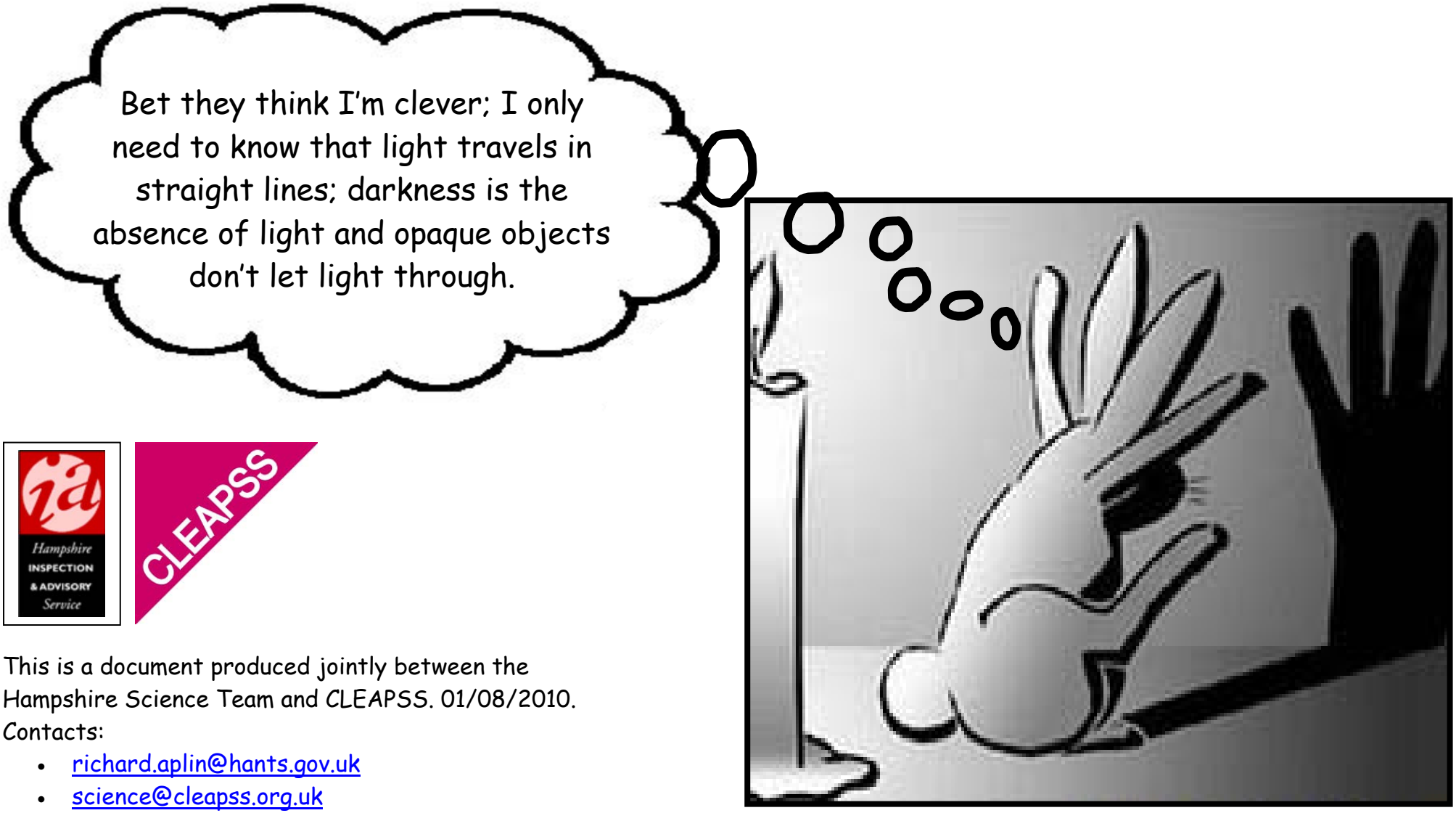
Key Ideas in Primary Science

(CLEAPSS Reference E264)



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Primary Science Key ideas

What do we mean by Key Ideas?

The aim of science is finding new knowledge, and scientific enquiry is the means by which it is found and tested. Scientific knowledge is an essential tool for making predictions, hypothesising and explaining. Children need knowledge to develop these skills. Whether this is achieved through studying cross-curricular topics or in designated science lessons is not important; what is essential is that knowledge is taught in a planned way that allows children to see how one idea flows from another.

The sum total of knowledge is enormous, so how do we decide what is helpful and what is less useful? Some scientific ideas are more powerful than others because they can explain more. For example the idea that light travels in straight lines is essential to explain how shadows form, or how reflections work, or why pencils appear bent when dipped in water. 'Light travels in straight lines' is a powerful idea and one that learners need to explore through enquiry. Some powerful ideas build upon other powerful ideas without which they will make little sense. For example unless a child understands that sound is produced by an object vibrating they will struggle to understand that sound travels through different media by vibrations.

The purpose of this document is to identify those powerful ideas which are relevant to primary age pupils and are taught as part of primary science. We have called these the ***Key Ideas***, and have arranged them in a way that shows how they are related to each other and how one idea builds upon another. They can be used to formulate enquiries and investigations. So the key idea 'changes to materials can happen at different rates' is open to investigation. The curriculum should not contain content simply because it is deemed 'important'. Developing ideas through enquiry and applying ideas whilst enquiring is the most powerful way of making understanding deep and meaningful. We have adopted the philosophy that scientific ideas are tools and so the *Key Ideas* are those that allow children to offer many predictions, hypotheses and explanations which could form the basis of further and immediate enquiry.

Not all the traditionally taught aspects of science are present in this document, but this does not mean they should not be taught. For example, 'how shadows form and change' is not mentioned, yet making and changing shadows forms the basis of exciting and challenging enquiries; and an understanding of shadows underpins later work on eclipses, how shadows change over the course of a day, and phases of the moon. So why is 'how shadows form' not a key idea? Because shadows can be explained by applying 'light travels in straight lines', 'without light it is dark' and 'light passes through some materials better than others' … all of which are key ideas. If children have this knowledge they could, and should, be challenged to think for themselves why shadows form.

How might schools and teachers use this document?

We anticipate that schools will find this a useful document to help them audit their current curriculum and adapt it where necessary to ensure better progression. It will help teachers to identify the key scientific concepts that need to be drawn out, assessed and revisited.

This document is not intended to be definitive. If you think an idea that is not included would help your children make predictions, hypothesise or draw out explanations when engaged in enquiry, you should add that idea to the list!

Hampshire County Council

Living things key ideas

There are some very important overarching ideas that need constant reference:

1. **Living things survive because they are adapted to their environment**. Challenge children to think about how adaptations help survival, and how changes to the environment affect the effectiveness of these adaptations (e.g. the colour of the coats of hares may change to blend with snow). This key idea permeates every aspect of the teaching of living things. A precursor is that there is variation **between** different species and **within** a species and children need opportunities to explore this idea from year 1. Organisms are adapted to fulfil life processes effectively. So a life process should be thought about in a variety of organisms and how they are adapted to perform this process. Behaviour is also an adaptation. For example some animals migrate to breed or give birth. This helps survival because it supports reproduction; an essential life process.

2. **Some things are living and others are not.** Children build an increasingly sophisticated picture of what constitutes life. Ask them if things are alive or not and challenge them to justify their choices. If children initially define life as movement, it makes sense to spend some time looking at how different animals move and why that might be important for their survival, which may move onto investigating nutrition and then plant nutrition. If children start by thinking about growth as a definition of life it makes sense to investigate how different animals grow before moving onto other characteristics of life. The 'characteristics of life' are not a simple checklist, some living things don't show all of these characteristics e.g. immature organisms don't reproduce. Some things show one or more characteristics of life but are not living. Determining if something is living is challenging!

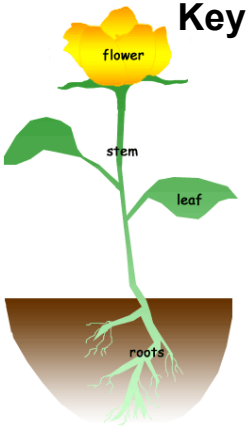
3. **All living things are interdependent**. Changing any part of a habitat affects all living things in that habitat through food chains and other effects on the environment. Changes to one habitat can affect others through animal movement, seed dispersal and broader environmental changes.

Note about classification and keys: The classification of living things is complex and based upon genetic similarities. It is therefore a useful tool to work out evolutionary patterns. This is beyond primary level science and so we need not worry too much about detailed classification. Important classifications are plants and animals (and animals with internal skeletons and animals without). When asking children to group and identify animals and plants we need to think carefully about the purpose of this activity. For example if we know an animal has a skeleton we can predict that it will move when its muscles pull on bones, if a fossil animal is found to have well-developed incisors and canines it was likely to be have been a carnivore. If we give children activities that require this kind of reasoning then grouping by characteristics is useful because it allows us to make predictions. Similarly, identifying every animal and plant in a pond is of little value; but identifying the number of a particular animal in a pond over a period of time may be very useful if it is related to answering a specific question.

Animals Key Ideas

	Key stage 1	Lower key stage 2	Upper key stage 2
Sensing	Animals have a nervous system to help them respond Animals have senses to help individuals survive		Animals are adapted to allow offspring to survive e.g. nurturing and mass production of eggs
Reproduction	Different animals mature at different rates and live to different ages Animals reproduce new animals the species survive All animals eventually die		Animals less well adapted may fail to live long enough to reproduce and therefore become extinct
Growth and nutrition	Animals need a variety of food to help them grow, repair their bodies, be active and stay healthy Animals need food to survive Animals grow until they reach maturity and then don't grow larger Medicines are not food but used well can help animals prevent or fight illness	Animals have teeth to help them eat. Different types of teeth do different jobs Different animals need different foods Bones work with muscles to help movement. Muscles can pull but not push	Food is broken down further in the stomach and intestines where nutrients go into the blood The Heart pumps blood around the body Oxygen breathed into the lungs is absorbed by the blood Muscles need oxygen to release the energy from food to do work. Oxygen is taken into the blood in the lungs; the blood is pumped by the heart to take oxygen and nutrients to the muscles
Movement and respiration	Exercise keeps animals bodies in good condition and increases survival chances Different animals move in different ways to help them survive Animals move in order to survive	Many animals have skeletons to support their bodies and protect vital organs Animals without internal skeletons have adapted other ways to support themselves, move and protect their vital organs	

Plants
Key Ideas



	Key stage 1	Lower key stage 2	Upper key stage 2
Reproduction	Plants eventually die, they make seeds to reproduce and make more plants. Some plants reproduce without seeds	Seeds need the right conditions to germinate. Seeds contain a food store for the first stages of growth	Seed dispersal improves chances of survival Flowering plants have adapted specific parts to carry out pollination, fertilisation and seed growth
Sensing		Growing shoots of plants always grow towards the light and roots always grow downwards	**Note:** Although this is as a result of plants sensing and responding to stimulus it is best to focus upon what they do and how this adaptation helps survival rather than the fact that they are sensing
Growth and nutrition	Plants need warmth, light and water to grow and survive	Plants have roots to provide support and to draw moisture from the soil and sometimes stems to take water to the rest of the plant	Plants make their own food to grow, repair, respire and reproduce Light, water and carbon dioxide from the air are needed for plants to make their own food. Oxygen is also produced which goes into the atmosphere
Movement and respiration	Plants aren't able to move around. Their seeds enable them to spread		

Notes:

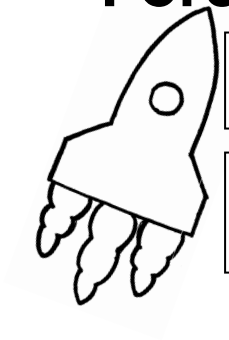
- 'Are any plants able to move?' is an interesting question to try and tackle. After looking at many plants children may well come to the conclusion that none can. Having established this, questions like 'how do they get their food?' and 'how do they reproduce?' become interesting, especially if they know that food and reproduction are essential life processes.
- Like animals plants also respire by taking oxygen into their leaves which reacts with sugar releasing energy to drive life processes. This idea is usually left to KS3 because it is likely to lead to confusion between respiration and photosynthesis.

Environment and interdependence key ideas

	Key stage 1	Lower key stage 2	Upper key stage 2
Micro-organisms and the environment	The environment is full of living things that are too small to see called micro-organisms. Most are harmless or beneficial. A few are harmful; good hygiene is essential to protect us from these	Micro-organisms feed on nutrients and can make useful products or be a nuisance or occasionally dangerous Micro-organisms cause decay which is essential for natural re-cycling e.g. fallen leaves rotting	Micro-organisms can grow and reproduce very rapidly in the right conditions
Living things and changing habitats	Different animals and plants often live in very different places Changing the environment can affect the plants and animals that live there There is variation between different species and between individuals within a species Living things are adapted to survive in different habitats	Nutrients made by plants move to primary consumers then to secondary consumers through food chains. Decomposers, some of them micro-organisms, recycle waste and dead organisms Different food chains occur in different habitats Environmental change affects different habitats differently	Changes to atmospheric gases affect the whole globe and its oceans Human activity significantly affects the environment

Food chain note: Understanding food chains within a habitat help us predict and explain how populations change as a result of changes to the environment.

Forces



Key Stage 1 | **Lower Key Stage 2** | **Upper Key Stage 2**

Notes on arrows: The use of arrows to depict forces should be slowly introduced. At KS1, model movement in the way and direction we push and pull without drawing arrows. At KS2 begin to use arrows to depict forces (size and direction). Later in KS2 draw arrows to represent different forces acting at the same time.

Notes on the word 'force': When do we start using the word force explicitly? It is only essential to use the word force when we introduce ways **other** than using our bodies to push and pull. That is, the word 'force' is needed as a label to describe different things that produce the same effect; for example magnets and my hand push things. They both exert forces. It is not wrong to use the word force when just discussing simple pushes and pulls but it is not essential.

Effects of pushing and pulling

Things can move in different ways

Pushing and pulling can make things move or stop

Pushing and pulling can change the shape of things

Pushing and pulling can make things move faster or slower

Larger masses take bigger pushes and pulls to move or stop them

Bigger pushes and pulls have bigger effects

Contact forces, increasing abstraction

Forcing an object to change its shape can sometimes cause it to exert a force when it goes back to its original shape (e.g. springs, elastic bands and elastic materials)

Friction is a force against motion caused by two surfaces rubbing against each other

Air resistance and water resistance are forces against motion caused by objects having to move air and water out of the way

Water exerts an upward force called **upthrust**

Investigating magnets

Magnets exert attractive and repulsive forces on each other

Magnets exert attractive forces on some materials

Magnets exert **non-contact** forces which work through some materials

Magnetic forces are affected by:

- Magnet strength
- Object mass
- Distance from object
- Object material

Effects of gravity

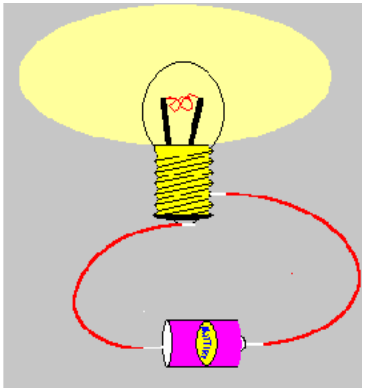
Objects with larger masses exert bigger gravitational forces

Smaller mass objects like planets orbit large mass objects like stars

Stars, planets and moons have so much mass they attract other things, including each other due to a force called gravity. Gravity works over a distance

Objects like planets, moons and stars spin

Electricity



Key Stage 1

Many everyday things use electricity

A source of electricity (mains or battery) is needed for electrical devices to work

Electricity sources **push** electricity round a circuit

A complete circuit is needed for electricity to flow and devices to work

Lower Key Stage 2

Circuit components can be represented by circuit symbols. Begin to use these symbols in lower KS2 and use them more independently and appropriately through upper KS2. (These are not key ideas because they are not used to explain things, but are international conventions)

More batteries will push the electricity round the circuit faster

Devices work harder when more electricity goes through them

Some materials allow electricity to flow easily and these are called conductors. Materials that don't allow electricity to flow easily are called insulators

Upper Key Stage 2

Batteries are a store of energy. This energy pushes electricity round the circuit. When the battery's energy is gone it stops pushing

Materials (or devices) that slow electricity more are said to have a greater resistance

Teacher notes:

- Electricity is a difficult abstract concept. We introduce models to help children offer predictions and explanations of their own observations; they are not definitive scientific explanations. We can imagine electricity to be in every material. It is part of the atoms it is made of; not **given** to a material by a battery. If this electricity can be made to move, an electrical current is produced. Materials that allow the electricity to move are conductors. Something needs to make the electricity move, to 'push it'. This is what batteries and mains power do; they give the electricity a push. The size of electrical current is a balance between the 'push' and the resistance (things in the circuit that make it harder for the electricity to flow). Adding devices and wires to a circuit increase the resistance. Different devices and wires have different resistances.

Ideas associated with 'push'	Ideas associated with resistance	Ideas associated with both resistance and 'push'

Key Stage 1 | **Lower Key Stage 2** | **Upper Key Stage 2**

Heat

- Objects can warm up and cool down
- Temperature is a measure of how hot or cold things are
- Heat always moves from hot to cold
- Insulators slow the movement of heat more than conductors
- Objects will warm up or cool down until they reach the temperature of the surroundings

How light travels

- Light comes from a light source
- Light travels in straight lines
- Transparent materials let light through them, translucent materials scatter light, and opaque materials don't let light through
- Light is absorbed by some materials (absorption)
- Light travels through some materials (transmission)
- Light bounces off some objects (reflection)
- Light reflects off shiny surfaces in an orderly way, producing 'reflections' and reflected beams
- Light reflects off non-shiny surfaces in a scattered way producing no 'reflections' or reflected beams

How we see

- There must be light for us to see. Without light it is dark
- We need light to see **things**, even shiny things
- We see when light enters our eyes
- We see with our eyes

What happens when light hits objects

Sound

Key Stage 1

We hear sound with our ears

We can describe different sounds

Sounds can be made in lots of different ways

We can make different sounds (loud / quiet and high / low)

Sound travels from its source in all directions and we hear it when it travels to our ears

Sound travel can be blocked

Sounds are quieter when listened to further away

Key Stage 2

Sound is produced when an object vibrates

Changing the shape, size and material of an object will change the sound it produces

Changing the way we vibrate an object will produce different sounds

Sound moves through all materials by making them vibrate

Faster vibrations (higher frequencies) produce higher pitched sounds

Bigger vibrations produce louder sounds and smaller vibrations produce quieter sounds

Animals hear when their ear drums vibrate

Exploring simple sounds

Describing how sound moves

Using the idea of vibration to explain sound

Materials

Although it is not a key idea, a key question is '***what material is the best for doing job X?***' As children learn more key ideas about materials their enquiries into this question become more sophisticated. To be able to tackle increasingly sophisticated versions of this question, children need to understand increasingly complex properties. A simple way to view a progression in properties is:

Easily observable properties e.g. colour, hardness, runniness, 'opaqueness', shininess, flexibility. → Properties that can be measured, e.g. temperature, distance, volume. (It is important we move onto these properties quickly if children are to do fair tests.) → Properties that require children to devise their own measurement scale, e.g. magnetic strength, electrical conductivity, absorbency, waterproofness, strength, light intensity, solubility, and viscosity.

	Key Stage 1		Lower Key Stage 2		Upper Key Stage 2
Describing materials	There are different materials		Materials can be divided into solids, liquids and gases	Solids, liquids and gases are described by observable properties	All matter (including gases) has mass
				Heating causes solids to melt into liquids and liquids to evaporate to gases Cooling causes gases to condense to liquids and liquids to freeze to solids	
Changing materials		Materials can be changed. (It is important to provide experiences of changes due to heating as well as changes due to forces)		Some changes can be reversed and some can't	Heating can sometimes cause materials to change permanently. When this happens, a **new** substance is made
					Changes to materials can happen at different rates

Teachers notes:
Separating mixtures applies the ***Key Idea*** that materials have properties. To separate mixtures, first identify the differences in the properties of the mixture's components, and then decide what would affect one material and not the other, to separate them. There is a progression in separation techniques. A mixture is made when the materials do not react and change. (We don't need to share this assumption with children as it is a KS3 idea.)