

Rick **Armstrong** | Elani **McDonald** | Jennifer **Barnett** | Rachel **Whan** | 2nd edition

Science

3

for the international
student



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About the authors

Authors

Rick Armstrong (series editor)

Rick Armstrong has been involved with MYP sciences guide writing since 1994. He has led science workshops in all International Baccalaureate regions, as well as Approaches to Learning workshops. He has been involved with moderation, school visits and authorisations, and has experience as a DP examiner. Rick is currently a freelance educational consultant in Madrid, Spain.

Jennifer Barnett

Jennifer Barnett has been involved with the MYP since 2005 and is a sciences workshop leader and school authorisation team member. Recently, Jennifer was chosen to be part of the International Baccalaureate service 'Building Quality Curriculum' to evaluate teachers' unit plans for school authorisation. She has also led a number of local and state workshops on incorporating technology in the science classroom and differentiating science for exceptional students. She currently teaches integrated sciences to MYP years 1–3 in Austin, Texas.

Elani McDonald

Elani McDonald has dedicated her entire teaching career to working in IB schools. She is a workshop leader and an MYP visiting team member. She has been involved in monitoring and moderation of assessment and was involved in writing the Science and Personal Project 2014 guides, as well as the 2014 teacher support material for physics. Elani is dedicated to making learning relevant and engaging and was shortlisted for the TES maths teacher of the year award in 2014/15. Elani is teaching mathematics and sciences full-time and doing consultancy work part-time.

Rachel Whan

Rachel Whan studied veterinary science before completing a Graduate Diploma in Education. Since then she has taught chemistry, biology, human biology, science, mathematics and agriculture in a variety of schools in Queensland and Western Australia. Rachel has taught in MYP schools since 2006 and has been the Science Team Leader at St Brigid's College in Lesmurdie, Western Australia since 2007.

How to use this series

The *Science for the international student* series provides students with a variety of engaging and stimulating formats for learning, understanding and immersion in both the Middle Years Programme (MYP) philosophy of the International Baccalaureate (IB) and the science content. The features of the student book have been specifically designed to support this and to deliver exciting content in a variety of ways.

Specific MYP features

Each unit begins with a unit opening page that specifies:

- the key concept that is covered in the unit
- the related concepts that are covered in the unit
- the Global Context of the unit
- the Statement of Inquiry
- inquiry questions, divided into factual, conceptual and debatable questions.

Key and related concepts

Each unit is based around one *key concept* of an enduring transdisciplinary nature and a small number of *related concepts* designed to help frame the unit in the minds of the students.

Global Context

Students will be encouraged to see science in the *global context* of its ability to provide a basis for creative inventions that are capable of enriching our lives in areas such as space, materials, sports and medicines.

Statement of Inquiry

The *Statement of Inquiry* drives the unit and is strongly related to the units' concepts and context.

The inquiry questions are divided into factual, conceptual and debatable questions. Factual questions are related to the unit content, conceptual questions are related to the unit concepts and debatable questions are related to both and designed to stimulate deeper thinking.

Performance assessment tasks

Opportunities for assessment tasks occur throughout each unit and these are each identified by a *performance assessment task* icon.

The *summative performance assessment task* associated with the Statement of Inquiry is identified at the beginning of each unit. The criteria assessed by the assessment task are also identified.

Approaches to Learning

Opportunities to develop and apply *Approaches to Learning* skills are identified by an 'ATL' icon. Teachers can use these prompts to discuss and reinforce learning strategies.

Investigation

Investigations challenge students to design and perform their own experiments either individually or in groups. Investigations are designed to satisfy criteria B and C.

Experiments

Experiments provide students with the opportunity to develop and practise their skills by following processes and procedures, to discover information for themselves and to build a greater understanding of, and interest in, scientific concepts. Experiments are designed to satisfy criterion C.

Taking action

Taking action suggestions are identified by a 'TA' icon and are designed to satisfy the MYP requirements for service as action.

Other features

Review

Review boxes contain questions and break the content into smaller sections, allowing students to review what they have learnt so far.

Activity

Activity boxes reinforce or develop concepts and skills through short, fun and hands-on activities.

Weblinks

Weblinks are identified by an icon and direct students to exciting websites to further explore the world of science.

Unit questions

Unit questions conclude each unit. They include review questions sorted under the MYP assessment criterion A, levels 1–8. Reflection questions are included to review the concepts underpinning the unit, to encourage further consideration of the debatable inquiry questions, and at times to consider further lines of inquiry.

NelsonNetBook

The *Science for the international student* NelsonNetBook is an interactive ebook that can be used online or offline. It is compatible with interactive whiteboards, computers and tablets, with optional Web 2.0 functionality for class groups. Students can add highlights, annotations, audio and video clips, and weblinks, and teachers can use it to share their personalised version with the class.

Visit the NelsonNet portal at www.nelsonnet.com.au to find out more, register, or log in if already registered.

NelsonNet teacher website

The NelsonNet teacher website contains further valuable advice, including draft MYP unit plans covering the first two pages of the revised MYP planner, and also a curriculum overview as required by the IB. Other resources include blackline masters (BLMs) containing possible further experimental work and classroom activities, ideas for further resources, and further advice relating to teaching in a conceptual way and for the use of the Approaches to Learning framework. Answers are also provided for all questions, as well as a list of extra resources for each unit.

Contact your sales representative for information about access codes.

Introduction

To the student

We hope you will enjoy using this exciting student book, which has been designed to provide an up-to-date science experience around the principles of the new enriched Middle Years Programme (MYP) offered by the International Baccalaureate (IB). You are likely to already be an experienced MYP student, proud of being an *internationally minded* student, and familiar with the distinctive way MYP students work in science. These revised books provide a greater emphasis on the global contexts for learning in science, ranging from the challenge to provide better and more equal access to medicines worldwide, to considering global environmental challenges such as global warming. The books emphasise investigative and experimental work and expect you to work and think like a real scientist. As you will be well aware, the MYP is also about encouraging you to develop effective learning skills that will stay with you for life, and you will see in these books many suggestions to help you with this challenge. We wish you all the success possible with MYP Science and beyond.

To the teacher

We have reviewed our original series, published in 2010–2011, to take account of the innovative developments and improvements in the MYP. In this new edition, we have deepened our coverage of MYP principles within each unit. The units are now much more contextual and more explicitly driven by the Statement of Inquiry. As you will be aware, the IB has attempted to give schools more flexibility in their delivery of the MYP and there certainly is no ‘correct’ model of how to put the MYP into practice. For that reason, we feel we should explain some of our approaches to constructing our units.

- 1 Conceptual framework:** We have closely followed the suggested framework but have added a small number of extra related concepts that will be useful to teachers and will allow coverage of the US cross-cutting concepts. We have also used concepts from other subjects when we felt their use would enhance the unit. Importantly, we accept that the key to teaching conceptually lies in appropriate classroom practices. To help this practice, we have included activities and questions to help strengthen students’ understanding of the conceptual framework as well as some further guidance in the teacher materials.
- 2 Content:** We have included academically challenging content that will provide an effective transition from MYP 1 through to 5, to the new e-examinations, and to higher study in the Diploma Programme (DP) or in other national systems. This content should also help teachers meet the requirements of local curricula. We have covered all the expected content for MYP Sciences e-examination in Books 4/5. Some of this content is also covered in more detail in Books 1, 2 and 3. We have ensured that the scope and sequence of our MYP Books 1–5 is well thought out and offers a coherent framework for the development of deep understanding based on the big unifying concepts in science.
- 3 Global Contexts:** The development of the Areas of Interaction into the Global Contexts is very liberating and opens the door for much more creative uses of contexts in the planning of MYP units. To take advantage of this potential, we have associated the Global Context chosen for the unit with a more specific ‘exploration into’ statement. This ‘exploration into’ feeds clearly into the Statement of Inquiry for each unit. This has helped us to make the science content up to date, interesting and relevant to the real world.

- 4 Statements of Inquiry:** We have written simple and clear Statements of Inquiry that are understandable to students and to teachers. We have been flexible in relation to trying to build all the chosen concepts into the Statements of Inquiry. Our priority has been to ensure that the Statement of Inquiry is easy to understand, has a conceptual feel, and, importantly, relates to the chosen Global Context.
- 5 Assessment tasks:** Most science units will require more than one summative performance assessment task because it is artificial to try to bring together a number of the sciences criteria in one task. Therefore, most units include assessments relating to investigation work (criteria B and C), a performance-type task relating to the impacts of science (criterion D) and end-of-unit questions to assess knowledge and understanding (criterion A). At the beginning of each unit, you will see a summative performance assessment task that relates closely to the Statement of Inquiry. We have given this task the most authentic performance nature possible. Other performance assessment tasks are included in each unit that can be used summatively or formatively. We expect that not all of the assessment suggestions will be used for summative purposes.
- 6 Approaches to Learning:** We are very impressed by the revised Approaches to Learning framework based on the ten clusters of ATL skills. We understand that the effective implementation of ATL is a whole-school challenge but have made suggestions for when teachers can explicitly introduce these skills and dispositions, both as part of summative assessment tasks, and also more generally in their daily teaching. You will also see a simplified ATL framework in the appendices that we think will be of great help to teachers.
- 7 Service learning:** We have also suggested a possible service learning activity (labelled 'TA' (Taking action)) for each unit.

The NelsonNet teacher website contains draft MYP unit plans, curriculum overviews, BLMs for experimental work and classroom activities, ideas for interdisciplinary tasks, further resources and advice for using the ATL framework, and answers to all questions.

We realise there may seem to be an inherent conflict between the idea of teachers working in a creative and collaborative way to produce MYP units of work and the use of a textbook. Schools will use this book in different ways. Some new schools might find it an invaluable stepping stone to getting an MYP Sciences programme up and running. Others may use it to enhance their existing courses. We encourage you not to use these books the way traditional textbooks have been used. Be creative, add to them, choose the bits you like, encourage the students to interact with them. They are there to help students in their deep learning of science, to encourage their interest and motivation. We hope the availability of materials of this kind will make your life as the teacher a little easier and give you more time to focus on the actual teaching and learning. Enjoy them.

Rick Armstrong (Series editor)

UNIT

1

INDIGENOUS KNOWLEDGE

KEY CONCEPT

Cultures

RELATED CONCEPTS

Environment

Balance

Perspective

GLOBAL CONTEXT

Personal and cultural expression – an exploration into Indigenous peoples' knowledge systems

STATEMENT OF INQUIRY

Indigenous peoples possess detailed and invaluable knowledge that allows them to live in a sustainable way with their local environments.

INQUIRY QUESTIONS

FACTUAL

- 1 What knowledge do Indigenous people have in relation to food, medicine and navigation?
- 2 What are the names of some Indigenous people who live in your region?

CONCEPTUAL

- 3 How does Indigenous knowledge compare with modern scientific knowledge?
- 4 What are the main challenges facing Indigenous people in the 21st century?

DEBATABLE

- 5 Is it possible for Indigenous peoples to live in the modern world while preserving traditional values and customs, sometimes called 'two-eyed thinking'?

Introduction

Indigenous peoples are people who have lived in a region for a very long time, and who have preserved their distinctive local cultures and traditions. Many Indigenous peoples live in a way that is very close to their traditions and has changed very little over the past hundreds or thousands of years. Other Indigenous peoples mix traditional and modern practices in their lives.

Indigenous peoples make up a significant percentage of the world's population. It is estimated that there are about 5000 different tribes of Indigenous peoples in the world: about 350 million people in total. The knowledge they have, particularly about local **ecology**, is immense and complex. In recent years, we have started to appreciate the value of this knowledge more and more.



Scientific knowledge of Indigenous peoples

Research

Choose one group of Indigenous people and carry out research into their customs. As a class, you might decide to concentrate on one particular group of Indigenous people, possibly a group that lives in your country. Concentrate on a small number of aspects of their lifestyle, such as their food, family structures, agriculture, hunting, clothing, use of herbal medicines and cooking. Also research the issues this group of Indigenous people experience from being part of modern society.

Your task

Write an article for a newspaper, or prepare a TV documentary, on the customs of this group of Indigenous people. Include a discussion on why it is important to understand that the implementation of modern scientific and technological developments does not always work well in Indigenous cultures.

Go to <http://mysci3.nelsonnet.com.au> and click on **Survival international** to see a list of some of the Indigenous peoples facing the most significant challenges.

ATL

CRITICAL THINKING
Recognising our personal cultural assumptions and biases

Indigenous knowledge

Reflection about learning

ACTIVITY

THINK-PAIR-SHARE

Brainstorm about Indigenous peoples you have some knowledge of. Where do they live? What are their customs? What beliefs do they have? How well have they been treated by newer peoples (often Europeans) who have taken over their lands? What problems are they facing in the modern world? What contributions do they make?

Work in pairs to share and discuss your findings.

Pair up with another group and share and discuss your findings.

Indigenous peoples have accumulated an enormously valuable and complex knowledge of their local environments. They have expert knowledge of local materials, weather, plants, animals and rivers/waterways. They often have advanced understanding of astronomy and navigation

techniques. They have developed distinctive local tools, forms of food preparation, shelter, medicines and language. Traditionally this knowledge is not written down. It is passed from generation to generation through hands-on experience, art, storytelling, dance and music.

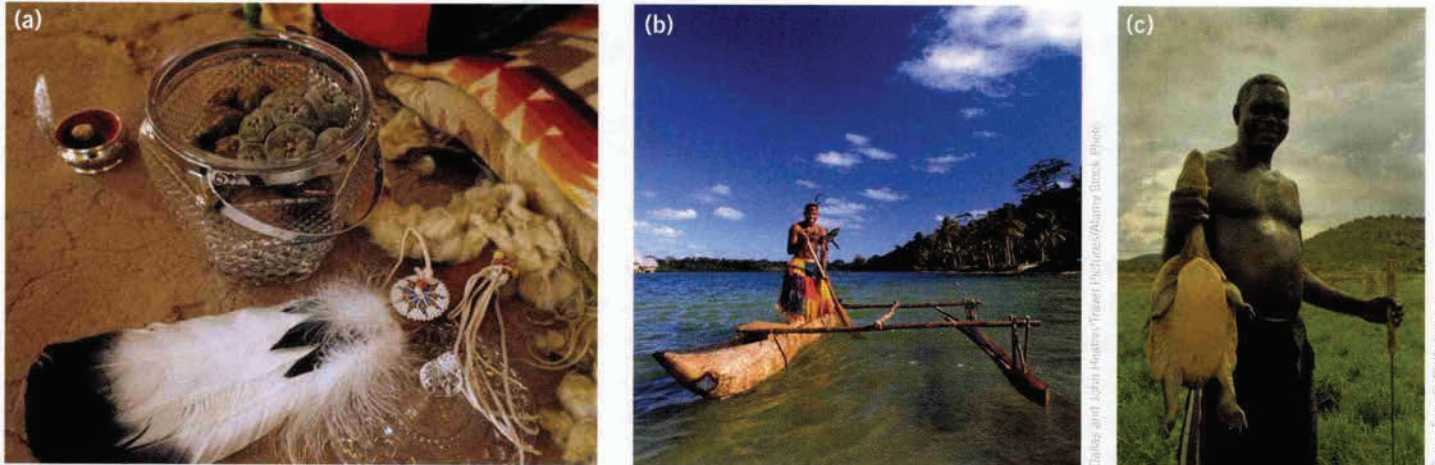


FIGURE 1.1 Indigenous customs are important for (a) medicines, (b) transport and (c) food.



FIGURE 1.2 Dancing is a powerful way of communicating information.

In the past, there has been a tendency to think of Indigenous cultures as primitive. As a consequence, many Indigenous cultures suffered when colonising people took over their lands. This attitude is now changing and the value of Indigenous knowledge is increasingly respected. In particular, we value the ability of Indigenous peoples to live in a **sustainable** way in their local environment – a knowledge we seem to have lost in modern times. On the other hand, we

must be careful not to over-romanticise all aspects of Indigenous cultures. Indigenous people have had to struggle against climate extremes, changing local ecosystems, limited diets, poor health, and inter-tribal conflicts.

Are Indigenous knowledge and modern scientific knowledge compatible?

The origin of modern science is debatable. Some people see the origins of modern science in the ancient Sumerian civilisation of 4000–2000 BCE and their ideas on astronomy and mathematics. Others see it beginning with the Greeks and their ideas on the atom. Many people link it to the scientific revolution in Europe over the 16th–18th centuries, which was associated with more sophisticated ideas on astronomy, gravity, theories of what matter is made of, the human body and electricity. Other people trace the modern scientific method back to Ibn al-Haythan in the Golden Age of Arabic science (Figure 1.3a).

In *Science 1 for the international student* Unit 1, you studied the use of the scientific method and how this way of working is reflected in MYP Sciences criteria B and C.

The scientific method involves a specific research question that has arisen from previous observations or considerations. It builds upon previous knowledge and usually involves the formulation and testing of a hypothesis. It involves the design of experiments with control of variables (fair testing) and very careful consideration of the evidence. An important aspect of the scientific method is that results are published and other scientists should be able to reproduce the method and the results.



FIGURE 1.3 (a) Ibn al-Haythan and (b) Isaac Newton were influential in the development of the modern scientific approach.

The way in which Indigenous peoples learn about their environment is likely to be different from the approach of modern science. The development of Indigenous knowledge doesn't insist on a theoretical explanation. It is not published in scientific journals. It is not normally the result of controlled experiments.

But there are similarities with modern science – Indigenous knowledge has developed from careful observation, questioning, trial and error, prediction, problem solving, interpretation and adaptation over a period of time. Indigenous knowledge is likely to have built up over hundreds, in some cases thousands, of years. Indigenous knowledge is often very practical and is usually locally based.

Both modern science and Indigenous knowledge are valid ways of making sense of the world around us. They often complement each other, particularly in areas such as health care. If you study the IB Diploma Programme you will study Theory of Knowledge (TOK). In TOK, you will consider the different ways we develop our understanding of the world.

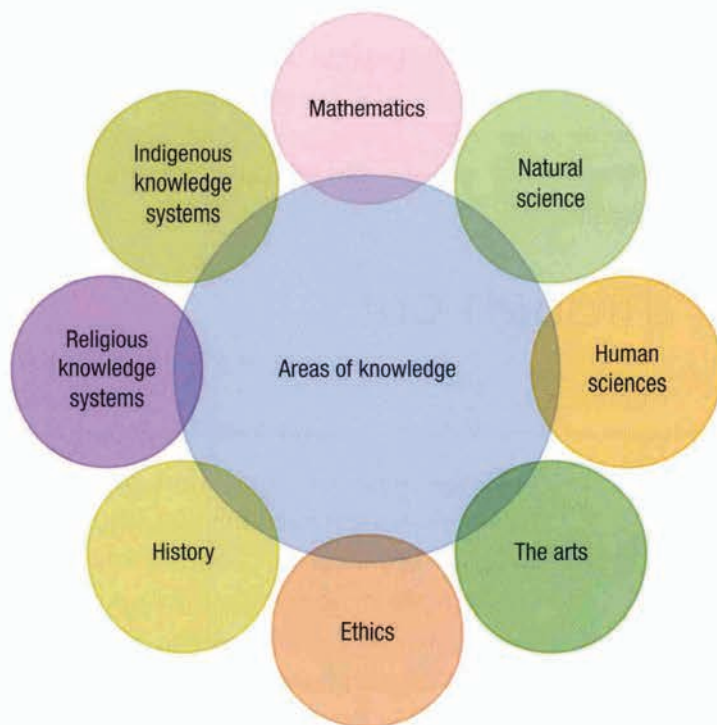


FIGURE 1.4 Areas of knowledge studied in the Diploma Programme



FIGURE 1.5 A Shuar Indian woman in Ecuador harvesting the medicinal apaye plant to treat amoeba infections

ACTIVITY

Further comparison of Indigenous knowledge with scientific knowledge

In 2008, UNESCO published a set of seven posters on the theme of Indigenous knowledge for use in education. Go to their website and choose one of the posters. Read through the poster in small groups and prepare a 3-minute presentation to your class summarising the message of the poster.



Go to <http://mypsc3.nelsonnet.com.au> and click on **UNESCO posters** to view the UNESCO posters.

Indigenous knowledge as holistic knowledge

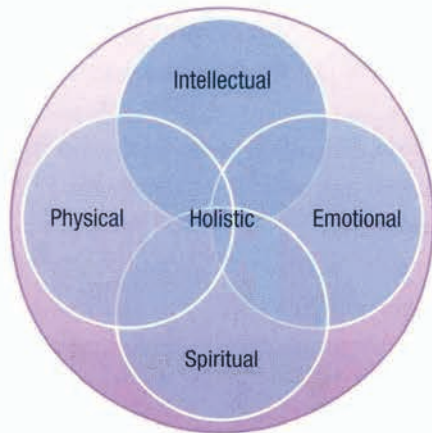


FIGURE 1.6 A holistic view

The knowledge in an Indigenous culture tries to link everything together. For example, Indigenous peoples tend to see the individual, family, society and nature as a related whole. We call this **holistic** knowledge. For example, Indigenous medicine treats the whole person, including their psychological, emotional, social, spiritual and nutritional needs. It does not just give a medicine to take away the symptoms. Interestingly, in recent times many people are turning to holistic medicine, which has a similar philosophy.

A holistic view of the world leads to an enormous respect for nature. Compare this with our modern world where we sometimes do considerable damage to local ecosystems, such as forests and grasslands, for short-term economic gain.

We see the world through our cultural values

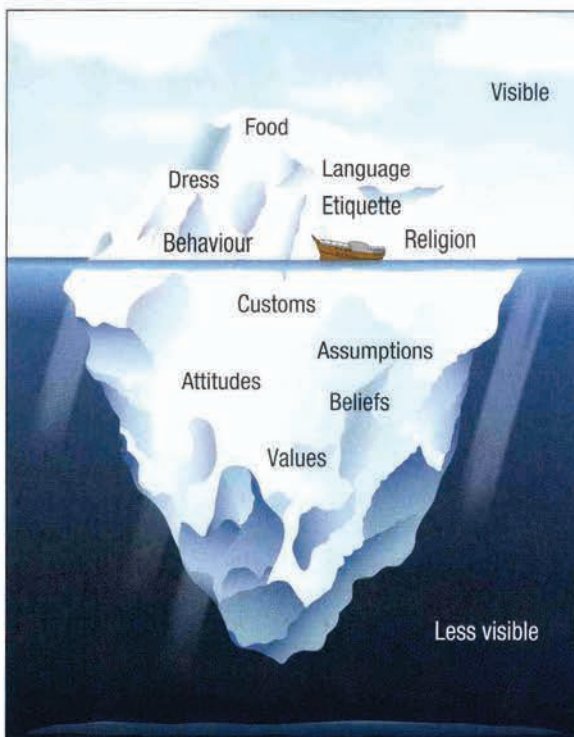


FIGURE 1.7 The culture iceberg

Different cultures see the world differently. Each culture may have different attitudes to family life, learning, cooperation between people in society, and how men and women should behave. This can make it very difficult for people of one culture to fully understand the customs and knowledge of those from another culture. We are all trapped to some extent by our cultural perspectives. The metaphor of culture being like an iceberg is often used to show why people find it difficult to understand other cultures.

Many students in international schools have experienced moving from one country to another, from one group of classmates to another. These students will probably have experienced the sensation of everything feeling different and strange. Perhaps they

have had a feeling of not understanding the new culture or not feeling understood by people in the new culture.

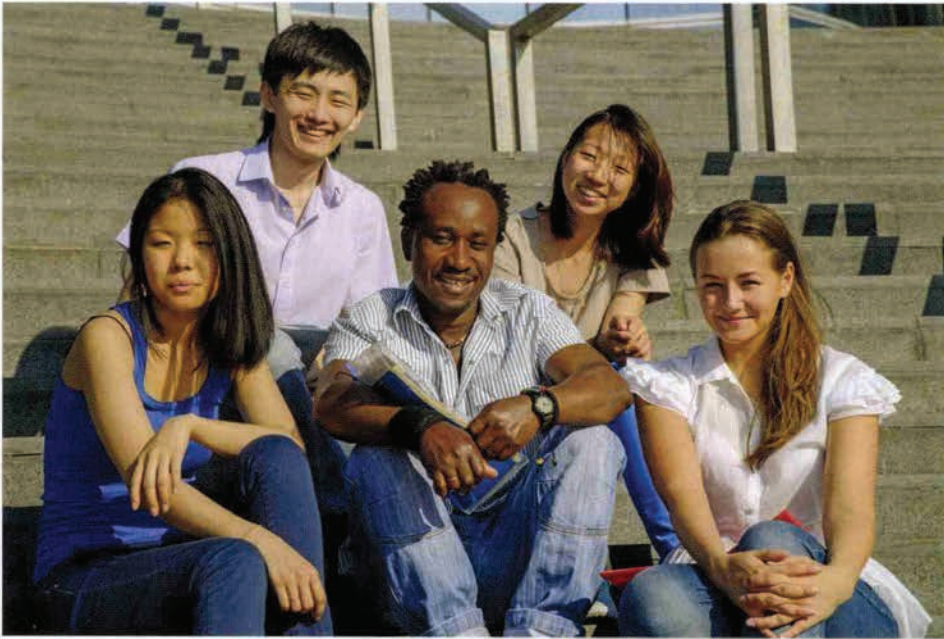


FIGURE 1.8 Students from different cultures

ACTIVITY

Comparing cultures

In small groups, consider peoples from other cultures you know, or other cultures you have lived in. Can you think of ways in which they see the world or behave differently? Do they have different values in relation to family life, respect for elders, learning, relationships between males and females etc.? What different customs do they have? How did you feel when (or how do you think you might feel if) you entered another culture?

- Make a table of the differences you have noticed.
- Make another table of the similarities you might see.
- Describe how you felt when (or how you might feel if) you entered a different cultural world.
- What advice do you have for someone going to live or work in a new culture?

REVIEW

- 1 How would you define the term 'Indigenous peoples'? Give four examples of Indigenous peoples from around the world.
- 2 Describe ways in which Indigenous peoples have developed their knowledge.
- 3 Discuss ways in which modern science and Indigenous knowledge are:
 - a similar
 - b different.
 Construct a table to show your answer.
- 4 What does the term 'holistic' mean? Why do we say that Indigenous knowledge is 'holistic'?
- 5 We say that different cultures have 'different world views'. What does this mean? Can you think of some examples?

Oral transmission of knowledge and use of mythical stories

Knowledge in Indigenous cultures is transferred in very special ways, usually by elders. The information is carefully passed down from generation to generation. This knowledge often has a spiritual dimension, something that people from other cultures often find difficult to relate to. Mythical stories are often used to help explain important ideas. What stories and information have been passed on to you from older generations? In a recent initiative to improve the health of Inuit people in Pangnirtung, Canada, the emphasis was placed on involving the elder people in storytelling about traditional diets.

Creation stories and Mother Earth

Some of the stories that Indigenous peoples tell are about the creation time – the time when the land and the landscape, and its animals, plants and people came into being (Figure 1.9). They also tell the people about their connection to the land and how they must look after it and each other.



FIGURE 1.9 A panel from the Aztec creation myth

ACTIVITY

How was the Earth formed?

What is your understanding about how the Earth and its inhabitants were formed? What other explanations are you familiar with? In pairs, choose a creation story from an Indigenous culture and create a poster that explains what happened in the creation story when the Earth and its inhabitants were created.

To Indigenous peoples, the land is the source of their life and it is where they return to when they die, so it has to be treated with respect. Many Indigenous peoples worldwide use the phrase 'Mother Earth' to describe this relationship. As part of this close relationship, they have a detailed knowledge of the plants and animals, the seasons and the landscape and how these affect them. It is the responsibility of each person to look after the land. The idea of individuals owning land can be strange for Indigenous peoples.



To read a useful summary of creation stories, go to <http://mypsci3.nelsonnet.com.au> and click on **Creation stories**.

Indigenous peoples' sourcing of food

Food will be what brings people together.

Imata gawano, Elder of the Secwepemc, an Indigenous people of British Columbia, Canada

Hunter-gatherers

Indigenous food systems depend on the local environment. They rely on detailed knowledge of what will grow well or what is available for hunting and fishing in particular seasons, what is sustainable, and what is healthy. Early humans were hunter-gatherers and often lived a nomadic lifestyle, such as that of the Kalahari Bushmen of southern Africa (Figure 1.10), who feed themselves by hunting wild animals and gathering wild plants.

Gathering and growing

About 10 000 years ago, some peoples learnt to domesticate wild animals and plants. They produced their own food. They became farmers. This led to permanent settlements of people and eventually to more sophisticated technology.

Present-day farming methods and food production are the result of generations of investigation and experimentation. Domesticated corn (maize), beans and squash were developed in South America and Mexico. Their use spread north into North America, then later to Europe.

These three crops have been referred to by Indigenous North American peoples as the 'three sisters' because the three are interdependent (Figure 1.11). The corn stalks provide support for the beans. The beans are legumes and contain nitrogen-fixing bacteria in their roots, which provide valuable nitrogen to the soil. Squash, which is planted between the rows of corn, reduces water loss and keeps weeds out. This is called **companion planting**.

Today, farmers and gardeners make use of the concept of companion planting. For example, marigolds are often planted with vegetable patches to repel whiteflies and beetles, as well as some weeds. There are many other instances of companion planting.



FIGURE 1.10 The Kalahari Bushmen are hunter-gatherers.

Alex Dabrowski/Getty Images



FIGURE 1.11 Growing the 'three sisters' together: corn, beans and squash are interdependent.



FIGURE 1.12 Growing rice and fish together in China has good environmental outcomes.

Rice and fish have been grown together in China for over 1000 years (Figure 1.12). The fish eat the rice pests, and the rice provides a good environment for the fish. This reduces the need for pesticides by around 70% and the need for chemical fertiliser by over 20%.

Indigenous farmers in Thailand have developed very complex systems of landscaping to include gardens for their homes, land for grazing cattle, rice paddies, and trees to provide a path for animals. Hence, the community meets its needs without causing destruction or affecting local wildlife.

Development of hunting techniques

Elaborate technologies for hunting have been developed. Australian Aboriginal people use the boomerang (Figure 1.13). The boomerang is a wooden implement with a number of uses, particularly for hunting and fighting. Boomerangs are probably best known because they can return to the thrower. Returning boomerangs are shaped like two wings joined together at an angle. In cross-section, they have the same aerofoil shape as the wing of a plane. One end is twisted slightly upwards; the other end is twisted slightly downwards, causing it to spin. It is this spinning action that causes the boomerang to return to the thrower.

Other Indigenous peoples have also developed methods to assist with hunting. Kite fishing and herbal fish poisons are used in the Pacific Islands, and elaborate fish nets and traps are common in many parts of the world.



FIGURE 1.13 The shape of a boomerang allows it to spin, which causes it to return when it is thrown.

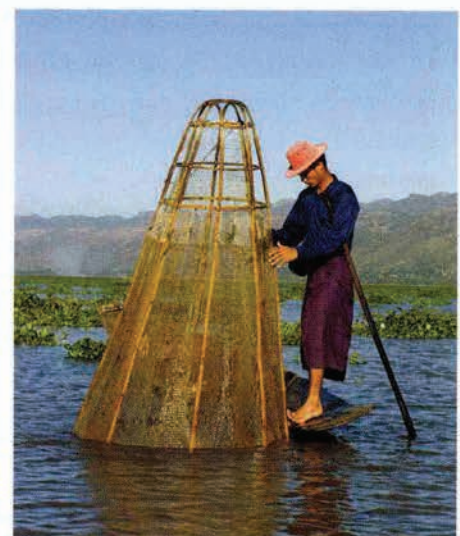


FIGURE 1.14 This fisherman in Myanmar is using a traditional fish-trap net.

REVIEW

- 1 Explain the expression 'Mother Earth' as used in many Indigenous cultures.
- 2 Give a summary of a creation-time story or myth.
- 3 What is meant by the expression 'hunter-gatherer'?
- 4 Describe the science of how a boomerang works.
- 5
 - a Describe what North American Indigenous peoples mean by the expression 'the three sisters'.
 - b What advantages are there in growing the three crops together? Do modern farmers use similar methods?
- 6 Beans are legumes that provide nitrogen to the soil. Explain:
 - a why this is so useful
 - b how legumes are able to do this.

Indigenous knowledge and diet

The Tlingit are an Indigenous people of the north-west coast of North America. A Tlingit expression is 'when the tide goes out, the table is set'. Salmon is a main component of their traditional diet. Herrings, herring eggs, halibut and hooligan are also important parts of the Tlingit seafood diet. Tlingit also hunt deer and goats, and use canoes to hunt seals, sea lions and sea otters.

A balanced diet

The traditional Tlingit diet includes plenty of protein from fish, but the Tlingit also need to ensure they have adequate **vitamins** and **minerals**. The Tlingit possess sophisticated knowledge about how to maintain a balanced diet. They recognise that vitamins are important for almost all bodily processes (including the immune, hormonal and nervous systems). Humans cannot make vitamins so they must be obtained from food. The Tlingit use:

- fish bones as a source of calcium, iron and vitamin D
- fish livers as a source of vitamin A
- fish intestines as a source of vitamins E and B
- wild berries as a source of vitamin C.

There are 13 vitamins necessary for human health. They can be classified as either water soluble (C and B group) or fat soluble (A, D, E and K). Fat-soluble vitamins are absorbed from the intestine into the bloodstream. Vitamins A, D and K are stored in the liver and vitamin E is distributed throughout the body's fatty tissues.



FIGURE 1.15 Freshly caught salmon is a main part of the Tlingit diet.

Water-soluble vitamins (vitamin C and the B group vitamins) are stored in the body for only a short period of time before they are removed by the kidneys. Hence, they need to be eaten daily.

The traditional Tlingit methods of trapping salmon are sustainable. They catch only what they need to feed themselves and do not overfish. Modern commercial methods can harm salmon runs and damage spawning populations. Salmon runs are under threat from many activities, such as dam building, irrigation systems, overfishing, agricultural pollution, and the genetic impact and diseases associated with modern salmon hatcheries.

Catching and preserving food

The Tlingit have developed sophisticated methods to harvest salmon. This harvest usually involves a high level of cooperation between the men, women and children. They build systems of walls and weirs, and drive the salmon into closed areas where they can be easily speared.

In the late 19th century, the Tlingit developed the fish wheel, which they used to capture fish as the fish came up the river. Fish wheels make use of the **kinetic energy** (movement) of the river water to make a wheel go around. This rotating wheel can lift up fish that are swimming upstream so they are trapped in a container above the wheel.

The salmon were cooked over fire or preserved by freezing, or drying and then smoking (Figure 1.17). Drying was done outside and the Tlingit had to be careful that the fish were not eaten by bears or birds.

For the smoking process, the Tlingit split the salmon fillets and slashed them to increase the surface area. The pattern of the slashes could be used to identify the person who carried out the smoking. The smoked salmon was sealed in boxes containing seal oil to protect the food from mould and bacteria. The chemicals in the smoke from the burning wood helped preserve the fish and gave it an agreeable taste. Smoking is now a common way of preserving food worldwide.



Go to <http://mysci3.nelsonnet.com.au> and click on **Salmon boy** to read the Tlingit myth about a boy who learnt to show respect to the salmon so the fish would return each year to feed the people. What is the importance of myths such as this?



FIGURE 1.16 A fish wheel on a salmon river

Health advantages of 'eating local'

As shown by the Tlingit example, Indigenous peoples have been 'eating locally' for thousands of years. Their knowledge about diet and good health is very sophisticated. One of the problems Indigenous people have when they abandon their traditional diets for more modern processed foods is that their health can suffer enormously. In Canada, Indigenous peoples have much higher rates of obesity and around 4.5 times higher rates of diabetes than the general population. On Pohnpei Island in Micronesia, concern about the health effects of imported food led to the campaign Let's Go Local with an emphasis on educating people about the importance of following traditional local diets.



FIGURE 1.17 The Tlingit method of drying fish prior to smoking

Buying locally

It is interesting that in recent years, people have returned to the idea of buying food grown locally, rather than depending on food transported large distances. Some cities have established community gardens for apartment dwellers, as well as issuing permits for small backyard chicken coops for egg production. This idea reflects many people's desire to live a more sustainable lifestyle.

TA BUY LOCAL

Next time you're buying groceries, consider where the food has come from. What food is grown or produced in your local area? What food is brought in from much further away? Discuss with a partner the top 10 reasons for buying locally, and make a flyer to distribute to fellow students.



Go to <http://mypsc3.nelsonnet.com.au> and click on **Sustainable food production** to learn more about the movement to eat local food.

Cooking with heated stones

Almost all Polynesian Indigenous cultures have developed methods of cooking with hot stones. A traditional New Zealand Maori *hangi* is laid by first digging a pit in the ground. Suitable stones are heated in a fire and then placed in the pit. Baskets of food are put on top of the hot stones and everything is covered with leaves, wet cloth and then soil. The food is cooked slowly (over about four hours) by the steam produced. A variety of meats, and vegetables such as kumara (sweet potato), pumpkin, carrots and cabbage, can be cooked in this way.

Igneous rocks are the most effective in this cooking method because they have quite high **specific heat capacities**. This means it takes a lot of energy input (from a fire) to heat the stones. The stones later release this heat slowly, to cook the food in the *hangi*.

The energy released by the hot stones heats the water from the wet cloths, forming steam. Steam contains a lot more energy than water so the food cooks more quickly. The soil on top traps the steam and the pressure inside the *hangi* rises. The *hangi* works in a similar way to a pressure cooker.

Kalua is a similar Hawaiian method of cooking. The underground oven is called an *imu*. Very hot volcanic rocks are used and it is common to cook pig covered in banana leaves. The Indigenous peoples in the Chiloe Archipelago of Chile use a similar method of cooking called *curanto*. Some people believe this supports the theory that there was contact between American and Polynesian peoples in the past.



FIGURE 1.18 A Maori *hangi* cooks with steam.



FIGURE 1.19 *Curanto* involves cooking over hot stones on Chiloe Island in Chile.



CRITICAL THINKING
Designing scientific investigations: consider how to write an effective research question.

Cooking with hot stones

INVESTIGATION 1.1

YOUR CHALLENGE

To design an investigation that compares the efficiency of different stones for use in a Maori *hangi*, a Hawaiian *kalua* or a *curanto* of the Chiloe Archipelago.

THIS MIGHT HELP

Some substances when heated to a certain temperature hold much more heat energy than other materials. This property is referred to as 'specific heat capacity'. The higher the specific heat capacity of a stone, the more effective it will be as a source of heat in a steam oven.

A basic method is to first heat a stone to quite a high temperature in hot water, then put the stone into cold water and measure the temperature change of the water. You could investigate variables such as the type and size of the stone. How will you make it a fair test? You could also investigate the speed at which the cold water is heated by the stone.

Carry out and write up your investigation following the guide in Appendix 3 on page 177 or as advised by your teacher.

SAFETY

Do not heat the stones in a direct flame, as they can shatter. Use tongs to handle the hot stones.

REVIEW

- 1 Outline the diet of the Tlingit people. Discuss whether it is a healthy diet.
- 2 Find out about the traditional diet of the Indigenous people in your area.
- 3 Discuss why it is important to get vitamin C in your diet every day. How does the body treat vitamin A and vitamin C differently?
- 4 Outline how the Tlingit catch and preserve salmon.
- 5 Discuss why many salmon runs are under threat.
- 6 Explain the science of how hot stones can be used for cooking, such as in the Maori *hangi*.
- 7 Outline what we mean by the 'specific heat capacity' of a substance.
- 8 Which would be better for an oven that uses hot stones for cooking: igneous rocks or sedimentary rocks? Explain your answer.



Go to <http://mysci3.nelsonnet.com.au> and click on **Tlingit** for more information on the Tlingit people.

Indigenous knowledge about medicines

Indigenous peoples knew many cures for illnesses long before medicine in Europe became a science. Table 1.1 summarises some of these Indigenous remedies.

TABLE 1.1 Traditional Indigenous remedies

Indigenous group	Remedy	Modern scientific explanation
North American people	They cured goitre by eating harvested sea kelp.	Sea kelp contains iodine, which prevents goitre.
The Hurons in Canada	They cured scurvy in the 1500s by boiling the needles from an evergreen tree then drinking the water.	The needles have high concentrations of vitamin C.
Indigenous peoples in North America	They use 'sacred bark' from the California buckthorn tree to clean out the bowel in cases of constipation.	'Sacred bark' extract is now the basis of some laxatives produced by pharmaceutical companies.
Aboriginal people in south-eastern Australia	They treat sore throats and skin infections with emu bush.	The bush has good antibacterial properties.
Many Indigenous peoples in Africa	They use a plant called <i>Securidaca longipedunculata</i> to treat wounds, sores and coughs. It is also used as a pesticide.	The plant has good antibacterial properties, and a substance known to work as a pesticide.



FIGURE 1.20 Bearded tongue is used by Indigenous North Americans for healing wounds, stings and sunburn.



FIGURE 1.21 The qinghao plant, the source of artemisinin, an antimalarial drug, was originally used in traditional Chinese medicine.



FIGURE 1.22 The chamomile plant and flower has a long history of use by Indigenous peoples.



FIGURE 1.23 African apes eat certain plants that get rid of parasites in their intestines.

Tribal people in north-east India use plants to treat fevers, bronchitis, blood and skin diseases, eye infections, ulcers, diabetes and high blood pressure. The knowledge of the plants and their uses is passed on by the *vaiyas*, Indian herbal medicine doctors.

Indigenous peoples can be seen as the custodians of the world's genetic plant heritage. Nearly a quarter of all modern medicines are derived from natural products, many of which were first used in traditional remedies.

Chamomile: a traditional herbal medicine

Chamomile has a long history as a medicine in various parts of the world. The active constituents of chamomile have anti-inflammatory properties, and ease spasm and discomfort in the digestive tract. Other uses include the treatment of anxiety, insomnia, fever, eye irritations, diarrhoea, eczema, menstrual disorders, irritable bowel syndrome and skin irritations. It is also thought to slow fungal growth.

Chamomile is thought to help the growth and health of other plants, especially those that produce essential oils. It is thought to increase production of those oils, making certain herbs, such as basil, stronger in scent and flavour.

Indigenous healers often claim to have learnt by observing sick animals. At times, the animals would change their food preferences to nibble at bitter herbs they would normally reject. Sick animals tend to eat plants rich in substances that have antiviral, antibacterial or antifungal properties.



Properties of chamomile

INVESTIGATION 1.2

YOUR CHALLENGE

To investigate one of the following questions.

- Does chamomile have antifungal properties?
- Does chamomile encourage the growth and/or oil production of other plants?

THIS MIGHT HELP

You could make chamomile solutions from commercially available chamomile tea preparations. Will you use a variety of concentrations?

Your teacher will help you grow some suitable samples of fungi. You could use slices of bread in closed plastic packages.

Carry out and write up your investigation following the guide in Appendix 3 on page 177 or as advised by your teacher.

SAFETY

- Moulds can cause allergies and infections. You should wear gloves and masks during this investigation.
- Do not open the plastic packages once the mould has started to grow. At the end of the experiment, the school will need to dispose of the plastic packages following local requirements.

The health of Indigenous people

Indigenous peoples have experienced serious health problems as a result of their encounters with their colonisers. Exposure of these previously remote Indigenous populations to European diseases caused many fatalities. The local people had previously not been exposed to these diseases and so had no natural resistance to them. For example, the Spanish conquistadors in the 15th and 16th centuries brought smallpox, chicken pox and measles with them to South America (Figure 1.24). Historians estimate up to 85% of the Indigenous population in South America was killed as a result of these diseases.

In modern times, many Indigenous peoples are experiencing a variety of health problems. This can be caused by poor diet, the disappearance of local knowledge, loss of their traditional homelands, environmental contamination and climate change. For instance, Indigenous people have a much higher rate of tuberculosis. Among the Guarani people in Bolivia it is 5–8 times higher than in the general population, and in the Kalaallit Nunaat in Greenland it is 45 times higher.

Some other health statistics from the World Health Organization in relation to Indigenous people include:

Diabetes: In some regions of Australia, the Aboriginal and Torres Strait Islanders have a diabetes prevalence rate as high as 26%, which is six times higher than in the general population.

Living conditions: In Rwandan Twa households, the prevalence of poor sanitation and lack of safe, potable water were respectively seven times and two times higher than for the national population.

Reproductive health: For ethnic minorities in Viet Nam, more than 60% of childbirths take place without prenatal care compared to 30% for the Kinh population, Viet Nam's ethnic majority.

Suicide: Among Inuit youth in Canada, suicide rates are among the highest in the world, at eleven times the national average.

Infant mortality: Average infant mortality among Indigenous children in Panama is over three times higher than that of the overall population (60–85 deaths per 1000 live births versus the national average of 17.6).



FIGURE 1.24 Spanish conquistadors brought new diseases to Indigenous peoples.



Incidence of infant mortality in Indigenous cultures

ACTIVITY

Consider the data shown in Figure 1.25.

- 1 What does this data show you about the differences between the incidence of infant mortality in Indigenous people and the population as a whole in these countries? What reason do you see for these differences?
- 2 Comment on the differences between countries. What reason do you see for these differences?

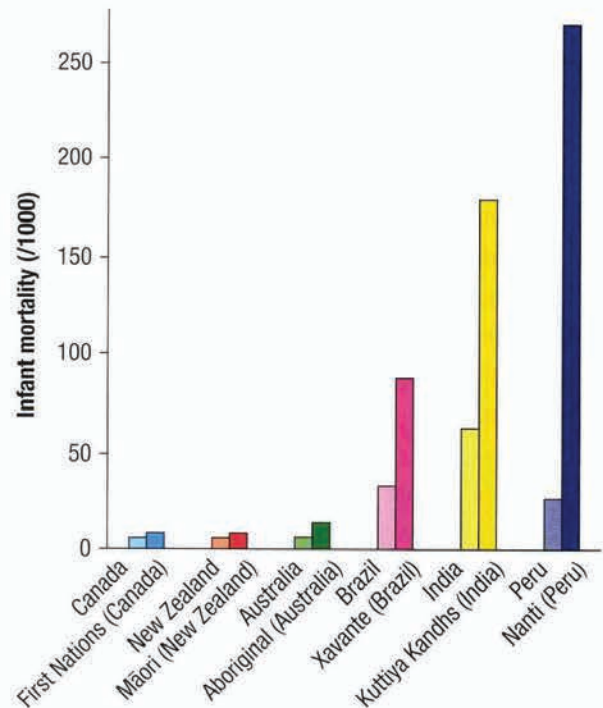


FIGURE 1.25 Incidence of infant mortality



ATL

RESEARCH
Evaluating information
from the internet
critically

Efforts to improve Indigenous health

ACTIVITY

RESEARCH

- 1 Carry out further research into efforts being made by many organisations to improve the health of Indigenous people worldwide.
- 2 Summarise what you feel are the major health-related issues facing Indigenous peoples.
- 3 Imagine you were in charge of the World Health Organization. What recommendations would you make to help improve the health of Indigenous people? Make sure you show understanding that simply making more modern medical care available is not the full solution.

Indigenous peoples and intellectual rights

Consider who owns (has the **intellectual rights** to) the knowledge that Indigenous peoples have of plants and their environment. Article 31 of the United Nations Declaration on the Rights of Indigenous Peoples (2007) states that:

Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts.

They also have the right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions.

UN Declaration on Rights of Indigenous Peoples (UNDRIP) related to Sustainable Development and Environmental Change, Article 31. © UNESCO <http://www.unesco.org/nipwip/indegnor-peoples-environmental-development-and-environmental-change/>

There are many different opinions on whether it should be possible for other people to **patent** the genetic information in plants used by Indigenous peoples.

The neem tree

Some people question the right of pharmaceutical companies to make large profits from medicines developed using Indigenous peoples' knowledge without their permission. This is sometimes called **biopiracy**.

The neem tree, which grows throughout India, has many traditional medical uses. Pharmaceutical companies have shown interest in producing modern medicines from its ingredients. In 1995, the US government awarded a patent to a pharmaceutical research company relating to a method of extraction of an antifungal compound from the tree. One of the conditions for the award of a patent is that it is based on new knowledge. The pharmaceutical company had argued that as the Indian knowledge about the neem tree had never been published in an academic journal, it was not proper knowledge.

This caused an enormous reaction within India. Eventually, after legal action by the Indian government, the patent was withdrawn in 2005. From cases like this, the Indian government has started a major project to document all available local knowledge of the medicinal uses of plants.

Other recent examples include the successful marketing of an appetite suppressant to help people lose weight, based on chemicals in a succulent plant found in South Africa.



FIGURE 1.26 A neem tree (*Azadirachta indica*) has many uses in traditional Indian medicine.

REVIEW

- 1 Explain why the local Indigenous populations of South America were very vulnerable to diseases brought by the Spanish conquistadors.
- 2 Many Indigenous peoples experience general health problems when they adopt more modern lifestyles. Why might this be? What solutions do you see?
- 3 Give two examples of Indigenous herbal medicines that have been developed by pharmaceutical companies.
- 4 Describe your thoughts on the idea of pharmaceutical companies being allowed to take out patents on products based on the traditional herbal medicines of Indigenous peoples.
- 5 **a** Find out about some other medicines that have their origins in traditional Indigenous remedies.
b Research the history of aspirin.



Go to <http://mypsci3.nelsonnet.com.au> and click on **Indigenous medicine** to discover more about the Indian government's project to document knowledge of medicinal uses of plants.

Indigenous knowledge about navigation



Go to <http://mypsc3.nelsonnet.com.au> and click on **Songlines** for more information on Australian Aborigines' use of the stars in their songlines.
Go to <http://mypsc3.nelsonnet.com.au> and click on **Navigation** to find out more about latitude and longitude.

Polynesians are well known for their navigation skills, developed during their voyages over the past 2000 years. During the day, they used knowledge of the Sun and the wave patterns caused by nearby islands. At night they used a sophisticated knowledge of the stars and planets to be sure of their direction. From the position of the stars, they could tell both their latitude and longitude. They had memorised the positions over the year of major constellations of stars such as the Pleiades, which they called *Makalii*, and the movement of planets such as Jupiter, which they called *Iao*, and the red planet (Mars), which they called *Hoku-ula*.



FIGURE 1.27 A Polynesian boat as observed in 1616 by Dutch sailors



FIGURE 1.28 The Pleiades (or Seven Sisters), a cluster of stars that is often used for navigation

The Kayapo: A modern case study

The Kayapo is an Indigenous group of people who live in the Brazilian rainforests, on the Xingu River. They use more than 650 different plants for medicinal purposes. They hunt and fish for their food, and carry out shifting cultivation. This means they are nomadic – they farm a certain area for a few years and then move to another area. This allows the old land to lie fallow and replenish its **nutrients** naturally.

This idea of leaving land to lie fallow has always been considered good farming practice. Modern intensive methods of agriculture usually don't follow this practice and instead replace lost nutrients with artificial fertilisers. This can lead to reduced soil quality and sometimes soil erosion.

The Kayapo people, and other Indigenous tribes of the Amazon rainforests, are under threat in many ways. Their land is being taken from them for agriculture and mining, often gold mining and petroleum. Pollution, particularly of their rivers, is also a problem.

A particular issue facing the Kayapo is that the Brazilian government plans to establish dams along the Xingu River. The Kayapo have been very effective in making their situation known to the world. They have protected their land and culture against the interests of people wanting their land for agriculture, logging and mining. For a while, their campaign stopped the Brazilian



FIGURE 1.29 The Kayapo people from the Amazon region live a traditional lifestyle, which is under threat.

government from damming the Xingu River, but this was short-lived. The world's third-largest dam is now being built on the Xingu River and the Kayapo face losing their ancestral homelands and way of life. They have been offered a large amount of financial compensation but this won't make up for the breakdown in their traditional way of life.

The Kayapo cleverly used modern technologies such as video and TV to tell their story. The rock star Sting made a highly publicised appearance at one of their demonstrations (Figure 1.30).

The Kayapo are also well known for their relationship with The Body Shop. In the early 1990s, the Kayapo entered into a relationship with The Body Shop to sell Brazil nut oil, which was used as an ingredient in cosmetics. This initiative was part of The Body Shop's 'Community Trade' projects, which encouraged fair trade with Indigenous peoples to make use of their local resources to generate an income. The Kayapo villages were paid above market rates for the Brazil nuts. However, some people, including some Kayapo themselves, have argued that the Kayapo were not well treated, and that adequate compensation was not paid for the use of their images in the advertising.

It is a difficult issue. Many people believe that Indigenous peoples such as the Kayapo should not become involved in trade with such large international companies.



FIGURE 1.30 The singer Sting appeared at a demonstration supporting the Kayapo in their fight against dams being built along the Xingu River.



Go to <http://myps3.nelsonnet.com.au> and click on **Xingu River** for a video of the Xingu River hydroelectric power station project.

Fair trade debate

ACTIVITY

Research other examples of fair trade. Prepare for a debate with your class, with half the class considering issues from an Indigenous group's perspective and the other half from the perspective of companies from industries such as cosmetics and food.

Some films to watch

ACTIVITY

CHILDREN OF THE AMAZON (2008)

This film of the Surui people was made by Brazilian filmmaker Denise Zmekhol. The film describes what happened to the Surui's life in the largest forest on Earth when a road was built straight through its heart.

AVATAR (2009)

James Cameron, the creator of *Avatar*, was recently on a panel with a number of Indigenous North Americans discussing Indigenous issues. Why would this be? *Avatar* deals with a fictional tribe of humanoid creatures called the Na'vi, who inhabit the rainforest world of Pandora. The Na'vi must fight to preserve the forest from a mining corporation backed up by military force.

CLASS DISCUSSION

- 1 As a class, discuss how *Avatar* parallels the situation of the Indigenous peoples in the Amazon rainforests.
- 2 What message did the films create?
- 3 Write and share a personal response to *Children of the Amazon*, perhaps a poem or a declaration speech.

Impact of modern conservation approaches on Indigenous people

Our great grandparents lived with the animals, and took great care of them. But we are being chased out from them. We need to be given our land. Now it is very difficult for us to survive.

Mwapele Mosemolepele, a Bushman who lives in the Central Kalahari Game Reserve

A challenging issue for conservation worldwide is the rights of Indigenous people to their ancestral lands. The quote above reflects the issue faced in the Central Kalahari Game Reserve in Botswana. On one hand, it is good to see the efforts being made to protect sensitive ecosystems and endangered animal species. On the other hand, Indigenous people argue that they have lived in harmony with their ancestral lands for centuries and are skilled in managing animal populations. It can be argued they are part of the ecosystem.

The Botswana Bushmen (Figure 1.31) are being forced off their ancestral lands by antipoaching squads. The Botswana Bushmen argue that there is a big difference between the sustainable hunting

carried out by Indigenous people and the illegal poaching being carried out for short-term economic gain.

Another seemingly positive step was the Convention on International Trade in Endangered Species (CITES), which banned the ivory trade (from elephant tusks) in 1989. Again this has had the effect of restricting the access of Indigenous peoples to traditional and sustainable hunting. It seems important that local Indigenous peoples are involved in conservation projects. This has happened successfully in the Namunyak Wildlife Conservation Trust, a community-run conservation area that was established in 1995 by the Samburu people in Kenya. The Canadian government has also successfully involved local Indigenous people in the conservation of polar bears.



FIGURE 1.31 Botswana Bushmen are protesting against local conservation policies that punish them for carrying out their traditional hunting practices.

REVIEW

- 1 Describe how the Polynesian people gained the skills to make long, complicated journeys.
- 2 State what is meant by 'shifting cultivation'.
- 3
 - a Outline the story of how the Kayapo tried to defend their ancestral lands.
 - b Describe your feelings about the conflict of interest between a country wanting to improve electricity supply to its people and Indigenous people defending their rights.
- 4 Explain what is meant by 'fair trade'. What issues does it try to overcome?
- 6 Explain why conservation projects sometimes cause conflict with the rights of Indigenous peoples.

UNIT QUESTIONS

CRITERION A

EXPLAINING SCIENTIFIC KNOWLEDGE

- List the main stages in the modern scientific method. (Level 1–2)
- How is most knowledge communicated in Indigenous cultures? (Level 1–2)
- State two examples of effective traditional medicines that have modern scientific explanations. (Level 3–4)
- State three diseases the Spanish conquistadors took with them to South America and the impact these diseases had. (Level 3–4)
- Outline the importance of creation stories for Indigenous peoples. (Level 5–6)
- Outline the importance of salmon fishing to the Tlingit people. (Level 5–6)
- Describe how the development of Indigenous knowledge is different from that of modern scientific knowledge. (Level 7–8)
- Describe the different categories of vitamins.
 - Explain why some vitamins, such as vitamins C and B, need to be consumed every day, whereas other vitamins need to be consumed less often. (Level 7–8)

APPLYING SCIENTIFIC KNOWLEDGE AND UNDERSTANDING TO SOLVE A PROBLEM

- Suggest how Indigenous peoples might have developed their knowledge about medicinal plants. (Level 1–4)
- Why do you think the health of some Indigenous peoples is worse than that of local non-Indigenous peoples? What solutions do you see? (Level 1–4)
- Recently the salmon in a river stopped running. What suggestions do you have for why this might have happened? What solutions do you propose? (Level 5–8)
- Modern agricultural methods and the movement of food around the world often cause a lot of environmental damage. Use your knowledge from this unit to suggest ways this situation can be improved.

INTERPRETING INFORMATION

- You read the following quotes on a website.

The environment is not separate from ourselves; we are inside it and it is inside us; we make it and it makes us.

Osvaldo Cruz, Instituto de Medicina, Universidade de São Paulo, Brazil

Our relationship to the forest is like a child to its mother. The Western environmental groups can't understand that.

Abraham, Jari Kaitila, Leader, India

- Apply what you have learnt in this unit to explain what these quotes are trying to communicate.
 - Give your opinion about whether Indigenous people should remain living in sensitive ecosystems where attempts are being made to conserve endangered species. (Level 1–8)
- Discuss whether biopiracy is a serious problem or whether all knowledge in the world should be freely available at no cost to anyone. (Level 1–8)
 - An article in a magazine suggests that Indigenous knowledge is poor, unscientific knowledge and has little worth. Write a letter to the editor of the magazine giving your views. (Level 1–8)

REFLECTION

- How much do you think the culture we grew up in affects our values and the perspectives we have on global issues?
- Discuss whether you think that people in modern Western societies use the word 'environment' in the same way as Indigenous people.
- Discuss how we can use the idea of balance in relation to protecting the environment.
- Do you think it is possible that Indigenous peoples can live in modern societies in a way that maintains their traditions and values?

UNIT

2

ADAPTATIONS OF ORGANISMS

KEY CONCEPT

Systems

RELATED CONCEPTS

Environment

Form

Function

Evolution

GLOBAL CONTEXT

Orientation in space and time – an exploration into how organisms have adapted over time to live in their environments

STATEMENT OF INQUIRY

The adaptations of organisms to changes in their environment can be explained by the theory of natural selection.

INQUIRY QUESTIONS

FACTUAL

- 1 What is meant by adaptations in organisms?
- 2 Who was Charles Darwin?

CONCEPTUAL

- 3 Why is the theory of evolution by natural selection very important to understanding how organisms adapt to their environments?
- 4 What are the different forms of adaptation, and how are they different?
- 5 How are humans responsible for the adaptations of organisms?

DEBATABLE

- 6 Scientists are now able to genetically modify certain organisms for a variety of purposes. Who should be responsible for setting limits on genetic modification, and how should this be done?

Introduction

Organisms have a wide variety of shapes, sizes, behaviours and habitats. During the 19th century, naturalists and explorers first started inquiring into the relationships of living organisms to each other and their environment. The human-built environment of highways and sprawling cities had not yet divided the Earth's natural landscape. Newly introduced **species** had not yet invaded established habitats.

Organisms thrive in certain places because of favourable conditions, where they can reproduce, obtain enough food and water, and find shelter. When conditions change due to natural events or human impact, the organisms must adapt to their changing habitat or die. Many organisms are able to adapt to extreme conditions.



Adaptations to extreme conditions

Research

Work in groups to carry out research into how organisms have adapted to:

- altitude
- chemicals in the environment
- cold
- dry conditions
- fire
- heat.

You will find a useful BBC website for research in the weblink.

Your product

Produce an informative and attractive poster for an online science museum. Your poster should summarise what you have learnt and be suitable for students of your age. Include suitable hyperlinks and acknowledge all sources you have used.

Go to <http://mypsci3.nelsonnet.com.au> and click on **Adaptations** to help your research on adaptations.



ATL

COMMUNICATION

Use of appropriate forms of communication for different purposes

Adaptations

Adaptations are adjustments or changes in the structure or function of an organism in response to conditions in the environment around them. These adaptations give the organism a better ability to compete for resources and hence a better chance to survive. Change in available food and water, change in **climate**, and change in the environment can each have a drastic effect on an organism. Organisms may not grow as large or reproduce as often when circumstances are severe. There are three main types of adaptation organisms can undergo: structural, behavioural and functional. The process of adaptation is explained by Darwin's theory of evolution by natural selection.

The basis of the theory of evolution is as follows.

- Individuals in a species show a wide range of variation in their characteristics.
- This variation is because of differences in their genetic make-up.
- Individuals with characteristics most suited to the environment are more likely to survive and reproduce.
- These successful individuals will pass these characteristics to their offspring (via their genes).

Structural adaptations

Adaptations help organisms survive in their environments. Examples of **physical** (or **structural**) **adaptations** in animals include a giraffe’s long neck, a beaver’s fatty, oar-like tail, the special sense organs in sharks and types of camouflage. The hair structure of a polar bear’s fur helps it stay warm in sub-freezing temperatures. Birds’ beaks have adapted to their habitat. Water birds may have webbed feet for paddling or long, spread-out toes for wading (Figure 2.1). Alligators and crocodiles have nostrils that stay above water while the rest of the animal is submerged. Structures such as teeth can tell you a lot about an animal’s diet, even one that is long extinct.

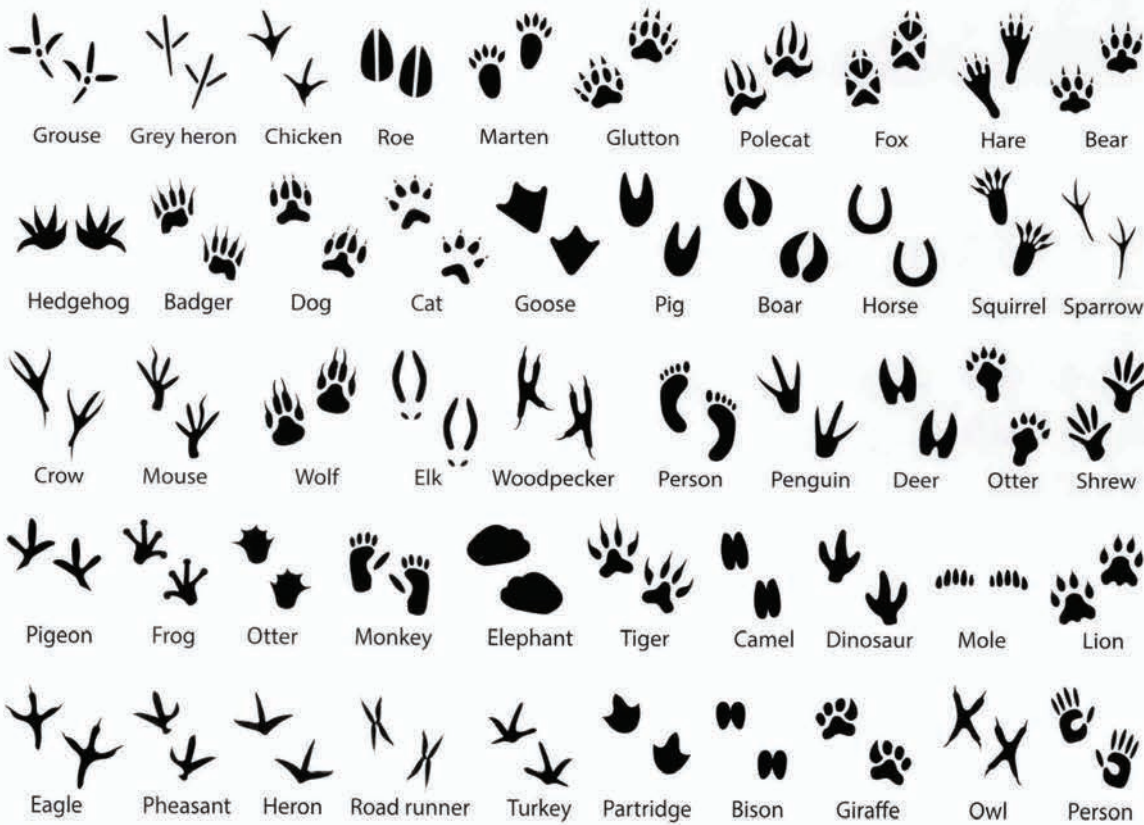


FIGURE 2.1 The structure of animal feet can show adaptations to their unique environments.

The thick wax on the leaves of the mirror bush (*Coprosma repens*, Figure 2.2) is an example of a structural adaptation in a plant. The wax reduces water loss, protects the plant against insect predation, and helps control leaf temperature by reflecting sunlight.



FIGURE 2.2 The glossy leaves of the mirror bush (*Coprosma repens*) keep the plant cool and prevent water loss.



FIGURE 2.3 The queen of the night (*Peniocereus greggii*) opens its flowers at night – a behavioural adaptation. What kind of adaptation is the colour of its flower?



FIGURE 2.4 This young fox will learn the hard way to stay away from skunks after it gets sprayed!

Behavioural adaptations

Organisms can change their behaviour to help survive. This is called a behavioural adaptation. Examples of **behavioural adaptations** in animals include postures (such as sitting very still to avoid detection by predators), spreading out and remaining inactive during hot weather, or huddling in a group to share body warmth in cold weather.

Plants can also modify their behaviour. For example, desert plants such as the queen of the night cactus (Figure 2.3) flower at night because the pollinators are **nocturnal** bats.

Functional adaptations

Functional adaptations generally involve the way the organism works, and include the ability to sweat, lower the rate of cellular reactions to hibernate, or release special chemicals that change the behaviour of others. The defensive smell released by skunks (Figure 2.4) and the fragrance of plants that attracts pollinators are examples of functional adaptations.

REVIEW

- 1 Very few adaptations are exclusively structural, behavioural or functional. For example, if an organism releases an offensive chemical, it may have a special structure to do so. Draw a Venn diagram of the three types of adaptations and decide where to place each of the following organisms on the basis of the adaptations described.
 - a A bombardier beetle can squirt hot acid at potential prey.
 - b A stick insect stays very still to avoid detection by predators.
 - c A chameleon traps its prey with its extremely long, sticky tongue.
 - d The sabre-toothed tiger had massive canine teeth, for a reason that is not known.
 - e Snails become dormant during hot seasons by sealing their shells with mucus.
 - f Elephants can manipulate tiny objects with their trunks.
 - g Snakes move using muscles attached to their ribs.
 - h Some species of edible butterflies mimic the appearance of nasty-tasting ones.
 - i The formic acid smell of many ants protects them from predation.
 - j The bright colour of poison arrow frogs is a warning and reminder to predators that they are inedible.