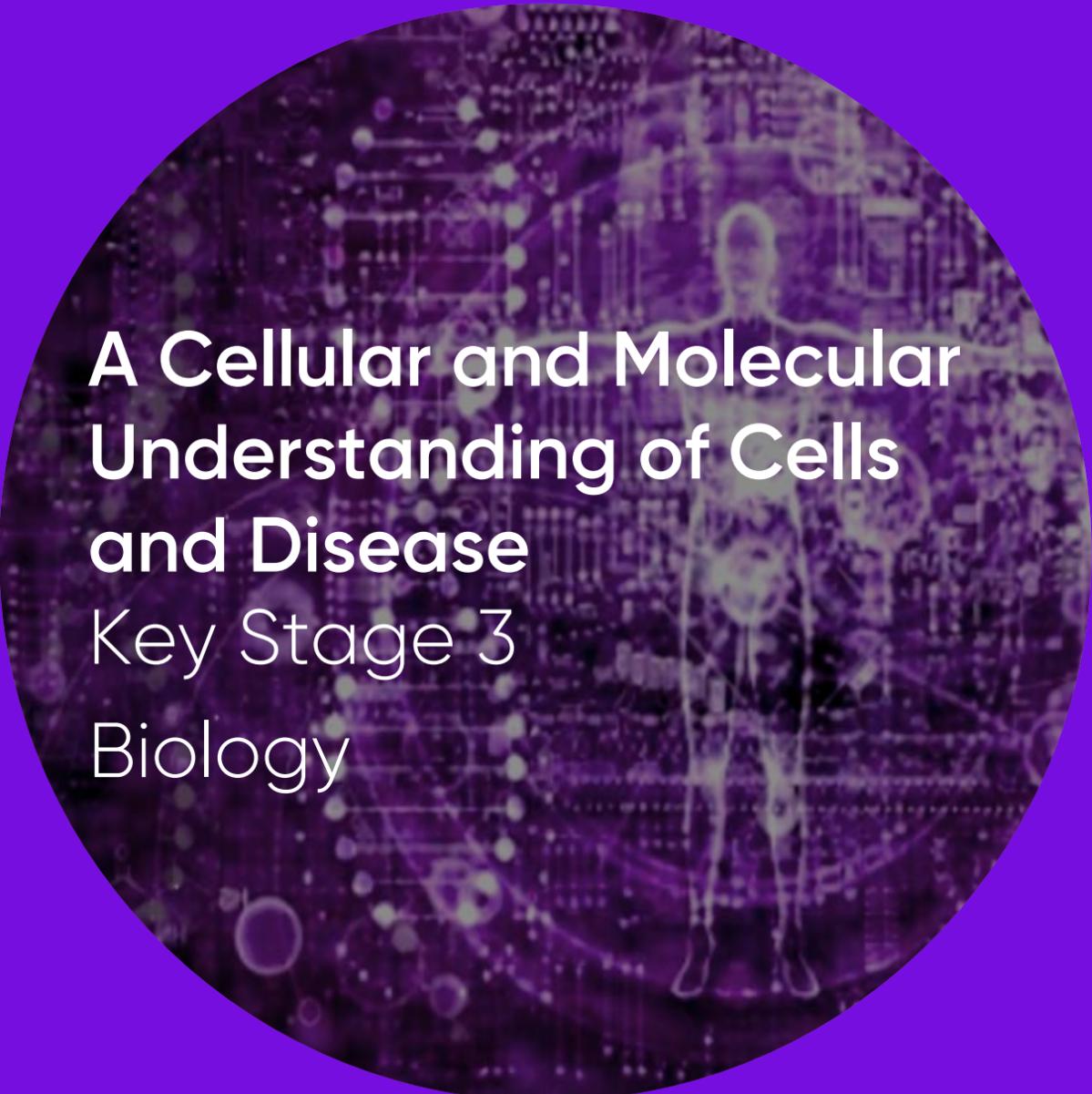


Research  
Based  
Curricula



**A Cellular and Molecular  
Understanding of Cells  
and Disease**  
Key Stage 3  
Biology

2021

heppSY



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# Part 1: Getting started



04	About this pack
05	Meet the Author
06	Building Key Skills
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# About this pack

## What's in this pack?

This booklet contains:

- ✓ Lots of activities and interesting information about how you can study this subject and why it is worth studying
- ✓ Four 'units', each as a lesson with activities
- ✓ A final assignment to check what you've learned
- ✓ Extra guidance and advice throughout about the skills you are building
- ✓ End notes on extra resources and where to find more information

## Who should complete this pack?

This pack was created for **all** students to enjoy and explore a new topic. It also gives you the opportunity to learn in a new way that's different to the classroom.

Each pack is written by a university student who is researching this topic and has special knowledge on the subject. By completing their mini-course, you will find out why it's interesting and you will build skills that help you with studying and learning.

## Why complete this pack?

- ✓ Learn about cool areas of a subject that you might not cover at school
- ✓ Sharpen your academic skills, like short essay writing and interpreting data
- ✓ Experience what it's like to explore a subject freely
- ✓ Better understand what you enjoy and don't – it will help you make decisions about your future studies and career choices!

**By completing this pack you will not only get better at this subject, you will also have fun learning something completely new!**





# Meet the Author

## Danielle Lambert



### My Journey

I am from a village on the outskirts of Sheffield called Chapeltown. I attended the local secondary school – Ecclesfield Comprehensive, studied A levels at Thomas Rotherham College and then went on to study a Bachelors degree in Biomedical Sciences at Sheffield Hallam University. Following this, I studied a Masters degree in the Cellular and Molecular basis of human Disease at The University of Sheffield and am currently completing my PhD at this university too. My PhD project centres around furthering the understanding of the mechanisms of progastrin and its role in tumour cancer progression. However, none of my family had previously gone to university and I had no idea what a PhD was until I got to university.

### My studies

#### A-Level Subjects

Mathematics, Biology, English Literature, Media Studies and General studies

#### Undergraduate

BSc Biomedical Sciences (with placement year)

#### Postgraduate

MSc The cellular and molecular mechanisms of human disease

PhD An investigation into the non-classical mechanisms of gastrins and their role in tumour development

### Why this subject?

To be honest, I chose biology at A level as my fourth option, on a whim. I didn't know what I wanted to be in the future when choosing these options, but I thought that a science would be a good subject to have studied and biology seemed the most interesting to me. During my A level studies I fell in love with biology and learning how the human body worked in complex and intricate ways. Biomedical Science is a branch of biology focusing on human biology and disease. Biomedical scientists not only diagnose diseases in hospital laboratories but are responsible for new and critical discoveries of how human bodies work and development of new treatments for all kinds of diseases. It is a fascinating and rewarding field of study!



# Building Key Skills

Look out for these **Key Skills Badges** throughout the **coursebook**. These show that you're building the study skills you'll need to succeed at school and beyond.



To complete this booklet, you will be using and building your learning and thinking skills. These skills are ones that teachers look for as you progress. All these skills that you will see here will demonstrate your abilities as a student – while you're still at school!

For example, every time you have to look something up, you are showing that you can work independently.

Every time you complete a challenging problem, you might demonstrate your ability to think logically.

Every time you evaluate the sources or data that you are presented with, you are showing that you can analyse and digest information on an unfamiliar topic and learn from it!

## Skills you may meet and build in this pack:

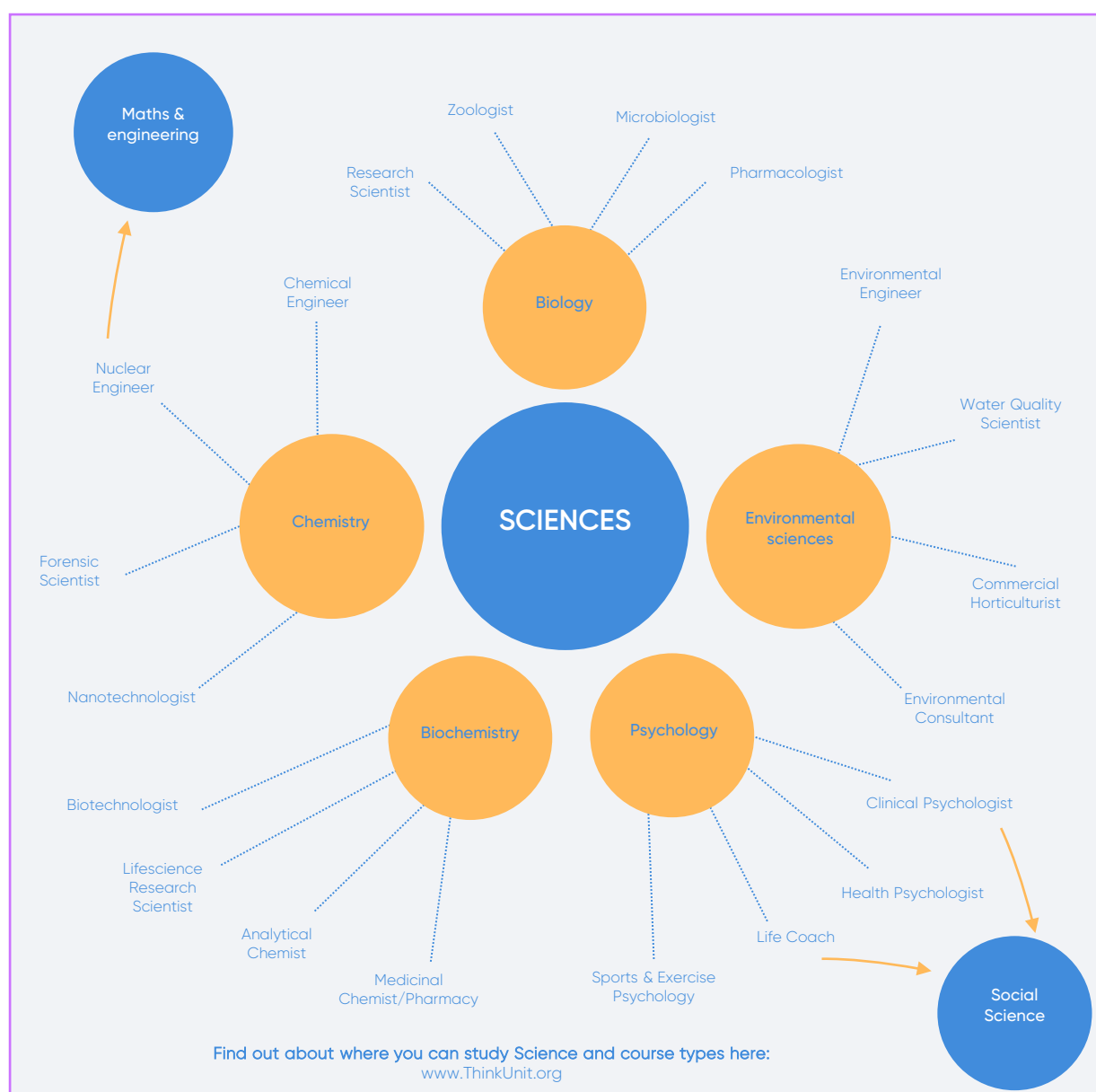
research	your ability to work on your own and find answers online or in books
creativity	your ability to create something original and express your ideas
problem solving	your ability to apply what you know to new problems
source analysis	your ability to evaluate sources (e.g. for bias, origin, purpose)
data analysis	your ability to evaluate data and numbers
critical thinking	Your ability to consider questions with an open mind and evaluate what is important or not
active reading	your ability to engage with what you are reading by highlighting and annotating



# Subject map: Sciences

Studies in Science lead to a large number of career choices. Many students who study Sciences go on to pursue Science degrees at University. However, a significant number of them also start looking out for jobs in many different fields like cancer research, protection of the environment, forensics and many other positions in this space.

**Did you know?** Being a scientist can open up many doors within many industries, from managing projects to working in a lab or with health policy teams in governments!





# Introduction to Topic: A Cellular and Molecular Understanding of Cells and Disease

## What is this topic about?

Cell Biology is the study of cell structure and function. It focuses on a detailed understanding of how cells grow and survive, communicating with each other on a cellular and molecular level to form larger functioning tissues and organs that enable humans to live.

### The topics within this pack will include:

An introduction to proteins

## Why is this an important topic?

There are many different types of proteins which participate in every aspect of life and every cellular process.

Mechanisms of the digestive system

The digestive system turns food into molecules and compounds necessary for cells, organs and tissues to survive, grow and repair.

Genetics and inheritance

Genes are the instructions for life and contain the information needed to make all proteins. Sometimes genes can carry advantages or disadvantages to the cells they are within and the individual they belong to.

Cell growth and cancer

Cell replication is vital for growth, repair and survival of human cells, but can sometimes go wrong and lead to cancer development.

### Other topics that link to this area of study:

Nutrition and Health

Genetics

## Curriculum links

**Working scientifically:** Experimental skills and Investigations; Analysis and evaluation

**Biology:** Structure and function of living organisms; Genetics and Evolution

**Other related topics:** Mitosis, Cell biology, Protein synthesis, Metabolism, Homeostasis, Hormones, DNA structure, Enzymes and more.



# Glossary

Term	Definition
Amino acid	A simple organic compound used as the building blocks of proteins
Biological activity	The capacity of a specific molecule to have a specific defined biological effect
Carbohydrate	Organic compound occurring in food and living tissues, including sugar starch and cellulose
Catalyse	Initiate or accelerate a chemical reaction
Chromosome	A long DNA molecule (polymer) containing many genes and genetic material of organisms
Compound	A substance containing atoms from two or more different elements
Cytoplasm	A thick solution that fills each cell, enclosed by the cell membrane
Deoxyribonucleic acid (DNA)	A molecule containing the biological instruction for life and all genes and proteins. It is passed to offspring during reproduction.
Digestive system	The system of organs involved in digestion, egestion and breakdown of food into components which can be absorbed and reused in the body
Enzyme	A type of protein that acts as a catalyst for chemical reactions. The molecules that enzymes act on are called substrates. The enzyme converts a substrate into a different or modified molecule.
Fats	(also called lipids) Fats are a group of compounds found in food and the body. They have the property of being hydrophobic and are composed of fatty acids.
Gene	A section of DNA responsible for a specific characteristic or molecule. It is a unit of heredity which is passed on to offspring during reproduction.
Hormone	Proteins which act as messenger molecules in the body. They can travel throughout the body to control cell and organ function.
Hydrochloric acid	A strong acidic solution of hydrogen chloride in water secreted into the stomach to aid in digestion. Also called gastric acid.



# Glossary

Term	Definition
Ligand	A molecule (usually protein) which binds to another biological molecule to form a complex with a specific function
Molecule	A group of atoms bonded together – the smallest fundamental unit of a compound
Nucleus	An organelle in most cells separated from the cytoplasm via a nuclear membrane. Mammalian Nuclei contain all the DNA within a cell.
Nuclear membrane	In humans, it is the two lipid bi-layer membranes which surround the nucleus inside a cell, separating genetic material from the cytoplasm.
Offspring	The new organism produced as a product of reproduction
Polymer	Molecules made from a large number of individual 'monomers' (small units)
Protein	A biomolecule (polymer) made of amino acids. They are essential for life and have many functions.
Receptor	A protein which binds a specific molecule (ligand). Binding causes a conformational change which causes further biological effects.
Secretion (to secrete)	The production and release of a substance by a cell or gland
Signalling molecule	Molecule responsible for transmitting information within a cell and between cells, tissues and organs. Usually proteins.
Signalling pathways	A series of compound interactions or chemical reactions which leads to a specific biological effect
Species	A group of organisms which can reproduce with each other to produce fertile offspring
Substrate	The substance on which an enzyme acts
Transcription	The process in which the information in a DNA strand is copied into a complementary strand of mRNA
Translation	The process in which proteins are synthesised from an initial DNA template



## Part 2: Subject learning

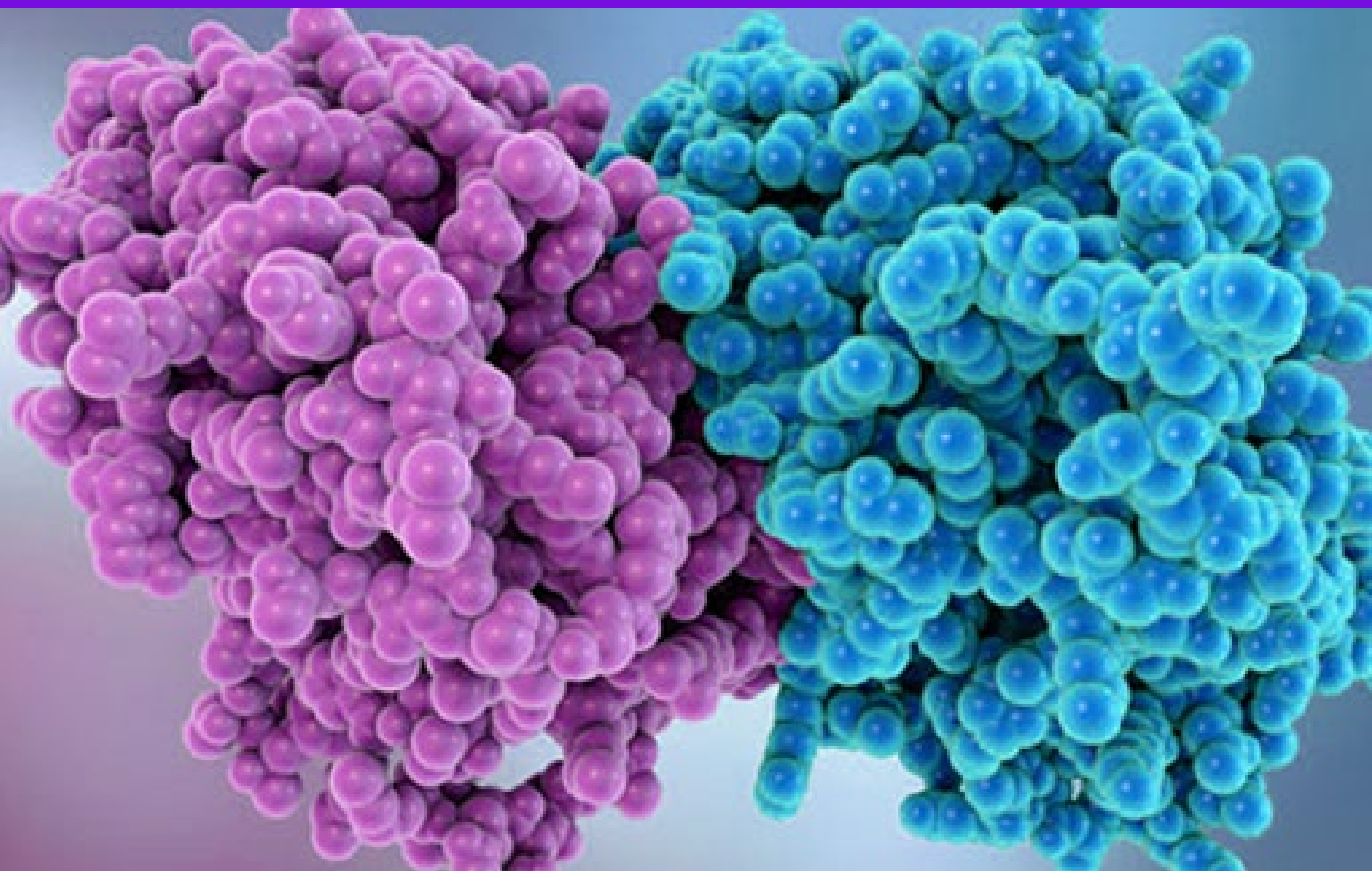
12	Unit 1 – An Introduction to Proteins
23	Mechanisms of the Digestive System
33	Genetics and Inheritance
46	Cell growth and Cancer
59	Final Reflection Activity

# Unit One Overview

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Topic	An Introduction to Proteins
Links to the Curriculum	Structure and function of living organisms; Cells and organisation; Nutrition and digestion
Learning objectives	<p>By the end of this unit, you will be able to:</p> <ul style="list-style-type: none"><li>✓ Understand and explain how proteins are produced and why they are important</li><li>✓ Distinguish between transcription and translation</li><li>✓ Discuss different protein functions</li><li>✓ Discuss side effects of proteins not working or not being produced normally</li></ul>
Instructions	<ol style="list-style-type: none"><li>1. Read and learn about the topic</li><li>2. Complete the activities</li><li>3. Explore the further reading</li></ol>





# Unit One

## Key Vocabulary & Structures

Term	Definition
Absorbed	The movement of digested food molecules through intestinal walls into the blood stream
Cell division	The division of a cell into two identical daughter cells with the same genetic material
Cell growth	The increase in cell numbers through repeated cell division (also called cell proliferation)
Cell repair	Cellular responses associated with DNA restoration of damage and breaks in DNA strands
Chemical messenger	A compound which transmits a message to other compounds resulting in a specific effect or response, for example hormones
G cells	A type of cell in the stomach and intestines which secretes gastrin
Gastrin	A hormone/protein secreted by G cells, responsible for the secretion of gastric acid (hydrochloric acid) into the stomach
Ingestion	The process of food entering the digestive system through the mouth
Messenger RNA (mRNA)	A single strand of nucleotides which corresponds to a specific section of DNA/gene code.
Primary structure	The sequence of amino acids making up a chain which is the initial linear form of the protein sequence before folding
Protein synthesis	The process by which cells make proteins. This involves transcription and translation.
Quaternary structure	A protein structure in which several protein sub-units interact and bind to form one functional protein
Secondary structure	A regular structure of amino acids in an amino acid chain. Usually occurs when primary structures twist/fold.
Tertiary structure	A 3D structure of a protein folded and twisted in specific ways and stabilised by several bonds and interactions

# Unit One

## Student New Vocabulary



When you find words you don't recognise, make sure you look them up. Use this page to write them down and make a note of their definition!

Term	Definition



# Unit One

## Reading and Learning

### Section A

#### What are proteins?



**Proteins** are molecules that are essential for life. Proteins are made of many **amino acids** (small molecules) and can be thought of as a chain with each chain link being an amino acid; this is the **primary structure** of a protein. These chains can all be different lengths and sizes, and can be folded and arranged in many different ways, just like a protein's primary structure which folds into **secondary**, **tertiary** and sometimes **quaternary structures**. There are at least 20,000 identified different proteins in humans so far, each with unique functions.

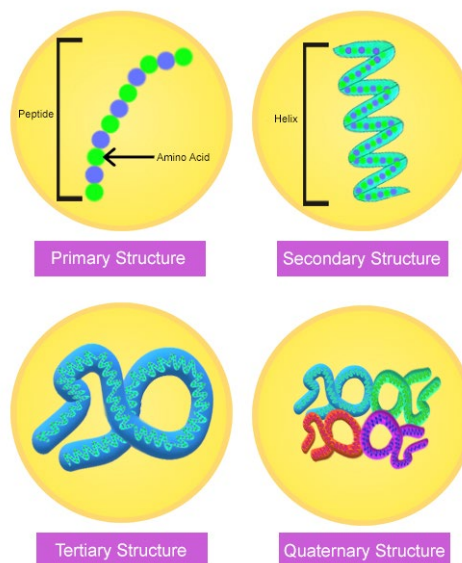


Figure 1.0  
Protein structure and  
folding

- **Primary structures** are a chain of amino acids with no structure to it.
- **Secondary structures** give shape to amino acid chain. Usually the primary structure twists around itself.
- **Tertiary structures** give a final 3D shape to proteins and the secondary structures are folded in specific ways that give proteins **biological activity** (specific functions).
- **Quaternary structures** can occur when two or more tertiary structures must associate to form a functioning protein with biological activity.



# Unit One

## Reading and Learning

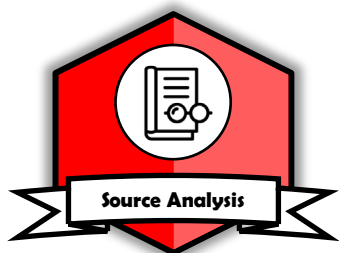
### Section B

#### You are what you eat!



**Proteins** are one of the three main food groups, along with **fats** and carbohydrates. Meats, eggs and beans are particularly high in proteins.

Human bodies have approximately 100 trillion **cells**, each consisting of and containing thousands of different proteins. It is vital to consume enough proteins as they are necessary for **cell growth**, **cell division** and **cell repair** if cells are damaged. It is recommended that 10%–15% of your daily food intake should be protein, equating to approximately half a gram per pound of body weight daily (50–70 grams average).



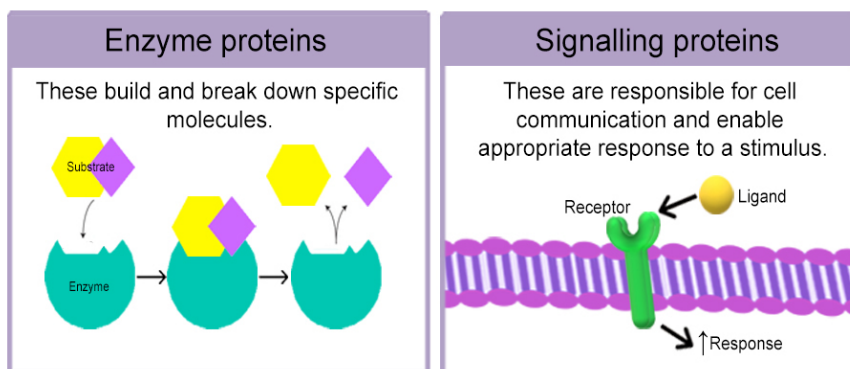
During **digestion**, proteins are initially broken down into long chains of amino acids. Amino acid chains are then further broken down into single amino acids which are **absorbed** by the small intestine and can be reused to make new proteins necessary for the human body that are different from the original **ingested** protein.

Figure 2.0

Two common proteins types

**Protein synthesis** is the process of producing proteins, and occurs in all cells. It consists of two main steps called **transcription**, in which DNA code in the nucleus is read and **mRNA (messenger RNA)** is made based on the DNA code, and then **translation**, in which the mRNA code is used to assemble specific protein structures in the **cytoplasm**.

Proteins are often classified into groups depending on their functions, such as enzymes and signalling proteins.





# Unit One

## Reading and Learning

### Section C Gastrin protein production



One of the many important proteins is **gastrin**. Gastrin is a specific type of signalling molecule called a **hormone**.

Hormones are **chemical messengers** produced by specific cells and **secreted** into the blood in order to tell other cells or tissues they need to respond to something.

Specific cells within the stomach, called **G cells**, produce and secrete gastrin in response to food consumption. Gastrin then travels in the blood and tells other stomach cells they need to produce hydrochloric acid (stomach acid) to aid digestion.

Think!  
Final Reflection  
Activity!

# Unit One Activities



## Activities

1. Choose the most appropriate word from the following list to complete the paragraph below.

Note: not all words are needed.



Transcribed	Translated	Amino Acids	Secondary
Molecules	Converted	Ingested	Carbohydrates
Enzyme	Large intestine	Primary	Functioning
Stomach	Small intestine	Quaternary	Helix

DNA is \_\_\_ in the nucleus of cells and \_\_\_ in the cytoplasm to produce molecules made of many individual \_\_\_, which are the breakdown product of \_\_\_ proteins absorbed in the \_\_\_ during digestion. Amino acid chains are the \_\_\_ structure of proteins which twist and fold to produce the final \_\_\_ forms. Proteins have several functions including signalling roles, structural roles and \_\_\_ roles.

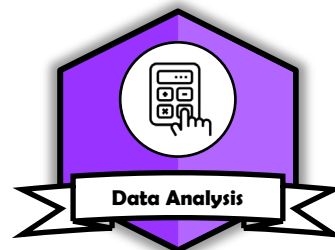


2. In your own words, define the following:
  - Amino acid
  - Primary structure
  - Transcription
  - Translation



# Unit One Activities

## Activities



3. **Get creative! Make a protein.** You will need paper, scissors and tape.

- Make many chain links and form a chain.
- Twist chain into a helix.
- Fold the helix into different 3D shapes.

4. In groups, brainstorm what you think would happen if a body does not consume enough protein?

5. Look at the nutritional information on the food packaging for everything you consume in a day and determine whether you eat the recommended amount of protein.

Breakfast	_____	Lunch	_____
Dinner	_____	Snacks	_____
Total		_____	

6. Looking around your cupboards, discuss the protein content of several items of your choice. Do any foods/drinks surprise you?

# Unit One Challenge & Further Reading



## Challenge Activity



Based on what you have learned about protein production, research transcription and translation further in order to define and describe the role of mRNA (messenger RNA).

Note: Think about how mRNA is made from the DNA template and how it is involved in protein production/amino acid assembly.

Use the next page to write your response!

- Ducksters Protein synthesis and Amino acids:  
[https://www.ducksters.com/science/biology/proteins\\_and\\_amino\\_acids.php](https://www.ducksters.com/science/biology/proteins_and_amino_acids.php)
- BBC Bitesize protein synthesis:  
<https://www.bbc.co.uk/bitesize/guides/z3mbqhv/revision/>
- RNA is just as cool as DNA:  
<https://www.youtube.com/watch?v=0Elo-zX1k8M>
- Protein synthesis:  
<https://www.youtube.com/watch?v=x5ZXQo-xeMo>

## Explore further

- Eufic article on 'What are proteins and what is their function in the body?' <https://www.eufic.org/en/whats-in-food/article/what-are-proteins-and-what-is-their-function-in-the-body>
- Introduction to cell signalling:  
<https://www.youtube.com/watch?v=-dbRterutHY>
- Khan Academy: Proteins  
<https://www.khanacademy.org/science/biology/macromolecules/proteins-and-amino-acids/v/introduction-to-amino-acids>
- Article 'How much protein does a person require?'  
<https://www.medicalnewstoday.com/articles/196279#daily-needs>
- What are proteins?  
<https://www.youtube.com/watch?v=JGZj6DsUZhE&t=53s>

# Unit One

## My research



Challenge Question

What is messenger RNA (mRNA) and what is its purpose during transcription and translation?

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# Unit One

## My research



Handwriting practice lines consisting of 15 horizontal dashed purple lines.

# Unit Two Overview

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Topic	Mechanisms of the Digestive System
Links to the Curriculum	Structure and function of living organisms; Cells and Organisation; Nutrition and Digestion
Learning objectives	<p>By the end of this unit, you will be able to:</p> <ul style="list-style-type: none"><li>✓ Outline the digestive system and discuss what happens to the food you consume</li><li>✓ Discuss the roles of gastrin in the digestive system</li></ul>
Instructions	<ol style="list-style-type: none"><li>1. Read and learn about the topic</li><li>2. Complete the activities</li><li>3. Explore the further reading</li></ol>





# Unit Two

## Key Vocabulary & Structures

Term	Definition
Absorbed	The movement of digested food molecules through intestinal walls into the blood stream
Bile	A thick fluid made and released by liver cells and stored in the gallbladder until used to aid in digestion of fats
Cell survival	The ability of cells to grow and divide
Cell movement	The directed movement of a cell(s) in response to a specific signal
Digestion	The sequence by which food is broken down and absorbed by cells for reuse and maintenance of bodily processes
Egest	The process of voiding and removing undigested food as faeces
G cells	A type of cell in the stomach and intestines which secretes gastrin
Gastrin	A hormone/protein secreted by G cells, responsible for secretion of gastric acid (hydrochloric acid) into the stomach
Hydrochloric acid	A strong acidic solution of hydrogen chloride in water secreted into the stomach to aid in digestion. Also called gastric acid.
Ingestion	The process of food entering the digestive system through the mouth
Metabolism	The chemical reactions in the cells of the body which change food into energy

# Unit Two

## Student New Vocabulary



When you find words you don't recognise, make sure to look up their definition. Use this page to write them down and make a note of their definition!

Term	Definition



# Unit Two

## Reading and Learning

### Section A

#### Overview of the digestive system



The **digestive system** consists of a group of organs all working together to break down the molecules in food into smaller molecules which can be transported or stored in the body for reuse in energy, cell growth or cell repair.

**Digestion** begins at the mouth where not only is food broken down by chewing, but by amylase, an **enzyme** found in saliva which **catalyses** (initiates/speeds up) the breakdown of carbohydrates into sugars.

Partially digested food is then swallowed down the oesophagus and lands in the stomach, where it is exposed to different enzymes for further breakdown.

The stomach contracts to churn food and also releases **hydrochloric acid (stomach acid)** to kill bacteria and further break down food into small molecules.

Food passes into the small intestine where smaller molecules and broken down molecules are **absorbed** into the bloodstream.

The breakdown and recycling of ingested molecules provides energy and essential compounds for survival. The sum off all these reactions is an individual's **metabolism**, which is essential for maintaining life.

Some of the nutrients absorbed from the small intestine are processed by the liver, which also makes the fluid **bile**. Bile is stored in the gallbladder and secreted into the small intestine to aid in fat digestion.

The remaining nutrients and molecules move through the large intestine, where water is absorbed back into the body and undigested food molecules form faeces. Faeces passes through the anus and is **egested** (excreted).

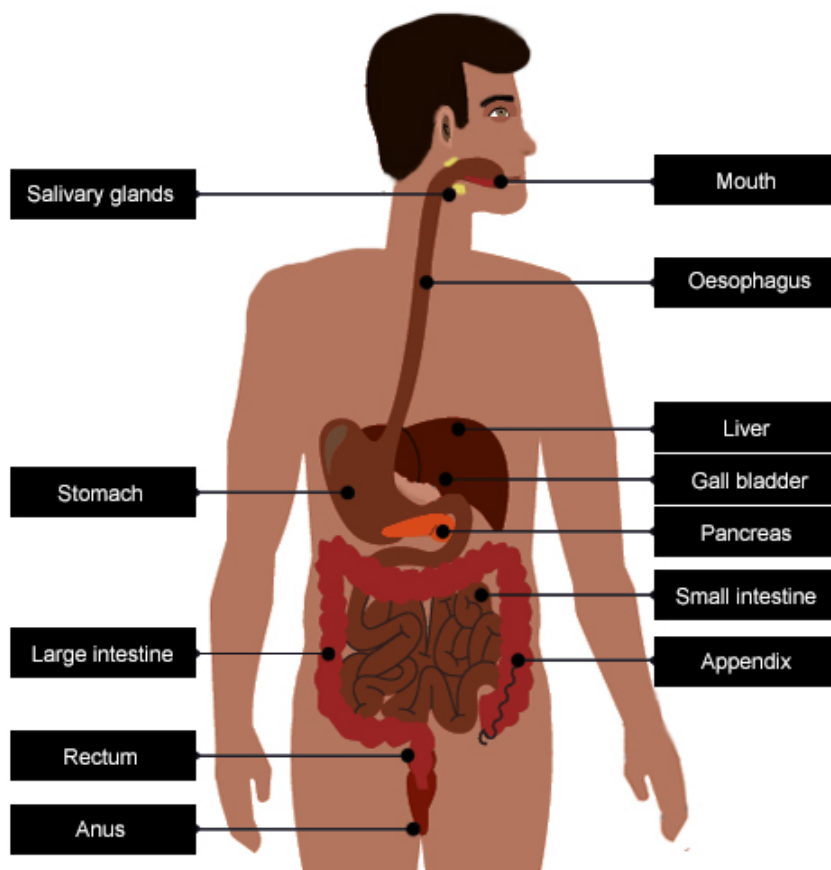
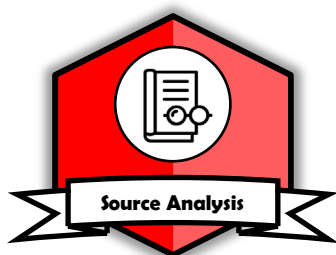


# Unit Two

## Reading and Learning

Figure 3.0

The organs of the digestive system



### Section B

Gastrin release and function



**G cells** in the lining of the stomach and upper small intestine produce and release the protein **gastrin** in response to several food-based stimuli. The main stimulus triggering gastrin production is the **ingestion** of protein-based food.

**Gastrin** is a hormone which acts as a signalling molecule by binding to a specific **receptor** on the surface of many cells, particularly in the stomach. This receptor protein is then activated by gastrin and signals to cells to release hydrochloric (**gastric**) **acid** from these cells to aid in digestion.

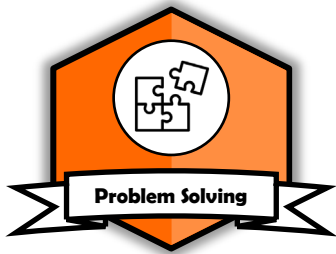
Gastrin was initially discovered for its role in gastric acid secretion but has since been implicated in **cell movement**, **cell survival** and can be found increased in many cancers.

# Unit Two Activities



## Activities

1. Number these events in chronological order:



Ingested food enters the stomach

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Undigested food form faeces

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Food travels down the oesophagus

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Small and broken down molecules are absorbed

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Digested food enters the small intestine

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Amylase begins to digest food

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Digested food enters the large intestine

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Hydrochloric acid begins to break food down

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Water is absorbed

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2. In your own words, define the following:

- Digestive system
- Gastrin
- Metabolism
- Bile

# Unit One Activities



## Activities



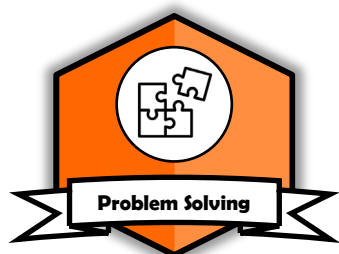
3. **Get creative!** Write a song or poem to help you remember the steps of digestion!  
Alternatively, create a digestion presentation for your classmates!

4. Explain how proteins are digested.

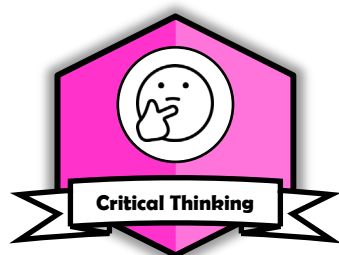
5. Match the definition to the word.  
Note: not all words are needed.



Gastrin	Gallbladder	Amylase
Hydrochloric acid	Enzyme	Bile
Hormone	Liver	Antibodies



- a) A substance which kills harmful bacteria and helps digestion
- b) The organ that stores bile
- c) A type of protein that is secreted by the cells that produce it
- d) An enzyme found in saliva
- e) The protein responsible for hydrochloric acid release in the stomach



6. In groups, discuss what you think may happen to humans with impaired or increased production of the hormone gastrin. Write down your thoughts to share with the class.

# Unit Two

## Challenge & Further Reading



### Challenge Activity



Based on what you have learned about digestion of food into smaller molecules, consider what these different molecules are (primarily amino acids, glycerol, fatty acids and sugars), and how these molecules are stored and reused by the body.

Use the next page to write your response!

### Useful links

- BBC Bitesize – Biological molecules:  
<https://www.bbc.co.uk/bitesize/guides/z8wsgk7/revision1>
- BBC Bitesize – Digestion:  
<https://www.bbc.co.uk/bitesize/guides/z9pv34j/revision/1>
- Khan Academy cell membrane review (Think Fatty Acids and glycerol):  
<https://www.khanacademy.org/science/high-school-biology/hs-cells/hs-the-cell-membrane/a/hs-the-cell-membrane-review>
- Introduction to chemistry (think fatty acids and glycerol:  
<https://courses.lumenlearning.com/introchem/chapter/phospholipids/>
- Video on protein:  
<https://www.youtube.com/watch?v=HSCUAjZQhXI>
- Video on Carbohydrates and Sugar:  
<https://www.youtube.com/watch?v=jQi84Tnstl4>
- An article on carbohydrates and sugar:  
<https://www.livescience.com/51976-carbohydrates.html>
- Biological molecule fact:  
<https://ccea.org.uk/downloads/docs/Support/Factfile/2019/GCSE%20Biology%20Factfile%20Unit%201.3%20Food%20Tests.pdf>

### Explore further

- Gastrin facts:  
<https://www.yourhormones.info/hormones/gastrin/>
- Advanced gastric secretion fact:  
<https://www.britannica.com/science/human-digestive-system/Gastric-secretion>
- BBC Bitesize – Blood glucose contro:  
<https://www.bbc.co.uk/bitesize/guides/zq4mk2p/revision/4>
- Video on small intestine structure:  
<https://www.youtube.com/watch?v=5VW5-VXIWic>

# Unit Two

## My research



Challenge Question

Digestion breaks down different food types into several small molecules. What are these small molecules, how are they stored, processed or reused by the body?

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# Unit Two

## My research



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# Unit Three Overview

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Topic Genetics and Inheritance

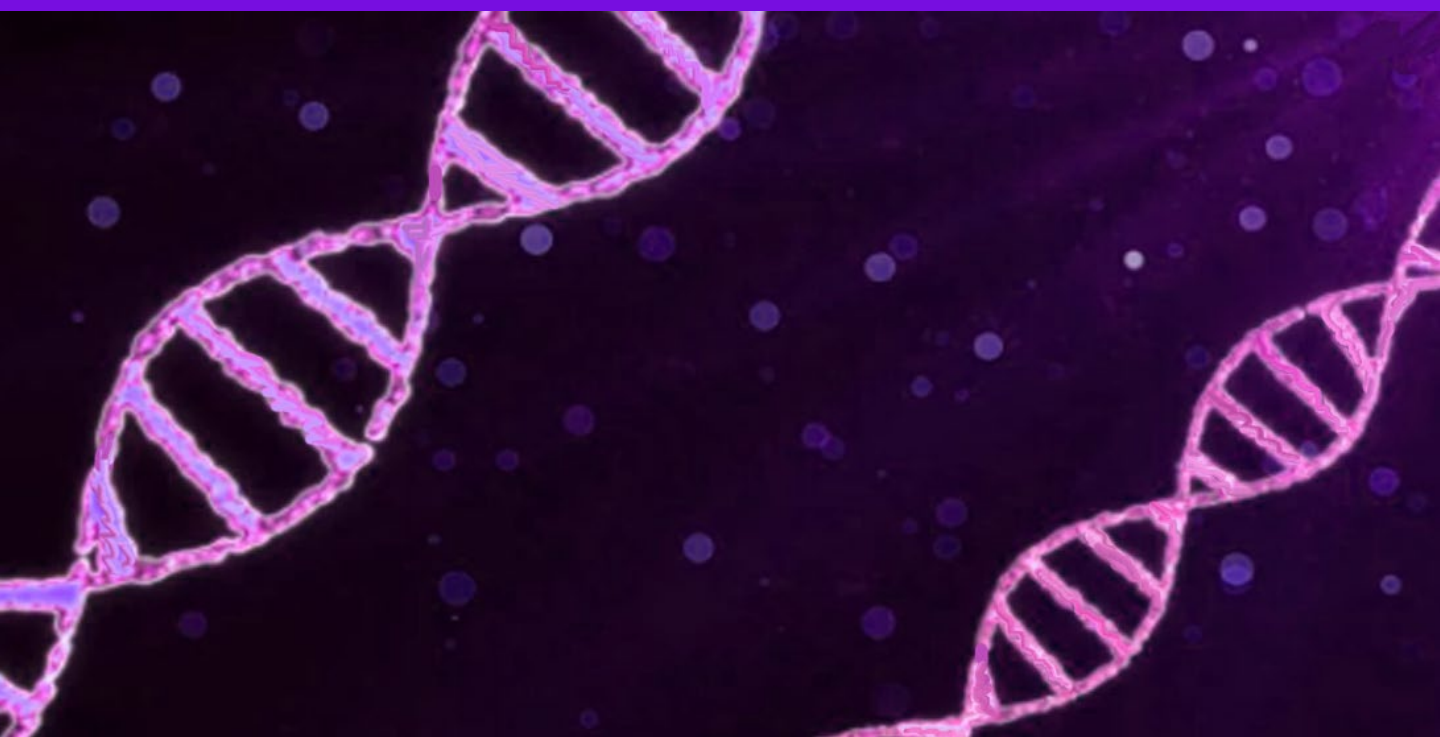
Links to the Curriculum Structure and function of living organisms; Cells and Organisation and Genetics and evolution; Inheritance, chromosomes, DNA and genes

Learning objectives By the end of this unit, you will be able to:

- ✓ Explain the structure and shape of DNA
- ✓ Understand how genes lead to observable characteristics
- ✓ Predict the likely outcomes of offspring genetics

Instructions

1. Read and learn about the topic
2. Complete the activities
3. Explore the further reading





# Unit Three

## Key Vocabulary & Structures

Term	Definition
Dominant	A gene characteristic meaning it is always expressed in some form and will mask <b>recessive</b> genes
Double helix	The structure formed by two strands of DNA (two individual helix structures)
Environmental variation	The alteration of an organism's <b>phenotype</b> as a result of environmental or lifestyle conditions
Gamete	An organism's reproductive cells (sex cells). Female gametes are ova or egg cells, and male gametes are called sperm.
Gastrin	A hormone/protein secreted by G cells, responsible for the secretion of gastric acid (hydrochloric acid) into the stomach
Genetic disorder	A disorder/disease caused partly or wholly by a change in DNA sequence deviating away from the normal
Genotype	The genetic constitution of a single organism
Inherited variation	The difference in a characteristic among individuals of a species as a result of genetic information from parents
Nucleotide	The building block of nucleic acids, which DNA and RNA are made up of. A nucleotide consists of a sugar molecule, a phosphate group and a nucleotide base.
Outcompete	When a cell or organism of one type competes for something needed such as space, food and resources, with another cell or organism and wins
Phenotype	Observable characteristics of an organism, resulting from specific genes
Recessive	A gene type in which two copies of the same gene are needed to produce the associated characteristic
Survival of the fittest	A term used to describe organisms adapting to their environment via mutations and evolution to outcompete other organisms
Variation	The differences between cells or organisms of a species. It can be caused by genetic or environmental factors
Zollinger-Ellison Syndrome	A disease which can be inherited or random, in which patients produce tumours that over produce gastrin

# Unit Three

## Student New Vocabulary



When you find words you don't recognise, make sure to look up their definition. Use this page to write them down and make a note of their definition!

Term	Definition

# Unit Three

## Reading and Learning



### Section A

#### DNA

#### The instructions for life



DNA stands for **deoxyribonucleic acid** and carries the instructions for life. DNA is made of basic units called **nucleotides**. Think of these nucleotides as building blocks which join together to form a long chain of nucleotides, called a DNA strand.

In humans, DNA is usually double stranded in the form of a **double helix**. In the double helix, two strands of DNA twist around each other into a helical structure, similar to two corkscrews wrapped around each other.

DNA carries genetic information containing all the instructions for life, growth and reproduction. DNA is contained in the nucleus of every human cell.

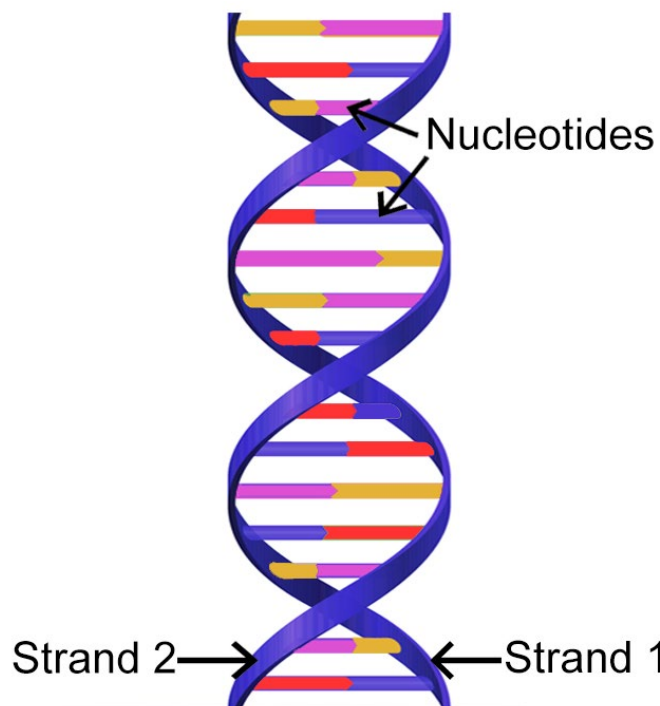


Figure 4.0  
The structure of a DNA double helix. Two strands of DNA twist and bind to form a double helix structure. Nucleotides on opposite strands bind to each other.



# Unit Three

## Reading and Learning

### Section B

#### Genes

The instructions for specific characteristics

**Genes** are short sections of DNA which are the genetic code for a specific characteristic, such as eye colour. It is estimated that humans have up to 25,000 different genes and humans carry two copies of each gene, one inherited from each parent.

### Section C

#### Chromosomes

The carriers of genes

In the nucleus of animal cells, DNA is organised into **chromosomes**. Chromosomes are coiled DNA strands containing hundreds to thousands of genes on each. Humans have 46 chromosomes (23 pairs, one of each from each parent) in every cell except for **gametes** (sex cells) which contain 23 chromosomes that can be passed on to offspring.



Other living creatures have different amounts of chromosomes. The Northern Lamprey fish has 174 whereas the Jack jumper ant has 1 or 2!

Within one **species**, characteristics can vary greatly. The differences in characteristics between different individuals is called **variation**. Some variation is inherited by passing on genes to offspring, such as eye colour (**inherited variation**) and some is the result of environmental factors in the surroundings such as different food intakes leading to different body masses (**environmental variation**).



Figure 5.0 Northern Lamprey Fish

Source: Sciencemag.org

Credit: Great Lakes Fishery Commission



Figure 6.0 Jack Jumper Ant

Source: www.ozanimals.com



# Unit Three

## Reading and Learning

### Section D Variation makes us unique!



**Variation** is important for survival. Variation helps individuals in a species to survive better and **outcompete** others. If, for example, the fur colouring of a rabbit helps to camouflage it better from predators, it will survive longer than those without that fur colour – this is **survival of the fittest!** The animal that is better fit to survive will then be able to pass on its genes to its offspring.

However, sometimes we can pass on genes to offspring which are not advantageous but instead could lead to disease! There is a whole range of inherited diseases.

### Section E Genes control everything!

Different versions of the same gene exist – for example, hair colour genes can code for brown or blonde hair. Genes may be **dominant** (they will always be the resulting characteristic) or **recessive** (two copies of the gene are required to be the resulting characteristic). Offspring inherit two of each gene, one from each parent – if a child may has one gene for brown hair and another for blonde hair, the dominant gene (brown) will be the resulting characteristic observed. Sometimes individuals have two different genes which are both dominant or recessive, in which case a mixture of the two is usually observed!

Think!  
Final Reflection  
Activity!

**Genetic disorders** are diseases or illnesses that occur when faulty genes are inherited from either one (dominant) or both parents (recessive).

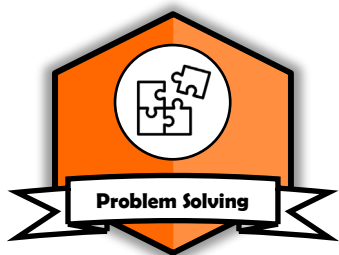
### Section F Zollinger-Ellison Syndrome

One example of a dominant inheritable disease is **Zollinger-Ellison Syndrome (ZES)**. Patients with ZES develop tumours which over-produce the hormone gastrin, leading to a variety of stomach and intestine symptoms such as stomach ulcers. ZES may also occur randomly due to gene mutations.

# Unit Three Activities



## Activities



1. Disease X is an inherited **recessive** disease, and occurs due to faulty gene X.

Jenny has one faulty gene X and her husband Mohammed has disease X (two copies of the faulty gene).

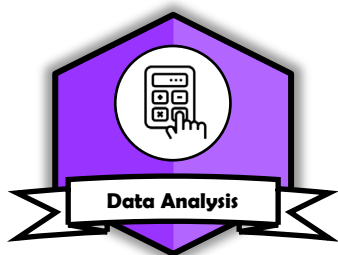
What is the probability of Jenny and Mohammed's offspring NOT having disease X?

2. Are brown eyes dominant or recessive?
3. What human cells do not have 23 pairs of chromosomes?
4. Define the following in your own words:
  - DNA
  - Gene
  - Environmental variation
  - Genetic variation



5. If trait T (can roll tongue) is dominant and t (cannot roll tongue) is recessive. Explain whether people with the following pairs of genes can tongue roll or cannot tongue roll.

A) TT    B) Tt    C) tt



6. Tongue rolling is a dominant trait. According to research, approximately 70% of the population can roll their tongue. Take a survey of your classmates and determine if this estimate is accurate for your class! Report your findings

# Unit Three Activities



## Activities



7. In pairs, use the template on the next page to each design a butterfly from the following criteria (don't show your partner). Then show your creation to your partner. Imagine the two butterflies produced offspring together, and determine the likelihood of the offspring having each of the traits

**Extra challenge:** create your own traits to add to the list!

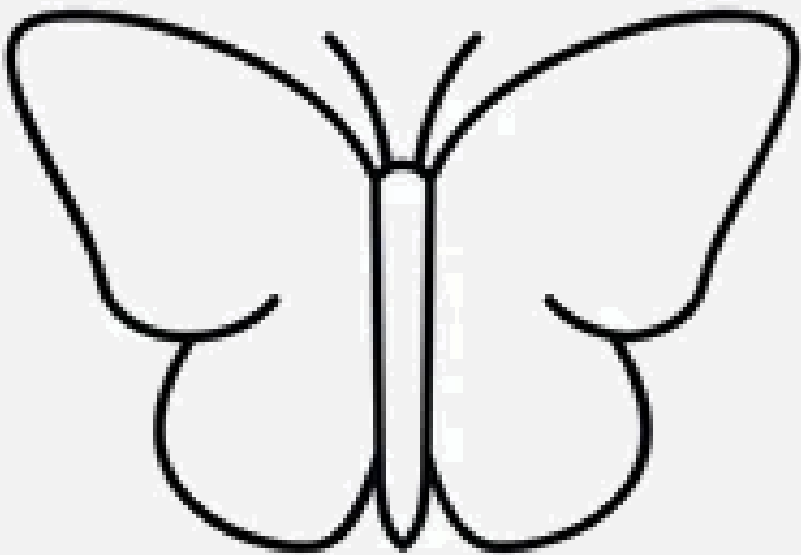
# Unit Three

## Activities



Colour me in choosing from the below traits

PRINT 



**Characteristics to choose from:**

- Purple spots (dominant)
- Yellow spots (recessive)
- White wings (recessive)
- Orange wings (recessive)
- Pink wings (dominant)
- Blue centre (dominant)
- Black centre (dominant)
- No spots (recessive)

**Advanced:** Make your own traits!

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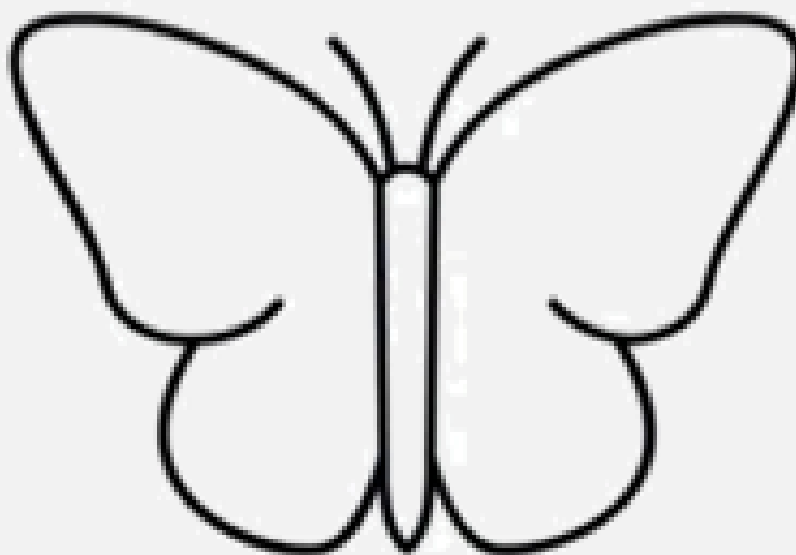
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# Unit Three Activities



Pair up!  
Colour me in as the resulting offspring

PRINT 



Discuss the resulting phenotype!

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# Unit Three

## Challenge & Further Reading



### Challenge Activity



Based on what you have learned about genes and DNA, research how forensic scientists can obtain DNA from crime scenes to help solve a case. Do you think this is a good method to identify criminals?

Use the next page to write your response!

### Useful links

- BBC Bitesize: What is DNA?  
<https://www.bbc.co.uk/bitesize/topics/zpffr82/articles/zvwbcj6>
- Explaining DNA fingerprinting:  
<https://www.youtube.com/watch?v=AkBUriMK9u8>
- DNA and inheritance:  
<https://www.bbc.co.uk/bitesize/guides/z8nxtyc/revision/6>

### Explore further

- BBC Bitesize – Genetics:  
<https://www.bbc.co.uk/bitesize/topics/zpffr82>
- BBC Bitesize – Chromosomes, DNA and genes:  
<https://www.bbc.co.uk/bitesize/guides/zp7thyc/revision/2>
- Genetics facts:  
<https://www.ducksters.com/science/biology/genetics.php>
- Mendel and the history of genetics:  
<https://www.youtube.com/watch?v=SOgVM904cPc>

# Unit Three

## My research



Challenge Question

How do forensic scientists obtain DNA from crime scenes to help solve a case. Do you think this is a good method to identify criminals?

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# Unit Three

## My research



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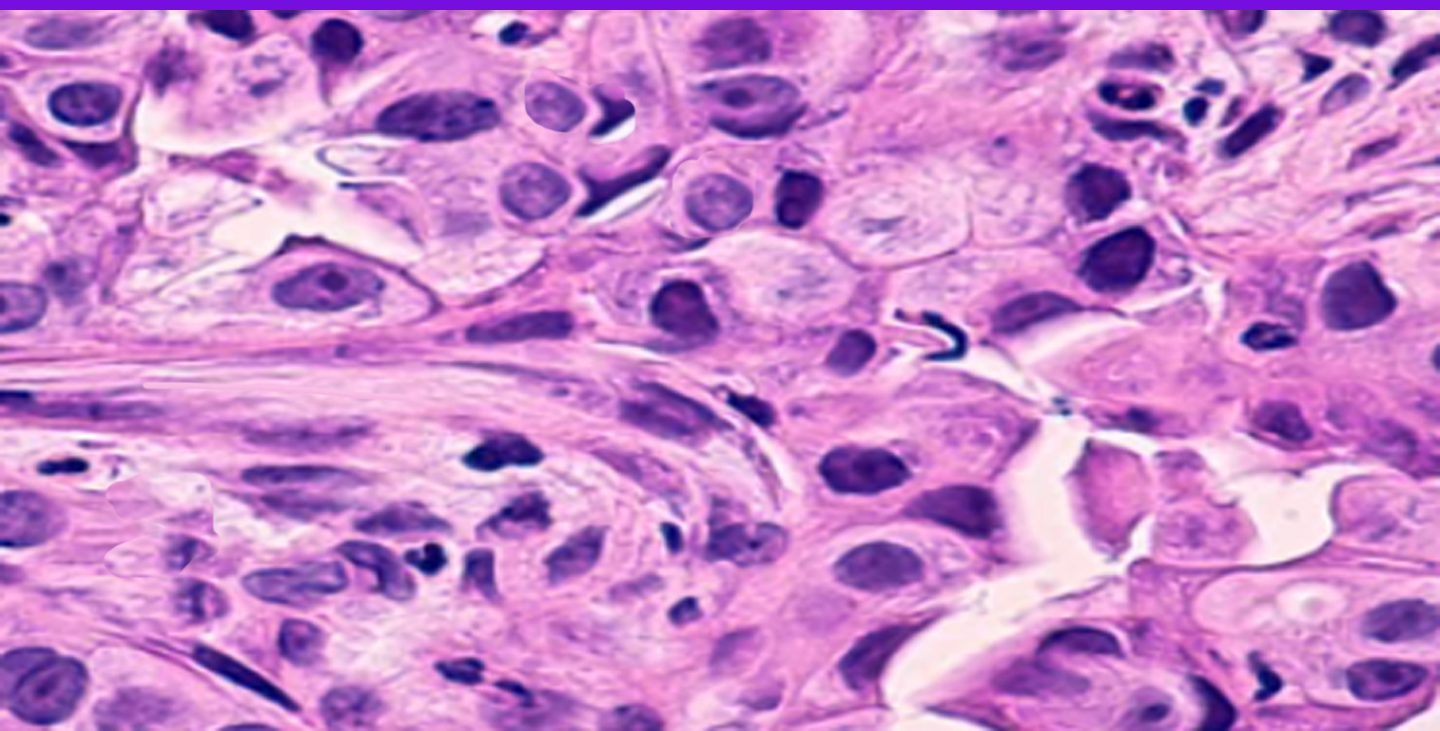
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# Unit Four Overview

heppSY



Topic	Cell growth and Cancer
Links to the Curriculum	Structure and Function of Living Organisms; Cells and Organisation; Genetics and Evolution; DNA and genes
Learning objectives	By the end of this unit, you will be able to: <ul style="list-style-type: none"><li>✓ Distinguish between healthy cells and cancer cells</li><li>✓ Describe different steps of the cell cycle</li><li>✓ Discuss how tumour cells can arise</li></ul>
Instructions	<ol style="list-style-type: none"><li>1. Read and learn about the topic</li><li>2. Complete the activities</li><li>3. Explore the further reading</li></ol>





# Unit Four

## Key Vocabulary & Structures

Term	Definition
Benign tumour	A contained tumour which is slow growing and relatively unharmed
Carcinogens	A substance capable of causing cancer development
Cell cycle	The series of events in cells leading to cell division
Cell death	The event of a biological cell no longer being able to carry out functions and being broken down or removed
Cell division	The division of a cell into two identical daughter cells with the same genetic material
Cell migration	The directed movement of a cell or cells in response to a specific signal
Cholecystokinin B Receptor (CCKBR)	A receptor protein found on the surface of cells, particularly in the brain and gastrointestinal tract. It binds to its <b>ligand</b> (gastrin) to activate signalling pathways and gene transcription.
Daughter cell	Identical cells produced during cell division. Each round of mitosis produces two new daughter cells.
G cells	A type of cell in the stomach/intestines which produces and secretes gastrin
Gastrin	A hormone/protein secreted by G cells, responsible for secretion of gastric acid (hydrochloric acid) into the stomach
Hydrochloric acid	A strong acidic solution of hydrogen chloride in water secreted into the stomach to aid in digestion
Interphase	A phase between successive rounds of mitosis. DNA is duplicated and resources are replenished.
Invasion	The ability of cells to become mobile and navigate through different/neighbouring tissues.
Malignant tumour	Cancerous tumours, quick-growing, harmful
Mitosis	The process of cell division which gives rise to two identical daughter cells
Risk factor	A defined characteristic or event associated with increased disease frequency or severity

# Unit Four

## Student New Vocabulary



When you find words you don't recognise, make sure to look up their definition. Use this page to write them down and make a note of their definition!

Term	Definition



# Unit Four

## Reading and Learning

### Section A

#### The cell cycle: cell growth and replication

Figure 7.0  
Chromosome structure

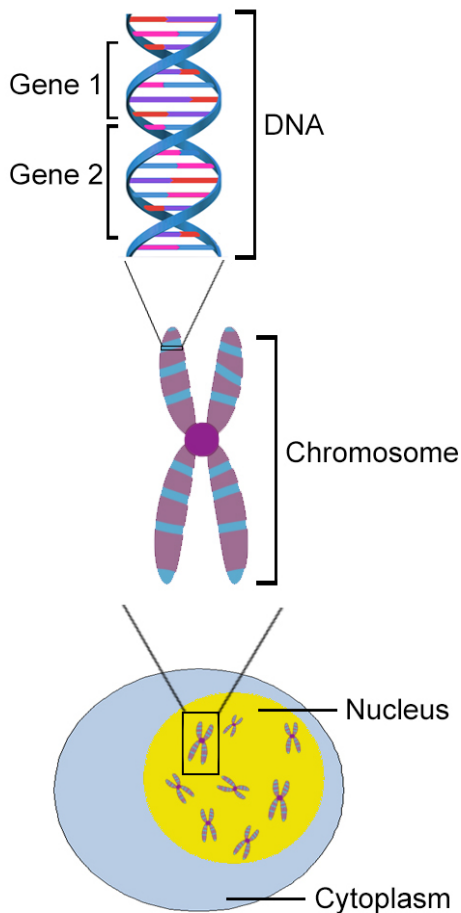
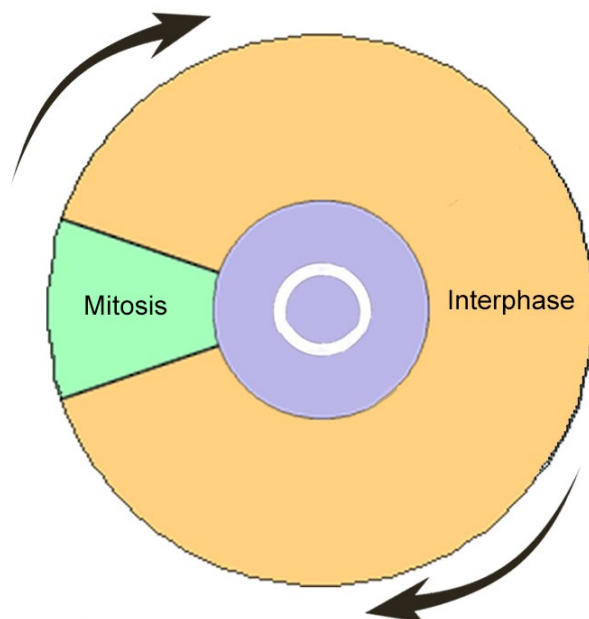


Figure 8.0  
The cell cycle.  
Arrows indicate the direction which cells progress through the cell cycle phases in order to replicate.

In healthy individuals, new cells are constantly growing and replacing damaged cells by going through the **cell cycle**. The cell cycle is a series of steps involving DNA replication in which exact copies of the DNA strands making up chromosomes are produced. It consists of two main stages: **Interphase** and **Mitosis**.

During **interphase**, cells accumulate resources, proteins and energy needed to grow, and divide as well as replicate the chromosomes to form two copies of each.

**Mitosis** (the process of cell division) can then occur, in which original and replicated chromosomes separate into two identical sets and a new nuclei forms around each set. Cells divide into two, producing two identical **daughter cells** which maintain the desired number of chromosomes.





# Unit Four

## Reading and Learning

### Section B

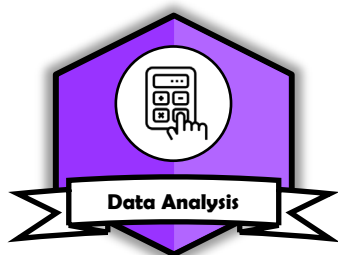
#### When the cell cycle goes wrong! Tumours and Cancer



Usually, cells check that things are normal before they can progress through the cell cycle. Sometimes cells lose the ability to check these things due to mutations of genes involved, leading to uncontrolled cell division and eventual growth of tumours.

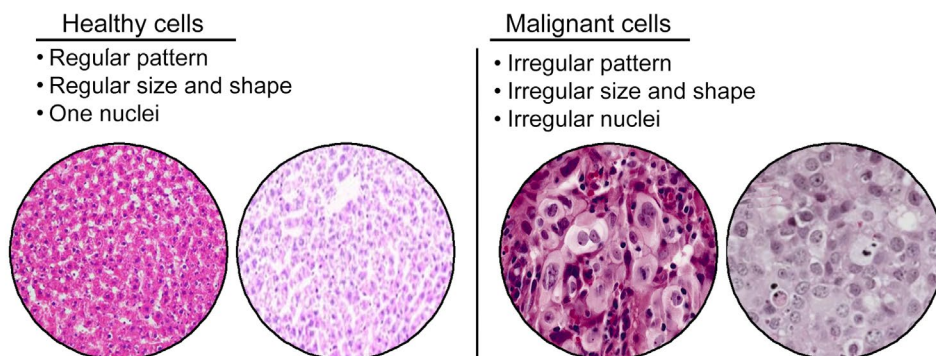
Tumours may be **benign** or **malignant**. Benign tumours are generally slow growing, can usually be removed and are contained to one area. Malignant tumours are cancerous, quick-growing, and can spread to other areas in the body.

Not all genetic mutations have a tumour-enhancing effect and one tumour-enhancing mutation alone does not cause cancer; many mutations are required – this is why cancer is rarer in younger individuals as it takes time to acquire multiple tumour-enhancing mutations. Nevertheless, anyone can develop cancer and some cancer-causing mutations are even inherited!



Several environmental **risk factors** also increase the likelihood of cancer development including viruses, cigarette smoke, alcohol, UV radiation, diet and exposure to chemical carcinogens such as asbestos. **Carcinogens** are chemicals which cause cancer by damaging DNA, increasing the chance of mutations occurring.

Figure 9.0 A comparison of healthy cells and malignant cells under a microscope





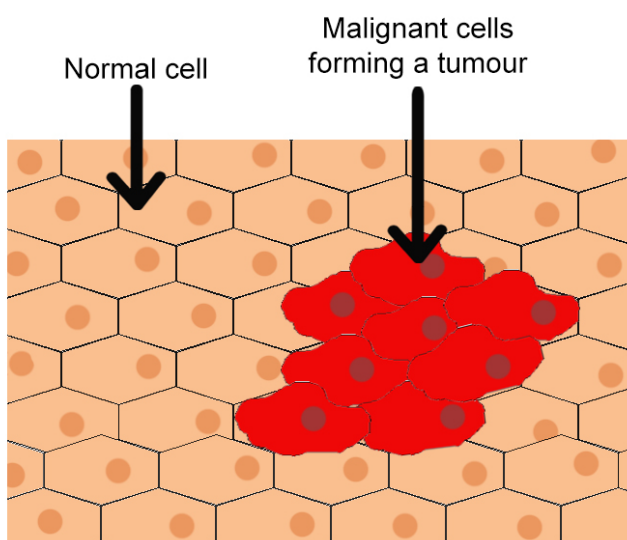
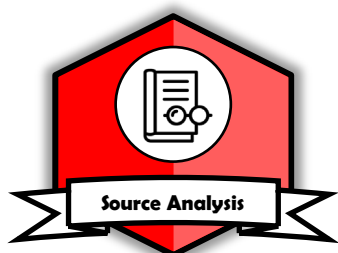
# Unit Four

## Reading and Learning

### Section B

#### How to spot a cancer cell

As cancer cells progress to more severe stages of cancer, the cells look progressively irregular. Cancer cells can initially appear normal but after multiple rounds of the cell cycle, cancer cells often grow into irregular shapes, sizes and patterns compared to healthy cells. They can also have irregular-sized nuclei and irregular amounts of nuclei. At advanced stages, cancerous cells begin to **invade**



Malignant cells keep dividing, becoming more irregular and invade surrounding tissue.

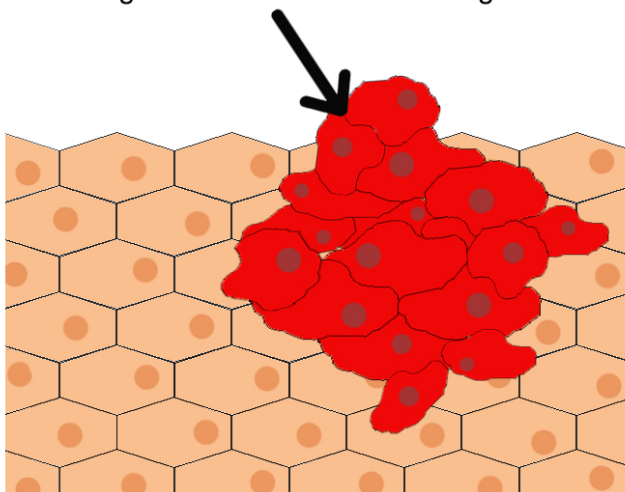


Figure 10.0: Cancer cell progression. A comparison of healthy cells (orange) and tumour cells (red) with irregular shapes and sizes. The lower panel shows tumour growth and invasion into surroundings.



# Unit Four

## Reading and Learning

### Section D

#### Gastrin enhances tumour progression



The hormone **gastrin** is produced by **G cells** in the stomach in response to food intake, and was first discovered for its role in the release of **hydrochloric acid** into the stomach. However, it was later discovered that gastrin had many functions.

Gastrin is the **ligand** (binding molecule) of the **cholecystokinin B Receptor (CCKBR)**, meaning they specifically bind to each other to have an effect. Binding of gastrin activates CCKBR and initiates many different effects inside cells, such as gastric acid secretion.

Gastrin is often produced at very high concentrations in many tumours, particularly (but not limited to) tumours of the gastrointestinal tract such as colorectal, stomach, pancreatic and oesophageal tumours.

Think!  
Final Reflection  
Activity!

Tumour cells which have mutated to over produce gastrin progress through tumour development stages quickly because gastrin increases **cell division** (more tumour cells appear quickly), can inhibit **cell death** (mutant cells don't die when they should) and has an impact on **cell migration** (leading to tumour cells spreading further throughout the body).

# Unit Four Activities



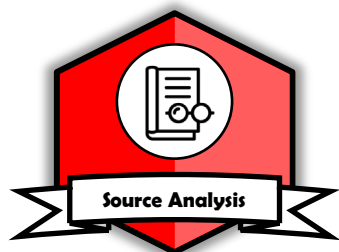
## Activities



1. In your own words, define the following:

- Cell growth
- Cell cycle
- Mitosis
- Tumour
- Genetic mutation

2. Look at the list of cell descriptions below and identify them on the following image of a group of cells. Label the cells with the correct descriptions. Note: All descriptions can be seen at least once on the image.



- A. Healthy cell
- B. Single nuclei
- C. Regular mitosis
- D. Regular cell shape
- E. Cancer cell
- F. Small amount of cytoplasm
- G. Irregular mitosis
- H. Irregular cell size
- I. Irregular cell shape
- J. Binucleated cell (two nuclei)

# Unit Four Activities



## Activities



3. Typically, humans have 23 pairs of chromosomes (46 chromosomes). Before mitosis occurs, DNA is replicated. Explain why the daughter cells do not have 92 chromosomes.



4. Get creative! Make a flip-book of a healthy section of tissue/cells becoming more and more cancerous. Alternatively, make a video with narration!
5. Describe what happens during interphase and why it is important.
6. Why is cancer more common as an individual ages?

# Unit Four

## Challenge & Further Reading



### Challenge Activity



Based on what you have learned about the cell cycle and mitosis, do some research and have a more in-depth look at the steps and stages involved in mitosis. Describe them in your own words. Draw and label a picture to illustrate your description.

Use the next page to write your response!

### Useful links

- Ducksters – cell division and cycle notes:  
[https://www.ducksters.com/science/biology/cell\\_division.php](https://www.ducksters.com/science/biology/cell_division.php)
- BBC bitesize – KS3 cell division:  
<https://www.bbc.co.uk/bitesize/clips/z3rp82p>
- BBC Bitesize – cell division:  
<https://www.bbc.co.uk/bitesize/guides/zpkx8mn/revision/3>
- BBC Bitesize mitosis:  
<https://www.bbc.co.uk/bitesize/guides/zq4sk2p/revision/1>

### Explore further

- BBC Bitesize – cell division  
<https://www.bbc.co.uk/bitesize/guides/zs8y4qt/revision/1>
- Cell division: <https://www.bbc.co.uk/bitesize/clips/z2h87ty>
- Cell division facts:  
[https://www.ducksters.com/science/biology/cell\\_division.php](https://www.ducksters.com/science/biology/cell_division.php).

# Unit Four

## My research



**Challenge Question**

Describe what happens during mitosis in your own words and draw a labelled diagram to illustrate your description.

Note: Think about the different stages of mitosis. There is space for your drawing on page 58.

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# Unit Four

## My research



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# Unit Four

## My research

Please draw your illustration here:

PRINT 

# Final Reflection Activity



The Final Reflection is the final activity where you are able to show what you have learned from this pack. It allows you to put forward your own ideas based on your learning and your research.

## For Students – Reflection activity

Write 400 words answering the following question:

**Describe how and why gastrin is produced by G cells, what its functions are, and the effects that can occur if gastrin production is too high or too low.**

Note: Remember that all protein production involves transcription, translation and protein folding to produce a fully functional protein. Mutations can occur to genes which code for proteins randomly or by inheritance.

### **Top tips:**

1. Don't forget to use your earlier activities to help you answer the question.
2. Make sure you back up your answer with evidence from this pack or from your own research.
3. Ask a trusted adult or teacher to read your response and give you helpful feedback. Does it make sense to them even though they are not an expert? Can they give you advice for improving it?

– Or –

## For Teachers – Reflection classroom discussion

Hold a group or class discussion on the importance of maintaining normal gastrin production and the consequences of irregular gastrin production.

# Final Reflection Activity

## My research



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# Final Reflection Activity

## My research



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# Part 3 – Study Skills, Tips & Guidance

This section includes helpful tips to help you complete this pack, as well as improve your study skills for any courses you take next year.

It also includes a few fantastic easy-to-use resources on what to do next and where else to look for more information on the subject.

In this section:

## Study Skills:

- ✓ Key Instruction Words
- ✓ Academic Writing
- ✓ Referencing

## Subject Guidance:

- ✓ More on studying this subject





# Study Skills

## Key Instruction Words

These words will often be used by teachers and tutors as you go through school. It is a good idea to carefully read instruction words before attempting to answer a question.

**Analyse** – When you analyse something, you consider it carefully and in detail in order to understand and explain it. To analyse, identify the main parts or ideas of a subject and examine or interpret the connections between them.

**Comment** – When you comment on a subject or the ideas in a subject, you say something that gives your opinion about it or an explanation for it.

**Compare** – To compare things means to point out the differences or similarities between them. A comparison essay would involve examining qualities/characteristics of a subject and emphasising the similarities and differences.

**Contrast** – When you contrast two subjects, you show how they differ when compared with each other. A contrast essay should emphasise striking differences between two elements.

**Compare and contrast** – To write a compare and contrast essay, you would examine the similarities and differences between two subjects.

**Criticise** – When you criticise, you make judgments about a subject after thinking about it carefully and deeply. Express your judgement with respect to the correctness or merit of the factors under consideration. Give the results of your own analysis and discuss the limitations and contributions of the factors in question. Support your judgement with evidence.

**Define** – When you define something, you show, describe, or state clearly what it is and what it is like. You can also say what its limits are. Do not include details but do include what distinguishes it from the other related things, sometimes by giving examples.

**Describe** – To describe in an essay requires you to give a detailed account of characteristics, properties or qualities of a subject.

**Discuss** – To discuss in an essay, consider your subject from different points of view. Examine, analyse and present considerations for and against the problem or statement.

# Study Skills

## Key Instruction Words



### Continued

**Evaluate** – When you evaluate in an essay, decide on your subject's significance, value or quality after carefully studying its good and bad features. Use authoritative (e.g. from established authors or theorists in the field) and, to some extent, personal appraisal of both contributions and limitations of the subject. Similar to **assess**.

**Illustrate** – If asked to illustrate in an essay, explain the points that you are making clearly by using examples, diagrams, statistics etc.

**Interpret** – In an essay that requires you to interpret, you should translate, solve, give examples, or comment upon the subject and evaluate it in terms of your judgement or reaction. In other words, give an explanation of what your subject means. Similar to **explain**.

**Justify** – When asked to justify a statement in an essay, you should provide the reasons and grounds for the conclusions you draw from the statement. Present your evidence in a form that will convince your reader.

**Outline** – Outlining requires that you explain ideas, plans, or theories in a general way, without giving all the details. Organise and systematically describe the main points or general principles. Use essential supplementary material but omit minor details.

**Prove** – When proving a statement, experiment or theory in an essay, you must confirm or verify it. You are expected to evaluate the material and present experimental evidence and/or logical argument.

**Relate** – To relate two things, you should state or claim the connection or link between them. Show the relationship by emphasising these connections and associations.

**Review** – When you review, critically examine, analyse and comment on the major points of a subject in an organised manner



# Study Skills

## Academic writing

### What is academic writing?

'Academic writing' is a special way of writing when talking about research or a point of view.

It has a logical structure and uses formal language. Various sources of information are also used to support what is being said.

### Academic writing: how to guide

- Use words you know and are confident using, making sure that what you write makes sense and is clear.
- Do not use contractions, like 'don't' or 'can't'. Instead, write these out fully: 'do not', 'cannot'.
- Do not use colloquialisms, meaning words or phrases that are not formal and that you would use when you speak. Examples include 'ace', 'brilliant', 'like chalk and cheese', etc.
- Do not use slang or jargon, for example 'daft', 'bloke', 'dodgy'.

### Expressing your opinion in academic writing

In academic writing, it is best to express an opinion without writing in the first person. Your work should show that it is supported by specific evidence and facts, rather than your personal intuition.

Therefore, rather than saying 'In my opinion, this proves that', you can express the outcome of your reasoning in other ways:

- 'This indicates that...';
- 'The aforementioned problems in Smith's argument reveal that...';
- 'Such weaknesses ultimately mean that...', and so on.

# Study Skills

## Referencing



### What is a reference or referencing?

A reference is just a note in your work (*M. Gupta, 1985*) that tells your reader where specific ideas, information or opinions that you have used from another source have come from.

As well as being academic good practice, referencing is very important, because it will help you to avoid plagiarism.

**Plagiarism** is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe.

### Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you from losing marks, or failing, due to plagiarism.

### When should I use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

### How should I reference?

For short assignments like the ones in this pack, you can mention the author or source in the sentence in brackets (*M. Gupta, 1985*) or at the bottom of your piece of work. If you are not sure about when or if you should reference, check with your teacher.



# More on studying this subject

## Further studies and career options

### Further studies

- GCSE Options: Biology and Chemistry
- A level studies: Biology, Chemistry and Mathematics
- BTEC Level 3 National Extended Diploma in Biomedical Science
- University Undergraduate studies: Biomedical Science
- Postgraduate studies: A more specific biomedical science aspect

### Career options

Scientific Researcher (in academia or industry), Hospital Biomedical Scientist, Drug development, Analytical chemist, Biotechnologist, Clinical scientist, Forensic scientist, Microbiologist, Toxicologist, Food safety analyst, Geneticist, Bioengineering and many more.

Some biomedical science graduates go on to study medicine. Due to the overall high recognition of a biomedical science degree, lots of non-science careers and non-lab based careers become available to graduates too such as teaching, intellectual property law, scientific writing, medical liaison, design and marketing of biomedical products, research analysts and many more.



# More on studying this subject

## A Deeper Look Into Biomedical Science

### ✓ Read:

Careers in Biomedical Science:

1. <https://www.ibms.org/resources/documents/careers-in-biomedical-science-leaflet/>
2. <https://blog.nuhs.edu/the-future-of-integrative-health/7-careers-you-didnt-know-you-could-pursue-with-a-biomedical-science-degree>

### ✓ Watch:

Should you study biomedical science? [https://www.youtube.com/watch?v=x\\_JDJRLb3Q](https://www.youtube.com/watch?v=x_JDJRLb3Q)

The Big Bang Theory (TV Series) – Bernadette and Amy both have careers stemming from a biomedical science degree.

### ✓ Listen:

The Institute of Biomedical Science podcasts:

<https://www.ibms.org/resources/podcasts>

### ✓ Do:

1. Search for the above career options on <https://www.prospects.ac.uk/> to learn more about them.
2. Arrange a guided tour of the hospital's biomedical science facilities or the university research departments you may be interested in. Enquire about work experience days!
3. Research the biomedical science departments at universities you are interested in, or that are local to you such as the University of Sheffield's: <https://usic.sheffield.ac.uk/programmes/subjects/biological-and-biomedical-science>



# In partnership with

# heppSY

**The Higher Progression Partnership South Yorkshire (HeppSY)** is part of a national programme to help school and college students aged 13–19 across South Yorkshire. We support those at most risk of missing out on Higher Education by providing impartial outreach work including information to help students make well informed decisions about their future and routes into university, higher and degree apprenticeships or other providers. HeppSY works in partnership with Sheffield Hallam, The University of Sheffield and schools and colleges across our region. You can visit us at [www.heppsy.org](http://www.heppsy.org), follow us on Twitter @HeppSYPlus or find us on Youtube where there are many resources.





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