National 4 Biology

Unit 1 / Cell Biology

August 2013

The eTextbook for National 4 Biology can be found online at: http://nat4biopl.edubuzz.org

This PDF/Print version is provided for use when access to the internet is unavailable. The online version of the textbook is the most up to date version and needs to be accessed in order to make use the links and quizzes.

Unit Introduction

Welcome to the Cell Biology Unit of National 4 Biology. In this unit we start by thinking about the very small building block that make up all living things - cells. These simple building blocks make up every living thing from tiny bacteria, to enormous trees to complex thinking living things like ourselves. We will think about how cells make more of themselves, how a whole organism is coded for by our DNA and then finish with some of the important chemical reactions which are essential to life and how they are controlled.

Topics

1. Cell Division
2. DNA, Genes & Chromosomes
3. Therapeutic Use of Cells
4. Enzymes
5. Microorganisms
6. Photosynthesis
7. Respiration
8. Controversial Biological Procedures

Unit Project

To succeed in this unit we've devised a project to help you learn.

Your task for this project is to answer the following question...

What's the future for gene therapy?

Some questions you need to consider...

- What will you focus your project on?
- What questions are you trying to answer?
- What are you going to produce to communicate your findings?
- Where will you get your information from?
- How will you manage your information?
- How will you manage your time?

1. Cell Division

What you need to know…

- Why is cell division important to organisms?
- What happens in cell division?
- What is cancer?

Notes

Living things are made of cells

All living things are made of cells. The cell is the **basic unit of living things**.

Some living things like bacteria are only made up of one cell. Other living things like us are made up of lots and lots and lots of cells.

Making new cells

So why do living things make new cells?

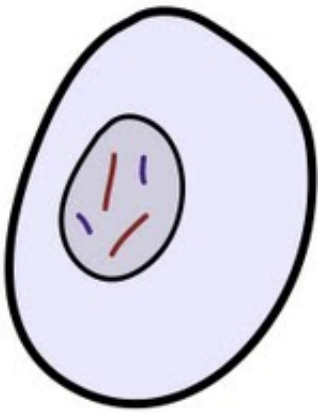
Basically, an organism (living thing) needs to make new cells so that they can **grow** and **repair** damaged parts of themselves e.g. cuts, broken bones.

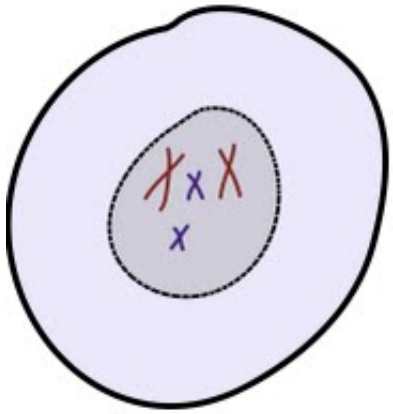
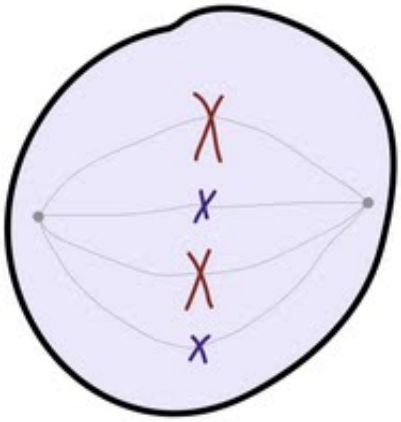
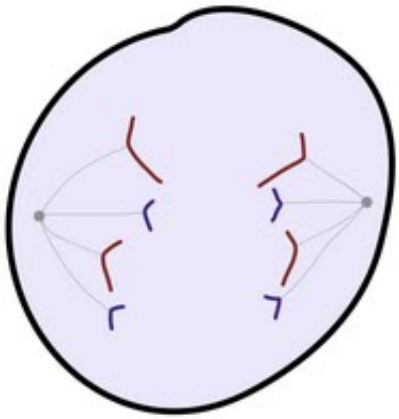
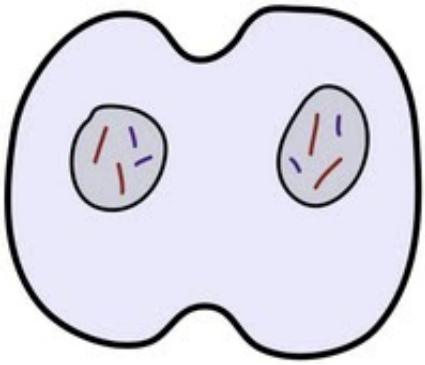
To make new cells, cells undergo a very special process called **cell division**. In this process a single cell which we call the parent cell, divides in half to produce two identical daughter cells.

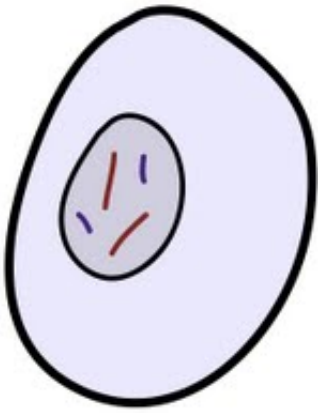
Cell division

The following table shows the sequence of events of cell division stage by stage.

To keep things simple this cell has four chromosomes - two matching pairs.

Diagram	*Description*
	Before cell division the DNA in the nucleus is long, thin and unwound.
	The DNA is copied. The DNA winds up into duplicated chromosomes.

	
	The duplicated chromosomes line up along the middle of the cell.
	The duplicated chromosomes are pulled apart.
	Two nuclei are formed containing a full set of single chromosomes.
	Two daughter cells have been formed. They have the same number of chromosoems as the parent cell.



The key point to remember is that during cell division: the parent cell divides to produce **two identical cells**, which contain the **same number of chromosomes** in their nuclei as the parent cell.

Cancer is a disease of cells.

You have probably heard about cancer but may not know that cancer is a disease of cells. It develops when **normal cell division goes out of control**. Unlike normal cells, cancer cells make too many new cells and they don't die when they are supposed to. They can form a group of cells called a tumour which grows into and damages the healthy cells around them. This can makes a person very sick.

So why do healthy cells start to divide uncontrollably? It is all down to the DNA. You already know that DNA contains the genetic instructions for a living thing. Well if the DNA in a cell gets damaged these instructions get broken and a cell can start to behave in a strange way.

Usually cancer is a disease of old age. But there are some things that can damage the DNA in a cell and lead to cancer. Things like smoking, unhealthy diet, lack of exercise, overexposure to sun, infection with a certain viruses (HPV) can all increase our risk of cancer. It is important to stress that many causes of cancer are simply unknown.

Check Your Understanding

1. Why do living things make new cells?

   - ○ Energy and repair
   - ○ Growth and repair
   - ○ Growth and energy
   - ○ Growth, energy and repair

2. The process which makes new cells is called...

   - ○ cell division
   - ○ Cell multiplication
   - ○ respiration
   - ○ photosynthesis

3. After cell division what is produced?

- Two identical cells
- Three identical cells
- Two non identical cells
- Three non identical cells

4. Compared to the original parent cell. How many chromosomes do the daughter cells have?

   - Half the number of chromosomes
   - Same number of chromosomes
   - Twice the number of chromosomes
   - Four times the number of chromosomes

5. What disease is caused by uncontrolled cell division?

   - Diabetes
   - Haemophillia
   - Cancer
   - Heart disease

Grade Me

2. DNA, Genes & Chromosomes

What you need to know…

- What are DNA, genes and chromosomes?
- What do genes code for?
- Why are we unique?
- How do we inherit characterisitics from our parents?

Notes

DNA, Chromosomes and Genes.

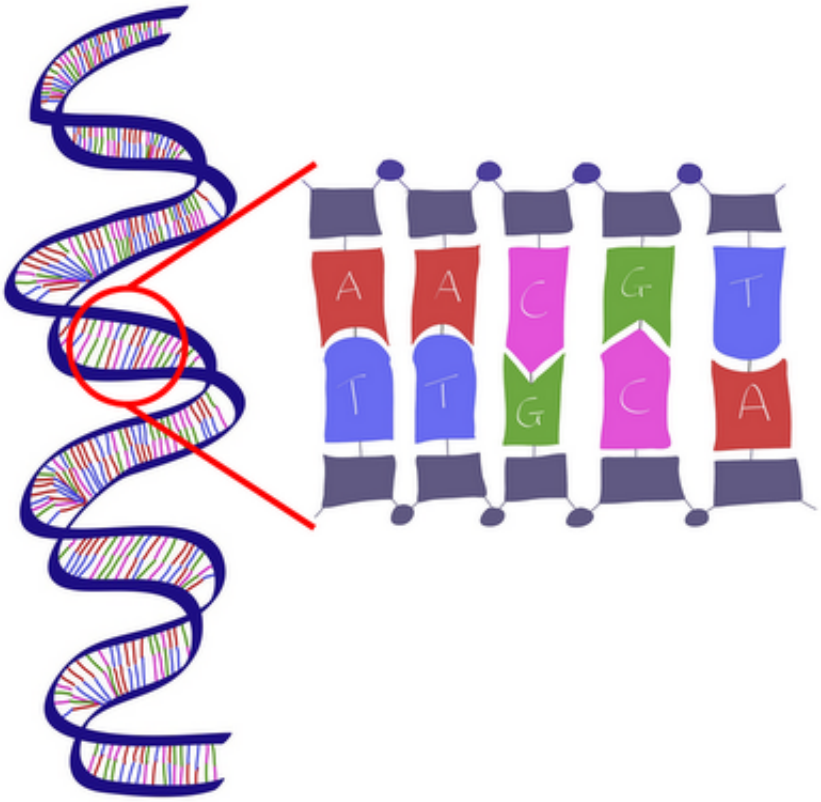
You may remember from S1 that the nucleus controls the activities of the cell. This is because the nucleus contains a very special molecule which provides the instructions for a living thing. This molecule is DNA.

DNA is a very long molecule because, as you can imagine, there are many, many instructions needed to make a living thing. To get all of these instructions to fit into a tiny cell the DNA is wound up very carefully into structures called **chromosomes**.

Chromosomes from Wikimedia Commons

DNA provides the code for proteins

Now let us take a closer look at a simplified model of DNA:



This shows us that DNA is made up of four different chemicals. These chemicals can be represented by the letters: A, T, C and G.

We can read the message by reading one side of the molecule from top to bottom. In class you will get the opportunity to decode some DNA messages!

If we decode the message in real life what we get are actually instructions to make lots of different **proteins**. These proteins will work together to make a living thing! Some of these proteins will be messenger molecules called hormones, some will form the structure of our tissues, some will help chemical reactions take place.

So remember:

- The long molecule which contains the genetic blueprint for life is **DNA**.
- Found on chromosomes, a bit of DNA which codes for a protein is called a **gene**.
- DNA is organised into rod like structures which are called **chromosomes.**

Why are we unique?

We are all unique because our DNA is unique. Our genetic code is 3 billion letters long and these can code for many different characteristics. Different combinations of charactersistcs make us all different. Only identical twins have identical DNA. The uniqueness of our DNA is useful to forensic scientists who can identify people from the smallest sample of DNA.

Where do we get our genes?

We inherit our DNA and our genes from our parents. Half our DNA come from our mother, half our DNA from our father. If we know what versions of genes two parents have we can predict the chance that children will inherit certain characteristics. This is useful where parents know that they may be a carrier for a genetic condition.

Check Your Understanding

1. What is a chromosome?

   - ○ A long molecule which holds the genetic instructions for a living thing.
   - ○ Rod like structures which are made of DNA
   - ○ Found on chromosomes, they hold the instructions for a protein.
   - ○ A long molecule made of amino acids.

2. What is DNA?

   - ○ A long molecule which holds the genetic instructions for a living thing.
   - ○ Rod like structures which are made of DNA
   - ○ Found on chromosomes, they hold the instructions for a protein.
   - ○ A long molecule made of amino acids.

3. What is a gene?

   - ○ A long molecule which holds the genetic instructions for a living thing.
   - ○ Rod like structures which are made of DNA
   - ○ Found on chromosomes, they hold the instructions for a protein.
   - ○ A long molecule made of amino acids.

4. What is a protein?

   - ○ A long molecule which holds the genetic instructions for a living thing.
   - ○ Rod like structures which are made of DNA
   - ○ Found on chromosomes, they hold the instructions for a protein.
   - ○ A long molecule made of amino acids.

5. Each individual's DNA is unique except...

   - ○ Parents and children
   - ○ Non-identical twins
   - ○ Identical twins
   - ○ No exceptions, everyone is unique.

Grade Me

3. Therapeutic Use of Cells

What you need to know…

- What is genetic engineering?
- What are some useful products of genetic engineering?
- To investigate other therapeutic examples such as stem cell technology or using cells to grow artificial organs.

Notes

The genetic code is common to all forms of life

One of the most amazing things about life on earth is that all life uses the same DNA code to store its information and make proteins.

Because all life uses the same DNA code, we can now take DNA from one species and add it into another species. We can use this to create species with new characteristics or which make new proteins for our benefit.

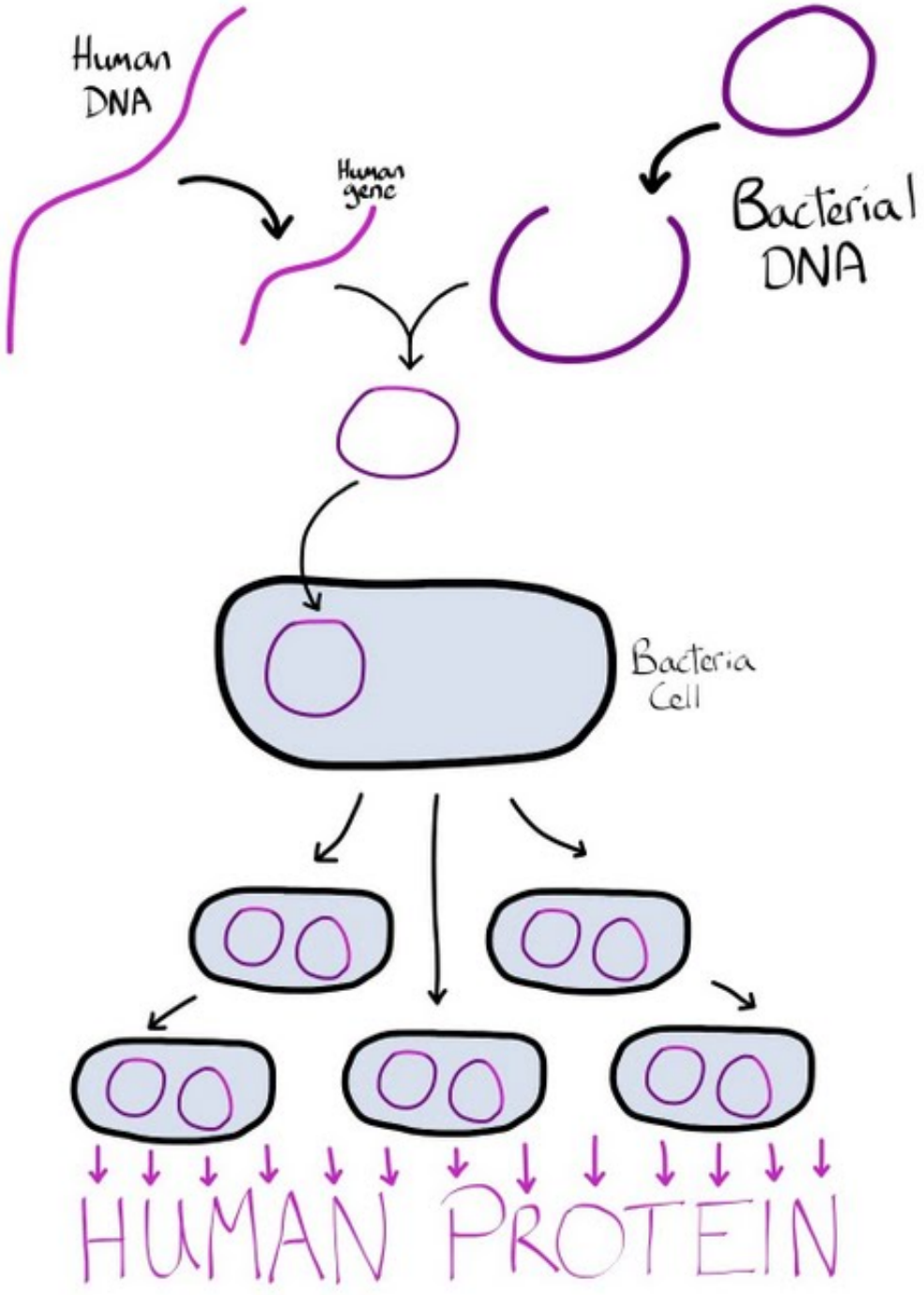
Genetic Engineering

This process of genetic engineering is revolutionising science and medicine.

Scientists have already used genetic engineering to create glow in the dark pigs, tomatoes that do not rot, crops that are resistant to pests and more.

People are often surprised, however, that one of the most common organisms to genetically modify are **bacteria**.

Bacteria are useful because they are relatively simple to modify, they grow and multiply easily, and can **quickly produce lots of a particular protein**. We have seen in class that bacteria can be used to quickly produce important proteins that some people are not able to produce naturally. Examples include **growth hormone** for people with genetic dwarfism, **factor VIII** for people with haemophilia and **insulin** for people with diabetes.



Check Your Understanding

1. Name the process that involves the transfer of DNA between species

   - Natural selection
   - Evolution
   - Genetic engineering
   - Selective breeding

2. What is transferred between species in genetic engineering

   - A cell
   - A chromosome
   - A gene
   - A protein

3. Which of the following can be made by genetic engineering?

- Factor VIII
- Insulin
- Growth hormone
- All of the above

4. What organism is genetically engineered to made insulin?

- Bacteria
- Yeast
- Fungi
- Viruses

5. People with diabetes have trouble controlling their blood levels of...

- Oxygen
- Protein
- Glucose
- Carbon dioxide

Grade Me

4. Enzymes

What you need to know...

- What are enzymes?
- Where are enzymes found?
- What kind of reactions do enzymes help take place?
- What biotechnology industries are enzymes used in?

Notes

In the previous topic we learnt how the code contained in DNA bases results in the production of proteins. Proteins are crucial for the functions of cells and in this topic we'll discuss the variety of proteins in cells and focus in on one particularly important group: enzymes.

Enzymes

Life consists of a series of complex chemical reactions. Later in this unit you will learn more about two such complex chemical reactions: respiration and photosynthesis. In order for most of the chemical reactions which take place in living things to occur they need special substances called enzymes.

Enzymes are molecules which **speed up** chemical reactions, **without being changed** in the process. Enzymes are found in **every cell** and are made of **proteins**. Enzymes can **build-up** and **break-down** molecules.

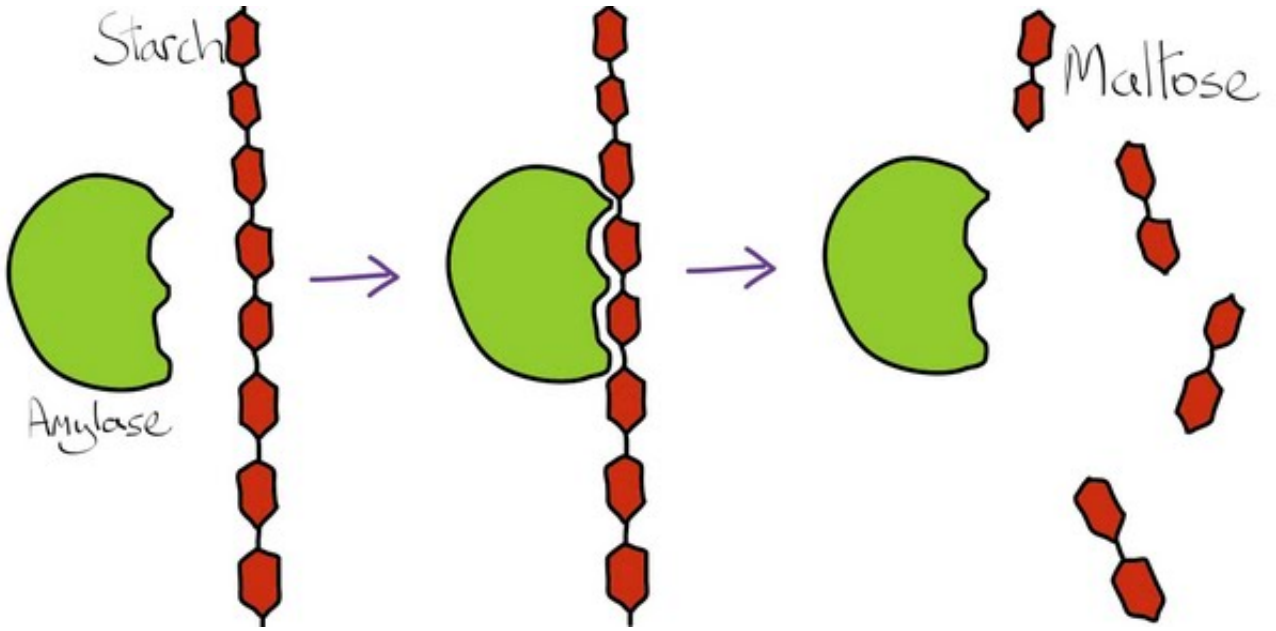
Breaking down reactions

Make the enzyme amylase for example. This is found in your saliva and helps the breakdown of a large molecule called starch into small sugar molecules [try keeping a plain flavoured crisp in your mouth for a few minutes without swallowing and you might just be able to taste this sugar being produced by your salivary amylase].

We can summarise this reaction using the word equation:

We write amylase on the arrow to show that it is helping this reaction take place but is **not used up** in this reaction.

This diagram shows how enzymes work.



There are a few key things you should notice:

- Enzymes have a shape which is complementary to the substance it is helping react. This is why enzymes are **specific**.
- The enzyme molecule remains **unchanged** as a result of the reaction – remember this is a key feature of an enzyme along with speeding up the reaction.

Building up reactions

As well as breaking down molecules, you should also know that enzymes can help make bigger molecules from smaller ones. We call these reactions "building up reactions".

Enzymes in industry

Enzymes are essential for our cells but can also be used in a range of biotechnology industries.

Do you know that enzymes are added to some washing powders? We know which washing powders have these enzymes added because they are called “biological washing powders”. The enzymes are added because of their ability to speed up breaking down reactions. Enzymes are added which help break down fat and protein stains on our clothes and make these stains easier to remove. Clever huh!

Do you know that enzymes are used to make cheese? An enzyme called rennet is used which speeds up the clotting process of milk. The solid bits (curds) are used to make cheese.

Check Your Understanding

1. Name the substances which speed up chemical reactions in living cells without being changed by the reaction.

- Catalyst
- Enzyme
- Protein
- DNA

2. What word describes the fact that enzymes only work on one particular substance?

   - Particular
   - Unaltered
   - Specific
   - Reused

3. Which of the following is true of enzymes?

   - Enzymes are changed by a reaction and can be reused
   - Enzymes are unchanged by a reaction and can be reused
   - Enzymes are changed by a reaction and cannot be reused
   - Enzymes are unchanged by a reaction and cannot be reused

4. Name a food made using enzymes.

   - Cheese
   - Yoghurt
   - Bread
   - Beer

5. Name an everyday product made using enzymes

   - Soaps
   - Washing up liquids
   - Shampoos
   - Biological washing powders

Grade Me

5. Microorganisms

What you need to know…

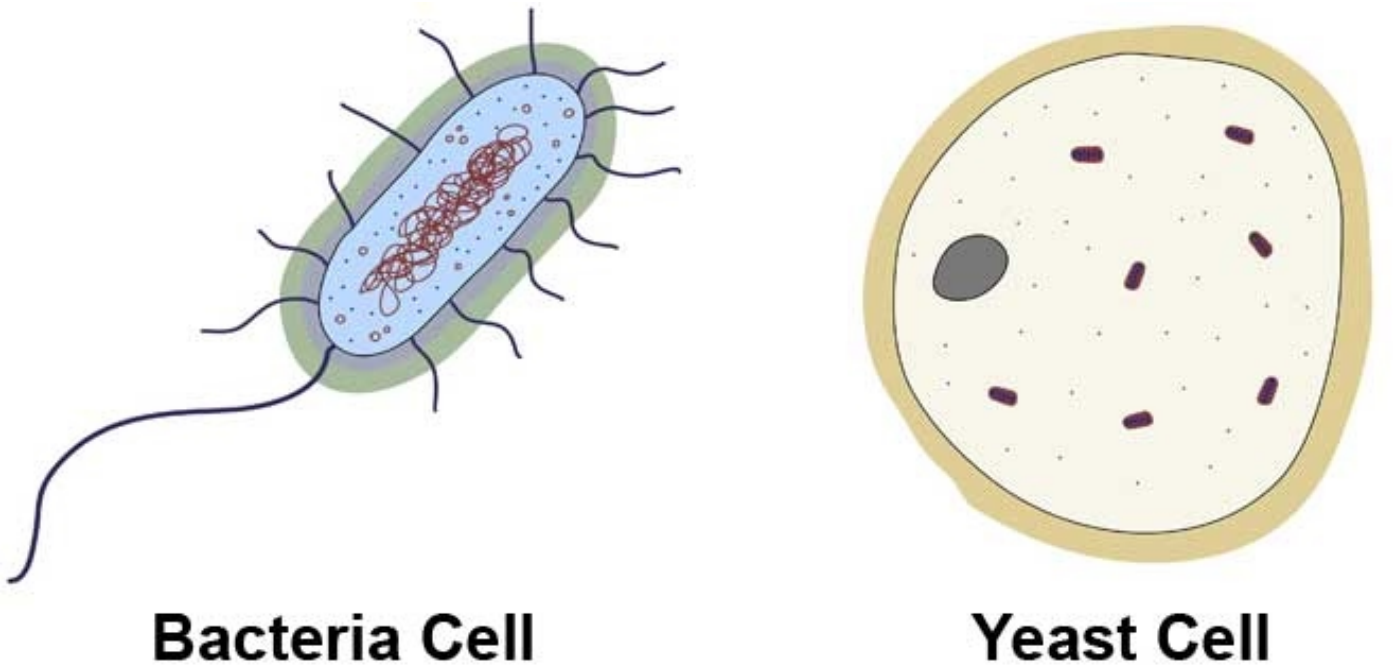
- What are microorganism?
- What are the properties of microorganisms?
- How is yeast used in baking and brewing?
- How is bacteria used to make yoghurt, cheese and biofuels?

Notes

What are microorganisms?

What are microorganisms? Well it is all in the name:

There are three main groups of micro-organisms: These are bacteria, viruses and fungi. The ones that we need to know about for now are are **bacteria** and a particular fungus called **yeast**.



As you can see from the pictures, these living things are made of a single cell.

Microorganisms are so useful because they growth very quickly, they use many different types of food and they produce a wide range of products.

Yeast

Yeast is useful in many industrial processes because when it feeds on sugar it makes alcohol and carbon dioxide.

- **Beer and wine making** – Yeast used in beer and wine making because when it feeds on sugar is makes **alcohol**.
- **Breadmaking** – Yeast produce **carbon dioxide** which is used in dough to make the dough rise. When the bread is baked the spaces created by the yeast keep the break light and fluffy. Baking also gets rid of the alcohol which evaporates off.

Bacteria

Bacteria are used in lots of industrial processes:

- **Yoghurt making** – Some bacteria are added to milk to make yoghurt. The bacteria feed on the lactose sugar in milk to make **lactic acid**. This lactic acid **thickens** the milk and makes it **sour** to give yoghurt its characteristic taste and texture.
- **Cheese making –** When making cheese, bacteria are added to milk (along with the enzyme rennet) to make cheese. The enzyme acts with bacteria to clot the milk and make **curds** and **whey**. The whey is the liquid bit which is just drained off. The curds is the solid bit which is used to make cheese.

Check Your Understanding

1. Which of the following is not a microorganism?

   - ○ Yeast
   - ○ Virus
   - ○ Bacteria
   - ○ Ant

2. Which of the following foods involve yeast in their manufacture?

   - ○ Cheese and yoghurt
   - ○ Beer and cheese
   - ○ Bread and cheese
   - ○ Bread and beer

3. Which of the following foods involve bacteria in their manufacture?

   - ○ Cheese and yoghurt
   - ○ Beer and cheese
   - ○ Bread and cheese
   - ○ Bread and beer

4. In breadmaking, name the useful substance produced by a microorganism which makes the dough rise.

   - ○ Enzymes
   - ○ Alcohol
   - ○ Carbon dioxide
   - ○ Oxygen

5. What kind of microorganism is used to make biogas?

- Viruses
- Bacteria
- Yeast
- All of the above

Grade Me

6. Photosynthesis

What you need to know…

- What is photosynthesis?
- What are the requirements for photosynthesis?
- What happens if any of the requirements for photosynthesis are in short supply?
- How might be overcome limiting factors to photosynthesis?

Notes

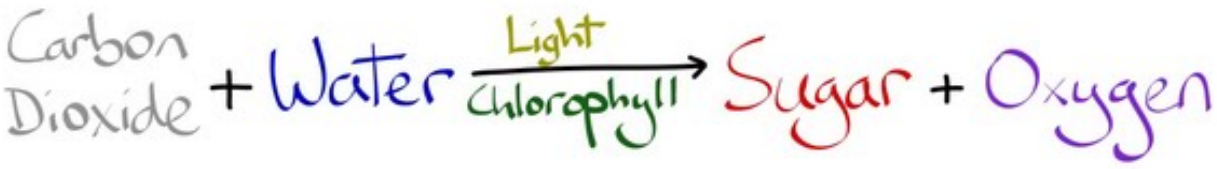
What is photosynthesis?

What do we do when we are hungry? We might buy a snack, go to a cafe or look in the fridge for some food.
But what about plants, well they have a different plan! When they need food they can carry out a very clever process called **photosynthesis**!

So what is photosynthesis? Well again, the clue is in the name:

Photo (light) + synthesis (making) = making with light.

In photosynthesis, plants use the light energy from the sun to react water and carbon dioxide together to make food in the form of sugar. We can summarise this as a word equation:



Limiting factors to photosynthesis

If any of the requirements (light, water, carbon dioxide or a suitable temperature) are low or missing, the photosynthesis rate is **limited**.

By overcoming these limitations, faster growth rates can be achieved.

- **Light** – can be increased using **artifical lights** in greenhouses
- **Water** – can be increased using an **irrigation system**.
- **Carbon dioxide** – can be increased by burning a **paraffin stove** or getting extra supplies from a **factory** which produced carbon dioxide as a waste product.
- **Temperature** – can be increased by using **heaters** in a greenhouse.

Check Your Understanding

1. What is the best description of photosynthesis?

- ○ A reaction where food energy is used to create light for plants.
- ○ A reaction where light energy is used to create food for plants.
- ○ A reaction where food is broken down to release energy.
- ○ A reaction where energy is broken down to release food.

2. Which of the following are needed for photosynthesis

   - ○ Light, water, oxygen, suitable temperature
   - ○ Light, water, carbon dioxide, suitable temperature
   - ○ Light, glucose, oxygen, suitable temperature
   - ○ Light, glucose, carbon dioxide, suitable temperature

3. If any of the requirements for photosynthesis are low...

   - ○ The rate of photosynthesis speeds up.
   - ○ The rate of photosynthesis slows down or stops.
   - ○ The rate of photosynthesis stays the same.
   - ○ The rate of photosynthesis will change in an unpredictable fashion.

4. If carbon dioxide is too low, a method of increasing the rate of photosynthesis is:

   - ○ To put the plants into a greenhouse or polytunnel.
   - ○ To use artificial lights
   - ○ To provide carbon dioxide from a factory.
   - ○ To use an irrigation system

5. If the temperature is too low, a method of increasing the rate of photosynthesis is:

   - ○ To put the plants into a greenhouse or polytunnel.
   - ○ To use artificial lights
   - ○ To provide carbon dioxide from a factory.
   - ○ To use an irrigation system

Grade Me

7. Respiration

What you need to know…

- What is respiration?
- What are the word equations for respiration with and without oxygen in animals, plants and fungi.
- What type of respiration creates the most energy .
- To be able to name two factors that are needed for the process of respiration.

Notes

What is respiration?

Respiration is a very important process carried out in every cell. In this process, a type of sugar called glucose is broken down to release **energy**.

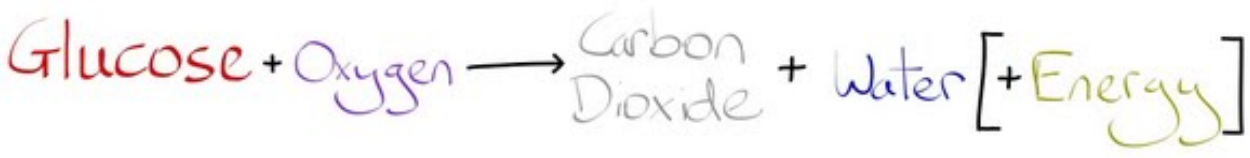
Things that we need energy for include:

- Making new cells through cell division.
- Making substances e.g. proteins such as insulin, enzymes and more.
- Making our muscle cells work.
- Sending information along brain cells
- And many many more

How much energy we get from respiration depends on whether oxygen is present or not. We breathe in oxygen and this is carried to our cells in our blood. Usually there is plenty of oxygen for all our cells. Sometimes, however there is not.

Respiration with oxygen

Animals like us get our oxygen from the air when we breathe. Plants get oxygen from the air through their leaves. When oxygen is in good supply animal cells can use this to break down glucose to water and carbon dioxide.
Lots of energy is released.

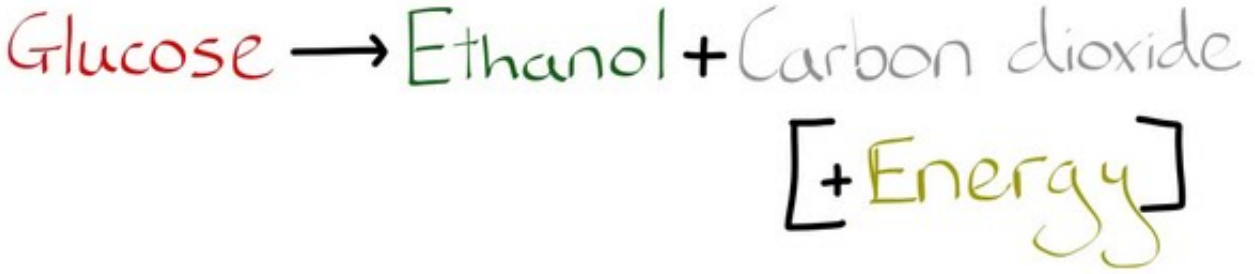


Respiration without oxygen

Sometimes our cells cannot get enough oxygen. What happens is different depending on whether the organism is an
animal, plant or fungus.

- **Animal cells:** In animal cells if there is not enought oxygen, glucose cannot be fullt broken down and instead another substance called **lactic acid** is produced and only a **small amount of energy** is produced. This happens when we exercise strongly, the build up of lactic acid in our muscles is what causes our muscles to get tired and painful.

- **Plants & fungal cells**: If there is not enough oxygen in plant or fungal cells, glucose is broken down to something ethanol and carbon dioxide. You might remember this from when we were studying yeast as part of the Microorganisms sub-unit.



Other requirements for photosynthesis

Like photosynthesis, respiration is a set of complex chemical reactions and so needs **enzymes** to keep it all going.
Respiration is also affected by **temperature** and so all organisms do not cope very well with very high or low temperatures.

Check Your Understanding

1. What is the best description of respiration?

   - A reaction where food energy is used to create light for plants.
   - A reaction where light energy is used to create food for plants.
   - A reaction where food is broken down to release energy for plants and animals.
   - A reaction where energy is broken down to release food for plants and animals.

2. Which of the following are needed for respiration?

   - glucose, oxygen, suitable temperature
   - glucose, carbon dioxide, suitable temperature
   - water, oxygen, suitable temperature
   - water, carbon dioxide, suitable temperature

3. Which of the following statements about respiration is true?

   - Respiration needs oxygen, without oxygen no energy is released.

- Respiration does not need oxygen, without oxygen more energy is released.
- Respiration does not need oxygen, but without oxygen less energy is released.
- Respiration needs oxygen, without oxygen lots of energy is released.

4. Which of these is the word equation for respiration with oxygen:

- glucose + carbon dioxide ---> oxygen + water + energy
- glucose + oxygen ---> carbon dioxide + water + energy
- oxygen + water + energy ---> glucose + carbon dioxide
- carbon dioxide + water + energy ---> glucose + oxygen

5. Which of these is the word equation for respiration without oxygen in animals:

- glucose + carbon dioxide ---> oxygen + water + energy
- glucose + oxygen ---> carbon dioxide + water + energy
- glucose ---> carbon dioxide + alcohol + energy
- glucose ---> lactic acid + energy

Grade Me

8. Controversial Biological Procedures

What you need to know...

- To investigate an interesting but controversial biological procedure.

The unit project will allow you learn about a controversial biological procedure.

Have a look at some of these great websites to explore others:

- **BBC News**
- **Newsround**
- **Bioethics Education Project (BEEP)**