SCIENCE

Level

F	1	2	3	4	5	6	B6

Science now and then

Strand
Science and Society

Key concept
Historical and cultural factors influence the nature and direction of science which, in turn, affects the development of society.

Purpose

Activities in this module are designed to help students understand that scientific ideas have changed and will continue to change as new evidence is collected. Students have opportunities to:

- explore ideas held by scientists in the past;
- reflect on factors that have influenced change;
- investigate the impact that different tools and equipment have on the type, nature and quality of information collected;
- access and synthesise information from a variety of sources;
- consider the importance of different sources of information.

Overview of activities

The following table shows the activities in this module and the way in which these are organised in **introductory**, **developmental** and **culminating** phases.

Introductory ►	Developmental ►	Culminating
Why do I think that?	Discovering atoms	Influences on science
	Ideas about earthquakes have changed	
	Better tools — more information	
	Medicine then and now	
	Transplants	

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Core learning outcomes

This module focuses on the following core learning outcomes from the Years 1 to 10 Science Syllabus:

Science and Society

4.1 Students outline some contributions to the development of scientific ideas made by people from different cultural and historical backgrounds.

5.1 Students consider how and why scientific ideas have changed over time.

Core content

This module incorporates the following core content from the syllabus:

Science and Society

History and philosophy of science

Influential scientists
- Western
- other cultures

Uses of science
- influence on Australia
- Western influence
- other cultures

Changes of scientific ideas over time
- comparison of ideas

Assessment strategy

Suggestions for gathering information about student learning are provided in each of the activities in this module. Once sufficient information has been collected, judgments can be made about students' demonstrations of outcomes. Typical demonstrations of this module's intended outcomes are provided here to indicate the pattern of behaviour to look for when making judgments.

Science and Society

4.1 Students outline some contributions to the development of scientific ideas made by people from different cultural and historical backgrounds.

Students may:
- explore the contributions of a range of cultures to the development of ideas in science;
- explore the contributions of people at different times to ideas in science;
- discuss the limitations of instruments used to make observations;
- synthesise information from different group investigations and from different sources;
- formulate questions to structure and further develop investigations.

Science and Society

5.1 Students consider how and why scientific ideas have changed over time.

Students may:

- discuss the evidence that led to changes in thinking about ideas in science, in particular the structure of the atom;
- examine and evaluate evidence to support the theory of continental drift, plate tectonics and the occurrence of earthquakes;
- assess the effect of using tools on the type, nature and quality of information collected;
- reflect on the changes in understanding that result from different or additional information;
- recognise the effects that increased knowledge and advances in tools and techniques have on changing scientific ideas.

Background information

Current scientific conceptions

Structure of the atom

The current model to describe atomic structure is the electron cloud model. Electrons are in constant, rapid motion within an energy level. This rapid motion creates a 'cloud' around the nucleus. The electron cloud determines the size and shape of the atom.

Causes of earthquakes

The surface of the Earth comprises a number of tectonic plates that move relative to one another. The movement is associated with earthquakes and volcanic activity. Movement of these plates has also caused the continents to change position on the surface of the Earth.

Middle Ages

The Western world created calendars and named specific periods of time based on a Euro-centric view of the world and its history. Other cultures in Asia, Africa, the Americas and Australia used other ways of describing the passage of time. Since a Euro-centric view has been pre-eminent in the history of Western science, periods of scientific development are frequently identified with reference to the 'Middle Ages', the 'Renaissance' and so on.

The Middle Ages or Medieval Period extended from the fifth to fifteenth centuries AD. In Europe, from the fifth to the eleventh centuries there appeared to be a general decline in education and government. This time is known as the Dark Ages.

Students' prior understandings

Students' prior understandings may differ from current scientific conceptions in a range of ways.

Some students may think that:

- ideas in science are full explanations, fixed and unchangeable;
- there are no new ideas in science; they were all developed a very long time ago;
- scientists have answers to all questions about natural phenomena.

Terminology

Terms associated with science and scientists are essential to the activities in this module — for example:

antibodies	Gondwana	Pangea
anticoagulant	Laurasia	platelets
antimetabolite	live donation	proton
atom	microscope	regenerative tissue
bacteria	neutron	tectonic plate
cadaveric donation	non-regenerative tissue	telescope
continental drift	nucleus	tissue transplant
earthquake	organ transplant	virus
electron		

Students may already be familiar with some of these terms and understand their meanings and use in scientific contexts. If so, the activities in this module will provide opportunities for them to evaluate current usage. If not, these activities will provide opportunities for students to develop their understandings.

School authority policies

Teachers need to be aware of and observe school authority policies that may be relevant to this module.

Safety policies are of particular relevance to the activities that follow. It is essential that demonstrations and student activities are conducted according to procedures developed through appropriate risk assessments at the school.

Support materials and references

Websites

People and Discoveries. Available URL:
http://www.pbs.org/wgbh/aso/databank/ (accessed December 2000).

History of the atom
Garfield County School District, *The Atom*. Available URL:
http://www.garfield.k12.ut.us/PHS/HISTORY/US/1940/H-BOMB/atom (accessed December 2000).

Medicine

Islamic Alchemy in the Context of Islamic Science. Available URL: http://www.levity.com/alchemy/islam.html (accessed December 2000).

Articles on alchemy are available on the following website: http://www.levity.com/alchemy/articles.html (accessed December 2000).

Mythology

Joyzine and the Adventures of Zoe. Available URL: http://www.joyzine.zip.com.au/australia/dreaming/dreaming.htm (accessed December 2000).

Myths and Legends. Available URL: http://www.fcs-net.com/biddled/myths_legend.htm (accessed December 2000).

Uranus — Deity of the Heavens. Available URL: http://www.dreamscape.com/morgana/uranus.htm (accessed December 2000).

Transplants

Australian Kidney Foundation. Available URL: http://www.kidney.org.au (accessed December 2000).

News International [search under 'transplants']. Available URL: http://www.thetimes.co.uk (accessed December 2000).

News Limited [search under 'transplants']. Available URL: http://www.news.com.au (accessed December 2000).

Heart Foundation of Australia. Available URL: http://www.heartfoundation.com.au (accessed December 2000).

The Transplantation Society of Australia and New Zealand. Available URL: http://www.racp.edu.au/tsanz/ (accessed December 2000).

United Network for Organ Sharing. Available URL: http://www.unos.org (accessed December 2000).

The following website has links to many other websites associated with organ and tissue donation and transplantation: http://www.argonet.co.uk/body/lnks.html (accessed December 2000).

Kit

Australian Kidney Foundation 1999, *The Kidney Kit* (contains a video, teacher background information and classroom activities for Years 5–12).

Available from the following organisations:

Australian Kidney Foundation
Floor 4, 133 Leichhardt Street
Spring Hill Q 4001
Tel: (07) 3832 2520
Fax: (07) 3832 3453

Education Image Pty Ltd
Floor 1, 176 Bridge Road
Richmond Vic. 3121
Tel: (03) 9429 6299
Fax: (03) 9427 0836

ACTIVITY

Why do I think that?

Introductory

Focus

This activity provides opportunities for students to reflect on ways in which they gain knowledge and the influences that might cause them to change their ideas.

Materials

For each group of students:

- Resource Sheet 1, 'What are these?'

Teaching considerations

Individuals make sense of new experiences using information gained from previous experience. The photographs on Resource Sheet 1 are presented without a scale and the subject matter may be unfamiliar to students. Students' attempts to interpret the images will reflect the experiences of early scientists trying to make sense of their observations. The images are of:

(a) scouring pad (c) surface of steel nut (e) human hair (European)
(b) house fly — foot (d) moth scales (f) concrete mineral from Berlin wall

Working scientifically

Time: 45 minutes

Seeking reasons
Formulating and elaborating ideas
Judging credibility
Reflecting and considering
Discussing thinking
Expressing points of view

▶ Students brainstorm what is meant by the term 'source of information'.

▶ Students individually list sources of information they believe to have been important in making a significant contribution to their knowledge base. They describe the nature of the information they gained from that source. Students could record their ideas in a table like the one below.

Collecting information

Source of information	Nature of information
parents/caregivers	• facts about their interests (e.g. sports, hobbies, work) • information about the family • ....
books	• facts about a wide variety of topics • knowledge about how to write • ....

▶ In small groups, students discuss examples of beliefs they no longer hold or understandings that have changed as they have grown older. They discuss their reasons for changing their ideas.

Resource Sheet 1

▶ Students study the images on Resource Sheet 1. Each person in the group suggests what the image represents and explains the suggestion. The group discusses the various ideas and the reasons for them. Students come to an agreement about what the images represent.

▶ Students examine the nature of the information provided through observation of the images and discussion with others. They decide which type of information had the greatest influence on their final decisions.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' completed tables.

ACTIVITY

Discovering atoms

Developmental

Focus

This activity provides opportunities for students to explore some ideas that have developed over time, leading to current models of the atom.

Materials

For the teacher:

- Resource Sheet 2, 'Scientists' contributions to current understandings of the atom'

For the class:

- resources from the library or Internet on scientists throughout history (see below)

Teaching considerations

Students work in small groups to collect information about individual scientists whose work has contributed to our knowledge of atomic structure. Scientists to be studied include:

Aristotle
Niels Bohr
Robert Boyle
James Chadwick
John Douglas Cockcroft and Ernest Thomas Walton
John Dalton
Democritus
Galileo Galilei
Werner Heisenberg
Maria Goeppert-Mayer
Dmitri Mendeleev
Robert Millikan
Isaac Newton
Ernest Rutherford
Joseph John Thompson

Students share their information to create one timeline for the class.

Resource Sheet 2

Information about each of the scientists is provided on Resource Sheet 2 for teacher reference.

Working scientifically

Accessing resources
Collecting information
Dealing in an orderly manner with the parts of a complex whole
Synthesising
Clarifying ideas and concepts
Creating presentations
Discussing thinking

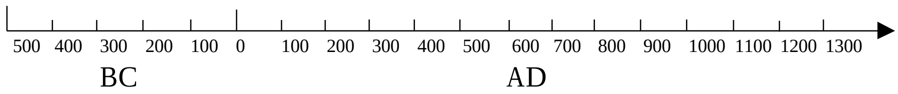
Time: 45 minutes

▶ In groups, students select one of the scientists from the list and collect information about:

- the time period in which the scientist lived;
- where the scientist lived and worked;
- ideas the scientist had and the contribution made to understandings about atoms;
- the nature of the research and how the findings contributed to the scientist's ideas.

▶ Students report the information they have collected to the class.

▶ As a class, students create a timeline showing the chronological order of the scientists and the ideas they developed. They identify the earliest and latest dates and then draw a line to scale that will enable that range of dates to be represented. The name, dates and one sentence outlining significant ideas are added for each of the scientists.



▶ Students discuss what the information on the timeline reveals about possible influences on scientific ideas. Points for discussion could include:

- the length of time between the work of Aristotle and that of Galileo when no significant changes to thinking are recorded;
- the predominance of male Europeans in the list of scientists studied.

▶ Students may recognise that there was a long time period when no significant new ideas were recorded. Students suggest reasons for this.

Additional learning

▶ Students collect information about the uses made of current knowledge of atomic structure.

Gathering information about student learning

Sources of information could include:

- students' use of resources and selection and synthesis of information;
- students' contributions to the completion of the timeline;
- students' contributions to discussions.

ACTIVITY

Ideas about earthquakes have changed

Developmental

Focus

This activity provides opportunities for students to explore different explanations for the occurrence of earthquakes and to reflect on the evidence supporting current scientific explanations.

Materials

For the teacher:

- Resource Sheet 3, 'Timeline: Ideas about earthquakes'

For students:

- Resource Sheet 4, 'Distribution of earthquakes and volcanoes'
- Resource Sheet 5, 'Making Gondwana'
- Resource Sheet 6, 'A map of Gondwana'
- library or Internet resources about explanations for earthquakes, from early times to the present

Teaching considerations

Teaching strategies

In early times, people created stories to explain the occurrence of earthquakes. In many of these stories, earthquakes were attributed to the movements of animals. For example, the Hindus of India told stories about elephants, the Mongolians about twitching frogs, and the Japanese about catfish. There were also stories of the gods being responsible for earthquakes. Some examples of such stories will need to be collected before the activity begins. Try to obtain stories from as many different cultures as possible. The following website may be a useful source: http:// www.fcs-net.com/biddled/myths_legend.htm

Resource Sheet 3

Resource Sheet 3 provides a timeline of ideas about earthquakes. The Resource Sheet has been provided as background information but could be used as stimulus for class discussion. Similarities between some of the ideas could be discussed. This resource sheet is included for teacher use but could be provided to students.

Resource Sheet 5 requires students to look at the symbols for organisms on the map. They then use this information to suggest which parts of the land masses may have originally been close together.

The lack of new ideas from dates BC to 1760 could also be discussed. Some of this time is the Medieval period when there appeared to be little general development of ideas in the Western world. This is also reflected in the timeline associated with the structure of the atom in the activity, 'Discovering atoms'.

Students with vision impairment

Some students with vision impairment may need assistance for this activity. Seek advice from their support teacher.

Working scientifically

Time: 90 minutes

Collecting information
Hypothesising
Constructing meaning
Dealing in an orderly manner with the complex parts of a whole
Interpreting data
Selecting and justifying
Synthesising
Describing
Exploring and elaborating ideas
Summarising and reporting

Resource Sheets 4–6

▶ Students read stories created by various peoples in early times to explain the cause of earthquakes. They reflect on the stories and identify similarities and differences. Students suggest reasons for similarities and differences that have arisen in the stories from various cultures. Questions for discussion could include:

- Why do you think so many cultures linked earthquakes to animals?
- Why were particular animals included in the stories — for example, elephants and fish?

▶ Students discuss the current scientific explanation for earthquakes — that is, they result from movements of the tectonic plates of the Earth's crust (see 'Background information', p. 3). Students work in small groups to answer the following questions:

- What are the basic ideas underpinning the theory of plate tectonics?
- When was the theory of plate tectonics first suggested and by whom?
- What evidence has the scientific community used to support the theory?

▶ Students reflect on any patterns they observe on Resource Sheet 4. They make links between these patterns and the idea that tectonic plates move relative to each other.

▶ In groups, students use Resource Sheet 5 to reconstruct Gondwana. Information is provided about where fossils have been found and where there has been an ice sheet in the past (286 million years ago). Students use these clues and suggest the relative positions of the continents 250 to 300 million years ago. They cut out the continents from the Resource Sheet and paste them onto a sheet of A4 paper showing a suggested organisation of Gondwana.

▶ Students share their ideas with the class and discuss the different ideas that have been represented. They compare their maps with the map of Gondwana in Resource Sheet 6.

▶ Students clarify their ideas by reflecting on and discussing the following question:

- Do you think that the evidence presented is enough to support the theory of plate tectonics? Why or why not?

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions of stories about earthquakes and answers to the questions;
- students' use of resources and selection of information;
- students' discussions and completion of resource sheets;
- students' responses to the validity of the evidence for the theory of plate tectonics.

ACTIVITY

Better tools — more information

Developmental

Focus

This activity provides opportunities for students to become aware of the effect tools or equipment have on the nature and quality of information collected.

Materials

- Resource Sheet 7, 'First look through the telescope: Galileo Galilei'
- magnifying glass or hand lens
- microscope
- binoculars
- telescope
- material to examine using the microscope
- slides and coverslips
- library and Internet resources on various types of microscopes and telescopes (see suggestions below)

Teaching considerations

Approach

As an alternative to all students reading the material on Resource Sheet 7, some students could role-play Galileo's account, adopting the character of Galileo.

Prior learning

Students need to know how to use a microscope, binoculars or telescope before they begin this activity. This activity provides an opportunity for students to further develop skills in preparing material for microscopic examination.

Links to other activities

Link this activity with others where the effect of lenses is examined. If no such activities have been planned, provide students with opportunities to explore the magnifying effect of lenses of different shapes and combinations.

This activity could also be combined with an astronomy night with students observing the stars or the moon.

Organisation

Locate a suitable place for students to use the binoculars and telescope.

Providing students with opportunities to view materials through poor quality lenses or scratched, damaged lenses would help them to appreciate the benefit of having good quality lenses. If a video microscope is available, it could be used to provide students with an opportunity to examine a wider range of materials and to discuss their observations as a class.

Instruments that could be studied in the last part of this activity include:

- stereo microscopes;
- polarising microscopes;
- electron microscopes (scanning, tunnelling, transmission);
- radio telescopes.

Students with vision impairment

Some students with vision impairment may need assistance for this activity. Seek advice from their support teacher.

Working scientifically

Time: 70 minutes

Engaging with problems
Handling materials
Making and judging observations
Interpreting data
Making comparisons
Illustrating

Resource Sheet 7

▶ Students read the story of Galileo's first look through the telescope (Resource Sheet 7) as an introduction to the activity. They then discuss:

- the nature of the new observations Galileo was able to make;
- his reaction to his discoveries;
- their reaction to a situation where they have 'seen' something they were not able to see before.

▶ Students prepare a piece of material suitable for examination under the microscope — for example, soft stem of a geranium shoot, onion leaf, onion skin from between the fleshy layers of the bulb, cheek cells, coloured picture from a newspaper. They examine these materials using the naked eye, a hand lens or magnifying glass, and a microscope. They record any detail they can see. The observations could be recorded in a table like the one below.

	Naked eye	Hand lens	Microscope — magnification		
			x 4	x 10	x 100
What could be seen?					

▶ Students select a subject that can be observed using a telescope. They then record the detail of the subject that is visible, using the naked eye, binoculars and telescope. A table like the one shown here could be used to record the results.

	Naked eye	Binoculars	Telescope
What could be seen?			

▶ Students discuss both sets of observations. Discussion questions could include:

- What were you able to see with the binoculars/hand lens that you could not see with the naked eye?
- What were you able to see with the telescope/microscope that you could not see with the naked eye?
- How has this increased your knowledge or understanding of the subject (leaf, onion skin, stars) that you were looking at?
- How has this new understanding changed your ideas about ___ (*for example, living things, the solar system*)?

▶ Students research other types of microscopes and telescopes and how they are used. They prepare an information report that they share with the class. Information could include:

- the name of the instrument;
- when it was developed;
- the nature of the information that can be collected using it;
- how and/or where this information is used;
- benefits derived from information collected.

Additional learning

▶ Students investigate ways in which computers have been used to enhance observations made using telescopes or microscopes. They then explain how this has further increased understanding of natural phenomena.

▶ Students investigate the nature of information being collected through the use of rockets and spacecraft. They describe ways in which this information has been used.

Gathering information about student learning

Sources of information could include:

- students' observations using the telescope or microscope;
- students' contributions to discussions about the benefits of using instruments to enhance observations;
- students' selection and synthesis of information about instruments.

ACTIVITY

Medicine then and now

Developmental

Focus

This activity provides opportunities for students to reflect on changes in the understanding and treatment of disease.

Materials

For each student:

- Resource Sheet 8, 'When did I live?'

For the class:

- resources from the library and the Internet (see suggested topics below)
- butcher's paper
- overhead transparency

Teaching considerations

Place time limits on the brainstorming and compilation of a class list of ideas.

Provide a timeline for students' preparation and completion of research. Possible stages to identify are completion of guide questions; completion of research; first draft; and final draft. Topics that are worthy of inclusion in the list are:

- development and use of antiseptics and the work of Lister;
- bacteria as disease-causing organisms and the work of Pasteur and Koch;
- immunisation and the contribution of Pasteur, Koch, Jenner and Salk;
- discovery and development of antibiotics and the roles of Fleming and Florey;
- viruses as causes of disease;
- use of leeches in medicine in the past and present.

Information

The person described in Resource Sheet 8 is Al-Razi who lived and worked in Ray (near Tehran) and Baghdad from the mid-ninth century to about AD 925.

The story has been modified from *Arabic (or Islamic) Influence on the Historical Development of Medicine (2)*, edited and prepared by Professor Hamed A. Ead.

Sensitive issues

Be sensitive to students' experiences and circumstances — for example:

- Some students may have family members or friends who are ill and may not wish to discuss specific diseases.
- Students may come from families or communities where specific treatments of disease are regarded as unacceptable.

Working scientifically

Time: 40 minutes; 2–3 lessons plus homework time for research

Resource Sheet 8

▶ Students read the information on Resource Sheet 8, 'When did I live?'. In pairs they discuss the information and suggest answers to the following questions:

- When was this person living?
- What evidence do you have to support this idea?

Collecting information
Engaging with problems
Formulating questions
Formulating and elaborating ideas
Reflecting and considering
Selecting and justifying
Creating presentations
Retelling and restating
Using scientific terminology

▶ Students share their answers and reasoning with the class. They are told who the person was and when and where he was working. Students comment on the relevance of any ideas in the story to issues today.

▶ Working in groups of four, students brainstorm words and phrases associated with diseases and their treatment and record these on butcher's paper. Two groups join to form a group of eight. Students combine their lists and delete any duplicate words, creating a single list of words and phrases.

▶ The list from one of the groups of eight is transferred to an overhead transparency. Spokespersons from the other larger groups add to the overhead transparency any words or phrases from their groups' lists that are not included. In this way a whole-class list will be compiled.

▶ As a class, a decision is made about categories for grouping the words on the list. A possible grouping could be:

- names of diseases;
- causes of diseases;
- treatments.

▶ Students individually decide on a topic they wish to explore further. They are reminded that the focus of this activity is on the **changes in understanding** that have occurred and **reasons for** or **causes of** the changes. They identify questions to guide research of the topic — for example:

- When were (antiseptics, antibiotics) first developed? Or when were bacteria first discovered?
- What were the names of the scientists who were involved in the research into (antiseptics/antibiotics/immunisation)?
- What were the beliefs of the people at the time about the causes of disease?
- How were the new discoveries made?
- What was the response of the scientific community to the new discoveries?

▶ Students present the information collected to the class. Formats for presentation could include:

- a poster for display in the classroom or library;
- an information report;
- a biography of the researcher or information about the disease.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' contributions to the brainstorming session;
- students' presentations of information.

SCIENCE NOW AND THEN • LOWER SECONDARY

ACTIVITY

Transplants

Developmental

Focus

This activity provides opportunities for students to recognise that transplants are a significant part of modern medicine.

Materials

For teacher reference or for students' use:

- Resource Sheet 9, 'Transplants'
- Resource Sheet 10, 'Transplant timelines'

For the class:

- access to the Internet
- newspaper articles (from relevant websites; see suggestions, p. 5)

Teaching considerations

Prior understanding

Before undertaking this activity, students need a basic understanding of the functioning of the systems to which transplants relate. This activity could be used as a culminating activity associated with study of the human respiratory, circulatory and excretory systems.

Ethical issues

Discussions in this activity should focus on the way transplants have changed the treatment of disease. Although questions related to ethical issues may arise, the focus of the activity should be maintained. Opportunities to explore the issue from an ethical perspective are included in the module 'Scientists — past and present' (Science and Society, Level 6).

Organisation

R Resource Sheets 9, 10

Resource Sheets 9 and 10 have been provided as background information for teachers. Information from them could be made available to students who are experiencing difficulty finding their own information for this activity.

Visit to a renal unit

For students living in Brisbane, a visit to the renal unit at the Princess Alexandra Hospital could be arranged.

Sensitive issues

Be sensitive to students' experiences and circumstances — for example:

- Some students may have family members or friends who have had a transplant or who are awaiting a transplant.
- Students may come from families or communities where transplants are not an acceptable option.

Working scientifically

Time: 10 minutes for brainstorming and compilation of list; class and homework time to collect information and prepare the presentation; 20 minutes to compile the timeline

Collecting information
Formulating questions
Making links
Synthesising
Creating diagrams
Creating presentations
Summarising and reporting

▶ Students brainstorm ideas they have about tissue or organ transplants. They then make a list of the different types of tissues or organs that can be transplanted — for example, blood, heart valve, cornea, kidney, heart, lungs, and liver.

▶ In small groups, students research one type of tissue or organ transplant. They formulate questions to guide their research, gather information about one of the transplant procedures and prepare presentations for the class. Presentations could be in the form of a poster, an information report or a pamphlet. Questions to guide their research could include:

- When and where did this type of organ transplant first take place?
- Who developed the process?
- What advances in technology enabled the procedure to occur in the first place or to be refined?
- What advances in knowledge of the functioning of the body contributed to the success of the procedure?

▶ Using information from all the groups, construct a timeline showing when and where each type of transplant was first undertaken and, if possible, by whom.

Additional learning

▶ A transplant recipient from the local community could be invited to talk to the class about his or her experience of, and reaction to, the transplant.

Gathering information about student learning

Sources of information could include:

- students' contributions to the brainstorming session and compilation of the list of transplanted organs;
- students' identification, interpretation and synthesis of relevant information;
- students' presentations;
- students' contributions to the development of the timeline.

ACTIVITY

Influences on science

Culminating

Focus

This activity provides opportunities for students to reflect on causes of change in scientific ideas.

Materials

- information gathered during previous activities

Teaching consideration

Development of the concept map could be completed individually, in groups or individually after group discussion.

Working scientifically

Time: 20 minutes

Constructing meaning
Making links
Synthesising

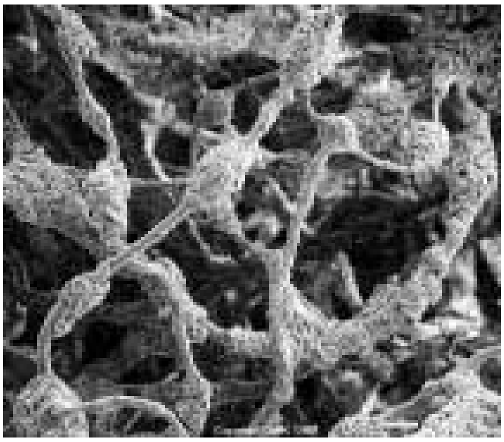
▶ Students reflect on the previous activities, focusing on the changes in scientific thinking and the ways scientists work. They identify the causes of change and develop a chart showing the relationship between causes and effects. For example, sophisticated instruments such as microscopes have been developed. These enable objects invisible to the naked eye to be seen. This technology led to identification of bacteria and to an understanding of bacteria as the cause of many diseases.

Gathering information about student learning

Sources of information could include:

- students' charts.

What are these?



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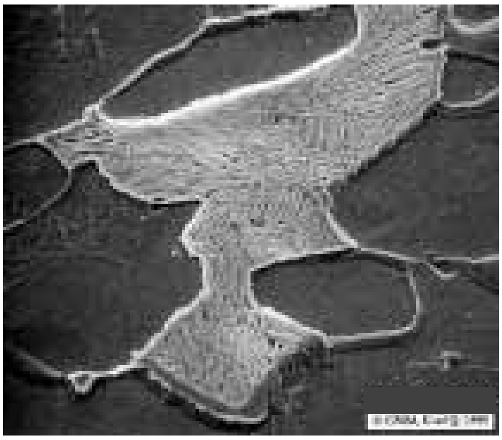

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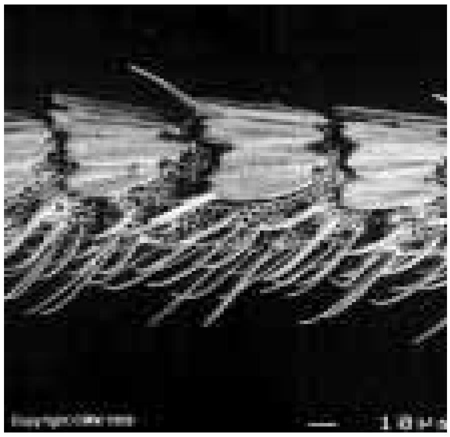

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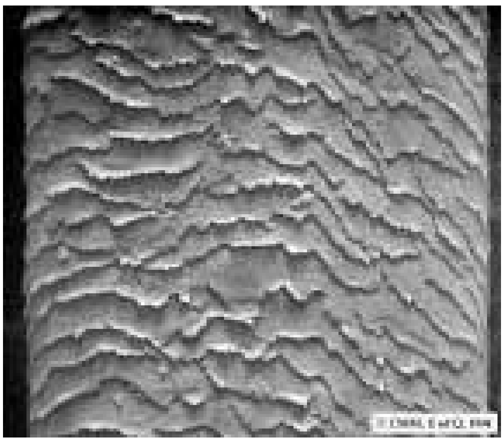

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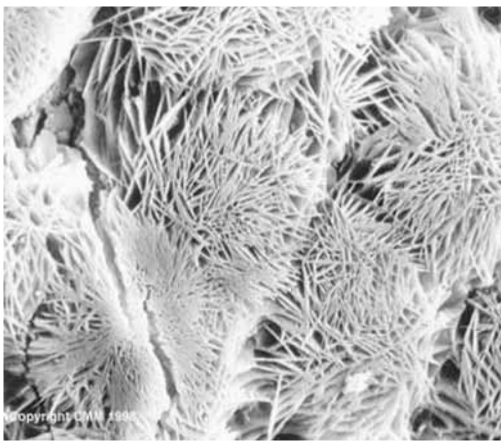


(f)

Source: The Centre for Microscopy and Microanalysis, The University of Queensland, by permission.

Scientists' contributions to current understandings of the atom

Scientists	Dates	Nationality	Contribution
Democritus	460?–370? BC	Greek	He imagined that in nature there is constant motion of small, indivisible particles, which he called atoms. He described atoms as the basic building blocks of matter, being of different shapes and sizes, and unchanging.
Aristotle	384–322 BC	Greek	His ideas opposed those of Democritus. He thought that substances were made up of four qualities: dryness, wetness, heat and cold. His ideas overshadowed Democritus's theories for many centuries.
Galileo Galilei	1564–1642	Italian	He revived Democritus's ideas and imagined a world consisting of countless atoms separated by a vacuum. He saw atoms as being indivisible but having no predetermined shape or dimension.
Robert Boyle	1627–1691	English	He carried out many experiments on matter. His results suggested that air is composed of separate moving atoms that stay a considerable distance from each other. He suggested that different types of matter could be decomposed into a 'simple body'. Beyond that they could not be decomposed any further. The number of 'simple bodies' was unknown.
Isaac Newton	1642–1727	English	He thought that matter consisted of atoms. He also thought that light was composed of atoms and that solar rays were streams of particles. Interactions between materials were interactions between atoms.
John Dalton	1766–1844	English	He used the theory of atoms to explain the results of his experiments. He suggested that atoms of different elements had different masses. He took the mass of hydrogen as the unit of mass and laid the foundation for the calculation of atomic masses for all elements. Up until this time, ideas about atoms were hypothetical. Dalton provided empirical evidence indicating that atoms were real. He visualised atoms as being solid spheres. He proposed his ideas in 1808 and 1810.

(continued)

Scientists' contributions to current understandings of the atom *(continued)*

Scientists	Dates	Nationality	Contribution
Dmitri Mendeleev	1834–1907	Russian	He recognised that, when placed in order of mass, every eighth element had similar characteristics. He created a periodic table in 1869. At that time there were many empty places in the table. He predicted that other elements would be discovered.
Joseph John Thompson	1856–1940	English	He completed the first experiments that led to an understanding of the composition of the atom. He found that atoms were not simple solid spheres. They contain smaller, subatomic particles. The particles he identified were very small and negatively charged, and he called them electrons. He made this discovery in 1897. Since Thompson knew that atoms had no overall charge, he reasoned that the atom must contain a positive charge to balance the negative charge of the electrons. He visualised a model later called the 'plum pudding' model in which electrons are stuck into the surface of a positively charged sphere.
Ernest Rutherford	1871–1932	New Zealander	He knew that the atom contained positively charged protons. The theory of the time suggested that electrons and protons were uniformly distributed throughout the atom to minimise electrostatic repulsions. He completed experiments in 1906 that indicated that the protons are concentrated in a very small area in the centre called the nucleus. The nucleus contains most of the mass of the atom; and most of the atom is empty space. Rutherford's model has been called the planetary model with the electrons being compared to the planets orbiting round the sun.

(continued)

Scientists' contributions to current understandings of the atom *(continued)*

Scientists	Dates	Nationality	Contribution
Niels Bohr	1885–1962	Danish	In 1913 he modified Rutherford's model by suggesting that the electrons are in constant motion around the nucleus, moving in orbits of fixed size and energy. The energy of an electron is lower for small orbits close to the nucleus and higher for larger orbits. Electrons can jump from one orbit to another but cannot move closer to the nucleus than the lowest energy level. Energy levels surround the nucleus in rings or shells like the layers of an onion.
Robert Millikan	1868–1953	American	He calculated the charge on an electron and was subsequently able to calculate the mass of an electron.
Werner Heisenberg	1901–1976	German	He discovered in 1926 that it is impossible to predict accurately both the position and the momentum of any object (including an electron) at the same time. This idea became known as the Heisenberg uncertainty principle.
James Chadwick	1891–1974	English	He showed in 1932 that the nucleus of most atoms contains a third type of subatomic particle called a neutron. The neutron has no charge and a mass similar to the proton.
John Cockcroft and Ernest Walton	1897–1967 1903–1995	British Irish	They split the atom in 1932 to release an amount of energy greater than the amount of energy used to split it.
Maria Goeppert-Mayer	1906–1972	German — working in the United States of America	She thought that protons and neutrons were orbiting in pairs within shells in the nucleus. These shells were like the rings in an onion. This theory, developed in 1948, explains why some nuclei are more stable than others and why some elements produce isotopes.

Timeline: Ideas about earthquakes

Name	Dates	Why earthquakes occur
Thales	Between 625 and 640–547 BC	The Earth is a disc that floats on water. Movements in the water cause earthquakes.
Anaximander	610–546 BC	Great clefts open up in the Earth after drying caused by excessive drought and after excessive rain. Air enters these clefts with excessive violence causing the Earth to shake.
Anaximenes	585–525 BC	When the Earth is dry following drought, it breaks and falls in. If rain makes the Earth excessively wet, it falls apart. Both drought and excessive rain cause earthquakes.
Democritus	460–370 BC	The Earth is full of water. When large amounts of rain fall, the cavities in the Earth cannot contain it all. Water forcing its way out causes the earthquake. If the Earth becomes very dry, water is lost from the cavities and they impact, again causing earthquakes.
Aristotle	384–322 BC	Wind blowing through cavities in the Earth causes earthquakes.
Seneca	4 BC–AD 65	Earthquakes are caused by air moving quickly from one place to another. The air within the Earth remains calm until a force from outside causes it to move. If it cannot escape, then it pulls any barriers apart.
Thomas Digges	1576	Earthquakes are caused by trapped wind.
Nathan Bailey	1730	Fire or hot air trapped in hollow parts of the Earth force their way out causing a violent shock that can destroy cities.
Theory of continental drift		
Alexander von Humboldt	1800	Lands bordering the Atlantic Ocean had once been joined.
Antonio Snider-Pellegrini	1850	The presence of identical fossils and coal deposits in North America and Europe suggests that the two continents had been joined in the past.
Frank Taylor	1908	Some of the world's mountain ranges were formed by the collision of continents.

(continued)

Timeline: Ideas about earthquakes *(continued)*

Name	Dates	Why earthquakes occur
Alfred Wegener	1912	Brought together geological and palaeontological data and hypothesised that throughout most of geological time there was only one continent, called Pangea. The continent fragmented (245–208 million years ago), and the parts began to move apart. He proposed the theory of continental drift.
Alexander Du Toit	1937	Modified Wegener's hypothesis by suggesting that originally there were two continents, Laurasia, to the north and Gondwana to the south.
During the 1950s and 1960s information was collected that enabled people to refine the theory about the movement of continents.		
J. Tuzo Wilson	mid-1960s	Formulated the theory of plate tectonics. According to this theory, the lithosphere consists of a number of plates that move relative to one another. While plates are moving, they cause mountains to rise and continents to pull apart. Earthquakes and volcanic activity are associated with this movement.

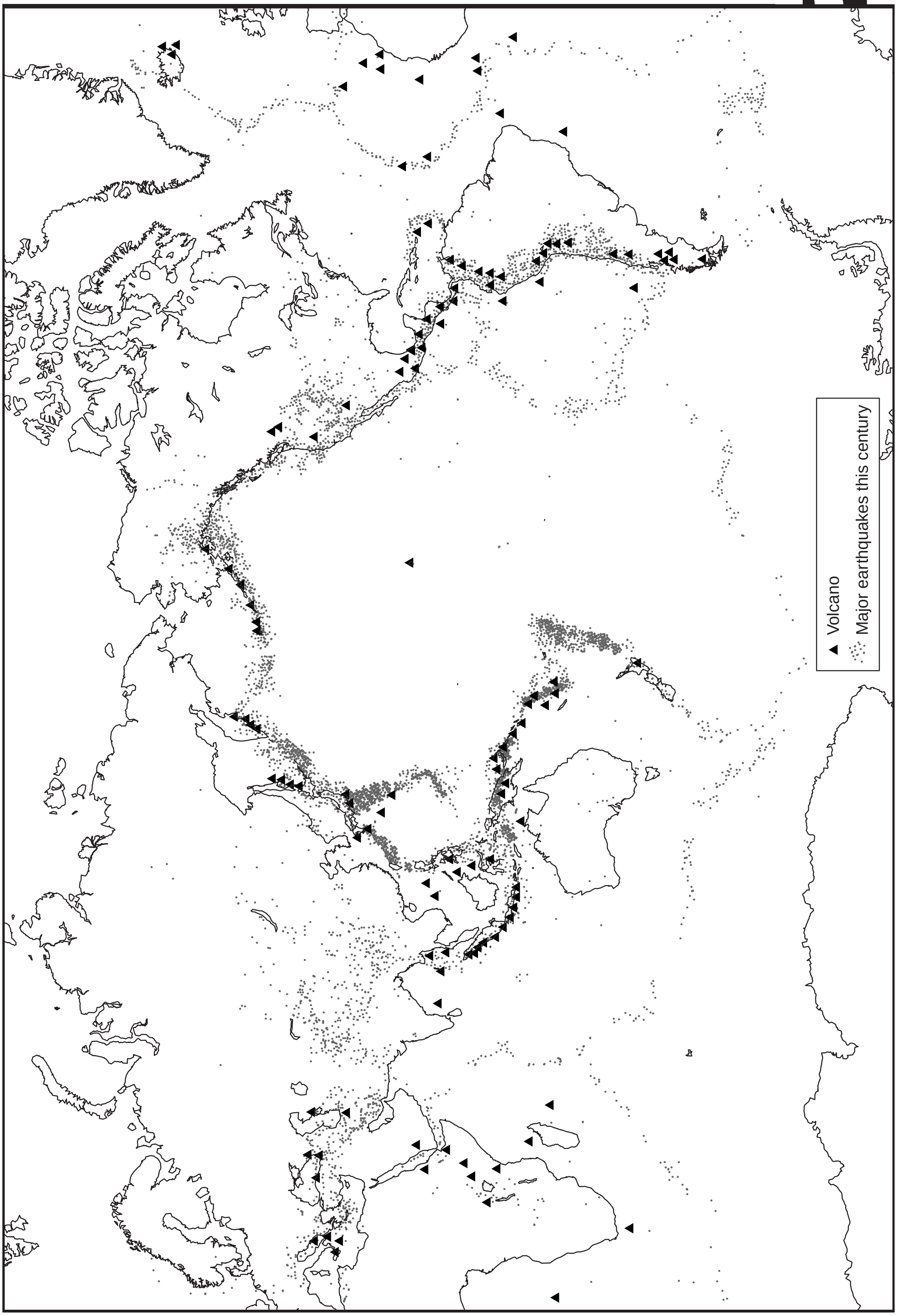
The theory of plate tectonics is likened to a scientific revolution. It had significant impact on:

- reconstructing understanding about the past geography of continents and oceans;
- the study of mountain-building and ancient climates;
- understanding of the evolution of life.

Most people now accept this theory. The process causing the plates to move is not fully understood.

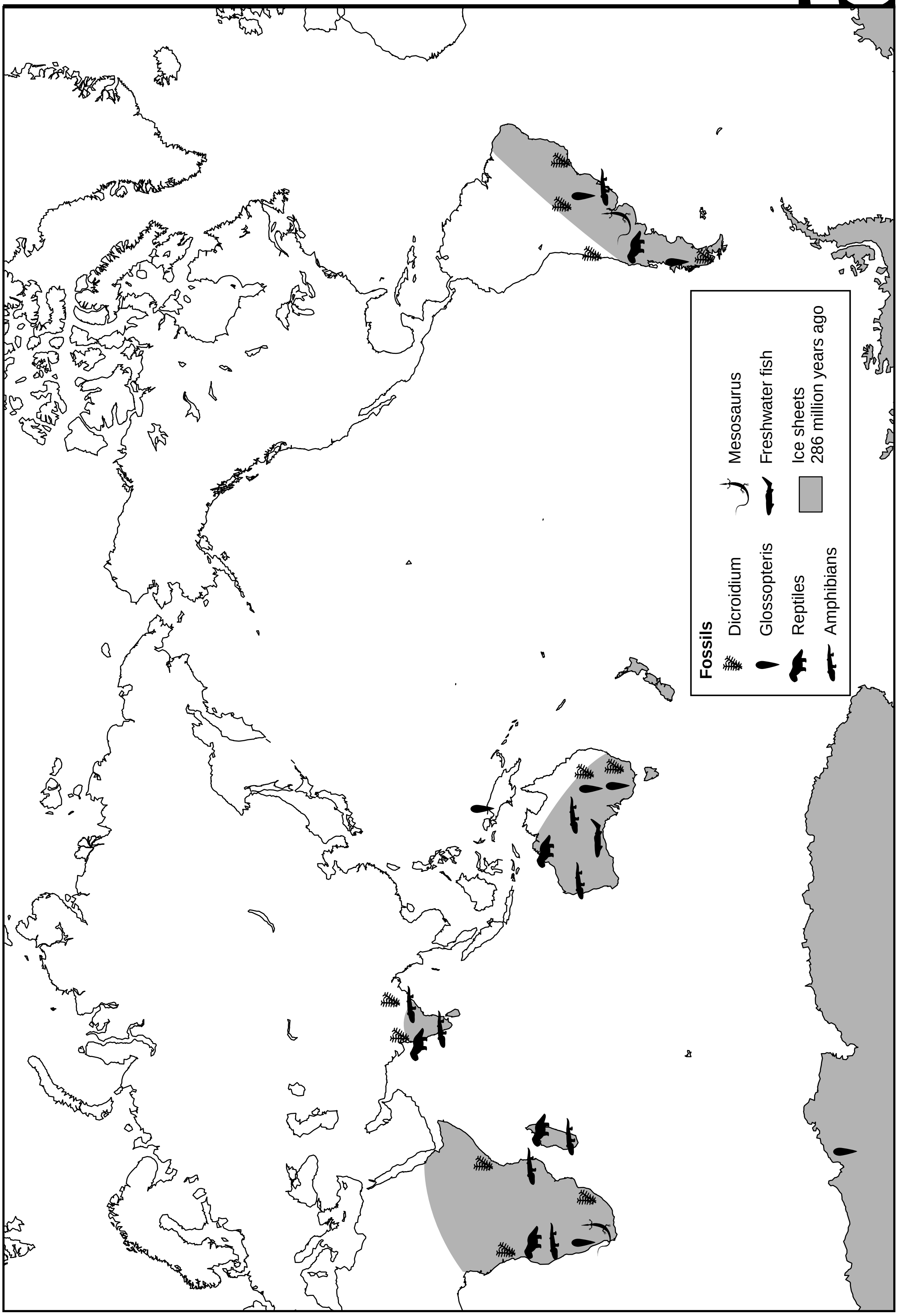
Distribution of earthquakes and volcanoes

R4 Resource Sheet 4



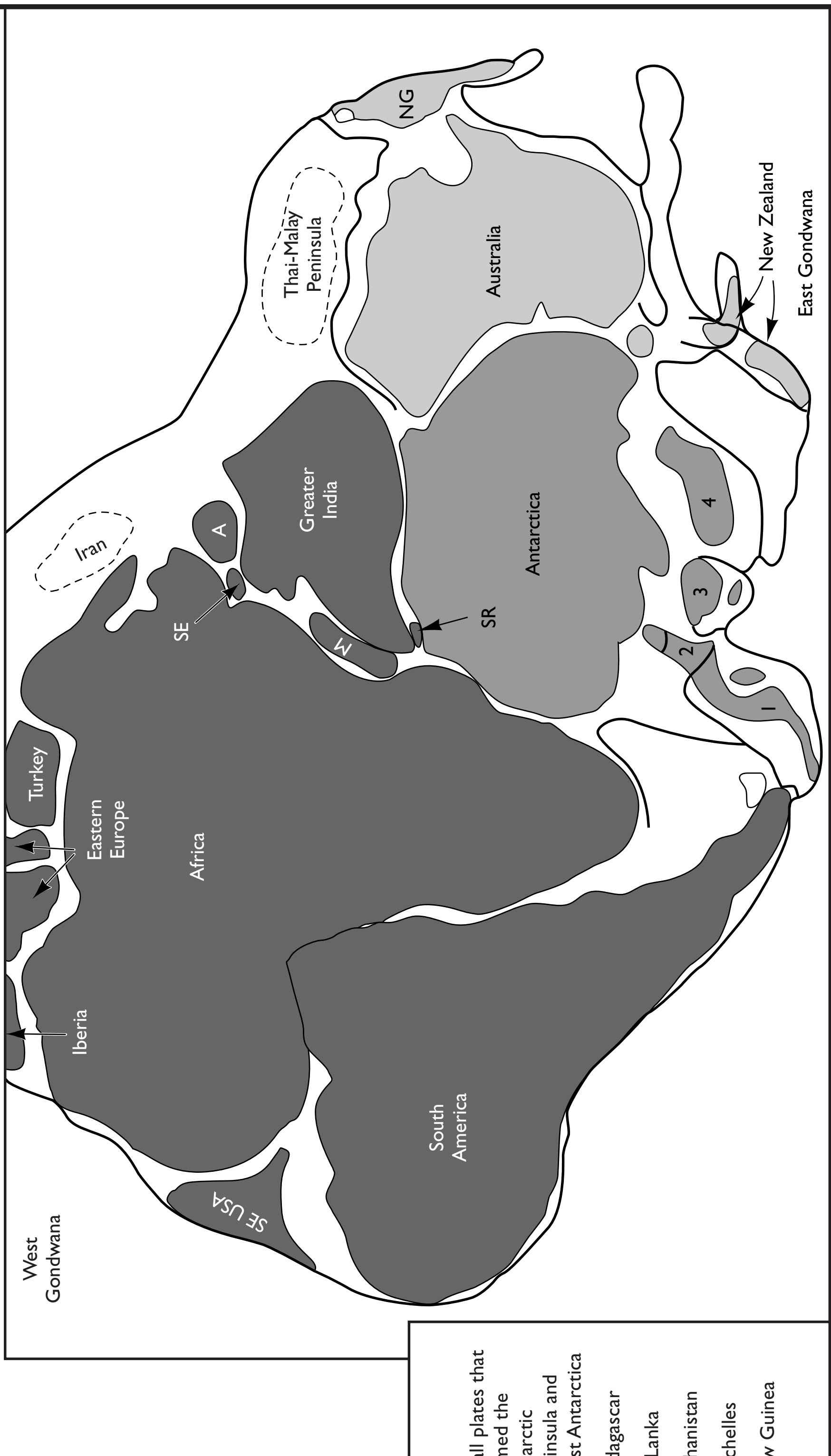
Source: Queensland Department of Education 1986, *Topicbook 1 — Planet Earth: Guidelines for Secondary Schools, Years 8–10 Science*, by permission.

Making Gondwana



A map of Gondwana

R6 Resource Sheet 6



Source: White, M. E. 1997, *After the Greening: The Browning of Australia*, Kangaroo Press, Kenhurst, NSW, by permission.

First look through the telescope: Galileo Galilei

R7 Resource Sheet 7

The Moon

Let me review the observations made by me during the two months just past ... inviting the attention of all who are eager for true philosophy to the beginnings which led to the sight of most important phenomena.

Let me speak first of the surface of the Moon which is turned towards us. For the sake of being understood more easily, I distinguish two parts in it, which I call respectively the brighter and the darker. The brighter part seems to surround and pervade the whole hemisphere; but the darker part, like a sort of cloud, discolours the Moon's surface and makes it appear covered with spots. Now these spots, as they are somewhat dark and of considerable size, are plain to every one, and every age has seen them, wherefore I shall call them great or ancient spots, to distinguish them from other spots, smaller in size, but so thickly scattered that they sprinkle the whole surface of the Moon, but especially the brighter portion of it. These spots have never been observed by any one before me; and from my observations of them, often repeated, I have been led to that opinion which I have expressed, namely, that I feel sure that the surface of the Moon is not perfectly smooth, free from inequalities and exactly spherical, as a large school of philosophers considers with regard to the Moon and the other heavenly bodies, but that, on the contrary, it is full of inequalities, uneven, full of hollows and protuberances, just like the surface of the Earth itself, which is varied everywhere by lofty mountains and deep valleys.

The appearances from which we may gather these conclusions are of the following nature: — On the fourth or fifth day after new-moon, when the Moon presents itself to us with bright horns, the boundary which divides the part in shadow from the enlightened part does not extend continuously in an ellipse, as would happen in the case of a perfectly spherical body, but it is marked out by an irregular, uneven and very wavy line, as represented in the figure given, for several bright excrescences, as they may be called, extend beyond the boundary of light and shadow into the dark part, and on the other hand pieces of shadow encroach upon the light: — nay, even a great quantity of small blackish spots, altogether separated from the dark part,

(continued)

First look through the telescope: Galileo Galilei *(continued)*

sprinkle everywhere almost the whole space which is at the time flooded with the Sun's light, with the exception of that part alone which is occupied by the great and ancient spots. I have noticed that the small spots just mentioned have this common characteristic always and in every case, that they have the dark part towards the Sun's position, and on the side away from the Sun they have brighter boundaries, as if they were crowned with shining summits. Now we have an appearance quite similar on the Earth about sunrise, when we behold the valleys, not yet flooded with light, but the mountains surrounding them on the side opposite to the Sun already blaze with the splendour of his beams; and just as the shadows in the hollows of the Earth diminish in size as the Sun rises higher, so also these spots on the Moon lose their blackness as the illuminated part grows larger and larger.

Again, not only are the boundaries of light and shadow in the Moon seen to be uneven and sinuous, but — and this produces still greater astonishment — there appear very many bright points within the darkened portion of the Moon, altogether divided and broken off from the illuminated tract, and separated from it by no inconsiderable interval, which, after a little while, gradually increase in size and brightness, and after an hour or two become joined onto the rest of the bright portion, now become somewhat larger; but in the meantime others, one here and another there, shooting up as if growing, are lighted up within the shaded portion, increase in size, and at last are linked on to the same luminous surface, now still more extended. An example of this is given in the same figure. Now, is it not the case on the Earth before sunrise, that while the level plain is still in shadow, the peaks of the most lofty mountains are illuminated by the Sun's rays? After a little while, does not the light spread further, while the middle and larger parts of those mountains are becoming illuminated; and at length, when the Sun has risen, do not the illuminated parts of the plains and hills join together? The grandeur, however, of such prominences and depressions in the Moon seems to surpass both in magnitude and extent the ruggedness of the Earth's surface ...

Source: 'First Look Through a Telescope', *The Sidereal Messenger*, 1610.

When did I live?

After completing my studies, I returned to my hometown to take up a position as director of the hospital. Within a few years I was appointed director of a new hospital and my first job was to help decide where to build it. I hung pieces of meat in various parts of the city and suggested that the hospital be built at the site where there had been the least decay.

I often worked with children and might be considered to be the 'father of paediatrics'.

I identified hay fever and its causes and did classic work on kidney stones.

I advocated that doctors observe their patients and listen to their medical histories rather than just look up the symptoms in a book to get the diagnosis. I always felt that doctors should help each other and that consultation between them could sometimes result in a more appropriate treatment for some patients.

I led a fight against quacks and charlatans and wrote a book exposing their methods. I believe strongly in professional standards for doctors and insisted on continuing education for qualified people. This is the only way they could keep up to date with new developments.

I was always willing to try new ideas but still depended on medicines that had been tested and shown to be beneficial.

I was interested in many things. I wrote papers about:

- diet and drugs and their effects on human bodies;
- mother and child care;
- skin diseases;
- oral hygiene;
- climate and the effect of environment on health;
- epidemiology (the study of epidemics) and toxicology (the study of poisons).

I was the first to be able to distinguish between measles and smallpox. The guidelines I prepared for treating these diseases are still useful.

Source: Adapted from Prof. Hamed A. Ead (ed.), *Arabic (or Islamic) Influence on the Historical Development of Medicine (2)*. URL: http://www.levity.com/alchemy/islam23.html (accessed August 1999).

Transplants

Two types of tissues can be transplanted, regenerative tissue and non-regenerative tissue. They can be transplanted in two ways: from a live donor or from a cadaveric donation (that is, from a person who has died).

Live donations

Regenerative tissue, which includes blood and bone marrow, can be donated by anyone and there are no restrictions on who can receive it. This is the most common type of transplant from a live donor and carries very low risk.

Kidneys, lungs and liver are non-regenerative tissues and the transplant of these is less common although its frequency is increasing. The number of donors restricts the number of transplants and the donors are usually restricted to blood relatives or people who are emotionally linked — for example, husband and wife. High risks for the donor are associated with this type of donation. It involves invasive surgery with its potential for associated problems.

In all transplant situations there needs to be matching of tissue type.

Blood	ABO blood group + rh factor + cross-matching to ensure that the recipient does not have antibodies for any antigens in donated tissue. If antibodies are present, the chances of rejection are greatly increased.
Platelets	ABO blood group + tissue type compatibility
Bone marrow	ABO blood group + tissue type compatibility + cross-matching
Kidney	ABO blood group + tissue type compatibility + cross-matching
Liver	ABO blood group + size
Lungs	ABO blood group + size + cross-matching when antibodies are detected
Heart	ABO blood group + size

Cadaveric donation

Most people die because their heart stops beating and the circulation of blood and, therefore, oxygen around their body ceases and cannot be restarted. When tissues are starved of oxygen, irreversible changes take place within them that make them unusable for donation. The kidney is the organ least affected by these changes but 40 minutes after circulation has ceased, it can no longer be used. Structural or connective tissues, such as bone, tendon and heart valves, can be recovered in some cases since they are less affected by oxygen deficit than softer tissue.

(continued)

Transplants *(continued)*

Tissues for transplantation usually come from people who have been declared brain dead. This often occurs as a result of head injury or stroke, and the person is in hospital on a ventilator when brain function ceases. The heart can be kept beating, thus maintaining circulation for one to two days following brain death. This provides time for decisions to be made about the organ donation and for recovery of the organ.

Once consent for donation has been given, a national database is searched for recipients who could receive the organ. Blood group, size, tissue type and cross-matching are considered. A delicate surgical procedure ensures that organs are not damaged in any way when removed from the donor. Highly trained technicians collect tissues. Any wounds are closed, and only the tissues for which there are recipients are removed.

The removal procedure

The removal procedure involves:

- flushing the blood from the organ to prevent it from clotting in the small blood vessels — the presence of clots would prevent the recipient's blood from flowing freely through the organ after transplantation;
- cooling the tissue to 4°C to reduce the metabolic rate;
- giving anticoagulants to the donor;
- giving vasodilators, chemicals that cause the small blood vessels to dilate, thus keeping them open;
- flushing the tissue with cold saline solution to cool it and remove any remaining blood;
- filling any vascular spaces within the tissue with preservatives.

Only after these steps have been completed is the ventilator removed.

The organ is removed and placed in a sterile plastic bag surrounded by a preserving solution. This bag is placed within a second plastic bag and then into an insulated container of ice. The preserving solution surrounding the organ prevents ice burn of the outside layers of tissue and maintains an even temperature distribution throughout the tissue.

There is a limit to the time organs can 'survive' between removal from the donor and once again being supplied with blood — this time by the circulatory system of the recipient. For kidneys the time is 24 hours, for a liver 12–16 hours, a lung 6–8 hours and a heart 4–6 hours. Where the donated organ is the heart, lung or liver, the recipient is prepared for the operation at the same time as the donated organ is being recovered.

(continued)

Transplants *(continued)*

Implanting an organ

Implantation of an organ may occur in the correct anatomical position (orthotopic) or the organ may be placed in a different part of the body (heterotopic). The heart is usually placed in the correct anatomical position.

A transplanted kidney, however, is usually placed low in the abdominal cavity and the recipient often then has two of his or her own plus the donated kidney.

Once the recipient has received the organ, two to three different drugs must be taken:

- steroids;
- antimetabolite to reduce the formation of white blood cells that could cause rejection;
- blocking agents that reduce the interaction of white blood cells.

After the transplant has established, the steroids and, possibly, the antimetabolites may be stopped. Seldom can the recipient stop taking blocking agents.

Tissues and organs that can be transplanted

Blood, platelets, kidney, liver, lungs, heart, heart *and* lungs, bone, cornea, sclera, heart valves, tendon, ligament.

Transplant timelines

R10 Resource Sheet 10

Date	Event
18th century	Tissues were grafted in chickens.
19th century	Transplants and grafts were seen as important in the study of physiology and led to an understanding of the endocrine system.
1804	Skin was successfully grafted from one position on a sheep's back to another. Exchanges of skin between cows and mares were unsuccessful.
1808	Skin grafts in humans were used to treat ulcers and burns. The skin was taken from another part of the patient's body.
1851	Blood transfusions took place. By this stage it was recognised that the success of grafts was related to: • the closeness of the relationship between the donor and recipient; • the youth of the donor; • the amount of new vascular tissue that develops in the grafted tissue; • the cooling of the grafted tissue that preserved it by reducing metabolic rate.
1877	The first corneal graft was attempted.
1893	Bone grafts were tried.
1880–1900	Techniques were developed that enabled arteries and veins to be rejoined successfully.
1906	The first kidney transplant in humans; it was unsuccessful.
1912	Alexis Carrel was awarded the Nobel prize for his work on vascular surgery and organ transplantation. In the early twentieth century, the anatomy and general function of organs had been established. Almost every type of organ had been transplanted in animals — heart, lungs, intestines, ovary, testis, spleen, thyroid gland.
1902–1914	Techniques of surgery were perfected. It was recognised that the relationship between donor and recipient influenced survival. • Transplants within the same individual survived several years. • Transplants between individuals of the same species survived several days to several months. • Transplants between individuals from different species survived several hours to several days.
1912–1914	Application of X-rays was used to prevent the formation of antibodies in the recipient. This could lead to transplantation of organs between individuals of the same species. (It is the antibodies that cause rejection.)

(continued)

Transplant timelines *(continued)*

Date	Event
1922–1923	The process of rejection was described. Genetic factors (such as blood group) and the formation of antibodies were recognised as important influences on whether a transplant would be accepted or rejected. This idea led to cross-matching of tissues.
World War II caused resources to be channelled elsewhere, and there was no further research into transplants.	
1954	A kidney was transplanted successfully from a man to his identical twin brother.
1959–1960	Total body irradiation (exposure to radiation) was used to paralyse the immune system and prevent rejection. Paralysis of the immune system allowed infections to invade the body.
1959	Successful kidney transplants took place between non-identical twins.
1960	Successful kidney transplants took place between unrelated people. Immunosuppressant drugs replaced total body irradiation as a means of preventing rejection. To begin with, these were toxic but improved rapidly.
1964–1968	Donor organs were used from people who had died.
1967	The use of immunosuppressant drugs, antimetabolites and steroids made kidney transplantation a realistic therapy. The first heart transplant took place.
1969	The first lung transplant took place.
1970–1972	A new immunosuppressant — cyclosporin — was developed and trials showed it to be effective. It revolutionised transplantation. The survival rate from transplants has increased from 30 per cent to 70 per cent since cyclosporin was developed. Transplants became a viable form of treatment.
The development of preservation fluids through the 1960s and 1970s meant that more time could elapse between the organ becoming available and the transplant taking place. Recipients could come from more distant centres and better matching could occur.	
1983	Liver transplants are seen as a viable treatment for some diseases of the liver.

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