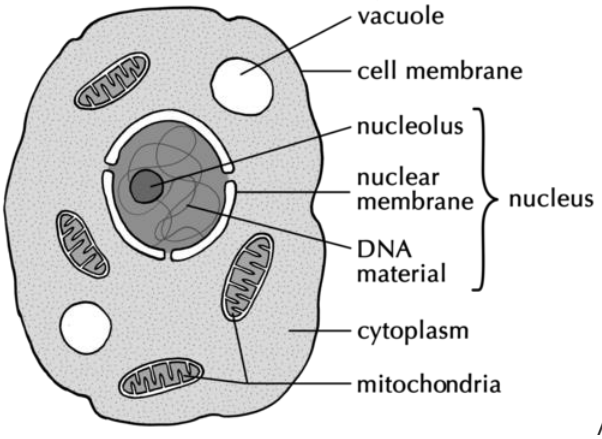
Cell Structure

- cell membrane
- cellular respiration
- mitochondria
- nuclear membrane
- nucleolus
- organelle
- protein
- selectively permeable
- vacuoles

As we have mentioned before, all cells have some common structures. These are:

- a **cell membrane**
- **cytoplasm**; and
- in most eukaryotic cells, a nucleus

Let's now have a look at the structure of these components of the cell, and some of the other organelles common to cells. An **organelle** is a specialised structure within the cell that performs a function for the cell. Examples of organelles in cells are **vacuoles** and **mitochondria**. Look at the diagram which identifies the different components in a simple animal cell.



A drawing of a typical animal cell

Cell membranes

All cells have a cell membrane around them. The cell membrane is a thin layer that encloses the cell's contents and separates the cell from its environment.

Many different substances have to pass in and out of a cell in order for it to function. The cell membrane controls which substances are allowed to enter and leave the cell. We say the cell membrane is **selectively permeable**. The organelles are also surrounded by membranes.

If something is 'permeable', then it means that substances, such as gases and liquids, can pass through it freely.

Cytoplasm

In Natural Sciences we speak of a **medium** when we talk about a solution in which organelles, cells or organs are grown or suspended. Can you think of other meanings for the word medium?

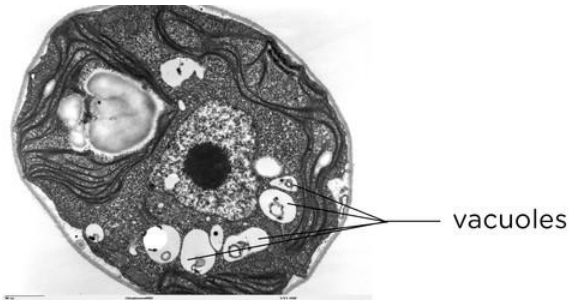
The cytoplasm (cytosol and organelles) and the nucleus together is referred to as **protoplasm**.

The cytoplasm includes all living parts of the cell within the cell membrane, but excluding the nucleus. The cytoplasm is made up of the cytosol and the cell organelles. The cytosol is a watery, jelly-like medium made of 70%-90% water, and is usually colourless.

The cytosol is a mixture of different substances dissolved in water. Do you remember what a mixture is from Matter and Materials? These substances within the cytosol include salts, various elements, such as sodium and potassium, and more complex molecules, such as **proteins**.

The cytosol is also where many chemical reactions take place. Next term, in Matter and Materials, we will learn more about chemical reactions.

The cell organelles making up the cytoplasm include mitochondria, chloroplasts and vacuoles. Vacuoles are organelles enclosed by a membrane and contain mostly water with other molecules in solution. The size and number of vacuoles within a cell varies greatly and depends on the type and function of the cell.



This is a micrograph of a plant cell. Can you see the clear, white organelles, which are the vacuoles? The cytoplasm appears very granular in this image.

Nucleus

Plant and animal cells have a **nucleus** inside the cytoplasm. It controls all the processes and chemical reactions that take place inside the cell. The nucleus also contains the cell's genetic material which is organised into long **DNA** molecules.

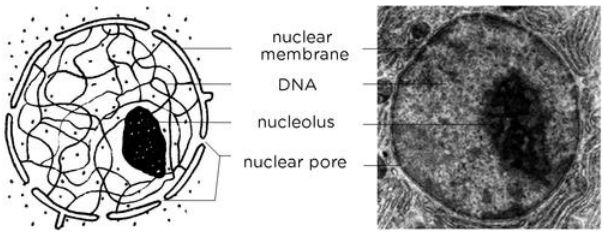
The difference between eukaryotic and prokaryotic cells is that eukaryotic cells have a nucleus which contains the genetic material surrounded by a membrane. Prokaryotic DNA floats in the cytoplasm without a membrane.

The nucleus is structured as follows:

- A double membrane called the **nuclear membrane** encloses the DNA. This nuclear membrane contains pores (holes) for substances to pass through.
- There is a **nucleolus** inside the nucleus. This is often seen as a darker area within the nucleus.

- The DNA contains information about **inherited** characteristics (**hereditary**), such as whether the person will have blue, brown or green eyes.

Have a look at the micrograph of a nucleus and the diagram of the nucleus.



Left) A Diagram of a nucleus. Right) A micrograph of a cell nucleus.

Researchers are starting to use DNA molecules to store data! In 2012 Harvard scientists were able to store 5.5 petabits (about 700 terabytes) of data on 1 gram of DNA! "DNA USB hard drives" are not available yet, however they might still be possible in your lifetime!

DNA is a very important part of all cells and therefore of all life. DNA contains information that encodes all our inherited traits or characteristics. This refers to characteristics which are passed down in families, such as your skin and eye colour, whether you have allergies and also the likelihood of contracting different types of illnesses.

Identical twins come from the same fertilised egg which splits in two. They have the same DNA. However, they are not*exactly* the same due to environmental factors that can influence how they develop. Non-identical twins developed from two different eggs and two different sperm.

Every organism has unique DNA. The difference in DNA that occurs between individuals is called **variation**. Even the slightest difference in DNA might cause significant variations within **species** and between species. Within species DNA differences or variations can lead to albino animals or the transference of similar illnesses, like sickle cell anemia.

Based on the work of many genetic researchers, we can now say that all humans share 99.9% identical DNA. The differences in the last 0.1% account for all the differences we see in humans.


An albino (white) lion lacks pigment due to an alteration in the lion's DNA.

Learn more about genes http://learn.genetics.utah.edu/content/begin/tour/

Mitochondria

Do you remember that we spoke about food as the energy source for our bodies? Just as wood is burned to use the stored potential energy to make a fire to heat some water, the food that we eat needs to be broken down in order to release the energy so that our bodies can function. **Mitochondria** are responsible for doing this.

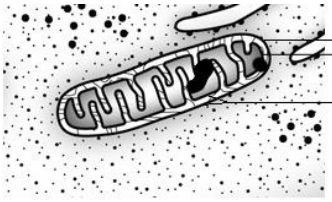
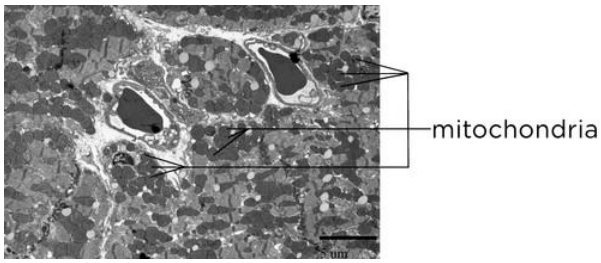


Diagram of a mitochondrion.

Singular or Plural? mitochondr*ion* is the singular and mitochondr*ia* is the plural form of the word.

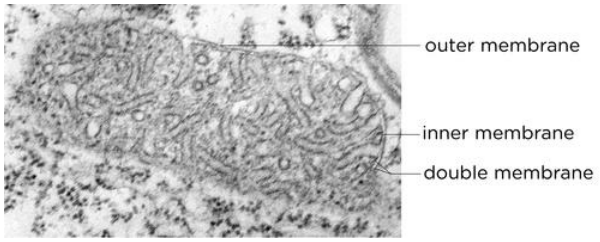
Mitochondria are organelles enclosed by a double membrane. Cells that are very active would typically have more mitochondria than cells that are less active. Which type of cell, do you think, will have more mitochondria: a muscle cell or a bone cell?



A micrograph of muscle tissue in a mouse. Can you see all the darker grey circles? These are mitochondria.

Once food molecules enter the cells and pass into the mitochondria, they are used by the mitochondria in a process called **cellular respiration**. During respiration the mitochondrion can combine molecules from food with **oxygen** to release energy that the cell can use. **Carbon dioxide**, water and waste materials are by-products of this process.

Mitochondria have their own*mitochondrial DNA* that is completely different to the DNA in the nucleus. What do you think we can we deduce from this fact?



Micrograph of a mitochondrion within a cell.

Look at the micrograph of the mitochondrion in the image. What differences can you see between this mitochondrion and the diagram shown previously? In the diagram, it was very clear that the inner membrane folds, whereas in the micrograph it is not as easy to see this. This is because of the way that the cell was sectioned (cut) before it was viewed on the transmission electron microscope. In a diagram, we show an ideal representation of the organelle. But, when we view an actual organelle under a microscope, it may look quite different depending on how it was cut into a very thin section to view.

If you would like to find out how mitochondrial DNA (mtDNA) is responsible for 'old age', read this article by Dr Barry Starr from Stanford University
http://genetics.thetech.org/ask/ask165

Now that you've studied the internal structure of a cell, let us summarise what we have learnt so far. Complete this table filling in the main function of each of the cell structures.

Cell Structure	**Function(s)**
Cell membrane	
Cytoplasm	
Nucleus	
Mitochondrion	
Vacuole	

Cell Structure	**Function(s)**
Cell membrane	regulates / controls passage of substances in and out of cell
Cytoplasm	where many of the chemical reactions and processes in the cell takes place
Nucleus	contains DNA (hereditary material) of cell and controls the cell's activity
Mitochondrion	releases energy from food for the cell
Vacuole	stores substances, water, nutrients

Difference between plant and animal cells

- cell wall
- cellulose
- chloroplast
- turgid
- flaccid

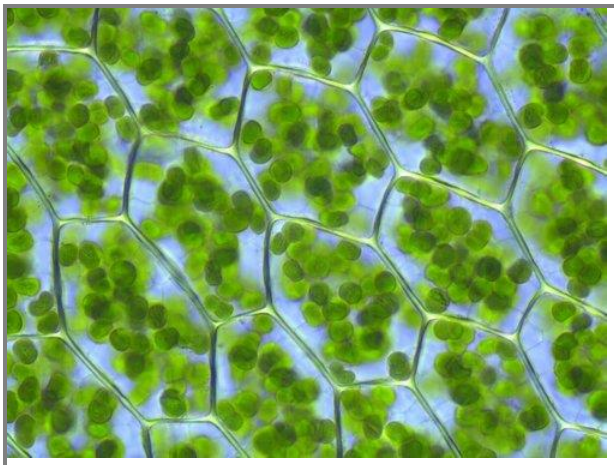
Now that we know what the main similarities are between all plant and animal cells, let's see how they are different.

Plant cells differ from animal cells

Why do plant and animal cells have differences? Plant and animal cells differ because they have to perform different functions.

1. Study the pictures below. On the left is a picture of plant cells and on the right is a picture of some animal cells, which have been stained blue.
2. Write differences that you observe in the table below the pictures of the cells.

Plant cells	**Animal cells**



http://commons.wikimedia.org/wiki/File:Plagiomnium_affine_laminazellen.jpeg

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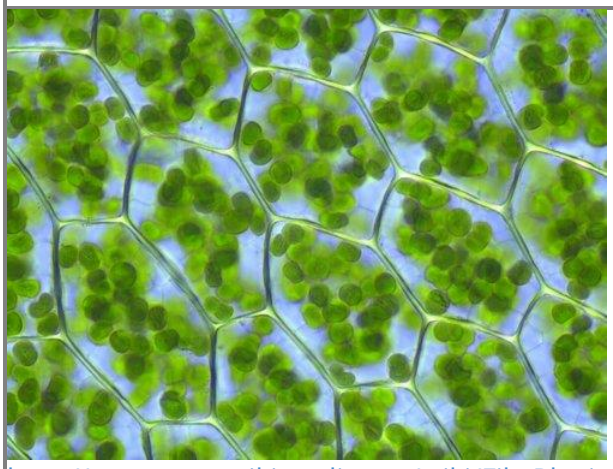
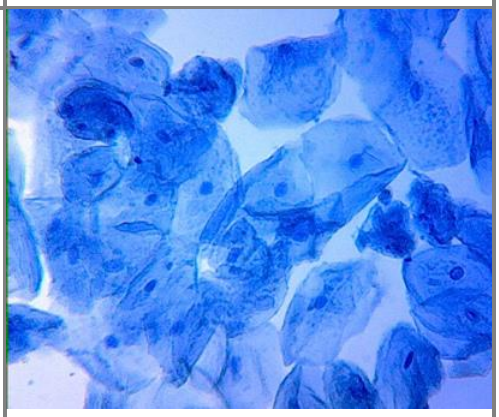
Plant cells	Animal cells
 http://commons.wikimedia.org/wiki/File:Plagiomnium_affine_laminazellen.jpeg	 http://www.flickr.com/photos/codonaug/6936088946/
• Plant cells have a regular shape and structure and keep their shape easily • A thick outer layer (two 'layers' enclose the cell although this is not very evident in the image) • Green chloroplasts for photosynthesis.	• Animal cells have an irregular shape and structure and bend and fold easily • Thin outer layer (only a cell membrane encloses the cell.) • No green chloroplasts can be seen.

Cell wall

All animal and plant cells are enclosed or surrounded by a cell membrane as we learned before. However, as you probably noticed in the previous activity, animal cells often have an irregular shape, whereas plant cells have a much more regular, rigid shape.

Plant cells have an additional layer surrounding the cell on the outside of the cell membrane. This is called the **cell wall**. This wall provides a protective framework for support and stability for the plant cell.

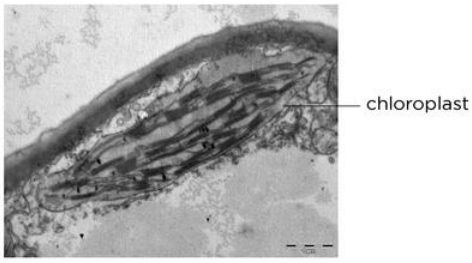
The cell wall is formed from various compounds, the main one being **cellulose**. Cellulose helps maintain the shape of the plant cell. This allows the plant to remain rigid and upright even if it grows to great heights.

Other organisms also have cell walls, like bacteria or fungi, but in these organisms their cell walls are not the same as plant cell walls. Only plant cells are made of cellulose.

Chloroplasts

You might remember learning about photosynthesis in previous grades. Can you still remember why photosynthesis is so important to all life on earth?

→→Did you notice the green organelles present in plant cells which were not there in the animal cells in the previous activity? These are **chloroplasts**. Chloroplasts are the only cell organelles that can produce food from the sun's energy. Only plants with chloroplasts are able to photosynthesise because they contain the very important green pigment, **chlorophyll.** Chlorophyll can absorb radiant energy from the sun and convert this to chemical energy that plants and animals can use. Animal cells lack chloroplasts and are not able to photosynthesise.



A large chloroplast next to the cell wall is visible in this section of a cell.
http://commons.wikimedia.org/wiki/File:Chloroplast_in_leaf_of_Anemone_sp_TEM_12000x.png

The sea slug,*Elysia chlorotica,* has evolved to take up the chloroplasts from the algae that it eats and incorporate them into its own cells where the chloroplasts function as if in a plant!

Article and video on the solar powered sea slug,*Elysia chlorotica.*
http://www.newscientist.com/article/dn16124-solarpowered-sea-slug-harnesses-stolen-plant-genes.html

Vacuoles

Does a plant have a skeleton? Turn to a friend and discuss what could possibly be used in a plant cell as a skeleton. Think for example of a blade of grass or a long stemmed rose.

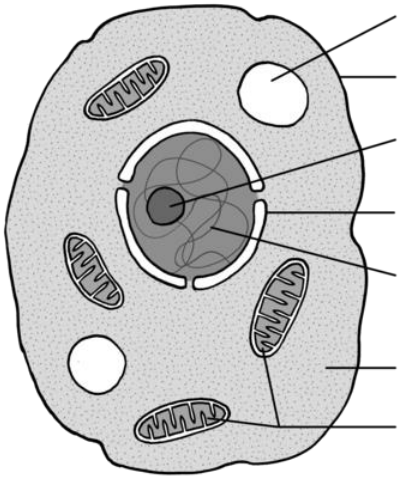
Vacuoles in plant cells are usually quite large organelles that can occupy as much as 90% of the cell's volume. The liquid in the vacuole, called cell sap, helps to support the plant. The full vacuoles push out against the cell wall and make the cells, and therefore the plant, rigid. We say the cells are **turgid** in this condition. The opposite to turgid is **flaccid**.

  Left) A plant with turgid vacuoles is rigid and stands upright. Right) A plant with flaccid vacuoles droops (called wilting).

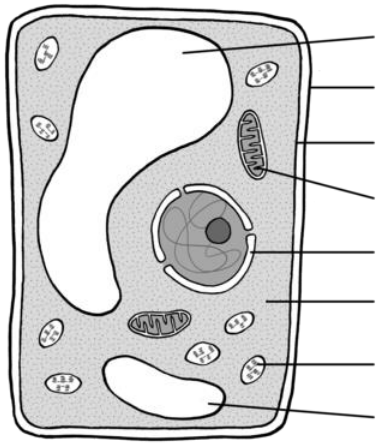
You can easily see when a plant's vacuoles are full and when they are not. When the vacuoles are full the plant's stem and leaves will be held upright and firm. However, if the leaves and stem are drooping, the vacuoles might have lost a lot of water because the soil is too dry and the cell was forced to use up this water to survive.

Vacuoles are only present in some animal cells and they are typically very small and have a short life-span.

1. Study the two diagrams of plant and animal cells below.
    1. Draw a table of differences between the two cell types in the space provided. Give your table a suitable heading.
    2. Also provide labels for the different cell structures and organelles.



A typical animal cell.



A typical plant cell.

Characteristic	Animal cells	Plant cells
Shape	Have an irregular shape	Have a rigid, regular shape
Cell wall	Do not have a cell wall, only a cell membrane	Have both a cell membrane and a cell wall.
Vacuoles	Have small vacuoles, which are often temporary or absent	Have large vacuoles
Chloroplasts	Do not have chloroplasts	Have chloroplasts to photosynthesise

We use models all the time in science, whether they are actual built models out of materials, a mathematical model, or even models made using computer programmes. A model is a representation of an actual object or system to help us understand it.

In a 3D cell model, we will be making built models out of materials where we will use other objects to represent the actual parts of the cell.

INSTRUCTIONS :

1. You must create a 3D model of a cell.
2. You may use whatever materials or 'media' you choose to create your cell.
3. Your model must clearly show the following:
    - cell membrane
    - nucleus with nuclear membrane
    - cytoplasm
    - mitochondria
    - vacuoles
    - chloroplasts
    - Any other organelles that you might have learnt about

Requirements for your cell model:

- Your model and the examples of the organelles need to show some resemblance to the real organelle that we have learnt about so far.
- Your model needs to be clearly marked with a heading and your name.
- Each organelle needs to be clearly labelled and with each label you need to add a description of the function of that particular organelle.
- You also need to make an accompanying drawing (at least the size of an A4 page) including the labels of the structure of a basic plant and animal cell.
- Your teacher will assess your model according to a rubric.

Cells in tissues, organs and systems

- multicellular organisms
- cover slip
- slide
- specimen
- unicellular
- wet mount

Now that you have learnt all about different cells, are you ready to see them for yourself?