source of cross-contamination of meat bacteria to lettuce (lettuce not cooked to destroy bacteria).
- Recommendation: Air dry hands or use clean paper towel/clean hands after scratching head/remove pet from kitchen and clean surfaces where animal was.
- Unsafe practice: Meat stored over cheese.
- Description: Juices from the meat will drip onto cheese and contaminate it; cheese will not be cooked to destroy the bacteria.
- Recommendation: All food stored in sealed containers; meat stored bottom of the fridge.
- Unsafe practice: Consumed scrambled eggs left at room temperature for long period of time.
- Description: Due to a long time being at room temperature/in danger zone, eggs could hold bacteria in dangerous numbers/food poisoning potential.
- Recommendation: Eggs to be discarded.
- Unsafe practice: Re-heating left-over food twice.
- Description: Food passes through the danger zone multiple times, increasing the chances of it containing bacteria in dangerous numbers/food poisoning potential.
- Recommendation: Pizza to be discarded.
6. (a) The independent variable is the temperature (°C) the roast chicken was exposed to during the 24-hour testing period.
- (b) Constant Factors:
- Swabbing site on the chicken e.g. thigh on same roast chicken.
 - Time of swabbing.
 - Incubation time (24 hours).
 - Medium for inoculating (nutrient agar plate).
 - Same exposure to environmental conditions e.g. oxygen, moisture.
 - Method used to count the bacterial colonies.
- (c) The number of bacteria colonies increased from 0 to 9 as the temperature increased from -5°C to approximately 37°C; however the number of bacteria colonies decreased back to 0 as the temperature continued to increase to 52°C.
- (d) At 37°C, bacterial enzymes are functioning optimally, allowing for faster reproduction; the changes above and below 37°C are due to enzymes slowing.

- (e) Cook just before lunch service/place in fridge rather than bench top until lunch time/don't give leftovers. Leaving the chicken on a bench for extended period at room temperature is allowing pathogenic bacteria to grow to dangerous numbers. From morning to lunch passes the 2h/4h food safety rule, according to this rule it needs to be refrigerated or bacteria could be at dangerous food poisoning levels.
7. It is important to reduce the temperature of soup as quickly as possible. This can be achieved by storing soup in smaller individual containers, to ensure the temperature of the soup drops below the danger zone within 2 hours. Prior to storing in the freezer, ensure the soup drops to a temperature of 60°C to prevent any surrounding foods in the freezing more defrosting and increasing to a temperature within the danger zone.

2.5: Safe Food: Government Regulation

Topic Solutions

1. infants, pregnant females, elderly or those who are immunocompromised e.g. cancer patients.

2.

Role	Indicate if each is a role of FSANZ with a 'yes' or 'no'
Provides food standard codes for fortification	Yes
Regulates food additive use	Yes
Provides food standards for hygiene for food handlings	Yes
Enforces the food standards code and fines manufacturers not compiling	No
Provides food standards for fundraising events selling foods	No
Regulates food labelling laws	Yes

3. Milo cereal, as it has over 25% of the RDI for calcium in a serve, by 5mg.

4. Folic acid fortification: spina bifida/neurological disorder in the fetus; megaloblastic anaemia;

Vitamin D fortification: indirectly osteoporosis (via Calcium absorption).

5. A new way of processing broccoli could help you get your servings of vegetables, while dealing with the wastage of "unsightly" food. We're talking dried, ground to fine powder, and stirred into your coffee. But coffee isn't the only potential application for the powdered brassica. The CSIRO has also added it to extruded snacks, and it could also work as an ingredient for smoothies, muffins, and soup.

Approximately two tablespoons of the powder is equivalent to one serve of vegetables, as per the Australian government's recommended five to seven daily serves. "Research shows the average Australian is still not eating the recommended daily intake of vegetables a day, and options such as broccoli powder will help address this," said Hort Innovation's John Lloyd.

A lot of produce is wasted before it even gets to the store shelves because it's "ugly". Some of these ugly fruits and vegetables can be used for juicing, and "superfood" powders made from vegetables such as chia and kale have been around for a while. In the case of the new broccoli powder, it uses the whole broccoli – florets and stems. No wasted chunks thrown in the bin like in your typical cooking process.

To make broccoli coffee, the powder is added to the cup after the espresso shot has been pulled. Steamed milk is added, and more broccoli powder is sprinkled on top. It sounds... rather more broccoli-flavoured than many might usually prefer their coffee to be, and doesn't take into account drinkers who prefer their brew without milk.

The next step, however, is to investigate bringing powdered broccoli to the consumer market, so you might soon have a chance to try it out yourself at home. "I see this project as the emerging new food trend," said John Said of broccoli producer Fresh Select. "Australians don't eat enough vegetables and farmers across Australia will have access to an alternative market whilst improving farm yields and sustainability. They will also be contributing to healthier lifestyles!"

We're not entirely sure it's going to catch on as a coffee additive, but, as the blue algae latte shows, stranger things have happened!

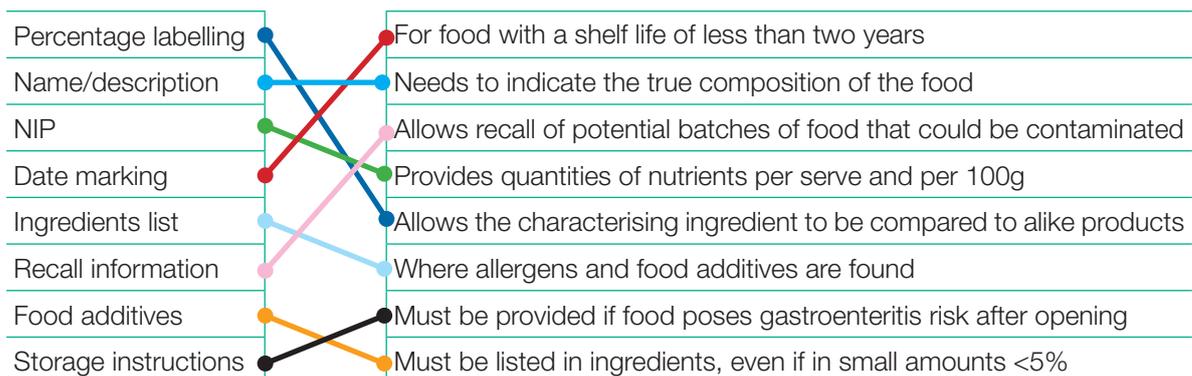
(Communication & Collaboration, Influence, Development, Application and Limitation)

*some highlighted aspects of development can also be considered development and vice versa.

6. Best-before date can still be consumed after its date marking, but may have lost quality/nutritional value; while food with a use-by date should not be consumed after its date marking for health/safety (food poisoning) reasons.
7. Whole milk
8. Strawberries
9. Country of origin, percentage labelling of key ingredient, storage instructions after opening, NIP information/100g.
10. (a) Compared to Soxhlet testing, NMR tends to be non-destructive, leaving the food intact to allow repeat of measurements of that food item, which could improve data reliability. Soxhlet is dependent on solvent extraction techniques taking up to an hour (or 6 hours including set up, etc) of testing while NMR can scan food to provide measurements within 20 seconds (or up to a few mins including set up, etc). A more efficient testing time can allow additional items within the produce packaging to be analysed (i.e. data collection of a larger sample size is possible), giving a clearer overview of whether a food manufacturer is in compliance of (or misrepresenting) their total fat content on the NIP.
 (b) NMR can detect and identify many other nutrients and ingredients, even traces of them, to ensure ingredient and NIP accuracy and therefore product quality, as well as discovering food fraud or adulteration (ingredients being added or substituted and not declared on the ingredients list/NIP by the food manufacturer). Within the same scan it can also detect an array of contaminants, even if they are not typically expected in that food and monitor moisture content to ensure shelf life specifications parallel the date labelling.
11. Too much saturated fat/sugar can increase LDL levels/decrease HDL and therefore risk of hypertension/CVD; excess sugar can increase insulin resistance, leading to Type 2 Diabetes; salt can cause water retention in bloodstream/increase blood volume, leading to high blood pressure.
12. Preservatives, to increase the shelf life of the muffin; flavouring, to give a distinct blueberry flavor to the muffin; Colouring, to restore any colour lost in cooking process; Humectants, so that the muffin remains soft/moist and doesn't dry out; sweeteners, to replace sugar and still give a sweet taste without the calories i.e. 'diet' muffin; raising agent/bulking agent, to increase the size of the muffin, particularly as sweeteners have less volume than sugar.
13. Humectant/glycerol/salt, to allow bar to maintain its softness/not dry out; Emulsifiers/soya lecithin/ rapeseed lecithin, to ensure ingredients remain dispersed and improve texture of the bars; food acid/ citric acid to maintain the food pH/reduce microbe growth; salt/flavouring, to enhance the flavours of the food; raising agent/sodium bicarbonate, to add volume to the bar/stop the bar being so dense or hard/improve texture.

Review Solutions

1. (a) FSANZ
 (b) Monitoring/approving food additive or food fortification use; monitoring nutrition/health/gluten claims; enforcing mandatory food labelling requirements (including food irradiation labelling); providing food recall information; providing NIP calculators; etc.
2. Vitamin D in oil spreads such as margarine, butter, etc; Iodine in bread; Vitamin B1 (thiamine) in bread; and folate/folic acid/B9 in bread.
3. (a) Match the mandatory labelling law with its description:



- (b) Unpackaged food or food packaged at its point of sale e.g. a bakery as it is prepared in front of you/selected yourself.

Foods sold at fundraising events, as they are one-off and occasional foods, not consistently sold Very small packaged foods/coffee/tea as they tend to be without significant nutritional value.

4. Excess sodium can increase blood volume and therefore blood pressure. Sodium is therefore required on NIPs for someone with hypertension to monitor their intake/compare to alike foods to find the one with lowest sodium.
5. Product of Australia it is not only substantially made or manufactured in Australia (like 'made in Australia') but substantially uses Australian grown ingredients as well.
6. Rice cereal is plant-based and therefore already low in cholesterol.

7. (a)

Type of additive	Foods/beverages used in	Benefit to consumer
Sweetener	Soft drinks; Confectionery	Sweet taste without the calories; potential weight loss
Antioxidants	Margarine; Chocolate	Stop rancidity in foods that contain fats
Food colouring	Confectionery; cereals; jams	Food has a vibrant colour that is more appealing to eat
Emulsifier	Salad dressing; mayonnaise; chocolate spread; ice-cream; etc (only one needed for 1 mark)	Stops oil and water separating into layers

- (b) Improve appearance (oil layer off-putting) and therefore increase sales/profit.

8. (a) Two additives:
- Thickener (1422): increases the viscosity of a liquid
 - Mineral Salt (509): Enhances flavour or reduces the water activity
 - Acidity Regulators: helps to maintain a constant acidic pH in the food, maintaining flavour and reducing the growth of bacteria
 - Colour: adds or restores colour to many processed foods
 - Flavour: adds to/enhances the existing taste of food
 - Sugar: enhances the sweetness or reduces the water activity

- (b) Any two of the following breaches:
- Recall information: there is no information (address or contact details) of the manufacturer, in case the consumer needs to make contact.
 - Nutrient claim is not listed in NIP: The label claims to be high in fibre, so fibre should be in the NIP so the claim can be substantiated
 - No percentage labelling of a key ingredient: The characterizing ingredient (tomato puree) needs to include the percentage that is present in this food product as the product is marketed as being in tomato sauce

- (c) Any two of the following:
- Storage or preparation conditions: provides information to the consumer on how best to store, prepare and use the product to maintain its quality and safety.
 - Best before date: provides consumers with a date to consume the product by to ensure the quality of the product is maintained.
 - Warning and advisory statement: identifies if the product contains any allergens (e.g. traces of nuts) that may cause severe health effects.
 - Origin Labelling information: this indicates where the food was grown, produced, made/manufactured or packaged and provides the choice to consumers about purchasing local or imported products.

9. $490/1220 \times 100\% = 40.16\%$.

Yes – FSANZ would allow the reduced salt product to be labelled as such as it has lowered salt by around 40%.

Topic two test solutions

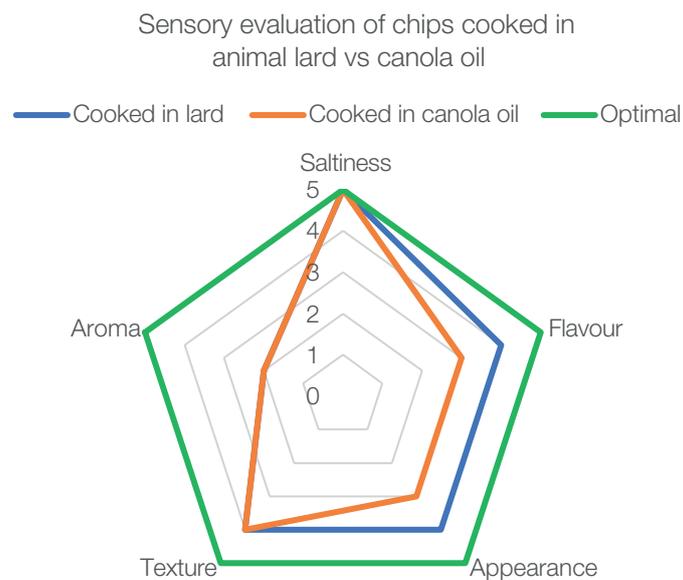
1. (a) A scientific or mathematical tool used by doctors, dieticians, nutritionists, scientists or researchers to ascertain nutritional/health status and diagnose nutritional/health problems.
- (b)
$$\text{BMI} = \frac{\text{weight (kg)}}{\text{height (m}^2\text{)}}$$

$$\text{BMI} = \frac{76}{1.53^2}$$

$$\text{BMI} = 32.5 = 33$$
- (c) This person is not in a healthy weight range as they have a BMI > 30, indicating they are obese.
- (d) BMI does not take into account the distribution of muscle mass on the body.
- (e) Higher likelihood of measuring waist circumference inaccurately compared to familiar height or weight measures (at home)
- (f) NRVs comparisons; blood analysis (or others not mentioned in text such as urine, MRIs, etc.).
- (g) BMI is not as accurate, NRVs/blood analysis can specifically analysis kJ balance/blood triglycerides
2. (a) Children aged between 5-12 years old are easily influenced and during this stage is when healthy behaviours are established, which are then likely to be carried through to adulthood. This can reduce the prevalence of diet related disorders. These healthy eating initiatives can also ensure the consumption of a range of nutrients which are essential for good health, growth and development.
- (b) Discretionary foods that are typically high in saturated fat, sugar, salt can become addictive and lead to young children refusing nutrient-dense foods or using pester power and tantrums to obtain 'red' foods that are linked to poor dietary habits and diet-related disorders.
- (c) (i) Red
(ii) Amber
3. (a) Food B; it meets ADG 3 best, being lower in saturated fat and sugar or it meets ADG1 being lower in kJ to meet energy needs/maintain healthy weight.
- (b) fibre, riboflavin, niacin, B6, folate, iron, zinc
- (c) Date marking (best before date); non-misleading name/description of food; net weight; food recall information (name/address of manufacturer and/or barcode/batch number); advisory statement; NOT country of origin (its mandatory requirement is overseen by Australian consumer laws);
- (d) voluntary
- (e) amount/serve allows nutrient intake to be tracked as serving sizes indicated a typical amount eaten as a serve; while amounts/100g allow for comparison between products to select a product more appropriate to health goals.
4. Any of the following campaigns (but not limited to):

Name	Discussion
2 & 5	Vegetables presented in exciting ways which is appealing (especially to children); campaign also aimed lists benefits of vegetables to health.
Swap it, Don't Stop it	As long as justified to a vegetable alternative e.g. potato chips to carrot sticks.
Measure Up	Adults with children compelled to increase vegetable intake by strong message linking to their health benefits. Campaign aims to change the eating habits of adults and therefore their children.
Traffic Light Colours (Rite Bite)	Used as a guideline for children to eat less of 'red light' foods, sometimes 'orange/amber foods' and more of 'green light' foods which include vegetables.
Stephanie Alexander program & similar (check program details)	Must link to increasing vegetable consumption.

5. (a) Characteristics of a fad diet are: they are short-term/temporary; promise/provide rapid/short-term weight loss; heavily restrict kilojoules/food/entire food group
- (b) Dehydration, weight lost is water; slowed metabolism, muscle mass can be lost as weight, and muscles are large kilojoule users; weakness/fatigue, not enough energy as kilojoules/food are restricted e.g. carbohydrates removed from diet and they give energy; under-nutrition diseases e.g. anaemia, from removal of a food group e.g. meat disordered eating pattern may develop such as bulimia, due to fad dieting leading to constant hunger and cravings that may result in bingeing
6. If animal rights are valued, abstaining from animal products could mean restrictions or fewer options from the 'milk, yoghurt, cheese and/or alternatives' and 'lean meat and poultry, fish, eggs' food groups. Or it could also mean reliance on 'grain (cereal) foods, mostly wholegrain and/or high cereal fibre', 'vegetables and legumes/beans' and 'fruit' groups' and the nuts, seeds, tofu options from the 'lean meat, poultry, etc. food group.
7. (a) 1 mark title; 1 mark axes labelled; 1 mark data set animal fat chips correct; 1 mark canola oil chips; 1 mark optimal (5) also on graph



- (b) Fat cooked in (canola vs animal lard)
- (c) Factor one: the sample size eaten, so that each tester is provided with an equal amount of chip to eat. e.g. receive similar amounts of the edge and the centre (edge may be crispier for example) or may taste saltier if receive a larger serving size i.e.. 2 chips vs 1 chip.
- Factor two: Similar times tested for each chip, so that level of satiety similar which can impact taste.
- Time cooked/temp cooked in oil, longer/higher cooking times may change appearance (darker)/lose water = crispier.
- Potato type, different potatoes can have different nutrient quantities that may affect taste.
- Similar cooking equipment, for example deep frying = larger quantity fat absorbed vs oven bake, etc.
- (d) Sensory evaluation is impacted on by other factors influencing food choices, namely psychological factors. Food attitudes, beliefs, past experiences, cultural values, etc may already predispose a taster negatively or positively towards a food. For example, chip cooked in animal lard may cause someone who has strong values about healthy food to score the chip negatively. It is also based on human response which is highly variable i.e. a subjective method.
- (e) Highest ranking characteristic: Saltiness Lowest ranking characteristic: Aroma
- (f) An individual with a cold has a blocked nasal cavity, therefore would not be able to score the flavor or aroma of the dip accurately. This is because odour of a product can be detected directly through the nose or after entering the mouth and flowing to the back of the throat and up into the nasal cavity. And the flavour of a food product specifically is a combination of taste, aroma and mouthfeel. Aroma is especially important as it contributes approximately 75% to a food product's flavour.
- (g) A large sample size reduces the impact of random errors and outliers, making the results obtained more reliable.

8. Any of the following:
- Peer pressure:
 - Children and their parents can be influenced by food choices of their friends, children wanting what other children have. If a child dislikes a food, for example vegetables, then this can influence children around this child to also dislike this vegetable.
 - Family–older sibling’s role modelling food choices; therefore, modelling dislikes of vegetables. Both examples could result in parent reluctance to keep trying to consume vegetables against children’s wishes.
 - Working parents and busy lifestyles resulting in less prepared fresh food and reliant on convenience and processed foods, children have low attention span and not interested foods etc. that may seem not as appealing
 - Advertising–fast foods and convenient foods and promoted more frequently, whereas vegetables are advertised the least and therefore not seen as ‘normal’ to consume vegetables. This can cause peer power where children pressurise parents to purchase foods that are readily advertised.
 - Geographical location – families may have limited access to wide variety of fresh vegetables and may cost more.
 - Socioeconomic status – households may have limited income and/or limited access to resources and therefore have reduced affordability of healthier foods, including vegetables.
 - Seasonal vegetables – in season, more abundant and therefore cost is less, but when out of season more expensive and therefore harder to purchase vegetables that children prefer.
 - Level of education – parents may have a low level of education and therefore food knowledge and may not be aware of the importance of children consuming nutrient high vegetables. Parents may also lack the skills and abilities to cook vegetables in a way that children enjoy them.
9. (a) Modifications: 400g fresh prawn to frozen; 3 spring onions/bok choy to a pickled vegetable alternate/frozen vegetable; ¼ bunch flat leaf parsley to dried parsley; ready to cook pasta to packet/dry pasta.
- (b) Look for reduced prices/specials; use promotional coupons (e.g. shopping docket buy one get one free); buy in bulk; buy food in season; buy canned/frozen alternatives (often cheaper); buy generic brand; look to buy legumes vs meat for all meals.
10. (a) Anorexia is an eating disorder where the individual affected places a severe restriction over the kilojoules/food they eat, it is often coupled with excessive exercise all in an effort to be thin due to a distorted body image (feeling large even though underweight)/fear of gaining weight.
- (b) Young female adults or female adolescents; or people who are models/gymnasts/jockeys/have been through trauma/bullying; or people with other psychological issues e.g. anxiety/impulse control, those who fad diet; those with poor self-esteem/image, etc.
11. It can be considered suitable due to pork/pork products being high in fat, removing pork/pork products may reduce fat and therefore the chance of excess adipose tissue/weight gain/obesity; suitable due to being a source of saturated fat, reducing saturated fat lowers LDL/atherosclerosis/CVD risk; not suitable as pork is a good source of complete protein contains all essential amino acids needed for functions e.g. muscle repair; not suitable as pork is high in haem iron (or B12) easily absorbed to reduce chance of anaemia.
12. Comfort eating is eating to feel good/calm/reduce the emotion that led to the food intake e.g. eating doughnuts when depressed to feel good; it can be recognised as its eating when not necessarily hungry; involves a craving of a certain food; may lead to feeling guilt/regret after
13. Food safety issues when reheating leftovers and consuming them the next day:
- Food does not heat evenly throughout, so that some of it is not reheated to above 60°C/danger zone. This increases the risk of food poisoning if bacteria can reproduce.
 - Using a container that is not microwave safe, therefore can release chemicals into the food contaminating it and make it not safe for consumption.
 - Left-over food is kept at room temperature while at university for more than 4 hours, promoting the growth of pathogenic bacteria and reaching a dangerous level causing food poisoning.
14. Food spoilage can be defined as changes in food and/or beverages that renders the product undesirable for consumption, due to an unusual texture, odour, taste and appearance which develops. These signs are generally visible to the consumer. Food poisoning is typically caused by pathogenic bacteria or viruses, leading to illness. Food poisoning is generally not visible to the consumer.



15. Any one of the following conditions:
- (a) Optimal temperature 5-60°C
 - (b) Neutral pH of 7, but most can reproduce in a range of 4.5-10
 - (c) Presence of nutrients
 - (d) Water activity of 0.90 or higher
 - (e) Availability of oxygen
 - (f) Time
16. It is good practice to prepare cooked meat first prior to raw meat, to reduce the risk of cross contamination. Raw meats are a good source of pathogenic bacteria as they have not been exposed to high temperatures, which can destroy and denature these microorganisms.
17. (a) Any on the following reasons;
- The implementation of education programs targeting hospitality workers, which has led to better hygiene practices
 - Better surveillance of Health Regulations
 - Employment of more health inspectors
 - More effective public campaigns educators consumers about way to care for and store food appropriately
 - Eating out less often e.g. corona virus restrictions (assuming better food safety practices in the home)
- (b) Any of the following groups:
- People who eat out regularly: greatest risk as they are relying on the hygiene practices of other people making their food
 - Infants and Children: immune system has not developed properly, therefore cannot fight infection of pathogenic bacteria that are present in food
 - Elderly: weakened immune system, especially as some medications can suppress immune system function
 - Immunocompromised: weakened immune system, due to medications or treatments or genetics
 - Pregnant and Lactating Females: weakened immune system due to the changes to their metabolism and circulation, as well as sharing the nutrients with the foetus.

18. (a)

Stage	Hazard and Food Safety Practice
A Storing the fish cakes	Fish cakes not stored in fridge/freezer: ensure these items are place in a cool environment below the danger zone until required to slow/stop bacterial growth. Not sealing fish cakes: reduce the exposure to air/oxygen by storing ingredients in airtight containers or prevent opening the packaging until required, to prevent bacteria contamination or reduce oxygen which encourages growth.
B Cooking the fish cakes	Undercooked fish cakes: check the temperature of the fish cakes with a thermometer to ensure they have reached a temperature above 75°C or until the fish is flaky. This will ensure that pathogenic bacteria have been destroyed.
C Serving the fish cakes	Cross-contamination (hands/other equipment): canteen staff to use clean surfaces/equipment and separate hand (gloved) for food and other hand for money to avoid contamination from objects with bacteria.

(b) listeria, E. coli, salmonella

19. (a) The strong link between sugar-sweetened beverages (SSBs) and increased energy intake as a cause of obesity, plus the obesity being a risk factor for further over-nutrition diseases such as CVD and Type 2 Diabetes. The number of people suffering from these diseases would also have a large influence over the need for a campaign to reduce their consumption. Finally, many reputable organisations are recommending the campaign such as the Heart Foundation, Cancer Council Australia and Diabetes Australia.
- (b) To avoid being taxed for adding sugars to beverages, manufacturers may look to limit sugars or replace them with artificial sweeteners. This may in turn result in reduced kilojoule intake from consumers and a flow on effect of lowering obesity and other obesity-related diseases. Food manufacturers may increase the price of their beverages to counteract the tax added to their food product and ensure a profit.
- (c) Checking and monitoring all public areas, workplaces, etc. to ensure sugar-sweetened options are not available would be impractical/very difficult (manpower, time and identification of all public areas that are selling food).

3.1: Food Processing

Topic Solutions

- Food can be stored in small individual servings or in shallow containers to speed up the cooling down process.
- Any two of the following:
 - raw meats, cooked meats and food containing meat, such as casseroles, curries, lasagna, and meat pies
 - dairy products and foods containing dairy products, such as milk, cream, custard, and dairy-based desserts
 - seafood (excluding live seafood) and food containing seafood, such as seafood salad
 - processed fruits and vegetables, such as prepared salads and ready-to-eat fruit packs
 - cooked rice and pasta
 - processed foods containing eggs, beans, nuts, or other protein-rich food, such as quiche and soya bean products
 - foods that contain any of the above foods, such as sandwiches, rice salads and pasta salads.
- This is because it takes more than four hours for food poisoning (pathogenic) bacteria to grow to dangerous levels.
- Food that has already been frozen and defrosted is likely to have a higher bacterial count due to going through the danger zone multiple times (e.g. when being frozen and then again when being defrosted), which provides optimum conditions for microorganism growth.
- The water molecules available are converted into ice, making it unavailable to microorganisms which require it for growth and reproduction. The reduction in temperature also slows enzymatic changes within the food and slows microbial growth, as microbes become dormant when temperatures are below the danger zone.
- 0.90
- Bacteria tends to reproduce best at a pH of 7; however, can reproduce within a range of 4.5-10.
- Food Standards of Australia and New Zealand (FSANZ)
- Food packaging could contaminate food in the following ways:
 - Releasing chemicals (toxins or heavy metals) that are present in the packaging into the food.
 - If the packaging material contains micro-organisms, dirt or other foreign material that can be transferred to the food.
 - If parts of the packaging itself break off into the food, for example broken plastic or glass.
- Any one of the following (but not limited to):
 - Squeeze bottles
 - Ring pull tops on cans
 - Pop tops on drink bottles
 - Screw top jars
 - Containers suitable for refrigeration, freezing or microwaving
 - Packaging coming in individual servings (portion controlling)
 - Zip lock bags

	Type of active packaging	Scavenger or Emitter	Component Released or Absorbed
11.	Modified Atmosphere Packaging	Scavenger and Emitter	Oxygen is absorbed, CO ₂ and nitrogen are released
	Vacuum packaging	Scavenger	Oxygen has been evacuated
	Oxygen Absorber	Scavenger	Oxygen is absorbed
	Moisture Scavenger	Scavenger	Moisture is absorbed
	Carbon Dioxide Emitter	Emitter	CO ₂ is released
	Ethylene Scavenger	Scavenger	Ethylene is absorbed

Review Solutions

1. (a) Any two of the following:
 - Extends the shelf life of food products
 - Makes food safe for consumption, reducing food poisoning cases
 - Increases the range of food available, allowing food to be consumed out of season
 - Reduces the shopping frequency
 - Reduces the cost of food
 - Saves time preparing food at home
- (b) Any of the following could be applied to the food products but are not limited to, however, make sure to provide a different processing method to each to demonstrate your understanding and avoid double dipping:
 - Freezing: slows down the growth of microorganisms and enzymatic activity responsible for spoilage by exposing it to a temperature below the danger zone and reducing water availability (applicable to chicken, milk, and tomatoes)
 - Cooking/canning exposes food items to temperatures above the danger zone (121°C), destroying bacteria and denaturing enzymes. Foods that are canned are also vacuum sealed, expelling any remaining oxygen left in the can (applicable to tomatoes and apricots).
 - Pasteurisation: exposes foods to temperatures above the danger zone (72°C) which kills pathogens and inactivates spoilage enzymes (applicable to milk).
2. As lifestyles across Australian cities become faster and busier, consumers are wanting more ready to eat meals on the go, pre-cut, pre-portioned quick cook meals at home, or even single serve beverages and quick snacks while they are on the go.
3. Principle 1: Canning heats foods to a temperature of 121°C for 15minutes, which destroys and denatures bacteria and enzymes.

Principle 2: The product is filled with an accompanying liquid to replace as much of the air as possible, which many microbes require for growth. The liquid fill also aims to reduce water availability with the addition of solutes that bind to available water and lower the pH making it more acidic, which cannot support the growth of bacteria.
4. Any two of the following:
 - Exposes milk to light, therefore light sensitive nutrients can break down e.g. Vitamin B2.
 - Fragile- easily broken, making transport an issue/safety issue e.g. injury/wastage.
 - Shape makes it awkward to pack, more liable to break during handling and transport.
 - Has a negative impact on the environment as it uses resources e.g. uses water and electricity to recycle bottles.
 - The cost of glass is greater in comparison to cheaper alternatives such as plastic and cardboard, therefore greater manufacturing costs.
5. (a) Approximately 3.2-3.4 hours.
- (b) The longer the juice is kept at high temperatures the more vitamin C that is lost.
- (c) Any one of the following:
 - The brand / type of juice = Different brands may have different vitamin C contents to begin with.
 - The volume of juice = greater volume may increase Vitamin C loss due to having a greater amount to begin with.
 - Temperature of juice maintained = If temperature increases, vitamin C loss will increase due to its heat sensitivity.
 - Exposure to light = greater light reduces the content of Vitamin C content due to being light sensitive
 - Time of measurement = if greater time then greater vitamin C loss, as greater exposure to light, oxygen or heat will cause greater loss and denaturing of this water-soluble vitamin.
 - Same experimenter = may measure the amount of Vitamin C/temperature incorrectly therefore decreasing the reliability/precision.

6. The disadvantages of Aluminium Cans can include:
- To open an aluminium can, one end needs to be cut open or the ring tab is pulled; therefore, they cannot be reused or resealed. This contributes to landfill if not recycled appropriately.
 - Aluminium cans are not transparent; therefore, the consumer is unable to view the contents inside the packaging.
 - Producing aluminium cans uses non-renewable resources, and releases greenhouse gases into the atmosphere, contributing to global warming.
 - Aluminium cans cannot be microwaved; therefore, are not convenient for the consumer.
 - Can corrode when storing acidic foods, therefore contaminating the contents inside and causing the food to taste like the metal.
7. (a) Any one of the following:
- Cheap to produce, therefore making the product more affordable for the consumer.
 - Lightweight, therefore easy to carry and transport from the store to home and limits the likelihood of breakage.
 - Transparent, therefore allowing the consumer to see the food and make an informed decision about it.
 - Easy to label, providing information to the consumer and allowing them to read and understand it clearly to make an informed decision.
 - Hygienic, limiting contamination and ensuring it is safe for the consumer.
- (b) Any one of the following:
- Contributes to landfill – increases deforestation and clearing of land.
 - Non-biodegradable – nonrenewable.
 - Pollutes ecosystems – destroys animals homes and causes them harm.
 - Confusing with recycling – which plastic goes where, therefore contributes to landfill if not recycled properly.
 - Different plastics – different recycle methods requires energy.
 - Creates pollution – contributes to air and noise for producing plastic.
 - Production of greenhouse gas emissions during production, contributing to global warming.
8. (a) Breakfast Cereal
- Risk Factor: moisture, insects/rodents/bacteria, oxygen
- Packaging Material: Plastic bag and exterior strong cardboard box
- Explanation: Has two barriers to prevent exposure to moisture (which can cause the growth of mold) or oxygen (which can cause cereal to go stale) or contamination from insects/rodents/bacteria.
- (b) Fresh Eggs
- Risk Factor: Breakage
- Packaging Material: Egg carton (cardboard)
- Explanation: Separates eggs so they do not touch and crush each other during transportation and thus break
- (c) Orange Juice
- Risk Factor: Light exposure
- Packaging Material: Frosted Plastic container or UHT packaging
- Explanation: Reduces penetration of light to limit the denaturing of water-soluble nutrients which are light sensitive

3.2: Food Systems and their Effect on the Environment

Topic Solutions

1. (a) Farming land (pastures/crops) will increase and land covered by forest will decrease.
(b) Cropland grows plants that are sources of human foods while pastures grow plants that are used for animal consumption.
2. (a) Employment has decreased over the last 19 years (or from about 2000 to 2019) by around 90 000 people/level (or from around 380 000 to 290 000).
(b) People don't seek employment in agriculture due to not wishing to be isolated (away from services, socialisation, etc); or experience hardships such as drought affecting income; or are aware it is a career that is heavily labour-intensive; or can cause ill mental health; etc.
3. Stress/anxiety or depression due to isolation in rural areas with limited facilities and socialisation opportunities.
4. (a) A = Land with dryland salinity; B = before clearing; C = After clearing.
(b) Before clearing (B), most of the water is used by the plant roots or is transpired back to the atmosphere which is why the precipitation block is only thin. After clearing (C), the precipitation block enlarges as the rain is not used by plant roots as effectively and it remains in the soil, causing the water table to rise. It is larger again in dryland salinity as the salt kills the plant life and no plant roots are available to use any precipitation from the soil.
5. (a) Bread (the salt that is added to bread must be iodised)
(b) Food Standards Australia New Zealand (FSANZ)
6. (a) Tree roots can bind soil to reduce erosion; tree roots utilise precipitation to ensure water table remains below the surface of the earth, reducing salinity concerns; native vegetation can provide leaf litter and nutrients for the soil, improving soil fertility. More arable soil for aforementioned reasons means less farming land sizes are needed, therefore less land clearing.
(b) Corridors can increase the area of habitat of native flora and fauna and therefore improve biodiversity. Plant life utilises carbon dioxide, therefore a positive impact upon climate change.
7. (a) pH 3-4.5
(b) Nitrogen with a pH anywhere between around 4.5-7.5 acceptable; phosphorus with a pH range 5.5-7 & 8-9 (or greater than 8); potassium with a pH range 6.5-9.
(c) Molybdenum is available in larger amounts in a pH range of 6.5-9. Below 6.5, its availability constantly decreases until there is minimal quantities at a pH of 3.
8. (a) iron
(b) symptoms of anaemia (fatigue, pale skin, etc)
9. Answers are not limited to and may include:
 - Labelling requirement of storage instructions or date marking (due-by-date) to reduce chance of food poisoning bacteria growth/consumption.
 - Monitoring of food additives (types and quantity) to ensure no adverse allergy reactions.
 - Packaging regulations to ensure packaging used is 'safe' and won't introduce contaminants or won't damage the food and allow pathogenic bacteria to flourish.
 - Stringent rules for 'gluten' free to avoid adverse health implications like poor nutrient absorption for those with coeliac disease.
 - Food recall listing on FSANZ website to remove potential food poisoning produce.
10. Wash fruit and vegetables, grow your own, buy organic, peel off the skin before eating.
11. (a) Society and ethical concern (especially from farmers who are at high-risk of pesticide exposure) over pesticide dangers such as headaches to birth defects may have led to scientists designing the neonics to begin with as they were formulated to be less hazardous to mammals, they only require one application/season and they leave very little residue remaining on fruit/vegetables after spraying.

Economic consideration may have also influenced neonic design of being water-resilient and not vulnerable to UV breakdown. Costs to farmers can be reduced as they don't need to spray as often and neonics are very effective and allow high crop yields giving higher profits (this is also a society influence in relation to increasing food security for a growing population).

- (b) The scientific reports linked neonics to declining bee populations which has been an influence over society banning this pesticide.
- (c) The application of declining bee populations is one phenomenon driving a move towards sustainable agriculture: farming methods incorporating indigenous, traditional or organic practices to decrease the use of pesticides. It could further influence science into creating other pesticide formulations. It could also result in more corridors and areas of native vegetations over agricultural lands and areas of urbanisation, better bee husbandary and commercial pollination practices, and more awareness campaigns to build public education.
- (d) Being very effective in killing pests like aphids may see the natural animal life flourish, rather than the pests using all food resources. Neonics being UV degradation and water resistant means less pesticide spraying and therefore reduced water and air pollution that is known to reduce biodiversity.
- (e) Answers may include but are not limited to:

Bees are required to pollinate many of our food growing crops, like apples! Therefore without sufficient bee populations, we could suffer poor food security. Drastic impacts of this could see reliance on plants that don't need pollination and animals that feed from plants not requiring pollination. Restriction of food choices could result in some deficiency diseases resurfacing. Alternately, science may need to develop technologies such as drones that artificially replace bees.

12.

Chemical	Purpose	Advantage	Disadvantage
Pesticides	Kill pests (insects, weeds, fungi) consuming crops/pastures	Less crop/pasture destroyed, better yields	Air, water, soil/land pollution Reduced biodiversity Human side effects e.g. cancer
Fertilisers	Provide nutrients for plant growth	Better plant growth, better yields	Air, water, soil/land pollution Reduced biodiversity
Antibiotics	To kill bacterial infections in animals	Healthy animals; reduced animal disease	Potential antibiotic resistance; possible allergen in foods

13.

Human labour	Prevents soil nutrient depletion and reduces weed and insect invasion of crops
Natural pesticides	Braconid wasps are encouraged around lettuce crops for the purpose of their larvae being a parasite to the caterpillars that consume lettuce
Biological control	Workers hand-picking potatoes using a hoe to dig them up
Mixed farming (form of free range farming)	Pyrethrin, a compound extracted from the chrysanthemum flower can be sprayed on crops as an organic insecticide
Crop rotation	Can improve soil fertility by adding nutrients through manure
Intercropping	Field planted with rows of lettuce, spinach and carrots

14. (a) oil
- (b) Approximately 61 years (114 -53)
- (c) Answers may include but are not limited to:

Application – as fossil fuels deplete, prices of energy increases. Agriculture could make a more concerted effort to convert to renewable energy sources or increase human labour on farms rather than rely on machinery. Governments could offer incentives/rebates/financial support to convert to renewable energy.

Impact – without fossil fuels to power machinery and equipment that increased productivity, food productivity and availability could dwindle, food prices could increase and poverty, deficiency diseases and malnutrition may rise.

15. Plants, especially trees, absorb carbon dioxide from the atmosphere and store it as carbon. When cleared, this carbon is released as carbon dioxide resulting in increased levels of this greenhouse gas. Levels are also elevated by less carbon dioxide being absorbed by plants.



16. Cattle requiring large amounts of feed for their size can equate to large areas of land being needed or cleared. Link to an environmental issue for a further mark (biodiversity reduction, salinity).

Cattle release methane which is a powerful greenhouse gas. This can be linked to global warming or climate change.

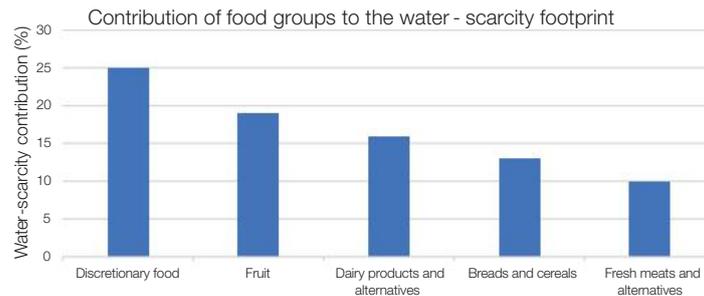
Cattle can over-graze, removing vegetation and leaving soils bare and subject to erosion. Erosion can reduce soil quality as the fertile topsoil is lost.

Cattle can compact soils which heightens water erosion.

Cattle urine and manure can cause eutrophication and reductions in biodiversity of near-by water ways.

Dairy farms require large amounts of water for cow health and growth, cleaning and sanitization.

17. (a) Marks – title, axes (with units), correct plotting, choice column graph

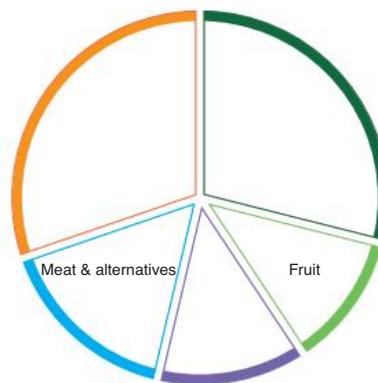


- (b) (i) Discretionary food as it's production is using 6% more water than any other food production (or it has the largest water-scarcity footprint at 25%).

(ii) Answers may include but not be limited to:

- Discretionary food is typically energy-dense or high in fat and is associated with obesity and other diet-related diseases
- Discretionary food is high in simple sugars which can cause Diabetes Type 2 or any other diet-related diseases
- Discretionary food is high in sodium which is linked to hypertension
- Discretionary food is low in fibre which is associated with obesity and other diet-related diseases

(c)



18. Salt reaches the root-zones of shallow-rooted plants in the topsoil; if it is crop/pasture they will die (or severely decreased yields), if it is natural vegetation, it will disrupt natural food chains

19. Increase in nutrient concentration in a body of water

20. 'Product of Australia' labelling as ingredients are sourced across Australia and the product is made in Australia

21. Any two of the following:

1. Grow own vegetables, fruits and herbs
2. Buy local e.g. farmers markets
3. Buy produce in season
4. Buy 'product of Australia' as much as possible
5. Buy fresh foods and freeze them (or alternate preservations methods, see 3.2) to extend their shelf life over the 'off-season'

22. As lifestyles across Australian cities become faster and busier, consumers are wanting more pre-cut, pre-portioned quick cook meals at home, plus ready to eat meals, single serve beverages and quick snacks while they are on the go. This convenience requires more of our raw or whole foods to be processed and therefore additional packaging (vs cooking at home using raw/whole foods).
23. We're increasingly aware of how plastic is polluting our environment. Plastic debris is gradually broken down into smaller and smaller fragments in the ocean, until it forms particles smaller than 5 mm, known as microplastics, which will likely never biodegrade!

From what little we know about microplastics in air, food and water, Canadian researchers have now estimated that the average person consumes more than 74,000 particles of plastic each year. In all likelihood, the authors admit, this undervalues the reality. Due to a lack of data, the research was limited to only a few categories, including fish, shellfish, added sugars, salts, alcohol, tap or bottled water, and—of course—the air we breathe. Based on a thorough review of the literature, including 26 peer-reviewed studies, the team created a microplastics database which they then compared to US dietary data. Depending on a person's age and sex, the number of particles consumed yearly sat somewhere between 74,000 and 121,000 particles. Of all the items in the database, air, bottled water, and seafood accounted for most of the microplastic intake, although these also had the most variation depending on your location and food intake.

While the results might sound scary at first, the authors themselves admit that there's a lot of variation in the underlying data. They also remind readers that their estimates are based solely on the average American's daily food consumption, and only 14 percent of the caloric intake at that. "Extrapolating the number of microplastics consumed with the remaining 85 percent of calories is not possible," the authors write, "however, if our findings are remotely representative, annual microplastic consumption could exceed several hundred thousand."

Without including cultural differences in diet, or staples like meat, dairy, grains, and vegetables (data which does not yet exist), these results are more of a ballpark figure. What's more, the research says nothing about the costs, if any, to human health. Today, the effects of consuming microplastics are largely unknown, and yet there's little doubt that it's going on right now at unprecedented volumes. The potential pathways for harm are many, and scientists have only proposed a few. Once microplastics enter the gut, they could release toxic substances causing oxidative stress or even cancer, according to the researchers. Particles small enough could be taken up by cells in the lungs and gut; while larger ones might be absorbed in the digestive tract. What happens from here is anyone's guess. Many questions for the scientist to try to answer in a short period of time because this is urgent."

If the goal in the meantime is to avoid microplastic ingestion, the authors suggest quitting bottled water first. In their findings, microplastic consumption in water changed considerably depending on whether it came from a bottle or the tap. Compared to water from a pipe, for instance, the authors found bottled water contained 90 more microplastic particles per litre.

Still, in all likelihood, avoiding bottled water is just a drop in the bucket. While more direct research needs to be done, the trend so far suggests that microplastics will continue to be found in many, if not all, items intended for human consumption. "If the precautionary principle were to be followed, the most effective way to reduce human consumption of microplastics will likely be to reduce the production and use of plastics," the authors conclude.

(Communication & Collaboration, Influence, Development, Application and Limitation)

24. Influence
25. The food has potential to allow microbes to grow; it has food poisoning potential after the use-by date.
26. Carbon dioxide or nitrous oxide have the ability to trap heat radiation from the sun, thereby warming the Earth and changing the world's weather systems which is known as climate change.
27. Answers may include but are not limited to:
- Cook food evenly above 60 degrees (ideally above 75) or as instructions require
 - Allow food cool (no more steam) before placing into cold storage
 - Do not leave food on a bench for longer than 2hours
 - Cover and store in a fridge/freezer
 - Ensure good hygiene before commencing cooking e.g. wash hands with soap
 - Ensure fridge is below 5 degrees.

Review Solutions

1. (a) Crop rotation involves replacing a farming field with a different plant or crop each season. It can rotate through two to multiple different types of crops on the same field but only one crop is grown at a time. Intercropping allows different crops to grow in the same field at the same time, often in alternating rows.
- (b) Different crops use and replace different nutrients from the soil which reduces the need of fertiliser. Less fertiliser to seep into the soil means less hydrogen is released into the soil from fertiliser breakdown. Hydrogen being added to the soil lowers pH and creates soil acidity. This can be reversed if fertiliser use is reduced.
- (c) Free range, mixed farming, human labor, alternate energy sources, biological control, intercropping and more.

Practice	Organic Farming	Monoculture
Using synthetic pesticides	x	✓
Typically produces higher yields	x	✓
Uses manure as fertiliser	✓	x
Conserves energy by using human labor where possible	✓	x

3. Depression, stress or poor mental health from living rurally and isolated on farms without many facilities and socialising opportunities.

Goitre, from consuming plants low in iodine due to it being depleted from soils (topsoil depletion or loss from erosion).

Skin or eye irritation, respiratory symptoms similar to hayfever or gastroenteritis from blue-green algal toxin contact, inhalation or ingestion.

Problems with depleting oxygen levels or increased chance of cancer from water containing nitrates from fertilisers.

Headaches, skin/eye/respiratory tract irritations and vomiting, through to birth defects, nervous system disorders and some cancers with pesticide exposure.

Allergic reactions or antibiotic resistance from antibiotic residue in animal products like meat or milk.

Unpredictable weather patterns of climate change like floods and hurricanes, from high energy use in agriculture, can put lives in danger.

4. (a) Rice, cotton, sugarcane, pastures/cereals
 - (b) Rice
 - (c) Excess water may seep through the soil causing the water table to rise (irrigation salinity) with dissolved salts that hinder crop growth. This reduces yield and food availability.
5. Agriculture–Produce discarded: due to pest, disease or weather damage; due to poor handling e.g. bruising; due to fall in market prices or consumer preferences so crops are not harvested but left to rot; due to imperfections e.g. size.

Processing and distribution – Produce discarded: due to damage or food spoilage caused by handling/poor transportation e.g. inadequate cold temperature; due to excessive trimming of food skins; due to changing consumer demand; due to packaging damage leaving food unfit to consume.

Retail and food service – Produce discarded: due to over-ordering food, improper storage or handling; due to being ‘imperfect/unappealing’; due to limited food waste storage/disposal facilities.

Households – Produce discarded: due to not recognising ‘best-before’ date marking is still edible past its date; due to over-purchasing or cooking; due to limited food storage knowledge; due to limited food waste collection facilities.

6.

Level	Strategies to reduce food waste
Global	<ul style="list-style-type: none"> • Each country needs to recognise that food waste is an issue and align with UN's sustainable goal 12.3: aiming to reduce food waste by 50% by 2030; each country can do this by: • Developing a voluntary commitment program from food industry organisations to identify solutions to reduce food waste • Diverting more surplus food to the food rescue sector so that it can be redistributed (creating partnerships between food businesses and food rescue charities) • Supporting educational campaigns around food waste (increasing public awareness about the magnitude of the food waste problem and its negative impacts) • Investment into research and technological improvements • Investment into agricultural efficiency and waste treatment infrastructure (for example funding for projects that encourage composting) • Providing incentives for alternatives to landfill disposal • Creating value from food waste (for example providing funding to projects that focus on capturing methane from landfills to produce electricity) • Providing food waste data to track and monitor food waste.
Local – retail, food service	<ul style="list-style-type: none"> • composting organic materials in an effort for food waste to then be converted into energy sources (this could see investing in facilities to allow on-site processing of food waste) • developing solutions to convert food waste into animal food • exploring and experimenting how different types of packaging can reduce food waste • marketing aesthetically imperfect produce, discounting product that is near expiry date, and forecasting and planning to avoid over-ordering • partnering with food rescue organisations to donate food that would otherwise be wasted • developing web-based wholesale marketplaces for surplus food and ingredients.
Local – government	<ul style="list-style-type: none"> • Organise food waste collection and disposal from their council area • Provide community information sessions and demonstrations on appropriate food storage and composting at home • Provide grants and rebates for households to purchase compost bins and worm farms • Trial and run programs for restaurants and cafes to assess their food waste practices and reduce the amount of food they send to landfill • Support local businesses to collect food waste and turn it into valuable products like compost and fertiliser.
Local–Community	<ul style="list-style-type: none"> • Make and use your own compost bin • Be open to purchasing and consuming 'ugly' fruit and vegetables • Check food labels date markings and know that food can be consumed after its best before date (as long as the food has not been opened) • Freeze food you know you want get a chance to eat before it passes its use-by date. • Check the fridge before shopping, don't go hungry and write shopping lists so that you stick to buying only the food you need • Plan meals so that you only buy what is needed and don't cook too much food, • Should you buy additional take-away food for convenience, leaving food planned to be cooked sitting in the fridge, rather than leave it to spoil: cook and store safely for an alternate day. • Use left-overs (store correctly) • Donate unwanted food.

7. (a) Olive tree roots hold the soil more effectively than potato roots, thereby reducing soil erosion/increases soil quality.

Olive tree roots ensure the water table remains below the surface of the earth, thereby reducing salinity issues.

Olive tree leaves/etc provide nutrients to the soil where they fall and decay, thereby increasing soil quality/fertility. This in turn reduces the need for fertilisers, reducing its environmental impacts (toxic waterways affecting biodiversity; leached fertilisers reaching groundwater; leached fertilisers in soil reducing its quality). More fertile soil can also increase yields, allowing less land needing to be allocated to farms which saves deforestation and its environmental impact e.g. loss of biodiversity.

Existence of different crops can reduce exploitation of a crop via a pest, leading to reduced pesticides and its negative effect on biodiversity.

Trees utilise CO₂, reducing greenhouse gases/global warming/climate change and its negatives on the environment e.g. biodiversity reductions.

- (b) Olive trees may interfere with potato yields (taking land space), thereby further land would need to be cleared which can harm biodiversity.

Olive roots could be more successful at utilising water applications, therefore further water may be needed adding to water scarcity (negative affect on biodiversity if waterways are re-directed to farms); and irrigation salinity (negative effect on soil quality).

Farmers may need to develop new skill sets to care for two types of plants and this may create stress and poorer mental health; it may also require additional costs to care for both e.g. alternate equipment for pruning, different fertilisers/pesticides and therefore be financial burden.

8.	Rainwater seeps through the soil, unable to be trapped and used by tree roots	2
	Crops planted in topsoils perish in saline soils	4
	Food supply dwindles	5
	Deforestation removes natural habitats to allow for agricultural crops to be planted	1
	Water table rises dissolving saltwater as it rises	3

3.3: Research and Development

Topic Solutions

1. Digital farming creates autonomous farms that essentially run on their own. This could allow farmers to run farms remotely, reducing the need to live rurally and isolated which has been known to cause depression.

Higher yields could provide economic benefits that improve optimism and mental health.

2. The following answers focus on influence and application and limitation, to which the article lends itself. Answers may include, but may not be limited to (note: answers are more extensive than required for the marking scheme):

The introduction of automated food production methods into farming has been influenced by environmental and socioeconomic considerations. Consumer trends towards foods produced with environmental sustainability in mind has motivated the automated move to seeing farming robotics being scientifically designed, for example, to apply only the required chemicals like fertilisers and pesticides, hence smaller amounts in total compared to current farming method amounts. The application of reduced chemical use has further environmental impacts such as improving biodiversity and soil and water quality, which can be negatively affected by chemical use.

The socioeconomic influence comes over the concern of food availability for an ever-growing population to feed. Farm automation is predicted to be able to meet this need due to robotic farming machinery being able to increase the productivity of farms. The application of this could increase farming profits and may have an impact upon improving the current decline in farming employment. The decrease in farmers and willing farm laborers was another influence over the need for development of automated farms, so that its application—the intensive labor or hands required to run a farm was heavily reduced. Increased yields could also ensure better food security or food for all and drive food prices down.

However, moving from people to technology may have unexpected consequences on farming communities as its use is new and will require monitoring as to whether the expected benefits are reached. Its movement into farms may also be limited by economic considerations: it would be very costly for the initial set up and have on-going repair burden. This could see automation limited to larger companies or farms and have a negative effect on smaller farming businesses. Success of automated farms would also require farmers to obtain new knowledge, training and experience running the technology to ensure its use was effective.

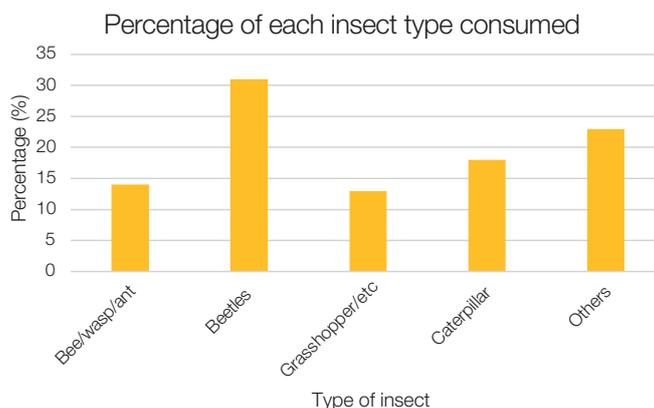
3. Farming areas that are less arable may have lower rainfall and higher temperatures which decreases yield, therefore negatively affecting food availability.
4. Enclosing areas of plant growth can reduce chances of pest exploitation (insects and weeds) and therefore need for pesticides which have negative effects on biodiversity (non-target species).

5. Nutrient concentration increases (called eutrophication) and this encourages algal growth. Blue-green algae can use and deplete oxygen in water making the water toxic to other water life.
6. Herbicides are sprayed over crops to kill weeds.
7. (a) disaccharide
(b) Macronutrient: carbohydrates (soluble fibre), protein, fat – the essential fats Omega 3 and 6
Micronutrient: B-vitamins (particularly folate), calcium, iron
8. (a) Additional soluble fibre would slow stomach emptying and therefore decrease the rate of monosaccharide absorption into the blood more readily (this results in a lower GI).
(b) Type 2 Diabetes, atherosclerosis (and therefore hypertension and CVD) and obesity
9. (a) Answers may include, but may not be limited to (note: answers are more extensive than required for the marking scheme):

Researchers from Australia and Uganda have worked collaboratively over 10 years at the Queensland University of Technology to develop a new banana with improved vitamin A levels. Researchers and the university have further collaborated with the Bill and Miranda Gates Foundation in order to gain support for the research. Effective collaboration and communication between Uganda and Australian governments would be required to permit banana testing field sites in both countries and between researchers coordinating the field studies. Findings of the research have been communicated in the Plant Biotechnology Journal.

- (b) Discovery of genetic modification processes have benefited the development of the pro-vitamin banana. Its development genetically modifies the cavendish banana with a gene from a Papua New Guinea banana high in vitamin A. This development allows for a type of banana with higher vitamin A that can grow in larger bunches that could feed more people, especially children in Uganda.
10. Answers may include but are not limited to:
 - Regulates food additives in products
 - Governs labelling laws
 - Sets packaging regulations
 - Monitors food fortifications
 - Assesses food for contamination
 - Communicates food recall

11. (a)



- (b) Beetles are consumed more commonly, about 10% more than others/13% more than caterpillars; grasshoppers/etc are the least popular, by around (as before); other conclusions are possible.
12. polyunsaturated or monounsaturated fats
13. Insect flour is a good source of soluble fibre (or iron, vitamins, minerals) and unsaturated fats which increase the nutrient-density in comparison to plain flour.
14. Macronutrient: protein; Micronutrient: iron, B12.
15. Genetic modification
16. Acellular processes harvest or collect what the cells, namely microbes (bacteria/yeast) makes, while cellular agriculture harvests what the cell culture multiplies or grows into

17. Insects use less resources to feed them (convert feed to protein body weight more readily and grow/reproduce quickly); less water to rear; less land to rear.
18. Cattle can over-graze areas leaving soil bare. Bare soil is subject to erosion and erosion remove the fertile topsoil of land. Erosion and removal of topsoil are forms of land degradation.

Cattle can compact the soil causing precipitation to run-off, leaving soils dry and less able to support plant life and therefore fauna dependent on the plant-life. Compacting soils is a form of land degradation.

Rearing cattle in areas with pastures requires deforestation. Deforestation can result in water tables rising, bringing saltwater to the surface (called dryland salinity). Saline soils will not support biodiversity. Dryland salinity and deforestation and forms of land degradation.

19. Litter entangling wildlife and landfill

Review Solutions

Food production method	Definition or example
Digital farming	Uses soilless techniques such as aquaponics and hydroponics to grow crops
Vertical farming	Foods derived from a crop or animal that has had a gene that will express a desirable trait introduced into its genetic make-up
Cellular agriculture	Food manufactured from syringes that hold food pastes
Entomophagy	Myosatellite cells producing muscle tissue
3D printing of food	Novel foods that have not been consumed to a significant degree in the past in Australia
Genetically modified food	Robotic egg collection and sorting by weights
Acellular agriculture	Eggwhite production from bacteria

2. GM of foods is pinnacle to nutritional health as they have the ability to modify foods to contain elevated levels of nutrients; for example, wheat with added protein and soluble fibre. Aeroponics, a form of vertical gardening, has been found to improve crop uptake of nutrients. Fruit and vegetables will therefore become more nutrient-dense to aid in human nutritional health.

Entomophagy provides a rich animal protein source with additional nutritional benefits such as fibre and mono- and poly-unsaturated fats.

3D printing of food is able to fortify nutrients into food pastes to match individual nutritional needs and promote health (reducing chance of deficiency diseases for example).

3. Entomophagy can potentially reduce food waste issues as certain insects can utilise food waste as a food source.

Digital farming can detect poor animal or plant health more readily, minimising loss and therefore food waste.

3D printing of food can utilise foods that would be ordinarily be discarded, for example, abnormal-appearing fruit and vegetables can be turned into purees that are used to 3D print visually appealing foods.

4. Vertical farming/cellular agriculture/3D printing food production methods are all conducted within enclosed areas and therefore growth of crops of man-made livestock produce are not affected by environmental weather conditions.

Genetically modified foods can have crops altered to be more tolerant of dry hot conditions. For example, genes from plants that encourage growth in periods of rain and halt growth in dry/hot conditions can be inserted into crops to allow them to survive harsh drought conditions they would normally perish in.

5. (a) Available arable land has decreased substantially from approximately 3.4 hectares/person to 2 hectares/person over a period of about 53 years or by around 0.1 hectares/person every 5 years.
- (b) Data values around 1965-70 fluctuate above and below the line of best fit (or average or true value) which indicates random errors may be at play. The data values are also further from the line of best fit indicating poorer precision which lowers the reliability of the results. In comparison, data values between 1985 to

1990 are all above the average which indicates systematic errors may be responsible for these findings. Systematic errors affect accuracy but as the data values are relatively close to the line of best fit, results can be said to be quite accurate during these years.

- (c) (i) Insects (entomophagy)
- (ii) Insects require less water and feed resources to grow as they can convert their food to protein body mass more readily than cattle. Using less resources from the environment ensures they are not depleted for needed biodiversity.

Insects can use food waste as a source of nutrition which combats environmental issues surrounding food waste such as greenhouse gas production and its associated climate change with unpredictable weather patterns.

- (iii) Apart from comparable protein and iron levels, insects can provide additional fibre which is useful in dietary prevention of a number of over-nutrition diseases for example Type 2 Diabetes. They can also provide unsaturated fats while meat from cattle would be high in saturated fats (when meat is not a lean cut), therefore insects would be more beneficial in prevention/management of over-nutrition diseases such as CVD.
- (iv) Insects may not be appetising/appealing and therefore an unsuccessful farming replacement for cattle if consumers do not wish to purchase or eat them.

Insects may cause an allergic reaction in those people with shellfish/crustacean allergies.

- (v) Cellular agriculture/cultured meat/3D meat bioprinting can produce meat tissue from cell cultures in laboratory settings that would not require vast areas of farming land.

GM of food could be used to create cattle that are faster growing and with higher amounts of lean muscle tissue. This would reduce the number of cattle needed to gain the same amount of meat, thereby reducing land needs.

6. Vertical farms are able to be grown in buildings within areas of urbanisation. This would heavily reduce the food miles required for crop harvests to reach consumers.

GM crops are able to produce higher yields (for example, by being resistant to pests), therefore the land size required to be viable would be less, reducing how far farms would need to expand away from cities, potentially reducing food miles.

7. (a) Elderly are more at risk as the prevalence of dementia and cancer are higher in this age group.
- (b) Cooking can decrease a food's nutritional-density. This is because heat-sensitive nutrients such as vitamin C can be destroyed in high heat.
- (c) 3D food printing could be useful as it produces softer-texture foods
- (d) 3D printing of food can allow foods to be in a range of shapes, colours, textures and flavours. It can also be programmed to create foods that replicate pizzas, burgers, cakes, chocolates and other meals. This would create better variety, improved appearance and allow more control and choice over one's diet for someone with dysphagia. The application on this could see a reduced negative impact on one's mental health and fewer cases of depression.



Topic Three Test solutions

1. Answers may include, but not be limited to:
 - Primary food production can replace deep tree roots for shallow-rooted crop/pastures. This allows the water table to rise, creating saline soils i.e. poor soil quality.
 - During periods after harvest, fields can be left bare and subject to erosion which removes the fertile topsoil i.e. reduces soil quality
 - Intensive farming methods may over-use fertiliser which can seep into the soils, making them more acidic i.e. reduces soil quality
 - Intensive farming methods may over-use pesticides which seep into soils, reducing soil quality.
 - Intensive farming can deplete the soil of nutrients; less fertile soil reduces soil quality
 - Farming practices of adding fertilisers can improve soil fertility and therefore soil quality.
2. Answers may include, but not be limited to:
 - Agriculture can cause water to become saline (decreases water quality) due to deforestation resulting in rising water tables that dissolve salts and reaches waterways
 - Agricultural chemicals (for example fertiliser and pesticides) can leech through soils and contaminate the groundwater i.e. reducing water quality
 - Fertiliser run-off can wash into waterways to increase nutrient levels in water (eutrophication) that encourage algal blooms. These algal blooms deplete oxygen in the water, leaving it toxic and unusable (i.e. reduces water quality)
 - Pesticide run-off into water ways can cause water pollutions i.e. reduces water quality
 - Aquaculture can result in high concentration of nutrients in water from waste or feed pellets, with similar results as earlier bullet point.
3. Answers may include, but not be limited to:
 - Processing plant construction sites may clear natural habitat which can destroys native flora and fauna.
 - Food manufacturing relies heavily on fossil fuels. Mining of fossil fuels (and for packaging materials) can destroy natural habitats (as above). Fossil fuel use releases greenhouse gases which lead to climate change. Climate change is associated with increased incidence of extreme weather patterns; for example, flood and drought can wipe out flora and fauna populations. Global warming can make it hard for biodiversity to thrive in warmer environments. Rising sea levels saline waters can cause typical coastal area plant life to perish which disrupts coastal food webs.
 - Oceans absorbing CO₂, result in water acidification which is destroying coral reefs and negatively affecting marine life in other various ways (students may go into any of these further effects).
 - Food packaging can end up as litter instead of in landfill (landfill also reduces natural habitat). Litter can entangle animals or be mistaken as food.
4. Any two of the following:
 - Tomatoes are naturally acidic (pH = 4), therefore pathogenic bacteria less likely to multiply in acidic conditions.
 - High sugar/salt content preserves chutney by binding to free water molecules, reducing its availability to microorganisms, which require it for survival and reproduction.
 - Heat sterilisation (bottling) exposing to high temperatures, which denature and destroys micro-organisms and enzymes.
 - Airtight jars, reducing oxygen exposure and therefore the growth of aerobic bacteria.
5. Answers may include, but not be limited to:
 - Livestock can overgraze which exposes the soil to erosion. Reduced livestock will allow fertile topsoil to remain.
 - Livestock can compact soil, disallowing precipitation to penetrate. This can also increases rain run-off and water erosion. Reduced livestock will allow water to enter soils for improved plant growth (and maintain fertile topsoil).
 - Native grazing livestock compete with native animals for food. Reduced livestock will therefore allow native fauna (and flora) to flourish.
 - Livestock require vast areas of land and may also require additional pastures for feed. Reduced red meat in the diet will therefore result in reduced deforestation and all its associated environmental impacts (for example salinity issues, reduced biodiversity, etc).

- Livestock take a long time to rear. That means substantial amounts of water and energy (plus feed as covered last bullet point). Reducing red meat will therefore improve water scarcity issues. Less energy needed reduces one's environmental footprint in a multitude of ways (see food processing relying on fossil fuels in previous question answers). Reduced greenhouse emissions and reduced food miles for livestock processing can lessen air pollutants, for example, ozone.
 - Cattle produce methane which is a potent greenhouse gas. Therefore reducing red meat can decrease global warming, climate change and its associated environmental impacts (see answers from previous question).
6. (a) (i) Households
- (ii) Primary production/households/manufacturing contribute heavily to food waste, around 20-33% more; or wholesaling/retail/hospitality/institutions have small contributions to food waste, between 0.4-4%.
- (iii) Any of the following:
- Confusion over 'use-by' and 'best-before' date labelling
 - Over-purchasing or over-cooking of food that is then thrown away
 - Limited knowledge of how to safely repurpose or store food leftovers
 - Limited access to food waste collection systems
- (b) (i) Tasmania
- (ii) Answers may include but not be limited to:
- Governments enlisting farming businesses to voluntarily commit to reducing food waste.
 - The government may have set up partnerships between farms and food rescue charities.
 - Educational programs about food waste may have been delivered to farmers, or to consumers about 'ugly' produce allow farmers to sell additional produce normally discarded.
 - Governments may have invested into providing food wastage infrastructure (for example composting facilities) on farms.
7. Cans are filled with an accompanying liquid to replace as much of the air as possible. The application of heat can also expand the food, which expels any remaining air, therefore after sealing, it produces a partial vacuum within the container. Both techniques reduce the amount of oxygen that remains in the packaging after being sealed.
8. Packaging can reduce the exposure to light, moisture, oxygen, and heat from external conditions by creating an inert barrier. This reduces the nutritional changes to the food as some nutrients especially water-soluble are denatured when exposed to these optimal conditions.
9. (a) Food miles is the distance the food has travelled from its place of harvest, slaughter, or collection to its place of consumption.
- (b) Despite using less petroleum (and therefore fossil fuels) for travel purposes, the food may have been grown in conditions that over-use energy and other resources for example water. This is typically seen in food grown out of season in glasshouses or greenhouses. Link to an environmental concern for additional mark.
10. (a) Aeroponics development was in an effort to grow plant foods for astronauts, with little water and no soil, conditions compatible with space. This development for use in space has benefited another field of science: agriculture, in particular, as a method of vertical farming. Its development has improved the science of growing plants: in vertical farming, plants are able to take up additional nutrients as they grow compared to other methods of land or vertical farming. It has also improved scientific procedures whereby plants are able to grow with substantially reduced water needs. These findings may see aeroponics replace traditional methods of crop production in the future.
- (b) Aeroponics delivers nutrients and water through an air/mist spray and plant roots are not suspended in water. Hydroponic plants have their roots suspended in water and nutrients are delivered through the water.



- (c) Aeroponics and hydroponic methods of vertical farming are both conducted in enclosed areas. This can be extended into a number of possible answers including:
- This can allow control of environmental factors such as LED lighting and temperature.
 - This can allow for high yields of crops even during unpredictable weather patterns such as drought which are brought on by climate change
 - This can allow for higher yields of crops as they are protected from pests such as insects
 - This can allow for higher variety of crops to be grown due to both methods not having shared soil spaces
 - This can allow for reduced need of pesticides and therefore less air/water/land pollution or impact upon biodiversity

11. (a) The following answers provide more detail than required for the marking scheme.

SHE concept one:

Communication and collaboration is evident in this article as CSIRO are working with a food waste company called Goterra while running experiments to increase the breeding rate of a fly that can break down food waste. This collaborative effort could help find a technique that breaks down food waste most efficiently. CSIRO is also collaborating with University of Adelaide to find out the nutritional composition of a number of insects, plus local aboriginal communities to find out information about insect palatability in order to steer Australian's entomophagy industry with which insects would be best to farm. Scientists will gather at an international conference to communicate their findings and impart knowledge to ensure prospect of Australian entomophagy becomes a successful enterprise.

SHE concept two:

Scientific results collected from testing fly egg laying under different environmental conditions will enable scientists to develop the most effective way for flies to breakdown food waste. The application of the findings can help reduce the issues surrounding the sustainability of the environment, namely reducing food waste which rots and releases methane greenhouse gas releases plus adds to landfill pollution. Scientific testing discoveries could allow for effective conversion of food waste into compost which can be used as a fertiliser, offering an application of economic value.

Through building scientific knowledge of insect nutritional composition and palatability, scientists can make reliable predictions as to farming which insects would be most successful to market. Success in this industry could see a move away from traditional animal proteins towards insects and the application of this would be a reduced energy, water and land needs. Biodiversity could be positively affected as a result.

- (b) (i) temperature
- (ii) food waste consumed (g)
- (iii) Answers may include, but are not limited to:
- Number of flies (including the same balance in male/females), as more flies in an aquarium enclosure could result in more eggs/larvae/food waste consumption, rather than resulting from temperature.
 - Breed/age of flies, as different species/ages may breed at faster rates
 - Type of food waste, as some types may be converted into compost more readily
 - Mass of beginning food waste, as a smaller mass could result in lack of food source and consumption/breeding rate slowing
 - Lighting, as additional lighting may signal day/night and activity levels may alter based on amounts of light
 - Moisture in the food waste, as higher levels may allow compost to be broken down more readily.
- (iv) 30°C
- (c) Entomophagy
- (d) 3D printing of food

12.

Preservation Method	How it Extends Shelf Life
Canning	Exposes food and packaging to high temperatures (121°C), which destroys pathogenic bacteria. The product is also filled with an accompanying liquid to the top expelling as much air as possible prior to being sealed.
Dehydration	Removes water activity, reducing enzymatic activity and microorganism contamination.
Freezing/ Refrigeration	Slows down the growth of bacteria and enzymatic changes, due to exposing the food product to a temperature below the danger zone. Freezing causes bacteria to be dormant, therefore making them inactive.
UHT	Exposes food to a temperature above 135°C for 1-3 seconds, which kills bacteria spores.

13. (a) Cultured meat can produce substantial amounts lean muscle tissue (meat) from only one small sample of muscle stem cells from a cow. Harvesting such large quantities of meat has the potential to feed a greater amount of people in comparison to slaughtering the cow for meat.
- (b) Procedures to produce cultured meat can be performed in laboratory conditions, not requiring the feed resources or land that cattle need. The cattle feed, which includes grains consumed by humans e.g. wheat, can therefore be re-directed to growing populations. The land could also be re-distributed for growing crops for human consumption.
- (c) SHE concept one: Development. Tissue engineering techniques to grow and replace human cells/tissues/organs in regenerative medicine have been developed and crossed into agriculture in order to culture meat tissue from cow stem cells. The development in regenerative medicine has been a benefit to meat production by offering scientific procedures that can improve animal welfare and environmental issues. It may even become a method of meat production that replaces current processes of cattle farming for meat.

SHE concept two: Communication and collaboration. The principals of cultured meat were communicated to society in a scientific paper in the early 2000s which has allowed for this method of food production to gain interest and popularity in the community. To ensure its future progresses, scientists interested in contributing to the advancements in this method of meat production are able to collaborate and conduct further research through an organisation called New Harvest.

14. (a) Any one of the following for the consumer:
- Lightweight, therefore easy to carry and transport whilst holding the pizza safe from potential contaminants
 - Strong and durable, therefore safe food delivery for Sally
 - Biodegradable and recyclable therefore less impact on the environment, consumers feel satisfaction when recycling
 - Protects food from light therefore food is kept safe to consume and retains its nutrient content
 - Can keep food warm, which would reduce risk of food poisoning or contamination to Sally
 - Can be printed on which provides information to the consumer regarding NIP etc. allowing her to make an informed decision.
- (b) Any one of the following for the manufacturer:
- Reasonably low cost to produce so manufacturers are not at loss of profit
 - Provides a surface for labels to be placed on for manufactures to advertise and give instruction
 - Can be delivered flat packed – cheaper transport costs
 - Can be made from recyclable materials and therefore cheaper to manufacturer, good promotion for the business or increases sales to consumers who are environmentally aware
 - Strong and durable, therefore reduced risk of mechanical damage reducing risk of contamination to food product.
- (c) Any of the following could be added to ensure the safety of food is maintained in cardboard box:
- Oxygen absorber can be added, which absorbs oxygen in the air by causing the iron powder inside to rust.
 - Moisture Scavenger could be added, which absorb and hold moisture from the air and controlling the humidity in the cardboard box.
 - Carbon dioxide emitter could be used, which produces and releases carbon dioxide within the package and pushing oxygen out of the cardboard box.

15. (a) The environmental application of wheat crops growing nodules to home nitrogen-fixing bacteria would be the benefits of reduction in fertiliser use and therefore reduction of its run-off into waterways. Less fertiliser in waterways means eutrophication that leads to algal blooms and consequential harm to biodiversity would be less likely. Lower reliance on fertiliser could have applications on climate change as well: with less fossil fuels and energy needed to synthesis fertilisers.

Reduced fertilisers seeping into the soil would benefit soil pH and ensure soil microbes and fauna are not harmed by the acidic soils fertiliser breakdown produces.

The social application relates to genetically engineering wheat having potential to improve yields, helping to meet growing food demands of communities.

Economically, farmers could save money on fertiliser costs and this could have further application of reduced wheat prices.

- (b) It is scientifically known that the issue of dryland salinity is brought on by the deforestation of deep-rooted trees for crops such as rice. It is also understood that salts brought to the surface by a rising water table after tree roots are removed, results in poor plant growth. This could be behind scientists seeking to create a sustainable solution in salinity-resistant crops by altering the genetic make-up of rice with a salt-resistant gene found naturally in coastal panic grass.
- (c) Consumer trends for food are towards those that are environmentally sustainable. This may influence research into methods that can reduce the use of fertilisers to lessen their environmental damage, such as symbiotic microbial biotechnology in agriculture.

Society may also be influencing research into the microbial biotechnology with followings of veganism and food production that doesn't harm animals becoming more popular (especially with a large public celebrity endorsement of veganism and campaigns against animal-cruelty). This surging trend in food choices can influence methods such as microbial biotechnology of crops because of a need to improve plant (vegan) yields to match food demands.