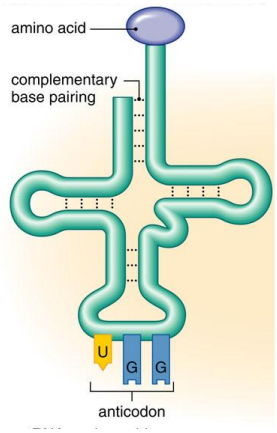
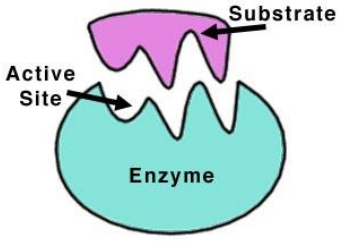
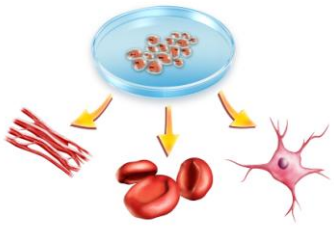


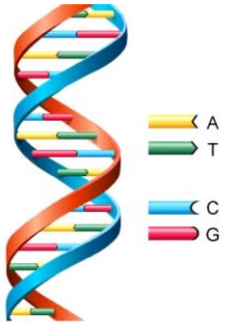


Higher Human

BIOLOGY

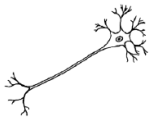


UNIT 1 - NOTES



Name:


Liver cells


Nerve cells


Cardiac muscle cells

Cell Types

Cells may be grouped into **somatic cells**, **germline cells** and **stem cells**.

Differentiation in somatic cells

Somatic cells These are non-sex cells (e.g. muscle, skin, bone, blood e…). They have **two sets** of chromosomes, so somatic cells are _____ cells.

Differentiation The process which results in cells becoming **specialised** – i.e. they have their own specific **structure** and _____.

Somatic cells divide by _____ to form more somatic cells. These cells then differentiate to form different body tissue types of which the main ones are:

Epithelial these cells cover the body surface and line body cavities (e.g. bladder, windpipe etc),

Connective includes bone, cartilage, and _____ cells. These cells form tissues and the body organs are formed from a variety of these tissues.

Body organs are formed from a variety of these tissues. During cell division the _____ of a somatic cell divides by mitosis to **maintain** the diploid _____ number. Human, diploid cells have ____ pairs of **homologous** chromosomes.

Differentiation in germline cells

Germline cells are _____ cells, and in humans they are called gamete mother cells. The nucleus of a germline cell can either divide by:

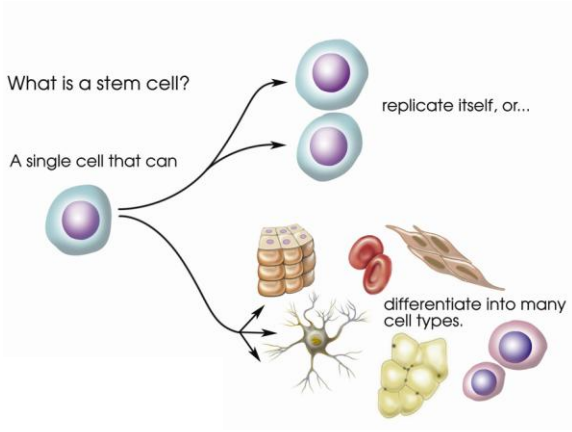
- **MITOSIS** to produce more **diploid** germline cells or
- **MEIOSIS** to produce **haploid** _____.

Mutations that occur in **germline** cells **will be passed on** to offspring (where as mutations in **somatic** cells **will not be passed to offspring)**.

Differentiation in stem cells

There are **two** different types of stem cells:

- Embryonic
- Adult (or tissue)



Stem cells are relatively **unspecialised** cells. They can continue to make copies of themselves (self-renew) and can _____ into specialised cells of one or more types. (*See National 5 notes, Unit 2 page 11*).

Embryonic Stem Cells

In the very early embryo, embryonic stem cells can differentiate into **any type** of human cell. For this reason they are said to be _____. This is because **most** of their **genes** are still _____ _____ (or **expressed**).

Adult stem cells

Adult (or tissue) stem cells are involved in the growth and repair and renewal of the cells found in that tissue. Unlike embryonic stem cells, they can only produce a **limited range** of cell types. For example, the stem cells in our bone marrow will only give rise to different types of **blood** cells e.g. red blood cells, platelets, and the various forms of white blood cells e.g. phagocytes and lymphocytes. For this reason adult stem cells are said to be _____.

Once a cell differentiates, it can only **express** the **genes** that produce the **proteins** that in turn make cells different. For example the gene for the production of the oxygen carrying protein _____ will **only** be **expressed** in red blood cells. Although **all cells** will possess this gene, it **will not be expressed** (i.e. "switched on") and this is why these cells **do not produce** haemoglobin.

Research and therapeutic value of stem cells

Stem cell research provides information on how cell processes such as cell growth, differentiation and gene regulation work. Stem cells can also be used as model cells to study how _____ develop or for drug testing.

Therapeutic uses of stem cells includes:

- ✓ bone marrow transplants
- ✓ skin grafts for burns
- ✓ repair of damaged or diseased organs (or tissues)

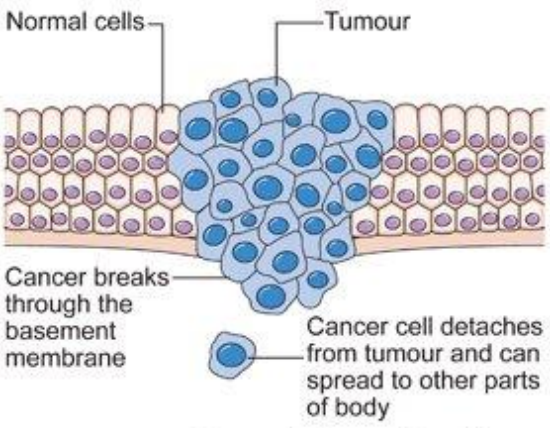
Ethical issue of stem cell use

Since one source of stem cells is embryonic tissue, their use can be **controversial**. Current UK law states that embryonic cells cannot be allowed to develop beyond 14 days (around the time an embryo would implant into the uterus). Ethical concerns have led to **regulations** on the use of embryonic stem cells.

Web site
http://www.youtube.com/watch?v=8JTw2RpDo9o

Cancer cells

Cancer cells **do not respond** to signals that regulate them. As a result, these cells divide excessively to produce a mass of **abnormal cells** (a _____). If the cancer cells fail to **attach** to each other, they can spread throughout the body where they form _____ tumours.



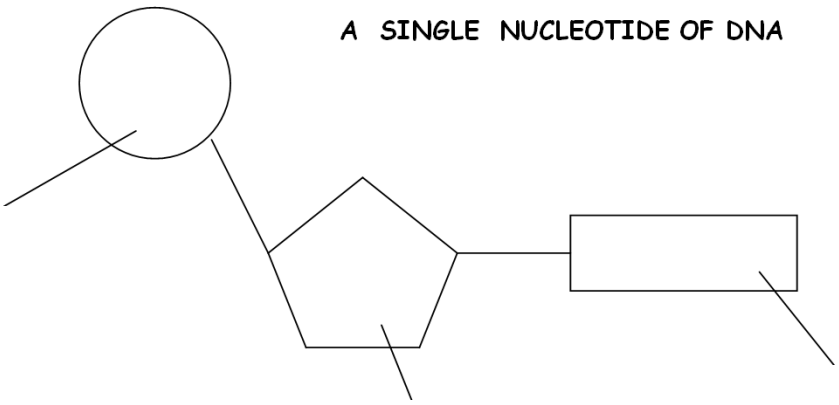
Web site
http://www.youtube.com/watch?v=8LhQllh46yI

Structure and Function of DNA

Structure of DNA

DNA is an example of a _____ acid. Nucleic acids like DNA are made from repeating units called _____ like the one shown below.

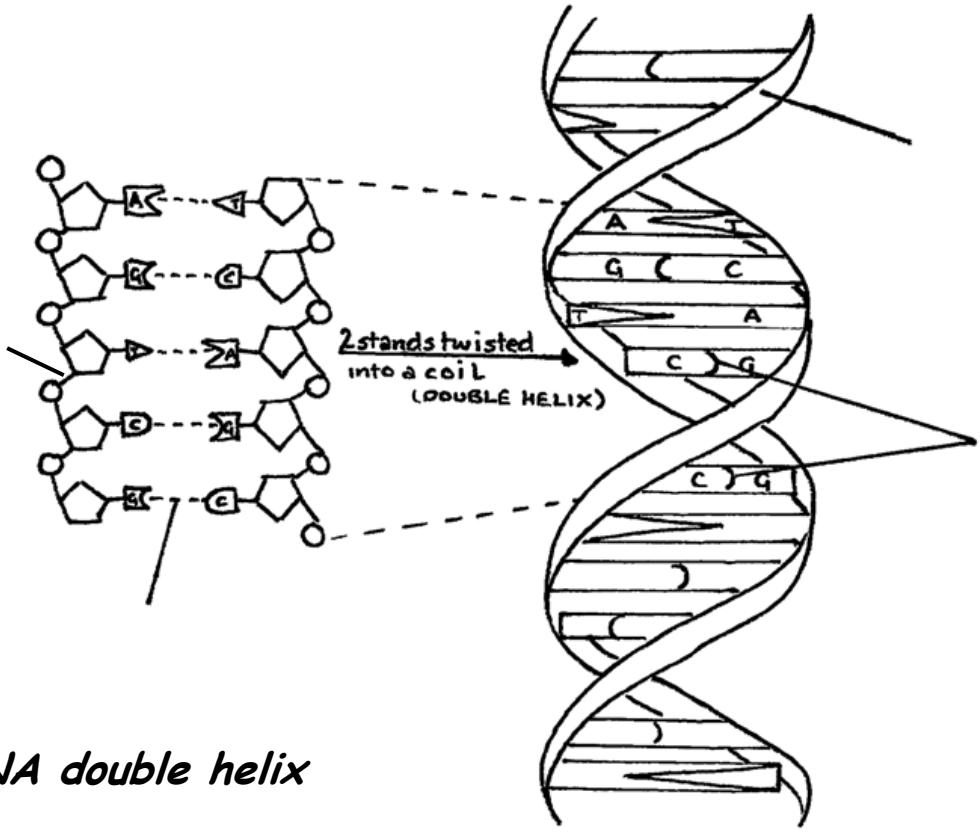
A SINGLE NUCLEOTIDE OF DNA



The four bases in DNA are _____, _____, _____ and _____. It is only the **bases** which makes one nucleotide **different** from another. So, since there are only four different bases, there can only be four different _____ in DNA .

Nucleotides join together to form a sugar-phosphate **backbone** – see next page. The bases pair off and are held together by weak _____ bonds, forming a twisted double _____ as shown on the next page. Adenine is always opposite _____ ; _____ is always opposite cytosine.

Web site
http://www.youtube.com/watch?v=BmDG_fKUTR8



DNA double helix

Web site
http://www.youtube.com/watch?v=qy8dk5iS1f0

The two strands of the DNA run in **opposite directions** – i.e. they are **anti-parallel** with deoxyribose at the 5′ end and phosphate at the 3′ end of each strand. (One strand runs in a 5′ to 3′ direction; the other runs in a 3′ to 5′ direction.)

Chromosomes consist of DNA that is tightly coiled around **proteins**. This is so that all 2 metres of it can fit into the _____ of a cell.

DNA replication

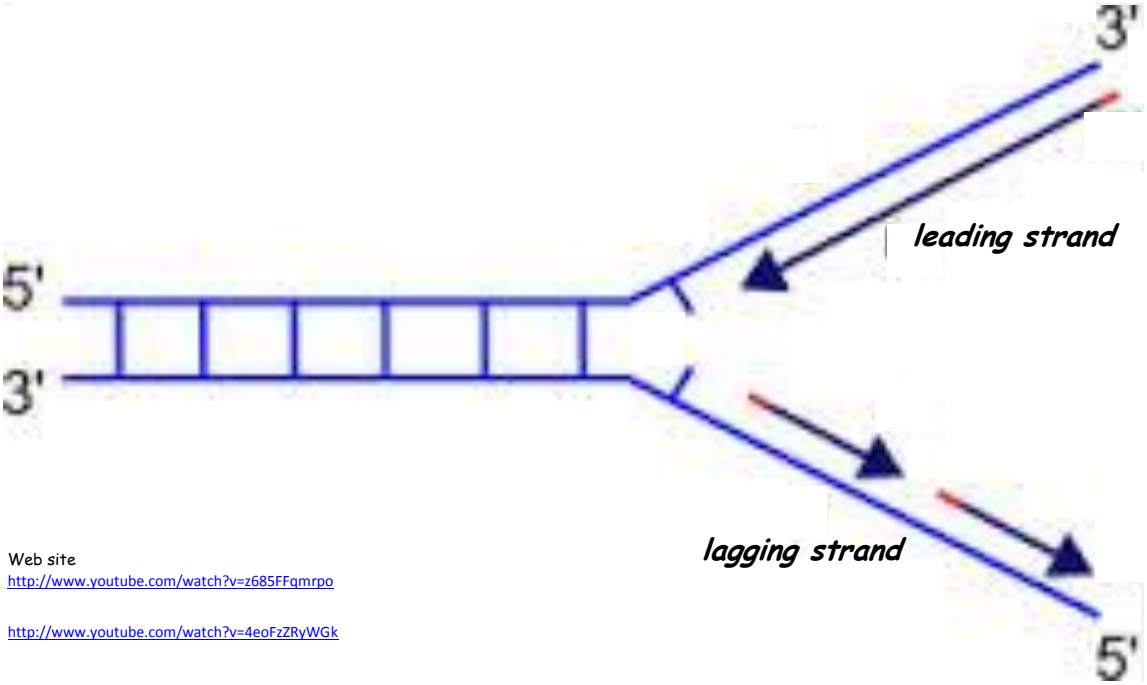
Before cells **divide**, an **exact copy** of the DNA must be made. This process is called DNA _____ . This process is important because it ensures that each **new cell** receives a full set of _____, and therefore no genetic information will have been _____.

Two **enzymes** are involved in DNA replication. The two enzymes are:

1. DNA _____
2. ligase

DNA replication begins when DNA is **unwound** and **unzipped** to form two single template strands. DNA polymerase needs a _____ to **start** DNA replication. DNA polymerase can only add free **complementary** DNA _____ to the deoxyribose **3′ end** of a DNA strand. This results

in **one** of the strands of DNA being replicated **continuously** – this is called the **leading strand**. The other strand is replicated in fragments. These fragments are then joined together by the enzyme _____ – this is called the **lagging strand**. (Ligase joins **single nucleotides together** in the continuous leading strand and also joins the DNA **fragments together** in the lagging strand.)



Web site
http://www.youtube.com/watch?v=z685FFqmrpo

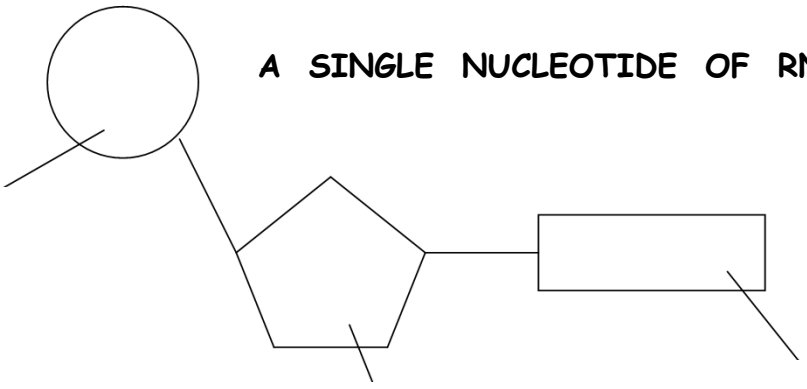
http://www.youtube.com/watch?v=4eoFzZRyWGk

Structure of RNA

There are three different types of RNA. These are:

1. mRNA (messenger RNA which carries the genetic code from DNA in the nucleus to a _____).
2. rRNA (ribosomal RNA. rRNA and proteins form the ribosome)
3. tRNA (transfer RNA – each tRNA carries a **specific** amino acid to a **ribosome**).

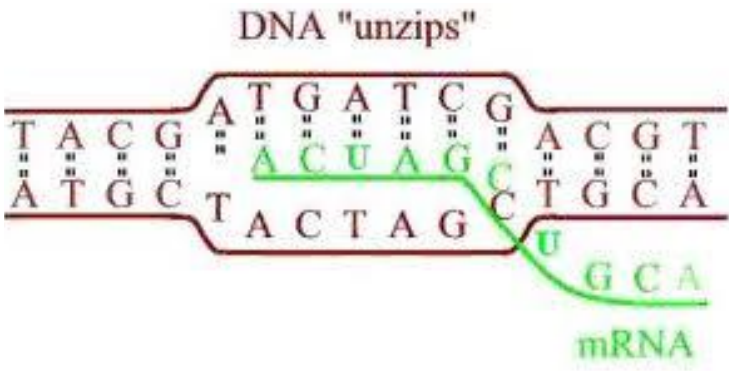
All three types of RNA are also made from nucleotides.

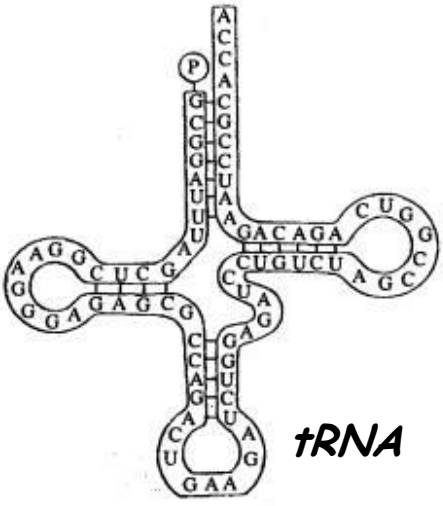


The table below summarises the differences between the structure of DNA and **mRNA**.

	DNA	***mRNA***
SUGAR		
BASES		
STRANDS		

The diagram below shows a typical mRNA and tRNA molecule.

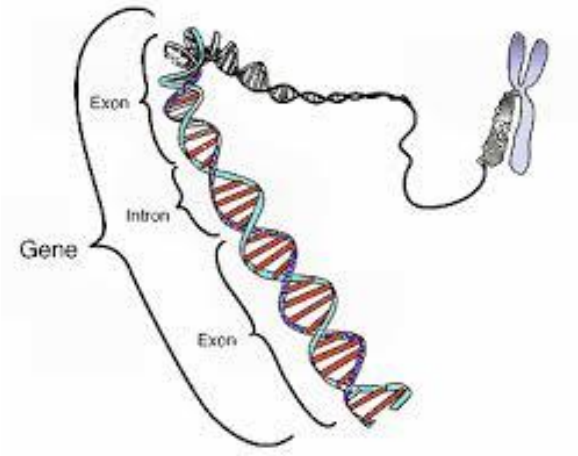


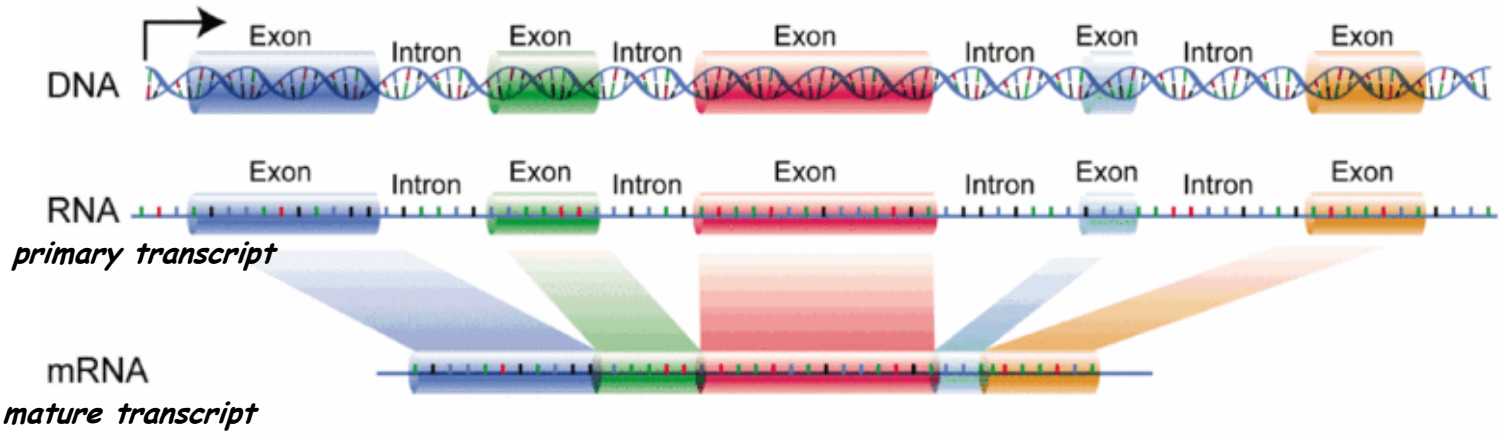


Transcription (of DNA into mRNA)

RNA polymerase moves along DNA unwinding a section of the double helix (this represents a _____) , and synthesising a primary transcript of mRNA by complementary base pairing (A-U; T-A; C-G and G-C). Genes have **introns** (non coding region of a gene) and **exons** (coding regions of a gene).

During transcription the **introns** in the primary transcript are **removed**. This process is called RNA _____. The exons are then **joined together** to form the mature transcript mRNA as shown in the diagram at the top of next page.





Web site

http://www.google.co.uk/url?sa=t&rct=j&q=RNA+splicing+site%3Ayoutube.com&source=web&cd=3&cad=rja&uact=8&ved=0CD8QtwIwAg&url=http%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DaVgwr0QpYNE&ei=roBrU7jtDIeGOPa8gPgN&usg=AFQjCNGZ_SShG3NSuKlR3H4XA1IZoZRuaQ

The mRNA now holds the genetic code which provides the **recipe** to make a protein e.g. haemoglobin, insulin etc. **Three** bases in a row (one after the other) on the mRNA strand "code" for **one** specific _____ _____. A **triplet** of **three bases** on an **mRNA** strand is called a _____. It is for this reason that the genetic code is called a "**triplet**" code.

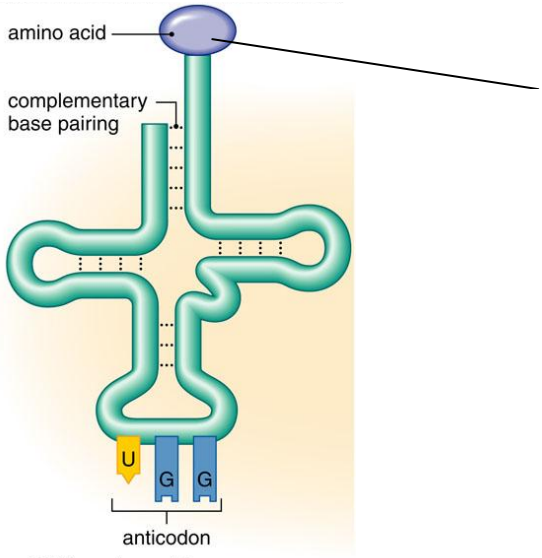
One gene, many proteins

Different mRNA molecules are produced from the **same primary transcript**. This is due to the fact that during RNA **splicing**, exons are sometimes removed **along with** the intron(s) next to them. [All the _____ are always removed from the primary RNA transcript]. This is called _____ **RNA splicing**.

This means that the same primary mRNA transcript has the potential to produce **several different mRNA molecules**. Each mRNA molecule will have a different sequence of base triplets and each mRNA molecule will therefore code for a **different** polypeptide/protein. In other words, one gene can code for **several different** proteins – remember this depends on which exons have been discarded during mRNA splicing.

tRNA structure and function

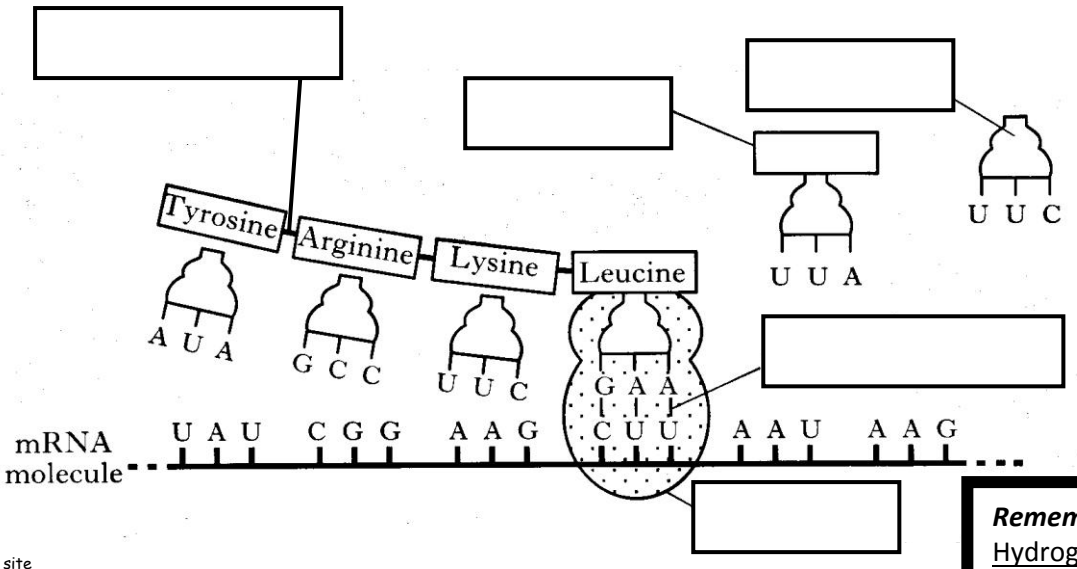
The **folds** in a tRNA molecule are due to base pairing as shown in the diagram below.



At one end of each tRNA molecule is a **triplet** of bases called an _____. At the opposite end is an _____ _____ which the tRNA molecule is responsible for carrying to a _____. It is the **anticodon** that will **determine** the _____ amino acid that each tRNA molecule will pick up and then carry to a ribosome.

Translation (of mRNA into a polypeptide chain)

mRNA is translated into a _____ chain (a short chain of 6 – 8 amino acids joined together) at a _____. The diagram below shows what happens during **translation** (of mRNA into a polypeptide).



Web site
http://www.youtube.com/watch?v=B6O6uRb1D38

Remember Bonds
Hydrogen - between bases.
Peptide – between amino acids.

Before translation can **begin**, a ribosome must bind to **one** of the ends of the mRNA strand. The **first three bases** on this mRNA strand (i.e. the first codon) is called a _____ codon. Eventually a final codon, called the _____ codon on the mRNA is reached and the ribosome releases the newly synthesised polypeptide chain. This process **requires energy** which is provided by **ATP**.

The **sequence** of the **codons** on the mRNA strand will determine the sequence of the _____ _____ in the polypeptide that will be synthesised. Note that the anticodons on the _____ are **complementary** to the _____ on the mRNA strand as shown in the diagram on the previous page. After a _____ bond has formed between two adjacent amino acids, the tRNA molecule is released from the amino acid and it then leaves the ribosome to go and pick up another one of its specific amino acid present in the cytoplasm.

Remember:
Transcription - in **nucleus**.
Translation - at **ribosome**

After translation, the structure of the protein is modified. This is done through the cutting and joining of polypeptide chains or by the addition of a carbohydrate or a phosphate group to the final protein molecule.

Web site
http://www.google.co.uk/url?sa=t&rct=j&q=translation+animation&source=video&cd=17&cad=rja&ct=8&ved=0CHIQtwIwBjgK&url=http%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3D-zb6r1MMTkc&ei=2I5wU47uOYin0AW_iICoCw&usg=AFQjCNEw4L7w_4hsU3B3aAIcCQUN9wmyJg

mRNA versus tRNA

Structural differences between mRNA and tRNA are summarised below.

Similarities	Differences
• Both contain the bases A, U, C and G	• tRNA is **folded**, mRNA is not • tRNA has base pairing, mRNA hasn't • mRNA is single-stranded; tRNA is double stranded

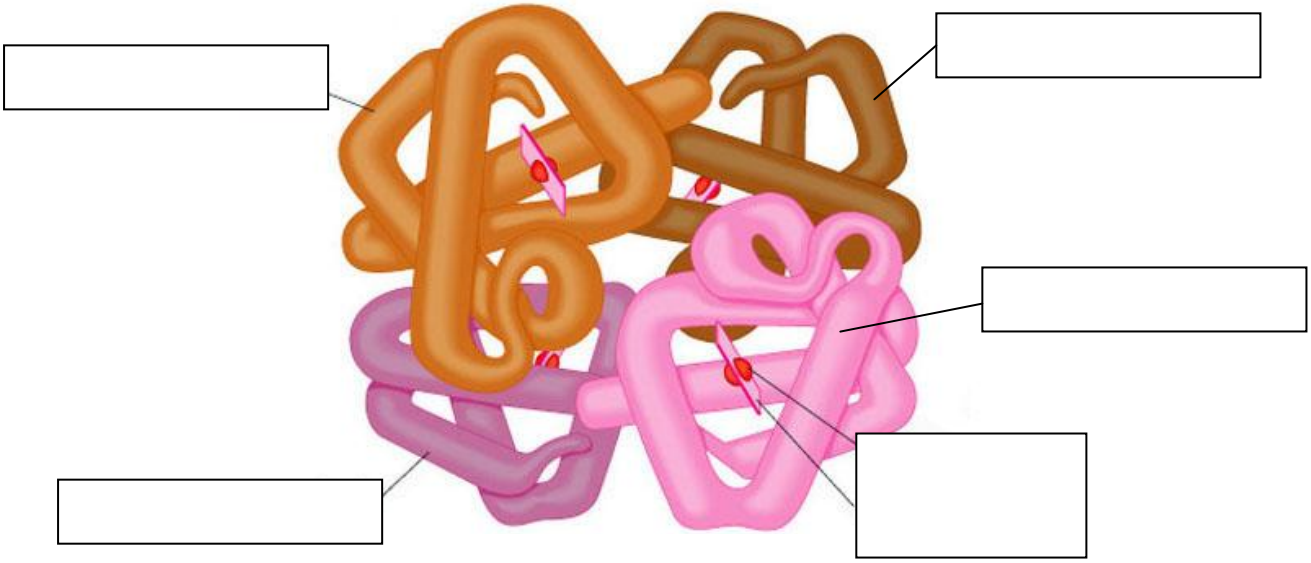
Gene expression – through protein synthesis

Gene expression (i.e. whether a gene is "switched on" or "switched off") is controlled by regulating the processes of transcription and _____. mRNA is **transcribed** from _____ in the nucleus and then it is **translated** into a _____ by ribosomes in the cytoplasm. An organism's _____ is determined by the **proteins** produced as a result of genes **being expressed** (i.e. "switched on"). Only a fraction of the genes in any one cell are actually expressed. The genes that are expressed are influenced by intra- and extra-cellular environmental factors.

Genes and proteins in health and disease

Proteins have a large variety of structures and shapes. This results in them having a wide range of _____. Amino acids are linked by _____ bonds to form a _____ chain. The polypeptide chains then fold to form a particular **three dimensional shape.** These chains are held together by peptide bonds, hydrogen bonds and other interactions that form between different amino acids. The diagram below shows the structure of the oxygen-carrying protein _____ present in red blood cells.

Haemoglobin molecule - do not learn



Refer to page 16 of the Unit 1 National 5 Biology booklet for further examples of proteins.

Mutation and genetic disorders

Genetic disorders are caused by changes to genes or _____ - these changes are called _____. Mutations result in _____ either **not being synthesised** at all or proteins which are synthesised not _____ properly.

Single gene mutations

Single gene mutations happen when the _____ of the bases (nucleotides) in the **DNA** that a gene is made of is **altered**.

There are **three** different types of single gene mutations:

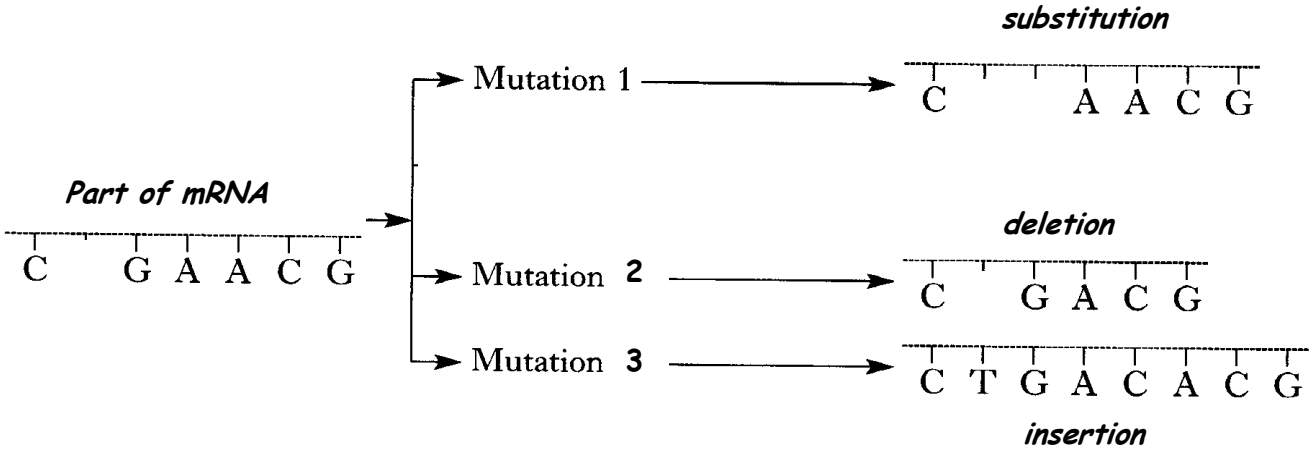
1. **substitution**
2. **insertion**
3. **deletion**

} of DNA bases/nucleotides

Duchenne muscular dystrophy (DMD) , cystic fibrosis (CF) and PKU are just three examples diseases/conditions that are caused by a single gene mutation. These are not diseases that can develop, people are **born** with them because they have **inherited** a _____ gene from one or both of their parents. The diagram below shows how these three **single gene mutations** can affect the _____ of the bases in the DNA of which a gene is made, which in turn affects the order of the bases in _____.

Web site
http://www.youtube.com/watch?v=d7orBvuiZDw

Web site
http://www.youtube.com/watch?v=d7orBvuiZDw



Single base/nucleotide **substitution mutations** include:

Missense: where one amino acid **codon** is **replaced** with another **different** amino acid **codon**. In the above example (mutation 1) the amino acid codon CUG is **replaced** by the amino acid codon ***CGG***. This results in **only one** _____ _____ in the sequence being **changed**.

Nonsense: where **one** amino acid codon is **replaced** with a premature _____ codon. The effect of this type of mutation is to bring the process of _____ to a **premature stop** and the polypeptide chain will be _____ than it should be. This is the type of mutation that causes Duchenne Muscular Dystrophy(DMD).

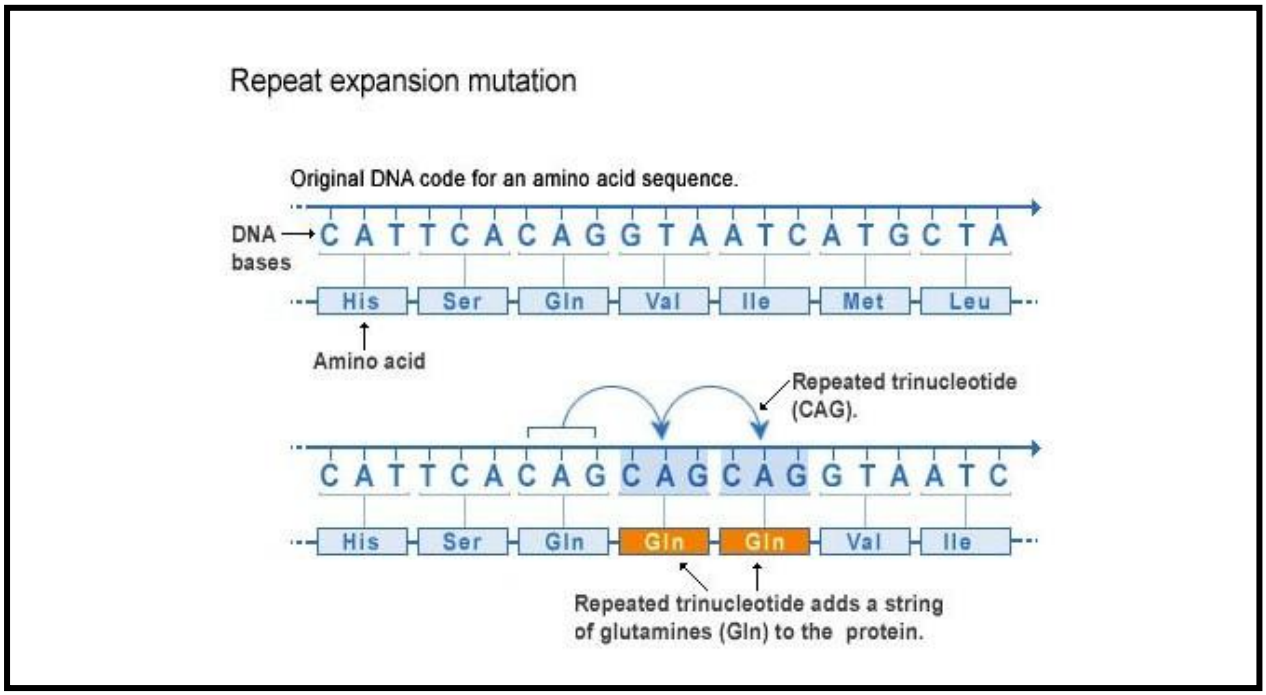
Web site
http://www.google.co.uk/url?sa=t&rct=j&q=duchenne%20muscular%20dystroophy%20site%3Ayoutube.com&source=web&cd=8&cad=rja&uact=8&ved=0CGwQtwIwBw&url=http%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DAF4D4TyE9NM&ei=IldrU4n0LKrX0QXPh4GwCw&usg=AFQjCNGxEjNA-8NnaepYgzVQwKLEXsEHCg&bvm=bv.66330100,d.d2k

Splice-site: RNA splicing is controlled by **specific** base/nucleotide **sequences** found at a **splice site** on the primary RNA transcript where introns flank exons. (Remember RNA splicing is when _____ are **removed** from the primary mRNA transcript leaving only the _____ which then produces the mature mRNA transcript – see pages 6/7). If a **mutation** occurs in an **intron** in the primary RNA transcript it will not be _____. Instead, it will be **retained in error** and so ends up in the mature mRNA transcript. If one or more introns are retained in the mature mRNA transcript, this results in the production of a _____ that **does not** _____ properly.

Insertion and deletion mutations

Insertion and deletion mutations result in **frameshift** mutations. During translation, mRNA is read as a series of _____ (triplets). Therefore if a base/nucleotide is **inserted** or **deleted** from a gene (DNA), **every codon** after where the mutation has occurred will be altered during transcription. This in turn, alters every _____ _____ **after** the mutation site. The protein formed is almost certain to be non-functional – in other words the protein **will not work**.

Another type of **insertion** mutation is a **nucleotide sequence repeat expansion**. This occurs when the **same triplet** i.e. when the **same sequence** of 3 _____ bases (e.g. CAG) on the original DNA is **inserted** into the same DNA strand **after** the **original** triplet of bases/nucleotides as shown in the diagram below.

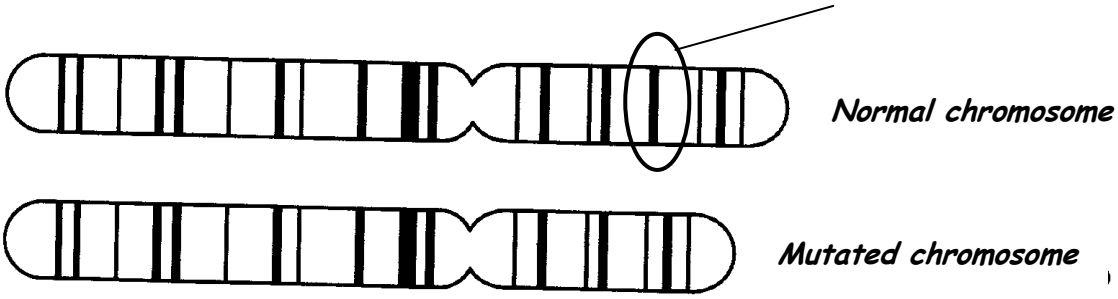


Again, this will result in a protein being synthesised that is almost certain to be non-functional.
These gene mutations **can affect** the _____ of individuals as they can result in conditions such as Tay-Sachs syndrome.

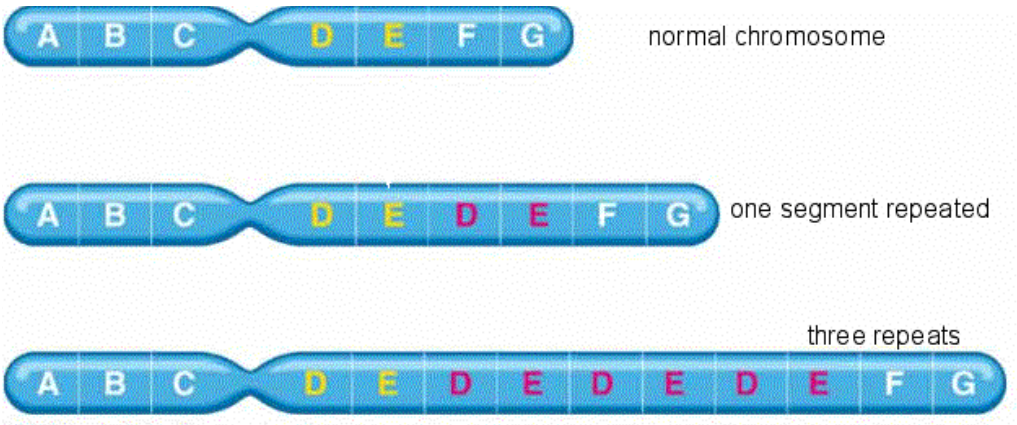
Altered Chromosome Structure and Genetic Disorders

A chromosome mutation occurs when the _____ of a chromosome is altered. There are three main types of chromosome mutation:

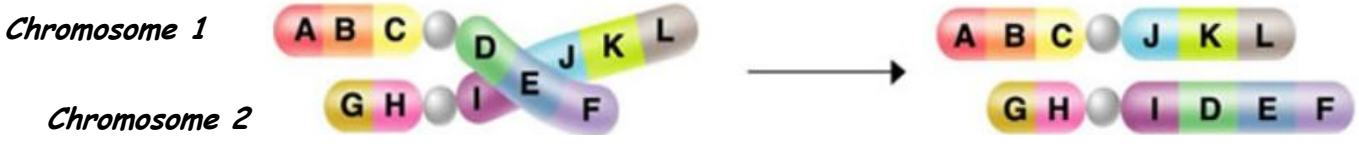
1. **Deletion** (the loss of a segment of a chromosome)



2. **Duplication** (the repetition of a segment of a chromosome)



3. **Translocation** (when a section of one chromosome breaks off and becomes attached to another chromosome that **is not** its _____ partner).



These substantial changes in chromosome _____ often results in these mutations being **lethal** (i.e. they result in the _____ of the organism.

Human Genomics

Advances in faster and cheaper computer processing has made it possible to determine the **sequence of DNA bases** for individual _____ and entire **genomes**. A genome is the **complete DNA** of an organism.

Bioinformatics is when _____ are used to analyse the sequence of **bases** in DNA and the sequence of _____ _____ in proteins.

Systematics compares the human genome to the genomes of **other species**. This then provides information on _____ **relationships** and the **origins** of **related** species.

Personalised medicine is based on an **individual's genome**. By understanding the link between a person's genes and certain diseases could lead to **personalised** medicine. For example, it may be that individuals carrying a particular allele of a gene have an _____ **risk** of developing a particular disease like breast cancer. Once this is known, a patient's medicines will be specifically geared **to them** resulting in **increased drug efficiency** whilst reducing side effects. This means that in the future, "the one size fits all" approach would be consigned to history.

Sequencing DNA

Many **copies** of a specific segment of DNA can be produced using a technique called _____ _____ _____ (PCR for short). The copying (_____) of this DNA segment is done *in vitro* – outside the body. In order to amplify (copy) DNA, three things must be present:

1. many of the four free _____ of DNA
2. **primers** these are _____ to a specific target sequence of bases at the **two ends** of the region of DNA that is to be amplified
3. DNA **polymerase** this is a heat-tolerant _____. The DNA polymerase synthesises two complementary strands of DNA by joining the free DNA _____ together.

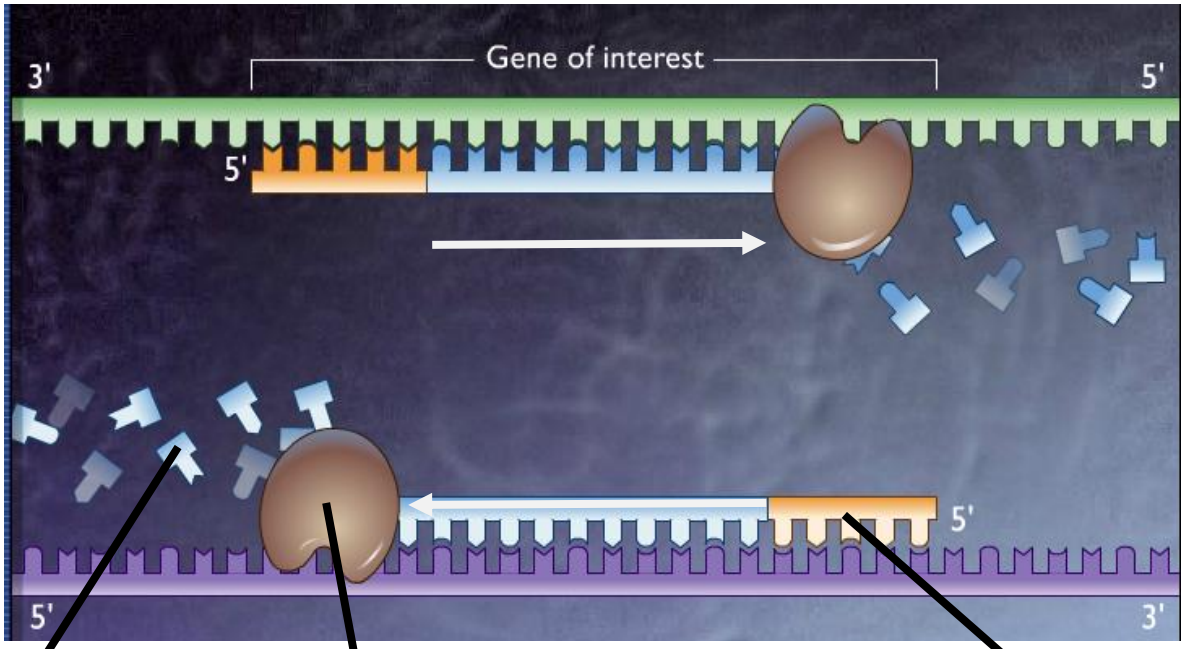
Stages of PCR

1. DNA is firstly **heated** in order to _____ the two strands (by **breaking** the _____ bonds between the complementary bases). This is called _____ .
2. The DNA is then **cooled**. Cooling allows the _____ to bind to the complementary target sequences. This is called _____.
3. Heat-tolerant _____ _____ then replicates (copies) the of DNA (by joining free DNA _____ together) using the _____ as a starting point.

Repeated cycles of heating and cooling are used to amplify this section of DNA. It would take _____ cycles to produce 64 molecules of DNA from **one** DNA double helix. After only 21 cycles, one molecule of DNA can be amplified to produce over a million copies!!!! This is called _____ .

The diagram below outlines what happens during PCR.

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



1

2

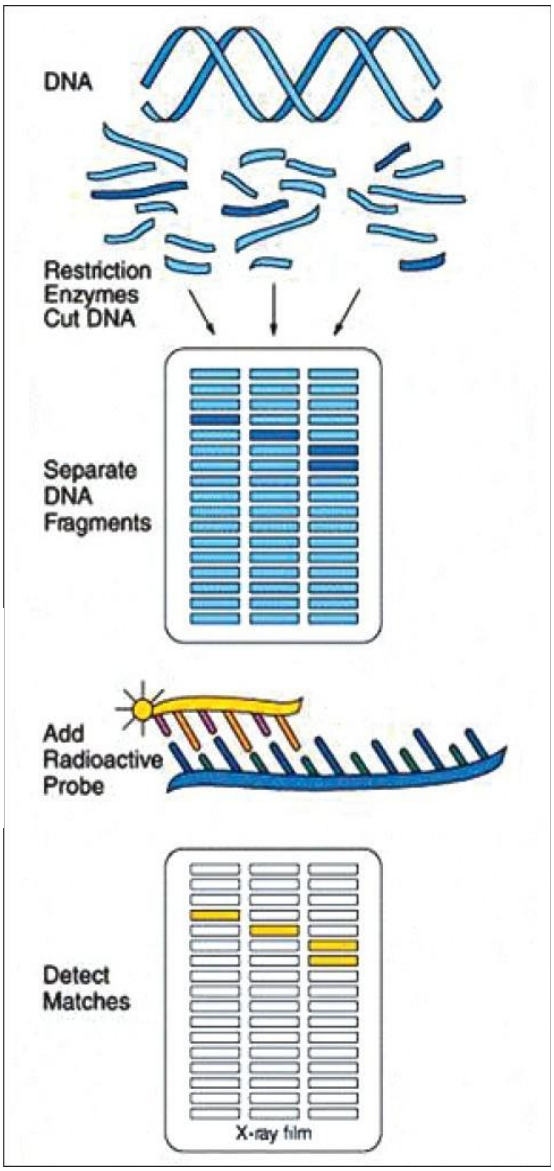
3

DNA probes

DNA probes are used to detect the presence of **specific DNA base sequences** in a sample of DNA – this is called DNA _____. A DNA probe is a short, _____ -stranded man-made fragment of DNA that is **complementary** to the specific sequence of DNA bases that are being tested for. **If the target sequence is present**, the probe will **bind** to it via complementary _____ pairing. The probe can then be detected using a **fluorescent** or **radioactive** label. DNA probes can be used to detect single gene mutations. They are also used to determine who the _____ of a child is (Jeremy Kyle would be out of a job without DNA paternity tests!!) or for solving _____. Many **different DNA probes** can be used on a microarray (1000's of genes) to give a fuller DNA profile.

Web site
http://www.google.co.uk/url?sa=t&rct=j&q=what+is+a+microarray&source=web&cd=4&cad=rja&uact=8&ved=0CEcQFjAD&url=http%3A%2F%2Flearn.genetics.utah.edu%2Fcontent%2Flabs%2Fmicroarray%2F&ei=1SUwU47DO5Hy7AbZs4G4Bg&usg=AFQjCNEMqM5YlBl30nFPfe7alpK7r7JeNg

1. DNA is cut into fragments of varying lengths.



2. The fragments are separated according to their length.

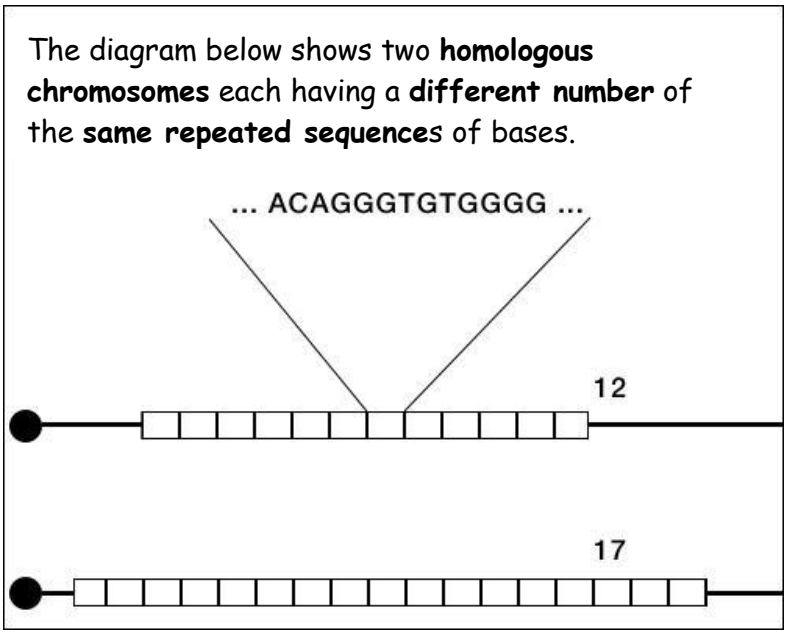
3. A probe with a known base sequence is added. If it is complementary to a base sequence on a fragment, it binds to this fragment via complementary base pairing.

4. If there is a match, it shows up.

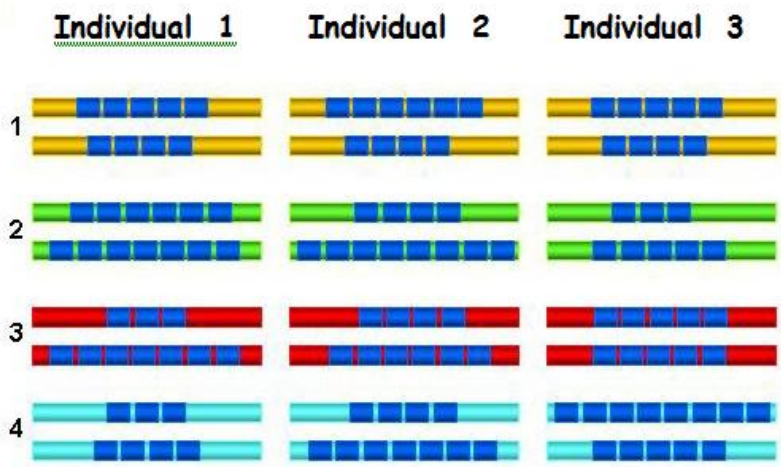
Medical and Forensic Application

By screening a cell sample from a patient for the presence or absence of a particular nucleotide / base sequence (called DNA profiling), a diagnosis of a **disease** can be made **or** how **at risk** they might be of getting a disease or **passing** a disease on to their children can be worked out. DNA profiling allows the identification of individuals through comparison of regions of the genome with **highly variable** numbers of **repetitive sequences** of DNA.

These highly variable number of repetitive sequences of DNA are located on chromosomes. An example of a repeated sequence of DNA bases is shown below.



These repetitive sequences of DNA have been useful in forensic crime investigations as the possibility of two people having the same number of these repeated sequences is **extremely low** as shown below.



The numbers of repeat sequences even between _____ chromosomes are usually different as demonstrated by the diagram on the previous page. Since these repetitive sequences are a part of a chromosome, they are **inherited** from **both** parents. Family relationships can then be confirmed by the number of repetitive sequences that they _____.

Cell Metabolism

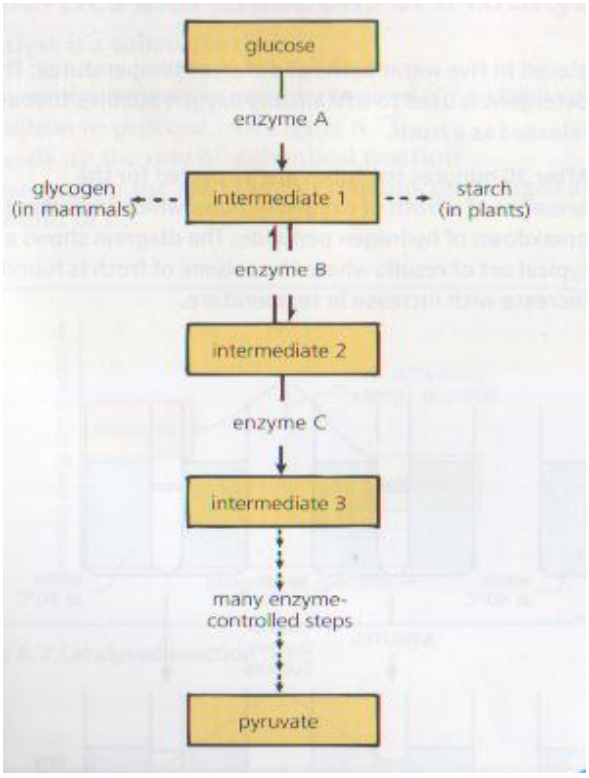
Metabolism is **all** the _____-controlled reactions that occur in a cell at the **same time**. These reactions involve **pathways** where one compound is converted into a different compound. Compounds can either be broken down (**catabolism**) or synthesised (**anabolism**). Anabolic reactions require an **input** of **energy;** catabolic reactions usually **release** energy.

Aerobic respiration is an example of _____ which releases energy. This energy can then be used for the synthesis of proteins from amino acids Which is an example of _____ .

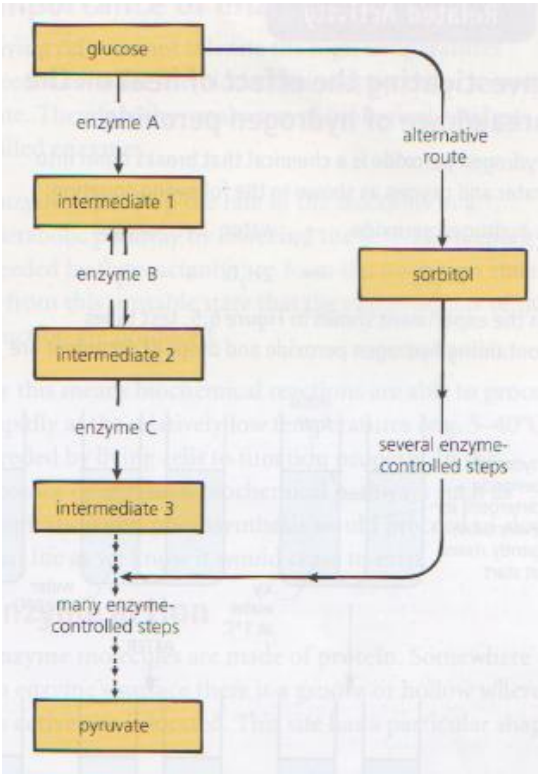
Metabolic pathways can be **reversible** or **irreversible** e.g. during fermentation,

1 pyruvate to lactic acid in _____ cells is **reversible**
2 pyruvate to ethanol and CO_2 in _____ cells is **irreversible.**

Alternative routes that can **bypass** steps in a pathway may also exist as shown below.



Example of a metabolic pathway



Alternative route

Control of metabolic pathways

Metabolic pathways are controlled:

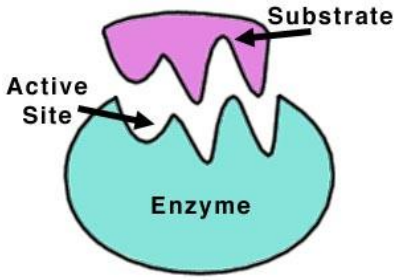
1 by the **presence** or **absence** of particular _____ in the metabolic pathway and

2 through the **regulation** of the _____ (speed) of reaction of key enzymes within the pathway. (Regulation can be controlled by intracellular or extracellular _____ molecules.)

Enzyme action

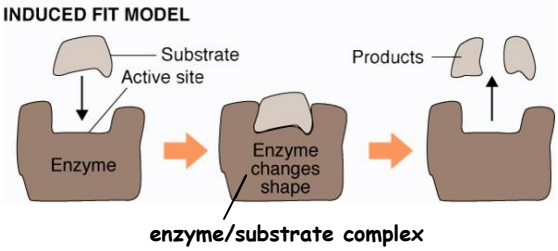
Enzymes are _____ because they only react with **one** substrate. The activity of enzymes is linked to their _____ . The part of an enzyme molecule into which the **substrate fits** is called the _____ _____ as shown in the diagram below.

Web site
http://www.bbc.co.uk/schools/gcsebitesize/science/videos/enzymes_video1.shtml



Induced fit model of enzyme activity

The basic mechanism by which enzymes catalyse reactions begins with the binding of the **substrate** (or substrates) to the active site on the enzyme.
The **active site** has a unique shape that is _____ to the shape of the substrate molecule(s).
When the enzyme and substrate form a complex, structural changes occur so that the active site fits precisely **around** the substrate, in other words, the substrate **causes** (induces) the **active site** to change _____ .



Web site
http://www.google.co.uk/url?sa=t&rct=j&q=howenzymes+work&source=web&cd=7&cad=rja&uact=8&ved=0CE8QFjAG&url=https%3A%2F%2Fhighered.mcgraw-hill.com%2Fsites%2F0072495855%2Fstudent_view0%2Fchapter2%2Fanimation__how_enzymes_work.html&ei=fIlfU_2aH6Gv7AaYzIDAAQ&usg=AFQjCNFfEXPYZ7cIa6SdGbZz66oGQDpL3g

Enzymes **speed up reactions** by orientating then holding the reactants **close together** and by **reducing** the _____ energy required for the reaction to occur. The end products of the reaction have a _____ **affinity** for the enzyme than the substrate and are therefore _____ from the active site.

The direction and speed of an enzyme-controlled reaction can be affected by the _____ of **both** the substrate and end product.

Most 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**.

Enzymes often act in **groups** where the product of one reaction becomes the substrate for the next, or as **multi-enzyme complexes** where a number of enzymes work **together** at the same time on the **same substrate molecule(s)**, as demonstrated by pyruvate dehydrogenase which is a complex of **three different enzymes** that **collectively** catalyse the breakdown of pyruvate at the end of _____ .

Regulation (control) of metabolic pathways

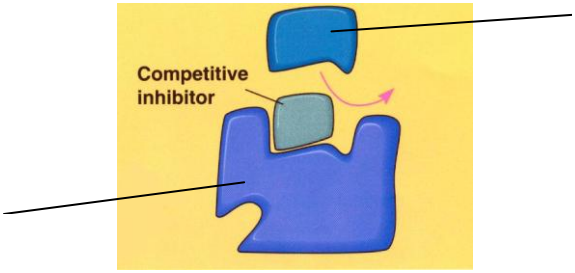
The _____ that are responsible for the production of **some** enzymes are **continuously** expressed ("switched on"). These enzymes are therefore **always present** in the cell. **Control** of **enzymes activity** is achieved via **regulating** the _____ **of the reaction** that they catalyse. An **enzyme inhibitor** is a molecule that can affect the rate of a reaction. It does this by either _____ the active site of an enzyme or by _____ the enzyme.

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

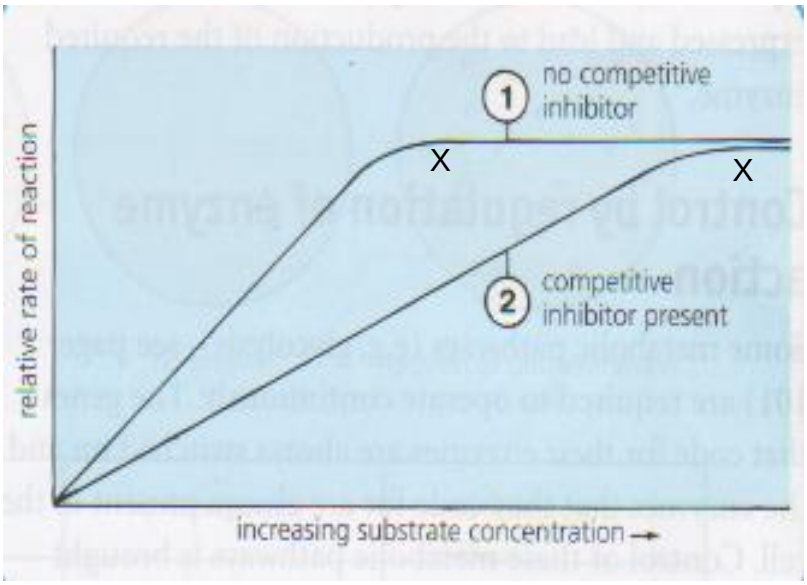
1. competitive inhibition
2. non-competitive inhibition **or** stimulation
3. feedback inhibition

1 Competitive inhibition

This type of inhibition occurs when a molecule that resembles the **shape** of the **substrate** competes with the _____ for the active site as shown in the diagram below.



This can be **reversed**, and therefore the rate of the reaction can be increased by _____ the **concentration** of the **substrate** molecules as shown in the graph on the following page.



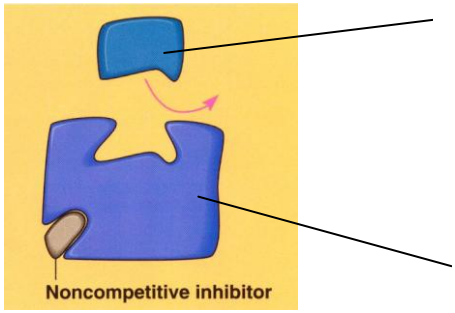
When a **competitive** inhibitor **is** present (graph 2), the **rate** of the reaction is _____ compared to a reaction when **no** inhibitor is present (graph1).

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 _____ as shown in graph 2. This **does not happen** with a non-competitive inhibitor.

When the graph levels off (at point X on both graphs) some factor other than substrate concentration must now be _____ the rate of the reaction e.g. _____.

2 Non-competitive inhibition/stimulation

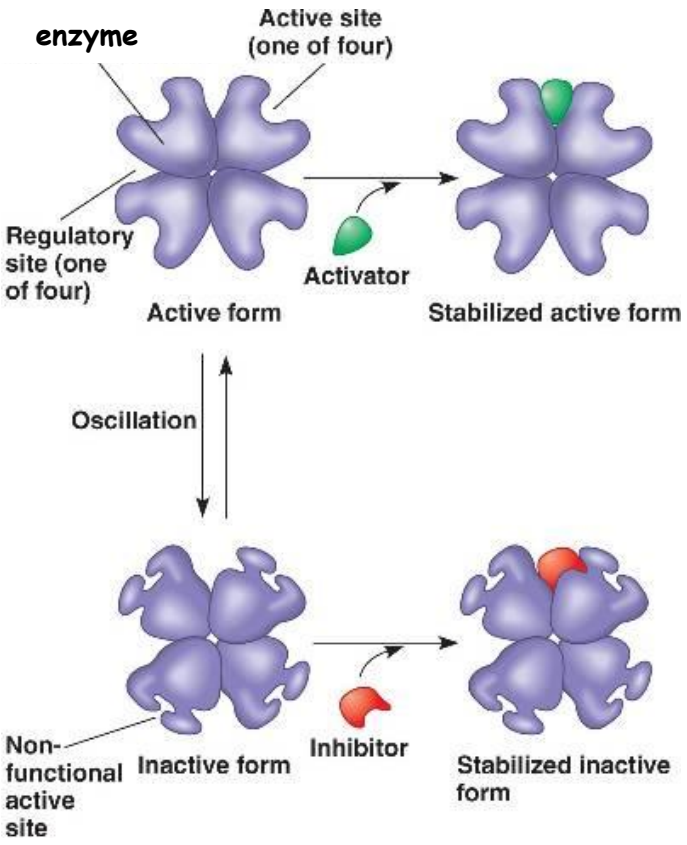
These molecules affect the activity of an enzyme by changing the shape of the enzyme's _____ _____ when they bind to it. This prevents the binding of the _____ as shown below and can either inhibit **or** stimulate enzyme activity.



Note that this type of molecule binds to a part of the enzyme molecule **away from the active site**.

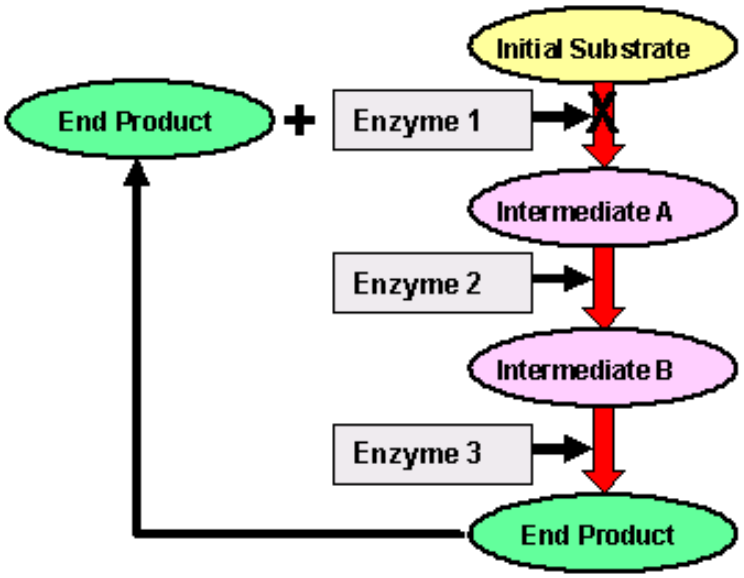
These molecules can either inhibit or _____ a reaction. One type of molecule when it binds to the enzyme, stabilises the **active** form of the enzyme and this _____ the **rate** of the reaction. (This type of molecule is called an _____). Another different type of molecule, when it binds to the enzyme, stabilises the **inactive** form of the enzyme and this _____ the rate of the reaction. (This type of molecule is called an _____). This is shown by the diagram on the next page.

Web site
http://www.google.co.uk/url?sa=t&rct=j&q=mcGraw%20Hill%20enzyme%20inhibitors%20site%3Ayoutube.com&source=web&cd=1&cad=rja&uact=8&ved=0CDEQtwIwAA&url=http%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DPILzvT3spCQ&ei=sZ5fU_7wGIyv7Qb16IHICg&usg=AFQjCNGq7erOYQ09G4BpEGEzURy7m7oyKg



3. Feedback inhibition

This occurs when the end product of a metabolic pathway binds to the _____ enzyme involved in the pathway, thus reducing that enzyme's activity. This slows down the metabolic pathway by preventing the production of more of the _____ _____ until its concentration **falls** and the **inhibition is removed**.



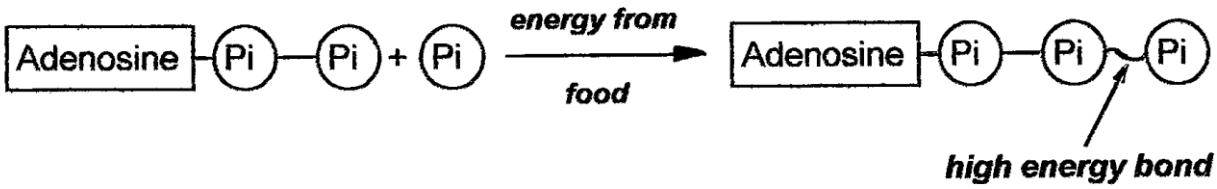
Web site
http://www.youtube.com/watch?v=4Y0mxJ7BPGA

Cellular Respiration

Respiration involves a series of _____-controlled metabolic steps which releases the _____ energy in food.
Some of this energy from food ends up being **transferred** to a high energy compound called _____.

ATP

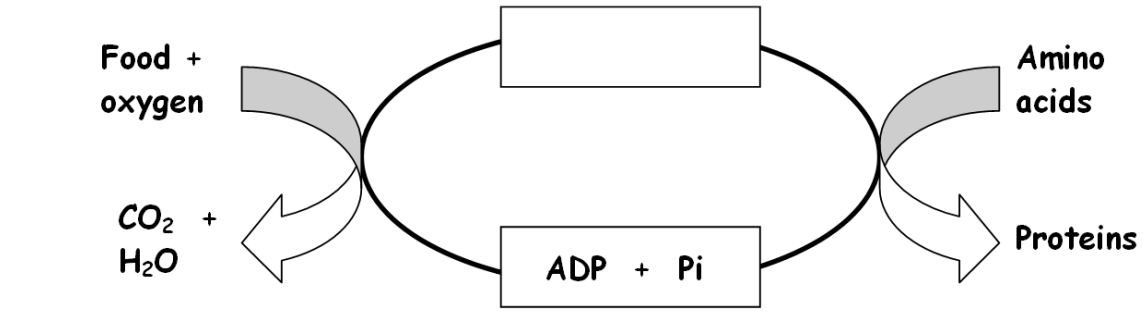
ATP is made by joining a **ADP** with a single inorganic phosphate (**Pi**) molecule. To join these two molecules together requires **energy**. This energy comes from food (e.g. _____) .



When cells require an _____ source of energy, the "high energy" bond between the last two _____ molecules **breaks** and energy is released for **cellular processes** that include:

- muscle _____
- _____ transport
- mitosis/meiosis (to separate the chromosomes)
- DNA _____
- _____ synthesis

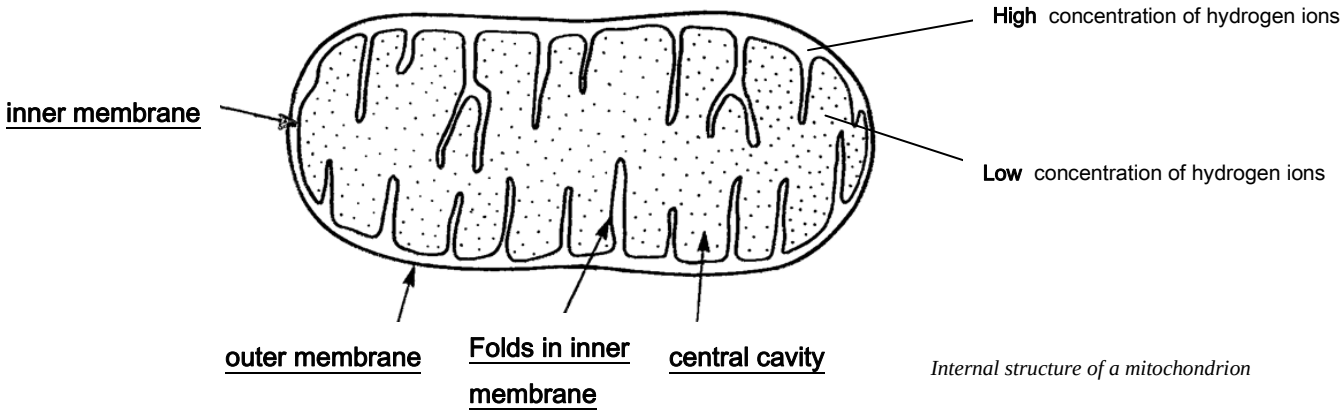
Cells need a **constant supply** of ATP, so it is re-generated as quickly as it is broken down. The importance of ATP to cells is that it _____ **chemical energy** by acting as a **link** between aerobic respiration and other cellular processes which require ATP to drive them e.g. protein synthesis as shown in the diagram below.



Phosphorylation

Phosphorylation occurs when a _____ group (supplied by the breakdown of ATP) is _____ to a molecule. The addition of this phosphate group **alters the reactivity** of the molecule to which it has been added.

To synthesise the bulk of its ATP requirements, a cell uses a source of high energy _____ to pump _____ ions across the inner membrane of a mitochondrion _____ a concentration gradient. This helps to maintain a higher concentration of hydrogen ions on one side of the membrane as shown below.



Internal structure of a mitochondrion

The **return flow** of these hydrogen ions (from a high to lower concentration by _____) **rotates** part of an inner membrane protein which is called ATP synthase. ATP synthase is an _____ and it is involved in the synthesis of ATP from ADP and Pi.

Web site
http://www.google.co.uk/url?sa=t&rct=j&q=atp%20synthase%20animation&source=web&cd=2&cad=rja&uact=8&ved=0CDgQFjAB&url=http%3A%2F%2Fvcell.ndsu.edu%2Fanimations%2Fatpgradient%2Fmovie-flash.htm&ei=eJtoU-7fLIOb0AWlhIDACA&usg=AFQjCNHTkQAg92xKN0zsVVufS3kZM1YY3w

The Chemistry of respiration

The metabolic pathways of cellular respiration are central to metabolism. In short, the whole point of respiration is to break down glucose in a series of enzyme-controlled steps during which _____ and high energy _____ are removed from the original glucose molecules and then used to produce ____.

Respiration can be divided into **3** separate but **continuous** processes:

1. _____
2. The _____ _____ cycle
3. The _____ transport chain

Glycolysis

Glycolysis takes place in the _____ of a cell. No _____ is needed for glycolysis to occur. Glycolysis a chain of enzyme-controlled steps where glucose is broken down into _____.

Glycolysis itself, is split into two enzyme-controlled phases:

Phase 1: **<u>Investment</u> phase**

The first phase is the **energy** _____ **phase** where **<u>2</u>** ATP molecules are **used up** per molecule of glucose. This is because two intermediate compounds in the pathway are _____ (i.e. a **phosphate** (Pi) from the breakdown of ATP is **added** to these compounds).
The **first** of these phosphorylations leads to a product that can continue to a number of pathways and the **second** phosphorylation which is catalysed by an enzyme called _____, is an _____ **reaction** as the resulting compound only leads to the final stage of the **glycolytic pathway**.

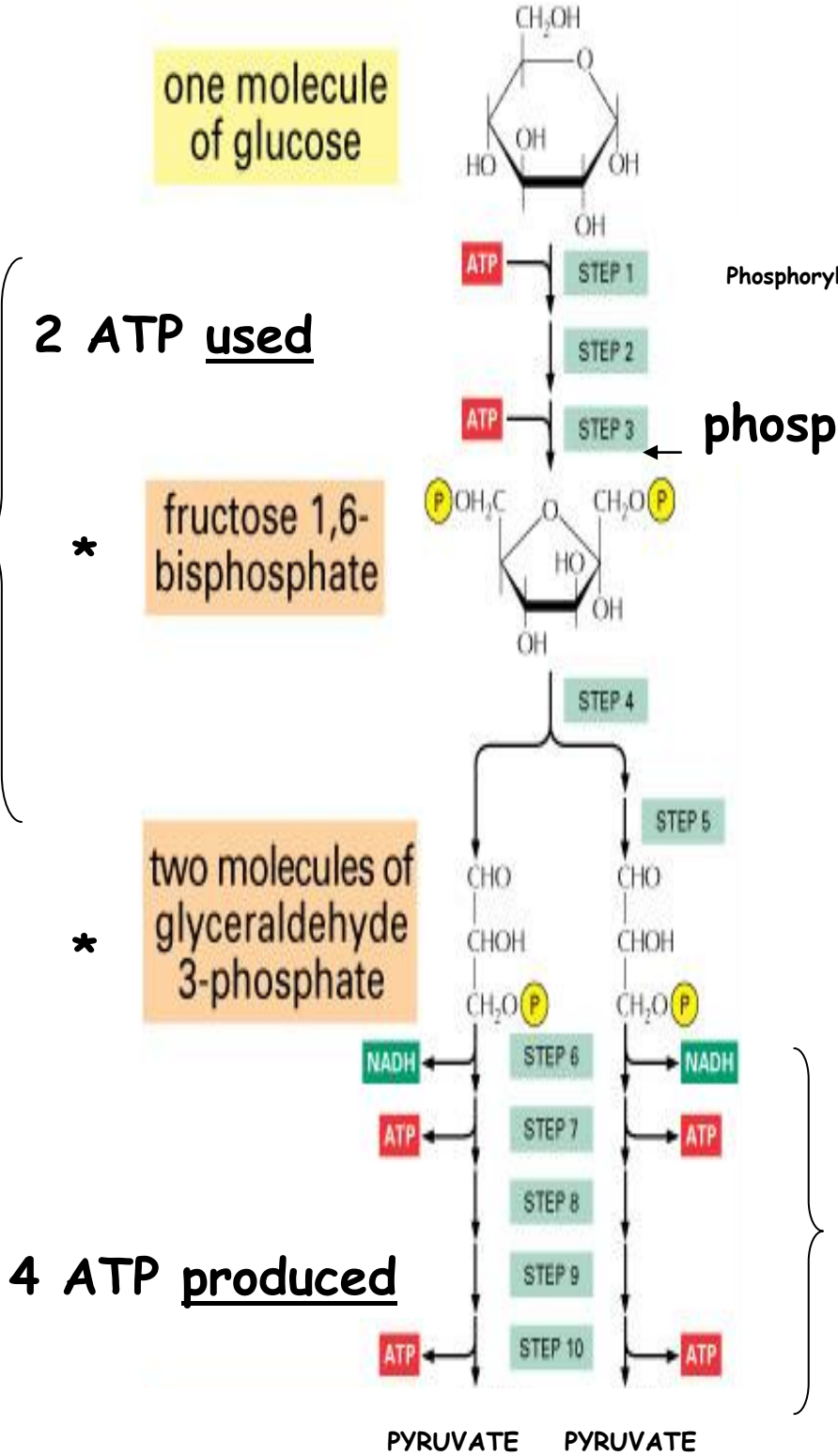
Phase 2: **<u>Pay</u> <u>off</u> phase**

The second phase is the **energy** _____-_____ **phase** where **<u>4</u>** molecules of ATP are produced per molecule of glucose. In addition, during this phase, an enzyme called _____ releases **hydrogen** ions from some of the compounds in this part of the pathway. These hydrogen ions are picked up by a carrier molecule called _____ which in turn becomes _____.

Web site
http://vcell.ndsu.edu/animations/glycolysis_overview/index.htm

The diagram on the following page outlines these two phases of glycolysis.

GLYCOLYSIS



Phosphorylation occurs at steps 1 and 3

2 ATP used

phosphofructokinase

* fructose 1,6-bisphosphate

* two molecules of glyceraldehyde 3-phosphate

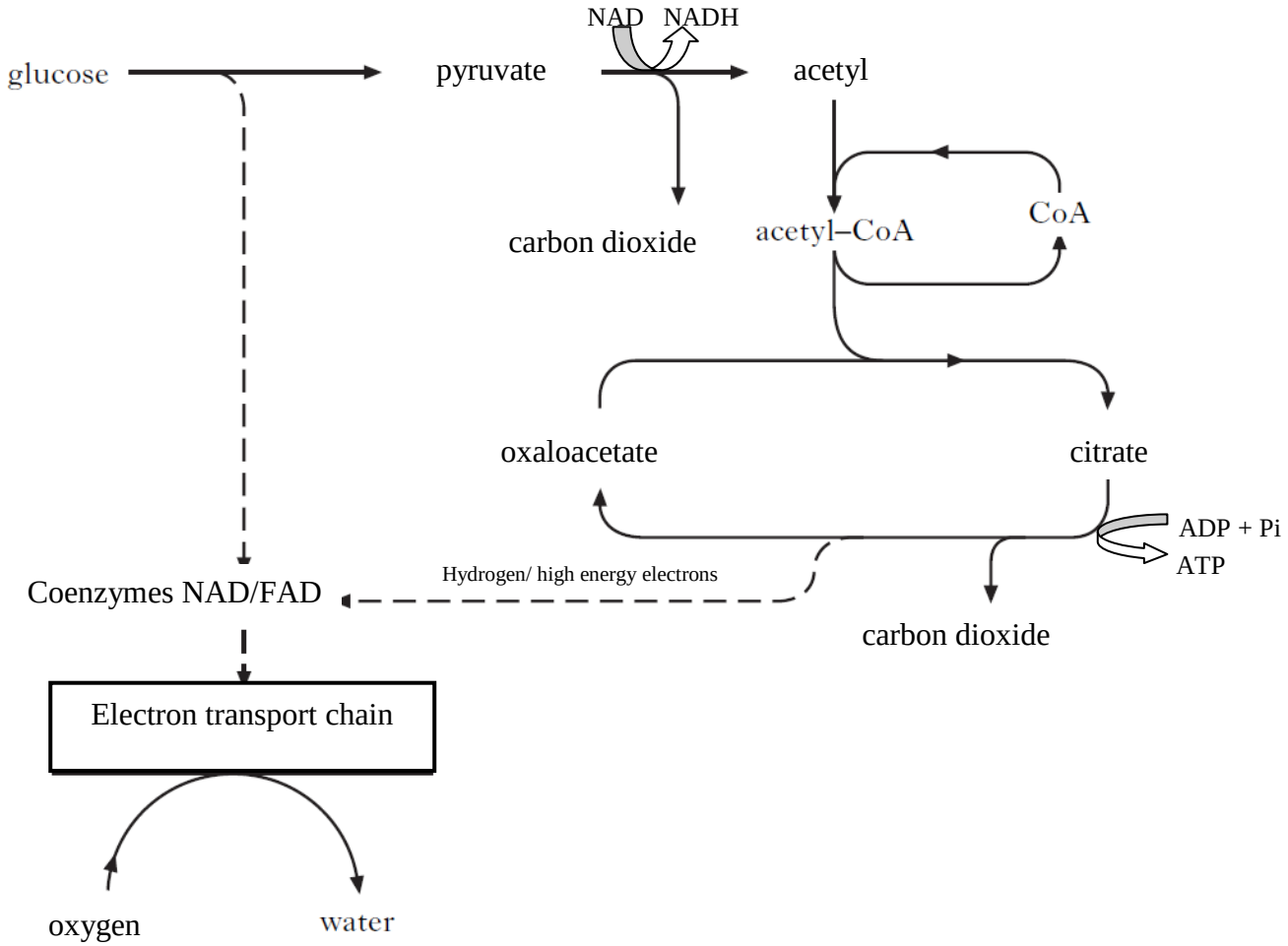
4 ATP produced

* Don't learn name of compounds

Since ____ molecules of ATP are **produced** (in the pay off phase), but ___ molecules of ATP are **used** (in the investment phase), the **NET GAIN** during glycolysis is **2** molecules of ATP (i.e. 4ATP – 2ATP = 2ATP) .

Citric acid cycle

If _____ **is present**, pyruvate is broken down into carbon dioxide **and** an acetyl group. The carbon dioxide is _____. The acetyl group then **combines** with **coenzyme A** temporarily forming acetyl coenzyme A. Coenzyme A joins the acetyl group with _____ in the citric acid cycle to form _____. (Coenzyme A is released to pick up more _____.) Citrate is **regenerated back to** oxaloacetate in a series of enzyme-controlled steps during the citric acid cycle. During these steps, _____ _____ is also **released**. Also during the citric acid cycle, _____ ions along with associated high energy _____ are removed from compounds by _____ enzymes. These hydrogen ions and high energy electrons are then passed to **other coenzymes** called _____ or _____ forming NADH or FADH2. The coenzymes **carry** these hydrogen ions to the**electron transport chain.**



The electron transport chain

It is during this third and final stage of respiration that **most** ATP is synthesised. The electron transport chain consists of a collection of _____ that are attached to the _____ membrane of a mitochondrion. NADH and FADH2 from the glycolytic and/or citric acid pathways release high energy _____. The electrons are then released from these two coenzymes to the electron transport chain where they cascade down the chain and **release energy**. This energy is used to pump hydrogen ions _____ the inner mitochondrial membrane from the inner cavity side to the inter-membrane space, where a **higher concentration** of hydrogen ions is **maintained** – see diagram on page 24. The **return flow** of these hydrogen ions drives ATP _____ and produces the **bulk** of ATP (from ADP and Pi) generated by cellular respiration.

Web site
http://www.google.co.uk/url?sa=t&rct=j&q=atp%20synthase%20animation&source=web&cd=2&cad=rja&uact=8&ved=0CDgQFjAB&url=http%3A%2F%2Fvcell.ndsu.edu%2Fanimations%2Fatpgradient%2Fmovie-flash.htm&ei=eJtoU-7fLIOb0AWlhIDACA&usg=AFQjCNHTkQAg92xKN0zsVVufS3kZM1YY3w

When the electrons come to the **end** of the electron transport chain, they **combine with** _____ . Oxygen is therefore the _____ _____ _____ . At the same time, the oxygen combines with a pair of hydrogen ions to form _____. In the **absence of** _____, the electron transport chain (and the ctric acid cyle) **does not operate**.

Web sites

http://highered.mcgraw-hill.com/sites/0072507470/student_view0/chapter25/animation__electron_transport_system_and_formation_of_atp__quiz_1_.html

http://www.google.co.uk/url?sa=t&rct=j&q=electron%20transport%20chain%20animation&source=web&cd=1&cad=rja&uact=8&ved=0CCwQtwIwAA&url=http%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DxbJ0nbzt5Kw&ei=Vu1oU-PaJvPL0AW0soHgAw&usg=AFQjCNG4HjrZMb0wDZypzrMzSNzd40FUew

Substrates for respiration

The following molecules can be used as _____ **respiratary substrates** to glucose:

1. _____ (in plant cells) and _____ (in animal cells) are both **storage carbohydrates** which are boken down to **glucose**.
2. **Other sugar** molecues (e.g. maltose and sucrose) can be converted to glucose or intermediate compounds produced during glycolysis.
3. **Proteins** can be broken down to _____ _____ and converted to intermediate compounds produced during glycolysis and/or the citric acid cycle.
4. **Fats** can also be broken down into intermediate compounds produced during glycolysis and/or the citric acid cycle.

Regulation of the pathways of cellular respiration

During glycolysis, the **activity** of the enzyme _____, can be _____ by the **accumulation** of ATP and/or citrate. This is an example of _____ **inhibition.** This meachanism helps to synchronise and regulate the **rate** of glycolysis and the citric acid cycle. Its **importance** to a cell is that:

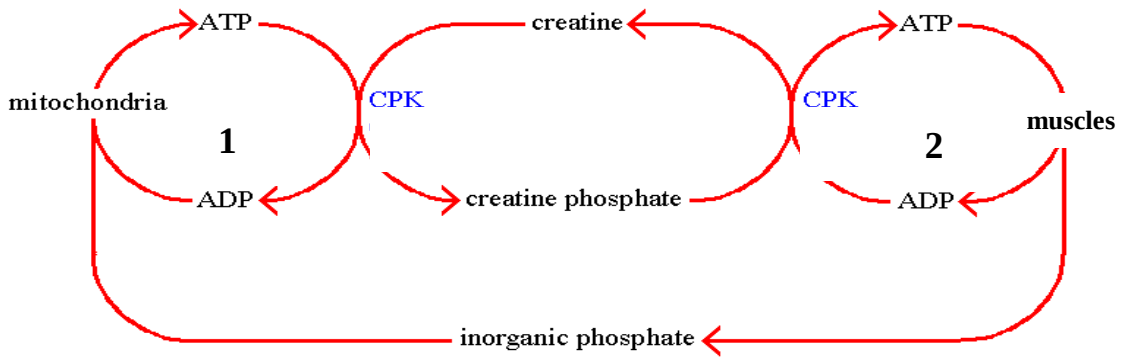
- it **prevents** the needles _____-_____ of an intermediate compounds
- ATP is only produced when it is _____
- it **conserves** _____

The creatine phosphate system

Only ATP can transfer energy to cells for cellular processes e.g. muscle conraction. During strenuous activity, muscle cells break down ATP releasing ADP and phosphate (Pi) along with _____ that muscle cells use for contraction. However, each muscle cell only **stores enough** ATP for a **few contractions**. At this point, the energy required for **repetitive** muscular contraction comes from a compound called _____ _____ which is present in the muscle cells. The creatine phsophate breaks down to provide energy and a _____ which are then used to convert ADP to ATP by phosphorylation (as shown by **2** in the daigram below). The creatine phosphate system therefore helps an athlete to sustain **maximum muscle contraction** for a _____ period of time e.g. about a 100metre sprint lasting 9 – 10 _____.

When the demand for energy in muscle cells is _____ (e.g. during rest), the ATP that is produced during cellular respiration (in the mitochondria) acts as a source of _____ **and** energy for the phosphorylation of creatine into creatine phosphate (as shown by **1** in the daigram below) which acts as a **high energy reserve** available to muscle cells during strenuous activity.

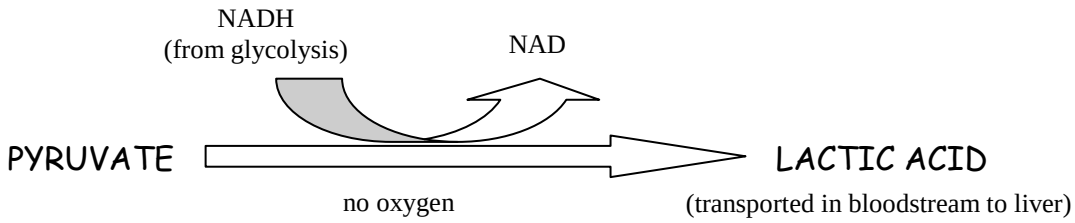
Web site
http://www.youtube.com/watch?v=t6AwXiWyybk



Lactic acid metabolism

During **vigorous** exercise, muscle cells don't get **sufficient oxygen** which is needed to support the electron transport chain. Under these conditions, pyruvate is converted to _____ _____ – a process called fermentation (_____ respiration).

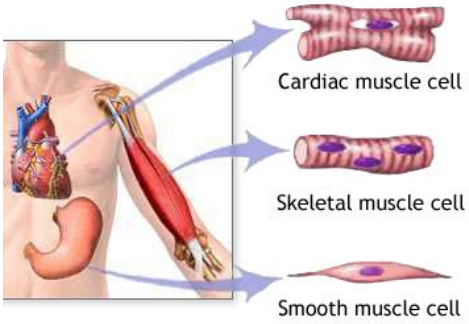
This conversion of pyruvate to lactic acid involves the transfer of _____ from NADH molecules that are produced during glycolysis (see page 26).



The NAD that is **regenerated** returns to the glycolytic pathway where it is needed to maintain ATP production.

Over time, the lactic acid _____ in the muscle cells causing _____ and an _____ _____ to build up. The oxygen debt is repayed when exercise **stops**. This then allows aerobic respiration to provide the **energy** to convert the lactic acid back to pyruvate and glucose in the liver.

Types of skeletal muscle fibres



There are two different type of skeletal muscle fibres:

1. **<u>slow</u>** twitch (type 1)
2. **<u>fast</u>** twitch (type 2)

1. **Slow twitch**

   These type of muscle fibres are good for _____ activities (e.g. long distance running or cycling). They can therfore **sustain contractions** for **long periods of time**. They rely on aerobic respiration to generate ATP and therfore these cells have:

   - many _____
   - a large _____ _____
   - a **high concentration** of the oxygen-storing protein called _____

The **major storage fuel** of slow twitch muscle fibres is **<u>FATS</u>**.

2. Fast twitch

These type of muscle fibres **contract more quickly**, but **can't sustain** these contractions for as long as slow twitch muscle fibres. These muscle fibers are good for activities like _____ or weightlifting. Fast twiitch muscle fibers can generate ATP through **glycolysis only** and therfore these cells have:

- few _____
- a _____ blood supply

The **major storage fuels** of fast twitch muscle fibres are **GLYCOGEN** and **CREATINE PHOSPHATE**.

Web site –start at 4 minutes
http://www.youtube.com/watch?v=2O7K-8G2nwU