national science week 2015

15-23 August www.scienceweek.net.au

making waves

THE SCIENCE OF LIGHT

A resource book of ideas for National Science Week 2015

This Inspiring Australia initiative is supported by the Australian Government as part of National Science Week

An Australian Government Initiative

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Australian Science Teachers Association

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Contents

Safety awareness

All activities included in *Making waves: the science of light* have been designed or selected to minimise hazards. However, there is no guarantee that a procedure will not cause injury. Teachers and community educators need to be aware of the special considerations surrounding practical activities in the classroom and ensure that students are suitably clothed for outdoor experiences. Teachers and community educators should test all activities before using them in class and observe the OH&S requirements of their own state or territory. All necessary safety precautions should be outlined clearly to students prior to the commencement of any activity.

President's Message

Making waves: the science of light is #31 in the series of National Science Week resource books published annually by ASTA since 1984, and the fifth web-based, digital version. ASTA is proud of this contribution to National Science Week each year. The resource book is designed specifically for teachers and community educators and this year's book provides stimulating lessons for years F–10 on light and light based technologies, focusing on their role in everyday life.

The resource book could be used in planning for National Science Week 2015 but as it is fully mapped to the Australian Curriculum: Science and has a lesson plan for each year level, it is a resource that can be used every year. Gather inspiration from this resource and connect your students to the International Year of Light events occurring in your area.

I would like to thank all those involved in the production of the resource book *Making waves: the science of light* and in particular the teachers who have shared exemplary learning activities.

ASTA would like to acknowledge the funding support for this resource from the Australian Government through the *Inspiring Australia* Initiative and also acknowledge the eight state and territory Science Teachers Associations and their National Science Week representatives for their ongoing support of National Science Week in schools at the local level.

Robyn Aitken,
ASTA President

Acknowledgements

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Minister's foreword

A light journey of discovery

Light gives us vision, heat energy and high-speed communications. It delivers our food crops through photosynthesis and has shaped the nature of plants and animals according to where they live, whether that be in forests, deep in the ocean, or on rolling plains.

Most natural light on Earth comes from the Sun, and as this book explains, light is much more than illumination. As soon as you begin to explore light it opens up a captivating journey of discovery.

Sunlight powers the evaporation cycle which gives us our atmosphere, our weather, our fresh water: an impressive start for our light journey. Understanding this is particularly relevant to people who live on a hot, dry continent like Australia. We also harness the same solar energy to make electricity.

We are surrounded by colour. Not just the blue of the sky, the green of the grass and the red of the Australian outback, but also the colours we choose to paint our homes and workplaces. Colour is used on traffic signs to alert us to danger and by companies in their branding and marketing. Colour is also important economically – the paint and surface coating industry employs 7500 people and produces $2.7 billion of products in Australia each year.

Much of what we do with light comes from the ways in which we use it. We reflect it to give us mirrors and their numerous applications. We bend it to change its direction for use in objects such as contact lenses and we make it to illuminate the night. This book presents a unique opportunity to investigate further the many ways in which we can harness light.

I am pleased that National Science Week is recognising the importance of light and encouraging thoughtful consideration, discussion, and action by a new generation of scientists.

The Hon Ian Macfarlane MP
Minister for Industry and Science

Introduction

2015 is the UN-declared International Year of Light and Light-based Technologies (IYL). It is a world-wide celebration of the importance of light and optical technologies to the development of society.

Light is everywhere and is fundamental to our existence. In fact, photosynthesis is at the origin of all life. Light enables us to enjoy a rainbow, scan our purchases at the supermarket, conduct research at a synchrotron, take photos and x-rays, study the cosmos and read a book at night – just to mention a few. You can discover more about the science of light and its applications at the official IYL website http://www.light2015.org/. The Australian IYL Committee also has a website http://light2015.org.au/ that provides information on local activities and events to celebrate the Year.

The Australian Science Teachers Association has chosen to celebrate the IYL 2015 with the publication *Making waves: the science of light*, its annual resource book for National Science Week.

This book has been designed to provide teachers and community educators with a selection of lesson plans, accompanying background information and further activity ideas to enhance their students' knowledge and understanding of the science of light and its applications. These are provided as a stimulus for teachers to develop further age-appropriate, inquiry-based lessons/units related to the topics covered.

How this book is structured

Making waves: the science of light curriculum map:

ASTA has developed an abbreviated curriculum map of the Australian Curriculum: Science F–10. This has been used to develop a curriculum map of topics that investigate the science of light. For each year level and against almost every content description in the Science Understanding and Science as a Human Endeavour sub-strands, topic ideas have been specified that complement the *Making waves: the science of light* theme.

Lesson plans:

For each year level, a content description and topic was chosen and developed into a full lesson plan. The book contains eleven lessons, one for each year, F–10. Teachers may choose to use the lesson relevant to their year level and/or develop a similar one using a different/complementary content description. Relevant content descriptions from the Science Inquiry sub-strand are included in all the lessons.

The eleven lessons have been prepared using the same structure giving the teacher all the information needed to prepare for and conduct the lesson. Each lesson has:

- an introduction
- a list of the relevant Australian Curriculum: Science content descriptions and codes. Each code is hyperlinked to the ACARA website.
- reference to the relevant assessment standard/s
- brief background information
- materials and equipment list
- safety advice (if relevant)
- a teaching sequence
  - Lesson objective
  - Introduction
  - Core
  - Conclusion
- lesson resources – could include digital resources and/or worksheets
- useful links to websites for more information or additional activities.

A page of interesting background information for teachers prefaces each lesson. This provides some context for the topic.

Curriculum map

National Science Week 2015 | **Making waves: the science of light**

Science as a Human Endeavour

	Nature and Development of Science	Use and Influence of Science
F	ACSHE013: Science involves exploring and observing the world using the senses ▪ **What are the sources of light?**	
1	ACSHE021: Science involves asking questions about, and describing changes in, objects and events	ACSHE022: People use science in their daily lives, including when caring for their environment and living things ▪ **What type of container do you store your ice cream in? Clear or coloured?**
2	ACSHE034: Science involves asking questions about, and describing changes in, objects and events ▪ **Sunlight heating water or melting chocolate**	ACSHE035: People use science in their daily lives, including when caring for their environment and living things ▪ **How to care for pets on a bright sunny day.**
3	ACSHE050: Science involves making predictions and describing patterns and relationships ▪ **Earth and sun investigations**	ACSHE051: Science knowledge helps people to understand the effect of their actions ▪ **Pinhole viewers**
4	ACSHE061: Science involves making predictions and describing patterns and relationships ▪ **The spinning Earth**	ACSHE062: Science knowledge helps people to understand the effect of their actions ▪ **Light and the nature of seeing**
5	ACSHE081: Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena ▪ **Make a mirage** ACSHE082: Important contributions to the advancement of science have been made by people from a range of cultures ▪ **Research which scientists are working in teams to improve sustainable energy**	ACSHE083: Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives ▪ **What are X-rays?** ACSHE217: Scientific knowledge is used to inform personal and community decisions ▪ **Investigate types of electric light**
6	ACSHE098: Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena ▪ **Adaptations of plants** ACSHE099: Important contributions to the advancement of science have been made by people from a range of cultures ▪ **Research the use of solar panels in other countries**	ACSHE100: Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives ▪ **Consider how solar power has changed the way some people live** ACSHE220: Scientific knowledge is used to inform personal and community decisions ▪ **Why choose to use solar panels / solar energy?**
7	ACSHE119: Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world ▪ **Optical illusions** ACSHE223: Science knowledge can develop through collaboration and connecting ideas across the disciplines of science ▪ **Earth and Space (Science by Doing)**	ACSHE120: Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations ▪ **Can using solar panels have a positive or negative impact on the society?** ACSHE121: Science understandings influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management ▪ **How did Indigenous Australians develop their six seasons?** ACSHE224: People use understanding and skills from across the disciplines of science in their occupations ▪ **Set up and use a light microscope**
8	ACSHE134: Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world ▪ **Polarisation of light** ACSHE226: Science knowledge can develop through collaboration and connecting ideas across the disciplines of science	ACSHE135: Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations ▪ **Are solar cars a viable option for the future?** ACSHE136: Science understandings influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management ACSHE227: People use understanding and skills from across the disciplines of science in their occupations

Curriculum map

National Science Week 2015 | **Making waves: the science of light**

Science as a Human Endeavour

	Nature and Development of Science	Use and Influence of Science
9	ACSHE157: Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community ▪ **Why is the sky blue?** ACSHE158: Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries ▪ **How solar panels work?**	ACSHE160: People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions ▪ **Which are the most cost effective household light bulbs to use?** ACSHE161: Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities ▪ **Examine the results of PET, MRI, colonoscopies and radiotherapy on patients** ACSHE228: The values and needs of contemporary society can influence the focus of scientific research ▪ **Jelly optics**
10	ACSHE191: Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community ▪ **Splitting light** ACSHE192: Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries ▪ **Charge your light bulbs**	ACSHE194: People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions ▪ **What makes the sun shine and where does its energy come from?** ACSHE195: Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities ▪ **Fibre optics and total internal reflection** ACSHE230: The values and needs of contemporary society can influence the focus of scientific research ▪ **Seeding clouds to reflect light and reduce global warming**

Science Understanding – Biological and Chemical Sciences

	Biological Sciences			Chemical Sciences	
	Structure and function	Diversity and evolution	Interdependence	Properties and structure	Interaction and change
F			ACSSU002: Living things have basic needs, including food and water ▪ **Plants need light to survive**	ACSSU003: Objects are made of materials that have observable properties ▪ **Making alien underpants that block all light**	
1	ACSSU017: Living things have a variety of external features ▪ **Why do lizards walk on their toes in the desert?**		ACSSU211: Living things live in different places where their needs are met ▪ **Some plants prefer shade, others prefer bright sunlight**		ACSSU018: Everyday materials can be physically changed in a variety of ways ▪ **Which substances melt the fastest in bright sunlight?**
2	ACSSU030: Living things grow, change and have offspring similar to themselves ▪ **Why are most baby animals born in spring?**				ACSSU031: Different materials can be combined, including by mixing, for a particular purpose ▪ **Choosing the best colour clothing to wear if working outside in bright sunlight**
3		ACSSU044: Living things can be grouped on the basis of observable features and can be distinguished from non-living things ▪ **Is the sun alive?**			ACSSU046: A change of state between solid and liquid can be caused by adding or removing heat ▪ **Does a magnifying glass speed up the melting of ice?**

Curriculum map

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Science Understanding – Biological and Chemical Sciences

	Biological Sciences			Chemical Sciences	
	Structure and function	**Diversity and evolution**	**Interdependence**	**Properties and structure**	**Interaction and change**
4	ACSSU072: Living things have life cycles ▪ **Migration of butterflies**		ACSSU073: Living things, including plants and animals, depend on each other and the environment to survive ▪ **Do plants need light and if so, how much?**	ACSSU074: Natural and processed materials have a range of physical properties; These properties can influence their use ▪ **Which colour of the same material gets hotter in sunlight?**	
5	ACSSU043: Living things have structural features and adaptations that help them to survive in their environment ▪ **Why do some animals that live in the snow have hollow hairs?**			ACSSU077: Solids, liquids and gases have different observable properties and behave in different ways ▪ **What shadows do solids, liquids and gases create?**	
6			ACSSU094: The growth and survival of living things are affected by the physical conditions of their environment ▪ **How much sunlight does a plant need?**		ACSSU095: Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting ▪ **Do liquids flow faster along a reflective surface?**
7		ACSSU111: There are differences within and between groups of organisms; classification helps organise this diversity ▪ **Using eyes to classify organisms (eye number, size, complexity)**	ACSSU112: Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions ▪ **Where does a plant's energy come from?**		ACSSU113: Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques ▪ **How does sunlight affect the water cycle?**
8	ACSSU149: Cells are the basic units of living things and have specialised structures and functions ▪ **The effect of UV light on mitosis** ▪ **Arrangement of pigment in cells to cause a change in colour** ACSSU150: Multi-cellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce ▪ **How the body copes with water loss due to exposure to light**			ACSSU151: The properties of the different states of matter can be explained in terms of the motion and arrangement of particles ACSSU152: Differences between elements, compounds and mixtures can be described at a particle level ▪ **Spectra as evidence of electron shells**	ACSSU225: Chemical change involves substances reacting to form new substances ▪ **Colour change as evidence of a chemical change** ▪ **Chemoluminescence** ▪ **Exothermic reactions**

Curriculum map

National Science Week 2015 | **Making waves: the science of light**

Science Understanding – Biological and Chemical Sciences

	Biological Sciences			Chemical Sciences	
	Structure and function	**Diversity and evolution**	**Interdependence**	**Properties and structure**	**Interaction and change**
9	ACSSU175: Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment ▪ **The power of sight**		ACSSU176: Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems ▪ **Photosynthesis**	ACSSU177: All matter is made of atoms which are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms ▪ **The science behind glow in the dark toys** ▪ **Flame colours**	ACSSU178: Chemical reactions involve rearranging atoms to form new substances; during a chemical reaction mass is not created or destroyed ▪ **Breakdown of ozone by sunlight** ▪ **Breakdown of plastics by UV light** ACSSU179: Chemical reactions, including combustion and the reactions of acids, are important in both non-living and living systems and involve energy transfer ▪ **Burning magnesium gives out bright white light**
10		ACSSU184: The transmission of heritable characteristics from one generation to the next involves DNA and genes ▪ **UV light as a mutagen** ▪ **Environmental influence of light on gene expression**		ACSSU186: The atomic structure and properties of elements are used to organise them in the Periodic Table ▪ **Colours of the elements**	ACSSU187: Different types of chemical reactions are used to produce a range of products and can occur at different rates ▪ **Chemistry of photography** ▪ **Chemistry of photosynthesis** ▪ **Photolysis in the atmosphere**

Science Understanding – Earth, Space and Physical Sciences

	Earth and Space Sciences		Physical Sciences	
	Systems in space	**Changes to the Earth**	**Transformation and conservation of energy**	**Force and motion**
F		ACSSU004: Daily and seasonal changes in our environment, including the weather, affect everyday life		ACSSU005: The way objects move depends on a variety of factors, including their size and shape ▪ **Does light slow down an object?**
1		ACSSU019: Observable changes occur in the sky and landscape ▪ **Weather worksheet - BOM**	ACSSU020: Light and sound are produced by a range of sources and can be sensed ▪ **Luminous and non-luminous objects** ▪ **Shadows – what happens when we block light?**	
2		ACSSU032: Earth's resources, including water, are used in a variety of ways ▪ **Where is the coolest place to play outside on a sunny day?** ▪ **Disappearing puddles**		ACSSU033: A push or a pull affects how an object moves or changes shape ▪ **The brightness and colour of shooting stars**

Curriculum map

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Science Understanding – Earth, Space and Physical Sciences

	Earth and Space Sciences		Physical Sciences	
	Systems in space	**Changes to the Earth**	**Transformation and conservation of energy**	**Force and motion**
3	ACSSU048: Earth's rotation on its axis causes regular changes, including night and day Is the grass still green at night?		ACSSU049: Heat can be produced in many ways and can move from one object to another Heat transfer by radiation	
4		ACSSU075: Earth's surface changes over time as a result of natural processes and human activity **▪ The seasons of the Earth**		ACSSU076: Forces can be exerted by one object on another through direct contact or from a distance **▪ Touchless touch screens**
5	ACSSU078: The Earth is part of a system of planets orbiting around a star (the sun) **▪ Star power** **▪ Does the moon emit its own light?**		ACSSU080: Light from a source forms shadows and can be absorbed, reflected and refracted **▪ Light shows** **▪ Coloured shadows** **▪ Light filters**	
6		ACSSU096: Sudden geological changes or extreme weather conditions can affect Earth's surface **▪ Blocking and scattering of light caused by volcanic activity**	ACSSU097: Electrical circuits provide a means of transferring and transforming electricity **▪ How to make a light globe shine brighter or dimmer** ACSSU219: Energy from a variety of sources can be used to generate electricity **▪ What is solar energy?**	
7	ACSSU115: Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon **▪ Modelling eclipses**	ACSSU116: Some of Earth's resources are renewable, but others are non-renewable **▪ How do we best harness solar energy?** ACSSU222: Water is an important resource that cycles through the environment **▪ How does sunlight affect the water cycle?**		ACSSU117: Change to an object's motion is caused by unbalanced forces acting on the object **▪ Can sunlight exert a force? (radiometer)** ACSSU118: Earth's gravity pulls objects towards the centre of the Earth **▪ Black holes**
8		ACSSU153: Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales **▪ How does sunlight affect the rock cycle?**	ACSSU155: Energy appears in different forms including movement (kinetic energy), heat and potential energy, and causes change within systems **▪ Transformation and transfer of solar energy**	
9		ACSSU180: The theory of plate tectonics explains global patterns of geological activity and continental movement **▪ Lightning discharge during volcanic eruptions**	ACSSU182: Energy transfer through different mediums can be explained using wave and particle models **▪ Light, sound, action – Science by Doing**	
10	ACSSU188: The universe contains features including galaxies, stars and solar systems and the Big Bang theory can be used to explain the origin the universe **▪ Distance to the sun** **▪ Why is the sun yellow?** **▪ Life and death of stars (Science Web)** **▪ Observing the universe (Science Web)**	ACSSU189: Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere **▪ Heating of the Earth by light**	ACSSU190: Energy conservation in a system can be explained by describing energy transfers and transformations **▪ The light dependent resistor (LDR)**	ACSSU229: The motion of objects can be described and predicted using the laws of physics **▪ Bending of light by gravity**

Waves of light and colour

Many marine creatures, such as the box jellyfish and the glass octopus, and some insects, are transparent. They transmit rather than absorb or reflect light. This property means they are disguised from predators in areas where there is nothing to hide behind or blend in with.

Predators see right through them, to the background beyond, and are fooled into thinking there is nothing there.

Whether a material transmits, absorbs or reflects light depends on how that material interacts with the light energy, which reproduces in the manner of a wave. For example, imagine an ocean wave striking a rocky outcrop, a marshy mangrove swamp or the mouth of a river; the wave behaves differently in each situation. It reflects off the rock, is partly absorbed by the swamp and transmits onwards up the river.

When it comes to light, different materials behave like the rock, swamp and river.

What we – and the box jellyfish and glass octopus predators – see in this world is the result of light that is reflected off objects and into our eyes as opposed to being absorbed by the object or transmitted through it. An object that completely absorbs light is opaque; one that completely transmits light is transparent. A material that partly absorbs and partly reflects light will appear coloured.

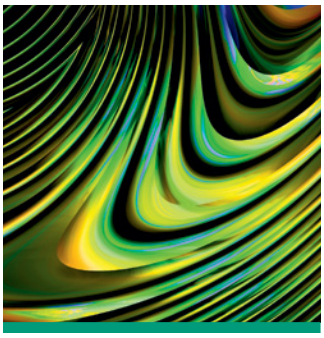
Colour occurs because visible 'white' light is made up of many wavelengths, corresponding to a colour spectrum that ranges from violet, indigo, green and blue to red, orange and yellow – the colours of the rainbow.

It is light that colours the world rather than colours being actual properties themselves. The colour shows the wavelengths that remain once an object has absorbed some wavelengths and reflected others. A red ball, for instance, lacks the ability to absorb the colour red: it reflects the red light back into the world and so the ball appears red to us.

White light is made up of all visible wavelengths combined, and objects that appear to be white reflect light of all the wavelengths of a rainbow. Objects that appear to be black absorb all colours, so no light is reflected.

The ability to transmit light relates to the atomic make-up of the material itself. For example, glass is excellent at transmitting light but a thin tinted or silver layer can be applied to reduce transmission and increase reflection.

Scientists are also working on different ways to temporarily change the characteristics of glass, which would allow it to respond to different privacy requirements, light and temperature conditions.



DID YOU KNOW?

- The human eye can differentiate 10 million different colours.
- A mirror does not absorb any colours and reflects all colours equally.
- Light from a laser is monochromatic, which means it only produces one colour. (Lasers are extremely dangerous and can cause permanent eye damage. Extreme care must be taken to ensure that light from a laser never enters someone's eyes.)

LESSON PLAN: FOUNDATION

Making alien underpants with materials that block all light

Introduction

This lesson provides an opportunity for students to consider the properties of familiar materials and how light reacts when it encounters them. This lesson also makes links to Physical Science understandings that will be introduced in year 1 in relation to light energy being something that can be sensed. Students work as a class to test materials and select the most appropriate materials to create alien underpants that will not be transparent (see-through).

Students are introduced to the science vocabulary of *opaque*, *translucent* and *transparent*; however will also consider materials as being 'see-through' or 'not see-through' to incorporate more familiar terminology that is easier to understand at this age. Materials will be tested as suitable using a small torch to determine whether light can easily be seen through the material. Students will sort materials by their ability to block light and then choose an appropriate opaque material for making their own alien underpants.

Australian Curriculum content descriptions

Science Understanding

Chemical sciences

Objects are made of materials that have observable properties (ACSSU003)

Science as Human Endeavour

Nature and development of science

Science involves exploring and observing the world using the senses (ACSHE013)

Science Inquiry Skills

Questioning and predicting

Respond to questions about familiar objects and events (ACSIS014)

Planning and conducting

Explore and make observations by using the senses (ACSIS011)

Processing and analysing data and information

Engage in discussions about observations and use methods such as drawing to represent ideas (ACSIS233)

Communicating

Share observations and ideas (ACSIS012)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of the Foundation year, students describe the properties and behaviour of familiar objects. They suggest how the environment affects them and other living things. Students share observations of familiar objects and events.

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

This lesson explores the transparency of various materials familiar to young students to determine the materials' suitability for 'underpants for an alien'. Students explore the properties of a range of materials to determine whether light can pass through them or not.

At a Foundation level, students will not yet have been exposed to specific scientific information in relation to light being a form of energy that travels in straight lines, however a background knowledge of light energy is not required to determine whether materials allow any light through or not.

Students use their sense of sight/vision to determine whether materials allow any light through or not. This lesson can link in to other lessons involving exploring using our senses that are appropriate to Foundation level science. Students can be introduced to more specific physical science vocabulary of 'opaque', 'translucent' and 'transparent' for this lesson; however they will also discuss whether materials 'let no light through', 'let some light through' or 'let lots of light through' and sort materials accordingly.

Materials and equipment

Per class:

- *Aliens Love Underpants* book (or audio reading online, see link below)
- a range of opaque, translucent and transparent materials cut into large squares (about 10–15 cm squares) – about 10–12 materials, or enough for one per pair of students in the class. Suggested materials include:
  - thick denim
  - cellophane
  - tissue paper
  - plastic wrap
  - leather
  - polar fleece
  - alfoil
  - cardboard
  - thin paper
  - bubble wrap
  - sheer organza
  - thin cotton
  - fur
- Is the material suitable for alien underpants chart created on a poster size card
- small torch for testing materials

Per student:

- smaller sample squares of the materials listed above for students to cut out into underpants and glue on to their own alien
- Alien underpants worksheet
- crayons/pencils
- scissors
- glue stick

Safety advice

Students should be cautioned about the dangers of shining torches directly into their own eyes or other students' eyes.

Care should be taken when using scissors to cut materials and students may require assistance cutting thicker materials, as they will require sharp scissors.

Teaching sequence

Lesson objective

Students test and sort materials by the extent by which they block light (opaque, translucent and transparent) and then choose an appropriate opaque material to create some alien underpants.

Introduction

Teacher note: Young students generally find 'underpants' highly amusing – be prepared for giggles and amusement!

Seat the whole class on the mat and read them the story *Aliens Love Underpants* by Claire Freedman and Ben Cort or set up the video version for the class to watch.

Discuss how aliens keep stealing people's underpants and that to stop them from doing this we need to make some underpants especially for them. The only condition is that the underpants cannot allow any light to pass through, as this would make them see-through and would be inappropriate and embarrassing for the aliens.

Ask students if they could think of any materials that would not be see-through and make a list of suggested materials on the board.

Core

Teacher note: This section of the lesson will work best if the room is darkened.

1. Tell the class you have collected a range of materials that may or may not be suitable for making underpants for aliens and that you will require their assistance to be 'alien underpants material testers'.
2. Explain that two students at a time will work together and use a torch to shine at a material to check if it is see-through. They will report back to the whole class on what they think about the material's ability to block light. Demonstrate this process first to the students so it is clear what they will do.
3. Select pairs of students to come to the front of the class to test one material with a torch while other students observe. Instruct one student to hold the fabric up while the other shines the torch at it from the other side. The student holding the fabric will determine whether there is 'lots of light' coming through, 'a little light' or 'no light'. The students then attach the fabric to the class chart in the appropriate section and this will be repeated with the other materials.
4. As a whole class, once all testing is complete, review where the materials have been placed on the chart. Ask students which materials they think would make the best underpants (the materials which allowed no light through – opaque). Ask the students if there were any materials they thought would not be see-through and if any materials surprised them.
5. Distribute the My alien underpants worksheet telling them they will draw and colour their own alien after selecting a square of material that they think is an appropriate material for alien underpants. They will use their chosen material to cut out some underpants and glue them on to their alien. They will fill in the information regarding what material they chose and why. (It would be beneficial to have names of materials added to the whole class chart to assist students in labelling their own chosen material accurately.)

Conclusion

Once students have completed their alien picture they can return to the mat as a whole class. Choose some students to present their alien to the class and tell the class what material they chose and why they chose it.

Review the whole class chart and read out the materials that were opaque, translucent and transparent.

Discuss with the students whether they thought all the materials would make comfortable underpants for an alien. Ask them whether they would they wear something made of alfoil, cardboard, gladwrap etc. This could then lead into a following lesson where students consider softness and flexibility of materials and whether the material would be comfortable or not.

Lesson resources

Digital resources

Aliens Love Underpants by Claire Freedman and Ben Cort, YouTube (2:38 min)

Worksheets

My alien underpants

Useful links

Aliens Love Underpants, Website on the *Underpants* series. Games and activities

Bobo Explores Light, Game Collage, LLC. App (downloadable from App Store for iPads)

Light Facts, Science Kids. Information for teachers

Name: .... Class: .... Date: ....

Is the material suitable for alien underpants?

 Opaque Lets no light through	 Translucent Lets some light through	 Transparent Lets a lot of light through

Name: .... Class: .... Date: ....

My alien's underpants

by

____

My alien's underpants are made from

____

I used this material because it is

____

Between the sun and the Earth's surface

We all have the ability to block at least a little bit of the sun: it's called a shadow.

But even when light is blocked, a shadow is not totally lightless. While the blue ambient light of the sky is hard to see in bright, direct sunlight, it does become visible as a blue tinge in a shadow.

Not surprisingly, shadows have long been associated with ghosts or supernatural creatures and feature in the mythologies of many cultures. The Earth's largest shadow show – and one imbued with mystical symbolism and portent – is a solar eclipse.

When the moon moves between the sun and the Earth, it casts its shadow on our world below. For the few long minutes when the sun, moon and Earth are in perfect alignment, it seems as if the massive sun has been swallowed by the tiny moon.

The size and shape of a shadow is determined by the angle at which the light strikes the object, and the distance between light source and object. So although the moon is 400 times smaller than the sun, it is able to fully block the sun during solar eclipses because it is close to the Earth.

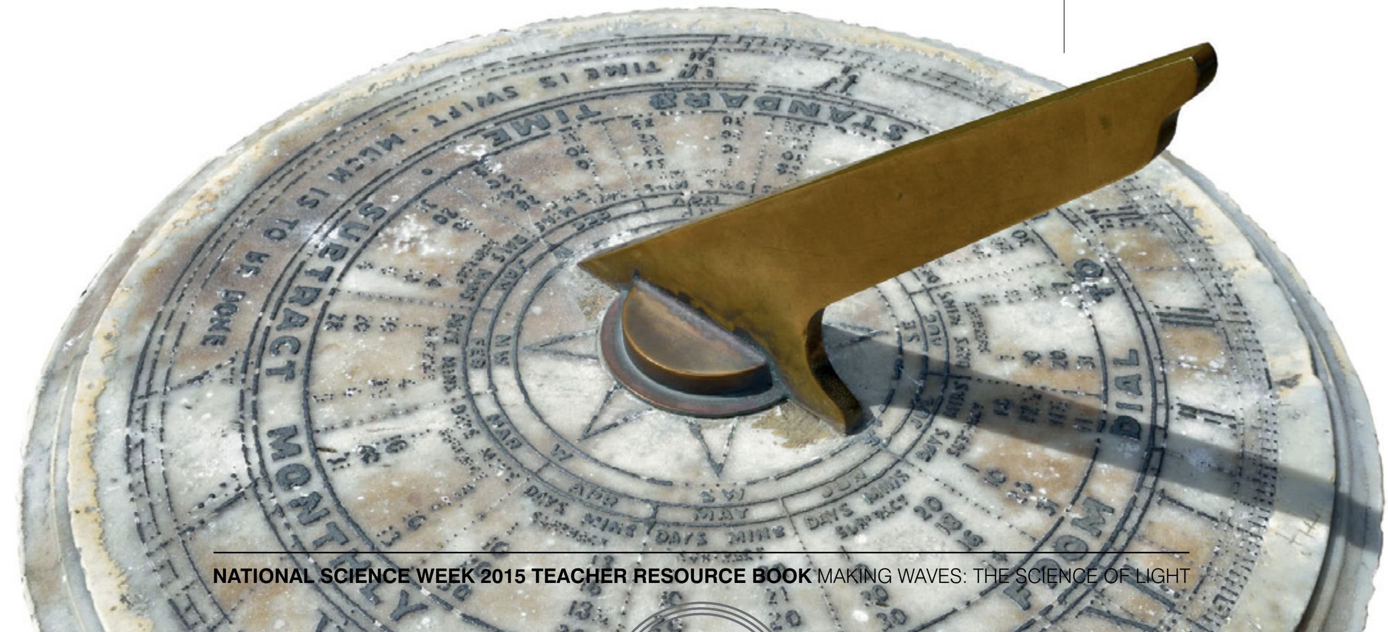
The phenomenon of solar eclipses was first recorded as early as 2000 BCE, in ancient China. However, it was in ancient Egypt and Babylon, as early as 1500 BCE, that an understanding of shadows was put into official use, in the first recognisable forms of sundial technology.

A sundial consists of a point or edge known as a 'gnomon' positioned to cast shadows onto specially marked parts of a flat plane as the day progresses. Often the gnomon is wedge shaped, but sundials can also be designed so the time is indicated by a point of light that passes through an aperture.

One of the largest sundials in the world, the Samrat Yantra in Jaipur, India, is more than 27 metres high and is part of an observatory built during the early 18th century. It tells the time to within two seconds of the modern benchmark, the atomic clock.

DID YOU KNOW?

- Two solar eclipses take place each year. These can be total, partial or annular (when the moon does not completely obscure the sun and a ring of light appears around the shadow).
- You should never look directly at a solar eclipse without eye protection. The heat energy from the sun will only be completely blocked for the tiny percentage of the time when the moon fully obscures the sun. During the rest of the eclipse, there is enough heat energy to burn the retina.

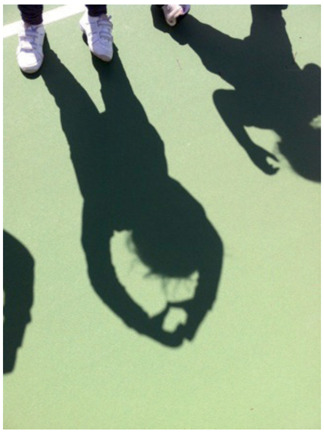


LESSON PLAN: YEAR 1

Shadows – What happens when we block light?

Introduction

This lesson provides opportunities for students to explore how shadows are formed and how they change, and will take away some of the mystery that could surround shadows through exploring them through active, hands-on activities that will promote their understanding of the science concepts behind shadow formation.



Shadows are a phenomena observed on a daily basis by young students that are possibly not fully understood. Young children may have a curiosity about what shadows are and how they are made, and could also be frightened of shadows at night.

Australian Curriculum content descriptions

Science Understandings

Physical sciences

Light and sound are produced by a range of sources and can be sensed (ACSSU020)

Earth and Space Sciences

Observable changes occur in the sky and landscape (ACSSU019)

Science as Human Endeavour

Nature and development of science

Science involves asking questions about, and describing changes in, objects and events (ACSHE021)

Science Inquiry Skills

Questioning and predicting

Respond to and pose questions, and make predictions about familiar objects and events (ACSIS024)

Processing and analysing data and information

Use a range of methods to sort information, including drawings and provided tables (ACSIS027)

Through discussion, compare observations with predictions (ACSIS212)

Evaluating

Compare observations with those of others (ACSIS213)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 1, students describe objects and events that they encounter in their everyday lives, and the effects of interacting with materials and objects. They identify a range of habitats. They describe changes to things in their local environment and suggest how science helps people care for environments.

Students make predictions, and **investigate everyday phenomena**. They follow instructions to record and sort their observations and share their observations with others.

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

This lesson would be the introductory lesson in a series of lessons looking at shadows, and would ideally follow previous Physical Science lessons discussing light and various light sources, as well as the sun as a light source.

Students will review previously learnt concepts that light is a form of energy that travels in straight lines and that the sun is the primary source of light energy on Earth. Students learn that shadows occur when an object blocks a light source and that shadows move and change as the light source or the object blocking the light source moves. They will also develop the understanding that the shadow is cast on the opposite side of the object from the light source.

Students may hold the misconception that shadows are not connected to the objects and may see the shadows as a copy of the object, rather than a silhouette. Students may experiences difficulty understanding why shadows are shaped differently to the object. Students could confuse shadows with reflections that occur because of light reflecting off a surface into our eyes, rather than from an object blocking light.

Lessons following this could include the creation of shadow puppets and exploring the use of opaque (card) and translucent (cellophane) materials to create different puppets and to also develop the understanding that as objects move closer to the light source, the shadow becomes larger and vice versa.

This lesson on shadow exploration would ideally be conducted in two parts – with a second observation occurring later in the day once the sun has moved in the sky, so students can observe that shadows change position and shape as the sun moves through the sky over the day.

Materials and equipment

- A fiction text about shadows (if available) such as:
  - *The Shape of Me and Other Stuff* by Dr Seuss;
  - *Who's There?* by Caroline Bindon;
  - *Guess Whose Shadow*' by Stephen Swinburne;
  - *Colin and the Wrong Shadow* by Leigh Hodgkinson
  - *Whose Shadow is This?* by Claire Berge
- A stick of chalk for each student
- A paved surface in the sun for students to explore their shadows and draw on with chalk
- 'Me and My Shadow' worksheet, enough for class
- Coloured/lead pencils
- A shadow 'KWL' chart created on a poster or created on the IWB (What we **know** already, What we **want** to find out, What we have **learnt**)

Safety advice

Conduct appropriate risk management prior to implementing outdoor activities.

Consult the sun safety and outdoor activity guidelines for your school or organisation prior to implementing outdoor activities.

Ensure students wear sun protective hat, clothing and sunscreen when working outdoors.

Teaching sequence

Lesson objective

In this lesson, students firstly reiterate that the sun is a source of light for Earth and, secondly, identify that when an object blocks the path of the sun's light that a shadow is formed.

Students also identify that shadows can move and change as the light source or the object blocking the light source moves and that their shadow occurs on the ground on the opposite side to the light source.

Students create a shadow drawing and write a shadow fact that they have discovered.

Introduction

1. Read students a fiction book or watch a video clip (see suggestions in 'Useful links' below) about shadows.
2. To elicit students' prior knowledge about shadows, ask:
    - What is a shadow?
    - How do shadows get there?
    - Does your shadow look exactly like you?
    - Do you think you can change your shadow? Could you make it bigger/smaller?
    - Why does our shadow follow us?
    - Can you run away from your shadow?
3. Record students' ideas about shadows on a KWL chart in the 'What we know already' section – add questions to the 'What we want to find out' section.

Core

Activity 1: Shadow detectives

1. Take students outside onto a sunbathed basketball court or similar paved surface so they can observe and explore their own shadows.
2. Tell students to look at their own shadows and make note of whether their shadow looks exactly like them.
3. Encourage students to move around and observe if their shadow follows them. Elicit a discussion by asking the students the following questions:
    - Is your shadow long/thin/tall/small etc.?
    - Can you separate yourself from your shadow?
    - What happens to your shadow when you go fast/slow/stop?
    - Can you make interesting shapes with your shadow?

Activity 2: Shadow tag

Instruct students how to play 'Shadow tag':

Students 'catch' the shadows of other students by stepping on their shadows without touching the other person. Give students a boundary and a time limit (e.g. 5 minutes) for this activity and ensure that they be careful not to touch or bump into each other. When a student is tagged they should bob down and stay still. Finish the game when there is only one person left tagging or the time limit is up.

Activity 3: Shadow tracing

1. Students stand in a line and you can discuss:
   - Where is the light coming from?
   - What is the light source?
   - What is making the shadows on the ground?
   - Is the shadow on the same side or opposite side to the light source?
   - What colour is your shadow? Are shadows ever coloured?
2. Provide each student with a piece of chalk and allocate partners. In pairs, the students take turns drawing each other's shadows on the ground and labelling them with their name and the time the shadow was drawn. Once completed, return to class.
3. Later in the day, return to the location where students drew their shadows and ask them to redraw them. Discuss what they notice has happened. Ask them why have their shadows have moved and why the shadows have changed in shape/length/size.

Conclusion

Activity 4: Me and my shadow

1. When back in the classroom, distribute to students the Me and my shadow worksheet.
2. Instruct the students to draw themselves in the middle of the page and then to determine from the position of the sun on the page and their observations outside, which side their shadow will be and what it would look like. (The shadow should be on the opposite side to the sun and lying horizontally on the ground and also be black.)
3. Ask students to make an observation about their shadow in relation to what they noticed outside and write this under their picture. (My shadow is on the ground on the opposite side of me to the sun. My shadow is taller and thinner than me. My shadow is flat on the ground and is black.)
4. Conclude the lesson by viewing another video clip on shadows (see ideas in 'Useful links' below) and discuss and reiterate the concepts learnt about shadows and add them to the KWL chart in the 'What we have learnt' section.

Lesson resources

Digital resources

Justine Clark – My shadow and me, You Tube (2:40 mins). Song

Peep and the Big Wide World: Shadow Play, YouTube (8:52 mins)

Pilobolus European TV show – Shadowland, YouTube (5:59 mins)

Raymond Crowe – Amazing Shadow Show, YouTube (2:24 mins)

What causes a shadow? YouTube (3:59 mins)

Worksheets

Me and my shadow

Useful links

Bobo Explores Light, Game Collage, LLC. App (downloadable from App Store for iPads)

Light, Brainpop Jr. Lesson ideas, video (requires subscription)

Light, Scholastic StudyJams, Video

Light and shadows, BBC School Science Clips. Learning object

Light Shows, PrimaryConnections. Unit of work for Year 5 but has useful information about light (via Scootle)

Look! Listen! PrimaryConnections, Unit of work for Year 1 (via Scootle)

Name: .... Class: .... Date: ....

Me and my shadow

Where does water go?

As the sun shines it dries out puddles in playgrounds and the washing on the line. Solar energy also evaporates water from the ocean, lakes and rivers, lifting (on rising air currents) millions of litres of water into the atmosphere as an invisible gas, or water vapour.

The same forces are also responsible for evaporating fresh water that has been carefully collected and stored in dams or reservoirs for agriculture and industry, and for our towns and cities.

In Australia more than 40 per cent of the water stored in dams can evaporate each year, depending on weather conditions. Cloud cover, air temperature and wind speed all affect the rate of evaporation. The drier the air, the greater the evaporation rate: less water evaporates in humid conditions because the air is already full of moisture.

This evaporated water later condenses in the atmosphere, forming clouds before returning to the Earth as rain, some of which will soak into the soil and be used by plants and food crops. This water cycle, powered by the sun, is the cycle of life.

One estimate of the volume of water in the atmosphere at any one time is about 13,000 cubic kilometres (km^3). That may sound like a lot, but if all of the water in the atmosphere rained down at once, it would only cover the Earth to a depth of 2.5 centimetres.

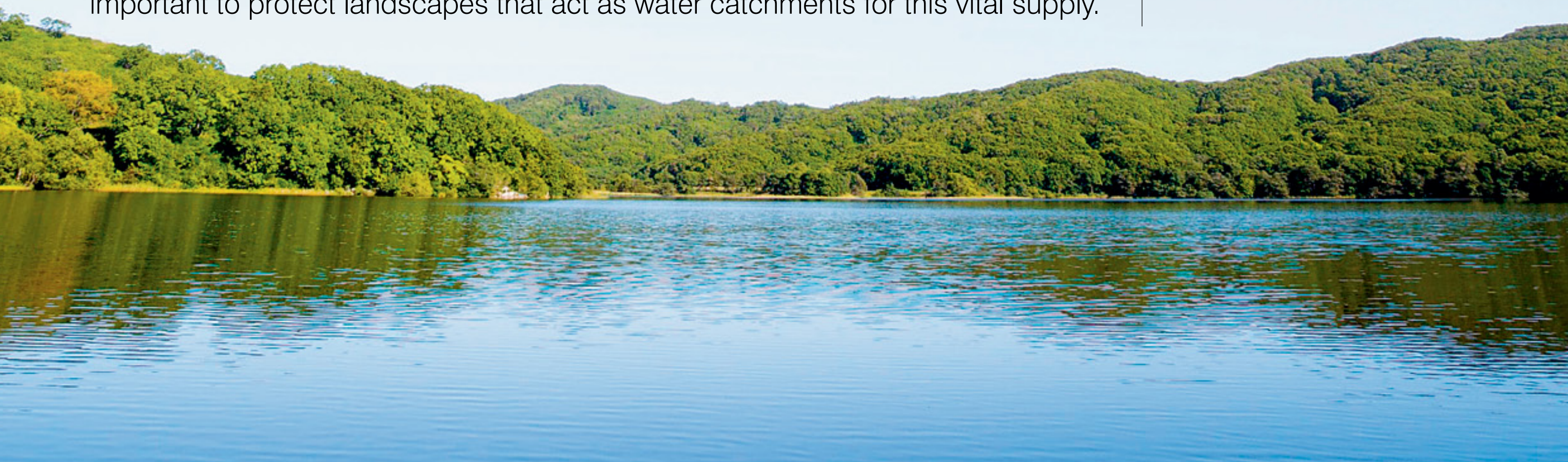
Some rainwater filters right through the ground and collects in layers of rock, sand or gravel. These natural underground storages are called aquifers. Rain also collects on the surface of the Earth, in puddles and dams, or runs into streams and rivers, which eventually flow into lakes and the oceans.

While water managers around the world attempt to store as much of this fresh water as possible for later use – such as with Australia's Snowy Mountains Scheme – all open storages are affected by evaporation, be they simple farm dams and backyard swimming pools, or huge lakes and reservoirs. The larger the area of water exposed to the sun, the more water will evaporate.

Almost 70 per cent of fresh water in the world is used in agriculture for food production, so the evaporation cycle is critical to human life. It is also why it is important to protect landscapes that act as water catchments for this vital supply.

DID YOU KNOW?

- A person can survive one month without food, but only one week without water.
- Sweat from your body is part of the water that evaporates into the air and later falls back to Earth as fresh, clean, drinkable rainwater.
- In a 100-year period, a water molecule spends 98 years in the ocean, 20 months as ice, about two weeks in lakes and rivers, and less than a week in the atmosphere.



LESSON PLAN: YEAR 2

Disappearing puddles

Introduction

Water is a precious resource. One that is essential to life on Earth. Furthermore, Earth has a limited supply of fresh drinking water and many people in countries across the globe lack access to clean drinking water. We have potential for water shortage in Australia with growing populations and increased water usage making it vital that students understand the importance of maintaining this precious resource for future generations.

In learning how water is used on Earth, students need to understand the journey water takes before it can be used and what happens to water when it seems to disappear. In developing a deeper understanding of the water cycle, students will observe and discuss what occurs to water when it evaporates. Students will investigate what happens when water is poured on a hard surface and develop the understanding that water does not simply disappear but is transformed from a liquid to a gas by heating from the sun through a process called evaporation. They will also compare the evaporation process in a sunny location compared to a shady location and suggest reasons for differences in evaporation rates.

This lesson will assist in developing understandings in relation to cross-curricular priority of sustainability and Organising Idea.1 ‘the biosphere is a dynamic system providing conditions that sustain life on Earth’.

Australian Curriculum content descriptions

Science Understanding

Earth and space sciences

Earth’s resources, including water, are used in a variety of ways (ACSSU032)

Science as Human Endeavour

Nature and development of science

Science involves asking questions about, and describing changes in, objects and events (ACSHE034)

Science Inquiry Skills

Questioning and predicting

Respond to and pose questions, and make predictions about familiar objects and events (ACSIS037)

Planning and conducting

Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources (ACSIS038)

Use informal measurements in the collection and recording of observations, with the assistance of digital technologies as appropriate (ACSIS039)

Processing and analysing data and information

Use a range of methods to sort information, including drawings and provided tables (ACSIS040)

Through discussion, compare observations with predictions (ACSIS214)

Evaluating

Compare observations with those of others (ACSIS041)

Communicating

Represent and communicate observations and ideas in a variety of ways such as oral and written language, drawing and role play (ACSIS042)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 2, students describe changes to objects, materials and living things. They identify that certain materials and resources have different uses and describe examples of where science is used in people's daily lives.

Students pose questions about their experiences and predict outcomes of investigations. They use informal measurements to make and compare observations. They follow instructions to record and represent their observations and communicate their ideas to others.

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

Without water there would be no life on Earth. Whilst our Earth is covered in approximately 70% water, most of this is salt water, or frozen, leaving around 1% of this as drinkable water. Fresh water is a natural resource that is in such short supply that 1 out of 9 people around the world lack access to safe drinking water. More than 840,000 people die each year from water-related disease and women and children around the globe spend a collective 140 million hours a day collecting clean drinking water for their families. (Source: http://water.org/water-crisis/water-facts/water/)

In a country where clean water flows so freely from a tap and we are prone to wanton use and disregard for using water wisely, young students may have little knowledge about how many people across the world do not have this privilege. The worldwide water crisis is sure to be far from the minds of many students who may never have considered how the water gets into our taps. This makes it critical that young students develop an understanding of how precious this natural resource is, as well as the process by which water comes to us and how water moves around in our biosphere.

This lesson on evaporation would ideally be one lesson in a sequence of lessons for year 2 that would assist students in identifying and describing sources of water, ways we use water and leading to considering how we can help conserve water. In understanding how water gets to our taps, students should develop an insight into the 'water cycle' and the processes by which water changes state throughout the water cycle (evaporation, transpiration, condensation, precipitation and collection).

Useful facts about water that will be important for students to consider are:

- Water is a molecule made up of two hydrogen atoms and one oxygen atom and is represented by the chemical formula H_20.
- Water can take the form of a solid (ice), liquid (water) and gas (water vapour).
- Living things (animals and plants) are primarily made of water, with the human body being about 70% water.
- Water in its purest form has no taste, odour or colour. (PrimaryConnections – Water works)

We have a limited supply of water on Earth. Any water we use or drink has always been here on Earth and is possibly billions of years old. This water just moves around in an ongoing process we call the 'water cycle' or 'hydrologic cycle'. Four main processes are involved in this cycle – evaporation/transpiration; condensation, precipitation and collection.

Fresh water is created by water evaporating from oceans, lakes, rivers, wet soil and plants. The sun heats the water causing it to turn to a gas. Any salt is left behind as salt water evaporates; meaning pure water vapour rises and cools, condensing back into liquid around dust particles in the air to form clouds. When the water droplets become large enough, they fall as rain and sometimes other forms of precipitation such as snow, sleet or hail. Water falls back to land in oceans, lakes, rivers and on the ground and is either collected or soaks in and becomes ground water. The water cycle then begins again… (Source: http://www.kidzone.ws/water/)

Materials and equipment

This lesson will require a sunny day and two large concrete/paved areas to pour water on and make observations. One area should be shaded (i.e. undercover/canteen area) and the other in full sun (i.e. basketball court). This lesson will work better in the middle of the day or a time when the sun has had opportunity to heat the concrete more. It is also ideal if the surface is flat to allow the water to puddle, rather than running off. It can pay to advise the Physical Education teacher/groundsperson or the administration about wanting to draw on the ground with chalk to ensure this is not problematic.

Per group of 4:

- 4 Disappearing puddles worksheets (a copy on an IWB would be handy to model what is expected)
- 4 pencils
- 1 small plastic cup with a line marked about 1/3 the way up (You don't want their puddle to be too large as it may not evaporate in time!)
- 1 small bottle of water
- stick of coloured chalk (or four different coloured chalks)
- digital timer
- digital camera or iPad (if available)
- 4 clipboards

Safety advice

Conduct appropriate risk management prior to implementing outdoor activities.

Consult the sun safety and outdoor activity guidelines for your school or organisation prior to implementing outdoor activities.

Ensure students wear sun protective hat, clothing and sunscreen when working outdoors.

Teaching sequence

Lesson objective

Students predict, observe and describe what happens to water poured on a concrete surface in a hot, sunny place and compare this to what happens to water poured on a concrete surface in a cooler, shady location. Students will record changes using diagrams and digital technology if available.

Introduction

Watch the video Where do puddles go? (Stop the video clip at **1:35** after the dog asks "Do you know where the puddle could have gone?") Ask students, "Where did the puddle go?"

Get students to 'turn and talk' or 'think, pair, share' and tell their partner where they think the puddle went. Choose some students to share what their partner's belief is.

Ask students the following questions:

- What happens to water when it lands on the ground?
- What have you observed happens to water that lands on paving/roads/concrete surfaces when it rains? Does the water stay there forever?
- Where do you think it goes?
- If we pour water on the concrete in the sun, what do you think will happen?
- What do you think will happen if we pour water in the shade?
- Will the water disappear faster on one surface than the other? Why/why not?

Explain to students that they are going to go outside and test what happens to puddles of water in the sun and in the shade. Distribute the Disappearing puddles worksheet.

Students will first write down on their 'Disappearing puddles' worksheet their belief about what happens to puddles that disappear. Discuss and model this before getting students to fill in their answer. Discuss making a prediction with students. Do students know what a prediction is?

Students will be then be asked to write a prediction as to whether they believe the water puddle will disappear more quickly in the sun or in the shade and explain why. Model an example of writing a prediction and encourage students to use the word 'because' to ensure they provide a reason for their prediction.

Once students have written their predictions they will prepare to go outside and test their predictions. They should be given a clipboard to attach their worksheet to and be reminded to bring their pencil with them so they can draw and record results.

Core

1. Divide students into groups of four and give each group a small plastic cup with a line marked about one third the way up, a small bottle of water, a stick of chalk (or four colours), a stop watch and a digital camera/iPad (optional).

2. Discuss working in a group and how they each should have a job to do. Students can determine who will undertake the various roles in their group such as using the timer, pouring the puddle, drawing the puddle with chalk and taking pictures (if cameras are being used).

3. Direct students to a sunny concreted area and ask them to spread out.

4. Instruct them to pour one small cup of water (filled to the marked line) onto the ground and draw the border of the water puddle with chalk once the water settles. They should start their timer and will draw the shape of their puddle carefully in the first box whilst they wait for 3 minutes to pass.

5. Students then observe their puddle at three-minute intervals (This time may need to be altered up or down depending on the temperature on the day). They redraw the border of the puddle with chalk and they will draw the shape and size of the puddle on their worksheet (and take a photo if possible) at each interval. They will draw their puddle four times (0, 3, 6 and 9 minutes).
6. This process will then be repeated in a cool, shady concreted area such as an undercover canteen area.

Conclusion

Students return to class and complete written observations about what they noticed in relation to what happened to the puddle in the sun compared to the shade in their 'Conclusions' section. Selected students will be asked to share their observations.

Discuss why this result may have occurred.

Students are then asked to compare what they discovered with what they predicted earlier and to determine how accurate their prediction was and write this in the 'Evaluation' section of their worksheet.

Discuss student's understanding of what happened to the water to make the puddle smaller and why the puddle became smaller much faster in the hot sun.

Finish with completing watching the video clip 'Where do puddles go?' from the place where it was paused earlier.

Lesson resources

Digital resources

'Where do puddles go?' YouTube (4.00 min)

Worksheets

Disappearing puddles

Useful links

Millions lack safe water, Water.org. Water facts

The water cycle, KidZone Science. Information for students

The water cycle, YouTube (1:57 min). Animation

Water Works, PrimaryConnections. Unit of work via Scootle

Name: .... Class: .... Date: ....

Disappearing puddles

Question:

What happens to a puddle when it seems to disappear from the concrete/ground?

Prediction:

Will the puddle disappear more quickly in the sun than the shade? (Why?)
I believe that …____________________

Observations:

(Draw what the puddle looks like at each of these times)

Sunny area			
At the beginning	After 3 minutes	After 6 minutes	After 9 minutes
Total time taken for the puddle in the sun to disappear:			

Shady area			
At the beginning	After 3 minutes	After 6 minutes	After 9 minutes
Total time taken for the puddle in the shade to disappear:			

Conclusions:

We discovered that… (Why do you think this happened?)

Evaluation:

Was your prediction accurate? (Why/why not?)

Solar energy solutions

Direct sunlight is by far the most abundant source of energy available on Earth. Get into a car parked in the sun on a hot day, and you'll know that this energy includes both visible light and heat energy, also known as thermal radiation, which is not usually visible.

When the sun 'goes down' around the world we rely on electricity to light our way and keep us warm. For most power-generation plants, heat is a critical part of the process of generating eelectricity. The burning of fossil fuels, such as coal, has been traditionally relied upon to generate this heat. However, we now know that burning fossil fuels is a major source of greenhouse gas emissions, which are contributing to climate change. Fossil fuels are also a limited resource and already running low in many parts of the world.

Communities and governments are increasingly looking for other ways to generate power from renewable sources that have a lower environmental impact. Hydro-electricity and nuclear power are two options, but it is solar energy that is in the spotlight. This is the energy that already runs the planet's environmental systems – powering the global water cycle, and heating and cooling the atmosphere and oceans to produce winds and currents that together help to stabilise the Earth's temperature.

The issue for science has been to find ways of capturing the sun's light and heat that enable this energy to be converted, affordably, into electricity. There are two main approaches – solar photovoltaic systems and solar thermal systems.

Solar photovoltaic systems, such as the solar panels used to recharge batteries, capture sunlight and convert it directly to electricity. Solar thermal systems capture and convert solar radiation into heat. The latest solar-panel technology combines both approaches. Systems can range from large-scale commercial power generation – in other words, a solar power station – down to household units that supply hot water and which can also be wired to supply surplus electricity into the national power grid.

Solar concentrators can be used to intensify the amount of sunlight hitting solar cells to increase their efficiency. These work in much the same way as a magnifying glass can be used to concentrate light into a small, specific location – such as using a magnifying glass to burn paper. On a larger scale, this focused energy can power electricity generation. Some solar electricity systems use lenses, others use mirrors and reflectors to redirect and concentrate the sun's energy.

Solar energy for electricity can be considered as 'coming of age' – no longer a curiosity but a mainstream source of energy that can compete economically with more traditional fossil fuel sources.

DID YOU KNOW?

- Ivanpah is the world's largest solar power plant. It is based in the Mojave Desert, California, in the US, and uses a vast field of mirrors to focus the power of the sun onto solar receivers.
- Solar energy currently provides just three per cent of the world's electricity.

LESSON PLAN: YEAR 3

Does a magnifying glass speed up the melting of ice?

Introduction

During this lesson, students are introduced to the concept of heat transfer. They explore and examine objects to gain understanding of how heat is transferred from one object to another. They observe and conduct a simple investigation to answer the question 'Does a magnifying glass speed up the melting of ice?' They use this knowledge to identify familiar contexts where heat transfer could be used in their everyday lives.

Australian Curriculum content descriptions

Science Understanding

Physical Sciences

Heat can be produced in many ways and can move from one object to another (ACSSU049)

Science as a Human Endeavour

Nature and development of science

Science involves making predictions and describing patterns and relationships (ACSHE061)

Science Inquiry Skills

Questioning and predicting

With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge (ACSIS064)

Planning and conducting

Suggest ways to plan and conduct investigations to find answers to questions (ACSIS065)

Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate (ACSIS066)

Processing and analysing data and information

Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends (ACSIS068)

Communicating

Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports (ACSIS071)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 3, students use their understanding of the movement of the Earth, materials and the **behaviour of heat to suggest explanations for everyday observations.** They describe features common to living things. They describe how they can use science investigations to respond to questions and identify where people use science knowledge in their lives.

Students use their experiences to pose questions and **predict the outcomes of investigations. They** make formal measurements and **follow procedures to collect and present observations in a way that helps to answer the investigation questions. Students suggest possible reasons for their findings.** They describe how safety and fairness were considered in their investigations. **They use diagrams and other representations to communicate their ideas.**

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

Transfer of heat, ScienceWeb. Unit of work for year 3–4. See Background information

A **Think-Pair-Share** activity is conducted by having students '**Think**' on the topic for one minute, discuss the topic and their ideas in a '**Pair**' for 2 minutes and then '**Share**' with another group/pair for 3 minutes. Time frames can be adjusted to suit your students and/or classroom requirements.

Materials and equipment

Think-Pair-Share activity

Per pair

- 1 metal object
- 1 plastic object
- 1 wooden object
- students' science journals

Teacher demonstration – Invisible heat

- plastic plate or bowl (white in colour)
- ice cube
- access to a brightly sun lit area

Investigation – Melting ice cubes

Per group

Indoor group

- 1 ice cube
- 1 plastic plate or bowl (white in colour)
- 1 stopwatch

Sunlight group

- 1 ice cube
- 1 plastic plate or bowl (white in colour)
- 1 stopwatch
- Access to a brightly sun lit area

Magnifier group

- 1 ice cube
- 1 plastic plate or bowl (white in colour)
- 1 stopwatch
- 1 magnifying glass
- Access to a brightly sun lit area

Safety advice

Conduct appropriate risk management prior to implementing outdoor activities.

Consult the sun safety and outdoor activity guidelines for your school or organisation prior to implementing outdoor activities.

Ensure students wear sun protective hat, clothing and sunscreen when working outdoors.

Teaching sequence

Lesson objective

In this lesson, students understand how heat is transferred from one object (or system) to another.

Introduction

Ask students to make suggestions about what heat is. Discuss their responses.

Inform students that heat is a type of energy and that energy is the ability to make things happen.

Explain to students that heat energy is not always easy to see, but one way to observe it is to use our sense of touch.

Show students a selection of objects. Inform students they will conduct a 'Think-Pair-Share' activity to determine if the items are hot or cold.

Distribute the items. Tell students to touch the items and record their ideas in their science journals and to then share their ideas from the activity with the class.

Explain to students that heat is transferred from a system (or an object) of higher temperature to an object of lower temperature.

Explain that the object felt hot or cold because of the action of heat transferring from either their hand or the object.

Inform students that when they were touching the items, they were causing heat to transfer from the object they touched to their hand or vice versa by the process of **conduction**.

Explain that if you had two objects with equal temperatures, there would be no transfer of heat energy. When you have two objects with different temperatures, the heat energy flows or is transferred.

Inform students that they are going to investigate how the sun could melt ice.

Ask students to make suggestions about how the heat from the sun is transferred to us on Earth.

Inform students that the heat from the sun is transferred to us/our skin/the Earth through space and the air, by **radiation**.

Explain that the heat is transferred through the air/space between the objects (systems). The objects (systems) do not need to be physically touching in order for the heat to be transferred.

Conduct the teacher demonstration – **Invisible heat** to show students the concept of radiation.

- Place the ice cube in the plastic bowl in the sunlight. Allow time for the ice to melt. (Do not measure the time the ice cube takes to melt). Ask students to suggest explanations about how the ice cube melted.
- Explain that heat from the air, was transferred to the ice cube to make it melt. The heat is considered 'invisible' as there was no obvious touching of the ice cube by any other object.
- Explain to students that the sun is a very strong source of heat energy and that they are going to conduct an activity to see if they can speed up the melting process that they have just observed.

Teacher note: Time needs to be allowed for the ice cube to melt in the sun. Time will vary due to the weather/sunlight on the day. Take this into consideration when planning your lesson.

Core

1. Show students the equipment they are to use.
2. Allocate each student to one the nominated groups in one of the areas – indoor, sunlight and magnifier group.
3. Explain that each group will have one ice cube to observe over the activity.
4. Inform students that once they have conducted the activity, they will come together to compare their findings and to make their conclusions.
5. Give each group the relevant section of the sheet Melting ice investigation.
6. Read through the activity, explaining the steps and clarify any questions.
7. Ask students in each group to make a prediction about how quickly they think their ice cube will melt.
8. Remind students to think about the teacher demonstration they observed to help them nominate an appropriate length of time.
9. Ask students to conduct the investigation and to record their findings (timing).
10. Show students how to use the magnifying glass to direct the sunlight onto the ice cube. Support students to use the magnifying glass where required.
11. Return to the classroom work area.
12. Ask students from each nominated area to present their findings. (Indoor group, then sunlight group, then the magnifier group).
13. Collaboratively construct a table to display the data from each area.
14. Review the results and discuss which situation resulted in the ice melting faster.
15. Ask students to suggest reasons for the results.

Conclusion

Review the activities and ask students to draw a diagram of what they observed during their investigation.

Ask them to indicate on the diagram (using labels and arrows) how the heat was transferred to the ice cube in order to make it melt.

Explain to students how understanding about heat transfer can help them in their everyday lives.

Ask students where they might use the concept of heat transfer, such as in the kitchen for cooking.

Ideas for further learning

Conduct further investigations into heat transfer by working through activities with apprentice chef Pierre Puppet in the Science Web unit – Year 3-4 Transfer of Heat

Lesson resources

Worksheets

Melting ice investigation.

Useful links

Energy topic card, ASTA. SPECTRA program

Heat, Explainthatstuff! Information for students

Heat, Physics4kids. General information on heat transfer, conduction, convection and radiation

Transfer of heat, ScienceWeb. Unit of work for year 3–4. See Background information

Melting ice investigation

Cut an instruction card for each group

Indoor group

Equipment you need:	Method:
• 1 ice cube • 1 plastic bowl or plate • 1 stopwatch	1. Place the ice cube in the bowl 2. Start the stopwatch and time how long it takes to melt 3. Record your observations in your science journal 4. Draw a diagram to show what happened

Sunlight group

Equipment you need:	Method:
• 1 ice cube • 1 plastic bowl or plate • 1 stopwatch • A bright sun lit area	1. Place the ice cube in the bowl 2. Place your bowl in the bright sunlight. 3. Start the stopwatch and time how long it takes to melt 4. Record your observations in your science journal 5. Draw a diagram to show what happened

Magnifer group

Equipment you need:	Method:
1 ice cube 1 plastic bowl or plate 1 magnifying glass 1 stopwatch A bright sun lit area	1. Place the ice cube in the bowl 2. Place your bowl in the bright sunlight. 3. Hold the magnifying glass over the ice cube to catch the sunlight. 4. Direct the sunlight onto the ice cube. 5. Start the stopwatch and time how long it takes to melt 6. Record your observations in your science journal 7. Draw a diagram to show what happened.

Life on Earth is solar powered

The sunlight that bathes Earth's surface is responsible for sustaining life … all life.

It is sunlight that provides the energy for plants – both terrestrial and aquatic – to convert or 'fix' carbon dioxide and water into the sugars that allow plants to grow and reproduce. This process is called photosynthesis. In addition to forming the basis of the planet's food pyramid, photosynthesis is also responsible for creating – as a waste by-product – all the oxygen in the atmosphere.

Photosynthesis evolved into two main subtypes, which are called C3 and C4 (in reference to the number of carbon atoms in the first molecule formed by photosynthesis). These subtypes fix carbon dioxide with different efficiencies and are better adapted to different growth conditions. Collectively, they allow plants to colonise the planet's many different habitats.

C3 plants tend to thrive where sunlight intensity and temperature are moderate. From an evolutionary perspective, they predate C4 plants and make up 95 per cent of Earth's plant biomass.

C4 plants evolved later and have a competitive advantage under drought and hot conditions, such as in the tropics. They are able to concentrate carbon dioxide in a way that makes photosynthesis more efficient but also prevents water loss from the apertures (or 'stomata') that leaves use to draw in carbon dioxide from the atmosphere. As a result, C4 plants are responsible for 30 per cent of carbon dioxide fixed by plants but constitute just five per cent of Earth's plant biomass.

The photosynthetic efficiency of C4 plants is especially attractive to scientists working to protect the world's food crops from the hotter and drier conditions expected in many parts of the world as a result of climate change.

Present-day C4 plants include food crops such as corn, sugarcane, millet and sorghum. Excluded from this group are the two most important staples for global food security – rice and wheat.

Internationally, multimillion-dollar research programs, such as the C4 Rice Project, are working to make photosynthesis in C3 food crops more C4-like and, therefore, more efficient and resilient under global warming conditions. Wheat, too, is undergoing a C4-inspired photosynthetic efficiency boost. Included in these important research drives are Australian efforts, such as those at the Australian Research Council Centre of Excellence for Translational Photosynthesis.

Being able to measure and modify plant growth in response to sunlight is at the cutting edge of global food security research and development.

DID YOU KNOW?

- The C4 pathway was discovered in Australia in 1966 by Marshall Davidson Hatch and C. R. Slack and is sometimes called the Hatch-Slack pathway.
- C3 grasses, when grown in the same environment (at 30°C), lose about 833 molecules of water for each carbon dioxide molecule that is fixed, whereas C4 grasses lose only 277.
- The increased water-use efficiency of C4 grasses means that soil moisture is conserved, allowing the grasses to grow for longer in arid environments.

LESSON PLAN: YEAR 4

Do plants need light and if so, how much?

Introduction

In this lesson, students review the basic needs of living things and consider what plants need to maintain growth and health. Students explore how light affects the growth of plants and determine the effects of light deprivation and/or too much light on various plants. Students consider how science involves making predictions and gathering evidence to formulate explanations about phenomena. They use data from their investigations to make conclusions about how light affects plant growth and discuss how this knowledge could be used in their everyday lives.

Australian Curriculum content descriptions

Science Understanding

Biological sciences

Living things, including plants and animals, depend on each other and the environment to survive (ACSSU073)

Science as a Human Endeavour

Nature and development of science

Science involves making predictions and describing patterns and relationships (ACSHE061)

Use and influence of science

Science knowledge helps people to understand the effect of their actions (ACSHE062)

Science Inquiry Skills

Questioning and predicting

With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge (ACSIS064)

Planning and conducting

Suggest ways to plan and conduct investigations to find answers to questions (ACSIS065)

Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate (ACSIS066)

Processing and analysing data and information

Compare results with predictions, suggesting possible reasons for findings (ACSIS216)

Communicating

Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports (ACSIS071)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 4, students apply the observable properties of materials to explain how objects and materials can be used. They use contact and non-contact forces to describe interactions between objects. They discuss how natural and human processes cause changes to the Earth's surface. They **describe relationships that assist the survival of living things** and sequence key stages in the life cycle of a plant or animal. They identify when science is used to ask questions and make predictions. **They describe situations where science understanding can influence their own and others' actions.**

Students follow instructions to identify investigable questions about familiar contexts and predict likely outcomes from investigations. They discuss ways to conduct investigations and safely use equipment to make and record observations. They use provided tables and simple column graphs to organise their data and identify patterns in data. **Students suggest explanations for observations and compare their findings with their predictions.** They suggest reasons why their methods were fair or not. **They complete simple reports to communicate their methods and findings.**

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

Growth in plants depends on a variety of factors both extrinsic and intrinsic. Green plants require minerals and other essential elements for normal growth and development. These nutrients come from the soil and the growth of plants is affected by the amounts of nutrients in the soil. Water is also an essential requirement for plant growth right from the early stages of growth. Water is essential for plants to complete photosynthesis and without water, plant growth and functioning is severely impaired. Oxygen is also an essential requirement as it is necessary for cellular respiration in plants, and directly affects growth processes. Plants are also greatly influenced by temperature and variation in temperature of the soil in which they grow and in the surrounding environment. Most plant species prefer temperature in the range of 20°C–40°C. Light also influences the growth processes of plants. Plants that grow well under bright, direct sunlight are called photophilic plants. Plants that prefer low light conditions are called photophobic. Light also affects the stems and leaves of plants – plants growing in darkness are often characterised by long, weak stems and leaves that are underdeveloped, pale and yellow.

Materials and equipment

Preparation is required prior to commencing this lesson.

- science journal per student

Investigation 1

- access to an area in the school grounds that has green grass in full or nearly full sunlight.

Per group/pair:

- 1 dark coloured ice-cream container or plastic box (weather-proof)
- marking pen
- digital camera

Investigation 2

- three different locations:
  1. cupboard (with no light)
  2. semi-shaded area (inside the classroom, not in direct sunlight)
  3. brightly sunlit area (outside the classroom)
  4. 6 healthy seedlings or mature plants with leaves (in pots)
- water

Safety advice

Conduct appropriate risk management prior to implementing outdoor activities.

Consult the sun safety and outdoor activity guidelines for your school or organisation prior to implementing outdoor activities.

Ensure students wear sun protective hat, clothing and sunscreen when working outdoors.

Teaching sequence

Lesson objective

In this lesson, students observe the effect of light deprivation on plants and recognise that plants require light in order to stay healthy and to grow.

Introduction

Review the basic needs of living things, such as access to food, water and air and consider the other needs that living things require, including sunlight, warmth or shelter.

Discuss how not all living things require the same amount of sunlight or warmth; considering animals and plants living deep underwater, in dark caves or in extreme cold environments.

Clarify with students that plants and animals have similar needs despite their differences.

Inform students that they will:

- conduct investigations to determine whether plants need light in order to sustain healthy growth; and to observe the effects of light deprivation on a plant
- set up the investigations
- conduct observations over time for each plant.

Core

Setting up the investigations

Teacher note: Be aware that these investigations require extended time (7–14 days) to see maximum effects of light on plant growth.

Investigation 1

1. Ask students to consider the question: “What might happen if a plant was deprived of light?” and collate their answers.
2. Inform students that they will be examining what happens to grass when it is deprived of light.
3. Explain to students that they will be working outdoors and clarify safety procedures for working outside.

4. Divide students into groups/pairs and give each group an ice-cream container or plastic box.
5. Have students write their group's name and the date on the container with the marking pen.
6. Locate an area within the school grounds that contains a patch of grass in full sun. Explain to each group that they are to find a patch of grass and photograph it.
7. Have students place the container upside down on the grass and take another photo.
8. Ask students to make and record a prediction about what they think will happen to the grass.
9. Explain to students that they will return to observe the effects in approximately 1 week.
10. Return to the classroom.

Investigation 2

1. Inform the students that they are now going to set up an investigation to determine how much light plants need in order to grow and remain healthy.
2. Show students the 6 plants and have them make suggestions about how healthy they appear – bright green leaves, standing upright or new buds.
3. Ask students to make suggestions about how they could conduct an investigation into whether plants need light and collate their answers.
4. Discuss their ideas and determine if there are any that are valid.
5. Remind students that the investigation needs to be fair and follow the process of changing one variable, measuring one variable and keeping everything else the same.

Idea for further learning: Use the learning object Fair test to remind students how to conduct a fair test.

6. Inform students that they will be placing the plants in 3 positions in and outside the classroom that have varying amounts of light. They will observe the effects of the light on the plants over the coming 7–14 days.
7. Clarify that light is the variable that is being changed in the investigation.
8. Ask students to determine the remaining variables that would need to stay the same – such as the same amount of water being given to the plant; and the variable to be measured – such as the colour of the leaves and the growth of the plant.
9. Allocate the 3 areas where the plants will be housed – cupboard, semi-shaded area, full sunlight.
10. Have students make and record predictions about what effects they think each position will have on the plants growth and the colour of its leaves.
11. Remind students that they need to make observations of each plant as a baseline and record the details in their science journal.
12. Allocate time each day for students to provide water to the plants.

Observations could be made daily however the effects may not be as dramatic if viewed on a daily basis, versus if seen after 7 and 14 days.

Gathering data and evidence from Investigation 1

1. Return to the grassed area outside after 7 days, and remove the containers.
2. Have students make observations of the grass and compare their predictions to their findings. Ensure students take photographs of the effects on the grass.

Teacher note: Cover the grass with the container and leave for a further 7 days for a greater effect if preferred.

3. Return to the classroom and show students the sheet Light deprivation investigation – Photo journal to demonstrate ways they could document their images.

Gathering data and evidence from Investigation 2

1. View the 6 plants in their positions after 7 and 14 days to observe the effects of the amount of light shining/ or not shining on them.
2. Have students make observations of the leaf colour and growth of each plant and record their findings in their science journal.
3. Ask students to compare their findings to their predictions.
4. Ask each group to share their findings with another group.

Conclusion

Making conclusions from investigations based on evidence.

Review the findings of each investigation.

Have students suggest reasons for their results.

Teacher note: Results will vary however; It is quite possible that students will determine that the plants were not only affected by lack of light, but also by too much light. The plants deprived of light will most likely appear yellow and have weakened stems. The plants in full sunlight may become scorched if the sunlight was strong and very hot. These plants would most likely have patches of brown on their leaves and may be limp and shrivelled.

Show students the learning object, Plants to consolidate their understanding of why plants need light to grow and be healthy. Discuss the learning object and compare the information with what they observed in their investigations.

Remind students that science involves making predictions by gathering data and using evidence to develop explanations.

Discuss with students how conducting the plant investigations had them gathering data in order to develop explanations about how light affects plants.

Ask students to make suggestions about how people could use this scientific knowledge in everyday life; such as determining the most suitable areas to plant crops, vegetables or trees; in the farming industry, plant nurseries, and even in their home vegetable gardens.

Lesson resources

Digital resources

Plants, BBC Bitesize. Learning object

Worksheets

Light deprivation investigation – Photo journal

Useful links

L540 Fair test, NDLRN. Learning object

Light deprivation investigation – Photo journal

Photo taken 15.02.15

Sample area of grass indicated in red.

Grass sample area taken before container placement.

Grass blades are green and sample area fully covered with grass.

Photo taken 15.02.15

Sample area of grass indicated covered by container.

Photo taken 22.02.15

Container removed – after 7 days.

Sample area of grass shows discolouration including yellowing of some blades of grass and others brown.

Grass also appears patchy and thinner.

Light deprivation investigation – Photo journal

Photo taken 28.02.15

Container removed – after 13 days

Sample area of grass shows further discolouration including more yellow and brown blades of grass.

Grass has become thinner and more visible earth is able to be seen through the grass.

Minimal green grass is now present in sample area.

Photo taken 28.02.15

Close-up of grass section directly under edge of container.

Sample area of grass shows yellow and white blades of grass.

Brown blades of grass also visible.

Images: Shelley Murphy. Used with permission.

Starlight – a window to the universe

Light is central to the study of the cosmos, including our nearest celestial object, the moon. But as light pollution from Earth's cities blankets the view of our home galaxy, the Milky Way, only the brightest objects – the ones capable of actually casting shadows on Earth – remain readily observable. These are the sun, Venus and the moon.

If seeing is believing, then the moon appears to both shine brightly and, during an eclipse, to produce no light at all. It changes shape, waxes and wanes, on a 27-day cycle.

Understanding these contradictory antics requires the ability to build models with which to explore celestial mechanics and observational tools that exceed the limitations of our eyes.

Such tools have included telescopes of evolving sophistication that produce ever finer images, starting with the first drawing ever made of the moon through a telescope on 26 July 1609, by Thomas Harriot, and the first manuscript, produced by Galileo Galilei, in 1610.

Exploration culminated in the manned space flights, the US Apollo program, that first reached the moon's surface on 20 July 1969. When astronauts walked on the moon, they reported a dark-grey surface, the colour of pavement. The moon does not emit any light. Rather it acts as a mirror, reflecting sunlight onto the dark, night side of Earth. But there is a twist.

The moon and Earth rotate around their axes in exactly the same amount of time. That means the same side of the moon faces the Earth in a 'synchronous rotation'. The side seen on Earth is lit by reflected sunlight, while the side facing away from Earth lies in darkness and can only be observed from a spacecraft.

Observational technology continues to build our understanding. For example, the 381 kilograms of lunar rocks brought back by the Apollo 12 astronauts revealed the dramatic story of the moon's origin from a collision between an object the size of Mars and a moonless Earth. The moon formed 4.6 billion years ago, about 30 to 50 million years after the formation of the solar system, and it is slowly drifting away from Earth.

A laser reflector left on the moon's surface by Apollo astronauts revealed the drift, which has been measured at about four centimetres a year.

The view of the night sky is a lightshow that can reveal the nature of the universe. But it takes cunning minds and wily methods to learn to decode these messages.

DID YOU KNOW?

- The moon is actually a poor mirror, reflecting only about 12 per cent of sunlight.
- The moon orbits Earth at a distance of 384,000 kilometres.
- The moon's elliptical, 27-day orbit changes its distance to Earth and its brightness.
- At its closest to Earth, a full moon can be 20 per cent brighter than normal and is called a 'supermoon'.

LESSON PLAN: YEAR 5

Does the moon emit its own light?

Introduction

In this lesson, students answer the question 'Does the moon emit its own light?' They make observations to draw conclusions about the moon and use a model to confirm why the moon is brightest when it is full. Students discuss how scientific study and exploration of the moon has benefited our everyday lives.

Australian Curriculum content descriptions

Science Understanding

Earth and space sciences

The Earth is part of a system of planets orbiting around a star (the sun) (ACSSU078)

Science as a Human Endeavour

Nature and development of science

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena (ACSHE081)

Use and influence of science

Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives (ACSHE083)

Science Inquiry Skills

Planning and conducting

With guidance, plan appropriate investigation methods to answer questions or solve problems (ACSIS086)

Use equipment and materials safely, identifying potential risks (ACSIS088)

Processing and analysing data and information

Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (ACSIS090)

Communicating

Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts (ACSIS093)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 5, students classify substances according to their observable properties and behaviours. They **explain everyday phenomena associated** with the transfer of **light. They describe the key features of our solar system.** They analyse how the form of living things enables them to function in their environments. Students discuss how scientific developments have affected people's lives and how science knowledge develops from many people's contributions.

Students follow instructions to pose questions for investigation, predict what might happen when variables are changed, and plan investigation methods. **They use equipment in ways that are safe** and improve the accuracy of their observations. **Students** construct tables and graphs to **organise data and** identify patterns. They **use** patterns in **their data to suggest explanations and refer to data when they report findings. They** describe ways to improve the fairness of their methods and **communicate their ideas, methods and findings** using a range of text types.

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

The moon

The moon is Earth's only satellite and moderates Earth's wobble on its axis and the tides. This has led to the Earth having a reasonably stable climate over billions of years.

The moon is not round, but is in fact egg-shaped with the large end pointed towards Earth.

The moon has remained unchanged for billions of years and is arid and lifeless. The light areas of the moon are known as the highlands. The dark features are impact basins that were filled with lava between 4.2 and 1.2 billion years ago. These light and dark areas represent rocks of different composition and ages. The atmosphere is sparse and therefore, the moon contends with impacts from meteoroids, comets and asteroids. These constant impacts have resulted in the surface being ground up into fragments of rock, some as big as boulders, others to powdery dust. The entire moon is covered in this charcoal-grey rubble, dust and rocky debris. The craters provide an impact history for the moon and other bodies in the inner solar system.

From Earth, we always see the same side of the moon because the moon is spinning on its axis at the same speed that it is going around the Earth, however only about 59% of the moon's surface is actually visible to us on Earth.

A full moon occurs every 29.5 days. The moon keeps the same side to us, but not always the same face. Because of the tilt and shape of its orbit, observers from Earth see the moon from slightly different angles over the course of a month. Interestingly, whilst everyone sees the same phases of the moon, people south of the equator who face North, see the moon upside down, so that the reverse side is lit.

Source: Earth's Moon – Moon facts, NASA

Common misconceptions about the moon

Misconception: The moon makes its own light (the same way the sun does).

Reality: The moon reflects the light of the sun, just as the planets do. In fact, the bright part of the moon is experiencing daytime.

Misconception: The moon is only visible at night.

Reality: We frequently see the moon in the day; the only phases of the moon that cannot be seen in the day are full moon (which starts at sunset and ends at sunrise) and the new moon (which is not visible from Earth at all).

Source: Earth's moon – Common moon misconceptions, NASA

Think-Pair-Share

A **Think-Pair-Share** activity is conducted by having students '**Think**' on the topic for one minute, discuss the topic and their ideas in a '**Pair**' for 2 minutes and then '**Share**' with another group for 3 minutes. Time frames can be adjusted to suit your students and/or classroom requirements.

Materials and equipment

Per group:

- orange or other piece of round fruit
- piece of foil to cover fruit
- torch
- ruler, 30 cm

Safety advice

Remind students not to stare directly at the sun during outdoor observations.

Advise students not to shine torch light into their eyes or other students' eyes.

Teaching sequence

Lesson objective

Students understand that the moon:

- is made up of rock and reflects the light from the sun
- does not emit its own light.

Introduction

Ask students to list objects/phenomena that are sources of light and record their responses.

Group the items into the categories of Natural and Artificial. Clarify that the natural phenomena, being the sun and stars, are a part of our solar system.

Inform students that during this lesson, they are going to examine natural phenomena that are sources of light and explore the question "Does the moon emit its own light?"

Ask students to conduct a 'Think-Pair-Share' activity to discuss their ideas about how the objects in the solar system emit light. (This could include the sun, stars, the moon and planets.)

Discuss students' ideas from the activity.

Clarify that many of the light sources in the sky consist of stars, including the sun.

Clarify facts about the sun:

- The sun is a yellow dwarf star.
- The sun's colour is white, however atmospheric scattering has the Sun appearing yellow, red, orange or even magenta at different times.
- The sun is made up of mostly the burning gases of hydrogen and helium
- The sun emits light.
- The light from the surface of the sun takes 8 minutes and 20 seconds to reach Earth.

Display the image A handle on the sun to illustrate how the sun is a hot ball of glowing gases. Confirm that there are other objects in the sky such as planets and moons that appear to emit light.

Ask students to conduct some observations of the sun outdoors (students can look out classroom windows to avoid having to prepare for a full field walk). **Remind students to not stare directly at the sun.**

Ask students to make note of what they see – whether it be the sun or the sun and moon.

Ideas for further learning – Make observations of the night sky – either by conducting an incursion at school to view objects in the night sky, (which could include the use of telescopes) OR ask students to make observations of the night sky at home.

Core

1. Conduct a TWL activity on what students know about the moon and record their responses.
2. Display the stimulus pictures on the PowerPoint presentation The moon.

Teacher note: Run the slideshow on a loop so students can continue to view images during their observations.

3. Clarify that images on slides 2–4 show the moon as it can be seen during the day; slides 5–7 show the moon during a lunar eclipse and at night and the remaining slides show astronauts on the moon, a view from the moon of the Earth rising and a sample of rock from the moon.
4. Ask students to examine the images and make note of their feature and then to share their ideas about the images.
5. List the visible features of the moon, including the colour of its surface and the presence of craters, rocks and powdery dust.
6. Point out the obvious difference of the moon's brightness at night as compared to the moon during the day. Ask students to discuss their ideas about the difference in brightness.
7. Review the image of the sun, A handle on the sun informing students that the sun always looks the same and that it is only our position on Earth in relation to the sun for why we have day and night.

Teacher note: Day and night is a science understanding introduced in Year 3 – see ACARA content description Earth's rotation on its axis causes regular changes, including night and day (ACSSU048)

8. Ask students to draw a preliminary conclusion about whether the moon emits its own light.
9. Watch the Why does the moon shine? video.

Ideas for further learning – Navigate to the website Earth's moon to find out facts and details about the moon; see amazing images and find out the importance of the moon's history and the scientific endeavours of those that have visited and studied the moon.

10. Discuss the information presented in the video and ask students to compare their ideas to those of the scientists in the video.
11. Confirm that the moon does not emit its own light, but reflects the light being emitted from the sun.
12. Inform students that they will now confirm some of the information presented in the video. Explain that they will be performing some explorations regarding how light is reflected off the moon.
13. Remind students that the scientists in the video stated that the moon was brighter when light shone directly onto it in comparison to when the light was at an angle to the moon.
14. Show students the equipment they will be using and ask them how they might go about confirming this.
15. Ask students to read through the instruction sheet Exploring light and the moon.
16. Ask students to make predictions about what they think will happen.

17. Divide students into groups and have them conduct their explorations.

18. Ask students to discuss their findings.

Conclusion

Review the information covered in the lesson, including findings from their observations and explorations.

Ask students to confirm whether the moon emits its own light and to justify their reasoning.

Discuss how scientists and astronauts have studied and explored the moon to find out this information.

Inform students that there have been many missions to the moon and that these missions have allowed us to better understand the moon, Earth and sun.

Ideas for further learning – Find out about NASA missions to the moon, Mars and beyond by exploring the NASA missions website. Find out about the many missions to space including the Apollo, Curiosity and Odyssey missions. View videos and images on these missions to learn more about space exploration and how it benefits society.

Ideas for further learning – Research how space exploration has created some amazing spin-off inventions and technology. Visit the NASA Spinoff website for images, videos and interviews.

Lesson resources

Digital resources

The moon, PowerPoint (1.3 MB)

A handle on the sun, NASA. Image

Why does the moon shine? Universe Today (4:48 min). Video

Worksheets

Exploring light and the moon

Useful links

Earth's moon, NASA. Information for teachers and students

NASA missions, NASA. Information for teachers and students

Technology Transfer Program – Spinoff, NASA. Information for teachers and students

Exploring light and the moon

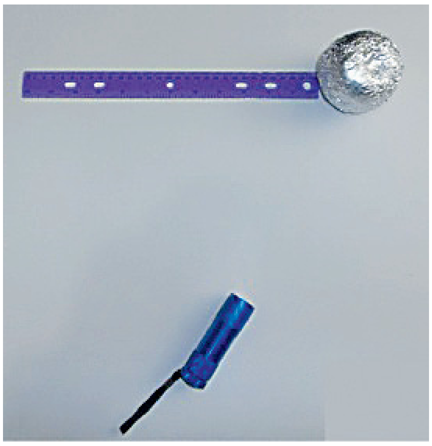
Instructions:

1. Take the piece of foil and crush it gently, so it is crumpled all over.
2. Unwrap it carefully and cover the piece of fruit completely.
3. The piece of fruit is now a representation of the moon.
4. Place the moon on a flat surface.
5. Place the ruler against the moon with the zero (0) cm mark it closest to you and the 30cm mark it closer to the moon.
6. Place the torch at the 10cm mark on the ruler, so that it is 20cm away from the moon.
7. Refer to the image below to see the set-up.
8. Turn the torch on and shine it directly at the moon.
9. Squat down to the level of the table and look at the brightness on the foil. Do not look at the moon from above.
10. Observe the strength of the brightness.
11. Move the torch so it is at approximately a 60° (degree) angle.

View from this position →

12. Refer to the image below to see the next set-up.
13. Ensure the torch stays 20cm away as before.
14. Turn the torch on and shine it at the moon.
15. Remain in the first position to observe strength of the brightness.

View from this position →



16. Compare the effects between the brightness at each position.
17. Record your results.

Refer to the last image in the slideshow 'The moon' – Apollo 15 Genesis rock.

Note the effects of the light reflecting off the rock. You can clearly see that the rock is grey in colour, however part of it is quite white and shiny.

This is due to a source of light being shone onto it.

Only part of the rock appears shiny, due to the light source shining on it from an angle and not from directly in front of it.

The atoms that light the world

Light is a form of energy that can be emitted by atoms. Science has learnt to harness these emissions, manipulating solid materials – semiconductors and diodes – to produce devices of extraordinary efficiency. Among these are today's light emitting diodes (LEDs) that are replacing the incandescent light bulbs in many homes.

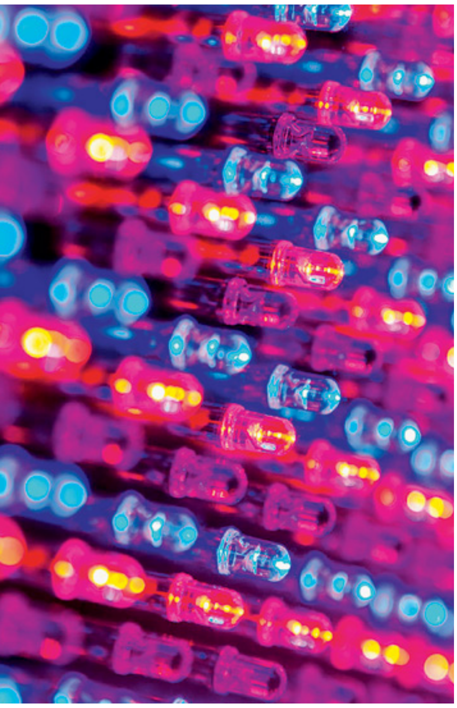
The relationship between matter and light is due to the negatively charged electrons that whiz around the nucleus of atoms. It arises because electrons change energy states by absorbing and emitting photons – the particle-like basic unit of light.

Every type of atom and molecule has a unique, telltale way of absorbing and emitting photons, and it can be analysed (by mass spectrometry) like a fingerprint. This is how light can be used to reveal the identity of a material, be it in a forensic sample at a crime scene or the fuel within a distant star.

The light emitted, however, can take very diverse forms, from infra-red, X-rays and microwaves, to the light spectrum visible to human eyes.

This diversity occurs because light has a dual aspect. It behaves as a particle (mediating energy transfers between electrons) and as a wave (vibration) within an electromagnetic field. The wave aspect defines the light's wavelength and frequency – or to the human eye, its colour.

LEDs use layers of carefully selected materials (semiconductors) to generate bright and durable light sources that are extremely energy efficient. They can also transmit information, such as from audiovisual remote controls (usually in the form of infra-red light) and they can form images – which is why they are used in increasingly thinner and lighter televisions.



The choice of materials in the light-emitting diode is important. Visible LEDs typically involve aluminium, gallium and arsenide. However, these atoms bond perfectly to their neighbours, leaving no electrons free to conduct an electric current. So a process called 'doping' is used to add other atoms that either free up or capture electrons and create semiconductor material.

Diodes are formed by bonding a semiconductor that has free electrons with a semiconductor that can store extra electrons. A diode will conduct electricity when electrodes are attached. But reverse the +/– orientation of the electrodes and instead of conducting electricity, a diode emits light.

The physical characteristics of the diode determine whether the light shines in infra-red, ultraviolet or the colours of the visible spectrum.

DID YOU KNOW?

- Only about 44 per cent of the sunlight energy that reaches Earth's surface is visible light.
- LED-based lights can be up to 10 times more energy efficient than traditional incandescent lights, which emit only 10 per cent of their energy as light. The rest is emitted as infra-red (heat).
- The most basic light source is the glowing solid particles in flames, but these too emit most of their radiation in the infra-red range (as heat) and only a fraction in the visible spectrum.
- Atoms and molecules such as carbon dioxide that absorb and emit infra-red light are responsible for the warming atmosphere and climate change.

LESSON PLAN: YEAR 6

How do we dim the lights?

Introduction

In this lesson, students investigate how to vary the light emitted by a light emitting diode (LED) by using a variable resistor as a dimmer switch. Dimmable lights are often used to create mood lighting in our homes. Students construct the variable resistor from the graphite in a lead pencil. Changing the resistance in the circuit controls the current that flows through the LED and hence this determines the brightness of the light. Household dimmer switches work in a similar way. LEDs come in a range of colours. This adds to the fun of the investigation, especially if it is performed in a darkened room.

Australian Curriculum content descriptions

Science Understanding

Physical sciences

Electrical circuits provide a means of transferring and transforming electricity (ACSSU097)

Science as a Human Endeavour

Use and influence of science

Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives (ACSHE100)

Science Inquiry Skills

Questioning and predicting

With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be (ACSIS232)

Planning and conducting

With guidance, plan appropriate investigation methods to answer questions or solve problems (ACSIS103)

Decide which variable should be changed and measured in fair tests and accurately observe, measure and record data, using digital technologies as appropriate (ACSIS104)

Use equipment and materials safely, identifying potential risks (ACSIS105)

Processing and analysing data and inform

Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (ACSIS107)

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Evaluating

Suggest improvements to the methods used to investigate a question or solve a problem (ACSIS108)

Communicating

Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts (ACSIS110)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 6 students compare and classify different types of observable changes to materials. They **analyse requirements for the transfer of electricity** and describe how energy can be transformed from one form to another to generate electricity. They explain how natural events cause rapid change to the Earth's surface. They describe and predict the effect of environmental changes on individual living things. Students explain how scientific knowledge is used in decision-making and identify contributions to the development of science by people from a range of cultures.

Students follow procedures to develop investigable questions and design investigations into simple cause and effect relationships. They identify variables to be changed and measured and describe potential safety risks when planning methods. They collect, organise and interpret their data, identifying where improvements to their methods or research could improve the data. They describe and analyse relationships in data using graphic representations and construct multi-modal texts to communicate ideas, methods and findings.

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

The light emitting diode in this activity acts like a light globe and emits light as electricity flows through it. If the electrical current flowing through the diode is high, the light will be bright. Reducing the current reduces the amount of light. What is needed is a simple way of controlling the amount of electricity passing through the LED. The answer is to use a dimmer switch which is simply a resistor that can change value or be varied. This reduces the current to a level that the LED can handle without burning out and the fluctuations in the resistance allow more or less current to flow, making the LED brighter or dimmer.

Manufactured variable resistors are available but it is fun for students to make their own using the graphite in a lead pencil. Graphite in a lead pencil is sheets of carbon atoms with spare electrons which allow electricity to pass through. If the length of graphite is long, the resistance is large and the current flow will be small. A shorter length of graphite will have a lower resistance and more current will flow.

In this activity, students draw and colour in a 'graphite box' on a sheet of paper. The box acts as a variable resistor. Connecting wires to the LED are placed at different distances along the box hence changing the amount of graphite between them and changing the resistance, controlling the current and the brightness of the light.

Materials and equipment

- if possible, an old (or new) domestic dimmer switch/dial control (available from hardware stores)

Per group

- 12 V DC power supply
- red, green or yellow LED
- 1 alligator clip
- 2 connecting wires
- smooth paper
- graphite pencil (2B or darker)

Safety advice

If the LED is connected to the 12 V power supply directly for any length of time it will burn out. To check that the LED works it should only be touched to the connecting wires as outlined below.

Teaching sequence

Lesson objective

In this lesson students:

- create a variable resistor by drawing and colouring in a graphite box
- create an electric circuit that dims the light produced by an LED.

Introduction

Ask students if they are familiar with dimmable lights controlled by a dial switch (and if possible show them the dial control for lights and explain that by turning on the lights and turning the dial, the brightness of the lights can be changed).

A good analogy for students who haven't seen one of these devices before is to compare it to the volume control on such devices as an iPod, television or laptop. A dimmer control does the same thing for lights – it changes the brightness of the lights.

Ask students how a dial device, such as a dimmer or volume control, might work. It obviously controls the electricity that is supplied to the lights but how? (Answer: by changing the resistance in the circuit, which changes the current supplied to the lights and hence the brightness of the lights.)

Explain that if the lights have more current passing through them they will be brighter, and if they have less current they will be dimmer. (Note: the voltage supplied to domestic dimmable lights doesn't change – it is always 240 V).

Changing the resistance occurs as the dial is rotated, but some changeable resistors involve sliders rather than dials. In this activity, students will model the action of a sliding dimmer control.

Core

Divide students into small groups and direct them to the materials/equipment already set up.

Instruct students to:

1. draw a box approximately 1 cm wide and 5 cm long on their piece of paper and to colour it in completely with the graphite pencil, making it as heavy and as dark as possible.
2. plug one end of one of the connecting wires into the positive (+) terminal of the power supply set on 10 V, and clip the other end to the long leg (the +) of the LED using the alligator clip.
3. take the second wire and attach it to the negative (–) terminal of the power supply. Briefly touch the other end of this wire to the short leg (the –) of the LED to make sure it works. **DO NOT ATTACH** the second clip to the LED as it could burn out your LED if linked together for too long.
4. press the short negative (–) leg of your LED to one end of the coloured-in box on the paper. Press the loose end of the second wire to the opposite end of the coloured-in box and slowly drag it along the box closer to the LED. What happens to the LED's light?

Conclusion

Summarise and confirm with students what they have learned this lesson (refer to lesson objectives).

Inform students that different substances conduct electricity in different ways. Graphite isn't particularly good at conducting electricity. Metals are much better conductors. Graphite however, is a good resistor. Resistors can also be made out of long lengths of wire. The old style electric kettles had a coil of wire inside them (called an 'element') that heated up and caused the water to boil. Similarly, old style light globes had a wire 'filament' in them that heated up and created the light.

The role of resistors in an electric circuit is to control the amount of current passing through the various components, stopping them from overheating and burning out and allowing them to operate correctly.

Dimmer switches in our homes are more conveniently made into dials that are rotated to vary the resistance in the circuit. Other simple variable resistors are the dials on volume controls or the speed controller on a fan etc.

Lesson resources

Useful links

Sliding light: How to make a dimmer switch, Science Buddies. Project idea for students

Pencil graphite as a variable resistor, YouTube (1:37min)

Fresh water from the sun

Our planet's vast oceans seem an obvious source of water to help overcome the shortage of safe, clean drinking water that already affects about 700 million people around the world.

The power of the sun, through the natural water cycle, has recycled and purified the world's water supplies for billions of years. But given that the amount of water on Earth is essentially limited, and only one per cent is actually accessible as fresh water for human and other uses, the demands of the world's seven-billion-strong human population are exceeding the planet's natural ability to supply.

Ozone depletion has increased the amount of the sun's ultraviolet radiation reaching the Earth, which has also increased the rate of evaporation of water from the planet's surface. While more evaporation results in more rain, and potentially more fresh water, the pattern of rainfall is becoming increasingly variable. The rain is not necessarily falling in areas where it can be captured for re-use.

Water shortages, caused by urban sprawl into natural catchment areas, and over-exploitation of resources such as rivers and aquifers, are major challenges for food production and, in the long term, for human survival. Competition for freshwater resources is high and already causing political friction in regions where countries are forced to share river systems – such as India and Pakistan and Middle Eastern countries.

Many communities are seeking new ways to create their own fresh water supplies, to improve water security. Mimicking the natural process of evaporation is a well-established method of turning salt water into fresh water, through distillation. This process, or modern high-tech-variations in the form of large-scale water desalination facilities, is becoming increasingly relevant as the world faces growing fresh water shortages.

Basic solar stills are used most commonly in rural areas, as a low-tech and low-energy option for communities that do not have access to other forms of water-purification infrastructure, or the electricity to run such a system. The process can be used to purify seawater, less-salty 'brackish' estuarine water, groundwater and polluted fresh water.

On an industrial scale, desalination plants relying on distillation processes are highly energy intensive, which has limited their use. However, newer technologies such as reverse osmosis use less energy, relying on pressure rather than heat to separate pure water from contaminating elements. An ongoing issue for industrial-scale desalination is the potential environmental impact of discharging highly concentrated brine into the ocean.

DID YOU KNOW?

- By 2025, an estimated 1.8 billion people will live in areas of water scarcity and two-thirds of the world's population will live in water-stressed regions as a result of use, growth and climate change.
- More than 120 countries, including Australia, use desalination to create additional fresh water for domestic, industrial and agricultural uses.
- 100 per cent of the fresh water in Kuwait and Qatar comes from desalination plants.

LESSON PLAN: YEAR 7

How does sunlight affect the water cycle?

Introduction

Modelling relationships is an important skill and is frequently used by scientists to examine the impacts of changes upon a system.

In this lesson, students will model the water cycle, and examine how it can be harnessed to supply the needs of communities with severe water shortages. Students will use their understanding of the separation of mixtures to examine how light energy can be used to obtain fresh water from dirty water.

Australian Curriculum content descriptions

Science Understanding

Chemical sciences

Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)

Earth and space sciences

Water is an important resource that cycles through the environment (ACSSU222)

Science as a Human Endeavour

Nature and development of science

Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world (ACSHE134)

Science knowledge can develop through collaboration and connecting ideas across the disciplines of science (ACSHE226)

Use and influence of science

Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations (ACSHE120)

Science understanding influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management (ACSHE121)

Science Inquiry Skills

Questioning and predicting

Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)

Planning and conducting

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS140)

Processing and analysing data and information

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate (ACSIS144)

Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions (ACSIS145)

Communicating

Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate (ACSIS148)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 7, students describe techniques to separate pure substances from mixtures. They represent and predict the effects of unbalanced forces, including Earth's gravity, on motion. They explain how the relative positions of the Earth, sun and moon affect phenomena on Earth. **They analyse how the sustainable use of resources depends on the way they are formed and cycle through Earth systems.** They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. **Students describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem. They explain how the solution was viewed by, and impacted on, different groups in society.**

Students identify questions that can be investigated scientifically. They plan fair experimental methods, identifying variables to be changed and measured. They select equipment that improves fairness and accuracy and describe how they considered safety. Students draw on evidence to support their conclusions. They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. They communicate their ideas, methods and findings using scientific language and appropriate representations.

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

The underlying concept of the water cycle is conservation of mass. It is important for students to realise that water vapour contains the same water particles as liquid water or solid water (ice). Water contained in the soil evaporates (becomes water vapour) and joins other gases in the air. As this water moves away from the earth, it cools until it joins with other water molecules to form a small droplet of water. Millions of these droplets can become a cloud. In the solar mini still, the evaporated water vapour condenses on the cling wrap covering the still. When a large enough droplet forms, it will move down the plastic and drop into the cup underneath, just like rain falling back to earth.

Thermal heat energy and light energy comes from the sun. The thermal energy will have difficulty reaching the water in the soil, however the light (in particular the UV light) can easily pass through the cling wrap to reach the soil. This light energy is transferred to the water molecules, giving them enough kinetic energy to break the bonds with the surrounding water molecules, causing the water to evaporate.

Dark colours (i.e. black painted container) absorb more light energy and therefore heat the soil more quickly.

Adding aluminium foil flaps to the outside of the plastic container may allow extra light energy to be concentrated onto the soil. Both these features may cause more water to evaporate and therefore more water to be collected in the cup overnight.

Prior knowledge

Students will require some prior knowledge on separating mixtures. There is an excellent unit on mixing and separating for year 7 on the ScienceWeb website.

Materials and equipment

Prepare a model solar still prior to the lesson for the students to examine and to act as a control/comparison.

Per group

- large plastic tub or ice-cream container
- plastic cup
- small rock or marble
- watering can
- measuring cup or cylinder
- roll of plastic cling wrap
- roll of wide tape to seal the still
- 2–4 litres of soil or sand
- 1–2 cups of water
- aluminium foil (optional)
- black plastic sheeting (optional)

Safety advice

Conduct appropriate risk management prior to implementing outdoor activities.

Consult the sun safety and outdoor activity guidelines for your school or organisation prior to implementing outdoor activities.

Ensure students wear sun protective hat, clothing and sunscreen when working outdoors.

Teaching sequence

Lesson objective

In this lesson, students utilise their knowledge on separating mixtures to obtain pure water from moist soil. Sunlight is used in the distillation process.

Introduction

Ask students what things they would need to survive on a desert island.

Allow students to make a list of essential items. Divide the list into ‘needs’ and ‘wants’. Suggest to students that they could survive 60 days without food but only 3 days without water. Ask students to suggest a meaning for the sailors’ phrase ‘Water, water, everywhere but not a drop to drink!’

Core

1. Remind students of the various separation techniques they have already learnt about. Distillation involves the capture of water vapour and cooling it until it forms drinkable liquid water, leaving behind other solutes such as salt and dirt. Ask students how they could create water vapour from water in the soil with no electricity or gas (sunlight).
2. Divide the class into teams of three. Each team should examine the teacher's version of the mini solar still.
3. Each team should be given a plastic container of the same size with which to build its distillation equipment. Their goal is to modify the design so that more water is produced than the teacher's design. Questions that can be asked include:
   - What colour could the box be painted to make it heat up more?
   - Would a reflective surface (e.g.aluminium foil) help capture more sunlight?
4. Ask students what variables should be the same between all the groups. (The amount of soil, water, size of box, time allowed for distillation etc)
5. Students draw a model of their design and write a list of the materials they will need.
6. Students build their solar stills and set them up in the same area with the same amount of sunlight. (The middle of an oval would be ideal.) Let the students take photos of the mini solar stills for their final reports.
7. After 24 hours, students use a measuring cylinder to measure the amount of fresh water that was collected in the cup. Record the results in a table.
8. Ask students where the water in the cup came from. Discuss where the water that evaporates from the soil goes, if it is not trapped inside a still.
9. Discuss which design was the most effective method of distillation. Brainstorm why this might be the case. Ask how the energy of the light was captured most effectively.

Conclusion

Ask students:

- How would you modify your solar still design to increase the amount of water collected? (If time allows, students could retest their new design.)
- What material/s could you substitute for the box? The cups? The cling wrap?
- What societies throughout the world might benefit from this technique?

Lesson resources

Useful links

Mini water cycle, ABC Science, Surfing Scientist. Lesson plan

Mixing and separating, ScienceWeb. Unit of work for years 7–8

Separating mixtures with distillation, You Tube (9:05min)

Solar water distiller, You Tube (2:48 min)

The water cycle, You Tube (7:14 min)

The science of sunglasses and 3D

Visible light from the sun travels through space like a wave.

But while some waves, like those in the ocean, only oscillate up and down in a vertical plane, or with linear vertical polarisation, relative to their direction of travel, light waves can be polarised in any direction perpendicular to the direction of their travel.

Most sources of light are unpolarised, but by filtering light through a material that absorbs all the planes of oscillation except one, the light can be polarised. So polarised light is defined as light in which vibrations occur in a single plane.

Human vision is adapted to prefer vertically polarised light because horizontally polarised light creates glare and reduces visibility in our line of sight. This polarisation of the light is the principle behind sunglasses.

Most of the light that is reflected from surfaces such as roads or the sea is horizontally polarised, which is why we wear sunglasses in situations where clear vision is needed. Aviator sunglasses were invented in 1936 to eliminate horizontally polarised light to improve the vision of pilots pioneering advanced flight, and remain largely unchanged today.

Wearing polarised sunglasses also makes it easier to see beneath the surface of water because light from reflections is partially polarised in the horizontal direction. Filtering out these light waves makes the water appear more transparent. When worn by drivers, polarised lenses eliminate the bright reflections in front of us, providing clearer vision and reducing eye fatigue.

The same principle applies to the glasses worn to watch 3D films. These are made from two opposing linear polarising filters. One of your eyes receives vertically polarised light while the other eye receives horizontally polarised light. This gives the perception of depth because human vision is 'stereoscopic'.

The separation of our eyes (roughly 50 to 75 millimetres) means we see slightly different images in each eye; our brain fuses the images so that we can see in three dimensions and perceive depth. So, a flat movie screen can project a three-dimensional image by having two slightly offset images. Two cameras sitting side by side are used to film the movie, the same as the way our eyes work.

The two reels of film are projected simultaneously through two opposing polarising filters. Each eye will only be able to see the image that is destined for it, and because each image is offset, just as it is when we see things in the real world, the 3D glasses trick our brain into combining both images to give us the perception of depth.

DID YOU KNOW?

- Vikings used calcite crystals to polarise the light from the sun on cloudy days to help them navigate.
- Edwin Land invented the world's first polarising material 'Polaroid' in 1929.
- Depending on the height of the sun, its glare can be almost completely horizontally polarised, making it impossible to see.

LESSON PLAN: YEAR 8

Polarisation of light

Introduction

Polarisation is an interesting feature of light and has many applications, some to everyday life and some that are more specialised. Polaroid sunglasses, 3D glasses used at the cinema, viewing the sky in daylight, viewing LCD screens, and the navigation of bees and other insects are some of the everyday contexts for polarised light. This lesson will introduce the idea of polarisation and enable students to carry out tests on different light sources to test if they are polarised or unpolarised as well as investigating some other interesting effects.

Australian Curriculum content descriptions

Science as a human endeavour

Nature and development of science

Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world (ACSHE134)

Use and influence of science

Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations (ACSHE135)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 8, students compare physical and chemical changes and use the particle model to explain and **predict the properties and behaviours of substances.** They identify different forms of energy and describe how energy transfers and transformations cause change in simple systems. They compare processes of rock formation, including the time scales involved. They analyse the relationship between structure and function at cell, organ and body system levels. Students examine the different science knowledge used in occupations. **They explain how evidence has led to an improved understanding of a scientific idea** and describe situations in which scientists collaborated to generate solutions to contemporary problems.

Students identify and construct questions and problems that they can investigate scientifically. They consider safety and ethics when planning investigations, including designing field or experimental methods. They identify variables to be changed, measured and controlled. Students construct representations of their data to reveal and analyse patterns and trends, and use these when justifying their conclusions. They explain how modifications to methods could improve the quality of their data and apply their own scientific knowledge and investigation findings to evaluate claims made by others. They use appropriate language and representations to communicate science ideas, methods and findings in a range of text types.

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

Light is a transverse electromagnetic wave consisting of a varying electric field and a varying magnetic field. The orientation of the electric field determines if light is unpolarised or polarised. If the light has many different orientation planes of the electric field, it is called unpolarised light. If it has only one plane of orientation of the electric field, it is called polarised light. Polaroid filters only transmit a particular plane of orientation of the light. Other orientations are blocked. When polarised light is viewed through a polaroid filter and the filter is rotated through 360 degrees, two positions will occur that will block all the light. If none of the light is blocked during the 360 degree rotation, the incoming light was unpolarised. Rotating the filter therefore is a standard test for polarised light.

Sunglasses often contain polaroid filters in order to reduce glare. The polaroid lenses in 3D glasses at the cinema are slightly offset and only allow one image to enter each eye and hence our brains re-create the 3D image. When light is scattered it becomes polarised. Viewing different parts of the sky in daylight while wearing polaroid sunglasses and rotating your head shows the sky as partly polarised. LCD screens produce polarised light and can be tested through a rotating polaroid filter. The stress in plastics becomes visible when viewed under polarised light and analysed through polaroid filters.

Common misconception: Not all sunglasses have polaroid lenses! Students can test their own sunglasses to see if they are polaroids or not.

Materials and equipment

- sunglasses and calculators. Students can bring their own.
- several LCD screens – computers, TV, projector image – turned on in the classroom when students arrive
- pre-stretched ziplock plastic bags
- spare polaroid filters (for students who forget their sunglasses or whose sunglasses are not polaroids)
- slinky
- normal light globe
- fluorescent light
- 3D glasses (for demonstration only)

Safety advice

Remind students not to stare directly at the sun during outdoor observations.

Teaching sequence

Lesson objective

In this lesson students:

- test a computer screen to confirm if it emits polarised light
- test their sunglasses to confirm if they are polaroids or not
- test other sources of light to determine if they emit polarised or unpolarised light
- model transverse and longitudinal waves with a slinky
- model polaroid filters using the ‘picket fence’ analogy
- investigate the stress in plastic which becomes visible under polarised light

Introduction

Instruct students to bring their calculators and to wear their sunglasses into class one day and to observe things along their way to class. As they come into class, have as many computer screens or LCD TV screen or projector images on as possible and ask students to look at one of the screens while they move their heads from side to side. (Try this yourself first. The screen should look dark when your head is rotated one way and bright when it is rotated the other way. This is due to the polarised nature of the light coming from the LCD devices).

If this surprises students ask them to turn on their calculators, type a really long number that fills the screen and then look at the screen while wearing their sunglasses. Turn the calculator through 360 degrees and ask them what they see during one full rotation (the screen should go dark twice during 360 degrees).

Finally, give the students some pre-stretched ziplock bags and instruct students to view them through their sunglasses while holding the bag in front of the computer screen (they should see a coloured pattern in the area of the stretching). Tell them to stretch the bags some more and see what happens (the colours will spread – this is most visible when they turn their heads to make the screen background go dark – try it yourself too).

Core

1. Ask students to write down on a sheet of paper, an explanation for any of their observations above.

2. Collect the student responses and read them out – ask the class to comment on each one.

3. Introduce the concept of light being a wave and the idea of how that wave is oriented – this produces the effects they've seen.

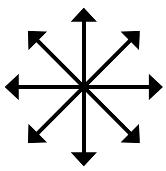
4. Demonstrate (yourself or use the students) the different types of waves using a slinky, stretched out on the floor and held by another student at the far end, with the rest of the class looking on from both sides. Push forward and back on one end of the slinky to create a type of wave – longitudinal. Can students describe the motion of the section of slinky in front of them (forward and back or parallel to the wave motion)? Move or wiggle the slinky from side to side to create another type of wave – transverse. Can the students describe the motion of the section of slinky in front of them (up and down or at right angles to the wave motion)?

5. Explain that light is a transverse wave of electric and magnetic fields called 'electromagnetic radiation'. If there were a picket fence across the classroom the pickets would stop the transverse wave from getting through (you could model this with a student standing over the slinky with their legs representing the pickets on a fence, if their feet are close together it should block the wave on the slinky from getting through). Ask the students if the orientation of the transverse wave, or the pickets, could be changed so the wave still gets through (make the wave vertical or the pickets horizontal).

6. Tell the students that if the slinky were wiggled from side to side we'd call this horizontally polarised light. If it were wiggled up and down we'd call that vertically polarised light. In the above example, the slinky represents the light waves and the picket fence represents the polaroid sunglasses. If the light coming from the computer screen is polarised in a particular way and the polaroid sunglasses positioned a particular way, they block the light coming from the screen. Rotating your head lines up the polaroid (represented by the pickets), with the orientation of the light (represented by the slinky) and the wave gets through. So this is how to test polarised light – view it through a filter and rotate the filter. There should be two total blockings per 360-degree rotation.

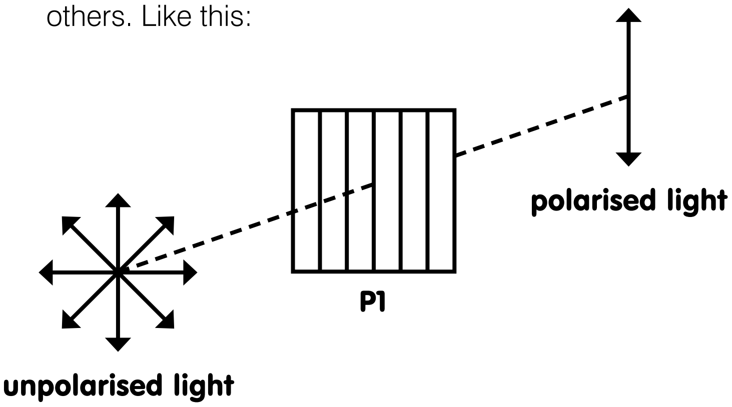
   But what about unpolarised light …

   Unpolarised light has lots of different orientations of the transverse wave and is often drawn like this:



unpolarised light

Passing this light through a polaroid filter selects one orientation and allows it to pass while blocking the others. Like this:

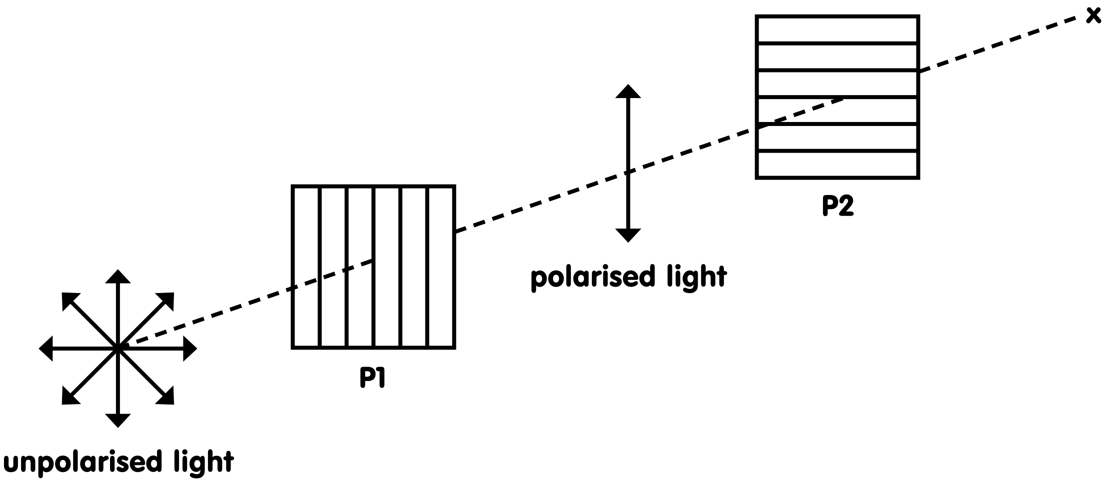


The light will appear dimmer but not totally blocked. Rotating the polaroid will always let some light through so there is never any blocking of the unpolarised light. (If students found no difference when they rotated their heads while viewing the screens in the intro activities their sunglasses are not polaroids)

7. To test if a light source produces polarised or unpolarised light, view it through a polaroid and rotate the polaroid. For students with sunglasses, tell them to hold the sunglasses in front of them rather than wear them. Test different light sources such as normal light globes, fluorescent tubes, reflected sunlight from windows, concrete, bitumen road if possible, mobile phone screen, and the sky itself, near the sun and opposite to the sun. Record observations and decide which are polarised and which unpolarised.

8. Finally, test 'crossed polarisers'. Take two pieces of polaroid sheet and look through one of them. The light should be dimmer. Now put the second polaroid sheet over the first and rotate it. When the polaroids are 'crossed' no light should get through at all.

   Ask students to use similar diagrams to those above to draw this combination. They should produce something similar to this, with no light being visible at X.



Conclusion

Summarise and confirm with students what they have learned this lesson (refer to lesson objectives).

The polarisation of light confirms that light is a transverse wave. There are many sources of polarised light around us. Students should now know how to detect polarised light using a polaroid sheet or polaroid sunglasses and the transverse wave nature of light. Polarised light is an interesting phenomenon and probably one that students are unlikely to have come across in full before.

Many extension questions remain: (some of the topics below could be incorporated into this lesson plan, if desired, or they could form the basis of a future lesson or your students could research them as a project or homework)

- Why do LCD screens emit polarised light?
- Why do 3D glasses use polaroid filters?
- How and why do bees navigate using polarised light?
- Which other insects have this ability?
- How does the art form known as 'polage' use polarised light?
- What is Brewster's law and Brewster's angle?
- What is photoelasticity?

Lesson resources

Useful links

Black out your sunnies, Surfing Scientist, ABC Science. Student information

How do 3D glasses and polarisation work? You Tube (6:02 min)

Photoelasticity, Encyclopædia Britannica. Teacher information

Polarized light, You Tube (14:48 min)

Sight relies on light

Simply put, without light, we can't see: human vision is dependent on it – we are effectively blind in the dark.

This is because our eyes detect light generated by something luminous such as the sun or a candle, the light of which is then reflected off all the objects it reaches.

Visible light itself is a type of energy called electromagnetic radiation. This energy moves in a series of waves at different lengths and frequencies, known as wavelengths. The human eye can detect only a tiny fraction of wavelengths on the electromagnetic spectrum. In fact, visible light occupies just one-thousandth of a per cent of the spectrum, sitting between invisible radio waves, microwaves and infra-red light on one side and ultraviolet light, X-rays and gamma rays on the other.

Wavelength size within the visible light spectrum determines the light's colour, with red being the longest and violet the shortest. White light is a combination of all colours on the visible spectrum, which is why we see a rainbow when that light is split by a prism – or moisture in the atmosphere.

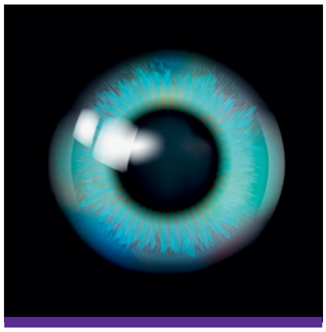
We 'see' these colours as light passes through the eye's cornea, controlled by a contracting or expanding pupil and then focused by the lens on to the retina on the back of the eye. Processing this light in the retina are two types of cells. These are 'rods', which handle vision in low light, and 'cones' for colour and detail. Chemicals in these cells trigger electrical impulses transmitted to the brain via the optic nerve where this visual information is interpreted.

So while it is often said we 'see' with our brains, it is the physical structure of our eyes that determines what we can detect.

This is why other species, such as nocturnal animals, can see more in the dark than humans. Not only do their bigger pupils let in more light, but their retinas are also packed with rod cells. The trade-off is that while this gives them superior night-vision, it also means they have a reduced sense of colour.

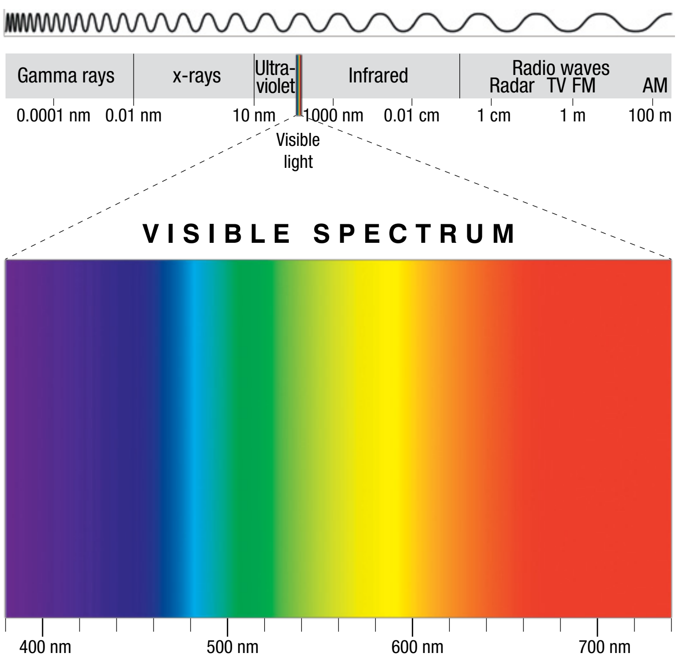
Eye structure has long been mimicked by technology – through camera lenses and microscopes, for example – as we seek to capture images.

It is also now commonplace for the use of light itself to correct eyesight through laser therapy. Lasers – a source of light with one pure colour, or wavelength – can be focused to a tiny spot with enough energy to cut through metal. In eye surgery, laser light is used to remove or reshape microscopic tissue to help restore normal vision for people who are long-sighted, short-sighted or who have an uneven eye surface.



DID YOU KNOW?

- People who lack vitamin A often suffer from night blindness (they cannot see in the dark).
- In dim light you can see more clearly out of the side of your eye, because the light-sensitive rods are more highly concentrated off to the side in the back of your eye.



LESSON PLAN: YEAR 9

The power of sight

Introduction

In this lesson, students complete various vision activities that reveal how amazing our power of sight really is. They compare the process of creating an image through a convex lens onto a sheet of paper to how an eye works and how the lens in the eye produces an inverted image on the retina, which the brain then turns the right way up. Other activities investigate the near point, binocular vision, dominant eye, judging distance, the blind spot and seeing double. Possible extension activities follow these.

Australian Curriculum content descriptions

Science understanding

Biological sciences

Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment (ACSSU175)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 9, students explain chemical processes and natural radioactivity in terms of atoms and energy transfers and describe examples of important chemical reactions. They describe models of energy transfer and apply these to explain phenomena. They explain global features and events in terms of geological processes and timescales. They **analyse how biological systems function** and respond to external changes with reference to interdependencies, energy transfers and flows of matter. They describe social and technological factors that have influenced scientific developments and predict how future applications of science and technology may affect people's lives.

Students design questions that can be investigated using a range of inquiry skills. They design methods that include the control and accurate measurement of variables and systematic collection of data and describe how they considered ethics and safety. They analyse trends in data, identify relationships between variables and reveal inconsistencies in results. They analyse their methods and the quality of their data, and explain specific actions to improve the quality of their evidence. They evaluate others' methods and explanations from a scientific perspective and use appropriate language and representations when communicating their findings and ideas to specific audiences.

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

Students may have some existing knowledge of the human eye and vision. This lesson may be a stand-alone lesson or may form part of a series of lessons about the eye. The lesson can be extended if some or all of the extension activities are incorporated.

The eye forms an inverted, real image on the retina which the brain then turns the right way up to give us our view of the world. This is modelled in the introductory activity.

As we get older our eyes start to deteriorate and the lens becomes less flexible. This affects our near point (the closest point at which an object can be brought into focus by the eye).

Having two eyes in the front of our heads give us binocular vision where each eye sees a slightly different view. The brain superimposes them to form a three-dimensional image. This aids us in depth perception. Animals with an eye on either side of their heads (most birds) don't have this ability but instead they have 'all round protection' from a wider field of view.

Where the optic nerve enters our eye, a 'blind spot' appears in our vision and our brains 'fill in' the missing image to complete the picture we see.

Our ability to focus on near and far objects can create our own optical illusions and enables us to view 3D images or 3D stereograms. These are fascinating and a challenge to master.

Materials and equipment

Per student:

- convex lens
- blank sheet of A4 paper
- ruler, 20 cm or 30 cm
- sharp pencil or pen
- small mirror (maybe one out of a ray box kit)
- worksheet, Vision activities

Safety advice

Normal eye safety awareness – beware of sharp objects near the eye.

Teaching sequence

Lesson objective

In this lesson students:

- using a lens, project an image on a sheet of paper from a view out a window and relate it to the functioning of the human eye
- carry out a range of vision activities including investigating their near point, demonstrating binocular vision, determining if they have a dominant eye, judging distances, locating their blind spot and adjusting their focus
- draw a picture of their own eyes using a mirror.

Introduction

Review with students what they know about the eye already – this may be based on past lessons or knowledge from past year levels. This can be done with question and answer or with a Know / Want to Know / Learned (KWL) chart. At the start of the lesson, ask students to list (as a group) everything they know about the eyes and vision under the heading 'Know'. Next, students list what they want to know about the eyes and vision under the heading 'Want to know'. At the end of the lesson, students list what they have learned about the eyes and vision under the heading 'Learned'.

Give each student (or in pairs if lenses are limited) a convex lens and blank sheet of A4 paper. Instruct students to find a clear view into the distance (usually from a classroom window) and use the lens to form an image of the outside on the paper. (They hold the lens near the window and the A4 paper behind it at the focal length of the lens – try this yourself first). Ask the students what they notice about the image (it is smaller and inverted).

Students then compare this activity to how the human eye works. Ask them where the lens is situated in the eye and what in the eye is represented by the paper. (The lens is behind the cornea and the paper is the retina at the back of the eye). Continue to ask how the inverted image is made upright. (By the brain).

Discuss vision problems in humans when the lens cannot form a focussed image on the retina and the various methods that are used to correct vision. Draw on student experiences to enhance this discussion. Ask students who wear glasses or contacts to share their experiences.

Core

The core of the lesson is a set of vision activities on the worksheet Vision activities which should be printed double-sided. Students can work individually or with a partner to determine what is required for each test. The teacher can work with the students too and instruct each activity or students can be allowed to work at their own pace. You should trial all activities yourself before the lesson so you can discuss the students' observations and even compare your (older person) results with theirs (the near point one can be revealing!).

Conclusion

Summarise and confirm with students what they have learned this lesson (refer to lesson objectives).

Our eyes work in unique and interesting ways. How different the world would look if for some reason the brain lost its ability to invert everything we see.

Extension activities:

Some of the topics below could be incorporated into this lesson plan if desired or they could form the basis of a future lesson (or your students could research them as a project or homework).

Tell your class about the following fascinating facts about animals' eyes:

- Clams have a row of eyes around their shells
- Flies have hundreds of separate little eyes
- An eagle can see its prey about 2 km away
- An owl can see a mouse moving over 50 m in light equivalent in brightness given off by a burning candle
- Animals that prey on others generally have their eyes located in the front of their heads while animals who are preyed upon usually have their eyes located at the sides of their heads for 'all round protection'.

Ask students to research one of these animals, or another animal of their choice, to learn more about its eyes and how it sees.

View the cow's eye dissection or perform a class eye dissection during another lesson.

Lesson resources

Useful links

All you can see - The visual system, National Eye Institute. Learning object

Cow's eye dissection, Exploratorium. Step by step instructions, videos, student information

Diagram of the eye, National Eye Institute. Line drawing

Vision crossword puzzle, University of Washington. Crossword puzzle

Vision activities

Equipment required

- blank sheet of A4 paper
- ruler
- pencil or pen
- small mirror

Part A: Testing your 'near point'

Our eyes have the ability to focus on objects near and far by changing the shape of their lens. This is process is known as 'accommodation'. To focus on close objects the muscles squash the lens and make it thicker. However it is hard to focus on really close objects as the lens cannot change shape indefinitely. The closest object that can be focused on gives us our 'near point' of vision. How close is your near point?

To find the near point of your left eye:

1. Cover your right eye with your hand.
2. Hold a pencil or pen at arm's length and focus your left eye on it.
3. Slowly bring the pencil or pen closer to your eye until the tip first becomes blurred.
4. Measure the distance from your eye to the tip of the pencil.
5. Repeat the above procedure to find the near point for the right eye.

Q1.

Are your near points for each eye the same distance or is one closer than the other?

Q2.

Does a shorter or longer near point indicate better eyesight?

Part B: Two eyes are better than one.

With two eyes on the front of our heads we get two images of everything we see. Our brains then overlap these slightly different images to form a compound image that appears in 3D. This type of vision is known as 'binocular' vision, 'bi' meaning two. Not all creatures have eyes in the same position as ours. Birds for example, mainly have their eyes on the sides of their heads. Can you imagine what they'd see?

To confirm your binocular vision:

1. Make your sheet of paper into a tube of approx 3–4 cm diameter.
2. Hold your tube up to one eye and look through the tube with that eye.
3. Hold your open hand next to the tube and look at that hand with the other eye.
   It's a bit tricky but you should do this:

4. Keep both eyes open.

Q3.

Describe what you see.

Q4.

How does this happen?

Part C: Do you have a 'dominant eye'?

The vision from both of your eyes might be equal in strength or one eye might tend to dominate your vision. Some people who are right-handed have a right dominant eye and some who are left-handed have a left dominant eye. Is this true for you?

You can identify your dominant eye in the following way:

1. **Make that 3–4 cm diameter paper tube again.**
2. **Hold your paper tube out in front of you at arms length and look through it at an object across the room with both eyes open.**
3. **Close first one eye, open it and then close the other eye.**
4. **The eye that kept the object in view through the tube is your dominant eye.**

Q5.
Which is your dominant eye?

Q6.
Does your dominant eye match your 'handedness'?

Part D: Judging distances

1. **Hold both of your arms straight out to the side (parallel to the floor) with your index fingers pointed forwards.**
2. **Keeping both eyes open, bend your arms and try to make the finger tips meet at about 30 cm in front of your face.**
3. **Repeat this procedure with one eye closed.**
4. **Repeat it again with the other eye closed.**

Q7.
Can you judge distance as accurately with one eye closed?

Part E: Find your blind spot

1. **Hold this page approximately 10 cm in front of you.**
2. **Look directly at the dot with your right eye while keeping your left eye closed.**
3. **Slowly move the page closer to and away from you until the cross disappears from your vision.**
4. **Move the page across so the cross is in front of your left eye and your right eye is closed.**
5. **Slowly move the page closer to and away from you until the dot disappears from your vision.**

Q8.
Explain why each shape 'disappears' (using the structure of the inside of your eye to explain).

Q9.
When the shape disappears what do you see instead? How is this achieved?

Part F: Seeing double (and in 'stereo')

1. **Hold page 2 about 40 cm in front of you.**
2. **Line up the dot above with your nose. Focus on the dot with both eyes open.**
3. **Put your thumb about 10 cm in front of your nose. Continue to focus on the dot. What do you see?**
4. **Switch your focus to your thumb. What do you see?**

Q10.

The first time, you should see two thumbs with the dot in between. The second time you should see two dots with a thumb in between. How can you see two dots when there is only one dot on the page?

Q11.

If this activity 'worked' for you, you are a prime candidate for 3D viewing.

Go to www.vision3d.com/sghidden.html or Google '3D stereograms' and see if you can view the hidden 3D images.

Part G: Draw your own eyes

1. **Use the mirror to examine the shape and colour of your own eyes in detail.**
2. **Draw a picture of your own eyes but don't put your name on it. Pin it up in the classroom and try to work out whose eyes are shown in each diagram.**

Q12.

How are your eyes distinctive?

Q13.

Are both your eyes the same?

Light-sensitive responses

As night falls in towns and cities, just as it is becoming difficult to see, the streetlights come on. We take it for granted, without pausing to consider the quite remarkable science that achieves this. This automated light response is based on the science of photosensitive electrical semiconductors and light-dependent resistors (LDRs).

LDRs are also known as photo resistors or photocells. Resistance, which is measured in ohms, determines the amount of electrical current that can flow in a specified material when a voltage is applied to it. At a microscopic level, resistance is determined by the number of electrons that are available in a material to contribute to the electrical current.

Metals have large numbers of available electrons and are excellent electrical conductors. But in other materials, such as glass or ceramics, the electrons are tightly bound to the atoms from which the material is constructed. Few electrons are available to carry a current, which gives them high resistance to electricity. These materials are often used as insulators.

In the photosensitive semiconductors used in LDRs, exposure to light makes more electrons available to conduct electricity. Reducing light makes fewer electrons available. This fundamental change in the electrical properties of the materials allows them to be used to create light-triggered switches – ideal for applications that require turning on or off as light conditions change, such as streetlights.

It is also possible to detect an increase in light simply by measuring the change in the electrical current flowing through the material. Depending on the sensitivity of the semiconductor, this can include non-visible light such as infra-red or ultraviolet radiation.

The chemical compound cadmium sulphide responds to the same light range as the human eye, and is used in LDRs triggered by visible light – from sunlight to torches, and even the backlighting on a mobile phone. Streetlights, security lights, even garden lights are all commonly switched on and off automatically by these LDRs. They are also used in flame, smoke and burglar alarms, card readers and in camera light meters.

Smoke alarms work by providing a light within the device that shines directly onto an LDR. When there is enough smoke in the air, it blocks the flow of light, reducing the electrical conductivity of the LDR, and this triggers an alarm.

DID YOU KNOW?

- Cadmium sulphide LDRs were once used as components in heat-seeking missiles to sense for targets.
- English electrical engineer Willoughby Smith discovered the photoconductivity of selenium in 1873, which was the basis for the creation of light-dependent resistors.
- The photoconductivity of selenium also provided a way to convert the light variations that form photographic images into electrical signals, providing a theoretical basis for the development of television.

LESSON PLAN: YEAR 10

The Light Dependent Resistor (LDR)

Introduction

This lesson extends student knowledge about energy transformations. It covers the electronic device of a light dependent resistor (LDR) and how it is used in electric circuits; for example, to control when street lights, and other security light systems, turn on and off automatically.

In Part A, students investigate how the resistance of an LDR varies with light intensity.

In Part B, they will perform a virtual experiment to record data and draw a graph.

In Part C, they will build a circuit that uses an LDR to control an LED light; turning it on in the dark and off in the daylight.

Use all three parts or any desired combination that best suits your needs or the abilities of your students. If all three parts are to be implemented, several lessons may be required.

Australian Curriculum content descriptions

Science Understanding

Physical sciences

Energy conservation in a system can be explained by describing energy transfers and transformations (ACSSU190)

Science as a Human Endeavour

Nature and development of science

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE192)

Science Inquiry Skills

Processing and analysing data and information

Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS203)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204)

Communicating

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208)

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Achievement standard

This lesson sequence provides opportunities to gather information about students' understanding related to the sections in bold in the achievement statement below:

By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. They explain how chemical reactions are used to produce particular products and how different factors influence the rate of reactions. They explain the concept of energy conservation and **represent energy transfer and transformation within systems.** They apply relationships between force, mass and acceleration to predict changes in the motion of objects. Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their review.

Students develop questions and hypotheses and independently design and improve appropriate methods of investigation, including field work and laboratory experimentation. They explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of data. When analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty. Students evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views, the quality of the methodology and the evidence cited. **They construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes.**

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

Additional information for teachers

Background information

Some electric circuits are controlled by light. Probably the most common is the humble streetlight. In the past, they were turned on and off by switches. Today, light sensors detect sunset and turn the lights on and when the sun rises, the lights turn off. Control circuits are achieved by a voltage divider circuit of two resistors in series, one of which is a light dependent resistor or LDR. An LDR has a low resistance in bright light conditions and a very high resistance in dark conditions. If a lamp such as a streetlight is connected in parallel with an LDR, current will flow through the LDR in the light rather than through the lamp, and the opposite happens in the dark.

Similar circuits are used to control heating and cooling systems and utilise a temperature dependent resistor or thermistor instead of the LDR.

Some students may struggle with the mathematical side of this lesson so guidance is given below where appropriate.

Materials and equipment

- 0–12 V DC power supply
- LDR (light dependent resistor)
- LED (light emitting diode)
- possibly 10 kΩ, 22 kΩ and other resistor values up to 100 kΩ (will depend on the characteristics of your LDRs)
- connecting wires
- alligator clips
- torch
- cardboard (to be cut into circles the same size as the head of the torch and with different sized holes in the centres – can be made by the students if desired)
- masking tape
- scissors
- retort stand and clamp

- metre rule
- multimeter
- computer with internet access
- a room that can be darkened
- worksheet, Design, build and test a control circuit with an LDR

Safety advice

Be aware of the safety implications of the use of bright lights.

Teaching sequence

Lesson objective

In this lesson students:

- investigate how the resistance of an LDR varies with light intensity
- gather and plot data from a virtual experiment
- design a simple control circuit that automatically turns on an LED in the dark and turns it off again in the light

Introduction

Have the Part C LDR control circuit set up in the classroom at the start of the lesson; however do not divulge the details of the circuit to the students, as they will be tasked with the challenge of making their own circuits during that part of the lesson.

Make the room dark and show students how the LED automatically turns on. Light up the room again and demonstrate how the LED automatically turns off. (The circuit required is a power supply, fixed or variable resistor and LDR connected in series. The LED is connected in parallel across the LDR. The fixed resistor and power supply values are chosen, depending on the characteristics of the LDR, so the LED turns on in the dark and off in the light. Try this yourself first if you have prior knowledge or use this lesson plan as a guide. The values of the required resistor may need to be altered from the materials and equipment list depending on the characteristics of the LDRs you have available).

Discuss with students where they may have come across such a control circuit before in their everyday lives (streetlights or security lights). Pass out some LDRs to the students for them to examine. Explain that this device has a variable resistance depending on the light intensity that falls on it. Demonstrate how to measure the resistance of the LDR by connecting it to a multimeter on the resistance setting. Students should have some experience of multimeters from their previous science work on electric circuits.

Core

Part A: Investigate the effect of light intensity on the resistance of an LDR

In the first part of the lesson students design and conduct an investigation to determine how the resistance of an LDR varies with the intensity of the light shining on it. This part is best done in a darkened room. Students will have torches to provide illumination while they work.

1. Explain to students the basic outline but allow students to design their own way of varying the light intensity of the torch. They could change the distance of the torch from the LDR or reduce the light output of the torch by cutting different sized holes in cardboard circles that are taped over the front of the torch. This reduces the light intensity. If using this method, the distance between the torch and the LDR should be constant.

2. Students record at least 5 different resistance measurements and relate the resistance of the LDR to the light intensity striking it. (Resistance increases as light intensity reduces OR resistance decreases as light intensity increases i.e. they are inversely proportional).

Part B: Data collection via a virtual experiment

To gather and plot more precise data for resistance and light intensity, students can perform the virtual experiment Light-dependent resistor.

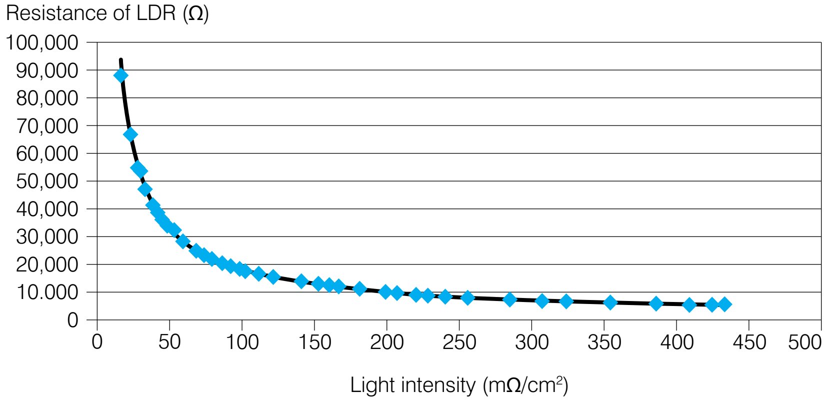
This experiment gives light intensity readings and voltage values for another resistor (red-red-orange bands = 22,000 Ω or 22 kΩ) that is in series with an LDR. The supply voltage is 10 V.

1. Students read the instructions, turn on the measuring instruments and record the data. This could be done by individual groups or as a class experiment with student input.

Teacher note: This activity is a little complicated so students may need guidance. Sample data is supplied with far more data than students would be expected to record. The resulting graph is very typical of an LDR. It is well worth trialling this data collection task yourself first to verify if it is appropriate for your students.

Since the supply voltage is 10 V the data is for the 22 kΩ resistor plus the voltage across the LDR must add up to 10. Hence a formula can be used to calculate the LDR voltage. The current can be calculated from Ohm's Law (I = V ÷ R). Hence the resistance of the LDR can also be calculated from Ohm's Law (RLDR = VLDR ÷ I). Note that for voltage in volts, resistance in kΩ (i.e. 22) the current is in milliamps. A scatter plot of R v's light intensity gives a clear inverse relationship for the LDR.

Resistance vs light intensity for an LDR



Give students as much assistance as required.

Part C: Control circuit design, building and testing

In this part, students design their own circuit using the LDR and another resistor to illuminate an LED automatically in the dark and to turn it off again in the light.

1. Distribute the worksheet Design, build and test a control circuit with an LDR to students. Again, give as much assistance as required.

Teacher note: Under strong light conditions the resistance of an LDR is usually of the order of a few kilo ohms and current will flow through it well enough. If there is a branch circuit (i.e. in parallel with the LDR), with an LED in it, the LED may be off, as the current prefers to pass through the low resistance LDR. In the dark, the resistance of the LDR is much higher, of the order of hundreds of kilo ohms and virtually no current will flow through. If there is a branch circuit with an LED in it, the current will most likely flow there and illuminate the LED. So the LDR and LED must be connected **in parallel**.

The other resistor is chosen to control the switching point and it is the ratio of this resistance, to that of the LDR that controls the circuit. The full voltage of the power supply is shared between the two so they are wired in series.

A useful video that students are directed to on the worksheet is Mr Lall – LDRs and street lights!

The correct circuit is: the power supply in series with the resistor and LDR, with the LED connected in parallel across the LDR.

Conclusion

Summarise and confirm with students what they have learned this lesson (refer to lesson objectives).

Extension questions/topics:

The topics below could be incorporated into this lesson plan if desired or they could form the basis of a future lesson or your students could research them as a project or homework)

- How does an LDR work?
- Often LDR control circuits found on the Internet involve a 'transistor' – what is this device and why is it used with the LDR circuit?

Lesson resources

Digital resources

Mr Lall – LDRs and street lights! YouTube (6:09 mins)

Useful links

Light-dependent resistor, University of Reading. Virtual experiment

Light dependent resistor, photoresistor or photocell, Radio-Electonics.com. Information for teachers and students

The Light Dependent Resistor (LDR) Sample data

Light intensity	Voltage across resistor (V)	Resistance of resistor (ohms)	Current (mA)	Voltage across LDR (V)	Resistance of LDR (ohms)
15.0	2.00	22000	0.091	8.00	88,000
21.5	2.49	22000	0.113	7.51	66,353
27.2	2.89	22000	0.131	7.11	54,125
29.4	2.91	22000	0.132	7.09	53,601
32.4	3.19	22000	0.145	6.81	46,966
38.4	3.46	22000	0.157	6.54	41,584
40.0	3.54	22000	0.161	6.46	40,147
41.4	3.61	22000	0.164	6.39	38,942
44.9	3.77	22000	0.171	6.23	36,355
48.1	3.92	22000	0.178	6.08	34,122
51.9	4.07	22000	0.185	5.93	32,054
59.3	4.36	22000	0.198	5.64	28,459
67.4	4.65	22000	0.211	5.35	25,312
72.0	4.79	22000	0.218	5.21	23,929
77.6	4.96	22000	0.225	5.04	22,355
81.2	5.06	22000	0.230	4.94	21,478
85.5	5.17	22000	0.235	4.83	20,553
93.2	5.37	22000	0.244	4.63	18,968
100.3	5.54	22000	0.252	4.46	17,711
110.0	5.74	22000	0.261	4.26	16,328
120.0	5.95	22000	0.270	4.05	14,975
139.7	6.25	22000	0.284	3.75	13,200
151.9	6.43	22000	0.292	3.57	12,215
160.0	6.59	22000	0.300	3.41	11,384
165.8	6.68	22000	0.304	3.32	10,934
179.9	6.76	22000	0.307	3.24	10,544
198.3	6.96	22000	0.316	3.04	9,609
206.3	7.03	22000	0.320	2.97	9,294
219	7.14	22000	0.325	2.86	8,812
227	7.28	22000	0.331	2.72	8,220
240	7.30	22000	0.332	2.70	8,137
255	7.41	22000	0.337	2.59	7,690
284	7.59	22000	0.345	2.41	6,986
306	7.71	22000	0.350	2.29	6,534
323	7.79	22000	0.354	2.21	6,241
354	7.93	22000	0.360	2.07	5,743
386	8.05	22000	0.366	1.95	5,329
408	8.12	22000	0.369	1.88	5,094
425	8.18	22000	0.372	1.82	4,895
433	8.20	22000	0.373	1.80	4,829

Design, build and test a control circuit with an LDR

Your task:

Design, build and test your own circuit using the LDR and another resistor to illuminate an LED automatically in the dark and to turn it off again in the light of a torch.

Equipment you will need:

- **LDR**
- **LED**
- **another resistor (value to be determined by you)**
- **DC power supply**
- **connecting wires with alligator clips**

Hints

Under strong light conditions the resistance of an LDR is usually in the order of a few kilo ohms and current will flow through it well enough. If there is a branch circuit (i.e. in parallel with the LDR), with an LED in it, the LED may be off, as the current prefers to pass through the low resistance LDR.

In the dark, the resistance of the LDR is much higher; in the order of hundreds or kilo ohms and virtually no current will flow through.

If there is a branch circuit with an LED in it, the current will most likely flow there and illuminate the LED. So the LDR and LED must be connected in ______________. (check this answer with your teacher)

The other resistor is chosen to control the switching point and it is the ratio of this resistance to that of the LDR that controls the circuit. The full voltage of the power supply is shared between the two so they are wired in series.

A useful YouTube video that explains this is '<u>Mr Lall - LDRs and street lights!</u>'

The LED illuminates when more than 0.7 V is across it (depending on colour). The positive leg (the long one) and the negative leg of the LED should be connected correctly. Answer the following questions:

1. **What is the resistance of your LDR in bright light?**

   ____

2. **What is the resistance of your LDR in the dark or when covered by your finger?** __________________

   ____

Choose another resistor value between the two amounts above.

First choice: ______________________________________ **(this can be changed later if need be)**

Decide what DC voltage setting to use on the power supply,

start small ______________________________________ **(this can be changed later if need be)**

Design your circuit in the space below.
Draw a circuit diagram first and get it checked by your teacher.

Construct the circuit and cover the LDR with your finger to see if the LED comes on.
When you release your finger the LED should automatically turn off.
Demonstrate your circuit to your teacher.

Discussion:

1. **Explain why the LED turns on in the dark and turns off when light shines on the LDR.**

2. **Where could this circuit be used in practice?**

Making waves: the science of light
A resource book of ideas for National Science Week 2015

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