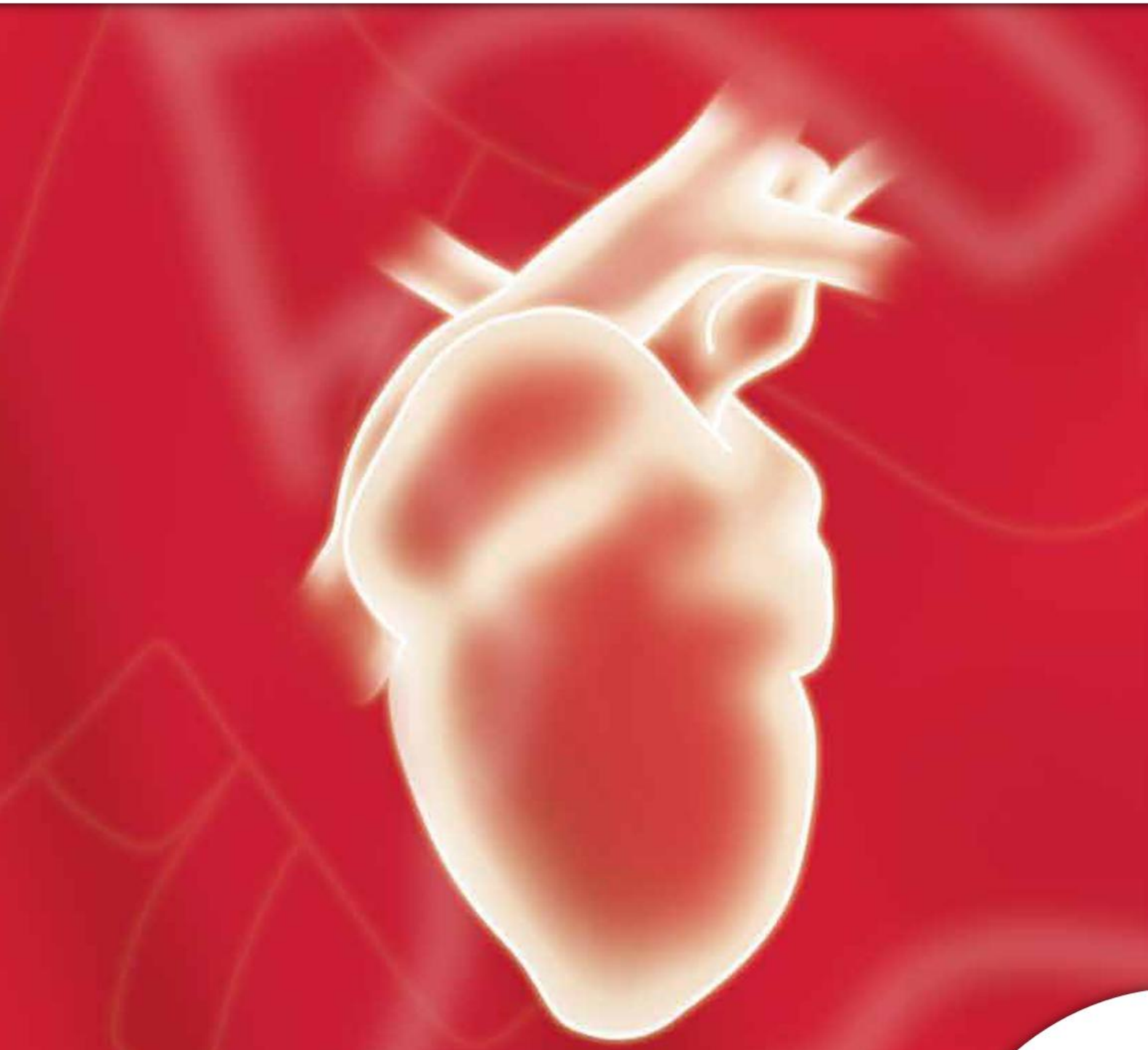
EXPLORING

HUMAN BIOLOGY

YEAR 11 - ACTIVITIES & INVESTIGATIONS



STAWA
SCIENCE TEACHERS' ASSOCIATION OF WESTERN AUSTRALIA

YEAR 11 ATAR

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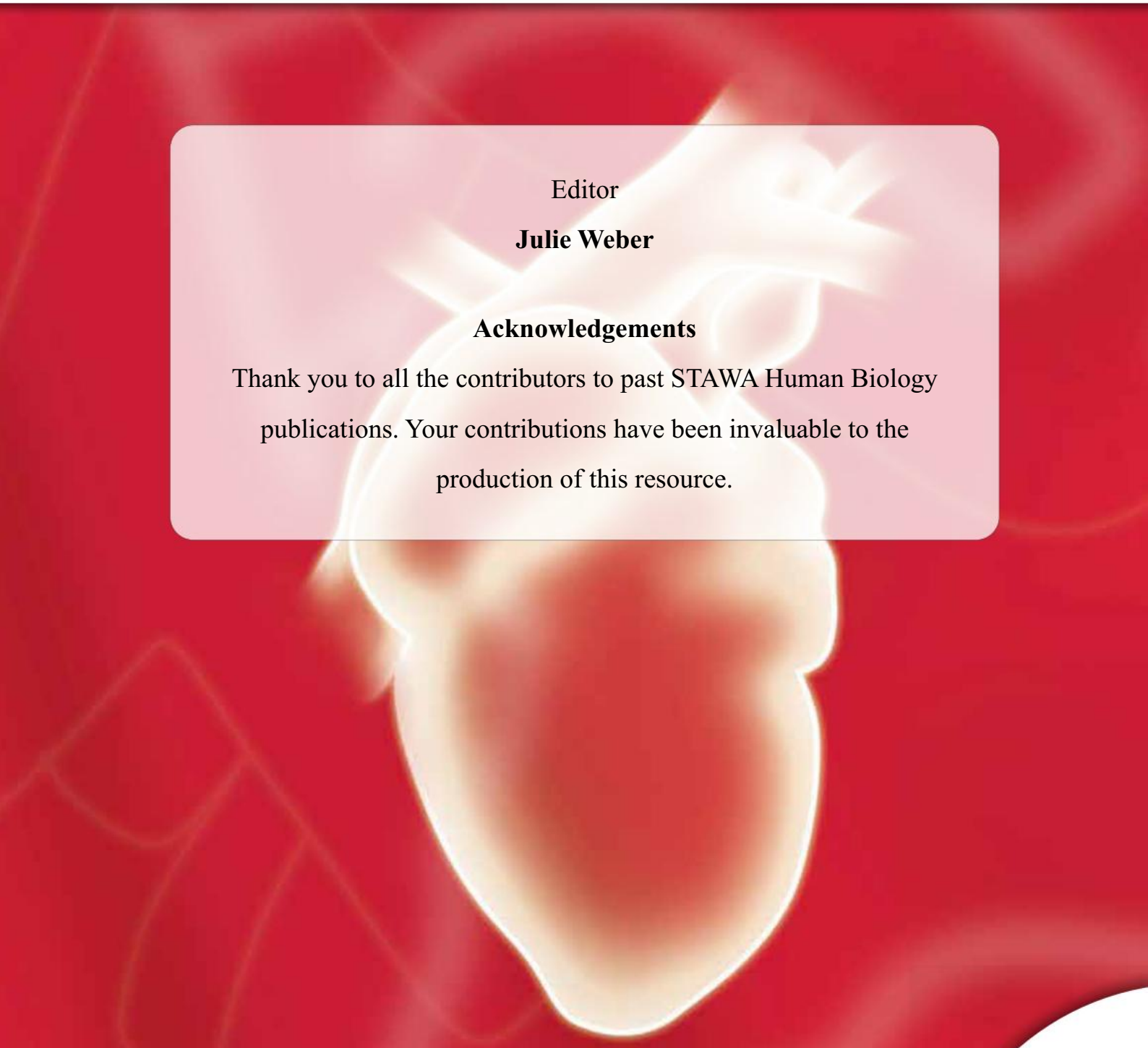

Editor

Julie Weber

Acknowledgements

Thank you to all the contributors to past STAWA Human Biology publications. Your contributions have been invaluable to the production of this resource.

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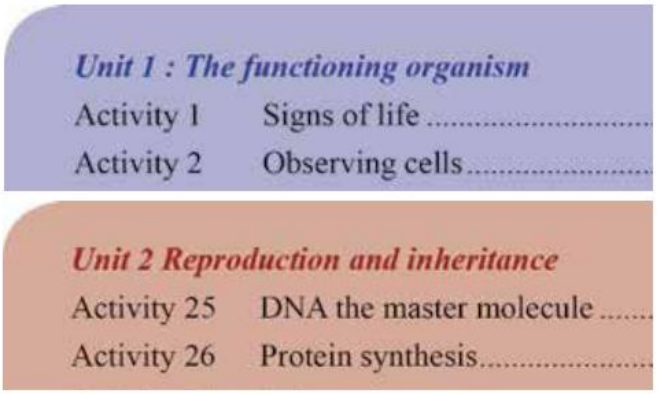
How to use this book

Yr 11 ATAR Human Biology continues to develop student understanding and skills from across the three strands of Science: Science Inquiry Skills, Science as a Human Endeavour and Science Understanding.

Content organisation

Exploring Human Biology Yr 11 ATAR is organised into two units: Unit 1 *The functioning human body*, and Unit 2 *Reproduction and inheritance*. Each unit is accented in a different colour.



Activities

The activities, discussion and summary sections in this book use primary and/or secondary observations to build understandings and skills in Human Biology. The discussion and summary questions require information from these activities, and in some instances other resources, to produce suitable answers based on scientific evidence. Answers based on opinion and myths are not appropriate.

Recording observations and answering questions

Scientists record their thoughts, ideas, notes, planning and observations in a logbook/journal. Whilst completing the activities in this book you will be required to record your observations and answer questions. You may also be required to plan and conduct investigations.

A suggested format for recording your observations and answering questions in your logbook/journal is provided below.

Title: *Activity 4: The exchange of materials in cells*

Results
Under this heading record

- *the answers to question while conducting the activity (e.g. Q1, Q2).*
- *observations in tables - a sample table may be provided or you could be asked to produce your own.*
- *observations as biological diagrams.*

Discussion Questions
Record the answers to discussion question under this heading. The discussion questions refer to the observations made during the activity. The use of reference material may be required to answer questions.

Summary
Record the answers to summary questions under this heading. Summary questions elaborate and/or apply what has been learnt in the activity. The use of reference material may be required to answer questions.

Every effort has been made to ensure there are no errors in this book. If you find any errors please let us know.
Email: info@stawa.net
Thank you.

Exploring Human Biology Year 11
Contents

Unit 1 : The functioning organism

Exploring Human Biology Year 11 Contents

Unit 2 Reproduction and inheritance

Unit 1: The functioning human body

Unit 1 explores how human structure and function supports cellular metabolism and how lifestyle choices affect body functioning.

The content covered in Unit 1 activities includes:

- cells, the basic structural and functional unit of the human body
- cells contain structures that carry out a range of functions related to metabolism, including anabolic and catabolic reactions
- materials are exchanged in a variety of ways within and between the internal and external environment to supply inputs and remove outputs of metabolism
- metabolic activity requires the presence of enzymes to meet the needs of cells and the whole body
- the respiratory, circulatory, digestive and excretory systems control the exchange and transport of materials in support of metabolism, particularly cellular respiration
- the structure and function of the musculo-skeletal system provides for human movement and balance as the result of the co-ordinated interaction of the many components for obtaining the necessary requirements for life.

Activity 1

Signs of life

Part A: Life Processes

Background information

How do you know if someone is alive or dead? This is an important question for emergency service people when they are called to help someone with a life-threatening condition. It is also important in understanding the needs of people to keep them alive in extreme conditions such as in deep sea, space, high altitude climbing or in areas of natural disasters.

All living things carry out life processes in order to keep the cells metabolising and supplying energy for body activities.

Purposes

- to collect evidence that indicates the operation of life processes in the human body
- to recognise life processes in the living body and link them to specific body systems and functions

Materials

- drinking straw
- 50 mL lime water
- 100 mL beaker
- cotton buds
- callipers
- reflex hammer or rule
- reference material

Procedure

Q1. What are the seven life processes?

Are you respiring?

1. Pour the lime water into the beaker.
2. Blow gently through a straw into a solution of limewater.
3. Note the colour change.

Q2. What causes the limewater to change colour?

Q3. What evidence does this test give to indicate that you are respiring?

Have you ingested today?

Q4. What materials have you eaten today?

Q5. What evidence do you have that the body has digested (changed the food chemically) and absorbed it?

Are you excreting?

4. Pass urine and note the colour.

Q6. Does the colour of your urine match the colour of anything you have had to eat or drink in the last 24 hours?

Q7. Where would the chemicals that made your urine that colour have come from?

Q8. Where, in the body, would you look for further evidence of excretion?

Q9. What is the difference between excretion and elimination?

Q10. Can the eliminated material be used as evidence for digestion? Explain.

Are you moving?

5. Sit on a chair with your legs crossed so that the foot of the crossed over leg is off the floor.
6. Try to sit as still as possible for 2 minutes.

Q11. What happened to the crossed-over leg? What causes this movement?

Q12. What other movements occur without you thinking about them?

Q13. What evidence do you have that there is movement of your internal organs?

Are you growing?

Q14. Nails are made of dead cells. How can the accumulation of dead cells (your nails) be used to indicate the life process of 'growth'?

Q15. What is the evidence to indicate that nails ARE made of non-living material?

Do you respond to stimuli?

7. Close your eyes and have someone gently touch your eye lashes with a cotton bud.
8. Sit on a table with your legs dangling over the edge.
9. Gently tap the tendon beneath your kneecap with a reflex hammer, edge of a rule or hand.

Q16. Can you stop the reactions caused by the cotton bud or the tap on your tendon?

Q17. Did you have to think about the reaction to either stimulus?

Reproduction

Reproduction can be asexual or sexual. Asexual reproduction of cells occurs in all bodies but not all bodies reproduce sexually.

Q18. What type of reproduction occurs in humans?

Discussion questions

Are you alive?

1. Do you need all the information gathered during this activity to conclude you are alive?

2. Explain which evidence of life processes are not always present in living humans.

Signs of life

Part B: Dead or Alive?

Background information

Terri Schiavo, aged 26, collapsed in her home in 1990 and experienced respiratory and cardiac arrest. She slipped into a coma in February of 1990 after a heart attack caused by a potassium imbalance from bulimia. Within three years, she was diagnosed as being in a persistent vegetative state (PVS). Terri Schiavo was left as a woman who essentially died but was resuscitated, though not entirely. Her brain had suffered enormous damage from the heart attack. As time passed, her brain deteriorated further to the point where much, if not most, of her cerebral cortex (the portion of the brain that controls conscious thought, amongst other things) was literally gone, replaced by spinal fluid. In other words, she was effectively 'brain dead', but her bodily functions still occurred. She was placed on life support systems to aid her breathing and to feed her.

There was an on-going court battle between her parents (who wanted the life support systems to remain) and her husband (who wanted the life support systems turned off).

In 1998, when it became legal to do so, Terri's husband and guardian Michael Schiavo petitioned the courts to remove her gastric feeding tube; Terri's parents, Robert and Mary Schindler, opposed this. The courts found that Terri was in a PVS and that she should not be kept alive. In 2003, the matter began to receive national attention.

The courts continued to hold that Schiavo was in a PVS, and would want to cease life support. Her feeding tube was removed a third and final time on March 18, 2005. She died thirteen days later at a Pinellas Park hospice on March 31, 2005, at the age of 41.

Was Terri Schiavo alive or dead between 1990 and 2005?

Purpose

- to appreciate the problems of applying scientific definitions to the human condition

Materials

- access to reference material

Procedure

1. Research the condition called PVS.

   Q1. How do we know something is alive or dead?

   Q2. Find three medical definitions of death.

   Q3. What is the final irreversible sign of death?

One of the arguments put forward by Terri's husband was that prior to her heart attack, he and Terri had seen a TV program on a person kept on life support. After the program when they had discussed the situation, Terri said she did not want to be kept on life support.

2. Survey at least 10 people to ask them if they would prefer to be put on life support or not in a situation like Terri's. Ask for their main reason for their selection. Record your results in a suitable table.

   Q4. How can you make sure that your wishes are adhered to if you are in a situation like Terri's?

   Q5. Would you donate your organs after death? Explain your reasons.

   Q6. What organs can be donated after death?

Activity 2

Observing cells

Background information

Your body contains approximately 10^{14} cells, however, the cells are not all the same. Cells can differ greatly in structure and function. Tissues are parts of your body made up of similar cells.

As a human biology student you will study the structure of tissues, and individual cells. Scientists call the study of the structure of tissues histology, and call the study of cells cytology.

Since cells are so small, your naked eye is not much use in the study of tissues and cells. Microscopes allow us to observe cells. The magnification range of most light microscopes is from around 40× to 600×, depending on the combination of lenses on the microscope. To study material with this type of microscope the material must be only a fraction of a millimetre thick to allow light to pass through. Unless the tissue consists of loose cells such as blood, you have to study a thin section of the material.

The thin sections of tissue are often stained with special chemicals to highlight various features. When you place a slide containing the thin section on the stage of your microscope, light passes through it then through a series of lenses to form an image which is detected by your eyes.

Purposes

- to set up and use a microscope correctly
- to make measurements of cells using the microscope

Materials

- monocular microscope
- lens tissue
- prepared slide of the letter ‘e’
- prepared slides of animals, animal parts or cells
- prepared slides of human or animal tissues
- mini-grid slide or clear plastic ruler with 1 mm graduations

Part A: How to use a microscope

Procedure

Before you start this activity it is important that you are familiar with the names of the various working parts of the microscope shown in Figure 2.1. You will need to become familiar with the type or types of microscope available at your school.

- Some microscopes are fitted with a built-in light source, in which case they will have no mirror.
- Others will have a simple wheel diaphragm and lens instead of a sub-stage condenser and iris diaphragm.
- Some microscopes have a vertical body tube, which you move up and down to focus. Others have the body tube slanted and you move the stage up and down to focus.

Observing cells

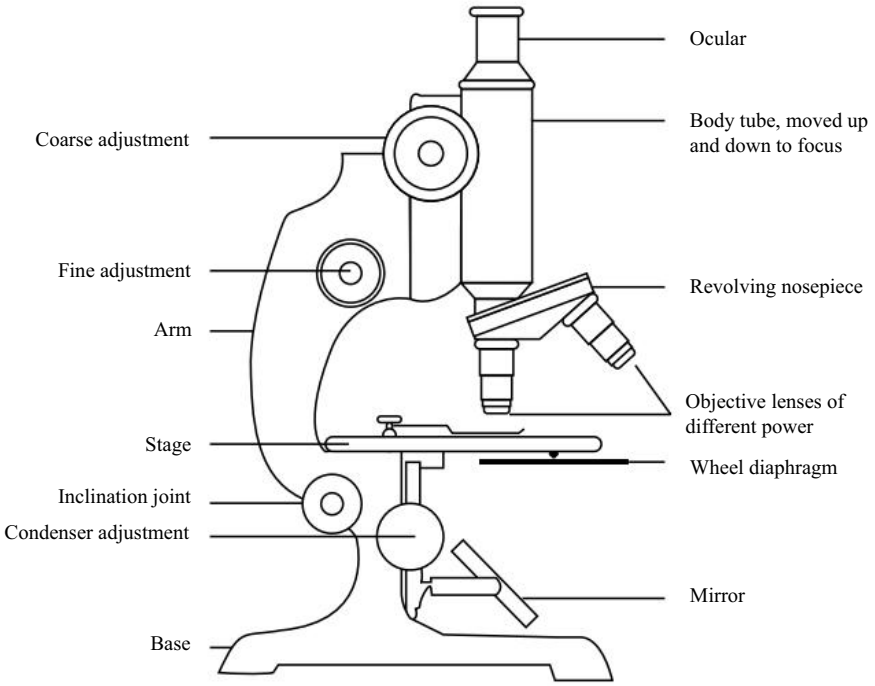


Figure 2.1: Monocular microscope with a moving body tube and no built-in light source

Q1. Do you focus your microscope by raising and lowering the body tube or by lowering and raising the stage?

Q2. How many objective lenses does your microscope have and what is their individual magnifying power? You can find the magnification etched on each lens casing, for example 5×.

Q3. Which has the greater magnification, a larger lens or a smaller one?

Q4. What is the magnification of the ocular lens?

2. Use a small square of lens tissue to carefully clean the lenses and mirror.
3. If your microscope relies on an external light source ensure you have positioned it close to a well-lit bright light source but do not point the mirror directly at the sun. If it has an internal light source, make sure you have it switched on.
4. Rotate the nose piece so the low power objective lens is in line with the body tube. It should click into place. The low power objective is normally the shortest lens. Use the course adjustment knob to lower the body tube or *raise the stage* until the objective lens is as close to the stage as it will go.
5. Remove the ocular lens and put it safely to one side. Raise the sub-stage condenser, if your microscope has one, and ensure the iris diaphragm is open. Check by looking down the body tube.
6. For microscopes with an external light source adjust the mirror as follows: Look through the open end of the body tube, and adjust the mirror until the light source evenly illuminates the field of view. If your microscope has a condenser, use the flat mirror surface, if not, use the curved surface. Replace the ocular lens.
7. Position the letter ‘e’ slide so the letter is over the hole in the centre of the stage. The letter should be in the middle of the hole. While you look at the objective lens from the side of your microscope, wind the body tube down *or stage up* until the objective lens is just clear of the slide. Never wind the body tube down *or stage up* while you are looking through the ocular lens.

Q5. What is the reason for this precaution?

8. While you look through the ocular lens, use your course adjustment to slowly raise the body tube or *lower the stage* until the letter comes into sharp focus. You may have to move the slide around a bit to centre the image in your field of view. Microscopists call the distance between the objective lens and the slide the working distance.

Q6. What is the new working distance in mm?

9. When the image is as sharp as possible try changing the iris diaphragm or wheel diaphragm. Adjust the diaphragm until it just fits your field of view.

10. Draw a diagram of what you see through the microscope. See Appendix 1 for information on drawing from a microscope slide

Q7. In what way is the image of the letter different from the real 'e'?

11. With most microscopes you can change directly from low power to high power without major refocussing, because the microscope is par focal. If, however, your high power lens will not move clear of the slide when you rotate the nose piece follow the following steps:
    a. Raise the body tube or lower the stage until the low power objective is well clear of the stage
    b. Rotate the nose piece until the largest of the objective lenses is in line with the body tube.
    c. While looking from the side, lower the body tube or raise the stage until the objective lens is almost touching the slide.
    d Looking through the ocular lens and using the fine adjustment, bring the image into sharp focus by raising the tube or lowering the stage.
    e. If necessary, change the diaphragm and condenser until the image is as bright and sharp as possible. Reducing the light makes the image sharper, but dimmer. You need the best compromise.

Q8. What is the new working distance in mm?

Part B: Measuring with Microscopes

Background information

When working with microscopes it is important to have an understanding of magnification and its effects. Whilst you should now know what the ocular and objective lenses are, you also need to have an understanding of their importance in determining the magnification and the size of the field of view.

Sample Microscope Calculations

Ocular magnification	=	10×
Low power objective lens	=	10×
High power objective lens	=	40×
Low power field of view	=	1.6 mm = 1600 µm
Low power magnification	=	10 × 10 = 100×
High power magnification	=	10 × 40 = 400×

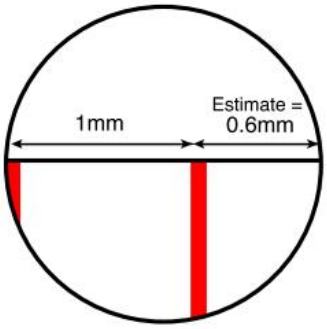


Figure 2.2: View of a plastic millimetre ruler at low power showing a 1.6 mm field of view

High power magnifies 4× low power so,

High power field of view	=	¼ × low power field of view
	=	¼ × 1600
	=	400 µm
	=	0.40 mm

In Figure 2.3 the object takes up approximately ⅕ of high power field of view.

Size of object	=	⅕ × high power field of view
	=	⅕ × 400
	=	80 µm
	=	0.080 mm

You can use the same method to estimate the size of objects at low power, but you must use the low power field diameter.

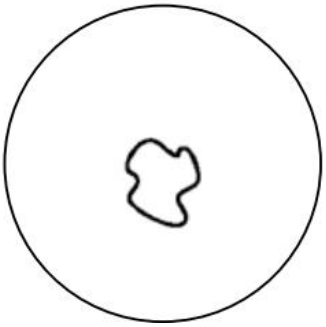


Figure 2.3: An object viewed with the same microscope at high power

Observing cells

Procedure

1. Copy and complete Table 2.1 for your microscope.

Table 2.1: Total magnification for the lens combinations of my microscope

	Ocular Lens magnification	Objective lens magnification	**Total Magnification**
Low Power			
Medium Power			
High Power			

2. Place the mini-grid slide or clear plastic ruler on the stage under low power. Use the mini-grid or clear plastic ruler to measure the diameter of the field of view (FoV). Copy and complete Table 2.2.

Table 2.2: The diameter of the field of view for different magnification of my microscope

	FoV diameter (mm)	FoV diameter (µm)
Low Power		
Medium Power		
High Power		

3. Repeat step 2 for the other magnifications on your microscope and record the measurements in Table 2.2.
4. When you work with microscopes you will often see the symbol µm which means micrometre. There are 1000 µm in 1 mm. Convert the FoV diameters in Table 2.2 from mm to µm and record them in the final column in Table 2.2.

Discussion questions

1. When you increase the magnification, what happens to the diameter of the FoV?

2. Collect a slide of a small animal or animal part.
   a) Measure the animal by estimating the fraction of the field of view it takes up. Multiply the field diameter by this fraction. An example of how to calculate the size of an object can be found in the background information for Part B.
   b) Draw a diagram of the animal/animal part you can see in the field of view.

Activity 3

Recognising cells

Background information

According to *cell theory* all living things are made up of cells or the products of cells. The cell theory is base on observations of structure invisible to the naked eye. Without the extension of vision made possible by microscopes, scientists could never have made such observations. The microscope you will be using has only a limited resolving power. Because of this you will not be able to see many cell organelles. A high resolving power is needed to see small things that are close together.

Your microscope is useful for observing the main structure of cells. This is the main objective of this exercise. Staining the cells will help your observations. You can also use your microscope to estimate the size of cells, using the data you obtained in Activity 2.

Purposes

- Prepare a wet mount of living onion tissue.
- Estimate the size of onion epithelial cells.
- Recognise the following structural features of onion cells: *cell wall, nucleus, cytoplasm*.
- Observe a prepared slide of human cheek cells.
- Identify the following cell organelles in a human cheek cell: *nucleus, cytoplasm, cell membrane*.
- Compare the advantages of high and low power magnification.

Materials

- 2 × microscope slides
- Molecular microscope
- Mounted needle
- Forceps, sharp
- Iodine in a dropper bottle
- Small beaker
- Paper towel
- 2 × cover slips
- lens tissue
- Onion segment
- Tooth picks
- Pasteur pipette
- Knife
- Prepared slide of human cheek cells

Procedure

Part A: Preparing a wet mount slide

Onion cells are good to practice microscopy on because they are large, easy to measure and display the major cell structures better than most animal cells.

1. Half fill your beaker with tap water
2. Use a Pasteur pipette to place a drop of water in the middle of the microscopic slide, which must be flat on the bench. This prevents water running about the slide as you prepare it.
3. Use a mounted needle and forceps to carefully peel of a small piece of the delicate outer membrane from a fresh onion. If you lift the membrane in one corner of the segment and then peel it back you should end up with the required one cell thick layer. About half the size of the nail on your smallest finger is enough.
4. Place this membrane carefully in the drop of water on the microscope slide so it isn't wrinkled or folded over itself. You can manoeuvre it with the forceps and mounted needle.
5. Use your Pasteur pipette to put another drop of water on the onion membrane.
6. Holding the cover-slip gently by the edges, so that you do not cover it with finger prints, lower one edge to just in front of the drop of water. The water will follow the edge.
7. Support the cover-slip with the mounted needle and slowly move the needle out. This allows time for air bubbles to escape. Don't fuss if there are small air bubbles; they may not be over the cells you want to use. You should aim to be able to prepare wet mounts without any bubbles.
8. Learn what an air bubble looks like. If you don't have one on your slide, look at someone elses. This will protect you from the mistake of drawing an air bubble thinking it is a cell!

Recognising cells

9. Ensure there isn't too much water on the slide and check to see that the underside of the slide is dry.
   - Too much water makes the cover-slip float loosly on the top, blurring the image as it floats back and forth with every tiny vibration in the room.
   - If there is water under the slide, you will not be able to move the slide about easily on the stage, as air pressure will hold the slide and stage pressed together.
   - If there is water on top of the cover-slip, the image may be blurred or water may wet the tip of the objective lens, especially at high power.
10. Your cover-slip should have a small rim of water, less than 1 mm, around its edge. This allows for evaporation as you work, preventing air bubbles moving under your cover-slip.
11. If your slide begins to dry out use a Pasteur pipette to carefully add more waterbeside but not on the cover-slip.
12. Switch your microscope to low power and examine your slide. When you use a wet mount it is best to keep your microscope in an upright position. Don't use the inclination joint if your microscope has a vertical body tube. If you have any difficulty focusing, refer back to the hints given at the end of the previous exercise.
13. Sketch what you see. The cells are arranged like bricks in a wall. Each 'brick' is a single cell.

    Q1. What magnification are you using and what is the diameter of your field of view at this magnification? Refer to Activity 2 to find out how to do this.

    Q2. How many cells span your field of view from left to right?

    Q3. What is the average length of each cell in µm?

    Q4. In which direction do the cells appear to move when you move the slide from left to right ?

    Q5. In which direction do the cells appear to move when you move the slide toward and away from you?

14. Refocus your microscope on high power.

    Q6. Can you see the structures inside the cell? If so make a quick drawing of a cell showing these structures.

15. Repeat steps 2 - 24 replacing the drop of water in step 4 with a drop of iodine solution.

    Q7. Do you think it's easier to estimate the size of a cell under low power or high power? Explain.

    Q8. What difference does staining the cells make?

Part B: Observing human cheek cells

1. Use your microscope to observe human cheek cells.
2. Draw one typical cell, labelling the following structures, if you can find them: *nucleus, cytoplasm, cell membrane.*
3. Record the magnification used.

    Q1. Estimate the diameter of a typical cheek cell in µm.

Discussion questions

1. What are the main differences between plant and animal cells? Could you observe these differences in the onion and cheek cells you studied?

2. At the magnification you were using, the cytoplasm probably appeared granular. What could these grains be?

3. What are the advantages of high-power over low-power in a light microscope?

4. What are the advantages of low-power over high-power in a light microscope?

5. Which power is best to use?

Activity 4

The exchange of materials

Background information

A cell must have a means of obtaining its needs from its surroundings and losing its wastes if it is to continue to function. In this activity you will investigate two of the processes, diffusion and osmosis.

Purpose

- to observe how materials move into and out of the cell

Part A: Diffusion

Materials

- safety glasses
- gas jar
- 10 mL measuring cylinder
- 25 cm of dialysis tubing
- distilled water
- concentrated ammonia solution
- dropper bottle universal indicator

Procedure

1. Pour distilled water into the gas jar until it is about ¾ full, then add 1 mL of concentrated ammonia solution.
2. Tie a knot in one end of the dialysis tubing.
3. Wet the tubing with water so you can easily open the end of the tubing.
4. Fill the tube with water to within 5 cm of its open end.
5. Add universal indicator drop by drop to the tube contents until it has a recognisable colour.
6. Tie a knot in the open end of the tubing.
7. Wash the resulting 'sausage' in water to remove any chemicals that may be stuck to the outside.
8. Immerse the tubing containing the universal indicator solution to the ammonified water, and leave for 10 minutes.

Results

Record any changes you observed in the contents of the jar and tubing.

Discussion questions

1. In this activity you have used a model to simulate what happens in a cell. In your model what represented the:

   a. cell

   b. cell membrane

   c. the liquid in which the cell lives

2. What caused the change in the universal indicator?
3. What do you conclude happened to cause the colour change in the tube?
4. Why didn't the universal indicator move out of the dialysis tubing?

Part B: Osmosis

Materials

- 4 de-shelled fresh eggs *
- electronic balance
- 250 g table salt
- 200 mL 0.1 M salt (NaCℓ) solution
- paper towel
- 200 mL distilled water
- 4 beakers (250 mL) labelled A, B, C and D
- digital camera (optional)

**Eggs can be de-shelled by leaving them in vinegar overnight. Make sure the whole egg is immersed to remove all of the shell. The skin-like membrane will hold the egg together.*

Procedure

The experiment requires eggs to be treated in different ways under controlled conditions. Accurate recording of the weight of each egg at the start of the experiment and at the end of the experiment is very important. Handle the eggs very carefully as things could get messy. Egg membranes are easily broken.

1. Weigh each egg and record its weight in the column headed **Starting Weight of Egg** in Table 4.1.
2. **Egg A** - place some of salt crystals in the base of Beaker A and make a hollow in the middle. Place the egg into the hollow and cover it with more salt. Make sure none of the egg is showing above the salt.
3. **Egg B** - gently place the egg in Beaker B and cover with distilled water.
4. **Egg C** - gently place the egg in Beaker C and cover with 0.1 M salt solution.
5. **Egg D** - carefully wrap the egg in plastic wrap and place in Beaker D.
6. Cover each beaker tightly with plastic wrap.
7. Leave eggs overnight in a location where they will not be disturbed.

Next lesson:

8. Remove the eggs CAREFULLY from each treatment. Gently wash off the excess salt and dab the eggs with paper towel to remove excess water.
9. Re-weigh each egg and record its weight in the column headed **End Weight of Egg** in Table 4.1.
10. Calculate the amount of water lost or gained by finding the weight difference between Column 1 and Column 2. Record the difference in the column headed **Amount of Water Lost or Gained**
11. Calculate the percentage water loss/gain using the following formula and write your answers in the column headed **Percentage Weight Change**

$$\text{percentage change} = \frac{\text{weight column 3} \times 100}{\text{weight column 1}}$$

Results

Copy and complete Table 4.1 and record observations of any visible changes that have occurred to the eggs. Digital photos may be useful for the collection of extra supporting data.

Table 4.1: Observations of eggs in different treatments

Treatment	1. Starting Weight of Egg (g)	2. End Weight of Egg (g)	3. Amount of Water lost/gained (g)	4. Percentage Weight Change
A. Egg in salt crystals Observations:				
B. Egg in distilled water Observations:				
C. Egg in 0.1M salt solution Observations:				
D. Egg in plastic wrap Observations:				

The exchange of materials

Discussion questions

1. Why was the starting weight of the eggs recorded?
2. Why was Egg D included in the experiment?
3. Describe the changes that occurred to the salt that was packed around Egg A.
4. State which substance moved, and explain its movement in the treatment of Egg A. What evidence do you have for your answer?
5. State which substance moved, and explain its movement in the treatment of Egg B. What evidence do you have for your answer?
6. State which substance moved, and explain its movement in the treatment of Egg C. What evidence do you have for your answer?
7. State which substance moved, and explain its movement in the treatment of Egg D. What evidence do you have for your answer?
8. Which treatment showed the greatest percentage change in weight? Explain why.
9. Why was the percentage change calculated for each egg?
10. Compare the percentage change of eggs in similar treatments from the other groups. Explain any differences between different group's results.
11. What type of membrane surrounds the egg? What materials can pass across this membrane?
12. Predict what would happen if Egg B was placed to the salt crystals in Beaker A. Explain your answer.
13. Use a diagram to show the movement of materials across the membrane of the egg.

Summary

1. In Part A the substance which moved was ammonia. In a living cell what kinds of materials would enter or leave? List as many as you can.
2. Our kidneys use osmosis to remove excess fluid from our blood. Describe another example in the human body where osmosis takes place.

Activity 5

Properties of the cell membrane

Background information

There have been many different models of the cell membrane proposed to explain observations of cells in different environments. Cell membranes are too thin to observe them directly but it is possible to infer cell membrane structures from the reactions to different materials and different conditions.

Cell membranes are important in that they can:

- regulate transport in and out of cells or organelles
- provide a passageway into or out of the cell for certain molecules that are too large to move by diffusion
- regulate the fusion with other membranes in the cell via specialised junctions such as for exocytosis
- allow cell recognition
- provide anchoring sites for cytoskeletal filaments or components of the extracellular matrix.
- provide a stable site for the binding and catalysis by enzymes.

Purpose

- to investigate the nature of the cell membrane by observing the effects of different solutions and conditions

Part A: Treatment with different solutions

Cells are usually surrounded by solutions, whether inside the body or in places where cells are in contact with the external environment. These solutions can change in composition and pH.

Materials

- safety glasses
- 50 fresh beetroot pieces approximately 1 mm thick, 5 mm × 5 mm square
- about 30 mL of each of the ten solutions
  - pH 2, 4, 6, 8, and 10
  - ethanol 1% and 20%
  - detergent 1% and 5%
  - distilled water
- sheet of white A3 paper
- 10 petri dishes
- labels or marking pen
- coloured pencils or digital camera

Procedure

1. Label the petri dishes with date, your group and the letters A - J.
2. Arrange the petri dishes on white paper.
3. Add enough of the treatment solution to the petri dish to a depth of 4-5 mm.
4. Very gently place 5 pieces of beetroot into each petri dish making sure they do not overlap and that all are covered by the treatment solution.
5. Cover the petri dishes with the lids.
6. Observe any immediate colour changes in the dishes and record the colour in Table 5.1. Rate the colour of the solution on a scale of 0 (no pink) - 5 (dark red). Use coloured pencils to show the shade indicated by the scales 0 - 5 OR use images from a digital camera to record the colour changes.
7. Observe the dishes again after about 1 hour and record the colour in Table 5.1.
8. Observe the dishes again after about 24 hours and record the colour in Table 5.1.

Properties of the cell membrane

Results

Copy and complete Table 5.1

Table 5.1: The effect of different treatments on cells

Petri dish	Treatment solution	Colour changes observed		
		Immediately	After 1 hour	After 24 hours
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				

Discussion Questions

1. Which treatment caused the greatest colour change?
2. How does detergent disrupt the cell membrane?
3. What was the ideal pH for the beetroot cell mambrane? Why did you choose this pH value?

Part B: The effect of temperature on cell membranes

Background information

Human body cells are usually kept at or around 37°C, although extremities such as fingers and toes can be hotter and colder than this. How does heating and freezing cells affect the cell membrane?

Plan and conduct your own investigation to answer this question.
Use the guide to investigations in Appendix 2.

Materials

The materials required will depend on your experimental design. Some suggested materials are provided below.

- test tubes
- 250 mL beakers (for water baths)
- 10 fresh beetroot pieces approximately 1mm thick, 5 mm × 5 mm square
- 5 frozen beetroot pieces approximately 1 mm thick, 5 mm × 5 mm square

Discussion Questions

1. What physical changes were caused by freezing the beetroot pieces? (Hint: think about what happens to water as it freezes.)

2. How does heating the beetroot pieces change the cell membrane?

Summary

1. When first learning about cells, a diagram of a cell has a solid line indicating the cell membrane. Explain why this is not a good analogy of the cell membrane.

2. Another simple model of the cell membrane shows it as a dashed line (- - - -) surrounding the cell contents. Does this model explain the changes that you observed with the beetroot? Explain your answer.

3. Figure 5.1 shows another model for the cell membrane. How is this model an improvement on the dashed-line model? Use evidence from your observation to support your answer.

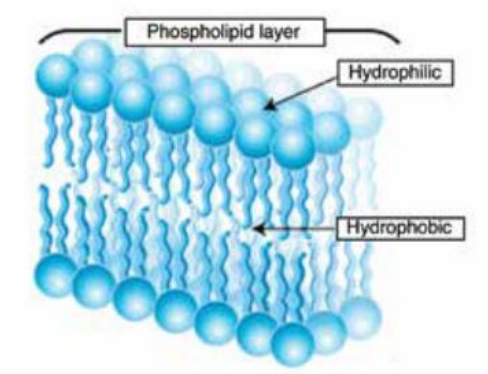


Figure 5.1: A cell membrane model
(http://www.biologycorner.com/APbiology/cellular/notes_cell_membrane.html)

4. Figure 5.2 shows the fluid mosaic model of the cell membrane. Explain how this model appears to account for all properties of the cell membrane.

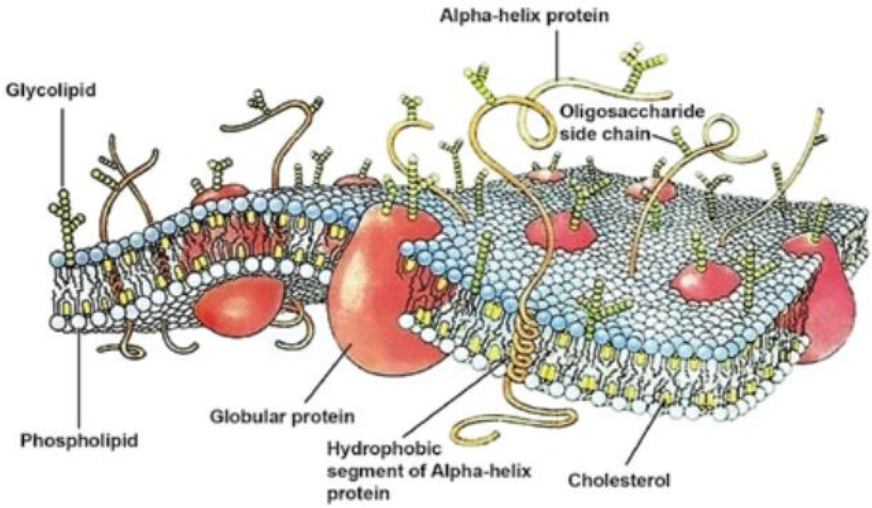


Figure 5.2: The fluid mosaic model of the cell membrane
(http://www.commons.wikimedia.org/wiki/File:Cell_membrane_drawing-en.svg)

Activity 6

SA:Volume - why is it important?

Background information

All cells must exchange materials with their surroundings across their cell membranes. The amount of material the cell will need to exchange with its surroundings will depend on the volume of the cell. The greater the cell's volume, the greater its need for energy, nutrients and gases, and the more wastes it will produce. One very important factor controlling the rate at which a cell can gain or lose materials is the area of the cell membrane available for exchange of materials. The larger the surface area of the membrane available, the greater the rate of exchange.

Purpose

- to observe the effect of surface area and volume on the exchange of materials

Part A: Surface area:volume

Materials

- sheet of A4 paper
- rule

Procedure

1. Calculate the surface area and volume of the A4 sheet of paper (assume the thickness of the paper is 0.1 mm).
2. Record your answers in Table 6.1.
3. Fold the sheet of A4 paper in half. Calculate the surface area and volume of paper exposed to the outside.
4 Continue this for two, three and four folds of the sheet of A4 paper.

Results

Copy and complete Table 6.1.

Table 6.1: SA:Vol of folded paper

A4 paper	Exposed Surface Area (cm^3)	Volume (cm3)	SA:Vol
no fold			
1 fold			
2 folds			
3 folds			
4 folds			

Discussion Questions

1. Did the volume of the paper change?

2. Did the area of the paper exposed to the outside change?

3. What happened to the SA:Vol as the exposed area decreased? Explain why.

Part B: Surface area:volume and exchange of materials

Materials

- agar cubes containing phenolphthalein made pink with sodium hydroxide:
  3 × 1 cm cubes 3 × 2 cm cubes 3 × 3 cm cubes
- 300 mL of 0.1 M dilute hydrochloric acid
- 3 beakers (250 mL) labelled A, B and C
- 1 sheet of graph paper per student
- blade
- plastic forceps
- rule
- safety glasses

Procedure

1. Calculate the SA:Vol of each cube and record the results in Table 6.2.
2. Place one of each size agar cube into each of the three beakers. Make sure they are not touching.
3. Add enough hydrochloric acid to cover the cubes in each beaker.
4. After 5 mins remove all three cubes from Beaker A.
5. Cut each cube in half with a sharp blade.
6. Measure the dimensions of the coloured section remaining. This must be done as quickly as possible after removing the cube from the acid solution. Record the results in Table 6.3.
7. Repeat steps 4-6 at 10 minutes (Beaker B) and record the results in Table 6.4.
8. Repeat steps 4-6 at 15 minutes (Beaker C) and record the results in Table 6.5.
9. Calculate the SA:Vol of the coloured section in Tables 6.3, 6.4 and 6.5.
10. On graph paper, graph the SA:Vol against the size of the cube.

Results

Copy and complete tables 6.2-6.5.

Table 6.2: Initial dimensions of the cubes

Cube	Dimensions of coloured cube	Surface Area (cm^2)	Volume (cm^3)	SA: Vol
1 cm				
2cm				
3cm				

Table 6.3: Dimensions of coloured section remaining after 5 minutes

Cube	Dimensions of coloured cube	Surface Area (cm^2)	Volume (cm^3)	SA: Vol
1 cm				
2cm				
3cm				

Table 6.4: Dimensions of coloured section remaining after 10 minutes

Cube	Dimensions of coloured cube	Surface Area (cm^2)	Volume (cm^3)	SA: Vol
1 cm				
2cm				
3cm				

SA:Volume - why is it important?

Table 6.5: Dimensions of coloured section remaining after 15 minutes

Cube	Dimensions of coloured cube	Surface Area (cm^2)	Volume (cm^3)	SA: Vol
1 cm				
2cm				
3cm				

Discussion Questions

1. Look carefully at the cubes taken out after 5 minutes. Has the coloured area changed since taking them out of the acid solution? Explain.
2. Describe the relationship shown in the graph.
3. What does the relationship in question 2 mean?
4. Suppose the cubes were cells and the acid solution was oxygen, which cell would be more efficiently supplied with oxygen? Explain why.
5. Which one of the 'cells' would be able to remove wastes the most efficiently? Explain.
6. Some cells contain microvilli. How do these structures help the exchange of materials?

Activity 7

Observing tissues

Background information

Humans are multicellular organisms. The thousands of millions of cells in your body organise themselves into collections of cells with common structures and functions. People call such collections tissues.

Histologists normally classify human tissues into one of the following types:

- epithelial tissue
- connective tissue
- muscle tissue
- nervous tissue

Each tissue type has cells with characteristic features depending on its function in the body. The organs of your body are always composed of a variety of tissues. The most common way to study tissues is to observe sections of the tissues under a microscopic. Histology is the study of the microscopic structure and function of tissues.

Purposes

- to observe, identify and draw tissues viewed under a microscope
- to describe the function of different tissues
- to recognise that organs consist of two or more tissues

Part A: Identifying tissues

Materials

- monocular microscope
- a selection of prepared microscope slides, labelled A-J, containing a selection of examples of each tissue type
- lead pencil
- coloured pencils
- mini-grid slide or clear plastic ruler with 1 mm graduations
- reference materials

Note: the name of the tissue type on each slide has been covered.

Procedure

Microscopes containing slides of unidentified human tissues have been set up around the room. The tissue you are required to observe is in the field of view. Try not to move the slide.

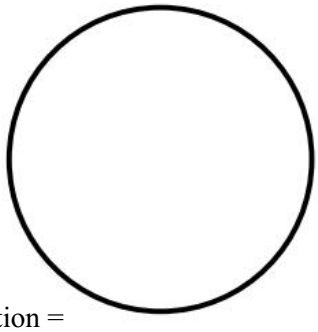
1. Visit each microscope in turn, under the direction of your teacher.
   a. Draw a diagram of what you observe in the field of view. See Appendix 1 for information on drawing from a microscope slide.
   b. Label any parts of the cell you can identify.
   c. Record the magnification of the microscope.
   d. Draw a scale bar under your diagram. You can use the diameter of the field of view from Activity 2 or remeasure the diameter of the field of view. Make sure you check the magnification you recorded for each diagram, as they may be different.
2. Once you have drawn diagrams of all the tissues on display
   a. Use reference materials to identify each tissue type and record this above your diagram.
   b. Next to your diagram describe the function of each tissue type and give an example where it can be found in the body.

Observing tissues

Results

An example of how to draw your results is shown in Table 7.1.

Table 7.1: Human tissues

Slide	Tissue drawing	Tissue function
A	Tissue type_____  Magnification = _____	

Part B: Identifying tissues in an organ

Materials

Per group

- monocular microscope
- Transverse cross-section (TS) of mammalian small intestine

Per class

- section of skeletal muscle
- section of gut showing smooth muscle
- section of gut showing epithelial tissue
- section of adipose tissue
- section of areola connective tissue
- section of nervous tissue

Procedure

1. Examine the prepared slide of a small intestine under low power.

   Q1. How many different tissues can you see?

2. Make an outline sketch of what you can see under low power.

3. Label each tissue type on you diagram. Check the class demonstration slides if you cannot identify particular cell types.

4. Now observe the slide under high power.

   Q2. Can you see any individual cells under high power?

Discussion Questions

1. What organelles could you distinguish in the human cells at the highest magnification?
2. Why is it difficult to distinguish cell organelles?
3. Why would you expect to find different cells and tissues in an organ?
4. What function would each of the tissues you observed have in the gut wall?
5. Pap Smear samples contain cells taken from the cervix area for identification of pre-cancerous or cancerous cells among the normal cells. What would you need to know before you could reliably conduct this test?
6. Why is the Pap Smear test not 100% reliable in detecting abnormal cells?

Activity 8

Anaerobic respiration

Background information

Respiration is the chemical reaction in the cell which releases energy from the oxidation of glucose. There are two types of respiration.

- **Aerobic respiration** occurs in the presence of oxygen. Glucose is completely broken down to carbon dioxide and water. It is the only reaction in the body that uses elemental oxygen. The first part of this reaction is called glycolysis where the glucose molecule is split into two pyruvate molecules. These are then metabolised into carbon dioxide and water releasing most of the available energy in glucose.
- **Anaerobic respiration** occurs when oxygen is NOT available. The glucose is broken down to pyruvate (glycolysis) but then pyruvate is converted to lactic acid and carbon dioxide. Much less energy is released in anaerobic respiration because the energy is still tied up in the chemical bonds in the lactic acid molecule.

Purpose

- to measure the rate of anaerobic respiration

Materials

- 4 zippered plastic bags approximately 15 cm × 15 cm
- 4 labels
- warm tap water
- 4 sachets of dried yeast
- 2 sachets of sugar
- 1 sachet of sugar-substitute sweetener
- rule
- 2 L beaker filled with water
- tray
- measuring cylinder
- access to a fridge
- a sheet of graph paper per student

Procedure

1. Label the bags 1 - 4.
2. **Bag 1** - add 20 mL of warm water and the contents of 1 yeast sachet.
3. **Bags 2 and 3** - to each bag add 20 mL of warm water and the contents of 1 yeast sachet and contents of 1 sugar sachet.
4. **Bag 4** - add 20 mL of warm water and the contents of 1 yeast sachet and content of 1sweetener sachet.
5. Smell the contents of each bag before sealing it.
6. Seal the bags making sure that there is the minimum amount of air in the bag.
7. Measure the volume of each bag by the water displacement method.

   Displacement method:

   Fill the 2 L beaker with water. Sit it in the tray. Carefully put the zippered plastic bag into the beaker until it is completely submerged. Water will have spilled out of the beaker into the tray. The volume of the water displaced into the tray is the volume of the bag and its contents.
8. Dry the bags and place Bags 1, 2 and 4 in a warm position where they will not be disturbed.
9. Place Bag 3 in the fridge.
10. Record the volume of the bags in 10 minute intervals.
11. Graph the volume of gas produced at 10 minute intervals on the graph paper provided.

Anaerobic respiration

Results

Copy and complete Table 8.1.

Table 8.1: Volume of gas produced at 10 minute intervals.

Bags	Volume measured at Time (minutes)						Odour
	0	10	20	30	40	50	
1							
2							
3							
4							

Discussion Questions

1. In which bag(s) did respiration occur? What evidence do you have for your answer?
2. What was the purpose of including bag 1?
3. What was the gas that accumulated in the bag? How could you determine this?
4. Why were bags 2 and 3 set up in the same way?
5. What happened in bag 4? Explain if this was what you expected to happen.
6. What is the difference between sugar and the sweetener?
7. Compare the results of bags 2 and 3. Suggest an explanation for the difference.
8. Which bag do you think would have released the most energy? Explain why you think so.
9. Which bag(s) had a different odour? Explain why the odours changed in some bags and not others.
10. What are the products of anaerobic respiration in plants and animals?
11. How could you determine if the contents in the bag contain either of these products?

Summary

Anaerobic respiration provides only a temporary energy supply for tissues that have energy needs above their aerobic ability. Anaerobic respiration can only occur for a limited time (longer in skeletal muscles and shorter for the heart) when the ratio of oxygen supply to oxygen needed falls below a critical level. Anaerobic respiration is an emergency procedure that provides some energy until the emergency (oxygen deficiency) has passed. Increased lactic acid concentrations contribute to muscle fatigue.

1. Explain what may happen if human cells produced alcohol as a product of anaerobic respiration instead of lactic acid.
2. Suggest why cardiac muscle of the heart has a lower lactic acid tolerance than skeletal muscles.
3. Using your results, determine the rate at which carbon dioxide was produced for each bag.

$$\left[\text{Hint: } \frac{\text{change in amount of gas produced}}{\text{change in time}}\right]$$

4. Does the rate of carbon dioxide production indicate the rate of respiration occurring in the bag? Explain your answer.
5. Could this measure of respiration be useful in determining respiration rate in humans? Explain your answer.

Activity 9

Investigating metabolic rate

Background information

All metabolic processes require energy to proceed. Metabolic processes are either anabolic or catabolic.

- **Anabolism** includes such things as protein synthesis, glycogen synthesis, lipid synthesis, nucleic acid synthesis, etc.
- **Catabolism** involves processes that break large molecules into simpler ones.

Oxygen is required for our cells to break down glucose and release energy. The amount of oxygen consumed is directly related to the amount of energy released.

If the amount of energy the body needs to perform only its most essential activities was measured, we would be measuring what is known as our Basal Metabolic Rate (BMR). This is the amount of energy needed to fuel basic processes such as breathing and heartbeat and brain, kidney and liver functions.

In clinical tests for humans, BMR is determined after fasting for 12 to 14 hours, in the morning after at least 8 hours of sleep, with no voluntary muscle movement for at least half an hour before the test. The subject is to be both physically and mentally unstressed. Under these conditions, the average BMR for adult females is 5500-6300 kilojoules (kJ) per day and the average BMR for adult males is 6700-7500 kJ per day.

Purpose

- to use breathing rates and respiratory volumes to calculate resting metabolic rate

Procedure

Figure 9.1 traces the amount of oxygen used during a three minute breathing test.

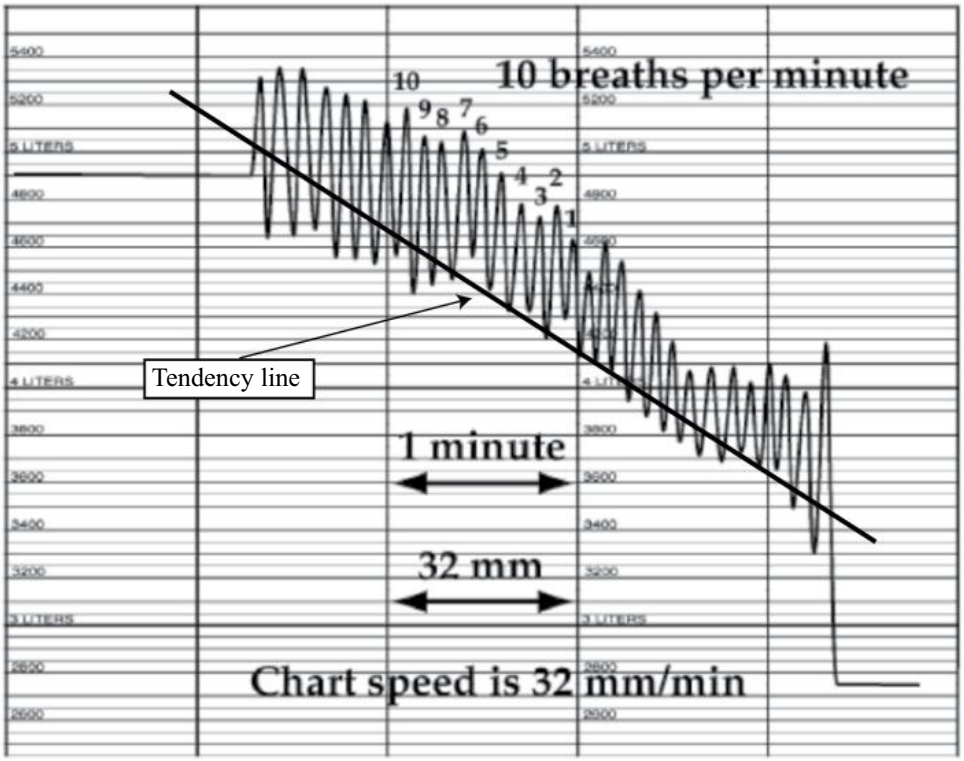


Figure 9.1: Respirometer of a resting subject for a three minute breathing test.
(http://cibt.bio.cornell.edu/labs/dl/RES2.PDF)

Q1. Use the tendency line to calculate the oxygen consumed by subtracting the volumes indicated at the beginning and end of one minute on the tendency line on Figure 9.1.

Q2. Was this consistent across the test time of three minutes?

Q3. Calculate the metabolic rate of the subject in Figure 9.1 in kJ/min (for every 1 L of oxygen used, 9.6 kJ of energy is released).

Q4. How many kilojoules would the subject in Figure 9.1 burn in one hour and in one day.

Q5. How might you improve the accuracy of this measurement?

Discussion Questions

1. List five factors that might affect metabolic rate?
2. Is oxygen used in any other metabolic reaction besides the breakdown of sugars in the respiration reaction?
3. What other material could be used as a measure of metabolic rate? Why?
4. The measurement of BMR is done under very strict conditions as indicated in the Background Information. Why is it important that these conditions are adhered to?
5. Two friends eat the same amount of food and do the same amount of exercise, yet one gains weight and the other doesn't. Explain a possible reason for this.
6. The subject in Figure 9.1 just had 350 mL of orange juice with an energy content of 690 kJ. For how long would they be energised after drinking the juice? (Hint: Use your metabolic rate calculated in Question 3).
7. Excess energy intake is stored as fats. When energy requirements are greater than intake, then energy is released from storage. Relate the energy input to energy output for losing weight.
8. State two ways, based on the relationship stated above, to lose weight.

Activity 10

Nutrients contained in food

Background information

Your diet contains chemicals from six basic nutrient groups: carbohydrates, proteins, lipids, vitamins, minerals and water. These groups are needed in varying amounts in different people and are present in varying amounts in different foods.

Nutritionists need to know the composition of foods so that they can accurately formulate diets for a wide variety of people, for example, people with certain diseases, and people needing to lose or gain weight.

There are many chemical tests that can be used to establish the constituents of food. Table 10.1 shows some common tests.

Table 10.1: Chemical tests for food

Nutrient	Test		Colour Change/Positive Result
Carbohydrates - glucose - starch	Benedicts Testape Diastix Iodine	Benedict's reagent – warm gently Testape Diastix 2 drops of iodine	Blue to Yellow/Orange or Yellow to Green Check container Yellow to Blue/Black
Proteins	Biuret Sakaguchi	Biuret reagent 2 drops of sodium hydroxide 2 drops of α-napthol and 2 drops of sodium hypochlorite	Red precipitate Pale blue to Purple/mauve
Lipids	Brown paper	Brown paper. Rub small amount onto paper and leave to dry.	Becomes translucent

Purpose

- use food tests to identify the following nutrients in food samples: glucose, starch, protein and lipid

Materials

- dehydrated food samples - A, B, C & D.
- 2 test-tubes per food sample
- 2 white depression tiles
- Biuret reagent
  or
  5% sodium hydroxide (NaOH), alpha-naphthol solution (1 g in 100 mL ethanol) and sodium hypochlorite (10% solution in water)
- Testape, Diastix or Benedict's solution
- iodine solution (KI)
- 2 sheets of brown paper (approx. 10 cm)
- safety glasses
- Bunsen burner
- forceps

Nutrients contained in food

Procedure

As you progress through this activity record your results in Table 10.2. If you observe a colour change enter a ✓ (nutrient is present). If there is no colour change enter an ✖ (nutrient is not present).

1. Put on your safety glasses. These are especially important when heating any substance in a test-tube.
2. Follow the procedure for each nutrient test below for each food sample.
3. **Glucose**
   Use either the Testape/Diastix or Benedict's test.
   Testape/Diastix
   a. Add a small amount of water to the sample in a test-tube and mix thoroughly.
   b. Pour the liquid into a depression in your depression tile.
   c. Tear off 10 mm of Testape or obtain a Diastix. Avoid touching the free end of the Testape.
   d. Use the forceps to hold the free end of the Testape and dip the free end in the solution for 5 seconds, or dip the Diastix into the solution for 5 seconds.
   e. Remove and wait for 60 seconds.
   f. Compare the colour of the Testape/Diastix with the colours on the dispenser. Record this in Table 10.2.
   Benedict's
   a. Take a test-tube containing a sample and add about ten drops of Benedict's solution.
   b. Heat the tube very gently over a small flame for about 20 seconds. Do not boil.
   c. Observe any colour change and record this in Table 10.2.
4. **Starch**
   Iodine Test
   a. Add a sample of food to the depression tile.
   b. Add two drops of iodine to the sample.
   c. Observe any colour change and record it in Table 10.2.
5. **Protein**
   Use either the Sakaguchi or Biuret test
   Sakaguchi.
   a. Add two drops of 5% sodium hydroxide to the food sample in a test- tube and mix.
   b. Now add two drops of alpha-naphthol solution and mix again.
   c. Lastly, add two drops of sodium hypochlorite and record any colour changes in Table 10.2.
   Biuret.
   a. Add about 5 mL of Biuret reagent to the food sample in a test-tube.
   b. Shake the test-tube and observe any colour change. Record in Table 10.2.
6. **Lipid**
   a. Add two drops of water to the food sample in a depression of the depression tile.
   b. Rub it with your finger until it becomes a dry paste.
   c. Rub some of this firmly onto one corner of your brown paper.
   d. Mark the corner with the food sample letter (A, B, C or D).
   e. Leave the paper to dry and observe if the paper becomes translucent. Record your observation in Table 10.2.

Results

Copy and complete Table 10.2

Table 10.2: The result of nutrients tests on food samples

		Colour change or positive result for sample			
Nutrient	**Test**	**A**	**B**	**C**	**D**
Glucose					
Starch	Iodine				
Protein					
Lipids	Brown paper				

Discussion Questions

1. Which test was the easiest to perform? Were the results consistent from this easy test?
2. Which test gave the least reliable results? How could it be improved?
3. Which nutrient was the most common across the food samples? Why would this be the case?
4. Which nutrients are the most common in snack foods?
5. If you had to choose one food from A, B, C, or D to take on a 3 day bush walk which would you pick? Give reasons for your choice.
6. Other nutrient groups were not tested for in this activity. Give a specific example and a function of nutrient groups not tested.

Summary

Food can be labelled as low or high GI. GI is the Glycemic Index.

a. What does the Glycemic Index measure?

b. What sorts of foods have a high GI?

c. Which GI foods are good for sustained energy supply?

d. What GI foods would you want to have during an endurance race such as a marathon or a long bike race? Explain why.

Activity 11

Effective enzymes

Background information

Enzymes have been used by humans for thousands of years, but the knowledge of how they work is quite recent. The effect of yeasts in brewing and bread making, and the effects of stomach secretions on milk for cheese making all rely on enzymes. Pineapple juice was used by the inhabitants of Caribbean islands to cure stomach aches caused by feasting on large quantities of meat.

Purpose

- to observe the factors affecting the functioning of enzymes

Part A: The activity of enzymes

Materials

- 5 mL crushed fresh pineapple pieces
- 5 mL crushed canned pineapple pieces
- 5 mL crushed fresh capsicum pieces
- 1 g meat tenderizer powder in 5 mL water
- 4 labels
- packet of jelly crystals
- 4 measuring cylinders (50 mL)
- 4 small marbles
- boiling water
- mixing bowl
- access to refrigerator
- digital camera (optional)

Procedure

1. Label each of the measuring cylinders A - D with the group name and date.
2. Make the jelly according to the instructions on the packet.
3. Pour about 40 mL of jelly into each measuring cylinder.
4. Place the measuring cylinders in the refrigerator to set.
5. When the jelly is set, remove the measuring cylinders from the refrigerator. (This could be the next day or later in the same day.)
6. Add the materials to the measuring cylinders as follows:
   A - fresh pineapple paste C - capsicum paste
   B - canned pineapple paste D - meat tenderizer paste
7. Gently place a marble on the top of the contents in each measuring cylinder.
8. Take a reading against the measuring cylinder graduations at the lower edge of the marble.
9. Leave the measuring cylinders in a cool place.
10. Record the position of the marble over the next 2-3 hours. If possible, take a photo showing all four measuring cylinders together. Use the photos to help collect data.

Results

Design a suitable table to record your data.

Discussion Questions

1. What did the marbles in the measuring cylinders experiment demonstrate?

2. What does the speed of movement of the marble indicate about the activity of the enzymes present?

3. How could you make the marble move faster without melting the jelly?

4. Why is meat tenderizer added to marinades and stews that use cheap cuts of meat?

Part B: Investigating factors affecting enzyme activity

Background information

There are a number of factors that can affect the efficiency of enzymes. Two of these factors are pH and temperature. Design an experiment to investigate the effect of **one** of these factors on enzyme activity. Use the guide to investigations in Appendix 2.

Activity 12

Respiratory volumes

Background information

The lungs are the main part of the respiratory system. They are located in the chest cavity and are like big sponge-filled balloons. There are three main volume measurements to do with the lungs:
Vital capacity is the largest volume of air that can be exhaled following a deep breath.
Tidal volume is the amount of air inhaled during normal breathing.
Expiratory reserve is the air that is left in the lungs following normal exhalation.

Each of these is useful to know because they can be used to give information about the functioning and efficiency of your respiratory system. Asthmatics will have their vital capacity measured and the rate at which they can exhale that volume of air.

Purpose

- to measure lung capacities and flow rate

Materials

Method 1

- 5 L plastic container
- large bucket/trough
- water at body temperature
- balloons (one for each person)
- permanent marker
- 250 mL measuring cylinder
- plastic tubing

Method 2

- vitalograph

Procedure

Choose **one** of the following methods before you begin this activity. If time permits try two methods to confirm your data or compare your data with another group.

Part A: Determining vital capacity

Method 1 – Water displacement

Make a measuring instrument from a 5 L plastic container, to measure the amount of air you blow out of your lungs

1. Measure 250 mL of water using the measuring cylinder and pour it into an empty 5 L plastic container.
2. Use a permanent marker to mark the water level and write '250 mL' at this line on the container.
3. Measure out and add another 250 mL of water to the plastic container.
4. Mark the water level and write '500 mL' at the water line on the container.
5. Continue this process until the plastic container is full of water and you have marked a series of water levels on the outside of the container.

Use your instrument to measure your lung capacity.
Beware: This could be a very messy procedure. Have mops and buckets ready to clean up the spilt water.

1. Fill the bucket/trough approximately half full with water.
2. Fill the plastic container, turn it upside down in the bucket and remove your hand once the top is under the water level making sure that there are no air bubbles in the container.
3. Place one end of a clear plastic tube through the submerged opening of the plastic container.
4. Work with a partner to place a clean mouth piece* into the tube end that is out of the water and pinch the tube so no air enters. * A mouth piece can be made by cutting the blowing end from a balloon.
5. Hold the container up so that it does not tip over.
6. Hold your nose closed and exhale as deeply as possible into the container through the tube.
7. Measure the volume (mL) of air in the plastic container.

Respiratory volumes

Method 2 – Vitalograph
Follow the instructions that come with the vitalograph machine to measure your vital capacity.

Results

Draw up a suitable table in which to record your data, and that of at least 4 others.

Discussion Questions

1. Why is it important to know your vital capacity?

2. Does vital capacity change with the size of the person? How does it change and why?

3. Why is it useful to check your experimental results using two different methods?

Summary

How are respiratory volume values changed in disease? In the introduction, mention was made of the use of measuring respiratory volumes for understanding the impact of different diseases or conditions.

Research the following respiratory conditions:
- emphysema
- fibrosis, which may be called pulmonary or interstitial fibrosis
- asthma
- bronchitis

If no specific information is available on the respiratory volume values, infer the changes from the symptoms of the condition.

Activity 13

Heart dissection

Background information

Your heart is a muscular organ which keeps your blood circulating. Functionally, you can think of your heart as two pumps, working together as a single organ. It has four muscular chambers covered by a non-wettable shiny membrane called the *pericardium.* It also has valves and associated blood vessels. Your heart is the central organ in your systemic and pulmonary circulations. The structure of your heart muscle, size of its chambers and its valve types all contribute to sn effective pumping organ that maintains the flow of blood to all your body cells.

Purpose

- to identify the features of the heart that allow for efficient movement of blood

Materials

- safety glasses
- sheep heart
- scalpel
- blunt probe
- dissecting scissors
- rule
- pair of gloves per person
- dissecting or stereo microscope
- dissecting board or tray
- forceps

Procedure

1. Orientate the heart as shown in Figure 13.1.
2. Identify the structures shown in Figure 13.2 on your heart.
3. Locate the arteries and veins.
4. Answer discussion questions 1-3.
5. Use the blunt probe or use your finger to follow each blood vessel into the heart.
6. Answer discussion questions 4-6.
7. Use the scissors to cut lengthwise down the blood vessels to the top of the heart and continue to cut through the wrinkled areas of the heart where the blood vessels end.
8. Stretch the wrinkled walls.
9. Answer discussion questions 8-12.

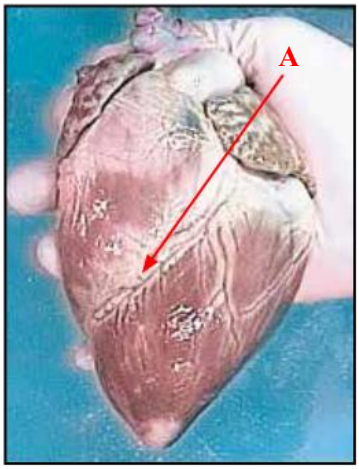


Figure 13.1: Orientation of the heart for dissection of the ventricles

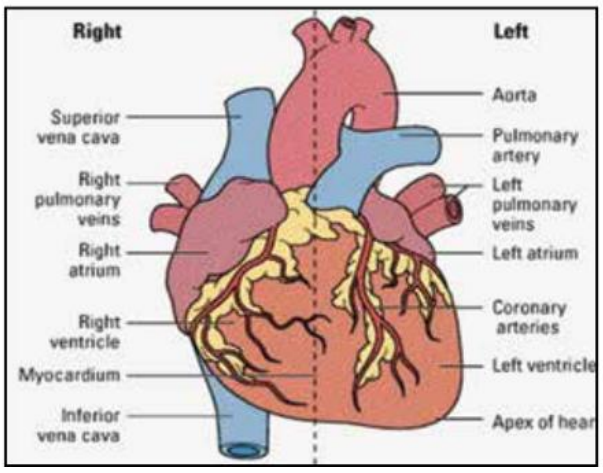


Figure 13.2: External anatomy of the heart (From: http://www.nku.edu/~dempseyd/HEART_1.htm)

You have been looking at the atria and the blood vessels attached to them. Now you will explore the larger chambers of the heart - the ventricles.

10. Reorientate the heart as shown in Figure 13.1.
11. Use the scalpel to cut a line about 1 cm away from and parallelto the blood vessel A. Cut gently, using your fingers to spread the incision so you can tell when you reach the cavity. Make the opening about 5 cm long.
12. Do the same for the other side - again about 1 cm from blood vessel A.
13. Answer discussion question 13.
14. Keep cutting through to the atria on each side.
15. Locate the valves between the atria and the ventricles. Name these valves.
16. Look carefully at the valves to explain why they have the prefixes ‘tri’ and ‘bi’ in their names.
17. Adjacent to the bicuspid valve is the point where the aorta is attached to the left ventricle. Look at the valves located here.

Heart dissection

18. Carefully manipulate them with the blunt probe.
19. Answer discussion questions 13 and 14.
20. The tricuspid and bicuspid valves are anchored in the walls of the heart at the papillary muscles by the 'chordae tendinae' (cords made of tendons).
21. Try pulling one of these cords out of the muscle.
22. Answer discussion questions 15-18.

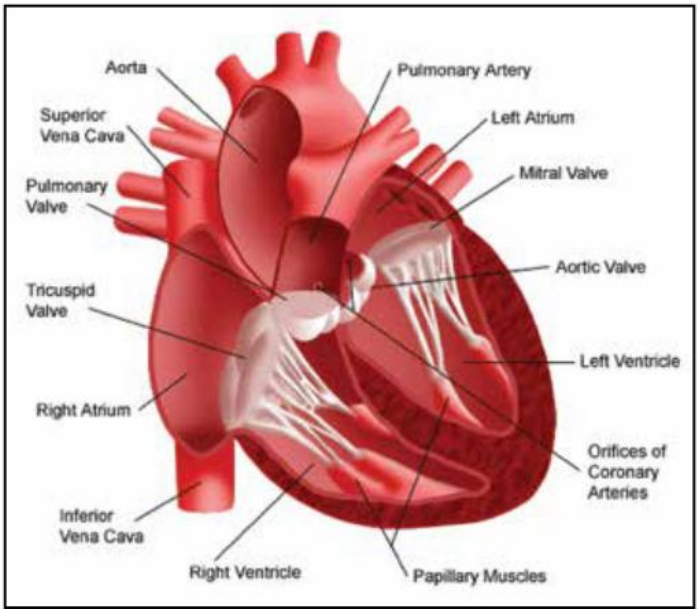


Figure 13.3: Internal structures of the heart.
(http://www.ohsu.edu/health/health-topics/topic.cfm?id=8485&parent=12326)

Discussion Questions

1. How could you tell which blood vessel is the aorta?
2. Identify two differences between the arteries and veins attached to the heart.
3. What is the white material around the top of the ventricles? What function might it have?
4. Identify the blood vessels attached to each heart chamber and name each.
5. Did you meet any resistance when trying to getthe probe into the heart? In which vessels? What would be the cause of this?
6. Why are they called 'semi-lunar' valves?
7. How many parts does each valve have?
8. What are the wrinkled areas called?
9. Are the wrinkled areas thick or thin?
10. Is there any difference between the left and right wrinkled areas?
11. How far will the walls stretch? Measure them stretched and unstretched.
12. Why do these chambers have these characteristics?
13. What did you notice about the thickness of the walls of each ventricle?
14. How do the heart valves function to regulate the direction of blood flow?
15. Why are the chordae tendinae (cords) important?
16. Why are the cords so strong?
17. Why don't the semi-lunar valves have cords?
18. What structure did you find in the sheep's heart that is not found in the human heart?

Summary

1. Draw a flow diagram to show the movement of blood in the circulatory system. Your diagram should include arrows showing the direction of blood flow. Label the arrows with the names of the structures/vessels they represent. Start by creating a circle with the following structures: Lungs, Left Atrium, Left Ventricle, Body, Right Ventricle, Right Atrium.

2. There is no direct connection between the right and left sides of the heart. Why not?

3. State the differences between the following and explain why they occur.

   a. atrial and ventricular walls.
   b. left and right ventricular walls.
   c. bicuspid and tricuspid valves.
   d. aorta and pulmonary arteries.
   e. semi-lunar and tri/bi-cuspid valves.
   f. arteries and veins.
   g. left and right sides of the heart.
   h. blood in the pulmonary artery and the aorta.
   i. pulmonary circulation and systemic circulation.

Activity 14

Blood vessels and blood flow

Background information

English physician William Harvey's discovery of what the heart does and how the blood circulates is widely regarded as the single greatest medical achievement of all time: It established the principle of doing experiments in medicine to learn how the body's organs and tissues function. His work was published in 1628, but was not widely accepted until 20 years later. At the time Harvey began his work, anatomists believed that the liver produced blood from the food that the body consumed. The blood was then carried by veins to the heart, purified in the lungs, and then pumped to the various organs of the body, where it was consumed. Over a period of 12 years in a series of brilliant experiments with animals and humans, Harvey demonstrated how blood circulates in the body. He based his theory on the following anatomical facts:

- the existence of two distinct sets of tubes in connection with the heart: we know them as arteries and veins.
- the existence in the heart, and also in the veins, of valves which allow the passage of blood flow in one direction only.

When an artery was blocked, the veins draining this artery collapsed. When a vein was blocked, it swelled below the blockage and collapsed above it, but the swelling disappeared when the blockage was removed. He also showed that the valves in veins allow blood to flow only in the direction of the heart. Together, these discoveries allowed Harvey to hypothesise that the same blood must circulate continuously throughout the body. That is, there is a circulation.

William Harvey measured the volume of the left ventricle of the heart to be roughly 100 mL. He also measured that the heart beats an average of 64 times per minute.

Veins carry blood to the heart. Valves in the veins are flaps of tissue designed to close when the blood flows away from the heart and open when the flow is towards the heart as shown in Figure 14.1.

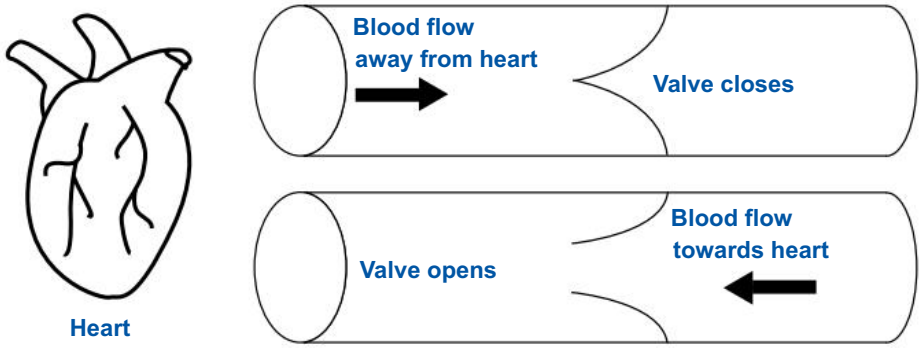


Figure14.1: The opening and closing of valves in veins

Figure 14.2 depicts one of William Harvey's experiments in his *On the Circulation of the Blood* (1628). Valves in veins had already been discovered, but here Harvey shows that venous blood flows only toward the heart. He gently tied a piece of cloth around an arm to make obvious the veins and their valves, then pressed blood away from the heart and showed that the vein would remain empty because it was blocked by the valve.

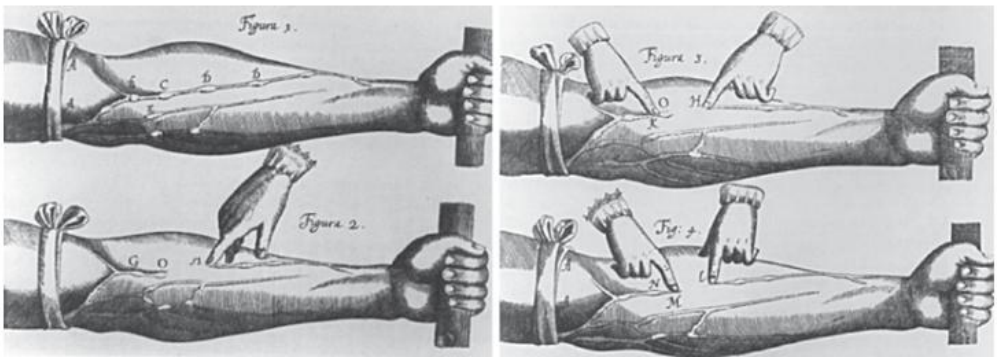


Figure 14.2: One of William Harvey's experiments
(http://www.princeton.edu/~his291/Harvey.html)

Purpose

- to observe external changes of the body to infer functions

Part A: William Harvey's demonstration of the valves in arm veins

Materials

- Sphygmomanometer or tourniquet

Procedure

1. Place a pressure cuff attached to a sphygmomanometer on the arm of a subject above the elbow. Inflate it to 20 – 30 mm Hg. This compresses the veins inhibiting, but not preventing, blood from leaving the arm. Blood will still enter the arm through the artery as its pressure is greater than the cuff pressure.
2. After a short time you should be able to see the veins becoming distended and "lumpy". The lumps represent the presence of the valves.

   Q1. Do swellings occur where veins branch or in straight stretches of the veins?

3. Find a length of vein with at least two valves present. Place a finger on the vein just before the valve at the shoulder end of the vein (proximal). Press down firmly to block the vein. Place another finger alongside the first and, without removing the first finger, drag the second along the vein towards the heart until it has passed the next valve.

   Q2. What happens to the vein between your fingers?

4. Still keeping the first finger in place, put the second finger a few centimetres to the other side of the second valve and squeeze the blood back toward that second valve.

   Q3. What happens to the vein between your fingers?

5. Finally remove the first finger and observe what happens to the section of vein between it and the second valve.

   Q4. When the vein refills does the blood come from below (away from the heart) or above (towards the heart)?

Discussion Questions

1. What do these experiments indicate about the direction of blood flow through the valves?
2. Why didn't people believe Harvey when he first put forward his ideas about circulation?

Blood vessels and blood flow

Part B: Measuring heartbeat

Background information

How many times in movies and on TV have you seen someone feel for the heartbeat of an accident victim? It appears to be the first thing that rescuers do when they reach a victim. “He’s alive, but only just. His heartbeat is very weak.”

Can you really tell that much about a person from their heartbeat? Would you know if the heartbeat was weak or strong? Normal or abnormal?

You will have the opportunity to experience a range of different heart beats when working with a group of people in this activity.

Materials

- stopwatch or watch with seconds hand
- stethoscope

Procedure

1 Locate three different places on your body surface where you can feel your pulse.
2. Try to count your pulse rate at each location.
3. Change the pressure you use on the pulse point when trying to count your pulse.
4. Use the stethoscope to listen to your pulse at each of the pulse point.
5. Find the best location to listen to your heart beat.
6 Measure your heart rate and calculate your average heart rate

Results

Draw a suitable table to display your results.

Discussion Questions

1. What is the difference between a ‘strong’ and a ‘weak’ heart beat?
2. Which location had the strongest pulse? Suggest a reason for this.
3. Why does your pressure have to be “just right” to easily count your pulse to get the best feeling of the pulse?
4. Your heart is located just near the V at the base of your sternum. Why can’t your feel your pulse the best at this point?
5. Why should you count your heart rate more than twice?
6. How can you reduce the error when counting your heart rate?
7. Was it easier to count your heart rate with the stethoscope or by using a pulse point?
8. How does the heart rate relate to your pulse?
9. Compare the heart rates of different people. Why would heart rate differ between people?
10. Listen to your heartbeat while feeling your pulse. How do they compare? Explain any differences.

Activity 15

Blood - specialised cells

Background information

The human body can not be composed of only one type of cell. There are many specialised activities that the body needs to do. Having specialised cells increases the efficiency with which these activities are carried out. Blood is a very good example of where cells are specialised to carry out the different functions of blood.

Purposes

- to observe different functions of specialised cells
- to relate the different structure of cells to their functions

Materials

- prepared slides of blood cells
- microscope
- micrographs of blood cells - coloured photographs would be preferable
- reference material containing diagrams of blood cells

Procedure

1. Set up your microscope to view the blood slides.
2. Use the micrographs or reference materials to identify the types of cells you can see.
3. At high power, count the number of different types of cells in the field of view.
4. Draw a table to list the types of blood cells. Draw a diagram and list the function for each cell type in your table.
5. Describe the differences between the cells seen under the microscope.

Discussion Questions

1. What are the functions of blood?
2. How many different types of cells are found in blood?
3. Were all the types of cells visible on your blood slide? Explain why you may not have seen all the blood cell types on your blood smear slide.
4. Explain why blood cells look different under the microscope (eg. colour, shape etc) when compared to textbook descriptions.
5. Are platelets blood cells? Explain your answer.
6. Why are platelets important?
7. The photomicrograph in Figure 15.1 shows the cellular contents of blood. There is no information on the size of the cells or the magnification.

    a. Given red blood cells (erythrocytes) are approximately 7.5 µm in diameter, calculate the magnification of the photomicrograph in Figure 15.1.
    b. Calculate the size of a thrombocyte and neutrophil.

Blood - specialised cells

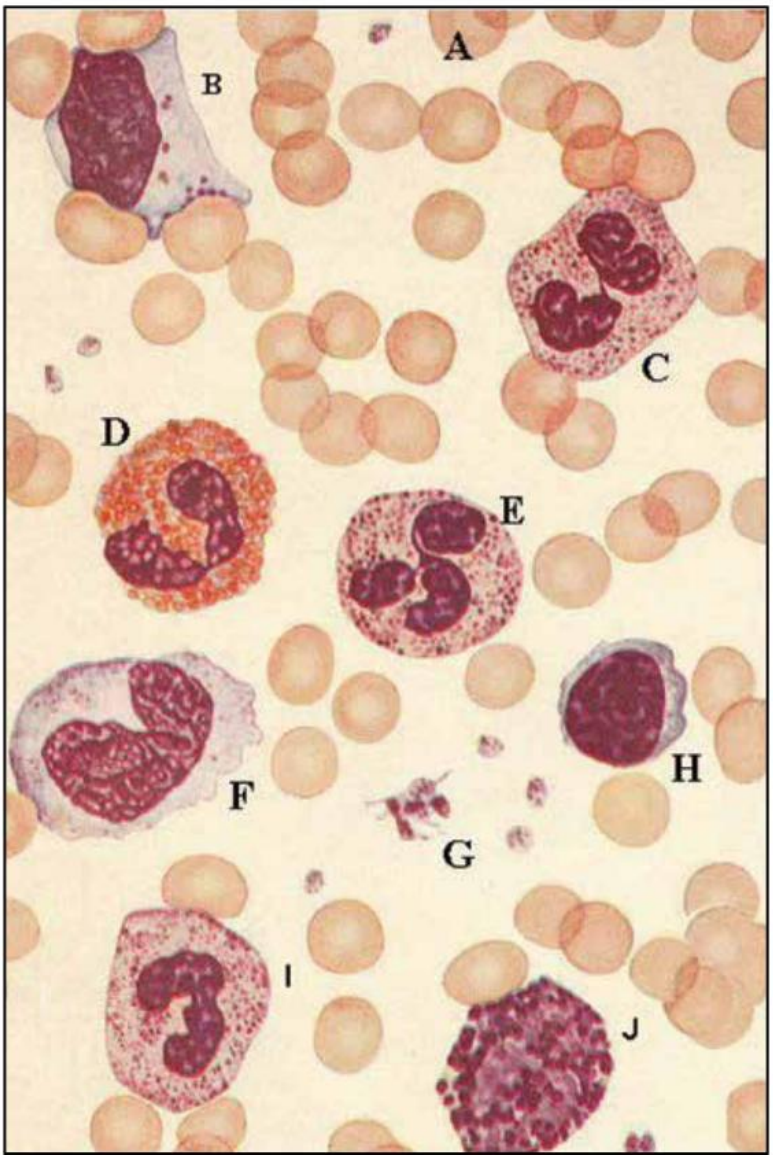


Figure 15.1: Cell types found in smears of peripheral blood from normal individuals. Note: The arrangement is arbitrary and the number of leucocytes in relation to erythrocytes and thrombocytes is greater than would occur in an actual microscope field of view.

A: Erythrocytes

B: Large lymphocyte

C: Neutrophil

D: Eosinophil

E: Neutrophil

F: Monocyte

G: Thrombocytes

H: Lymphocyte

I: Neutrophil

J: Basophil

Activity 16

Blood groups

Background information

An important part of modern medicine is the use of blood and blood components. About 75% of blood donations are transfused as red cells. The remainder is used as plasma. Different people have different types of blood and it is important that any blood given to a patient is compatible with that patient's blood. The first step in ensuring compatibility is in determining the ABO blood group of the patient.

Red blood cells have on their surface a number of different proteins called *antigens*. The actual number and type is genetically determined and is similar for every red cell in the body. Two major antigens that a person may have are called *Antigen A* and *Antigen B*.

Associated with these antigens are *anti-bodies* that are found in the plasma. *Anti-A* reacts with *Antigen A* and *Anti-B* reacts with *Antigen B*. Therefore nobody normally has both *Antigen A* and *Anti-A* present in their blood. The presence of both, none or one of the anti-bodies and antigens determines a person's ABO blood group according to Table 16.1.

Table 16.1: ABO blood groups and the antigens and antibodies present.

Blood Group	Antigen on red cell	Antibody in plasma
A	Antigen A	Anti-B
B	Antigen B	Anti-A
AB	Antigen A and B	None
O	None	Anti-A and Anti-B

The test for the ABO blood group involves mixing samples of blood with solutions known to contain Anti-A and Anti-B and observing any reaction (agglutination) that takes place. The reaction pattern can be matched to Table 16.2 to determione your probable ABO blood group.

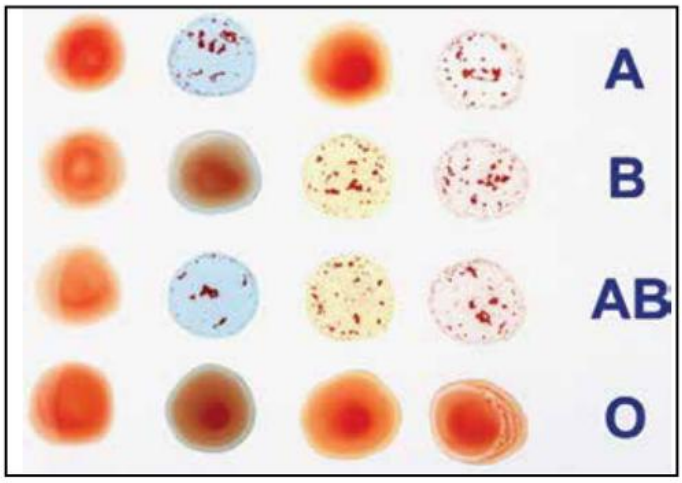


Figure 16.1: A blood-type test shows four blood-type reactions to antibody serums (http://www.dailymail.co.uk/health/article-1028274/Are-A-B-O--Duffy-Why-know-blood-type.html#)

Table 16.2: Reaction of Anti-A and Anti-B with known ABO blood samples

	Reaction Pattern	
Actual blood group	**Anti-A**	**Anti-B**
A	Reaction	None
B	None	Reaction
AB	Reaction	Reaction
O	None	None

Note: your blood contains several other grouping systems like ABO and these can be tested for in hospitals in a similar manner.

Blood groups

Purposes

- to simulate the process of ABO blood typing to determine blood groups

Materials

- two spotting tiles
- dropping bottle labelled 'Anti-A serum' (2.0 mol dm-3 hydrochloric acid solution)
- dropping bottle labelled 'Anti-B serum' (2.0 mol dm-3 sulfuric acid solution)
- dropping bottle of each 'blood sample' (solutions can be made to resemble blood by with food colouring and thickened with glycerol):
  - labelled 'Blood group O' (distilled water)
  - labelled 'Blood group A' (0.1 mol dm-3 silver nitrate solution)
  - labelled 'Blood group B' (0.1 mol dm-3 barium nitrate solution)
  - labelled 'Blood group AB' (50:50 mixture of 0.1 mol dm-3 silver nitrate and barium nitrate solution)
  - dropping bottle of an unknown 'blood sample'.

Procedure

1. Add one drop of 'blood sample A' to each of the three depressions in the first column of the spotting tile.

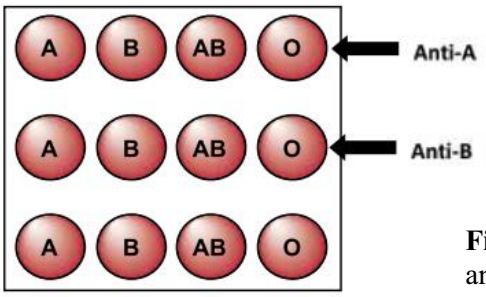


Figure 16.1: Adding 'blood samples' and 'serum' to spotting tiles

2. Add one drop of each of the other 'blood samples' to the other depressions on spotting tile, as shown in Figure 16.1.
3. Add one drop of 'Anti-A serum' to each 'blood sample' in the first row of the spotting tile as shown in Figure 16.1.
4. Add one drop of 'Anti-B serum' to each 'blood sample' in the second row of the spotting tile as shown in Figure 16.1. The third row can be used as a comparison.
5. Record your results in Table 16.3.
6. Add one drop of the unknown 'blood sample' to each of the three depressions in the first column of the second spotting tile.
7. Add one drop of 'Anti-A serum' to the 'blood sample' in the first row of the spotting tile.
8. Add one drop of 'Anti-B serum' to the 'blood sample' in the second row of the spotting tile.
9. Observe what has occurred in each depression on the spotting tile. If agglutination (clumping) occurred then a reaction took place. If there was no agglutination then no reaction occurred. Record your observations in Table 16.3.
10. Use your results and Table 16.2 to determine the blood group of the unknown 'blood sample'.

Results

Copy and complete Table 16.3.

Table 16.3: Reaction of Anti-A and Anti-B serum with blood samples

Blood Group	Reaction with Anti-A serum	Reaction with Anti-B serum
A		
B		
AB		
O		
Unknown		

Discussion Questions

1. What blood group is the unknown blood sample? Explain how you determined the blood group.
2. Use the information in Table 16.1, 16.2 and 16.3 to identify from which blood groups each of the ABO blood groups can receive transfusions. Record your answers in a copy of Table 16.4.

Table 16.4: Blood group compatibility

Blood Group	Accepts transfusions from the following blood groups:	Percentage of people in Australia with this blood group
A		38%
B		10%
AB		3%
O		49%

   a. What antigens are found on then blood cells of a person with blood group A?
   b. What antibodies are found in the plasma of a person with blood group A?
   c. What blood group/s can a person with blood group A receive blood from?
   d. What blood group/s can a person with blood group A give blood to?
   e. Which blood group is referred to as the *Universal donor*? Explain your answer.
   f. Which blood group is referred to as the *Universal receiver*? Explain your answer.
   g. Why is it dangerous for a person to receive a transfusion of blood from the wrong group?
   h. Use the information in Table 16.4 to draw a pie chart showing the percentage of people in Australia with each ABO blood group.

Summary

Donating blood

1. The Australian Red Cross provides a range of services in Australia, including blood donations. Visit the Australia Red Cross Lifeblood website: https://www.donateblood.com.au/ to find out about blood donations in Australia. Use the information to answer the following questions.
   a. What are the different types of blood donations the Red Cross collects?
   b. Take the eligibility quiz to see if you are eligible to give blood. What are the eligibility requirements for giving blood?
   c. Donated blood can be made into 22 different medical treatmentds and help save three lives. List some examples of where donated blood is used.
2. In some places in the USA, donors are paid for giving blood. In Australia people donate blood with no payment involved. What are the pros and cons for each system of blood donation?
3. Explain what happens during an incompatible blood transfusion. In your answer include an understanding of agglutination.

Rhesus blood groups

There are many different blood grouping systems. The two main blood grouping systems are the ABO blood grouping system and the Rhesus blood factor system.
Around 83% of people in Australia carry the rhesus antigen on their red blood cells, these people are said to be rhesus positive (Rh^+). People who lack the factor are referred to as rhesus negative (Rh^-). Under normal circumstances, rhesus negative individuals do not possess rhesus antibodies.

1. Knowing your Rhesus blood factor is important, especially couples planning on starting a family. Explain why being Rhesus negative can be a problem for pregnant women and babies.
2. Haemolytic disease is a condition caused by a baby's blood cells being destroyed by antibodies passing from the mother, through the placenta, into the baby's blood stream.
   a. Why is the first baby of an Rh^- mother unlikely to be affected by haemolytic disease?
   b. Why is haemolytic disease more likely to occur in their second and subsequent babies?
   c. Why is haemolytic disease now uncommon?

Activity 17

Digestion: a simulation

Background information

Digestion is the breaking down of food you eat to allow the nutrients it contains to be absorbed and be transported to each cell in your body. Food undergoes five important processes before it becomes useful to the body: it is ingested, digested mechanically and chemically, absorbed and assimilated. The digestive system is responsible for the processes of ingestion (eating), digestion and absorption. It consists of a series of organs, some of which food passes through, while others only contribute chemicals that aid in digestion.

Purpose

- to simulate the digestive process

Materials

- safety glasses
- baby carrot (canned)
- cutting board
- small ziplock plastic bag
- 25 mL 0.1 M HCℓ
- 50 mL 0.1 M $NaHCO_3$
- 1 mL pepsin solution
- 1 mL trypsin solution
- light microscope
- 1 mL amylase solution
- gauze square
- plastic knife
- filter funnel
- funnel stand
- 200 mL beaker
- 2 plain slides and cover slips
- 2 small sticky labels

Procedure

1. Place the carrot on the cutting board and chop with the knife. Keep all the pieces together.
2. Use the flat blade of the knife to squash the chopped carrots.
3. Scrape the carrots from the board into the ziplock bag.
4. Pour the 25 mL of HCℓ into the ziplock bag.
5. Add 1 mL pepsin solution to the bag.
6. Seal the bag carefully so it doesn't leak.
7. Massage the bag for 3 minutes to mix the acid and pepsin with the carrot.
8. Carefully open the bag and pour in the 50 mL of $NaHCO_3$
9. Add 1 mL trypsin and 1 mL amylase.
10. Seal the bag carefully so it doesn't leak.
11. Massage the bag for 5 minutes to mix the alkali and enzymes with the carrot.
12. Set up the filter apparatus with 3 layers of the gauze in the funnel. Make sure it is three layers of the gauze material NOT three pieces of gauze.
13. Gently pour the contents of the ziplock bag onto the gauze in the funnel. BE CAREFUL not to let the content overflow the gauze.
14. Take a sample of the filtrate from the beaker and place it on a microscope slide and cover with a cover slip.
15. Label this slide A.
16. Take a sample from the material left in the gauze (residue) and place it onto another microscope slide and cover with a cover slip.
17. Label this slide B.
18 View the slides under the light microscope at medium and high power.
19. Clean up and put things away.

Discussion Questions

1. What do the following steps in the procedure represent in the digestive system?
   a. chopping and squashing the carrot
   b. scraping carrot from the board into the bag
   c. adding HCℓ and pepsin to the bag
   d. massaging the bag for a few minutes
   e. adding the alkali, trypsin and amylase
   f. filtering the contents of the bag

2. Describe the change in the appearance of the carrot during the procedure.

3. Draw diagrams of the microscopic view of Slide A: Filtrate and Slide B: Residue. Refer to Appendix 1 for information on drawing from a microscope slide.

4. What was the main difference between the filtrate and the residue?

5. In the body, what would happen to the 'residue'?

6. Why were the pepsin and acid put in the bag together? What area of the digestive system does this represent?

7. Why was more alkali than acid used?

8. Why were the alkali, trypsin and amylase put into the bag together? What area of the digestive system does this represent?

9. Why does our body need to break down the food that we eat?

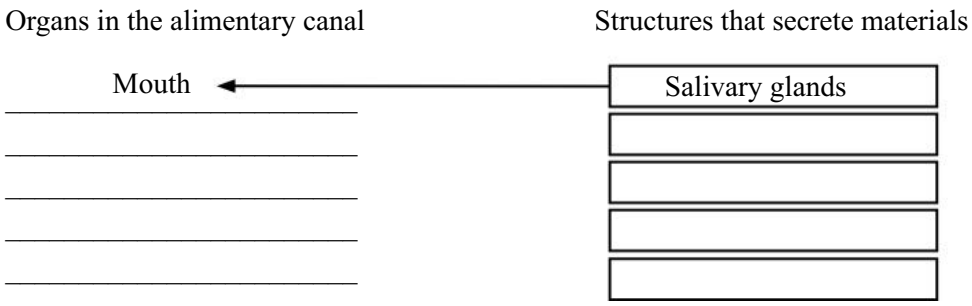
10. Explain the difference between mechanical and chemical digestion. Give an example of where each occurs in your body and in this activity.

11. Why do we have so many different enzymes in our digestive system?

12. What processes in the simulation represented peristalsis? Was it a good representation? Explain your answer.

Summary

Copy the structure below, list the organs through which a piece of food passes from the time it enters the mouth, to the time it exits the digestive system. In the boxes, name the organs that secrete materials into the digestive system. Draw an arrow from the box to the organ into which it secretes its material. An example has been given to help you complete this task.



Activity 18

The stomach

Background information

Stomach acid plays a key role in digestion of proteins, by activating digestive enzymes. The digestive enzymes cause ingested proteins to unravel, breaking down the long chains of amino acids. The acid also reacts with the carbonates found in foods such as dairy products and bone. The acidic environment of the stomach prevents the growth of most bacteria or kills most of the bacteria found in food.

Purpose

- to observe the effect of acid on bones

Materials

- 8 dry, cooked chicken bones with flesh removed - femurs would be best to use
- safety glasses
- 100 mL 0.1 M HCℓ
- 100 mL 1.0 M HCℓ
- 100 mL 2.0 M HCℓ
- 100 mL distilled water
- a sheet of graph paper per student
- 4 beakers (250 mL)
- 4 labels
- plastic wrap
- forceps
- digital camera (optional)

Procedure

1. Label each of the beakers A-D with group name and date.
2. Place two bones into each beaker.
3. Add 100 mL of each solution to the beakers:
   A. distilled water
   B. 0.1 M HCℓ
   C. 1.0 M HCℓ
   D. 2.0 M HCℓ
4. Tightly cover each beaker with plastic wrap.
5. Leave the beakers in a warm location, where it will not be disturbed, for 2-3 days.
6. Remove the bones using forceps and wash thoroughly to remove any residual acid.
7. Gently try bending the bones.
8. Measure the degree of bending of bones from each solution. A quantitative measurement can be made by accurately drawing the bones and measuring the bending angle. Another option is to take a photo of the bone at maximum bend. Measure the angle of bend in the photo. Place your drawings or attach the photos in the space on the next page.
9. Record the bending angles in Table 18.1 and calculate the average bending angle.
10. Draw a graph of your results.

Results

Copy and complete Table 18.1.

Table 18.1: The bend angle of bones placed in different solutions

Solution concentration	Bending angle		
	Bone 1	Bone 2	Average
Distilled water			
0.1 M HCℓ			
1.0 M HCℓ			
2.0 M HCℓ			

Discussion Questions

1. Describe the relationship between the concentration of the acid solution and the bending of the bones.

2. The stomach has a pH of 2. Specialised cells in the lining of the stomach produce HCℓ. How can the concentration of acid in the stomach be altered?

3. People do not often swallow whole chicken bones. If bone material is swallowed it is usually smaller chewed pieces. What are the dangers of swallowing chewed bones?

4. The whole bones took 2 - 3 days to lose their calcium compounds, making them flexible. How long do you think it would take for small chewed bones to lose their rigidity in the stomach? Give two reasons for your answer.

5. The material that makes bones hard is mostly calcium carbonate. Write the chemical reaction between calcium carbonate and hydrochloric acid as a word or chemical equation.

6. Did you notice any gas bubbles in beakers A - D? If so, what gas would have been in the bubbles?

7. Why does the stomach need to be acidic?

8. Why don't the digestive contents of the stomach digest the stomach wall?

9. Sometimes things do go wrong and the stomach wall is digested. What is the result of this action

10. How could this situation be treated?

For many years Western Australians, Barry Marshall and Robin Warren worked to convince the medical world that the majority of stomach ulcers were not caused by acid imbalance, but by a specific type of bacteria. They were awarded the Nobel Prize in Physiology or Medicine in 2005.

11. It has been found that *H. pylori* produce ammonia which they secreted into their surroundings. Explain how this would help the *H. pylori* bacteria survive in the stomach.

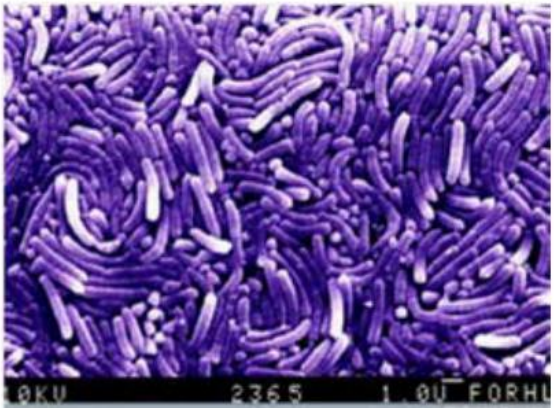


Figure 20.1: Helicobacter pylor

Activity 19

Major bones of the skeleton

Background information

The skeletal system is made up of bones, cartilage and ligaments. It is responsible for support, protection, blood cell production, mineral storage and helps in body movement. There are 206 bones in the adult human and approximately 100 joints. Some bones are very small, such as the ones that transmit sound vibration through the ear. Many of the larger bones are known by either their common names or their scientific names. Often these can be the same. The names of bones help identify areas of the body and are used to name other features found nearby.

Purpose

- identify and locate the major bones of the body

Materials

- access to a life size skeleton
- textbook with labelled diagrams of the skeleton
- sticky labels
- large felt pen (non-permanent ink)
- unlabelled diagram of skeleton (Appendix 3)

Part A: What bones do you know?

Procedure

1. In a copy of Table 19.1, list all the names of bones you know (before looking in the textbook). If you know where the bones are in the body, fill in the right hand column.
2. Write the names of the bones you have listed in the table onto separate sticky labels.
3. Place the sticky labels on what you think are the correct bones on the skeleton.
4. Discuss your placement of the labels with your group to get consensus. If there is no agreement on some, use two different sticky labels with each person's name.
5. Check with the textbook to see how well you went.

Results

Copy and complete Table 19.1.

Table 19.1: The bones I know

Bones I know	Where I think the bones are in the body

Discussion Questions

1. How many bones did the people in your group know?
2. How many bones did you know the scientific name for?
3. Give three examples where the scientific name of the bone is the same as the common name.
4. How well did your group locate the bones?

Part B: The axial skeleton

Background information

Imagine your body without a skeleton. You'd be like a rather odd-shaped bean bag flopped on the ground, unable to move and with nothing to protect your vital organs.

Your skeleton, in common with most vertebrate skeletons, is a series of fairly rigid bones and flexible cartilages that lie within your body. We therefore call such a support system an endoskeleton. Anatomists often considered the human skeleton to be composed of two main sections:

1. The axial skeleton is the principal supporting structure and forms your body's main axis. It consists of the:
   - skull
   - vertebral column
   - ribs
   - sternum
2. The appendicular skeleton supports your limbs and attaches them to your axial skeleton. It consists of the:
   - limb girdles
   - limb bones

Procedure

The skull

1. Examine the skull and find the:
   a. cranium which protects the brain
   b. facial bones which form the framework for the face
   c. maxilla or upper jaw
   d. mandible or lower jaw
2. Feel your own nose. Squeeze and flex it from side to side. Now look at the nasal region on the model of the skull.
3. Holding the cranium in the palm of your hand, carefully turn the skull over and view the underside. Notice the large hole in the base of the skull. This is called the foramen magnum.
4. Answer discussion questions 1-13

The vertebral column

Several small bones called vertebrae make up the human vertebral column. The singular for vertebrae is vertebra. Between each vertebra is a pad of cartilage called the intervertebral disc. All vertebrae have a similar basic structure, but the size and shape vary according to the region of the vertebral column it is corresponding function.

5. Observe the vertebral column and identify the five different regions. Count the vertebrae in each region and answer question 14.

View the vertebral column from the side and notice the curves. These curves are important because they increase the strength of the column and help maintain balance in the upright position.

6. Answer discussion questions 15-16

Major bones of the skeleton

The rib cage
The ribs articulate with the thoracic vertebrae. The ribs join with the sternum to form the rib cage.

7 Trace a rib from the vertebral column to the sternum.
8. Colour and label all bones of the axial skeleton on your skeletal diagram (Figure 19.2)
9. Answer questions 17-19.

Discussion Questions

1. Describe how the cranial bones are linked together to form a continuous covering for the brain.
2. What type of joint links the cranial bones? Freely movable, slightly movable or immovable.
3. What is the name of these joints in the skull?
4. At birth these joints were movable. There are also gaps, called fontanelles, between some of the skull bones. During birth, distortion and movement of one bone over the other occurs. The fontanelles close by the age of three years. Growth occurs where the skull bones interlock, slowing after the first few years and ceasing about the time of puberty. What is the value of this arrangement?
5. The facial bones are irregular and angular. Why are there small holes in many places in these bones?
6. How are the eyes protected? Describe the special features of the skull that help with this function.
7. Why is the frame of the nose mostly missing in the model?
8. What is the value of this form of support for the tip if the nose?
9. What other sense organs does the skull protect?
10. The mandible or lower jaw bone is the largest, strongest facial bone. What unique feature does this bone have?
11. What feature is shared by both the mandible and the maxilla?
12. What important digestive function do they help carry?
13. What is the function of the foramen magnum?
14. Copy and complete the following information about the five vertebral column regions.

    A cervical or neck vertebrae …….
    B thoracic or chest vertebrae ……
    C lumber or back vertebrae ……..
    D the sacrum or several fused vertebrae ……..
    E coccyx or several lower fused vertebrae ……..

15. Copy Figure 19.1 and label the four curves that correspond with A-D in Question 14.

Figure 19.1: A human vertebral column

16. Although the vertebrae in the vertebral column appear to have different shapes, they all have certain features in common. Draw a diagram of a 'typical vertebra and label the following parts:

    a. vertebral or neural canal
    b. vertebral body or centrum
    c. transverse process
    d. neural arch
    e. neural spine

17. Briefly describe the structure of a rib.

18. The rib cage encloses the chest cavity. List the organs located in this cavity.

19. Suggest two functions of the rib cage.

Part C: The appendicular skeleton

Background information

Your appendicular skeleton consists of your limb bones. These are the bones of your arm and hands, legs and feet, together with the limb girdles which attach your limbs to your axial skeleton.

Procedure

Pectoral girdle and upper limb

1. Find and examine the two scapulae (shoulder blades) and the two clavicles (collar bones).
2. Stretch your arm out straight with your hand facing down and elbow resting on the desk.
3. Turn your hand to face upwards. Notice how you can rotate your hand without moving your upper arm.
4. Look carefully on the skeleton at the relationship of the radius with the ulna.

    Q1. Which bone of the lower arm is larger at the elbow joint?
    Q2. Which bone is larger at the wrist?

5. Look at the hand

    Q3. How many metacarpal bones are there in a hand?
    Q4. How many phalanges are there in each finger?
    Q5. How many carpal bones are there?

6. Make your thumb touch each finger in turn. You can do this because you have an opposable thumb.
7. Answer discussion questions 1-6.

Pelvis girdle and lower limb

The pelvic girdle has two halves joined by a cartilage in the mid ventral line called the pubic symphysis. Each half is called an innominate bone and is really composed of three fused bones, the ilium, pubis and ischium.

8. Identify and name the bones of the pelvic girdle.
9. After puberty a female pelvis is wider and shallower than a male pelvis. You can determine the sex of a skeleton by measuring the angle of the pubic arch. To do this locate the pubic symphysis and at the lower edge measure the angle between the ischial bones. If the angle is greater than 90° the skeleton is probably that of a female. If the angle is less than 90° the skeleton is probably that of a male.

    Q6. What is the sex of your model skeleton?

10. Identify the two bones of the lower leg.
11. Compare the lower leg bones with the lower arm bones.

    Q7. Is the same degree of movement possible in your foot compared with your hand?

Major bones of the skeleton

12. As a human you have an upright stance and your foot is therefore an important mobile, weight bearing structure. Look closely at the arrangement of metatarsals and the relationship of their size to the phalanges. Identify the two arches in your foot.
13 Colour and label all the bones of the appendicular skeleton on your skeleton diagram (Figure 19.2). Use a different colour for the appendicular skeleton.
14. Answer discussion questions 7-15

Discussion Questions

1. How are the bones of the pectoral girdle connected to the axial skeleton in a living human body?
2. How does this affect the mobility of the upper arm?
3. What is the function of the clavicle?
4. Name the bone of the upper arm and the two bones of the lower arm.
5. Describe how the structure and arrangement of bones in the lower arm allows the hand to rotate.
6. Describe two different hand grips an opposable thumb makes possible. Give an example where humans use each type of grip.
7. Describe how the pelvis is attached to the axial skeleton.
8. How does this compare with the attachment of the pectoral girdle? Give reasons for the difference.
9. Suggest some reasons for the differences found in the male and female pelvis.
10. What is the name of the thigh bone?
11. How does the thigh bone compare in shape with the humerus?
12. What is the ratio of the length of the humerus : thigh bone?
13. Which is thicker the humerus or thigh bone? Account for the length and thickness of the thigh bone as compared with the humerus.
14. Explain why the degree of movement in your foot and hand is different.
15. Name the two arches present in the foot.

Summary

1. Write a paragraph to illustrate how the axial skeleton offers support and protection in the human body.
2. Explain the similarities and differences with relationship to the specific functions and location of the hand and foot.
3. Explain the functions of the skeleton and relate each function to specific examples described in Parts B and C of this activity.
4. What functions of the skeleton could not be examined in this activity? Describe each in one or two sentences.
5. The intervertebral discs are attached to the vertebral bodies of the vertebrae and cannot ‘slip’. Explain what is meant by a ‘slipped disc’ and suggest causes for this condition.
6. What precautions can you take to avoid this type of injury?

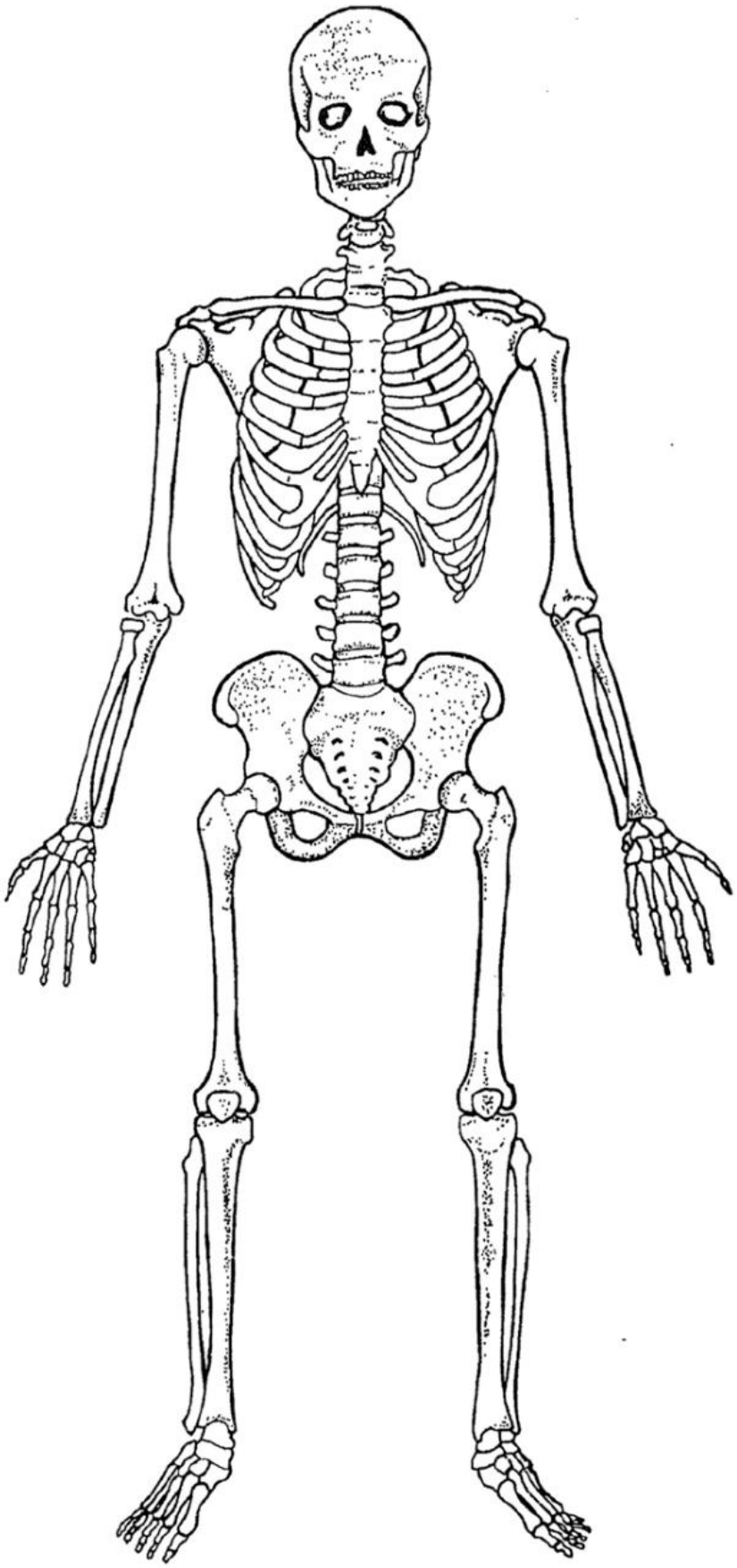


Figure19.2: Bones of the human body.

Activity 20

Bones and osteoporosis

Background information

Your bones support your body and must therefore be strong enough to carry the weight. Bones are made up of living cells that must have a blood supply therefore they can't be solid. A long bone must have the strength to support the body while being light enough to move without costing the body too much energy. Bone has a high tensile strength, similar to that of cast iron, to allow for some flexibility while being fairly rigid.

Purposes

- to describe features and explain the functions of the following parts of a long bone: diaphysis (shaft), epiphysis (head), medullary cavity (marrow cavity)
- to analyse the features of the long bone that give it strength but allow it to grow and repair damage.
- to relate the location and characteristics of the periosteum and articular cartilage to their functions.
- to describe the changes in bone structure that occur due to osteoporosis and relate these to the symptoms of the disease.

Materials

- safety glasses
- fresh beef long limb bone longitudinally cut
- old dried beef bone
- prepared slides of compact and spongy bone
- access to a microscope
- scalpel
- hand lens
- forceps - blunt

Procedure

1. View the outside of the fresh long bone. Press outside of bone with your fingernail.
   Q1. Describe how it feels.

2. Make an incision through the outer layer to the solid bone beneath. Peel back the fibrous layer.
   Q2. What is the name and function of this layer?

3. Look at the epiphysis of the bone.
   Q3. Describe the outer layer of the epiphysis.

4. Use the scalpel and forceps to peel some of the layer from the epiphysis of the long bone.
   Q4 Compare the bone exposed under the outer layer of the diaphysis with the bone exposed at the epiphysis.

5. Look at the cut section of the diaphysis of the bone. Feel the fatty substance in the medullary cavity: this is called the yellow marrow.

6. Use the hand lens to observe the bone on the outside of the diaphysis and compare it with the bone in the epiphyses in both the fresh and the old bones.
   Q5. Which areas of the long bone have densely packed compact bone? Explain why it would be an advantage for these areas to have compact bone.

7. Find the epiphyseal cartilage which is the remnant of cartilage between a diaphysis and an epiphysis. Starting before birth, bone progressively replaces the cartilage in a process known as ossification. Ossification begins in the diaphysis, and progresses towards the epiphyses. Later it starts in the epiphyses and progresses towards the diaphysis. When bone in the diaphysis meets bone in the epiphysis, ossification is complete. This happens about the end of puberty and is often used to age skeletal remains.

8. **Optional:** View the slides showing a cross section of a compact bone and cartilage. Draw a diagram of the compact bone and cartilage viewed under the microscope.

Discussion Questions

1. What can no longer happen once the epiphyseal cartilage has ossified?

2. Explain how the presence/absence of the epiphyseal line can be used to forensically age skeletons.

3. Copy Figure 20.1 and dentify the bone cells, or osteocytes, haversian canals, canaliculi, lamellae and bony matrix.

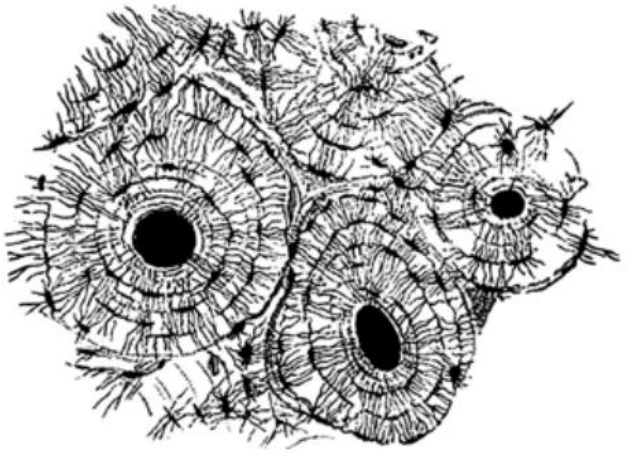


Figure 20.1: Bone tissue (×50)

People often think bone is dead, but as you are now aware, it contains osteocytes, or live bone cells, and blood vessels. There are nerves too, as you will know if you have ever damaged a bone. They are in the haversian canals with the blood vessels. Bone is a metabolically active tissue.

4. If bone were dead, what would be the consequence if you broke a bone?

5. Copy Figure 20.2 and label the following parts: epiphysis, epiphyseal cartilage, diaphysis, cancellous or spongy bone, compact bone, periosteum, articular cartilage, medullary cavity, yellow marrow, red marrow

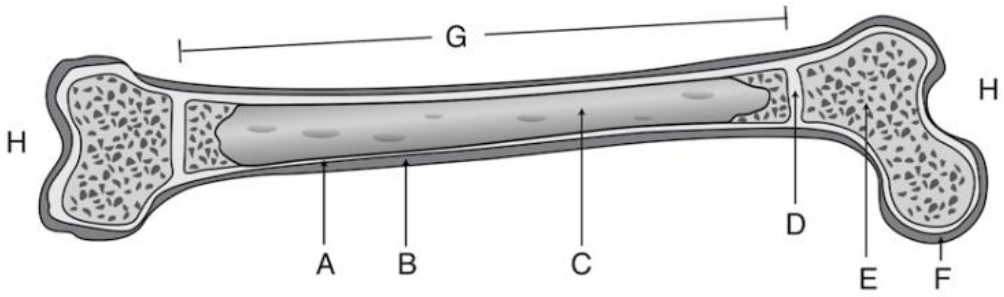


Figure 20.2: Structure of a long bone.

The ends of long bones are covered with cartilage.

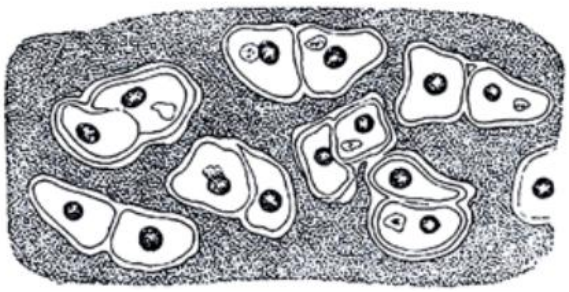


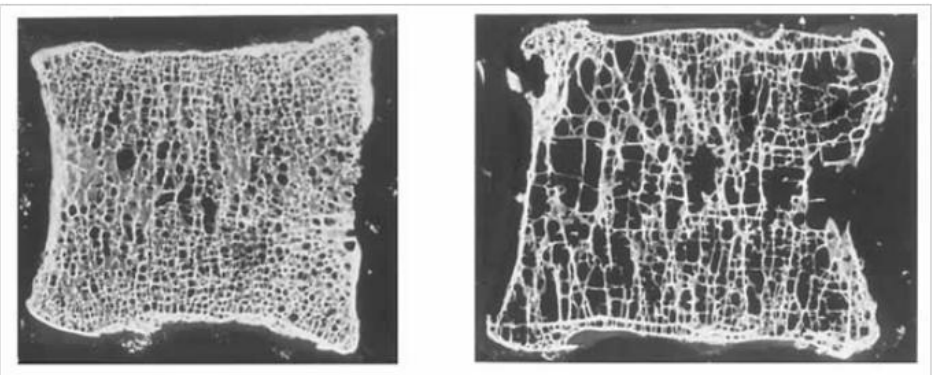
Figure 20.3: Cartilage tissue (×150)

Bones and osteoporosis

6. Compare the structure of cartilage with that of bone. (Consider the magnification)

Osteoporosis is a condition in which the bones become fragile and brittle, leading to a higher risk of fractures (breaks or cracks) than in normal bone.

Osteoporosis occurs when bones lose minerals, such as calcium, more quickly than the body can replace them, leading to a loss of bone thickness (bone mass or density). As a result, bones become thinner and less dense, so that even a minor bump or accident can cause serious fractures.



A: Bone of normal density

B: Bone of reduced density with fracture due to osteoporos

Figure 20.4: Comparison of normal bone and bone with osteoporosis.
(http://www.engr.iupui.edu/~turnerch/index.htm permission granted 30 Oct 2009)

7. Explain, referring to Figure 20.4, why osteoporosis leads to an increase risk in older people breaking bones when they fall.

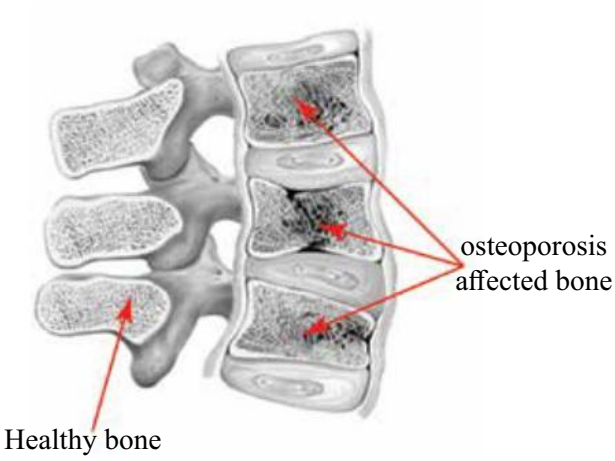


Figure 20.5: Drawing showing damage to vertabrae caused by osteoporosis

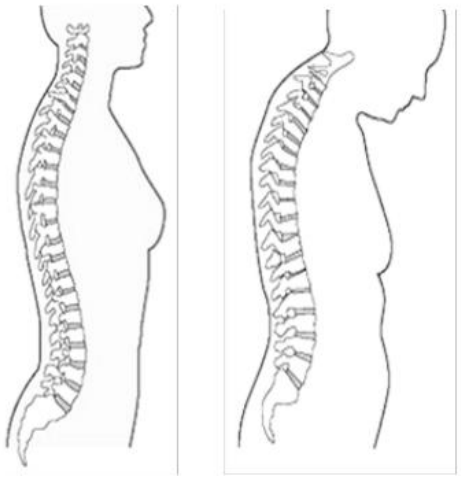


Figure 20.6: Changes in posture due to osteoporosis

8. Use the information from Figures 20.4 and 20.5 to explain why the spine changes shape due to the effect of osteoporosis, as shown in Figure 20.6.

9. How does your life style in adolescence influence your chances of having osteoporosis later in life?

Activity 21

Joints and arthritis

Background information

Where two bones meet in the body there is a joint. Anatomists classify joints according to how much movement they allow. Joints can be:

- fixed or immovable, which allow no movemenat
- slighly movable, which allow a small amount of movement
- freely movable, which allow free movement

Anatomist classify joints further according to the type of movement allowed. This depends on the shape of the bones making the joint. There are four types of freely movable joints:

1. ball and socket
2. hinge joint
3. pivot joint
4. gliding joint

Materials

- access to a human skeleton or a model human skeleton
- models of joints, if available
- reference material

Procedure

1. Fixed or immovable joints are held together by a tough fibrous material. Because of this anatomists also call them fibrous joints. Carefully observe the following areas and try to fuind the immovable joints:
   a. Skull
   b. Lower end of vertebral column
   c. Rib cage

   Q1. Name all of the immovable joints that you can find.

2. Slightly movable joints have a pad of cartilage between the bones that form this kind of joint. Because of this, anatomists call them cartilaginous joints. Look at the vertebral column and the pelvis to find examples of cartilaginous joints.

   Q2 Describe the positions of cartiliginous joints.

3 Answer discussion questions 1-3

4. Freely movable joints are lubricated by a synovial fluid. Because of this, anatomists also call them synovial joints. Most freely-movable joints are found in the appendicular skeleton. Observe the upper and lower limbs.

   Q3. List examples of ball and socket joints
   Q4. List examples of hinge joints
   Q5. List examples of gliding joints

5. A pivot joint is made up of a ring of bone which can twist around a bony process or peg. Find the pivot joiny in the axial skeleton.

Joints and arthritis

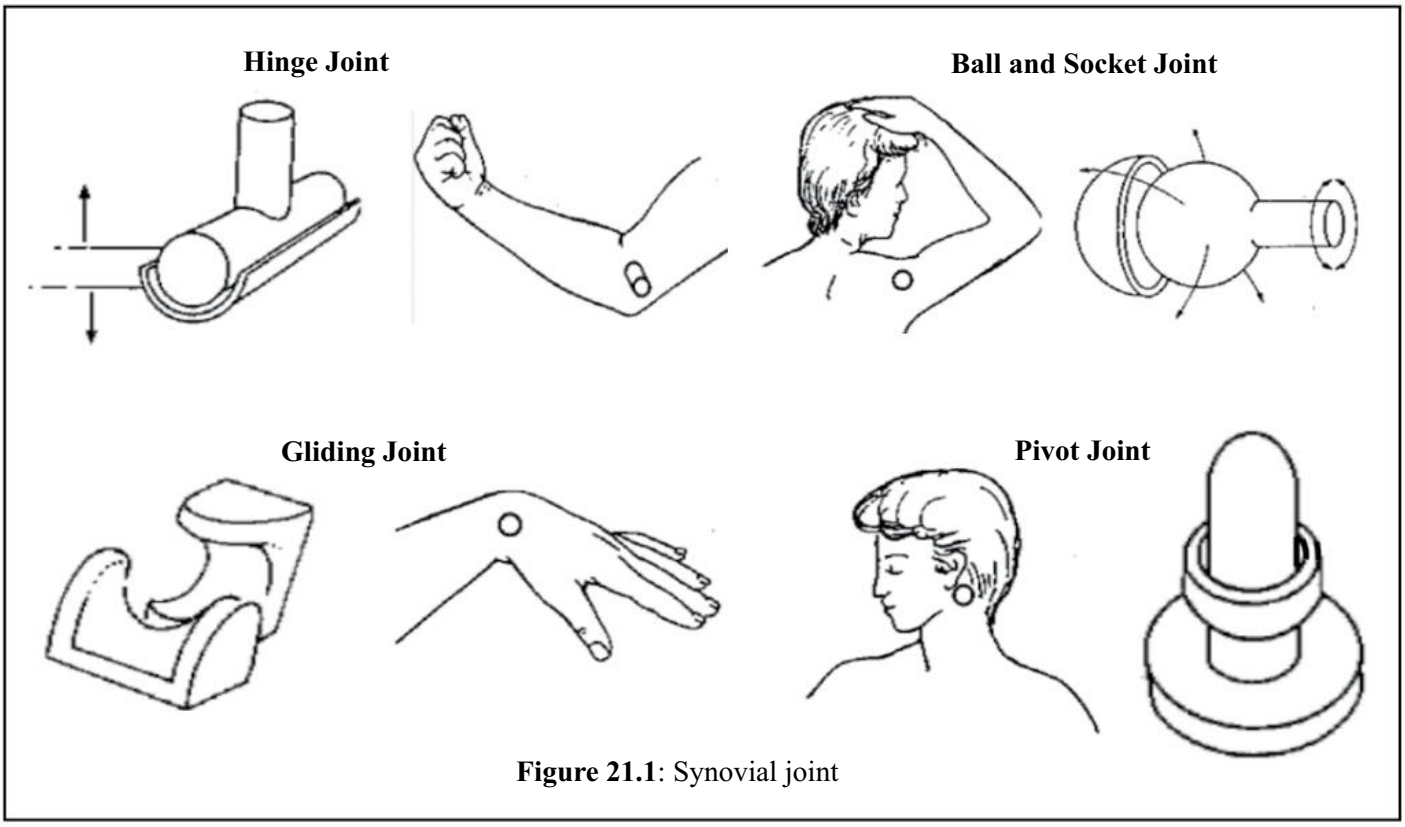


Figure 21.1: Synovial joint

Q6. Name the bones forming the pivot joint and describe the movement the joint allows.

Q7. Name the bones involved in a:
- a. shoulder joint and a hip joint
- b. These joints are of the same type. What do we call this type of joint?
- c. Compare the *range* of movement the shoulder joint allows with the *range* of movement the hip joint allows.
- d. Answer discussion questions 4-7

Discussion Questions

1. The movement the joint between each vertabra permits is small, yet we can bend our backs and achieve considerable movement. Explain how we achieve this considerable movement in our vertebral column.
2. Both males and females have cartiliginous joints in the pelvis. Explain why the cartiliginous joint in the female pelvis is more flexible than the male.
3. What could cause this change in flexibility?
4. Give the meaning of the following terms:
   a. flexion
   b. extension
   c. rotation
   d. abduction
   e. adduction

5. Copy and complete the following table.

	Joint name	Bones in joint	Type of movement	Range of movement
Elbow				
Knee				
Ankle				
Wrist				
Thumb				

6. You can freely move your knee joint. We call such a freely moving joint a synovial joint. Synovial joints all have the following parts: bone, joint capsule, synovial membrane, articular cartilage, synovial fluid, ligaments. Draw a large, clear, labelled diagram of a knee joint.

7. Briefly describe the structure of the following features of this synovial joint and state the function of each structure.
   a. joint capsule
   b. synovial membrane
   c. articular cartilage
   d. synovial fluid
   e. ligaments

Summary

1. Dislocation of a joint occurs when it is put under excessive force, usually at an unusual angle. When a joint is dislocated the bones are shifted out of alignment. As part of this activity you may have observed a hip joint and a shoulder joint. Based on your observations of how these joints are put together, explain why the shoulder joint is more likely to be dislocated than the hip joint.

2. The hip and the shoulder are both ball and socket joints. Contrast these two joints with respect to the bones forming the joint and the range of movements capable at each joint.

3. The knee joint is the largest and most complex joint in the body. It is frequently damaged while playing sport and knee injuries have ended the careers of many elite athletes. Locate the anterior cruciate ligament on your diagram of a knee joint. Football and basketball players often tear this ligament. Predict what would happen to the knee joint if the anterior cruciate ligament was torn.

4. The knee has a structure called the meniscus. Locate it on your diagram of a knee joint. What is its function?

5. The knee also has structures called bursae. They are filled with fluid. What is their function?

In osteoarthritis, the cartilage becomes brittle and breaks down. Some pieces of cartilage may even break away and float around inside the synovial fluid. This can lead to inflammation. Eventually, the cartilage can break down so much that it no longer cushions the two bones.

Joints and arthritis

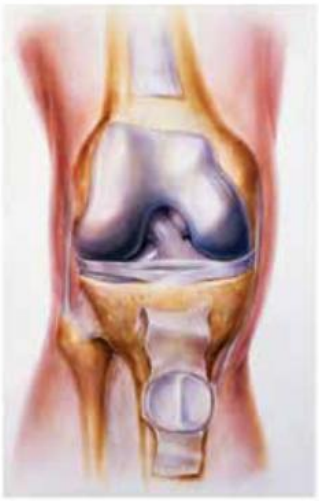


Figure 21.2: Normal knee
N0019548 Normal anatomy, right knee showing joint open
Credit: Medical Art Service, Munich/Wellcome Images

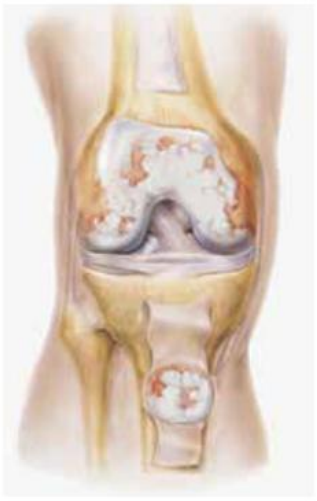


Figure 21.3: Arthritic knee
N0022608 Arthritis of knee Credit :Medical Art Service, Munich/Wellcome Images

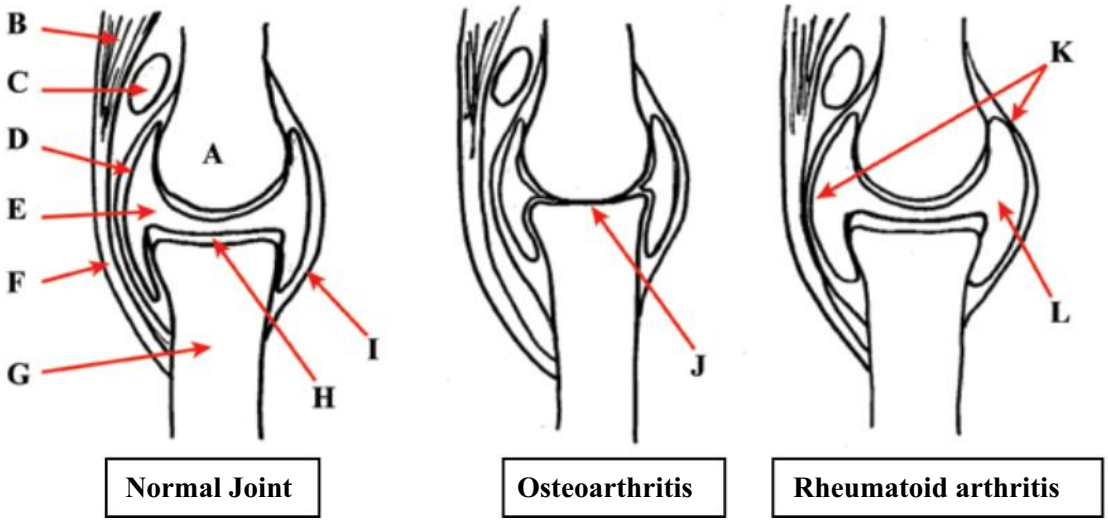


Figure 21.4: Normal joint compared to osteoarthritic and rheumatoid arthritic joint

6. Figure 21.2 and 21.3 show the development of arthritis due to injury and heavy use of the joint. Explain what is happening.
7. Use the information in Figure 21.4 to describe the differences between osteoarthritis and rheumatoid arthritis.
8. Why is it important to have some flexibility in joint movement?
9. Give an example where flexibility is not advantageous.
10. Why do athletes stretch before playing sport?
11. What happens when a joint is dislocated?
12. Some sports people have their ankles, knees or shoulders strapped with tape when they play. Why is this done?

Activity 22

The relationship between muscles and bones

Background information

It is very difficult to think of muscles and bones as separate unrelated systems. For one of these systems to operate properly, it needs the cooperation of the other. How these systems are linked, their structure, and the tissues involved are important aspects of your study of human biology.

Purposes

- to identify the interrelationship between muscles and bones
- to identify tendons, ligaments and cartilage

Materials

- chicken wing
- dissecting tray or board
- sharp forceps
- dissecting pins
- dissecting scissors
- probe
- microscope
- microscope slides and coverslip
- scalpel
- prepared slides of striated muscle, fibrous connective tissue and cartilage

Procedure

1. Place the chicken wing on the dissecting tray as shown in Figure 22.1. Starting from the single bone, use the scissors to cut the skin longitudinally, or down, the length of the wing.

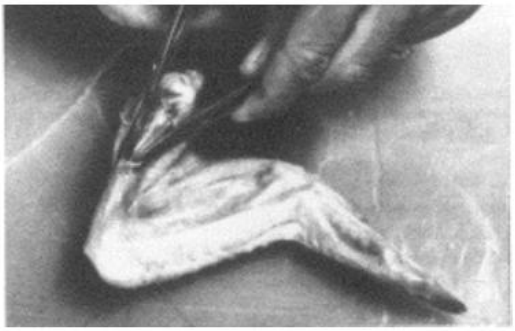


Figure 22.1: Chicken wing showing surface features and position of first incisions

2. Pin back the skin and view the exposed muscle. Examine the excised skin and exposed muscle.

3. Fatty deposits may be present under the surface of the skin. What might be the purpose of this tissue?

4. Observe the muscle tissue and describe its appearance and colour.

5. Look closely at the surface of the muscle tissue. Do you notice any tissue surrounding or covering the surface of the muscle? What might be the purpose of this tissue?

6. Remove a very small piece of muscle with the forceps and scalpel. Smear this tissue onto a clean microscope slide and cover with a coverslip.

7. Observe your prepared slide under low and high power of your microscope. Draw a diagram of your muscle tissue, viewed under low and high power below. See Appendix 1 for information on drawing from a microscope slide.

8. If prepared slides of striated muscles are available compare the structures to those of your chicken tissue.

9. Use the scalpel to cut the muscle tissue away from the bone down the length of the upper wing and continue to the end of the lower wing.

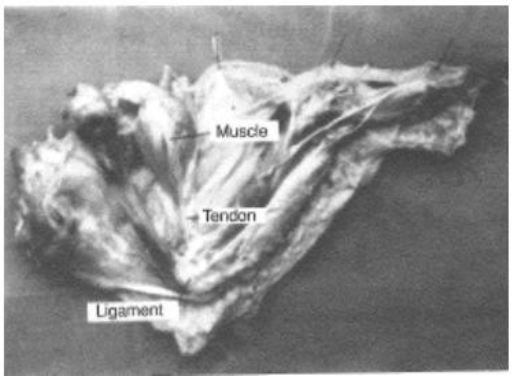


Figure 22.2: The tissue of a chicken wing exposed back to the bone

10. Pin back the tissue to expose the bone and other structures. Figure 22.2 shows the exposed tissues.

11. Trace a muscle from the upper part of the wing to the lower part of the wing. At the end, where the muscle inserts into the bone, you should see a shiny white tissue. Cut away excess muscle tissue until the white tissue is exposed. This tissue is called a tendon.

12. Remove as much tissue as possible from the joint between the upper part of the wing and the lower part of the wing. You should see another white shiny tissue. This tissue is a ligament.

13. Use the scalpel to carefully separate the upper and lower wing bones at the joint. A gristly, slippery tissue should be present between the bones at the joint. This tissue is called cartilage.

Discussion Questions

1. The shiny white covering that you observed on the surface of all of the joints is made of cartilage. Why is cartilage so smooth? What is its purpose?

2. If you carefully examined the diaphysis of most bones you would observe areas that are rough or bulge outward. Why are these surfaces not smooth, like the epiphyses of the bones?

3. How is the function of a ligament different to that of a tendon?

4. The lower wing section in chickens corresponds to the forearm of a human. Name the two bones that are found in the forearm.

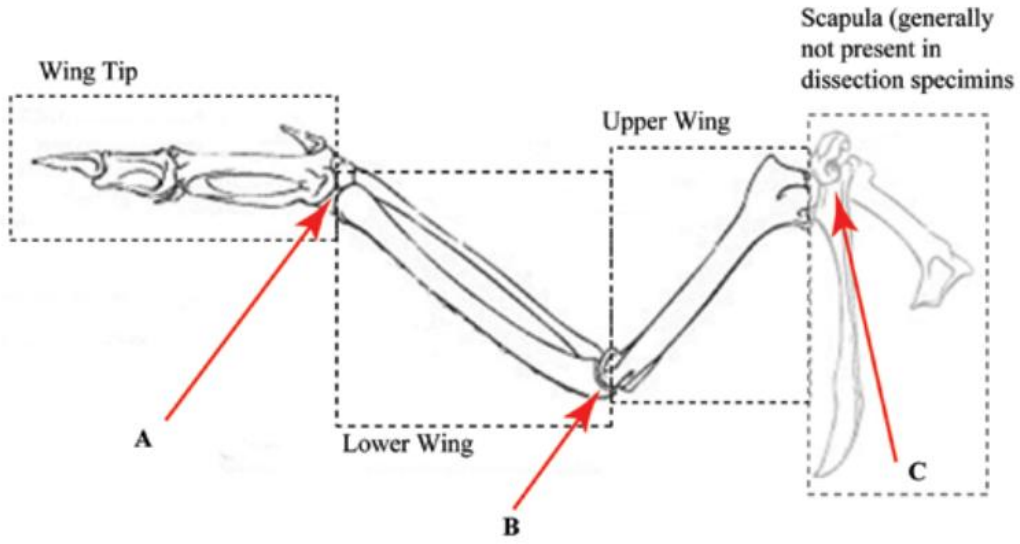


Figure 22.3: Bones in a chicken wing

5. The upper wing section, as shown in Figure 22.3, corresponds to the upper arm of a human. What is the name of the bone in the upper arm?

6. The wingtip, as shown in Figure 22.3, corresponds to the human hand, but is quite different. Describe some differences between the bones of your hand and the bones in the wingtip. (Consider the number of bones, the arrangement of the bones and the range of movement.)

7. Identify the joints labelled A, B and C in Figure 22.3.

8. The ends of bones in a joint never touch. If they did, moving would be very painful. What fluid in the joint, helps keep the bones from touching?

Activity 23

The kidney - organ of excretion

Background information

Your kidneys are bean-shaped organs, each about the size of your fist, located either side of your spine at about the level of your waist.

Your kidneys filter blood. The filtering occurs in tiny units inside your kidneys called nephrons. One kidney has about a million nephrons. They remove waste products and extra water, which become urine. The urine flows through tubes called ureters to your bladder, which stores the urine until you go to the toilet.

Metabolic reactions in the cells produce wastes which are removed from tissues by the blood. If your kidneys did not remove these wastes, they would build up in the blood and detrimentally effect the functioning of cells.

Purposes

- to observe the structure of the kidney
- to understand the role of the kidney in maintaining metabolism

Materials

- safety glasses
- disposable gloves
- scalpel
- hand lens
- dissecting dish or board
- sheep's kidney, preferably with some ureter
- forceps, fine
- blunt seeker
- scissors, fine point

Procedure

The urinary system consists of two kidneys, two ureters, the urinary bladder and urethra.

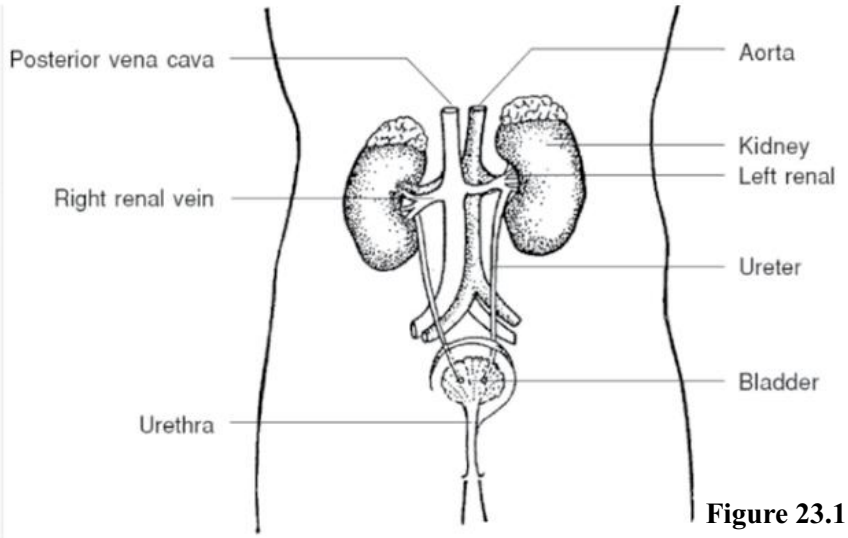


Figure 23.1: Organs of the urinary system

1. Remove any fatty tissue from around the kidney, taking care not to damage any of the tubes emerging from the concave surface.

   Q1. What is the function of the adipose fatty tissue?

2. Identify the ureter and any blood vessels.

   Q2. How are you able to determine which is which?

   The kidney may be covered by a transparent layer, the renal capsule. This layer is continuous with the outer coat of the ureter.

   Q3. Suggest the function of this layer.

The kidney - organ of excretion

3. Refer to Figure 23.2. Cut the kidney in half lengthways starting from the concave side just to one side of the central line.Initially do not cut through to the point where the tubes exit. Stop when you fully expose the cream-coloured pelvis.

4. Note the colour changes as you work inwards.

5. If you maintain the cut halfway, you should find the external exit point of the ureter. Poke a blunt seeker down it to verify which tube is the ureter. Leave the tubes to one side of the dissection.

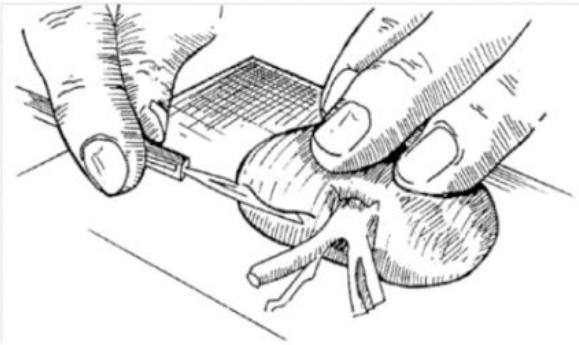


Figure 23.2: How to cut a kidney to obtain a longitudinal section

6. Observe the internal appearance of the kidney. The cortex of the kidney contains the renal capsules and the convoluted tubules, while the medulla contains the loopd and collecting ducts. Identify the cortex, medulla, pelvis of ureter, pyramids and calyces (singular - calyx). You may be able to detect fine radial striations in the lighter pink area. These are due to the loops and collecting ducts, which are aligned parallel to each other.

   Q4. Compare the colour and appearance of the cortex, medulla and pelvis.

7. Draw and label a diagram of your dissection. Choose an arrangement that allows you to show as much as possible.

Discussion Questions

1. What is a possible function of the renal capsule?

2. Does your circulatory system supply blood first to the cortex, then the medulla, or first to the medulla and then the cortex? Explain your reasoning.

3. Compare the colour of the cortex and medulla of the kidney. What is the reason for the difference?

4. What is the filtering unit of the kidney called?

5. What parts of the filtering unit are found mainly in the cortex?

6. What part of the filtering unit is found mainly in the medulla?

7. Your kidneys produce urine continuously and your bladder stores it. Without a bladder you would continuously release urine as you produce it. Why would health be at risk if humans were to release urine continuously?

8. Human urine is sterile, unless the person has an urinary tract/genital infection. Why are there no bacteria or viruses in urine?

9. Why is a functioning kidney important in maintaining an efficient rate of metabolism?

Activity 24

Nephron structure and function

Background information

There are about 1 300 000 nephrons in each human kidney. The nephrons are extremely specialized tubules which accomplish the production of urine through a series of processes, namely, filtration, reabsorption, active secretion and concentration.

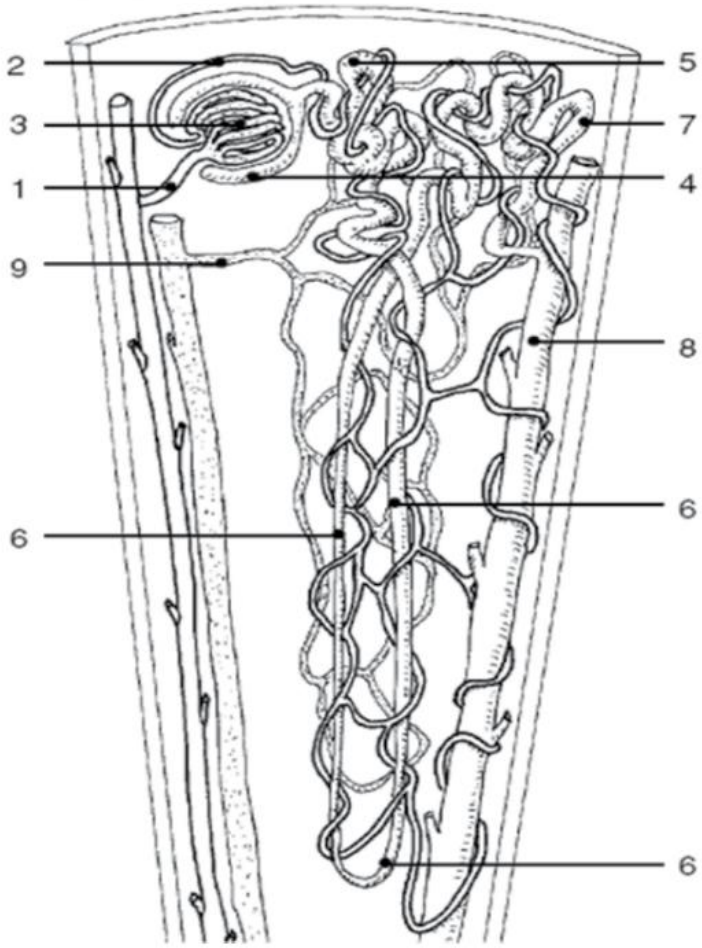


Figure 24.1: The nephron

Purposes

- to identify the following major parts of a nephron: glomerulus, glomerular (Bowman's) capsule, proximal convoluted tubule, Loop of Henle, distal convoluted tubule, and collecting duct.
- to understand the processes of filtration and selective reabsorption as they relate to the functioning of the nephron
- to comment on the normal composition of urine

Materials

- particle mix of sand, iron filings, pink and blue silica gel beads, and small grain rice
- magnets in small ziplock plastic bags
- butcher's paper or newspaper
- large beaker labelled 'Blood'
- sieve which allows rice through
- tweezers
- filter funnel with long tubing attached
- a copy of Figure 24.1, if required (Appendix 4)

Nephron structure and function

Procedure

The beaker contains four types of particles representing blood components.

Pink silica gel	Blood cells
Blue silica gel	Proteins
Iron filings	Glucose and amino acids
Sand	Water
Rice	Urea and wastes

Process 1: Filtration

1. Pour the contents of the beaker slowly into the sieve over the paper. Shake the sieve for about 10-15 seconds to simulate the movement of particles. The material on the paper is called the 'filtrate'.

   Q1. What part of the nephron is simulated by the sieve?
   Q2. What feature of the sieve will control the types of particles it will allow through?
   Q3. Two types of particles did not cross into the filtrate. What property do they have in common?
   Q4. Which part of the nephron does the filtrate enter after being filtered from the blood?
   Q5. Rank these in terms of size, from smallest to largest: blood proteins, urea, amino acids, glucose, blood cells.
   Q6. What do the contents of the beaker represent?
   Q7. How do the contents of the blood differ between the afferent and efferent arterioles?
   Q8. How would the change in contents alter the osmotic pressure of the blood in the efferent arteriole?

2. Indicate where filtration occurs on your nephron diagram (Figure 24.1) by colouring it with a dark green pencil.

3. Return the contents of the sieve to the beaker.

Process 2: Selective Reabsorption

4. Pass a magnet, in its ziplock bag, over the paper several times.

   Q9. What is left on the paper?
   Q10. What then is left in the tubule in the real kidney?
   Q11. What has the magnet picked up?
   Q12. What is being reabsorbed from the tubule to the blood?

5. Indicate where selective reabsorption occurs on your nephron diagram (Figure 24.1) by colouring it with blue pencil.

6. Return the material the magnet picked up to the beaker.

   Q13. Where does selective reabsorption occur in the nephron?
   Q14. What is left of the original contents of the glomerulus?

Process 3: Active secretion

7. Not all of the rice may have come through the sieve during the filtration process.
8. Use the tweezers to remove the rice from the beaker and place it on the paper.

   Q15. Why is this an 'active' process?

Process 4: Concentration

9. Separate some of the sand on the paper and return it to the beaker.

   Q16. If you remove the sand (water) from the filtrate, what happens to the concentration of the urine?
   Q17. The distal tubule and collecting duct need to be directed to put sand back into the sieve (reabsorb water). What substance carries this message?
   Q18. What is the composition of material on the paper and how does it compare with the composition of the contents in the beaker?
   Q19. Compare the contents and volume of material passing through structure 4 in Figure 24.1 with the fluid at the end of structure 8.
   Q20. Where, on Figure 28.1, are the contents of the tubule called 'urine'? Where in its journey through the tubule will there be no more changes to the contents of the urine?

10. Indicate on your nephron diagram (Figure 24.1) where urine is found by colouring it in yellow pencil.

11. Colour the blood vessels and capillaries on your nephron diagram (Figure 24.1) with red pencil.

Discussion Questions

1. Whenever a large organism, such as a human, exchanges substances with the external environment, there has to be a large surface area for such exchange. Organs usually achieve large surface areas by folding the surface involved to fit a large total surface area in a small space or volume. However, the surface area of a single glomerular capsule is small. How does a kidney therefore get a large enough surface area to provide efficient filtration?

2. On average about 180 L of plasma filtered through a kidney in 24 hours during normal conditions. The kidney receives about 1800 L of blood (about 900 L of plasma) per day. A person's body contains about one litre of blood per kilogram of body weight. Calculate how many times your blood is filtered per day.

3. Copy and coplete the table below comparing the composition of normal urine with that of plasma.

Contents	Plasma	Urine

Nephron structure and function

4. Explain the effect of each of the following on the volume and concentration of urine:
   a. drinking a large amount of water

   b. eating a very salty meal

   c. a hot, dry day

   d. a cold winter's day

5. When your bladder is full, you feel the urge to urinate. Sometimes this is not socially convenient and you put off going to the toilet. Why is it not a good idea to delay urination for too long?

6. A particular health risk exists in females because they have short urethras therefore they should be especially careful about their personal hygiene habits. Explain this risk and the precautions you think they should take.

7. The hot climate of Australian summers means a high water loss through sweat. What action should we take to maintain the health of our kidneys in hot weather and why should we do this?

8. Tests can be done for the presence of glucose and amino acids in urine. What does the presence of these chemicals in the urine indicate?

Unit 2: Reproduction and inheritance

Unit 2 explores the mechanisms of transmission of genetic materials to the next generation, the role of males and females in reproduction, and how interactions between genetics and the environment influence early development. The cellular mechanisms for gamete production and zygote formation contribute to human diversity. Meiosis and fertilisation are important in producing new genetic combinations.

The content covered in Unit 2 activities includes:

- the DNA molecule, including its structure and role in cell division
- protein synthesis and the transcription and translation of the genetic code into an amino acid sequence in the ribosome with the aid of RNA
- the study of phenotypic expression of genes, which depends on the factors controlling transcription and translation during protein synthesis, the products of other genes, and the environment
- variations in the genotypes of offspring that arise as a result of the processes of meiosis, fertilisation and environmental factors
- the production of offspring facilitated by the structure and function of the female and male reproductive systems in producing and delivering gametes for fertilisation and providing for the developing embryo and foetus
- the establishment of a pregnancy, the development of the embryo after implantation and the birth, during which there are circulatory system changes in the child
- contraception methods and the risks and benefits associated with each method
- sexually transmitted infections (STIs) their transmission, prevention, early detection and treatment of infection and the serious health consequences of STIs
- assisted reproductive technologies used in overcoming infertility problems, along with the limitations, risks and benefits of each
- genetic screening of embryos before implantation or during early development

Activity 25

DNA - the master molecule

Background information

The concept of a 'hereditary material' has been a part of scientific thinking for hundreds of years. But no one knew what the material was. It was known that information had to pass from one generation to the next because of the similarities in family members through the generations. The breakthrough came in 1944 when it was shown that DNA, not proteins, was this mysterious hereditary material.

A 'double helix' of the DNA molecule is probably the best known of any molecular shape. Within its spiral shape is all the genetic information your cells need to make a human being. DNA is an extraordinary molecule. If yoiu couls unravel the DNA of all your chromosomes in every cell in your body and join it end-t-end it would stretch to the moon and back 8000 times!

Purposes

- to explore the structure and properties of DNA to understand the genetic code
- to realise that genetic inheritance can be understood only with an understanding of the DNA molecule and its replication

Materials

- DNA kit or
- Cut out the molecules in Appendix 3 and Appendix 4 (save them for Activity 26) of:
  - Deoxyribose sugar (about 20)
  - Phosphate (about 20)
  - Four different bases. Six of each of A = Adenine, T = Thymine, C = Cytosine and G = Guanine

Procedure

Part A: The structure of DNA

The basic unit of structure of a nucleic acid is called a nucleotide. This consists of three molecules bonded together; a sugar, a phosphate and a base.

a. Assemble one of these on the desk in front of you

Q1. Write down the structure of the nucleotide you have made.

The D.N.A molecule is made up of a series of these nucleotides, linked togather into a ladder-like structure; the 'rungs' of the ladder formed of paired bases.

The bases are of four kinds: adenine (A) and guanine (G) which are known as purines, and cytosine (C) and thymine (T) which are known as pyramidines. In D.N.A. molecule purines and pyramidines always pair together to from complementary base pairs.

A always pairs with T, and C always pairs with G.

b. Build more nucleotides from the bank of molecules in your envelope and assemble them to make two chains of sugar and phosphate linked by paired bases. You should now have made a small segment of a D.N.A. molecule.

Q2. Record the structure of the D.N.A. molecule you have made.

Discussion questions

1. Why is it that the number of adenine units is always the same as the number of thymine units in any D.N.A. molecule?

2. Could there be different numbers of adenine and guanine bases in a molecule? Explain your answer.

3. How might D.N.A. molecules differ from one another?

Part B: DNA Replication

1. Now carefully separate the D.N.A. molecule you have built into two chains of nucleotides.

2. Using extra shapes from the class bank, create new D.N.A. molecules from each of the separated nucleotide chains by adding sugar and phosphates and base units to them.

Discussion questions

1. How does the structure of each new molecule compare with the original?

2. How does the structure of each new molecule compare with each other?

3. Biologists call the process you have just carried out 'replication'. Why is this a suitable name?

Part C: Properties of DNA

Soluble in water

1. How does the solubility of DNA explain why DNA does not cross the nuclear membrane into the cytoplasm of the cell?

Melting point of DNA is variable.

The melting temperature depends on the base sequence in the sample of DNA. The hydrogen bonds between the A - T are weaker than those between G - C. If the sequence has more A - T then the melting temperature will be lower.

2. How can the melting temperature of a sample of DNA be used to determine its composition?

DNA has a negative charge.

This is important in the application of electrophoresis in separating DNA fragments.

3. a. When running a DNA separation gel, in which set of wells would you place the sample of DNA in the tank show below? Why?

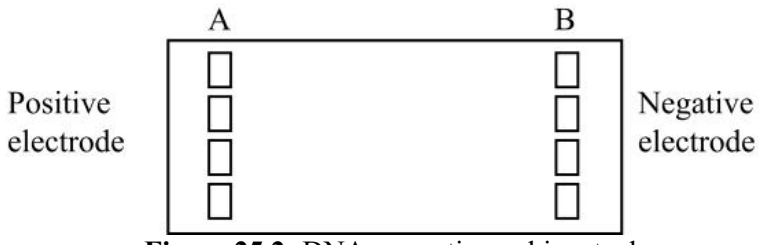


Figure 25.2: DNA separation gel in a tank

b. In what direction would you expect the DNA to move if the power was turned on?

c. What factors other than electrical charge will affect the movement of DNA through the separating gel?

DNA absorbs ultraviolet light.

Ultraviolet light of 260 nm wavelength is absorbed strongly by DNA. This feature can be used in determining the amount of DNA in solution by measuring the amount of UV light absorbed.

4 a. What observable evidence would enable you to tell the difference between samples with low and high amounts of DNA using UV light?

b. How does the UV absorption feature of DNA help explain why people with light skin are prone to greater incidence of skin cancer than those with dark skin?

DNA - the master molecule

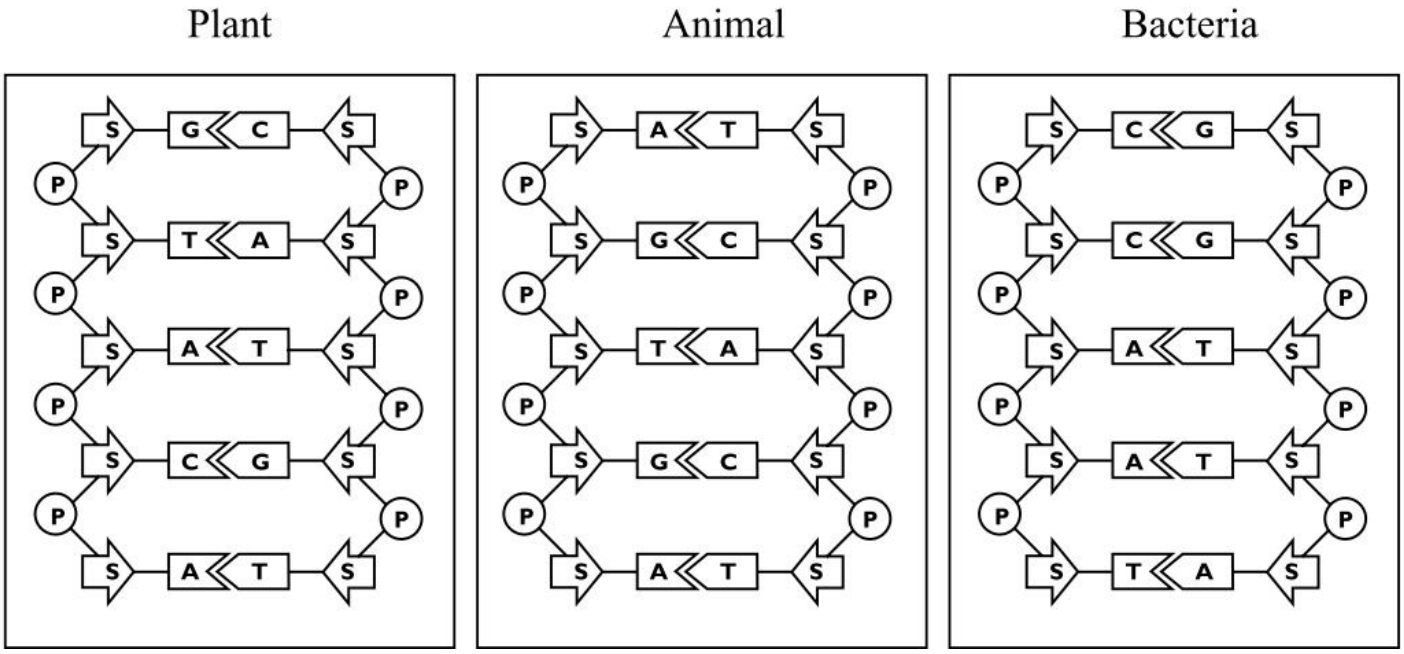
DNA denatures and anneals easily.
The temperature required to break the chemical bonds (covalent bonds) between the components of the side rails is very high, this makes DNA a temperature stable compound.

5 a. High temperatures will cause DNA to separate into two strands by breaking the hydrogen bonds between the nucleotides. What is this process called?

b. When the temperature is lowered, the strands will re-connect. What is this process called?

c. Explain why DNA can be easily obtained from mummified remains of Egyptian pharaohs, but difficult to get from victims of intense fires.

d. Compare the DNA from the three different sources shown below. What are the similarities and differences?



e. Can the components of DNA from a bacteria be swapped for the ones found in plants or humans? Explain your answer.

Summary

Discovering the structure of DNA timeline

Table 25.1: Timeline of the development of the concept of DNA through to the 1953 description.

Year	Events
1663	**Robert Hooke** describes cells as seen through his simple microscope
1833	The nucleus was described as a particular part of the cell
1863	G**regor Mendel** suggested hypothetical 'factors' of inheritance and indicated that some factors were 'dominant' over others.
1869	**J. F. Miescher** isolates 'nuclein' from white blood cells.
1871	**Miescher** identifies 'nuclein' as DNA in an extract from trout sperm.
1879	**Albrecht Fleming** uses stains to discover chromatin in the form of rod shaped structures in the cell. These are later called chromosomes.
1880 - 1885	**August Wiesmann** makes the distinction between reproductive cells (germ cells) and body cells (somatic cells).
1882	**Eduard Van Beneden** shows that each species has a particular number of chromosomes in its cells. **Walther Fleming** describes mitosis.
1885 - 1901	**Fleming** and his students discover the component compounds of nucleic acids: adenine, cytosine, guanine, thymine, and uracil.
1900	**Hugo deVries** uses the term 'genes' to describe Mendel's 'factors' Drosophila fruit flies were first used in the study of genes.
1902	**Walter Sutton** described the relationship between chromosomes and heredity.
1905	The behaviour of the X and Y chromosomes in sex determination was described by two separate researchers: **Nettie Stevens** and **Edmund Wilson**.
1906	The introduction of the term 'genetics'.
1908	**Archibald Garrod** stated that 'human diseases were inborn errors in metabolism' and speculated that lack of enzyme function resulted from a defective gene.
1910	**Thomas Hunt Morgan** began his studies in genetics using the fruit fly leading to many discoveries including linkage of genes.
1927	**Hermann Muller** discovers that X-rays cause mutations in Drosophila
1941	**George Beadle** and **Edward Tatum** proposed the 'one gene - one enzyme' theory.
1944	**Oswald Avery**, **Maclyn McCarty** and **Colin MacLeod** showed that DNA was the inheritance material not the proteins that formed the inheritance part of the chromosomes.
1949	**Linus Pauling** demonstrated that sickle celled anaemia was as a result of a mutation of the gene controlling haemoglobin.
1953	**Francis Crick**, **James Watson**, **Maurice Wilkins** and **Rosalind Franklin** determined the structure of DNA based on X-ray crystallography.

1. Use the information in Table 25.1 and reference materials to answer the following questions:
   a. Explain how the development of the microscope was important in the understanding of cells and heredity.
   b. Explain how the use of chemical analyses would help in identifying and understanding the structure of DNA.
   c. Why were fruit flies (*Drosophila*) more useful in studying genetics than humans?
   d. Gregor Mendel's work was published in an obscure scientific journal in 1863 and was not 'found' by genetic researchers until about 1900. Explain how Mendel's findings could have influenced research in the early 1900's.
   e. Why was it important to understand the structure of DNA in order to understand how DNA worked?
2. DNA forms the chromosomes in a cell nucleus. Suggest what might happen to the DNA when a cell divides so that each daughter cell contains the same genetic information as the parent cell.
3. Briefly describe the structure of DNA molecule.
4. Briefly explain how replication of DNA happens.

Activity 26

Protein synthesis

Background information

The production of proteins by cells was not fully understood until the structure of DNA was known (1953). Even then, researchers took a while (1961) to determine the coding method used to translate the information in the genetic code and how it was used to produce specific proteins.

Researchers could then understand the basis for genetic conditions produced by gene mutations. Changes in the DNA sequence can gave rise to differences in proteins which controlled cellular functioning.

Purposes

- to outline the steps in protein production
- to analyse the link between the DNA sequence and protein production to understand the problems caused by mutations

Part A: Modeling protein synthesis

The nucleus is able to direct the activities of the cell because it contains genetic information in the form of DNA Coded instructions are formed from DNA. and pass into the cytoplasm where they direct the formation of enzymes and structural proteins. These determine how a cell is made and what kinds of chemical processes it can carry out.

Materials

- The cut out molecules used in the construction of DNA in Activity 25 (Appendix 3)
- Piece of A3 paper labelled 'nucleus'
- Piece of A3 paper labelled 'ribosome'
- Cut out molecules in Appendix 4 of ribose sugar: 9 per group; uracil (base): 6 per group
- Transfer RNA and amino acid units

Procedure

1. Make up a DNA strand having a sequence of bases on one nucleotide chain reading:
   T-A-G-C-G-A-A-T-G
2. Place the nucleotide chain on to the piece of A3 paper labelled 'nucleus'
3. On the exposed bases of this chain make up a new complementary molecule which matches the template half DNA molecule. However, use ribose sugar instead of dioxyribose and substitute the base uracil for thyamine wherever it is required.
   You have now made a new nucleic acid known as RNA This particular molecule carried coded instructions out of the nucleus into the cytoplasm ans is therefore known as messenger RNA or simply mRNA. The copying process is called transcription.

   Q1. List three obvious differences between DNA and RNA

4. The strand of mRNA now moves out of the nucleus ans into the cytoplasm where it attaches to the surface of a ribosome. Simulate this by using the piece of paper labelled 'ribosome'.

   Q2. Through which structures of the nuclear membrane might this mRNA pass?

   Q3. What might be the role of the endoplasnic reticulum in this process?

5. Now select units of Transfer RNA (tRNA) and amino acids which are coded for by the sequence of bases on the tRNA.
6. Find a position on the mRNA where this tRNA will fit.
7. Do the same for other tRNA and amino acid units.

Part B: Understanding the code

There are 20 different amino acids that are the basis for making proteins. DNA is made up of 4 different nucleotides: **A**denine, **T**hymine, **C**ytosine and **G**uanine.

Discussion questions

1. How many different **pair** combinations can be made from the four nucleotides?
2. How many **triplet** combinations can be made from the four nucleotides?
3. How many **quad** combinations can be made from the four nucleotides?
4. Researchers decided that the triplet code was the mostly likely combination. Suggest a reason why.
5. DNA does not directly assemble the amino acids into proteins. RNA is the linking chemical. How many different forms of RNA are there and what does each do?
6. How does RNA differ from DNA

Summary

1. Summarize the synthesis of proteins in a table similar to the one shown below.

Processes	**Description**	
Transcription (1)		
Translation	initiation (2)	
	elongation (3)	
	termination (4)	

2. Copy Figure 26.1 and use the numbers from the table above to indicate where the processes are occurring.

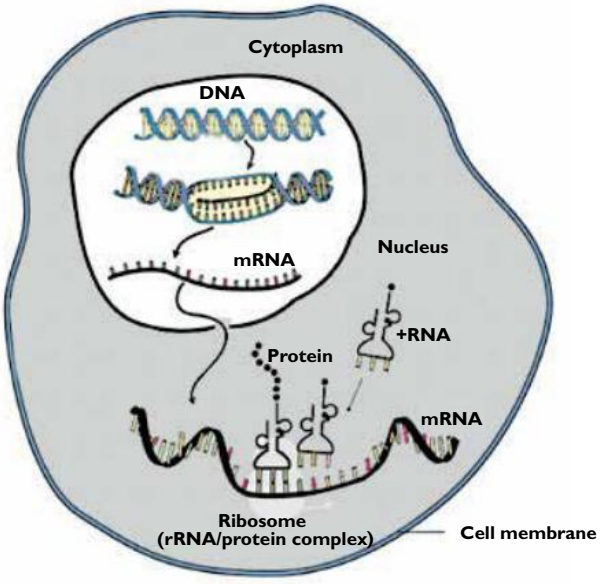


Figure 26.1: Protein production (Figure adapted from National Human Genome Research Institute)

3. The amino acid sequences produced at the ribosomes are not the final active form of the protein. Explain the roles of the endoplasmic reticulum and Golgi body in finalising protein structure.
4. In 1966, Marshall Nirenberg and Gobind Khorana made synthetic RNA of all uracil nucleotides. The protein produced using this RNA was made up of only the amino acid phenylalanine. The results of the Nirenberg & Khorana investigations are summarised in Table 26.1.

Protein synthesis

Codon	AA	Codon	AA	Codon	AA	Codon	AA
UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys
UUC		UCC		UAC		UGC	
UUA	Leu	UCA		UAA	STOP	UGA	STOP
UUG		UCG		UAG		UGG	Trp
CUU		CCU	Pro	CAU	His	CGU	Arg
CUC		CCC		CAC		CGC	
CUA		CCA		CAA	Gin	CGA	
CUG		CCG		CAG		CGG	
AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser
AUC		ACC		AAC		AGC	
AUA		ACA		AAA	Lys	AGA	Arg
AUG	Met	ACG		AAG		AGG	
GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly
GUC		GCC		GAC		GGC	
GUA		GCA		GAA	Glu	GGA	
GUG		GCG		GAG		GGG	

Table 26.1: Triplet codons in RNA and corresponding amino acids (AA).

Symbol	Name of Amino Acid	Symbol	Name of Amino Acid
Ala	alanine	Met	methionine
Asx	asparagine or aspartic acid	Asn	asparagine
Cys	cysteine	Pro	proline
Asp	aspartic acid	Gin	glutamine
Glu	glutamic acid	Arg	arginine
Phe	phenylalanine	Ser	serine
Gly	glycine	Thr	threonine
His	histidine	Val	valine
Ile	isoleucine	Trp	tryptophan
Lys	lysine	Tyr	tyrosine
Leu	leucine	Gix	glutamine or glutamic acid

Table 26.2: Abbreviated symbols for the amino acids.

a. How could this technique be used to link the genetic code to the amino acid sequence in proteins?

b. There are 22 abbreviations on the list in Table 26.2, yet there are only 20 amino acids. Explain the difference.

c. Amino acids are coded by different numbers of codons. Which is coded by the

   i. least number of codons?

   ii. the most number of codons?

d. What is the role of the STOP codons?

e. Write the amino acid sequence for the following RNA code.

   A U G C C U G G U C A U G U A C U A C A A C U U C A U U C U U U A A A G U C U U A A

f. What is the DNA code for this particular protein?

Activity 27

Epigenetics

Background information

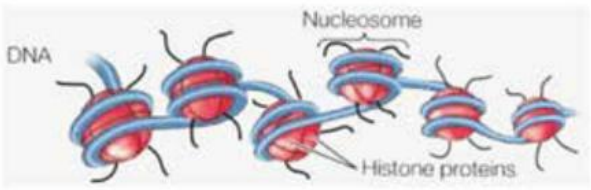


Figure 27.1: Part of a coiled chromosome

The human genome is carried in the nucleus of cells and is surrounded by a sea of proteins and other chemicals. When the cell divides, the DNA becomes tightly coiled, winds around histone proteins then coiled again into the visible chromosomes observed during mitosis and meiosis. The hereditary materials passed from generation to generation contain DNA, the histone and other chemicals. DNA is the genome but the histone and other chemicals are called the epigenome. There is currently much debate about how much epigenetic information is inherited across generations. In general, epigenetic markers are reprogrammed between generations in order that the cells of the pre-implantation embryo are totipotent (have the capacity to develop into all cell types). We do know that epigenetic information controls when genes can be accessed for transcription. Almost all cells in the body have the same genome, but some become blood cells and others become bone or muscle cells. This is associated with changes in the particular subset of genes that are transcriptionally active and is the result of epigenetic changes.

Epigenetics is defined as mitotically heritable changes in gene activity and expression that occur without the alteration of the genetic sequence (genome). Gene activity or expression can be altered by the chemical modification of DNA (methylation of cytosine residues) or the histone proteins. Together with the control of transcription, they modify the gene activity and expression during differentiation and development. The epigenome can also be affected by the environment. Epigenetics may explain the mysteries of why identical twins become more distinguishable with age and have different susceptibility to conditions such as diabetes and cancer.

Purposes

- to explore the concept of epigenetics to explain apparently inherited conditions
- to examine factors that affect gene expression
- to understand the influence of the environment on the gene expression

Part A: DNA methylation (gene silencing)

Background information

The best known epigenetic process is 'methylation' of DNA. This is the addition or removal of a methyl group (CH_3). Methyl attaches to the DNA between a cytosine and a guanine in locations known as CpG islands. These islands are not uniformly distributed throughout the genome. Methylation of the CpG islands is associated with transcriptional repression - gene silencing. Nutrients such as folate, choline and methionine play an important role in this process as they are major dietary sources of methyl groups. DNA methylation is a normal part of embryonic cell differentiation and its influence persists through the life of the cell and can be passed on during cell division

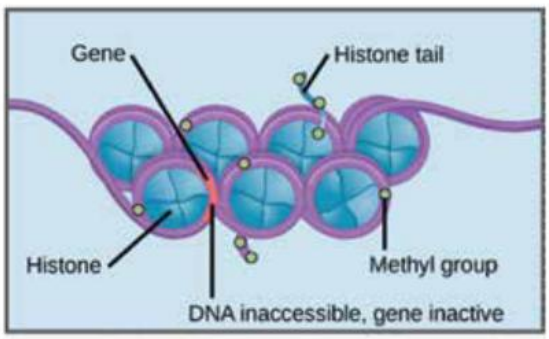


Figure 27.2: Methylation of DNA histones

Methylation of DNA and histones causes nucleosomes to pack tightly together. Transcription factors cannot bind the DNA, and genes are not expressed
(From: http://cnx.org/content/m49659/latest/)

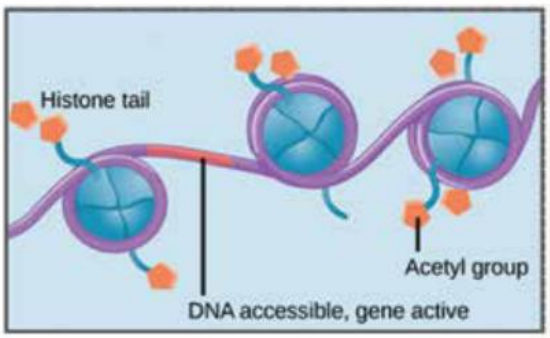


Figure 27.3: Packing of nucleosomes

Histone acetylation results in loose packing of nucleosomes.
Transcription factors can bind DNA and genes are expressed
(From: http://cnx.org/content/m49659/latest/)

Epigenetics

Materials

- 40 cm piece of string
- small sticky labels in different colours for the cell process below:
  - cell division control enzyme (Genes 4 & 7)
  - myosin proteins (Genes 3, 6 & 9)
  - melanin production (Genes 2, 8 & 10),
  - cell membrane repair enzyme (Genes 1 & 5)
- about 100 chads (circles of paper produced from a hole punch)

Procedure

1. The sticky labels represent genes. The gene numbers that control the cell processes being represented this activity can be found in the materials list. Number the sticky labels 1 – 10
2. Attach the labels along the length of the string - choose even or random spacing. Either fold a larger sticky label over the string or use two smaller labels, one on each side of the string as below as shown in Figure 27.4 and with more detail in Figure 27.5 on page 106.

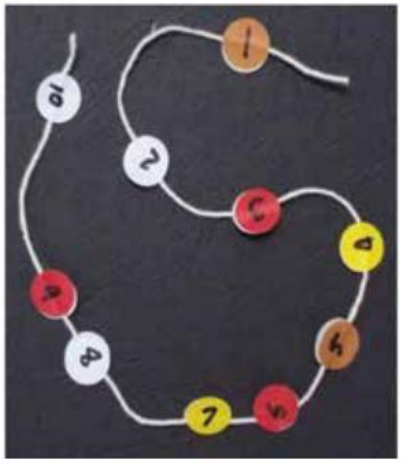


Figure 27.4: Model chromosome

3. To simulate to effect of methylation,
   a. arrange the string chromosome into any shape on a flat surface.
   b. drop the chads from about 30 cm above the string chromosome.
   c. the genes (labels) that are in contact with a chad are methylated.
   d. remove all chads not in contact with the labels.

   For this simulation, methylation means that the gene is deactivated or 'silenced'.

Discussion questions

1. Which genes were 'silenced' by the chads?

2. Use the information about the genes to describe the genetic problems that would arise from the methylation of the genes in contact with the chads.

3. How do the effects of acetylation compare with those of methylation?

4. Repeat the methylation process. (You may like to re-arrange the string chromosome and/or the height of the chad fall.) What genetic problems arise this time?

5. What genetic problems would you have if the methylation was cumulative over the two chad falls?

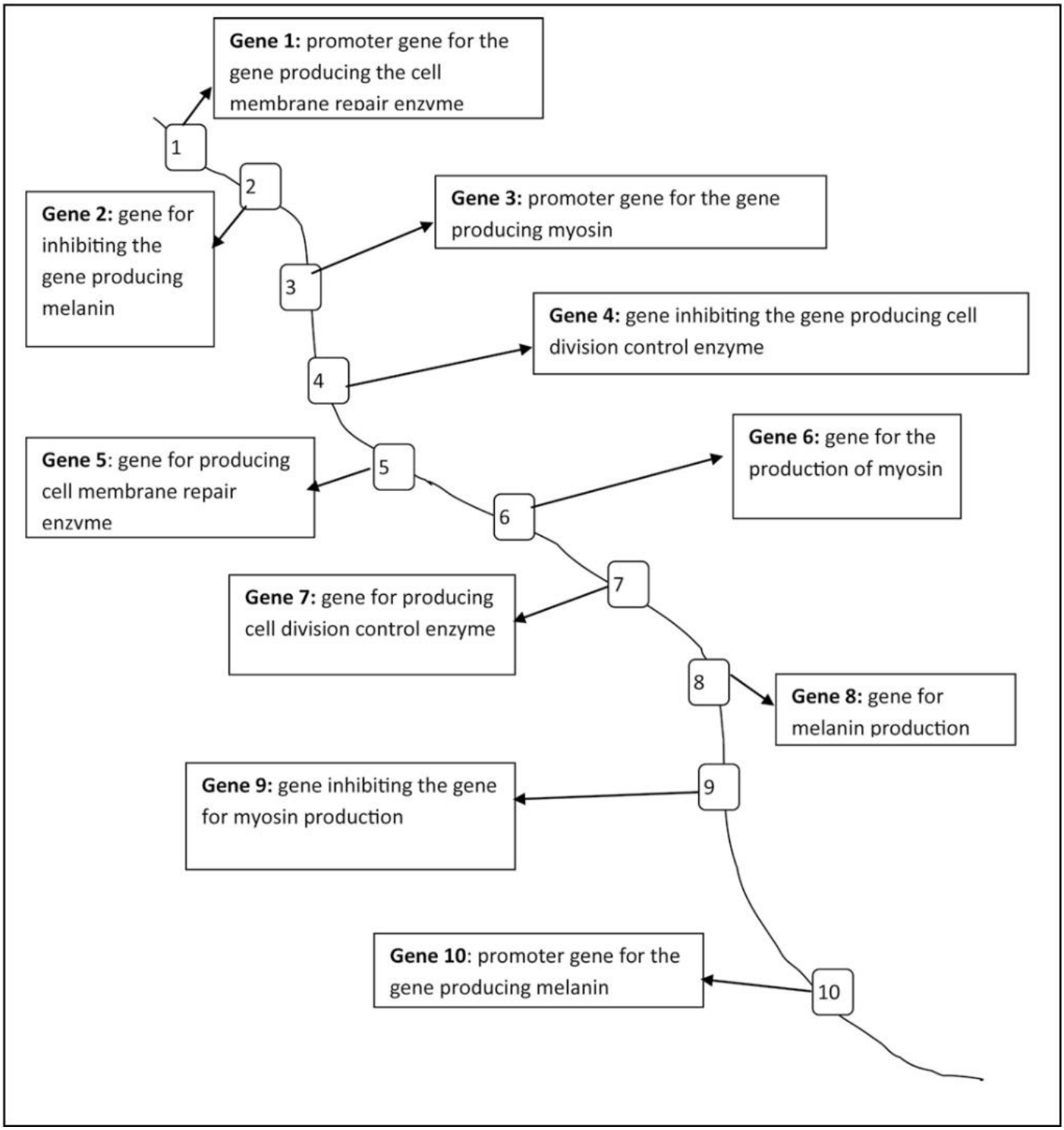


Figure 27.5: Genes located in model chromosome

Epigenetics

Part B: Histone modification

The histone proteins associated with DNA can also be changed by environmental factors. This causes the DNA to be more tightly or loosely bound to the histones, making them more or less available for transcription.

Materials

- string chromosome made in Part A
- a pen or pencil

Procedure

1. Arrange the string chromosome of a flat surface.
2. Drop the pen from about 20 cm onto the string chromosome.
3. Where the pen touches the string chromosome, loop the chromosome around the pen.
4. The genes that are touching the pen are not available for transcription.
5. Answer Questions 1-3.
6. Arrange the string chromosome into a tight flat coil.
7. Drop the pen onto the coil.
8. The genes labels touching the pen are now available for transcription.
9. Answer question 4.

Discussion questions

1. Which genes were 'silenced' in your first pen drop?

2. What observable symptoms would be shown by this 'person'?

3. Explain how the location of coiling could affect the phenotype.

4. How would these genes change the phenotype of the 'person'?

Summary

The changes produced by methylation and histone modification are localised to the particular cells in which it occurs. If, for example, Gene 8 - the melanin production gene, was silenced in a germ cell of the dermis of the skin, it would show as a white patch on the skin. If it occurred in the epidermal cell that is about to be removed by naturally sloughing of skin cells, then there would be no observable effect.

Methylation is affected by the following:

- diet
- stress
- heavy metals
- pesticides
- diesel exhaust
- tobacco smoke.

1. Use your understanding of epigenetics to explain the following situations:

   a. Identical twins have different rates of incidence of cancer.
   b. Some smokers develop lung cancer after smoking cigarettes for a very short time, while long-term smokers never develop lung cancer.
   c. More cancers occur in older people.
   d. Why women wanting to get pregnant or are in the early stages of pregnancy should be conscious of their diet and lifestyle.

Normal methylation patterns require a source of methyl groups from the diet. Folate (folic acid) is a major source. The WA government has recently legislated for folate to be added to all bread produced in WA. During the debate about the risks and benefits of the addition of folate to food materials, the following information was put forward:

- the number of neonates with spinal cord defects was reduced to almost zero in countries where folate had been added to food products.
- a small research project conducted in Europe reported a link between folate intake and an increase in the incidence of prostate cancer in men aged over 50 years.

2. Explain how each of the points could have influenced the debate and the final decision.

Identical Twins and Epigenetics:
Watch the video at the following website: Identical twins: pinpointing environmental impact on the epigenome
http://learn.genetics.utah.edu/content/epigenetics/twins/

3. What happens to the epigenetic markers at fertilization?

4. What environmental factors influenced the epigenome of the twins?

5. Why do identical twins become less identical as they grow older?

6. Why do twins who lived apart still look and act alike?

Activity 28

Modelling mitosis

Background information

Mitosis is a type of cell division. The cell divides to produce two daughter cells that have the same genetic content as the parent cell, but is smaller in size. Between cell divisions, the cell makes new parts and grows in size. It is very important that the genetic material is copied and distributed to the daughter cells in an organised manner. Mitosis is a part of a larger process called the cell cycle.

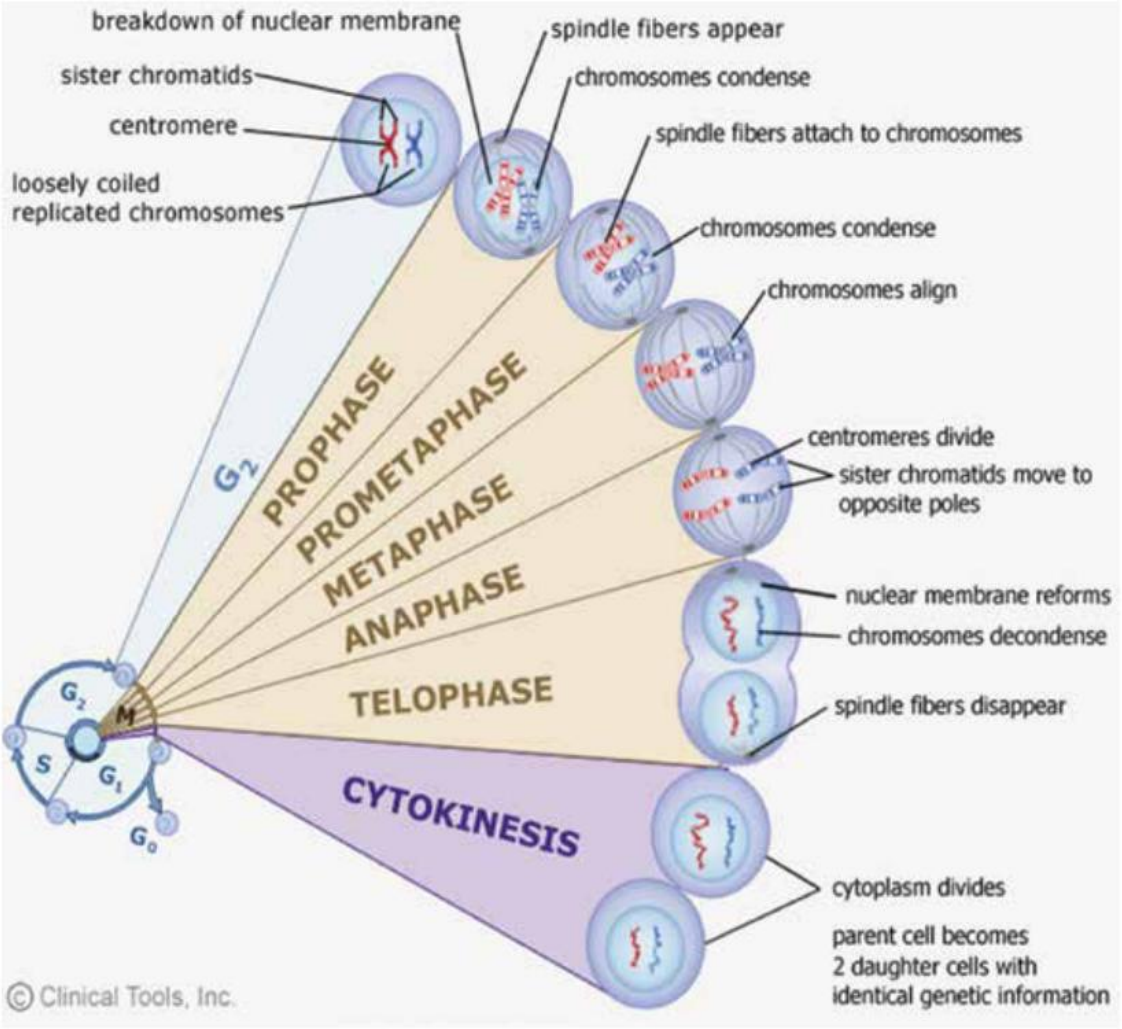


Figure 28.1: Mitosis' part in the cell cycle
This information was provided by Clinical Tools Inc. and is copyrighted by Clinical Tools Inc.
(http://www1.geneticsolutions.com/PageReq?id=3844:27768)

Purpose

- to model the process of mitosis to understand how the chromosome number is maintained

Materials

- pipe cleaners colour 1 cut into (cut into 2 × 4 cm and 2 × 3 cm pieces)
- pipe cleaners colour 2 cut into (cut into 2 × 4 cm and 2 × 3 cm pieces)
- 4 pieces of a drinking straw ~ 0.5 cm in length
- 2 different coloured pencils (preferably to match pipe cleaner colours)

Procedure

1. The pipe cleaners represent chromosomes. Chromosomes occur in homologous pairs so use the same length pipe cleaner for each homologous pair. You should have two sets of two lengths of pipe cleaners.
2. Assemble a diploid set of chromosomes as shown in Figure 28.1. A diploid set contains pairs of homologous chromosomes. Each chromosome is will only be a single strand.
   Note: You will have an extra set of each length of each colour left over.

Figure 28.2: A diploid set of chromosomes

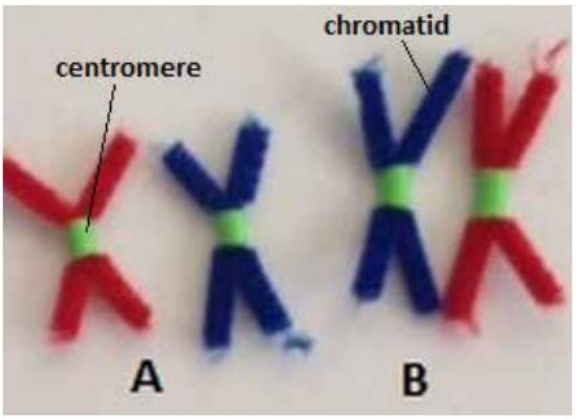


Figure 28.3: Doubling of chromosomes during cell division

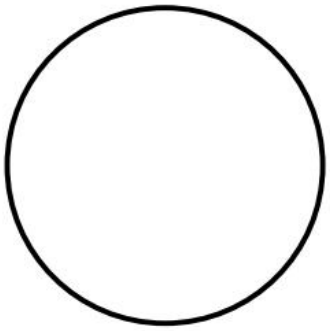
3. Your cell is currently in Interphase. Use your coloured pencils to draw the position of the chromosomes in the cell in Step 1: Interphase.
4. Your cell is getting ready to start dividing. The first thing that happens is the amount of DNA doubles. That means each chromosome replicates and is made up of two chromatids. Using the left over pipe cleaners join your chromosomes to their matching pipe cleaner with a piece of drinking straw as shown in Figure 28.2. You now have a set of four doubled chromosomes arranged in homologous pairs.
5. Your cell is now in Prophase. Use your coloured pencils to draw the position of the chromosomes in the cell in Step 2: Prophase.
6. Continue this activity by reading the description for each phase of mitosis in each step. Use your pipe cleaners to model each step. Then use the coloured pencils to draw the position of the chromosomes in the cell.

Results

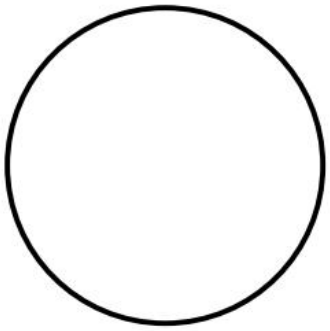
Copy and complete the diagrrams below.

General steps in mitosis

Step 1: Interphase:
The parent cell has 4 chromosomes each consisting of one chromatid.

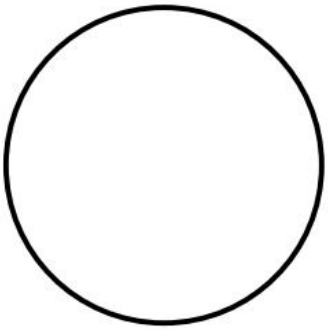


Step 2: Prophase
Before the cells starts to divide, the single chromosomes replicate to form chromosomes with two chromatids.

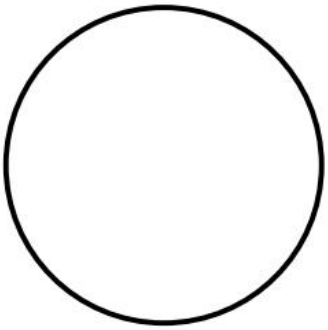


Modelling mitosis

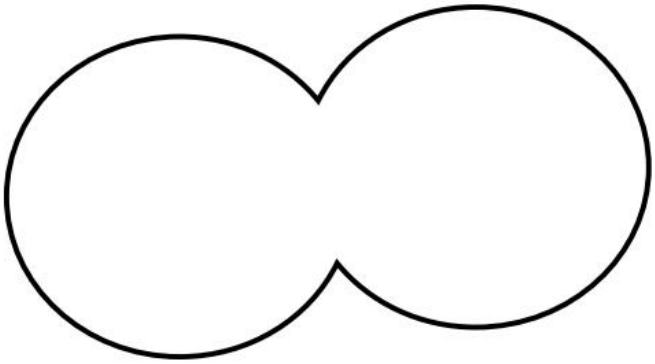
Step 3: Metaphase
The chromosome pairs in the parent cell line up along the centre of the cell



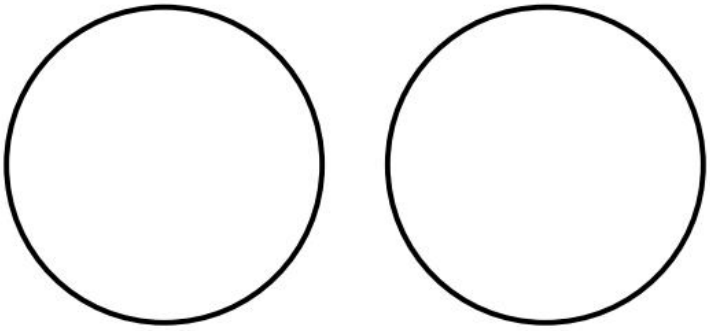
Step 4: Anaphase
The chromatids separate and move to different ends of the cell.



Step 5: Telophase
The chromatids arrive at opposite ends of the cell and the cell starts to divide.



Step 6: Cytokinesis
The cell divides.



Discussion questions

1. Why do cells undergo mitosis?
2. Where in the body does mitosis take place most often and least often?
3. How do you know that mitosis is happening in your body at this moment?
4. Why do the chromosomes have to make copies of themselves during mitosis?
5. How does the cell make sure each daughter cell gets a complete set of chromosomes?
6. Why is it important for each daughter cell to get a complete set of chromosomes?
7. The two daughter cells end up with an exact copy of the genetic material from the parent cell. How does your simulation support this statement?
8. Red blood cells are produced by mitosis from cells found in the bone marrow. They are destroyed in the spleen at a rate of about 90 million cells per minute. How many red blood cells have to be made per minute? How does this indicate the rate of mitosis in the bone marrow?
9. What would happen if the rate of red blood cell production didn't match the rate of destruction of red blood cells?

Activity 29

Meiosis - dividing to multiply

Background information

General steps in mitosis

Humans have 23 different chromosomes. In each body (somatic) cell there are two of each or 46 chromosomes. In the sex cells (gametes) there are 23 chromosomes - one of each.

Meiosis is the type of cell division that produces specialised cells for reproduction. During the process, the genetic material in the cell doubles, then divides twice in a very closely controlled series of steps. This is done to maintain the chromosome number from generation to generation.

To clearly understand the process of meiosis you will need to understand the following terms:

chromosome	sister chromatids	diploid
chromatid	homologous chromosomes	haploid

Purposes

- to identify and describe the steps in meiosis
- to describe the importance of the sequence of steps in meiosis
- explain how crossing over can result in different combinations of genetic material

Part A: Modelling meiosis

Materials

This activity uses the same materials as Activity 28.

- pipe cleaners colour 1 cut into (cut into 2 × 4 cm and 2 × 3 cm pieces)
- pipe cleaners colour 2 cut into (cut into 2 × 4 cm and 2 × 3 cm pieces)
- 4 pieces of a drinking straw ~ 0.5 cm in length
- 2 different coloured pencils (preferably to match pipe cleaner colours)

Procedure

1. The pipe cleaners represent chromosomes. Chromosomes occur in homologous pairs so use the same length pipe cleaner for each homologous pair. You should have two sets of two lengths of pipe cleaners.
2. Assemble a diploid set of chromosomes as shown in Figure 29.1. A diploid set contains pairs of homologous chromosomes. Each chromosome is will only be a single strand.
   Note: You will have an extra set of each length of each colour left over.

Figure 29.1: A diploid set of chromosomes

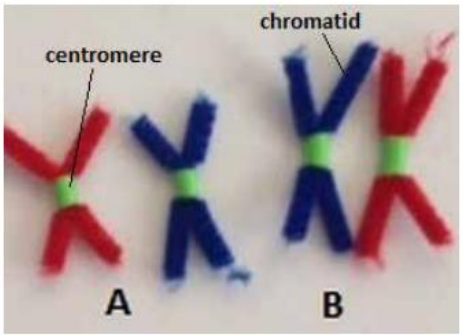


Figure 29.2: Doubling of chromosomes during cell division

3. Your cell is currently in interphase. Use your coloured pencils to draw the position of the chromosomes in the cell in Step 1: Interphase.
4. Your cell is getting ready to start dividing. The first thing that happens is the amount of DNA doubles. That means each chromosome replicates and is made up of two chromatids. Using the left over pipe cleaners join your chromosomes to their matching pipe cleaner with a piece of drinking straw as shown in Figure 29.2. You now have a set of four doubled chromosomes arranged in homologous pairs.

Meiosis - dividing to multiply

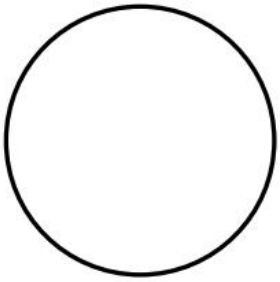
5. Your cell is now in Prophase I. Use your coloured pencils to draw the position of the chromosomes in the cell in Step 2.
6. Continue this activity by reading the description for each phase of meiosis in each step. Use your pipe cleaners to model each step. Then use the coloured pencils to draw the position of the chromosomes in the cell. Name the phase represented by each step.

Results

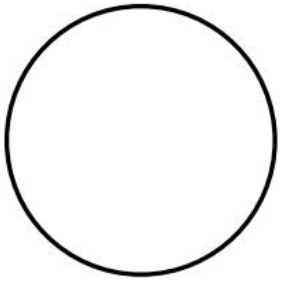
Copy and complete the diagrams below.

General steps in meiosis:

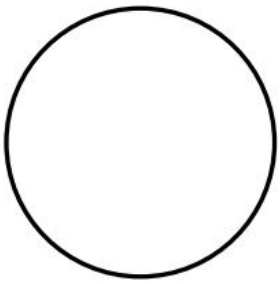
Step 1: Interphase
The parent cell has 4 chromosomes each consisting of one chromatid.



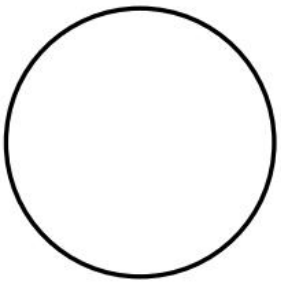
Step 2: Prophase 1
Before the cells starts to divide, the single chromosomes replicate to form chromosomes with two chromatids.



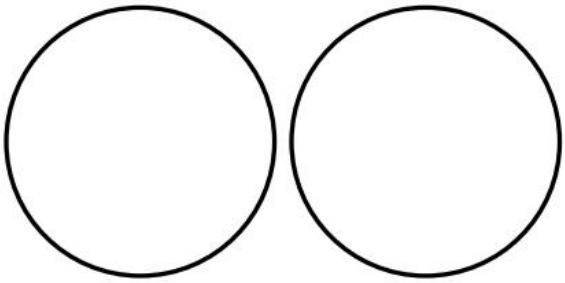
Step 3: Phase – _____
The chromosome pairs in the parent cell line up along the centre of the cell with their homologous partner.



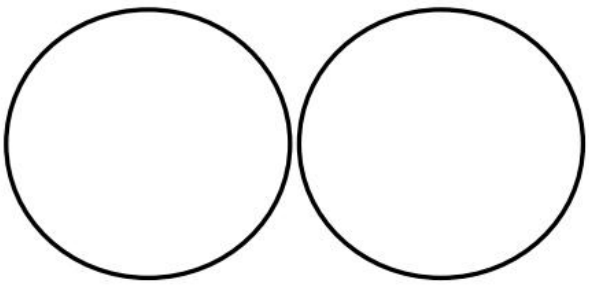
Step 4: Phase – _____
The homologous pair of chromosomes separate and move to different ends of the cell.



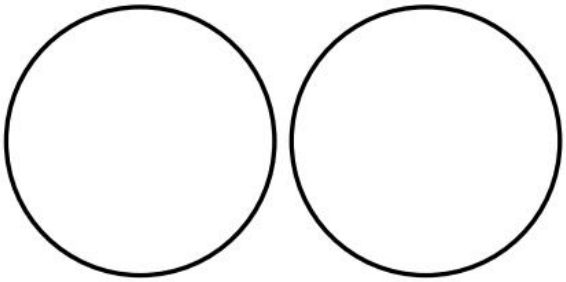
Step 5: Phase – _____
The cell divides.



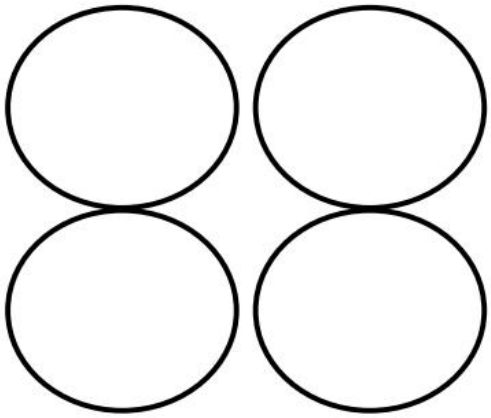
Step 6: Phase – _____
The chromosomes, consisting of 2 sister chromatids, line up along the centre of each cell again.



Step 7: Phase – _____
The sister chromatids now separate and move to opposite ends of each cell.



Step 8: Phase – _____
These cells now divide so that the four resulting cells contain a single chromatid chromosome from each of the pairs present in 7.



Discussion questions

1. When does the genetic material double?
2. Why does the genetic material need to double?
3. How many sister chromatids are present when the homologous chromosomes get together?
4. Why don't organisms have odd numbers of chromosomes? What happens if by some mutation, they do have an odd number of chromosomes?
5. Where does each of the sister chromatids in the homologous chromosomes end up?
6. Where does meiosis occur in humans?
7. In this activity with 4 chromosomes, how many different kinds of gametes are produced from meiosis?
8. What are the daughter cells of meiosis in males and females called?
9. How many of each type of gamete in males and females are produced from the meiosis of one parent cell?
10. Why is there a difference in the cytokinesis phases of meiosis in females?
11. Why do gametes require just one set of chromosomes?

Activity 30

Menstrual cycles

Background information

Every month a sexually mature female experiences a cycle in which an egg matures in the ovary and is released to journey down the fallopian tube. During this time the uterus undergoes changes preparing to support an embryo should the egg be fertilized. If the egg is fertilized, it may implant in the uterine wall, in which case a pregnancy is established and the menstrual cycle will stop for the duration of the pregnancy. If not, the lining prepared in the uterus to support the potential embryo breaks down, resulting in loss of blood, mucus and dead tissue producing the menstrual flow. The cycle then begins again. The whole process takes on average 28 days but may differ greatly among individuals.

The timing of ovulation can be determined by keeping a record of the basal body temperature. The woman records her temperature first thing in the morning for several months. The temperature is lower before ovulation, although the difference may be only a fraction of a degree. The change in the temperature occurs at the time of ovulation. After several months of accurate charting it is possible to pin point the date of ovulation and hence determine the most fertile period.

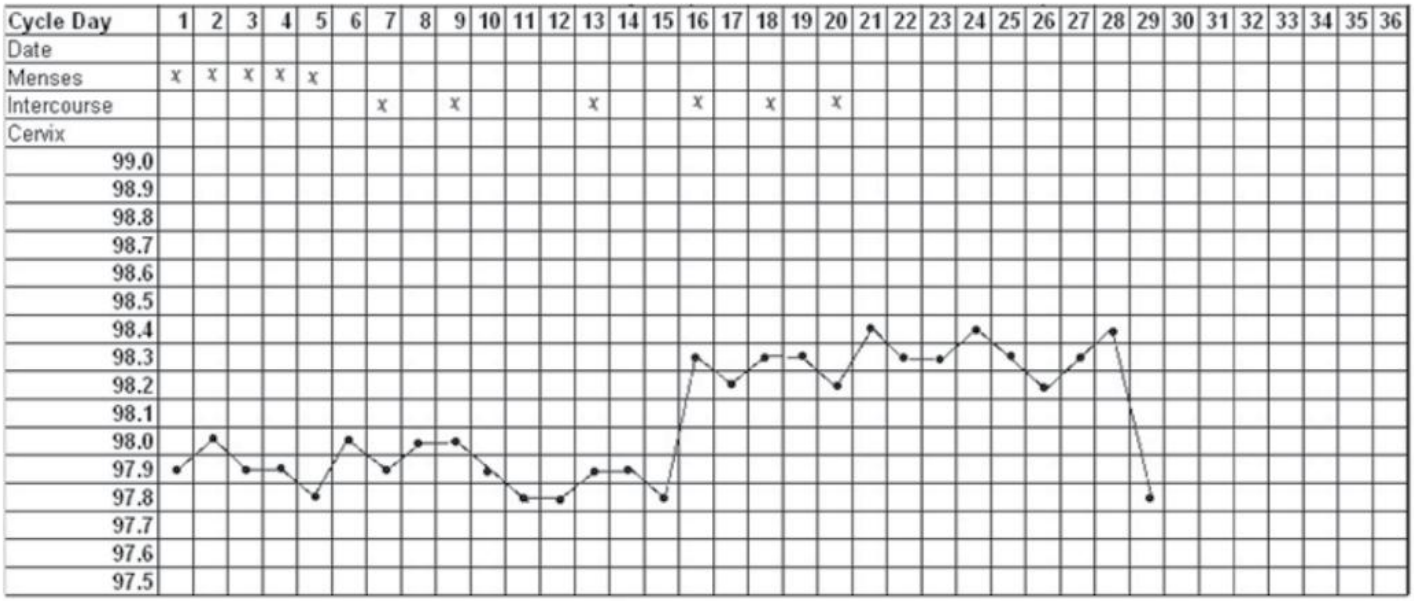


Figure 30.1: An example of temperature changes for a female during one menstrual cycle.
(From: http://pregnancy.allinfoabout.com/graphics/bbtsample.JPG)

Purposes

- to relate the stages of the menstrual cycle to natural methods of contraception and the treatment of infertility
- to determine the safe period or the most fertile period in the menstrual cycle
- to consider decisions related to the control of pregnancy and treatment of infertility

Materials

- graph paper

Discussion questions

1. Female X recorded her temperature during the months of July and August. Her temperatures are recorded in Table 30.1.

Table 30.1: Temperature changes for Female X during July and August.

Date	Basal Temp °C	Date	Basal Temp °C
7 July	36.4	21 July	36.7
8 July	36.3	22 July	36.9
9 July	36.3	23 July	37.0
10 July	36.2	24 July	36.9
11 July	36.3	25 July	36.9
12 July	36.3	26 July	37.1
13 July	36.4	27 July	36.9
14 July	36.2	28 July	37.0
15 July	36.3	29 July	36.9
16 July	36.4	30 July	36.7
17 July	36.3	31 July	36.5
18 July	36.4	1 August	36.5
19 July	36.4	2 August	36.4
20 July	36.0	3 August	36.4

a. Graph the data for Female X.

b. According to the chart on what date did Female X ovulate?

c. What day of the menstrual cycle was this?

d. What temperature difference did she record on this date?

e. What was the average temperature during the menstrual cycle during the first half and second half?

f. Why is it important to measure the temperature first thing in the morning before doing anything else?

g. If female X wanted to become pregnant, which dates should she have intercourse? Explain your answer.

h. Is fertilisation possible if intercourse occurs outside these dates? Explain why.

i. What are the advantages of using fertility charts as a means of contraception?

j. What are the disadvantages?

Menstrual cycles

2. Female Y recorded her temperature during one menstrual cycle. A graph of her temperatures is shown in Figure 30.2.

   a. What problems could Female Y have in determining the actual timing of ovulation using this chart?

   b. How could this affect her choices with respect to a planned pregnancy?

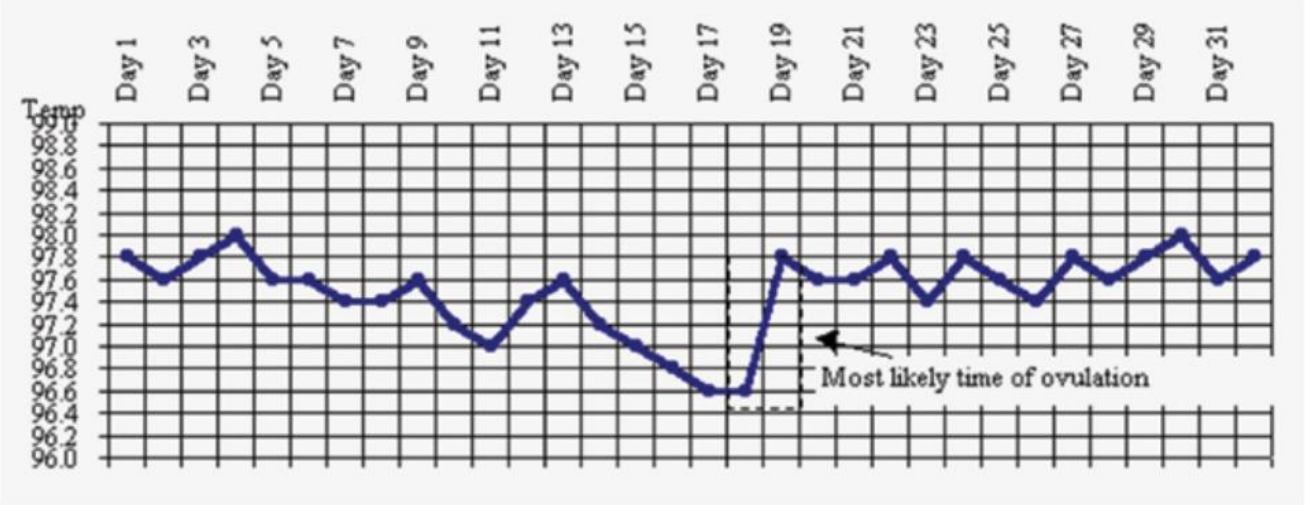


Figure 30.2: Temperature changes for Female Y during one menstrual cycle
(From: www.fwhc.org/ birth-control/fam.htm)

3. Copy and complete Table 30.3 by calculating the number of days since the last menses.

Table 30.3: Female Z's menstruation dates over 3 years - date of first menstrual flow

2018	Days since last menses	2019	Days since last menses	2020	Days since last menses
28 Jan		27 Jan		12 Jan	
23 Feb		20 Feb		25 Feb	
21 Mar		16 Mar		30 Mar	
16 Apr		20 Apr		23 Apr	
10 May		27 May		26 May	
3 June		2 July		25 June	
25 June		26 July		28 July	
18 July		16 Aug		22 Nov	
25 Aug		11 Sept		21 Dec	
22 Sept		1 Oct			
14 Oct		7 Nov			
1 Nov		2 Dec			
30 Nov					
25 Dec					

a. What is the average length of Female Z's menstrual cycles over 2018 and 2019?

b. What is the range of the duration of menstrual cycles?

c. Why are there more cycles in 2018 than in the other two years?

d. What could be some causes of the long break in menstruation in 2020?

e. When would you expect the next menses after 21 December 2020? Explain the level of confidence you have in your prediction.

f. Why is it useful to know when the next menses is due?

g. What could affect the timing of menstruation?

h. Why is the menstrual cycle taken from the first day of menstrual flow?

4. Copy and complete theTable 30.4 by calculating the number of days between the recorded dates.

Table 30.4: Female Z's menstruation dates over 2 years - date of first menstrual flow

2019	Days since last menses	2020	Days since last menses
10 Jan		14 Feb	
23 Feb		13 July	
28 Mar		27 Oct	
21 Apr			
24 May			
23 June			
26 July			
20 Nov			
19 Dec			

a. Suggest two reasons for the timing of menstruation in 2020 for Female Z.? What other evidence would be useful to support your answer?

Activity 31

Foetal growth and development

Background information

During gestation, the period between conception and birth, a foetus grows in size. This growth is accompanied by changes in form and function or development.

Purposes

- to describe the structural and physiological changes happening during embryonic and foetal development
- to name the techniques presently available for studying the foetus in utero

Materials

- graph paper

Discussion questions

1. Graph the data for embryo and foetal length and mass that appear in the table below. Indicate the trimesters on your graph.

Table 31.1: Timetable of embryo and foetal growth and development

Time (weeks)	Length (mm)	Mass (g)	Developmental Stages
0	0	0	Fertilisation.
1	0	0	Embryo reaches uterus. Implantation.
2	0		A flat, 2-layered disc i.e. only ectoderm and endoderm. Sac-like digestive tract with no mouth or anus. Umbilical cord forming.
3	2.5		3 layers present; ectoderm, mesoderm and endoderm. Beginnings of skeletal and nervous systems.
4	6		Simple 2-chambered heart, beating 60 beats/min. Tail, gill pouches, limb buds. Muscular system forming. Neural tube closing to form spinal cord and brain.
5	12		Mouth, eyes, webbed fingers and toes, lungs and regions of digestive canal form.
6	16	1	Cerebral hemispheres, face, ears form.
7	19	2	Eyes open. Tail disappears.
8	26		All major systems formed. Now called a foetus. Ossification (replacing cartilage by bone) begins. Makes small movements, but not yet felt by mother.
9	38		
12	90	30	External genital organs developed.
16	150	180	'Quickening' (movement) felt by mother. Heart can be heard.
21	300	450	Heart rate 140 beats/min. Head hair appears. Skin glands produce vernix caseosa a white creamy paste to protect delicate new skin. Sleeps and wakes.
25	350	875	Vigorous movements.
30	400	1425	Testes descend. Fat deposited. Fine hair (lanugo) covers head and body.
34	450	2375	Lanugo drops away. Takes up birth position, head down usually.
38	500	3250	Full term. Skin covered with cheese-like vernix caseosa. Foetus has moved down in pelvis. Foetus' pituitary signals for birth to begin.

Note: These data have been obtained by combining several sources. Figures are rounded for simplicity.

2. In which of the following intervals does the baby form the major body systems?months 0-3, months 4-6, months 7-9

3. a. During which of the following time intervals is increase in length most rapid?months 0-3, months 4-6, months 7-9

   b. How do you know this from the graph?

4. a. During which of the following intervals is increase in mass most rapid?months 0-3, months 4-6, months 7-9

   b. How do you know this from the graph?

   c. What developmental changes could cause this increase in mass?

   d. What process increases cell numbers as the baby grows?

5. a. The data supplied come from several sources, some pre-dating modern techniques for examining the foetus in utero. How do you think these older data were obtained?

   b. In the light of your answer do you think the older data are reliable for studying human foetal development? Explain.

Summary

1. What new techniques are available for studying the foetus *in utero*?

2. Are there any problems involved in combining data from several sources? Explain.

3. Babies born at 25 weeks have a very small chance of survival. State the main problems that affect the survival of very premature babies.

4. Use reference materials to find out the effects of the following drugs on embryonic and foetal development. Where possible explain how the drug acts.

   a. Alcohol

   b. Cigarette smoke, particularly nicotine and carbon monoxide.

   c. Heroin

   d. Select another drug of your own choice.

Activity 32

Birth control

Background information

Birth control is used to promote or prevent conception.

In early history, it was known that intercourse was required to establish a pregnancy, but not all intercourse resulted in a pregnancy. Reliable birth control could only occur when the reproductive processes were fully understood. It wasn't until the 1950's when the Pill was introduced that women had a reliable way of controlling their fertility.

Here are some of the major historicxal steps in understanding reproduction in humans:

Year	Event
1677	Leeuwenhoek reports the existence of sperm
1827	human eggs are seen for the first time
1920s	understanding meiosis and production of gametes is used to demonstrate fertilisation and sex determination
1950s	understanding of the role of hormones in reproductive cycles leads to the development of the 'Pill'
1978	first 'test tube' baby born
2000s	research into the male 'Pill'

Purposes

- to research various birth control / contraceptive methods
- to understand the risks, benefits and reliability of each method

Materials

- A3 paper
- access to the internet

Procedure

1. Draw up a table using the following headings: Method (and alternative names); description; risks (including side-effects); benefits (including reliability); costs; availability.
2. Find at least 8 methods of contraception to research and add to your table.

Discussion questions

1. Rank of methods of contraception that you researched in a table similar to the following.

	Ranking	
Methods of Contraception	**Effectiveness**	**Cost**

2. Compare the ranked lists with other members of your class.

   a. What factors influence the choice of contraception by young adults?

   b. What factors influence the use of contraception by young adults?

3. Which of the contraceptive methods helps control the spread of STI's?

4 A 19 year old single mother of three and pregnant with her fourth child was asked if she had thought of using contraceptives such as the Pill. Her response was: "I don't use the Pill because it makes you fat."
Is there any scientific basis to her claim? Explain.

5. How do the current contraceptive pills differ from the original ones available in the 1950's?

6. Which of the contraception methods in your list can help plan a pregnancy?

Activity 33

The ART of making babies

Background information

Reproductive technologies are procedures and treatments used to overcome the problems of infertility and assist couples conceive. These procedures and treatments are often referred to as assisted reproductive technologies or ART.

Infertility refers to the inability to conceive naturally after at least 12 months of regular, unprotected sexual intercourse. It affects approximately 15% of Australian couples of reproductive age. In one fifth of infertility cases the causes are unknown.

Before the advent of ART, infertile couples had a choice of remaining childless or adopting a baby. From the late 1970's, medical advances have given hope to many couples of having their own child.

Purposes

- to understand the cellular manipulation required in reproductive technologies
- to appreciate the range of technologies available to promote conception and maintain pregnancy
- to understand the limitations of assisted reproductive technologies
- to appreciate the range of causes of infertility

Part A: Micro-manipulation

Materials

- microscope
- 2 fine point probes or fine point toothpicks
- strand of hair
- pepper flakes (ground from a pepper mill)
- fine tube Paster pipette
- cavity slide
- water

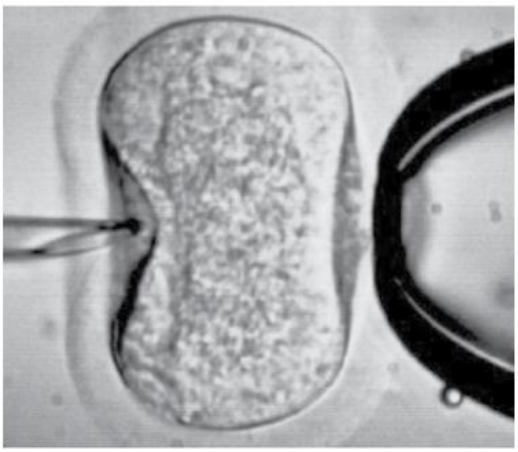


Figure 33.1: Artificially fertilising an ovum

Procedure

1. Place a drop of water in the cavity slide.
2. Gently sprinkle the pepper flakes in the water drop.
3. Place the slide on the microscope stage and focus on the pepper flakes.
4. While looking through the microscope, use the fine probes or toothpicks to separate individual pepper flakes into two groups according to their characteristics.
5. Carefully place the strand of hair between the two groups of pepper flakes on the slide.
6. Select a pepper flake from one group with the fine Pasteur pipette and place it on top of the strand of hair.
7. Select a pepper flake from the other group and place it next to the other flake on the strand of hair.

Discussion questions

1. A human hair has the average diameter of 100 µm. A human ovum is about 120 µm in diameter. How do the size of the pepper flakes compare with the size of the human ovum?
2. Was it easy to manipulate the pepper flakes? Explain.
3. Were some people better at manipulating the pepper flakes than others? Why?
4. What micro-manipulation is required in ART processes?
5. Use texts and other sources to explain the following acronyms:
   a. IVF
   b. GIFT
   c. ZIFT
   d. ICSI
   e Gestational carrier
   f. Donor
   g. Cryopreservation

The ART of making babies

Part B: Report on ART

ART CYCLE PROFILE								
Type of ART[a]					Patient Diagnosis			
IVF	>99%	Procedural Factors:			Tubal factor	11%	Other factor	8%
GIFT	<1%	With ICSI	58%		Ovulatory dysfunction	6%	Unknown factor	11%
ZIFT	<1%	Unstimulated	<1%		Diminished ovarian reserve	12%	*Multiple Factors:*	
Combination	<1%	Used gestational carrier	<1%		Endometriosis	6%	Female factors only	12%
					Uterine factor	1%	Female & male factors	18%
					Male factor	17%		

PREGNANCY SUCCESS RATES				
Type of Cycle	Age of Woman			
Fresh embryos from nondonor eggs	<35	35–37	38–40	41–42
Number of cycles	40,853	21,019	19,174	8,487
Percentage of cycles resulting in pregnancies	42.5	35.5	26.5	17.3
Percentage of cycles resulting in live births [b]	36.9	29.3	19.5	10.7
Percentage of retrievals resulting in live births [b]	40.2	33.3	23.2	13.3
Percentage of transfers resulting in live births [b]	42.7	35.5	25.3	14.8
Percentage of transfers resulting in singleton live births	27.3	24.3	19.0	12.3
Percentage of cancellations	8.4	12.0	15.8	19.5
Average number of embryos transferred	2.5	2.7	3.0	3.3
Percentage of pregnancies with twins	32.7	28.0	21.2	14.5
Percentage of pregnancies with triplets or more	5.1	5.6	4.4	2.5
Percentage of live births having multiple infants [b]	36.1	31.5	24.9	16.8
Frozen embryos from nondonor eggs				
Number of transfers	8,790	4,123	2,618	765
Percentage of transfers resulting in live births [b]	30.6	27.7	23.1	18.7
Average number of embryos transferred	2.5	2.6	2.7	2.9

	All Ages Combined [d]	
Donor eggs	Fresh Embryos	Frozen Embryos
Number of transfers	9,283	4,439
Percentage of transfers resulting in live births[b]	50.5	30.5
Average number of embryos transferred	2.4	2.7

[a] Reflects patient and treatment characteristics of ART cycles performed using fresh nondonor eggs or embryos.
[b] A multiple-infant birth is counted as one live birth.

Figure 33.2: ART cycle profile and pregnancy rates
(From: http://apps.nccd.cdc.gov/ART2004/nation04.asp)

Discussion questions

1. What is the relationship between the rate of success and age of the woman?

2. Compare the average number of embryos transferred across the age range of women. Suggest why there is a difference.

3. Even with a higher average number of embryos transferred in older women, the rate of multiple births is lower than the other age groups. Suggest a reason why.

4. Which is more successful: using fresh embryos from non-donor eggs or using frozen embryos from non-donor eggs? Why?

5. In Australia, the number of embryos transferred at one time is restricted to two. Suggest why this would produce a better rate of successful live births than larger numbers.

6. In 2006, the federal government was considering limiting Medicare financial support to six ART attempts. Suggest why this was chosen as the cut-off number.

Summary

1. For females, there are three general categories of infertility:
   1. ova are not produced
   2. embryo does not implant
   3. pregnancy is not maintained.

   Describe the variety of reasons why each occurs.

2. For males infertility categories are:
   1. low sperm production,
   2. sperm are not viable or
   3. sperm can't be delivered to the right place for fertilisation to occur.

   Describe the variety of reasons why each occurs.

3. Young cancer suffers are often given the opportunity to have eggs or sperm 'harvested' and stored before undergoing treatment. Explain how and why this is done.

Activity 34

Reproductive technology

Background information

In 1978, the first test-tube baby was born. Since then, over 10,000 babies have been born using the technique of 'in vitro fertilisation'. Some of the fertilised eggs (now called pre-embryos) are transferred to the woman's fallopian tubes for the trip to the uterus, where pregnancy will start if the fertilised egg successfully implants in the uterine wall. Usually four to eight eggs are harvested from the ovary. Only two to four eggs of the fertilised eggs are returned to the woman's body. The remaining embryos are frozen (quickly at -90°C) for future IVF procedures in case the first one doesn't result in a pregnancy. Pregnancy is established if the pre-embryo implants in the uterus and then begins the production of those hormones which will direct and support the development and sustenance of the embryo through the development of the placenta. Only when implantation and hormone production begins is the woman pregnant. It is the hormone human chorionic gonadotropin, which the new home pregnancy tests detect. Differentiation also begins on implantation and only then can one technically call the cell mass an embryo. Only about ¼ of the procedures result in a pregnancy which goes to a full term with the delivery of a healthy baby. Incidentally, scientific evidence indicates that in normal situations only ⅓ to ⅔ of all fertilised eggs ever succeed in implanting.

Purposes

- to appreciate and understand the ethical considerations and impacts of reproductive technologies procedures
- to make decisions and take appropriate actions based on scientific knowledge and evidence

Materials

For individuals or small groups:

- access to reference materials

For whole class:

- white board

Procedure

1. Each student will participate in the discussion of the following discussion questions in the capacity of a judge (among apanel of judges) who is called to settle a dispute.
2. All findings in the form of arguments and discussion points will be collated on the white board.
3. At the end, each student is to write a summary paragraph about the class' overall response to the case study.

Case Study: In Vitro Fertilisation

Maria and Dean Robertson were married in 1981. After trying for seven years to have a child, they decided to approach an infertility clinic for help. Previous damage to Maria's fallopian tube made her a candidate for zygote in vitro fertilisation transfer (ZIFT), a form of in vitro fertilisation where Dean's sperms were mixed with about 4 to 8 of Maria's eggs in a petri dish where some eggs were fertilised. Four of the zygotes were returned to Maria's lower fallopian tubes in the hope that the zygotes would implant in the uterus and establish a pregnancy. The remaining zygotes now called 'pre-embryos' are frozen at -90 degrees Celsius for future IVF procedures if needed.

No pregnancy resulted and subsequently the Robertsons decided to divorce. Maria requested the custody of the extra fertilised pre-embryos from the IVF treatment. Dean insisted that the infertility clinic not release the embryos, as he no longer wished to become a parent. Since no laws have been developed regarding the disposal and dispersal of pre-embryos in the event of divorce or death of genetic parent, the case went to the courts for settlement.

Discussion questions

1. As the judge in this case, what do you see as the ethical problems present here?
2. What facts are relevant to making your decision?
3. Who have stakes in the decision?
4. What values are involved in the decision?
5. What options are available to the judge?
6. What criteria should the judge consider in coming to a decision?
7. Between the members of the jury panel, did opinions differ? Suggest reasons why.
8. Write a summary paragraph about the class's overall response to the case study.

Activity 35

Human karyotypes

Background information

Humans have around 30,000 genes. Because all these genes have to fit into the small nucleus of each cell, they need to be tightly coiled into a package. This package is called a chromosome. Most human cells have 46 chromosomes in total, made up of 23 pairs. Twenty-three chromosomes come from your mother and 23 from your father.

An easy way to think about DNA, genes and chromosomes, is to compare them with a library. A library (human cell) contains books (chromosomes), these books contain many chapters (genes) and the chapters are composed of words (DNA). That is, human cells contain chromosomes, chromosomes contain many genes and genes are made of DNA.

Twenty-two of the chromosome pairs are similar between human males and females and these are called autosomes. The last pair is different between human males and females and these are the sex chromosomes, as they determine if you are male or female. A male will have an X and Y pair of sex chromosomes. A female will have two X chromosomes.

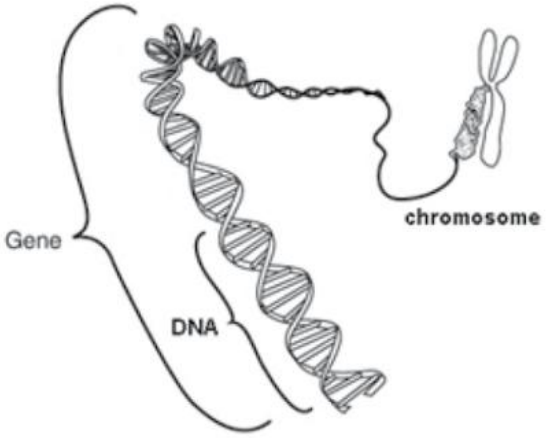


Figure 35.1: The relationship between DNA and chromosomes

Purposes

- use karyotypes to determine the sex of an individual
- identify and research syndromes that occur due to the incorrect number of sex chromosomes

Materials

Cut out Appendix 5 - a copy of Figure 35.3: Chromosomes from a human body cell, to comlete question 2

Procedure

The karyotype in Figure 35.2 shows the entire set of human chromosomes. The chromosome pairs are numbered in order of size – number 1 being the largest through to 22, which is the smallest. The sex chromosomes are labelled X or Y and are not numbered. To make a karyotype, scientists take a sample of cells from a person, stain them with dye so they can see them, separate the chromosomes from all the other stuff in the cell and take a picture. The chromosome pairs can then be matched up and placed in order by their size.

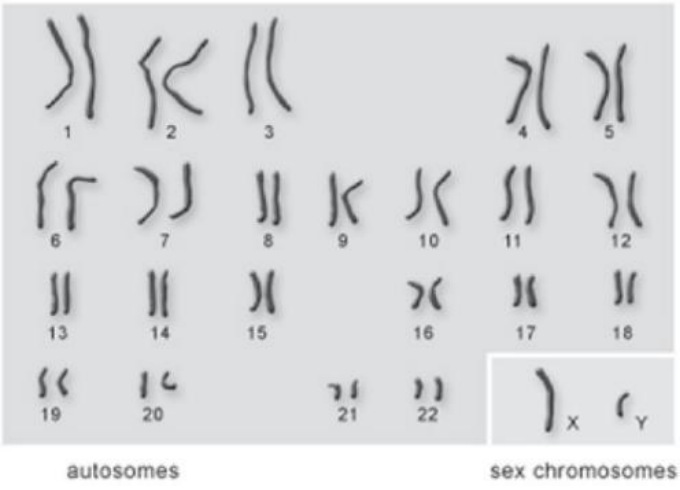


Figure 35.2: An example of a human karyotype

Q1. Are the chromosomes in Figure 35.2 from a male or a female? Explain your reasoning.

1. Log on to the following website to try an interactive karyotype activity: http://learn.genetics.utah.edu/content/basics/karyotype

2. Figure 35.3 shows a spread of chromosomes from a human body cell. To make your own karyotype, use the copy of Figure 35.3 in Appendix 5, cut out the chromosomes, match the pairs and arrange them in their correct order.

Figure 35.3: Chromosomes from a human body cell
(From: http://www.pathology.washington.edu/galleries/Cytogallery/main.php?file=human%20karyotypes)

Q2. Were the above chromosomes from a male or female?

Q3. Is the correct number of chromosomes present?

Human karyotypes

Discussion questions

1. What would be the benefit of being able to look at someone's chromosomes?

2. Figure 35.4 and 35.5 show the chromosomes found in different individuals. Are the karyotypes from a male or female? Explain your answer.

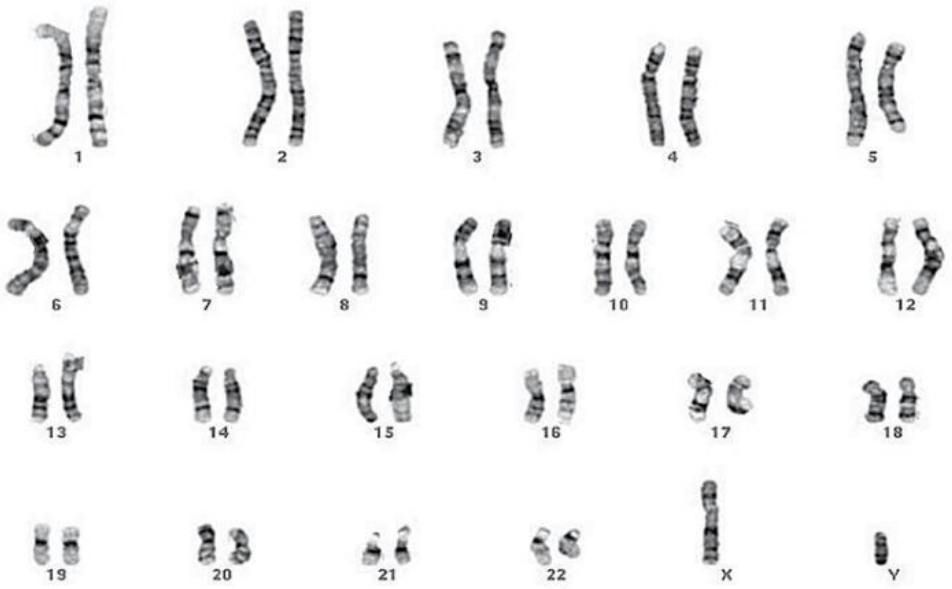


Figure 35.4: Karyotype A
(From: http://www.pathology.washington.edu/galleries/Cytogallery/main.php?file=human%20karyotypes)

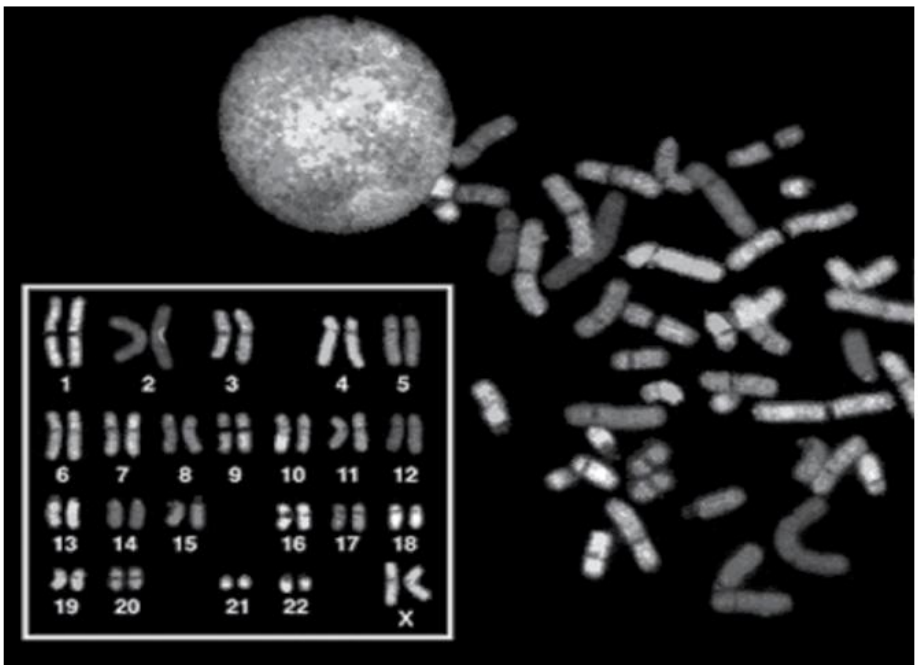


Figure 35.5: Karyotype B
(From: http://www.genome.gov/Pages/Hyperion/DIR/VIP/Glossary/Illustration/sky.cfm?key=spectral%20karyotype%20%28SKY%29)

3 Look carefully at the karyotypes of humans in Figures 35.6, 35.7 and 35.8.

i. **Figure 35.6:** How are these karyotypes the same as the normal human karyotype?

ii. **Figure 35.7:** How are these karyotypes different from the normal human

iii. **Figure 35.8:** Would these be males or females? Explain your answer.

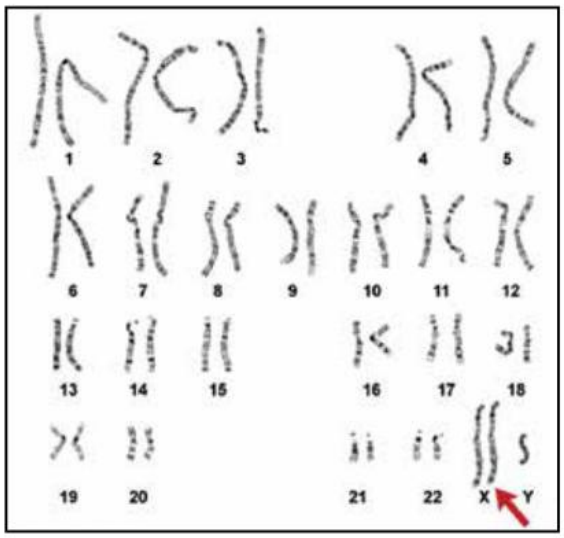


Figure 35.6

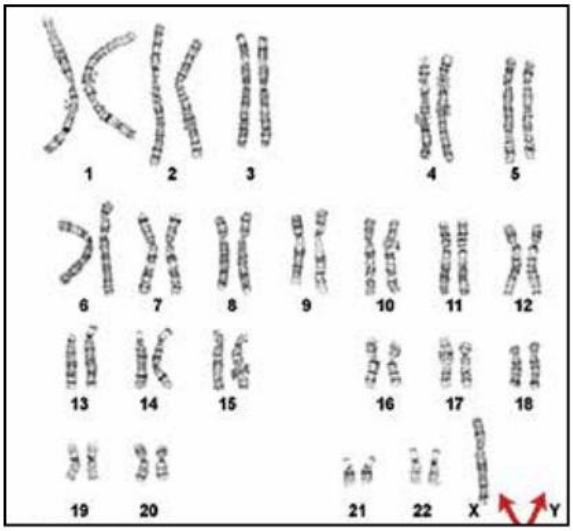


Figure 35.7

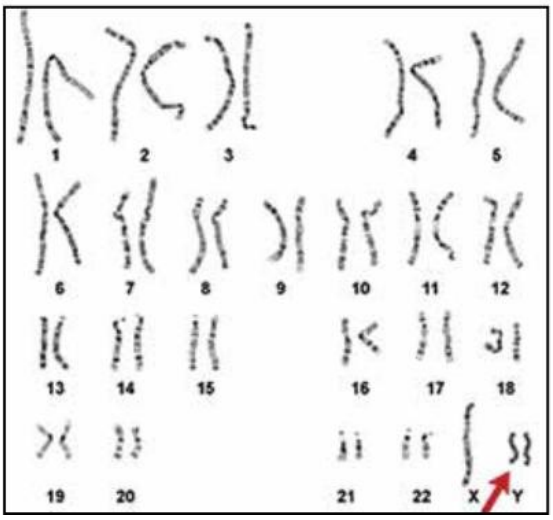


Figure 35.8

(Figures 35.6, 35.7 & 35.8: Provided by Clinical Tools, Inc., and copyrighted by Clinical Tools, Inc. http://www1.geneticsolutions.com/PageReq?id=1:27768)

Human karyotypes

Summary

1. Copy and complete the table below.

Syndrome	Gender	Chromosome Number	Characteristics
Klinefelter's			
Turner's			
Down's			
Edward's			
Patau's			
XXX			
Cri Du Chat			

2. What is the difference between Cri Du Chat Syndrome and the other syndromes you researched?

Activity 36

Prenatal testing

Background information

Prenatal testing involves the testing of the foetus before birth to determine whether it has a particular hereditary characteristic or somatic abnormality. Most of the tests are offered primarily to couples with an increased risk of having a baby with a genetic abnormality. Some tests, such as ultrasound imaging is offered to all pregnant women to monitor the progress of foetal development. There is also a range of tests that can be conducted on the embryo prior to implantation when couples are undergoing fertility treatment involving ART procedures.

Purposes

- to understand the reasons for prenatal testing
- to appreciate the range of prenatal tests
- to understand the risks and benefits of prenatal testing

Discussion questions

A family's choice

> **'Designer' baby gets OK**
> **Ill child's only chance is umbilical cord blood from matched sibling**
> A couple has been given approval to use IVF to conceive a genetically screened "designer" baby in a desperate bid to cure their terminally ill child.
> It is thought to be the first time in Australia that approval has been granted to use IVF in combination with genetic screening and tissue matching to create a 'donor' child for a sick sibling.
> The sick child is believed to have a terminal illness and the only chance of survival rests in getting a transfusion of umbilical cord blood from a perfectly matched brother or sister.
> The technique involves screening embryos created using IVF to ensure they are free of disease, then further testing to guarantee the embryo and the child's tissue are compatible. It is called pre-implantation genetic diagnosis (PGD).

Figure 36.1: Newspaper Article: 'Designer' baby gets OK (West Australian 12 March 2003)

Later news reports indicated that the implantation of matched embryos did not result in a pregnancy.

1. What tests were carried out on the embryo prior to implantation?
2. Explain the genetic chances behind the production of a matching embryo.
3. Draw a flow chart of the procedures involved in the production of embryos using IVF techniques.
4. At what stage in the chart are the embryos tested using PGD?
5. What could have caused the failure of the embryo to implant?

Prenatal testing

Summary

1. If your child had a rare genetic disorder, would you go through the process to have a tissue matching baby? Explain your reasons.

2. If you knew you were a carrier of a rare genetic disorder, would you use PGD? Explain your reasons.

3. What are the choices available to couples who have a prenatal test result indicating the presence of a genetic disorder in the offspring?

4. Historically, the biggest unknown at childbirth was the sex of the child. Today, many couples know the sex of the foetus, but many couples also don't want to know. Explain why couples would like to know the sex of the child before it is born.

5. Explain a situation when knowing the sex of the foetus could be detrimental.

6. Copy Table 36.1 then research the variety of tests available to parents to monitor the genotype, health and development of their offspring during the embryonic and foetal periods.

Table: 36.1: Prenatal testing

Test	When is tested carried out?	What condition(s) are diagnosed by this test?	When would this test be offered to pregnant women?	What are the risks?	What are the benefits?

Activity 37

Why have I got red hair and freckles?

Background information

Humans have thousands of genes but have only 46 chromosomes. Some features appear to be inherited together, eg. red hair and freckles.

During meiosis, chromosomes randomly separate into the gametes. If two genes occur on the same chromosome they have a high probability of being inherited together.

Purposes

- to consider the inheritance of linked genes
- to observe the effect of crossing over during meiosis
- to understand the use of chromosome maps

Materials

- 50 poppit beads of colour 1 (eg. red)
- 50 poppit beads of colour 2 (eg. blue)
- 6 garden ties
- 16 small sticky dots
- coin
- dice
- digital camera (optional)

Part A: Crossing over

Procedure

You will be modelling the process of meiosis using strings of poppit beads. The imaginary cell has a diploid number of 4, ie a pair of Chromosome 1 and a pair of Chromosome 2.

1. Make a pair of Chromosome 1: 10 beads long; one strand of each colour.
2. Make a pair of Chromosome 2: 15 beads long; one strand of each colour.

During the first steps of meiosis, the DNA replicates, forming a second strand of each chromosome present.

3. Make duplicates for each of your four chromosomes - matching the length and colour.
4. Join the identical strands together using garden ties.

You should now have 4 chromosomes each consisting of two strands or chromatids. The garden tie represents the centromere.

5. Count three beads from one end of a chromatid of the red Chromosome 1 and label it with a sticky dot with the letter A.
6. Count two beads from the other end of the same chromatid and use a sticky dot to label it b.
7. Do the same on the replicate chromatid. See Figure 37.1.

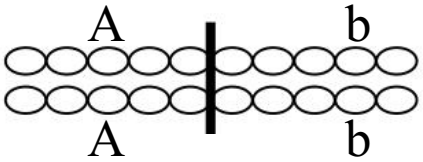


Figure 37.1: Location of sticky dots on Chromosome 1, colour 1

8. For the other colour Chromosome 1, add the sticky labels as shown in Figure 37.2.

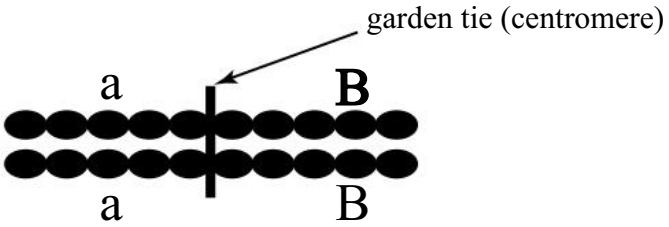


Figure 37.2: Location of sticky dots on white Chromosome 1, colour 2

9. Pair up the Chromosome 1s to form a homologous pair. One of each of these will move to each end of the cell.
10. Pair up the Chromosome 2s to form another homologous pair. Place sticky dot C two beads from one end of one chromatid and sticky dot D three beads from the other end. Copy this to the other chromatid of the same colour as shown in figure 37.3.
11. On the other colour Chromosome 2, place sticky dots c and d in similar locations as on the other chromatids as shown in figure 37.3.

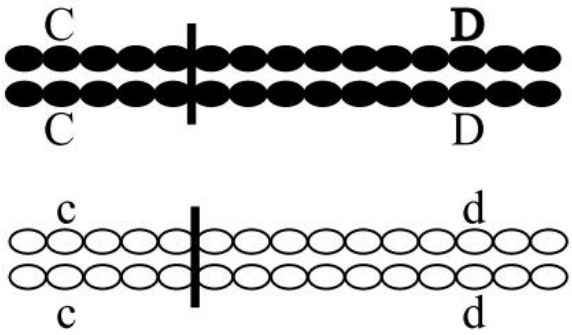


Figure 37.3: Location of sticky dots on Chromosome 2

During meiosis when the chromosomes form homologous pairs, the chromatids wave around like ribbons in a breeze. Sometimes they get tangled. If the chromatids cross over at the same points, then they can swap sections.

12. Swap the portions of Chromosome 1 as shown in Figure 37.4 below.

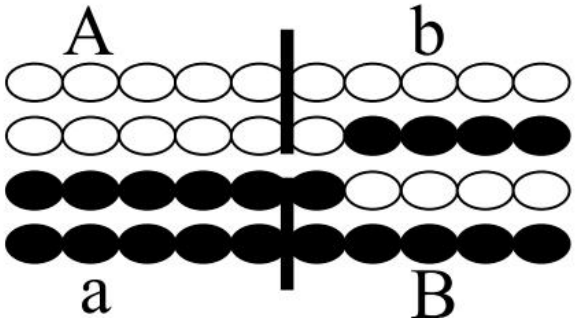


Figure 37.4: Crossing over in Chromosome 1

13. Leave Chromosome 2 with no crossing over.
14. Separate the homologous chromosome as they would in the first division of meiosis.
15. Undo the garden ties and separate each chromatid to the ‘gamete’. Each gamete should have one Chromosome 1 and one Chromosome 2.

Discussion questions

1. How many beads in total were in the original strands?

2. How many beads are there in the chromosomes after replication?

3. What does this indicate about the amount of DNA in the cell?

4. What allele combinations are in each of the 'gametes'?

5. Use the following information to answer the questions below.

A - brown hair	C - cheek dimples
a - red hair	c - no cheek dimples
B - freckles	D - mid-digital hair
b - no freckles	d - no mid-digital hair

   a. How many gametes have both red hair and freckles alleles?

   b. How many gametes have no cheek dimples and mid-digital hair?

Part B: Will the child have red hair AND freckles?

Procedure

Use your gametesfrom Part A to complete Part B.

1. Label the four 'gametes' 1, 2, 3 and 4.
2. Throw the dice. Whichever number appears will become the sperm (if 5 or 6 show, throw again).
3. Throw the dice again. What ever number shows will be the ovum. (If 5 or 6 shows, throw again.)
4. Place these two sets of chromosomes together to form the genotype of the offspring.
5. Repeat step d again with the two remaining gametes.

Discussion questions

1. Will all the offspring have dimples? Explain your answer.

2. Will all the offspring have red hair and freckles? Explain your answer.

Summary

Chromosome Maps

The location of different genes can be indicated by the probability of crossing over. If crossing over occurs relatively frequently, the distance between the two genes on the chromatid is large. And conversely, if crossing over is rare, then this distance between the genes is small.

This was the main way of finding the location of specific genes within the genome. Today, with the use of biotechnology, the location of genes can be found using probes.

Why is it important to know where a specific gene is located?

Activity 38

Monohybrid crosses

Background information

The inheritance of particular characteristics was known in ancient times, but it was only when Gregor Mendel did his experiments with pea plants in the 1860s did anyone have any hypothesis of how this happened. Mendel suggested that each parent had 'factors' that were contributed to the offspring and that inheritance followed a basic set of 'laws'. This was far-reaching thinking for someone who did not have any knowledge of meiosis, chromosomes or genes. He demonstrated that some 'factors' - what we now call alleles, were dominant and others were recessive.

But not all inheritance patterns of characteristics could be explained in this way. In 1905, the behaviour of the sex chromosomes was described by Nettie Stevens and Edmund Wilson. In 1910, Thomas Hunt Morgan demonstrated that some characteristics were sex-linked. At this time Reginald Punnet popularised a shorthand method to follow traits through experimental crosses. It was not until 1931 that Barbara McClintock and Harriet Creighton obtained cytological proof that crossing over occurs during meiosis to form new combinations of characteristics. In the late 1950's geneticists established a direct relationship between human genetic disorders and abnormal chromosome numbers in cells. All of this information can now be used to understand and predict genetic disorders in families.

Purposes

- use the Principles of Mendelian genetics to predict variations in offspring
- understand inheritance patterns to distinguish:
  - dominant,
  - recessive,
  - co-dominant,
  - autosomal and
  - sex linked inheritance.
- understand sex determination
- use punnet squares in the predictions for monohybrid crosses
- calculate simple probabilities for offspring from monohybrid crosses

Part A: Monogenic inheritance - Punnet squares

Background information

Scientific convention for representing alleles is:

- the dominant allele is written as a capital letter , and
- the recessive allele is written as a lower case letter (not a small capital letter).

The letters chosen should have different forms for the capital and lower case letters to make identification easier.

For example: Ee, Ff, Gg, Hh, Dd.

Ss, Cc, Pp, Ww are more difficult to differentiate, especially using hand written letters.

Materials

- 10 poppit beads of 2 different colours (eg. red and white)
- 1 opaque bag

Procedure

1. Place the 20 poppit beads in the bag.
   Q1. Write down the colours that represent the dominant and recessive alleles.
2. Without looking, select 2 beads and place under the heading Mother's genotype in Figure 38.1.
3. Select two more beads and place under the heading Father's genotype in Figure 38.1.
4. Record the bead colours for each parent Figure 38.1.
5. Separate the beads for each parent and place them in the gametes line in Figure 38.1.
6. Record the gametes each parent produces Figure 38.1.
7. Move the beads (gametes) to the Punnett square in figure 38.1.
8. Record the colour of the beads at each location Figure 38.1.
9. Now produce offspring by combining the gamete from the column and row for each square. Record the colour combinations produced in Figure 38.1. These are the genotypes of the offspring possible from these parents.
10. Repeat the procedure using parents of different genotypes and record combinations in Figure 38.2.

What will the offspring actually look like? If the genotype contains one of each colour then the dominant colour will be expressed in the phenotype.

11. Record the colour of each of the four possible offspring under the heading Phenotype of offspring in Figure 38.1 and 38.2.

Results

Copy and complete Figures 38.1 and 38.2

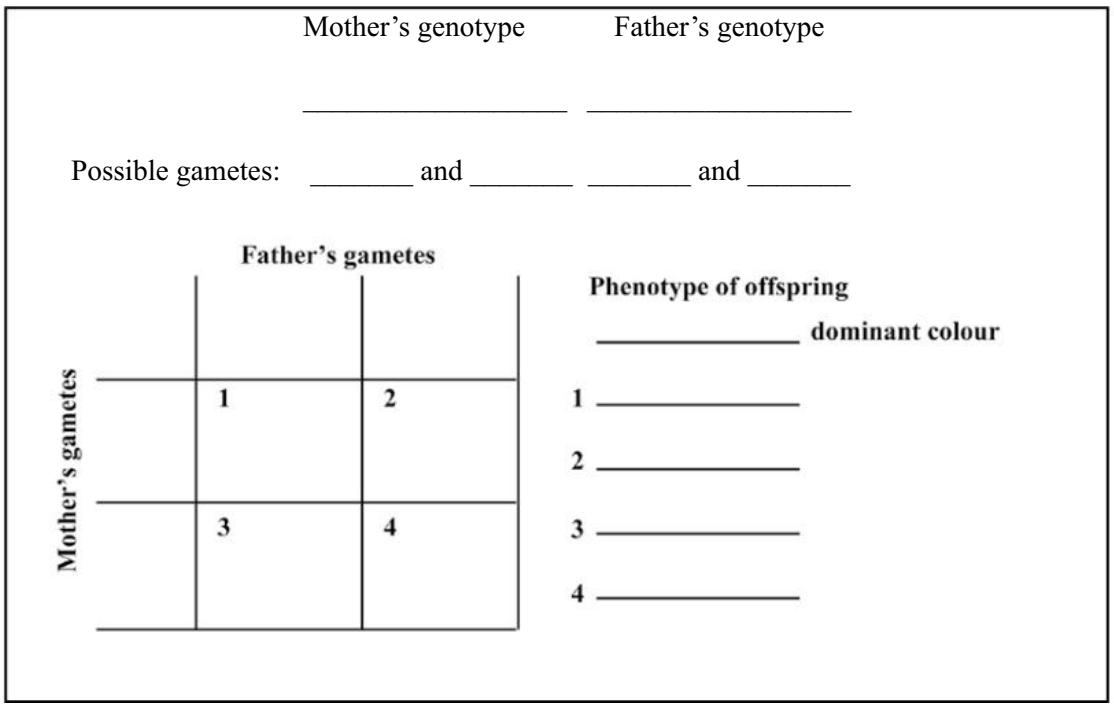


Figure 38.1: Possible offspring genotypes and phenotypes of first cross

Monohybrid crosses

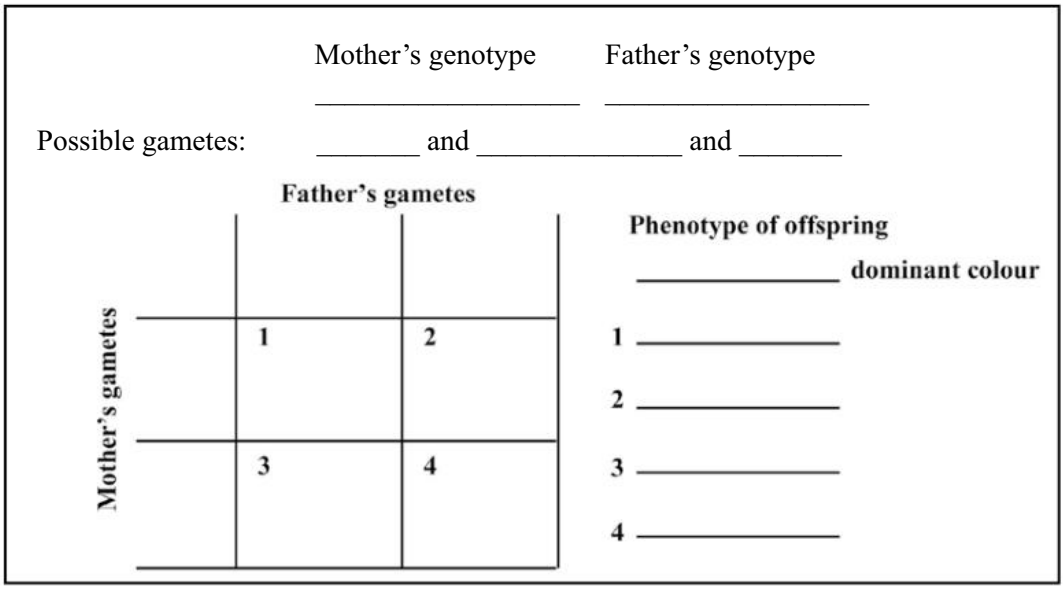


Figure 38.2: Possible offspring genotypes and phenotypes of second cross

Discussion questions

1. How many characteristics are determined by each gene?
2. How many alleles does one person have for each gene? Explain your answer.
3. If a characteristic has a dominant and a recessive allele, how many different genotypes are possible?
4. If the gene has a dominant and a recessive allele, how many different phenotypes are possible?
5. How can you determine if one allele is dominant over another?
6. How can the parental genotypes be determined from the offspring produced?
7. Human hair form (curly or straight) is incompletely dominant. How does this differ from co-dominance?

Part B: Prediction calculations

Can you predict what your children will look like? Many people would like to know but chance still plays a large part in the combination of characteristics produced in any particular offspring.

Materials

- 10 poppit beads of 2 different colours (eg. red and white)
- opaque bag

Procedure

1. Place the 20 poppit beads in the bag.
2. Select one bead from the bag.

   Q1. What is the probability of selecting that colour bead from the bag? Why?
3. Select another bead from the bag.

   Q2. What is the probability of selecting that colour bead from the bag? Why?
4. The probability of two separate events (selecting the two beads) happening is a product of the individual events (multiply the probabilities of each event together).

   Q3. What was the probability of getting the two beads you selected from the bag?

Discussion questions

When determining the probability of each phenotype in the possible offspring, add up all the probabilities for the same genotype in the punnet square.

For example:

	B	b
B	**BB**	**Bb**
b	**Bb**	**bb**

If there are two Bb genotype offspring.
Both have a probability of 0.25.
Therefore, 0.25 + 0.25 = 0.50.
The probability of getting a Bb from that cross is 0.50 or 50%.

Use Punnett squares to determine the possible offspring genotypes and phenotypes for the followingcrosses in Question 1and determine the probability of the offspring phenotypes.

i. Male: Bb crossed with Female bb
ii. Male: BB crossed with Female Bb
iii. Male: bb crossed with Female BB

2. Is there any combination of parental genotypes that will give a 100% probability for the offspring phenotypes? Explain why.

3. Is there any combination of parental genotypes that will give a 0% probability for the offspring phenotypes? Explain why.

Part C: Sex-linked inheritance

Background information

Sex-linkage is caused by genes being carried on the sex chromosomes. Males and females have different sex chromosomes. Females have XX and males have XY. When solving any problems showing sex-linkage, the X and Y chromosomes need to be shown. But so does the allele carried on the X chromosome. Therefore the X will always be accompanied by a small superscript letter - lower case for recessive and capital letter for dominant: No letter is attached to the Y as the chromosome does carry that gene. It is physically not there.

For example: X^B and X^b

There is a size difference between the X and Y chromosomes indicating that the X chromosome carries more DNA and therefore more genetic information than the Y chromosome.

Discussion questions

1. Record the possible genotype combinations for males and females carrying the sex-linked B and b alleles.

2. Determine the possible phenotype combinations for males and females carrying the sex-linked B and b alleles. Colour blindness is a sex-linked condition in humans. It occurs in about 20% of males and about 1% of females. The normal vision allele is dominant over the colour blind allele.

3. What offspring will be produced from a colour blind father and a normal mother? Use the Punnett square method to show your working.

4. What offspring will be produced from a normal father and a colour blind mother? Use the Punnett square method to show your working.

5. Why are there fewer colour blind females when compared with the male population?

Activity 39

What will my children look like?

Background information

You have your mum's eyes, your dad's hair, your grandfather's ears and your aunt's nose. What a mixture! If you have features similar to different members of your family, what are your children going to look like?

This will depend very much on the partner you choose to genetically contribute to the zygote that will grow into your future child. But even then, there could be problems. When someone said to Albert Einstein that he should have children with Marilyn Monroe to produce beautiful geniuses, he replied, "but what if they have her brains and my looks?"

It is difficult to make predictions on the features of your offspring for three reasons:

1. the chance of a particular allele being in the gamete involved in fertilisation.
2. many human characteristics are controlled by more than one gene (polygenic).
3. many features are affected by the environment.

But some characteristics are controlled by a single gene (monogenic) and you can have some fun trying to predict your child's features, depending on the chosen reproductive partner.

Table 39.1: Some examples of human features controlled by a single gene

Features	Dominance/ recessiveness
Attached ear lobes - ears have no free section below the point of attachment to the head	recessive
Widow's peak - the hairline forms a distinct point in the centre of the forehead	dominant
Tongue rolling - ability to roll the tongue into a u-shape tube from front to back	dominant
Bent little finger - the last joint of the little finger distinctly bends inwards towards the fourth finger when the hands are flat on the table	dominant
Hitchhiker's thumb - can bend the distal joint of the thumb back to about a 90 degree angle without pressure. It may only be in one thumb.	recessive
Pigmented iris of eyes - lack of pigment in the front layer of the iris allows the blue layer at the back to show through, ie. look for blue eyes or other coloured eyes.	recessive
Curly hair - wavy hair - straight hair - determined by cross-sectional shape of hair. Flat hair - curly, round hair - straight	incompletely dominant
Mid-digital hair - complete absence of hair from the middle phalange of all fingers	recessive
Blood group A - I^AI^A or I^Ai B - I^BI^B or I^Bi AB - I^AI^B O - ii	A and B co-dominant O recessive
Index finger shorter than ring finger	males: dominant females: recessive
Interlocking fingers - when fingers are interlocked the left thumb is over the right thumb	dominant
Cheek dimples	dominant
Chin dimple/cleft	dominant
Long eyelashes	dominant
Wide nostrils	dominant
Freckles	dominant

Purposes

- to observe human characteristics that are controlled by a single gene
- to make inferences about personal genotypes based on observed phenotypes
- to predict phenotypes of offspring from crosses of known parents

Part A: Personal characteristics

Procedure

1. Observe your features as listed in the Table 39.1.
2. Record your phenotype in Table 39.1
3. Determine your possible genotype.

If you have the recessive phenotype, then you are homozygous recessive.
If you have the dominant phenotype, you could be homozygous dominant or heterozygous. If you can't work out if the second allele is dominant or recessive, record it as a - (dash).

For example:

Cheek dimples are dominant over no dimples.
If you have dimples, then you have at least one D.
If one of your parents has no dimples, then your other allele is d.
If you can't tell, then you are D -.

There is variability in the expression of dimples which can cause one or both cheeks to have dimples. The environment can also affect expression, e.g. weight can alter dimples.

4. Record the percentage of people in the class with the recessive phenotype.

Results

Copy and complete Table 39.2

Table 39.2: Human features controlled by a single gene

Feature	Dominance/ recessiveness	Personal Phenotype	Personal Genotype	% in class with recessive phenotype
Attached ear lobes	recessive			
Widow's peak	dominant			
Tongue rolling	dominant			
Bent little finger	dominant			
Hitchhiker's thumb	recessive			
Pigmented iris of eyes	recessive			
Curly/wavy/straight hair	incompletely dominant			
Mid-digital hair	recessive			
Blood group	A and B co-dominant O recessive			
Index finger shorter than ring finger	males: dominant females: recessive			
Interlocking fingers	dominant			
Cheek dimples	dominant			
Chin dimple/cleft	dominant			
Long eyelashes	dominant			
Wide nostrils	dominant			
Freckles	dominant			

What will my children look like?

Discussion questions

1. Which characteristics were hard to decide if you have it or not? What other information would you need?
2. What are the possible genotypes for a person with the dominant phenotype? How could you tell if they were of a particular genotype?
3. How many recessive characteristics do you have?
4. Which characteristics were more common in your class - dominant or recessive?
5. How can index fingers have different dominance in different genders?
6. How can you have only one Hitchhiker's thumb when you have the recessive genotype?
7. Were there any characteristics not shown in the phenotypes of the class? What does this indicate about how common the allele is in the population?

Part B: What would 'our' child look like?

Materials

- coin

Procedure

1. Select a partner to work with.
2. For each characteristic on your list, use a coin toss to randomly select an allele to add to a gamete to Gamete 1 allele column in Table 39.3.
3. Repeat the process for your partner and record the allele in Gamete 2 allele column in Table 39.3.
4. Work out the likely phenotype of your 'offspring' and record the result in the last colums of Table 39.3.

Results

Using the features listed in Table 39.2, copy and complete a table similar to Table 39.3

Table 39.3: Possible offspring phenotypes

Feature and description	Gamete 1 allele	Gamete 2 allele	Phenotype 3 allele
Attached ear lobes			
Widow's peak			
Tongue rolling			
Bent little finger			

Discussion questions

1. Who will the 'offspring' look more like? You or your partner?
2. How many features could not be determined? What are the possibilities?
3. This activity has only 16 monogenetic characteristics. How many phenotype combinations are possible?
4. Why is it almost impossible to have an identical double if you are not an identical twin?

Activity 40

Multi-allelic inheritance

Background information

The first documented successful human to human blood transfusion was in 1818. The doctor who performed this also did 10 other transfusions over a period of 5 years, but only 5 were successful. He had no way of telling if a transfusion would work or not. It wasn't until around 1901 that the ABO blood groups were recognised. Cross matching of blood donors and recipients decreased the complications of transfusions. It was also becoming apparent that blood groups were inherited in a simple Mendelian pattern.

For many human inherited traits there are only two possible alleles: the normal and the affected

For example:

- normal pigmentation and albino
- normal haemoglobin and sickle cell anaemia
- normal enzyme and PKU.

Blood groups are determined by three alleles. The alleles code for specific glycoproteins found on the surface of red blood cells. The *I* alleles cause the red blood cells to produce the glycoproteins. The alleles are:

I^A - red blood cells have glycoprotein A

I^B - red blood cells have glycoprotein B

i - red blood cells have no glycoproteins present

I is dominant over *i* and the I^A and I^B alleles are co-dominant.

A person can only have two alleles for the trait - one from each parent.

Purposes

- to relate the genotypes and phenotypes for blood groups
- to predict genotypes from blood group information across generations
- to solve genetic inheritance problems involving multiple alleles

Discussion questions

1. CopyTable 40.1 and complete by recording all the possible genotypes for the ABO blood groups that occur in the human population. Remember that a person has only two alleles for their ABO blood group and that the alleles available are I^A, I^B, and *i*.

Table 40.1: Genotypes of human blood groups

Genotype	Blood Group (phenotype)

2. Is there an observable difference between homozygous and heterozygous forms of the blood groups A and B? Why?

Multi-allelic inheritance

In about 1940, researchers found the Rh factor and recognised its importance in the success of blood transfusions. The test for the Rh factor was added to ABO testing to improve the matching between donor and recipient. The Rh factor has an important impact on the success of pregnancies and birth by Rh-ve mothers carrying Rh+ve babies. The Rh factor is a protein found in the plasma.

When tested with different anti-serums, blood can have one of two reactions as shown in Figure 40.1.

no agglutination agglutination

Figure 40.1: Reaction to anti-serum

The results of blood testing different blood types are shown in Figure 40.2.

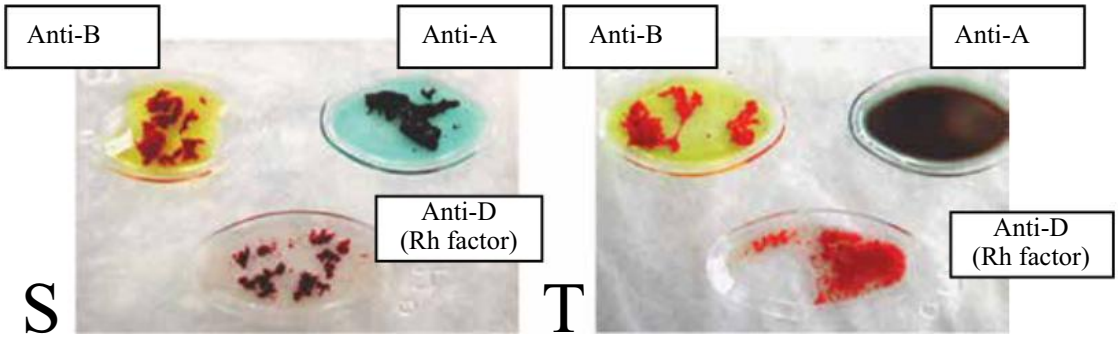


Figure 40.2: Results of blood testing

3. Look closely at Figure 40.2. Write down the test that showed no reaction to the serum added.

4. What blood group is indicated in: Figure 40.2 S and T:?

5. The anti-serums contain antibodies that react with the A, B and Rh factors. What antibodies would be produced by people with the following blood types?

   i. B^+

   ii. A^+

   iii. O^+

   iv. A^-

   v. B^-

   vi. O^-

6. Copy table 40.2 and complete by indicating whether the following combinationswould have an antibody reaction.

Table 40.2: Blood group and antibody reaction

	Recipient			
Donor	A	B	AB	O
A				
B				
AB				
O				

7. Which blood group can donate to all others?

8. Which blood group can receive blood from all others?

9. How would the presence of the Rh factor affect the ability of these people to donate or receive blood?

Summary

1. Blood typing is used to help determine paternity/maternity. Individuals could be proved **not** to be the parent of a particular child. Children could be tested to see if they **could** be the offspring of the stated parents. In neither of these situations could the parental link be actually proven. Explain why.

2. Mr and Mrs Allan have type A blood. Mrs Allan gives birth to a baby girl who gets mixed up with two other new born girls in the crowded hospital nursery. Baby 1 has type B blood. Baby 2 has type O blood and Baby 3 has type AB blood. Which baby belongs to the Allans? Give evidence from possible genotype pairings.

3. Mr Davis has type B blood. Mrs Davis has type A blood. Baby R has type B blood, Baby S has type O blood and Baby T has type A blood. Which baby could be theirs? Explain why.

4. Which of the following sets of parents could produce the greatest genetic variation in blood groups in their children? Explain.

   Parents 1: A and B
   Parents 2: A and O
   Parents 3: AB and O
   Parents 4: B and O

5. A man's maternal grandfather has blood type AB. All of his other grandparents are blood type O. What are the chances of the man having the following blood types?

   i. O

   ii. A

   iii. B

   iv. AB

6. John has blood type O, his father has blood type B and his mother has blood type A. What are the genotypes of John's parents? Explain your answer.

Multi-allelic inheritance

Hypothetical Multi-allelic Inheritance

In a post-nuclear explosion zone, several different mutations in a particular trait were observed. Researchers found the alleles responsible for the different phenotypes and determined the dominance of each. Their results are in table 40.3.

Table 40.3: Dominance of different mutations of a particular trait

Allele	Dominance	Phenotype
A	co-dominant with **A**+ dominant over all **a** alleles	black
A+	co-dominant with **A** dominant over all **a** alleles	white
a	co-recessive with other **a** alleles recessive to **A** alleles	blue
a+	co-recessive with other **a** alleles recessive to **A** alleles	yellow
a -	co-recessive with other **a** alleles recessive to **A** alleles	red

Use Table 40.3 to help answer Questions 7, 8 and 9.

7. What would be the colour of the following individuals?

   i. A A+

   ii. A+a

   iii. a a+

   iv. a a-

   v. A a -

8. What coloured offspring could be produced by the following crosses?

   i. A A+ and aa

   ii. A+a and a+a -

   iii. a a+ and a a

9. What combination of parents would give the greatest possible colour range of offspring?

Activity 41

Family trees

Background information

Family trees or pedigrees show the relationships within families and indicate the individuals with particular genetic conditions. By looking for patterns within the family tree, the inheritance mode for that condition can be determined and the occurrence in future generations can be predicted. Different modes of inheritance will produce different patterns within the family tree.

Purpose

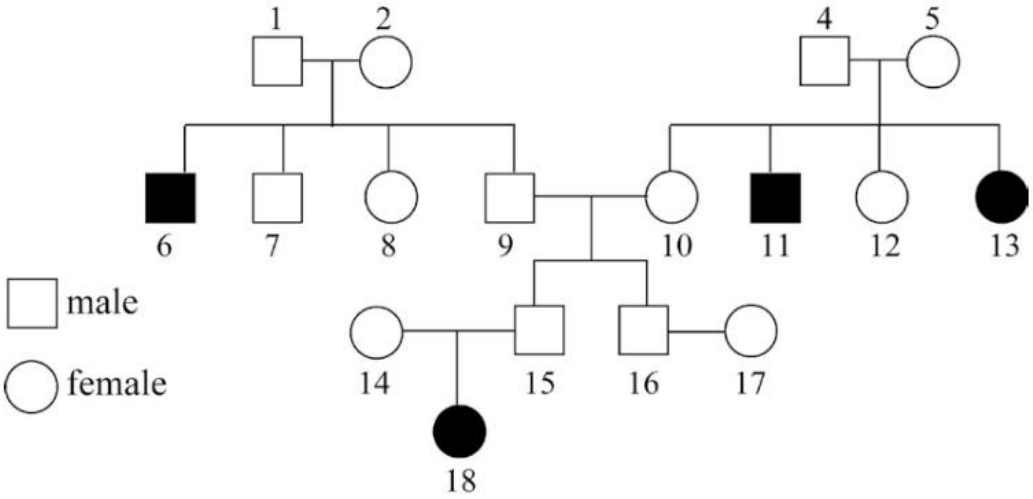
- to investigate use of family tress to predict the inheritance of different genetic the characteristics

Materials

- Appendix 6 - case pedigrees
- Ishihara test (optional)

Case 1: Webbed Toes

This family has members that have webbed toes - there is skin joining at least two toes together. The black shapes indicate individuals with the condition. The others have normal toes.



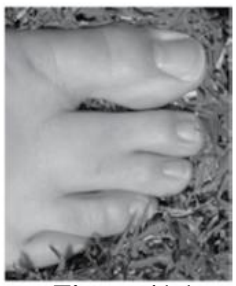


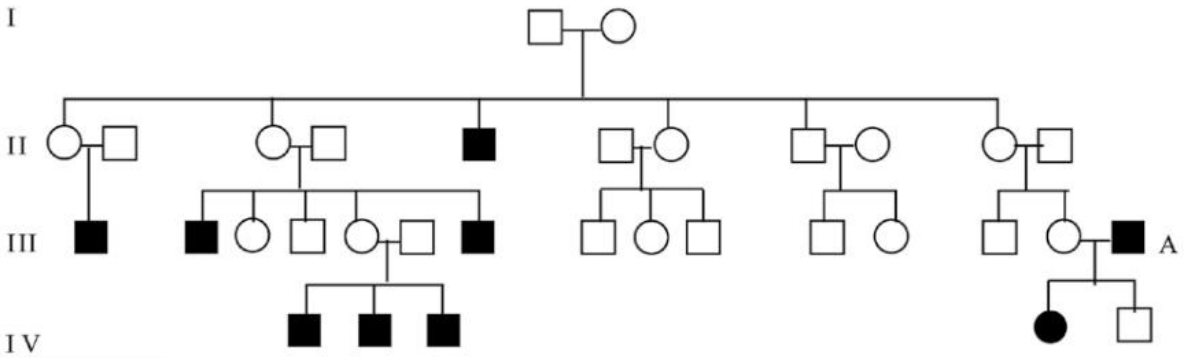
Figure 41.1: Webbed toes

Discussion questions

1. How many generations are shown in the family tree?
2. What is the relationship between individuals 5 and 15?
3. How many children do individuals 1 and 2 have?
4. Is this condition a recessive or a dominant trait? Explain.
5. Using the letters B (dominant trait) and b (recessive trait), what are the genotypes of individuals 6, 10 and 14?
6. What was the probability of individuals 14 and 15 having a child with the condition? Show all your working out.
7. Individual 17 has come from a family with no history of webbed toes. What is her most likely genotype?

Family trees

Case 2: Rare genetic condition
The following pedigree was drawn for a family in which individuals had a rare genetically determined condition. This condition was unknown in previous generations of this family.

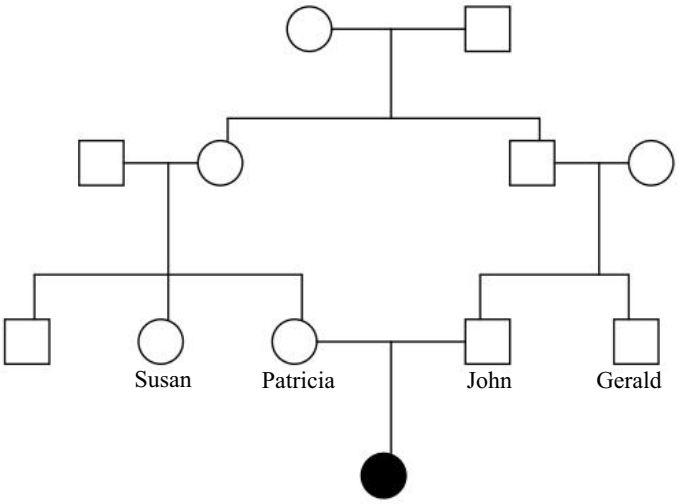


Discussion questions

1. Describe the inheritance pattern of this condition and justify your answer with evidence from the pedigree.
2. Shade the squares and circles of individuals who are heterozygous for the condition.
3. Is this condition a lethal condition? Explain your answer.

Case 3: Amaurotic Idiocy
Amaurotic Idiocy (AI) is a distressing genetic disorder which is caused by defective chemistry of the brain cells. It causes blindness, severe mental degeneration and death in childhood.

Below is a family tree of a healthy young couple, Patricia and John who have a child who suffers from AI.



Discussion questions

1. Is this condition dominant or recessive? Use information from the family tree to support your answer.
2. On the family tree identify the genotype or possible genotypes of all the individuals shown in the family tree. Use the symbols A and a to indicate the alleles of the gene responsible for AI.
3. If Patricia and John have other children, is it possible that they could suffer from AI? Explain.
4. Patricia's sister Susan is planning on marrying John's brother Gerald. What are the chances of their children inheriting AI?

5. This is a very rare condition. Explain using this family tree, why Patricia and John have a high probability of having AI children.

6. If Patricia's brother married someone completely unrelated to this family, what are the chances of them having AI affected children? Explain your answer.

Case 4: Huntington's Disease

Huntington's disease (HD) is a rare genetic disorder that causes the loss of brain cells. This leads to physical and mental deterioration with associated symptoms such as dementia, erratic movements and depression. HD sufferers usually die of complications from the disease such as infections, breathing problems or heart failure. Approximately 1200 Australians have been diagnosed with this disease. The symptoms do not appear until the age of 35 to 40 years, by which stage the person may have passed the gene for the disease on to their children. There are no cures for HD although medical procedures can help manage some of the symptoms.

In 1993 a group of researchers from the USA and Britain identified the gene for HD. The gene codes for a protein found in the brain. If a person carries the mutant form of the HD gene they will eventually develop the disease at some stage in their life.

John Wilson is forty-five years of age and has just been diagnosed as having HD. His father, Bill, died of the disease three years ago at the age of sixty-eight. His mother did not have the disease. John Wilson and his wife Mary have three children, David, Susan and Raymond. David has recently married and his wife Lynda is expecting a baby. There is no history of the disease in Lynda's or Mary's family.

Discussion questions

1. Draw a family tree showing John Wilson, his parents, his wife and children, and Lynda and her parents.

2. Is HD dominant or recessive? Use information from the Wilson family tree to support your answer.

3. Identify the genotype or possible genotypes of all the individuals shown in the family tree. Use the symbols H and h to indicate the alleles of the gene responsible for HD.

4. Calculate the probability of David Wilson inheriting the disease.

5. Calculate the probability of Lynda's unborn baby inheriting HD.

6. What is the probability of all three of John's children NOT having the HD allele?

7. What is the probability of all three of John's children having the HD allele?

Case 5: Red-Green Colour Blindness

Red-green colour-blindness is quite common, with both males and females being affected. Roger has just found out he is colour-blind by using the Ishihara test. When he told his parents, he found out that his mother's brother was colour-blind and his father's uncle was colour-blind.

You can try this test too if your school has an Ishihara test or at: http://www.toledo-bend.com/colorblind/ishihara.html

Discussion questions

1. Draw a family tree to show Roger, his parents, his uncle, great uncle and other family members linking these people.

2. What is the mode of inheritance? Use information from Roger's family tree to support your answer.

3. Roger has a brother and a sister. What are the chances of them being colour-blind?

4. Roger's grandfather died when Roger's father was very young, so it is unknown whether he was colour-blind. Can the grandfather's phenotype be inferred from the information given in this question? If not, what other information would you need to make an informed prediction?

Activity 42

DNA profiling

Background information

DNA profiling was first used for human identification in 1985. It was used to solve an immigration case in the UK. The members of a family arrived in UK from Ghana, West Africa at different times. The mother and three children immigrated to the UK first, then the son moved to UK to be with them two years later. The immigration authorities were not convinced that the boy was actually their son. DNA profiling showed beyond reasonable doubt that he was indeed their son.

The DNA sample is treated with several different restriction enzymes. The resulting solution is placed in an electrophoresis chamber to separate the DNA fragments according to size. The fragments form bands in the gel. The location of the bands gives a distinctive pattern unique to individuals. The more lines on the pattern that match up the more likely the sample came from the same person.

Purposes

- to understand the steps required to produce a DNA profile
- to be able to interpret the results of a DNA profile

Materials

- gel electrophoresis equipment (optional)
- copy of Figure 42.1 (Appendix 7)

Procedure

Part A: Producing a DNA profile using gel electrophoresis

Profiling is based on comparisons of known with unknown. The degree of similarity will determine the likelihood of a match between samples and standards. DNA profiling requires DNA to be treated with 'restriction' enzymes before being put through electrophoresis.

1. Conduct a virtual or real gel electrophoresis activity to produce a 'DNA' profile.

   The restriction enzyme XhoI (5'-CTCGAG-3'3'-GAGCTC-5') cuts up the DNA between C and G.
2. Indicate where this enzyme will cut up the sequence in Figure 42.1 using a '/'.

ATTCTTTTGAGTCGGGAGAACTAGGTAACAATTCGGAAACTCCAAAGGGTGGATGAGGGGCGCGCGGGGT
GTGTGTGGGGGATACTCTGGTCCCCCGTGCAGTGACCTCTAAGTCAGAGGCTGGCACACACACACCTTCC
ATTTTTTCCCAACCGCAGGATGGCGCCTCATCCCTTGGATGCGCTCACCATCCAAGTGTCCCCAGAGACA
CAACAACCTTTTCCCGGAGCCTCGGACCACGAAGTGCTCAGTTCCAATTCCACCCCACCTAGCCCCACTC
TCATACCTAGGGACTGCTCCGAAGCAGAAGTGGGTGACTGCCGAGGGACCTCGAGGAAGCTCCGCGCCCG
ACGCGGAGGGCGCAACAGGCCCAAGAGCGAGTTGGCACTCAGCAAACAGCGAAGAAGCCGGCGCAAGAAG
GCCAATGATCGGGAGCGCAATCGCATGCACAACCTCAACTCGGCGCTGGATGCGCTGCGCGGTGTCCTGC
CCACCTTCCCGGATGACGCCAAACTTACAAAGATCGAGACCCTGCGCTTCGCCCACAACTACATCTGGGC
ACTGACTCAGACGCTGCGCATAGCGGACCACAGCTTCTATGGCCCGGAGCCCCCTGTGCCCTGTGGAGAG
CTGGGGAGCCCCGGAGGTGGCTCCAACGGGGACTGGGGCTCTATCTACTCCCCAGTCTCCCAAGCGGGTA
ACCTGAGCCCCACGGCCTCATTGGAGGAATTCCCTGGCCTGCAGGTGCCCAGCTCCCCATCCTATCTGCT
CCCGGGAGCACTGGTGTTCTCAGACTTCTTGTGAAGAGACCTGTCTGGCTCTGGGTGGTGGGTGCTAGTG
GAAAGGGAGGGGACCACAGCC

Figure 42.1: A DNA sample

Q1. How many pieces of DNA are produced from cutting this DNA sample with this restriction enzyme?

Q2. Each band produced in a DNA profile contains pieces of DNA of the same size. How many bands of DNA would be produced on the profile?

DNA profiling

Discussion questions

1. Why is the DNA treated with restriction enzymes before it undergoes gel electrophoresis?
2. Why do all the samples need to be treated with the same restriction enzyme?
3. Each DNA profile has a size standard column, usually located on each side of the samples used. Of what use is the DNA size standard column?
4. S1 and S2 were suspects in a murder-rape case in 1988. DNA profiles were produced using blood samples taken from the suspects. These profiles were matched against the DNA profiles from the semen taken from the female victim. E(vs) is theevidence from the victim.
    a. Who did it? Justify your answer using evidence from the profiles in Figure 42.2.
    b. The sample from the victim was in the form of semen, yet the sample from the suspect was a blood sample. Explain how you can get a matching DNA profile from two different sample types.
    c. The vaginal swab of the victim would have contained some of her epithelial cells from the lining of the vagina. How could DNA just from rapist be separated for use in the DNA profiling process?
5. Forensic investigators were called to a crime scene outside a nightclub. They took body fluid samples from a suspect believed to be involved in a gang fight which resulted in one person being severely injured. The suspect's clothes were also swabbed for evidence of body fluids.
    a. The prosecution is using this evidence to show that the defendant (suspect) is guiltyof assault| causing grievous bodily harm to the victim. Does the evidence **prove** the defendant is guilty of assault? Explain your reasons.
    b. Is there another possible reason the defendant would have the victim's blood on his shirt?
    c. Suggest a reason why no lines showed for the jeans sample.

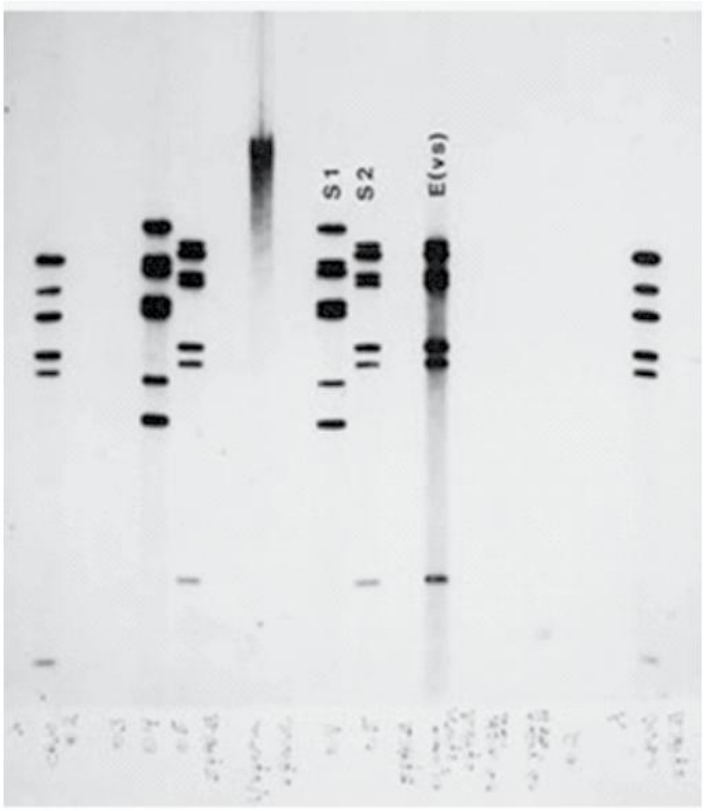


Figure 42.2: DNA profile used in the first conviction obtained through use of DNA profiles.

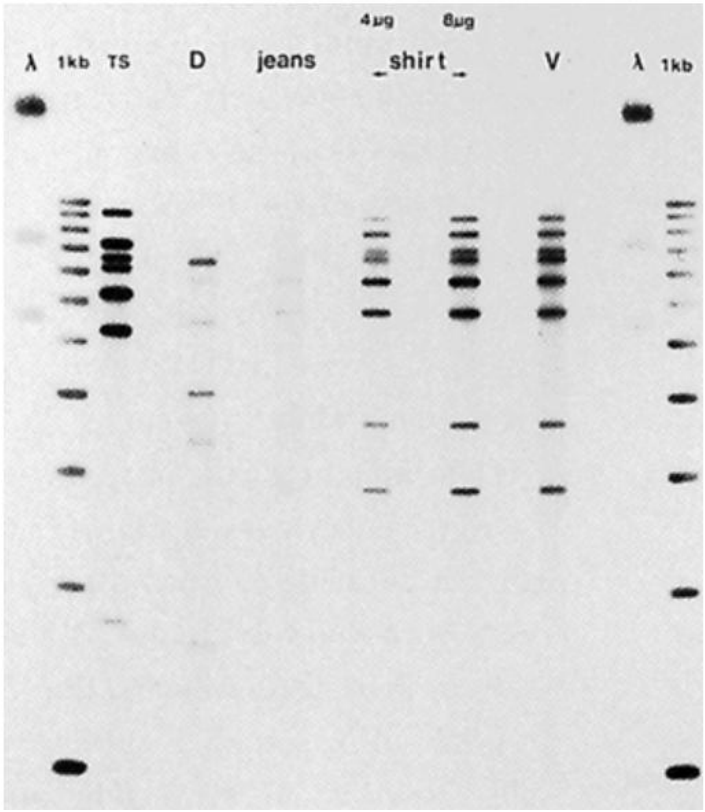


Figure 42.3: DNA profiles taken from people involved in a nightclub gang fight.

DNA profiling

Part B: Interpreting DNA profiles produced by column electrophoresis (Short Tandem Repeat)

Short tandem repeats (STR) in DNA occur when a pattern of two or more nucleotides are repeated and the repeated sequences are directly adjacent to each other. The pattern can range in length from 2 to 10 base pairs eg. CAGT sequence. These are usually found in the non-coding region of DNA. By identifying the number of repeats of a specific sequence, it is possible to create a genetic profile of an individual.

STR profiles still rely on the separation of fragments of DNA produced from the action of restriction enzymes on the sample. Instead of the DNA samples being placed on a flat gel electrophoresis, they are poured into a column electrophoresis. When the DNA fragments reach the end of the column, they are detected and recorded automatically. The result is in the form of a graph like the one shown in Figure 42.4 opposite.

The different colours indicated in the STR refer to different restriction enzymes used in treating the samples of DNA.

6. The DNA profiles shown in Figure 42.4 were produced by STR analysis of DNA from a crime scene. There is information from the victim, the suspect (who was wounded during the struggle) and the crime scene. The profile shows data from 9 different loci plus an XY marker. Tests were also conducted for four other loci and the results for all fourteen tests are shown in Figure 42.4. Each locus represents a particular 'marker' or fragment of DNA.

   Each marker can have a number of variations, but an individual will have a maximum of two. Each marker peak variation represents an allele. Some people have 2 peaks – heterozygous, others have one, usually larger peak – homozygous.

   a. Is the suspect guilty? Justify your answer.

   b. What sex are the people involved in this crime? How do you know?

   c. In a flat gel electrophoresis the 13/16 and 13/14 alleles would often not be distinguishable as separate bands. In column electrophoresis, the alleles consistently produce double peaks. How would this affect the reliability of the interpretation of results for each type of profiling method?

   d. How does this increase the efficiency of storage and searching for matches, compared to the storage of flat gel electrophoresis pictures?

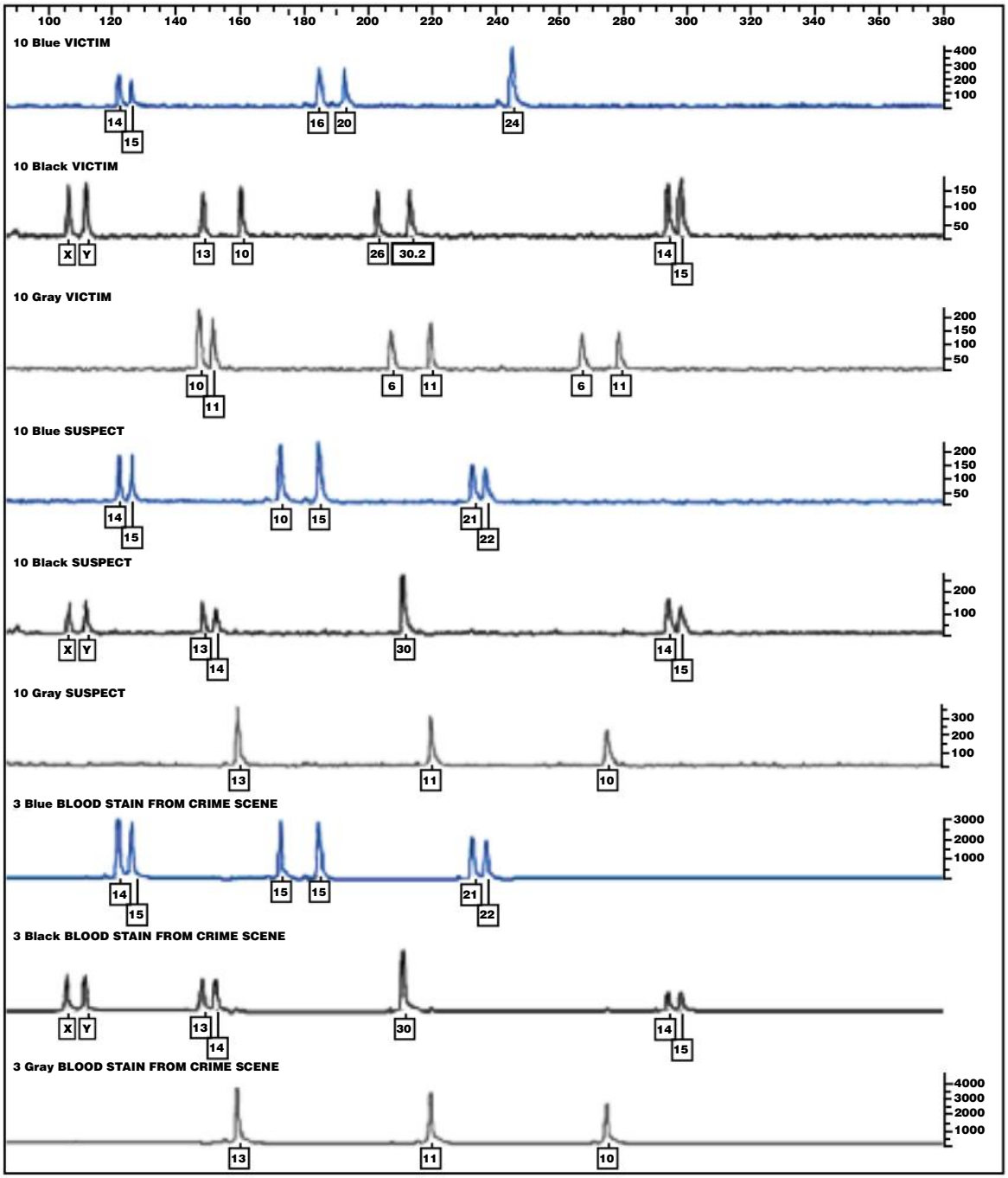


Figure 42.4: STR profiles from victim, suspect and crime scene

The data from the profiles can be stated as a set of numbers as shown in Table 42.1.

Sample	Amelogenin	D3S1358	vWA	FGA	D8S1179	D21S11	D18S51
Victim	XY	14, 15	18, 20	24	13, 16	28, 30.2	14, 15
Suspect	XY	14, 15	15, 18	21, 22	13, 14	30	14, 15
Blood Stain from Crime Scene	13	11	10	9, 12	6, 9	8, 11	9, 12

Sample	D5S818	D13S317	D7S820	D16S539	THO1	TPOX	CSF1PO
Victim	XY	14, 15	18, 20	24	13, 16	28, 30.2	14, 15
Suspect	XY	14, 15	15, 18	21, 22	13, 14	30	14, 15
Blood Stain from Crime Scene	13	11	10	9, 12	6, 9	8, 11	9, 12

Figure 42.1: Alleles detected in samples

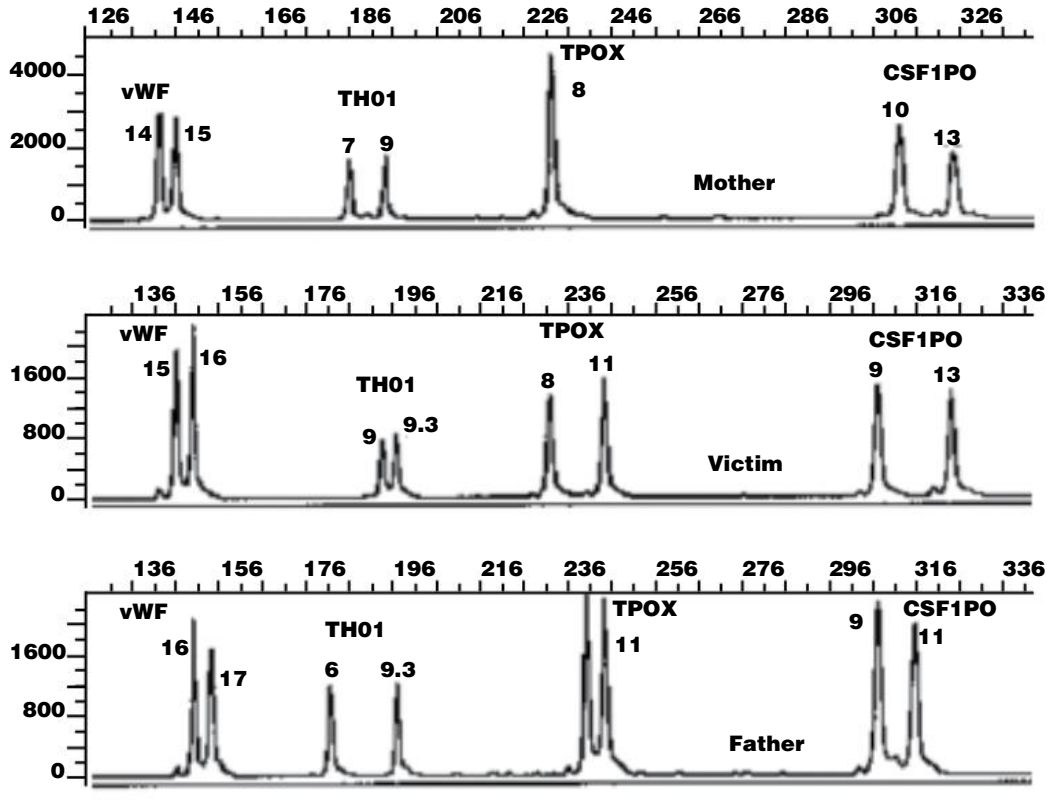


Figure 42.5: Comparison DNA profilesfor tsunami victim identification
From: http://www.promega.com/geneticidproc/ussymp6proc/ricc.htm copyright granted 28 Oct 2009

7. The profile of a tsunami victim (centre) was compared to the profiles of the couple who are believed to be the mother (top) and father (bottom).
   a. Is the victim the daughter of this couple? What evidence from the profiles can be used to justify your answer?
   b. Write the STR profiles for these three people as STR number profiles.

8. The remains of a human were found in the burned out ruins of a house. A sample was taken from the ruins and the suspected victim's hair brush for analysis. The STR profiles for the samples can be seen in Figure 42.6.

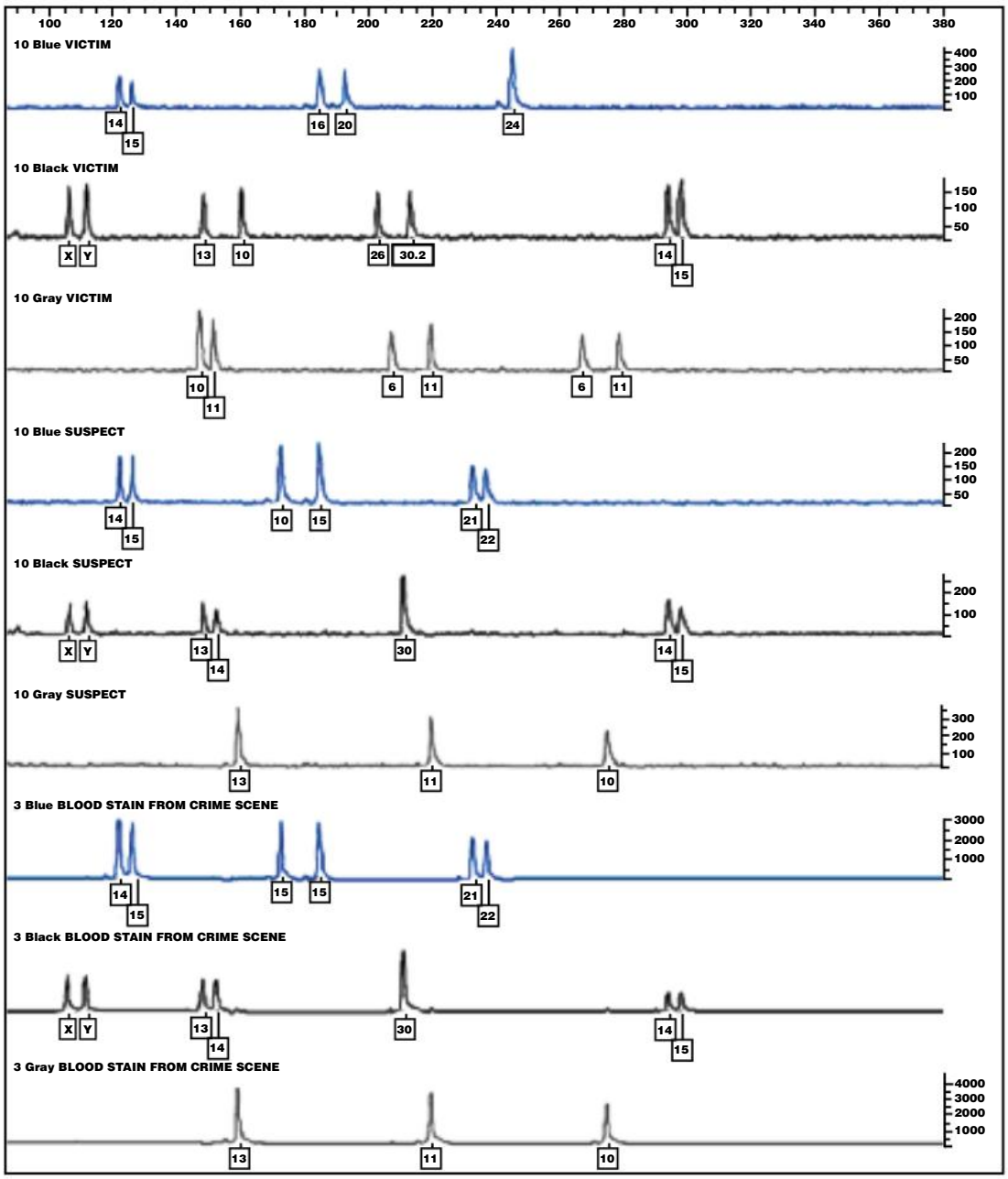


Figure 42.6: Comparison DNA profilesfor house fire victim identification

From: http://www.promega.com/geneticidproc/ussymp6proc/ricc.htm copyright granted 28 Oct 2009

Explain how this STR profile was used to identify the remains.

Part C: Parental testing

1. Read the articles in Figure 42.7 and Figure 42.8.

THE WEST AUSTRALIAN SATURDAY SEPTEMBER 2 2000 7

Ethics fear on Internet DNA tests

Web site offers hair follicle testing to determine paternity

MELBOURNE
By Gareth Malpeli

PATERNITY tests being sold over the Internet have raised privacy, ethical and legal concerns.

The tests, in which DNA is taken from hair follicles, are processed at a laboratory at Melbourne's Monash University, with university staff acting as unpaid technical consultants.

They can be ordered from a Web site called DNAnow.com and do not need the permission of both parents.

The company running the service, DNA Solutions, this week launched its British Web site, which is run in tandem with services in Australia, the United States and South America.

Company head Vern Muir could not be contacted for comment.

The tests range in price from $495 — for tests which do not require the mother's DNA — to $1235, depending on the number of children to be tested.

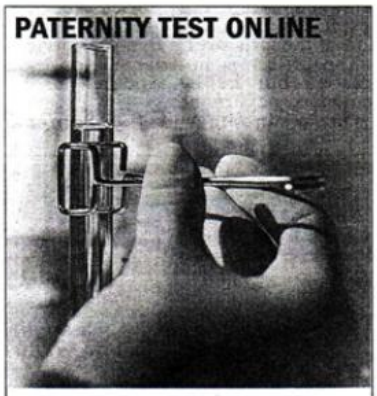
Laboratory technicians need at least four hairs to conduct the tests and the hairs must be pulled from the head, chest, eyebrow or underarm.

Cut hair is useless because it does not carry the small clump of skin at the root of the hair needed to collect enough DNA for the tests.

Consultant ethicist Nicholas Tonti-Fillipini said ordering DNA tests over the Internet raised privacy concerns.

"This sort of test can be done on a child without anybody's consent," he said. "Anybody can do it, not just the person whose hair it is.

"There's no need to be identified and no consent to be obtained so, in effect, it is a test on somebody without their consent, so it violates all sorts of principles in relation to confidentiality and privacy.



How to find out whether you are the father without leaving home

- Tests paid by credit card over Internet via secure link. Prices start from $495.
- Kits then posted by DNA Solutions for collection of hair samples.
- Samples are sent to laboratory at Monash University, Melbourne, and DNA tested to see whether the owners of the hairs are related.
- Results in up to three weeks.

"It's not the sort of thing that should be handled on the Internet."

Mr Tonti-Fillipini said the involvement of a university in the service also set ethical and legal concerns.

Monash biochemistry and molecular biology senior lecturer Stephen Ralph said ethical concerns about the service rested with those using it.

Dr Ralph, who supervises Monash's collaboration with DNA Solutions' research projects, said a university bioethics committee had considered all ethical concerns.

"The ethics of the people involved and where they get their samples from and so on, that's a different issue, and I think that's outside our governance."

Figure 42.7: Ethics fear on Internet DNA tests
(Reproduced courtesy The West Australian)

From hearsay to paternity

1997

There are rarely doubts about a mother's identity – pregnancy and babies are hard to hide . But, sometimes, the father's identity is difficult to pin down. Now, for a few dollars, probable parents can check who daddy really is, writes **Gina Chon**.

SHE may have her father's nose but does she have his genes as well? Proving the paternity of a child was once an inexact science. Now, anyone who can use a medical cotton swab to swipe cells from the mouths of mother, baby and probable father can find out with near-certainty.

"A lot of people wanted to get this testing but they never knew who to ask or were too embarrassed," said Caroline Caskey, founder and president of Identigene, a company that conducts the paternity tests.

Based in Houston, Texas, the company has been advertising the toll-free number in the US, mainly in the South, and said it had received 150 calls each day.

The ads — with the slogan, "Who's the father? 1-800-DNA-TYPE" — have appeared on billboards in Chicago and even on taxi in New York City.

Ms Caskey said the service offered many advantages. For one thing, it's discreet: just swipe and mail in the swabs. It's fast: test results are usually back in a week.

And it's accurate: the company says a match means it's more than 99 per cent certain the man is the father.

In Chicago, a 23-year-old woman said she rang because her boyfriend wanted to make sure he was the father of her 10-month-old girl. The child's grandmother saw the billboard and told her daughter about it.

"I didn't mind doing it and I think there is a need for this service," said the woman. I thought you could only get the test done at a hospital."

With out-of-wedlock births exceeding 60 per cent in some urban areas, figuring out a father's identity is often not a matter of simply looking at the marriage licence.

While there may have been a time when mothers were content not to know, the costs of raising a child and changes in welfare laws are making paternity a much bigger issue.

Court systems are increasingly demanding fathers pay for their children's upbringing, using wage attachments, jail time and liquidation of assets to make their point.

Welfare departments are also forcing the issue, trying to take the load of child-rearing off taxpayers and give it back to fathers.

The US government is requiring States to establish paternity in 90 per cent of welfare cases within six months, instead of the previous 75 per cent of cases within 18 months. So both fathers and mothers have a big stake in knowing who daddy is.

"Location, finding the father and the legal burden of proof is the most difficult part," said Dianna Durham-McLoud, head of the Child Support Enforcement Division of the Illinois Department of Public Aid. "But it's so important because the first step in collecting child support is establishing paternity."

Illinois previously established paternity in 4000 cases each year but from the first three months of this year alone, 12,500 cases were resolved. About 330,000 cases were pending, two-thirds of which involved people on welfare.

Identigene charges $800 for a DNA test. Privacy is often paramount. Callers are not only those interested in child support benefits. People who were adopted as children and want to confirm the identity of a biological parent also use the service.

"It's also important for adopting couples — you want to know that the right man is giving up his adoption claims," Ms Caskey said.

Figure 42.8: From hearsay to paternity (Weekend Australian 26 July 1997)

2. a Who would want to have DNA testing done?

   b. Why would people want DNA testing to be done?

   c. What types of samples of tissue can be used for DNA testing?

   d. Compare the price of private DNA testing in the USA (by Identigene) and in Australia (at Monash University).

   e. How does the price of the tests impact on its accessibility to different groups in the population?

   f. List the advantages and disadvantages of DNA testing for parent-child identification.

   g. What are the ethical dilemmas involved in DNA testing?

   h. Why is the consultant ethicist in Figure 42.8 concerned about internet testing? Would the same arguments apply to non-internet testing? Explain your answer.

   i. What 'rights' and 'responsibilities' are involved in the issues of DNA testing?

3. Read the article in Figure 42.9 and answer the questions.

13th June 2003
By Holly Hickman

MIAMI, Florida, June 13 AP - Thinking they had caught a French fugitive who had kidnapped her two children from their father, authorities held a mother in jail for six nights until DNA tests proved them wrong.
When officers brandishing guns ran toward her car, Nona Cason thought they were after somebody else. Instead, they arrested Cason, accused her of being fugitive Nadine Tretiakoff, and seized her children.
"People kept calling me, and made me sign things saying I was her," she said.
"I'm not Nadine Tretiakoff. I'm Nona from Macon, Georgia," she said yesterday, with no trace of an accent.
Both French and US federal authorities mistook her for Tretiakoff, accused in France by ex-husband Pierre Fourcade of kidnapping their children.
Cason spent the next six nights in jail. Arrested on a Friday, she said she had no knowledge of the whereabouts of her children until the following Monday, May 19. On that day, she stood "three feet" in front of Fourcade in a Fort Lauderdale courtroom where he testified repeatedly that she was his ex-wife.
Finally, the state ordered a DNA test. The results eviscerated any possibility of a blood link between Fourcade and Cason's two children. She was subsequently released.
"I was sure it was her," Pierre Fourcade said yesterday from France. "The French authorities assured me this was the woman, these were my kids."
"It's a horrible situation. I haven't seen my family in six years, and she really does resemble my ex-wife. I'm furious with the French officials."
Cason, 39, said that she was arrested by US Marshals in front of her children.
"I was in traffic and I see this row of police cars in front of me and behind me."
Courtesy: Australian Associated Press

Figure 42.9: Florida woman arrested as French fugitive

   a. Mr Fourcade was adamant that Ms Cason was his wife. How could he have made this error?

   b. What would have happened if DNA testing was not available for the situation in Figure 42.9?

   c. What is the role of nature and nurture on people's identity?

4. Read the article in Figure 42.11 and answer the questions.

   a. Why is maternity rarely questioned?

   b. There is an 'old wives tale' that says all mothers know their own babies. Suggest why this was not the case for the mothers in Figure 42.11.

   c. What would you do if you were

      i. Carlton Conley?

      ii. Whitney Roger's parents?

A tragic error leaves families holding the babies

1998 pg 12

New York correspondent **Cameron Stewart** discovers love knows no DNA boundaries

Victims: Chittum and Rogers, with Rebecca, left, and Lindsey and, right, a distraught Johnson Picture: Reuters

SHORTLY before midnight on June 29, 1995, a 27-year-old secretary named Paula Johnson gave birth to a 4.2kg baby girl in the University of Virginia Medical Centre.

Johnson and the girl's father, Carlton Conley, named the baby Callie Marie. But they barely had a chance to hold Callie before she was whisked off to the nursery to have tests.

When the nurses brought Callie back the next morning, the baby seemed lighter, say Johnson and Conley. However, they had no reason to suspect anything was wrong.

When Johnson walked with Callie along the corridors of the hospital in the following days, she would pass other mothers, including a teenager called Whitney Rogers, who had given birth to a young baby, Rebecca, only hours after Johnson had Callie.

After several days, Johnson and Rogers took their babies to their respective homes, 120km apart in rural Virginia. For the next three years, each girl was raised lovingly. No one suspected anything was amiss.

No one would have been any the wiser if Johnson had not taken former boyfriend Conley to court earlier this year to try to extract an increase in his $US75 ($120) weekly child support.

Conley — who was confused by the fact that Callie looked nothing like him — wanted to confirm he was the father.

When the tests showed that he wasn't, Johnson was shocked. She undertook DNA tests herself and on July 2 discovered, to her horror, that Callie was not her biological child. The only possible explanation was that Callie had been switched at birth.

The hospital investigated and concluded Callie was probably Rogers' biological baby, which made it logical to assume that Rogers had taken home Johnson's biological child.

The chastened hospital dispatched a nurse and a doctor to tell the bad news to Rogers, 19, and Kevin Chittum, a 25-year-old builder, who were raising Rebecca. But the hospital didn't make it in time.

On July 4, Rogers and Chittu were killed in a car accident th claimed seven lives.

When the saga eventua broke in the US media this we there seemed to be a thousa questions that needed answ ing.

But eventually, both famil said they were leaning towar having each child stay with t family that raised them, wh allowing visiting rights for t biological parents or, in Calli case, her biological grandparent

Adding to the confusion, t hospital has not yet confirm that Rebecca is Johnson's chi or Callie is Rogers's child.

DNA tests will be done soon determine who the parents ar

In a news conference this week distraught Johnson said no fir decisions had been made abo who should keep which child. F now, both families are anxious settle the matter privately. Th say psychologists, is by far the b way to deal with the mess.

Figure 42.10: A tragic error leaves families holding the babies

Appendix 1

Biological drawing skills

Biological diagrams

Drawing and labelling diagrams in Human Biology is an important and useful skill. When drawing diagrams in Human Biology there are some important rules to follow.

All diagrams should be drawn
- with a sharp pencil
- in two-dimensions
- large enough to see the detail required
- using clear continuous lines, no sketching.

All diagrams should also include a title.

Labels and scales may also be required. A ruler should be used for label lines and scale bars.

Drawing specimens viewed under a microscope

When drawing specimens viewed under a microscope it is important you draw the details of the image you are viewing.

When drawing specimens you should
- represent the field of view with a circle
- use a sharp pencil
- use clear continuous lines, no sketching or shading
- include the magnification and scale bar.

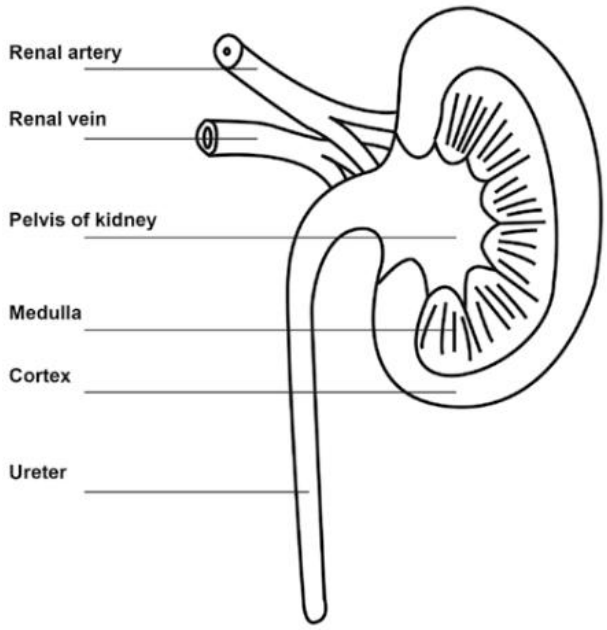


Figure 1: Human excretory system

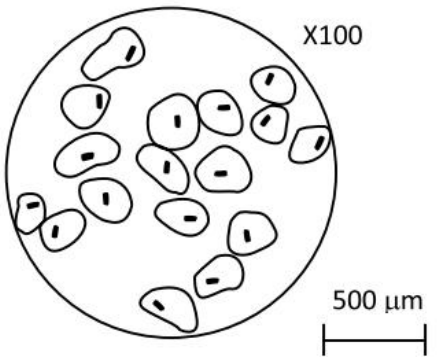


Figure 2: Human cheek cells (low power)

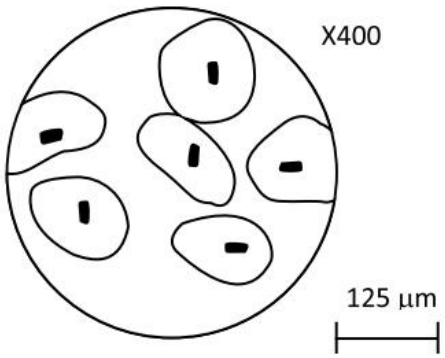


Figure 3: Human cheek cells (high power)

Appendix 2

A guide to investigations

Planning and conducting investigations

When scientists plan and conduct their scientific investigations they record all their planning and observations in a logbook/journal. These notes are then used to write up their scientific report.
When planning your investigation you need to record the following:

- Background research on the topic being investigated, including references used.
- Question and/or hypothesis being investigated
- List of all equipment and materials used
- The steps you will take in your investigation. As you work through your investigation your method may change. Make sure you record any changes you make. When you write your final report you should only record the steps you followed to get your results. Diagrams/photographs of your experimental set-up are should also be made as these are useful when writing your final report.
- If your investigation involves the changing and controlling of variables ensure you include these variables (e.g. independent variable, dependent variable, controlled variables).
- Record all of your observations. Taking photographs and/or drawing diagrams are also useful ways of recording results.

Communicating your findings

Once you have completed your investigation you may be required to produce a written report and/or do a scientific poster presentation.

Written report

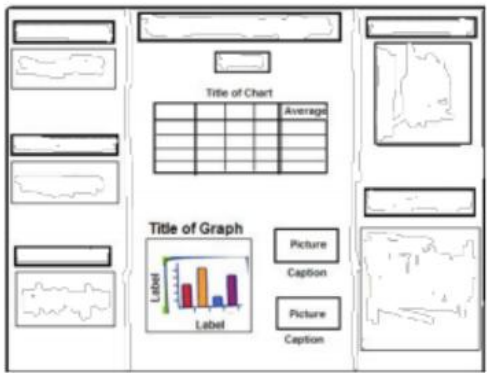
A written report should contain the following:

Title page	Include the project title and student name/s.
Table of contents	Include main headings and page numbers.
Abstract	A brief description of what you did and what you found out.
Introduction	What gave you the idea? How did you get started? Include any background research you have done on the topic.
Materials	List or describe the materials used.
Method	Describe the steps you took. Describe the safety requirements you followed in conducting this investigation. Photographs of your set up could be included.
Results	Everything you discovered (or found out). To show this use tables, graphs, pie charts, photos etc.
Discussion	Discuss your results describing the patterns and trends. Describe how you could improve your investigation.
Conclusion	List the main things you have discovered or found out. Go back to your results - What do they tell you? Did your results answer your research question/support your hypothesis? Use your research/scientific knowledge to explain your results.
Acknowledgements	Make sure you include a list of people who gave you help/advice. and list any books or websites you used.
References	List any books or websites you used.

A guide to investigations

Scientific poster

A scientific poster is not your written report, it is a summary of what you did and found out. It should be colourful, simply illustrated, well labelled and attractive.
Your poster should be organised like a newspaper so the reader can quickly follow the thread of your investigation by reading from top to bottom, then left to right. Therefore, you should start with the research question/hypothesis and end with your conclusion. The centre of your display board should contain your results and the main message you want the reader to see.



A scientific poster

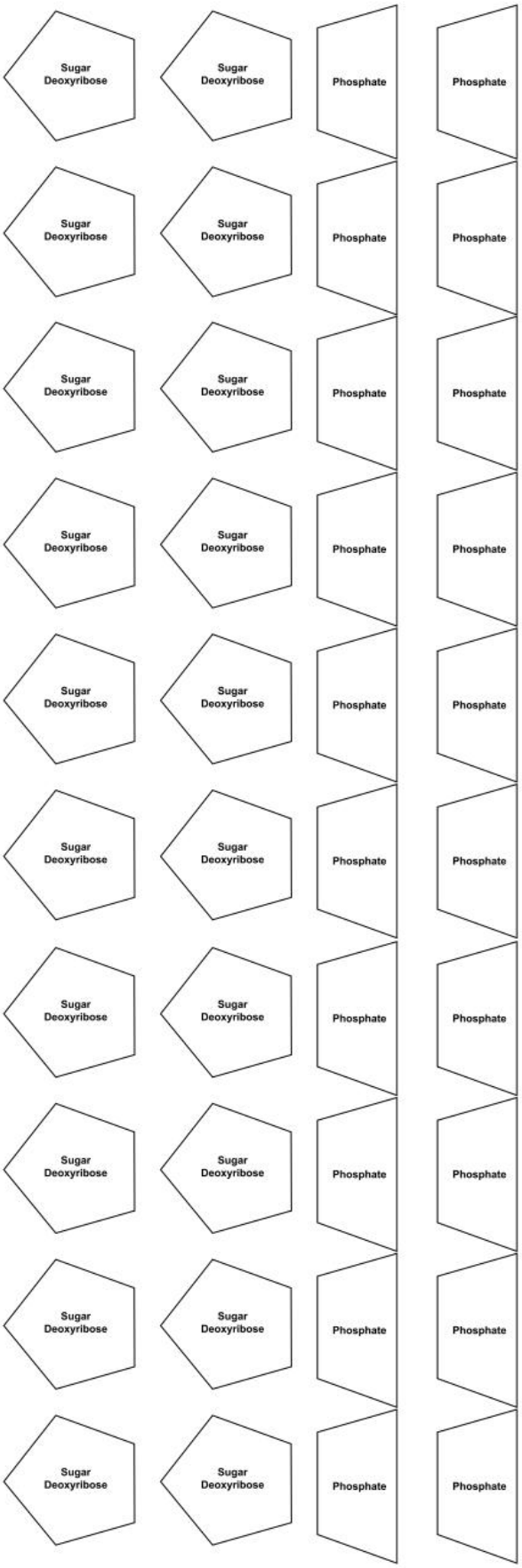
Presenting your poster

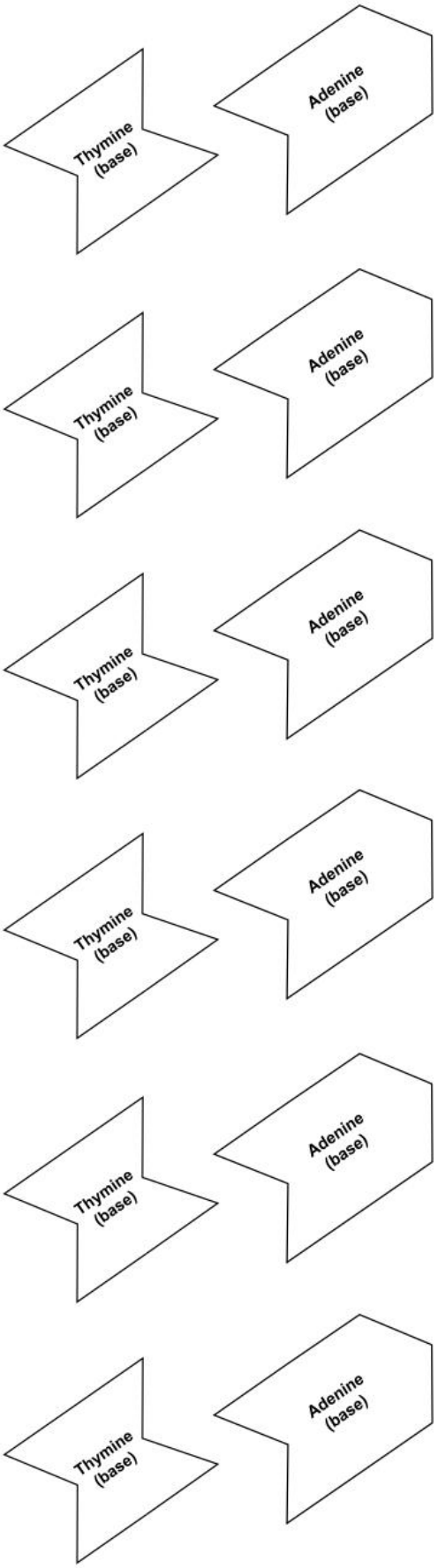
You may also be required to present your findings to an audience. Your poster should be used to during your presentation to point our key parts of your investigation. In your presentation you should mention:

- how you got the idea for your investigation.
- how you performed your investigation
- your results/findings
- why your investigation is important to today's society.

Appendix 3

Activity 25 - molecule template shapes





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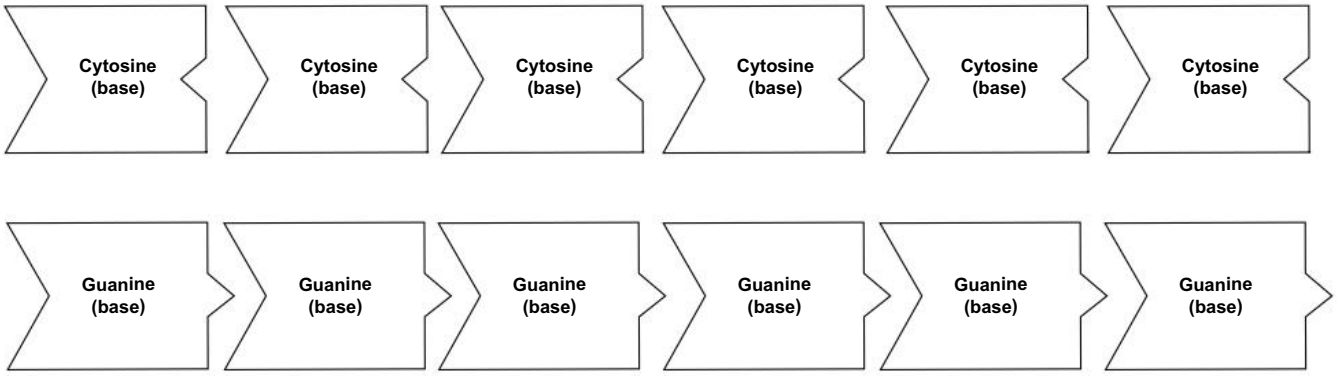
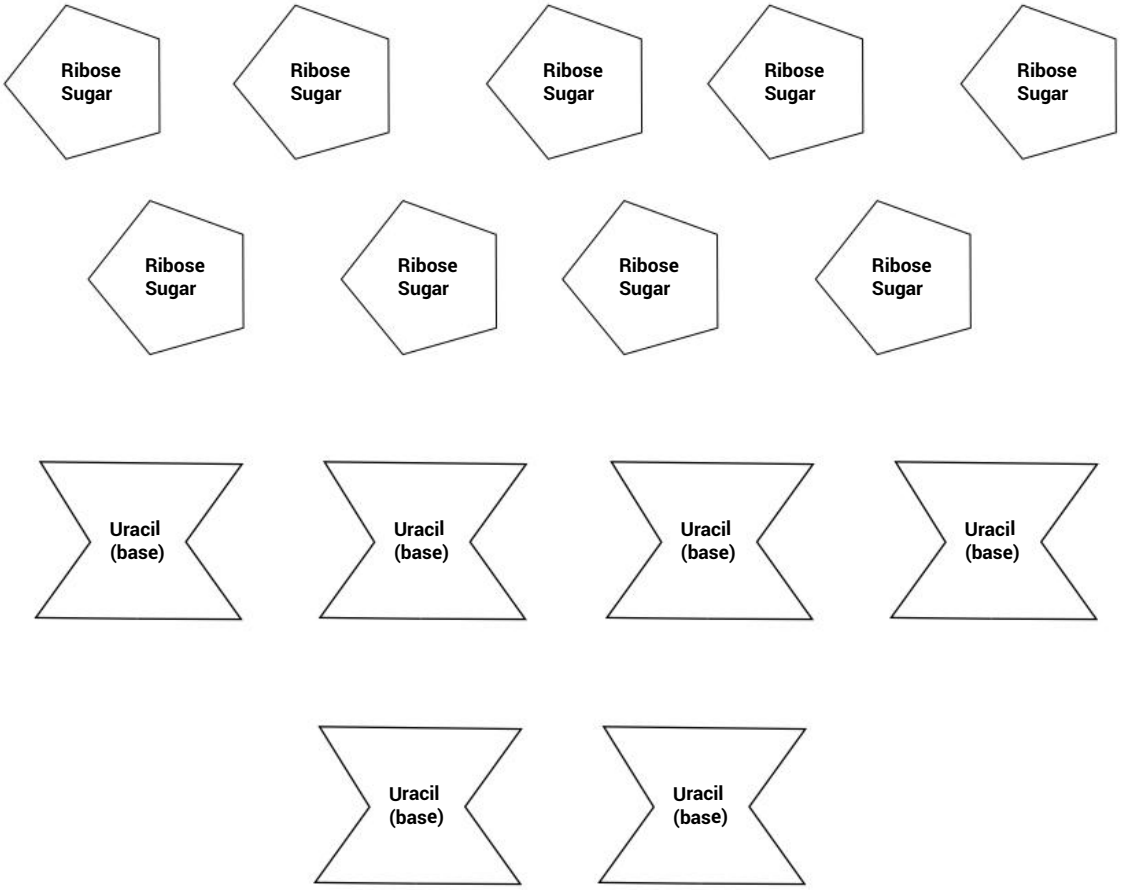
Appendix 3 (continued)

Activity 25 - molecule template shapes



Appendix 4

Activity 26 - molecule template shapes



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Appendix 5

Activity 35 - chromosomes from a human body cell

(From: http://www.pathology.washington.edu/galleries/Cytogallery/main.php?file=human%20karyotypes)

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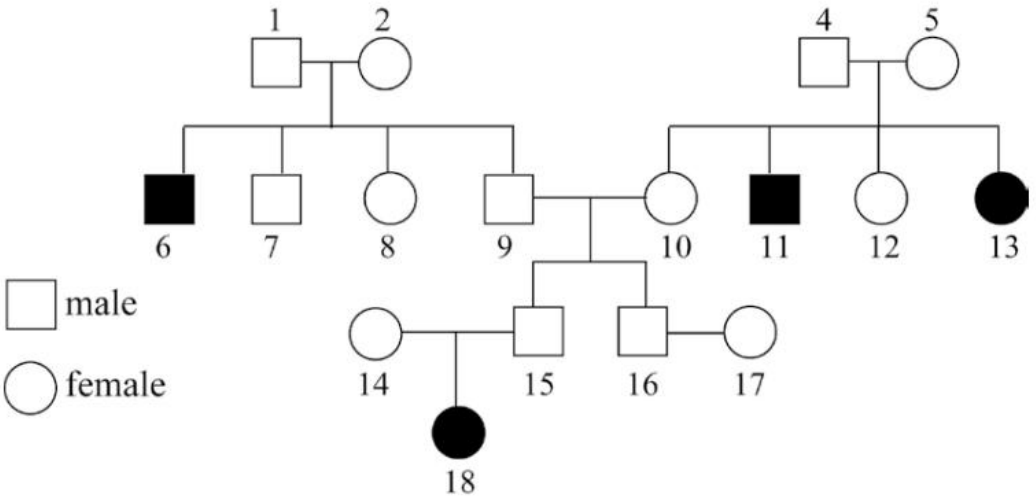
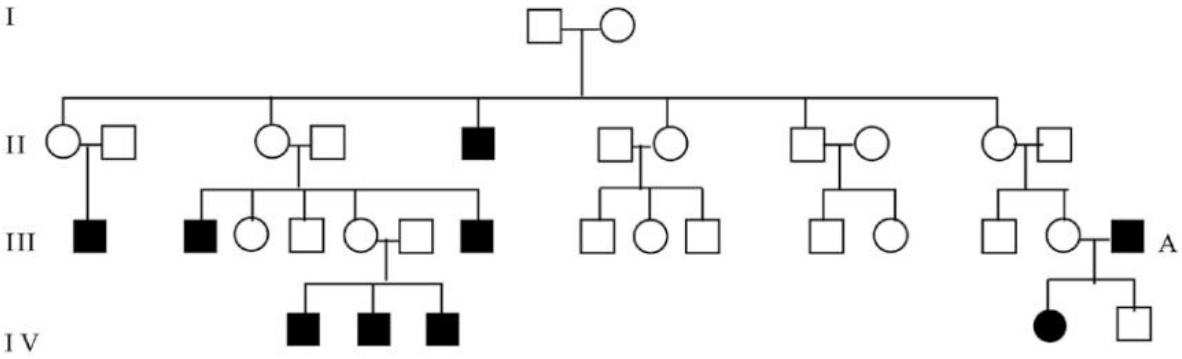
Appendix 6

Activity 41 - case pedigrees

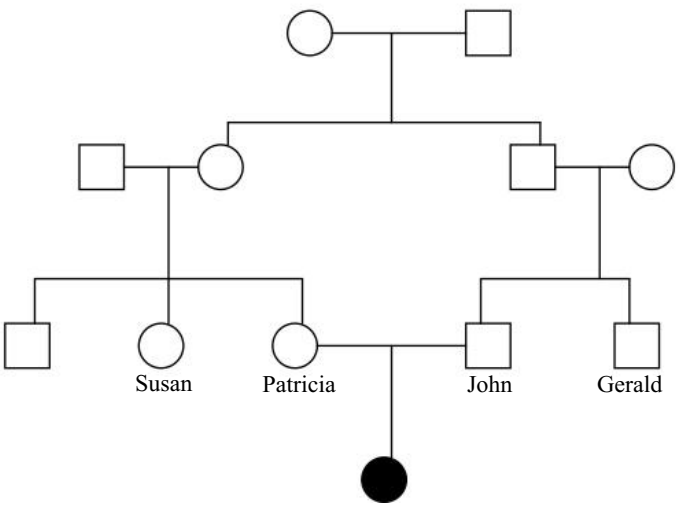
Case 1: Webbed toes



Case 2: Rare genetic condition



Case 3: Amaurotic idiocy



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Appendix 7

Activity 42 - DNA sample

ATTCTTTTGAGTCGGGAGAACTAGGTAACAATTCGGAAACTCCAAAGGGTGGATGAGGGGCGCGCGGGGT
GTGTGTGGGGGATACTCTGGTCCCCCGTGCAGTGACCTCTAAGTCAGAGGCTGGCACACACACACCTTCC
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CTGGGGAGCCCCGGAGGTGGCTCCAACGGGGACTGGGGCTCTATCTACTCCCCAGTCTCCCAAGCGGGTA
ACCTGAGCCCCACGGCCTCATTGGAGGAATTCCCTGGCCTGCAGGTGCCCAGCTCCCCATCCTATCTGCT
CCCGGGAGCACTGGTGTTCTCAGACTTCTTGTGAAGAGACCTGTCTGGCTCTGGGTGGTGGGTGCTAGTG
GAAAGGGAGGGGACCACAGCC

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Appendix 8

Writing a practical report

In general your practical report should reflect as accurately as possible all the measurements and observation made. It should also clearly illustrate your knowledge and understanding of the syllabus content covered by the practical work. Practical reports should include the following headings:

Purpose

This should be a short sentence or two, describing briefly what you are trying to find out from the practical activity you are conducting.

Materials and procedure

There is no point copying the materials and procedure when writing a report on a practical activity from this book.

Results

Numerical observations (quantitative data)

- You should record all measured quantities in your report.
- Record these quantities in a suitable table.
- You must include units for each quantity that you measure and record.

Non-numerical observations (qualitative data)

- You may be required to
  record descriptions in tables
  draw diagrams (Refer to A guide to drawing biological diagrams in Appendix 1)
  answer questions whilst working through the practical activity. Use full sentences for your answers.

Discussion questions

Include answers to all discussion questions in your report.

- You should use full sentences for your answers.
- Graphs should be drawn on graph paper, unless directed otherwise by your teacher.

Summary questions

Some activities contain summary questions that require you to elaborate on and/or apply what you have learnt in the practical activity. You should use full sentences for your answers. You only need to include this section if the activity contains summary questions.

Conclusion

The conclusion for a practical activity should relate to the purpose of the activity. It should answer the question asked or implied in the purpose