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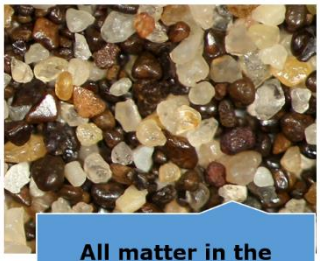
1 All matter in the Universe is made of very small particles

Atoms are the building blocks of all matter, living and non-living. The behaviour and arrangement of the atoms explains the properties of different materials. In chemical reactions, atoms are rearranged to form new substances. Each atom has a nucleus containing neutrons and protons, surrounded by electrons. The opposite electric charges of protons and electrons attract each other, keeping atoms together and accounting for the formation of some compounds.



All matter in the Universe is made of very small particles

5 - 7	All the 'stuff' encountered in everyday life, including air, water and different kinds of solid substances, is called matter because it has mass, and therefore weight on Earth, and takes up space. Different materials are recognisable by their properties, some of which are used to classify them as being in the solid, liquid or gas state.
7 - 11	When some substances are combined they form a new substance (or substances) with properties that are different from the original ones. Other substance simply mix without changing permanently and can often be separated again. At room temperature, some substances are in the solid state, some in the liquid state and some in the gas state. The state of many substances can be changed by heating or cooling them. The amount of matter does not change when a solid melts or a liquid evaporates.
11 - 14	If a substance could be divided into smaller and smaller pieces it would be found to be made of very, very small particles, smaller than can be seen even with a microscope. These particles are not in a substance; they are the substance. All the particles of a particular substance are the same and different from those of other substances. The particles are not static but move in random directions. The speed at which they move is experienced as the temperature of the material. The differences between substances in the solid, liquid or gas state can be explained in terms of the speed and range of the movement of particles and the separation and strength of the attraction between neighbouring particles. The stronger the force of attraction between the particles the more energy has to be transferred to the substance to separate the particles , for example in going from the solid to the liquid state or from the liquid to the gas state. This is why substances have different melting and boiling points. All materials, anywhere in the universe, living and non-living, are made of a very large numbers of basic 'building blocks' called atoms, of which there are about 100 different kinds. Substances made of only one kind of atom are called elements. Atoms of different elements can combine together to form a very large number of compounds. A chemical reaction involves a rearrangement of the atoms in the reacting substances to form new substances, while the total amount of matter remains the same. The properties of different materials can be explained in terms of the behaviour of the atoms and groups of atoms of which they are made.
14 - 17	Atoms themselves have an internal structure, consisting of a heavy nucleus, made of protons and neutrons, surrounded by light electrons. The electrons and protons have electric charge – that of an electron being called negative and that of a proton called positive. Atoms are neutral, charges balancing exactly. Electrons move rapidly in matter, forming electric currents and causing magnetic forces. Their net effect is a force of attraction holding atoms and molecules together in compounds. When some electrons are removed or added, the atoms are left with a positive or negative charge and are called ions. In some atoms the nucleus is unstable and may emit a particle, a process called radioactivity. This process involves the release of radiation and an amount of energy far greater than any reaction between atoms. The behaviour of matter at the scale of nuclei, atoms and molecules is different from that observed at the scale of ordinary experience.

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2 Objects can affect other objects at a distance

All objects have an effect on other objects without being in contact with them. In some cases the effect travels out from the source to the receiver in the form of radiation (e.g. visible light). In other cases action at a distance is explained in terms of the existence of a field of influence, such as a magnetic, electric or gravitational field. Gravity is a universal attraction between all objects however large or small, keeping the planets in orbit round the Sun and causing terrestrial objects to fall towards the centre of the Earth.

5 - 7	This big idea is best introduced to ākonga during the 7-11 year age group due to the compexity of the concept. Perhaps at this age students could be encouraged to notice the effects of non-contact forces.
7 - 11	Objects can have an effect on other objects even when they are not in contact with them. For instance, light, both from close sources such as light bulbs or flames and from the Sun and other stars very long distances away, is seen because it affects the objects it reaches, including our eyes. These sources give out light, which travels from them in various directions and is detected when it reaches and enters our eyes. Objects that are seen either give out or reflect light that human eyes can detect. Sound comes from things that vibrate and can be detected at a distance from the source because the air or other material around is made to vibrate. Sounds are heard when the vibrations in the air enter our ears. Other examples of objects affecting other objects without touching them are the interactions between magnets or electric charges and the effect of gravity that makes things falls to the Earth.
11 - 14	Gravity is the universal attraction between all objects, however large or small, although it is only apparent when one of the objects is very large. This gravitational attraction keeps the planets in orbit round the Sun, the Moon round the Earth and their moons round other planets. On the Earth it results in everything being pulled down towards the centre of the Earth. We call this downward attraction the weight of an object. The object pulls the Earth as much as the Earth pulls the object, but because the Earth's mass is much bigger, we observe the resulting motion of the object, not of the Earth. The effect of gravity on an object on the Moon is less than that on Earth because the Moon has less mass than the Earth, so a person on the Moon weighs less than on Earth even though their mass is the same. The pull of the Earth on the Moon keeps it orbiting the Earth while the pull of the Moon on the Earth gives rise to tides.
14 - 17	Visible light is one example of radiation, which spreads out in a way resembling how waves spread across water. Other kinds of radiation are not visible to the human eye and include radio waves, microwaves, infra-red, ultra-violet, X rays and gamma radiation, which differ from each other in wavelength. These can all travel through empty space (vacuum). Thinking of radiation as waves can help to explain how it behaves. Although sound spreads out like waves it cannot travel through empty space; there has to be some continuous material, in a solid, liquid or gas state, between the source and the receiver for the vibrations to travel through. When radiation hits another object, it may be reflected, absorbed or scattered by it, pass through it, or a combination of these. When reflected by a mirror or transmitted through a transparent material, the radiation remains the same, but when it is absorbed in an object it changes and causes a rise in temperature of the object. Some cases of action at a distance are not explained in terms of radiation from a source to a receiver. A magnet, for example, can attract or repel another magnet and both play equal parts. Similarly, the attraction and repulsion between electric charges is reciprocal. The idea of a field is useful for thinking about such situations. A field is the region of the object's influence around it, the strength of the field decreasing with distance from the object. Another object entering this field experiences an effect – attraction or repulsion. Gravity, electric and magnetic interactions can be described in terms of fields.

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3 Changing the movement of an object requires a net force to be acting on it

A force acting on an object is not perceived directly but is detected by its effect on the object's motion or shape. If an object is not moving the forces acting on it are equal in size and opposite in direction, balancing each other. Since gravity affects all objects on Earth there is always another force opposing gravity when an object is at rest. Unbalanced forces cause change in movement in the direction of the net force. When opposing forces acting on an object are not in the same line they cause the object to turn or twist. This effect is used in some simple machines.

Changing the movement of an object requires a net force to be acting on it

5 - 7	Forces can push, pull or twist objects, making them change their motion or shape. Forces act in particular directions. Equal forces acting in opposite directions in the same line cancel each other and are described as being in balance. The movement of objects is changed if the forces acting on them are not in balance.
7 - 11	The speed of a moving object is a measure of how far it would travel in a certain time. How quickly an object's motion is changed depends on the force acting and the object's mass. The greater the mass of an object, the longer it takes to speed it up or slow it down, a property of mass described as inertia.
11 - 14	All objects on the Earth are affected by gravitational forces. An object which stays at rest on the surface of the Earth has one or more forces acting on it counter balancing the force of gravity. A book lying on a table does not fall because the atoms in the table are pushing upwards on the book with a force equal to the downward force of gravity. An object floating in a liquid or in air does not move because there is an upward force balancing the downward force of gravity. The upward force is equal to the weight of the fluid displaced so heavy objects can float if they are hollowed out to displace a large weight of water.
14 - 17	When forces acting on an object are not equal and opposite in direction, their resulting effect is to change the object's motion, to speed it up (acceleration) or slow it down (deceleration). Often the force that is acting is not recognised as a force and a moving object, such as a rolling ball, is assumed to slow down automatically. In fact its motion is gradually being slowed by the force of friction with its surroundings. In all cases change in motion is caused by unbalanced forces. If no net force is acting any motion will not change; the object will remain stationary or, if in motion, go on forever in a straight line. Change in motion is in the direction of the net force; motion at right angles is not affected. Satellites stay in orbit round the Earth because they are sent off with enough force to reach a height where their motion is in a curved orbit around the Earth due to the force of gravity constantly changing the direction of motion and there is no air resistance to slow them down. When opposing forces acting on a solid object are not in the same line, they act to turn or twist the object. The turning effect of a force depends on its distance from the axis about which it turns. The further the distance from the turning point the less force is needed but the further it has to move. This has many applications in tools and machines where a small force acting over a large distance is used to produce a large force acting over a small distance. Pressure is a measure of the amount of force acting on a particular area. A force spread over a larger area produces less pressure than when spread over a smaller area, a relationship with many applications, from snow shoes to drawing pins. The pressure in a fluid (liquid or gas) at particular point depends on the weight of fluid above that point, so air pressure on Earth decreases with increasing height above the ground and pressure in a liquid increases with depth.

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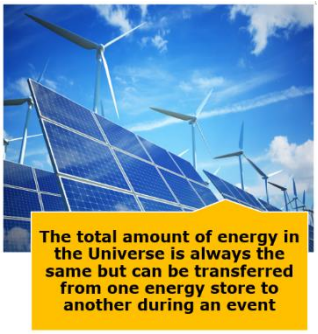
4 The total amount of energy in the Universe is always the same but can transferred from one energy store to another during an event



Many processes or events involve changes and require an energy source to make them happen. Energy can be transferred from one body or group of bodies to another in various ways. In these processes some energy becomes less easy to use. Energy cannot be created or destroyed. Once energy has been released by burning a fossil fuel with oxygen, some of it is no longer in a form that is as convenient to use.

5 - 7	There are various ways of causing an event or bringing about change in objects or materials. Objects can be made to change their movement by pushing or pulling. Heating can cause change, as in cooking, melting solids or changing water to vapour. Electricity can make light bulbs glow. Wind can rotate the blades of wind turbines.
7 - 11	In all these changes, energy is transferred from one object, which is an energy source or resource, to another. Fuels such as oil, gas, coal and wood are energy resources. Some energy resources are renewable, such as those produced by wind, waves, sunlight and tides, others are non-renewable such as from burning fossil fuels with oxygen.
11 - 14	Objects can have stored energy (that is, the ability to make things change) either because of their chemical composition (as in fuels and batteries), their movement, their temperature, their position in a gravitational or other field, or because of compression or distortion of an elastic material. Energy can be stored by lifting an object higher above the ground. When it is released and falls, this energy is stored in its motion. When an object is heated it has more energy than when it is cold. An object at a higher temperature heats the surroundings or cooler objects in contact with it until they are all at the same temperature. How quickly this happens depends on the kind of material which is heated and on the materials between them (the extent to which they are thermal insulators or conductors). The chemicals in the cells of a battery store energy which is released when the battery is connected so that an electric current flows, transferring energy to other components in the circuit and on to the environment. Energy can be transferred by radiation, as sound in air or light in air or a vacuum. Many processes and phenomena are described in terms of energy exchanges, from the growth of plants to the weather. The transfer of energy in making things happen almost always results in some energy being shared more widely, heating more atoms and molecules and spreading out by conduction or radiation. The process cannot be reversed and the energy of the random movement of particles cannot as easily be used. Thus some energy is dissipated.
14 - 17	Energy cannot be created or destroyed. When energy is transferred from one object to others the total amount of energy in the universe remains the same; the amount that one object loses is the same as the other objects gain. When the Sun heats the Earth, the Sun is gradually losing energy through radiation, heating the Earth and other planets. The mass of atoms is a form of stored energy, called nuclear energy. Radioactive atoms release this energy which may become available as heat. Across the world, the demand for energy increases as human populations grow and because modern lifestyles require more energy, particularly in the convenient form of electrical energy. Fossil fuels, frequently used in power stations and generators, are a limited resource and their combustion contributes to global warming and climate change. Therefore, other ways of generating electricity have to be sought, whilst reducing demand and improving the efficiency of the processes in which we use it.

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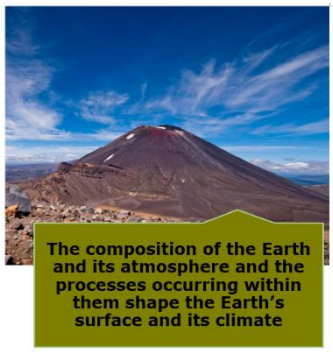
5 The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate

Radiation from the Sun heats the Earth's surface and causes convection currents in the air and oceans, creating climates. Below the surface heat from the Earth's interior causes movement in the molten rock. This in turn leads to movement in the plates which form the Earth's crust, creating volcanoes and earthquakes. The solid surface is constantly changing through the formation and weathering of rock.



5 - 7	There is air all around the Earth's surface but there is less and less further away from the surface (higher in the sky). Weather is determined by the conditions and movement of the air. The temperature, pressure, direction, speed of movement and the amount of water vapour in the air combine to create the weather. Measuring these properties over time enables patterns to be found that can be used to predict the weather a short time ahead. Long-term patterns in the weather are referred to as the climate of different parts of the world.
7 - 11	Much of the solid surface of the Earth is covered by soil, which is a mixture of pieces of rock of various sizes and the remains of organisms. Fertile soil also contains air, water, some chemicals from the decay of living things, particularly plants, and various living things such as insects, worms and bacteria. The solid material beneath the soil is rock. There are many different kinds of rock with different compositions and properties. The action of wind and water wears down rock gradually into smaller pieces – sand is made of small pieces of rock and silt of still smaller pieces. About two-thirds of the surface of the Earth is covered by liquid water, which is essential to life. Water is constantly recycled through processes involving evaporation from oceans and other surfaces, such as soil and plants, condensation in clouds and precipitation as rain, snow or hail.
11 - 14	The layer of air at the Earth's surface is transparent to most of the radiation coming from the Sun, which passes through. The radiation that is absorbed at its surface is the Earth's external source of energy. Radioactive decay of material inside the Earth since it was formed is its internal source of energy. Radiation from the Sun provides the energy that enables plants containing chlorophyll to make glucose through the process of photosynthesis. The radiation from the Sun absorbed by the Earth warms the surface which then emits radiation of longer wavelength (infrared) that does not pass through the atmosphere but is absorbed by it, keeping the Earth warm. This is called the greenhouse effect because it is similar to the way the inside of a greenhouse is heated by the Sun.
14 - 17	Oxygen in the atmosphere, produced by plants during photosynthesis, indirectly protects the Earth from the short wave (ultra-violet) part of the Sun's radiation which is harmful to many organisms. The action of ultra-violet radiation on oxygen in the upper atmosphere produces ozone which absorbs this harmful radiation. The temperature at the Earth's surface results from a delicate balance, which can be upset by adding gases to the atmosphere. Human activities produce carbon dioxide and methane which increase the greenhouse effect and leads to global warming and climate change. Beneath the Earth's solid crust is a hot layer called the mantle. The mantle is solid when under pressure but melts (and is called magma) when the pressure is reduced. In some places there are cracks (or thin regions) in the crust which can allow magma to come to the surface, for example in volcanic eruptions. The Earth's crust consists of a number of solid plates which move relative to each other, carried along by movements of the mantle. Where plates collide, mountain ranges are formed and there is a fault line along the plate boundary where earthquakes are likely to occur and there may also be volcanic activity. The Earth's surface changes slowly over time, with mountains being eroded by weather, and new ones produced when the crust is forced upwards.

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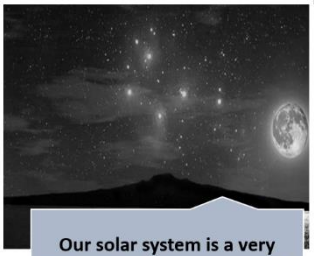
6 Our solar system is a very small part of one of billions of galaxies in the Universe

Our Sun and eight planets and other smaller objects orbiting it comprise the solar system. Day and night and the seasons are explained by the orientation and rotation of the Earth as it moves round the Sun. The solar system is part of a galaxy of stars, gas and dust, one of many billions in the Universe, enormous distances apart. Many stars appear to have planets.



Our solar system is a very small part of one of billions of galaxies in the Universe

5 - 7	There are patterns in the position of the Sun seen at different times of the day and in the shape of the Moon from one night to another.
7 - 11	The Earth moves round the Sun taking about a year for one orbit. The Moon orbits the Earth taking about four weeks to complete an orbit. The Sun, at the centre of the solar system, is the only object in the solar system that is a source of visible light. The Moon reflects light from the Sun and as it moves round the Earth only those parts illuminated by the Sun are seen. The Earth rotates about an axis lying north to south and this motion makes it appear that the Sun, Moon and stars are moving round the Earth. This rotation causes day and night as parts of the Earth's surface turn to face towards or away from the Sun. It takes a year for the Earth to pass round the Sun. The Earth's axis is tilted relative to the plane of its orbit round the Sun so that the length of day varies with position on the Earth's surface and time of the year, giving rise to the seasons.
11 - 14	The Earth is one of eight (so far known) planets in our solar system which, along with many other smaller bodies, orbit the Sun, in roughly circular paths, at different distances from the Sun and taking different times to complete an orbit. The distances between these bodies are huge – Neptune is 4.5 billion km from the Sun, 30 times further than Earth. As seen from Earth, planets move in relation to the positions of the stars which appear fixed relative to each other. Exploring the solar system is possible with robotic missions, or by humans at shorter distances from the Earth.
14 - 17	Occasionally a large chunk of rock orbiting the Sun gets close enough to the Earth to be pulled into its gravitational field and accelerates through the atmosphere where friction between the air and the surface of the rock causes it to heat up and glow, when it can be seen as a 'shooting star'. A meteor is a rock that is all burnt up on entering the atmosphere but if some of it reaches the Earth's surface it becomes a meteorite. Otherwise movements of object within the solar system are mostly regular and predictable. The same scientific laws – generalisations about how things behave – that apply on Earth also apply throughout the Universe. There is evidence from space exploration that changes have taken place on the surface of the planets since they were formed. Life has not (yet) been discovered anywhere outside Earth. Our Sun is one of many stars that make up the Universe, essentially made of hydrogen. The source of energy that the Sun and all stars radiate comes from nuclear reactions in their central cores. The Sun is one of millions of stars that together make up a galaxy called the Milky Way. The next nearest star is much further away than the distance of the furthest planet, Neptune. The distances between and within galaxies are so great that they are measured in 'light years', the distance that light can travel in a year. There are billions of galaxies in the universe, almost unimaginably vast distances apart and perceived as moving rapidly away from each other. This apparent movement of galaxies indicates that the Universe is expanding from an event called a 'big bang', about 13.7 billion years ago.

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7 Organisms are organised on a cellular basis and have a finite life span

All organisms are constituted of one or more cells. Multi-cellular organisms have cells that are differentiated according to their function. All the basic functions of life are the result of what happens inside the cells which make up an organism. Growth is the result of multiple cell divisions.

5 - 7 7 - 11	There is a wide variety of living things (organisms), including plants and animals. They are distinguished from non-living things by their ability to move, reproduce and react to certain stimuli. To survive they need water, air, food, a way of getting rid of waste and an environment which stays within a particular range of temperature. Although some do not appear to be active, all will at some stage carry out the life processes of respiration, reproduction, feeding, excretion, growth and developments and all will eventually die.
11 - 14	All living organisms are made of one or more cells, which can be seen only through a microscope. All the basic processes of life are the results of what happens inside cells. Cells divide to replace aging cells and to make more cells in growth and in reproduction. Food is the energy source they need in order to carry out these and other functions. Some cells in multicellular organisms, as well as carrying out the functions that all cells do, are specialised; for example, muscle, blood and nerve cells carry out specific functions within the organism. Cells are often aggregated into tissues, tissues into organs, and organs into organ systems. In the human body, systems carry out such key functions as respiration, digestion, elimination of waste and temperature control. The circulatory system takes material needed by cells to all parts of the body and removes soluble waste to the urinary system. Stem cells, which are not specialised, are capable of repairing tissues by being programmed for different functions. Cells function best in certain conditions. Both single cell and multi-cellular organisms have mechanisms to maintain temperature and acidity within certain limits that enable the organism to survive.
14 - 17	Within cells there are many molecules of different kinds which interact in carrying out the functions of the cell. In multi-cellular organisms cells communicate with each other by passing substances to nearby cells to coordinate activity. A membrane around each cell plays an important part in regulating what can enter or leave a cell. Activity within different types of cell is regulated by enzymes. Hormones, released by specialised tissues and organs, regulate activity in other organs and tissues and affect the overall functioning of the organism. In humans, most hormones are transported in the blood. Many medicines operate by speeding up or slowing down the regulatory mechanisms of enzymes or hormones. The brain and spinal cord also contribute to the regulation of cell activity, by sending messages along nerve cells in the form of electrical signals, which travel quickly between cells. Given a suitable medium, cells from a variety of organisms can be grown *in situ*, that is, outside the organism. These cell cultures are used by scientists to investigate cell functions, and have medical implications such as the production of vaccines, screening of drugs, and in vitro fertilisation. Plant tissue culture is used widely in the plant sciences, forestry, and in horticulture. Most cells are programmed for a limited number of cell divisions. Diseases, which may be caused by invading microorganisms, environmental conditions or defective cell programming, generally result in disturbed cell function. Organisms die if their cells are incapable of further division.

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8 Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms

Food provides materials and energy for organisms to carry out the basic functions of life and to grow. Green plants and some bacteria are able to use energy from the Sun to generate complex food molecules. Animals obtain energy by breaking down complex food molecules and are ultimately dependent on green plants as their source of energy. In any ecosystem there is competition among species for the energy resources and the materials they need to live and reproduce.

5 - 7 **7 - 11**	All living things need food as their source of energy as well as air, water and certain temperature conditions. Plants containing chlorophyll can use sunlight to make the food they need and can store food that they do not immediately use. Animals need food that they can break down, which comes either directly by eating plants (herbivores) or by eating animals (carnivores) which have eaten plants or other animals. Animals are ultimately dependent on plants for their survival. The relationships among organisms can be represented as food chains and food webs. Some animals are dependent on plants in other ways as well as for food, for example for shelter and, in the case of human beings, for clothing and fuel. Plants also depend on animals in various ways. For example, many flowering plants depend on insects for pollination and on other animals for dispersing their seeds.
11 - 14	Interdependent organisms living together in particular environmental conditions form an ecosystem. In a stable ecosystem there are producers of food (plants), consumers (animals) and decomposers, (bacteria and fungi which feed on waste products and dead organisms). The decomposers produce materials that help plants to grow, so the molecules in the organisms are constantly re-used. At the same time, energy resources pass through the ecosystem. When food is used by organisms for life processes some energy is dissipated as heat but is replaced in the ecosystem by radiation from the Sun being used to produce plant food. In any given ecosystem there is competition among species for the energy resources and the materials they need to live. The persistence of an ecosystem depends on the continued availability in the environment of these energy resources and materials. Plant species have adaptations to obtain the water, light, minerals and space they need to grow and reproduce in particular locations characterised by climatic, geological and hydrological conditions. If conditions change, the plant populations may change, resulting in changes to animal populations.
14 - 17	Human activity which controls the growth of certain plants and animals changes an ecosystem. Forestry which favours the growth of certain trees over others removes the food plants of certain animals and so reduces the diversity of species dependent on these plants and of other organisms in the food chain. Modern farming is designed to reduce biodiversity by creating conditions that are suited to particular animals and plants in order to feed the human population. The widespread use of pesticides to preserve one type of crop has widespread effects on pollinating insects on which many other plants depend. Human activity of this kind creates a simple and unnatural ecosystem which limits biodiversity and results in the loss of culturally valuable landscape and wildlife.

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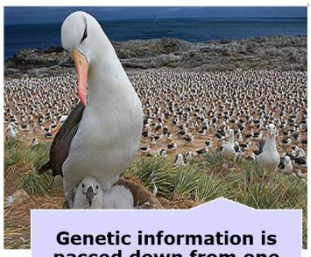
9 Genetic information is passed down from one generation of organisms to another

Genetic information in a cell is held in the chemical DNA. Genes determine the development and structure of organisms. In asexual reproduction all the genes in the offspring come from one parent. In sexual reproduction half of the genes come from each parent.



Genetic information is passed down from one generation of organisms to another

5 - 7 7 - 11	Living things produce offspring of the same kind, but offspring are not identical with each other or with their parents. Plants and animals, including humans, resemble their parents in many features because information is passed from one generation to the next. Other features, such as skills and behaviour, are not passed on in the same way and have to be learned.
11 - 14	Inside the nucleus of animal and plant cells are structures called chromosomes which hold large complex molecules of DNA. When cells divide the information that is needed to make more cells is in the form of a code represented in the way that the parts of the DNA molecule are put together. A gene is a length of DNA; and hundreds or thousands of genes are carried on a single chromosome. In the human body most cells contain 23 pairs of chromosomes with a total of about twenty thousand genes. When a cell divides, as in the process of growth or replacement of dead cells, genetic information is copied so that each new cell carries a replica of the parent cell. Sometimes an error occurs in replication, causing a mutation, which may or may not be damaging to the organism. Changes in genes can be caused by environmental conditions, such as radiation and chemicals. These changes can affect the individual but only affect the offspring if they occur in sperm or egg cells. In sexual reproduction, a sperm cell from a male unites with an egg cell from a female. Sperm and egg cells are specialised cells each of which has one of the two versions of each gene carried by the parent, selected at random. When a sperm and egg combine half the genetic material in the fertilised egg is from the sperm cell and half from the egg cell. As the fertilised egg divides time and time again this genetic material is duplicated in each new cell. The sorting and recombining of genetic material when egg and sperm cells are formed and then fuse results in an immense variety of possible combinations of genes, and in differences that can be inherited from one generation to another. These provide the potential for natural selection as a result of some variations making organisms better adapted to certain environmental conditions.
14 - 17	Asexual reproduction, which occurs naturally in a wide range of organisms including some bacteria, insects and plants, leads to populations with identical genetic material. Biotechnology has made possible the production of genetically identical organisms through artificial cloning in a range of species including mammals. The overall sequence of genes of an organism is known as its genome. More is being learned all the time about genetic information by mapping the genomes of different kinds of organisms. When sequences of genes are known genetic material can be artificially changed to give organisms certain features. In gene therapy special techniques are used to deliver into human cells genes that are beginning to help in curing disease.

What is important is the general direction of progress towards useful explanatory frameworks built on sound understanding at each stage. The ideas developed at all stages should be seen as contributing to this ongoing development.
At each stage the aim is to move a little further towards a big idea, not to try to forge a link between every activity and the most sophisticated form of the idea. How far students can move in this direction at any time depends on a number of contextual variables, not least the pedagogy they experience.

10 The diversity of organisms, living and extinct, is the result of evolution

All life today is directly descended from a universal common ancestor that was a simple one-celled organism. Over countless generations changes resulting from natural diversity within a species lead to the selection of those individuals best suited to survive under certain conditions. Species not able to respond sufficiently to changes in their environment become extinct.

The diversity of organisms, living and extinct, is the result of evolution

5 - 7 7 - 11	There are many different kinds of plants and animals in the world today and many kinds that once lived but are now extinct. We know about these from fossils. Animals and plants are classified into groups and subgroups according to their similarities. For example within the group of animals called birds, there are families of birds such as sparrow, and different kinds (species) within a family such as house sparrows, tree sparrows, and great sparrows. Organisms of the same species breed more of the same. Different species cannot interbreed to produce offspring that can reproduce. Although organisms of the same species are very similar they vary a little from each other. One of the results of sexual reproduction is that offspring are never exactly like their parents.
11 - 14	Living things are found in certain environments because they have features that enable them to survive there. This adaptation to their environment has come about because of the small differences that occur during reproduction, resulting in some individuals being better suited to the environment than others. In the competition for materials and energy resources, those that are better adapted are more likely to survive and may pass on their adapted feature to their offspring. Those less suited to a particular environment are more likely to die before reproducing, so later generations will contain more of the better adapted individuals. This only applies to changes (mutations) in the reproductive cells; mutations in other cells are not passed on. Over time, these changes can accumulate to the point where the survivors have become a different species. The natural selection of organisms with certain features that enable them to survive in particular environmental conditions has been going since the first form of life appeared on Earth about 3.5 billion years ago. Simple single-celled organisms arose early in the history of life. About two billion years ago some of these evolved into multi-cellular organisms that eventually gave rise to today's large animals, plants and fungi. Other forms remained unicellular.
14 - 17	When climatic, geological or population changes occur, the benefit of particular inherited features may be enhanced or diminished. The process of adaptation that occurs naturally and very slowly is speeded up by human intervention through the selection for breeding those animals or plants with the features that suit them for particular functions or environments. Human activity can change the environment more quickly than organisms can respond through adaptation. Water, air and soil pollution as well as intensive farming can impose far-reaching effects on the environment and has already resulted in changes that are damaging to many organisms. The present rate of extinction as a result of human activities is hundreds of times what is would be if there were no people. A reduction in the diversity of life can lead to significant ecosystem degradation and loss of ability to respond to changes in the environment. Evolution of life on Earth is only a limited aspect of what is called 'cosmic evolution'. This refers to the gradual changes in the physical and chemical conditions of the galaxies, such as the appearance of the carbon atom, which has led to favourable conditions for the existence of life, at least on Earth.