Exploring TIME

A Resource Book of Activities & Information for National Science Week 1999

AUSTRALIAN
SCIENCE
TEACHERS
ASSOCIATION

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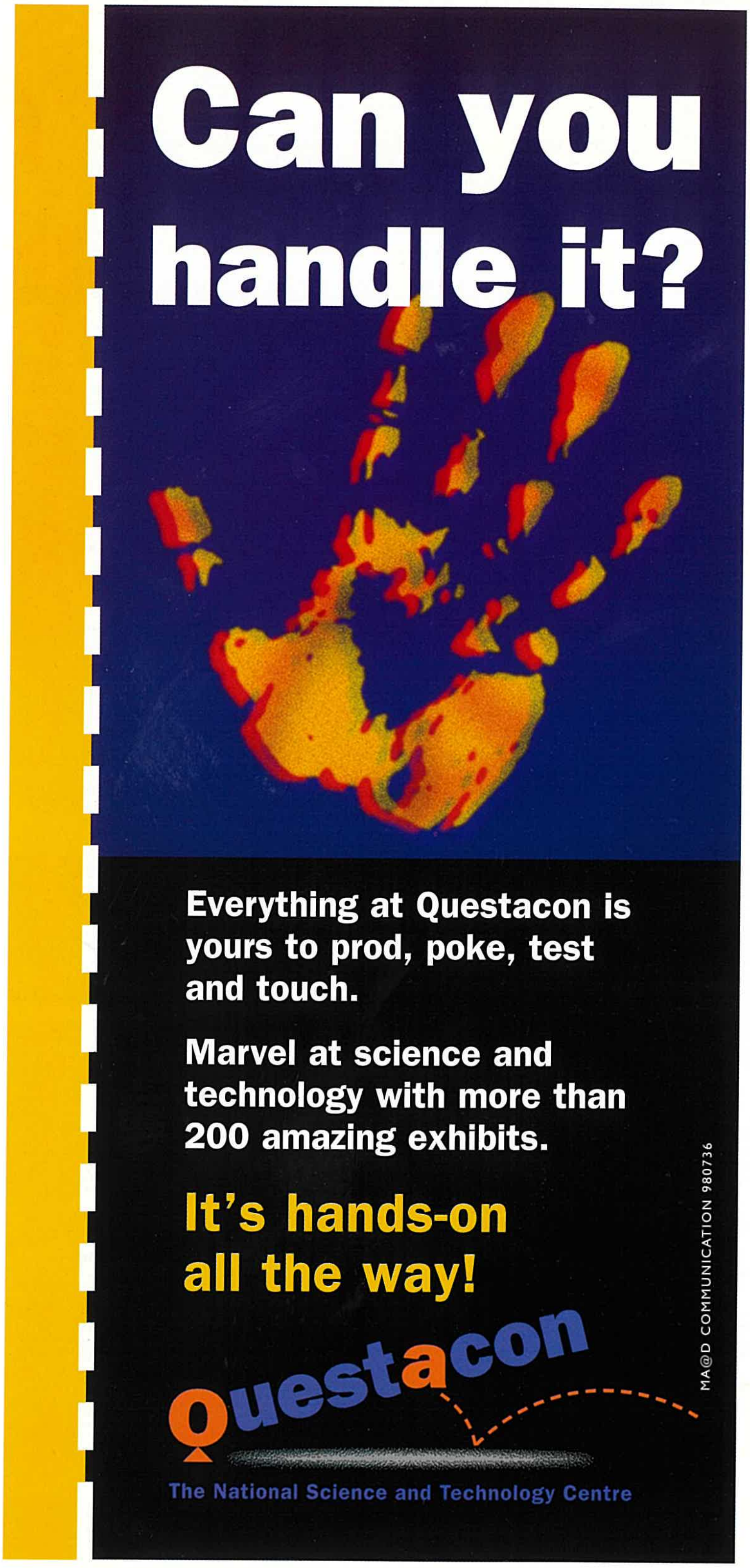
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INDUSTRY SCIENCE RESOURCES

Exploring time

A resource book for National Science Week 1999

Exploring time is a resource book of activities and information published by the Australian Science Teachers Association (ASTA). It is designed for teachers and students and provides many exciting activities for use at school and at home. The book can be used during National Science Week and throughout the year.

National Science Week is a partnership between ASTA, the ABC and the Australian Science Festival. It builds on *Science in Schools Week*, an initiative of ASTA which was first held in 1984 and has been held every year since. It aims to focus community attention on science and its importance in the school curriculum and to promote the image of science. National Science Week involves students at all levels of schooling, parents, scientists and other members of the community in a broad range of science-related activities which show that science is enjoyable.

During National Science Week, ASTA hopes that teachers will be able to organise a celebration of science and that this book will provide useful ideas for the theme *Exploring time*.

As well as providing this resource book, ASTA has a National Science Week Coordinator in each State and Territory who organises activities and events during National Science Week. If you would like to know what is going on in schools in your State, contact the ASTA Coordinator listed in the pull-out Resource List in the centre of this book.

If you would like more information about community activities planned for your State/Territory please contact your local National Science Week Coordinating Committee. The contact details of the Chair of that Committee are also listed in the Resource List.

National Science Week is one of many programs which ASTA organises to enrich school science education for students and teachers in primary and secondary schools. If you would like to find out more about these and other programs, please contact ASTA or your State/Territory Science Teachers' Association. A free copy of this resource book is one of the many benefits of membership.

On behalf of ASTA I would like to thank and congratulate the authors and designers of this book *Exploring time*, the National Science Week Coordinators in each State and Territory of Australia and all the teachers who become involved with National Science Week activities.

I do hope you find this resource book useful, interesting and enjoyable. Please write to me or ring me to let me know your views and opinions about the resource book or National Science Week in general.

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Introduction

From an early age we learn to tell the time, to interpret digital and analogue clocks and to read a watch. As we grow we develop a sense of time. We can learn and choose to use our time wisely, we can waste time, we can wonder about what we could achieve if we had time. Life consists of a series of decisions about how we will use our time on a day to day basis.

But what is time? It is a fascinating question, which can lead to animated group discussions. It can also lead to many other fascinating and stimulating questions. How do we define time? Do philosophers and scientists define time in the same way? Is time a figment of our imagination? Does the past and the future exist? How can time be measured? How accurately can time be measured? When is a clock not a clock? Where does the word clock come from? Where does the word watch come from? Can we measure time using only candles? What is a day? What is a second? Is there such a thing as a biological clock? Is time relative or absolute? How do we measure geological time? We hope this book will enthuse students to discuss and to search for answers to these questions and many others.

The investigations indicated in this book are starting points. Many of these are designed to raise further questions and to lead students into designing and carrying out further investigations of their own.

Safety Warning!

All student activities included in *Exploring Time* have been designed to minimise hazards. However, there is no guarantee expressed or implied that an activity or procedure will cause no injury. Teachers selecting an activity should test it with their own materials before using it in class and consider the Occupational Health & Safety requirements within their state or territory.

Any necessary safety precautions should be clearly outlined by the teacher before starting the activity. Students must also be provided with all safety equipment prior to commencement.

CHAPTER 1–DEFINING TIME

Teachers' Notes

Few words are as easy to use and as difficult to define as the word 'time'. We can measure time, we can use time, we can waste time, BUT, can we define time? In everyday language we use the word often in such well known phrases as

- it's time;
- all in good time;
- time and time again;
- it's time you did your homework;
- is this a bad time?;
- you timed it well;
- in the fullness of time, etc.

We use and give meaning to the above expressions, but when we try to explain what time is, most of us have great difficulty.

Many scientists, philosophers and writers throughout history have given us their definitions. Many believe time is a continuum, a progression, or succession in which change can occur. Without time, no change can occur, nothing can happen. Others think of time as a cycle with life and with the universe repeatedly cycling through different stages.

A group of year 10 students at Telopea Park School derived the following definition from a class discussion. 'Time is a dimension, which involves a succession of changes and events. Change can only occur as a result of the passage of time.' One scientific definition of time is 'Time is a period during which an action or event occurs; also a dimension representing a succession of such actions or events. Time is one of the fundamental quantities of the physical world, being similar to length and mass in that respect.' *Australian Infopedia 1995, Future Vision Multimedia Inc.*

Human perception allows us to divide time into the past, the present and the future. The present is continually changing and becoming the past as the future continues to supply us with the present.

Some interesting questions to ponder are

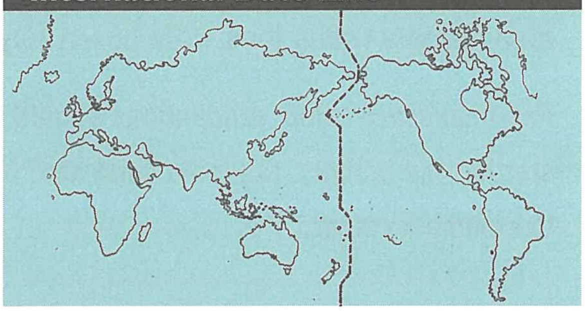
- If there were no humans, would there be a past, present and a future?
- Was there a beginning to time?
- Will there be an end of time?
- Is there a better way to measure time than in hours, minutes and seconds?

Sir Isaac Newton (1642–1727) believed in absolute time. He believed there was a fixed quantity of it, which was used up at a constant rate. Albert Einstein said that this was not so. He said time and space were interrelated and that time could be stretched or dilated by movement through space.

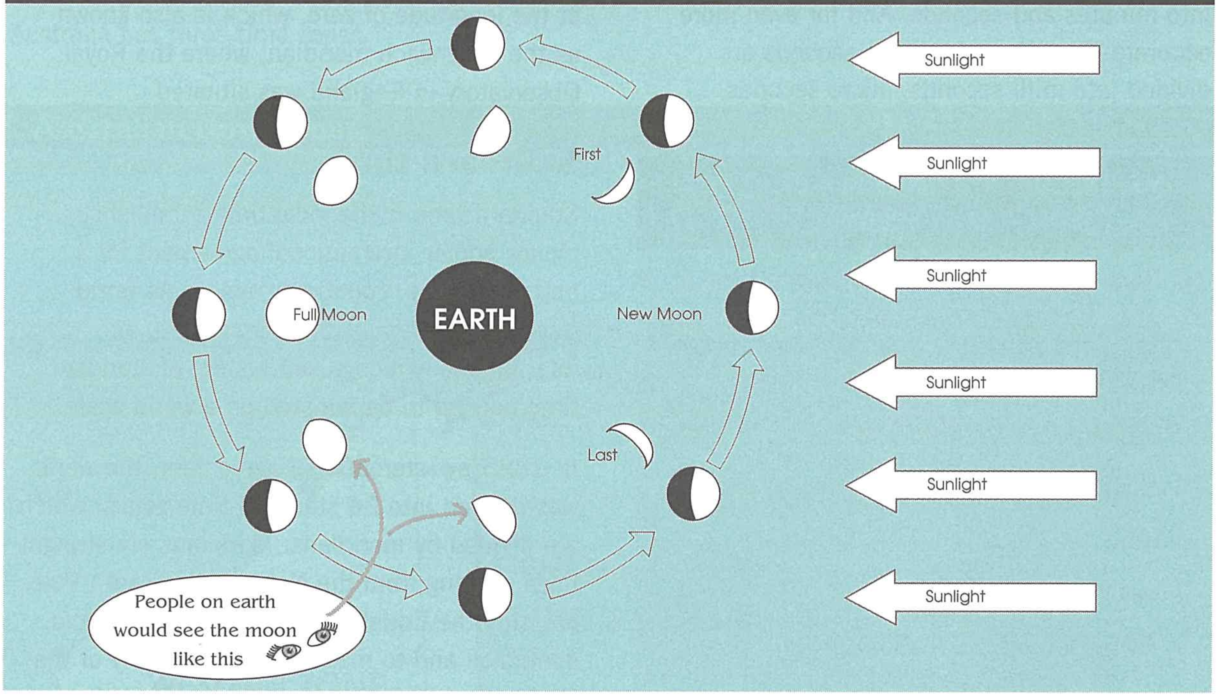
Time can be measured. Early humans measured time by the passing days, the passing of the seasons, the phases and movement of the Moon and the position and movement of the stars. During the day, time was measured by the position of the Sun and the length and direction of shadows.

A day begins at midnight on the International Date Line. The International date line follows

International Date Line



Phases of the Moon



the meridian at 180° longitude, except for where it diverts around an area or country, so that the times in that country will be the same. It passes through the Pacific Ocean not far from New Zealand.

Most calendar years are 365 days, with every fourth year, known as a leap year, having 366 days. The extra day is placed in the calendar on February 29. The extra day every four years is necessary because a solar year—the time it takes the Earth to revolve around the Sun is 365.25 days. Therefore our calendar needs to make an adjustment every four years. As well as leap years, leap seconds are added to our clocks so that our time keeps pace with the movement of the Earth around the Sun.

The year is divided into calendar months. The word 'month' is derived from Moon. They are not equal, precise or based on natural events. Lunar months, on the other hand, are based on the phases of the Moon. A lunar month is the time between two consecutive new Moons. A new Moon occurs when the Moon is between the Earth and the Sun and all that is seen is a faint ring. A full Moon appears as a bright illuminated circle in the sky. This is seen when the whole area of the Moon's surface facing the Earth is illuminated by the Sun. It occurs halfway between two consecutive new Moons. A lunar month is 29 days, 12 hours, 44 minutes and 2.8 seconds.

The names of the calendar months are derived from the ancient Roman calendar in which the year started in March. July was named after Julius Caesar and August after Emperor Augustus, September (seventh), October (eighth), November (ninth) and December (tenth) refer to the order of months in the Roman calendar.

The day is divided into two equal portions, each of which is then divided into 12 hours. To avoid unnecessary confusion, one period of 12 hours is called AM (ante meridian—before the Sun is directly overhead) and one is called PM (post meridian—after the Sun is directly overhead). A meridian is an imaginary straight line, which passes from one pole to the other through a reference point. When the Sun is directly over the meridian it is said to be noon at that location.

Teachers' Notes

For more accurate timing, hours are divided into minutes and seconds. And for even more accurate time measurements, seconds are divided into milli seconds, micro seconds, and nano seconds.

TIME UNIT	NUMBER OF SECONDS
1 Nano second	0.000 000 001
1 Micro second	0.000 001
1 Milli second	0.001
1 Second	1
1 Minute	60
1 Hour	3 600
1 Day	86 400
1 (365 day) Year	31 536 000

Some time measuring systems

Solar time

Solar time is time based on the movement of the Earth in relation to the Sun. At any point on the Earth's surface, when the Sun is at its highest point, then it is midday at that particular place. A solar day is the time between two successive occasions when the Sun is at its highest point. However, this time period or 'day' can vary in length making time measurement difficult and inaccurate. As a result, solar time became based on the average position of the Sun, which gives the solar day a constant length. Solar time based on this hypothetical position of the Sun was called mean solar time and could be accurately measured by clocks and watches.

Greenwich Mean Time (GMT)
=
Universal time (UT1)
=
Mean solar time at the zero meridian

These terms all apply to the mean solar time at the longitude of zero, which is also known as the Greenwich meridian, where the Royal Observatory in England was situated.

Standard time

Standard time is the local time established by law and/or international agreement for a particular zone, country or region. As world travel and communication increased, an internationally recognised system of standard time needed to be adopted on a world scale.

In 1883 by international agreement, the world was divided into 24 standard time zones, which are divided by meridians. Meridians are straight lines running from the North to the South Pole, crossing the Equator at right angles. To avoid confusion and to make life easier, many of the time zones don't exactly follow the meridian lines but have been bent around countries, states or cities.

The standard of time

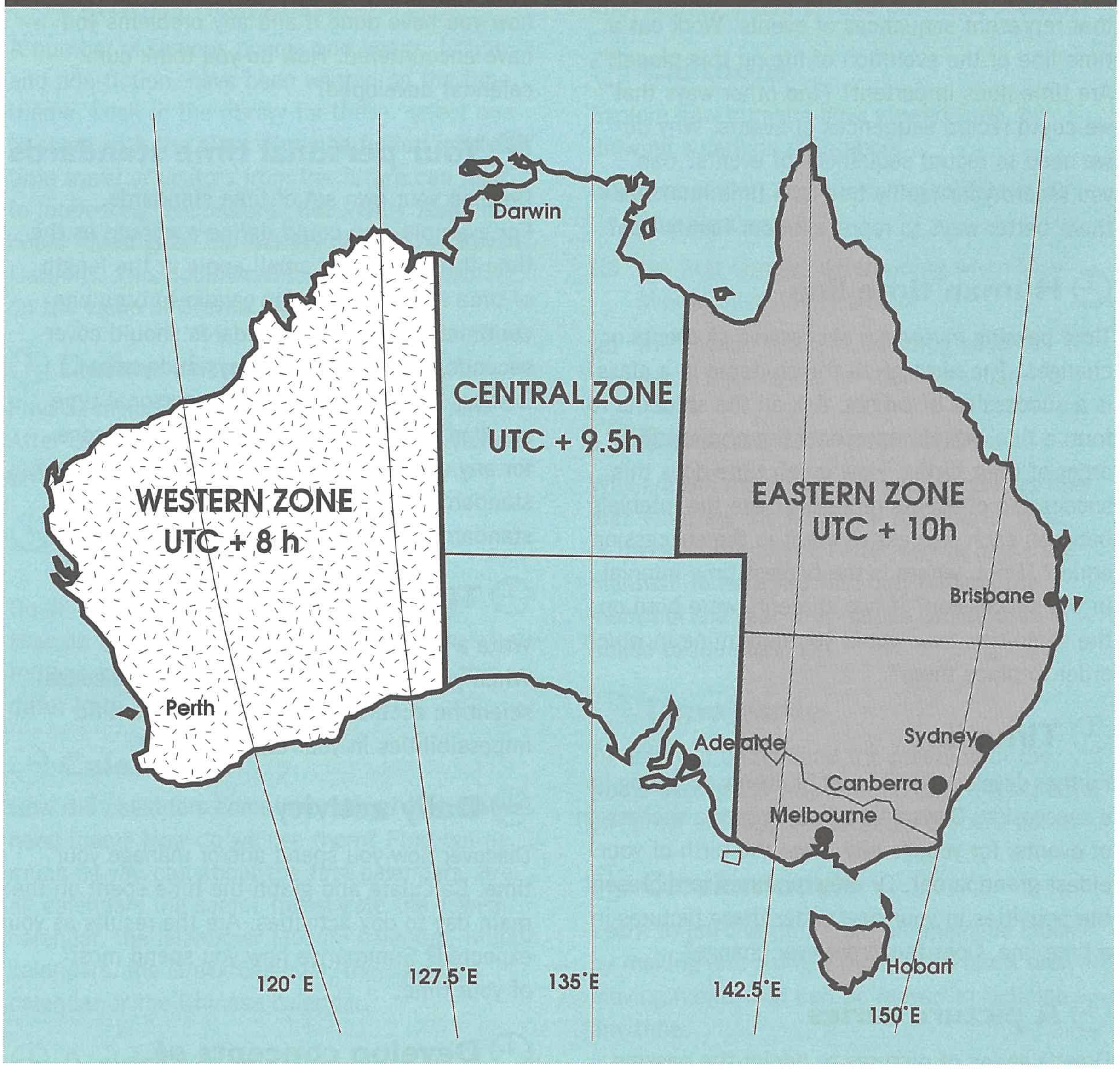
How do we know that the seconds other countries measure with their clocks and their watches are the same as the seconds that we measure in Australia? Like all basic measurements there has to be an internationally agreed standard. The standard for the second, until 1995, was 1/86 400 of the mean solar day. In 1955 time was defined by the International Astronomy Union as '1/31 556 925.9747 of the solar year 1899'. Advances in scientific measurement, particularly the advent of the atomic clock, made a more accurate definition possible. In 1967 the International System of Units defined the second as the 'duration of 9 192 631 770 periods of radiation, corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.' This definition is now being challenged with other more accurate standards being proposed, e.g. the period of rotation of a particular pulsar.

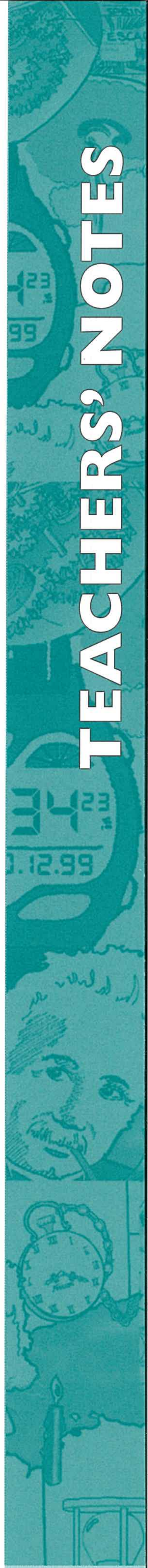
Teachers' Notes

Time zones

Australia has three time zones.

Australian time zones





Student Activities

A time line

Work out a time line of the things you do in an average day. This will help develop the concept of a sequence of events. Make up other time lines that represent sequences of events. Work out a time line of the evolution of life on this planet. Are time lines important? Find other ways that we could record sequences of events. Why do we need to record sequences of events? Can you record your family tree as a time line? Are there better ways to represent your family tree?

Human time line

Time passing involves a succession of events or changes. The birth of all the students in a class is a succession of events. Ask all the students to form a line, which represents the chronological order of their births. How much time does this succession of events represent? Are the intervals between each successive event in the succession equal? If not, where is the biggest time interval in the succession? If two students were born on the same day, how would you determine in which order to place them?

Time line

Further develop the concept of events occurring in a succession. Draw a time line, or give a succession of events, for your family since the birth of your eldest grandparent. Or draw pictures to represent the activities in your day. Order these pictures in a time line. Does this order ever change?

A picture series

Draw a series of pictures to depict the passing of time. Cut them into individual pictures. Have a friend place them in the correct sequence. Use a series of pictures from a magazine, which represent events over a period of time and place them in a correct time sequence. Place newspapers or magazines in a time sequence.

A lunar calendar

Months on our calendar vary in length or the number of days that make them up. A lunar month is the time it takes for the Moon to rotate about the Earth. Would it be more sensible to base a calendar on lunar months? Investigate this question. By drawing up a one-year calendar (365 days) based on lunar months. Explain how you have done it and any problems you have encountered. How do you think our calendar developed?

Your personal time standards

Develop your own set of time standards. For example, you could define a minute as the time it took to eat a small apple or the length of time it took a birthday candle to burn one centimetre. Your time standards should cover seconds, minutes, hours, days and years. Discuss the usefulness of your personal time standards to you. Do they serve any purpose for any one else? Discuss the accuracy of your standards and the need for an agreed set of standards. How do time standards help us?

Time travel

Write a short story involving time travel. When you have completed your story, discuss scientific accuracy and apparent scientific impossibilities in your story.

Daily activity

Discover how you spend and/or manage your time. Calculate and graph the time spent on the main day to day activities. Are the results as you expected? Summarise how you spend most of your time.

Develop concepts of time units

Discuss how much can be done in a day. How much can be done in an hour, how much can be done in a minute.

Common expressions

Time is a word that is used continually. Does it always mean the same thing? To investigate this question make a list of common expressions involving the word 'time'.

Student Activities

Beside each write the meaning of the expression. Illustrate your favourite expression or draw a cartoon where the humour involves the concept of time.

Famous literature

A number of famous poems and books, fiction and non-fiction, have been written on the time theme. Look in the library for these, select one to share with the class. Science fiction involving time travel or visitors from the future can lead to interesting discussions. Secondary students could investigate *The History of Time* by Steven Hawkins. This could lead to a class discussion on the views of Steven Hawkins.

Define time

Find as many definitions of time as you can. After considering these, write a single sentence giving your own definition of time.

Time as seen by different cultures

Do all cultures view time in the same way? How do Indigenous Australians, American Indians and the Chinese view time? Does this differ from a European view of time?

Calendars

How did calendars come into being? Why do we need them? How do we use them? Find out as much as you can about the first calendars. Are all calendars the same? Investigate the Jewish calendar, the Islamic or Muslim calendar, Indian calendars, the Greek calendar, the Egyptian calendar or the Chinese calendar.

A riddle

Find out why it is that if all the clocks on Earth stopped, many ships, planes and satellites would not know where they were.

How do you know if your clock or watch is correct?

How does a radio station know that the times it broadcasts are correct? Where in Australia is the official Australian time kept? How often is it corrected?

Correctly using time units

Make up sentences or write out sentences using words, which represent the units of time including, year, day, hour, minute, second, milli second, micro second and nano second.

Cartoons

Explore how humans have viewed time, by drawing a cartoon strip about

(a) neanderthal humans trying to determine how old they are;

(b) the first farmers determining when they should plant their corn; or

(c) the ancient Romans deciding what to name the months on their calendar.

Rename the months

Why are the months of the year named as they are? What are the historical reasons for this? Is there a different or better way to name the months? To help you find out, rename the month of the year with names, which are linked to the seasons.

Time game

To help you understand the meaning of the words associated with time, create a word bank on 'time' and use it to develop a board game.

Clock models

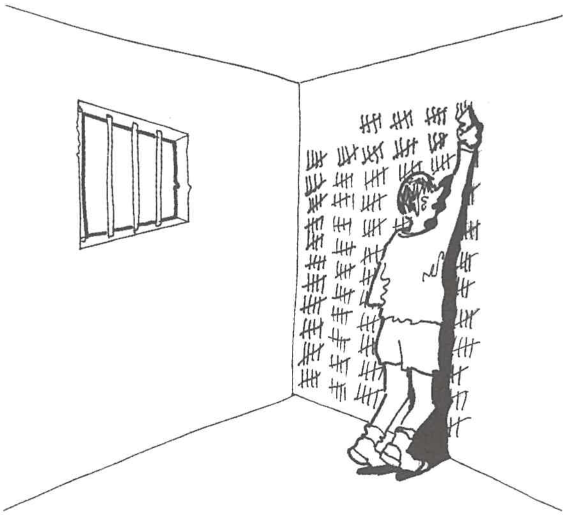
Learn to tell the time from an analogue clock by making and using a model of a clock with moving hands that can be moved to indicate any time.

Telling the time

Younger students can learn to tell the time from digital and analogue clocks.

CHAPTER 2–MEASURING TIME

Teachers' Notes



In times past, prisoners have been known to count days by scratching marks into the walls of their cell.

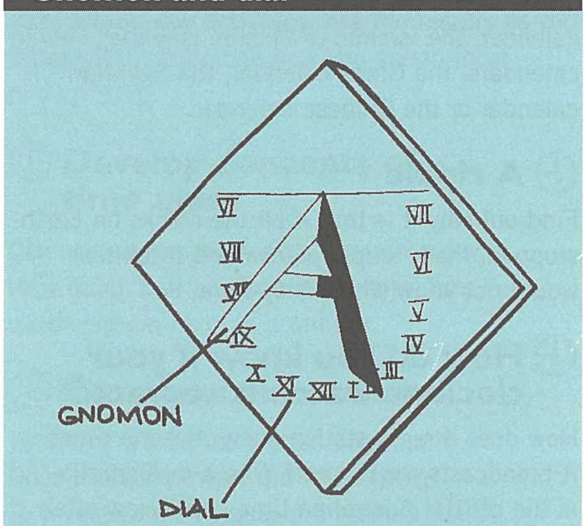
Before clocks, time could be measured by the seasons, the position of the Sun, Moon and stars, or by the phases of the Moon. Early agriculturists planted their crops by the phases of the Moon. The years were counted by the seasons and the months by the full Moons. If you had lived thirty summers it meant that you were thirty years old.

A year is approximately the time that it takes for the Earth to orbit the Sun. Hours, minutes and seconds are artificial divisions of the day. They do not relate to major Earth events. Water clocks, candle clocks, sundials and sand clocks were all early methods used by humans to measure the duration of time.

The position of shadows can be used to indicate time. sundials are devices used for measuring time when the Sun is shining. A sundial has two main components, a face or dial that has markings on it from which the time can be read and a gnomon.

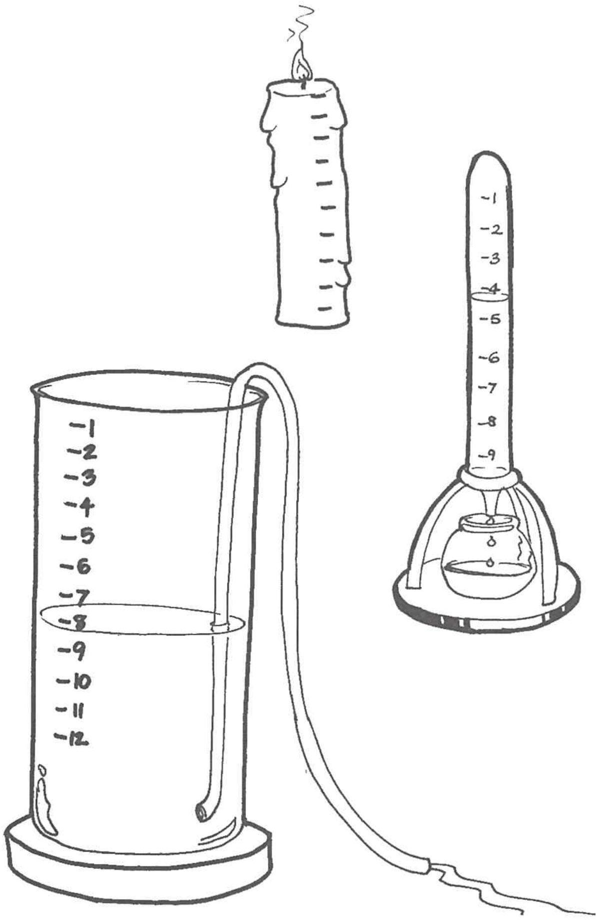
The gnomon (pronounced with a silent g) is the upright piece that casts a shadow. The gnomon is often a flat pie shaped piece of metal attached at right angles to the dial. The gnomon is set in the Northern Hemisphere to point due north and in the Southern Hemisphere to point due south. sundials often give different readings to our watches. This is because the world is now divided into arbitrary time zones to which we all set our watches. A sundial depends solely on the position of the Sun and the longitude, so can give a different time to a clock within any time zone. Time zones were devised for our convenience so that all people in a particular time zone would be referring to the same time. sundials give different readings with any change

Gnomon and dial



Teachers' Notes

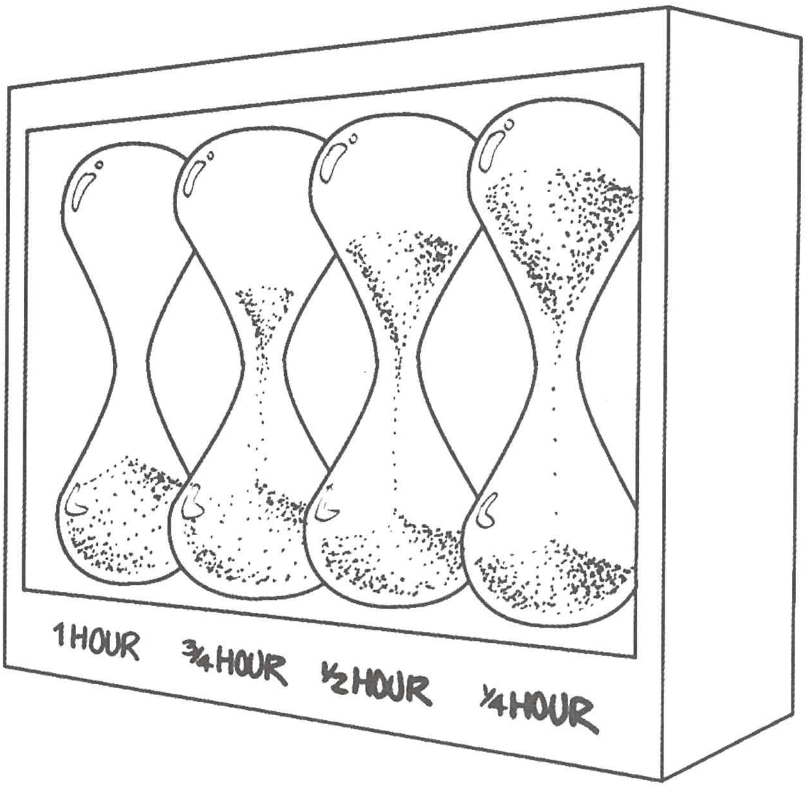
in longitude. The big disadvantages of a sundial are that they do not work at night and are not portable.



Water clocks rely on water draining from a container at a predictable rate. A scale can be drawn on the water reservoir, to indicate how long the water had been dripping or draining. Unlike a sundial, a water clock could be used in cloudy weather and at night. The rate at which the water leaves the cylindrical reservoir will vary depending on the depth of water remaining. This can be compensated for, by using a reservoir with sloping sides. Ancient civilisations including the Romans had sophisticated water clocks, which were used to time speeches and events.

Candle clocks were very crude time measuring devices based on the fact that the longer a candle burned, the shorter it became. A scale was drawn down the length of the candle. It was not accurate as burning rates varied with wax and wick quality and with the amount of air movement.

Sand clocks are also called sandglasses and include hourglasses and egg timers. They consist of two glass reservoirs joined by a narrow neck through which fine sand can pass from one to the other. The time taken for the sand to move from one reservoir to the other is always approximately the same. If it takes one hour for the sand to move from the top to the bottom it is called an hourglass. Sand clocks were generally more accurate than candle clocks and most water clocks.



Student Activities

Estimating time

Do we need a clock or watch to tell the time? Can we use other cues or our senses? How accurately can we estimate time without a clock or watch? Investigate these questions by using your senses, your body and your observation skills (but definitely no watches, clocks or radios) on ten separate occasions over a two day period, to estimate the time. List the factors used to estimate the time, and calculate the accuracy of your estimates. You could fill in a table like the one following.

TIME	FACTORS USED TO ESTIMATE TIME	CALCULATED ERROR

How can this method of estimating time be useful? What are its limitations? Could you learn to estimate the time more accurately using your senses? How would this be helpful?

How do we spend our time?

Carry out a survey to find out how much time members of your class spend doing different activities, e.g. eating, sleeping, and watching television. You could fill out a table like the following.

ACTIVITY	ESTIMATED HOURS PER DAY	ESTIMATED HOURS PER WEEK
Eating		
Sleeping		
Reading		

Graph your results, collate class results and discuss. Publish selected results in a school newspaper. Pick an aspect of your investigation to create an interesting headline e.g. 'The class that eats for eight hours a week.'

Reaction time

Do you have a reaction time? Does reaction time vary from individual to individual? Using a stopwatch, measure your own personal reaction time. Measure the reaction time of a partner and compare it to your own. One way to do this is to start and stop a stopwatch as quickly as you can. Can you reduce the time interval between starting and stopping the stopwatch by practising?

What are some of the possible consequences of this reaction time? What effect would the reaction time of a driver have on the stopping distance of a car travelling at 100 kilometres per hour when the brakes were applied? What effect could this have in an accident situation?

Measuring a minute

Can you use your body to measure a minute? Place a heavy object in your hand and hold it directly out from your body for one minute and then put it down. Have a friend time the activity for you. Repeat this procedure three times in all.

Student Activities

Then without any help from your friend, hold the weight out again and tell your partner when you think one minute has passed. Calculate your error. Repeat the exercise while listening to your favourite music. Again calculate the error involved. Repeat the exercise again while someone is talking to you about the most boring thing imaginable. Again calculate the error. Interpret any differences in your results. What does this tell you about human perception and endurance? Find other ways that you can use your body to measure time. Are there any ways that can help you measure time on a day to day basis? Does your level of tiredness ever help you to estimate time?

Can you tell how long a minute is?

Sand and water timers

How did early civilisations measure equal periods of time? To help you investigate this, explore simple sand and water timers. Fill a funnel with sand or water and time how long it takes the sand or water to flow through it. Repeat this a number of times to see how accurate your timer is. Experiment with different types of sand and different shaped funnels. Design a timer using the most 'accurate' sand and funnel combination. Use your timers to measure time allocated for a particular activity in the classroom. You could allocate your teacher the time it takes for the water or sand to run through, to explain something or give a set of directions. What other ways could you use your timers in the classroom? Use them over a period of a week to time as many activities as you can.

Time standards

Discuss the different units of time used in everyday language. Make a list and discuss what each term means. Your list could include things like the weekend, and the Christmas holidays. Write them on cards and arrange them in order. What is your favourite period of time? Attempt to translate this into weeks, days, hours, minutes and seconds. Why do we use expressions like weekend to describe a period of time?

Biological timing

Can we use biological functions and rhythms to measure time? To help you answer the question, count how many breaths you take per minute while resting and how many times your heart beats while resting. Now use each of these in turn to estimate when one minute has passed. Older students could measure their resting heart rate, their heart rate after sport and the time it takes after exercise for their heart rate to return to normal. This information could be used to monitor personal fitness. The shorter the time it takes for the pulse rate to return to normal after exercise, the fitter the person is. Can you think of any ways that biological timing could be useful? How could you use it to measure the time that it takes you to move from one place in the school to another place in the school? Move between the same two places several times using the number of breaths taken to measure the time. What factors could affect the accuracy of these time measurements? Think of other ways that you could biologically time similar activities.

Student Activities

Design, calibrate and evaluate a candle clock

Can you measure equal time intervals using only a candle? Using a range of candles, construct different clocks, which record minutes and hours. Draw a scale onto each of these clocks and determine their accuracy. What uses could you make of your candle clock? Use candle clocks to measure the length of a science lesson. Repeat this several times and measure your accuracy. Redesign your candle clock to improve accuracy.

Extension: *Design a candle clock with rotating hands, powered by the heat of the candle.*

Making a stop watch

Can you make a stopwatch? Students who wish to accept the challenge, should design, construct, evaluate and redesign a stopwatch to record as accurately as possible how long it takes to run around the playground.

The following challenges involve students producing and refining different kinds of clocks. These clocks could be used to time lessons, or the length of breaks or could be used in time dependent experiments.

Dripping water clock

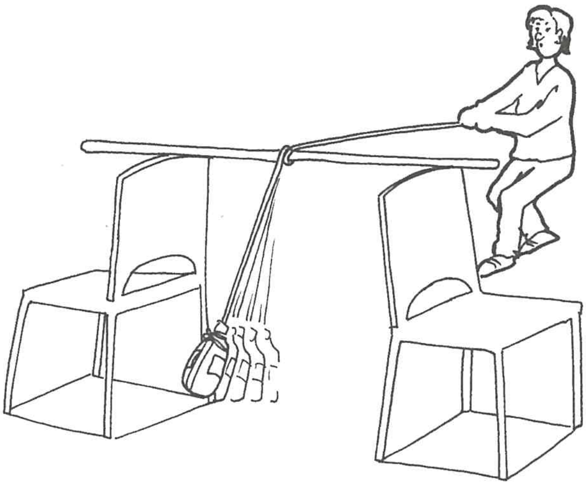
Can you measure equal periods of time using the drip rate of water from one container to another? To help you answer this question, design, construct, evaluate and redesign a dripping water clock. Using a variety of containers of different sizes and volumes, design and construct a clock where water drips through a hole at a particular rate. Determine how much water drips through the hole per minute. Calibrate your timer, test its accuracy, and redesign it to give greater accuracy. Use water clocks to measure the length of a science lesson. Repeat this several times and measure your accuracy. Redesign your water clock to improve accuracy.

Design and make a similar timer using draining water rather than dripping water.

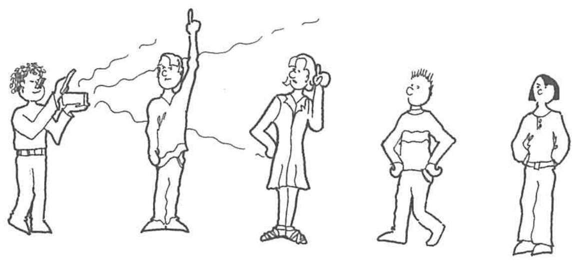
Pendulum timers

How could you use the constant swing of a pendulum to measure seconds? Design, construct, evaluate and redesign a pendulum timer. The following ideas may help to get you started. Tie a heavy weight to the end of a rope or chord. Support the rope or chord from a fixed support and swing the weight to produce a pendulum. Using a stopwatch, find the time it takes for the weight to swing from side to side. By adjusting the length of the rope or chord, make a pendulum where the swing from side to side takes exactly one second. As your pendulum swings it will then measure seconds. How accurate are your 'seconds'? List the uses of a 'second' pendulum. Again use the stopwatch, to time sixty swings. Discuss your error. Adjust your pendulum to increase your accuracy. How close to one minute can you get with sixty swings?

Compare light and heavy weights with the 'one second' length of string. Does it make a difference? Compare swing times with different amplitudes.



Extension: *Add cardboard cogs to your pendulum to make a clock with hands that count out the seconds. Add a mechanism that automatically swings the pendulum for you.*



Design, construct, evaluate and redesign a smelly timer

Find something very, very smelly and place it in an airtight container. Make sure that your very smelly item is safe to smell. Line up students in your class one metre apart. Stand one metre from the first person in the line and open the container. Ask students to put their hand up when they can smell the odour. Do the hands going up measure equal intervals of time? Can you improve on this smelly timer? What are the big disadvantages of this timing device? Try a different smell and see if it travels at the same speed. Can you think of any application for this timer? What factors would cause inaccuracies? How could you improve accuracy?

Make a sundial

Find out how to make a sundial. Create a list of instructions on how to make a sundial, highlight the most important features. Make your sundial.

Egyptians and Romans

Is there only one way of measuring time? How did the ancient Egyptians and Romans measure time?

Time and early humans

Why did hunters and gatherers need to understand time? Find out how knowledge of the approximate time helped the early humans.

Planting by the Moon

Early farmers often planted their crops by the phases of the Moon. Was there a reason for this? Was it a system that worked? Find out as much information as you can about planting by the Moon. Would you try planting by the Moon if you were growing your own vegetables? Discuss your answer.

Telling the time at night

How did early humans tell the time at night? For what reasons might they have wanted to know the time at night? List reasons why it is still useful to tell the time at night.

Student Activities

Ancient and modern sundials

For centuries, sundials were a reliable tool for telling the time. Find out if there are any famous sundials still in existence today. Why are sundials still in existence today? Why do you think some people still like to have a sundial in their garden?

Reading shadows

Place a stake in the school area in full sunlight and draw the line of shade at various times during the day. When a shadow line is drawn the time could be recorded. When are the shadows longest? When are the shadows shortest? Why do they go in different directions at different times of the day? Use your stake over a period of a week to determine the time. At the beginning of the week, mark the shadow position that indicates the beginning and end of the school day and lunchtime. How accurate is your shadow reading? Is there any variation in the shadow positions over a week? Monitor variation in shadow positions over a period of two months.

Build a sundial

Build a very ornate sundial and landscape it into the school environment. How accurate is your sundial? Can you use it to measure accurate time in your time zone? Explain your answer. Could you adjust it for daylight saving? What would be the best solution for the daylight saving problem?

Who came first?

Design a timing device that can accurately record finishing positions in a race on sports day. How will you record the finishing time? List other tasks that you could use it for. Redesign your stopwatch to increase accuracy.

Comparing sundials

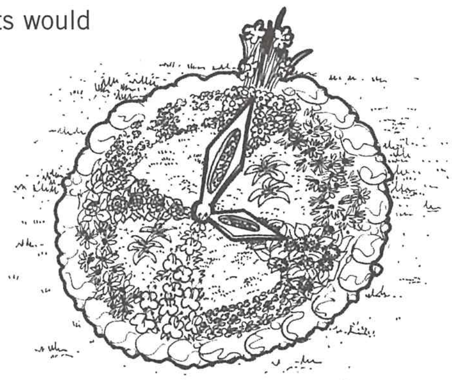
Are all sundials the same? How do they vary? Do they give the same time as your watch? Why is this so? Design and make, or collect a series of sundials. Determine their accuracy, determine any correcting factors that may be necessary and explain why these are needed.

Using a flagpole

Use a flagpole or corner of a building that casts a long shadow to make a sundial that can accurately measure time. Use your flagpole to predict the beginning of recess and lunchtime.

A floral clock

Design and draw a calendar clock with plants that open at different times of the year. What plants would you use? Try to include plants that flower in every month of the year. When do each of the plants flower? Plant your calendar clock.



What would you put in a time capsule?

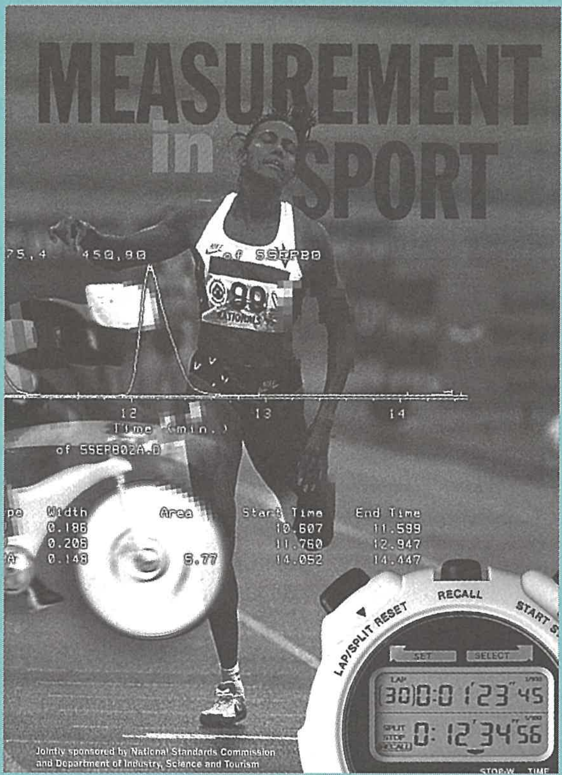
Put together a 'time capsule' for your class that records different aspects of the character of the class. List all the items that will go into the capsule and the reason for putting them in. Discuss why people create time capsules. Choose a date for opening the capsule.

Create designs with a pendulum

Can you do this? Design a pendulum with a container on the end of a rope. If sand, salt or paint can slowly drain from the container while the pendulum is swinging, interesting patterns can be made by moving a sheet of paper below the pendulum. Explore the variables that alter the patterns. What effect do string length, height from the paper or the material in the container have on the pattern produced.

MEASUREMENT IN SPORT

BRINGS SCIENCE ALIVE!



Here is a resource that students love to use!

This bright and attractive resource presents up-to-date relevant scientific material by posing problems requiring practical solutions. Learning is centred around students doing activities that are linked to their lives. Sport is used as a highly motivational context to provide students with an exciting and memorable learning experience in science.

Students enjoy the challenge of thinking more deeply about science and arriving at their own solutions.

Measurement in Sport contains a section called Perfect Timing, which shows how the accuracy of timing devices, false starts and reaction time can affect results.

If you would like to purchase class sets of *Measurement in Sport*, please contact the National Standards Commission on Telephone: (02) 9888 3922 Facsimile: (02) 9888 3033.

Cost: Class set of 10 Student Booklets $50.
Kit (1 teachers + 1 students book) $15

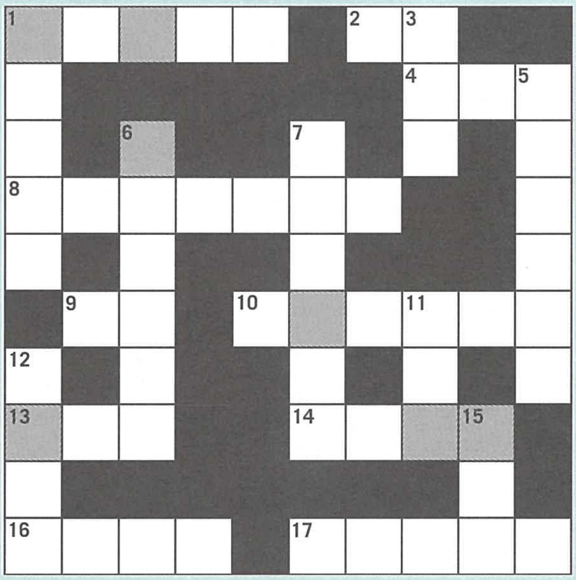
Puzzle Pages

Make a word list

This is a game for several players. Each player must make a list of all the words associated with time. Put them in alphabetical order and write the meaning of each word. When all the lists are complete, all players can act together to decide which words are acceptable. The player who makes up the greatest number of words is the winner.

Find the name of the watch

Complete the following crossword and then reading across and down, use the letters in the shaded squares to spell out the name of a type of watch.



Clues

ACROSS

1. Continental .... is a theory which explains the movement of continents.
2. Abbreviation for Post Meridian.
4. Abbreviation for a unit of time.
8. The name of an old super continent.
9. Abbreviation for Ante Meridian.
10. A gland which affects body rhythms.
13. The number of different single numbers which can be represented using seven LEDs.
14. That part of a clock which communicates the time to the reader.
16. A stop watch could be used to time this.
17. Big Ben has two of these.

DOWN

1. Counting these in some water clocks would help to estimate minutes.
3. Abbreviation for Mean Solar Time.
5. This was often used before mechanical time pieces were invented to measure the passage of time.
6. Part of a sundial.
7. A division of geological time.
11. Another period of geological time.
12. The Sun is a ....
15. Used to illuminate digital time pieces.

It is a [ ] [ ] [ ] [ ] [ ] [ ] [ ] **watch.**

What's the time?

Draw a clock face with the word or words below in the place of the numbers as listed.

1 = Radiometric dating
2 = Jurassic
3 = Mean Solar Time
4 = Melatonin
5 = Silicon chip
6 = Gears
7 = Time dilation
8 = Precambrian
9 = Anti meridian
10 = Einstein
11 = Nanosecond
12 = Pendulum

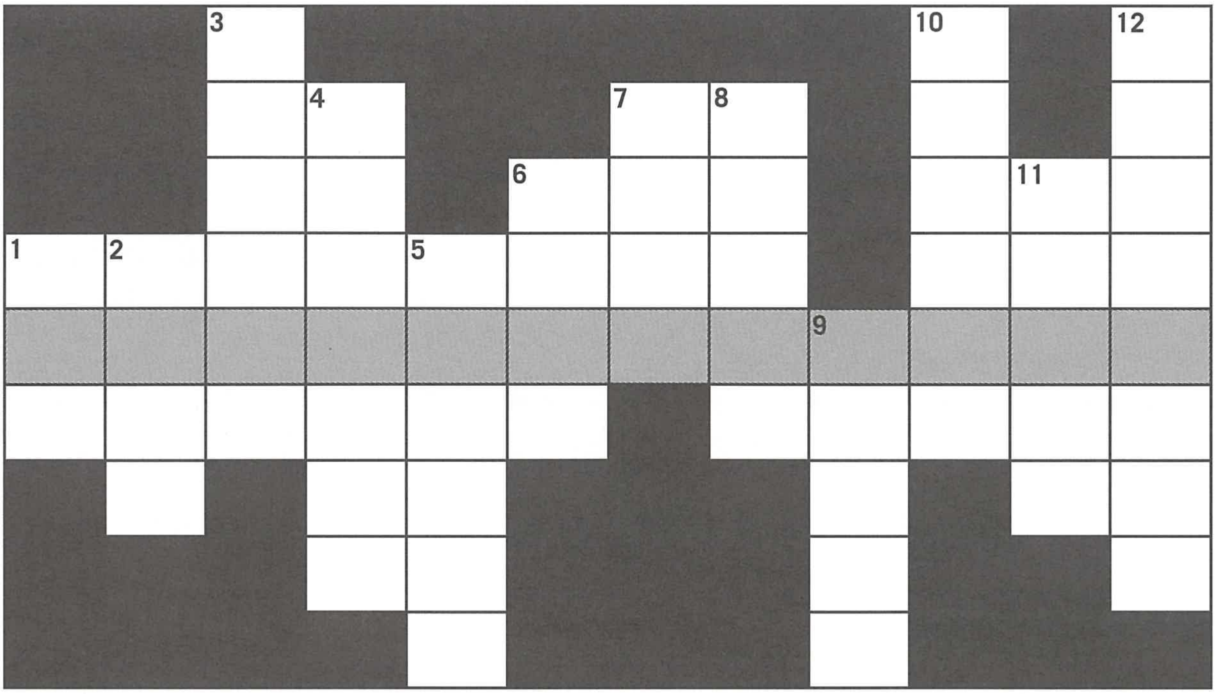
For each of the six instances listed in the grid, find the time indicated by the position of the hour hand and the minute hand. For example, if the hour hand was pointing to a hormone released by the pineal gland (Melatonin) and the minute hand was pointing towards the name of a famous physicist (Einstein), then the time would be 4:50.

WHERE THE HOUR HAND IS POINTING	WHERE THE SECOND HAND IS POINTING	TIME
1 To a small unit of time	To a part of a grandfather clock	
2 To the surname of a scientist who thought time was relative	To a term which refers to times between midnight and midday	
3 To a geological time during which life began	To a hormone released by the pineal gland	
4 To an measurable effect of time in space	To a way of determining the approximate age of very old rocks and fossils	
5 To an essential part of an old mechanical clock	To a solar time based on a hypothetical, predictable Sun	
6 To a time when dinosaurs were alive	To something you would find in a digital watch	

Australia was a part of where?

Find out by answering the following clues and writing the word downwards on the grid. Read the resulting word in the shaded spaces.

1. A long period of time in the history of the Earth.
2. Two of these equal the time difference between the western and eastern time zones in Australia.
3. A small unit of time.
4. This time piece was used by humans before and after the invention of mechanical clocks.
5. The number of calendar months in a year.
6. This could be found in a mechanical clock.
7. Early farmers timed planting seed by the phases of this.
8. A word that means 'related to the moon'.
9. A large unit of time is a .... year.
10. The name of a gland which produces melatonin.
11. The time it takes for the Moon to orbit the Earth is a lunar ....
12. AM is an abbreviation of Ante ....



SCIENCE ACROSS ASIA PACIFIC

A partnership between SEAMEO-RECSAM and BP in collaboration with education ministries and science teachers from across Asia Pacific, with support from the British Council and CIDA.

Why 'Science Across Asia Pacific'?

As the countries of Asia Pacific draw closer together both economically and politically, it is important to raise awareness in students of one another's societies. Many of the issues facing in the environment, such as energy supply, water quality and pollution are of common concern and related to scientific problems. Yet perspectives as to their causes and resolution may differ.

The Science Across Asia Pacific project aims to:

- introduce an Asian Pacific dimension into science education by raising awareness of different perspectives, ways of life and national traditions of students in other Asia Pacific countries;
- raise awareness of the ways in which science and technology interact with society, industry and the environment;
- provide opportunities to develop communication skills in the widest sense, including languages other than their own; *and*
- provide opportunities for schools in different countries to communicate and collaborate.

For students in years 7 – 10

Australia • Brunei Darussalam • China • Hong Kong • Indonesia • Japan • Korea • Malaysia Papua New Guinea • Philippines • Singapore • South Korea • Taiwan • Thailand • Vietnam

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http://sunsite.anu.edu.au/asta/

BP recsam SEAMEO asta

CHAPTER 3–CLOCKS & WATCHES

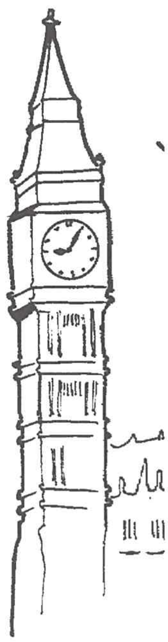
Teachers' Notes

TEACHERS' NOTES

A brief history

Clocks and watches help us to organise our lives, synchronise meetings and appointments and measure the passing of time. With our busy lifestyles we have become dependent on them and many of us would be lost without them.

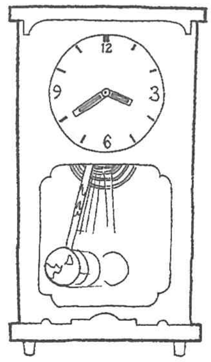
The word 'clock' is thought to come from the German word 'glocke' or the French word 'cloche', both of which mean 'bell'. Very early clocks measured hours only and usually indicated that the hour was up by ringing a bell. In many European towns, the town bell was then rung for all to hear. Clocks sounding the hour are still a feature of everyday life in some towns.



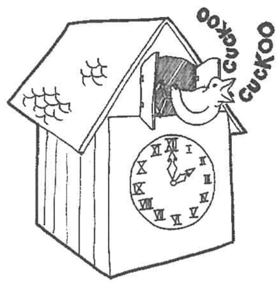
A watch is a portable personal clock, which out of necessity is small. Portable clocks were carried by watchmen, during a round of duty, or watch. The word 'watch' then came to mean a portable, personal clock.

Early mechanical clocks were made in the thirteenth century in Europe. They were large and cumbersome. They were probably invented and used in monasteries to call monks or priests to prayer. The inventor of the first mechanical clock is unknown.

PENDULUM CLOCK



Many early clocks were built in towers where they could be easily seen and heard. There are many examples of clocks in clock towers still in existence. Big Ben in London is one of the best known. P Henlein made the earliest known pocket watch in Germany in the early sixteenth century. C Huygens made the first pendulum clock in Holland in 1657. In the same year he made the first spring driven clock. The minute and second hands on clocks and watches began appearing in the seventeenth century, by which time there were many talented clock makers in Europe. From 1730, cuckoo clocks with ornate carved wooden exteriors and birds, which cuckooed on the hour, were produced in the Black Forest of Germany.



CUCKOO CLOCK

The earliest known wristwatch came from Switzerland in 1790. The early clocks and watches with a high degree of accuracy were made by extremely talented craftspeople. Parts had to be hand made and the clocks and watches were designed to last for long periods of time.

Teachers' Notes

Since the eighteenth century the Swiss have been famous for their clocks and watches. It was in Switzerland that the first production of clock parts to be sold to clockmakers and watchmakers began. At first families did this at home but in the 1800s the first factories producing parts came into existence.

In 1922, an Englishman called J Harwood made the first self-winding wristwatch. As the wearer moved his or her arm, the movement caused the mainspring to be rewound.

The first quartz clocks came from Canada in 1929, and were made by W Marrison. W Libby, an American, in 1946 invented the first clock based on vibrating atoms. This was the first atomic clock. L Essen and J Parry in Great Britain made the first caesium-based atomic clock in 1955. It is renowned for having an accuracy of one second in 300 years. The first battery powered wristwatches were made in the USA in 1956 by the Hamilton Walsh Company. In 1967 the Seiko Company in Japan produced the first quartz wristwatch.

As the number of clocks increased, clockmakers guilds began to form. One in Paris was formed in 1544. Its task was to control the quality of clock making and to oversee apprenticeships. In 1630, a clockmakers' guild was formed in London, and is still in existence today.

Many of the early town clocks were very decorative, with mechanisms that produced a display or rotation of figures on the hour. Statues of saints or the apostles were common, as were statues of musicians. Many of these are still tourist attractions in cities around the world.

Early mechanical clocks

A basic clock must have

(a) an energy source;

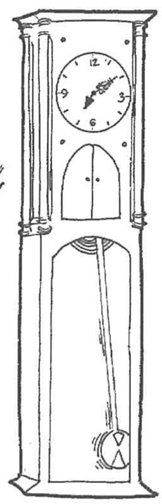
(b) a mechanism which measures equal periods of time; and

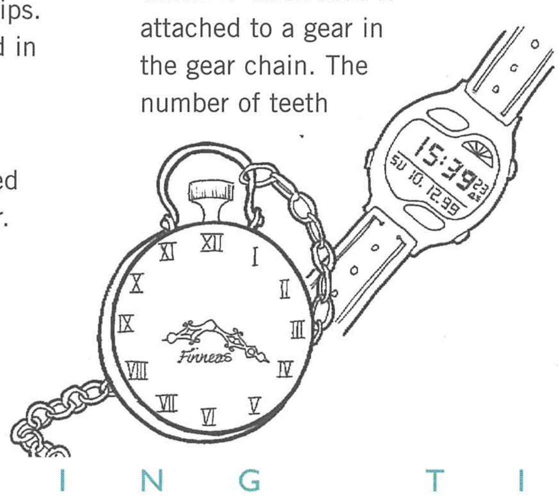
(c) a means of communicating the current time.

The mechanism which measures equal periods of time, usually has an action that is repeated. In grandfather clocks for example this action is the swing of the pendulum. A pendulum is a body suspended from a fixed point and free to swing from side to side from that fixed point. Gravity causes it to continue swinging with a time period which is constant. Galileo in 1583 recognised that the pendulum period was constant. He did this by comparing his pulse rate to the swing of a pendulum. It was not until Heygen's time that the pendulum was used as part of a clock.

Energy for a clock can come from a variety of sources such as a coiled spring, called the mainspring, a battery, or an electric current.

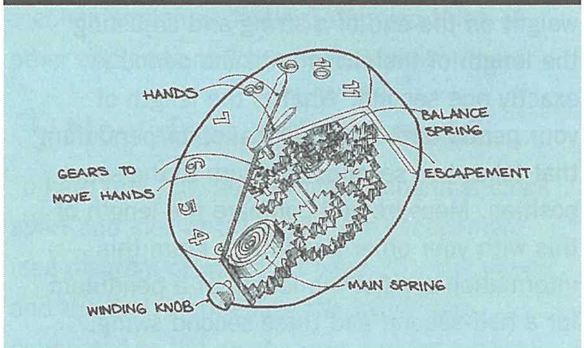
Energy is generally introduced into mechanical clocks by tightening their mainsprings. This energy is then passed on to the gear train and regulated by a device called an escapement—composed of toothed wheels and levers. The escapement regulates the periods of time measured by the clock, controlling the speed of the clock. Each hand on the watch or clock face is attached to a gear in the gear chain. The number of teeth





in each gear wheel is determined by the fact that the hour hand rotates only once for every 60 rotations of the minute hand and 3 600 rotations of the second hand.

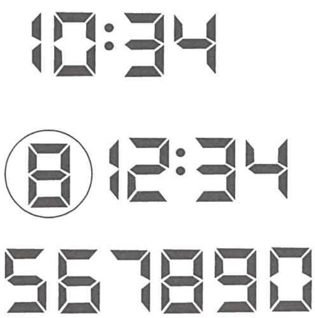
Inside a watch



Electric clocks are supplied with energy from alternating electric currents. In Australia these currents oscillate at 50 cycles per second. The clock converts the pulses created by the alternating current into a series of pulses at 60 per second. The pulses drive the time display mechanism.

Many domestic electric clocks have an electric motor which is synchronised to these pulses and which drives a gear system attached to the clock dial.

Digital clocks or watches are easily recognised by their characteristic number display. Each position from which a number can be read has seven bars, which can be illuminated. Different combinations of these bars are illuminated to display different numbers. The bars are usually light-emitting diodes, or LEDS, but can also be liquid crystals.

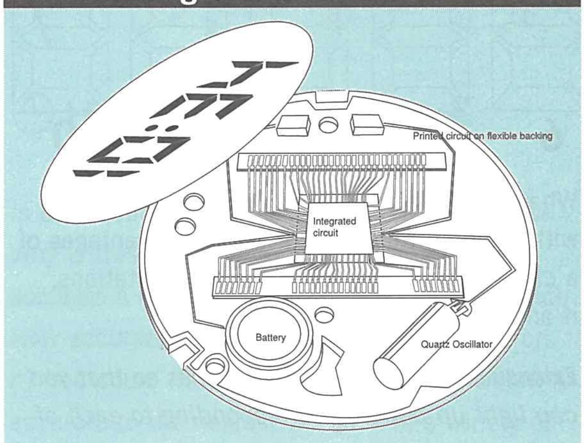


The timing mechanism in most digital clocks and watches is a quartz oscillator. When quartz crystals receive an electric charge, the charge 'vibrates' at a fixed frequency. This characteristic is known as the piezoelectric effect.

A quartz oscillator is made by longitudinally slicing a quartz crystal and attaching two electrodes. One electrode causes it to 'vibrate', the other electrode allows measurement of the vibration.

Inside a digital clock or watch, along with the quartz oscillator, is an integrated circuit which controls its functioning. This has a similar function to the gear chains in a mechanical watch. It translates crystal vibrations into time

Inside a digital clock



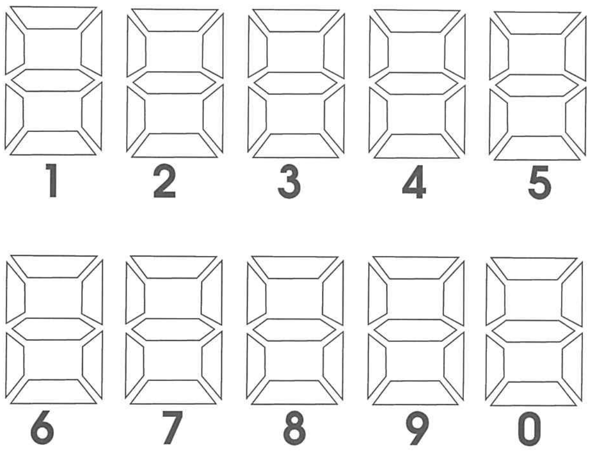
intervals and drives the mechanism, which displays the time. An electronic watch will also contain a small battery as its power source while an electronic clock may either be connected to an electricity supply or include a battery.

An atomic clock uses vibrating atoms of caesium to determine time intervals. They are so accurate that the second is now defined in terms of the vibrations of the caesium atom. Atomic clocks allow other clocks to be regulated with a greater level of accuracy.

Student Activities

Understanding digital numbers

Below is a diagram, showing the arrangement of the seven light-emitting diodes (LEDs) found in many digital clocks and watches. By highlighting different LEDs it is possible to make the ten primary numbers. Using a pen or pencil draw the arrangement of illuminated LEDs, which correspond to each of the numbers.



What are the advantages of a clock or watch with a digital timer? What are the advantages of a clock with hands? What are the limitations, if any, of either type of clock?

Extension: *Connect 20 small globes so that you can light up patterns corresponding to each of the numbers.*

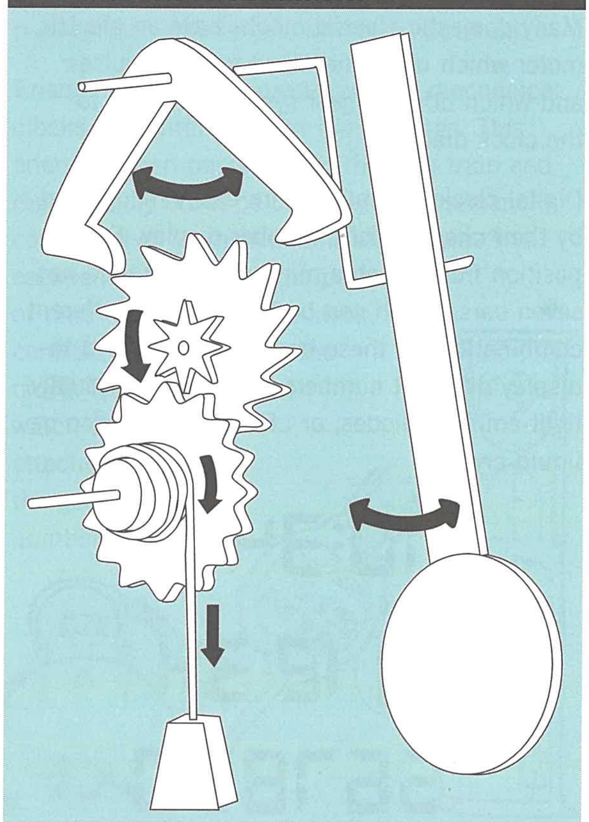
A pendulum in a vacuum is an excellent tool for measuring small equal periods of time. Many early clockmakers have incorporated pendulums into their clocks as a result. Grandfather clocks are an excellent example of a pendulum driven clock. Even when not in a vacuum, pendulum swings can be used as timers. Make a series of pendulums. Using a stopwatch, measure the period of each. The period is the time it takes for one complete swing. Which pendulum has the most consistent swing? Use what you have learned from these pendulums to design a better pendulum with a more constant period. Will the accuracy of the pendulum be affected by temperature? What causes the pendulum to slow down? How can this be minimised? Does the weight alter the swing?

Make a pendulum that takes one second to complete one swing and return to the same position. This can be achieved by securing a weight on the end of a string and adjusting the length of the string until the period is exactly one second. What is the length of your pendulum? Now make another pendulum that takes two seconds to return to the same position. Measure and compare the length of this with your other pendulum. From this information predict the length of a pendulum for a half-second and three second swing. Test your predictions.

Pendulum mechanism

If a pendulum is to be used to measure time, it needs to be able to display the time to be useful.

Pendulum mechanism



Student Activities

Design and make a model that demonstrates how a pendulum can be used to measure and display equal periods of time. The diagram on page 24 may be helpful. What does your model have in common with a grandfather clock? What materials would you use to make your pendulum mechanism longer lasting? Can you think of other applications for your pendulum timer?

How does a clock work?

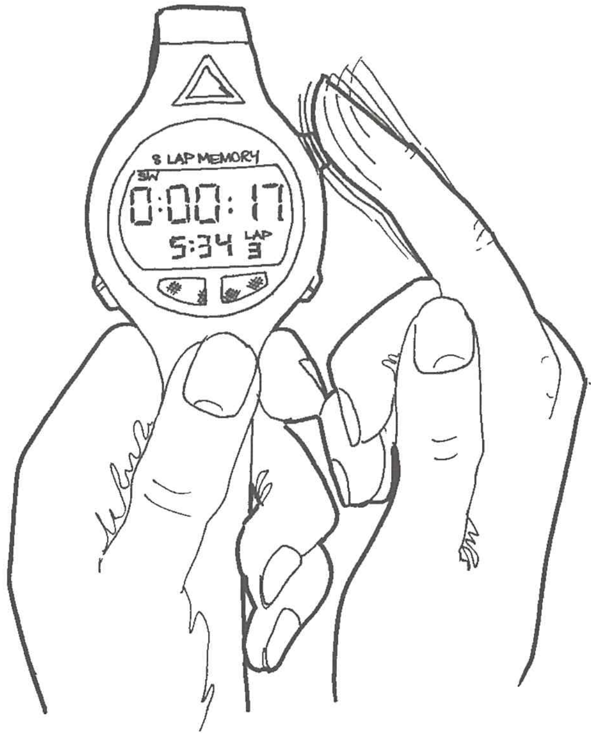
To help find out, pull an old mechanical clock apart and look at the gears, the escapement (see diagram of watch on page 23), the winder and the dial. Notice how the hands are connected to the mechanism and from where the energy to measure time comes. When you have investigated thoroughly what each part does and how it all works together, reassemble the clock. Write out an answer to the question 'How does this clock work?'

Pull apart an old digital watch or clock. Because the components are so small and complex it may not be possible to see how it works, however you may be able to identify the integrated circuit and the quartz crystal. Write out an answer to the question 'How does this clock work?'

Comment on the different technology of each clock. Which type of watch would you prefer? Give reasons for your choice.

Make your own clock

How can you make a clock? What sort of clock would you make? Using any principle for measuring equal periods of time, make a clock of your choosing. If this is too big a task, make a clock, which measures seconds or minutes only. Explain in writing how you made your clock. What factors limited your clock making? What sources of error will affect your time reading? How can you further minimise error and/or inaccuracy?



How accurate are time measurements?

Is the accuracy of a clock or watch important? Why is this so? How do you determine how accurate a watch or clock is? Look at your watch. How accurate is the time, which you read from it? You could finish the sentence, 'This watch is accurate to the nearest…'. Look at a variety of clocks and watches and determine their level of accuracy. Obtain a stopwatch, which measures accurately to 0.01, and determine how accurate your use of it is. If you were timing a 100 metre sprint, would you be able to measure it to the nearest 0.01 of a second, or would there be too great an error in your reactions? What other errors are involved? Set the stopwatch at zero. Start and stop the stopwatch as quickly as you can. How much time elapsed between the start and the stop? What do you think your reaction time is? Practise starting and stopping the watch for several minutes. Has your reaction time improved?

Student Activities

Timing time

How accurate were the early timers? Make several timers (e.g. candle clock, water clock, hourglass and sundial). Using a stopwatch record the accuracy of the clocks or watches against the stopwatch. Subject them to a variety of conditions, such as very hot, very cold and very windy. Which clock would be the best on a sailing boat? Which clock would be best in the desert? Which would be best in the kitchen? Why? Which clock would be best for timing the 100 metre sprint at the Olympics? Which would be best for timing a marathon?

Telling time before clocks were invented

Investigate how early humans told the time. Make a big book or a large drawing depicting early timing devices.

The history of clocks

Humans depend on each other to keep appointments, to get to work, to know when to stop work etc. Since the beginning of the human race, attempts have been made to measure the passing of time. Carry out an information search to find out how clocks have developed and changed in different cultures and throughout history. Which clock interests you the most? Give reasons for your answer.

The history of watches

When did humans begin to carry personal clocks or watches on them? How did they change throughout their history? Why did they feel a need to do this? Are we dependent on our watches today? What difficulties would you experience if you did not wear a watch? Younger students could list the reasons why it is important to be able to tell the time and why it is important to wear a watch.

Working the gears

How do the gears in an analogue watch work? Why are the gears there? What do they do? How many of them are there? How are they connected? How does the clock measure minutes? How does the clock measure hours?

Making it digital

How does a digital watch work? How do the numbers display? Is there a battery in there? What does it do? Is there a silicon chip in there? What does it do? How does it measure seconds?

Time line of time keeping devices

Make a list of all the main time keeping devices used throughout history and then put them into a time line. Reflect on how much thought, experimentation and making went into these devices.

Make a big book

Create a class big book or chart that shows different types of timepieces.

Write a poem or a story

Write a story about how and why clocks came into existence.

Write a story about the day in the life of a watch. Draw a cartoon character to be the central character. Write a poem about the meaning of time, or with time as the general theme.

CHAPTER 4–BIOLOGICAL TIME

We are conceived born, grow, walk, reach puberty, age and die, all in a biological sequence. Our biological clocks start to run down when our reproductive years are coming to a close. During our life, growth and aging will occur in their own order.

Biological clocks are systems, which allow organisms including humans to harmonise with their environment. While these biological clocks are internal, they depend on external cues for their continued accuracy. Light is one of our most important cues.

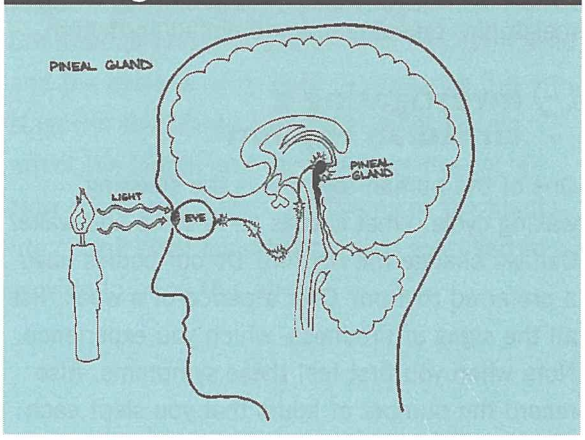
When people travel thousands of kilometres east or west they move into different time zones, with the Sun rising and setting at different times. It often takes a few days to feel comfortable and for our biological clocks to adjust to the new time. Jet lag is the name given to this period of 'time' confusion, which affects travellers.

Biological clocks exist in every cell of an organism. They have been shown to trigger the release of hormones, which can bring about activities such as the emergence of an adult insect from a pupa or the onset of breeding in bird species.

Melatonin, a hormone secreted by the pineal gland in the brain is known to play an important part in the biological rhythms of animals. The pineal gland, which is shaped rather like a pine cone shape, was probably named after the French psychologist Philippe Pinel, who was the first person to refer to and describe it.

The pineal gland is found at the top of the midbrain. It is sensitive and responsive to surrounding light levels. While its function is not totally understood, studies have shown that it secretes melatonin during darkness only and ceases production as soon as the eye registers light. It appears to inhibit reproductive activities in seasonal breeders by inhibiting the production of other sex related hormones. Administration of melatonin to birds, which are seasonal breeders, has allowed breeding times to be altered and lengthened.

Pineal gland



One very important biological rhythm in many animals, including humans, is the cycle of being asleep and being awake. When we are awake, the brain is active and involved in sending numerous messages or impulses throughout the body. When asleep these impulses decrease dramatically. After sufficient sleep the brain can resume its increased activity. This sleeping waking cycle is an example of a biological pattern called a circadian rhythm. Other circadian rhythms include: fluid intake and urine formation, body temperature, heart functioning, oxygen intake and use and cell division.

Many other circadian rhythms exist in nature. These are used by different organisms to time a great number of their activities. For example, they are used to time the emergence of adult cicadas and the time period between flowering in some plant species.

Student Activities

Information searches

Rhythmic changes in body temperature

Does body temperature vary in a rhythmic manner? How does it vary? Take your body temperature every four or six hours over a period of several days. Graph your results. Explain why these changes occur. Find out, by searching in your library or on the Internet, how your body knows the time. Look up key words like melatonin, pineal gland and circadian rhythm.

Investigating a circadian rhythm

One of the human rhythms is the sleeping waking cycle. What causes us to sleep and wake? Can we change the rhythm? Do our bodies have a preferred rhythm? Over a period of a week, list all the signs of tiredness, which you experience. Note when you first feel these symptoms. Also record the number of hours that you slept each night. Look back over your results for the week and interpret what they mean. Did you feel any tiredness symptoms in the morning? If so what do you think was the cause? What do you need to do to rectify this in terms of actual hours of sleep? Why is feeling tired useful? What would happen if we never felt tired?

Try to make yourself more alert or more tired by changing the lighting level in your room. Can you explain the way this may affect you referring to the levels of the hormone melaton in in your system?

Identify how you feel at different times of the day (e.g. sleepy, alert, ready to get going etc).

Studying cycles

Do other animals have cycles and rhythms? Study an ant colony in detail at different times of the day and night. Do ants have any behaviour patterns that vary with the time of day? Alter the amount of light ants receive and see if this affects their daily routine.

Make an ant farm

Observe patterns and cycles in the behaviour of ants by building a small ant farm between two transparent sheets of glass. Does the activity of the ants vary in a pattern? When is their busiest period? When is their quietest period?

Daytime and night time

List the things you do during the day and the things that you do during the night. Why are they different? Do other animals do different things during the day and night? Why does this happen? Why does it need to happen?

Biological clocks

Do we have biological clocks? What are they? Using any information source available to you, investigate the role of the biological clock in any organism or group of organisms. Find out what causes fruit trees to bloom in spring. How do birds and whales know when to migrate? Can the full Moon affect a person's brain or the brains of other animals? Think up more questions of your own. How are the biological clocks of shift workers and overseas travellers affected? Is jet lag real? How and why does jet lag affect us?

Biorhythms

Carry out an information search to find out what human biorhythms are. How do they affect our behaviour? Are they important? How do they affect us?

Melatonin

Does melatonin affect our biorhythms? Find out about melatonin and how it is used to combat jet lag. Find out how the hormones and the lives of shift workers and frequent overseas travellers are affected by melatonin.

Pineal gland

What connection does modern medical science make between the pineal gland and biological rhythms? Using any information source available to you, find out where the pineal gland is in humans and what its function is. Find out the name and function of any hormone produced. What is the main function of the pineal gland? Is it more developed in other species?

Circadian rhythm

What is a circadian rhythm? How do circadian rhythms affect the lives of humans and other animals? Find out what circadian rhythms are and how they regulate many biological events. Give as many examples as you can.

Model of a brain

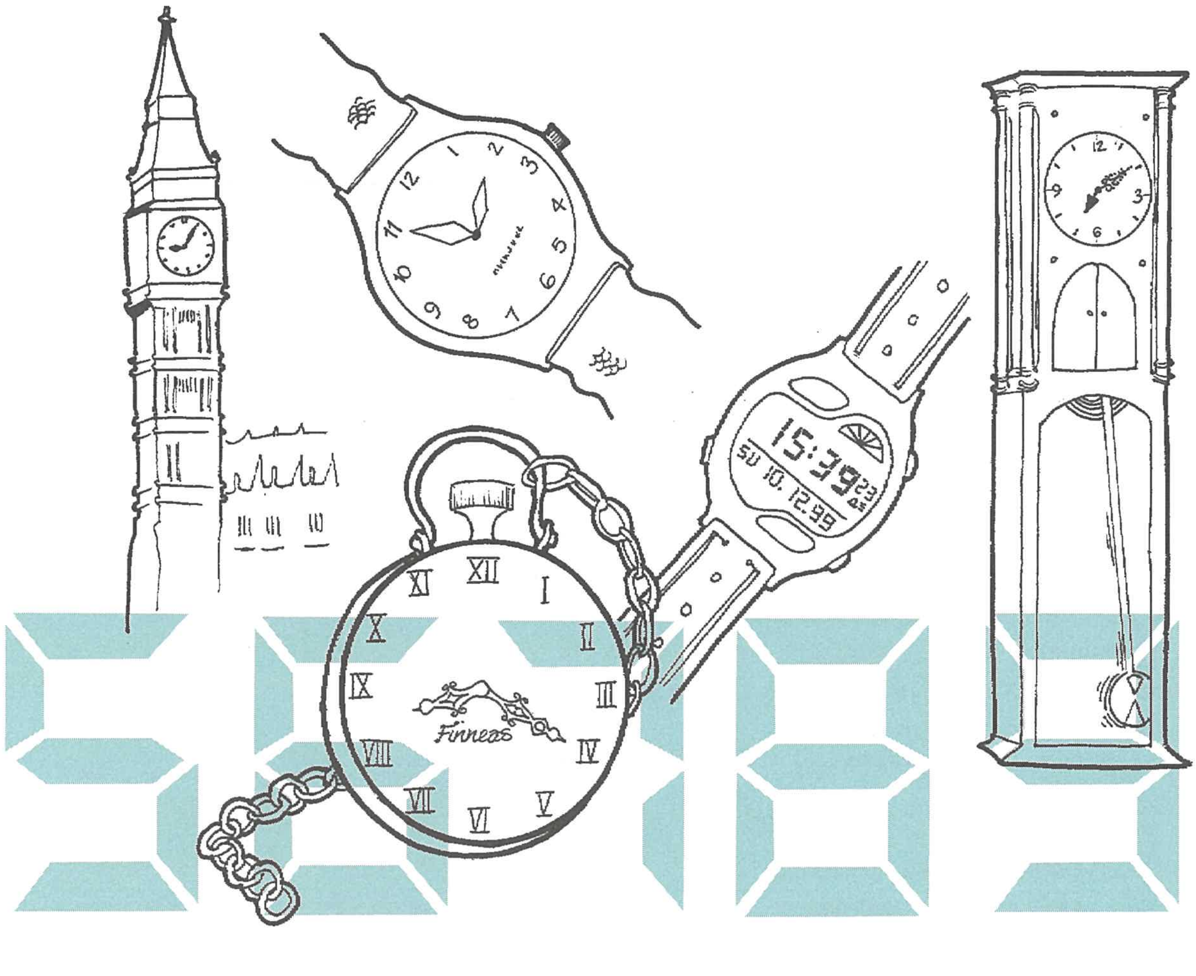
Draw or make a model of the human brain showing its complete structure including the pineal gland. What are the main parts of the brain? What are the functions of these parts?

The cycle of the seasons

What changes do the seasons bring about? List as many as you can. Include such things as soil temperature, insect activity and storm activity. Observe and record one seasonal change.

Grow plants from seed

Collect seeds, plant and grow them until they in turn produce seed. Keep records at different stages (e.g. measure, draw, photograph or video). Continue to grow the plants until they form seed and the cycle is completed. Summarise the stages in the plant's life cycle. What factors affect the length and the timing of the cycle? How could you change the timing of the plants life cycle? What conditions would you need to provide to bring this about?



CHAPTER 5–GEOLOGICAL TIME

Teachers' Notes

When discussing the history of the Earth and the history of our universe, the year as a unit of time is far too small to be meaningful. Time for these events is measured in millions of years. Time since the beginning of the Earth is also divided according to the geological time scale which is a calendar of the sequence of major events in the evolution of the Earth and its biomass. Time since the Earth formed is divided into time units of differing lengths, which begin and end with significant events. The major time divisions are called eons. These are divided into eras, which in turn are divided into periods, which are divided into epochs.

The following is a geological time scale listing the eras and periods and the more significant life forms which existed in each period.

MILLIONS OF YEARS SINCE ERA/PERIOD BEGAN (APPROX)	ERA	PERIOD	ADDITIONAL INFORMATION
1.8	Cainozoic	Quaternary	• Modern humans developed
65	Cainozoic	Tertiary	• Vast range of diverse organisms; plants, vertebrates and invertebrates • Mammal numbers and diversity increased
141	Mesozoic	Cretaceous	• Birds increased in diversity and number • First snakes • Extinction of dinosaurs
205	Mesozoic	Jurassic	• Prolific sea life including fish, algae, molluscs, brachiopods, crustaceans • Reptiles and dinosaurs common • First appearance of birds
251	Mesozoic	Triassic	• First dinosaurs • First mammals
298	Paleozoic	Permian	• Extinction of trilobites • Spread of cone bearing plants • First beetles
354	Paleozoic	Carboniferous	• Winged insects appeared, diversified and increased in numbers
410	Paleozoic	Devonian	• First trees • First insects • First land vertebrates
434	Paleozoic	Silurian	• Many fish • First land animals (invertebrates)
490	Paleozoic	Ordovician	• First fish • First land plants • First corals
545	Paleozoic	Cambrian	• First marine vertebrates • Trilobites • Sponges, molluscs, brachiopods
2500	Proterozoic		• Simple one and multicelled sea life including algae
4560	Archaeozoic		• Bacteria like organisms

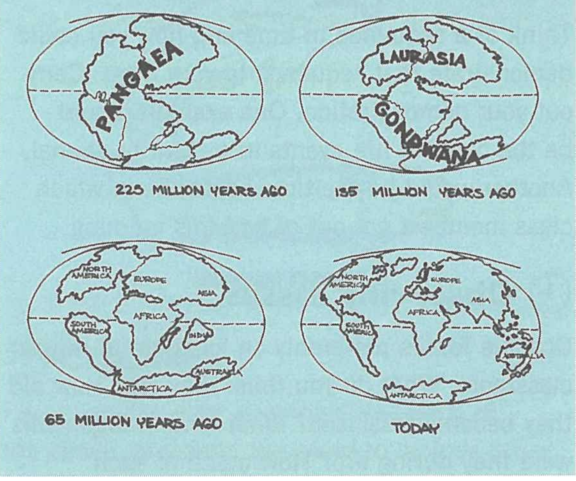
Teachers' Notes

There are five geological eras. Beginning from the oldest, they are the Archaeozoic, Proterozoic, Paleozoic, Mesozoic and Cainozoic. The Archaeozoic and the Paleozoic are also known as the Pre-Cambrian.

The division between the geological eons, eras, periods and epochs was determined by comparing rock strata and the fossils they contained. As organisms evolved over time they left a fossil record behind which shows a sequence of organism evolution, and a characteristic biomass for each period of time. The age of rocks was originally determined by their stratigraphy (the layer they occupied) and fossil content. As science and technology has advanced, these ages could increasingly be validated by methods such as radiometric dating. This method became possible after 1896 when Becquerel discovered that minerals containing uranium emitted radiation and in the process formed lead. This process occurred at a constant rate, so the age of a rock or mineral could be determined by the ratio of lead to uranium. Radiometric dating can also be based on the breakdown of other radioactive elements.

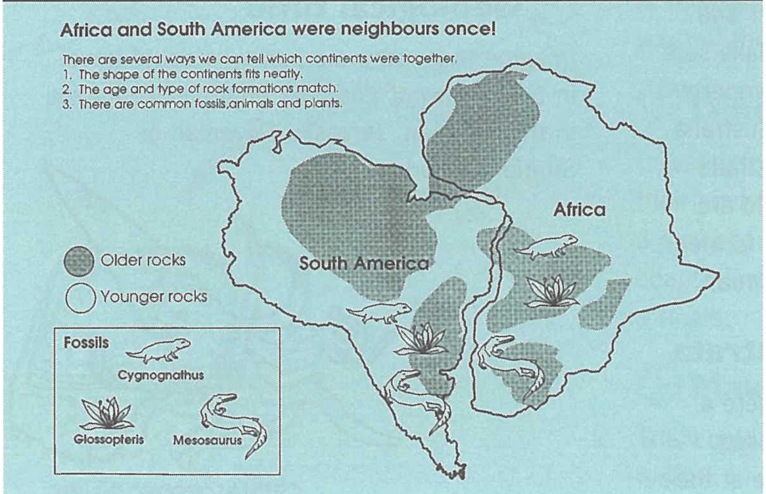
Using radiometric dating methods, rocks have been found on the Earth, which were formed as long ago as four thousand million years.

History of the continents



Not only were organisms evolving and changing over time, but so was the Earth itself. The Earth's land masses were continually changing shape and position. Approximately 200 million years ago, only one landmass existed on the Earth's surface. It has been named Pangaea. This large landmass split into two. One section called Laurasia drifted north and the other called Gondwanaland drifted south. Oceans formed in between the land masses. Gradually Laurasia and Gondwanaland split into smaller pieces. The resulting islands and continents have been drifting at an extremely slow rate ever since. This is known as Continental Drift. Australia was once part of Gondwanaland.

The continents fitting together



One of the strongest pieces of evidence for the *Theory of Continental Drift* comes from the neatness of the fit of the continents when they are put back together. The coastlines fit together and geological structures, rock strata and fossil records match. Evolutionary histories of organisms often indicate common ancestors in Gondwanaland.

There is also evidence from glaciation and paleoclimatic conditions.

Student Activities

Demonstrate a sequence in time

Think of a sequence in time and how you could demonstrate that sequence to your class. Carry out your demonstration. One example would be the order of life events in a plant or animal. Another would be the time sequence in which class members got out of bed this morning.

Observing fossils

Observe fossils preferably on location, or in your classroom. What do you think they are? How did they become fossilised? What kind of organisms were they during life? How much of each organism remains in fossil form? When did they live? Are similar organisms living today? Examine each fossil at your disposal using a hand lens, magnifying glass or magnifying microscope. After you are sure that you have observed all there is to see, describe each fossil in detail. This can be done by a combination of sketches and writing. Can you find out how long ago each fossil lived?

Investigate local rock ages

Some rocks are very, very old. The Earth has evolved over millions of years during which rocks have formed, changed, been weathered and eroded in an ongoing process of change. How old are the rocks in your area? Conduct an investigation to find out. Geological maps of your local area, a geological hammer and protective glasses would be helpful. Make sure you respect all local restrictions and property rights. Where are the oldest rocks in Australia found? How do the oldest rocks in Australia differ from the youngest rocks? How old are the rocks in your area? How were they formed? What is the geological history of your area?

Investigate local rock strata

Investigate a site in your local area where a sequence of sedimentary rocks is exposed. If you assume that the oldest rocks are at the bottom of the sequence and the youngest rocks are at the top, what do the rocks tell us about environments at this locality in the period of geological time which they represent?

Find a geologist

Can you find a local geologist who can tell you about the geological history of your area? Invite him/her to talk to your class or accompany you on a geological field trip.

Continental Drift

What is Continental Drift? What evidence exists to support this theory? Using any information source available to you, find out how the continents have drifted over the last 200 million years. Search for evidence of Continental Drift. Do you think Continental Drift occurred? Give reasons for your answer.

Gondwanaland

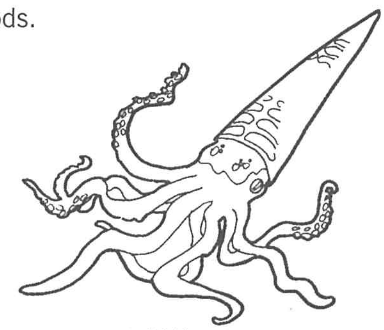
What was Gondwanaland? We were once part of Gondwanaland. What does this mean and why is it significant?

What is a fossil?

How are fossils made? What can we learn from fossils? Find and observe as many fossils as you can. Describe the detail of each fossil and determine as much as you can about its life style and living environment.

Geological time

Imagine that you are a bird who could travel in time. Draw or describe what you would see in the Permian, Jurassic, Devonian or Silurian periods.



CEPHALOPOD

Student Activities

Who am I?

Describe what you would look like and how you would live from day to day if you were a

(a) Trilobite

(b) Muttaburrasaurus

(c) Itchthyosaurs

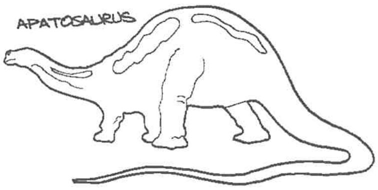
(d) Mesosaurus

(e) Cephalopod

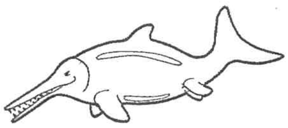
(f) Archaeopterys

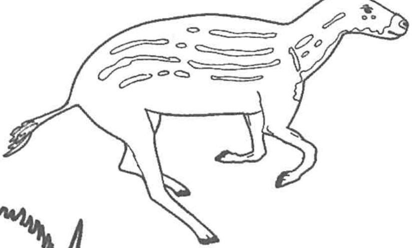
(g) Eohippus

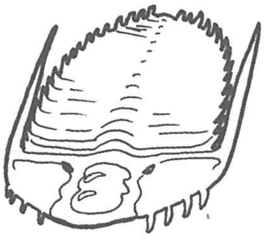
(h) Dinichthys



Study one of the organisms from the list. Write a 'Who am I' riddle for other members in your class to solve. Illustrate the answer but hide it under a flap on which the question is written. Find out as much as you can about the anatomy, lifestyle and living environment of the above.


ICHTHYOSAUR


EOHIPPUS


TRILOBITE


DINICHTHYES

Charades

Play charades after learning about each of the above, or extend the game to include other living things throughout time. Another alternative is to write clues on cards with the answer on the back and devise a game to use the cards.

Place the organisms above into an evolutionary time sequence. Explain the changes in the organisms along the time line.

Time line

To help you understand geological time, draw a time line from the Archaeozoic to the present day putting the main groups of organisms on the time line as they emerge. Illustrate and name these main groups of organisms.

Tell a story

Make up and tell a story about the life styles of dinosaurs. You could use some props to help you tell the story.

Dinosaur role play

Investigate ways that dinosaurs adapted to their environment. Role play, or write and act a play about dinosaurs that demonstrates these adaptations. Put the dinosaurs in a time line as a finale.

Make a dinosaur model

This could be done with a dinosaur kit, paper mache, play dough or plaster and wire.

CHAPTER 6–TIME AND SPACE

Teachers' Notes

Before the work of Albert Einstein, many people believed that time was constant. We had a certain amount of it and it was used up at a constant rate. This rate of time use could be measured with a variety of clocks, sundials etc. Einstein challenged this view and theorised that while this may appear to be true on Earth, in space something different may be happening.

Einstein in his special theory of relativity stated that the speed of light in space would always be constant regardless of the motion of the source or the motion of the observer. So regardless of the frame of reference in which the speed of light is measured it will always be the same. The speed of light in a vacuum is a constant, referred to as 'c', and is equal to distance divided by time. Therefore time and space are not constant but determined by their relationship to the speed of light. The speed of light does vary depending on the medium it is travelling through, e.g. it travels at different speeds through glass, air, or a vacuum but when it is travelling in the same medium its speed is always the same, regardless of from where you are measuring it.

The speed of an object such as a car is relative to the observer. For example, a car travelling at 100 kilometres per hour will appear to be travelling at different speeds to a stationary observer, an observer travelling in an adjacent car at 80 kilometres per hour and an observer travelling in another car in the opposite direction. To each observer the speed of the car is relative. In space the speed of light (in a vacuum) is not. It is an absolute constant.

Time in space can be lengthened or stretched. We call this 'time dilation'. A classic example refers to twins. One twin stays on Earth while the other twin travels through space at speeds approaching the speed of light. When the space traveller returns to Earth, he or she will be younger than the twin who remained on Earth. Time passed more slowly for the space traveller.

Time dilation can also be explained by imagining a spacecraft travelling at high speed directly away from an observer on Earth. The space ship flashes signals back to Earth at one minute intervals. The observer on the Earth will receive the signals, which will still be at equal intervals apart, but the interval will be greater than one minute. If the space ship moves through space at the same speed as the Earth and in the same direction, then the flashes will be received at exactly one minute intervals. As the space ship is returning to Earth still flashing the signals, they will be received on Earth at less than one minute intervals.

To people travelling through space at high speeds, time would appear to be passing at the same rate as it did for them on Earth. This is because they are inside the frame of reference. Their biological clocks and watches would progress at what would appear to them a normal rate. It is the observer who sees time as passing more slowly or faster.

Time dilation makes space travel in one human lifetime theoretically possible. If a space destination is 25 light years away, it takes 25 years for a light signal from Earth to reach that destination. A space traveller, moving at close to the speed of light could arrive there just over 25 years and be back in just over 50 years. When they returned friends and family would be 50 years older. The space travellers would, because of time dilation, be only a few years older. Therefore a parent could return to Earth younger than a son or daughter.

Teachers' Notes

ANSWERS TO PUZZLE PAGE

1 D	R	I	F	T		2 P	3 M		
R							4 S	E	5 C
I		6 G			7 P		I		A
8 P	A	N	G	A	E	A			N
S		O			R				D
	9 A	M		10 P	I	N	11 E	A	L
12 S		E			O		R		E
13 T	E	N			14 D	I	A	15 L	
A								E	
16 R	A	C	E		17 H	A	N	D	S

Find the name of the watch = DIGITAL

		3 S							10 P		12 M
		E	4 S			7 M	8 L		I		E
		C	U		6 G	O	U		N	11 M	R
1 A	2 H	O	N	5 T	E	O	N		E	O	I
G	O	N	D	W	A	N	A	9 L	A	N	D
E	U	D	I	E	R		R	I	L	T	I
	R		A	L				G		H	A
			L	V				H			N
				E				T			

Australia is part of where? = GONDWANALAND

What's the time? 1 = 11:00, 2 = 10:45, 3 = 8:20, 4 = 7:05, 5 = 6:15, 6 = 2:30

Student Activities

Plan a space trip:

Assume that

(a) you will live for 70 adult Earth years;

(b) you are able to travel through space at 99.5 percent of the speed of light; and

(c) ten Earth years are equal to one year in the spaceship.

Now plan a trip in space. You will need to check distances in space in terms of light years to your chosen destinations. Now plot your course for your space trip. What requirements will you need to exist? What potential hazards might you encounter? Write out a short story depicting a day in your life during the journey.

What is a light year?

Develop the concept of time in space by talking about how fast light travels and how far it can travel in a year. If we look at a star that is 10 light years away, how long ago did the light we are seeing leave that star? How big is space?

Einstein's special theory of relativity

Who was Einstein? What was his special theory of relativity? Why was it important?

Why is Einstein the most well known scientist of all time?

Planet orbit time

Is a year on Earth the same as a year on Jupiter? Give reasons for your answer. Research the length of time in Earth years that it takes for each planet to orbit the Sun. This investigation could also be carried out determining planet orbit time in Venus years or Jupiter years, etc.

A tall story

Write a creative short story, which involves someone travelling, in space at 99 percent of the speed of light, as part of your plot.

Write and perform a play

Your play could be about the life, times and work of Albert Einstein, about time travel, or a comedy about the life of a wristwatch. These few examples can be used to stimulate your own ideas.

ALBERT EINSTEIN

Glossary

Biological clocks
These are physiological systems, which assist organisms, including humans, to live in strong harmony with the cycles of nature.

Continental drift
The movement or drifting of land masses throughout geological time as a result of the activity of the large plates which make up the earth's surface.

Full moon
A full moon appears as a bright illuminated circle in the sky. This is seen when the whole area of the moon's surface facing the earth is illuminated by the sun. It occurs halfway between two consecutive new moons.

Gondwanaland
A large ancient land mass.

Greenwich mean-time (GMT)= Universal time (UT1)
These terms all apply to the mean solar time at the longitude of zero. It is the time zones that all other time zones relate to.

LEDs
Light Emitting Diodes or LEDS, are used on digital timers. A number of them are arranged in a figure eight pattern. When different LEDs glow, different numbers can be read.

Lunar month
A lunar month is the time it takes the moon to revolve around the earth and return to the same point. Its duration is 29 days, 12 hours, 44 minutes and 2.8 seconds.

Mean solar time
Solar time based on a hypothetical, predictable sun which moved at a constant rate and made all days equal periods of time.

Melatonin
Melatonin is a hormone secreted by the pineal gland that is known to play a part in the biological rhythms of organisms.

Meridian
A meridian is an imaginary straight line running from the North to the South Pole, crossing the Equator at right angles to it.

New moon
A new moon occurs when the moon is between the earth and the sun. During this time it is very difficult to see.

Period
Widely used time divisions in the geological time scale. Eras are divided into periods. Periods are divided into epochs.

Pangaea
The first huge land mass to form on the earth's surface. It is an ancient continent that divided into Gondwanaland and Laurasia.

Pineal gland
The pineal gland, which is found at the top of the midbrain, is sensitive and responsive to surrounding light levels. While its function is not totally understood, studies have shown that it secretes melatonin during darkness only and plays a role in biological rhythms.

Radiometric dating
A method used to date rocks and fossils based on the breakdown of radioactive elements present.

Second
The International System of Units defines the second as the 'duration of 9 192 631 1770 periods of radiation from the ground state of the caesium 133 atom'.

Solar time
Solar time is time based on the movement of the sun. At any point on the earth's surface, when the sun is at its highest point, then it is midday at that particular place. A solar day is the time between two successive times when the sun is at its highest point.

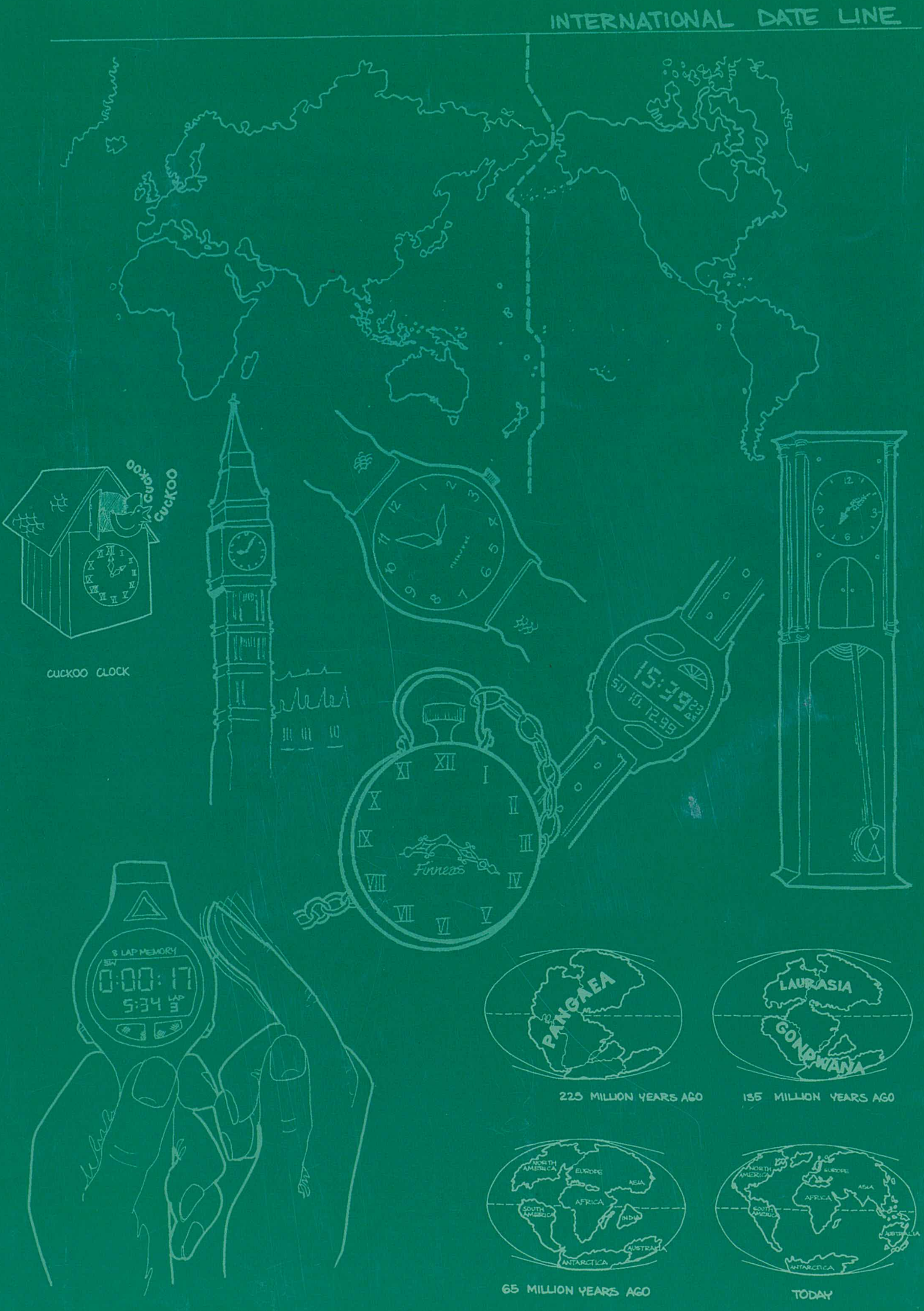
Standard time
Standard time is the local time established by law and/or international agreement for a particular zone, country or region. Within Australia there are three distinct time zones.

Sundial
Sundials are devices used for measuring time when the sun is shining. They use shadow lengths and directions cast by an elevated piece called a gnomon to indicate the time.

Time dilation
The lengthening or stretching of time in space in accordance with Einstein's special theory of relativity which says that the speed of light is constant, but time is not.

Universal Time (UT1)
This is an equivalent term for Greenwich mean-time (GMT).

Zero meridian + Prime meridian
Meridian at longitude zero, which runs through Greenwich in the United Kingdom.


INTERNATIONAL DATE LINE
CUCKOO
CUCKOO
CUCKOO CLOCK
15:39
Finneas
8 LAP MEMORY
0:00:17
5:34
PANGAEA
LAURASIA
GONDWANA
225 MILLION YEARS AGO
135 MILLION YEARS AGO
NORTH AMERICA
EUROPE
ASIA
AFRICA
SOUTH AMERICA
INDIA
AUSTRALIA
ANTARCTICA
65 MILLION YEARS AGO
TODAY