Key Stage 3
National Strategy

Strengthening teaching and learning of cells
Resource pack for participants
Key Stage 3
National Strategy

Science

Strengthening teaching and learning of cells
Notes for participants
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**Handouts**

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**Evaluation:**

**Strengthening teaching and learning of cells**

What were the most successful aspects of today's sessions?

What changes would you suggest if today's sessions were repeated?

Please grade each session on the basis of how well structured and organised it is to meet the learning objectives identified.

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<thead>
<tr>
<th>Session</th>
<th>Grade: please ring</th>
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<tbody>
<tr>
<td>1 What are cells? An overview</td>
<td>Class = 1 2 3 4</td>
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<td>5 Progression in teaching about cells</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Overall grade for the unit</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>

Please return this form to your tutor before leaving.
Objectives for the unit

- To remind participants about basic cell structures and how this can be taught
- To clarify some aspects of how cells are organised and function in multi-celled organisms
- To explore the teaching of selected systems, with a focus on cells, as defined by the Year 8 yearly teaching objectives
- To clarify the importance of some cellular processes, described in the Year 9 yearly teaching objectives, to the success of an organism
- To map the progression in the yearly teaching objectives for cells across Key Stage 3
Objective and outcomes for session 1

- To remind participants about basic cell structure and how this can be taught

By the end of this session, participants should:
- be able to name the main parts of animal and plant cells;
- be able to describe some similarities and differences between animal and plant cells;
- be able to use a microscope to look at some cells.

Task A: Knowledge of cells

- Share your highlighted list of yearly teaching objectives for cells with another participant.
- Look for similarities in what you already know about cells.
- Be prepared to share with the group one aspect of the yearly teaching objectives that you expect to learn more about during the day.

You have about three minutes for this task.

Hooke's microscope

Handout 1.7
Facts about cells
Did you know ...?
- The human body is made up of several million million cells.
- Individual cells are invisible except under high magnification.
- Cells measure on average 0.005 mm in diameter.
- Large ones can measure as much as 0.02 mm in diameter.
- Nerve cells can be up to 1 metre long.

Diagram of typical animal cell

Diagram of typical plant cell

Handout 1.10
Handout 1.11
Handout 1.13
Task B: Making slides of cells

- Make some slides of cells by following the instructions given on handouts 1.14 and 1.15.
- Look for similarities and differences between animal and plant cells.
- Find the various parts that have just been described.
- Find any parts that you cannot identify.
- Share your findings with another participant or your tutor.
- If you have any difficulty using the microscope, look at handout 1.16, which gives some hints and tips.

You have 15 minutes for this task.

Objective and outcomes for session 1

- To remind participants about basic cell structure and how this can be taught

By the end of this session, participants should:
- be able to name the main parts of animal and plant cells;
- be able to describe some similarities and differences between animal and plant cells;
- be able to use a microscope to look at some cells.
Cells to systems

Objective and outcomes for session 2

- To clarify some aspects of how cells are organised and function in multi-celled organisms

By the end of this session, participants should:

- recognise the links between growth of cells and growth of organisms;
- be able to explain why cell specialisation occurs and know about some common specialised animal and plant cells;
- be able to state the links between cells, tissues, organs, organ systems and organisms.

Single-celled to multi-celled organisms

A simple but useful evolutionary thread:

- Some single-celled organisms eventually clustered as multi-celled organisms in which all the cells are the same. The advantage is shared resources and size.
- Once multi-celled organisms evolved, cell specialisation (adaptation for function) – in which not all cells are the same or have the same function – became possible. The advantage is greater efficiency of the organism.
Strengthening teaching and learning of cells

Slide 2.4
The nucleus of the cell splits in two

Slide 2.5
A new cell membrane is formed in the middle

Slide 2.6
The cell splits up into two daughter cells
Slide 2.7

The daughter cells get bigger

Slide 2.8

Once the daughter cells have grown, they can divide

Handout 2.9

Slide 2.10

Task C: Misconceptions about cell growth

- Many pupils think that cells keep growing indefinitely.
- You know that growth of multi-celled organisms occurs because cells are able to multiply through cell division.
- What could you do to convince a group of pupils that their idea is a misconception?
- You have five minutes to talk about this with a partner.
- Feed back your ideas to the rest of the group after five minutes. Your thoughts will be recorded on a flipchart.
Task D: Cell multiplication demonstration

Specialised cells and tissues

Handout 2.11

Handout 2.12

Handout 2.14
Task E: alternative A

- Work on your own.
- Collect various colours of modelling clay and use to build a model cell of your choice.
- With a partner, compare models, explaining the parts as necessary.
- In your pairs, identify the strengths and weaknesses of your two models. Record your ideas on handout 2.17.
- If time permits, join another pair to compare and evaluate each other’s models.

You have ten minutes for this task.

Task E: alternative B

- Look at the various cell models that have been prepared by Year 7 pupils.
- On handout 2.17, record the strengths and weaknesses of each model in terms of the accurate representation of the cell.
- Be prepared to give brief feedback on what you have found.

You have ten minutes for this task.
Cells to organisms (animals)

- Specialised cell
- Tissue
- Organ
- System
- Organism

Cells to organisms (plants)

- Specialised cell
- Tissue
- Organ
- System
- Organism

Task F: What organs are made of

- Work with a partner.
- Look at the organ cards.
- Discuss with your partner what kinds of cells and tissues could be found in each organ.

You have five minutes to complete the task.
Objective and outcomes for session 2

• To clarify some aspects of how cells are organised and function in multi-celled organisms

By the end of this session, participants should:
• recognise the links between growth of cells and growth of organisms;
• be able to explain why cell specialisation occurs and know about some common specialised animal and plant cells;
• be able to state the links between cells, tissues, organs, organ systems and organisms.
Objective and outcomes for session 3

- To explore the teaching of selected systems, with a focus on cells, as defined by the Year 8 yearly teaching objectives

By the end of this session, participants should:

- be able to describe the role of cells in the digestive system;
- be able to explain that enzymes help to break down long-chain (big) food molecules into smaller molecules that can be absorbed;
- have completed a simple investigation using enzymes as biological catalysts;
- be able to give a simple explanation of the way the circulatory system operates.

Task H: Pupils’ misconceptions about digestion

- Handouts 3.3A to F reproduce what six Year 8 pupils drew when asked what happens, inside their bodies, to the food they had yesterday.
- Work with a partner.
- List on handout 3.5 the misconceptions that you think these pupils have.
- After 5 minutes, share with the whole group two of the misconceptions that pupils hold.
Task 1: Apple-juice production

You are provided with the equipment you need to carry out this enquiry.

- Use one of the planning posters in handout 3.9 and follow the plan that some pupils have started.
- Carry out the enquiry as the pupils have planned, collect your evidence and evaluate your findings. The posters provided give the framework for doing this.

You have 20 minutes to complete the task. Be prepared to share your findings.

The mammalian circulatory system

Blood cells
Task J: Cells and the circulatory system

• You have just heard about the mechanics of the circulatory system. What has this to do with cells?
• Work with a partner for three minutes and discuss what you believe is the role of cells in the circulatory system.
• How does this link to the digestive system?
• After five minutes, compare your list with another pair.
• Prepare a flipchart to display the result of your discussions, and share this with the rest of the group.

Objective and outcomes for session 3

• To explore the teaching of selected systems, with a focus on cells, as defined by the Year 8 yearly teaching objectives

By the end of this session, participants should:
• be able to describe the role of cells in the digestive system;
• be able to explain that enzymes help to break down long-chain (big) food molecules into smaller molecules that can be absorbed;
• have completed a simple investigation using enzymes as biological catalysts;
• be able to give a simple explanation of the way the circulatory system operates.
Respiration and breathing

Respiration

• Respiration is a biochemical process which takes place in both animal and plant cells; its function is the transfer of energy in chemical reactions to enable the MRS GREN functions, i.e. movement, reproduction, sensitivity, growth, respiration, excretion and nutrition.

Breathing

• Breathing is a mechanical process which involves the lungs. It is about gas exchange.
Aerobic and anaerobic respiration

- Aerobic respiration requires oxygen.
- Anaerobic respiration does not require oxygen.
- Cells such as muscle cells can respire both aerobically and anaerobically, but the latter process releases insufficient energy to sustain the cell for long.
- When discussing respiration at Key Stage 3, usually only aerobic respiration is taught.

Word equation for simple aerobic respiration

\[ \text{carbohydrate} + \text{oxygen} \rightarrow \text{energy} \rightarrow \text{carbon dioxide} + \text{water} \]

Chemical equation for aerobic respiration

\[ \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} \]

2898 kJ mol\(^{-1}\)
More misconceptions about respiration

Pupils often believe that:

- Respiration is a single-step process;
- Enzymes only cause the breakdown of molecules, they do not help build them up.

Burning glucose

\[ C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O \]  
2898 kJ mol\(^{-1}\)

glucose  oxygen  carbon dioxide  water

Word equation for anaerobic respiration

\[ \text{glucose} \xrightarrow{\text{enzyme}} \text{lactic acid} \]  

Energy
Chemical equation for anaerobic respiration

\[ \text{C}_6\text{H}_{12}\text{O}_6 \xrightarrow{\text{enzymes}} 2\text{C}_3\text{H}_6\text{O}_3 + \text{energy} \]

Useful example of anaerobic respiration

\[ \text{glucose} \xrightarrow{\text{yeast}} \text{ethanol} + \text{carbon dioxide} + \text{energy} \]

Anaerobic respiration – the fermentation process

\[ \text{C}_6\text{H}_{12}\text{O}_6 \xrightarrow{\text{yeast}} 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2 + \text{energy} \]
Task K: Introducing respiration to pupils

- Work with a partner.
- You are going to plan part of a lesson for a Year 9 class.
- How would you use the first 10 minutes of the first lesson of a topic on respiration to introduce the topic and identify or deal with some initial misconceptions? (You have about five minutes to jot down ideas.)
- Be prepared to share your ideas with the other participants.

Part of the Key Stage 2 programme of study

3 Pupils should be taught:
   a the effect of light, air, water and temperature on plant growth;
   b the role of the leaf in producing new materials for growth;
   c that the root anchors the plant, and that water and minerals are taken in through the root and transported through the stem to other parts of the plant.

Respiration and photosynthesis – a common misconception

- Pupils often believe that plant cells photosynthesise but do not respire.
Slide 4.18

Word equations for photosynthesis and respiration

Photosynthesis
\[ \text{carbon dioxide + water} \rightarrow \text{glucose + oxygen} \]

Respiration
\[ \text{glucose + oxygen} \rightarrow \text{carbon dioxide + water} \]

Handout 4.19

Slide 4.20

A typical green leaf

- carbon dioxide from the air
- water from the roots
- food transport to the rest of the plant
- energy from sunlight (or light)

Slide 4.21

Diagram of cross-section of a leaf

- upper epidermis
- mesophyll
- lower epidermis
- air space
- stomata
- chloroplast
- spongy mesophyll
- cuticle
- guard cell
Inherited characteristics – a common misconception

• By Year 9, pupils are confident that organisms inherit characteristics from both male and female parents.
• However, when they consider the characteristics they have inherited, many believe that boys, because they are male, inherit most of their dominant characteristics from their father. Girls, because they are female, inherit most of their dominant characteristics from their mother.

Inheritance themes in year 9

• Offspring generally have two parents.
• This results in variation of combinations of inherited characteristics.
• Offspring will therefore vary.
• Selective breeding increases the chances of desirable characteristics being inherited.
• It is the chromosomes in the cell nucleus which carry the information to determine the characteristics of the organism.
Sex cell division

- Parent cell with 4 chromosomes.
- Chromosomes replicate forming pairs of chromatids.
- Pairs of chromosomes arrange themselves in the centre of the cell.
- The chromosomes separate and move to opposite ends of the cell.
- The first cell division occurs.
- The chromosomes now separate from each other and move to opposite ends of the cells.
- The second cell division occurs.

Chromosome allocation in sperm and eggs

- The male parent’s cells contain an X and a Y chromosome.
- Because a sperm cell has half of the chromosomes of normal cells, it will have either an X or a Y chromosome.
- The female parent’s cells contain two X chromosomes.
- Because an egg cell has half of the chromosomes of normal cells, it will have only one X chromosome.
Handout 4.33

Task M: The chromosome game

- Work in pairs.
- Cut out the four chromosomes on handout 4.33 and sort them into a male pair and a female pair.
- The male pair divide to become part of two different sperm cells. The female pair divide to become part of two different egg cells.
- Move the chromosomes to identify what combinations of characteristics are possible in any baby.
- If, over time, two babies are produced, what is the chance that they will have the same hair colour?

You have 5 minutes for this task.

Determining sex in humans

Male parent provides sperm with either an X or Y chromosome. Female parent provides eggs with an X chromosome. The possible combinations in the offspring are:

<table>
<thead>
<tr>
<th>Male parent</th>
<th>Female parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
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</tr>
<tr>
<td>Y</td>
<td>XX</td>
</tr>
<tr>
<td>X</td>
<td>XY</td>
</tr>
<tr>
<td>X</td>
<td>XY</td>
</tr>
</tbody>
</table>

Slide 4.31

Determining sex in humans

Male parent provides sperm with either an X or Y chromosome. Female parent provides eggs with an X chromosome. The possible combinations in the offspring are:
Objective and outcomes for session 4

- To clarify the importance of some cellular processes, described in the Year 9 yearly teaching objectives, to the success of an organism

By the end of this session, participants should:

- be clear about the importance of respiration and photosynthesis, including some misconceptions about them held by pupils;
- be able to articulate the similarities and differences between respiration and photosynthesis;
- have clarified some aspects of how cells influence and control the characteristics of an organism.
Task O: Progression in the key idea of cells

- Work in pairs with a set of sorting cards.
- Sort the cards into a sequence which identifies progression in the key idea of cells.
- There is no single correct sequence.
- Some cards form a backbone of developing ideas of cells; others create side branches where an understanding of cells is used to explain other ideas.
- You may find it useful to lay your cards on a large sheet of paper so that you can draw connecting lines and/or write any notes.

Be prepared to explain to the group the rationale for the sequence you develop.
Objective and outcomes for session 5

- To map the progression in the yearly teaching objectives for cells across Key Stage 3

By the end of the session, participants should:
- have produced a progression chart showing how the key idea of cells could be taught;
- have identified some ideas that need further clarification.

What next?

- You should use the glossaries that you have produced during the sessions and the cards that you have selected to go in the ? and ✓ envelopes as the basis for discussion with a biology specialist in the department, or for further independent work.
- Feed back to the department the main messages leaflet and offer to team-teach a cells topic with a specialist.
- Ask your consultant to team-teach with you a cells topic you are not very confident with.
Objectives for *Strengthening teaching and learning of cells*

- To remind participants about basic cell structure and how this can be taught
- To clarify some aspects of how cells are organised and function in multi-celled organisms
- To explore the teaching of selected systems, with a focus on cells, as defined by the Year 8 yearly teaching objectives
- To clarify the importance of some cellular processes, described in the Year 9 yearly teaching objectives, to the success of an organism
- To map the progression in the yearly teaching objectives for cells across Key Stage 3
The discovery of cells

- During the 1660s an English naturalist called Robert Hooke designed a microscope. It was not unlike simple school microscopes that we use today and relied on sunlight to illuminate the image.

- In 1665 Hooke made a fortuitous observation while looking at a thin slice of cork. He saw something that he described as ‘looking like a honeycomb with a great many little boxes’.

- Hooke called these boxes cells from the Latin for ‘little room’.

- This was the first time that anyone realised that living things are not necessarily made of continuous material. People thought that the skin was made of a uniform substance and had no idea that it was made of much smaller constituent parts. The discovery caused great excitement in the scientific community.

- The word cell has survived to this day and has become a fundamental part of biologists’ language.

Cells are often described as ‘the units of life’ or ‘the building blocks of life’. These descriptions are very useful because they emphasise that these structural units build together to form all living organisms.
## Glossary of terms used in session 1

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell membrane</td>
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<tr>
<td>Cell wall</td>
<td></td>
</tr>
<tr>
<td>Cellulose cell wall</td>
<td></td>
</tr>
<tr>
<td>Chlorophyll</td>
<td></td>
</tr>
<tr>
<td>Chloroplast</td>
<td></td>
</tr>
<tr>
<td>Cytoplasm</td>
<td></td>
</tr>
<tr>
<td>Endoplasmic reticulum</td>
<td></td>
</tr>
<tr>
<td>Golgi apparatus</td>
<td></td>
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<tr>
<td>Mitochondrion</td>
<td></td>
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<tr>
<td>Nucleus</td>
<td></td>
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<tr>
<td>Organelle</td>
<td></td>
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<tr>
<td>Vacuole</td>
<td></td>
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<tr>
<td>Vesicle</td>
<td></td>
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</tbody>
</table>
This is a typical animal cell.

- The **cell membrane** is a thin ‘skin’ between the cytoplasm and the outside of the cell. It lets some substances through, but not others.

- The **cytoplasm** looks a bit like the uncooked white of an egg. It is situated inside the membrane but does not include the nucleus. It is a slightly opaque liquid in which many chemical reactions take place (more of this in sessions 3 and 4). These reactions keep the cell functioning.

- The cytoplasm contains many cell **organelles**, which have very specific functions. **Mitochondria**, for example, are sometimes called the power-house of the cell. They contain enzymes that enable the transfer of energy during respiration. Other organelles include the **Golgi apparatus** and the **endoplasmic reticulum**.

- The **nucleus** controls all the chemical reactions in the cell. It contains the chromosomes, which come from the parent cells (more of this in session 4).

- In animal cells, **vesicles** (fluid-filled spaces) sometimes briefly appear. These are small temporary vacuoles and are common in some fresh-water protists such as paramecium.
This is a typical plant cell. Plant cells contain all the parts described in the handout on animal cells (handout 1.11).

In addition:

- The plant cell has a **cellulose cell wall**. This cell wall is fairly rigid and gives a great deal of support. Remember that plants do not have skeletons! The presence of a cell wall makes plant cells more easily seen under the microscope.

- The plant cell contains **vacuoles**, which are fluid-filled spaces. Mature plant cells usually have large vacuoles, which make them very distinctive. Animal cells can also contain small vacuoles usually called vesicles. However, these are often a temporary feature.

- The presence of **chlorophyll** is a major difference between animal and plant cells. Chlorophyll is not found in animal cells, but remember that not all plant cells contain chlorophyll either. The chlorophyll is contained in disc-shaped organelles called **chloroplasts**. These are usually, but not exclusively, found in leaves.
Task B: How to make a slide (animal cells)

You will need:

Microscope slide
Cover slip
Cotton bud from a newly opened packet
Disinfectant such as freshly prepared 1% sodium chlorate (hypochlorite) solution
Stain (1% methylene blue in water). Note: *Methylene blue will stain if it comes into contact with the skin.*
Small piece of ripped paper towel

What to do

1. Take a new cotton bud and smear it on the inside of a cheek and along the lower side of the gum. Smear this on the middle of the microscope slide. Throw the cotton bud into disinfectant straight afterwards.
2. Place a drop of methylene blue solution on the slide.
3. Place the edge of a cover slip next to the liquid.
4. Slowly lower the cover slip onto the cheek cells and liquid. Use a mounted needle to make this easier.
5. Place the ripped edge of a paper towel next to the cover slip so that it draws out any excess stain and any trapped air.
6. When you have finished looking at the cells, remember to place the slide and cover slip in disinfectant solution.
Task B: How to make a slide (plant cells)

You will need:

Microscope slide
Cover slip
Mounted needle
Distilled water or stain (1% iodine solution). *Do not allow iodine solution to come into contact with skin, as it will stain. For pupils, eye protection is often recommended even at this dilution because of the slight risk of solution entering the eye. When working with adults this risk is considered so low as to not require eye protection.*
Small piece of ripped paper towel
Slice of raw onion

What to do

1. Peel off part of the thin membrane from the inside of the onion layer.
2. Place a drop of water or preferably iodine solution on the slide.
3. Carefully place the piece of thin membrane from the onion on the liquid. Be careful not to trap any air bubbles.
4. Place the edge of a cover slip next to the liquid.
5. Slowly lower the cover slip onto the onion and liquid. Use a mounted needle to make this easier.
6. Place the ripped edge of a paper towel next to the cover slip so that it draws out any excess stain and any trapped air.
How to use a microscope

Standard light microscope

1. Place the slide on the stage. Use the clips to keep it in place.
2. Look through the eyepiece. Move the mirror so that you can see a bright circle. Do not use the microscope in direct sunlight, as the Sun’s rays will be intensified and can damage your eyes.
3. Look through the eyepiece and slowly raise the stage. If you do this too quickly, the stage can break the slide. On some microscopes the objective lenses move, not the stage. Try out beforehand to see which kind you have.
4. Move the stage until you see a clear image.

Hints and tips

• Always use very thin sections to view.
• Always start with the lowest magnification objective and eyepiece lens to see the image. You can increase the magnification later by turning the objective lenses around.

Notes on the Intel microscope

1. The advantage of using an Intel microscope is that the image can be projected so that pupils’ attention can be focused on the important parts of cells. Misleading items such as hair or bubbles can be shown so that pupils know to ignore them.
2. Instructions for setting up the Intel microscope are given in the ICT section of the ASE Science Year Primary CD-ROM. This can be accessed online at www.sycd.co.uk, select Primary.
### Glossary of terms used in session 2

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Cell division</td>
<td></td>
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<tr>
<td>Daughter cell</td>
<td></td>
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<td>Meristem</td>
<td></td>
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<tr>
<td>Muscle cell</td>
<td></td>
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<tr>
<td>Nerve cell</td>
<td></td>
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<tr>
<td>Tissue</td>
<td></td>
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<tr>
<td>Organism</td>
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<tr>
<td>Palisade cell</td>
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<td>Red blood cell</td>
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<tr>
<td>Root hair cell</td>
<td></td>
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<tr>
<td>Sperm cell</td>
<td></td>
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<tr>
<td>System</td>
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</table>
Limitations of the model

The simple description of cell division is perfectly adequate for many purposes, but it is not fully correct in all instances. Some of these include:

- In single-celled organisms the daughter cells separate completely. In multi-celled organisms, they remain joined.

- Not all cells can divide like this. Some common examples of human cells that do not divide are red blood cells, nerve cells and skin cells.

- Cells like this are known as **specialised cells** and are produced by the division of **basic cells** which subsequently develop into a blood cell, nerve cell, etc. This is a complex process, which is a consequence of factors such as production site in the body, genetic information and hormonal control. So, for example, red blood cells are only produced in bone marrow. Nerve cells are only produced during gestation and very early growth. Once damaged in a child or adult they can re-grow to some extent, but no new nerve cells are produced to replace ones that are irreparably damaged.

- The basic cells divide to form new basic cells, to maintain the supply of specialised cells.

- Some basic cells retain the capacity to develop into a range of other cells. You can see this when a wound is repairing. Some of the basic cells help produce the clot and others produce the new skin and tissue underneath.

- In plants, cells only divide at the growing tips of roots and shoots (called **meristems**) and on the outer edges of tree trunks and other woody plants.
Task D: Cell multiplication demonstration

This 3D model should help pupils overcome misconceptions about growth. The demonstration shows that the individual bubble growth is not important. It is the increase in the number of bubbles (cells) that is important and which demonstrates how cell division leads to the growth of an organism.

- Put water into a Petri dish. For a class demonstration, it is very effective to put the Petri dish on an overhead projector.
- Add a few drops of washing-up liquid, a drop of dye (such as fluorescein) to help make the bubbles more visible, and a few drops of oil.
- Gently blow air into the solution with the bulb pipette. Bubbles will start to form and will take up a typical cell-packing shape in the dish.
- Compare this to the shape taken up by marbles in a Petri dish (placed on the overhead projector).
- Continue to blow air into the dish. The bubbles form a second layer and still hold their shape. This gives a good model of cells as 3D objects.
Some specialised cells
and tissues

There are about 200 varieties of specialised cells in the human body. This is just a small selection of specialist cells.

- The **sperm cell** has a tail to enable it to swim and a small amount of food as an energy resource for the journey.

- **Red blood cells** are bi-concave and disc-shaped to allow the maximum surface area for the exchange of gases (oxygen and carbon dioxide). They do not contain a nucleus. They are made in bone marrow. Their active life is about four months, after which they are broken down by the liver and spleen, where important chemicals such as iron are re-used to make new cells.

- **Nerve cells** (neurones) have a cytoplasm that extends outwards from the cell body, forming fine long threads as small as 0.005 mm in diameter. Fascinatingly, in humans the threads can be up to 1 metre in length (such as from the spinal cord to the tips of toes or fingers). The threads are the nerve fibres, which pass nerve impulses (messages) to all parts of the body. The reason for their length is that nerve impulses pass more quickly along the fibres than from one nerve cell to another. It is therefore more efficient to have very long fibres rather than lots of nerve cells. If these fibres are broken they do not rejoin, but some are able to re-grow to a limited extent.
- **Muscle cells** are different in that they do not have cell membranes between the different cells. Muscle tissue is thus quite complex. Muscle cells are elongated in shape and work by contracting. It is a common misconception that muscles expand, but this is not the case. To regain their original length, muscles relax and are stretched by the action of the antagonistic muscle. This is why muscles are always found in pairs – as one contracts, the other relaxes. Cardiac muscle cells (in the heart) are not the same as other muscle cells. These have bridges between the cells, and the whole muscle contracts rhythmically on its own. It does not need a nerve impulse to make it work.

- **Root hair cells** (plant cells) have two purposes: to absorb water and to help anchor the plant. They have a very elongated projection, which increases the surface area for water to be absorbed and penetrates between soil particles to help anchor the plant. Root hair cells function for only a few days and are then replaced by new ones. These new cells grow at the tip. This ensures that the root hair cells are always in contact with new regions of soil.

- **Palisade cells** are located towards the upper surface of a plant leaf. They contain lots of chloroplasts for maximum photosynthesis. Their positioning in the leaf and the position of leaves on a plant ensure that these cells receive as much as possible of the available sunlight.

**Tissues**

- A collection of similar specialist cells working together with a common function is called a **tissue**.

![muscle tissue](image1.png)

![plant tissue](image2.png)
### Task E: Recording sheet

<table>
<thead>
<tr>
<th>Type of cell the model represents</th>
<th>Strengths of the model</th>
<th>Weaknesses of the model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Organs

Organs are individual structures within an organism which carry out one or more specific functions. An organ can comprise more than one sort of tissue but all the tissues contribute to the organ’s function(s).

- The term organ is used for large structures only, which are generally easily visible. Parts of a cell which have a specific function are called organelles.

- Some obvious examples of human organs are the stomach, the brain, the heart, the liver, the kidney.

- Some obvious examples of plant organs include the flower, the leaf, the stem, the root.

- The heart contains several types of tissue, including specialised muscle tissue, blood vessels, ligament-like structures (the ‘heartstrings’) that prevent the valves from breaking, and connective tissue which helps bind it together.

- Some organisms are very simple, consisting of just a single cell, and others are extremely complicated. But all carry out the seven functions of a living organism. This is often remembered by the mnemonic MRS GREN. This mnemonic stands for Movement, Reproduction, Sensitivity, Growth, Respiration, Excretion and Nutrition. The systems of any organism enable these functions to take place.
Task F: Organ cards

- Brain
- Eye
- Heart
- Kidney
- Liver
- Lungs
- Stomach

Notes for participants © Crown copyright 2003
Task F: Organ cards
## Task F: What organs are made of

What cells and tissues do you think are found in each organ?

<table>
<thead>
<tr>
<th>Organ</th>
<th>Cells and tissues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td></td>
</tr>
<tr>
<td>Eye</td>
<td></td>
</tr>
<tr>
<td>Heart</td>
<td>Muscle, connective, blood vessels, tendon</td>
</tr>
<tr>
<td>Kidney</td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td></td>
</tr>
<tr>
<td>Lungs</td>
<td></td>
</tr>
<tr>
<td>Ovary</td>
<td></td>
</tr>
<tr>
<td>Pancreas</td>
<td></td>
</tr>
<tr>
<td>Skin</td>
<td></td>
</tr>
<tr>
<td>Skull</td>
<td></td>
</tr>
<tr>
<td>Tooth</td>
<td></td>
</tr>
</tbody>
</table>
# Glossary of terms used in session 3

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amylase</td>
<td></td>
</tr>
<tr>
<td>Appendix</td>
<td></td>
</tr>
<tr>
<td>Bile</td>
<td></td>
</tr>
<tr>
<td>Caecum</td>
<td></td>
</tr>
<tr>
<td>Chyme</td>
<td></td>
</tr>
<tr>
<td>Colon (large intestine)</td>
<td></td>
</tr>
<tr>
<td>Digestion</td>
<td></td>
</tr>
<tr>
<td>Duodenum (part of small intestine)</td>
<td></td>
</tr>
<tr>
<td>Enzyme</td>
<td></td>
</tr>
<tr>
<td>Gastric juice</td>
<td></td>
</tr>
<tr>
<td>Ileum (part of small intestine)</td>
<td></td>
</tr>
<tr>
<td>Oesophagus</td>
<td></td>
</tr>
<tr>
<td>Pancreatic juice</td>
<td></td>
</tr>
<tr>
<td>Peristalsis</td>
<td></td>
</tr>
<tr>
<td>Plasma</td>
<td></td>
</tr>
<tr>
<td>Platelets</td>
<td></td>
</tr>
<tr>
<td>Protease</td>
<td></td>
</tr>
<tr>
<td>White blood cell</td>
<td></td>
</tr>
</tbody>
</table>
What Year 8 pupils think about the digestive process

Notes

- Mum told the pupil that people who have a balanced diet eat less.
- Knew that food gives energy and energy was needed to play football.
- Thought that his arms and legs used up the sausages, eggs and beans when he played football.
What Year 8 pupils think about the digestive process

Notes

- The pupil's grandmother told him he had hollow legs because he is eating all the time.
- The pupil therefore believes that all the food he eats fills up from the bottom (like gravity)!
- Believes that when the food reaches his belly button then he needs to go to the toilet.
What Year 8 pupils think about the digestive process

Note

- Pupil believes that the stomach acts like a washing machine which mixes all the food up into good things and bad things. The bad things are separated into poo and pee. Not sure how the good things are used.
What Year 8 pupils think about the digestive process

Notes

- Pupil misinterpreted the lift-off test.
- Through discussion, explained that the body sends the food through a number of processes such as eating to break up the food, stomach to sort the food into good and bad, using the good food to help us do things and getting rid of the bad food.
- Believed that the body sorts out the bad food (fat and sweet things).
What Year 8 pupils think about the digestive process

Notes

- Pupil aware that the food goes through a number of processes before it is useful.
- Can explain that in the mouth the food is broken up so that it can pass through organs in the body.
- Knew energy from the food is passed into the blood system from the intestine (?).
- Explained how the intestine (?) removes unwanted food.
What Year 8 pupils think about the digestive process

Note
- Pupil completed this with no help from the teacher.
### Task H: Recording sheet

<table>
<thead>
<tr>
<th>Illustration</th>
<th>Misconceptions that pupils may hold</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>
Simple explanation of the digestive process

Food often consists of big ‘long-chain’ molecules, which in that form cannot be used by the body. The breaking down of these molecules into smaller ones is called digestion.

- Digestion of food actually starts in the mouth, where the teeth physically break up the larger items of food. The resulting mush is mixed with saliva, which is where the first enzyme reaction takes place. The enzyme in saliva is called amylase, and it breaks down starch (a major food component) into a soluble sugar called maltose (a smaller molecule).

- The moistened mush is then swallowed and a process called peristalsis pushes it down the oesophagus into the stomach and through the rest of the digestive system. The food is pushed down the oesophagus rather like pushing sausage meat through a tube. It is a myth that you cannot eat upside down!
• On entering the stomach the food is churned up by muscular contraction and relaxation of the stomach wall. It is then mixed with **gastric juice**. This juice is very acidic (an acidic mixture including hydrochloric acid) and includes another enzyme, **protease**, which starts breaking down proteins into smaller molecules.

• The food remains in the stomach until the contents are semi-liquid (**chyme**). The sphincter muscle opens and allows the liquid into the **duodenum**, which is part of the small intestine.

• In the duodenum the chyme is mixed with **bile** and **pancreatic juice**. Both are alkaline, which neutralises the effect of the gastric juice and emulsifies fats. The pancreatic juice (produced in the pancreas) also contains other digestive enzymes (protease and amylase) to further break down proteins and carbohydrates into smaller molecules.

• The liquid (modified chyme) then passes to the **ileum** (part of the small intestine) where the resulting smaller molecules of food substances are absorbed into the bloodstream.

• The **caecum** and **appendix** have no real purpose in human digestion but are large and highly developed in herbivores. A rabbit’s caecum and appendix contain millions of cellulose-digesting bacteria, which produce the enzyme cellulase to digest the cellulose in plant materials. Humans do not have the bacteria which produce the enzyme cellulase and cannot use cellulose. Anything left over is then passed into the **colon** (large intestine), where excess water is absorbed.

• Eventually, after entering the rectum where undigested ‘food’ is stored, the waste leaves the body via the rectum and urethra.

At each point along the way, **specialist cells** produce enzymes to break down the large food molecules, acids and alkalis to provide the optimum conditions for the enzymes to work, substances to ensure that the gut wall is not changed by enzymes (or acid in the stomach), and lubricants to make sure that the food passes smoothly along.
### Task I: Planning posters

#### Planning

**We are investigating ...**  
the best conditions for the enzyme pectinase to work

<table>
<thead>
<tr>
<th>We could change ...</th>
<th>We could measure/observe ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>The amount of apple we use.</td>
<td>The amount of enzyme we use.</td>
</tr>
<tr>
<td>Raw or cooked apple.</td>
<td>The amount of juice collected in 10 minutes.</td>
</tr>
<tr>
<td>The size of apple bits.</td>
<td>The time taken to collect 10 cm³ of juice.</td>
</tr>
<tr>
<td></td>
<td>The number of drips in 5 minutes, 10 minutes and 15 minutes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>We will change ...</th>
<th>We will measure/observe ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>(independent)</td>
<td>(dependent)</td>
</tr>
<tr>
<td>The amount of enzyme we use.</td>
<td>The time taken to collect 10 cm³ of juice.</td>
</tr>
</tbody>
</table>

**Our question is ...**  
Will putting in more enzyme give us more juice?

**We will keep these the same ...**

<table>
<thead>
<tr>
<th>The amount of apple pulp.</th>
<th>The temperature of the apple pulp.</th>
<th>The type of apple.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>We will use pulp.</td>
<td>Raw or cooked?</td>
</tr>
<tr>
<td></td>
<td>We will use pulp.</td>
<td>We will use cooked.</td>
</tr>
</tbody>
</table>

**Prediction (if appropriate)**

<table>
<thead>
<tr>
<th>When we change</th>
<th>Amount of enzyme [1, 3, 5, 10, 15 cm³]</th>
<th>we think what will happen to the apple is ...</th>
<th>We will get more.</th>
</tr>
</thead>
</table>

**This is because ...**

There will be more enzyme available to break down the plant cell walls and release the juice that is held inside.
### Obtaining evidence

<table>
<thead>
<tr>
<th>Change ... (independent)</th>
<th>Measure ... (dependent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of enzyme [1, 3, 5, 10, 15 cm³]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average</td>
</tr>
</tbody>
</table>

### Presenting the results

<table>
<thead>
<tr>
<th>Measure ... (dependent)</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Change ... (independent)</td>
<td></td>
</tr>
</tbody>
</table>
## Considering evidence and evaluating

<table>
<thead>
<tr>
<th>When we changed</th>
<th>what happened to</th>
<th>is ...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Why did this happen? (Explain the pattern scientifically if you can)**

**Was the prediction correct?**

**Were there any unusual readings?**

**Why do you think these happened?**

**In what ways could we have improved what we did?**

**What could we do next?**
## Planning

We are investigating ... the best conditions for the enzyme pectinase to work

<table>
<thead>
<tr>
<th>We could change ...</th>
<th>We could measure/observe ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>The amount of apple we use.</td>
<td>The amount of enzyme we use.</td>
</tr>
<tr>
<td>The size of apple bits.</td>
<td>Raw or cooked apple.</td>
</tr>
<tr>
<td>The amount of enzyme we use.</td>
<td>The time taken to collect 10 cm³ of juice.</td>
</tr>
<tr>
<td>The number of drips in 5 minutes, 10 minutes and 15 minutes.</td>
<td></td>
</tr>
</tbody>
</table>

### Prediction (if appropriate)

<table>
<thead>
<tr>
<th>When we change</th>
<th>we think what will happen to the apple pulp is ...</th>
<th>we will get more.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of enzyme [1, 3, 5, 10, 15 cm³]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This is because ... There will be more enzyme available to break down the plant cell walls and release the juice that is held inside.

Our question is ... Will putting in more enzyme give us more juice?

We will keep these the same ...

<table>
<thead>
<tr>
<th>The amount of apple pulp.</th>
<th>The temperature of the apple pulp.</th>
<th>The type of apple.</th>
<th>Raw or cooked?</th>
</tr>
</thead>
<tbody>
<tr>
<td>We will use pulp.</td>
<td>We will use cooked.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We will change ... (independent) We will measure/observe ... (dependent)

| The amount of enzyme we use. |
| The amount of juice collected in 10 minutes. |
Task I: Apple-juice production

The task

- You are provided with the equipment you need to carry out this enquiry:
  - Apple pulp, 200 ml
  - The enzyme pectinase in solution
  - 5 measuring cylinders
  - Filter funnel and papers
  - Syringe
  - Stopwatch
  - Glass rod

- Use handout 3.9A or 3.9B, and follow the plan that some pupils have started.

- Carry out the enquiry as the pupils have planned, collect your evidence and evaluate your findings.

- You have 20 minutes to complete the task. Be prepared to discuss your findings with other groups.

The pupils were set the problem as follows.

Investigation into the production of apple juice from apple pulp

There is a good market for apple juice in the UK. The climate is also good for growing apples. Manufacturers first pulp the apples and then squeeze them to extract the juice. However, they have found that this is not very efficient as lots of the juice is trapped in the apple pulp.

A particular manufacturer has decided that enzymes may be able to help. The food scientists know that pectins are components of plant cell walls and are very difficult to break down using physical means such as squeezing. This makes the juice difficult to extract. One of the scientists has suggested that the enzyme pectinase could be added to help break down the cell walls and release more juice.

Your task is to discover how much enzyme is needed to extract the maximum amount of apple juice from pulp.

Be prepared to make recommendations for the maximum apple-juice extraction based on your results.
The circulatory system consists of the heart and the three types of blood vessels.

The blood vessels are the arteries, veins and capillaries. The arteries carry blood away from the heart. The veins contain valves to stop the blood flowing backwards and carry blood back towards the heart. The capillaries connect the two, and the walls are only one cell thick so that dissolved gases and other substances can pass through into the surrounding cells (remember slide 3.8).

The heart in humans consists of four chambers and acts as a pump to move blood around the body. This is known as a double circulatory system, because the blood travels through the heart twice. This ensures that oxygenated and de-oxygenated blood do not mix. The blood follows a circuit through the lungs and then through the rest of the body. Some less complex organisms only have a single circulatory system.
• The right-hand side of the heart is smaller and only pumps blood to the lungs.
• The bigger left-hand side of the heart pumps blood around the rest of the body. Blood entering the right-hand side of the heart contains carbon dioxide, which is a product of respiration from the cells in the body. The blood is sent to the lungs, where the carbon dioxide diffuses into the air spaces and is expelled.
• At the lungs oxygen, which has been inhaled during breathing, is absorbed into the bloodstream and is then transported to the left-hand side of the heart where it is pumped around the body.
• The chemical substances (such as glucose and maltose, which are relatively small molecules that have been extracted from foods), are picked up, usually after being stored in the liver, and transported around the body to the cells at the same time.

Blood contains three main types of cell, and plasma.
• Red blood cells have no nucleus. They are disc-shaped in order to maximise their surface area for gas absorption. They carry oxygen to the cells of the body. When the oxygen has been given up to the cells, they pick up and transport carbon dioxide (the result of cellular respiration) away from the cells. Carbon dioxide is also dissolved in the plasma.
• White blood cells have a nucleus. They are responsible for combating disease. There are several different types, e.g. phagocytes, which surround ‘foreign’ bodies such as bacteria cells and digest them before they can release toxins into the body.
• Platelets have no nucleus and are fragments of larger cells. They are responsible for clotting the blood should a cut occur in a blood vessel.
• All of the above are carried around the body in plasma. This is a straw-coloured liquid that acts as a carrier not only for the cells but also for dissolved substances including urea, hormones, products of digestion, carbon dioxide and oxygen.
## Glossary of terms used in session 4

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic</td>
<td></td>
</tr>
<tr>
<td>Anaerobic</td>
<td></td>
</tr>
<tr>
<td>Breathing</td>
<td></td>
</tr>
<tr>
<td>Chromosome</td>
<td></td>
</tr>
<tr>
<td>DNA (deoxyribonucleic acid)</td>
<td></td>
</tr>
<tr>
<td>Gene</td>
<td></td>
</tr>
<tr>
<td>Photosynthesis</td>
<td></td>
</tr>
<tr>
<td>Respiration</td>
<td></td>
</tr>
<tr>
<td>Stoma (stomata)</td>
<td></td>
</tr>
</tbody>
</table>
Respiration – some useful information

Every organism needs energy to keep alive. Movement, growth, excretion, feeding and reproduction all need energy.

Organisms release this energy from their food, as we saw in session 3 where the process of digestion was described. Food is digested into smaller molecules, for example glucose, which are carried in the blood to all cells.

Under normal circumstances only carbohydrates and fats, suitably digested, are utilised for respiration.

Oxygen, also supplied via the blood, reacts in a series of controlled processes with carbohydrates and fats (after being converted into glucose), releasing energy to enable other cell processes to take place. This is called aerobic respiration. The products of reaction – carbon dioxide and water – go back into the blood.

In the respiration equation, we almost always indicate glucose (C\textsubscript{6}H\textsubscript{12}O\textsubscript{6}) as the initial substance on the left-hand side. This is because glucose is the most common substance used for respiration. Glucose is derived in various ways. Starch – a carbohydrate – is a major component of the diet of humans (e.g. bread, potatoes, rice). Starch is a large molecule made up of two glucose molecules. During digestion starch is broken down into glucose, which is then used in respiration.

Cellulose is also a large molecule, which is made of glucose molecules. The digestion of cellulose can also produce glucose for respiration. In herbivores the enzymes necessary to digest cellulose are supplied by bacteria in the gut.

Most animals include either starch or cellulose as a major component in their diet.

The chemical representation only shows the raw materials and end products. In reality the whole process involves about 50 separate reactions, each one catalysed by a different enzyme.

Although the examples that we have looked at have involved enzymes breaking molecules down, enzymes also catalyse reactions, such as protein synthesis, where molecules are built up. Pupils often think that enzymes only break up large molecules. This is a misconception that should be dismissed as early as possible (see session 3, ‘Enzymes at work’).

Aerobic respiration releases the same amount of energy that would be released if glucose was burned in oxygen gas, but much more slowly.
Anaerobic respiration

- In aerobic respiration, oxygen is used in a complex series of biochemical reactions with food substances (in the form of glucose or fats) to transfer energy to the cell. This is very efficient but relies on a regular supply of oxygen through the blood supply or to the blood for it to happen.

- When animals’ muscles are put under stress, e.g. when running hard, the oxygen supply to the muscle cells is often insufficient to cope with the demand. The muscle cells can then respire **anaerobically** (in the absence of oxygen), but this is a less efficient mechanism.

- Because the breakdown of glucose in the absence of oxygen is not complete (it does not produce carbon dioxide and water as products), there is far less energy transferred from the glucose to the cell. Therefore this form of respiration is not as efficient as aerobic respiration.

  \[
  \text{glucose} \xrightarrow{\text{enzymes}} C_6H_{12}O_6 \xrightarrow{2\text{C}_3\text{H}_6\text{O}_3} \text{lactic acid}
  \]

- The by-product of anaerobic respiration in animals is lactic acid (2-hydroxypropanoic acid). This can build up in the tissues and cause muscle cramp. When there is enough oxygen available again, the lactic acid is broken down into carbon dioxide and water.

Fermentation

- Fermentation is the term used for anaerobic respiration in yeast cells (some bacteria are able to do this too). Ethanol (alcohol) is produced and carbon dioxide is given off. This process has been used by humans in order to make wine, beer and bread.

  \[
  \text{glucose} \xrightarrow{\text{yeast}} 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2
  \]
Photosynthesis

Photosynthesis
\[ \text{enzymes} \]
\[ \text{light} \]
\[ \text{carbon dioxide} + \text{water} \rightarrow \text{glucose} + \text{oxygen} \]

Respiration
\[ \text{enzymes} \]
\[ \text{glucose} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water} \]

- Photosynthesis and respiration can be considered as opposite reactions. In photosynthesis, water and carbon dioxide are the raw materials used by the cell. Energy usually transferred by sunlight enables the reaction to take place whereby glucose and oxygen are produced. In respiration, glucose and oxygen are the raw materials used by the cell. Carbon dioxide and water are produced, and energy is released to enable other reactions to take place.

- Chlorophyll is needed for photosynthesis. It is located in small intracellular structures called chloroplasts which enable the reactions of photosynthesis to take place in an ordered sequence. Participants should have seen chloroplasts during session 1 but there will be a further opportunity to look at some at the end of this session.

- Some of the oxygen that green plants produce during photosynthesis is used in respiration. The rest diffuses out of the plant into the atmosphere (or water, in the case of aquatic plants).

- Glucose is one of the products of photosynthesis. It is rapidly converted into the sugar sucrose (roughly, two glucose units linked together), which has the property of being much less reactive than most other sugars. Sucrose is further converted into starch for temporary storage in the leaf. It is converted back into sucrose for subsequent transportation around the plant because sucrose, although more reactive than starch, is soluble.

- Through photosynthesis, plants produce much more glucose than is needed for respiration. Some is used for other life processes such as growth, water uptake from the roots and making new cells.

- Many plants store starch in a variety of structures, all of which are associated with reproducing more plants. These include seeds such as cereals, roots such as carrots, and stem tubers such as potatoes. All these storage organs provide excellent food for animals.
The leaf: an important plant organ

- A typical leaf is wide and flat to absorb as much sunlight as possible. The top and bottom sides are different. One side is positioned facing the Sun. Leaves are arranged on stems so that they shade each other as little as possible. They are thin, to reduce the distance over which carbon dioxide has to diffuse into the cells from the air (or water in the case of aquatic plants). They have a well-developed system of veins, which transports water to the cells and sucrose away to be stored.

- The palisade cells nearest the top side of the leaf have lots of chloroplasts.

- Leaves have many pores (stomata, singular stoma) to let carbon dioxide in. There are many air spaces (see diagram) in the leaf to allow the carbon dioxide to diffuse easily to individual cells.

- The mesophyll cells have a thin water layer on the outside, to allow carbon dioxide to dissolve so that it can pass into the cells to the chloroplasts.

- Water evaporates from this layer and diffuses out of a leaf through the stomata. Many plants have modified stomata or leaf surfaces to reduce this water loss.
Where do babies come from?

I’m sure when you were very young,
you used to say to dad or mum,
Mummy? Daddy? Where do babies come from?

Well your mum and dad reply
and suddenly they go all shy.
Well my dear you’ll learn some day
how you have turned out this way.

A little creature called a sperm
which lives inside a man
will swim towards a tiny egg
as fast as it possibly can.

The egg just waits inside a woman
waiting for a sperm.
It really is quite complicated
there’s quite a lot to learn.

The sperm with his little wiggly tail
and its pointy head
finds its way into the egg
while your parents are in bed.

Slowly then the egg splits and grows
as large as it can go.
Then forms into a sort of baby
called an embryo.

The embryo then grows and grows
and gets all its bits and pieces.
Then it grows a little bit bigger
and this is called a foetus.

In the next nine months your mum gets fat,
starts buying the baby clothes and hats.
She then goes into hospital
to wait for the baby to be born.

She screams and shouts
while the baby comes out, and daddy holds her hand.
Then you give it the name you want
and then you can take it home!

The above poem is reproduced with kind permission of the ASE. ‘Where do babies come from?’ is included in Science is like a tub of ice-cream – cool and fun, edited by Rosemary Feasey and published by the ASE (2001). (ISBN 086357 322 3)
The inheritance themes in Year 9

- Offspring generally have two parents unless they are hermaphrodites.
- This means that offspring inherit characteristics from both parents but in combinations which are difficult to predict.
- This means that offspring will vary both from their parents and from their siblings.
- By choosing the parents carefully, it is possible to increase the chances that certain desirable characteristics are inherited by the offspring.
- Nature exerts some influence over which parents mate successfully, because only those which are best adapted to their environment survive long enough to reproduce.
- In some species of animal it is the strongest male that mates with the females, and this increases the chance that the offspring will also be strong.
- Humans, by choosing which animals are allowed to mate (such as in dogs or horses), can increase the chances of desirable characteristics being passed on to the offspring.
The cell nucleus and its chromosomes

- The nucleus of a cell contains rod-shaped structures called chromosomes.
- Chromosomes are only visible when a cell is about to divide.
- There are two full sets of chromosomes, one set which comes from the female parent and the other from the male parent.
- Chromosomes comprise a very long chain molecule of a complex chemical known as DNA (deoxyribonucleic acid).
- Short lengths of DNA control different characteristics of an organism. Each such section of a chromosome is called a gene.
- Any chromosome is made up of many genes, often with non-functioning lengths of DNA between them.
- When a normal cell divides in two for growth of an organism, the process ensures that each new cell has exactly the same chromosomes as the original cell.
- In order to produce male sex cells (such as sperm) or female sex cells (such as eggs), the process of cell division ensures that the sex cells have only half the chromosomes of the normal cells in the organism.
- This means that when a male sex cell fertilises a female sex cell, the offspring regains the full number of chromosomes.
- It is vitally important that all the cells of any organism have the same, and correct, number of chromosomes for the species. Even one more or less can have disastrous effects on the individual, often leading to death.
Task M: The chromosome game

<table>
<thead>
<tr>
<th>Sex</th>
<th>Male</th>
<th>Male</th>
<th>Female</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hair colour</td>
<td>blonde</td>
<td>blonde</td>
<td>black</td>
<td>black</td>
</tr>
<tr>
<td>2 Hair type</td>
<td>straight</td>
<td>curly</td>
<td>curly</td>
<td>curly</td>
</tr>
<tr>
<td>3 Eye colour</td>
<td>blue</td>
<td>grey</td>
<td>grey</td>
<td>grey</td>
</tr>
<tr>
<td>4 Nose shape</td>
<td>round</td>
<td>pointed</td>
<td>round</td>
<td>pointed</td>
</tr>
<tr>
<td>5 Nose size</td>
<td>small</td>
<td>large</td>
<td>large</td>
<td>small</td>
</tr>
</tbody>
</table>

- To make the game manageable, each ‘chromosome’ contains five genes, but in reality a chromosome will contain many more than this. The five genes and the variations which we are considering (this is also a considerable oversimplification) are:
  1. hair colour (black or blonde)
  2. hair type (straight or curly)
  3. eye colour (blue or grey)
  4. nose shape (pointed or rounded)
  5. nose size (large or small)

The emboldened terms are dominant.

- Work in pairs.
- Cut out the four chromosomes and put them into a male pair and a female pair.
- The male pair divides to become part of two different sperm cells. The female pair divides into two different egg cells.
- Sort the chromosomes to identify what combinations of characteristics are possible in any baby.
- If, over time, two babies are produced, what is the chance that they will have the same hair colour?
### Task N: Card loop game

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What simple units are all living things made from?</td>
<td>Antibiotics</td>
</tr>
<tr>
<td>What type of cell has a vacuole and a cell wall</td>
<td>Cells</td>
</tr>
<tr>
<td>What does a chloroplast do?</td>
<td>A plant cell</td>
</tr>
<tr>
<td>What special feature does a sperm cell have?</td>
<td>It contains the pigment to absorb light energy for photosynthesis</td>
</tr>
<tr>
<td>Why are root cells long and thin?</td>
<td>A tail to allow it to move</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>What structures in animals and plants are made from different tissues joined together?</td>
<td>To give the maximum surface area to absorb water</td>
</tr>
<tr>
<td>Why do plant cells have cell walls?</td>
<td>Organs are made of tissue</td>
</tr>
<tr>
<td>What do enzymes do in digestion?</td>
<td>To keep their shape and support the plant</td>
</tr>
<tr>
<td>What is the proper name for the ‘food tube’?</td>
<td>They break down large molecules into smaller molecules</td>
</tr>
<tr>
<td>Which acid is found in the stomach?</td>
<td>The oesophagus</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Why are nerve cells long and thin?</td>
<td>Hydrochloric acid</td>
</tr>
<tr>
<td>Where is food absorbed into the body?</td>
<td>To carry nerve impulses around the body</td>
</tr>
<tr>
<td>What is the name of the time when the human body changes into an adult body?</td>
<td>In the small intestine</td>
</tr>
<tr>
<td>What useful waste product is made in photosynthesis?</td>
<td>Adolescence</td>
</tr>
<tr>
<td>How are food products carried through the body?</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>What carries oxygen round your body?</td>
<td>They are dissolved in blood plasma</td>
</tr>
<tr>
<td>What cells fight disease in your body?</td>
<td>Red blood cells</td>
</tr>
<tr>
<td>What are the three main food groups?</td>
<td>White blood cells</td>
</tr>
<tr>
<td>What is needed in a diet to keep you healthy?</td>
<td>Proteins, carbohydrates and fats</td>
</tr>
<tr>
<td>What is needed in a diet to keep your digestive system working?</td>
<td>Vitamins and minerals</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Does fat in your diet cause heart disease?</td>
<td>Fibre</td>
</tr>
<tr>
<td>What is the name of the process when cells use food and oxygen to release energy?</td>
<td>Not always. It depends on how much fat you eat and your lifestyle.</td>
</tr>
<tr>
<td>How many chambers are there in a human heart?</td>
<td>Respiration</td>
</tr>
<tr>
<td>What micro-organism is used in making bread and wine?</td>
<td>Four</td>
</tr>
<tr>
<td>What three types of micro-organism are there?</td>
<td>Yeast</td>
</tr>
<tr>
<td>Which infectious organism lives inside body cells?</td>
<td>Bacteria, viruses and fungi</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>What medicines work against bacterial infections?</td>
<td>A virus</td>
</tr>
</tbody>
</table>
Task O: Sorting cards for cells

These are the statements on the sorting cards for cells, grouped broadly into Years 7, 8 and 9.

Cells (Year 7)

- A cell is made up of different structures which have particular functions.
- Cells have a nucleus which controls growth, division and the activities within the cell.
- The nucleus contains the information that is transferred from one generation to the next.
- Fertilisation occurs when a male sex cell and a female sex cell join to make a unique individual.
- Plants and animals are made up of cells.
- Some living organisms are one cell only but many are multi-celled.
- Similar cells can be grouped into tissues with a particular function. Tissues can be grouped together to form organs.
- There are similarities and differences in structure between animal and plant cells.
- In multi-celled organisms cells are specialised to do different jobs.
- Sperm and egg cells are adapted to their functions.
- Increased cell size and cell division produce growth of the organism.

Cells (Year 8)

- Cells need nutrients such as proteins and minerals for growth and carbohydrates for energy.
- In digestion, foods are broken down physically and chemically into substances which have small molecules that can be transported in blood.
- Respiration takes place in cells.
- Blood transports substances to and from cells.
- Enzymes are essential to digestion because they speed up the breakdown of foods.
- Aerobic respiration requires oxygen to release energy from carbohydrates.
- All plant cells and animal cells respire but only some plant cells can photosynthesise.
- Arteries have to be strong and elastic to cope with and transmit the pressure of the heart. Veins carry blood at much lower pressure and so do not need to be so strong or elastic.
• Yeast is a one-celled organism; its metabolic processes are the basis for breadmaking and brewing.

• Some one-celled organisms live parasitically inside others. They may cause harm by consuming food or the host tissue, or may release toxins.

• Viruses are smaller than a cell and can only reproduce by using other cells to produce more viruses.

• White blood cells are part of the body’s defence mechanism against ‘foreign’ organisms.

**Cells (Year 9)**

• Respiration produces energy just as burning fuels does.

• Smoking, alcohol and drugs affect cells in different parts of the body. Sometimes these cells may die or cease to work and the body becomes ill.

• In the lungs, ciliated epithelial cells help sweep dust and other materials away from the alveoli.

• During fertilisation, genetic information from the male and female parents combine to produce a genetically unique new individual.

• A gene is a part of a chromosome which controls one characteristic or one particular aspect of how an organism works.

• Selective breeding can increase the chances of certain characteristics passing from parent to offspring.

• Living organisms are adapted to their environment.

• Exercise helps to maintain the cells of the body’s muscles and circulation system.

• Chromosomes are found in the cell nucleus.

• In leaves, palisade mesophyll cells are adapted to maximise photosynthesis.

• Plant cells grow using the products of photosynthesis and essential nutrients taken in by root cells.

• Respiration and photosynthesis are very similar chemical reactions which take place inside cells.
Web resources

The following websites have been found useful in answering questions and as a source of further resources.

The descriptions of the sites are taken from Planet Science:
www.planet-science.com/home.html

**Microscope World**

http://www.microscopeworld.com/wpglinks/link-partners.htm

This is the links section of microscopeworld.com where there is a diverse array of science links with a slant towards, as you might expect, the microscopic. I noticed the Virtual Frog dissection site, which looks worth a visit if you don’t want to do the real thing. You can also learn about and order microscopes from this site.

**Microbiology in the Classroom**

http://www.microbiologyonline.org.uk

This splendidly simple site is for any teachers who would like to include microbiology in their repertoire. It is very easy to navigate, not being too big and unwieldy, and provides lots of primary and secondary resources and information to get you going.

**Biology4All**

http://www.biology4all.com/

This is a great site hosted by the University of Central Lancashire, and covers all aspects of the post-16 biology curriculum, with a view to introducing pupils to biology courses at university. It has spectacularly good teacher resources, and links library and up-to-date news from the web on biological advances.

**Pharmaceutical Industry**

http://www.abpi-careers.org.uk/

This site explores some careers in the pharmaceutical industry in good detail, for anyone with a liking for chemistry/biology. As they say, it’s hard to imagine a world without some of the cures that this important industry has come up with. If you know anyone with asthma or diabetes, for example, then you know someone that the pharmaceutical industry has helped to live a near normal life. Definitely worth a look.

**Muscle Page for Kids**

http://danke.com/kidsmuscles/menu.htm

Cute home site – looks awful but has loads of info about musculature!
**Come to your Senses**

http://tqjunior.thinkquest.org/3750/

Good site for children, with clear and attractive pages, good straightforward information about the five senses.

**Innerbody**

http://www.innerbody.com

There is a lot of very good information on this site, simple and well set out.

**Gut Map**

http://www.vh.org/Patients/IHB/Peds/General/OrganMap/GutMap.html

This basic introduction to the digestive tract and liver is an ideal starting-point for Key Stage 3 learners. There is a clear, colourful graphic map that has links to a brief description of each organ’s function.

**Body**

http://tqjunior.advanced.org/5250/Body.htm

Discover how various organs interact within the body systems. Annotated diagrams and simple explanations provide information on each of the eight systems. There is an accompanying quiz for every section. The site would be useful for older Key Stage 2 and 3 classes or individual science projects. Written by school students, this is a naturally child-friendly site.

**Skeleton**

http://www.imcpl.org/kids_skel.htm

Two-page site about the skeleton.

**Bonus**

http://www.bonus.com

This is a site to entertain children in the holidays. It has good links to interesting stuff – a special part for teachers and parents, e.g. the visible body.

**Neuroscience for Kids**

http://faculty.washington.edu/chudler/newslet.html

Explore the human nervous system through a wealth of images and information. The site includes comparative studies, a brief history of neuroscience and sections on disease and injury. Numerous games and activities explore the functions of the brain. This provides an excellent resource for Key Stage 2 and 3 teachers studying the body and the senses. It contains lesson plans, worksheets and diagrams to colour.
Neuroscience for Kids – Experiments
http://faculty.washington.edu/chudler/experi.html
Experiment page of the site above.

Neuroscience Site
http://faculty.washington.edu/chudler/newslet.html
Great site full of information and teaching ideas, and brilliant links – everything you ever wanted to know about neuroscience.

Laugh Lab
http://www.laughlab.co.uk/home.html
Your chance to help judge which is the funniest joke, or contribute one! Psychology experiment on the web.

BSSRC Life
http://www.bbsrc.ac.uk/life/index.html
Great site full of information about relevant modern biological science issues – very clearly set out and easy to navigate – you’ll need to download Flash if you haven’t already.

Visible Human
http://www.madsci.org/~lynn/VH
Very visceral, but amazing images from our innards, cross-sections of the human body, etc., fascinating for the amateur pathologist!

More Visible Human
Find out with a guided tour of the Visible Human from MAD scientists – complete 3D images of the male and female human body. The anatomical detail is fascinating although perhaps too complex for younger children.

Cells Alive
http://www.cellsalive.com/
Good pictures showing bacteria, blood cells and viruses. See ‘Anatomy of a splinter’ which explains the inflammatory process.
Medical Museums

http://www.medicalmuseums.org/

Site to lead to the medical museums of London, for the history of medicine, ophthalmology, psychoanalysis, etc.

Sheffield College Science Links

http://www.sheffcol.ac.uk/links/Science/

Really awesome comprehensive site full of categorised links for science (and everything else if you go to the home page and start from there) that would be useful to the college students or staff. It was given a well deserved mention in TES Online. New sites can be added.

The Heart – Online Exploration

http://sln.fi.edu/biosci/heart.html

Clear information simply set out.

Testing Reaction Times

http://www.shu.ac.uk/schools/sci/sol/invest/react_1/react.htm

Class experiment set out.

Medical Research Council

http://www.mrc.ac.uk for the main site, aimed at the medical research community.
http://www.mrc.ac.uk/schools/s_p1.html is the schools section.
http://www.schoolscience.co.uk link is very useful for teachers with an interest in medical research topics.

Inner Learning Online

http://www.innerbody.com/htm/body.html

Large site, but good information to be found using the search. Clear diagrams and a good animation to explain. Navigation best with search.

Scientists for Global Responsibility

http://www.sgr.org.uk/

Site promoting ethics in science.
Blackpool Sixth Form College, Biology Links

http://www.blackpoolsixth.ac.uk/biology/home.html

Selected biology links, well presented.

The Bug Stops Here

http://www.thebugstophere.co.uk/

If you have a concern or want to learn more about germs and home hygiene, then The Bug Stops Here has the answers.

Vision 3D

http://www.vision3d.com/optical/index.shtml

Discover how to see in 3D and the benefits of exercising the eyes. Diagrams and information explain the mysteries of binocular vision. The gallery provides numerous examples of both traditional and 3D illusions. Suitable for Key Stage 2 and 3 classes.

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