2 Learning with your brain in mind

What are you? Are you just a bag of chemicals that are interacting with each other? What do chemicals have to do with you being able to detect and respond to your environment?

How can chemicals influence your emotions, behaviour, learning and memory? Where do *you* fit into all of this? How do chemicals help make you — *you*?

OVERARCHING IDEAS

- Patterns, order and organisation
- Form and function
- Stability and change
- Systems

SCIENCE UNDERSTANDING

Multicellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment.

SCIENCE AS A HUMAN ENDEAVOUR

Nature and development of science

Use and influence of science

Elaborations

Describing how the requirements for life (for example oxygen, nutrients, water and removal of waste) are provided through the coordinated function of body systems such as the respiratory, circulatory, digestive, nervous and excretory systems

Explaining how body systems work together to maintain a functioning body using models, flow diagrams or simulations

Identifying responses using nervous and endocrine systems

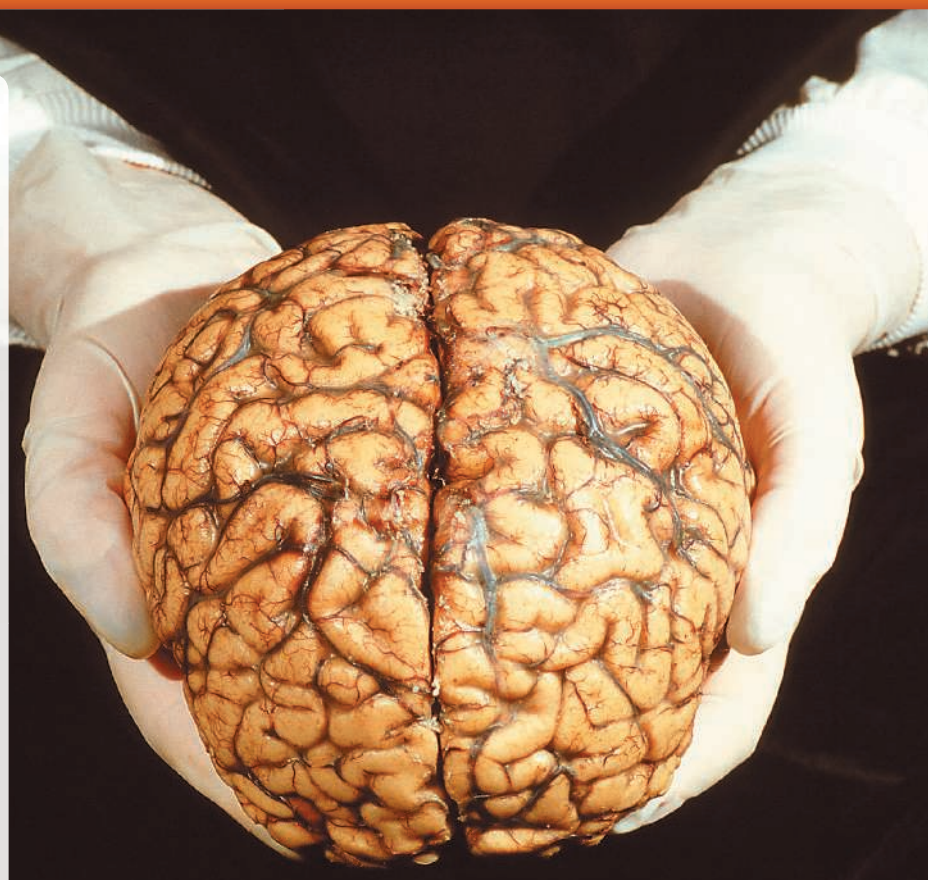
Considering how common properties of electromagnetic radiation relate to its uses, such as radar, medicine, mobile phone communications and microwave cooking

Considering how the development of imaging technologies have improved our understanding of the functions and interactions of body systems

Using knowledge of science to test claims made in advertising or expressed in the media

Recognising aspects of science, engineering and technology within careers such as medicine, medical technology, telecommunications, biomechanical engineering, pharmacy and physiology

This is an extract from the Australian Curriculum.
Any elaborations may contain the work of the author.



Look after that brain of yours.

THINK ABOUT LEARNING

- How do the different parts of your brain work together?
- How are memories stored?
- Can you improve the way you learn by using your senses?
- Can fish oil make you more intelligent?
- Does a good night's sleep just simply happen?

YOUR QUEST

Active learning

The best learning occurs when you take an active role rather than a passive role. Instead of letting yourself get into a 'brain drain' state, why not include some brain energisers into your learning? The activities in Investigation 2.1 are examples of brain energisers that can: strengthen key areas of your brain; reduce your stress levels by lowering cortisol levels that can kill brain cells; provide your brain with oxygen and glucose; trigger the release of endorphins (feel-good chemicals) and adrenaline ('challenge' hormone); and enhance the development of neuronal growth and new connections.

BRAIN GYM

When was the last time your brain had a workout? Have you done your brain gym lately? Current research has established some significant links between movement and learning. Some examples of ways to incorporate more movement into your learning include drama, role-plays, energisers, and brain gym exercises such as cross-crawling exercises.

Cross-crawling exercises use movements between one part of the body (such as your hand, arm or leg) and a different part on the opposite side of the body. These exercises activate your brain's **visual** (prefer to visualise or see), **auditory** (prefer to hear the spoken word) and **kinaesthetic** (prefer movement, involvement and action) senses. They also help you to improve your coordination, spatial awareness, breathing and stamina. Some examples include touching your feet to the backs of opposite heels; hands to opposite ears, elbows, knees or hips; or elbows to opposite knees or ankles.

INQUIRY: INVESTIGATION 2.1

Movin' and groovin'

KEY INQUIRY SKILL:

- questioning and predicting

- Using the table below, roll a die for each column to find out which movement activities you will act out. For example, rolling the die combination '5, 4, 5' would result in the action 'skip, with your arms out, and with a partner to a door'.
- Once you feel confident with knowing what to do, let your cerebellum take over the actions.

DISCUSS AND EXPLAIN

1 Brainstorm and record several 'What?', 'How?' and 'Where?' type questions about your brain and learning.

2 Select one of each type of question, research it and share your findings with your team members.

What?	How?	Where?
spin	like a frog	around a table
hop	slowly	in one place
jump	gracefully	across the room
shuffle	with arms out	touching every chair
skip	on one foot	with a partner to a door
dance	quickly	back and forth

INQUIRY: INVESTIGATION 2.2

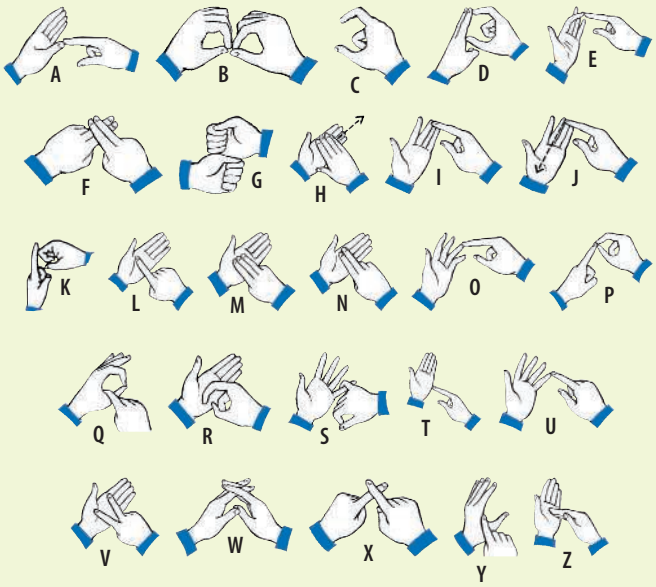
Hand gestures

KEY INQUIRY SKILL:

- communicating

1 Use the hand signals below to spell out the following words:
   - brain, visual, auditory, kinaesthetic, cerebellum, think, learn, cortisol, endorphins.

2 Use the hand signals on this page to sign to a student a word written in this chapter. Once they have responded correctly, let them sign a word for you to 'read'.



Getting in touch with your brain

Take a guess. What looks like a grey, clouded jelly dessert and is about the size of a large grapefruit?

Hint: you are using it to figure out what the mystery object is!

What is in your brain?

The average human brain weighs around 1.5 kilograms, is made up of about 80 per cent water, looks like a giant wrinkled walnut and is approximately the size of a grapefruit. Our brains contain billions of brain cells; however, only about 10 per cent are active **neurons** (nerve cells), with the remaining brain cells there to nourish and insulate the neurons. These neurons can grow up to 20 extensions called **dendrites**, which reach out like branches on a tree, allowing communication between other neurons. This communication is very important in relaying information about your environment and deciding what to do with it.

Brainy business

When you think, you are using your brain. Another name for thinking or mental activity is **cognition**. You also 'feel' with your brain. Happiness, sadness and anger are examples of feelings or **emotions** that are interpreted by your brain. The brain also has an important role in **regulating** life processes. To be able to do this, the brain detects your body's internal and external environments and responds accordingly to them. Some of the body's responses may be observable actions or behaviours, while others occur inside your body and may not be observed (without using technology).

More than just a bag of chemicals!

Your brain is more than just a mix of chemicals and cells. It is the control centre of all of your body's functions and is responsible for intelligence, creativity, perceptions, reaction, emotions and memories. It can be said that your brain is at the wheel, steering your body's systems so that it continues to function correctly, whether it's remembering the taste of chocolate, working out a crossword puzzle, controlling your heartbeat or monitoring the glucose level in your blood.

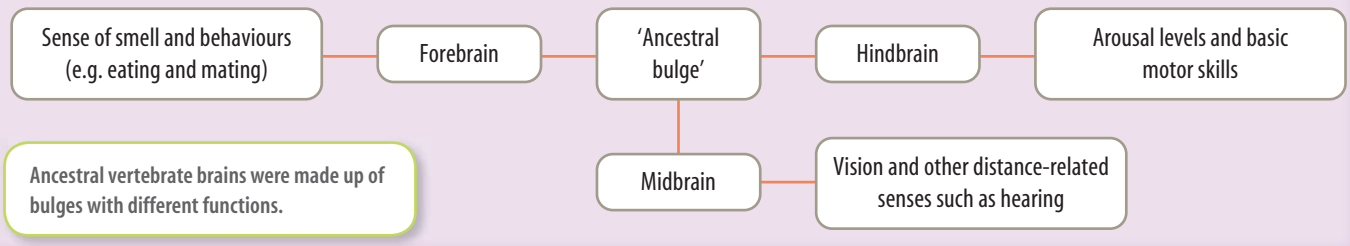
Patterns of organisation

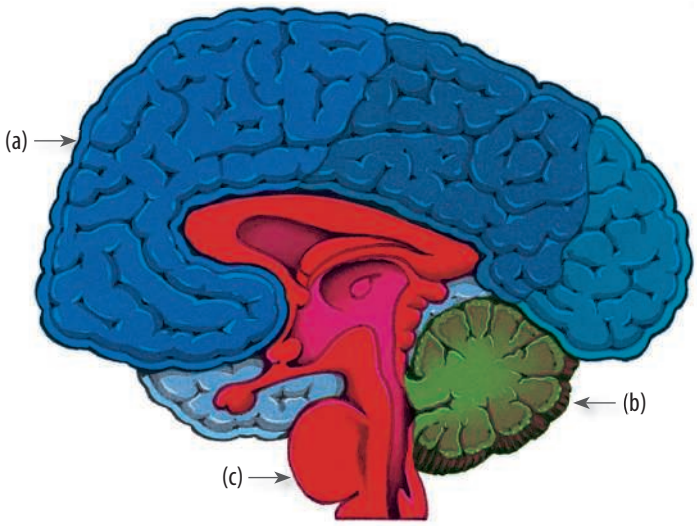
Your brain cells are organised into different areas within your brain. Although they may have different functions, they communicate and work together to keep you alive. There are a number of different models that are used to describe the structure of the human brain.

One model of the brain describes it as consisting of three main structures: the cerebrum, the cerebellum and the brain stem.

HOW ABOUT THAT!

Our vertebrate ancestors had brains that developed from a simple neural tube with bulges at one end. These ancestral bulges (or vesicles) were connected by nerve signals that wove their activities together. Although these bulges can still be seen in the early embryonic developmental stages of all vertebrates, as modern-day vertebrates develop, more divisions and complex connections are made.





Three key parts of your brain are (a) the cerebrum, (b) the cerebellum and (c) the brain stem (or medulla).

Cerebrum

The **cerebrum** is the largest part of the brain and makes up about 90 per cent of your brain's total volume. The cerebrum is responsible for **higher-order thinking** (such as problem solving and making decisions) and controls speech, conscious thought and voluntary actions (actions that you control by thinking about them). The cerebrum is also involved in learning, remembering and personality.

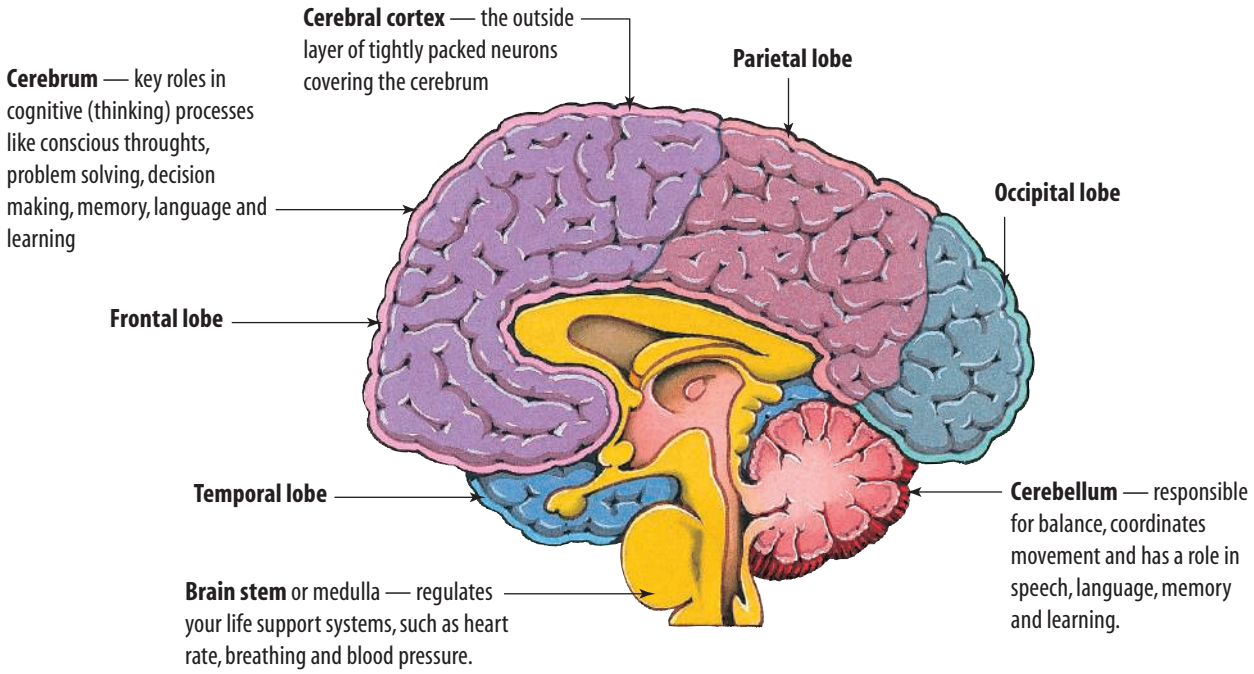
The cerebrum is made up of four primary areas called lobes. Each of these lobes is associated with particular functions:

- **Frontal lobe** — decision making, planning, working memory and higher order thinking
- **Temporal lobe** — hearing, explicit memories, words and pictures
- **Parietal lobe** — sensory information, motor functions and spatial awareness
- **Occipital lobe** — vision, pictures, colours and movement

You can use a piece of paper to model how the cerebrum can fit into such a small area. If you screw up the piece of paper so that it is roughly the size of your fist you can see how the cerebrum, with its large surface area, can fit into a small area within your skull. Its many wrinkles and folds are the reason that only about one-third of this structure is visible when you look at the outside of a brain.

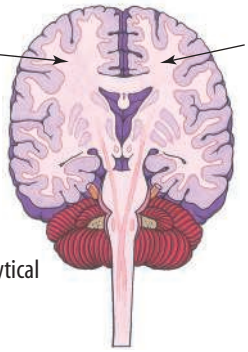
LEFT AND RIGHT — TWO BRAINS IN ONE?

Your cerebrum is divided into two grey wrinkly **cerebral hemispheres** — the right cerebral hemisphere (mainly responsible for the left side of your body) and the left cerebral hemisphere (mainly responsible for the right side of your body). While each hemisphere is specialised to handle different tasks they work together as an integrated whole, communicating with each other through a linking bridge of nerve fibres called the **corpus callosum**.



Left hemisphere:

- Recognises words, letters and numbers written as words
- Generates spoken language
- Tell how!
- Time-sensitive
- Deals with sequential and analytical processes
- Processes external stimuli



Right hemisphere:

- Recognises images (e.g. places, faces and objects) rather than words
- Interprets language through gestures, emotions, body language, tone of voice
- Show how!
- Deals with patterns and holistic information
- Processes internal stimuli

Although the left and right cerebral hemispheres communicate with each other, they have specialised functions.

Although each cerebral hemisphere processes information differently they are both involved in putting together the total picture of what you sense around you. During your learning, it is important to employ learning activities that utilise the strengths of both hemispheres (even if it can feel a little uncomfortable sometimes). This will allow you to focus on 'whole-brained' learning.

Cerebellum

What's grey on the outside, looks like two clams side by side, is about the size of your fist and without it you'd fall over? The answer is your **cerebellum**.

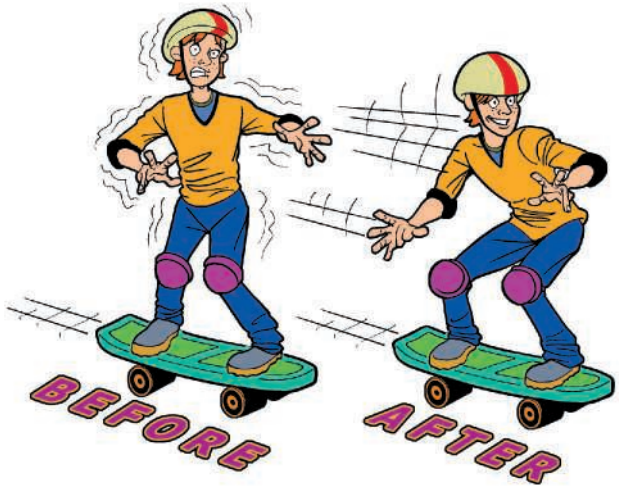
YOUR 'LITTLE' BRAIN

Your cerebellum is located near the brain stem, underneath the cerebrum. Although it takes up only about 10 per cent of your brain's volume, the cerebellum contains over half of all of your brain's neurons. Your cerebellum has key roles in posture, coordination, balance and movement. Current research also suggests that it may also be involved in memory, attention, spatial perception and language.

The word *cerebellum* means 'little brain' in Latin and that's just what it looks like. There are two halves (or hemispheres), one for each side of the brain. Each of these hemispheres consists of three lobes. There is a lobe that receives sensory input from your ears to help you to maintain your balance. Another lobe gets messages from your spinal cord to let your brain know what some other moving parts of your body are up to. There is even a lobe that communicates with your cerebrum, the thinking part of your brain.

Taking charge

When you start learning a new skill, you have to think carefully about what you are doing. Once you have got the hang of it, your cerebellum takes over from your thinking context to tell your body what to do. Research has shown that when the cerebellum is in charge, you can move faster and are less clumsy. Other research suggests that long-term memory traces for motor learning are located in your cerebellum and that movement may help your thinking because of increased signals travelling between your cerebrum and cerebellum.



Brain stem or medulla

Not all actions in your body require conscious thought. These are called involuntary actions and you don't need to think about them for them to occur. Breathing, heartbeat, blood pressure, coughing, vomiting, sneezing and salivating are all examples of involuntary actions controlled by your **brain stem**.

Your brain stem (or medulla) is located between your spinal cord and your cerebrum. If this vital structure is damaged, death may result. One of the reasons drugs such as heroin and cocaine are so dangerous is that they can impair the functioning of this structure, causing interruptions to heartbeats or breathing.

It's a bit like a . . .

Using **analogies** and **metaphors** can be very useful in helping you to connect information that you already know to new information. An example

INQUIRY: INVESTIGATION 2.3

Brain dissection

Equipment:

a semi-frozen sheep's brain

dissecting board

dissecting instruments (scalpel, forceps, scissors)

plastic ruler

paper towel

gloves

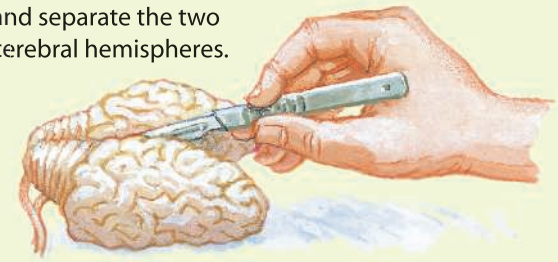
CAUTION: Handle dissecting instruments with care and ensure they are placed in a sterilising solution after use. Wear gloves throughout the dissection and wash your hands thoroughly at the end.

- Place the brain so that the cerebral hemispheres are at the top of the board and the brain stem is at the bottom.

- Identify the external features of the brain: the cerebral hemispheres, cerebellum and brain stem.
- Use your forceps and try to lift the meninges (membranes protecting the brain). You may be able to observe the cerebral fluid between these membranes and the hemispheres.
- Carefully observe the overall appearance of each structure and, using a plastic ruler, measure its size (length, width and height). Include this information in a table like the one above right.

Brain structure	Appearance			
	Colour	Texture	Other features	Size
Cerebrum				
Cerebellum				
Brain stem				

- Draw a diagram of the sheep's brain, labelling the external features.
- On your diagram, identify and label the part of the brain that controls the sheep's:
  (a) heart rate
  (b) balance required for walking
  (c) ability to locate its lamb.
- Using your scalpel, cut the brain in half between the right and left hemispheres, and separate the two cerebral hemispheres.



- Draw a cross-section of the brain. Be sure to label it!
- Now make a second cut down through the back of one of the hemispheres to see inside the cerebellum and brain stem.

DISCUSS AND EXPLAIN

1 Summarise your findings.

2 Suggest ways in which the experiment could be improved.

that has been used in the past is 'the brain is like a computer'. This provides a framework of known ideas to relate to new ideas.

While analogies and metaphors and models can be very useful in your learning, they also have limitations. The more we find out about the brain, the less suitable a previously used metaphor may be. Examples of other analogies that have been used for the brain include comparing it to a hydraulic system, a telephone switchboard and, more recently, an ecosystem in a jungle! These analogies often reflect the most current technological innovation of the time.

Did you notice examples of analogies and metaphors mentioned throughout these pages? How effective have they been in helping you 'get a handle' on new information about the brain?

FROM BACK TO FRONT

Your **hindbrain** is really a continuation of your spinal cord. It develops into the **pons** and cerebellum, and the **medulla oblongata** (medulla). Extending through your hindbrain and midbrain is a network of fibres called the **reticular formation** — a network of neurons that opens and closes to increase or decrease the amount of information that flows into and out of the brain. The reticular formation helps regulate alertness (from being fully awake or deeply asleep), motivation, movement and some of the body's reflexes (such as sneezing and coughing). The **forebrain** develops into the cerebrum, **cerebral cortex** (outer, deeply folded surface of the cerebrum) and other structures such as the **thalamus**, **hypothalamus** and **hippocampus**.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Name the organ that has been described as the control centre of your body.

2 Identify the part of your brain that:
(a) takes up the greatest volume
(b) regulates heartbeat, breathing and blood pressure
(c) generates the most complex thoughts
(d) coordinates movement
(e) manages communication between left and right hemispheres.

3 Use analogies to describe the appearance of the:
(a) brain
(b) cerebrum
(c) cerebellum.

4 What does the cerebellum look like?

5 About what percentage of your brain is taken up by your cerebellum?

6 Describe what happens when you learn a new skill such as riding a bike, knitting or skateboarding.

7 List some benefits of brain energisers.

8 What is cross-crawling and how may this be useful to you?

ANALYSE AND DISCUSS

Animal	Brain size as % of body mass
Mouse	10
Chimp	0.8
Elephant	0.1
Dolphin	1
Cat	1
Human	2

9 The table above shows the brain size as a percentage of body mass for a number of animals. Use this data, your own knowledge (and other resources if required) to answer the following questions.
(a) Construct a graph using the information in the table.
(b) Comment on any trends or patterns in the graph.
(c) Suggest and discuss two possible explanations for the observed patterns.
(d) Suggest a relevant hypothesis that could be investigated.
(e) Formulate three questions about how the data was collected (method used).
(f) Suggest three relevant questions that could be further investigated.

THINK, DISCUSS AND SHARE

10 Identify sensory system headings for each of the columns below.

?	?	?
I seem to be in the dark.	I hear you.	That feels right.
I see what you mean.	That sounded right.	Hold on…
I need to focus.	It just clicked.	Let's tackle…

INVESTIGATE, THINK AND DISCUSS

11 Christopher Reeve, the actor who played Superman in the early Superman movies, damaged his brain stem when he fell off a horse. Find out and report on:
(a) the effect this had on his brain function
(b) medical research that may help others with such damage.

12 Find out more about the cerebellum and how it may be involved in learning.

13 In teams, research the structure and functions of different parts of the brain.

INVESTIGATE, THINK, CREATE AND DESIGN

14 Design an instruction manual to help someone learn a new physical skill. Be creative and make it fun and exciting. Evaluate the effectiveness of your manual by trying it out on other students in the class.

15 Design an activity that uses the cerebellum to learn a more about the brain.

16 Nobel Prize winner Roger Sperry described the hemispheres of the brain as 'each with its own memory' and 'competing for control'.
(a) Find out why Roger Sperry was awarded the Nobel Prize in medicine in 1981.
(b) Do you agree with his comments about the brain's hemispheres? Explain.
(c) Construct a model of the right and left hemispheres that creatively shows the types of tasks that they are involved in.

17 Construct a plasticine model of the brain using different colours for different structures.

eBook*plus*

18 Use the **Brain interactive** weblink in your eBookPLUS to find out about the parts of brain that control your body.

The sights and sounds of learning

Look, hear, feel and explore! Your senses provide you with information about your external environment. They are important for your survival. They are also very important in your learning.

Light and learning

LOOK AND LEARN

Next time you enter your classroom, notice what you see around you. Are there posters, colours, objects, shapes or plants? Since 80–90 per cent of all information absorbed by your brain is usually visual, the colour, contrast, shapes and movement changes of your learning environment are very important. Your eyes can register 36 000 visual messages in an hour, and about 40 per cent of all of the nerve fibres in your brain are connected to the **retinas** of your eyes.

LEARNING LIGHTING

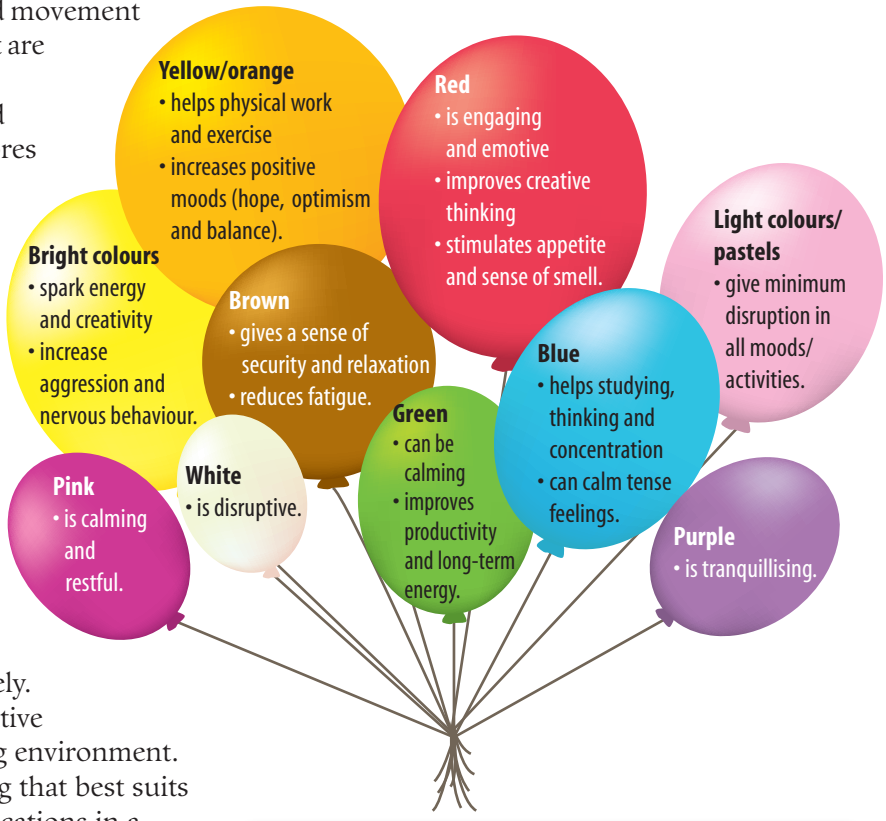
Light strongly influences learning. This may be the type of lighting used in a room or the length and brightness of daylight. For example, a flickering fluorescent light can have a very powerful effect on your central nervous system. Your brain may react by releasing a chemical called **cortisol** in your blood (in response to stress) and you may blink excessively. Soft natural light, however, has a positive impact on the quality of your learning environment.

There is a particular level of lighting that best suits your learning. Try sitting at various locations in a room and record how you feel and work in different types of lighting.

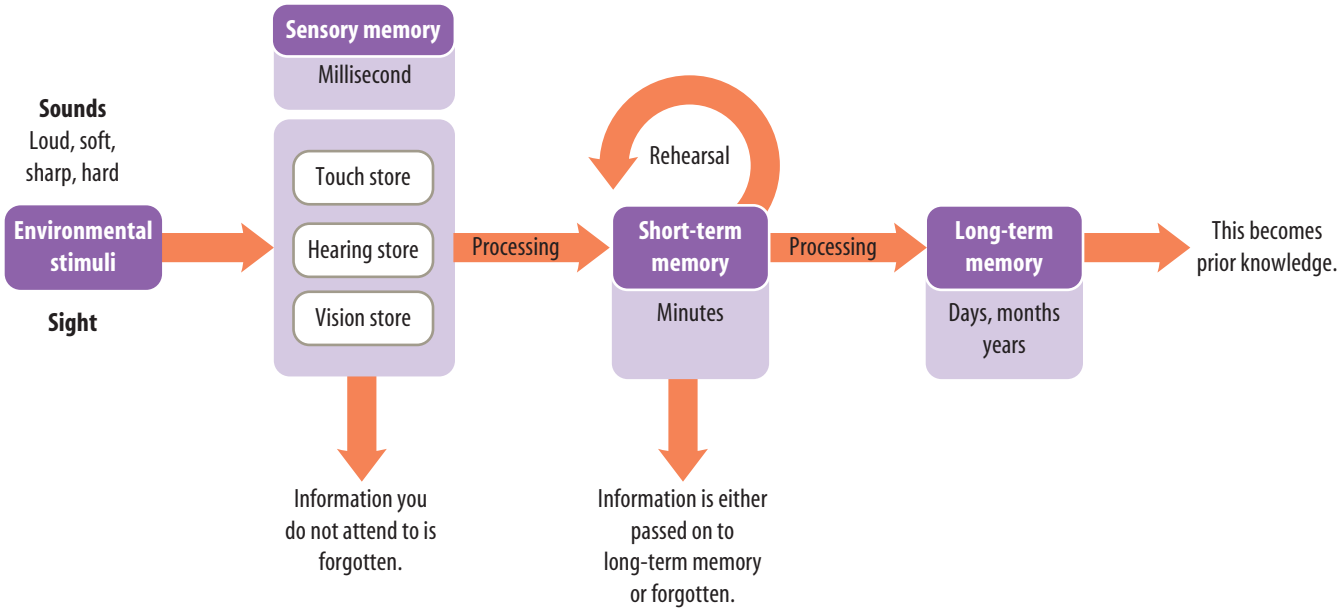
The seasons, with their varying amounts of daylight, can affect your body's **melatonin** and hormone levels and influence the release of neurotransmitters. This can affect your concentration, energy and moods and hence have an impact on your learning.

COLOURED LEARNING

The way in which a colour affects you depends on your personality, previous experiences and state of mind at that moment. Yellow, light orange, beige or off-white are colours that seem to stimulate positive feelings and may be used for optimal learning. In general, we remember colours first and content second.



Do you agree with the colour claims suggested in the balloons? How could these claims be tested? What effects do these colours have on your learning and moods? Which colour or colours do you consider to be most effective for your learning?



Sounds like learning

Is there a particular song or music that brings back memories when you hear it? Do different types of music have different effects on how you feel? Do you remember singing *The alphabet song* or *Twinkle twinkle little star*?

MOOD MUSIC

Music can influence your moods and how you feel about things. Some types of music lower your stress levels by lowering your heart rate, influencing your brain's chemicals and creating a receptive state of mind. Other types of music may improve your long-term memory and ability to think, concentrate and be creative. Music can be used to bind learning to meaning, trigger memories, help with emotional learning or get you ready for a particular learning activity or way of thinking.

USING MUSICAL CLUES TO LEARN

The use of music can contribute to helping learners feel happy and comfortable in their learning environments. Even using other sounds such as clapping games, singing, nature sounds and simple rhythms may alter physiological states and increase receptivity for learning.

Get someone to sing *The alphabet song* while you sing *Twinkle twinkle little star*. Did you realise that they are the same tune? This is an example of learning a melody and then 'gluing' other information — in this case, the letters of the alphabet — into the tune.

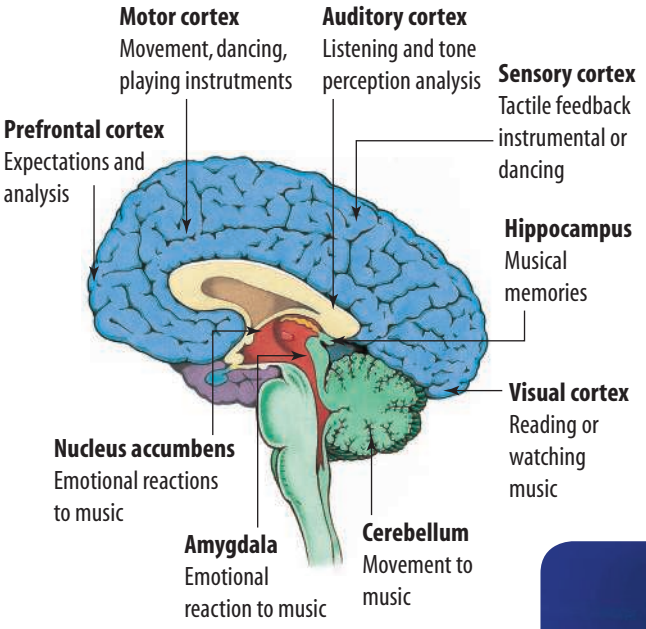
The volume, rhythm, structure, tone and pitch of music can influence your mood. Different types of activities and learning can also be enhanced by using music with different tempos, measured in beats per minute (bpm).

Examples of possible effects that different tempos of music might have on your learning are shown in the table below. Do you agree with these claims? What effects (if any) do you think different types of music have on your learning and moods? Do you think it is the same for everyone?

Beats per minute (bpm)	Possible effects on your learning
90–120	Great for when you need to be active and energetic
60–70	Works well when you need to be creative and solve problems
50–60	Helps stimulate your brain, useful for studying and learning
40–60	Calms body and mind and great for visualisation
30–60	Best for reducing anxiety, useful at exam time or when making presentations

MUSIC AND EMOTIONS

Singing can increase the production and release of the 'trust hormone' **oxytocin.** This hormone can increase feelings not just of trust but also of connectedness with others. Have you ever experienced this when you have sung with others? Is this why humans sing



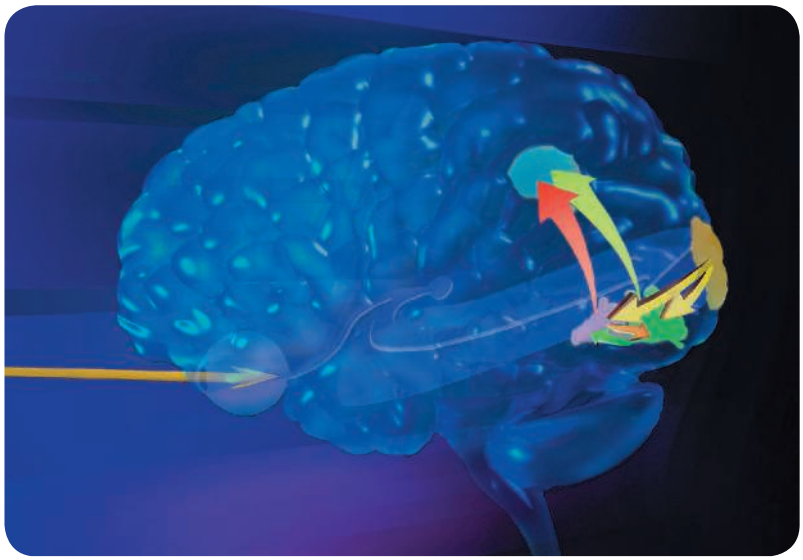
national anthems, hymns and other songs together? Has the possible connection between music and emotions increased the chances of the survival of our species?

TASTY WORDS AND COLOURFUL LETTERS?

A small percentage of the population have their senses crossed and associate letters with a flavour, numbers with a gender and sounds with colour. This condition is known as **synaesthesia**. It has been likened to receiving information in one sense and it triggering an experience in another. So while you might hear music, the sounds trigger seeing particular colours! There are thought to be at least 54 documented types of this condition. Currently there is exciting research being conducted in this area, investigating how people with this condition form and remember memories. Some of these investigations involve the use of **functional magnetic resonance imaging (fMRI)** to get a 3-dimensional image of the brain so that the areas of the brain that are activated during different mental tasks can be recorded.

SYNAESTHESIA
0123456789

Someone with synaesthesia might perceive certain letters and numbers as they are shown here.



An illustration of synaesthesia, showing a light stimulus carried through the visual pathway to the visual cortex and then sent to anomalous areas of the brain, giving rise to sensations other than vision. Synaesthesia is a neurological condition in which two or more bodily senses are coupled; for example, a colour may evoke a sound.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Approximately what percentage of:
   (a) information received by your brain is visual
   (b) nerve fibres in your brain are connected to your eye's retinas?

2 Construct a flowchart to shown the relationship between environmental stimuli, your senses, short-term memory and long-term memory.

3 State which colours are claimed to:
   (a) stimulate appetite and sense of smell
   (b) be calming
   (c) give a sense of security and reduce fatigue
   (d) stimulate an overall sense of optimism, hope and balance.

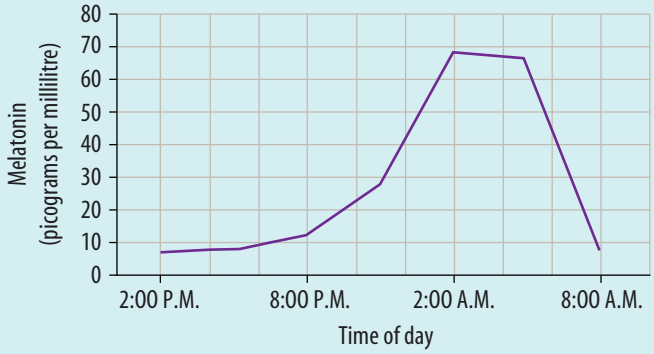
4 Outline ways in which music can influence moods and learning.

5 Suggest how music can be used to 'glue' your learning.

6 Outline a suggested link between oxytocin, singing and trust.

7 Suggest a difference between how people with synaesthesia experience the world and how those without the condition experience the world.

ANALYSE, INVESTIGATE AND DISCUSS



8 (a) Describe the pattern observed in the melatonin levels in the graph above.
(b) Suggest an interpretation of the observed pattern.
(c) Use other resources to find out more about melatonin and its effects on your body.
(d) Suggest a link between light, melatonin and the body's resulting responses.
(e) Suggest how melatonin levels may affect your learning.
(f) Research seasonal affective disorder (SAD) and determine a possible link to melatonin levels.
(g) Find out about and report on at least one example of research related to melatonin.

INVESTIGATE, THINK AND DISCUSS

9 *Brains react to music like a drug*. This was a claim made in the media in 2011. It was based on a scientific study that used PET (positron emission tomography) and fMRI brain scans to record brain activity of volunteers while they listened to their favourite piece of music. The PET scan detected a release of dopamine (a neurotransmitter responsible for feeling a sense of reward and pleasure) in their brains and the fMRI scan showed increased blood flow to the emotional response areas.
(a) For this investigation suggest:
(i) a hypothesis
(ii) the dependent variable(s) and independent variable
(iii) an appropriate control group
(iv) controlled variables.
(b) Find out more about similar investigations. Is the media claim supported by your findings? Explain.

10 Find out more about the Nobel Prize winning physicist Richard Feynman, who described seeing equations in colour, and the expressionist artist Wassily Kandinsky, who associated musical tones with specific colours.

11 Use the **Synaesthesia** weblink in your eBookPLUS to find out about different hypotheses regarding synaesthesia and the types of research that scientists are currently involved in. On the basis of your findings, what hypothesis, would you suggest?

12 Recently a technique called diffusion tensor imaging (DTI) has been used to compare the connectivity between the brains of grapheme–colour synaesthetes and non-synaesthetes. Find out more about this research and the findings.

INVESTIGATE, CREATE AND DESIGN

13 Do you think that music has an effect on how you learn? Suggest an appropriate hypothesis and design an experiment to test it.

14 Your sense of smell can also play a part in your learning. Investigate which smells (or odours) are claimed to:
(a) enhance mental alertness
(b) encourage relaxation
(c) generate feelings of pleasure and wellbeing.
Design an investigation to determine whether any of these claims can be supported. Graph your results so that they can be analysed and interpreted. Share your findings with others.

15 Select one of the environmental influences on learning listed below and find out the effects that it may have on your body, and hence on your learning.
- Colours
- Types of lighting
- Plants
- Room arrangement
- Objects
- Seating options

16 Find out about the relationship between melatonin, light and jet lag. Present your findings in a poster, brochure, cartoon, newspaper article or PowerPoint presentation.

17 What is seasonal affective disorder, when is it likely to occur and how can it be treated?

18 Think about the effect of your visual learning environment. What would you change to make it better suited to your personal learning? Design your ideal visual learning environment on a poster. Compare your design with those of other classmates and discuss the similarities and differences.

19 Find information on the suggested effects on learning of one of the following and then critically analyse its validity. Share your analysis with others.
(a) Colour
(b) Light intensity or light source
(c) Music

Getting emotional

Feeling happy, sad, scared, disgusted or angry? Did you know that these six basic human emotions are caused by the effects of chemicals binding to receptor sites on your cells?

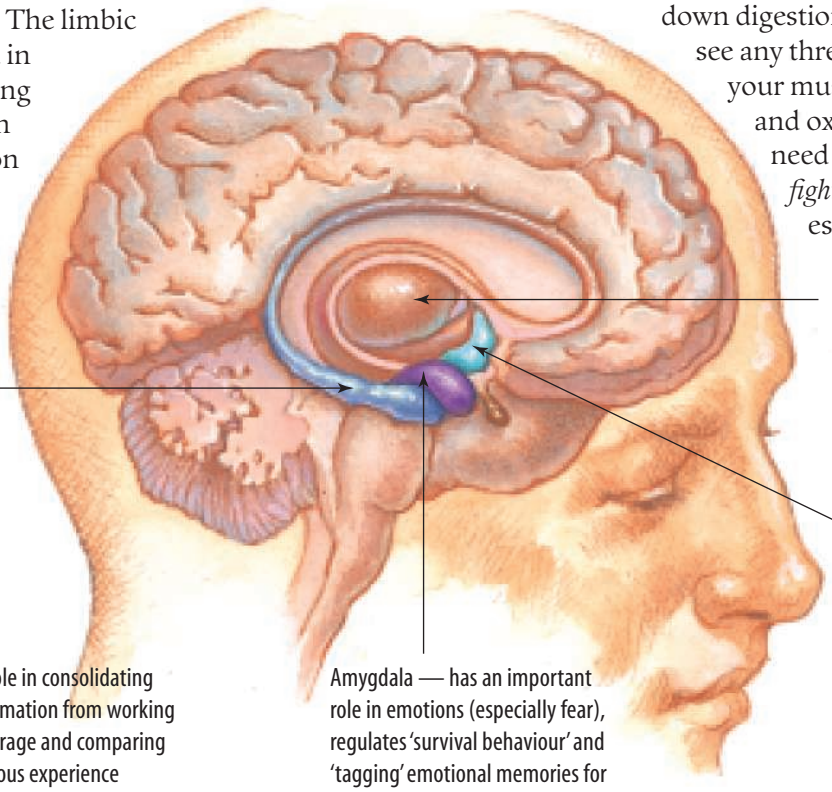
Just survive!

Imagine a situation in which you have felt threatened. How did you feel? How did you react? Did you want to run, or did you want to stay and fight?

Your emotions enable you to react to situations. They influence your behaviour. Our ancestors relied on their emotions to survive. Sometimes there is no time to think about how to react to a situation. This is when your emotional brain can get into the driver's seat and take control.

Your emotional brain

Your 'emotional brain' or **limbic system** is made up of a collection of structures within your brain. The limbic system is involved in memory, controlling emotions, decision making, motivation and learning.



Thalamus — all sensory information coming in from the outside (except smell) first goes to the thalmus and then is directed to other parts of the brain for additional processing.

Hippocampus — a key role in consolidating learning, converting information from working memory to long-term storage and comparing new information to previous experience (which is essential in the creation of 'meaning')

Amygdala — has an important role in emotions (especially fear), regulates 'survival behaviour' and 'tagging' emotional memories for long-term storage.

Hypothalamus — monitors internal systems and controls the release of hormones to maintain the normal body state (homeostasis).

These include parts of your thalamus, hypothalamus, hippocampus and **amygdala**. While your hippocampus has an important role in forming long-lasting memories, your amygdala seems to act as a memory filter, labelling information to be remembered by tying it to events or emotions that are experienced at the time.

Your angry brain

Feeling angry? Is your heart racing; are your hands cold; do you have a sick feeling in your stomach? Anger can be one of our most primitive emotions. It is certainly a powerful one. Uncontrolled anger can lead to physical fights, arguments and self-harm. Controlled anger, however, can be a very useful emotion that can help motivate you to make positive changes.

When you feel angry, your hypothalamus responds by sending messages to your **pituitary** to instruct your **adrenal glands** to release **adrenaline**. This hormone acts to increase your heart rate, dilate your pupils, constrict skin blood vessels and shut down digestion. This helps you to see any threats better and provides your muscles with more glucose and oxygen just in case you need to face the danger and *fight*, or take *flight* and escape it by running away.

Playing tag?

Your 'flight or fight' response actually originates in your amygdala. It is this tiny part of your limbic system (about the size of your thumbnail) that decides the emotional value of what is happening. It asks: 'Does this mean something significant to me?' It may sense a particular facial expression or tone as being threatening, or it may detect an event that was previously 'tagged' as being a negative experience.

Keeping the anger

Staying angry, or long periods of stress, can damage another part of your limbic system called your hippocampus. If the stress or anger lasts more than a few minutes, your adrenal glands also release cortisol. Sustained high levels of this hormone can lead to the death of hippocampus neurons, which may result in diminished learning, spatial recall and memory.

False alarms

Your prefrontal cortex or thinking brain is also involved in assessing a threat and placing it in context. If your thinking brain considers it to be a false alarm, it sends a message to your hypothalamus to trigger actions to calm things down; it does this by sending out messages to decrease your stress hormone levels and their effects.

Anger management

Feeling constantly angry or stressed can be unhealthy. It can not only make you feel unhappy and possibly be hurtful to others, but also interfere with the normal functioning of your body. It's good to be able to manage your anger and to do this you need some strategies to help calm you down and prevent outbursts.

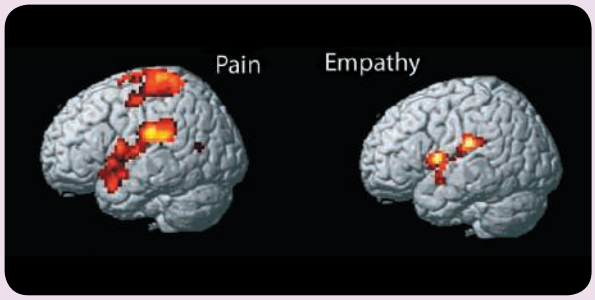
Mirrored feelings

Feel upset, or feel upset for someone else? **Mirror neurons** are a group of neurons that activate when you perform an action and when you see or hear others performing the same action. Research is suggesting that these neurons are important in being able to feel **empathy** towards other people. If this theory is further supported, how could this connection increase the chances of the survival of our species?

HOW ABOUT THAT!

MRI technology

Early brain research used dead or diseased brains. Advancements in scientific applications of technology have enabled researchers to examine living brains. One such technology is magnetic resonance imaging (MRI) which allows scientists to actually see which parts of the brain are active when various tasks are performed; these parts 'light up' with different colours to show brain activity.



Brain studies using MRI have produced some very interesting findings! These images show the responses of a person in pain (left) and a person watching someone in pain (right).

Mood chemistry

Neurotransmitters are chemicals involved in passing messages between your nerve cells (neurons). Within your brain there are many neurotransmitters that influence how you feel and react; **serotonin**, **norepinephrine** and **dopamine** are three examples. Imbalances of these neurotransmitters can contribute to a variety of mental illnesses.

Serotonin acts like the brakes on your emotions. It can produce a calming effect and is important for maintaining a good mood and feelings of contentment. It also plays a role in regulating memory, appetite and body temperature. Low levels of serotonin can produce insomnia, depression and aggressive behaviour and are also associated with obsessive–compulsive and eating disorders.

Norepinephrine can act like the accelerator. It can promote alertness, better focus and concentration. Your brain also needs this chemical to form new memories and to transfer them to your long-term storage.

Dopamine is important for healthy assertiveness and autonomic nervous system function. Dopamine levels can be depleted by stress or poor sleep. Too much alcohol, caffeine and sugar may also lead to reduced dopamine activity in your brain. People with Parkinson's disease have a diminished ability to synthesise dopamine.

HOW ABOUT THAT!

When you are experiencing a time of stress, your survival instincts take over. You produce chemicals that place your body in a heightened alert phase, to help prepare you for a possible dangerous situation. When you are in a stressed state it is difficult to use your higher order thinking, and you may find it difficult to learn effectively.

Feeding your emotions

To be able to make these neurotransmitters, your body needs the raw materials from nutrients in the food that you eat. Of particular importance are amino acids such as tryptophan (obtained from food sources such as cottage cheese, peanuts, red meat and brown rice), tyrosine (from foods such as almonds, avocados, bananas and dairy products) and phenylalanine (found in foods including meat, fish, eggs and soy products). Both dopamine and norepinephrine are made up of these three amino acids. Tryptophan is important in the synthesis of serotonin.

Fooling the brain

In order to pass a message from one neuron to another, neurotransmitters are recognised by a matching receptor on the membrane of the receiving nerve cell. Even though the receptor is supposed to recognise and accept only one specific neurotransmitter, it can be fooled. Some drugs, medicines or plant compounds have a chemical structure similar enough to trick a receptor and hence have an effect on your brain. (See section 1.8 for more information on this topic.

When a neuron receives a message, it travels along within it as an electrical impulse. Neurotransmitters are released by this activated cell and travel across the gap or **synapse** to activate the next cell, so that the message continues.

Neurotransmitters are chemicals that carry messages between neurons.

Emotions and learning

Are emotions gatekeepers to your intellect? Are emotions important to your learning too? If emotions are important to your learning, are some emotions better than others? Can some emotions actually interfere with your learning?

If this is the case your learning can be enriched if you are in a safe, caring and inviting climate for learning. If you were to describe your ideal learning environment, what would it look like, feel like and sound like?

FEELING SAFE AND TAKING RISKS

In a safe and caring environment, learners can learn by trial and error, ask questions and feel safe enough to risk making mistakes or getting something wrong. When the learner experiences stress or feels threatened, survival instincts can take over. Chemicals are released that place their body in a heightened alert phase, to help prepare them for a possible dangerous situation. If a learner is in this stressed state it is difficult to use higher-order thinking, and it can be difficult to learn effectively.

While your hippocampus has an important role in forming long-lasting memories, your amygdala can act as a memory filter, labelling information to be remembered by tying it to events or emotions that are experienced at the time.

When you are experiencing a time of stress, your survival instincts can take over. You produce

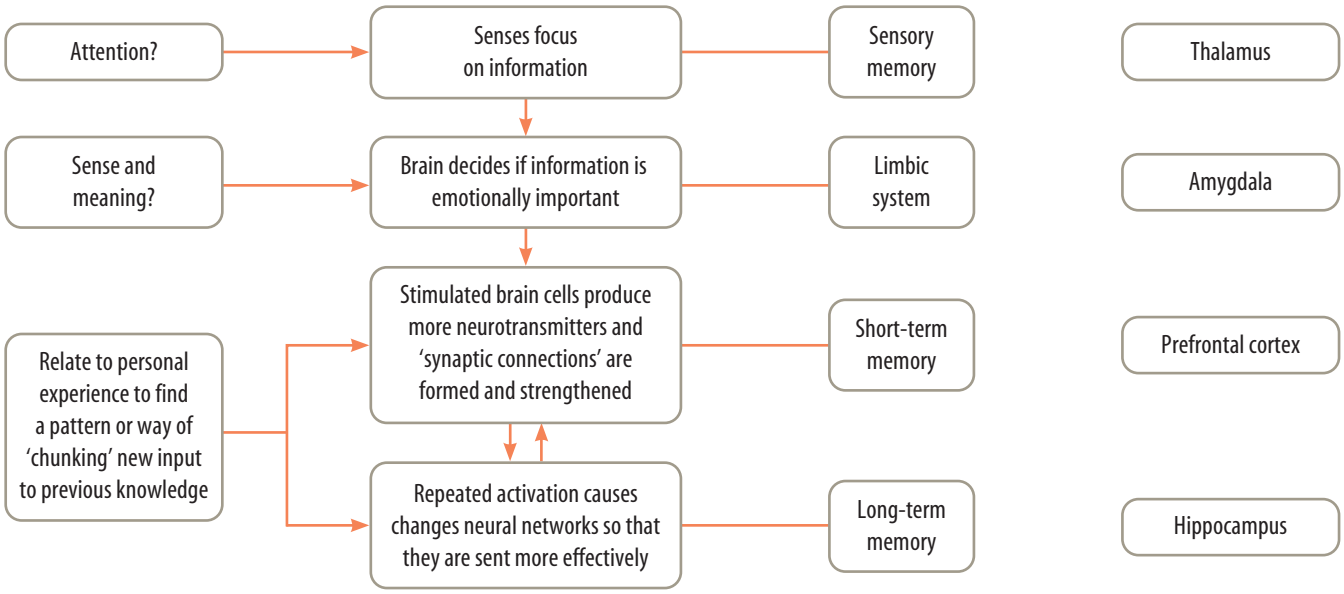
HOW ABOUT THAT!

Differences in the ways that male and female brains are 'wired up' can mean that their responses to some situations may be different. Being confronted with danger and anxiety is one such example. In reaction to danger or stress, your brain gives a signal to produce hormones that will trigger a chain reaction in your body. While most of the hormones are the same for both males and females, there are some differences.

When males are faced with danger, they often have a stronger tendency towards action, reacting in an outwardly directed fashion. This is due to the effects of testosterone. Females, however, are influenced by the effects of the hormone oxytocin. This can result in a tendency to seek safety, talk with others they trust and often to internalise their behaviour.

chemicals that place your body in a heightened alert phase, to help prepare you for a possible dangerous situation. When you are in a stressed state it is difficult to use your higher-order thinking and you may find it difficult to learn effectively.

Not all challenges and stresses are bad for learning. When the brain is faced with a challenging, intricate and complex problem, all of its parts can be involved and attention, meaning and relevance for learning can result.



Your emotions can influence what you pay attention to, where you find 'sense and meaning', and which previous knowledge you have stored into your long-term memory.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Name one of our most primitive emotions.
2 Is anger always a bad thing? Explain.
3 Name two hormones that may be involved when you are stressed.
4 Where is your amygdala located in your body?
5 What do neurotransmitters do?
6 How can some drugs trick your nervous system?
7 (a) Which amino acids are required for the synthesis of dopamine and norepinephrine? Name some foods that these are found in.
(b) Which amino acid is important for the synthesis of serotonin? Name some foods that it can be found in.
8 Construct a cluster or mind map to summarise what you know about neurotransmitters in your brain.
9 Suggest why males and females may not always react the same way when faced with a stressful situation.

INVESTIGATE AND DISCUSS

10 (a) Research the effects of at least three different human hormones, such as testosterone, adrenaline, cortisol and oestrogen, and then report your findings back to your team.
(b) Use this information and your own opinions to discuss the following question: *Do our hormones determine who we are and what we do, or can we have some conscious control over this?*
(c) In your team, decide on a brief statement that summarises the opinion.
(d) How strongly do you agree with your group's opinion? Rate your response on a scale of 0 to 5, with 0 meaning 'Strongly disagree' and 5 'Strongly agree.' Give reasons for your response.
(e) Survey your class or do a class spectrogram to determine how many of, or the degree to which, your class members agree with this statement.
(f) Find out and record differing opinions of as many of your class as you can.
(g) Have you changed your initial opinion or has it stayed the same? Explain.

CREATE AND CONSTRUCT

11 (a) On your own, in a pair or in a team, write a story about anger management.
(b) Present your story to the class as a puppet play, picture storybook or song.

THINK AND DISCUSS

12 What if no-one ever got angry? Would this be a good thing? Imagine what the world would be like. Construct a PMI chart about your imagined world.

13 (a) List some examples of angry behaviour that you have seen.
(b) Suggest ways in which this angry behaviour could have been managed.

14 Discuss appropriate ways of managing behaviour. Which of these appeal to you? Why?

15 (a) If you were angry with one of your team members or classmates, suggest appropriate ways of managing your anger.
(b) With your team, agree on a set of rules or strategies that could be used to manage anger or conflicts if they occur.

16 (a) Suggest questions to find out viewpoints, perspectives and opinions of others.
(b) With your team or class, discuss strategies that could be used to deal with situations when viewpoints differ.

17 If anger is one of our most primitive emotions, it must have some survival advantages. Discuss with your team what these advantages might be. Present your findings in a visual tool.

INVESTIGATE, THINK AND DISCUSS

18 Have you seen a young child throw a tantrum? This is a case of not being able to control emotions. Although the child's amygdala is fully mature, the necessary links with the cortex are not yet fully developed. Find out more about these links between different parts of the brain and their effects on behaviour. How could you explain this to the parent of a toddler?

19 Find examples of music that helps relax you and calm you down when you are feeling stressed. Share your music with others to see if it has the same effect on them.

20 Some convicted murderers may have killed in a 'fit of rage'. Find out if there are any documented links between committing murder and frontal lobe activity in the brain.

21 A high-carbohydrate meal can increase your brain's tryptophan levels.
(a) What effect might this have on your mood?
(b) Which neurotransmitter is likely to be involved?
(c) At what time of the day would it be a good idea to have such a meal? Why?

22 A high-protein meal can raise tyrosine levels in your blood and brain.
(a) What effect might this have on your mood?
(b) Which neurotransmitter(s) is/are likely to be involved?
(c) At which time of the day would it be a good idea to have such a meal? Why?
(d) If tyrosine is also needed to make active thyroid hormones, what may result if there are insufficient levels of this amino acid in your blood?

23 Find out about the connections between brain neurotransmitters, behaviour and the following medications: Prozac, Zoloft, Topamax, Provigil and Abilify. Report your findings to the class.

24 In 1947, the Swedish biologist Ulf von Euler discovered norepinephrine and later won a Nobel prize for his research. Find out more about research into this neurotransmitter and how it may be involved in helping you to learn.

25 *Our emotions are our personalities*. Do you agree with this statement? Discuss your opinion with others in your team. Present a summary of your discussion to the class.

26 Select one of the following statements, then find out what information you need to know in order to make a decision as to whether the statement is correct or incorrect.

- Males need competition so that they feel stimulated and know their place in the hierarchy, whereas females first do things to be liked and, if that doesn't work, then use a 'victim strategy'.
- Boys are more interested in objects, and girls in human relations.
- In order for boys to achieve at school, they need to compete and struggle through the class hierarchy.
- Male thinking is more competition-driven whereas female thinking is more security-driven.
- Males collect facts whereas females are more interested in the relationship between the facts.

27 Can fears or phobias be unlearned? Find out more about research involving chemicals such as glutamate to achieve this.

28 Investigate and report on problems associated with extreme emotions.

29 Select one of the statements below and use both your own experience and that of others expressed in the media to discuss it from different perspectives.

- To an extent, emotions can justify our actions.
- Emotion has its own language.
- Emotion is more powerful than reason.

2.1 Body continuum
2.2 The brain

Remember me?

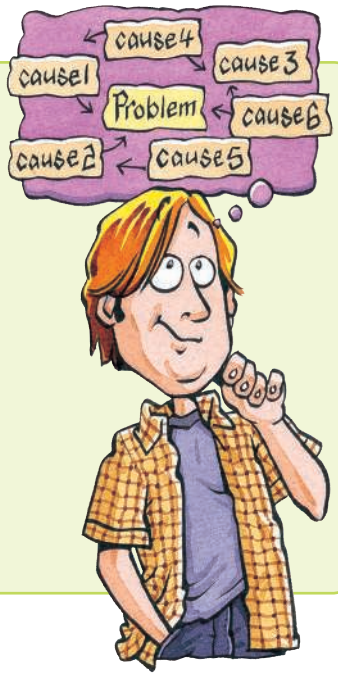
While learning is about gaining new knowledge, memory is about retaining and then retrieving that knowledge.

Learning memories

You have a number of memory systems for different types of learning. These include: spatial memory, procedural memory, episodic memory, working memory and semantic memory.

MENTAL MAPPING

Your **spatial memory** is your 'map' memory. You use this memory to make mental maps of where things are and how to get from one place to another. You can strengthen this memory by drawing maps, using visual thinking tools or graphic organisers.



SKILL LEARNING

Your **procedural memory** is your 'skill' or 'how to' memory. This memory system is often involved in learning physical activities such as throwing a ball, writing your name or riding a bicycle. Although skills can be difficult to master at first, repeatedly practising them can eventually make them easy and automatic.

WHAT'S ON YOUR MIND?

Your **working memory** is your 'thinking' memory. It refers to what you remember at a given moment — literally 'what's on your mind'. It allows you to deal with recent information and temporarily store it. Studies suggest that you can keep up to seven pieces of information in mind at one time. You can develop this memory by reflecting on your own thinking, taking notes and sharing your thinking with others.

EVENTFUL EPISODES

Episodic memory is designed for 'episodes' or events that occur at one time and place. When events are emotionally charged or rich in sensory details, they are more likely to be stored in long-term memory. When you are emotionally engaged in an event, your brain's neurons fire faster and increase the chances of you remembering it. Using memory journals, reliving the event or changing your learning environment can enhance this type of memory.

TELL ME FACTS

Your **semantic memory** is your 'fact' memory. These memories are created through practising repeatedly, connecting your new learning to your old learning, using mnemonics and making the information meaningful to you.

UNLOCKING YOUR MEMORY DOORS

There are keys that you can use to unlock your memory doors. Seven of these are primacy, recency, repetition, standing out, association, chunking and visuals.

Primacy and recency

When you read a book or see a movie you will usually remember the beginning and the ending. **Primacy** is about recalling and remembering the first time that you do something. **Recency** is the opposite. It is remembering the last time or the ending.

Repetition

Repetition, or regularly reviewing information, is needed to reactivate your stored memory and prevent it from being buried under layers of other information. Research suggests that you can achieve about 90 per cent recall if you review content within 24 hours. This drops to 30 per cent if you review after 72 hours (3 days). Repetition can be achieved visually, by reading, playing games with the new information, highlighting or using visual thinking tools.

Standing out

Think about a lesson that you remember well. What made it more memorable than other lessons? Was it fun? Was there something different or new about the experience? Did you use mnemonics or analogies? A **mnemonic** is a technique that helps you remember something. This may involve telling a tale (using key terms within a story), linking (linking terms and images) or using acronyms (using the first letters of words; for example, SPEWS). Some of these ideas are very effective because they overlap with other memory keys. All of these things can help content stand out and make it easier for you to remember it.

Association

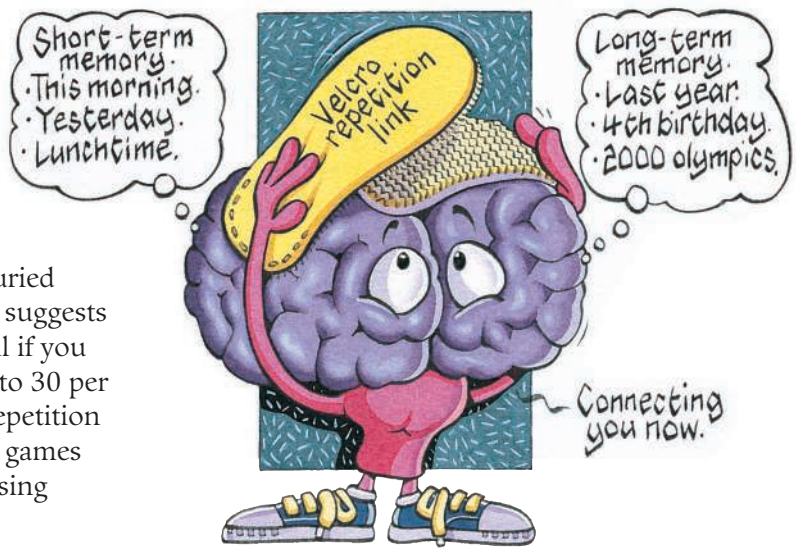
If new knowledge is linked to previous knowledge your recall is greatly enhanced. This is called learning by **association**. It helps you to anchor the information in time and space. Using real-life examples or metaphors can assist in this, as can the use of smell, music and colour.

Chunking

How do you eat a whole elephant? The answer of course is 'a bit at a time'. Learning is similar. You don't have to learn it all at once. The short-term memory of teenagers can usually contain only five (plus or minus two) bits of information at once. By organising information into small **chunks**, it is easier to remember it.

Visuals

Reading text in colour can help you to use both sides of your brain. The same can be said for a dramatic acting out; for example, performing the story of how blood flows through your body.



Repetition is like Velcro linking your short-term memory to your long-term memory.

How the brain learns

Your brain processes different types of learning through different pathways. This can depend on whether the source of the new information is from your **internal environment** (inside your body) or **external environment** (outside your body).

Memory neurotransmitter

A key neurotransmitter involved in learning and memory formation is **acetylcholine**. This neurotransmitter is released in the brain during learning. Acetylcholine is involved in the strengthening of connections between neurons in the brain and hence in the formation of new memories. Consequently, drugs that boost the amount of acetylcholine release are used as an effective treatment for diseases such as Alzheimer's, that impair cognition.

MEMORY BLOCKERS

Scientists are working on drugs to improve or even erase memory. Drugs that can enhance learning are being sought as an easy way to do well in tests and exams. However, there are disadvantages and advantages to drugs designed to block memories.

Current research includes studies on drugs that specifically block or erase problem memories at the molecular level. While this can be a great advantage to those who suffer post-traumatic stress disorder (PTSD), there are concerns that other memories could also be erased.

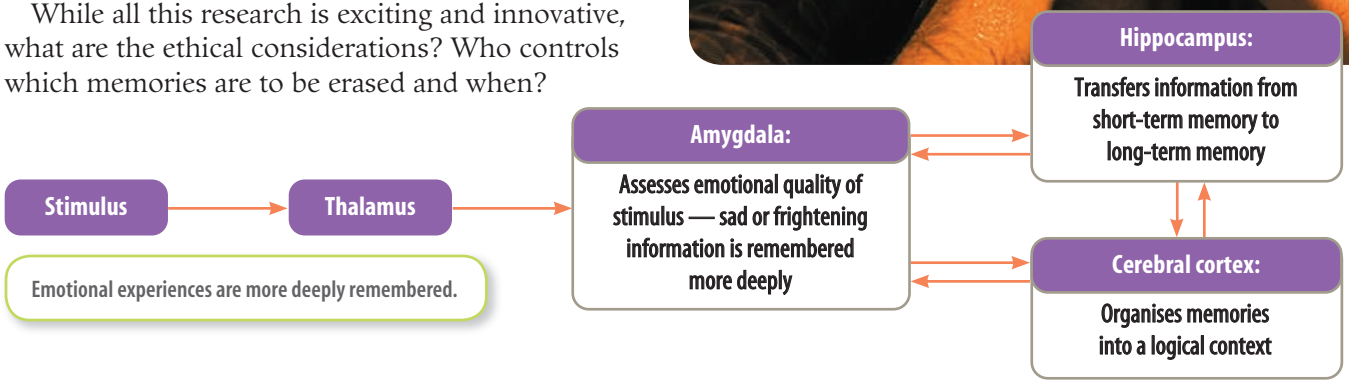
Researchers are exploring the possibility of using chemicals called beta-blockers, cortisol and hydrocortisone to alter our memory processes. Beta-blockers can bind to the receptors on the cell surface that would usually bind to adrenaline and noradrenaline. By blocking these hormones, beta-blockers may stop the hormones' stressful effects and prevent deep memory formation.

While all this research is exciting and innovative, what are the ethical considerations? Who controls which memories are to be erased and when? What do bad memories have to do with our consciences and our perceptions of right and wrong? Will there be global rules and regulations? If so, who will write them and make sure that they are maintained?

STRESSFUL MEMORIES DOWN DEEP

Your hippocampus and amygdala are also involved in emotional responses to an experience or memory. When your sense organs pick up a stimulus it goes to your thalamus and is then dispatched to your amygdala to assess its emotional quality. If it is recognised as potentially threatening, it triggers your body to release adrenaline and noradrenaline to set you up for fight or flight. The hippocampus then processes the memory and imprints it deeper than it would other memories. This will allow you to be primed quickly for action if it occurs again.

In this way, memories of traumatic or highly emotional events are burned into your brain more deeply and are remembered for longer. While in evolutionary terms this may have increased our chances of survival, traumatic events can result in PTSD.

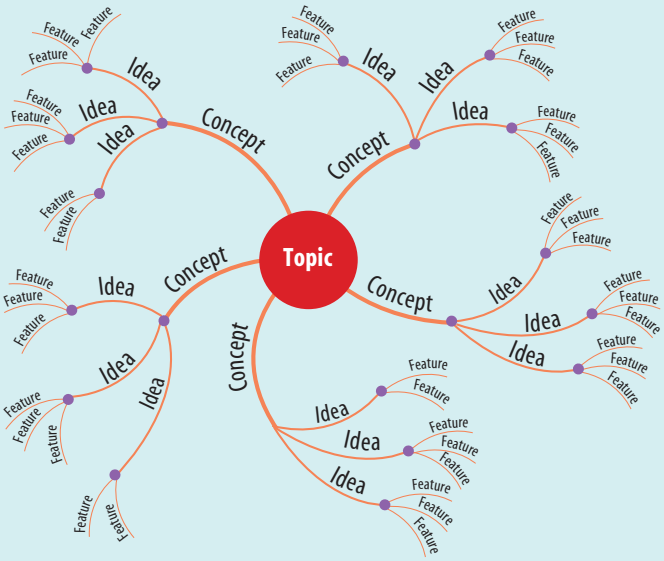


UNDERSTANDING AND INQUIRING

REMEMBER

1 How can you transfer short-term memory into long-term memory?

2 Construct a mind map to summarise the five memory systems.



3 Sketch seven keys. On each key, describe a memory key strategy.

4 Name the part of the brain that transfers information from short-term memory to long-term memory.

5 List the five different memory systems described in this section and write a brief description of each in your own words.

THINK, CREATE AND SHARE

6 (a) Name the memory system that:
- (i) is most useful during a geography lesson
- (ii) becomes automatic with lots of practice
- (iii) helps you to remember facts and formulae
- (iv) engages your emotions.

(b) Give examples of when and how you have used each of the memory systems.

7 The colour red is directly stored in your long-term memory. List examples of vehicles, signs and symbols that have applied this knowledge. Suggest why your brain processes the colour red in this way.

8 Create and present a rhyme, song or poem about:
(a) your memory systems
(b) memory keys.

INVESTIGATE AND SHARE

9 Suggest the advantage of traumatic or emotionally charged events being remembered more deeply.

10 Outline some research on chemicals that can affect memory.

11 Research one of the memory systems and construct a booklet, poster, PowerPoint presentation, web page, brochure or manual to show how you can use this system to improve your learning and memory.

INVESTIGATE, THINK AND DISCUSS

12 Research into falling in love suggests there are three stages: lust, attraction and attachment. How might these stages assist in the survival of a species?

13 Find out the possible effects of the following chemicals on learning.
- Adrenaline
- Phenylalanine
- Norepinephrine
- Calpain
- Choline

14 Find out more about memory-enhancing drugs. Construct a PMI chart to summarise and share your findings.

15 Create a newspaper article, cartoon or web page on ways to improve your memory.

16 Find out more about research into memory and chemicals that may be used to enhance or erase it. Organise a class debate on one of the following statements.
(a) Drugs that have an effect on memory should be illegal.
(b) Everyone should have access to drugs that erase memories.
(c) Research on drugs that alter memories should be stopped.

CREATE AND PRESENT

17 Use your semantic memory to create and practise a song, poem or jingle to help you remember the five different memory systems.

18 Use your episodic memory to create and then perform skits or acts to show the differences between the five different memory systems.

19 Construct a mind map to show the differences between spatial, working, episodic, procedural and semantic memory systems.

eBookplus

20 Complete the **Brain control** interactivity in your eBookPLUS and learn about how your brain controls all your thoughts, actions and feelings. **int-0010**

21 Use the **Brain** interactivity in your eBookPLUS to test your knowledge of the roles of the four lobes of the cerebral cortex. **int-1865**

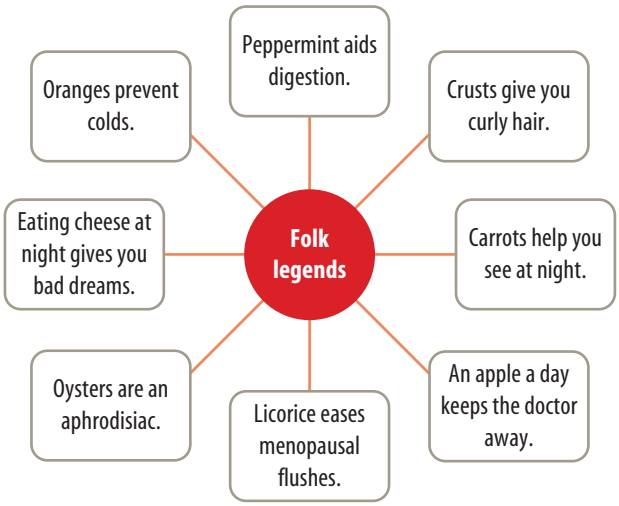
Myths, moods and foods

Folk legends

Knowledge often passes from one generation to the next through stories and tales. Some old-fashioned remedies have been passed on in this way. The truth of some of these folk legends may have altered or disappeared along the way, while others may have a sound basis.

For instance, is chicken soup good for fevers? Yes; but this is also true for many other protein-rich foods. Although your body produces about 2000 immune cells per second, many of these can be lost when you are feverish. The amino acids in proteins help you to reinforce and rebuild new immune cells and molecules.

There are many folk legends related to food, and some of these are shown in the bubble map at right.



DIET TO LIFT SPIRITS

Fay Burstin

We know them as comfort foods — those warm hearty meals or rich treats — because the mere act of eating them makes us happy.

But research suggests that consuming the right foods could make us feel so good they could even relieve depression.

Two key nutrients in fish, nuts and beets have been found to work just as well as prescription antidepressants in preventing depression in laboratory rats.

Harvard University researchers in the US found omega-3 fatty acids and uridine, both linked to improved brain function, affected the rats' behaviour during a standard depression test.

Rats forced to swim in chilled water with no way to escape will normally become hopeless and float motionlessly.

But when treated with antidepressants, they remain active for longer, searching for an escape.

A team led by neurobiologist William Carlezon at Harvard-affiliated McLean Hospital found rats whose diets were supplemented with high levels of omega-3 fatty acids for at least 30 days stayed active and focused on escape.

Similarly, the study published in Biological Psychiatry found rats injected with high levels of uridine were equally tenacious.

And combined doses of omega-3 oil and uridine were just as effective as three different antidepressants in prompting the rats to start swimming again, Dr Carlezon said. But they didn't see the same results in untreated rats.

Dr Carlezon speculated that the drugs and dietary supplements acted on brain cells' mitochondria, the power source that produces energy for cells.

'Imagine what happens if your brain does not have enough energy,' he said.

'Basically, we were giving the brain more fuel on which to run.'

Associate Professor Luis Vitetta, from Swinburne University's Graduate School of Integrative Medicine, said major medical advances had been made in recent years linking illnesses such as cancer and cardiovascular disease to diet.

Now, similar links were being drawn between nutrition and brain function disorders such as dementia, ADHD, depression and bipolar disorder, he said.

'We're starting to put the pieces of the puzzle together, based largely on why some cultures with certain diets suffer less from these disorders than others,' he said.

'Japan had one of the world's lowest rates of depression and we're beginning to think it's because they eat oily fish like salmon every day that's rich in omega-3 essential fatty acids.'

Dr Vitetta said at least 50 per cent of our brain was made up of essential fatty acids (EFAs).

But our brain can't manufacture EFAs itself so we need to get them from our diet.

Dr Vitetta said research showed anyone (or anything, including lab rats) fed omega-3 fatty acids performed better on brain function tests.

Studies show dyslexic children given an omega-3 dietary supplement can make two years' reading progress in six months and 70 per cent of kids diagnosed with ADHD no longer met the clinical criteria after four months of taking an EFA supplement.

But it's not just EFAs we need to lift our mood and brain power.

Dr Vitetta said good nutrition, including at least five or six portions of fresh fruit and vegetables a day, could ultimately have the same effect on the brain as antidepressant drugs.

'The vitamins and minerals in fresh fruit and vegetables are crucial for every bodily function, including the heart, the liver and the gastrointestinal system,' he said.

'When your body is working well, your weight is healthy and your skin looks good, all of which have a positive effect on your self-image.

'And if you feel good about yourself, you're less likely to feel anxious and depressed, which is reflected in good mental health.'

Source: Herald Sun, 2 June 2005

Mood food

Ever heard of 'mood food' or comfort food? Do you crave particular foods when you are in a particular mood? Some foods don't just make you feel happy, but actually affect your brain. The article *Diet to lift spirits* discusses some recent research on the antidepressant properties of two key nutrients.

MOOD FOOD

Dark chocolate (at least 70 per cent cocoa solids) contains catechins, strong antioxidants which enhance endorphins, the brain's natural feel-good chemicals, and increase libido.

Seafood and oily fish contain high levels of omega-3 essential fatty acids, nerve and brain cells' building blocks that will ultimately improve mood more than any other food.

Nuts and seeds, emu meat and other wild game also contain high levels of EFAs.

Chicken, turkey and legumes such as beans and lentils contain tryptophan, a protein converted into the brain chemical serotonin, usually low in people with depression.

Caffeine boosts mental alertness and concentration. But many regular tea and coffee drinkers confuse this effect with the unpleasant symptoms of caffeine withdrawal when they don't get their daily cuppa.

Carbohydrate cravings may be a subconscious attempt to raise levels of serotonin, as tryptophan is absorbed more quickly into the brain after eating carbohydrate 'comfort' food such as potatoes.

Junk food has high levels of sugar and animal fats, which send blood sugar and endorphin levels soaring, giving you an instant hit. But the effect is short-lived, quickly plunging blood sugar and energy levels downward, sending you into depression, so the overall effect is bad.

Seeing

Dr Lisa Smithers won the 2008 South Australian Young Investigators Award for her research on omega-3 oils, tuna oil and premature babies.

DHA (docosahexaenoic acid) is an omega-3 oil important for brain, nerve and eye tissue development. The highest concentration of omega-3 DHA in the human body is in the retina of the eye. Premature babies may have low levels of DHA and rely on milk to supply it to them after their birth.

Dr Lisa Smithers. Although they may look like jelly beans, these are omega-3-oil supplements.

Dr Smithers's PhD research at the University of Adelaide involved a clinical trial. One group of breastfeeding mothers ingested tuna oil capsules with DHA. This raised the levels of DHA in the milk to four times higher than would normally be present. The DHA-enriched milk was provided until the premature babies reached their full-term date. The other group of mothers received placebo capsules that did not contain DHA.

Testing the babies at four months of age showed that those who were fed higher levels of DHA were able to visually detect a finer pattern than those who had not. This suggests that the addition of DHA to the milk assisted in their visual development.

HOW ABOUT THAT!

In your great-grandparents' days, many children were given a daily dose of cod-liver oil to maintain good health. It turns out that your great-grandparents may have been right about the benefits of fish oil. Fish oil is rich in omega-3 fatty acids. These fatty acids are being investigated as a possible treatment for conditions including rheumatoid arthritis, depression, attention deficit disorder and heart disease.

A number of scientific studies have shown that omega-3 fatty acids affect behaviour and mood. For example, Bernard Gesch carried out an experiment involving British prison inmates. He gave half the people who had volunteered for his study a daily supplement that contained omega-3 fatty acids and other vitamins and minerals. The other prisoners were given a placebo (a tablet that looked just like the supplement but did not contain fatty acids, vitamins or minerals). Over time, he found that the prisoners taking the supplement were involved in a lot fewer violent incidents. The prisoners taking the placebo showed no significant change in their behaviour.

Omega-3 fatty acids are found in oily fish (for example, tuna), some seeds and vegetable oils, and supplements.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Read through the text entitled *Diet to lift spirits* and respond to the following questions.
   (a) Identify in which foods you would find the two key nutrients that act as antidepressants in depressed laboratory rats.
   (b) State the names of these antidepressant-type nutrients.
   (c) Identify which part of the brain cells Dr Carlezon suggested the drugs acted on.
   (d) List some links that were drawn between nutrition and brain function disorders.
   (e) Suggest why it is thought that Japan may have one of the world's lowest rates of depression.
   (f) What does EFA stand for?
   (g) State the percentage of our brain that is made up of essential fatty acids.
   (h) Describe the results of studies on dyslexic children given an omega-3 dietary supplement.

2 Suggest why you might get cravings for carbohydrates.

3 What are the benefits of ingesting caffeine?

4 Describe the effect of junk food on your endorphin and sugar levels.

5 Suggest why chicken and lentils might be good to eat when you are depressed.

THINK AND DISCUSS

6 Construct a bubble map on the benefits of eating portions of fresh fruit and vegetables each day.

7 Suggest why coffee and tea drinkers may crave more each day.

8 With a partner, read through the article *Diet to lift spirits* in this section. Outline the experiments performed on rats at Harvard University. How do you feel about this treatment of the rats? How do you think others may view these experiments and their outcomes?

THINK, DISCUSS AND INVESTIGATE

9 Select one of the folk legends from the bubble map at the beginning of this section. Using one of the visual thinking tools from section 2.10 to organise your thinking:
   - outline the history of the legend
   - make your own decision about the truth of the legend. What are your reasons for making this decision?
   - Share your findings with your partner, team or class.

10 Search for other folk legends that relate to food. Present your findings in the form of flash cards, with the legend on the front of the flash cards and the information on the back.

11 Research the following chemicals.
   (a) Omega-3 fatty acids
   (b) Endorphins
   (c) Uridine
   (d) Tryptophan
   (e) Catechins
   (f) Serotonin

   Summarise your findings in a mind map. With a partner, discuss your combined findings. Add any more relevant information to your mind map as you chat.

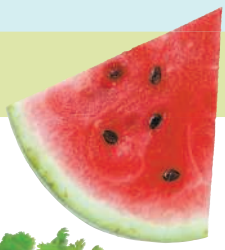
12 Investigate the history, manufacturing, composition and biological effects of dark chocolate.

13 Read through the text on the research by Dr Lisa Smithers and respond to the following questions.
   (a) Which of the two groups in her clinical trial were the control group? Why?
   (b) State the independent and dependent variables in her clinical trial.
   (c) Suggest which variables she would have needed to control.
   (d) In the clinical trial, some of the mothers were not breastfeeding. Find out or suggest how they could still be a part of the trial.
   (e) Suggest how Dr Smithers may have decided which mothers received DHA and which did not. How would have you decided? Why?
   (f) Discuss issues related to the decision of who gets the 'test drug/chemical' and who doesn't. If you had the choice, which group would you like to be in? Are there any other factors that may change your response? Discuss and explain.
   (g) State what the findings of this research suggested.
   (h) Suggest a myth that could result from this research.

14 (a) Formulate your own questions about one of the folk legends shown in the bubble map at the beginning of this section.
   (b) Research and report on relevant information or research on these.
   (c) State a hypothesis.
   (d) Design your own investigation.
   (e) Suggest results that would support your hypothesis.
   (f) Suggest limitations or difficulties that you may encounter if you were to actually conduct the investigation.

15 *Not all chocolate is created equal*. Suggest what this statement may mean and how it could relate to the myths and truths about the benefits of eating chocolate.

16 In a 2010 newspaper there was an article labelling some foods as superfoods. The table below provides some examples of these and the suggested implications of chemicals that they contain.
   (a) Research the active chemical in each of these 'superfoods'.
   (b) Find out whether there is any other scientific data to support:
      (i) the suggestion that these foods are high in these chemicals
      (ii) the implied effect of these chemicals on our health.
   (c) Summarise your findings and discuss these with others in your class.
   (d) Decide whether you think each of these foods deserves being labelled a superfood. Provide reasons for each decision.

Food	'Super' property	Active chemical	Examples of other foods with high levels of this chemical
Watermelon 	Sun protection	Lycopene	Red capsicums, tomatoes, green tea
Coriander 	Anti-ageing	Beta-carotene and vitamin C	Berries, broccoli, carrots
Onions 	Cancer fighting	Quercetin	Apples, oranges, parsley
Mussels 	Metabolism	Selenium	Tuna, eggs, Brazil nuts
Black pepper 	Antidepressant	Piperine	Salmon, dark chocolate, bananas

Sleep on it

Are you a night owl or an early bird? Do you get sleepy during the day or find it hard to wake up in the mornings? Did you know that sleeping is as essential to your health as food and water?

A very old network . . .

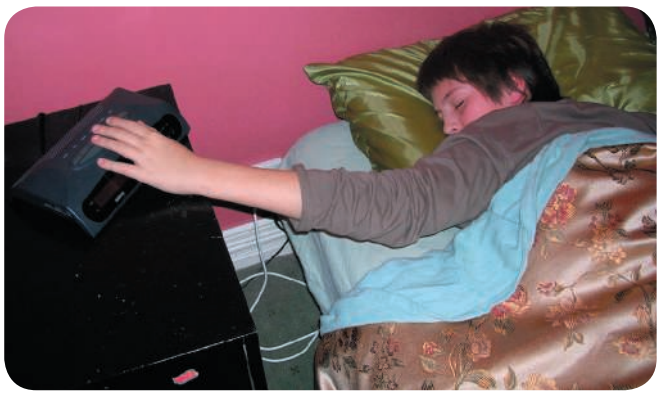
One of the oldest portions of your brain is your **reticular formation**. This network of fibres and cell bodies is located in the central core of your brainstem (medulla oblongata) and extends through other areas of your brain. It can be considered a network of neurons that opens and closes to increase or decrease the amount of information that flows into and out of your brain. It helps regulate your alertness (from being fully awake or deeply asleep), motivation, movement and some of your reflexes.

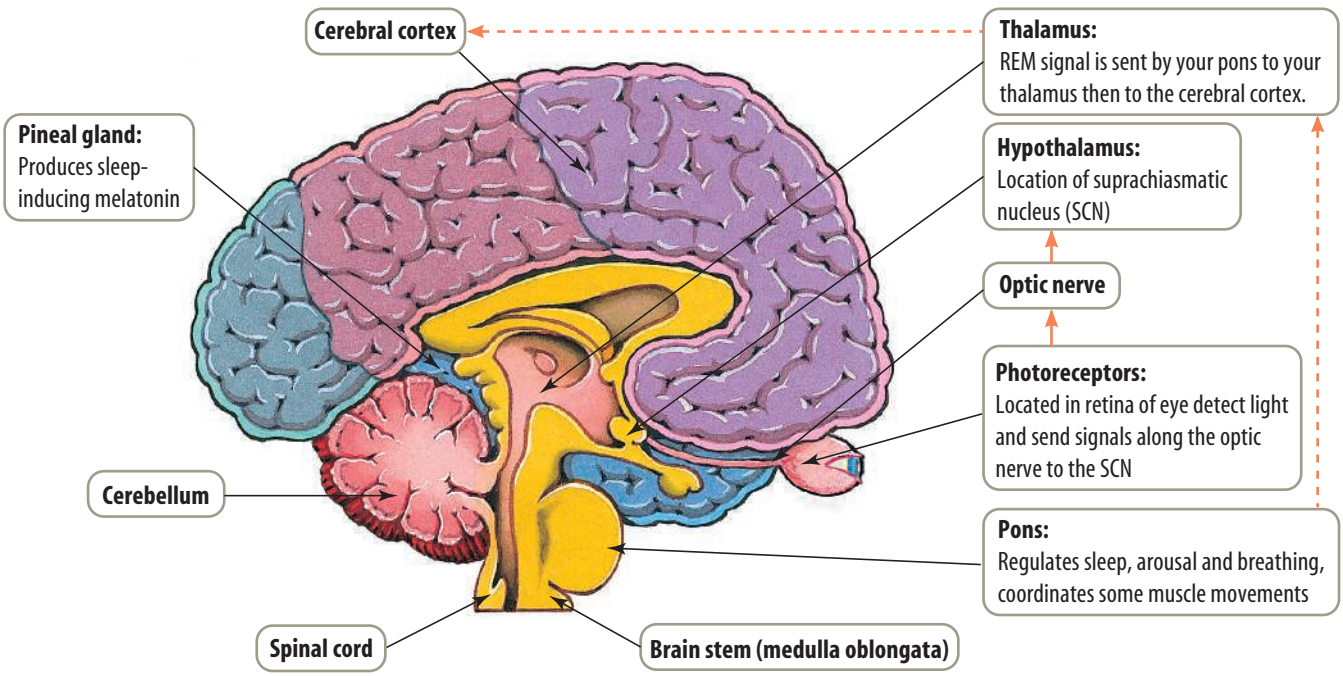
What's your rhythm?

Your **circadian rhythm** is the regular pattern of mental and physical changes that happen to you throughout a 24-hour time period. This rhythm may be controlled by your body's biological clock. This clock is really a pair of pin-sized structures made up of about 20 000 neurons called your **suprachiasmatic nucleus (SCN)**, which is located in your hypothalamus, near where your optic nerves cross.

Catch that yawn

Why do you often get drowsy when it is dark and wake up when it is light? The answer lies in your nervous system and levels of chemicals in your brain. **Photoreceptors** in the retina of your eye detect light and create signals that travel along your optic nerve to your SCN. Your SCN then sends signals to a number of different parts of your brain.





In the evening, the signal that light is decreasing travels from your SCN to your **pineal gland**, which then produces a hormone called melatonin. Increased levels of melatonin in the evening tell your body that it's time to sleep and you begin to feel drowsy. During adolescence, these levels peak later in the day, which may explain why you get tired later at night and want to sleep in the next morning.

There is also evidence that the accumulation of a chemical called **adenosine** in your blood while you are awake may cause drowsiness. While you sleep, this chemical gradually breaks down.

Sleeping switches

Neurotransmitters can also control whether you are asleep or awake by acting on particular groups of neurons in your brain. The neurotransmitters serotonin and norepinephrine keep some parts of your brain active while you are awake. During sleep, the production of these neurotransmitters is switched off. As these chemicals are involved in logical and consequential thinking, your judgement of time and location can become distorted.

Some foods and medicines can change the balance of your neurotransmitters and affect how alert or drowsy you are and also how well you sleep. Drinks or foods that contain caffeine stimulate some parts of your brain and can cause insomnia (inability to sleep).

Some examples of ways in which you can improve the quality of your sleep

Neurons involved in controlling sleep also interact closely with your immune system. Infectious diseases like the flu can make you feel sleepy. This may be because of the powerful sleep-inducing chemicals of our immune system called **cytokines**. Sleep may also help you to conserve energy and other resources that the immune system may need.

Catching sleep waves

During the night, your body experiences sleep cycles lasting 90–110 minutes, with periods of **REM** (rapid eye movement) and **non-REM** sleep. You might have three to five sleep cycles each night.

DROPPING OFF

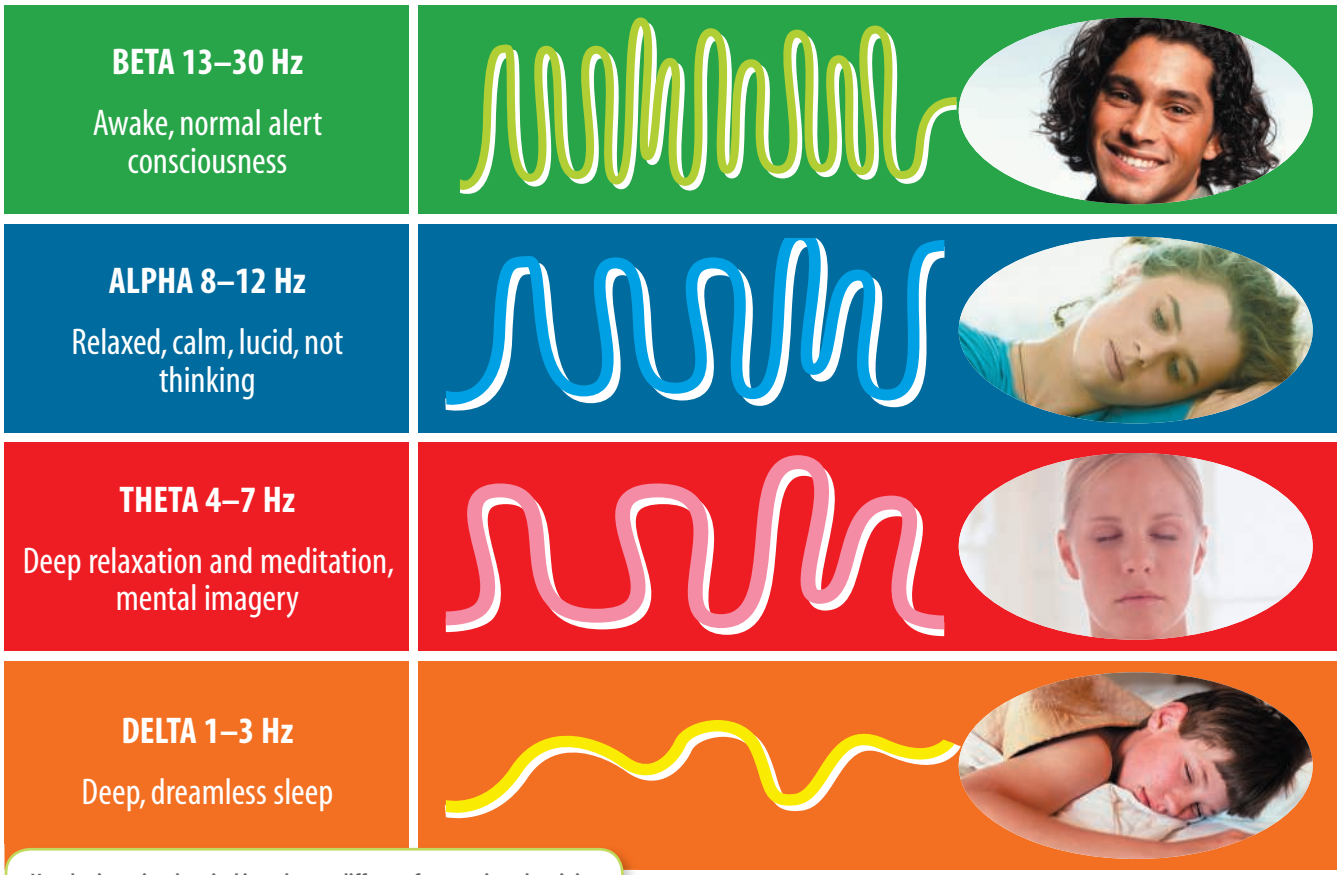
There are four stages of non-REM sleep, and about 75 per cent of your night's sleep is spent in non-REM sleep. Stage one lasts for about 5 per cent of your sleep and is a transition period from wakefulness to sleep. During this stage, your muscles may contract and you may feel 'jumps' or 'twinges' in your legs. In the second stage (45 per cent of an average night's sleep) your brainwaves become larger and eye movements cease. In your third (12 per cent) and fourth (13 per cent) stages of non-REM sleep, your brain will show delta wave activity. You will be in a deep sleep and be difficult to arouse.

DREAM TIME

Your REM sleep is your dream time, and usually makes up about 20–25 per cent of the night's sleep. In REM sleep your breathing becomes more rapid, irregular and shallow and your eyes flick in different directions. Your first REM sleep each night lasts about 70–90 minutes. If you are woken during REM sleep, you can often describe your dreams.

REM sleep is triggered by the pons in your brain. Your pons also shuts off neurons in your spinal cord to temporarily paralyse your limbs so that you don't act out your dreams. The REM sleep signal is sent by your pons to your thalamus, then to the cerebral cortex. As REM sleep stimulates the regions of your brain used in learning, some believe that dreams are the cortex's attempt to interpret and put meaning to new information and experiences.

Heavy smokers may have reduced amounts of REM sleep and sleep lightly. Although alcohol can help you to fall into a light sleep, it also reduces REM and deep restorative stages of sleep.



Your brain emits electrical impulses at different frequencies when it is engaged in different activities.

Sleep learning

Recent research has shown that, while you are asleep, your brain consolidates and practises what has been learned during the day. This suggests that learning continues to take place while you sleep. If this is true, it is another reason for getting a good night's sleep before a test or exam, rather than staying up all night studying!

REM sleep is triggered by a structure in the brain called the pons.

Catching brain waves

Your brain emits waves of electrical impulses at different frequencies when it is engaged in different activities. These frequencies are measured in cycles per second (cps) or Hertz (Hz). Technologies such as an **electroencephalogram (EEG)** can be used to measure the patterns of this electrical activity.

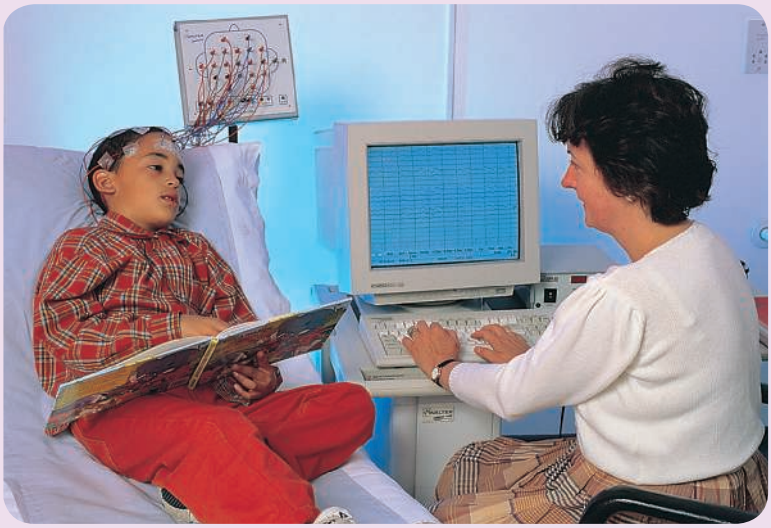
Beta (β) waves (13–30 Hz) are the fastest waves with the shortest wavelength. When your brain is emitting beta waves you are using many of your senses and are strongly engaged. An example of this may be if you were involved in an active conversation at a party or playing sport. This type of brainwave is associated with short-term memory, alertness and concentration and is in very high levels if you are anxious about something.

When your brain is emitting **alpha (α) waves** (8–12 Hz) it is likely that you are calm and relaxed, but still aware of your environment. If you are involved in solving a problem, reflecting on an experience or creatively visualising something, you may be emitting this type of wave. When your brain is in this state you may be processing information and activating your long-term memory.

When you are in a deep dreamless sleep, your brain will be emitting **delta (δ) waves**.

HOW ABOUT THAT!

An electroencephalograph (EEG) can be used to measure the overall patterns of electrical activity of your brain. When you are asleep, theta and delta wave activity is present. When you are awake, your brain tends to show alpha waves if you are relaxed and beta waves if you are alert.



An EEG records electrical activity in the brain via electrodes on the scalp.

UNDERSTANDING AND INQUIRING

REMEMBER

1 What is a circadian rhythm?
2 Where is your suprachiasmatic nucleus (SCN) located and what does it do?
3 How is light involved in whether or not you are sleepy?
4 What effect do increased levels of melatonin have on your body?
5 What effect can the switching off of serotonin and norepinephrine have on you?
6 Suggest why infectious diseases like the flu might make you feel sleepy.
7 Do you spend more time in REM or non-REM sleep? In which one are you likely to dream?
8 What stops you from acting out your dreams?
9 Which types of brainwaves are seen in deep, dreamless sleep?

THINK AND DISCUSS

10 Discuss the effect of light pollution in your bedroom.
11 Why might you be more vulnerable to asthma at night-time?

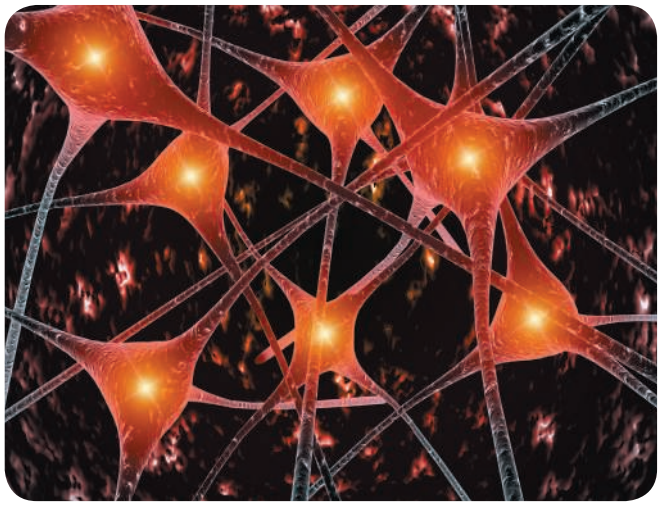
INVESTIGATE

12 Travelling from one time zone to another can disrupt your circadian rhythm and you can experience a condition known as jet lag. Find out more about how light therapy has been used to help reduce the effects of jet lag by helping to reset biological clocks.
13 While most adults need about 7 or 8 hours sleep, teenagers usually require about 9 hours. Find out more about research into adolescence and sleep.
14 Investigate and report on one of the following sleep conditions: sleep apnoea, narcolepsy, restless leg syndrome, talking in your sleep, sleepwalking, night terrors.
15 If you don't get enough sleep, you may be drowsy and unable to concentrate. Severe sleep deprivation may result in hallucinations and mood swings. What are some other consequences of sleep deprivation?
16 If someone is in a coma or under anaesthesia, are they really asleep?
17 There is an early morning dip in blood pressure at about 2 or 3 am. Investigate and discuss why there are more records of heart attacks within the first six hours of waking than at any other time.
18 Select one of the following, research it and:
   (a) summarise your findings into a poster or multimedia presentation to share with others
   (b) describe how scientific evidence or knowledge can be used to validate your findings
   (c) use internet research to identify two problems related to this topic that could be investigated.

- The effects of decongestants and antidepressants on sleep
- Theories for why we yawn. Do you agree with any of these? Why?
- Ways to sleep more effectively
- Theories of how sleep may affect learning
- Patterns of age and sleep
- The effects of 'sleep debt'
- Microsleeps
- Driver fatigue
- The effects of shift work on sleep
- The effects of total blindness on sleep

The teen brain

Did you know that you had more neurons in your brain before you were born? Most of your brain development occurs in two stages: growth spurts and pruning. Throughout the first months of your life, your brain grew rapidly, producing millions of brain cells. A few months before you were born, there was dramatic pruning of your brain cells to remove unnecessary cells.



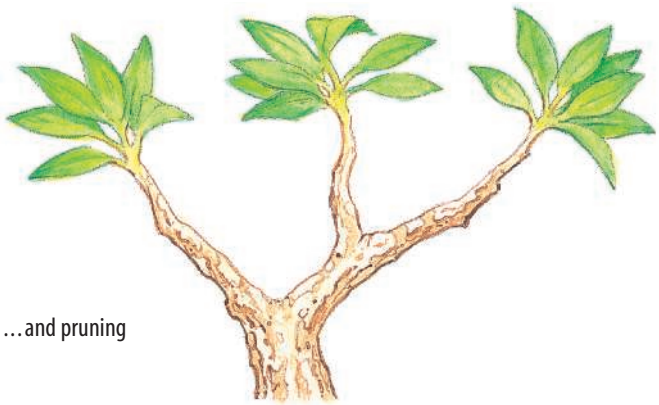
There are thousands of different neural pathways that can be travelled in the brain.

Like pruning a tree

Between the ages of about 6 and 11, neurons grow bushier and make dozens of connections (synapses) to other neurons, creating new pathways for nerve signals. This process peaks at around ages 11–12.

Use it or lose it! **Synapses** are the connections between the neurons where the message is passed from one neuron to the next. The synapses that carry the most messages get stronger and those that are not used much grow weaker. **Synaptic pruning** is the elimination of the weakest connections between neurons in the brain's cortex (grey matter). During this adolescent pruning up to 30 000 synapses may be eliminated each second. Only the connections that experience has shown to be useful are preserved. It is a bit like pruning a tree. The weaker branches are cut back to allow the other branches to flourish.

Nerve proliferation …



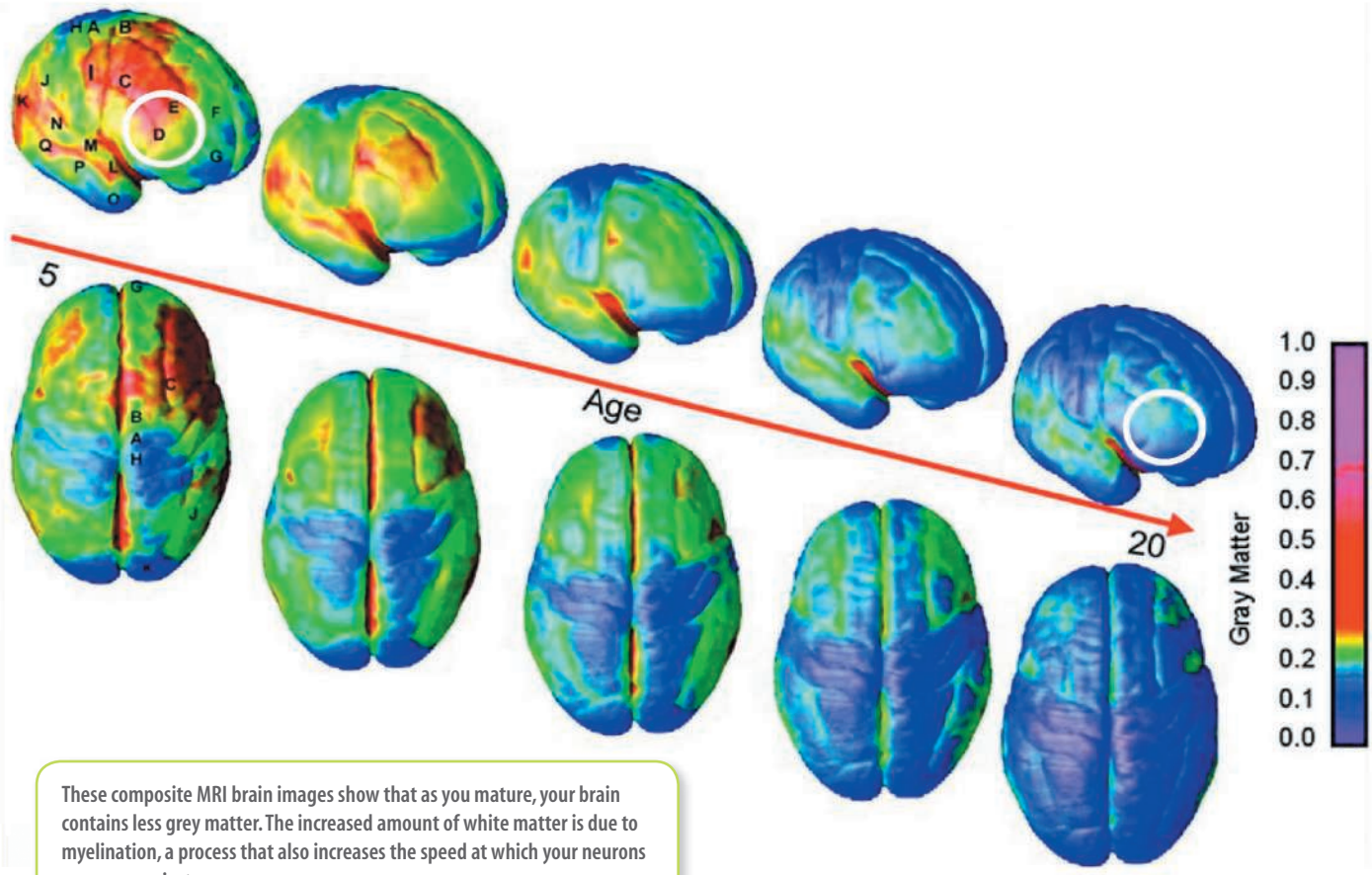
…and pruning

Wrapped in a white coat?

Your brain uses synaptic pruning to consolidate your learning by pruning away less travelled connections and myelinating neurons involved in the busy connections so that they become fixed as synaptic pathways.

In the process of **myelination**, neurons are coated with in a white material called **myelin**. The myelin coat acts like the plastic material wrapped around electrical wires for insulation. While myelination of neurons insulates, it also increases the speed at which the nerve impulse can move through it and hence the speed at which the message is communicated.

Images of the brain using MRI technology show that the amount of grey matter in the brain is reduced throughout childhood and adolescence and the amount of white matter increases. Does this suggest a link between increased cognitive (thinking) abilities and myelination?



These composite MRI brain images show that as you mature, your brain contains less grey matter. The increased amount of white matter is due to myelination, a process that also increases the speed at which your neurons can communicate messages.

'Teeny' neuroscience discoveries

Knowledge about the teen brain is definitely a work in progress. Neuroscience research is providing us with many new discoveries due to the development of technologies that can provide images of living, growing brains. Using technologies such as PET (positron emission tomography) scans and fMRI (functional magnetic resonance imaging), scientists can observe growth spurts and losses, and map our brain's activity while we are involved in a variety of experiences.

PREFRONTAL CORTEX

It was once though that brains had finished their development by the end of childhood, but we now know that adolescence is a very busy time for brain growth and change. The prefrontal cortex in the brain undergoes a growth spurt at about 11–12 years of age, followed by a period of pruning and organisation of new neural connections. It is often referred to as the 'area of sober thought', and is now thought not to reach full maturity until the age of around 25. The prefrontal cortex is responsible for impulse control, planning, decision making, strategising and judgement. Is this why some teenagers act before they think about the possible consequences of their actions?

BASAL GANGLIA

The basal ganglia act like a personal assistant to the prefrontal cortex, helping it to prioritise information. They grow neural connections at about the same time as the prefrontal cortex, and then prune them.

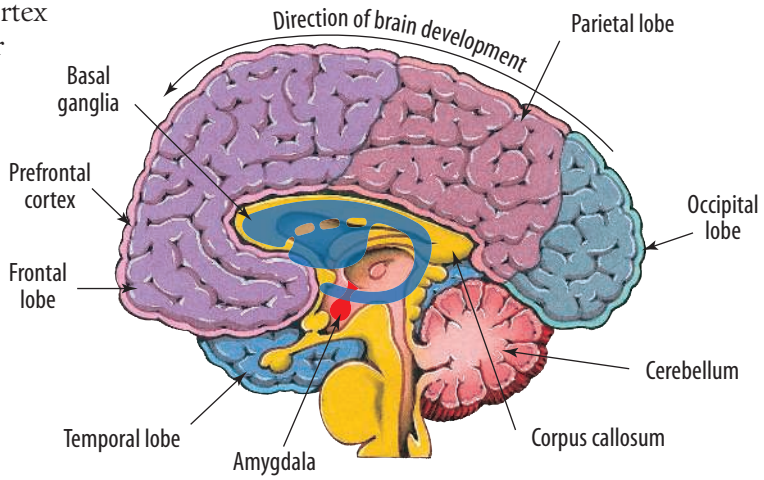
CORPUS CALLOSUM

This bundle of nerves that connects the left and right hemispheres of the brain is thought to also be involved in problem solving and creativity. During your teens, the nerve fibres thicken and increase the effectiveness of information processing.

AMYGDALA

The amygdala is the emotional centre of your brain. This is the brain's area for primal feelings such as

fear and rage. Since a teenager's prefrontal cortex may not yet have matured, they may use their amygdala and associated gut instincts when making decisions. Teenagers also tend to rely more on this part of the brain when processing emotional information, which may lead to impulsive behaviour. Adults are more likely to rely on their more developed and rational prefrontal cortex, which can balance out inappropriate emotions and impulses from their amygdala.



Your brain develops from back to front!

DOPAMINE SPIKES

Are adolescents neurally wired to take risks? In 2010, scientists observed fMRI images of participants involved in particular learning activities. Their research results led them to hypothesise that risk-taking in adolescents may be due to over-activity in the mesolimbic dopamine system of their brains.

What are the implications of this possible new knowledge? Is the risk-taking observed in many teenagers due to a spike in their levels of the neurotransmitter dopamine? While further research may support or disprove this hypothesis, the possibility that this may be the case opens many new possibilities for research and consequent issues. If it is supported, how accountable are teenagers for their behaviour? It can be seen that from research exciting new knowledge can be developed, but the implication of this knowledge also needs be considered or explored. Who determines the future uses of new knowledge in scientific discoveries?

The neurotransmitter dopamine is known to be important for motivation to seek rewards.

Back-to-front brain development

Did you know that your brain develops from bottom to top, from back to front, and from right to left? The development of your brain has been 'programmed' for the two tasks that confront survival of the human race (staying alive and getting into the gene pool). In the first 10 years of life, you learn the skills to stay alive. In the next 10 years, you learn how to be a productive and reproductive human. This wiring of your brain is essential to the survival of our species.

UNDERSTANDING AND INQUIRING

INVESTIGATE

Select one of the following statements and claims and list five questions that it raises. Investigate these questions and present your findings in a creative and interesting way.

(a) You were born with a very immature brain (about 1/3 adult size) because of your mother's upright stance (walking on two legs) and her relatively narrow birth canal.

(b) That we are a cooperative, social species with a rich language-driven culture is due to our limited and 'helpless' early brain development and long dependence as children.

(c) Some research suggests that the corpus callosum is bigger and more developed in women than in men. Other studies contradict this.

(d) Female brains may be smaller, but they mature a lot faster and have more synapses.

(e) Girls are better at … than boys because their brains are better.

(f) Boys are better at … than girls because of the way their brains develop.

(g) Teenagers get into so much trouble because they think and act through their amygdala.

(h) A drug should be developed so that the brains of teenagers are more like those of adults.

(i) It is important to survival of the species for adolescents to be wired to take risks so that they can learn new ways of doing things.

(j) Schools should start later in the day because teenagers need more sleep than those of other ages.

Drugs on your brain?

Popping a pill or taking something that you shouldn't? Are you aware of the short- and long-term effects of your actions?

Introducing various chemicals into your body can have both beneficial and terrifying consequences. After all, we all need to eat and drink to obtain our nutrients. But there are some chemicals that can cause you great damage.

Passing the message

Neurotransmitters are key players in our memory, learning, mood, behaviour, sleep and pain perception. These chemicals pass a message from one neuron (pre-synaptic neuron) to another (post-synaptic neuron) across a gap between them called a synapse.

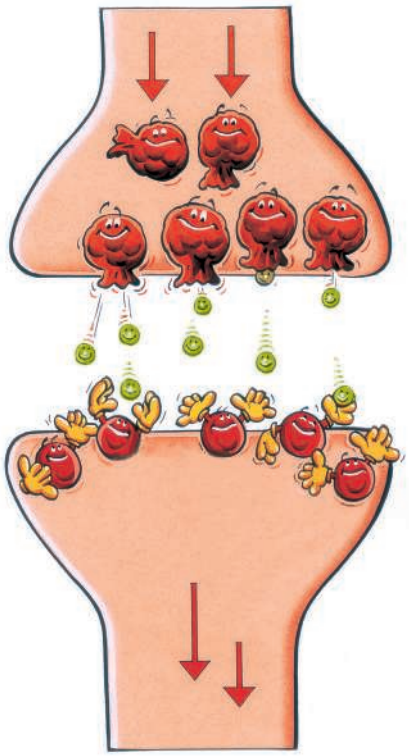
Although there are many different neurotransmitters, only one is used at each synapse. The type of neurotransmitter that is released at the synapse can be used to classify them into groups. For example, in your brain some synapses release acetylcholine, whereas others may release noradrenaline, dopamine or enkephalins. The effect that these neurotransmitters have depends on the type of receptor that is present on the membrane of the neuron that receives it. Once the message has been received, enzymes break the neurotransmitter down.

Uppers and downers

Some drugs can affect your brain or personality by either increasing or decreasing transmission of messages across the synapse. These are collectively known as **psychoactive drugs**. These drugs can bind to the receptors, mimic the neurotransmitter or block the binding of the neurotransmitter to its receptor. Nicotine is an example of a drug that mimics the working of acetylcholine.

Some examples of **excitatory psychoactive drugs** include nicotine, caffeine, cocaine and amphetamines ('speed'). Many of these drugs come from natural sources. They all stimulate or increase the synaptic transmission. Like many other drugs of abuse, these stimulants activate your brain's reward circuit.

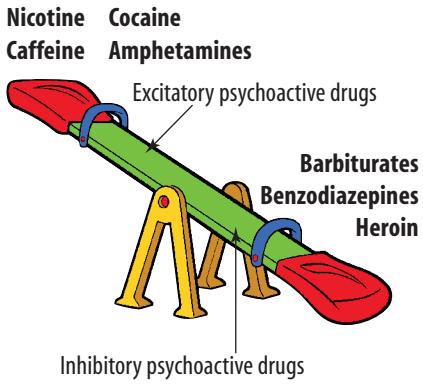
Excitatory psychoactive drugs can be thought of as **stimulants** or 'uppers', while **inhibitory psychoactive drugs** can be considered as **depressants** or 'downers'. As their name implies, they work by inhibiting or decreasing synaptic transmission. Barbiturates, benzodiazepines (such as Valium), alcohol and cannabis (marijuana) are examples of drugs that decrease the activity of your nervous system.



Neurotransmitters carry the message from one neuron to the next. They are stored in sacs called vesicles. When neurotransmitters are released from the vesicles of one neuron, they travel across the synapse to bind to specific receptors on the membrane of the next neuron.

CAFFEINE

What do coffee, tea, cocoa, chocolate and some soft drinks have in common? They all contain **caffeine**. In moderate doses, this central nervous system stimulant can increase alertness, reduce fine motor coordination, and cause insomnia, headaches,



Examples of excitatory psychoactive drugs and inhibitory psychoactive drugs

nervousness and dizziness. In massive doses it is lethal.

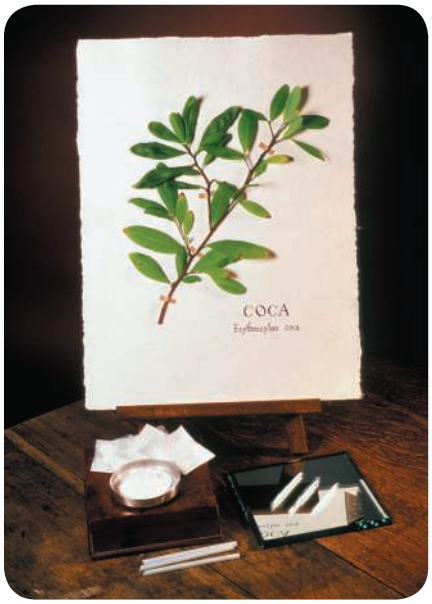
One effect of caffeine is to interfere with adenosine at multiple sites in your brain, but this drug also acts on other parts of your body. It increases your heart rate and urine production.

Substance	Quantity of caffeine (mg)
Filter coffee (200 mL)	140
Instant coffee (200 mL)	80
Tea (200 mL)	80
Dark chocolate (30 g)	35
Typical cola (330 mL)	32
Milk chocolate (30 g)	15

An adult's average daily consumption of caffeine is about 280 mg. A fatal dose is about 10 g.

COCAINE

Cocaine (coke, snow, crack, gold dust or rock) works by inhibiting or blocking the uptake of neurotransmitters — dopamine, norepinephrine or serotonin — in a synapse, prolonging effects within the central nervous system. This results in elevated heart rate and body temperature, increased alertness and movement, and dilation of pupils. High levels of norepinephrine may result in strokes, organ failure and heart attacks.



Large doses of cocaine can cause heart attacks, strokes, paranoia and hallucinations.

AMPHETAMINES

Amphetamines (speed, ice, ecstasy, meth, pep pills or fast) are synthetic chemicals that affect levels of neurotransmitters — dopamine, norepinephrine or serotonin. Long-term use can result in insomnia, hallucinations, tremors, and violent and aggressive behaviour. Some amphetamines are **neurotoxic** and cause neuron death.

While the short-term effects may be a dry mouth, enlarged pupils, headaches and increased confidence, frequent use of amphetamines may result in psychosis.

ECSTASY

Ecstasy or MDMA is distributed in small tablets, capsules or powder form. Short-term effects include increased blood pressure, body temperature and heart rate. Larger doses can result in convulsions, vomiting and hallucinations. There is also a risk of heart attack or brain haemorrhage and swelling, and there is evidence that it causes long-term damage to the neurons in your brain.

BARBITURATES

Barbiturates are often taken to calm someone down and are used as sedatives. Sleeping pills are one such example. One key problem is that they may lead to tolerance and dependence. A key danger associated with barbiturates is that there is only a small difference between a dose that produces sedation and one that may cause death.

MARIJUANA

In 1964, the psychoactive ingredient in **marijuana** (also known as grass, pot, reefer or weed) was identified as a **THC** (delta-9 tetrahydrocannabinol). This chemical comes from a plant called *Cannabis sativa*. THC activates cannabinoid receptors in your brain located on neurons in your hippocampus (memory), cerebral cortex (concentration), sensory portions of your cerebral cortex (perception) and your cerebellum (movement). High doses of this drug may cause hallucinations, delusions, impaired memory and disorientation. As it is one of the world's most commonly used

illegal drugs, there has been a great deal of research into how it works and the consequences of using it.

GHB

GHB (gamma hydroxybutyrate, sodium oxybate, also known as liquid E, fantasy or gamma-OH) is an odourless, colourless, salty liquid that acts as a depressant on your nervous system. One of the dangers of this drug is the difficulty of determining a safe dosage. Although a small amount may have a euphoric effect, more can lead to amnesia, respiratory difficulties, delirium, loss of consciousness and possibly death. Likewise, combining GHB with alcohol can also lead to deep unconsciousness and may cause coma or death. GHB also has the reputation of being used as a 'date-rape' drug.

HEROIN

Diacetylmorphine or **heroin** (also known as smack, jive, horse or junk) is an illegal opiate drug that contains morphine as its active ingredient. Its source is the opium poppy, *Papaver somniferum*. **Opiates** stimulate a pleasure system in your brain that involves the neurotransmitter dopamine.

In 1973, scientists found neurons in the brain that have receptors for opiates. These are located in areas involved in pain, breathing and emotions. The discovery of these receptors led to further research about their purpose. Two years later, scientists discovered that the brain manufactures its own opiates known as **endorphins**. Although endorphins are always present in the brain, when you are in pain or stressed they are released in larger amounts.

Blood and alcohol

Unlike water, some drinks can have a negative effect on your health. One such drink is **alcohol**.

Alcohol is a depressant and can alter your mood, thinking and behaviour. Many parts of your body are affected by alcohol, as shown on the next page.

ALCOHOL AND THE DIGESTIVE SYSTEM

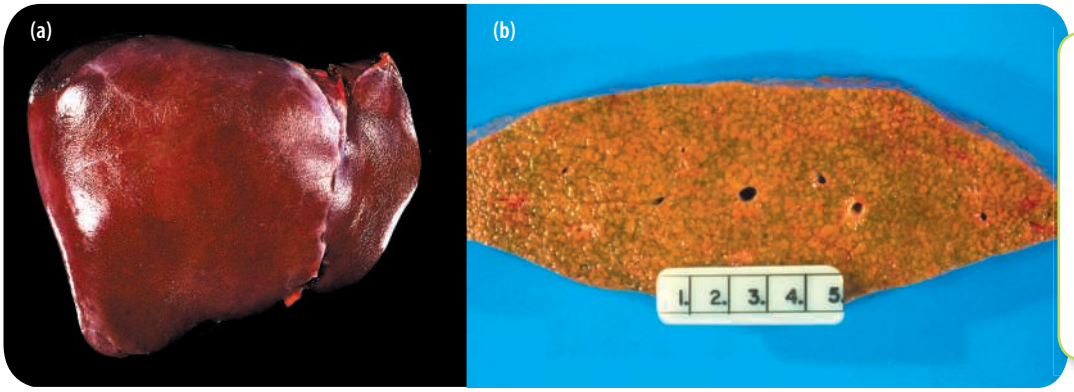
Alcohol is a substance that is directly absorbed into your bloodstream through your stomach and small intestine. It irritates your stomach and causes more stomach acid to be produced, which can result in painful heartburn and stomach ulcers. Alcohol is also linked to mouth, oesophagus, stomach and intestinal cancers. The part of the digestive system that is affected most is the liver. Alcohol can destroy liver cells and can cause fat to accumulate around the liver, resulting in a fatal condition known as cirrhosis.

ALCOHOL AND THE BRAIN

Did you know that alcohol slows down your brain activity by interfering with your cerebellum? This may affect your coordination and perception and cause memory blackouts. When alcohol reaches your midbrain, your reflexes diminish, confusion and stupor follow, and then you may lapse into a coma. When the alcohol reaches your medulla, your heart rate may drop and your breathing may stop, possibly resulting in death.

HOW ABOUT THAT!

Australian scientists are currently in the race to develop 'smart' drugs through research on neurotransmitters. Smart drugs belong to a class of drugs called ampakines. These drugs work by boosting chemicals that allow information to flow from one part of the brain to another. Our scientists are also discovering neurotransmitters that were previously unknown, and are trying to find out about the cause and effects of imbalances of brain chemicals and drug addiction.



(a) A healthy liver and (b) a liver from a person with cirrhosis caused by excess alcohol consumption. Alcohol is an example of a toxin broken down by the liver — excess consumption of alcohol can cause extra strain on liver tissue and damage to liver cells.

Alcohol affects all parts of your body.

Some common questions

DOES EATING FOOD STOP YOU FROM GETTING DRUNK?

The rate at which alcohol is absorbed may be slowed by the presence of food in your stomach but it won't prevent you getting drunk or intoxicated.

HOW CAN YOU SOBER UP MORE QUICKLY?

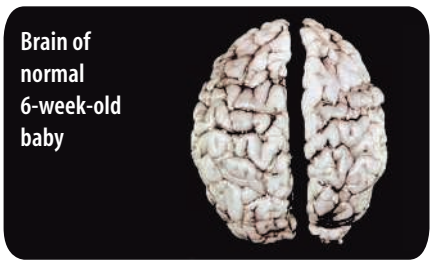
Your liver works at a fixed rate. It will detoxify or clear about one standard drink each hour (see the standard drinks guide in this section). So, black coffee, cold showers, fresh air and vomiting won't speed up the process of getting rid of alcohol from your body.

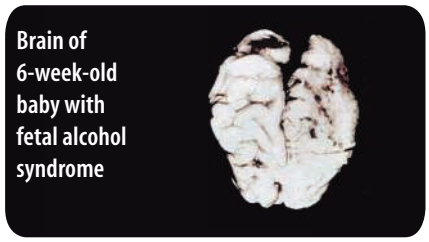
WHY DO PEOPLE WHO DRINK TOO MUCH ALCOHOL SMELL?

Although the liver breaks down about 90 per cent of the alcohol, the rest leaves the body in urine, sweat and breath.

SHOULD PREGNANT WOMEN DRINK ALCOHOL?

During the first three months of pregnancy, alcohol interferes with the migration and organisation of brain cells. Heavy drinking during the next trimester, particularly between 10 and 20 weeks after conception, can have the biggest impact on the baby, leading to fetal alcohol syndrome (FAS). Drinking during the last trimester may affect the baby's hippocampus, which may reduce the child's future ability to encode visual and auditory information (reading and maths).





Heavy drinking during pregnancy can damage the baby's brain.

Standard drinks guide

1.5
375 mL
Full-strength beer
4.9% alc/vol

0.8
375 mL
Light beer
2.7% alc/vol

1
285 mL
Middy full-strength beer
4.9% alc/vol

0.5
285 mL
Middy light beer
2.7% alc/vol

1.5
375 mL
Pre-mix spirits
5% alc/vol

1.5
300 mL
Alcoholic soda
5.5% alc/vol

1
30 mL
Spirit nip
40% alc/vol

0.9
60 mL
Port/sherry glass
18% alc/vol

1.5
170 mL
Sparkling wine/ champagne
11.5% alc/vol

1.8
180 mL
Average restaurant serve of wine
12% alc/vol

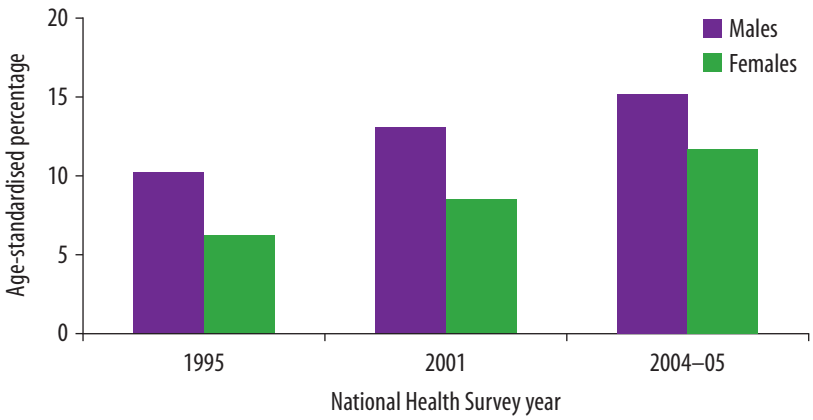
A standard drink contains about 10 grams of alcohol.
It takes the liver about an hour to break down the alcohol in one standard drink.

Australia and alcohol

Headlines in Australian news stories increasingly relate alcohol abuse to accidents or violence which result in injury or death. There is data to suggest that drinking at dangerous levels is increasing within our culture.

Over the last decade, there has also been an increase in the number of women drinking at risky or high levels. This has implications not just for the woman and those close to her, but potentially to the health of an unborn child.

While some Australians believe that they have a right to drink and eat whatever, whenever and however they wish, the government is not of the same belief. There are already restrictions on the amount of alcohol in your blood when you are driving and in a number of public places the consumption of alcohol is illegal. With increasing evidence of the dangers of alcohol not just to ourselves but also to others, where will the line be drawn and how will it be implemented?



This graph indicates that the proportion of adults in Australia drinking at a risky or high level is increasing. Suggest what the percentage of risky or high alcohol consumption may look like for 2010–2011.

UNDERSTANDING AND INQUIRING

REMEMBER

1 State the name of the gap across which neurotransmitters pass.

2 Use a flowchart to show the links between a pre-synaptic neuron, a neurotransmitter and a post-synaptic neuron.

3 List three examples of neurotransmitters.

4 What do the vesicles in neurons contain?

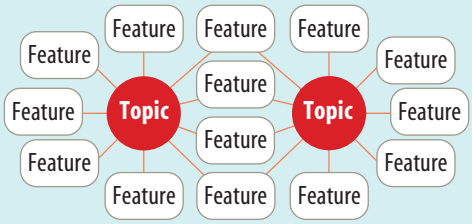
5 What are psychoactive drugs?

6 What is the key difference between excitatory and inhibitory psychoactive drugs?

7 State other names for:
(a) inhibitory psychoactive drugs
(b) excitatory psychoactive drugs.

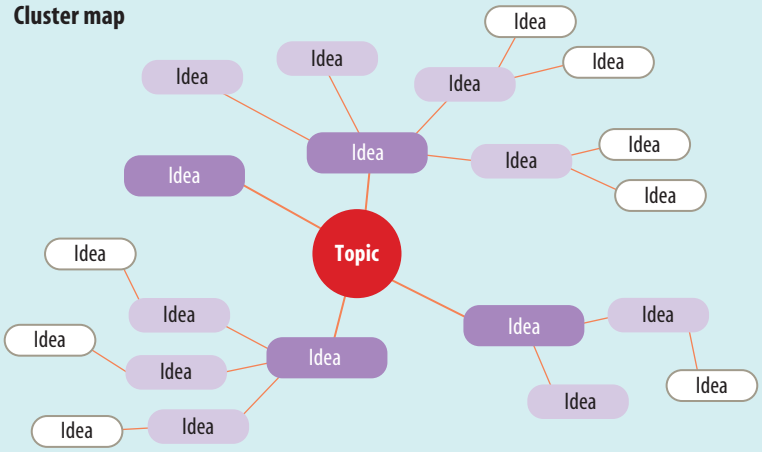
8 Construct a double bubble map to show the similarities and differences between excitatory and inhibitory psychoactive drugs.

Double bubble map



9 Use a cluster map to show examples of the effects of the following drugs.
(a) Caffeine
(b) Cocaine
(c) GHB
(d) Heroin
(e) Ecstasy

Cluster map



10 What is meant by the term neurotoxic?

THINK AND EVALUATE

11 Construct a mind map to summarise the effects of alcohol on your body.

12 Which type of alcoholic drink in the standard drinks guide has the:
(a) most alcohol (b) least alcohol?

13 How many standard drinks are there in three glasses of wine?

14 How many standard drinks are there in a 750 mL bottle of wine?

INVESTIGATE, THINK AND CREATE

15 Create a song that can be used to persuade people to reduce alcohol abuse.

16 Suggest ways in which young people can become more aware of alcohol abuse.

17 What is fetal alcohol syndrome? Find out about some other effects of alcohol on the developing fetus.

18 Construct graphs that show the different amounts of alcohol in different types of alcoholic drinks.

19 Find out how an alcohol breathalyser works. Construct a model.

20 *In Australia, increased abuse of alcohol is directly linked to increased drownings, violence, accidents and death.*
(a) Research various sources to see whether there is evidence to support this claim.
(b) Using a matrix table, summarise your findings for and against the statement.
(c) Discuss your findings with those of others, adding comments that you may have missed in your own research.
(d) Do you agree with the statement? Explain.
(e) In your team, construct a priority grid on 'Australia and alcohol'.
(f) Share your team's grid with other teams and discuss similarities and differences.

21 Research and report back to your team, for discussion, on one of the following.
- The caffeine content in a variety of foods, including different brands of coffee, tea, cola drinks, cocoa drinks and chocolates
- The history of coffee
- The symptoms of caffeine addiction
- The effects and dangers of inhalants and methods of prevention
- The connection between morphine, opium, codeine and heroin

22 The barbiturate sodium pentothal is also known as 'truth serum'. Find out how it works.

Opening up your brain

Your brain is amazing, mysterious and powerful. While you use it to formulate, ask and investigate questions, sometimes these questions are about the brain itself! What do you know about your brain? Why not open your brain up to new ideas, new discoveries and new questions about brains?

Brain in mind

Throughout history, humans have asked many questions about the human brain and there have been varied theories about its structure and how it works. Some questions have been about how brain cells interact with each other and what happens when the brain grows, ages or is damaged. Other questions relate to how it is involved in our learning, experiences and emotions, or how it contributes to make us who we are. There have even been investigations to design and construct artificial brains!

Phrenology

Frantz Joseph Gall, a German physician, developed the theory of phrenology in 1796. He believed that the brain was made up of a number of individual 'organs' which could be detected by visible inspection of the skull. This led to the belief that the size, shape and bumps of a person's skull determined their character and mental capacity. This theory was particularly popular between 1810 and 1840. While phrenology is now dismissed as a **pseudoscience**, some of its assumptions are still valid. The idea that mental processes can be localised in the brain is one such claim and is supported by our modern neuroimaging techniques.

WHAT DOES IT MEAN?

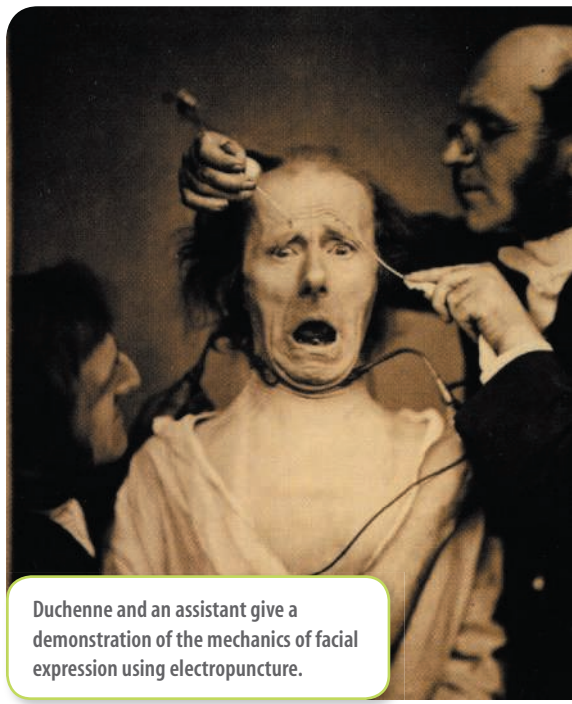
The word phrenology comes from the Greek terms ***phren***, meaning 'mind', and ***logos***, meaning 'knowledge'.

Neurology

Guillaume-Benjamin-Amand Duchenne de Boulogne (1806–1875) was a French neurologist who greatly advanced the science of muscular electrophysiology and electromyography. In 1835, he began experimenting on therapeutic electropuncture — which involved applying an electric shock under the skin with sharp electrodes to stimulate the muscles. This increased his understanding of the conductivity of neural pathways. Some refer to Guillaume as the father of modern neurology and in recognition of his research (and discovery), Duchenne muscular dystrophy is named after him.

An integrated approach

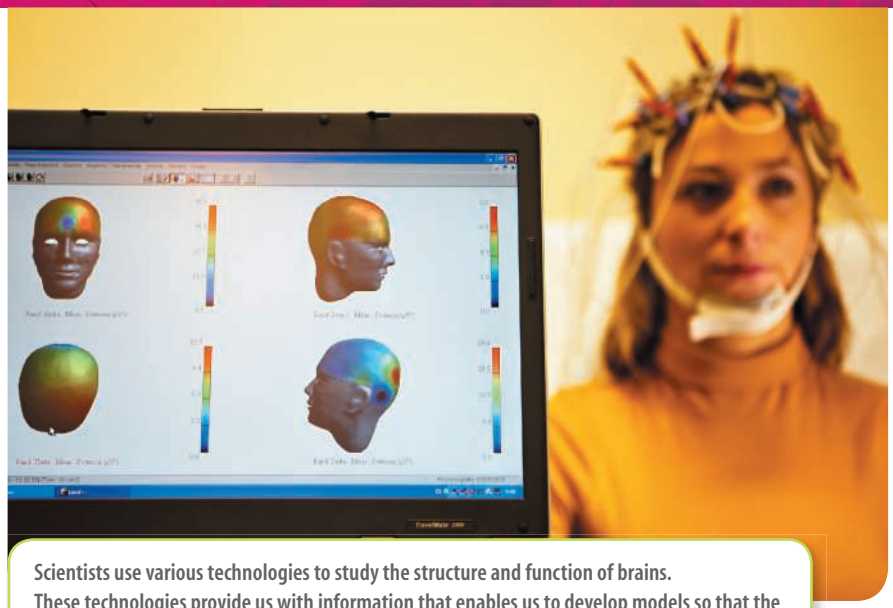
Our interest in brains has given rise to a variety of new branches of science. Examples of these include neurobiology, neuroscience, neurophysiology, neuropsychology and neuroanatomy. The frontiers of brain science also require an integrated approach that combines approaches and technologies from various scientific fields. Scientists in medical, biological, molecular biological, theoretical science, psychology, biophysics and various computer technologies can all be involved in trying to find out more about particular aspects of our brains.



Duchenne and an assistant give a demonstration of the mechanics of facial expression using electropuncture.

Brain on display

It is no wonder that some scientific terms are often referred to in an abbreviated form! This is especially the case with some of the names of imaging technologies used to look at the structure and function of the brain. **Computerised axial tomography (CAT)** and **magnetic resonance imaging (MRI)** produce computer images of the brain's internal structure. Scanning technologies that provide information about brain function include: **electroencephalography (EEG)**; **magnetoencephalography (MEG)**; **positron emission tomography (PET)**; **functional magnetic resonance imaging (fMRI)**; and **functional magnetic resonance spectroscopy (fMRS)**. A key advantage of these new scanning technologies is that they can analyse the brain while its owner is alive — and using it!



Scientists use various technologies to study the structure and function of brains. These technologies provide us with information that enables us to develop models so that the knowledge can be communicated to others.

PET

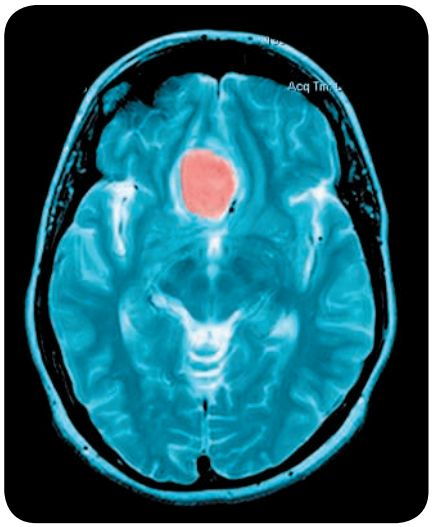
PET was the first technology used to observe brain functions. It involves injection of a radioactive solution into the brain. The amount of radiation measured in particular regions indicates levels of activity in those parts at that time.

EEGs and MEGs

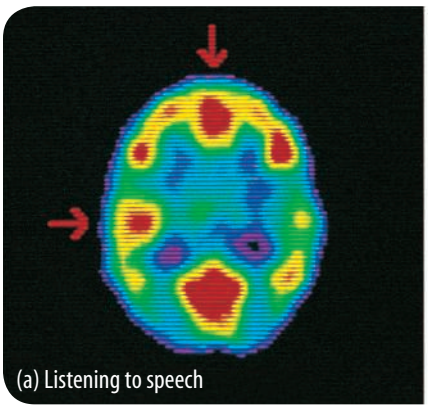
EEGs and MEGs involve the attachment of multiple electrodes to be the scalp and the measurement of either electrical or magnetic activity occurring in the brain during mental processing. These technologies record activation of groups of neurons responding to a specific event and help to determine how quickly this occurs in the brain.

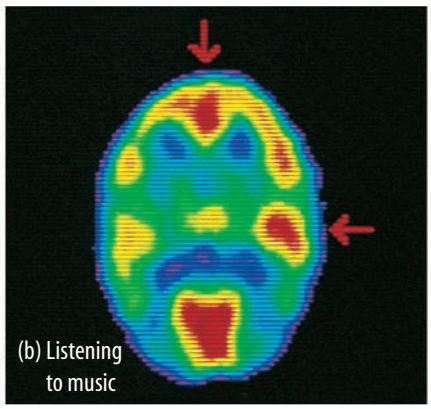
fMRI and fMRS

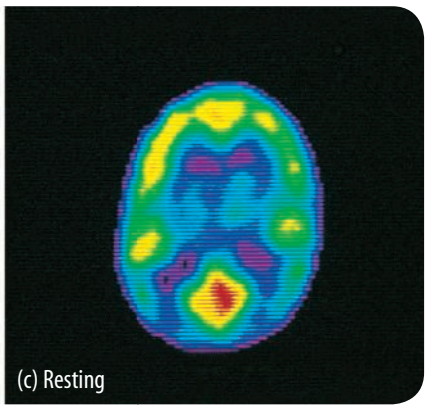
Areas in your brain involved in thinking require more oxygen than the parts not involved.



MRI scan of a benign brain tumour







PET scans of people with normal brain activity participating in different tasks. Red indicates the greatest level of brain activity, whereas blue indicates the brain areas that are least active.

This oxygen is transported by haemoglobin, a molecule that contains iron, which is magnetic.

fMRI uses a large magnet to compare the amount of oxygenated haemoglobin entering brain cells with the amount of deoxygenated haemoglobin that is leaving them. The computer generated images colour the regions with greater oxygenated blood. This allows the pinpointing of the activated brain regions to be located within a centimetre.

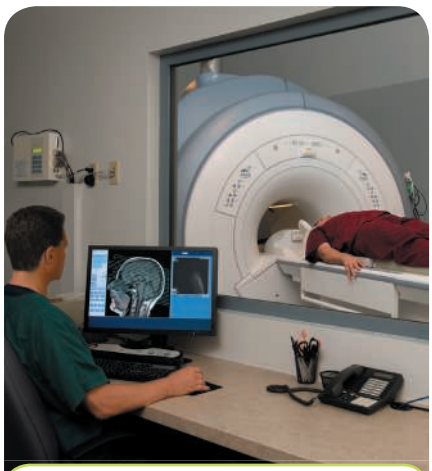
While fMRS uses the same equipment as fMRI it uses different computer software. This technology can record and identify levels of specific chemicals during brain activity and has been used to study language function in the brain.

Neurotechnology

We have learned more about the human brain in the past 10–15 years than we have in the rest of recorded history. This new information is leading revolutionary changes in how we use our brains and think about them. New technologies are providing us with new knowledge about the brain and how it works. With new knowledge, previously held ideas often need to be modified. In some cases, the previous understanding or theories have needed to be discarded completely so that new theories can be developed to replace them.

Neuroplasticity and neurogenesis

Contrary to what was believed in the past, our brains and brain connections, or neural pathways, are not static and unchanging. They are constantly wiring and rewiring. Stimulation and challenging your brain encourages the growth of dendrites and the production of new neurons. Lack of stimuli can result in weakening of existing connections and possible pruning of them. You may also lose new neurons in the process.



A technician monitoring a patient undergoing an MRI scan of the brain

eBookplus eLesson

Brain sell

Find out more about how advertisers are getting inside our heads using neuromarketing.

eles-1080

PMI chart on neurotechnology

Plus	Minus	Interesting
• New medicines For example, these may be individually styled and used to cure or treat mental illnesses with high efficacy and negligible side effects. This may lead to a major decrease in mental illnesses such as depression, schizophrenia, bipolar disorders, substance abuse and obsessive–compulsive disorders.	**• New weapons** For example, neuroweapons that influence how the brain (and person) responds to particular stimuli or situations	**• Neuroeducation** For example, a tablet to ingest or a connection to an implant in your brain to pass on the knowledge of a new language, topic or skill
• New chemicals For example, chemicals that may be ingested to: — influence learning, memory processes, decision making and attention — influence moods, motivation, feelings and awareness — restore and extend the capacity of our senses (enhancing the sense of sight, hearing, smell or taste)	**• New marketing strategies** For example, neuromarketing that uses knowledge of the brain to prioritise their products over others	**• Neuromodulators** For example, a tablet to ingest to help people feel happy all of the time

Currently there are some exciting research projects on **neurogenesis** (meaning 'the birth of new neurons'). This research is investigating whether factors such as exercise and different moods can influence how many neurons are being 'born' each day and how many survive.

SHAPED BY NEUROTECHNOLOGY

Our society shapes the development of new technologies. It is also shaped by these technologies. Discoveries in neurotechnology have been enhanced by developments in information technologies. Development of nanobiochips and brain-imaging technologies increase the accuracy of biological and neurological analysis. Nano-imaging techniques will enable analysis of events at the neuromolecular level in the brain. Knowledge of these events will enhance our understanding about how our brains work and give us power to modify their function.

In the future, neurotechnology may provide us with knowledge that may lead to the development of new treatments for diseases, new industries — and new problems to consider and solve. How will new neurotechnologies change human societies? How will they change us?

UNDERSTANDING AND INQUIRING

REMEMBER

1 Phrenology has a colourful history and varied interpretations. Give an example of how it has been used.

2 Phrenology is considered by many to be a pseudoscience. What is meant by this term? Do you agree? Explain your response.

INVESTIGATE, THINK AND DISCUSS

3 (a) Use the internet to identify claims regarding the effects of exposure to types of electromagnetic radiation (such as X-rays, microwaves and gamma rays) on humans.
(b) Find evidence that supports or negates the claims.
(c) Identify issues that are relevant to human exposure to these types of radiation and construct PMI charts to summarise the key points and concerns.
(d) Analyse the language used by media reports in terms of bias and perspective.
(e) Select one of the issues and organise a class debate.

4 Research ways in which the development of imaging technologies has improved our understanding of the structure and function of the human brain.

5 Investigate how electromagnetic radiation technologies are used in the detection and treatment of cancer. Report your findings as a television documentary, podcast or newspaper article.

6 There are claims that brain scans can reveal personality types and the type of career that you are best suited to. Find out more about these claims.
(a) On the basis of your findings, do you agree that brain scans are capable of this? Justify your response.
(b) Find out and discuss issues related to the use of brain scans in this way. Do you agree with using brain scans in this way? Explain why.

7 Frantz Gall believed that the brain was made up of a number of individual 'organs' that created one's personality. Find out examples of these 'brain organs' and how this information was used. Not everyone agreed with the ideas of phrenology. Find examples of arguments for and against phrenology, summarising your findings in a PMI chart.

8 If you were to hear about a new model or theory about the brain in the media, describe how you would use scientific knowledge to determine its possible validity.

9 Use your knowledge of science to test claims made in advertising or expressed in the media (or in this text) with regard to any of the following.
- The Mozart effect increases the depth of learning.
- Mobile phones can cause brain cancer.
- Neuro-linguistic programming (NLP) helps people lead better, fuller and richer lives.
- Some people are real left-brainers!
- Faulty mirror neurons can lead to autism.
- Sleep enhances memory.
- Zapping the brain using transcranial direct current stimulation can spark new ideas.

INVESTIGATE, THINK AND CREATE

eBook*plus*

10 Phrenology gave rise to the invention of the psychograph. Use the **Psychograph** weblink in your eBookPLUS to find out what it is and about its history.

11 Carefully observe the neurotechnology PMI chart in this section. Select one of the boxes and research a particular aspect of it that is of interest to you. Develop an advertising or political campaign (complete with multimedia aspects) to either promote or criticise your neurotechnology application.

Visual thinking tools

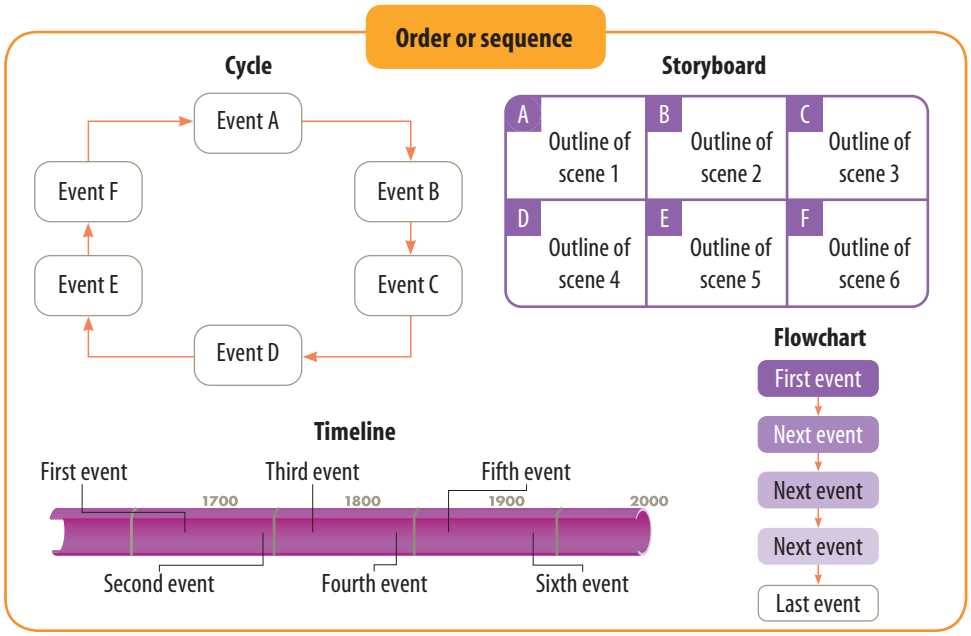
There are so many different ways to see and share what is happening inside your brain. Here are some tools that can be used to make your thinking visible so that you can share and discuss it with others.

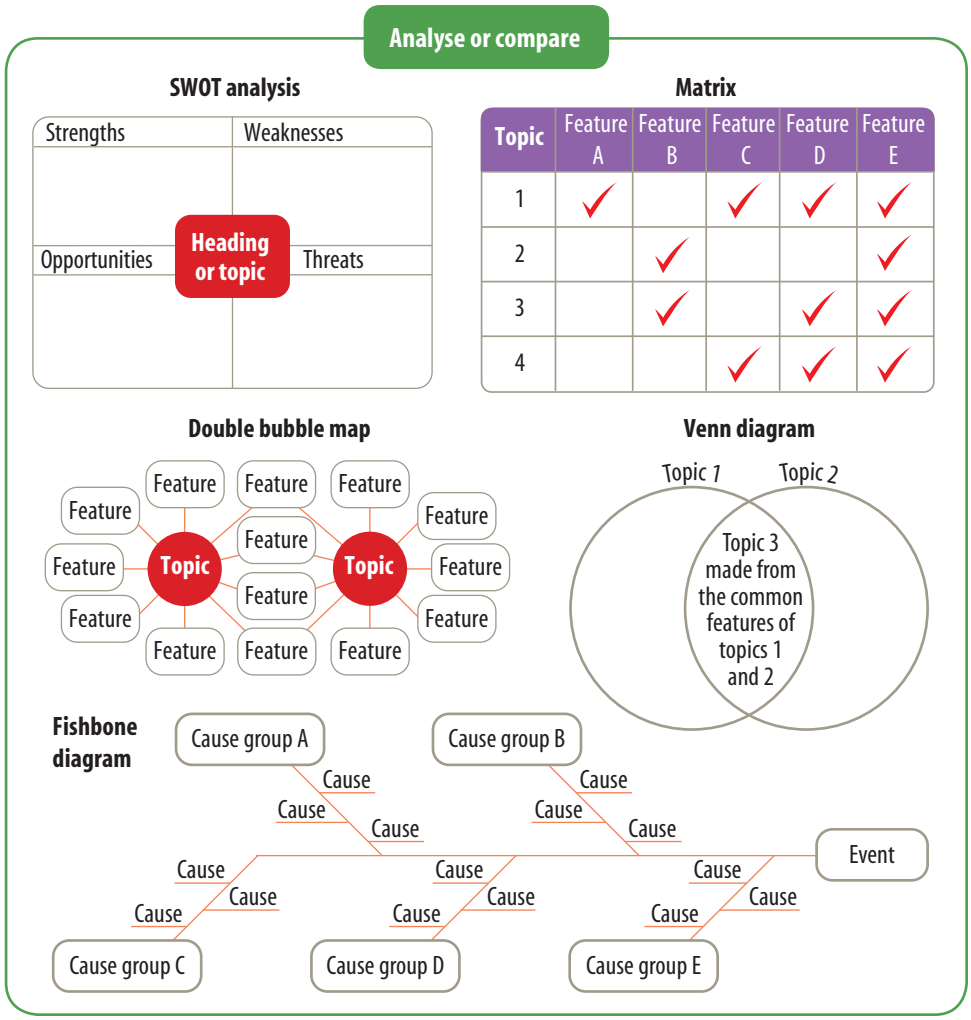
Structuring your thinking

It is important for you to use the right tool to get the job done.

- **Storyboards**, **flowcharts**, **timelines** and **cycles** are useful tools to sequence your thoughts.
- **Matrixes** and **bubble maps** are useful when you want to classify or organise your thoughts.
- **Priority grids**, **target maps**, **continuums** or **pie charts** can be used to quantify or rank ideas.
- **PMI charts** and **Y charts** help you visualise or reflect on an idea.
- **Concept maps**, **Venn diagrams** and **fishbone diagrams** are useful tools to focus your thoughts, such as when you need to analyse and compare things in order to make a decision.

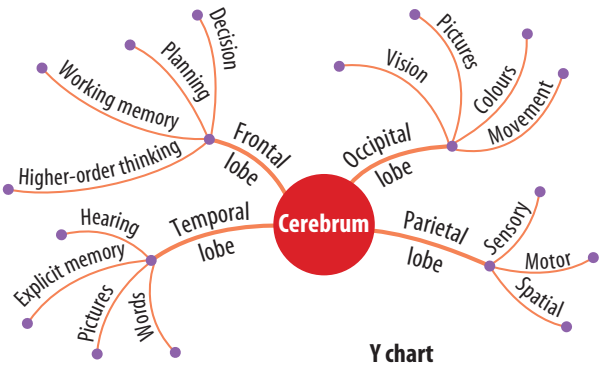
There are also times when combinations of these tools can help you to use your brain and time more effectively.



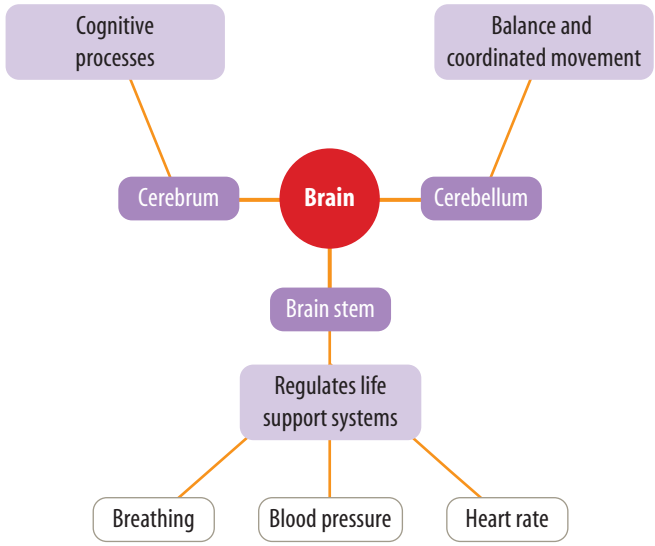


Visualise or reflect

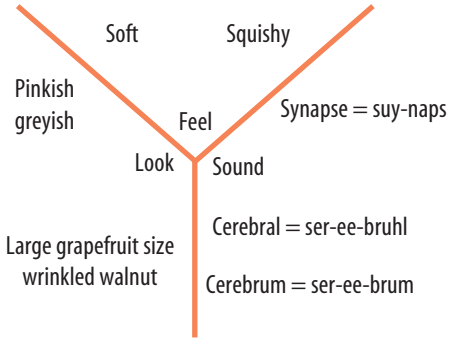
Mind map



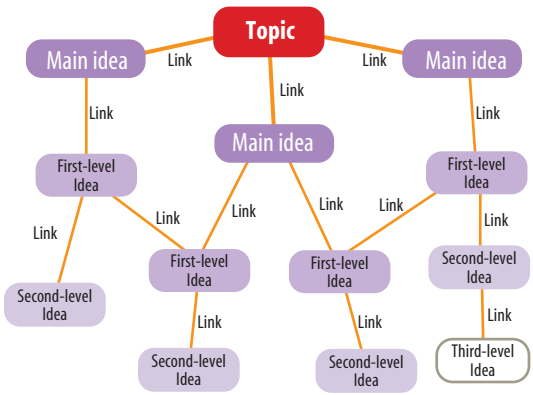
Cluster map



Y chart



Concept map

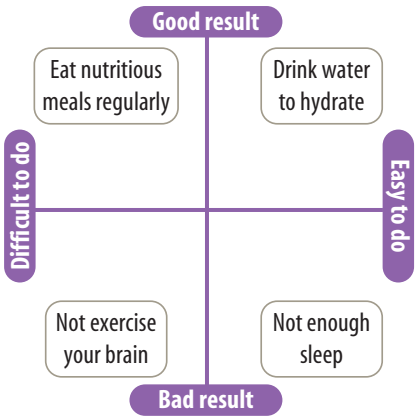


PMI chart

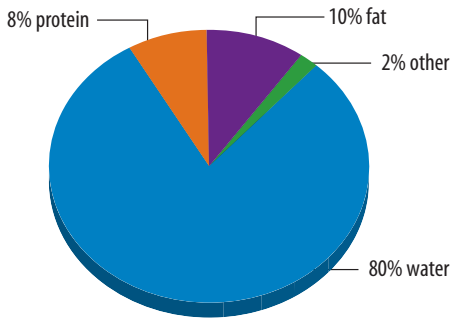
Plus	Minus	Interesting
• New medicine • New 'learning chemicals'	• New weapons • New marketing strategies	• Neuroeducation • Neuromodulators

Quantify or rank

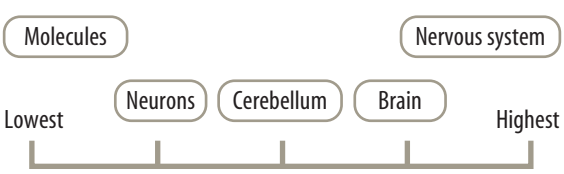
Priority grid



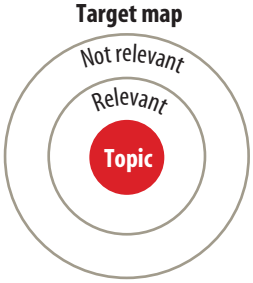
Pie chart



Continuum



Target map



UNDERSTANDING AND INQUIRING

REMEMBER

1 State the types of visual thinking tools that are best suited to:
   (a) quantifying or ranking ideas
   (b) visualising or reflecting
   (c) analysing or comparing
   (d) ordering or sequencing.

THINK AND CREATE

2 Select and copy five of the visual tools from this page and then add more information to each.

3 Use a visual thinking tool to summarise key or interesting points from each section within this chapter.

STUDY CHECKLIST

LEARNING

- suggest ways in which you can take an active rather than a passive role in your learning
- distinguish between the following learning preferences: visual, auditory, kinaesthetic
- suggest examples of learning activities for each type of learning preference listed above
- state the sense with which we detect the most information from our environment
- construct a flowchart that shows how the senses are involved in memory and learning
- suggest ways in which knowledge of how our senses are used in learning can be used to enhance your learning
- construct a mind map to summarise information about spatial, procedural, working, episodic and semantic memory

NERVOUS SYSTEM

- state another name for a nerve cell
- draw a neuron, labelling the dendrites, cell body and axon

THE HUMAN BRAIN

- distinguish between the following terms: cognition, emotion
- state four functions of a human brain
- recall which foods may aid brain function
- recall the types of brain waves and the chemicals the body produces that are associated with sleep drugs
- recall the effect of drugs on the brain
- identify the cerebrum, cerebellum and brain stem and outline their key functions
- outline the key functions of the frontal, temporal, parietal and occipital lobes of the cerebrum
- list three neurotransmitters in the brain that can influence feelings and actions

SCIENCE AS A HUMAN ENDEAVOUR

- consider how the development of imaging technologies has improved our understanding of the functions and interactions of body systems
- use knowledge of science to test claims made in advertising or expressed in the media
- recognise aspects of science, engineering and technology within careers such as medicine, medical technology, biomechanical engineering, pharmacy and physiology
- comment on how scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community

ICT

eBookplus Summary

eLesson

Brain sell
Watch an ABC Catalyst report to find out more about how advertisers are getting inside our heads using neuromarketing.
Searchlight ID: eles-1080

Interactivities

Brain control
Learn about how your brain controls all your thoughts actions and feelings.
Searchlight ID: int-0010

Brain
Use this interactivity to test your knowledge of the roles of the four lobes of the cerebral cortex.
Searchlight ID: int-1865

INDIVIDUAL PATHWAYS

eBookplus

Activity 2.1
Learning with your brain in mind

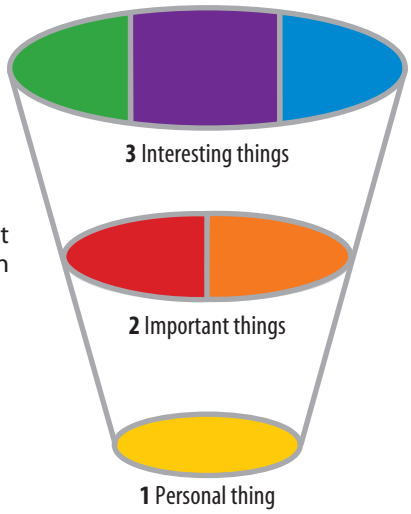
Activity 2.2
Investigating learning

Activity 2.3
Investigating learning further

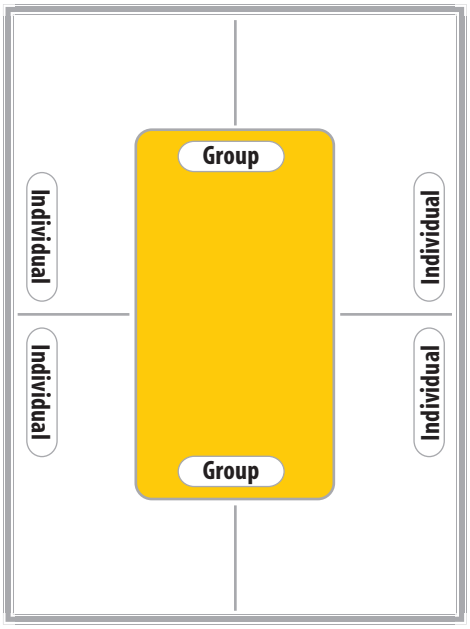
LOOKING BACK

1 In your learning journal, reflect on:
(a) what you have learnt from this chapter
(b) any parts of the chapter that were of particular relevance to you
(c) ways in which information in this chapter may have changed how you think or react to something.

2 Use the 321 tool shown at right to unlock your thinking on:
- 3 interesting points
- 2 important points
- 1 personal point for each section in this chapter.

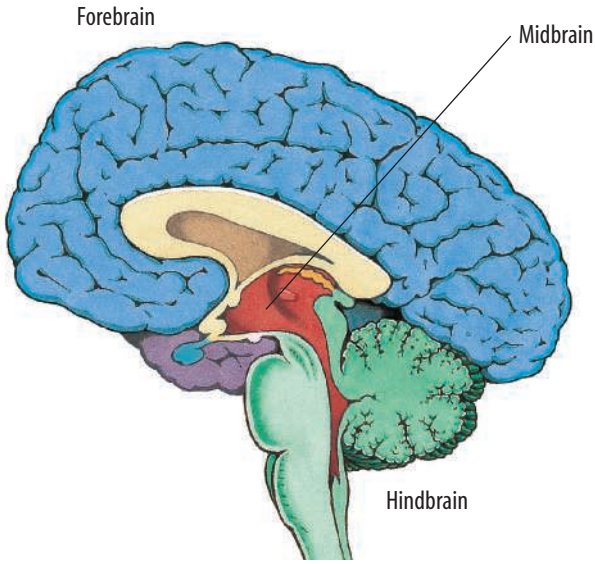


3 Working in groups of four, use the 'learning placemat' below to show:
(a) the key points that each team member remembers
(b) a group summary of a discussion about individual learning.



4 For one of the topics below, list at least five questions that you would like to answer about it. Use as many resources as you can to try to answer your questions. While you are searching for your answers, find at least one example of current relevant research in which scientists are involved.
(a) Anger and the brain
(b) Sleep
(c) Memory
(d) Drugs

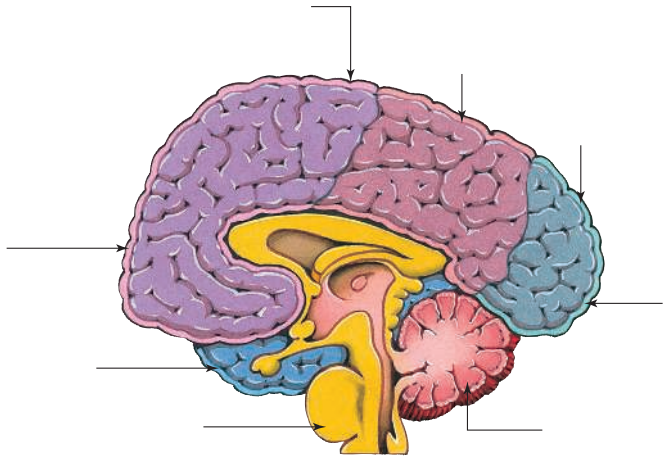
5 Using a cluster map or mind map, outline the key roles of your hindbrain, midbrain and forebrain.



6 Construct a game, song or puppet play that could help teach small children one of the following.
(a) The difference between left and right hemisphere thinking
(b) Ways of managing anger or conflict
(c) Ways to improve sleep
(d) Different types of memory systems

7 (a) In a team of four, brainstorm:
(i) examples of situations and tactics that might be used to encourage or pressure young people to take drugs
(ii) possible consequences of taking the drugs offered
(iii) strategies (both verbal and non-verbal) that could be used to say 'No thanks!' or remove the pressured person from the situation.
(b) Write a story or play that would help to provide young people with ideas on how to say 'no' or get out of difficult drug situations.
(c) Present your play to the class.

8 Label each of the parts of the brain below and state one of the functions of each.



9 Match the cerebral lobe with its associated function: occipital lobe, temporal lobe, parietal lobe, frontal lobe.
   (a) Decision making, planning, working memory and higher order thinking
   (b) Hearing explicit memories, words and pictures
   (c) Sensory, motor and spatial
   (d) Vision, pictures colours and movement

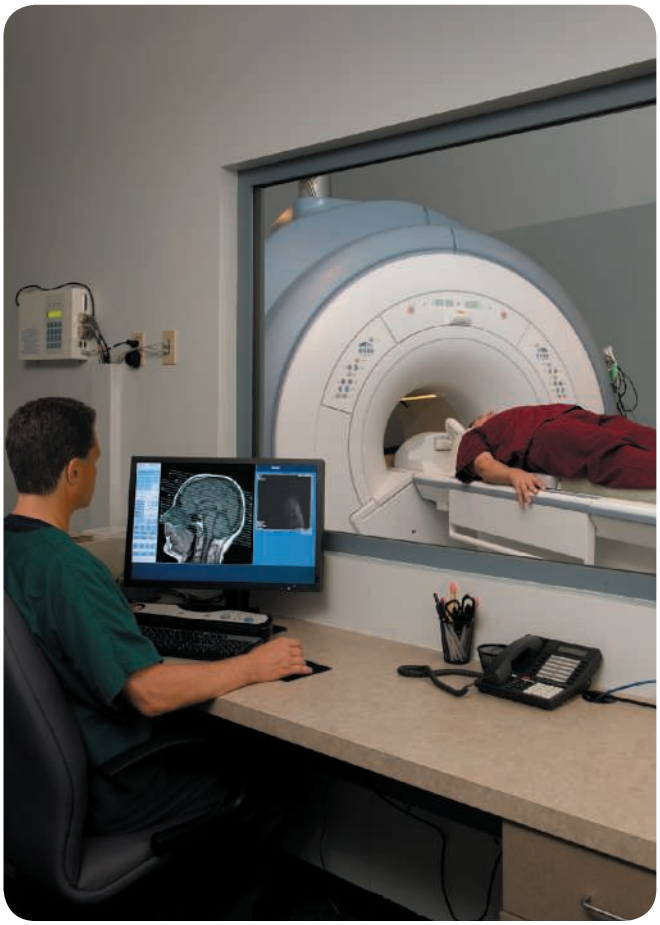
10 Learners were once described as being dominated by their brain's right hemisphere or left hemisphere. This theory has now changed to a more 'whole brained' version. Suggest reasons why.

11 Describe functions of the following parts of your brain.
   (a) Cerebrum
   (b) Cerebellum
   (c) Brain stem or medulla

12 Suggest how analogies and metaphors can be useful in helping you connect information that you know to new information. Provide an example.

13 Neurolaw? How do you feel about the idea of the determination of guilt or innocence on the basis of a brain scan? There have been suggestions that brain scans (e.g. fMRI) should be used within our legal system. Do you think that these should be allowed as evidence in courts? Discuss and share your opinion with others. Justify your opinion.

14 List the following in order from highest to lowest alcohol content (for a volume of 180 ml): whisky, full-strength beer, white wine, port.



15 Below are some examples of brain imaging techniques. Match the name of the technique to what it looks like or does.

Brain imaging technique	Description
CAT: Computerised axial tomography	A. Records electrical activity in defined areas, using colour to represent positive and negative locations in the cerebral cortex.
MRI: Magnetic resonance imaging	B. Reports on patterns of electrical transmission within an active brain which are seen as a squiggly line graph.
EEG: Electroencephalogram	C. Image that focuses on soft tissue and can show differences in chemical composition; some MRI techniques can monitor brain activity during cognitive activity.
SQUID: Superconductivity quantum interference device	D. Uses radioactive glucose to monitor blood flow through the brain as areas are activated. Can provide information of how and where an experience is processed in the brain.
PET: Positron emission tomography	E. Responds to small magnetic fields caused by electrical current of firing neurons and can identify source of electrical activity in the brain.
BEAM: Brain electrical activity mapping	F. Shows 3D graphical images of the density of tissue such as bone and tumours.

16 Construct a continuum to show the following from smallest to largest:
- nervous system
- cerebellum
- molecules
- brain
- neurons.

17 Classify the following as being (a) excitatory or (b) inhibitory psychoactive drugs.
- Barbiturates
- Nicotine
- Heroin
- Caffeine
- Amphetamines
- Benzodiazepines
- Cocaine

work sheet 2.3 Learning with your brain in mind: Summary