Higher Human Biology

Unit 1

Summary Notes with Fill in the Blanks

Human Cells

The small print: Key Area 1
Division and differentiation in human cells

(a) Division of somatic and germline cells.

- Somatic stem cells divide by mitosis to form more somatic cells…… ☐
- Germline stem cells divide by mitosis and by meiosis. …… ☐
- Division by **mitosis** produces more germline stem cells. …… ☐
- Division by **meiosis** produces haploid gametes…… ☐

(b) Cellular differentiation

- Cellular differentiation is the process by which a cell expresses certain genes to produce proteins characteristic for that type of cell. This allows a cell to carry out specialised functions. …… ☐
- Embryonic and tissue stem cells. …… ☐
- Cells in the very early embryo can differentiate into all the cell types that make up the individual and so are pluripotent. …… ☐
- Tissue stem cells are involved in the growth, repair and renewal of the cells found in that tissue. They are multipotent. …… ☐

(c) Therapeutic and research uses of stem cells.

- Therapeutic uses involve the repair of damaged or diseased organs or tissues…… ☐
- Research uses involve stem cells being used as model cells to study how diseases develop or being used for drug testing…… ☐
- The ethical issues of using embryonic stem cells…… ☐

(d) Cancer cells

- Cancer cells divide excessively because they do not respond to regulatory signals…… ☐
- This results in a mass of abnormal cells called a tumour…… ☐
- Cells within the tumour may fail to attach to each other, spreading through the body where they may form secondary tumours…… ☐

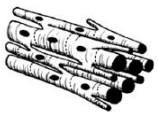
Unit 1: Prior knowledge

- ☐ Tissues, organs and systems
- ☐ Cell division
- ☐ Cell ultrastructure and function
- ☐ Cell division and chromosomes
- ☐ Base sequence and base pairing of DNA
- ☐ Function of proteins
- ☐ Enzymes
- ☐ Summary equation for respiration
- ☐ ATP and energy

*To ensure success, it is **vital** that you are secure in your previous Biology knowledge.*

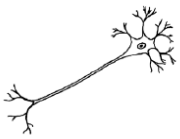
*Your first **homework exercise** will give you an opportunity to check you have a good basis to move on at Higher level.*

(a) Division of Somatic and Germline cells



Cardiac muscle cells

Liver cells



Nerve cells

The human body is made up of many _____ cells that have specific structural, _____ and biochemical properties. Specialised cells arise from the differentiation of unspecialised cells during _____ development.

Specialised cells with similar functions are grouped into _____. Similar tissues are grouped into _____ and similar organs are grouped into _____.

During differentiation, certain genes that express _____ important for the function of a specific cell are '_____'. This allows it to develop a more specialised structure to carry out a _____ function. Once a cell becomes differentiated it only expresses the _____ that produce the proteins characteristic for that type of cell.

Somatic Stem cells

Stem cells are _____ cells that have the ability to _____ to make more stem cells or _____ into specialised cells of one or more types.

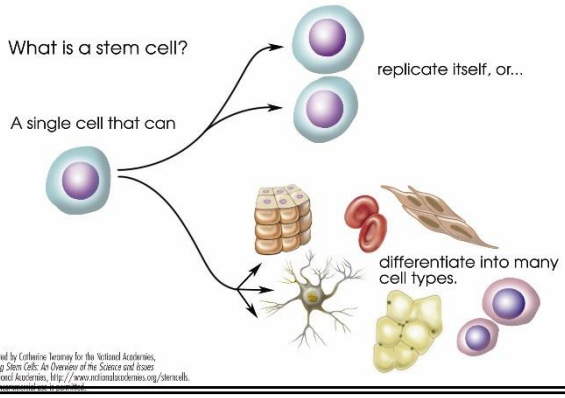


Image prepared by Catherine Teramy for the National Academies, *Understanding Stem Cells: An Overview of the Science and Issues* from the National Academies, http://www.nationalacademies.org/stemcells.

FACT CHECKER: Somatic stem cells:

Write a note above on somatic stem cells.

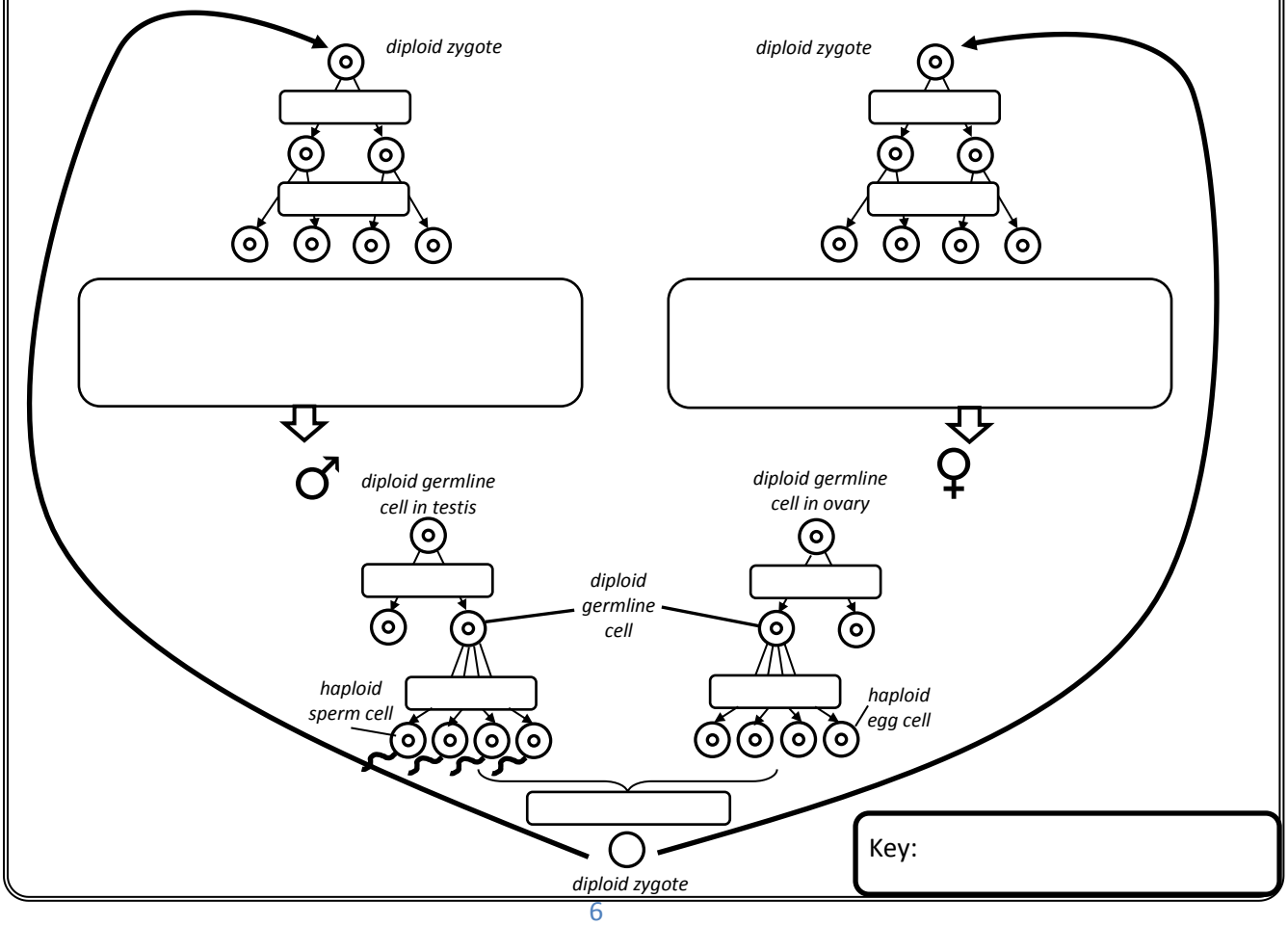
Germline Stem cells

Germline cells are gametes and the cells of the body that eventually form sex cells (_____). Like somatic cells, germline cells are _____ . This means that the nucleus contains two sets of chromosomes and are therefore able to undergo mitosis to make more germline cells.

FACT CHECKER: Germline cells:

Write a note above on <u>germline</u> cells.

Use the Torrance textbook (page 7) to complete the diagram below. It shows how the human life cycle alternates between haploid and diploid cells.

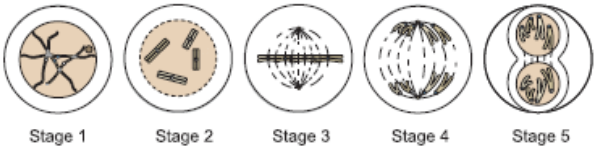


Division in somatic cells

All body cells (except gametes and the cells which make them) are called _____ cells. They divide by _____ and **differentiate** to form more cells of that tissue. _____ that occur in somatic cells aren't passed onto offspring.

Mitosis revision

Write a *sentence* to describe the main features of mitosis.



Stages of mitosis

Hint: Use the words somatic cell, diploid, chromosome number, division

Body organs are formed from a variety of **tissues** made from **somatic cells**.

Somatic cells make copies of themselves by mitosis.

Division in germline cells

Gametes and the cells that produce gametes are called germline cells. Germline cells can divide in two ways:

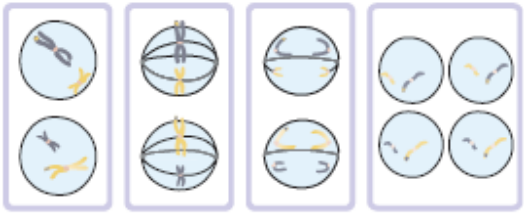
- By _____ to produce more **diploid** germline cells
- By _____ to produce **haploid** gametes

The nucleus of a germline stem cell can divide by mitosis to maintain the diploid chromosome number. Diploid cells have 23 pairs of homologous chromosomes.

The nucleus of a germline stem cell can divide by meiosis. It undergoes two divisions, firstly separating homologous chromosomes and secondly separating chromatids. Haploid gametes contain 23 single chromosomes.

Meiosis:

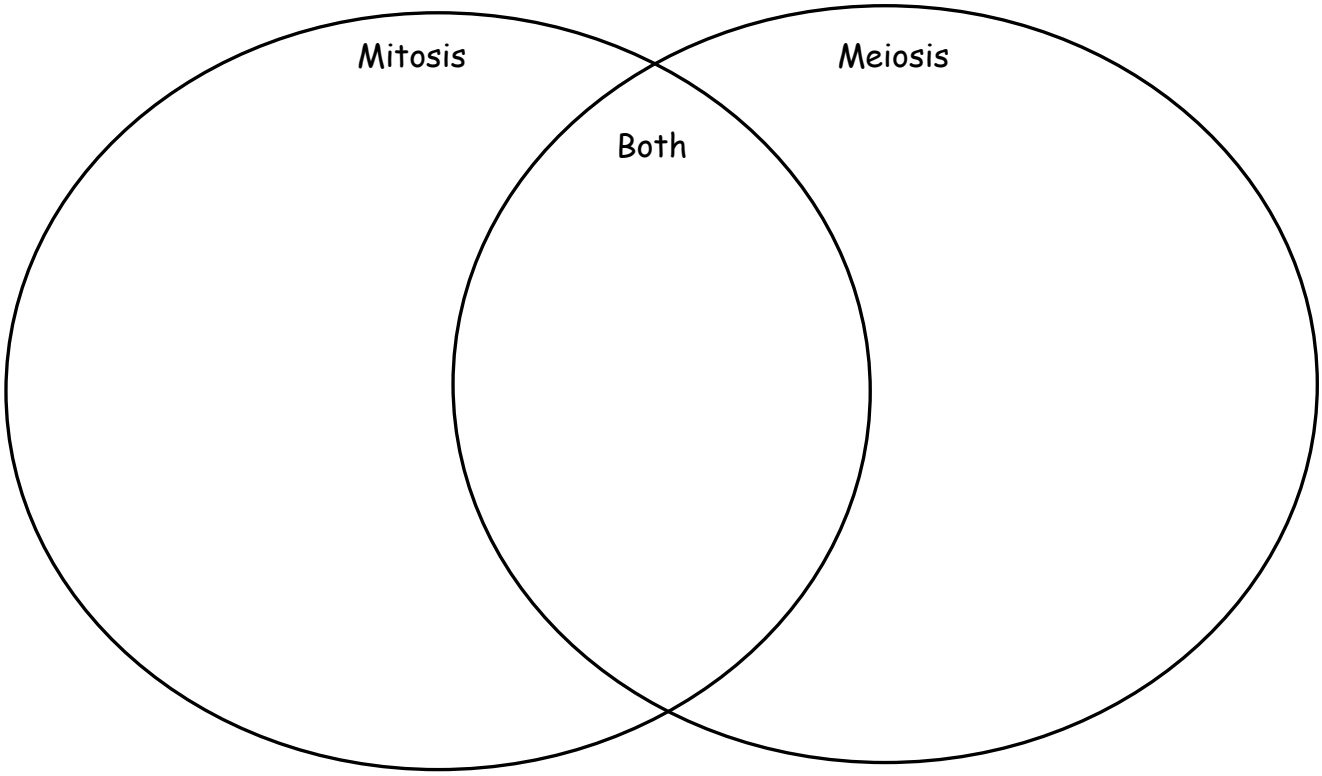
Stages of the first meiotic division during meiosis



Stages of the second meiotic division during meiosis

Use the following mitosis and meiosis facts to complete the venn diagram below:

Meiosis involves two divisions
Cell contents must be copied and divided
Meiosis produces haploid cells
Mitosis produces diploid cells
Meiosis produces 4 daughter cells (gametes)
Mitosis produces 2 daughter cells (somatic cells)
Involves cell division
Mitosis involves one division



(b) Cellular differentiation

Cellular **differentiation** is the process by which a cell **expresses certain genes** to produce **proteins characteristic** for that type of cell. This allows a cell to carry out **specialised functions**

Interpretation: What does the above sentence mean? *Write a note above*

Stem Cells

Stem cells are _____ cells that have the ability to _____ to make more stem cells or _____ **into specialised cells of one or more types**. There are **two** different types of stem cell:

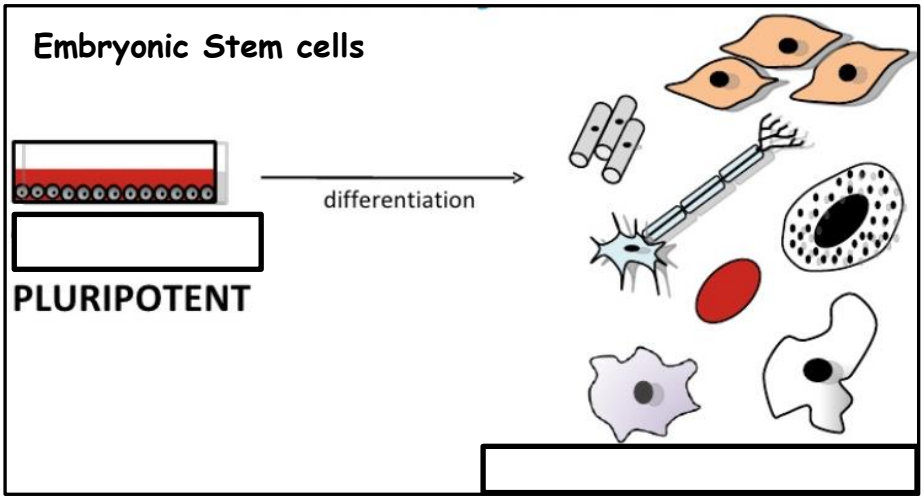
- Embryonic stem cells
  - Cells in the very early embryo can differentiate into all the cell types that make up the individual and so are **pluripotent**.
  - **Pluripotent** means _____

- Tissue (adult stem cells)
  - Tissue stem cells are involved in the growth, repair and renewal of the cells found in that tissue. They are **multipotent**.
  - **Multipotent means** _____

Embryonic Stem Cells

Embryonic stem cells are derived from **unspecialised** cells found within an **embryo**. They have the ability to **differentiate** into **all** cell types that make up an organism. This is because **most** of their **genes** are still 'switched on' or "**expressed**". All the genes in embryonic stem cells can be switched on so these cells can differentiate into any type of cell.

Embryonic stem cells are said to be **pluripotent**. This means that they have the potential to differentiate into **all** cell types of the body.

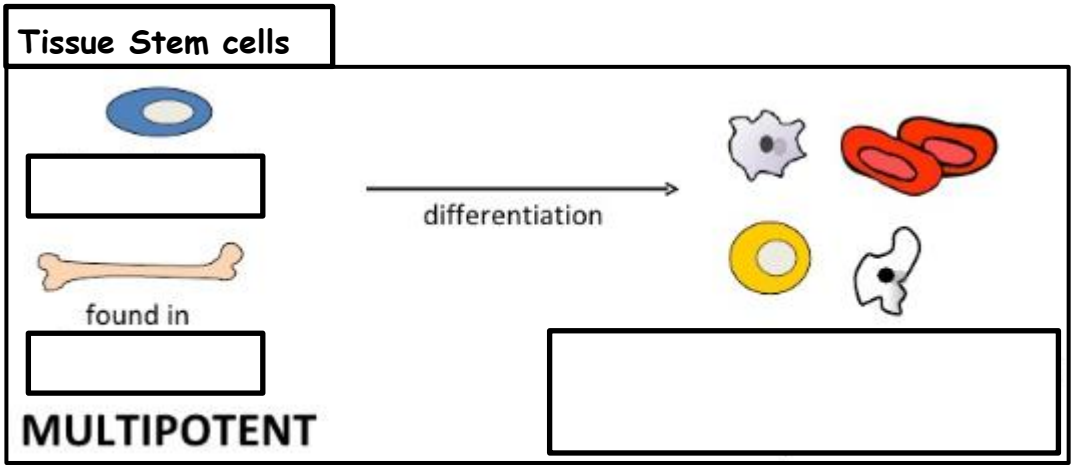


Tissue stem cells

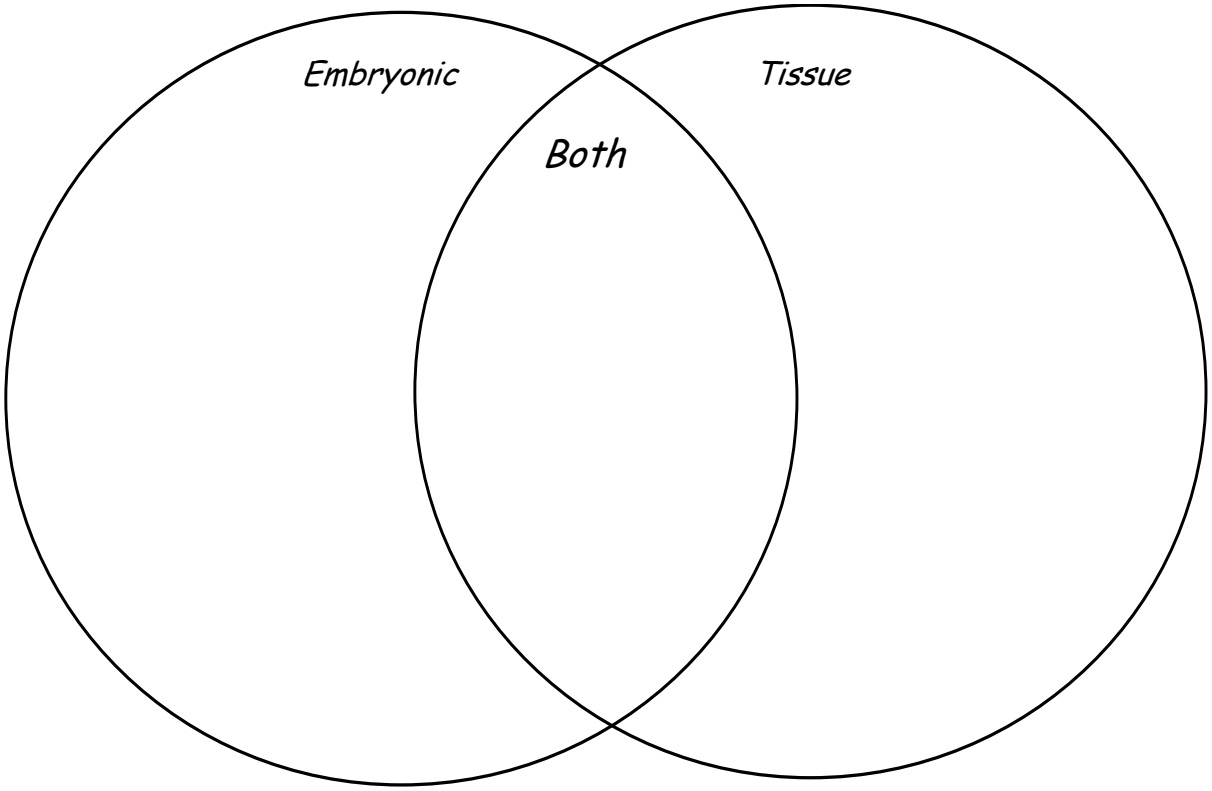
Tissue or adult stem cells are found in various tissues of adults and children, including the **brain**, **bone marrow**, **skeletal muscle** and **skin**. These cells **replenish differentiated cells that need replaced** through age or damage in the tissues in which they are found. They are able to differentiate into a much more **limited range of cell types** and will tend to develop into cell types that are closely related to the tissue in which they are found.

Eg tissue stem cells in bone marrow will produce red blood cells, platelets, phagocytes and lymphocytes.

Tissue stem cells are said to be **multipotent**. This means that they only have the potential to differentiate into a **limited** number of cell types of the body.



Use the notes above to summarise the similarities and differences between Embryonic stem cells and Tissue stem cells:



ESSAY

2013: Give an account of cell differentiation under the following headings:

(i) Stem cells (4)

(ii) Somatic cells (4)

(iii) Germline cells (2)

(c) Therapeutic and Research Uses of Stem Cells

Therapeutic uses of stem cells involve the repair of damaged or diseased organs or tissues. Stem cells are said to be "therapeutic" because they can be used to treat or even cure diseases. Stem cells from the embryo can self-renew, under the right conditions, in the lab. These cells can be used to make body tissues that are diseased or damaged.

Two examples of therapeutic uses of stem cells are **corneal repair** and **skin grafts**.

Make notes on how stem cells are used in **corneal repair** and **skin grafts**.

Sources: Torrance Pg 10 OR Eurostemcell factsheet

Other therapeutic uses of stem cells include:

- **Tissue replacement** (in addition to corneal repair and skin grafts):
  - heart valves for heart disease patients
  - brain nerve cells for Parkinson's sufferers
  - blood for transfusions
  - nerve cells for spinal injuries

Stem cell research provides information on how cell processes such as cell growth, differentiation and gene regulation work.

- **Model cells:** stem cells can be used to study how diseases develop
- **Drug testing:** stem cells can be used to test new medicines and treatments

Make notes on the advantages of using stem cells in research.

Source: Torrance Pg 9

Ethical issues surrounding stem cell use

Use of embryonic stem cells can offer effective treatments for disease and injury; however, it can involve destruction of embryos.

Carry out a debate on the use of embryonic stem cells. Compare and contrast the views on stem cell research and embryonic stem cells.

Alternatively, use Torrance Pg 11

(d) Cancer cells

Cancer cells divide _____ because they do not respond to _____ signals. This results in a _____ _____ _____ called a tumour. Cells within the tumour may fail to attach to each other, spreading through the body where they may form _____ tumours.

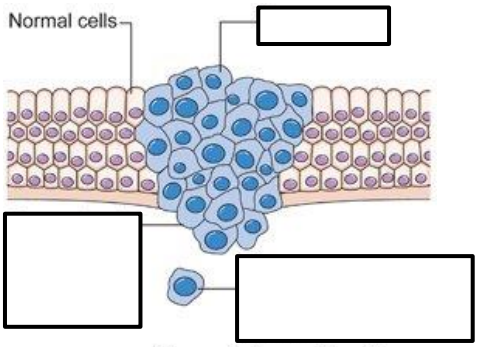


Diagram showing a malignant tumour
Copyright © CancerHelp UK

UV light and cancer: How much sun is too much? (SSERC)

http://www.sserc.org.uk/images/Bulletins/228/How_much_sun_is_too_much.pdf

Your teacher will allow you to carry out a practical using UV-sensitive yeast. You will be testing….

- The effects of UV radiation on UV sensitive yeast
- The protection offered by different sunscreens

Background information:

Over the last decade the incidence of skin cancer in Scotland (specifically malignant melanoma) has increased by a staggering 30%. The increased occurrence of this type of cancer can be attributed mainly to the rise in the number of Scots taking holidays abroad each year. A significant factor, particularly amongst younger people, is the use of sun-beds to achieve that healthy glow. When UV radiation hits living cells it may damage the DNA of the cells causing mutations. However, most cells can switch on repair mechanisms to deal with the mutations induced by UV radiation. Repeated damage to the DNA increases the chance of mutations being missed by these cellular repair systems. In humans this failure to repair may result in wrinkles, damage to the immune system and skin cancer.

End of Topic Tasks:

Unit 1 Key Area 1: Division and Differentiation in Human Cells

1. Which line in the table below describes cell division in a specific cell type?

	Cell Type	*Type of cell division*	*Chromosome number in cells produced*
A	somatic	meiosis	diploid
B	somatic	meiosis	haploid
C	germline	mitosis	haploid
D	germline	mitosis	diploid

2. In a developing embryo, tissues such as muscle and nerve are produced by

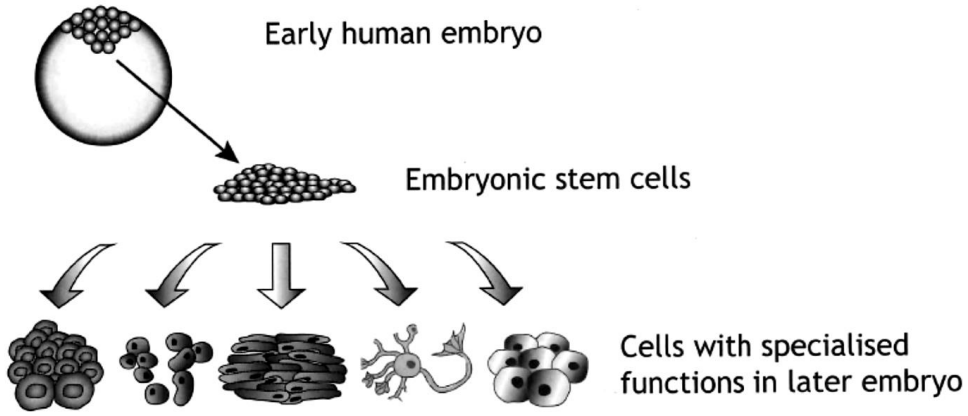
A somatic cells dividing by meiosis

B germline cells dividing by meiosis

C somatic cells dividing by mitosis

D germline cells dividing by mitosis

3. The diagram below shows the role of embryonic stem cells in the development of a human embryo.



a) Give the term used to describe the process by which a cell develops specialised functions.(1)

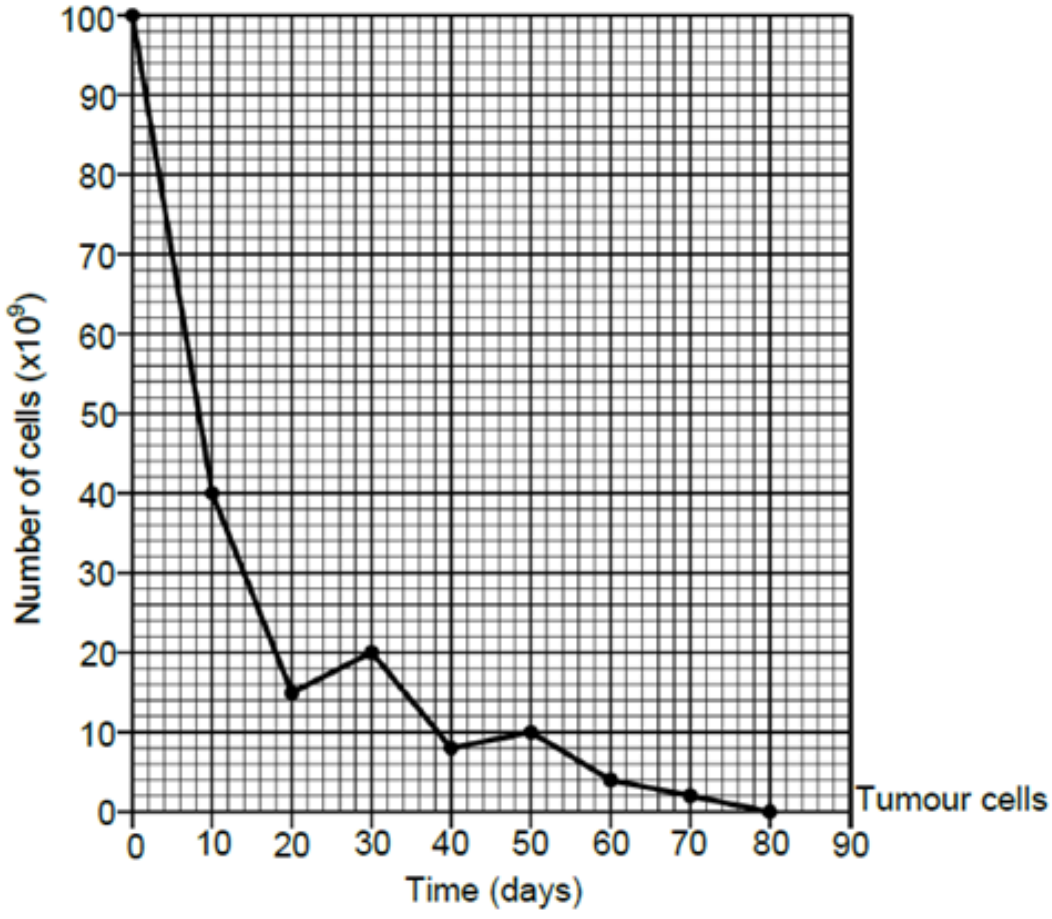
b) Describe **one** way in which tissue (adults) stem cells differ from embryonic stem cells. (1)

c) **Describe** how cancer cells form a tumour and **explain** how secondary tumours arise. (2)

4. Chemotherapy is used to kill tumour cells. When drugs are given to patients, the number of tumour and normal bone marrow cells are regularly monitored. The results for an individual who received chemotherapy are shown in the table below.

Time (Days)	Number of cells (x 10^9)	
	Tumour cells	Normal bone marrow cells
0	100	100
10	40	60
20	15	32
30	20	48
40	8	25
50	10	38
60	4	24
70	2	37
80	0	50

(a) Complete the line graph below by plotting the results for normal bone marrow cells. The line graph for tumour cells is shown on the graph. 1



Unit 1: Key Area 1: Glossary

Term	Definition
Cancer	
Carcinogen	
Chromatid	
Chromosome	
Differentiation	
Diploid cells	
Embryonic stem cell	
Ethical issue	
Gametes	
Gene	
Germline cell	
Haploid cells	
Homologous	
Meiosis	
Mitosis	
Multipotent stem cells	
Mutation	
Pluripotent stem cells	
Regulatory signal	
Somatic cell	
Stem cells	
Therapeutic use	
Tissue stem cell	
Tumour	

The small print: Key Area 2
Structure and replication of DNA

(a) Structure of DNA

- nucleotides (deoxyribose sugar, phosphate and base),…… ☐
- sugar-phosphate backbone,…… ☐
- base pairing (adenine–thymine and guanine–cytosine) by hydrogen bonds…… ☐
- double stranded antiparallel structure…… ☐
- deoxyribose and phosphate at 3′ and 5′ ends of each strand respectively…… ☐
- DNA forms a double helix…… ☐

(b) Replication of DNA by DNA polymerase and primers.

- DNA polymerase adds DNA nucleotides, using complementary base pairing, to the deoxyribose (3′) end of the new DNA strand which is forming…… ☐
- Fragments of DNA are joined together by ligase. …… ☐

(c) Polymerase chain reaction (PCR)

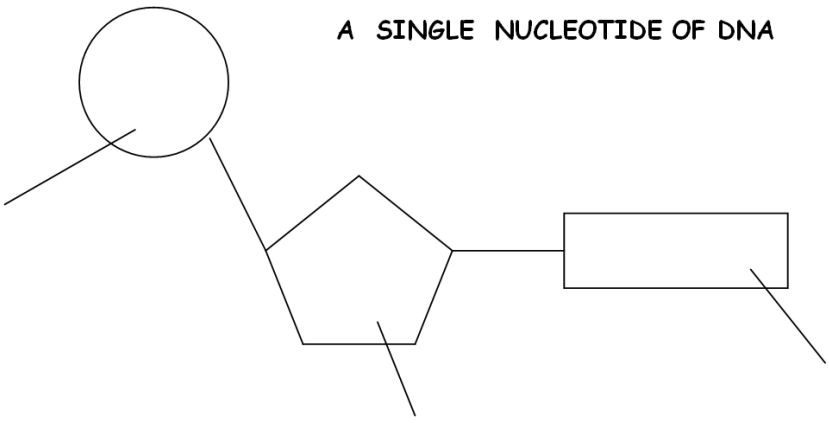
- PCR amplifies DNA using complementary primers for specific target sequences. …… ☐
- Repeated cycles of heating and cooling amplify the target region of DNA. …… ☐
- Practical applications of PCR. …… ☐

(a) Structure and Function of DNA

Chromosomes are thread-like structures found in the _____ of the cell. They are made up of tightly coiled _____ (deoxyribonucleic acid) along with associated _____. A molecule of DNA consists of two strands of _____ units called _____.

The basic units of DNA are called nucleotides.

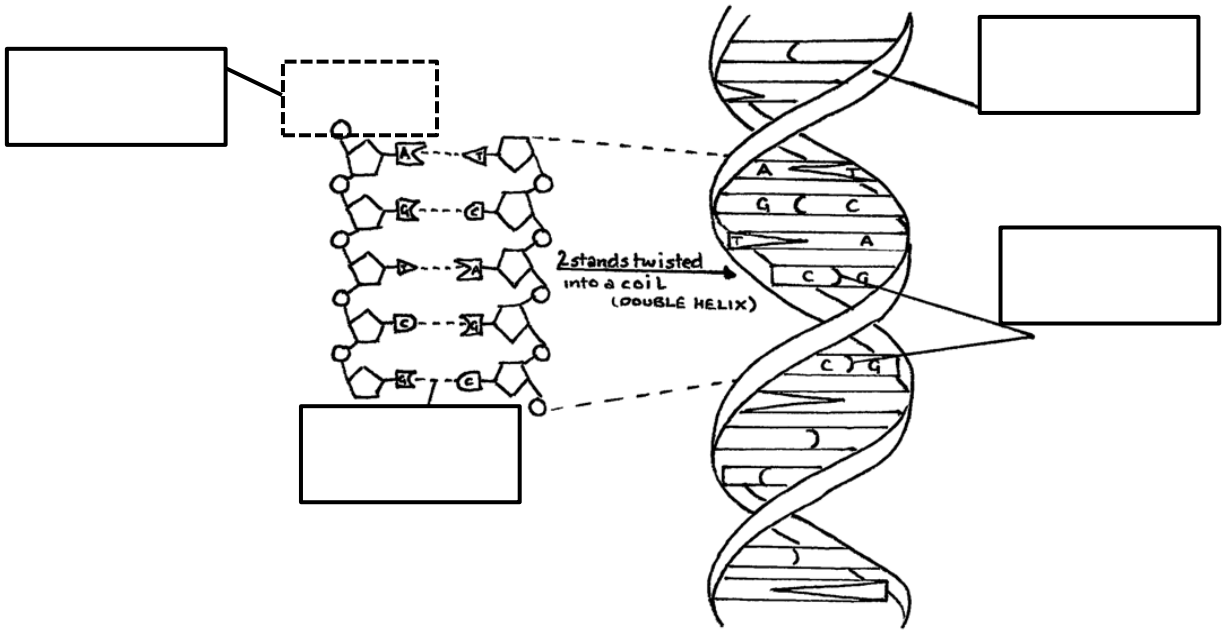
A SINGLE NUCLEOTIDE OF DNA



They contain _____ sugar, phosphate and a _____. The sugar and phosphate join together to form the DNA's _____. There are four possible bases, A, G, T and C which join in complementary base pairs: _____ (A) always joins with _____ (T) and _____ (G) always joins with _____ (C). The two DNA strands are held together by weak hydrogen bonds between the bases.

IMPORTANT

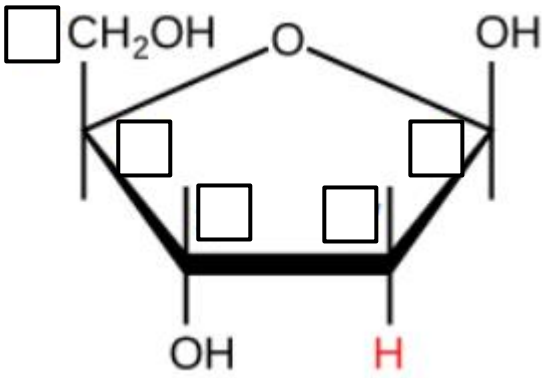
DNA double helix



The two strands stand alongside each other but run in _____ directions, i.e. they run in **opposite** directions. At the end of one strand, the end finishes with a _____ molecule and is named the 5-prime (5') end. At the end of the other strand, the end finishes with a _____ sugar molecule and is named 3-prime (3') end.

Your teacher will show you how to remember the 3′ and 5′ ends. Add the numbers to the deoxyribose sugar below:

Deoxyribose sugar structure:



What **two** features do you notice about the arrangement of the nucleotides in the DNA molecule shown?:

1._____

_____

_____

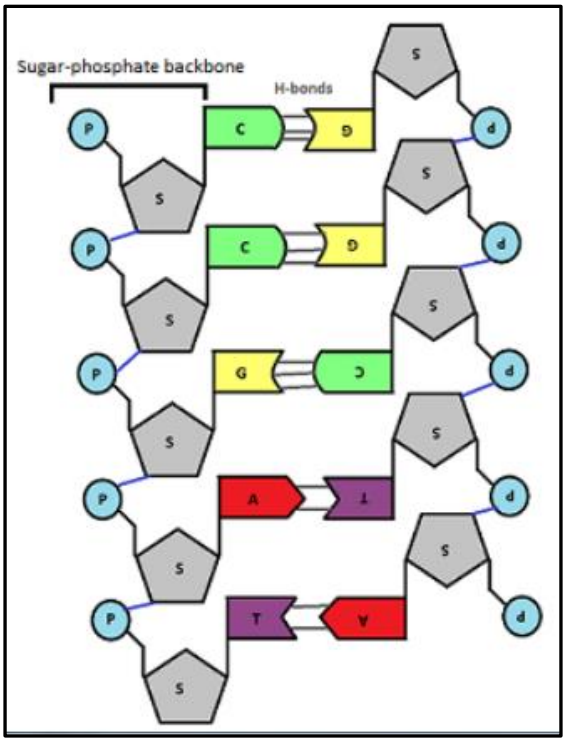
_____

2._____

_____

_____

_____



What feature of DNA structure is not shown in the diagram?

_____

_____

Draw a folded DNA molecule here…

Essay:

Describe the location and structure of DNA. *(8 marks)*

(b) DNA replication

DNA replication takes place prior to cell division (mitosis and meiosis)

Requirements:-

- DNA to act as a **template**
- **Primers**
- Enzymes including **DNA polymerase** and **ligase**
- Free **nucleotides**
- *ATP for energy*

Before DNA replication can occur, the length of DNA to be copied must be unwound and ~~unzipped~~ to form two separate single strands.

Describe what happens when the DNA is **unwound**:

_____

Describe what happens when the DNA is ~~**unzipped**~~:

_____

Unwinding and ~~unzipping~~ of DNA forms **two template strands**. The copying of the template strands requires appropriate enzymes and primers:
DNA polymerase – the enzyme that carries out replication - needs a **primer** to start replication. A primer is a short strand of nucleotides which binds to the 3' end of the template DNA strand. The function of a primer is to allow DNA polymerase to add DNA nucleotides making a new DNA strand complementary to the template strand.

DNA polymerase adds DNA nucleotides using complementary base pairing and is only able to add to the deoxyribose (3') end of the **new DNA strand** which is forming. This results in one strand (called the leading strand) being replicated continuously and the other strand (called the lagging strand) being replicated in fragments. The fragments of DNA are joined together using the enzyme **ligase**. As the replication is completed, the two new strands, each consisting of one new strand bonded to one from the original molecule, now fall away from each other and form two separate identical DNA strands. They each **coil** into their helical shape and the process is complete.

DNA Replication

Web site: For DNA replication animation

http://www.bbc.co.uk/education/guides/z36mmp3/revision/3

Your teacher will show you a step by step guide to DNA Replication. You should use this to label the diagrams below:

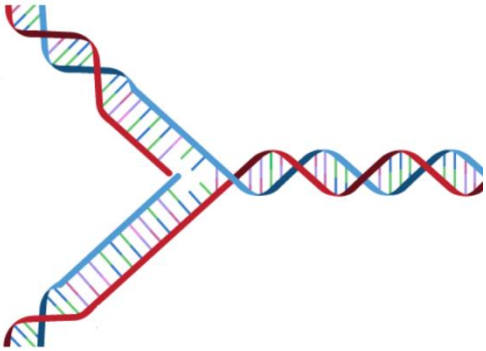
Stage 1

Stage 2

Stage 3

Stage 4

Stage 5



Stage 6

What are the differences between the leading strand and the lagging strand?

Leading strand: _____

_____

Lagging strand: _____

_____

Essay:

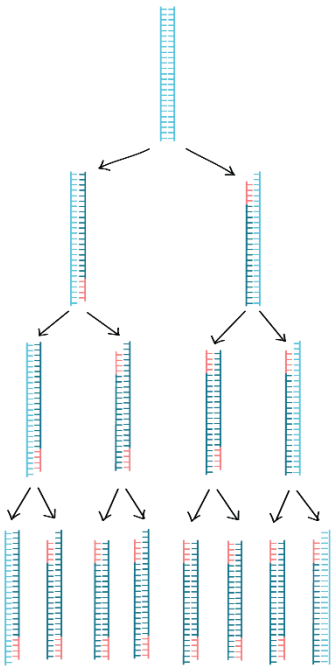
Give an account of the replication of DNA. (maximum of 7 marks):

(c) Polymerase Chain Reaction PCR

IMPORTANT

In PCR, _____ are short strands of nucleotides which are _____ to _____ _____ _____ at the two ends of the region of DNA to be amplified.

Repeated cycles of _____ and _____ amplify the target region of DNA.



Web site - McGraw Hill PCR
http://highered.mcgraw-hill.com/olc/dl/120078/micro15.swf

Stages of PCR

1. DNA is initially **heated** to between 92 and 98°C break the hydrogen bonds between base pairs, separating the two strands.
2. It is then **cooled** to between 50 and 65°C to allow primers to bind to specific target sequences on the DNA strand. Primers are short strands of nucleotides which are complementary to specific target sequences on the DNA to be amplified.
3. The temperature is **raised** to between 70 and 80°C. Heat tolerant DNA polymerase enzymes then add free DNA nucleotides to the primers at the 3' ends of the DNA strands. This amplifies the required region of DNA, meaning we only copy the section of DNA we are interested in.
4. **Repeated cycles** of heating and cooling occurs to create more copies of the DNA. Each cycle doubles the amount of DNA present.

Complete the PCR process summary below, using coloured pencils to show heating and cooling stages

PCR Process Summary

Hydrogen bonds between chains break	Separate into two strands
⇩	
Allows primers to bind to target sequences	
⇩	
Heat tolerant DNA polymerase then replicates the region of DNA	
⇩	
Repeated cycles of heating and cooling amplify this target region of DNA by thermal cycling (approximately 30 times)	

Practical Applications of PCR:

PCR can amplify DNA to help solve _____, settle _____ suits and _____ genetic disorders.

Unit 1: Key Area 2: Glossary

Term	Definition
Anti-parallel	
Complementary	
Deoxyribose sugar	
DNA	
DNA amplification	
DNA polymerase	
DNA primer	
Double helix	
Heat tolerant DNA polymerase	
Hydrogen bonds	
Lagging strand	
Leading strand	
Ligase	
Nucleotide	
Paternity suits	
PCR	
Phosphate	
Replication	
Sugar-phosphate backbone	
Target sequence	
Template strand	

The small print: Key Area 3
Gene Expression
(a) Gene expression involves the transcription and translation of DNA sequences.
Transcription and translation involves three types of RNA (mRNA, tRNA and rRNA).
Messenger RNA (mRNA) carries a copy of the DNA code from the nucleus to the ribosome.
Transfer RNA (tRNA) folds due to complementary base pairing. Each tRNA molecule carries its specific amino acid to the ribosome. Ribosomal RNA (rRNA) and proteins form the ribosome.

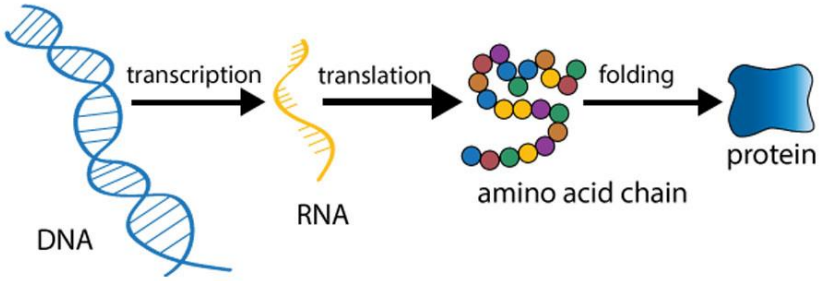
(b) The role of RNA polymerase in transcription of DNA into primary mRNA transcripts.
RNA splicing forms a mature mRNA transcript.
The introns of the primary transcript are non-coding regions and are removed.
The exons are coding regions and are joined together to form the mature transcript.

(c) tRNA is involved in the translation of mRNA into a polypeptide at a ribosome. Translation begins at a start codon and ends at a stop codon. Anticodons bond to codons by complementary base pairing, translating the genetic code into a sequence of amino acids. Peptide bonds join the amino acids together. Each tRNA then leaves the ribosome as the polypeptide is formed.

(d) Different proteins can be expressed from one gene, as a result of alternative RNA splicing. Different mature mRNA transcripts are produced from the same primary transcript depending on which exons are retained.

(e) Amino acids are linked by peptide bonds to form polypeptides. Polypeptide chains fold to form the three-dimensional shape of a protein, held together by hydrogen bonds and other interactions between individual amino acids. Proteins have a large variety of shapes which determines their functions.
Phenotype is determined by proteins produced as the result of gene expression.

Gene expression



IMPORTANT

Although a specialised cell has a complete set of the organism's genes, only those genes needed for its specialised functions are _____. All others are switched off.
Gene _____ is the activation of a gene that results in the formation of a _____. Gene expression is controlled by the regulation of both transcription and translation in protein synthesis. Only a fraction of the _____in a cell are expressed. An organism's appearance – its _____ – is determined by the proteins produced as a result of gene expression. Environmental factors can also influence phenotype.

Gene expression involves the **transcription** and **translation** of DNA sequences.

Transcription… _____

Translation… _____

Both transcription and translation involve three types of ____ :

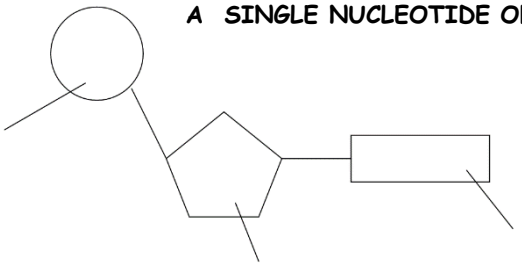
mRNA tRNA rRNA

We will consider the role that each type of RNA performs in more detail later. First, we must look at the basic structure of RNA.

Structure of RNA

All types of RNA are also made from nucleotides.

A SINGLE NUCLEOTIDE OF RNA



The table overleaf summarises the differences between the structure of DNA and **RNA**.

	DNA	*RNA*
SUGAR		
BASES PRESENT		
COMPLEMENTARY PARTNER OF ADENINE		
NUMBER OF STRANDS		

There are **<u>three</u>** different types of RNA. These are:

1. **mRNA** **messenger RNA** which carries the genetic code from DNA in the nucleus to the _____ .
2. **tRNA** **transfer RNA** folds due to complementary base pairing – each tRNA carries its **specific** _____ ____ to the ribosome.
3. **rRNA** (**ribosomal RNA**. rRNA and proteins form the _____)

mRNA

tRNA

rRNA

Transcription (of DNA into mRNA)

As DNA is too _____ to leave the nucleus through pores in the nucleus, a copy of it is made, called _____. This process is called transcription and requires:

- _____ to act as template
- Free **RNA** _____
- Enzymes including **RNA** _____
- **ATP** for _____

mRNA is transcribed from DNA in the nucleus and translated into proteins by ribosomes in the cytoplasm. Each triplet of bases on the mRNA molecule is called a _____ and codes for a specific amino acid. The enzyme RNA polymerase moves along DNA unwinding the _____ _____ and breaking the _____ bonds between the bases. This separates the DNA strands to expose the required gene. RNA polymerase synthesises a **primary transcript** of mRNA from free RNA nucleotides in the nucleus. These match up along the strand by_____ base pairings. The hydrogen bonds between bases then reform and the DNA coils back up into a double helix.

What is the primary transcript?

_____

Work out the primary transcript for the following DNA sequence. Remember that in RNA *uracil* is complementary to adenine:

DNA sequence: TAC GAA TAA CAA CCG TTG ATA CGA ACT

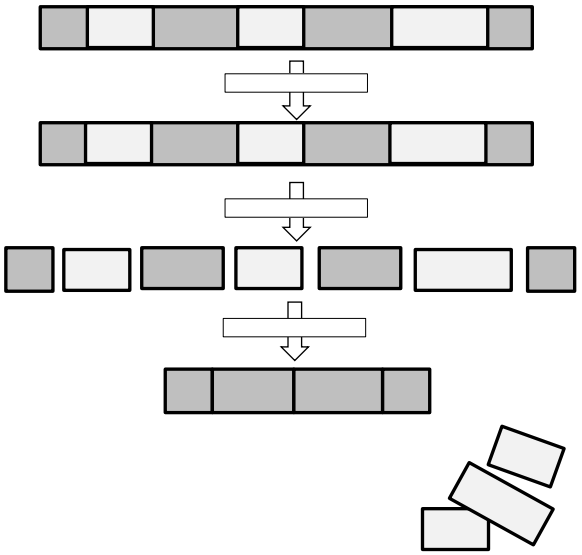
Primary transcript: ___ ___ ___ ___ ___ ___ ___ ___ ___

RNA Splicing

The primary transcript produced is a long straight chain of bases which contains non-coding regions in addition to coding regions that correspond to amino acids. RNA splicing is the process that removes non-coding regions of the primary transcript to form a mature transcript. Regions of the mRNA primary transcript that do not code for an amino acid are called **introns**. Regions of the mRNA primary transcript that code for amino acids are called **exons**.

Modification of the primary mRNA transcript

Use your notes to summarise how a primary mRNA transcript is modified to a mature mRNA transcript.

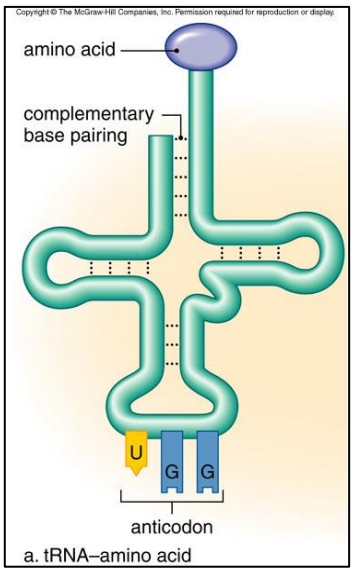


You may use Figure 3.6 on Pg 37 of the textbook to help you label the diagram above.
Ensure you have clearly labelled: introns, exons, and both the primary and mature transcripts

The mature transcript with all of the non-coding introns removed passes out of the nucleus to the cytoplasm, ready for the next stage of protein synthesis:

Translation (of mRNA mature transcript into a polypeptide chain)

The ribosome is the site inside a cell where translation of mRNA into polypeptides occurs. tRNA transfers specific amino acids to the ribosome according to the sequence of codons on the mature mRNA transcript.



tRNA molecules required for _____ are found in the cytoplasm. They contain an attachment site to carry a specific _____ to the ribosome. As there are 20 different amino acids, _____ different tRNA molecules exist. They also have a site where a triplet of 3 bases are exposed, called an _____.

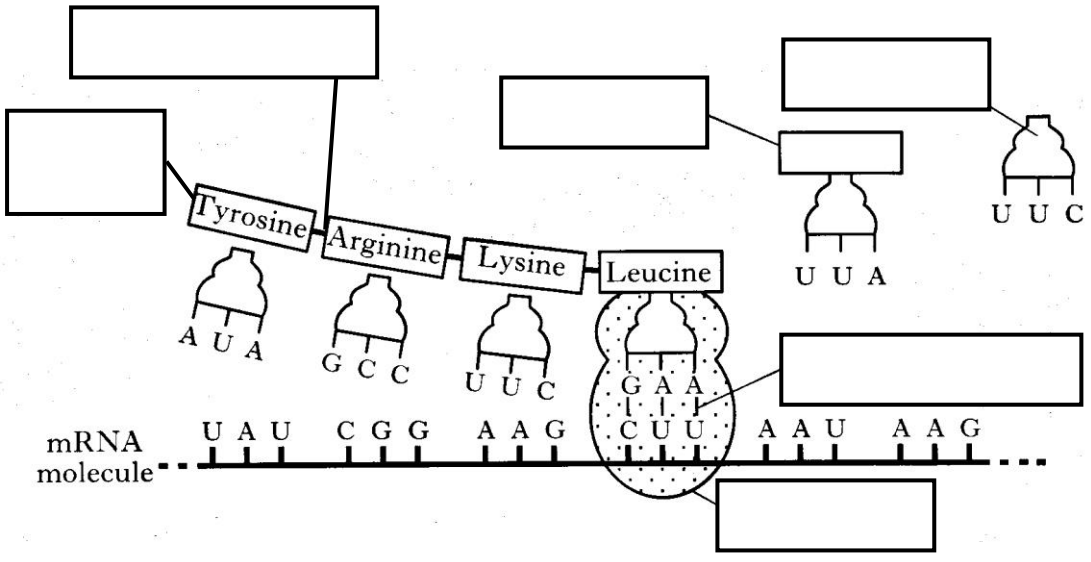
What would be the complementary codon on mRNA for the tRNA anticodon shown?

_____

During translation, the mRNA strand passes through the ribosome which '**reads**' the mRNA as it goes through. Certain **mRNA codons** act as '_____' codons to tell the ribosome where to start reading the strand. Translation begins at a start codon and ends at a stop codon. The ribosome identifies each mRNA codon and then matches it up with the correct tRNA _____ according to **complementary base pairs** (A-U, C-G). The appropriate **tRNA** brings its **amino acid** to the ribosome as it moves along the mRNA. Adjacent amino acids then join with a peptide bond to form a **polypeptide**. Each tRNA then leaves the ribosome as the polypeptide is formed. This process continues until a _____ 'codon' is reached which tells the ribosome where to end the polypeptide. The _____ is finally released.

Summary of translation:

Complete the diagram to show 'hydrogen bond', 'peptide bond', tRNA, 'amino acid', ribosome, 'growing polypeptide', 'asparagine' Use highlighters to show the codons and anticodons.*



One gene, many proteins

Products of alternative RNA splicing: Antibodies

From one gene, many different proteins may be expressed. This is due to _____ ____ _____. Different mature transcripts of mRNA may produced from the same primary transcript of mRNA **depending on which exons are retained.** An example of this in the human body is in antibody production. One gene may code for two slightly different antibody structures.

Polypeptides to Proteins

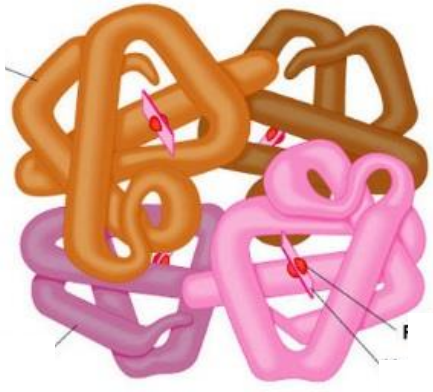
During translation, amino acids are joined together in sequence, linked by peptide bonds to form _____ . Proteins are long polypeptide chains, folded to form a specific three dimensional shape. These polypeptide chains are held in a three dimensional shape by hydrogen bonds and other interactions between individual amino acids. Such interactions between amino acids results in proteins having specific shapes:

IMPORTANT

Phenotype is determined by proteins produced as a result of gene expression. Environmental factors also influence phenotype.

An example of a protein in the human body is haemoglobin which transports oxygen in the bloodstream. The diagram below shows how the polypeptides in haemoglobin are arranged. The interactions between amino acids result in the haemoglobin protein having a structure which is perfect for the function of transporting oxygen.

Haemoglobin molecule - do not learn



Extra challenge: What determines the shape of haemoglobin? What do you think might happen if someone had an error in the gene that codes for haemoglobin?

End of Key Area 3 Activities

ESSAY

2014: Describe protein synthesis under the following headings:

(i) Transcription of DNA (4)
(ii) Translation of mRNA (6)

- *Test your knowledge: textbook page 37 qn's 1-4 and page 43 qn's 1-4 (not 4 e,f)*
- *Summary completion note*
- *Produce a summary poster of gene expression (textbook page 34 has a good overview)*
- *Use textbook page 39 to make a codon sequence for your partner to translate.*
- *Do a card sort to make a glossary*

Unit 1: Key Area 3: Glossary

Term	Definition
Alternative RNA splicing	
Exons	
Gene expression	
Introns	
Mature mRNA transcript	
mRNA	
Peptide bonds	
Polypeptide	
Primary mRNA transcript	
Ribosome	
RNA splicing	
RNA polymerase	
rRNA	
Transcription	
Translation	
tRNA	

The small print: Key Area 4

Mutations

(a) Mutations are changes in the DNA

- Mutations are changes in the DNA …… ☐
- Mutations can result in no protein or an altered protein being synthesised…… ☐

(b) Single gene mutations

- Single gene mutations involve the alteration of a DNA nucleotide sequence as a result of the substitution, insertion or deletion of nucleotides…… ☐
- Nucleotide substitution mutations include missense, non-sense and splice-site mutations. …… ☐
- Missense mutations result in one amino acid being changed for another. This may result in a non-functional protein or have little effect on the protein…… ☐
- Nonsense mutations result in a premature stop codon being produced which results in a shorter protein…… ☐
- Splice-site mutations result in some introns being retained and/or some exons not being included in the mature transcript…… ☐
- Nucleotide insertions or deletions result in frame-shift mutations…… ☐
- Frame-shift mutations cause all of the codons and all of the amino acids after the mutation to be changed. This has a major effect on the structure of the protein produced…… ☐

(c) Chromosome structure mutations

- Duplication is where a section of a chromosome is added from its homologous partner. …… ☐
- Deletion is where a section of a chromosome is removed…… ☐
- Inversion is where a section of a chromosome is reversed…… ☐
- Translocation is where a section of chromosome is added to a chromosome, not its homologous partner…… ☐
- The substantial changes in chromosome mutations make them lethal…… ☐

Key Area 4: Mutation

Mutations are changes to the DNA that can result in no protein or an altered protein being synthesised. In this topic we will look at different types of mutation. The two categories of mutation are:

Single gene mutations: _____

_____

Chromosome structure mutations: _____

_____

Single gene mutations

Mutations involving only one gene are called _____ gene mutations.
There are different types of single gene mutations:

1. **nucleotide substitution** : resulting in missense, nonsense and splice-site mutations
2. **nucleotide insertion** } Resulting in frame-shift mutation
3. **nucleotide deletion** }

1. *Substitution* mutations
A single DNA nucleotide in a gene is either substituted, inserted or deleted. This changes the nucleotide sequence in an mRNA codon and can result in alterations in one or more amino acids.

Different types of substitution mutations occur, depending on where the substitution occurs:

a) Missense – a nucleotide in a codon is substituted, causing a different amino acid to be produced. This may lead to the final protein not functioning e.g. _____.

b) Nonsense –a nucleotide in a codon is substituted, changing it from coding for an amino acid coding for a stop codon. This causes a shorter (usually non functioning) protein e.g. _____.

c) Splice-site - the nucleotide at which mRNA splicing occurs is substituted, causing the location of the splice site to change. This leaves non coding regions (introns) left in and coding regions (exons) removed from the mature mRNA, thus producing non functioning proteins e.g.
_____.

2. *Insertion* mutations

A nucleotide is added to the DNA.

Nucleotide insertions cause a _____. This is where adding a nucleotide causes that mRNA codon and _____ of the codons that follow on the mRNA to change and thus produce the wrong amino acids. This leads to a very different and generally _____ protein. E.g. Tay-Sachs syndrome

3. *Deletion* mutations

A nucleotide is _____ from the DNA. Nucleotide deletions also cause _____ mutations. E.g. cystic fibrosis

Single gene mutations that involve an insertion or a deletion of a nucleotide are called _____-_____ mutations. After the point of mutation, every subsequent codon will be altered along the length of the gene. This results in every amino acid after that point being altered and ultimately leads to expression of a non-functional protein.

Case studies: Group activity

There are six diseases described in the textbook that are caused by mutation single gene mutation (pages 55-59). Within your group, you should make sure you have information on all six of the following diseases:
Sickle-cell disease, Phenylketonuria (PKU), Duchenne Muscular Dystrophy (DMD), Beta thalassemia, Tay-Sachs disease, Cystic Fibrosis

You should include:

- Name of condition
- Type(s) of mutation
- Symptoms of disease/other information

Use what you have learned in your group to complete the summary table below:

Condition	Type(s) of mutation	Symptoms /information
Sickle-cell disease		
Phenylketonuria (PKU)		
Beta (β) thalassaemia		
Duchenne muscular dystrophy (DMD)		
Tay-Sachs syndrome		
Cystic fibrosis		

ESSAY

Describe the process of mutations in terms of:

i) single gene mutations

ii) effect on protein production (10)

Chromosome Structure Mutations

There are different types of chromosome mutations. The substantial changes which occur often make them _____.

1. ***Duplication*** – a section of a chromosome is **added** from its homologous partner

   Eg. _____

2. ***Deletion*** – a section of a chromosome is **removed**.

   E.g. _____

3. ***Inversion*** – a section of chromosome is **reversed**.

   E.g. _____

4. ***Translocation*** - a section of a chromosome is **added** to another chromosome that isn't its homologous partner.

   E.g. _____

End of Key Area 4 Activities:

Case studies: *Chromosome structure mutations (Cri-du-chat syndrome, Chronic Myeloid Leukaemia OR Familial Down's syndrome)*

Test your knowledge: *Page 62 qn's 1-4*

Unit 1: Key Area 4: Glossary

Term	Definition
Chromosome structure mutation	
Chromosome deletion	
Chromosome duplication	
Chromosome inversion	
Chromosome translocation	
Frame-shift mutation	
Homologous partner	
Mutation	
Nucleotide deletion	
Nucleotide insertion	
Nucleotide substitution - missense	
Nucleotide substitution – nonsense	
Nucleotide substitution – splice-site	
Single gene mutation	

The small print: Key Area 5

Human Genomics

(a) The genome of an organism is its entire hereditary information encoded in DNA..... ☐

- A genome is made up of genes and other DNA sequences that do not code for proteins..... ☐
- In genomic sequencing the sequence of nucleotide bases can be determined for individual genes and entire genomes..... ☐
- Computer programs can be used to identify base sequences by looking for sequences similar to known genes..... ☐
- To compare sequence data, computer and statistical analyses (bioinformatics) are required..... ☐

(b) An individual's genome can be analysed to predict the likelihood of developing certain diseases..... ☐

- Pharmacogenetics is the use of genome information in the choice of drugs..... ☐
- An individual's personal genome sequence can be used to select the most effective drugs and dosage to treat their disease (personalised medicine)..... ☐

Human Genomics

A genome is an organisms entire set of DNA. **Genomics** is the study of _____.
_____ is the **use of computer technology to map genomes and identify DNA sequences**.

Studying an individual's _____ may enable doctors to more accurately _____ a disease and then prescribe the correct _____, at the correct dosage (level) and at the correct _____. It may reduce the possibility of the patient suffering adverse reactions. It may further help to identify an individual's susceptibility to _____ diseases and enable steps to be taken to avoid or reduce the _____ of developing that disease.

ESSAY

Describe the benefits of genomics to the human population. (10)

End of Key Area 5 Activities

Case study: *Human Genome Project OR*
Alzheimer's disease - assessing the risk using bioinformatics

Test your knowledge: *Page 70 Qn's 1, 3, 4a, 4d only*

Unit 1: Key Area 5: Glossary

Term	Definition
Bioinformatics	
Genome	
Genomic sequencing	
Hereditary information	
Personalised medicine	
Pharmacogenetics	

The small print: Key Area 6

Metabolic pathways

(a) Metabolic pathways are integrated and controlled pathways of enzyme-catalysed reactions within a cell.....☐

- Metabolic pathways can have reversible steps, irreversible steps and alternative pathways.....☐
- Reactions within metabolic pathways can be anabolic or catabolic.....☐
- Anabolic reactions build up large molecules from small molecules and require energy..☐
- Catabolic reactions break down large molecules into smaller molecules and release energy.....☐

(b) Metabolic pathways are controlled by the presence or absence of particular enzymes and the regulation of the rate of key enzymes.....☐

- Induced fit occurs when the active site changes shape to better fit the substrate after the substrate binds.....☐
- The substrate molecule(s) have a high affinity for the active site and the subsequent products have a low affinity allowing them to leave the active site.....☐
- Some metabolic reactions are reversible and the presence of a substrate or the removal of a product will drive a sequence of reactions in a particular direction.....☐
- Competitive inhibitors bind at the active site preventing the substrate from binding.....☐
- Competitive inhibition can be reversed by increasing substrate concentration..... ☐
- Non-competitive inhibitors bind away from the active site but change the shape of the active site preventing the substrate from binding.....☐
- Non-competitive inhibition cannot be reversed by increasing substrate concentration.....☐
- Feedback inhibition occurs when the end-product in the metabolic pathway reaches a critical concentration. The end-product then inhibits an earlier enzyme, blocking the pathway, and so prevents further synthesis of end-product.....☐

Cell Metabolism

Metabolism describes all enzyme-catalysed reactions which occur within a cell. Metabolic pathways involve:

IMPORTANT

- Anabolism
- Catabolism

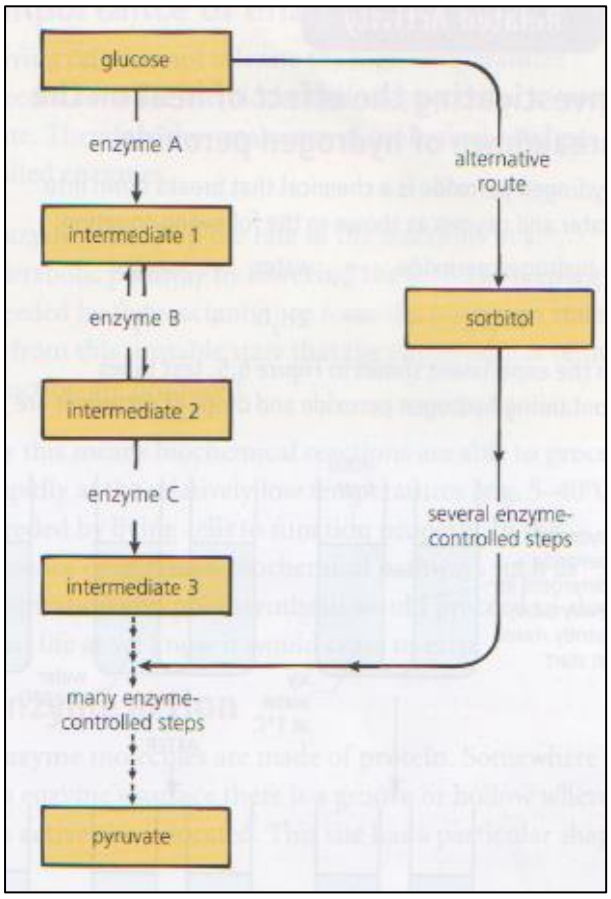
Some metabolic pathways can be reversible, others irreversible. Some metabolic pathways may have alternative routes:

- pyruvate to lactate in muscle cells is **reversible**

- pyruvate to ethanol and CO_2 in yeast cells is **irreversible.**

- Some pathways have more than one route. An example of an **alternative route** is shown:

The irreversible parts of a pathway are shown with arrows pointing in only one direction. Reversible parts of the pathway are shown with arrows pointing in both directions. Use highlighters to show the reversible steps, irreversible steps and alternative routes.



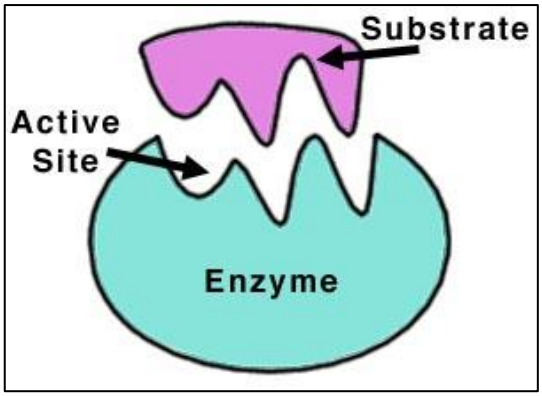
Control of metabolic pathways

Metabolic pathways can be controlled by the presence or absence of particular enzymes. For example, if an enzyme is absent, the reaction it catalyses will occur much more _____ or not at all. If the appropriate enzyme is present, the reaction will occur much more _____. The regulation of the rate of reaction of key enzymes will have an effect on the metabolic pathway.

What factors might regulate (increase/decrease) the rate of a reaction?

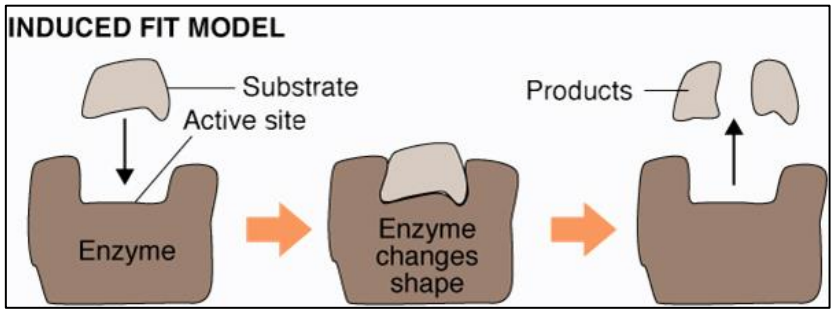
Enzyme action

Made of _____, enzymes possess a region called the active site where the reaction occurs. It has a _____ shape that is _____ to the shape of its substrate.



Induced Fit

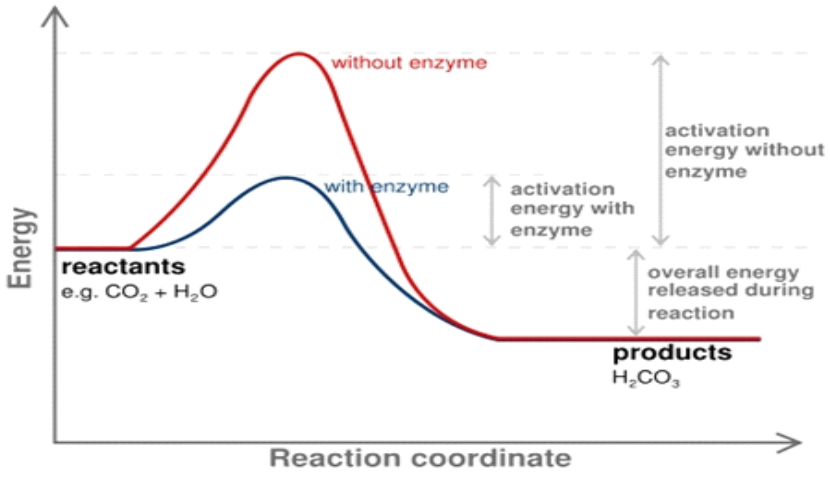
The enzyme's **active site** changes shape to better fit the substrate after the substrate binds to it. Enzymes are not directly involved in the reaction, therefore they remain _____ at the end.



Activation Energy

The energy required to break chemical bonds in the reacting chemicals and to start the reaction is called the _____ energy.

Enzymes _____ the activation energy required.

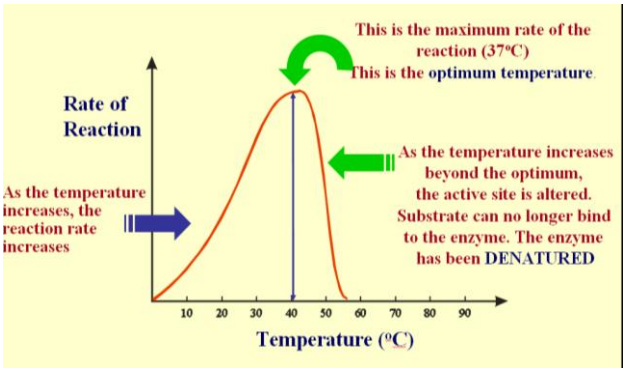


IMPORTANT	Affinity:

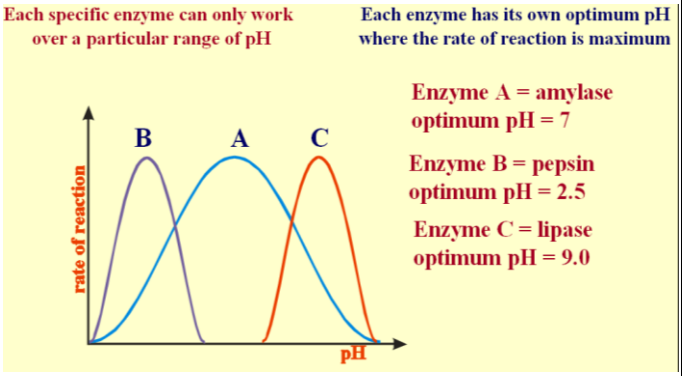
Factors affecting enzyme activity

N5 Revision: Enzyme activity is affected by pH and temperature:

Temperature



pH



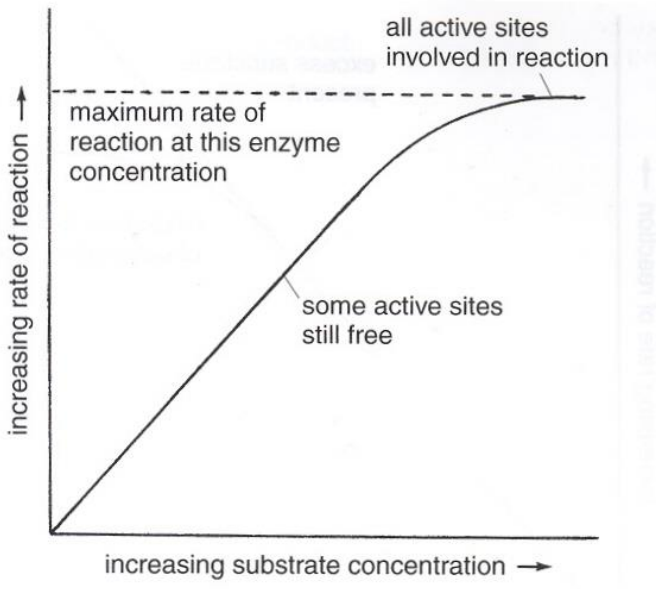
*As temperature increases up to the enzyme's **optimum**, rate of reaction increases. Above the optimum, rate of reaction dramatically slows as the enzyme becomes **denatured**. This means that the shape of its active site is permanently changed, meaning that the substrate can no longer fit.*

As pH increases up to the enzyme's **optimum**, rate of reaction increases. Above the optimum, rate of reaction dramatically slows as the enzyme becomes **denatured**. This means that the shape of its active site is permanently damaged, meaning that the substrate can no longer fit it.

In addition to temperature and pH, enzyme activity is also affected by the concentrations of the _____ and the _____.

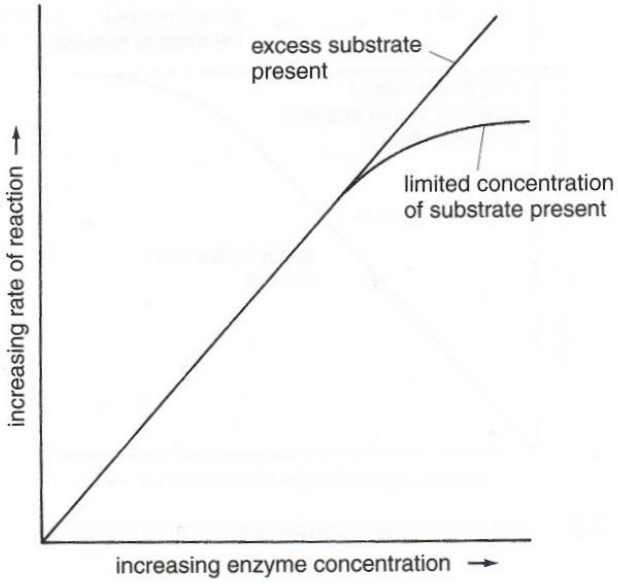
Substrate concentration

Increasing **substrate concentration** _____ rate of reaction as there as more active sites become occupied by _____. This is only until the point where all _____ _____ are filled and so rate of reaction levels off. As there are no more enzymes to react with more substrates, *enzyme concentration* becomes the limiting factor.



Enzyme concentration

Increasing **enzyme concentration** increases rate of reaction as there are more _____ to join with substrates. This is only until the point where all _____ _____ are used up and so rate of reaction levels off. As there are no more substrates to react with enzymes, *substrate concentration* becomes the limiting factor.



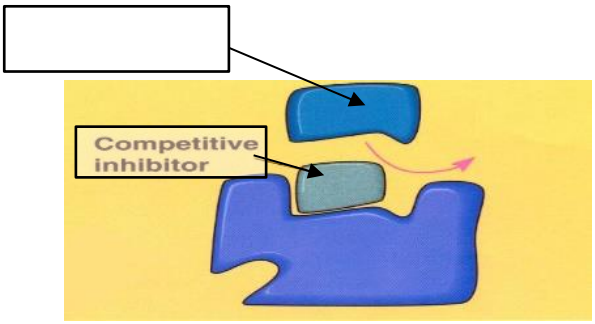
Regulation (control) of metabolic pathways

An **enzyme inhibitor** is a molecule that can affect the rate of a reaction.

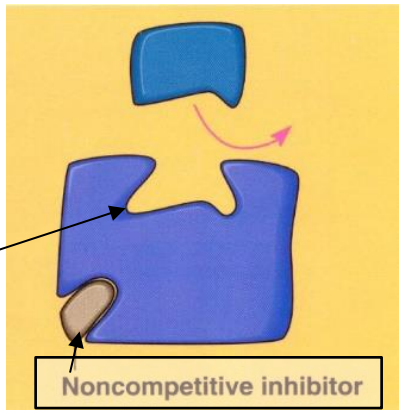
Control of metabolic pathways can be achieved in three different ways:

- **competitive inhibition**
- **non-competitive inhibition**
- **feedback inhibition**

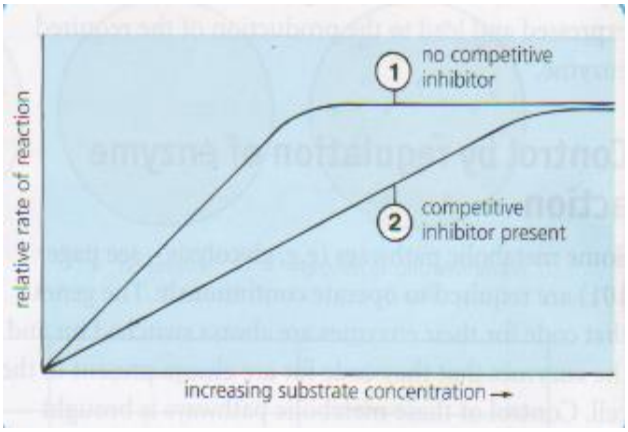
1. **Competitive inhibitors** bind to the active site and prevent the _____ from binding.



2. **Non-competitive inhibitors** bind to a point on the enzyme other than the _____ _____. They alter the shape of the active site so that the substrate can no longer fit in.



Graphing Competitive and Non-competitive Inhibitors

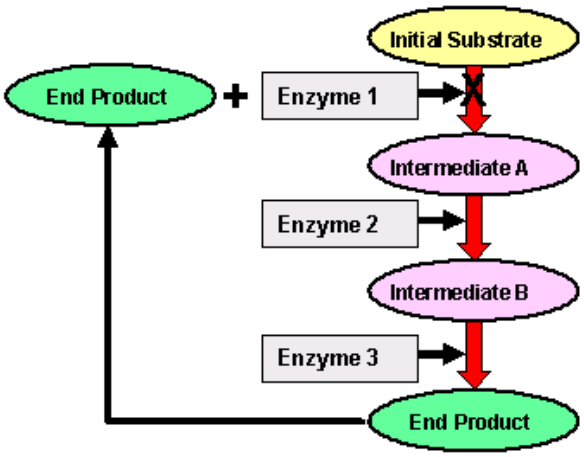


When a competitive inhibitor is present the rate of the reaction is _____ compared to a reaction when no inhibitor is present.

You can tell from a graph if an inhibitor is a competitive or non-competitive inhibitor. With a competitive inhibitor, when the substrate concentration is increased, the rate of the reaction _____. This does not happen with a non-competitive inhibitor.
e.g. _____.

3. Feedback inhibition

In order to control metabolic pathways the end product of the pathway can sometimes inhibit the activity of the first enzyme in the pathway. This is called _____ inhibition.
It avoids the excessive production and _____ of the intermediate and end chemicals in a pathway.



ESSAY

Give an account of the factors affecting enzyme activity. (10)

End of Key Area 6 Activities

Experiment write-up: Substrate Concentration:
Look at Figure 6.13 on Pg 84. Suggest a suitable aim for this experiment and write a conclusion that addresses this aim.
Feedback inhibition:
Look at Figure 6.32 on Pg 95. Suggest a suitable aim for this experiment and write a conclusion that addresses this aim.

Test your knowledge: Answer qn's 1-4 on Page 85 & qn's 1-4 on Page 96

Unit 1: Key Area 6: Glossary

Term	Definition
Activation energy	
Active site	
Affinity	
Alternative route	
Anabolic	
Catabolic	
Competitive inhibition	
Enzyme	
Feedback inhibition	
Induced fit	
Inhibitor	
Irreversible step	
Metabolic pathway	
Non-competitive inhibition	
Products	
Reversible step	
Substrate	

The small print: Key Area 7

Cellular Respiration

(a) Metabolic pathways of cellular respiration

- Glycolysis is the breakdown of glucose to pyruvate in the cytoplasm…… ☐
- ATP is required for the phosphorylation of glucose and intermediates during the energy investment phase of glycolysis…… ☐
- After energy investment phase, more ATP is generated in the pay-off stage, resulting in a net gain of ATP…… ☐
- In aerobic conditions pyruvate is broken down to an acetyl group that combines with coenzyme A forming acetyl coenzyme A…… ☐
- In the citric acid cycle the acetyl group from acetyl coenzyme A combines with oxaloacetate to form citrate…… ☐
- During a series of enzyme controlled steps, citrate is gradually converted back into oxaloacetate which results in the generation of ATP and release of carbon dioxide….. ☐
- The citric acid cycle occurs in the matrix of the mitochondria…… ☐
- Dehydrogenase enzymes remove hydrogen ions and electrons and pass them to coenzyme NAD, forming NADH. Occurs in both glycolysis and citric acid cycle…… ☐
- The hydrogen ions and electrons from NADH are passed to the electron transport chain on the inner mitochondrial membrane…… ☐

(b) ATP synthesis

- Electrons are passed along the electron transport chain releasing energy…… ☐
- The electron transport chain is a series of carrier proteins attached to the inner mitochondrial membrane…… ☐
- Energy released in electron transport chain allows hydrogen ions to be pumped across the inner mitochondrial membrane…… ☐
- Flow of hydrogen ions back through the membrane protein ATP synthase results in the production of ATP…… ☐
- Hydrogen ions and electrons combine with oxygen to form water.. …… ☐

(c) The role of ATP in the transfer of energy

- ATP is used to transfer energy to cellular processes which require energy…… ☐

Cellular Respiration

Respiration involves a series of enzyme controlled metabolic steps which release the chemical energy in food for activities such as _____ transport, ____ replication and protein synthesis. Cells use energy in the form of a chemical called adenosine triphosphate (_____) which is produced during respiration.

ATP Generation

ATP is formed from a molecule of adenosine diphosphate (ADP) joined with another inorganic phosphate (Pi). The addition of phosphate to a molecule is called _____. Energy is **required** to generate ATP.

ATP Breakdown

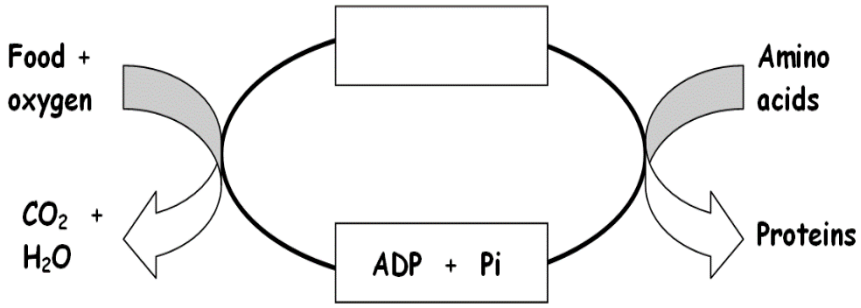
When the last phosphate is broken off the ATP, it forms ADP + Pi and chemical energy is **released** for cell processes. Levels of ATP in the human body remain fairly constant as it is produced at the same rate that it is used up.

Relationship between ATP and ADP + Pi

IMPORTANT

Respiration key message

Food contains stored chemical energy. This is released through a series of metabolic pathways and regenerates the high energy compound ATP. ATP can then be broken down to release energy when it is needed for cellular processes.



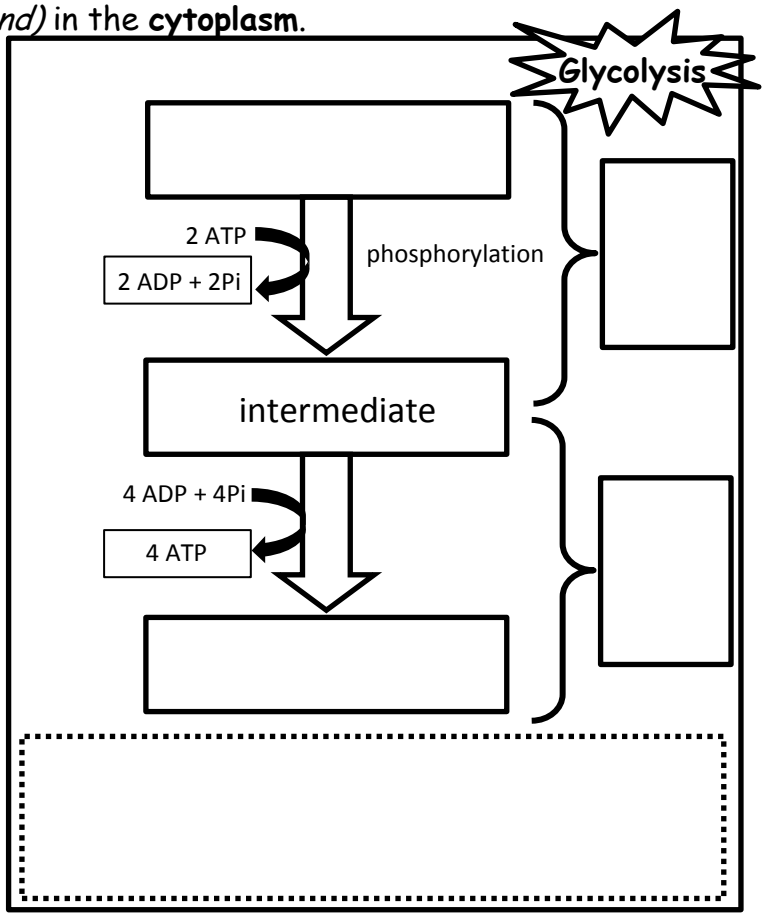
See page 97 to complete the diagram – arrows and labels

Respiration consists of 3 stages:

- **GLYCOLYSIS**
- **CITRIC ACID CYCLE**
- **ELECTRON TRANSPORT CHAIN**

1. Glycolysis

During glycolysis, **glucose** *(a 6 carbon compound),* is broken down into 2 molecules of **pyruvate** *(a 3 carbon compound)* in the **cytoplasm**.



<u>Energy investment phase</u>
For glucose (and other intermediates) to be broken down it must first be **phosphorylated** (**phosphate** is added glucose). The phosphate is provided by ATP. As **two ATP** are required for this, it is called the energy investment stage.

<u>Pay-off phase of Glycolysis</u>
Glycolysis also produces an additional **four ATP** - this is called the pay-off phase. Therefore a **<u>net gain of 2 ATP</u>** occurs in the reaction.

Dehydrogenase enzymes remove hydrogen ions and electrons and pass them to the **coenzyme NAD** forming **NADH**. NADH is passed onto the electron transport chain on the inner mitochondrial matrix.

As oxygen is not required, glycolysis can occur with oxygen (called **aerobic** respiration) or without oxygen (called fermentation).

IMPORTANT *Summary of Glycolysis end products and their fate*

2. Citric acid cycle

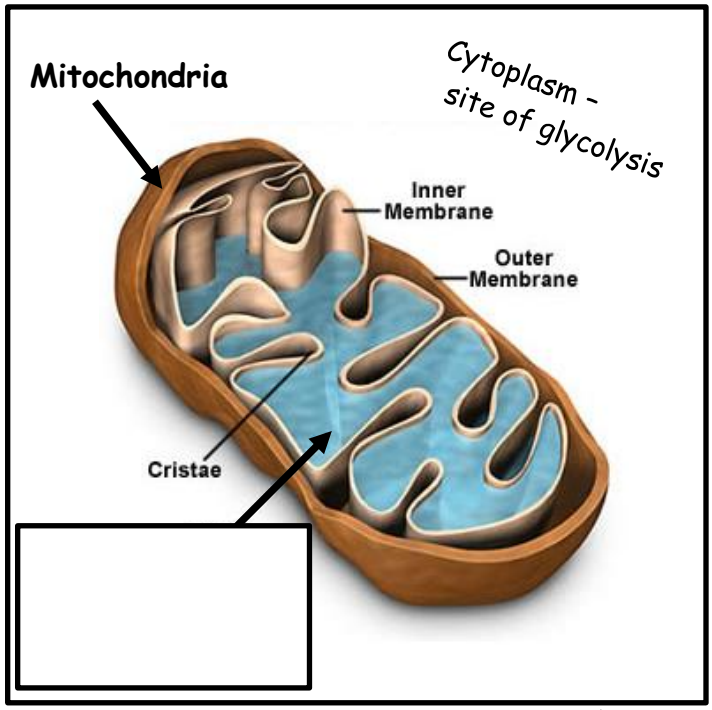
The Citric acid cycle takes place in the **matrix of the mitochondria**.

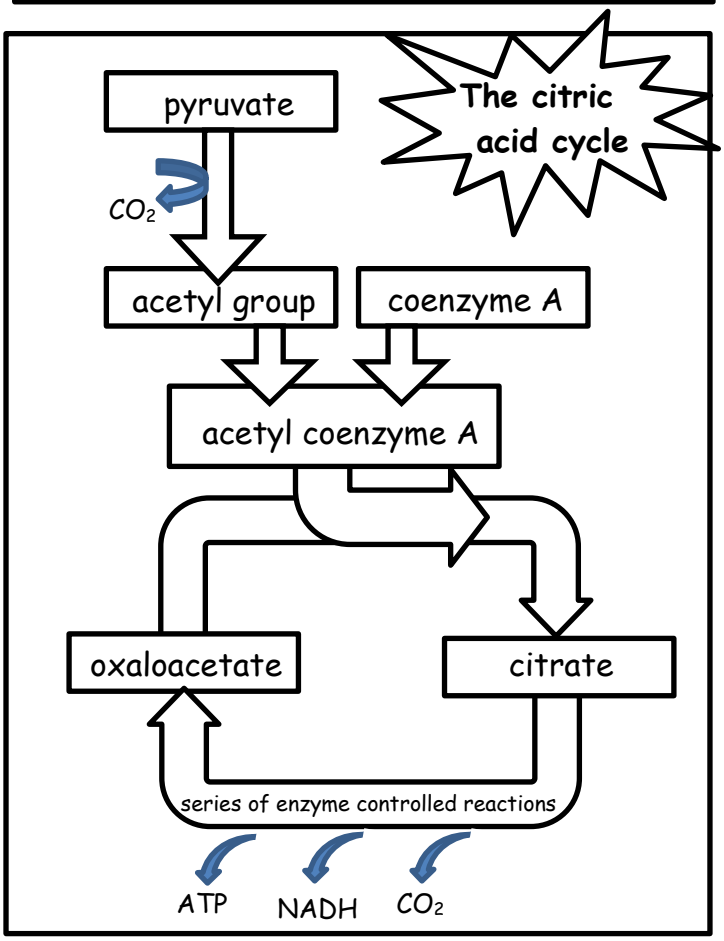
If **aerobic conditions,** (oxygen is available), the **pyruvate** from glycolysis is broken down into an **acetyl group** which combines with **co-enzyme A** to form **acetyl coenzyme A**. The carbon lost forms carbon dioxide.

In the citric acid cycle, acetyl coenzyme A combines with **oxaloacetate** to form **citrate.**

During a series of **enzyme controlled steps**, citrate is gradually converted back into oxaloacetate which results in the generation of **ATP** and release of **carbon dioxide.**

Dehydrogenase enzymes remove **hydrogen ions** and **electrons** and pass them to the **coenzyme NAD**, forming **NADH**. NADH is passed onto the electron transport chain on the inner mitochondrial matrix.



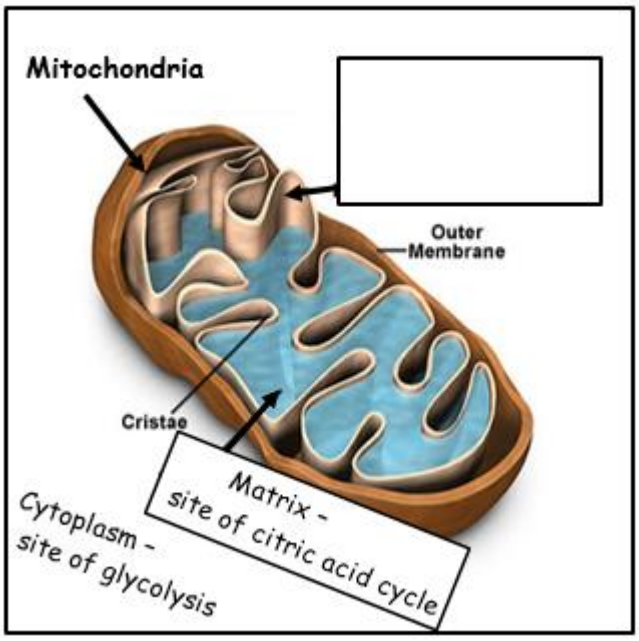


IMPORTANT

Summary of citric acid cycle end products and their fate

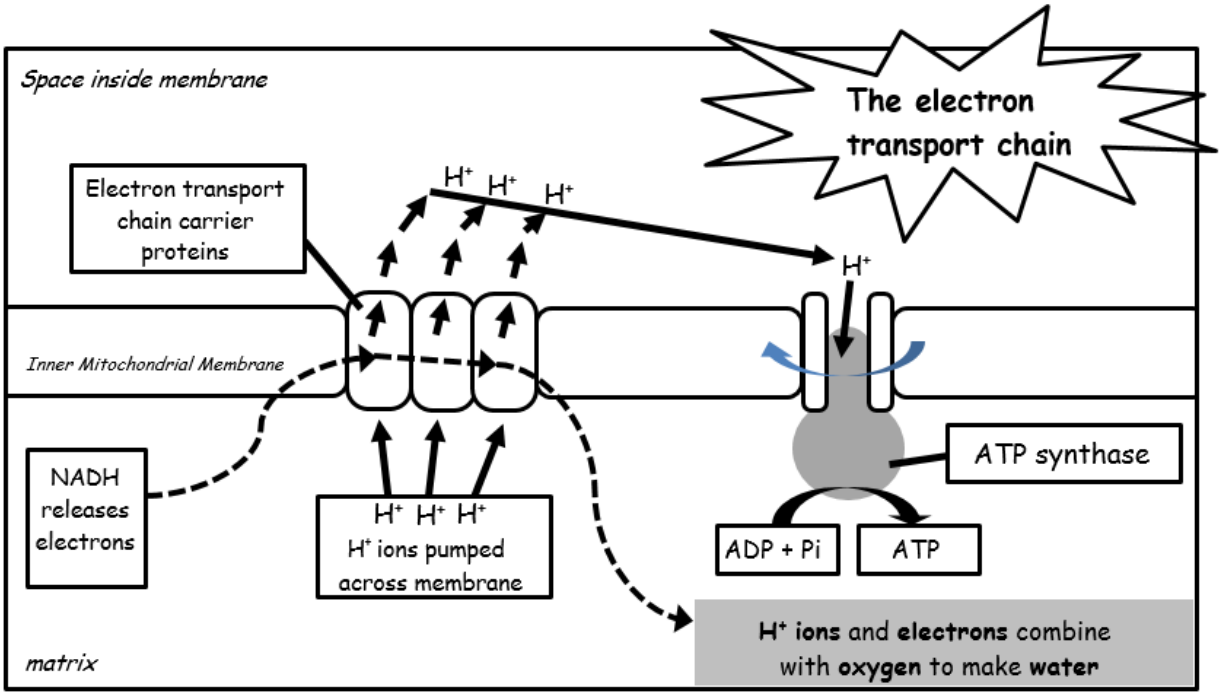
3. ATP Synthesis: Electron transport chain

The electron transfer chain occurs on the **inner membrane** of the mitochondria.



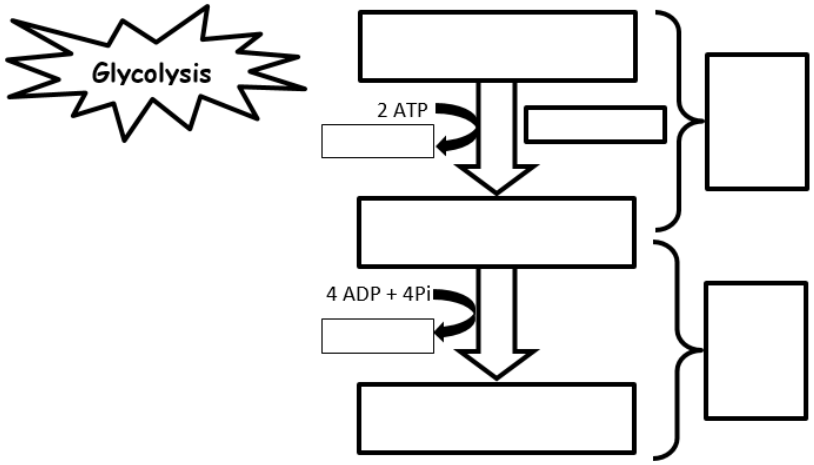
The electron transport chain is a **series of carrier proteins** attached to the inner mitochondrial membrane. The electrons and hydrogen ions from the NADH produced in Glycolysis and the Citric Acid Cycle are used to generate ATP in the electron transport chain. When electrons are passed along the carrier proteins of the electron transport chain, **energy is released**.
This energy allows **hydrogen ions** to be **pumped** across the inner mitochondrial membrane. The flow of these ions back through the membrane protein **ATP synthase** produces ATP.

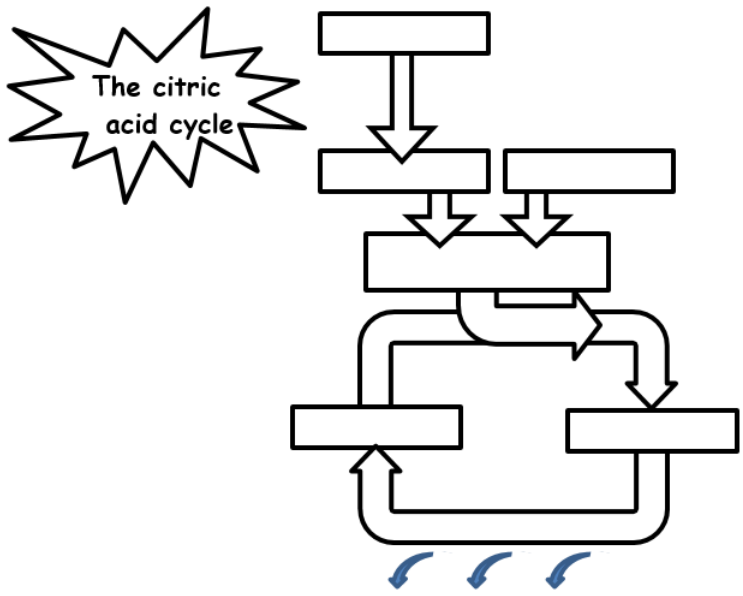
FINALLY, Hydrogen ions (H^+), **electrons** and **oxygen** combine to form **water**.

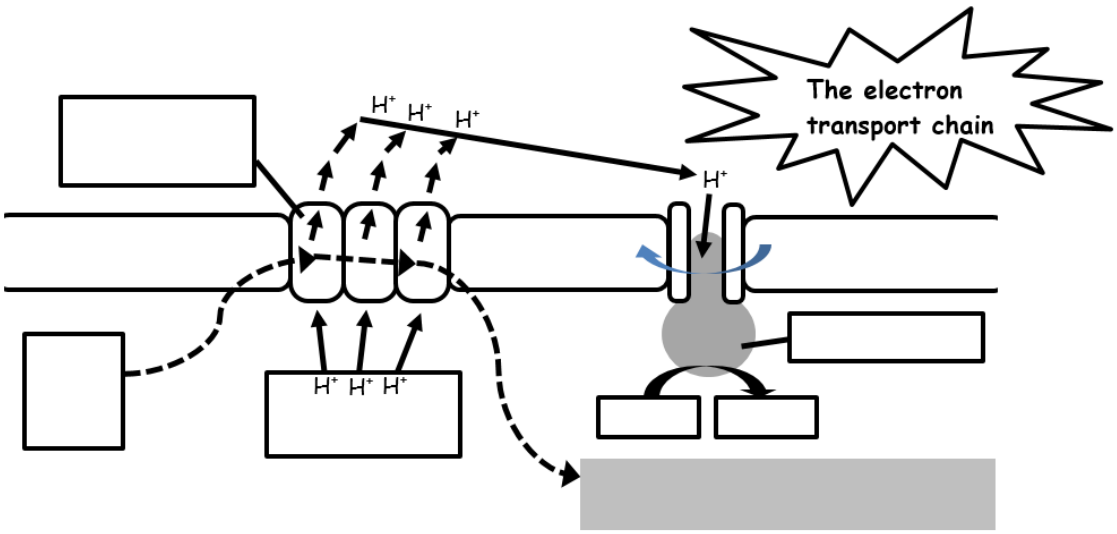


The ATP generated in cellular respiration is used to transfer energy to cellular processes that require energy.

You should now bring together all three stages of cellular respiration:







End of Key Area 7 Activities

ESSAY

2014: Describe aerobic respiration under the following headings

(i) The citric acid cycle (5)
(ii) The electron transport chain (5)

Unit 1: Key Area 7: Glossary

Term	Definition
Acetyl group	
Acetyl coenzyme A	
Aerobic conditions	
ATP synthase	
Citrate	
Citric acid cycle	
Coenzyme A	
Coenzyme NAD	
Dehydrogenase	
Electron transport chain	
Energy investment	
Energy pay-off	
Glycolysis	
Matrix of mitochondria	
Mitochondria	
Oxaloacetate	
Phosphorylation	
Pyruvate	

The small print: Key Area 8

Energy systems in muscle cells

(a) Lactate metabolism

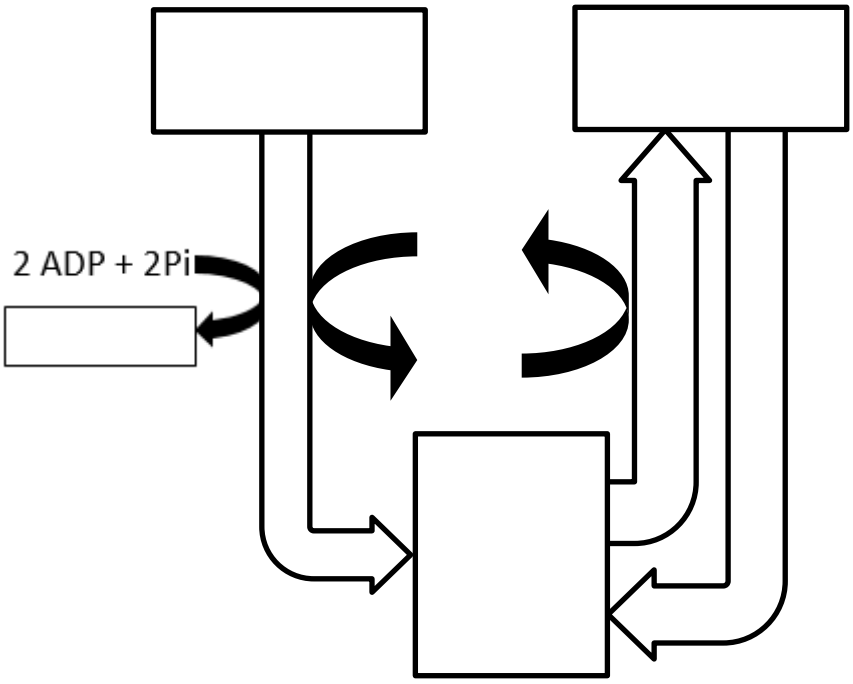
- During vigorous exercise, the muscle cells do not get sufficient oxygen to support the electron transport chain…… ……☐
- When there is insufficient oxygen, pyruvate is converted to lactate……☐
- Conversion of pyruvate to lactate involves the transfer of hydrogen from the NADH produced during glycolysis back to pyruvate…… ……☐
- This regenerates the NAD needed to maintain ATP production through glycolysis……☐
- Accumulation of lactate leads to muscle fatigue……☐
- The oxygen debt incurred by vigorous exercise is repaid when exercise is complete…☐
- When oxygen levels increase respiration provides the energy to covert lactate back to pyruvate and glucose in the liver…… ……☐

(b) Types of skeletal muscle fibres

- There are two types of muscle fibre: slow twitch and fast twitch……☐
- Slow twitch muscle fibres contract relatively slowly, but can sustain contractions for longer. …… ……☐
- Slow twitch muscle fibres rely on aerobic respiration to generate ATP and have many mitochondria, a large blood supply and a high concentration of the oxygen-storing protein myoglobin.……☐
- The major storage fuel of slow twitch muscle fibres is fats. ……☐
- Slow twitch muscle fibres are useful for endurance activities such as long distance running, cycling or cross-country skiing. ……☐
- Fast twitch muscle fibres contract relatively quickly, over short periods……☐
- Fast twitch muscle fibres are useful for activities such as sprinting or weightlifting..☐
- Fast twitch muscle fibres can generate ATP through glycolysis only and have fewer mitochondria and a lower blood supply compared to slow twitch muscle fibres.……☐
- The major storage fuel of fast twitch muscle fibres is glycogen. ……☐
- Most human muscle tissue contains a mixture of both slow and fast twitch muscle fibres……☐
- Athletes show distinct patterns of muscle fibres that reflect their sporting activities……☐

Lactate Metabolism

During _____ exercise, the muscle cells do not get sufficient oxygen to support the electron transport chain. Under these conditions, pyruvate is converted to lactate.



This conversion involves the transfer of hydrogen from the NADH produced during glycolysis to pyruvate in order to produce lactate. This regenerates the NAD needed to maintain ATP production through glycolysis.

Lactate accumulates in the muscle tissues and muscle fatigue occurs.

Activity: Try out the grip strength manometer

What are the symptoms of muscle fatigue?

When exercise is complete, the oxygen debt is repaid. This allows respiration to provide the energy to convert lactate back to pyruvate and glucose in the liver.

Types of skeletal muscle fibres

There are two different type of skeletal muscle fibres:

1. **slow** twitch (type 1)
2. **fast** twitch (type 2)

Most human muscle contains a mixture of the two different types of fibres. Athletes show disctinct patterns of muscle fibres that reflect their sporting activities.

1. ***Slow twitch*** (Type 1) muscle fibres contract more _____, but can sustain contractions for _____ and so are good for _____ activities. Endurance activities include long distance running, cycling or cross country skiing. Slow twitch fibres rely on _____ respiration to generate ATP and have many _____, a large blood supply and a high concentration of the oxygen storing protein _____. The major storage fuel of slow twitch muscles fibres is _____.

2. ***Fast twitch*** (Type 2) muscle fibres contract more _____, over short periods, so are good for _____ bursts of activity. They are useful for activities such as sprinting or weightlifting. Fast twitch fibres can generate ATP through _____ only and have few _____ and a lower _____ supply than slow twitch fibres. The major storage fuel of fast twitch muscles fibres is _____.

Feature	Type of skeletal fibre	
	Slow twitch	Fast twitch
Speed of contraction		
Length of contraction		
Speed at which fibres become fatigued		
Respiratory pathway(s) normally used to generate ATP		
Number of mitochondria		
Density of blood capillaries		
Concentration of myoglobin		
Major storage fuel used	Fats	Glycogen

End of Key Area 8 Activities

ESSAY

2013: Give an account of skeletal muscle cells under the following headings:

(i) Lactic acid metabolism (4)
(ii) Slow twitch muscle fibres (3)
(iii) Fast twitch muscle fibres (3)

Unit 1: Key Area 8: Glossary

Term	Definition