

UNIT 1 Variation

1.1 What makes you?

- 1 Your genes decide the features you inherit.
- 2 We cannot predict the features children will have because they inherit a random selection of genes from each parent. (Students may also mention that features like creativity and being brilliant at maths are influenced by your environment as well as genes.)
- 3 Students could give any example of environmental variation eg if you don't get enough nutrients you will not reach the maximum height your genes would allow.
- 4 Many inherited features are present at birth (eg eye colour) but others develop later (eg your final hair colour) and others are also influenced by the environmental factors you experience during your childhood (eg height and weight). Environmental factors begin to influence your development from the moment you begin to develop in the womb.
- 5 A developing embryo gets nutrients from their mother's blood by using their umbilical cord and placenta.
- 6 A fetus is most vulnerable to drugs and infections in its first 12 weeks when its organs are developing.
- 7 If Natalia was not immune to rubella, the virus could infect her and cross the placenta to the embryo. Rubella causes brain damage in early embryos and can leave them deaf and blind.
- 8 Pregnant women are advised not to drink at all because alcohol would damage their developing fetus.
- 9 The two things that determine your features are the genes you inherit and environmental factors.
- 10 A woman's diet, smoking and drinking all affect the development of her child eg cigarettes produce carbon monoxide which attaches to the haemoglobin in the red blood cells and reduces the amount of oxygen circulating in the embryo's blood; alcohol damages their developing brain and other organs; lack of essential nutrients limits the embryo's growth.

1.2 New life

- 1 The egg and the sperm both contain half a set of genes. When they fuse to form a fertilised egg cell, it gets a full set.
- 2 The nucleus of a fertilised egg cell is copied before each cell division, so each new cell gets a full set of genes.
- 3 Stem cells are unspecialised. When they divide they can eventually produce any other type of cell.
- 4 The cells divide, specialise, arrange themselves into tissues and organs and take different roles.

- 5 Nerves take messages from the brain to muscles and from sensors to the brain. Muscles contract to cause movement.
- 6 The first sense that develops is the sense of touch.
- 7 The height difference between Emma and her parents is caused by genetic factors.
- 8 Fertilisation happens when an egg and sperm fuse together.
- 9 Kasia is different from anybody else because she inherited a unique combination of genes - a random selection of each of her parent's genes.
- 10 A fetus moves by sending nerve messages to its muscles. This lets it practice movements it will need to make when it is born.

1.3 Investigating inheritance

- 1 Mendel's second generation pea plants were all tall so they only inherited their height from their tall parent.
- 2 Mendel used a brush to take pollen from one plant to another.
- 3 A dominant gene controls an organism's features, even when they also carry a different version of that gene.
- 4 The second generation are all tall because they have one of the dominant genes that makes the plants tall.
- 5 Some of the third generation plants are short because they don't inherit any of the dominant genes. Their parents each have one dominant gene so only half their sex cells contain one and some of the offspring don't inherit one.
- 6 If shortness dominated tallness, all the 2nd generation would be short and most of the 3rd generation would be short.
- 7 A dominant gene controls an organism's features, even when they also carry a 'short' version of that gene.
- 8 The diagram should show that Emma's parents both have the gene combination Aa, but Emma has the combination aa.
- 9 Brown hair could be caused by a dominant gene. Tony's parents could both have a gene for red hair as well as one for brown hair, but Tony has inherited two genes for red hair.

1.4 Evidence from twins

- 1 Identical twins are not totally identical even though they have identical genes.
- 2 The good thing about the design of the experiment was that babies with identical genes were influenced by different environmental factors.

- 3 Experiments like this are no longer allowed because it is unethical to experiment with people without their knowledge and consent.
- 4 The feature most influenced by genes is verbal reasoning.
- 5 The results show that children with low enzyme activity were more antisocial, but only when they suffered severe maltreatment.
- 6 Genes do not decide your exact features. They are influenced by environmental factors.
- 7 Identical twins are useful to scientists because they allow scientists to judge whether features are influenced more by environmental factors or genes.
- 8 Twin data tells us that most of our features depend on both our genes and environmental factors.
- 9 A gene could be found in 50% of boys, but 50% of boys are not badly behaved. Behaviour is likely to be influenced by environmental factors as well as genes.

1.5 Changing behaviour

- 1 A stimulus is a signal that triggers a response.
- 2 A baby's reflexes are useful because they help a baby to survive.
- 3 A baby uses its rooting and sucking reflexes to find food.
- 4 The swimming reflex is a surprising one for a baby to have.
- 5 No more children imitated the adult's behaviour when it was rewarded.
- 6 Seeing the behaviour punished stopped some children copying it.
- 7 Boys were more likely to copy a behaviour they had seen punished than girls.
- 8 When a baby listens and looks around, messages from their eyes and ears help the nerve cells in their brain link together.
- 9 Parents are advised to sing to their babies and teach them nursery rhymes because the stimulation helps nerve cells in their brains to form links. This makes it easier for them to learn later and more likely to grow up happy and well behaved.
- 10 This tragedy allowed the psychologists to study the effect of depriving babies of stimulation.
- 11 The children who spent more than eight months in an orphanage were most affected.
- 12 The main problems the children suffered from were a lower intelligence score and more behaviour problems.
- 13 Instincts are inherited and they are predictable behaviours. The same stimulus always causes the same response. Learned behaviour is more flexible and depends on the experiences an infant has.

- 14 Sai never learned to use her eye because it didn't send any messages to her brain while its nerve cells were linking together.
- 15 The evidence in favour of helping mothers to care for babies is that babies who don't get enough stimulation are more likely to have learning and behaviour problems later.

1.6 Using genes

- 1 Mosquito nets are important in countries where malaria is common because they prevent the mosquito bites that spread the disease.
- 2 Many people die of malaria because they can't afford medicine.
- 3 Artemisinin is so expensive because it is expensive to extract the chemical from the plant and too difficult to make it in a laboratory.
- 4 Even though artemisinin will cure malaria by itself, it is mixed with other chemicals so that the microbes that cause malaria don't become resistant to the medicine.
- 5 Reduce the number exposed to the microbe - control insects; increase their immunity - improve vaccines and develop new ones, improve nutrition, measure health; provide better medicines - cure infections, make sure they don't stop working - limit resistance.
- 6 Governments and charities need to pay for malaria treatments because the victims of the disease can't afford them.
- 7 Features that can take any value like height show continuous variation.
- 8 The most common yield is 10 µg/mg dry weight.
- 9 The highest yield is 52 µg/mg dry weight.
- 10 Genetic engineering adding genes from other species to bacteria or yeast so that they can make useful chemicals.
- 11 The technique makes the chemical is cheaper because microbes grow fast and the chemical is easier to extract from them.
- 12 It is difficult to wipe out malaria in Africa because the microbes are resistant to the affordable medicines originally used, and most African people cannot afford expensive new treatments.
- 13 Wiping out the disease will require international collaboration because it will cost £billions.
- 14 The genetically-engineered product will help to eradicate malaria because it will produce more affordable treatments quickly.

1.7 Living factories

- 1 Acid and alcohol get into cacao beans from natural yeasts and bacteria which grow in the pulp that surrounds them.
- 2 Spiders' silk is ultra-light, strong, and elastic.

- 3 Salmonella bacteria are useful for making silk because they throw it out as fast as they make it. Other bacteria would be poisoned by it.
- 4 BioBricks are single genes, or collections of genes that work together.
- 5 BioBricks could speed up progress in synthetic biology because they are easy to add to microbes and scientists already know how they work.
- 6 Modified microbes might be released into the environment to clear up pollution.
- 7 People are concerned about the modified microbes because they could mutate and become harmful.
- 8 Everyone should know how scientists are modifying microbes because they might want to be involved in deciding what safety regulations are needed.
- 9 In the past, natural microbes were used to make foods. Today, microbes can be genetically modified to make new products.
- 10 Regulations need to be put in place to control the modification of microbes because scientists cannot be completely sure that they won't do any harm.

UNIT 2 Extremes

2.1 Strength

- 1 To cause movement, muscles contract and pull on tendons which are attached to bones.
- 2 The muscles work against each other. When one contracts, the other relaxes.
- 3 The muscle on the front of the upper arm is stronger because it has to work against gravity to lift your lower arm.
- 4 Muscle contraction is controlled by nerves messages.
- 5 A lightning bolt causes all your muscles to contract at once, and the strongest muscles jerk your bones violently in one direction, which make you jump higher than you normally would.
- 6 The extra glucose and oxygen lets your muscles release more energy.
- 7 Your brain uses a chemical called adrenalin to increase the blood supply to your muscles.
- 8 The robotic exoskeleton uses sensors to detect our nerve impulses, and uses these to control its motors.
- 9 If the nerves to muscles are damaged, they don't receive messages from your brain so they can't contract.
- 10 Two sets of muscles are needed to bend and straighten your knee because they pull in opposite directions. While one contracts, the other relaxes.
- 11 Weight lifters need a high energy intake to provide energy for muscle contraction.
- 12 A nurse might find a robotic exoskeleton useful to help lift heavy patients.

2.2 Agility

- 1 Dancers can get a lot of joint injuries because jumps, turns, and changes in direction put a lot of pressure on their joints.
- 2 Shoulder and hip joints give you most freedom of movement because they work like joysticks.
- 3 Ligaments need to be strong to hold bones together, but stretchy enough to allow your bones to move.
- 4 Sprains occur when a sudden change in speed or direction tears or breaks a ligament.
- 5 Ice can be used to reduce the damage if you sprain a ligament.
- 6 The diagram should show a ball and socket with a layer of cartilage over each bone.
- 7 student opinion
- 8 Strong when squashed - bone and cartilage; strong when pulled - ligaments and tendons; rigid - bone; flexible - ligaments and tendons; smooth - cartilage.
- 9 Ligaments need strength and elasticity to hold bones together but still allow them to move. Cartilage needs to be smooth so that bones can turn without rubbing against each other and they withstand need to withstand crushing forces.
- 10 Older people may need expensive medical treatments like hip replacements.

2.3 Stamina

- 1 The reaction that releases energy inside cells is respiration.
- 2 Runners sip glucose drinks to top up their blood glucose to maintain supplies to their muscles.
- 3 One side of your heart pumps blood to your lungs to be oxygenated, and the other pumps it to every other tissue.
- 4 The left side of his heart sends oxygen-rich blood to his muscles.
- 5 To move oxygen into his blood faster, his lungs can breathe faster and deeper and his heart can pump blood around faster.
- 6 The amount of blood leaving her heart increased.
- 7 Her muscles and skin got more blood when she started to run.
- 8 The blood supply to her brain didn't change.
- 9 Your body stores most of its energy supplies as fat.
- 10 Carbohydrates are stored in your muscles and liver.
- 11 Martin's liver and fat cells keep topping up his blood to keep his muscles supplied.
- 12 A 1500 m runner uses carbohydrates faster because they run faster.

- 13 Respiration is important to athletes because it supplies the energy muscles need to contract.
- 14 Fit people can run faster because their circulatory systems can deliver glucose and oxygen to their muscles faster.
- 15 Glucose is the most suitable energy source to consume during a race because it doesn't need digesting.

2.4 Speed

- 1 Martin Lel runs marathons and averages speeds of 6 m/s whilst Usain Bolt runs 100m or 200m and averages speeds of 10 m/s.
- 2 The athletes have different average speeds and can keep going for different lengths of time.
- 3 Fast twitch muscles can exert most force.
- 4 Slow twitch muscles can keep going for longer.
- 5 Slow twitch muscles have more capillaries.
- 6 Sprinters have more fast twitch muscles.
- 7 A sprinter's muscles tire quickly.
- 8 Most cells contain a nucleus, membrane, cytoplasm, and mitochondria.
- 9 Muscle cells have more than one nucleus.
- 10 The table should summarise these facts: aerobic respiration uses oxygen, releases 100% of the energy in glucose and is the main source of energy in slow twitch muscles. It can provide energy continuously. It produces waste carbon dioxide and removes lactic acid. Anaerobic Respiration doesn't use oxygen, it only releases 5% of the energy in glucose and can carry on at full speed for only a few minutes because lactic acid builds up in the muscles.
- 11 Cheetah's leg muscles should contain fast twitch muscles.
- 12 Fast twitch muscles use anaerobic respiration which can only continue for a short time
- 13 Heart muscle cells have a lot of mitochondria because they use aerobic respiration.
- 14 Anaerobic respiration is useful because it can release a lot of energy instantly for a short time.

2.5 Keeping cool

- 1 We get hot when we exercise because muscles respire faster to give us energy to move, but this releases more heat.
- 2 Blood warms up as it runs through working muscles and spreads heat throughout your body.
- 3 The blood vessels that run near the surface of Jasmine's skin open up when she exercises and the extra blood near the surface makes her face glow.
- 4 Sweat takes heat from your skin as it evaporates, so it makes you cool down faster.
- 5 The only way to lose heat when the air temperature is higher than 37 °C is by sweating.

- 6 In a sauna, you sweat a lot and lose a lot of water, so feeling thirsty is a sign that you need to drink.
- 7 It is an advantage to have a large surface area of skin in hot countries to help you lose heat faster.
- 8 Long distance runners need to lose heat easily so they need to be thin.
- 9 When the athlete lost 3% of her body mass her speed decreased by 15% to 85% of its original value.
- 10 Your brain cells have a limited amount of space, so if you've drunk too much water they expand too much, and are squashed against the skull.
- 11 The average body temperature is 37 °C.
- 12 You lose heat to your surroundings through your skin and can increase the rate of heat loss by sweating.
- 13 If you drink too much water, all your cells can expand and may be damaged. If you drink too little, your cells can shrink, and if they shrink too much, they can tear away from places where they were attached.

2.6 Gasping for breath

- 1 The atmosphere is much thinner at the height planes fly, so there's less oxygen in each breath you take. An oxygen mask helps you get the oxygen you need until you can be brought down.
- 2 The diagram should show a hollow air sac with a blood vessel running around the outside. There should be a red arrow pointing from the air to the blood and a blue arrow pointing from the blood to the air.
- 3 Tissues get less oxygen at high altitudes because red blood cells leave your lungs half full.
- 4 When you spend time at high altitudes your body produces more red blood cells and extra capillaries.
- 5 Not everyone can adapt to high altitudes. Some people's lungs fill with fluid and they die.
- 6 Smoker's get more lung infections because their cilia become paralysed and can't brush mucus and trapped microbes out.
- 7 Jamie lets his carers pound his chest to free his mucus so he can cough it up, and takes antibiotics to combat the microbes that remain in his lungs.
- 8 It is harder to breath at high altitudes because each breath takes in fewer oxygen molecules.
- 9 Athletes who train at high altitudes adapt to the thin atmospheres so by making more capillaries in their muscles and extra red blood cells to carry oxygen to them for respiration. So they can release energy faster in their muscles.

- 10 Smokers' lungs can get clogged with mucus when their cilia are paralysed by tar from cigarettes, which means they can't take in oxygen so quickly.
- 11 Cystic fibrosis sufferers keep using new antibiotics because the bacteria that grow in their lungs become resistant when the same antibiotics are used over and over again.

2.7 Gravity

- 1 Astronauts circulatory systems are most affected when they are in space.
- 2 Arteries have thick muscular walls. Veins have thinner walls, wider centres and valves. Capillaries are very narrow and their walls are only one cell thick.
- 3 Arteries need to withstand the high pressure of the blood leaving the heart. Capillaries need thin walls to allow small molecules to diffuse between blood and cells. Veins need valves to stop blood flowing the wrong way. Their walls don't need to cope with high pressures.
- 4 Blood carries supplies like oxygen and glucose to every tissue, removes waste and helps keep them all at 37°C.
- 5 The diagram should show red cells in liquid plasma.
- 6 The red blood cells should be labeled - carries oxygen and the plasma - carries carbon dioxide.
- 7 On Earth your heart has to work harder to pump blood because the force of gravity is so much stronger than in space.
- 8 By the time an astronaut gets back to Earth their heart muscles will be weaker and their blood volume lower. So when they stand up, not enough oxygen might reach their brain so they feel faint.
- 9 When bones have no force on them they become hollow and weak.
- 10 Lack of gravity stops blood accumulating in an astronaut's legs and makes their bodies reduce blood volume. Their hearts don't need to work so hard, so they get weaker, and the circulatory system does not work so effectively when they get back to Earth.
- 11 If your body contains too much water, your kidneys take more water out of the blood to bring the volume down.
- 12 Exercise is important in space because it keeps your muscles working so they don't waste away as quickly.

2.8 Repair

- 1 Many people on the transplant list dies each year because there aren't enough organ donors.

- 2 People who do get transplants need to take medicines to avoid their immune systems rejecting the organs.
- 3 Kidney transplants are more common because we can survive with one kidney, so people can donate kidneys while they are still alive.
- 4 Doctors may advise against liver or lung tissue donations because donors can suffer complications.
- 5 New organs made from patient's stem cells could never be rejected.
- 6 Red blood cells are replaced by stem cells in the bone marrow.
- 7 When protein from a donor is used, every living cell needs to be washed away to prevent the tissue being rejected by the patient's immune system.
- 8 Embryonic stem cells can every type of body cell but adult stem cells have already become specialised and can only produce a small range of cells.
- 9 Organs made from a patient's stem cells cannot be rejected like transplants from other people. So there is no need for the patient to take special medicines for the rest of their life.
- 10 Stem cells need to be grown on a protein scaffold to produce the right shape for an organ.
- 11 Growth factors control stem cell growth and development.

2.9 Senseless

- 1 Sensory cells are specialized to detect things like light and sound.
- 2 Your brain processes the nerve messages from sense organs to produce hearing and vision.
- 3 Your sound-detecting cells are in your cochlea which is deep inside your ear.
- 4 Your outer ear collects sound vibrations from the air, and then your inner ear makes the vibrations bigger.
- 5 Nerves send messages from your cochlea to your brain. If they're damaged, they can't be replaced.
- 6 Your light-detecting cells are at the back of your retina.
- 7 Hearing and vision both rely on sensory cells. Sound makes the hairs on sensory cells in the cochlea vibrate, and light makes molecules inside light-detecting cells change shape. Then they both release chemicals which make nerves send out a signal to your brain.
- 8 We use touch, vision, smell, taste and hearing to monitor the world around us.

- 9 Light from the car headlights stimulates light-detecting cells in your retina. These cells release chemicals that stimulate nerves, and nerves send signals to your brain which processes them to produce the sense of vision.
- 10 At the moment artificial eyes and ears are far less sensitive than real ones.

UNIT 3 Interdependence

3.1 Lost world?

- 1 Orang-utans are endangered in Borneo because humans are destroying their habitat by cutting down the trees they rely on for food.
- 2 Biodiversity is the number of different species living in one place, i.e. a high biodiversity is when there are many species in an area, and a low biodiversity is when there are not many species in an area.
- 3 Animals rely on plants for creating new biomass, which they can use for food, and for releasing oxygen, which they breathe in and use in chemical reactions in the body to release energy.
- 4 Humans also get fuel, animal feed, building materials, clothing, paper and medicines from plants.
- 5 The rainforest produced most biomass.
- 6 Farmland produced the least amount of biomass per year.
- 7 It is an advantage to have many species growing in the same place because each species has different features, so natural disasters or pests, especially species-specific ones, will not destroy an entire rainforest at once. In addition, all resources are used, for example, the light that the top trees do not absorb is then absorbed by plants lower down.
- 8 Rainforests are less likely to be wiped out by disease than crop plants because the disease is not likely to affect every species in the rainforest, so while one species is dying, others will be flourishing, and this cycle can continue, whereas once one crop plant has a disease, most of the other plants in that crop will also die of it.
- 9 You are more likely to see a monkey or pig in the rainforest than a clouded leopard because clouded leopards live in the treetops and you are more likely to stay on the ground. In addition, a clouded leopard needs more biomass to support it than a monkey or a pig, so for the same amount of forest biomass, there will be more pigs or monkeys than clouded leopards.
- 10 Forests have a high biodiversity because all the organisms can work with each other and share resources, like sunlight or other food sources.
- 11 It is good for a place to have a high biodiversity because, if one species is hit by a disease, the entire area will not change dramatically. There

will still be lots of other animals and plants to keep the area similar to how it was. Secondly, it means resources are not wasted, for example if sunlight is not absorbed by higher trees, plants lower down will get it, and if an animal only eats half of its kill, another animal can come and eat what's left.

- 12 Forests that have existed for thousands of years suddenly under threat due to humans cutting down trees for making paper and building materials, and for farm land. This is leaving animals without a place to live and with nothing to eat, so their numbers are dropping rapidly.
- 13 It takes a lot of forest to support one clouded leopard because it is a carnivore, meaning it eats herbivores. These herbivores, which eat the plant life in the rainforest, only retain 10% of the biomass they take in. So energy is lost at each step in the food chain and it takes a huge area of land, with lots of vegetation, to support one leopard.

3.2 Species

- 1 Animals are classified by being grouped according to their similarities and differences. Groups are separated into smaller and smaller subgroups until the animals in each subgroup are different. This is the species, a name in Latin, which is not used for any other species.
- 2 All cats have fur and warm blood, as well as sharp claws, a short skull, eyes facing forward and long canine teeth.
- 3 Cat classification needed to change when clouded leopards were discovered because it did not fit in to any of the existing groups.
- 4 It is difficult to tell whether or not animals belong to the same species because there can be big differences between animals in the same species.
- 5 To make sure a male and female belonged to the same species you could let them breed and see whether their offspring are fertile, or you could do a DNA test.
- 6 Scientists think that clouded leopards aren't all the same species because they live in different habitats that have been separate for thousands of years, and differences between their environments mean they might have developed different adaptations.
- 7 Scientists all over the world give each species the same name so that people know they are talking about the same animal when they share information.
- 8 A species is a group of closely related animals or plants that share many features and can mate with each other successfully to produce fertile offspring.

- 9 Many classification systems changed when genetic evidence became available because it gave more definite evidence about how closely species were related than simple observations could.

3.3 Facing extinction

- 1 A habitat is where a species lives.
- 2 A habitat should provide nutrients, water, space and shelter.
- 3 If all the caribou were killed by hunters wolf numbers would decrease rapidly and if they did not find another source of food very quickly, they would die.
- 4 The number of tree snakes carried on rising when the number of birds dropped because they could still eat other organisms, such as rats or mice, so they didn't go short of food.
- 5 It is important to disperse seeds so they don't stay close to the parent plant where they would compete for space, nutrients and water. More plants survive when they are dispersed.
- 6 Trees compete for space, water, carbon dioxide, and light.
- 7 If trees have to compete they cannot photosynthesis at a fast rate. They will produce less glucose and grow more slowly.
- 8 There are more pine beetles in Canada now because they feed mainly on trees that are over 80. There are more of these now because the forest fires that used to kill them are less common. Since they have more food, they can grow and reproduce faster. Global warming is letting more of them survive the winter months which used to kill them off.
- 9 Most populations stay small even when many offspring are born because the offspring are killed by disease, predators and lack of food.
- 10 Animals are interdependent when predator numbers effectively control prey numbers, and prey numbers control predator numbers.
- 11 An animal's population could suddenly increase if there was a bigger food supply, fewer predators or a more suitable climate.

3.4 Fuel and the forest

- 1 Biofuels are renewable fuels made from plants.
- 2 Biofuels should release less carbon dioxide overall than petrol because the plants took in carbon dioxide while they were growing, and they can't release more carbon dioxide than this when they burn. Burning petrol releases carbon dioxide that plants took in millions of years ago.
- 3 Modern farmers are clearing more forest because the wood from the cut down forest, and

crops they can grow in its place, are needed all over the world, and can generate huge incomes.

- 4 There is a big demand for palm oil because it is used in food and to make bio fuel. Biofuels are becoming more popular because people are getting more and more concerned about global warming, and biofuels should decrease the carbon dioxide emissions that are thought to cause it.
- 5 Biofuel production can increase carbon dioxide levels when forests are burned down to free ground for growing plants, fuels are burned to move machinery in to remove trees, and new crops like oil palms take in less carbon dioxide than the original forest.
- 6 When bio fuels replace food crops there can be food shortages and this means food prices rise.
- 7 The advantages of making biodiesel from algae are that forests would not need to be cut down, so they can still take in a lot of carbon dioxide; food can still be grown, so there would be enough food for everyone, and the algae could use up waste carbon dioxide from power stations. They also grow very fast so should be able to meet demand.
- 8 Drawbacks to growing algae for food are that the algae ponds would have to cover a huge area, and a lot of sunlight would be needed. If the light were to be generated artificially using electricity, this would increase carbon dioxide levels - unless a renewable source of energy was used.
- 9 The whole of a sugar beet cannot be turned into bioethanol because it can't all be turned into sugar.
- 10 Two reasons for using biofuels instead of petrol are that they can release less carbon dioxide into the atmosphere, and they are renewable, so they will not run out in a few years time.
- 11 Two reasons for not using forestland to grow biofuels are that the area that has to be cleared would take in more carbon dioxide than the biofuel plants do, so this actually increases carbon dioxide levels; and deforestation destroys many species' habitats so they could become extinct.
- 12 You could make more biodiesel or bioethanol from the same mass of plant material if plant cell walls could be broken down so the whole of the plants' biomass could be converted to biofuel.

3.5 Mangroves

- 1 Mangrove forests are important to local people because they provide building materials, fuel, medicines and food, and the waters around them are full of fish.

- 2 Mangrove forests are important to the Earth as a whole because they have a huge biodiversity, with many species either living there or using the area as breeding grounds.
- 3 Bacteria and fungi are decomposers.
- 4 Most of the food chains in the mangroves depend on decomposers because few of the mangrove trees leaves get eaten before they fall into the water. The animals in the habitat feed on the leaf decomposers in the water, or the animals that eat them. So the decomposers are at the base of every food chain.
- 5 Photosynthesis slows down when the temperature is too high or too low, or there is not enough water, carbon dioxide or minerals.
- 6 Minerals are most likely to be missing from the oceans.
- 7 When mangroves roots are underwater they respire using air stored in their spongy tissues.
- 8 The carbon compounds decomposers take in from rotting leaves could get back into the air when they respire or when they die and their tissues are broken down by microbes.
- 9 Decomposers get their energy by breaking down the biomass in dead plants and animals.
- 10 Phytoplankton grow faster in shallow coastal waters because the rivers flowing into the sea bring lots of minerals, and let phytoplankton grow faster.
- 11 Plants release more carbon dioxide during the night because when there is no sunlight, they cannot photosynthesise. They respire for 24 hours a day though and this releases carbon dioxide into the air.
- 12 Life on Earth couldn't continue if there were no decomposers because they allow minerals and other raw materials to be recycled.
- 6 They were removed so that the wood could be used for fuel or building materials, and the space left behind for growing crops or building homes.
- 7 Reforestation can occur without moving people if they plant the trees around towns and villages and on disused industrial land like coal mines.
- 8 It is important to use a mixture of species to create different environments, which helps maintain biodiversity.
- 9 Carnivores are important to forests because they control herbivore numbers in a natural way. This means that the vegetation in the forest will not all be eaten by the herbivores.
- 10 Trees can be harvested sustainably by planting a new tree for every one they cut down.
- 11 Two things that affect the number of trees in an area are the climate and whether the original tree cover has been removed by humans.
- 12 Animal biodiversity drops when forests are removed because the animals have no where to live and nothing to feed on. Those that can't find a new habitat die.
- 13 Reforestation involves planting trees and moving forest animals into the area.
- 14 Reforestation can take in a lot of carbon dioxide from the air, and people can enjoy the greenery, peace and quiet, nature walks or adventure playgrounds in them. They also provide work.
- 15 Reforestation can bring are environmental, social, economic benefits.
- 16 To be sustainable a new development must conserve resources for future generations.

3.6 Bringing back forests

- 1 The UK was treeless 15 000 years ago because the climate was too cold and dry.
- 2 Trees spread because their seeds were carried by the wind, water or animals to other areas.
- 3 The climate decides where trees will survive. If it is too cold or too hot, the leaves cannot photosynthesise. Trees also die if there is too much or too little water or sunlight, or too much competition between trees for space.
- 4 Scientists can tell what grew thousands of years ago by studying the pollen trapped in layers of soil. The deeper the soil is, the older it is. Every tree type has different pollen, so by finding out what type of pollen is in the soil, scientists can find out what type of tree would have grown there.
- 5 The UK's forests started to disappear 6000 years ago when humans began to cut them down.

3.7 Restoration

- 1 It is important to remove radioactivity from water because radioactivity can damage living things and water can flow over a huge area. It takes a long time to decay.
- 2 Some metals need to be removed from soil because they are toxic. If they are left in the soil, they could be taken in by plants and kill them. Also, any animals eating the plants could die.
- 3 Minerals get into plants through root hair cells with water.
- 4 If plant cells don't have enough water to fill their vacuoles the cells become very floppy.
- 5 The experiment was designed to test the theory that locusts would not eat leaves with a high arsenic content.
- 6 The experiment confirmed the theory because much less of the arsenic-treated fern was eaten.
- 7 The ferns could remove arsenic from soil polluted by industry. But if beneficial insects took a bite from their leaves they might die and if the plants spread throughout the countryside they could cause major problems.

- 8 Bioaccumulation happens when an organism takes in a substance in small amounts and it builds up. Eventually organism may be poisoned.
- 9 The minerals plants need most of are nitrates, potassium and phosphates.
- 10 Water in the soil is absorbed by the root hair cells. The water then travels through the xylem, to the leaves, flowers or fruit. Stomata in the leaves let the water evaporate back into the air.
- 11 Sunflowers can stand up straight without skeletons to support them because each of their cells supports itself. They have water-filled vacuoles, which press against their cell walls, when they are full of water, and make the cell rigid.
- 12 A plant might store harmful chemicals in its leaves to deter animals from eating them.

UNIT 4 The carbon cycle

4.1 Diamonds are forever

- 1 An element - it contains only one type of atom.
- 2 the crust
- 3 below - magma; above - lava.
- 4 1 is weathering; 2 is erosion; 3 is transportation.
- 5 in the mantle
- 6 Diamond is an element because it is made of atoms of one element only.
- 7 Diamond is insoluble and very hard.

4.2 Diamond detectives

- 1 To make sure their results were reliable.
- 2 Subliming is the change from a solid to a gas, without first becoming liquid. It is a physical change.
- 3 The mass of Lavoisier's diamonds decreased. The decrease could be the result of the sublimation of some of the solid diamond.
- 4 Subliming is a physical change, when a solid changes to a gas. Burning is a chemical reaction, in which a substance reacts with oxygen and transfers energy to the surroundings.
- 5 carbon dioxide
- 6 After heating, carbon dioxide gas was present in the container.
- 7 On burning, diamond produced carbon dioxide. The only possible source of carbon to make this compound was the diamond.
- 8 Tennant discovered that diamond and charcoal make equal masses of carbon dioxide on burning. He concluded that diamond, like charcoal, is pure carbon.
- 9 carbon + oxygen \rightarrow carbon dioxide
- 10 The visible burning, and the scarlet glow on heating.
- 11 The carbon atom was joined to two oxygen atoms in a carbon dioxide molecule.

- 12 Weigh and burn a sample of graphite. Use limewater to check that the gas produced is carbon dioxide - if it is, it will make limewater milky. Weigh and burn another sample of graphite. Compare the mass of carbon dioxide formed with the mass made from the same mass of a known form of pure carbon, such as diamond. If the samples produce the same mass of carbon dioxide, then it is reasonable to conclude that graphite is pure carbon.

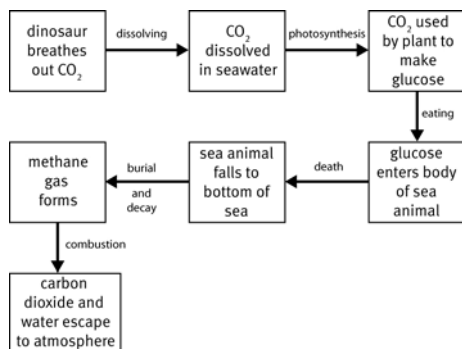
4.3 From dinosaur to seafloor

- 1 There are one carbon atom and two oxygen atoms in one carbon dioxide molecule.
- 2 Grace's model shows how the atoms are arranged in the molecule. The formula is quicker and easier to write, and shows at a glance how many atoms of each element are in the molecule.
- 3 Compound - carbon dioxide; elements - oxygen, nitrogen, and argon.
- 4 N₂
- 5 glucose and oxygen
- 6 A compound - it consists of atoms of more than one element.
- 7 There are 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms.
- 8 carbon dioxide, CO₂ and water, H₂O: they are compounds because they are made up of atoms of more than one element strongly joined together.
- 9 reactants - carbon dioxide and water; products - oxygen and glucose

4.4 From seafloor to sky

- 1 carbon and hydrogen
- 2 One atom of carbon and four atoms of hydrogen.
- 3 The molecules move around randomly in all directions. The molecules are spaced out, and not in any regular pattern.
- 4 The reactants are methane and oxygen.
- 5 carbon dioxide - CO₂; water - H₂O
- 6 octane + oxygen \rightarrow carbon dioxide + water

7



- 8 Because there is no oxygen beneath the rocks.
- 9 methane - CH_4 ; octane - C_8H_{18} (there are many other possible answers)
- 10 Because it takes millions of years to be formed.
- 11 carbon dioxide and water

4.5 Solid as a rock

- 1 The solvent is water. Carbon dioxide and salt (sodium chloride) are two of the solutes dissolved in sea water.
- 2 One carbon atom and two oxygen atoms.
- 3 It is made from tiny pieces of shells.
- 4 Some of the sea creatures the rock is formed from decayed without oxygen.
- 5 Areas of Britain made from limestone rock were once covered with shallow seas.
- 6 Marble is a metamorphic rock because it has been formed when high temperatures caused changes to another rock - limestone.
- 7 calcium, carbon, and oxygen
- 8 It is hard and virtually non-porous
- 9 reactant - calcium carbonate; product - carbon dioxide
- 10 Dead shellfish fall to the bottom of the sea. The shells remain on the bottom of the sea, and break into small pieces, with water flowing between them. These are sediments. More shells fall on top. Their weight squashes together the sediments and squeezes out the water. The water leaves behind a mineral 'cement'. This joins the shell pieces together to form a rock - limestone.
- 11 Heat makes the calcium and carbonate particles in limestone arrange themselves in a new pattern of bigger crystals which interlock tightly. This is marble.

4.6 The carbon cycle

- 1 photosynthesis reactants - carbon dioxide and water; respiration reactants - glucose and oxygen
- 2 Burning fossil fuels, respiration by land plants and animals, respiration by ocean plants and animals, coming out of solution from the sea.
- 3 dissolving in the sea, photosynthesis

4.7 Storing carbon in plants

- 1 To predict what will happen to the carbon cycle - and particularly the amount of carbon dioxide in the atmosphere - if trees are cut down or burned.
- 2 Method 1 - every tree is unique, so not all trees have the same mass as the sample tree; method 2 - the calculations are based on so-called standard trees, but few trees are standard; method 3 - the area of the forest can only be estimated, and there may be trees of many ages and types in the forest.
- 3 Destructive sampling, using one tree to represent the others.
- 4 non-destructive sampling
- 5 remote sensing
- 6 Many scientists with different skills and areas of expertise are working on the project, and are sharing their data and theories with each other; the project will predict the impacts of changes to the rainforest.
- 7 Photosynthesis removes carbon dioxide from the atmosphere, so if there is less photosynthesis less carbon dioxide will be removed; woody waste is broken down by fungi, and fungi releases carbon dioxide to the atmosphere when it respire.
- 8 destructive sampling - use to estimate the mass of carbon in a tree that can be cut down; non-destructive sampling - use to estimate the mass of carbon in one particular tree that must not be cut down; remote sensing - use to estimate the mass of carbon in a whole forest
- 9 They share data and theories to learn from each other, to review and check each others' data and theories and to suggest questions that others might research. They share data and theories at meetings and conferences, through scientific journals and on the Internet.

4.8 Carbon dioxide - climate culprit?

- 1 There were no people and no temperature measuring devices at this time. So early Earth temperatures can only be estimated from evidence such as that provided by tree rings, sea sediments and ice cores.
- 2 The shape of the graph is like that of an ice hockey stick.

- 3 To find out if this data too would support the conclusion that the Earth was warmer than it had been for over 1000 years.
- 4 In a big city, extra carbon dioxide from vehicle exhausts and other sources would give readings for carbon dioxide concentration that are higher than the concentration that is typical for most of the atmosphere.
- 5 Taking continuous readings 'levels out' the effect of unusually high or low readings.
- 6 The level of carbon dioxide has increased rapidly since 1955.
- 7 No. The increase in temperature could be caused by some other change.
- 8 Carbon dioxide absorbs infrared radiation (heat); carbon dioxide and temperature levels have followed similar patterns for the past 500 000 million years.
- 9 to find out if carbon dioxide causes climate change; to identify consequences of global warming; to find out if climate change can be prevented
- 10 The report's conclusions are reliable because they draw on the work of over 2500 scientists from over 100 countries.

UNIT 5 Transport of the future

5.1 *These shoes were made for running*

- 1 Making running shoes needs scientists with different skills and areas of expertise.
- 2 The thread must be strong, flexible and have a low density so the shoe is not heavy.
- 3 Vectran is flexible, it has a low density and it is stronger than steel.
- 4 Vectran thread is strong because its molecules line up in the same direction. It is flexible because its molecules can slide past each other.
- 5 your heel
- 6 your heel
- 7 The stages were: to create a 'Roman sandal' with straps attaching the sole to a runner's foot; to measure the forces on the threads to find where the forces were greatest and so which part of the foot would need the most threads; to study data to find a material with the desired properties for the threads; to test the materials and choose the best.

5.2 *Better boats*

- 1 Thin glass fibres reinforce the plastic resin, making it much stronger than plastic resin alone.
- 2 Metals are strong and slightly stretchy, so they are not holed on collision.
- 3 the aluminium alloy
- 4 the steel alloy
- 5 The one made of the aluminium alloy.

- 6 They are stronger and would bend more on collision.
- 7 Either, if backed up with a sensible reason.
- 8 aluminium + oxygen → aluminium oxide
iron + oxygen + water → hydrated iron oxide (rust)
- 9 Any metal higher than iron in the reactivity series.
- 10 Heat from inside the boat is quickly conducted into the water.
- 11 A paragraph stating clearly the benefits and drawbacks of fibreglass, aluminium, and steel boats.

5.3 *Cars*

- 1 To overcome challenges, to break records, and to create something new and exciting.
- 2 The wheels will spin fast, and so can easily be ripped; air could be sucked out of the cockpit if there are gaps in it.
- 3 carbon dioxide and water
- 4 24 000 g per kilometre
- 5 As car mass increases, so does carbon dioxide emission.
- 6 Any well reasoned answer, including that it is not possible to be sure from this data.
- 7 As heat from the engine and whilst idling at junctions and traffic lights.
- 8 Making cars lighter, reducing friction in the engine, having a stop-start system to cut off the engine when the car stops.

5.4 *Cleaner cars*

- 1 No, because the electricity used to charge them has probably been generated by burning fossil fuels.
- 2 The scientist works for an electricity generating company, so it is possible he is biased in favour of electric cars.
- 3 It is less easy for pedestrians to realise the car is approaching.
- 4 The hybrid car recharges itself as it goes along; it does not need plugging in to be charged up.
- 5 Hybrid cars burn less petrol than petrol cars, so they put less carbon dioxide into the atmosphere.
- 6 Hydrogen + oxygen → water
- 7 Hydrogen fuel advantages - the only exhaust product is water; disadvantages - it is difficult to transport and store.
- 8 Water.
- 9 Hydrogen cars burn hydrogen in their engines; in hydrogen fuel cell cars, hydrogen and oxygen react together in a fuel cell to generate electricity.
- 10 Carbon dioxide, which causes climate change.

SW3: answers to questions in the students' book

- 11 It depends how the electricity is generated. If the electricity is generated from renewable sources, then this may be a greener way of producing hydrogen. If the electricity is generated by burning fossil fuels, then carbon dioxide is produced in the process. This is almost certainly not a greener way of producing hydrogen.

12

Type of car	Advantages	Disadvantages
Electric	Quiet, so better for people living near roads. No exhaust gases from the car. Must be recharged from the mains.	The generation of most mains electricity produces carbon dioxide gas. Quiet, so pedestrians can't hear it coming.
Hybrid	Less exhaust gas produced. No need to recharge from the mains.	
Hydrogen fuel cell	The only exhaust substance is water.	Producing the hydrogen requires energy and may produce carbon dioxide gas. There are few places to refuel. Hydrogen is difficult to store and transport.

5.5 Let the train take the strain?

- They will use about 8.2 litres of fuel, and produce around 198 g of carbon dioxide.
- The values quoted are average values - actual values depend on speed of driving, how often they have to stop, and how laden the car is.
- Average fuel consumption and CO₂ emissions will be less if Callum's dad travels on the train compared to if he travels in his S-Max car. So, travelling by train is almost certainly better for the environment.
- Shorter trains are less heavy.
- Benefits - the plants from which cooking oil is extracted remove about the same amount of carbon dioxide from the air as burning the cooking oil puts into the air; the fuel is cheaper

than oil, and doesn't need to be transported far. Problems - it may not be easy to collect enough cooking oil; the cooking oil needs to be processed before it can be used as fuel.

- methane + oxygen → carbon dioxide + water
- Cow waste methane is renewable, but methane from natural gas is not.
- Cooking oil and petrol are both liquids. They both burn to make carbon dioxide and water as the main products. Petrol is a non-renewable resource - it takes millions of years to form from dead sea creatures. Cooking oil is a renewable resource - it is extracted from plants which take a short time to grow.
- Any sensible answer backed up with reasons.

5.6 When is a red bus green?

- The scientists wanted to know what 'extra' levels of diesel were inside the buses, compared to those in cars.
- They repeated the journeys so that they could calculate average readings to get accurate data.
- The estimates of cancer risk when people are exposed to different levels of diesel exhaust.
- Ten carbon atoms and 20 hydrogen atoms.
- It is cooler higher up the column. Petrol has a lower boiling range than diesel, so its vapours condense to liquids higher up the column where it is cooler
- Particulates penetrate deep into the lungs. They can cause cancer.
- The levels of diesel exhaust fumes inside school buses, and cars.
- Any sensible answer backed up with reasons.

5.7 Noise annoys

- The data was already available, so there was no point doing the work again.
- The instruments are accurate, and they eliminate human error.
- To ensure their data was as accurate as possible.
- To make their data as reliable as possible.
- The data would not be valid if other factors causing high blood pressure were not taken into account.
- 65
- 10%
- The European official might be more inclined to ban night flights.
- Possibly less - the funders might be biased in their views, and this might possibly have affected the way in which the scientists interpreted the data.

- 10 noise meter, MP3 recorder, blood pressure monitor
- 11 Blood pressure might be affected by sleep disturbances. So using blood pressure monitors that do not affect sleep removes one possible reason for the data not being valid.
- 12 Recruit a bigger number of volunteers.
- 13 They took three blood pressure measurements from each person, and calculated an average.
- 14 They recruited a large number of volunteers.
- 15 The scientists say that, because the results were similar for each country, the evidence from aircraft noise causing high blood pressure is strengthened.

5.8 Silent skies?

- 1 Creating a silent airliner is a very complex project, involving different and varied tasks. People with a huge variety of skills are needed for these tasks.
- 2 The people working on the project learnt from each other, helped each other and were inspired by each other.
- 3 The people on the project communicated regularly.
- 4 Engines above plane, so the plane reflects sound waves upwards; engines are lined with sound absorbing materials, so the intensity of sound waves leaving the plane is less; the undercarriage is partly enclosed, so there is less air turbulence under the plane, and less noise; there are brushes on the back edges of the wings, so there is less air turbulence and less noise; both the body and wings provide lift, so the noise of air rushing over the body is less.
- 5 Because people complain about aircraft noise, and at least one study shows that aircraft noise is likely to increase the risk of high blood pressure, which causes heart disease and other health problems.

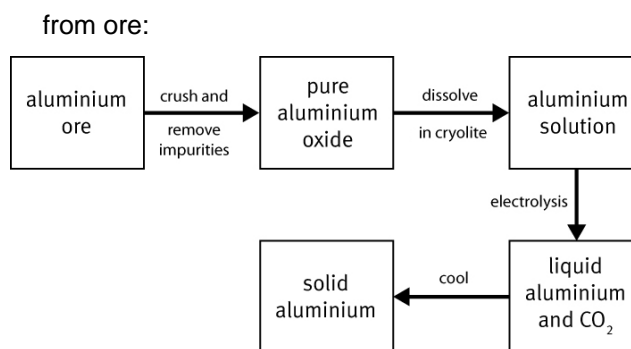
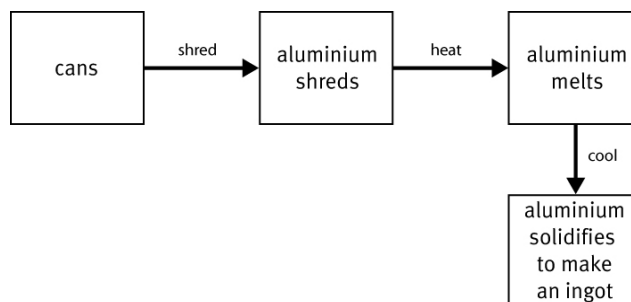
UNIT 6 The cost of your drink

6.1 Can conundrum

- 1 melting
- 2 660 °C. This is the lowest temperature at which aluminium is a liquid.
- 3 The aluminium would melt.
- 4 They use a great deal of electricity. Hydroelectric power is less polluting - and often cheaper - than electricity produced by burning fossil fuels.
- 5 Someone living near an aluminium mine - producing aluminium makes red mud waste; UK council official - cans that are not recycled go to landfill; Can Man - recycling companies pay for old cans; climate change campaigner - making recycled aluminium creates less carbon dioxide;

great grandparent - world's aluminium ore will not last for ever.

- 6 $67 \times 14.9 = 998.3$ g, which is about 1 kg.
- 7 $260 - 15 = 245$ MJ
- 8 $245 \div 2.45 = 100$ hours
- 9 recycled aluminium:



6.2 The can and its contents

- 1 No - it is possible (but unlikely) that the can is made from another metal that is not attracted to magnets.
- 2 reactants - iron oxide and carbon; products - iron and carbon dioxide
- 3 carbon dioxide
- 4 liquid
- 5 It contains atoms of more than one element (hydrogen and oxygen).
- 6 $6 + 8 + 7 = 21$
- 7 carbon, hydrogen, oxygen, sodium.
- 8 $C_{12}H_{22}O_{11}$
- 9 Diagram showing solute molecules in the gaps between the solvent molecules.
- 10 Iron ore contains iron oxide. The oxide is heated with carbon in a big furnace. The carbon takes oxygen away from the iron oxide.
- 11 Water - H_2O contains two hydrogen atoms and one oxygen atom; or carbon dioxide - CO_2 contains one carbon atom and two oxygen atoms.

6.3 Mineral water

- 1 The tap water.
- 2 To remove solid impurities from the water.
- 3 The water travels through tiny holes, or pores, in rocks. As it travels, minerals from the rock dissolve in the water.
- 4 Buxton water
- 5 The rock pores could be smaller or the distance the water travels could be greater.
- 6 water
- 7 two from: calcium, magnesium, sodium, potassium
- 8 Pennine Spring
- 9 $0.4 \times 2 = 0.8$ mg
- 10 $(0.5 \times 8.0) + (0.5 \times 24) = 16$ mg
- 11 Impurities might enter the water on its journey, perhaps from the tanker.
- 12 Find the mass of a very big evaporating dish. Heat the water until it boils. Continue to boil until all the water has evaporated. Find the mass of the dish and the solid residue from the water that is on the dish. Subtract the mass of the dish from this mass. The answer gives the total mass of solid substances dissolved in the water. SAFETY - do not try this at home!
- 13 Any sensible answers, including: High Peak - this water will help you to get the most out of life; Rock - people who like the outdoor life drink this water; Perfectly Pure - this water is very safe to drink.
- 14 Many people think that it is difficult to tell the difference between the tastes of different mineral waters, and most people choose what brand to buy based on brand image rather than taste.
- 15 Again, many people choose what brand to buy based on image rather than the minerals in the water.
- 16 Each type of mineral water flows through the pores of different types of rock on its journey to the surface. On its way, it dissolves a unique combination of minerals. The amounts and types of minerals in the water depend on the types of rock the water flows through.

6.4 Watery dilemmas

- 1 To increase the accuracy of the results.
- 2 As a 'control' group to compare to those who drank water with high mineral levels.
- 3 Knowing what type of water they were drinking might have affected what the volunteers expected to happen. These expectations might influence the actual results.
- 4 Conclusions based on data from bigger samples are more reliable than those based on smaller samples. The scientists probably didn't use a

bigger sample because this would have increased costs.

- 5 It is possible that the scientist was biased, and that he interpreted the data to make a conclusion that would benefit the mineral water company.
- 6 water directly from the spring
- 7 The concentration of antimony in water in plastic bottles is greater than that in glass bottles.
- 8 Rows 2 and 3. The antimony concentration is much higher in the bottle tested at least three months after purchase.
- 9 Any answer justified with sensible reasons.
- 10 No. Science cannot make moral judgements about whether something is right or wrong.
- 11 Possible answers include: it can tell us how we might prevent or treat health problems.

6.5 Fresh from the tap

- 1 the sand filter
- 2 the activated carbon filter
- 3 Some bacteria and viruses cause disease.
- 4 Ultraviolet radiation and ozone both destroy bacteria.
- 5 three
- 6 Correct answers include: source 1 - add chlorine; source 2 - microstrainers, sand filter, add chlorine or ozone; source 3 - microstrainers, sand filter, activated carbon filter trap, add ozone or chlorine.
- 7 No. The study shows that mineral water is not necessarily safer. It can be contaminated by arsenic compounds and carcinogens.
- 8 $160 \text{ p} \div 0.1 \text{ p} = 1600$ litres
- 9 The London tap water contains more dissolved calcium than all the bottled water brands.
- 10 No. Paula would take in more calcium from drinking tap water than from any of the mineral water brands.

Method	What it does and how it works
Sand filtration	Removes solids from the water by trapping them between the sand grains.
Microstrainer	Removes solids from the water by sieving the water through huge rotating sieves.
Activated carbon filter	Traps molecules causing bad tastes, colours and smells in its tiny holes.
Ultraviolet radiation treatment	Uses ultraviolet radiation to destroy bacteria and viruses.
Add ozone	A chemical that destroys bacteria and viruses and breaks down pesticides.
Add chlorine	A chemical that destroys bacteria and viruses.

6.6 Hot drinks

- 1 She must use the same amount of water at each temperature.
- 2 Calculating an average value from the three measurements means that the data is as close to the correct value as possible.
- 3 Using a thermometer and a balance that make accurate measurements.
- 4 523
- 5 The value is much smaller than the other two values at this temperature, so Shanice probably assumed she had made a mistake.
- 6 a line curving upwards
- 7 The solubility of sugar increases as temperature increases. The increase in solubility is greater between higher temperatures.
- 8 To make the chocolate powder dissolve more quickly.
- 9 boiling
- 10 Liquid water - molecules are touching, in a random pattern; steam - molecules are spread out in a random pattern.
- 11 A water molecule is made up of two hydrogen atoms joined to one oxygen atom.
- 12 Dinitrogen oxide is soluble in cream.
- 13 Several small particles, not touching each other, inside each bubble.
- 14 The spray cream has a lower density than the hot chocolate solution, so it floats on the solution.
- 15 The dinitrogen oxide molecules are in the air. The sugar molecules are dissolved in the liquid cream on the plate.
- 16 accurate, reliable
- 17 A foam is formed when bubbles of gas spread throughout a liquid, and are trapped.

6.7 Alcohol

- 1 carbon, hydrogen, and oxygen
- 2 acids
- 3 $500 \times (5 \div 100) = 25 \text{ cm}^3$
- 4 $175 \times (6 \div 1000) = 1.05 \text{ units}$
- 5 any well reasoned answer
- 6 $25 \times (40 \div 1000) = 1 \text{ unit}$
- 7 Because the percentage of alcohol in vodka is much greater than in drinks like wine and beer.
- 8 Any well reasoned answer.
- 9 Any poster that explains how to calculate alcohol units, and why it is important to drink safely.

UNIT 7 Earth and space

7.1 How far can we go?

- 1 C - six hours
- 2 C - just over 1 s
- 3 3000 km/s
- 4 4.3 light years
- 5 70 000 - 100 000 years
- 6 Mercury
- 7 400 hours/16.7 days

7.2 'A Grand Day Out'

- 1 13
- 2 Comparing how easy it is for one person to take one step with the technological progress made by mankind to allow him to do so - or words to that effect
- 3 Student should provide a reasoned argument in favour of or against space exploration
- 4 meteors/meteorites
- 5 stop body swelling up
- 6 go into orbit around the Earth/go round Earth and come back to diving board
- 7 B - slow down
- 8 There is no wind blow the dust or rain to wash it away.
- 9 It goes up and then comes back down again.

7.3 Gravity pulls

- 1 The Earth is more massive than Tom.
- 2 720 N
- 3 1800 N
- 4 288 N
- 5 Zero / 0 N
- 6 The gravitational force is increasing leading to a greater acceleration

7.4 What's up there?

- 1 light; and /or dust
- 2 There is no atmosphere.
- 3 The distance travelled by light in one year.
- 4 277 kg
- 5 2770 N

- 6 Zero/0 N
- 7 great distance/not very bright/near to a bright star
- 8 The dust cloud around the star was behaving as if there was a planet nearby.
- 9 Uses infrared which detects objects not bright enough to be seen in visible light.
- 10 They can see things which are not visible from Earth.
- 11 It takes a long time for light to travel from very distant stars - or words to that effect.

7.5 Life in space

- 1 too heavy to launch all in one go
- 2 solar cells/photo cells/solar panels
- 3 Karen Nyberg spent longer in space/did not have to wear space suit/free to walk around larger spacecraft.
- 4 Water is composed of hydrogen and oxygen
- 5 nitrogen/oxygen/carbon dioxide
- 6 photosynthesis
- 7 Student should provide a reasoned argument in favour of or against space experiments.

7.6 Moonbase 2020

- 1 no atmosphere/no known water/reduced gravity/no known oxygen/no plant life so no food chain possible
- 2 Water
- 3 n atmosphere to distort images
- 4 larger receiving aerial to detect weaker signals
- 5 Sound needs a medium to vibrate – there is nothing in space to vibrate.
- 6 Ultraviolet radiation is harmful / causes sun burn – skin cancer
- 7 For - lots of it available/Against - cost a lot to get it back to Earth
- 8 Could help to solve energy crisis by supplying resources or acting as "relay station" for energy from the Sun.
- 9 Earth has atmosphere which absorbs radiation but energy via Moon is transmitted using microwaves which pass through atmosphere.

7.7 Exploring Mars

- 1 He saw changes in bright and dark patches across the surface – this suggested clouds in an atmosphere.
- 2 more similar to Earth than any other planet/has an atmosphere similar to Earth; the presence of ice caps suggested water
- 3 temperature; atmospheric pressure; atmospheric content
- 4 craters on surface
- 5 surveyed entire planet surface not just part
- 6 beyond expected life/covered in dust so sunlight could not reach photocells

- 7 can analyse different places
- 8 Data is more reliable - first hand data/theories can be verified on the ground.
- 9 takes time for signals to reach and return from surface/any problem with equipment cannot be easily corrected

7.8 Destination Mars

- 1 presence of gully in 2005; not there in 1999
- 2 solid disappeared after a few days – possibly ice melting; salt deposits found which may have come from evaporating water
- 3 Water is essential for life as we know it so if there is water, there is possibly life.
- 4 rock which travels through space
- 5 carbonates found - which on Earth are caused by micro-organisms as they decay and die
- 6 methane is waste product from living things – amount on Mars is changing
- 7 carbon dioxide trapped in the ice caps would be released producing greenhouse gas – leads to global warming up to temperature needed to sustain life
- 8 plant crops to produce oxygen by photosynthesis; produce water
- 9 fossilised remains of bacteria found in meteorite from Mars; 3 billion years old
- 10 warm the planet by greenhouse effect; photosynthesis to produce oxygen

UNIT 8 Energy

8.1 Energy sources

- 1 by altering the amount of water in the tank
- 2 Water in the car at top has GPE due to gravity. Gravity makes the top car descend when released, pulling the other car up.
- 3 GPE is lost by water in tank of descending car is used to pull the other car up.
- 4 electrical energy → **Lift** → KE + GPE
- 5 any 5 correct suggestions eg person, motor, TV, kettle, iPod
- 6 heat
- 7 GPE lost by descending car helps to pull the other car up, reducing the electrical energy needed.
- 8 chemical energy of fuel - coal

8.2 Energy on a tropical island

- 1 Energy sources which are constantly being replaced and won't be used up.
- 2 Oil supplies are running out; renewables cause less pollution.
- 3 produces enough energy to supply its needs using local resources

SW3: answers to questions in the students' book

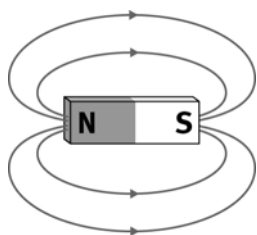
- 4 solar energy → **solar panel** → thermal energy
- 5 copper is a good conductor of heat
- 6 Black surfaces are good absorbers of radiation.
- 7 no fuel to transport; no long distance power lines needed to get electricity to local area
- 8 40 m²
- 9 10 000
- 10 renewable source; does not cause pollution
- 11 Reunion has a lot of sunshine
- 12 solar energy → **photocell** → electrical energy
- 13 renewable; no harmful pollutants produced
- 14 The Sun doesn't always shine.

8.3 Energy on a Scottish island

- 1 Eigg doesn't get a lot of sunshine.
- 2 Eigg is a very windy place.
- 3 The wind doesn't always blow.
- 4 hydro-electricity
- 5 146 kW
- 6 to store electricity for use in an emergency when renewable sources cannot supply sufficient energy
- 7 any sensible suggestions - Play station, CD player, hair drier
- 8 They thought the amount of electricity produced would be too small compared with the installation costs.
- 9 So that everyone has a fair share of the electricity available.
- 10 eg can have lots of electrical appliances, no noisy generators, no problems with transportation of fuel

8.4 Making electricity

- 1 coal, oil, gas
- 2 KE of wind
- 3 KE of falling water
- 4

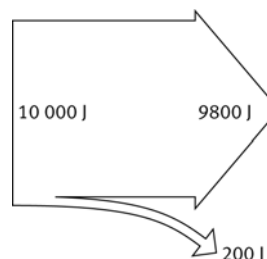


- 5 by pedalling
- 6 pedalling faster
- 7 to increase the magnetic field strength
- 8 more turns on coil; larger current
- 9 kinetic energy → **generator** → electrical energy
- 10 more turns on coil, rotate magnet (or coil) faster, stronger magnet
- 11 Electromagnets can be made stronger.

- 12 to light lamps when bike is stationary or moving slowly

8.5 Calculating energy

- 1 electrical energy → **television** → light energy + sound energy
- 2 heat energy due to friction in coupling between turbine and generator; sound energy
- 3 heat due to current in coil; sound
- 4 Arrow for energy losses in generator is very small.
- 5 dissipated in surroundings
- 6 1/3 approx
- 7 eg large quantity of coal needs to be transported to power station daily; burning coal causes pollution; coal is non-renewable and stocks are finite
- 8 400 J
- 9



- 10 directly heated (element is inside kettle); if plastic kettle, plastic is a good insulator

8.6 Every little bit helps

- 1 produces more electricity than conventional solar panels; uses glass in windows rather than an extra structure
- 2 The Sun doesn't always shine.
- 3 Children turn roundabout which is connected to a turbine. Rotation of the turbine turns a generator, producing electricity.
- 4 in towns and cities
- 5 can change from electricity to petrol if battery runs down or you want to go faster (eg on motorway)
- 6 less environmentally friendly as it still uses a fossil fuel, though less of it than a conventional petrol engine
- 7 lack of hydrogen fuelling stations
- 8 non-renewable sources are running out and pollute the environment
- 9 KE of children → **roundabout** → KE → **turbine** → KE → **generator** → electrical energy
- 10 Uses batteries which have to be recharged. Electrical energy to do this may be produced by burning fossil fuels.
- 11 pollution free - only gas produced is water vapour

8.7 The best energy source?

- 1 approximately 3/4 or 75%
- 2 approximately 1/10 or 10%
- 3 Carbon dioxide is a combustion product
- 4 Sites need to be windy, so restricted to higher ground and coastal areas.
- 5 Off-shore sites do not take up valuable land that could be used for farming, housing etc.
- 6 eg difficult to erect and maintain, hazardous to shipping and birds.
- 7 Demand for electricity is increasing; existing sources are insufficient and fossil fuels are running out.
- 8 takes land that could be used to grow food
- 9 eg advantages: no chemical pollution; renewable source; wind is free
eg disadvantages: noise and visual pollution; take up a lot of space; wind doesn't always blow
- 10 carbon dioxide is a combustion product
- 11 4000
- 12 long coastline

8.8 Changing lifestyles

- 1 too many lights
- 2 eg turning off lights when a room is empty; not leaving computers, televisions etc on stand-by; closing doors
- 3 so that the water in the pipes doesn't freeze in cold weather
- 4 raising awareness/reducing consumption
- 5 60 years
- 6 No: long payback times; wind turbine probably better in Scotland where there will be more wind than in Central London; solar cells probably better in London as it gets more sunshine than Scotland.
- 7 world population is increasing: more electrical devices are being developed; more people, particularly in the developing world, want electrical equipment
- 8 student response
- 9 It takes 10 years to recover the cost of installing the heat pump.
- 10 The payback time is much less.

UNIT 9 Sport

9.1 Fast and slow

- 1 25 km/h
- 2 Greater: she must have gone at faster and slower speeds than the average during her voyage.
- 3 Cyril
- 4 120 s
- 5 Cyril: 0.25 cm/s; Gertie: 0.19 cm/s; Harold: 0.1 cm/s
- 6 not moving

- 7 Gertie
- 8 Distance changes gradually; it doesn't change suddenly because a measurement is taken.
- 9 x 3600
- 10 6.9 m/s
- 11 snail: 0.0025 m/s; Usain: 10m/s (strictly speaking just over as his actual time was 9.69 s); Ellen: 6.9 m/s
- 12 Jake
- 13 10.6 km/h
- 14 Winds and currents take her off course.
- 15 4000 m (4 km)

9.2 Formula 1

- 1 203 km/h
- 2 120 degrees
- 3 (student's opinion)
- 4 There is only one set of numerical values; two are needed for a line graph.
- 5 9.6 to 14.4 s from graph (10 to 14 s from table);
- 6 14.4 to 18.0 s from graph (14 to 18 s from table)
- 7 0 to 9.6 s (10 s in table) and 18 to 20 s
- 8 430 m
- 9 speed constant; distance keeps increasing; car does not stop
- 10 The distance from the start keeps increasing (though at a slower rate) when car the decelerates.
- 11 233 km/h
- 12 315 km/h (accept 310 to 320 km/h)
- 13 approximately 950 m (answer should be > 900 m)
- 14 horizontal line for 10 s; horizontal line at speed zero

9.3 Record times

- 1 0.03 s
- 2 Human reaction time introduces an error.
- 3 so that part of their body cuts the finish line as soon as possible
- 4 Sound would take longer to reach athletes further from the starter gun or a single loudspeaker.
- 5 Any timing error is a greater proportion of the race time for a sprint.
- 6 Sam's; cannot tell
- 7 The automatic timer starts when pressure changes on starting block and stops when swimmer touches side pressure pad at end of race. (In a race covering several lengths contact with the pressure pads at the ends is used to ensure the swimmer completes the full distance.)

9.4 Forces on the go

- 1 They do not need a large acceleration at the start.
- 2 friction with ground small - eg high tyre pressure to keep area of tyres in contact with ground small; smooth tyres (slicks) in dry weather. Drag small - eg smooth shape (streamlined), crouched position
- 3 accelerate
- 4 increase backward force/ reduce forward force until they balance
- 5 travelling at a constant speed
- 6 Forces are balanced.
- 7 The backward force increased/forward force reduced so there is a bigger force backwards than forwards.
- 8 It accelerates to the left.
- 9 There are no forces, such as drag or friction, in space so when rockets stop firing there is no resultant force acting; so the rocket travels at a constant speed.

9.5 It suits them

- 1 increases
- 2 eg swimming, rowing, sailing
- 3 smaller mass to move ($KE = \frac{1}{2}mv^2$ so smaller mass (m) gives bigger speed (v) for same energy input)
- 4 streamlined shape
- 5 eg shape of bike, tight-fitting clothes, sleek helmet shape, cyclist bends over more
- 6 bar chart possibly best choice/other ideas should be judged on their merits
- 7 Not conclusive although there is a general downward trend in times. Eg professional, full-time training, better facilities, improved nutrition, more opportunities to participate. (see Q 10 below)
- 8 GB team worked its way up to Gold medal position; large improvement in time in 2008.
- 9 Yes – you cannot eliminate drag completely.
- 10 eg professional, full-time training, better facilities, improved nutrition, more opportunities to participate
- 11 features to make them more streamlined, such as: tight fitting swimsuits, using new materials, new technology, swimming caps, swimming style

9.6 How far can you go?

- 1 (just under) 10 m/s
- 2 The rider displaces fewer air molecules as he moves.
- 3 Reduce air resistance: wear tight-fitting clothes with streamlined helmet; not have a bag on his back
- 4 17 m/s

- 5 it is very large
- 6 2 m/s to the left
- 7 Anya
- 8 They are balanced.
- 9 eg keep a crouched position for as long as possible, keep arms close to body, wear tight fitting clothes, wear a cap or keep hair very short
- 10 she changes direction; velocity is a vector; 1 hour
- 11 Free-fall parachutists want to fall slowly so they make the drag force as large as possible; cyclists want to move quickly so they make the drag force as small as possible.

9.7 Jumping up and down

- 1 6 N, 2.5 cm
- 2 All points, except one, are very close to the best-fit line which suggests the results are quite accurate.
- 3 All extensions are given to 1 decimal place (nearest mm) so they are precise.
- 4 0 – 10 N
- 5 Extension increases by a greater amount each time another weight is added.
- 6 Too big a weight would overstretch the springs, permanently damaging the trampoline.
- 7 The elastic limit is the point beyond which a spring does not return to its original length when the force on it is removed.
- 8 smaller extension for each pulling force so the graph line would be less steep; line straighter for longer
- 9 120 N

9.8 Faster and slower

- 1 2.4 s
- 2 accelerating
- 3 0.2 m/s^2
- 4 12.3 m/s^2
- 5 9.26 m/s^2
- 6 12 m/s^2
- 7 8 m/s^2
- 8 0 to 60 mph in 6 s
- 9 2 m/s^2
- 10 6.35 m/s^2
- 11 4 s