

# MYP Life Sciences

A concept-based approach

Years

1–3



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# Introduction

The MYP Life Sciences course, like all MYP Sciences, is inquiry based. To promote conceptual understanding, the MYP uses key concepts and related concepts. Key concepts represent big ideas that are relevant across disciplines. The key concepts used in MYP Sciences are change, relationships and systems. Related concepts are more specific to each subject and help to promote more detailed exploration. Each chapter is focused on a topic area in Life Sciences, one key concept and two or three of the 12 related concepts.

The nine chapters in this book do not form a fixed linear sequence. They form a 3x3 matrix, organized by key concept:

Relationships	Systems	Change
Genes	Cells	Food
Reproduction	Organisms	Migration
Communities	Ecosystems	Evolution

There are many different ways of navigating through this matrix. The ideal route will depend on students' ages and any additional requirements from the local science curriculum.

The objectives of MYP Science are categorized into four criteria, which contain descriptions of specific targets that are accomplished as a result of studying MYP Science:

- A. Knowing and understanding
- B. Inquiring and designing
- C. Processing and evaluating
- D. Reflecting on the impacts of science

Within each chapter, we have included activities designed to promote achievement of these objectives, such as experiments and data-based questions. We have also included activities designed to promote development of approaches to learning skills. The summative assessment found at the end of each chapter is framed by a statement of inquiry relating the concepts addressed to one of the six global contexts and features both multiple-choice questions and questions that require longer answers.

Overall, this book is meant to guide a student's exploration of Life Sciences and aid development of specific skills that are essential for academic success and getting the most out of this educational experience.

# How to use this book

To help you get the most out of your book, here is an overview of its features.

## Concepts, global context and statement of inquiry

The key and related concepts, the global context and the statement of inquiry used in each chapter are clearly listed on the introduction page.



## Data-based questions

These questions allow you to test your factual understanding of life sciences, as well as study and analyse data. Data-based questions help you prepare for assessment criteria A, B & C.



## Activities

A range of activities that encourage you to think further about the topics you studied, research these topics and build connections between life sciences and other disciplines.

## ATL Skills

These approaches to learning sections introduce new skills or give you the opportunity to reflect on skills you might already have. They are mapped to the MYP skills clusters and are aimed at supporting you become an independent learner.

## ABC

Vocabulary features are designed to introduce and familiarize you with the key terms you will need to know when studying the life sciences.



## Community project feature

Community project features show how you can apply your understanding of science to make a positive impact on the community and collaborate with others through community service.



## Experiments

Practical activities that help you develop skills for assessment criteria B & C.

## Summative assessment

There is a summative assessment at the end of each chapter; this covers all four MYP assessment criteria.

# Mapping grid

This table shows you which key concept, related concepts, global context and statement of inquiry guide the learning in each chapter.

Chapter	Key concept	Related concepts	Global context	Statement of inquiry	ATL skills
<b>1 Genes</b>	Relationships	Consequences Models Patterns	Identities and relationships	Patterns in human identity that we see around the world are a consequence of both ancestral relationships and environment influences.	<b>Communication skills:</b> Organize and depict information logically  <b>Communication skills:</b> Negotiating skills
<b>2 Cells</b>	Systems	Function Balance Models	Scientific and technical innovation	Discoveries made using new techniques can change our understanding of the natural world.	<b>Creativity and innovation:</b> Making guesses
<b>3 Food</b>	Change	Energy Transformation	Globalization and sustainability	We will need to change how we transform materials and energy to achieve sustainable production and equitable distribution of food in the 21st century.	<b>Information literacy skills:</b> Present information in a variety of formats <b>Media literacy skills:</b> Evaluating websites <b>Communication skills:</b> Interpreting discipline-specific terms
<b>4 Reproduction</b>	Relationships	Consequences Form Patterns	Personal and cultural expression	The relationships between specific organisms are affected by their form of reproduction.	<b>Information literacy skills:</b> Present information in a variety of formats and platforms
<b>5 Organisms</b>	Systems	Form Function	Identities and relationships	Human identity includes the impulse to help family members and also those we are not closely related to.	<b>Collaboration skills:</b> Working effectively with others

Chapter	Key concept	Related concepts	Global context	Statement of inquiry	ATL skills
<b>6 Migration</b>	Change	Energy Evidence Movement	Orientation in space and time	Evidence can be used to detect changes in the spatial patterns of migrating birds.	<b>Critical thinking skills:</b> Evaluating evidence
<b>7 Communities</b>	Relationships	Interaction Balance	Fairness and development	To achieve fairness, development must balance the needs of current communities with the needs of future communities.	<b>Collaboration skills:</b> Use social media networks appropriately to build and develop relationships
<b>8 Ecosystems</b>	Systems	Environment Interaction Movement	Globalization and sustainability	The Earth will become uninhabitable for humans and many other organisms if we continue to damage the environment.	<b>Reflection skills:</b> Consider ethical, cultural and environmental implications
<b>9 Evolution</b>	Change	Environment Evidence Transformation	Orientation in time and space	Evidence of past changes helps us to understand life today and how it might be transformed in the future.	<b>Affective skills:</b> Analyzing and attributing causes of failure

A summary of how these chapters can be used to support Life Science Progression of disciplinary core ideas for Grades 6 to 8 (Middle School) in the Next Generation Science Standards is available on the support website ([www.oxfordsecondary.com/myp-science-support](http://www.oxfordsecondary.com/myp-science-support)).

# 3 Food

**Key concepts:** Change

**Related concept:** Energy, Transformation

**Global context:** Globalization and sustainability



◀ In 2003, illusionist David Blaine spent 44 days suspended in a transparent case with water to drink but no food. During this time his body mass decreased by 25% and his body mass index (BMI) dropped from 29.0 (overweight) to 21.6 (ideal weight). What are the dangers of fasting for this length of time? Would the consequences have been different if Blaine’s weight at the start of the experiment was the “ideal” weight? Under what circumstances might a human experience conditions similar to these? Carry out some research to determine the strategies the human body uses to survive starvation



◀ Have you ever heard the saying “You are what you eat”? Is this true? If so, could you identify someone as a meat-eater or a vegan, by just looking at them?



**Statement of inquiry:**

We will need to change how we transform materials and energy to achieve sustainable production and equitable distribution of food in the 21st century.

▲ To survive on Earth, humans need to compete with other species for air, water, food and space. For example, orangutans in South-East Asia have lost much of the forest habitat that used to feed them because the land has been cleared for palm oil production

How much of the food produced on Earth do humans need and how much should be available to all the other organisms? Through research, find out what fraction of food produced by agriculture is actually consumed and how much is wasted

► How do plants such as these lilies (*Cardiocrinum giganteum*) grow over two meters tall in just a few weeks without us having to feed them any carbohydrates, fats, protein or vitamins?



**Key concepts:** Change

**Related concept:** Energy, Transformation

**Global context:** Globalization and sustainability

**Statement of inquiry:**

We will need to change how we transform materials and energy to achieve sustainable production and equitable distribution of food in the 21st century.

## Introduction

- Food is the variety of chemicals that we need to sustain life.
- Food is both a building material and a fuel.
- Some organisms, including animals, get food by consuming other organisms.
- Other organisms, including plants, make their own food using photosynthesis.
- Energy from the Sun is used in photosynthesis to change simple chemicals, such as carbon dioxide and water, into foods by a sequence of chemical reactions.
- To use food as a fuel, we release its energy in a chemical process called respiration.
- Every cell has to carry out respiration to supply the energy that is needed to sustain life.
- Respiration is a series of chemical reactions, each of which changes food.
- Certain key stages in respiration release energy in a usable form.
- Respiration can occur either with oxygen (aerobic) or without oxygen (anaerobic).
- Two examples of the use of energy are maintaining body warmth and motion (movement).

▼ Photosynthesis in corn plants is particularly efficient in hot and dry conditions. Global production of corn is now greater than any other crop. It is used as a food for both humans and livestock and is also used to produce ethanol, which is a renewable fuel for vehicles. How is a corn crop changed into ethanol?

▼ On average, a person will use 11,000 kilojoules (kJ) of energy to run a marathon. Glucose (the sugar carried in blood) contains 16 kJ per gram, so nearly 700 g of glucose would be needed to supply this energy. The body stores glucose in the form of glycogen in the liver and muscles. Unfortunately, only about 500 g can be stored. What are the consequences of this for marathon runners?



- To use food as a building material in our bodies, it has to be in the form of small subunits.
- Digestion involves breaking down large complex chemicals in our food into small subunits.
- Our cells then use the small subunits to build large and complex chemicals that are key components of our bodies.
- Cells produce these complex chemicals when they are growing and also when repairs are needed.
- Without food neither growth nor cell repair is possible.

Photosynthesis produces vast quantities of food. In his book *Harvesting the Biosphere*, Vaclav Smil assesses how much of this is taken and used by humans. The amount is currently estimated to be between 17% and 25%. It is used in four ways: food for humans, food for livestock, fuel that is burned to provide energy, and material for making things such as buildings and paper.

Is it acceptable for one species to take up to a quarter of all the food produced on Earth, when there are millions of other species that also need food to survive?

The UN has projected the global human population to reach 11.2 billion by 2100. What percentage of food produced by photosynthesis would be needed for that population? What would the effect of this human population rise be on other species?

Biologist EO Wilson believes that half of the Earth's land surface should be designated a human-free natural reserve to preserve biodiversity. Do you agree? Research his Pulitzer prize-winning book *Half-Earth* on the internet.



▲ A snake may only feed once a month, or even less, but it is very effective at digesting the prey that it has swallowed. Only the tough protein keratin, which makes up hair and feathers, remains undigested.



### Hens' eggs

Laying hens produce about 330 eggs per year. To produce a typical egg weighing 55 g (not including the egg shell), a hen needs to eat 132 g of food containing about 1,560 kJ of energy. The egg contains 610 kJ.

Use pie charts to display this data. What happens to the energy in the hen's food that does not end up in the egg?



## ATL Information literacy skills

### Present information in a variety of formats

Pie charts are used to represent information in the form of proportions or percentages.

1. Looking at the data in the question on hens' eggs, what other formats could be used to display it?
2. How does the purpose of the data affect the choice of display format? For example, if the information were meant to indicate a food chain, why is the preferred format of data display usually a pyramid shape rather than a pie chart?

## What nutrients are needed in the human diet?

Humans need five types of chemicals in their food: carbohydrates, lipids (fats and oils), proteins, minerals and vitamins. These dietary chemicals are known as nutrients. Water is also needed in the diet but is not usually thought of as a food or a nutrient.

Study the information in the table below and then answer the questions that follow.

**Carbohydrates and lipids** are both mainly used to provide energy, though they are also used in smaller quantities for constructing parts of cells. For example, omega-3 fatty acids, found in some lipids, are needed for making cell membranes, especially in brain cells.

**Carbohydrates** are sweet-tasting sugars and chemicals such as starch that are made by linking sugars up to form larger molecules.

Sugars and starch only contain carbon, hydrogen and oxygen, in a CHO ratio at or close to 1:2:1.

**Lipids** are high-energy carbon compounds that do not dissolve in water. They contain only carbon, hydrogen and oxygen, but there is less oxygen than in carbohydrates. Two important types are fats and oils. Both are liquid at human body temperature (37°C) but at room temperature (20°C) fats are solid and oils are liquid.

**Proteins** can be used as an energy source, but more importantly they supply the building blocks for making the cell's own proteins. These building blocks are called amino acids. A protein molecule consists of a string of amino acids, often hundreds, and sometimes even thousands, of amino acids long.

There are 20 different amino acids in proteins. We need all of these, but some amino acids can be converted in our cells into other ones. There are 12 amino acids that we cannot make in this way, so they are called essential amino acids. These must be in our diet or we suffer a deficiency disease and cannot make enough protein in our cells.

Protein deficiency has various names around the world, including kwashiorkor, but the signs are always the same: restricted growth and fluid retention that makes the abdomen swollen.

**Minerals and vitamins** are needed in relatively small quantities and cannot supply the body with energy, but they are nonetheless all essential. If any mineral or vitamin is missing from the diet then a deficiency disease results. Rickets is an unusual example of a deficiency disease as it can be due to a lack of the mineral calcium or of vitamin D. Rickets is still common in some populations despite its causes and methods of prevention being well-understood.

**Minerals** are chemical elements that are absorbed as simple compounds or ions. The body needs five of these in quite small quantities including calcium and sodium. More than ten other elements are needed in very small quantities, including the metals iron and zinc and the non-metals iodine and boron. Each mineral has specific uses in the body. Iron is needed to make hemoglobin, the red oxygen-carrying chemical in blood. Iodine is needed to make thyroxin, a hormone that controls how fast we release energy in our body.

**Vitamins** are complex carbon compounds that the body cannot produce itself. They are chemically very varied but can be divided into two groups: fat-soluble (vitamin A and D) and water-soluble (vitamin C and all the B vitamins). Vitamins have many different roles in the body. Vitamin C for example is needed during the production of a tough rope-like protein called collagen that strengthens parts of the body such as skin, tendons, ligaments and blood vessel walls. Scurvy is a disease caused by vitamin C deficiency. The symptoms are due to insufficient collagen in the body.

Conduct some independent research to answer the following questions—the first question **a)** in each pair is easier than the second one **b)**, which is more of a challenge. Your choice!

- a)** Each of the following foods is rich in one of the five nutrient types—which one? Soy beans, honey, butter, bread, cheese.

**b)** Name a food that is rich in each of these chemicals: vitamin C, vitamin D, calcium, iodine, boron.
- a)** If you measured the amounts of the five nutrient types (minerals, vitamins, proteins, lipids and carbohydrates) in your body, which would be the largest?

**b)** Arrange the five nutrient types in order according to the amounts in your body, starting with the smallest.
- a)** Water is not usually considered to be a food. Why not?

**b)** Growth requires producing more cells and this requires producing more DNA. There is DNA in the foods that we eat. Is DNA therefore a sixth food type?
- a)** Look at the two groups of food on the right. What are each of these two groups of foods rich in?

**b)** Explain which is the “odd one out” in each group of foods.



### Should we drink smoothies or eat fruit?

Food scientists carried out an experiment on a group to compare the effects of drinking a fruit smoothie with eating fresh fruit salad—both containing the same quantity of protein, fat, carbohydrate and fiber.

Two hours after the participants had drunk the smoothie or eaten the fresh fruit, they were asked to rate how full they felt on a scale from zero (empty) to 100 (extremely full) and whether they felt more hungry or less hungry on a scale from minus 100 to plus 100. Average results are shown in the following table.

	Fullness	Hunger rating
smoothie	31	-21
fruit salad	48	-34

- Summarize the differences in the table for the smoothie and the fruit salad results.
- A feeling of fullness is called satiety. Suggest reasons for the difference in satiety, given that the quantities of protein and other food types consumed were the same.
- Discuss whether it is better to drink a fruit smoothie or eat an equivalent quantity of fresh fruit.

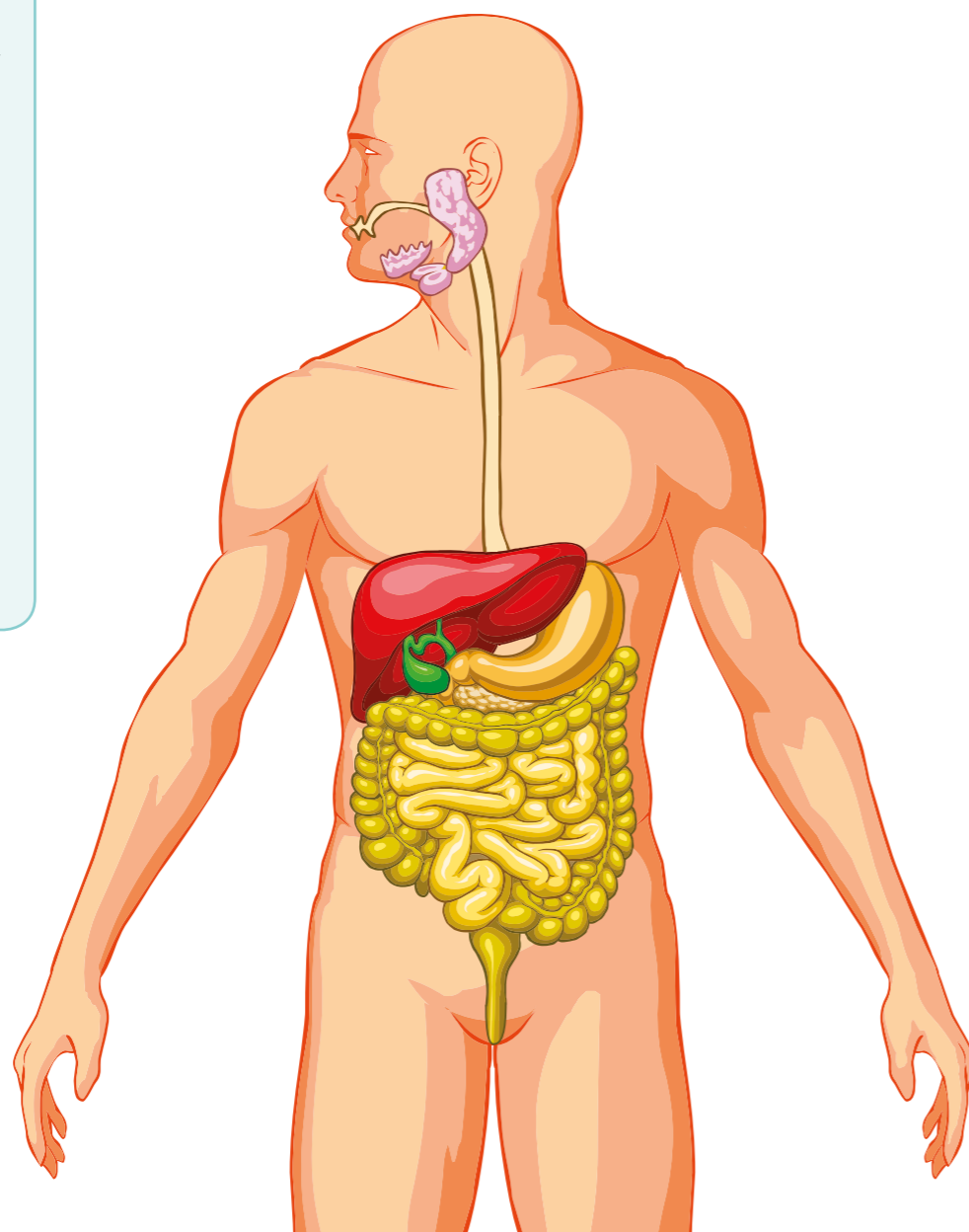
The full results of this experiment are available online in the article *A Comparison of the Satiety Effects of a Fruit Smoothie, Its Fresh Fruit Equivalent and Other Drinks*, by Peter Rogers and Roya Shahrokni. You could carry out a similar experiment to investigate smoothies.

## How does the human body digest food?

One of our major body systems has the job of digesting the food that we eat and absorbing the products of digestion. In simple terms, the digestive system is a tube that runs from our mouth to our anus, through which food passes. This tube is called the **gut** and consists of a series of **organs** that each specialize in particular aspects of breaking down or absorbing foods. For example, the stomach stores food after a meal, kills bacteria in the food and gets protein digestion started.

The sequence of organs used in the digestive system is:

mouth → esophagus → stomach → small intestine → large intestine → anus  
 (gullet)                      (duodenum      (colon and  
   and ileum)        rectum)



ABC

**Ingestion** is the taking in of food (usually through the mouth) for subsequent digestion.

**Feces** is material that reaches the end of the gut, mainly consisting of gut bacteria and undigested parts of foods such as plant fiber.

**Egestion** is the removal of feces from the gut (usually through the anus).

An **organ** is a part of an animal or plant that is composed of different tissues that work together to perform a function.

A **catalyst** is a substance that speeds up a chemical reaction.

The **gut** is the tube in the body that food passes through.

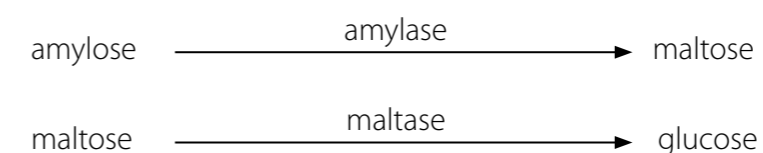
- Can you identify each organ and trace the route that food follows from **ingestion** to **egestion**?

## How do enzymes help with digestion?

Although teeth chop food into smaller pieces and the stomach and intestines churn this food to help break it up, digestion is mostly a chemical process. Large food molecules are broken down into smaller molecules until subunits are produced that are small enough to absorb into the bloodstream. The chemical reactions that break down food are carried out by enzymes—biological **catalysts**—which speed up the process. Digestive enzymes are made in big quantities by cells in the wall of the gut and also in special organs connected to the gut, primarily the salivary glands and the pancreas.

Over 20 different types of enzyme are used to digest our food. They are needed because each enzyme can only digest one type of chemical in food. The names of most enzymes end in **-ase** and the enzyme name as a whole usually tells you what it digests. Amylase digests amylose (a long chain of glucose molecules) into maltose (pairs of glucose molecules). A different enzyme is needed to digest maltose. Can you guess what this enzyme is called?

The digestion of amylose and maltose can be presented using chemical equations. The reactant (starting material) is shown on the left of the equation and the product on the right. The enzyme is shown above the arrow of the equation because it is not changed or used up during the reaction.



- ▲ These two cooked pasta shells were kept in a liquid for 24 hours. The one on the left was kept in saliva and the one on the right in tap water. What has happened to them? What conclusions can you draw about the properties of saliva?



### Experiment

#### Digesting starch

Starch is a carbohydrate that plants make to store glucose and therefore energy. Amylose is a common form of starch.

#### Materials and apparatus needed

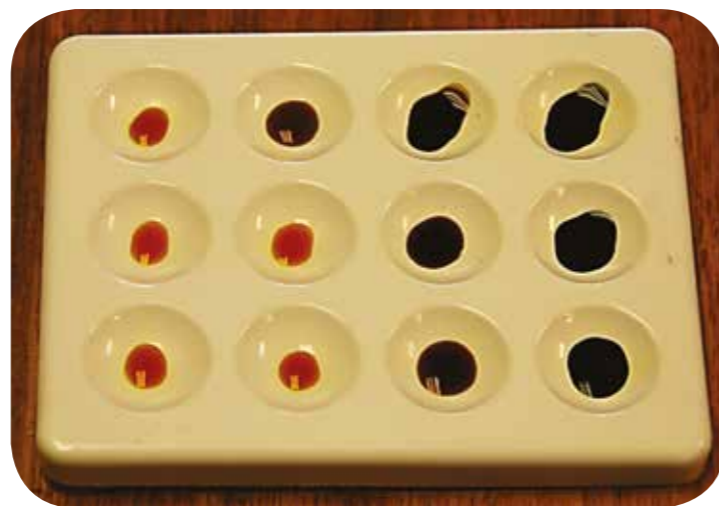
- Starch dissolved in water—a concentration of 1 g of starch per 100 ml of water is suitable. Heat is needed to dissolve starch.
- Amylase dissolved in water—this could be made from pure amylase powder, or from wheat seeds that have been germinated and ground up to release their enzymes.
- Iodine solution—this is used to test whether starch is present or not. If there is no starch present, the solution is brown; if starch is present the solution will be blue-black.



- Test tubes.
- Apparatus to measure quantities of liquid such as syringes, small measuring cylinders and pipettes.
- Spotting tiles for carrying out starch tests.
- Thermometer and apparatus for keeping test tubes at a constant temperature.
- Electronic timer.

### Basic procedure

1. Put 5 ml of starch solution in a test tube.
2. Put 1 ml of amylase solution in another test tube.
3. Heat up both tubes to 40°C.
4. Pour the starch solution into the tube containing amylase solution, mix the contents and start the timer.
5. Take a drop of the starch–amylase mixture and put it into a cavity on a spotting tile. Test for starch by adding a drop of iodine solution. Does the iodine solution go brown or black?
6. Repeat the previous stage 1 minute after mixing the starch and amylase, and again after 2, 4 and 8 minutes. How long does it take for the starch to be digested?



▲ Your results should look something like this

### Troubleshooting

- If the starch hasn't been digested after 8 minutes, repeat the basic procedure with starch solution that you have diluted with water. If the starch still isn't digested, your amylase is probably inactive.
- If the starch has already gone when you first test it, repeat with amylase solution that you have diluted with water.
- If you aren't sure whether test results are brown or black, put a drop of pure starch solution in a cavity and a drop of water in another cavity. Add a drop of iodine solution to each and compare the colors.

### Going further

When you have successfully digested some starch solution, you can devise an experiment to investigate something that might affect how fast the starch is digested by amylase. Here are some suggestions:






1. Test the effect of heat by repeating your procedure at higher and lower temperatures.
2. Test the effect of pH by repeating with different amounts of citric acid and sodium hydrogen carbonate.





## Fuelling Chris Froome's victory in the Giro d'Italia

Chris Froome won the Giro d'Italia (Tour of Italy) bicycle race in 2018. Early on in the race, Chris was suffering from an injured knee and his form was uncertain. However, in the 19th stage of the race, he was able to take the lead.

Stage 19 was a particularly gruelling one—185 kilometers with 3,500 vertical meters of ascent. Much of Chris's success was undoubtedly due to his team's plans for refuelling him far more often than is usual during cycle races. Look at the following infographic, which describes the refuelling plan.

BREAKFAST		Mass (g)	
	200ml juice	Carbohydrates	189
	400g rice	Protein	31
	egg (3 whites /1 yolk)	Fat	32
	4 pancakes with jam	Total energy (kcal)	996
	green tea with honey		

RACE (5 h 12 min):		Mass (g)	Mass per hour (g/hr)
	14 x energy gel	Carbohydrates	502
	2 x energy drink	Protein	4
		Fat	4
		Total energy (kcal)	2,348



1. Chris's team knew that only 90 g of carbohydrate per hour could be absorbed into the bloodstream from food in Chris's gut. How much in total could enter his bloodstream during the race?
2. What was used to supply this carbohydrate?
3. Chris's team staff were posted at key refuelling points along the race route to give Chris food. According to the plan, how many times did they aim to do this and why was this better than giving one large supply of food at the start of the race?
4. The expected energy expenditure during the race was 6,180 kJ. The amount of energy in food given at refuelling points during the race was 2,348 kilocalories. Convert this amount of energy into kilojoules (1 kilocalorie is equal to 4.2 kilojoules). Was it enough?
5. Fat contains more energy per gram than carbohydrate. Why was so much carbohydrate and so little fat given to refuel Chris during the race?
6. The content of Chris's breakfast and the food supplied to him during the race were very different. What are the reasons for this difference?

## Which is better— aerobic or anaerobic respiration?

**Respiration** happens in all plant and animal cells. Complex food molecules such as carbohydrates and lipids are broken down by a sequence of chemical reactions to release the energy stored in them. There are two ways of doing this. Human cells usually perform aerobic respiration, but sometimes they also use anaerobic respiration. This table compares these two processes in humans.

Aerobic	Anaerobic
uses oxygen	no oxygen needed
produces water and carbon dioxide	produces lactic acid
releases the maximum amount of energy from a food	only releases some of the energy in food
can only release energy moderately rapidly	can release energy very rapidly
can continue indefinitely	can only be done for brief periods
can be fuelled by sugars or lipids (fats or oils)	can only be fuelled by sugars

Both types of respiration consist of many chemical reactions but their overall effects can be summed up with a single equation each:

Aerobic respiration: glucose + oxygen  $\longrightarrow$  carbon dioxide + water

Anaerobic respiration: glucose  $\longrightarrow$  lactic acid

The oxygen used in aerobic respiration is breathed in and the carbon dioxide is breathed out through the lungs. Water produced by aerobic respiration helps to keep the body hydrated. The lactic acid produced by anaerobic respiration would be poisonous if it reached a high concentration. To prevent this from happening, we can stop respiring anaerobically, if necessary, by reducing the amount of energy that we are using.

Consider the activities in the following images (A–D) and decide which type of respiration is mainly being used to provide the energy needed in each image.

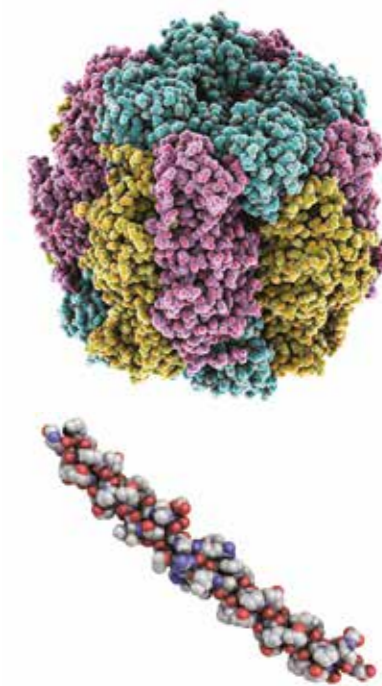


## What is the energy from respiration used for?

Our bodies need energy to:

- build proteins and other complex chemicals needed for growth
- keep the brain functioning and send messages using nerves
- pump blood round the body and food along the inside of the gut
- move the body by contracting muscles
- pump chemicals into and out of cells.

Whenever energy is used for these purposes, some of it is converted to heat. This helps to keep the body at 37°C, which is the average human body temperature. In cold conditions, not enough heat is generated to keep the body warm so extra respiration occurs in special tissues called brown adipose. Shivering is another way of generating extra heat.



### What is a Goldilocks diet?

Goldilocks had porridge for breakfast. It had to be just the right temperature. A Goldilocks diet gives us just the right amount of energy. How can we make sure we get this? Firstly, we can listen to what our body is telling us. Appetite and satiety are two feelings that tell us when to eat and when to stop eating. In the past this would have given us enough energy and also stopped us from becoming too fat. Unfortunately, we now tend to eat foods that are so rich in energy that it is easy to take in more than we need. If the body's natural system for controlling energy intake isn't working well enough, we may need to learn more about how much energy different people need and different foods contain.



▲ The most abundant protein in leaves is rubisco (top)—an enzyme used in photosynthesis. The most abundant protein in humans is collagen (bottom). What sequence of events has to happen for rubisco, eaten as part of the diet, to be converted into collagen?

Find a reliable website that gives recommendations for how much energy different people need and a database that gives the energy content of foods. Use this information to answer the following questions. Some sample websites include [www.nrv.gov.au](http://www.nrv.gov.au) and [www.foodstandards.gov.au](http://www.foodstandards.gov.au)

1. What happens to the amount of energy needed by a child as they grow older?
2. Compare the average amounts of energy needed by boys and girls.
3. For a child of your age and sex, what is the difference in energy requirement between the lowest and highest physical activity level? Try to give your answer as a percentage.
4. What happens to a woman's energy requirement during pregnancy?
5. Using your chosen website, find the highest daily energy requirement of all and describe a person who would need it.
6. Find three foods with a very high, and three foods with a very low, energy content.
7. Compare the dietary energy content of your favourite snack food with that of a carrot.
8. Foods containing starch and fiber take longer to digest and so make us feel satiated for longer, helping to reduce energy intake. Goldilocks ate porridge for breakfast. Explain whether this was a good choice, compared with other possible breakfast foods.

## ATL Media literacy skills

## Evaluating websites

Not all information sources are equal in value. When conducting internet-based research always ask yourself "Am I confident that this is a credible, authoritative website that can be used within a school setting?"

Here are some guidelines:

- What is the name of the creator or the author of this website? If you cannot locate the author, seek another source. There are exceptions to this—some credible sources such as the World Health Organization may not include the author on their websites.
- Is the author of this website reliable and qualified to write about the topic? If you cannot determine their credentials, seek another source. For example, a writer on nutrition should reasonably be expected to have some academic credentials.
- Is this website provided by an organization or a corporation? What does this organization or corporation do? You can determine this by clicking on a link that says "About us". Ask yourself, is it possible that their presentation of information is biased or one-sided?
- What kind of website is this? Is it a blog, an advertisement or an interview?
- Is this website appropriate for research within a school? What is the domain of the website? Typically .edu, .gov and .org organizations are more suitable sources than .com but this will still require some judgement.


**Trekking across the South Pole**

Aleksander Gamme is a Norwegian explorer. In 2011 he completed the first ever solo, unsupported trek to the South Pole and back. Aleksander spent 90 days on skis in the icy wilderness pulling a sledge with all his equipment and food. He traveled 2,270 kilometers and endured freezing temperatures, hunger, loneliness and hard effort.

Here are some answers to questions that Aleksander answered for readers of this book. Read Aleksander's answers and then answer the questions that follow.

*How much energy were you able to take in from food per day?*

"I started with 15,000–19,000 kJ [per day] in the first week, and then going up to 27,000 kJ a day. I had a diet with a fat percentage up to 50% and used a lot of effort testing out a diet with less refined sugar and more nutritious food with good fatty acids."

*How much body mass did you lose during the expedition?*

"I started with a body mass of 100.5 kg and finished with 76 kg."

*How much mass did you pull on a sledge or carry?*

"I started with 175 kg and 15 kg in a backpack."

*How far did you travel?*

"Approximately 2,280 km."

*What were the temperatures during the expedition?*

"Pretty much between  $-10^{\circ}\text{C}$  and  $-25^{\circ}\text{C}$ . But it's the wind making it cold, and it's pretty much windy all the time."



"The wind falls down from the icecap, so on the way in to the pole, it's always facing the wind. And then it's a lot faster the other way, with downwind, light pulls and picking up my own caches along the way. Cache with fuel and food every second degree (of latitude)."

*Did you feel cold or warm when you were sleeping?*

"When out of the coastal climate, Antarctica is cold but dry. On sunny days it's quite comfortable in the tent, because the sun's radiation heats up the tent. I had a double sleeping bag, but used only one on most of the trip. Because it's dry air it's easier to dry up socks and clothing and wet stuff, a lot easier than in the Arctic Ocean where the humidity makes that a real fuss. I also supplied myself with two solar panels, charging up a 10,000 mAh battery pack. That made me able to charge iPods, cameras and my satellite phone."

1. A typical adult male needs about 10,000 kJ of energy from food per day. How much energy from food did Aleksander consume per day during the main part of his expedition, expressed as a percentage of the typical adult male amount?
2. What are the reasons for Aleksander needing more energy during his expedition?

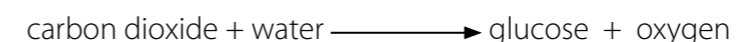


3. a) How much body mass did Aleksander lose during the expedition?  
b) What are the reasons for the loss of body mass?
4. A headwind blows against the direction of the travel of an object, whereas a tailwind blows with the direction of travel. What are the reasons for a headwind making Aleksander feel colder than a tailwind or no wind at all?
5. Why is it important for an Antarctic explorer to dry out wet clothing before putting it on again?

**What happens in photosynthesis?**

- In science *synthesis* means making a chemical and *photo* means light, so **photosynthesis** is making chemicals using energy from light.
- To make carbohydrates by photosynthesis, carbon and oxygen are obtained from carbon dioxide and hydrogen from water.
- Carbohydrates such as glucose are the main foods produced by photosynthesis but other foods needed for growth can be made, such as amino acids (the building blocks of proteins).
- Leaves absorb carbon dioxide from the air and light from the sun.
- Roots absorb water from the soil and also minerals.
- Minerals are simple chemicals found in the soil that are used to supply elements other than carbon, hydrogen and oxygen. For example, nitrate and sulfate are absorbed from the soil to supply nitrogen and sulfur, which are needed to make amino acids.

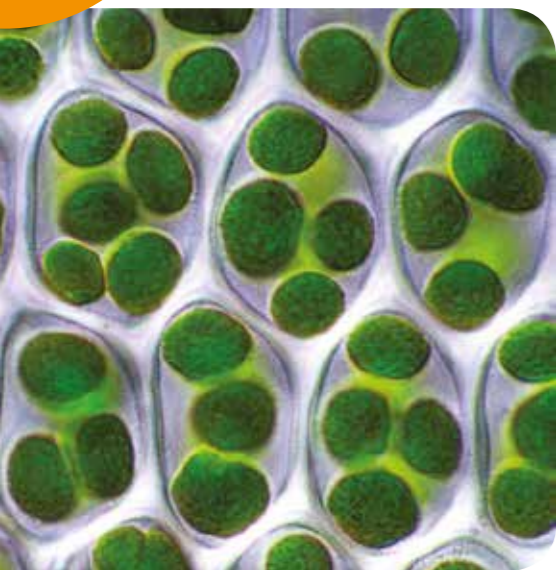
Synthesis of glucose in plants can be shown with a simple equation:



ABC

**Photosynthesis**

is using energy from light to split water into hydrogen and oxygen and to produce carbon compounds by combining the hydrogen with carbon dioxide.



▲ Chloroplasts in leaf cells of the moss *Atrichum androgynum*

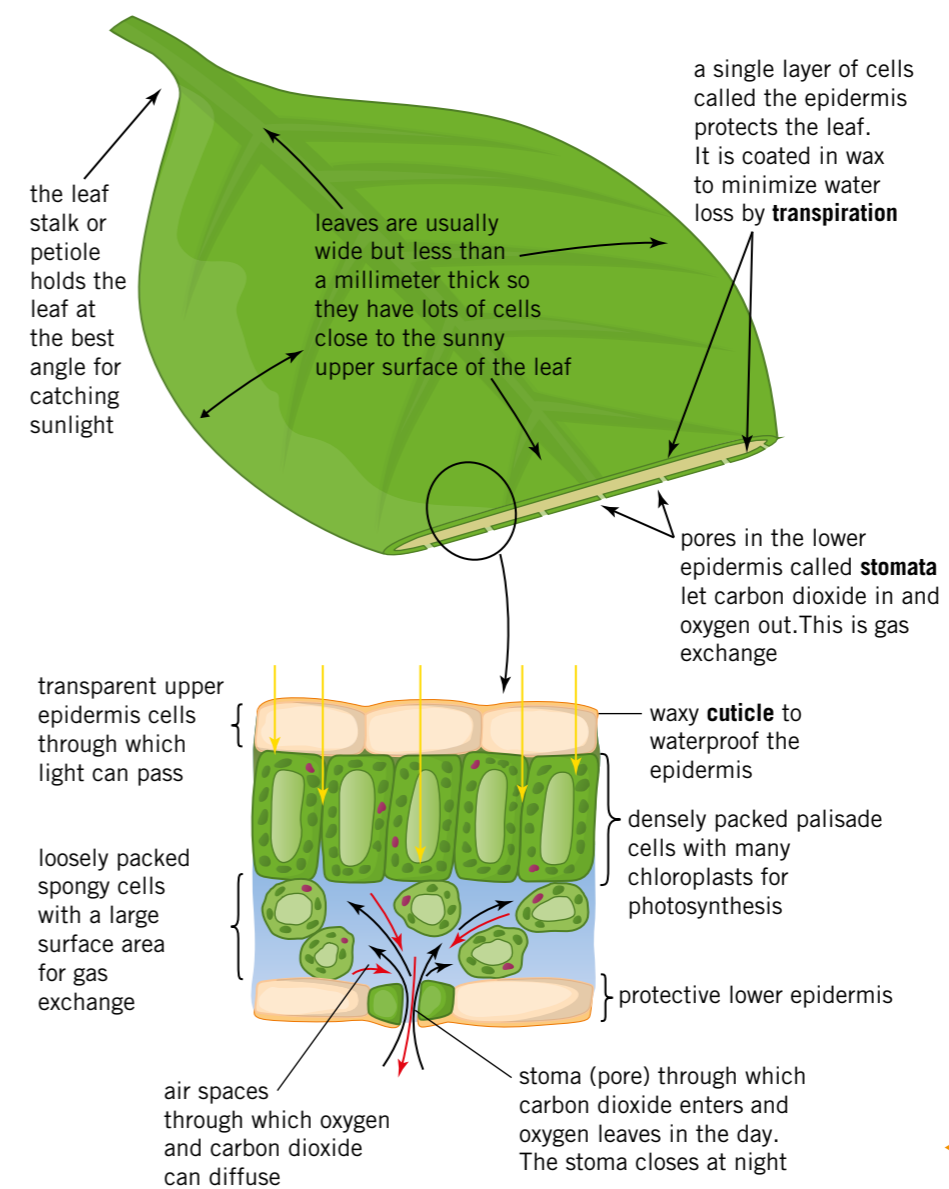
- Plants, chloroplasts, leaves and chlorophyll are all green in color. Each of them could be 5 meters, 5 millimeters, 5 micrometers or 5 nanometers long. Find out what size each is and then arrange them in order of size, starting with the smallest.
- Do you agree with the following claims? Explain your answers.
  - Plants grow faster when they are given green light than when they are given blue or red.
  - Plants acquire material for growth chiefly from air and water.
  - Energy is produced in photosynthesis.
  - All energy released by animals in respiration was once sunlight captured by plants.
  - Leaves are the lungs of a plant.

### ATL Communication skills

#### Interpreting discipline-specific terms

In the life sciences and other academic disciplines, we must be able to use and interpret discipline-specific terms and symbols. For example, terms that have a broad everyday meaning, but a more focused meaning within a discipline. The word 'food' in the life sciences is an example.

- Garden centers sell products that are labelled "plant food", but to a life scientist they are not real food as they do not provide the plant with any energy. They only contain minerals such as nitrate, phosphate and potassium. What discipline-specific term could be used for this product instead of plant food? Do you think that "fertilizer" or "mineral nutrient" is better?



**ABC** A **stoma** (plural: **stomata**) is a pore found in the lower epidermis of a leaf.

**Transpiration** is the process in which water is lost by evaporation from the leaves through the stomata.

The **cuticle** is a waterproof waxy coating that protects the leaf.

- ◀ What features of a leaf help with photosynthesis?

#### Are leaves perfectly designed?

The answer to this is no, for two reasons:

- Biologists don't use the word "designed" for things like leaves, because unlike buildings or machines, nobody designed them. There is fossil evidence to show that leaves have been developing by evolution over hundreds of millions of years.
- We cannot say that any leaf is perfect because new features could develop that make the leaf even better at photosynthesis. A plant with leaves that are better at photosynthesis will have a strong advantage over other plants.



▲ Leaves of a fern fossilized more than 300 million years ago

### Opportunities for contributing to research as amateur scientists

Citizen science initiatives are opportunities for community volunteers to get involved in experiments. Often this involves members of the public gathering data and submitting their findings to an online database. Coordinators of citizen science projects usually share the data that is generated, by giving public access to it. In some cases, the aim of an experiment is to educate or change local practice.

For example, in the summer of 2018, the organization at [www.permaculture.co.uk](http://www.permaculture.co.uk) challenged the public

to grow three garden crops separately, known as a monoculture, and also grow the three crops together in one plot, known as a polyculture. They provided a map of how the plots were to be constructed and a short online course on how to take measurements. Polyculture is viewed as a more sustainable form of agriculture.

Scientific American ([www.scientificamerican.com](http://www.scientificamerican.com)) maintains a database of citizen science projects as does [www.citizenscience.gov](http://www.citizenscience.gov).

One of the problems for plants is that a large wet surface area is needed inside the leaf for absorption of carbon dioxide and for excretion of oxygen, but valuable water tends to evaporate from this surface and be lost from the leaf. This water loss is called transpiration. When water is difficult to obtain, plants need to reduce water loss by transpiration. Use the internet to research leaf adaptations that reduce transpiration in plants living in dry areas.

### Which groups of organisms make food by photosynthesis?

Plants are not the only group of organisms that can make food by photosynthesis. Algae and some types of bacteria also do it. All bacteria and some algae are microorganisms—organisms that are so small that they can only be seen individually with a microscope.



- ▲ Phytoplankton are very small algae, but they make vast amounts of food by photosynthesis because there are such large numbers of them in lakes and seas



- ▲ Seaweeds are large algae usually found in shallow seas or along rocky shores that make food by photosynthesis, even if they look red or brown rather than green
- ◀ Several groups of bacteria make food by photosynthesis, including the cyanobacteria (blue-green bacteria), which sometimes multiply to form vast “blooms”. Brightly colored bacteria in hot springs also produce food by photosynthesis. Bacteria in this pool in Upper Geyser Basin of Yellowstone National Park are colored green and yellow



## Summative assessment

### Statement of inquiry:

We will need to change how we transform materials and energy to achieve sustainable production and equitable distribution of food in the 21st century.

- ▼ Special types of bee are needed to pollinate the flowers of the Brazil nut tree, such as *Eulaema meriana*, seen here. These bees are rarely found outside natural rainforest. Without pollination, no nuts are produced



- ▲ Brazil nut trees (*Bertholletia excelsa*) live in moist lowland Amazon rainforests. They grow up to 50 meters tall and can survive for 500 or more years

- ▼ The fruit of the Brazil nut tree is a large capsule (right) that is the size of a baseball. It can contain up to 24 individual Brazil nuts, each enclosed in a woody seed case (left). One tree could produce 50 capsules of nuts per year. One nut weighs approximately 5g and contains 137 kJ of energy



- ▲ Agoutis are large rodents living in the rainforest. They are able to break open the hard capsules and the woody seed cases and eat the nuts. They store Brazil nuts when they are abundant by burying them in the soil. Some of these buried nuts germinate and grow into new trees



## Growing Brazil nuts

Use the information accompanying the photos and your own knowledge to answer these questions.

- How many nuts could one Brazil nut tree produce per year? [1]
  - How much would these nuts weigh in total? [1]
  - How much energy would the nuts from one tree contain? [1]
- Which part of the Brazil nut tree collects the energy needed to make food? [1]
  - What process is used to make food in a Brazil nut tree? [1]
  - What conditions in a tropical rainforest allow this process to happen very rapidly? [3]
- What are two reasons for agoutis needing to eat food such as Brazil nuts? [2]

## Nutritional content of Brazil nuts

The table shows the nutritional content of Brazil nuts per 100 g. RDA is recommended daily allowance.

Nutrient	Content	% of RDA	Amino acid	Content
thiamine (B1)	0.617 mg	54%	tryptophan	0.141 g
riboflavin (B2)	0.035 mg	3%	threonine	0.362 g
niacin (B3)	0.295 mg	2%	isoleucine	0.516 g
vitamin B6	0.101 mg	8%	leucine	1.155 g
folate (B9)	0.022 mg	6%	lysine	0.492 g
ascorbic acid (C)	0.7 mg	1%	methionine	1.008 g
vitamin E	5.73 mg	38%	cysteine	0.367 g
calcium	160 mg	16%	phenylalanine	0.630 g
iron	2.43 mg	19%	tyrosine	0.420 g
magnesium	376 mg	106%	valine	0.756 g
manganese	1.2 mg	57%	arginine	2.148 g
phosphorus	725 mg	104%	histidine	0.386 g
potassium	659 mg	14%	alanine	0.577 g
sodium	3 mg	0.13%	aspartic acid	1.346 g
zinc	4.06 mg	43%	glutamic acid	3.147 g
			glycine	0.718 g
starch	0.25 g	-	proline	0.657 g
sugar	2.33 g	-	serine	0.683 g
dietary fiber	7.5 g	-	Nutrient type	Content
water	3.48 g	-	carbohydrate	12.27 g
			fat	66.63 g
energy	2,743 kJ	-	protein	14.32 g

- Calculate the total mass per 100 g in Brazil nuts of:
  - vitamins [2]
  - minerals. [2]
- Display the data for the content of the main food types in Brazil nuts using the style you think is most suitable. [3]
- The selenium content of Brazil nuts is 1.92 mg per 100 g. The RDA for adults is 0.060–0.075 mg per day. The safe limit is 0.4 mg per day and daily intake above 1 mg is toxic. What advice would you give to people about selenium in Brazil nuts? [3]

## Melting points

Vegetable oil is extracted from seeds. It varies in the content of saturated fat, monounsaturated fat and polyunsaturated fat. Vegetable oil is solid at cold temperatures and liquid at higher temperatures. The temperature at which this change occurs is called the melting or the freezing point. The table shows data for five types of vegetable oil.

Vegetable oil	Saturated fat (%)	Monounsaturated fat (%)	Polyunsaturated fat (%)	Melting point (°C)
flaxseed oil	8	21	71	-24
olive oil	11	79	8	-6
peanut oil	18	48	34	3
coconut oil	92	6	2	25
palm oil	52	38	10	35

Brazil nut oil contains 25% saturated fat, 40% monounsaturated fat and 34% polyunsaturated fat.

- Using the data in the table, decide what you would expect the melting point of Brazil nut oil to be. This is your hypothesis. [2]
  - Explain how you used the evidence in the table to decide on your hypothesis. [4]
  - Design an experiment to test your hypothesis. [4]

## Brazil nuts and sustainable food production

- Using scientific language, evaluate the sustainability and fairness of Brazil nut production. You could include these ideas:
  - Would it be better to clear natural rainforests and grow Brazil nut trees in plantations?
  - Which is more sustainable—agriculture, or gathering food from rainforests and other natural ecosystems?
  - Should agoutis be killed to stop them eating Brazil nuts?
  - What percentage of Brazil nuts should humans eat and what percentage should be left for other species?
  - What will happen as the human population rises and demand for Brazil nuts increases? [10]