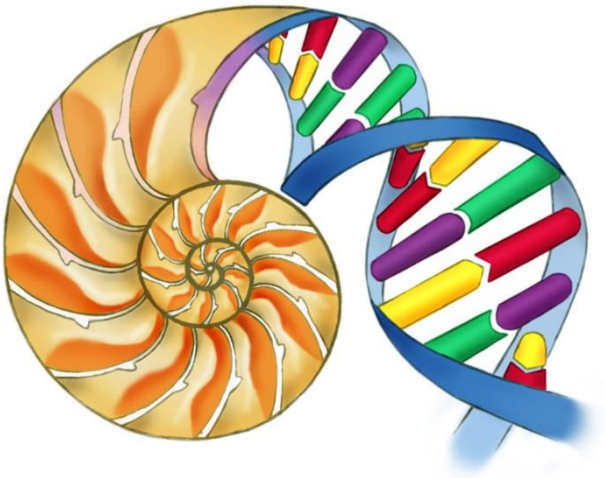
Name ……

Biology Unit 2

HT/FT Separates Revision Guide 2016 →

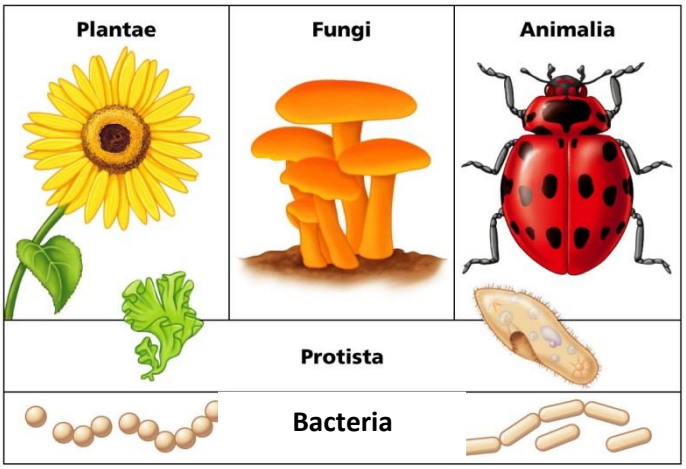


Contents:

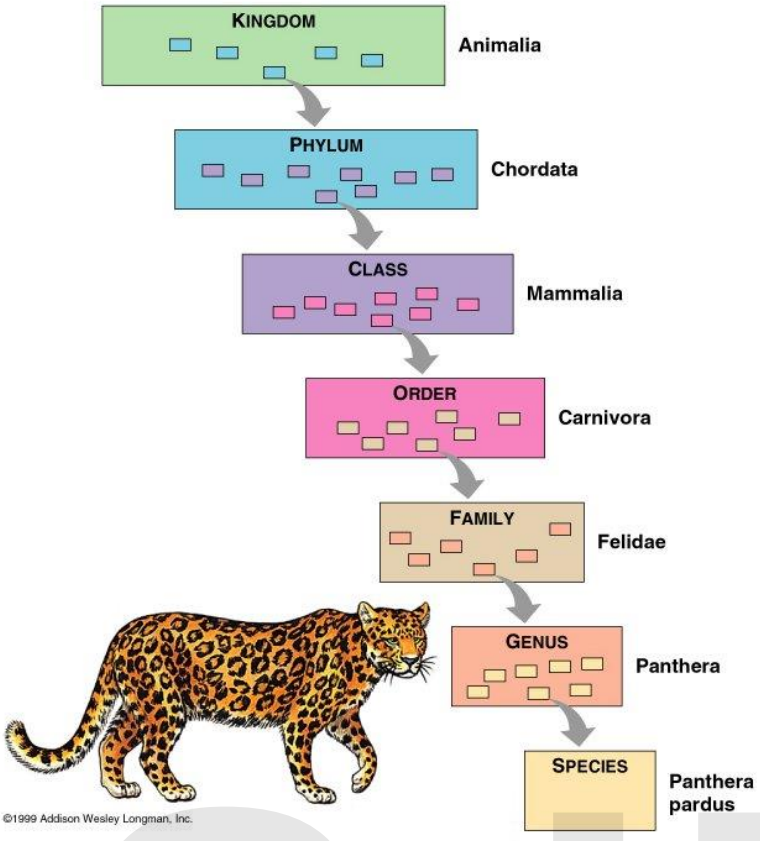
1. Classification and biodiversity.

All living things vary in shape, size and complexity. Scientists ***classify*** living things into groups that have similar features. Scientists put all organisms into one of ***five*** major groups called ***kingdoms***.

- ***Plant kingdom*** ~ these are divided into two major groups, flowering plants which reproduce using flowers e.g. roses, grasses; and non-flowering plants which reproduce using spores, e.g. ferns and mosses.
- ***Animal kingdom*** ~ these are also divided into two groups, vertebrates (with a backbone) e.g. horses and snakes; and invertebrates (without a backbone) e.g. flies and worms.
- ***Kingdom Fungi*** ~ a group of micro-organisms, which do not photosynthesise, and feed on dead material.
- Kingdom Protoctista ~ single celled microbes and the ***algae*** like seaweeds.
- ***Kingdom Bacteria*** ~ single celled organisms without a nucleus.



Scientists look for similar features to group organisms, the more similar features they share the more closely related they are. The features we use include:



- morphological features (shape and structure of the body)
- biochemical features like the structure of the DNA

A scientist called ***Linnaeus*** developed a system to classify organisms. Each large group of organisms is split into smaller and smaller groups. As the groups get smaller the organisms are more closely related and share more features. His system was much simpler than any before. Every organism is given a ***scientific name*** in ***Latin*** a ***universal*** language (understood by all). This avoids confusion when talking about the same organism in different languages. The common name is different in different countries. The names are now decided by an international committee. All organisms are known by two names (the genus and species). This is called the binomial system. Classification is always being updated as we learn more.

Scientists can tell how closely related organisms are by comparing their DNA. The genes are made of DNA. The more similar the DNA the more closely related the organisms are. The sequence of an organisms DNA is called its genetic profile. Genetic profiling is a more accurate way of checking how closely related organisms are.

Recently classification into three domains (ancient bacteria, new bacteria and all organisms with a nucleus) has become preferred.

Adaptations.

In order to survive in their environment, organisms have to become adapted to the physical conditions. They develop morphological and behavioural adaptations to help them survive.

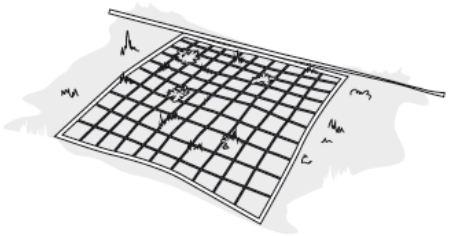
- Organisms obtain resources from their environment. These include food, water, and for plants light and minerals. This could affect the distribution of an organism.
- Some resources may be limited in supply. Organisms will compete to obtain them. This competition will limit population size.
- Predation can reduce the size of the prey population.
- Population size can also be reduced by disease and pollution.

Biodiversity

Biodiversity is the variety of different species, and numbers of individuals within those species in an area.

Measuring Biodiversity.

It is possible to measure abundance and distribution of species by using transects and quadrats.



▲ A transect line is a long tape which is laid through an environment. Quadrats can be placed at regular intervals along the tape; this prevents bias. A quadrat is a square frame. They can be placed at regular intervals along a transect line to obtain unbiased data, or placed randomly in an area. The numbers and types of organism are recorded in the quadrat. This supplies the quantitative data

Biologists need to record data about the distribution of organisms. With this quantitative data they can begin to look for relationships about the cause for the distribution. How can they record accurate unbiased data about an organism's distribution?

Obtaining valid data

Being accurate	Use appropriate apparatus for the task, as this will generate accurate results. Each recording should be a sufficiently large sample.
Being reliable	Take repeat readings. Repeats make results more reliable.
Being fair	Always use the same equipment for each test. Make sure that recordings are not biased. To do this, use regular points along a transect, or random **sampling**.

When carrying out this type of investigation, we need to collect sufficient data to make valid conclusions. If the data is collected in this way, it should be both valid and repeatable by other workers. Only then can any conclusions be accepted.

Analysing the data

Data collection of this type generates lots of numbers. Biologists often analyse the data to make sense of it. This may well mean looking for a central value to illustrate the data, for example, the mean size of a limpet's shell. This is a form of a simple statistical analysis.

Another common statistical analysis is to estimate a whole population from a sample collected in a number of quadrats. To do this, calculate the average number of organisms in the quadrats sampled. Then multiply this by the total area.

Estimating the population size for moving organisms (HT Only).

We use a technique called capture-recapture. In this approach the following steps are followed:

1. **A number of individuals of a species are captured using a set technique.**
2. **These individuals are marked.**
3. **The organisms are then released.**
4. **Some time later a second sample is taken in exactly the same way as before.**

The second sample will contain some of the marked organisms from the first sample. The proportion of marked to unmarked organisms can be used to calculate an estimate of the total population as follows:

$$\text{Total Population} = \frac{\text{First sample total} \times \text{Second sample Total}}{\text{Marked organisms re-captured}}$$

For the technique to be accurate certain conditions must apply:

There must be sufficient time between samples **Marking does not affect the survival of the animal.**	**There is no large scale movement into or out of the area.** **Marking does not increase the chance of recapture.**

The importance of Biodiversity.

A stable environment or ecosystem generally has a higher biodiversity.

The benefits of a high biodiversity are:

- They help to regulate the atmosphere, water supply, nutrient cycles and soil fertility.
- Biodiversity provides potential foods, industrial materials and medicines.

Threats to biodiversity include:

- Changes in land use – e.g. farming, deforestation and quarrying.
- Climate change – certain species can no longer survive in and area.
- Over exploitation – e.g. over fishing and hunting of animals for skins, tusks.
- Introduction of alien species – new species can force out existing species e.g. grey squirrels.

These process can lead to species becoming endangered, when their numbers become very low. If this is not halted they can eventually become extinct when there are none left alive.

- Protecting biodiversity:
- Legislation – laws to protect habitats and species.
- CITES – the convention on international trade in endangered species, stops the buying and selling of endangered.
- SSSI's – Sites of Special Scientific Interest, and National Parks which have a protected status.
- Fishing quotas – which will limit the amount of fish caught.
- Seed banks and Zoos – can be used to reintroduce species.

Computer programmes can be used to make predictions about population numbers and the effects of human activity. This may avert future problems.

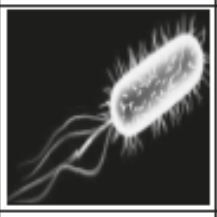
Biological Control.

Biological control is the use of natural predators to limit, control or remove a pests. (as opposed to using chemical control – pesticides). Sometimes biological control uses alien species (a species from a different area/country).

Advantages of biological control	Disadvantages of biological control
No chemicals are used, which lead to pollution/bioaccumulation	More complicated to operate than chemicals. Thus it can be more expensive.
A carefully selected organism will attack just the pest and nothing else. More selective.	Difficult to use outdoors, as the control organisms migrate. So is best used in greenhouses.
The pest population is reduced to manageable levels, not completely wiped out. The ecosystem is more stable.	The biological control agent may cause other problems in the ecosystem.

We have to be very careful when introducing an alien species. They may have no natural predators and their numbers may rapidly increase. They are then considered as invasive, and become a problem. Modern biological control uses detailed research and trials to learn about the control agents. This has reduced these problems.

1. The photographs show five organisms (**A** to E) and the group to which each one belongs.

Organism	A	B	C	D	E
Photograph					
Group	fungi	insects	bacteria	mosses	mammals
Magnifications of photograph	× 0.50	× 1.0	× 2000	× 0.40	× 0.25

(a) Use the magnifications below each photograph to place the organisms in order of size. Start with the **smallest**. One has been done for you. [3]

smallest organism: 1 .....

2 .....

3 ..A..

4 .....

largest organism: 5 .....

(b) Give the names of the two groups that cause decay.

1. .....

2. ..... [1]

(c) Two of the groups belong to the same Kingdom.

Give the names of the two groups and the Kingdom to which they belong. [2]

Name of group: ..... and .....

Kingdom: .....

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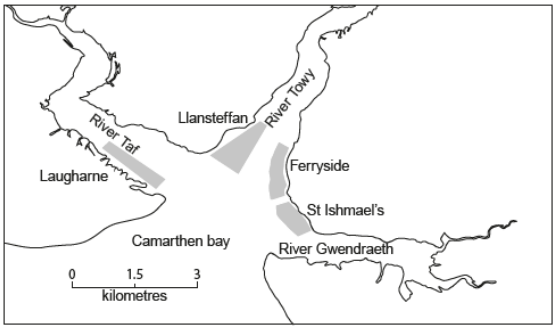
7. There is an increasing demand for food to feed the growing human population. This has both worldwide and local effects on wildlife and on the environment.

Cockles *(Cerastoderma edule)*

In 1984 a survey found that there was a small cockle fishery in the Three Rivers area of Carmarthenshire, South Wales with a few people harvesting the cockles. By 2014 the Three Rivers Cockle Fishery had become an important industry in South Wales with many fishermen harvesting the cockles for human consumption. The cockles are harvested from sandy mudflats at low tide.

Map showing the Three Rivers Cockle Fishery



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The table shows the number of fishermen that harvested cockles from the Llansteffan cockle bed on 4 days in the summer of 2007.

Date	Number of fishermen	Mass of cockles harvested (tonnes)
Tuesday 26 June	292	129
Tuesday 3 July	257	102
Tuesday 10 July	330	142
Tuesday 17 July	100*	37

*Tide not suitable for harvesting cockles

(a) Calculate the mean mass of cockles harvested per fisherman on Tuesday 26 June. Use the space below for your calculation. [2]

mean mass = ... tonnes

(b) (i) Cockles can only be harvested if there is a minimum of 50 cockles per m^2 of mud flats. If the number falls below this level then the Welsh Government closes the fishery. Suggest a reason why the fishery is closed if the number of cockles is less than 50 cockles per m^2. [1]

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(ii) Suggest a way in which the mass of cockles harvested could be managed effectively. [1]

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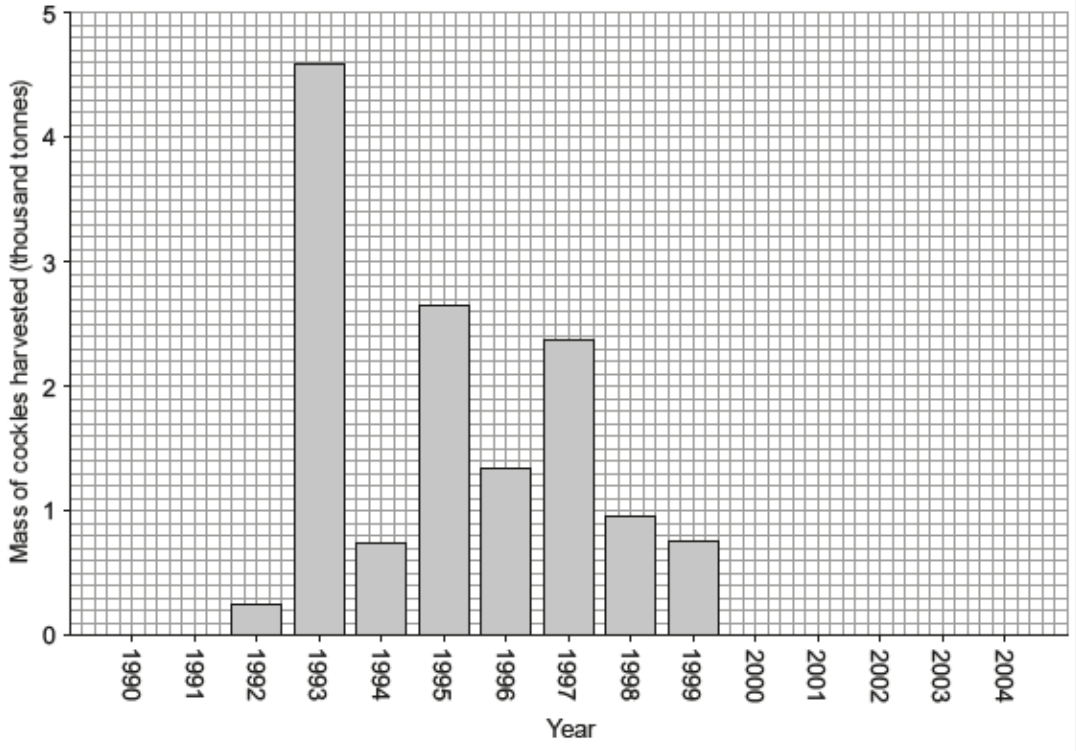
(c) The graph below shows the mass of cockles harvested in the Three Rivers Fishery between 1990 – 2004.



Adapted from South Wales Sea Fisheries Committee

Suggest **two** possible reasons why no cockles were harvested from 2000 to 2004. [2]

I. .....

II. .....

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(d) Oystercatchers *(Haematopus ostralegus)* are birds which often feed on cockles.

In recent years there has been an increase in the number of oystercatchers *(Haematopus ostralegus)* moving into the Three Rivers area. Cockles are a major source of food for oystercatchers.

Suggest **one** possible reason for this increase. [1]

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8. In 2013 specimens of sea snails (molluscs) were collected from a deep sea trench near the north of Scotland. They were sent to a scientist at the National Museum of Wales, Cardiff, for identification.

Most of the specimens were known as *Volutopsius norwegicus* but one showed some differences in appearance to the known specimens and also showed some similarities.

It was concluded that the unknown specimen belonged to the same genus as the known specimens. The scientist reported that the differences might be due to:

EITHER

A – the sea snail's development under different environmental conditions

OR

B – natural selection from a group of snails showing continuous variation

(a) Give the letter A or B which suggests that the known and unknown snails have: [2]

(i) different genotypes; .....

(ii) the same genotype .....

(b) Name the technique that could be used to confirm the scientist's conclusions. [1]

.....

(c) It was decided that the unknown specimen was of the genus *Volutopsius* but it was given the second name *scotia*. What term, used in classification, does this second name represent? [1]

.....

(d) Underline the correct statement from the list below. [1]

The scientific name of all newly discovered organisms is decided by:

(i) the person who discovered the organism;

(ii) the name of the place where it was discovered;

(iii) an international committee;

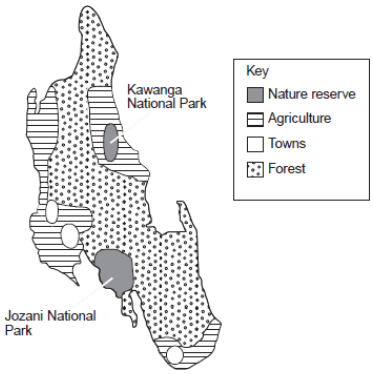
(iv) the National Museum of Wales;

(v) a committee from the United Kingdom.

5

1. The red colobus monkey *(Procolobus kirkii)* lives in forests on the island of Zanzibar, feeding on leaves and tree bark. It is an endangered species and its numbers are declining because of human activities. This is despite the species being protected in the National Parks.

In 2012 conservationists estimated that there were 1600 red colobus monkeys on the whole island, with 50% of them living in the Jozani National Park. 150 colobus monkeys were then moved from the Jozani National Park to the Kawanga National Park to increase the population there. The diagram below shows a map of the island of Zanzibar.



Fact File – Human activities which harm the red colobus monkey.
The illegal capture for sale as pets in other countries.
Destroying habitat by using land.
Poisoning and hunting by farmers.

(a) Use only the information opposite to answer the following questions.

(i) What is the habitat of the red colobus monkey on the island of Zanzibar? [1]

.....

(ii) Give **two** ways in which the use of land by humans has caused the habitat to be destroyed. [2]

.....

.....

(iii) The Kawanga National Park has not been as successful as the Jozani National Park in protecting the red colobus monkey. Suggest a reason for this. [1]

.....

(iv) Calculate the number of monkeys estimated to be living in the Jozani National Park after the conservationists had moved some of them to the Kawanga National Park. [2]

Number of monkeys= .....

(b) How could the Convention on the International Trade in Endangered Species (CITES) help to protect the red colobus monkey? [1]

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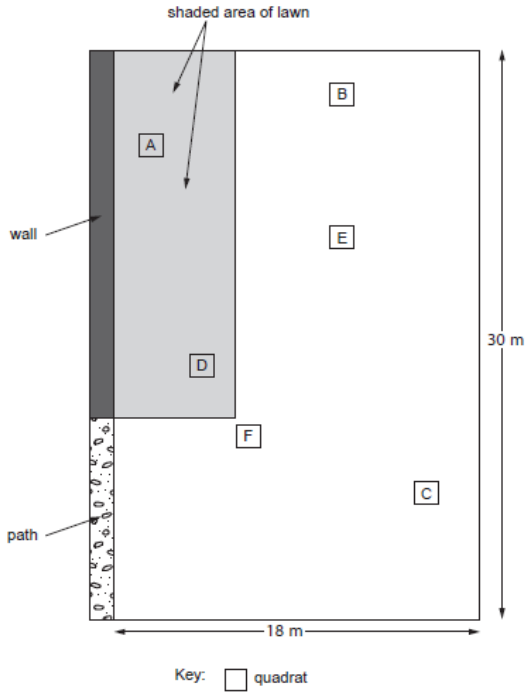
Biol 2 FT June 2016

6. Some students investigated the number of dandelion plants on a lawn. The diagram shows the lawn and the location of 6 quadrats (A to F) which the students had placed at random on the lawn.



The students counted the number of dandelions in each quadrat and recorded their results in the table below.

quadrat	number of dandelions
A	7
B	2
C	1
D	6
E	2
F	0

(a) Each quadrat measured 1 m^2.
Calculate the mean number of dandelions per square metre for the 6 quadrats. [1]

Mean number of dandelions = ...

(b) Calculate the area of the lawn. [1]

Area of lawn = ...

(c) Use your answers from parts *(a)* and *(b)* to estimate the total number of dandelions on the lawn. [1]

Estimated total number of dandelions = ...

(d) In fact, the **actual** number of dandelions on the lawn is 1250.
Use the formula below to calculate the percentage error of the estimate in part *(c)* above. [1]

$$\text{percentage error} = \frac{\text{estimated number of dandelions} - \text{actual number of dandelions}}{\text{actual number of dandelions}} \times 100$$

percentage error = ... %

(e) How could the strength of evidence in the investigation be improved? [1]

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Biol 2 HT June 2016

11. Write an account of some of the different methods of protecting endangered species of animals and plants around the world. Include the use of legislation in your answer. [6 QWC]

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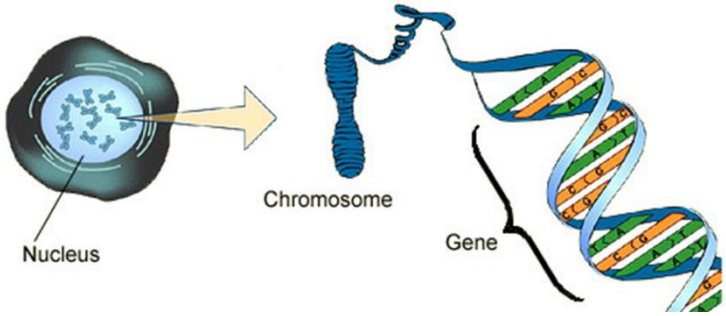
2. Cell Division and Stem Cells.



A ***gene*** is a short piece of DNA which controls a ***characteristic***, e.g. eye colour.
There are different versions of genes called ***alleles*** which control a version of the characteristic, e.g. blue eye colour.
Inheritance is about passing characteristics on from one generation to another.

The nucleus of the cell contains chromosomes

A chromosome is a long strand made of DNA divided into genes

A gene is a section of a chromosome, which code for making proteins.

How are ***chromosomes*** organised?
In adult cells chromosomes occur in pairs. This means that there are two copies of each gene or allele.

In the ***gamete*** the chromosome number is halved. Only one allele of the pair is present. The cells are not genetically identical.

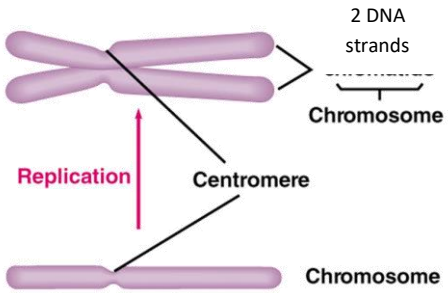
Cell Division.

Throughout an organisms life they need to make new cells:

- For growth
- For repair
- To replace old cells
- To make gametes.

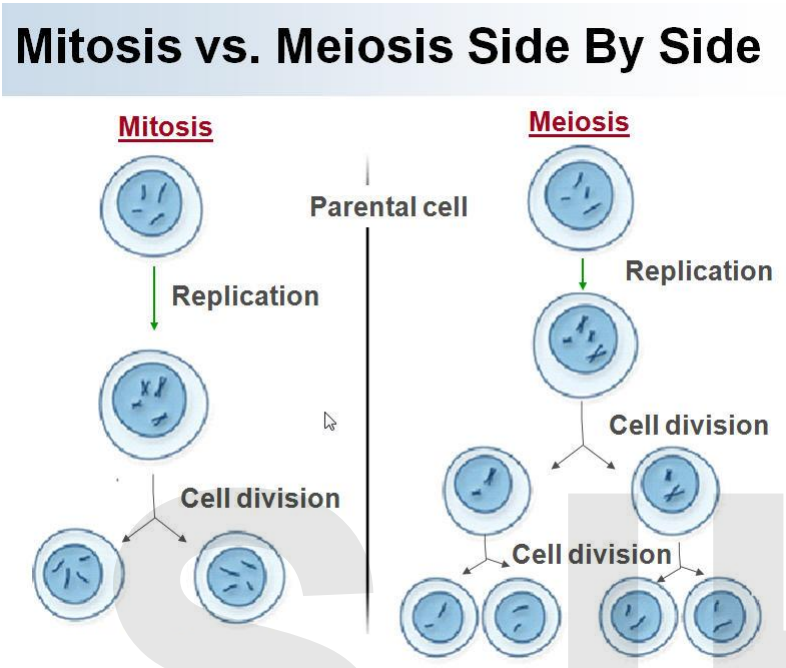
There are two types of cell division

- Mitosis
- Meiosis



Chromosome replication

In cell division the original cell is called the mother cell, the new cells are called daughter cells. Before any division the chromosomes make copies of themselves.



Comparisons between Mitosis and Meiosis.

Mitosis	Meiosis
Occurs in growth, repair, asexual reproduction and tumours. (over the whole body)	Occurs in the production of gametes for sexual reproduction. (in ovary and testes)
One cell division occurs	Two cell divisions occur
Two daughter cells produced	Four daughter cells produced
Daughter cells genetically identical	Daughter cells genetically different
Daughter cells contain same amount of DNA as the parents.	Daughter cells contain half the amount of DNA as the parents.

Mitosis and Cancer.

Sometimes cells divide by mitosis in an uncontrolled way. This results in the development of a growth or tumour, otherwise called a cancer. There are different types of cancer. This uncontrolled division can be caused by chemicals, or radiation damaging the DNA.

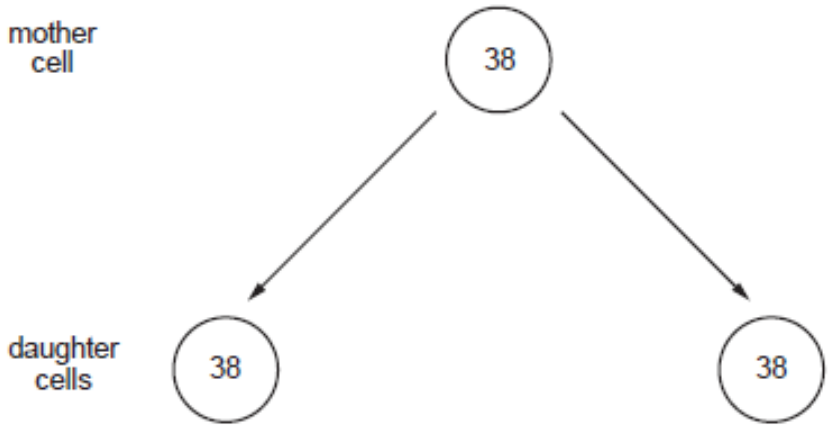
Stem Cells.

In mature tissues, cells have generally lost the ability to differentiate into different types of cells. Some cells in both plants and animals do not lose this ability, and are called stem cells. You need to know four things:

1. **Definition** : Stem cells are cells which have the ability to differentiate into some different types of cells in the body.
2. **Source**: three sources in humans:
    a. Adult tissues e.g. bone marrow ~ least effective, but less ethical issues, and best tissue match.
    b. Umbilical cord cells ~ quite effective, some ethical objections.
    c. Embryonic cells ~ most effective, great ethical issues, as it involves destroying an embryo.

    In plants, they are found in meristems (shoot and root tips)
3. **Use** : they can be used to replace damaged tissue in the treatment of conditions e.g. Parkinson's.
4. **Ethical issues**: expense of research (takes money from other research); umbilical cord cells means having a baby for the wrong reasons; embryo cells means destroying an embryo to obtain the cells.

3. The diagram below shows cell division of a cell from a cat. The number of chromosomes is shown.



(a) What name is given to the type of cell division shown in the diagram? Give a reason for your answer. [2]

Type of cell division .....

Reason .....

(b) The table shows the numbers of chromosomes in the cells of pigeons and humans before and after dividing by meiosis.

(i) Complete the table. [1]

	number of chromosomes	
	cell before meiosis	sex cells (sperm and egg cells) after meiosis
human	46	
pigeon		40

(ii) State how many sex cells would be produced from one cell by meiosis and give the scientific term for these sex cells. [2]

.....

.....

(c) The table below shows some animals, the number of chromosomes in their body cells and their adult body length.

animal (not shown to scale)		mean adult body length (cm)	number of chromosomes in body cells
carp fish		80	104
chimpanzee		100	48
earthworm		10	36
goat		65	60
hedgehog		15	88

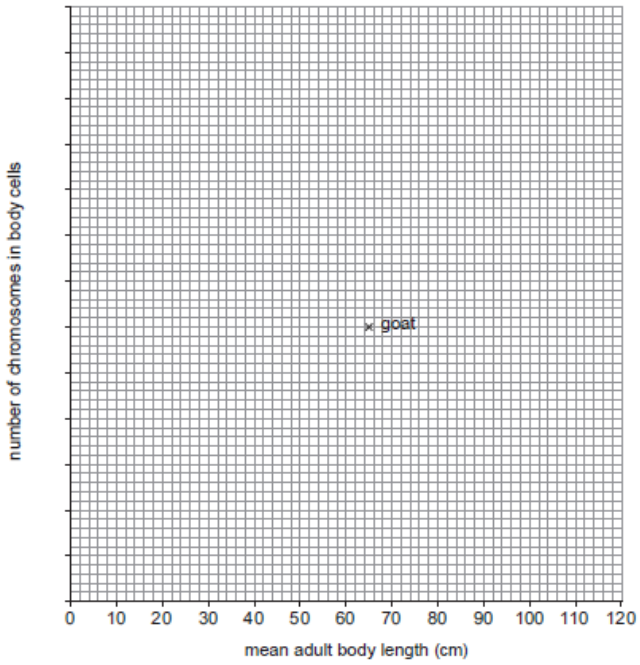
(i) Complete the **scattergraph** below by:

I. adding a scale for the number of chromosomes, [1]

II. plotting the values for each animal, [2]

III. labelling each of your plots.

The goat has been done for you.



(ii) What does the information in **this scattergraph** show?
Underline your answer. [1]

A. The larger animals have larger numbers of chromosomes.

B. The size of an animal is not related to the number of chromosomes.

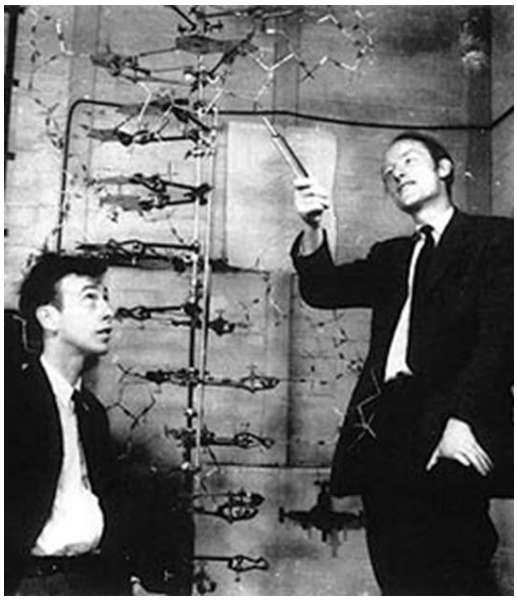
C. The smaller animals have larger numbers of chromosomes.

9

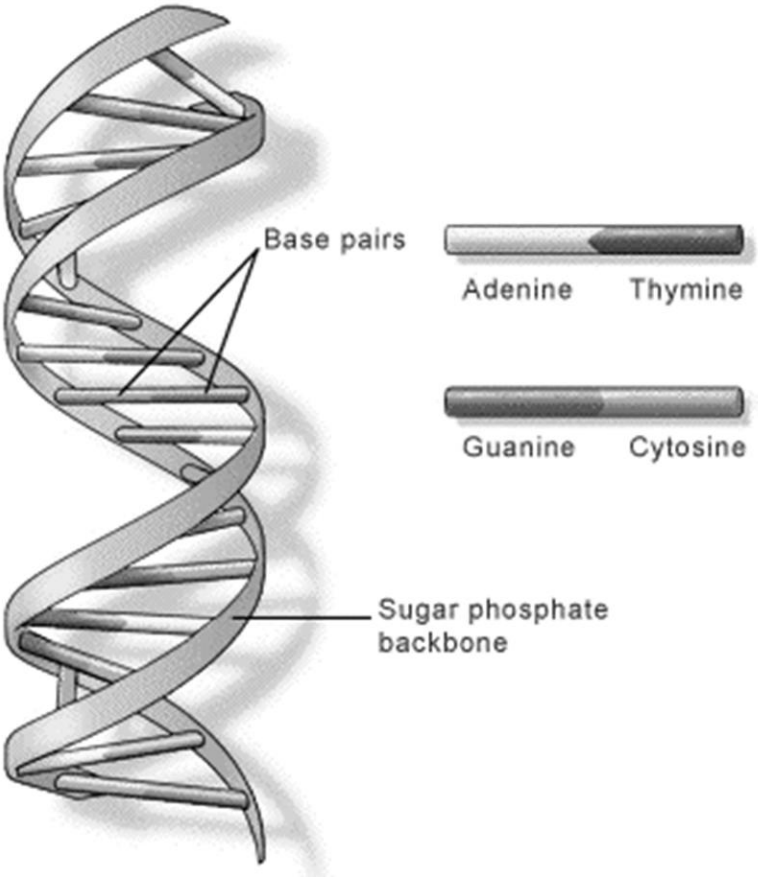
3. DNA and Inheritance.

DNA

DNA is one of the most important biological molecules we study. The structure of this molecule was finally described in 1953, by Watson and Crick. Much of the evidence came from Rosalind Franklin and Maurice Wilkins who studied the molecule using X-ray crystallography.



Structure of DNA



The molecule has a double helix shape. The long chains are of alternating sugar and phosphates molecules which form the backbones of the molecule.

The backbones are connected by pairs of bases.
There are four bases A,C,G, and T (**HT - need the names**)

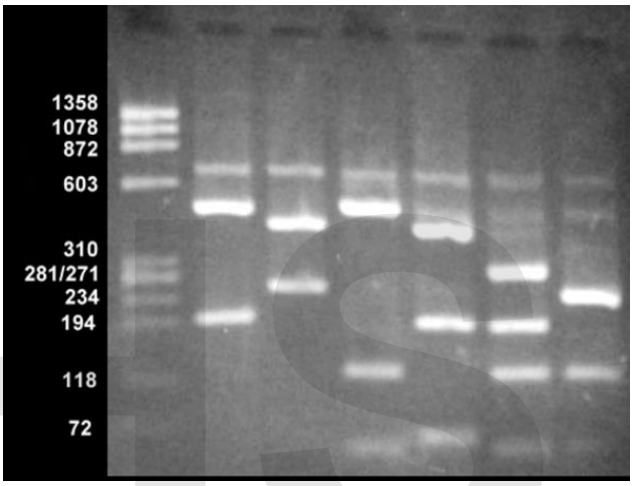
A always pairs with T; C pairs with G, this is called complementary base pairing.

The genetic code is contained in the bases.

HT ~ Three of the bases (triplet) in the DNA will code for one amino acid, in the protein chain.
The order of the bases determines the order of the amino acids in a protein. Different sequences of DNA form different proteins.

DNA Profiling or Genetic Fingerprinting.

We all have unique fingerprints. In the same way everyone has a unique sequence of DNA. Forensic scientists can make use of this fact to identify criminals at a scene of crime. It is also used in paternity cases. Scientists have also started to use the technique to help classification processes.



The Process.

Sample of tissue from a scene of crime. E.g. blood, skin, hair and semen. The DNA is extracted from the cells.
The DNA is cut into fragments using restriction enzymes. Since each person has different DNA, then the cuts occur in different places. This produces different length fragments. The fragments are separated in a kind of chromatography. They separate by size, small fragments travel further. This produces a series of bands as a result. Scientists compare the position of the bands. The band pattern of DNA taken from a scene of crime is compared to a suspect. If the location of the bands is the same then it links the suspect to the scene of crime.

Another use of genetic profiling is to identify genes which code for genetic disorders. Patients can give a blood sample to the hospital, and they will run the process described above, and identify the presence of a gene associated with a particular disease.

Inheritance.

Genetics is the study of inheriting characteristics from our parents. The questions on this topic expect a certain level of knowledge of key words.

Key terms.

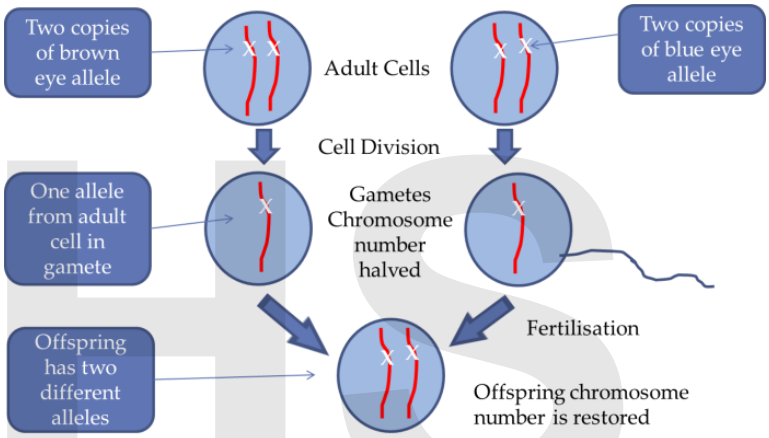
Gene ~ piece of DNA which controls a characteristic.
Allele ~ version of the gene.
Phenotype ~ description of the characteristic in words.
Genotype ~ list of alleles for each characteristic.
Homozygous ~ where both alleles are the same.
Heterozygous ~ where the two alleles are different.
Dominant ~ an allele which always shows in the phenotype.
Recessive ~ an allele which will not show up in the phenotype if the dominant allele is present.

Gregor Mendel

The pioneer of inheritance was an Austrian monk called Gregor Mendel. He found:

- Inheritance of a characteristic was controlled by 'factors' (we now call these genes)
- Factors/genes occur in pairs in the adult cells.
- Only one of the factors/genes will be in the gamete.
- The offspring would contain two genes, one from each parent.
- He could predict the outcome of crosses.
- The 3:1 ratio in the F2 is now called a Mendelian ration.

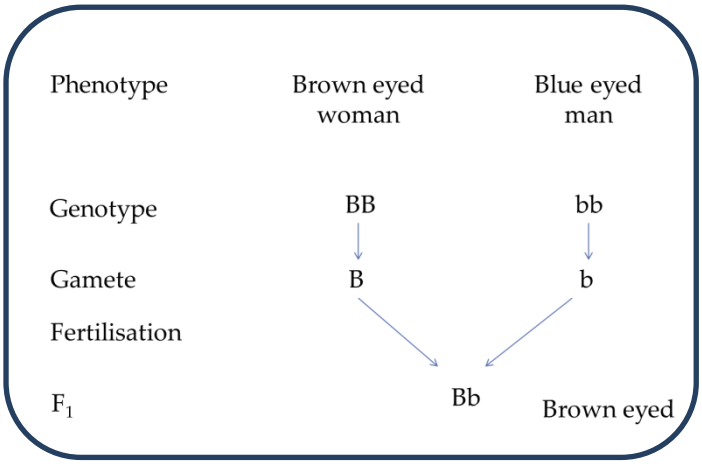
The importance of his work was not realised until after his death. His work was understood about 40 years later when other scientists could explain his results using genes.

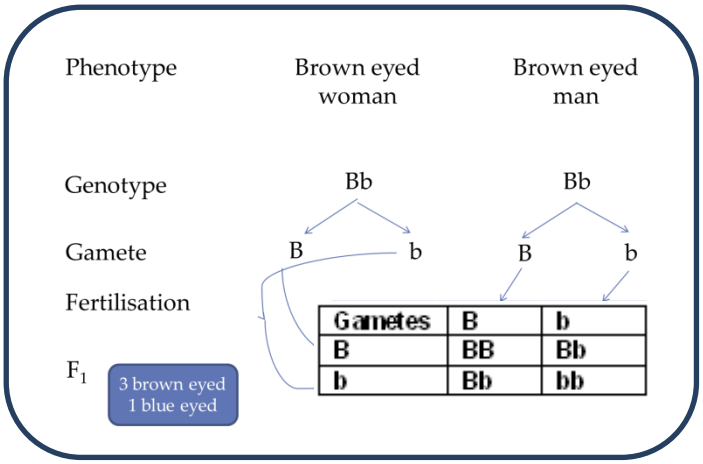


Inheriting a Characteristic.

It is possible to track an allele from one generation to the next, e.g. eye colour.

Exam questions will require you to write these crosses out in a specific way.



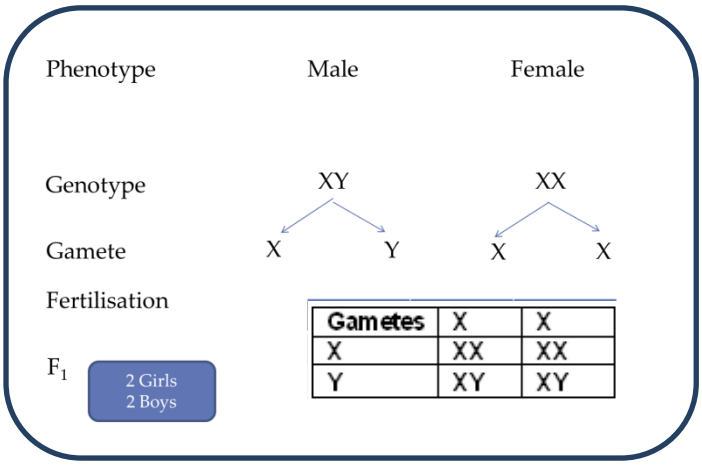


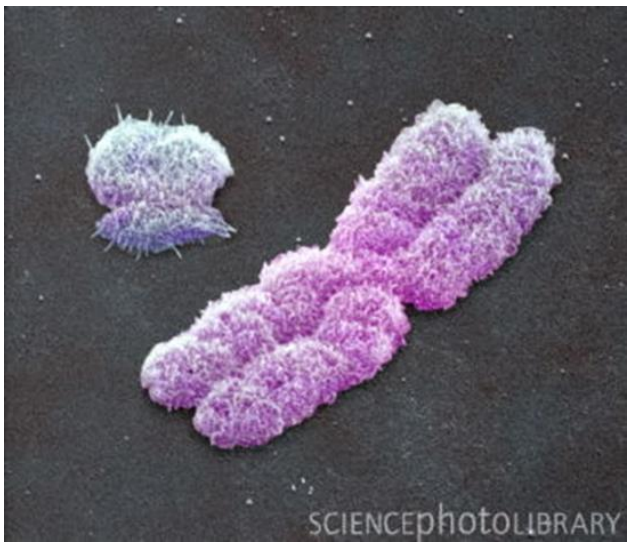
In fact, most phenotypic features are the result of multiple genes rather than single gene inheritance.

Sex Determination.

Human cells contain 46 chromosomes (23 pairs). 22 pairs are matching pairs, and control normal body features. One pair do not always match, and control gender. These are called sex chromosomes.
There are two types of sex chromosomes, 'X' and 'Y' chromosomes.

- Females have XX
- Males have XY



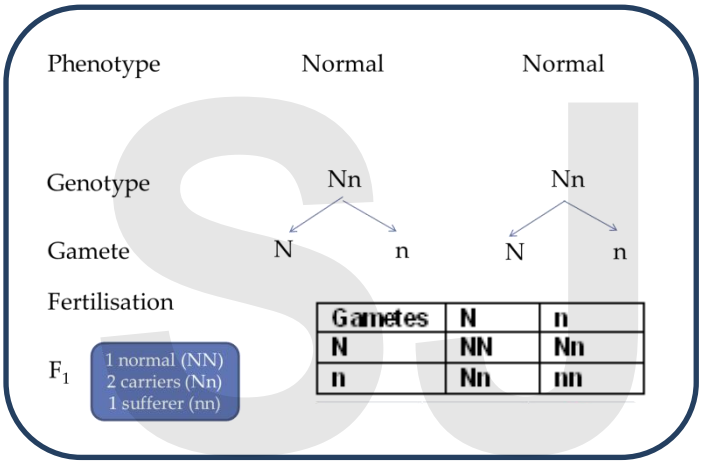


Genetic Disorders.

Some mutations will cause genetic disorders like ***cystic fibrosis***. Cystic fibrosis is caused by a recessive allele.

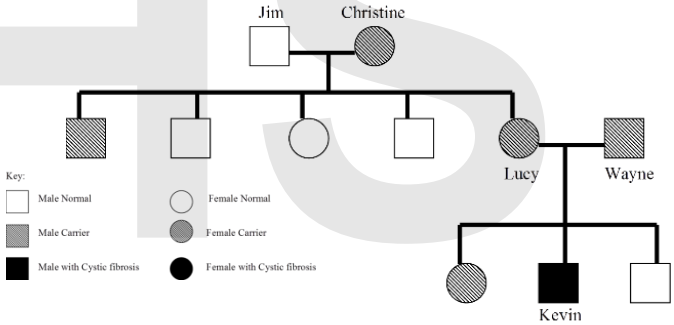
Use the following codes:-
Allele for normal = N
Allele for cystic fibrosis = n

Possible Genotypes are:-
NN = normal healthy person.
Nn = heterozygotes (carrier)
nn = sufferer



Family Trees.

The incidence of genetic diseases can be followed in family trees. This can allow us to track the disease from one generation to the next.

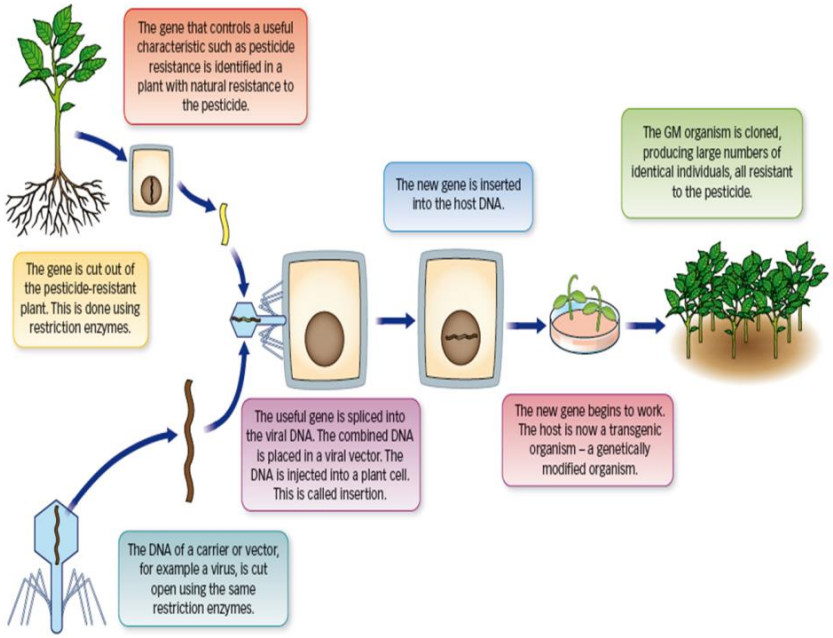


Gene Therapy.

Modern advances in medicine have allowed us to obtain the correct gene. We can then place it into the affected organ. Hopefully the gene will get into the cells in the organ and correct its function.
The success at the moment is limited. However, scientists hope that as advances in the therapy are being made, there will be improved success rates. The therapy is used at the moment for cystic fibrosis, but hopefully other conditions will be treated in the future.

Genetic Engineering.

This is a technique where a desired gene is removed from the chromosome of one organism (the donor), and transferred into a cell of a second organism (the host).
The host now acquires the desired characteristic.
An example is: Herbicide resistance in soya. The soya crop can be sprayed with herbicide, to kill weeds, reducing competition.



Arguments for Genetic Engineering	Arguments Against Genetic Engineering
Improved shelf life	Cost
Resistance to pests and herbicides	Public concerns
Resistance to drought and wind	Changing ecosystems
Higher yield	Super weeds
Improved nutritional value	Need for large trials.
Quicker process than breeding programmes	

To make informed decisions we need to have unbiased information from large scale experiments that are repeatable and reproducible. This allows scientists, governments and the public to make balanced judgements of the risks.

only

6. *(a)* (i) Gregor Mendel crossed purple flowered pea plants with white flowered pea plants. All the **F1** generation were purple flowered. Show this cross by completing the Punnett square below.
Use the letter **D** to represent the purple allele and the letter **d** to represent the white allele. [2]

	Gametes		
F1			

(ii) When Mendel selfed the **F1** generation he obtained a ratio of 3 purple : 1 white flowered pea plants in the **F2** generation. In the space below construct and complete a Punnett square to show this cross. [2]

only

(b) Mendel's experiments on genetics were carried out with garden peas *(Pisum sativum)*. In each of his experiments he used thousands of pea plants.
State the importance of the use of such a large number of plants. [1]

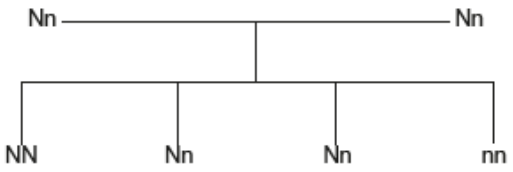
.....

(c) Mendel published his work on the genetics of pea plants in 1866. The significance of his work was not recognised until it was replicated in the early 1900s. Why is it important for scientists to replicate the work of other scientists? [1]

.....

6

9. The family tree shows how two parents, heterozygous for the cystic fibrosis allele, have a 1 in 4 chance of having a child who has cystic fibrosis.



Key:

N = the normal allele n = the cystic fibrosis allele nn = child with cystic fibrosis

(a) It is estimated, that one person in 25 in the population of the United Kingdom is heterozygous for the cystic fibrosis allele. Therefore the probability of both parents being heterozygous for the cystic fibrosis allele in the population of the United Kingdom is:

$$\frac{1}{25} \times \frac{1}{25}$$

(1 in 25 × 1 in 25)

If one in 4 of their children is nn, calculate the probability of a person having cystic fibrosis in the population of the United Kingdom.

Show your working: [2]

probability = ...

(b) State how cystic fibrosis affects the lungs. [1]

.....

(c) People with cystic fibrosis may be given a lung transplant. Give a reason why the transplanted lungs would not produce the symptoms of cystic fibrosis. [1]

.....

(d) (i) Gene therapy has been used to treat the symptoms of cystic fibrosis. State how lung cells are targeted with normal alleles. [1]

.....

(ii) Suggest why this type of gene therapy would have to be regularly repeated. [1]

.....

.....

(e) It took more than 20 years between the first research into this type of gene therapy and its final approval by the European Union. Suggest why this time was needed for detailed testing. [1]

.....

.....

7

7. The relative masses of bases in DNA, in three different animals, are shown in the table.

	mass of base /a.u.			
source of DNA	adenine	guanine	thymine	cytosine
human	30.9	19.9	29.4	19.8
salmon	29.7	20.8	29.1	20.4
sheep	29.3	21.4	28.3	21.0

(a) How do the data above give evidence for base pairing? [2]

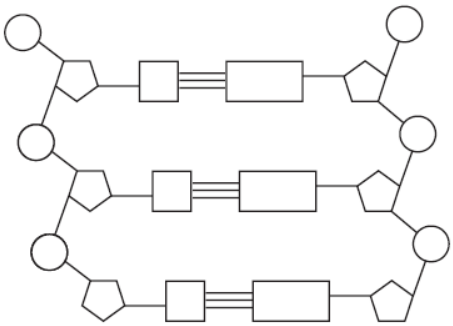
.....

.....

(b) The diagram below shows part of a DNA molecule.
Add labels to this diagram to show the position of: [2]

(i) the sugar and phosphate molecules;

(ii) a base molecule.



(c) Scientists have discovered a gene which, when defective, causes a genetically inherited disease. The normal gene controls the production of an essential protein.
The relevant base sequence in the normal gene is:

TAGTAGAAACCACAA

The relevant base sequence in the gene of people with the genetically inherited disease is:

TAGTAGCCACAA

Explain why the DNA in people with the genetically inherited disease will not be able to produce the essential protein. [3]

.....

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7

4. Variation and Evolution.

Variation is the differences in features between individuals. There are three causes of variation:

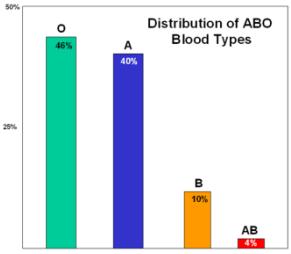
- Genetic ~ inheriting different genes from their parents, e.g. eye colour.
- Environment ~ by living in different environmental conditions, characteristics develop in different ways, e.g. weight.
- A Combination of the two ~ many characteristics are controlled by a combination of both, e.g. height.

Some variations are not visible, as they occur inside cells.

When we look at variation we can see two distinct types:

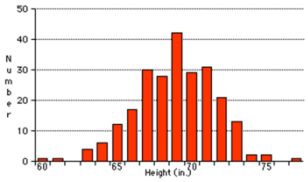
Discontinuous Variation.

Here the variants fit into one group or another. There are no intermediates. E.g. human blood groups.



Continuous Variation.

Here there are many intermediates. An individual can fit at any point along the range. e.g. Height



Reproduction.

Reproduction is the production of new individuals of the same species. There are two types of reproduction:-

Asexual reproduction ~ This is reproduction which does not involve the production of gametes.

Only one parent needed.
There is no mixing of genetic information.
All the offspring are genetically identical.
The offspring are called clones.

Advantages	Disadvantages
Quick	No variation
No mate needed	Parental weakness present in offspring

Sexual reproduction ~ This involves the production of sex cells or gametes (sperm & eggs) by the adults.
During fertilisation the two gametes are brought together and fuse to form offspring.
We inherit half our genes in the sperm.
Half from our mother in the egg.
We are genetically different from our parents.
So sexual reproduction leads to variation.

Advantages	Disadvantages
Variation	Slower
Improves chances of survival if conditions change.	Mate needed

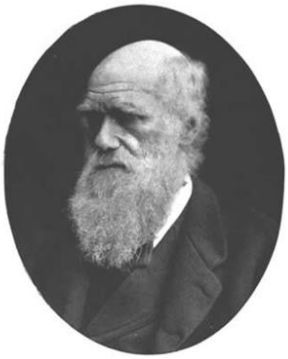
Mutations.

A mutation is a change in the gene.

- Some are helpful e.g. longer necks in giraffes.
- Some are neutral e.g. blue eye colour.
- Some are harmful e.g. genetic disorders e.g. cystic fibrosis (see later).

Mutations occur naturally, but things like ***ionising radiation*** and chemicals can increase the ***rate*** of mutations.

Evolution.



Evolution is the process of gradual change over time in the characteristics of an organism or population. The theory suggests that

- all the species of living things which exists today,
- and many more which are now extinct,
- have evolved from simple life forms
- Which first developed more than three billion years ago.
-

The theory that most biologists accept to explain how evolution occurs was proposed by Charles Darwin and Alfred Russell Wallace. Charles Darwin published the theory in 1859. It is called natural selection.

Natural selection suggests:

- Individual organisms within a particular species may show a wide range of variation because of differences in their genes (some caused by mutation).
- Predation, disease, environmental changes and competition cause large numbers of individuals to die.
- Individuals with characteristics most suited to the environment are most likely to survive and breed successfully.
- The genes which have enabled these individuals to survive are then passed on to the next generation.

Exam tip, This could be a standard answer:

- Large population.
- Variation exists (might be caused by mutations).
- Struggle to survive.
- Those with the best adaptations ('fittest') will survive.
- Pass on their genes (and adaptations) to the next generation.

Examples of Ongoing Evolution.

1. Galapagos Tortoises
2. Warfarin resistance in rats.
3. Drug resistance in bacteria.

Modelling Evolution.

It is possible to use computer models to predict the effect of factors like camouflage, colouring and predators on the evolution of species. This will predict what might happen to the species over a very long period of time, and be much quicker than observing the real thing. However, the models do have limitations, it cannot predict the mutations which might occur by chance. Also there are too many factors are involved.

Extinction.

Those individuals whose characteristics are not so favourable may decline in number. These organisms cannot evolve fast enough to survive in the new environmental conditions. This may continue until the number of individuals of a species falls to zero. This species is then extinct. E.g. dinosaurs.

Understanding Genes for Medicine.

As soon as Watson and Crick described the structure of DNA it has allowed scientists to make advances in medical science.

1. Identify individual genes, some of which are important as the cause of genetic disorders.
2. Identify and sequence the entire human genome.
3. Current research may enable diseases to be cured or prevented in the future, e.g. by replacing faulty genes. Also develop treatments for genetic disorders like gene therapy.

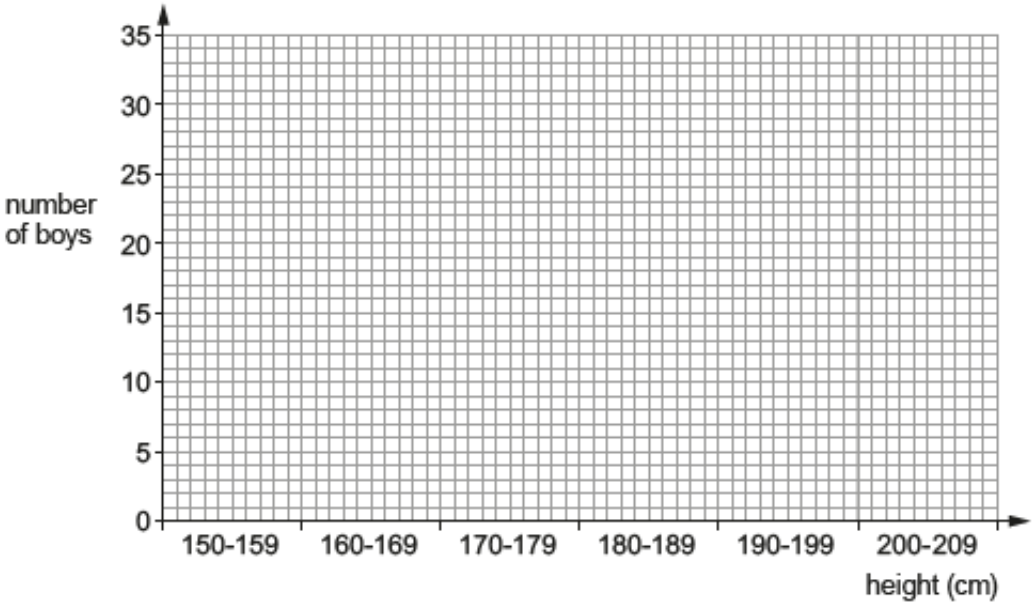
only

2. The heights of 100 boys were measured on their 15th birthday.

The results are shown in the table below.

Height (cm)	Number of boys
150-159	5
160-169	16
170-179	19
180-189	25
190-199	30
200-209	5

(a) (i) Draw a bar chart of the results on the grid below. [2]



only

(ii) The mean height of the boys was 180 cm.
Calculate the number of boys who were less than the mean height. [1]

number of boys .....

(b) Underline the correct word in the following sentence. [1]

The method used shows that the variation in heights **cannot** be due to differences in **age / diet / genes**.

4

only

7. Bananas that are cultivated commercially do not produce gametes. They are all grown as clones by asexual reproduction.

(a) What is meant by the term clone? [1]

.....

(b) Explain why populations of cloned bananas grown without the use of pesticides have very little chance of surviving outbreaks of diseases caused by fungi. [2]

.....

.....

Biol 1 HT June 2016

10. Cockroaches are pests which spoil food and spread disease. They have a gene which makes them attracted to sugar. In the 1980s pest controllers used a mixture of insecticide and sugar as a means of pest control. The sugar attracted the cockroaches and the insecticide killed them. In the 1990s certain populations of cockroaches had changed so that they were no longer attracted to sugar. The insecticide was still lethal but the cockroaches avoided eating it when it was mixed with sugar.

Explain how the cockroaches evolved to survive the pest control that was used in the 1980s. [6 QWC]

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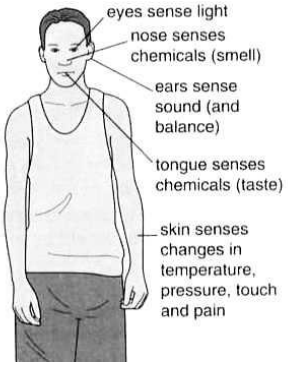
END OF PAPER

6

5. Response and Regulation.

Sensitivity is the ability to detect changes in the environment. These changes are called ***stimuli***. Being able to ***respond*** to these stimuli helps the organism to survive. Organisms use two ways to respond, nerves or hormones.

Sensitivity in Animals.

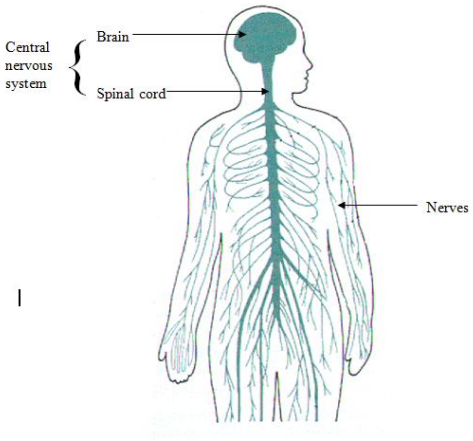


Rapid responses are brought about by nerves. Stimuli are detected by sense organs, which are groups of ***receptor cells***. The receptor cells send an ***electrical impulse*** along nerve cells (neurones) to the ***central nervous system*** CNS (brain or spinal cord). The CNS co-ordinates the response by sending an electrical impulse to an ***effector*** (usually a muscle or gland). The whole process is very quick and the time taken is called the ***reaction time***.

Stimulus → sense organ → co-ordinator → effector → response

Nervous System.

The nervous system is the control centre of the body. It consists of two parts.



1. The Central Nervous System (C.N.S.)

- The spinal cord, which is protected by the backbone,
- The brain which is protected by the skull.

2. The Peripheral Nerves.

These carry messages to and from the CNS. These messages are carried as electrical impulses called nerve impulses.

The Nerve Cells.

The nervous system is made of nerve cells called neurones. Neurones transmit an impulse electrically. There are three types of neurones.

1. **Sensory Neurones. ~** *These take messages from the receptors (sense organs) into the CNS.*
2. **Relay Neurone. ~** *These connect the sensory nerves to motor nerves, they are inside the CNS.*
3. **Motor Neurones. ~** *These carry impulses from the CNS to the effector (muscles and glands).*

The junction between two nerves is called a synapse. The impulse passes across a synapse as a chemical message.

The Reflex Action.

A reflex action is:

- Rapid
- Automatic response of the body to a stimulus.
- These are usually protective.

They include the iris response in the eye, blinking in light, or withdrawing from a hot object or pin. The route taken by the impulse in a reflex action is called a **reflex arc**.

The Sequence of a Reflex Action. (Higher Tier Only)

The route followed by a reflex arc involves five parts.

1. ***Receptor ~ which receives the stimulus. e.g. skin receptors.***

↓

2. A sensory nerve fibre ~ which carries impulses from the receptor to deep in the spinal cord.

↓

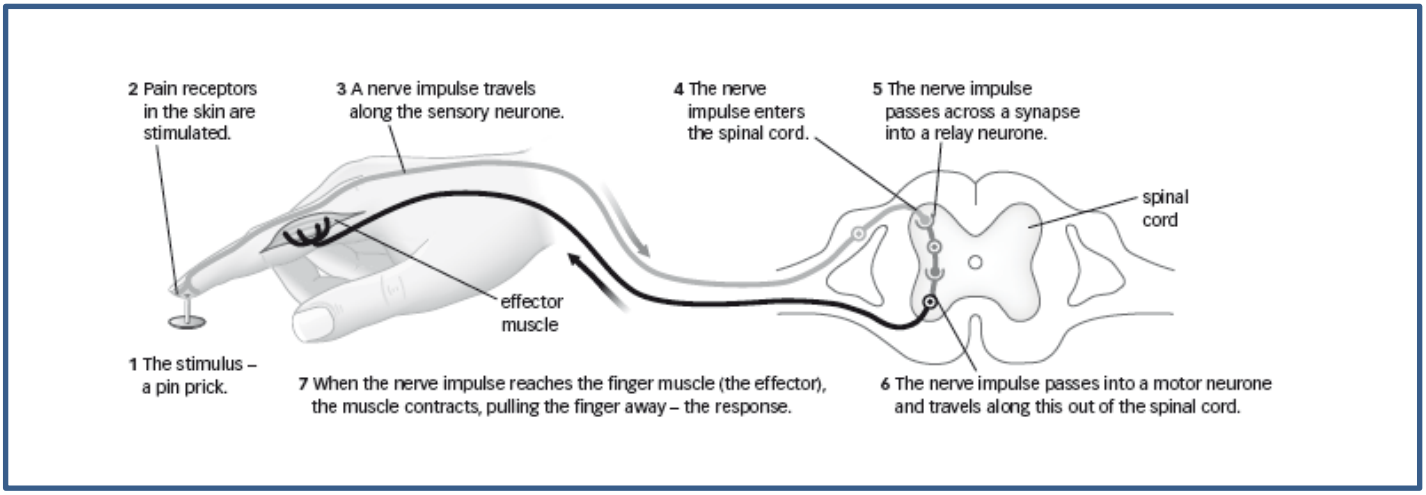
3. A relay nerve ~ which passes the impulse across the spine from the sensory nerve to the correct motor nerve. This occurs in the co-ordinator (brain or spine).

↓

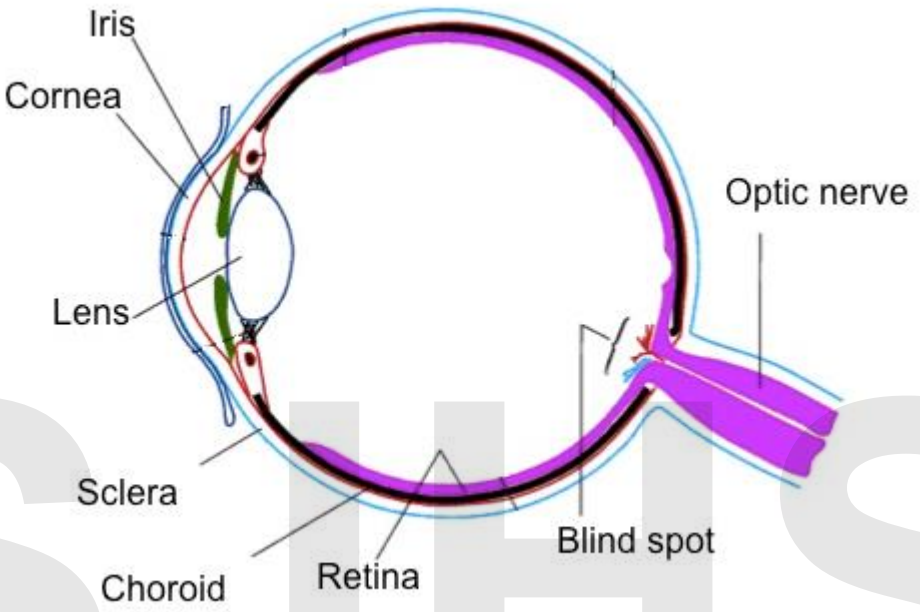
4. ***A Motor nerve fibre ~ which carries the impulse from the spinal cord to the muscle.***

↓

5. ***An Effector ~ which responds when impulses reach it.***



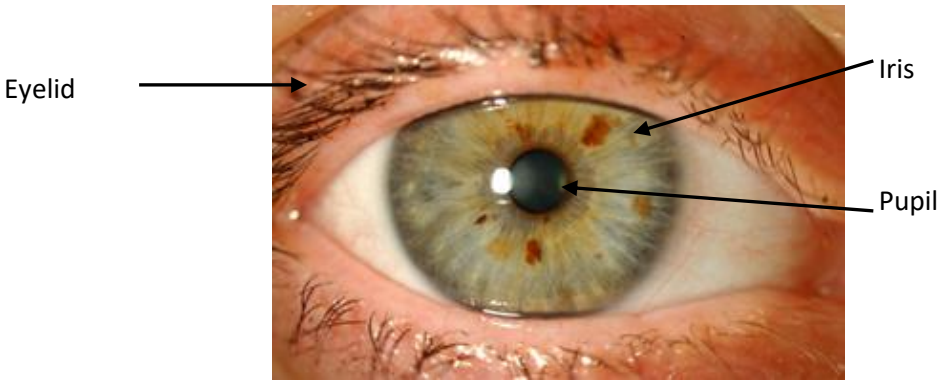
The Eye.



The Function of the parts of the Eye.

Sclera	A tough, white, fibrous layer around the outside of the eye, which protects the eye.
Choroid	This is a black layer that stops light being reflected round the eye. It has lots of blood vessels.
Retina	This is a layer of light sensitive cells on the inside of the eye. They send messages to the brain
Blind spot	This is where the blood vessels and nerves enter and leave the eye. It has no light sensitive cells, so it sends no messages to the brain.
Optic nerve	This sends impulses from the retina to the brain.
Cornea	A clear window in the sclerotic layer in the front of the iris, which lets light in.
Iris	Controls the amount of light entering the eye.
Pupil	This is the hole in the middle of the iris, through which the light rays penetrate the eye.
Lens	Helps focus the rays of light onto the retina. The lens is clear and can change shape.

Investigating the Iris Reflex Response.



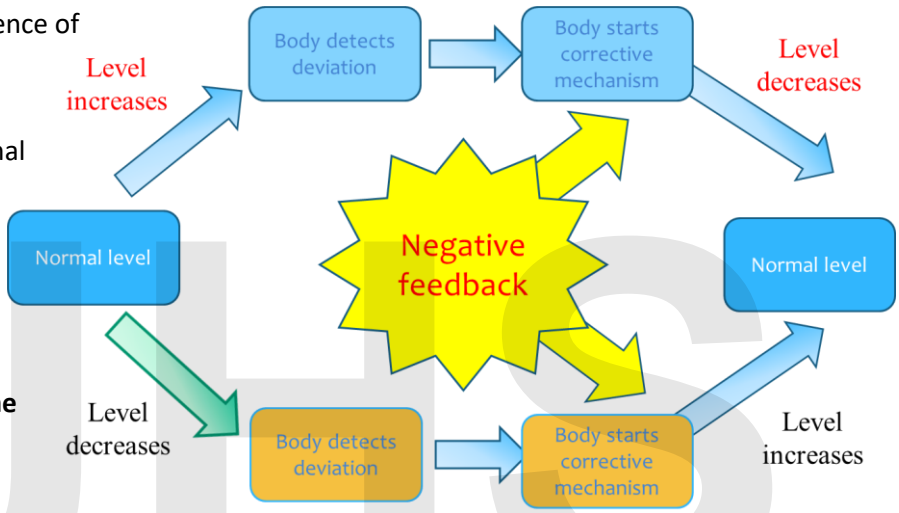
The size of the iris changes in response to light. When a bright light is shone at the eye, the iris enlarges, and the pupil becomes smaller. This reduces the amount of light entering the eye, protecting the receptor cells on the retina.

Homeostasis and Hormones.

Homeostasis means keeping the conditions inside the body constant. This is way the animal is able to regulate its internal conditions by co-ordinating a response to changes. Homeostasis keeps conditions in animals bodies relatively constant and protected from harmful effects. This is often achieved using hormones which are chemical messengers. They are produced by glands; travel in the blood system to target organs where they have their effect. Humans control their body temperatures, pH, concentrations (e.g. water) to allow enzymes to work at their optimum rates.

Homeostatic processes always follow a sequence of events.

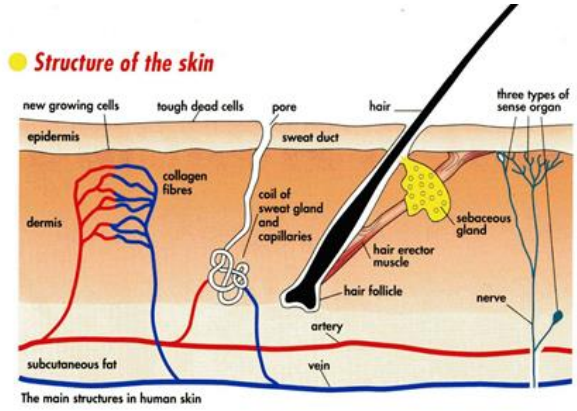
- There is a normal level.
- The body may deviate from the normal level.
- The body detects this.
- The body uses some form of corrective mechanism to return to normal.
- **When the body returns to normal the mechanism is switched off.**
- **This is called *negative feedback*,**



Skin and Temperature Control.

Learn the following structures in the skin:
Hair, erector muscle, sweat gland, sweat pore, sweat duct, blood vessels.

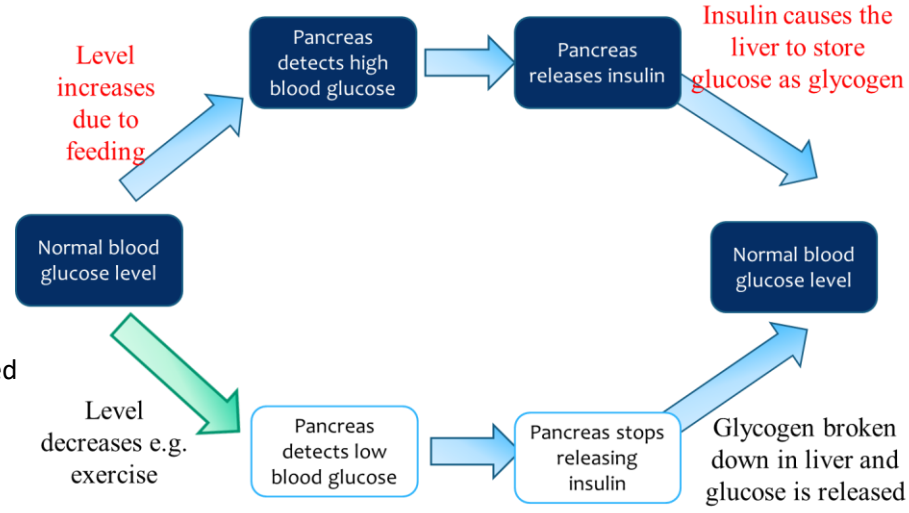
The skin has a number of functions. It acts as a barrier to infection, it has a number of receptor cells in it which detect stimuli, and it helps control our body temperature.



Hot Conditions	Cold conditions.
Sweat is produced which uses heat from the body to *evaporate*.	Little or no sweat produced.
Hairs lie flat. This traps only a thin layer of air, so there is less *insulation*.	Hairs stand erect. This traps a thick layer of air. Air is a good *insulator*, which helps keep the body warm
The blood vessels supplying the surface skin get wider. This brings more warm blood to the surface of the skin. This is called *vasodilation*. More heat is lost by *radiation*.	The blood vessels supplying the surface skin get narrower. This brings less warm blood to the surface of the skin. This is called *vasoconstriction*. Less heat is lost by *radiation*.
No shivering.	Shivering occurs. The muscles contracting release heat energy into the body.

Glucose Control and Diabetes.

Sugar (glucose) is needed in the body as a source of energy. The cells need a constant supply of sugar. But the level needs to be balanced. This is an example of homeostasis.
We take in sugar in our diets. It gets absorbed into the blood. Sugar can also be released into the body from ***glycogen*** stored in the liver.
Sugar is used in respiration to release energy, used for movement and warmth.
Excess is stored in ***liver***.



Diabetes is a condition where we are unable to control blood ***glucose*** levels. There are two types of diabetes:
Type I diabetes ~ (juvenile diabetes) usual starts during teenage years, this is where the pancreas fails to make ***insulin***. This is not caused by obesity, but is probably genetic. Treatment is by insulin injection.
Type II diabetes ~ (mature diabetes) more common in the over 50's. It is often linked with obesity. Here the pancreas makes insulin, but it does not affect the liver. Treatment is by diet control.
Diabetics need to balance their glucose intake and the amount of insulin that they inject. To do this they must know how much glucose is in their blood by:

1. Testing their blood glucose level using a blood test meter.
2. Testing urine using ***clinistix*** or ***Benedict's test***. The presence of sugar in the urine indicates diabetes, as sugar is normally reabsorbed in the kidneys, but diabetics have such high glucose levels that not all of the sugar is reabsorbed.

Some diabetics are now being treated using transplanted pancreatic tissue.

The Role of Glucagon. (HT only)

When our blood glucose falls, we need to release glucose back into the blood. The low blood glucose level is detected by the pancreas, which not only stops producing insulin, but also releases a second hormone called glucagon. This causes the liver to break glycogen into glucose which is released back into the blood. When the blood glucose rises back to the normal level, the production of glucagon switches off. This is an example of negative feedback.

Lifestyle choices.

Lifestyle choices can have an effect on our health.

Obesity. Obesity can result from a combination of an unhealthy diet and a lack of exercise. It can cause heart disease, some cancers, high blood pressure and type II diabetes. (NOT TYPE I DIABETES).

Drug Abuse.

Drug abuse is use of a drug (in excess) for no medical reason. It can have physical and mental effects on the body. Some drugs cause addiction, if you stop taking the drug unpleasant ***withdrawal effects*** occur.

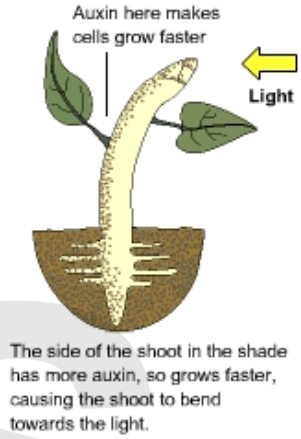
Examples of drugs:

Drug	Effects
Alcohol	Slows down body processes and reaction times. Causes liver damage when exposure is prolonged or excessive. Can also lead to diseases of the kidney and stomach.
Cannabis	Dizziness, sickness, panic, hunger, psychological problems.
Cocaine	Addictive, increased heart rate, psychological problems, heart attacks.
Anabolic steroids	Build muscle, liver problems, heart disease and strokes, affects fertility and secondary sexual characteristics.
Heroin	Highly addictive, painkiller, slows the body down, psychological problems.

Sensitivity in Plants.

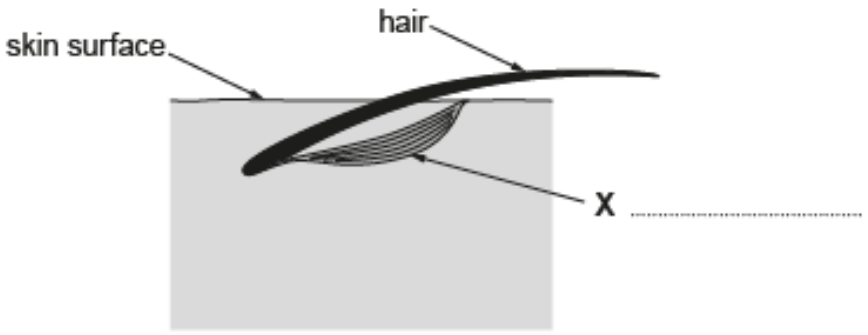
Plants do not have nerves, but use hormones (e.g. Auxin) to bring about growth responses to stimuli. These are called tropisms.

Stimulus	Response of the shoot	Response of the root	Tropism
Light	Grows toward light	Grows away from light	Phototropism
Gravity	Grows away from gravity (Up)	Grows toward gravity. (Down)	Gravitropism (Geotropism)



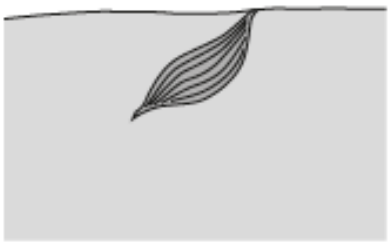
only

5. *(a)* The diagram below shows a section of skin with the position of a hair on a hot day.



(i) Label structure **X** on the diagram. [1]

(ii) Complete the diagram below by drawing in the position of the hair on a **cold** day. [1]



(iii) State how structure **X** causes the change in the position of the hair on a cold day. [1]

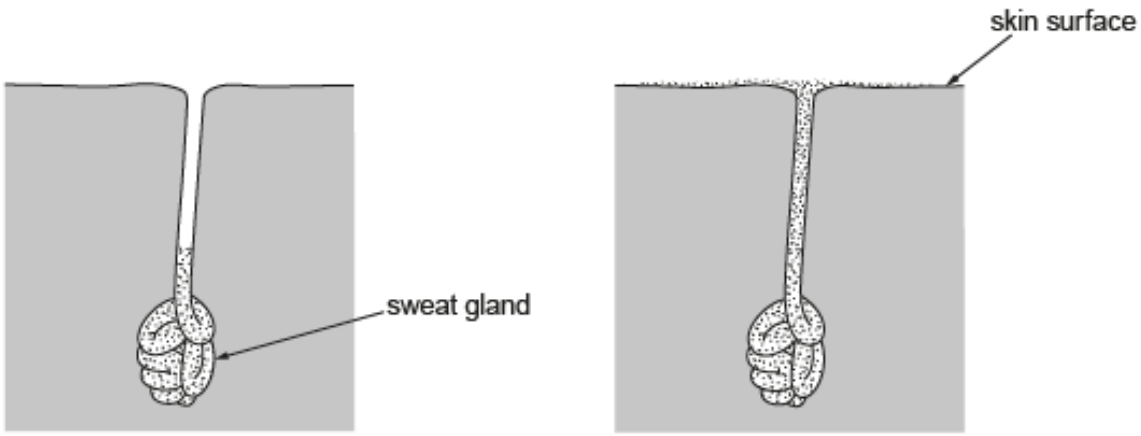
.....

(iv) Describe how hair reduces heat loss from the surface of the skin. [2]

.....

.....

(b) The diagram shows a section through the skin on a cold day and on a hot day.



Use the diagram to describe and explain how the processes taking place in the sweat gland **and on the skin surface** help to cool the body on a **hot** day. [3]

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8

Biol 3 HT June 2015

10. Define a reflex action. Describe the reflex arc involved in the blinking response to a flashing light. (Diagrams will not be credited.) [6 QWC]

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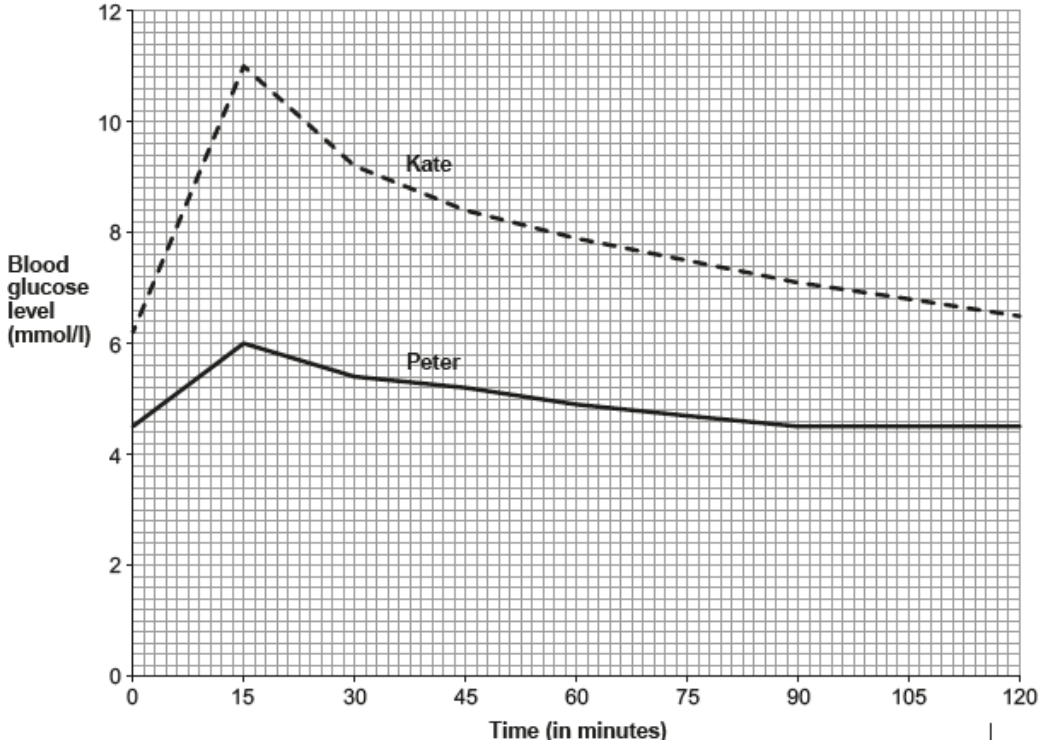
only

8. The graph below shows the blood glucose levels of Kate and Peter, after eating the same mass of sugary cereal at breakfast time. The normal blood glucose range before meals is 4.0 – 5.9 mmol/l.



(a) Explain why Peter's blood glucose level rises then falls. [3]

.....

.....

.....

.....

.....

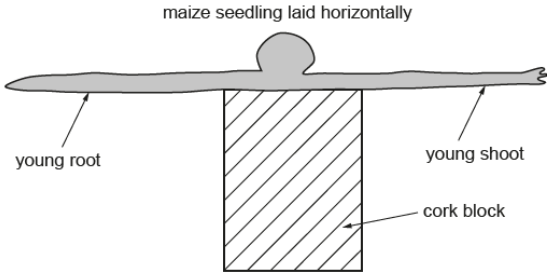
(b) State **two** pieces of evidence, shown in the graph, which indicate that Kate has diabetes. [2]

I. .....

II. .....

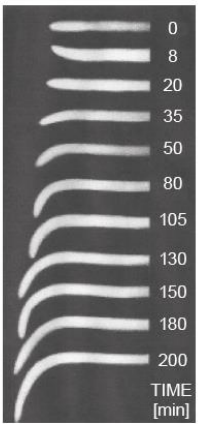
5

5. A young maize seedling was laid horizontally in a dark room.



A series of time-lapse photographs was taken of the **young root**, at various time intervals, over a 200 minute period.

The series of photographs is shown below.



(a) (i) State three observations, **shown in the photographs**, about the young root over the time of the investigation. [3]

I. .....

II. .....

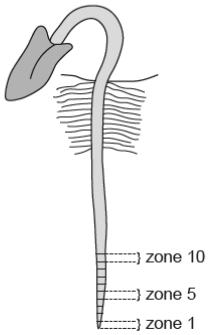
III. .....

(ii) Name the response shown by the young root between 35 and 200 minutes. [1]

.....

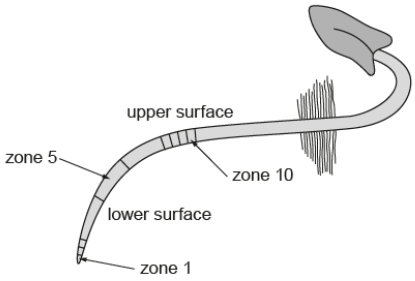
(b) The root tip of a young seedling was marked with ink at 2 mm intervals. Each of the 2 mm divisions is known as a zone and three zones are labelled in the drawing.

Drawing 1



The seedling was laid horizontally for 180 minutes after which time a drawing was made. This is shown below.

Drawing 2



(i) **Using Drawing 2 only** compare the growth rate of the upper and lower surfaces of the young root. [1]

.....

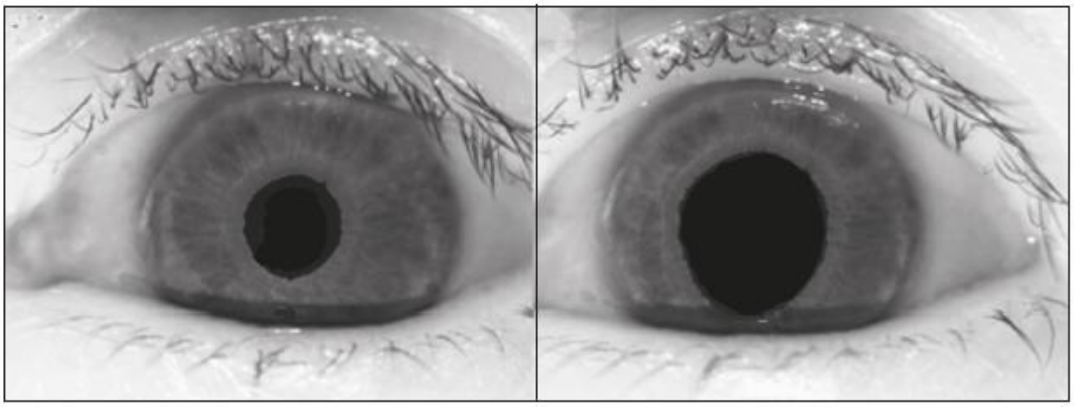
.....

(ii) Name the type of chemical responsible for the curvature of the young root. [1]

.....

6

7. The photograph below shows the eye of a volunteer who was taking part in a medical investigation into the effects of the drug LSD on the nervous system. One of the effects of LSD is that it causes dilation of the pupil of the eye. The pupil can remain dilated for many hours after the drug was taken.



Before taking LSD | After taking LSD

(a) (i) The photographs above show the pupil of a volunteer before and after taking LSD. Measure the diameter of the pupil in both photographs and calculate the percentage increase in the diameter of the pupil caused by LSD. [2]

Percentage increase in diameter = ... %

(ii) The part of the brain that controls pupil size is stopped from working by the drug LSD.
Explain why pupil size cannot be controlled if this part of the brain stops working. [2]

.....

.....

.....

(b) (i) Control of pupil size is a reflex action. One of the functions of reflex actions is that they protect the body from damage. Name the part of the eye which could be damaged in bright light if the pupil size could not be altered. [1]

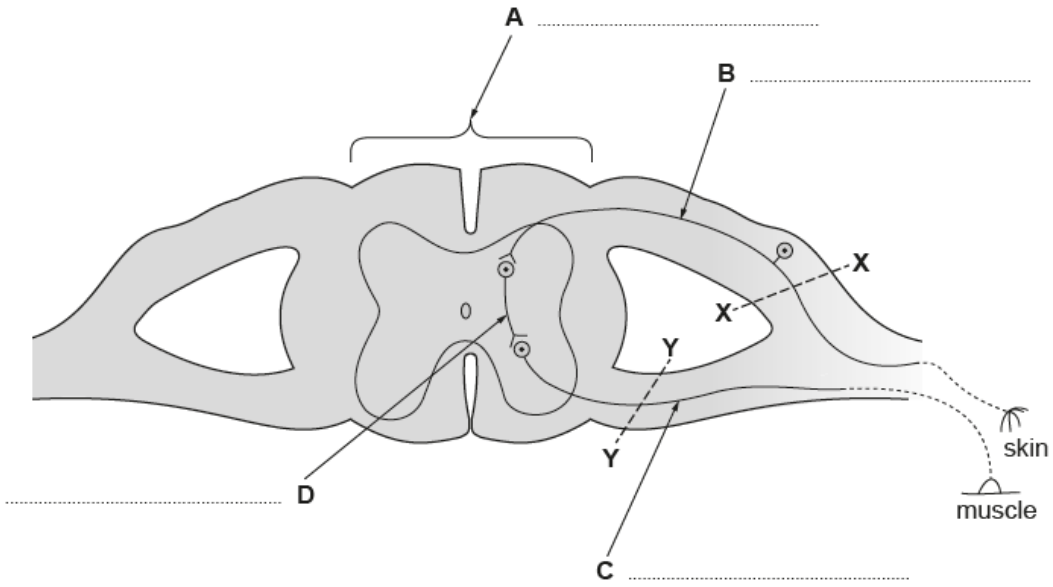
.....

(ii) Apart from protection, state **one** *other* property of reflex actions. [1]

.....

6

9. The diagram shows part of a human nervous system involved in a withdrawal reflex.



(a) Label **A** to **D** on the diagram above. [4]

(b) Add **two** arrows on the diagram, **one** on the structure labelled **B** and the **other** on the structure labelled **C** to show the direction of a nerve impulse during a reflex action. [1]

(c) Suggest the effect on the withdrawal reflex if cuts were made at [2]

(i) **X–X** .....

.....

(ii) **Y–Y** .....

.....

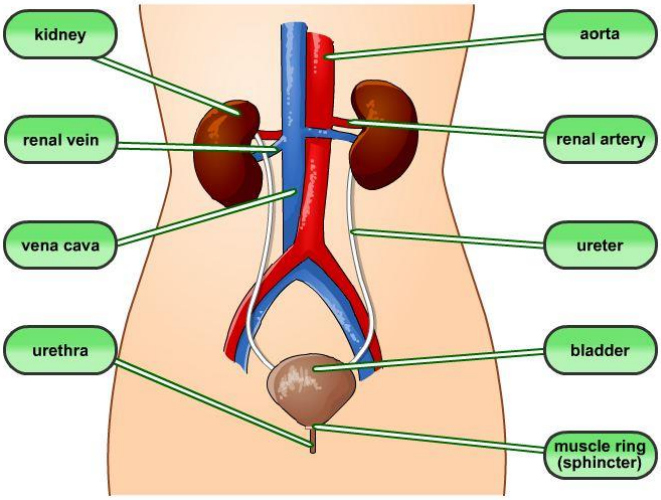
7

6. The Kidney and Homeostasis.

The cells of our bodies are sensitive to any changes in the environment around them. It is essential to maintain a constant internal environment. If these conditions vary they are brought back to the body's normal value. This is called **homeostasis**.

Internal conditions that are kept within narrow limits are:

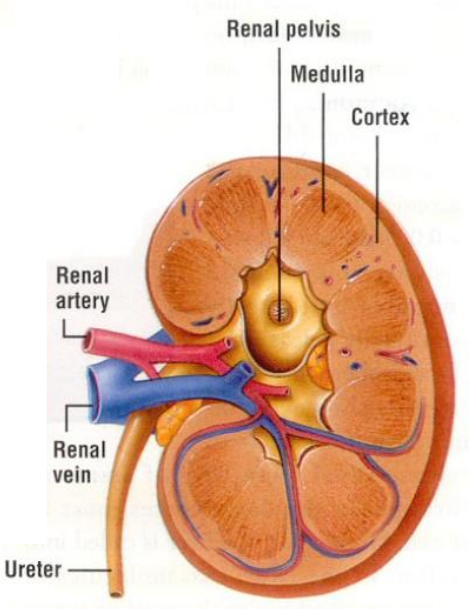
- **water** content
- ion (salt) content



The kidney

The kidneys are the organs which remove wastes like urea, excess water and ions from the blood. This is done by producing urine in the ***kidney***. This trickles down thin tubes, called ***ureters***, and is stored in an organ called the bladder. When the ***bladder*** is full we urinate and release the urine to the outside of our body, through a tube called the ***urethra***.

The structure of the kidney.



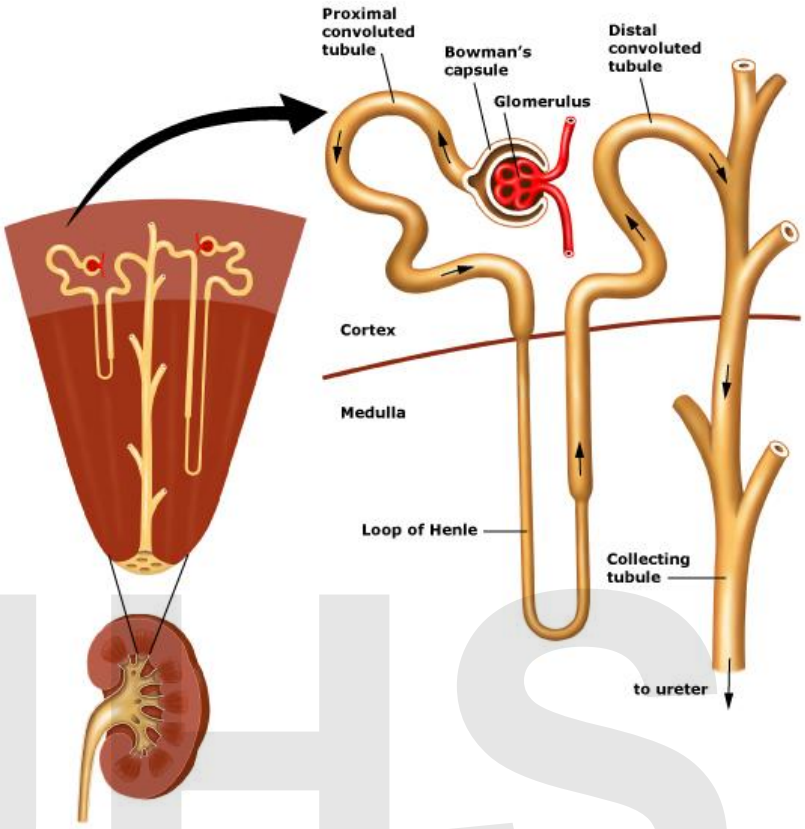
Blood arrives at the kidney in a blood vessel called the ***renal artery***. Filtered blood flows out from the kidney in the ***renal vein***. (Be prepared to put arrows on diagrams to show the direction.)

The kidney is divided into three zones. The outer zone is called the ***cortex***. This is where the blood is filtered. In the middle is the ***medulla***. This appears in lobes. This is where the urine drains and some re-absorption occurs. Finally at the centre is the ***pelvis***. This is where the urine collects and trickles into the ureter.

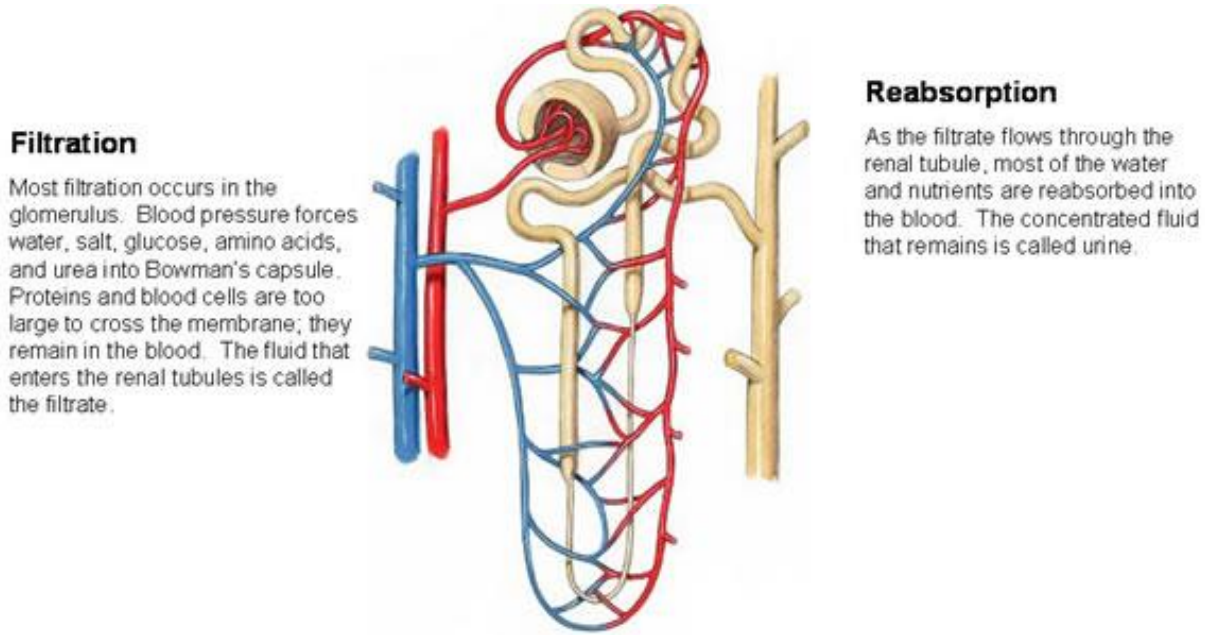
The Nephron. (HT only)

Inside the kidney are millions of small filtering units called nephrons.

Each nephron has a filtering unit called the Bowman's capsule. A branch of the renal artery called the renal arteriole rapidly divides and forms a knot of blood capillaries inside the capsule. (this is sometimes called the glomerulus).



Blood arrives in the knot of blood vessels under high pressure and fluid is forced out into the cavity of the capsule. This process is called ultrafiltration because it occurs under high pressure. Large structures like the blood cells and large proteins cannot be filtered. The fluid which is filtered is mainly water and urea, but also contains some sugars and salts. The filtrate then passes down a coiled tubule (small tube). This tubule is surrounded by blood vessels called a capillary network and useful molecules such as glucose, some salts and much of the water are re-absorbed. This is called selective reabsorption. The waste which now has a higher concentration of urea, and passes down a long tubule in the medulla, called the Loop of Henle. Then back up and through a second coiled tube into the collecting duct. Variable amounts of water can be reabsorbed along the tubule and collecting duct.



Composition of the filtrate. (HT only)

Substance	Concentration in Blood plasma (mg/l)	Concentration in Filtrate in capsule (mg/l)	Concentration in Urine (mg/l)
Water	92000	97000	95000
Proteins	4000	0	0
Glucose	100	100	0
Salts	142	142	300
Urea	26	26	2000

Controlling Water Levels.

The kidney can control blood water levels by regulating how much water it reabsorbs.
If we have drunk a lot of water and our blood has a high water level, then less water is reabsorbed in the tubule. This produces large amounts of dilute urine.
If we have not drunk much fluid and our blood water level is falling then we reabsorb as much water as possible in the tubule. This produces little but concentrated urine.
(HT only) This process is controlled by a hormone called anti-diuretic hormone (ADH). If our blood water level drops, it could be dangerous. Our brain detects this and causes the release of the hormone. The hormone acts on the kidney, causing it to reabsorb the water.

Kidney problems.

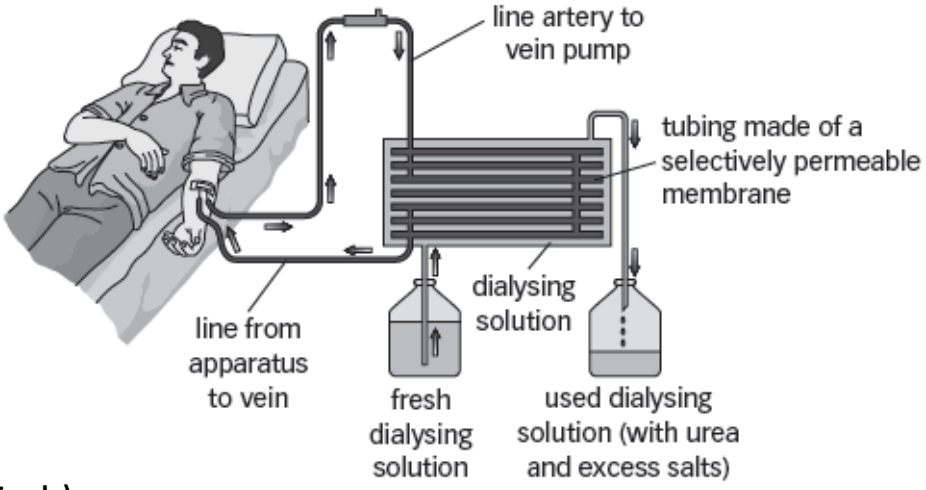
If blood, cells or proteins are present in the urine it indicates disease of the kidney. If this is not treated it could lead to kidney failure. The presence of glucose in the urine can indicate diabetes.

Kidney failure

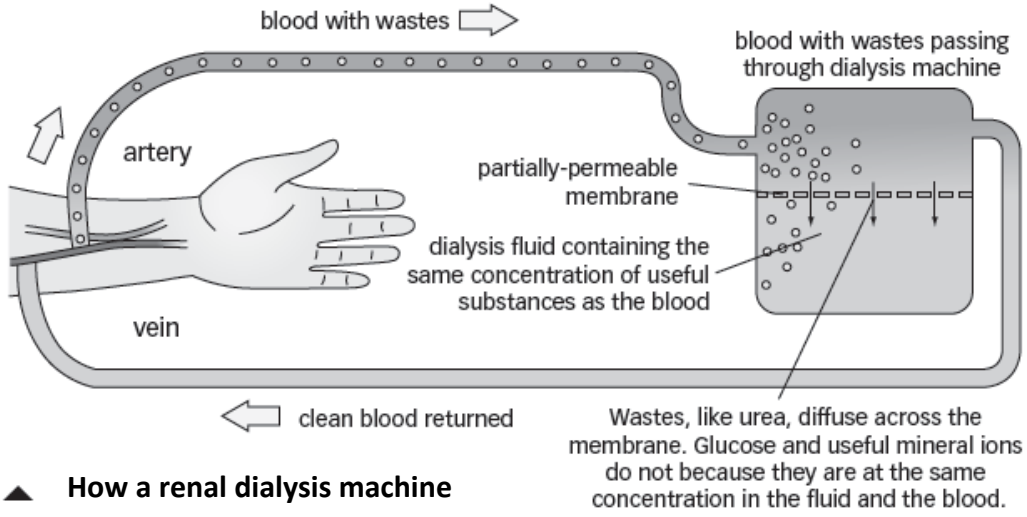
Kidneys are important organs because they remove toxic wastes from our bodies such as urea. If the kidneys stop filtering out these toxins, it can make us very ill. This is called kidney failure. This can happen in a number of ways. Treatment is either by dialysis or transplant.

Kidney dialysis

The aim of dialysis is to remove the waste products from the blood, and restore the concentrations of all dissolved substances in the blood, like salts, to normal.



How a renal dialysis machine works. (HT only)



▲ **How a renal dialysis machine works. (HT only)**

To achieve this, dialysis is usually carried out for five to six hours, three or four times a week. The patient is attached to a dialysis machine, and their blood is taken from a vein and flows through the machine to be filtered.
In the dialysis machine the waste products are filtered out by diffusion.

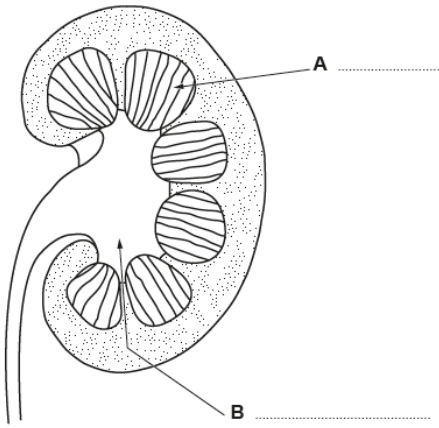
Kidney transplants

For patients with long term kidney failure due to diseased kidneys, dialysis limits their quality of life. A transplant may be a better option. Here the diseased kidney is removed, and replaced with a healthy kidney. The healthy kidney is taken from a **donor** who might be a similar tissue type as the patient, perhaps a close relative or someone who has recently died. Care is taken to prevent **rejection** of the kidney by the **recipient's** immune system. Drugs can be taken to suppress the immune response. There are ethical issues in the decision about who would get a transplant.

Evaluating treatments

Treatment	Advantages	Disadvantages
dialysis	• effective waste removal • allows time for the kidney to recover	• treatment time reduces quality of life • expensive
transplant	• long term solution • better quality of life • cheaper in the long term	• tissue matching • lack of donors • rejection

3. The diagram shows a section through the human kidney. The kidneys remove waste substances from the blood.



(a) (i) I. **Complete labels A** and **B** on the diagram. [2]

II. **Use an arrow to label** the ureter on the diagram above. [1]

(ii) I. Name the solution which passes through the ureter ..... [1]

II. State **one** waste substance which the solution passing through the ureter contains.

..... [1]

(b) If the kidneys fail to function, a person can be treated by dialysis or have a healthy kidney transplanted from a donor.

The photograph shows a dialysis machine in use in a hospital. Patients must visit a hospital every few days for treatment. In addition, they need to restrict their everyday activities, eat a special diet and take certain drugs.

(i) Describe **two** advantages of a kidney transplant compared with dialysis. [2]

I. .....

II. .....

(ii) Since 2015, a law in Wales has assumed that everyone is willing to donate his or her organs after death. Individuals are allowed to opt out of the donation scheme.

I. Give a reason for the introduction of this law. [1]

.....

.....

II. Suggest why some people may object to donating their organs. [1]

.....

.....

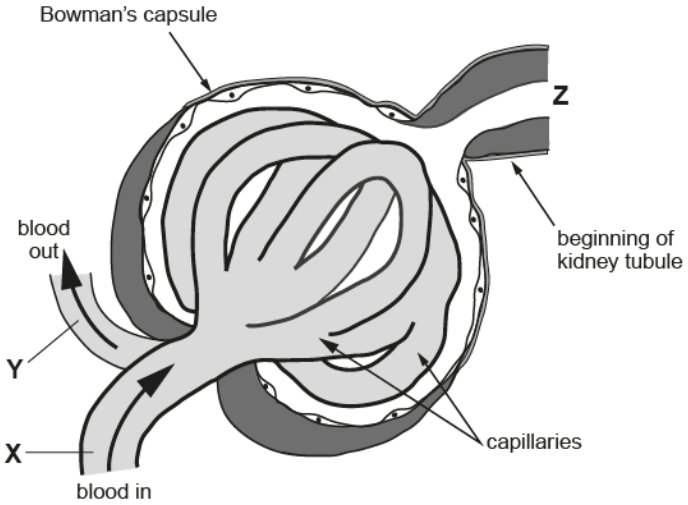
9

6. Each minute 1200 cm^3 of blood passes into a healthy human kidney. This volume of blood contains 700 cm^3 of plasma. 125 cm^3 of plasma passes into the kidney tubules.

(a) Calculate the percentage of plasma passing into the tubule to the nearest whole number. Show your working. [2]

Percentage of plasma = ... %

(b) The diagram shows the blood vessels in a Bowman's capsule.



(i) Explain the importance of the blood vessel labelled **Y** being narrower than the blood vessel labelled **X**. [2]

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(ii) Explain the role of ADH when the water content at point **Z** is decreased due to shortage of water in the blood. [4]

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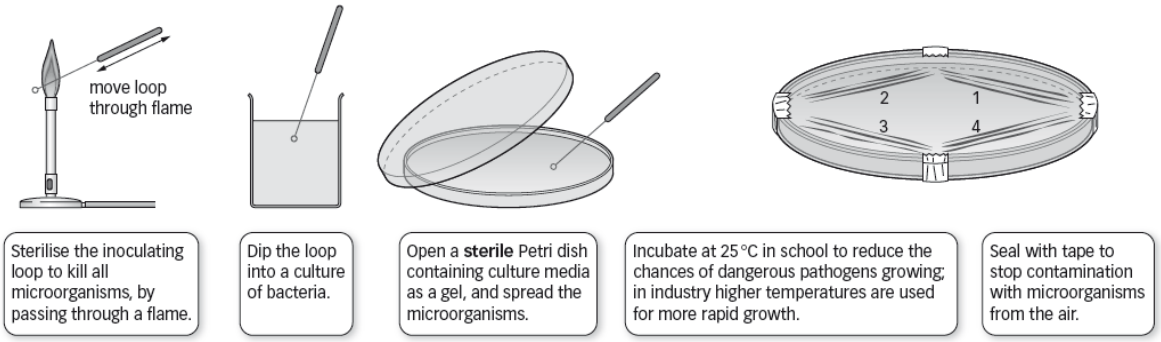
7. Microorganisms and Their Application.

Growing Micro-organisms.

It is important for biologists to be able to grow microorganisms like bacteria in the laboratory. This allows them to test treatments, such as **antibiotics** for disease, or to investigate how effective disinfectants might be at killing bacteria. There are now standard techniques for biologists to grow uncontaminated cultures.



To test the effect of an antibiotic or cleaning products, a disc containing the agent can be placed in the centre of the plate of bacteria, and measuring the zone of inhibition which results. The larger the size of the zone, the stronger or more effective the agent was at killing bacteria.

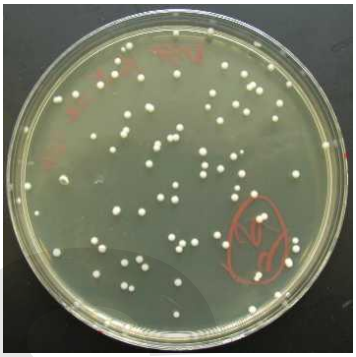
It is possible to calculate the area of the zone of inhibition by using the formula πr^2.

Aseptic Technique.

Keywords:

Sterile	**Free from all living organisms.**
Aseptic technique	Methods used to prevent contamination of apparatus or experiment.
Incubating	Placing the culture plates in a warm temperature incubator, to encourage growth of the microbes. (Usually 25-30^{o}C in schools to avoid dangerous microbes growing.)
Culture	The growing microbes.
Colony	A single group of bacteria on a agar plate. All the bacteria in a colony have arisen from a single bacterium.
Agar	The gel like medium for growing bacteria.
Inoculating	Placing micro-organisms into or onto a growth medium.
Plating	Smearing microbes over an agar gel.

Bacteria in milk.

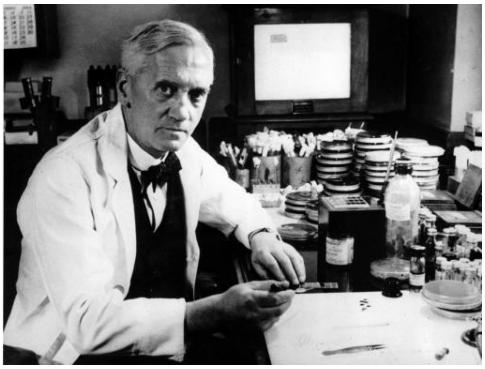


Milk contains bacteria. The older the milk the more bacteria it will contain. We can demonstrate that milk contains bacteria by adding a drop of milk onto agar, and spreading the milk over the surface of the agar using a sterile spreader. All repeat plates should have the same size (volume) drop of milk to keep the test fair. Then the plates are sealed and incubated for 24-48 hours. The number of colonies can then be counted. The more colonies the more bacteria were present in the original milk sample.

The Effect of Temperature on Bacterial Growth.

Microbes grow best in warm temperatures around 37^{o}C. Any lower tends to slow their growth, higher tends to kill the microbes. This information has allowed us to develop ways to preserve food.

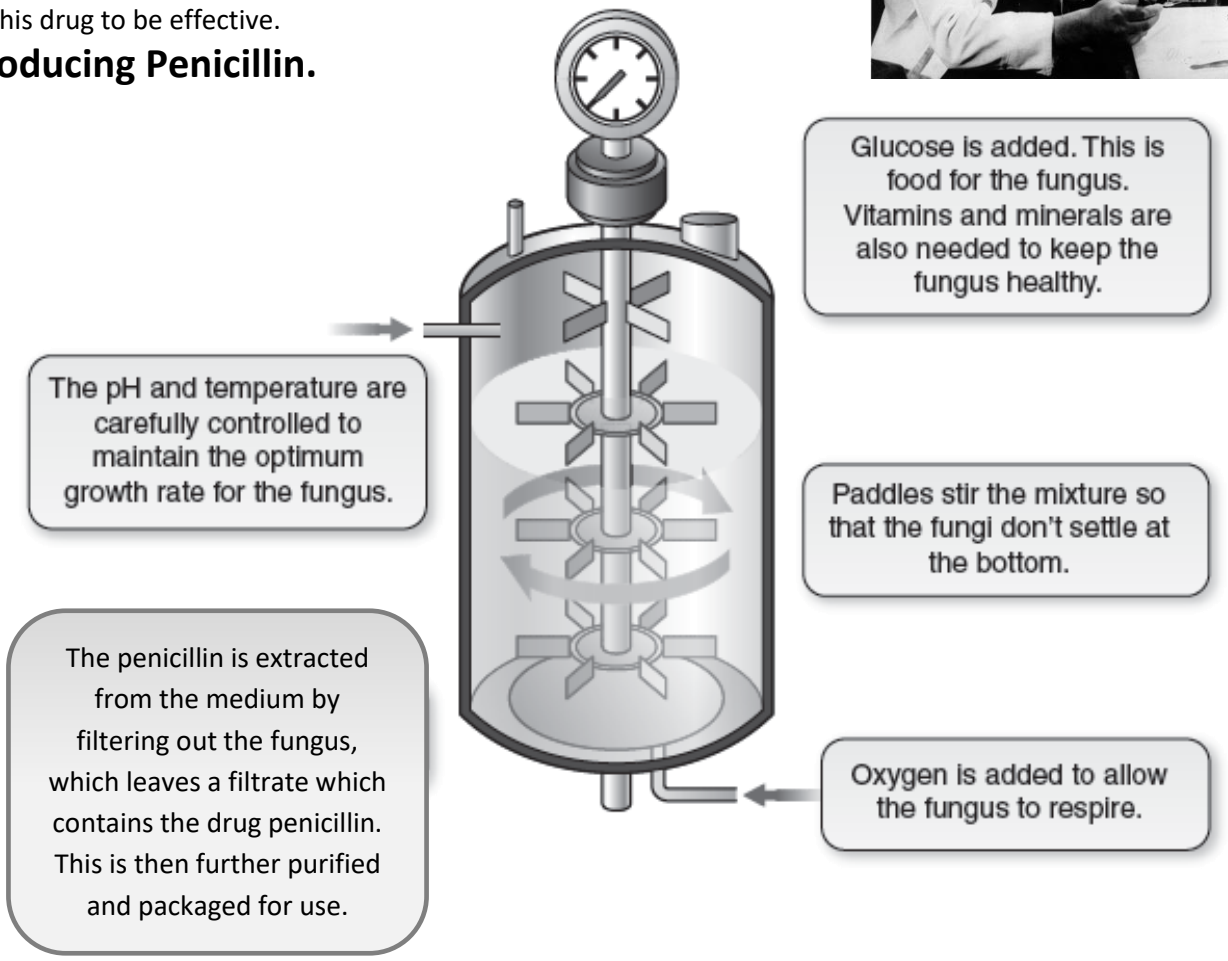
1. Freezing (less than 0^{O}C) ~ stops microbe growth. So food in a freezer will not decay for many months.
2. Refrigeration (around 4^{O}C) ~ slows microbe growth, so food will not decay as fast, and can last several days.
3. Cooking (above 100^{o}C) ~ this kills the microbes and it is microbe free to eat, but needs to be stored in a way e.g. a fridge, as bacteria will soon infect the food.



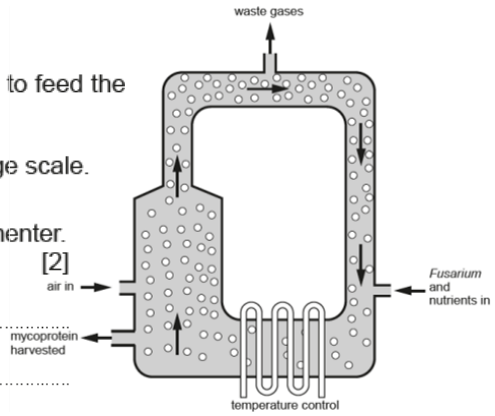
Penicillin.

In 1928 a British Scientist called Alexander Fleming discovered that bacterial growth could be stopped by a fungus called ***Penicillium***. The fungus was producing and releasing a chemical that we now call penicillin. It wasn't until WWII that scientists were able to extract enough of this drug to be effective.

Producing Penicillin.



5. In the 1960s scientists started to look for ways to obtain food from microorganisms to feed the world's growing human population.
They produced a mycoprotein by growing a microscopic fungus called *Fusarium*.
The diagram below shows a fermenter which is used to make mycoprotein on a large scale.



(a) (i) Explain why it would be necessary to maintain aseptic conditions in the fermenter. [2]

.....

.....

.....

(ii) Give **one** advantage of growing foods from microorganisms in a fermenter. [1]

.....

.....

(b) Many people now eat mycoprotein as a meat substitute.
The table shows some of the nutrients in a 200 g mycoburger compared with a 200 g beefburger.

Nutrient	Mass of nutrient in 200 g burger	
	mycoburger	beefburger
protein (g)	25.0	75.0
fat (g)	1.0	36.0
salt (g)	1.0	2.4
cholesterol (mg)	0.0	150.0

(i) How many of these mycoburgers would a person need to eat in order to obtain the same mass of protein as a 200 g beefburger? [1]

Number of mycoburgers = ...

(ii) Calculate the percentage of fat in a beefburger. [2]

Percentage of fat = ... %

(iii) Mycoprotein is often described as a "Healthy Option" food. From the table, suggest **two** reasons, other than low fat content, which support this idea. [1]

.....

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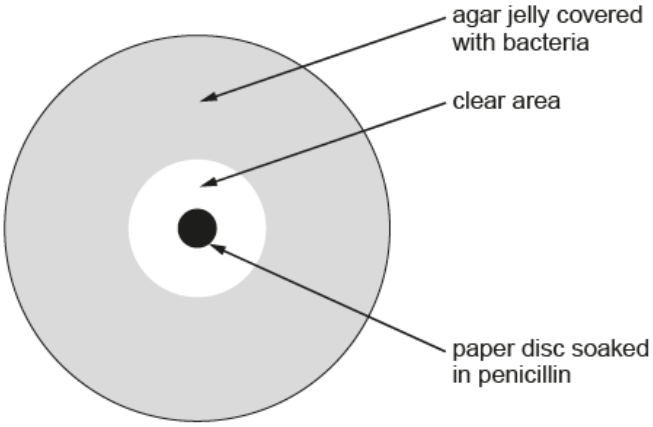
7

8. The diagram below shows a Petri dish containing agar jelly. The agar jelly has a very large number of disease causing bacteria growing on it. A paper disc soaked in penicillin was placed in the centre of the agar jelly. After 3 days the Petri dish appeared as shown in the diagram below.



(a) Explain the appearance of the clear area around the paper disc. [2]

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.....

.....

(b) If the bacteria on the dish had been MRSA no clear area would have developed. State why. [1]

.....

.....

(c) To which group of chemicals does penicillin belong? [1]

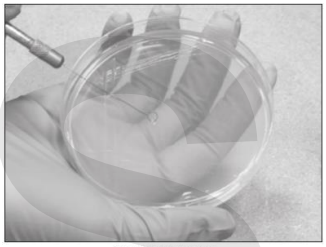
.....

4

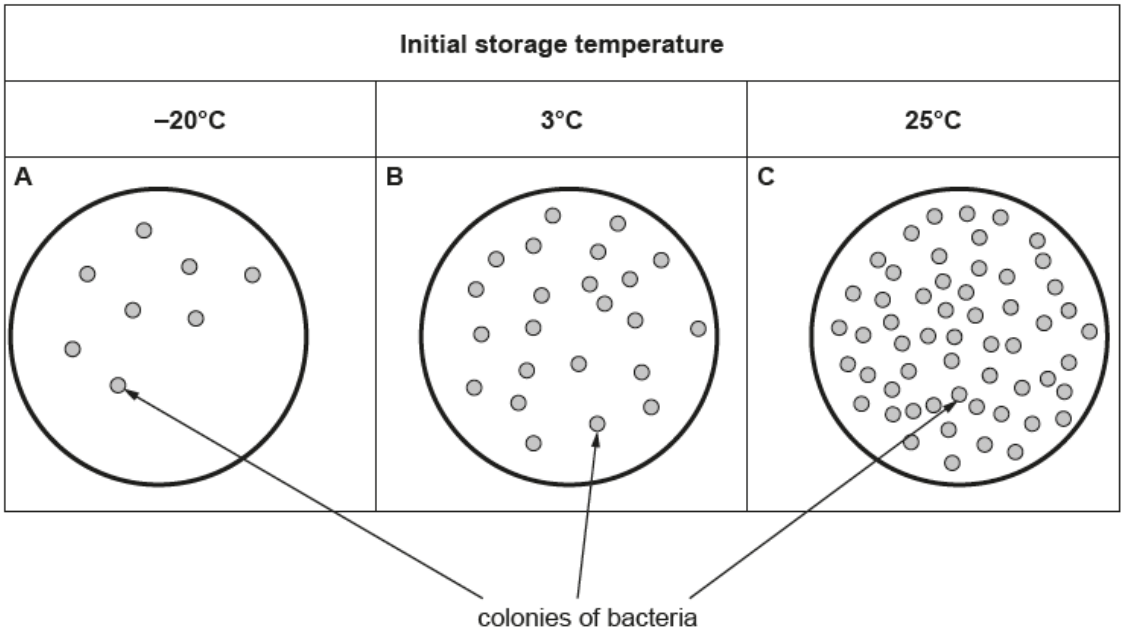
5. Some fresh meat was cut into three 100 g pieces. Each 100 g piece of meat was stored at a different temperature for 14 days. The three temperatures used were:

A –20°C (the temperature at which food is stored in a domestic deep freeze)
B 3°C (the temperature at which food is stored in a domestic refrigerator)
C 25°C

After 14 days, meat samples of equal mass from each temperature were inoculated onto agar jelly in Petri dishes. Aseptic techniques were used throughout the investigation.


Inoculating agar

The three Petri dishes were then kept in an incubator for three days at a temperature of 30°C. At the end of this period the Petri dishes were removed from the incubator and examined. The results are shown below.



(a) (i) State **one** conclusion which can be drawn from the results of this investigation. [1]

.....

.....

(ii) Each of the colonies consists of many thousands of bacteria.

I. How many bacterial cells were spread onto the agar which was inoculated with meat stored at –20°C? [1]

.....

II. Explain the advantage of storing meat at –20°C. [2]

.....

.....

.....

(b) (i) Why were aseptic techniques used throughout this investigation? [1]

.....

.....

(ii) Give **one** example of an aseptic technique which would have been used during the investigation. [1]

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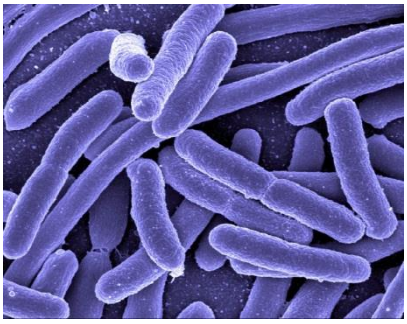
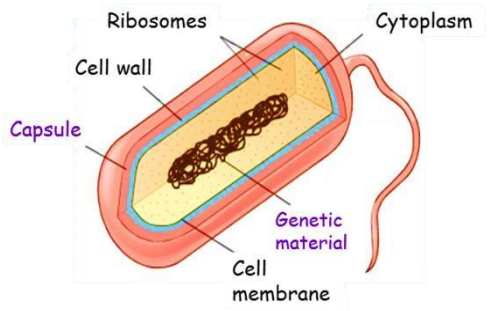
8. Disease, Defence and Treatment.



There is a wide range of organisms that can only be seen using microscopes. Some of these micro-organisms or microbes are helpful to humans; others are harmful. There are four main groups – Bacteria, Fungi, Protists and Viruses. Useful microbes can be involved in decay and recycling, or they can be used to make foods or drugs. Other microbes, called pathogens, cause diseases.

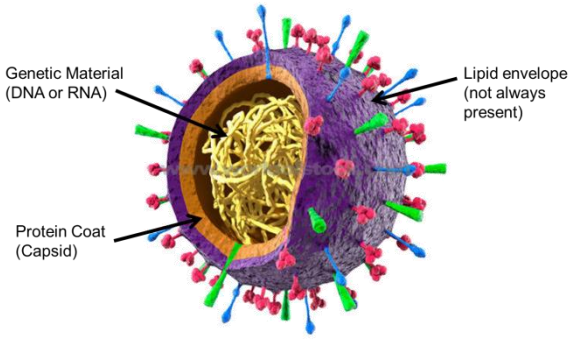
When infections are spread from one organism to another they are called communicable diseases.
e.g. Bacterial – Tuberculosis; Fungal – athletes foot; Protists – Malaria; Viral – Colds.

Bacteria Cell



DNA not in a nucleus.
Cell wall not made of cellulose.
Reproduces asexually by splitting into two.

Viruses



Smallest form of life, viruses are very simple. They consist of genetic material in a protein coat. They reproduce inside another living host cell. New viruses are then released from the host cell to attack new host cells. Since viruses do not have a cell structure, this has questioned the cell theory of the 1800's. Some biologists are not certain if viruses can be regarded as living things.

The Spread of Pathogens.

The pathogens responsible for communicable diseases can spread in a number of ways.

Insect Vectors

- These are organisms which carry the pathogen from one organism to another.
- e.g. insects carry the malarial parasite.

Direct Contact and Body Fluids

- If a healthy organism is in contact with an infected organism or fluids from that organism, a pathorgen can be transferred.
- e.g. the small pox virus will pass in fluids from wounds.

Aerosols

- Some pathogens can be carried in droplets in the air between organisms.
- e.g. the cold virus.

Water and Contaminated food.

- Pathogens can spread in dirty water, or on food.
- e.g. food poisoning caused by Salmonella.

Human Diseases

Studying human diseases allows us to identify the cause. We can then educate the public about how to prevent the spread, and develop suitable treatments.

Disease	Causative agent	Effect on infected organism	Prevention from spread
HIV/AIDS	Human immunodeficiency virus	Damages lymphocytes, destroying the immune system. Causes rashes, colds, cancers etc.	Avoid contact with body fluids, e.g. clean needles, protected sex. Inform public.
Chlamydia	Bacterium (*Chlamydia*)	Damages fallopian tubes blocking them. Causes infertility.	Avoid physical contact with infected person.
Malaria	Protists (*Plasmodium*)	Infects red blood cells and liver cells. It destroys the RBC leading to the release of toxins. This causes fevers.	Prevent mosquito vector spreading the protist, e.g. mosquito nets.

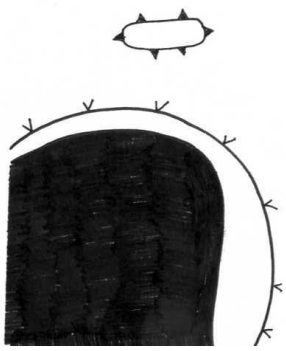
Diseases are more likely to occur if large numbers of micro-organisms enter the body as a result of unhygienic conditions or contact with infected people. The body has several methods of defending itself against the entry of micro-organisms.

Part of body	How does this prevent entry of microbes ?	How microbes get past the barrier.
Skin.	• Acts as a physical barrier to prevent microbes entering. • Washing reduces numbers of microbes. • Blood produces clots that seal cuts.	• Cuts in skin allows microbes in.
Digestive system.	• There are useful natural micro-organisms with which the pathogens have to compete. • Acids in stomach kill bacteria.	• Eating food with large numbers of microbes.

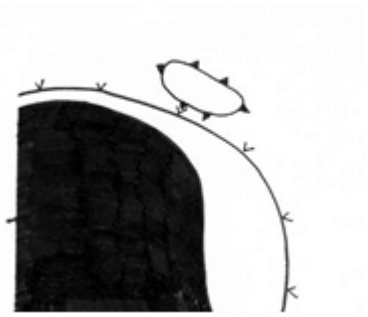
When pathogens do get into the body the white blood cells become involved in the immune response. There are two types of white blood cells, ***Phagocytes*** and ***Lymphocytes***, and they are involved in basically two methods of defence.

Phagocytes	Lymphocytes
	
• locates pathogen • engulfs pathogen • ingests it	• locates pathogen • reacts to **antigens** on specific pathogen • massively increases in number • produces **antibodies** • antibodies are proteins, and are specific to the antigens on the particular pathogen • antibodies destroy the specific pathogen • lymphocytes can also produce antitoxins specific to a toxin released by the pathogen

The Immune Response.



All cells have cell surface marker molecules called antigens. Pathogens like bacteria have different antigens to our cells, we call them foreign antigens.



Foreign antigens are recognised by the lymphocytes by fitting into a surface receptor. This triggers a response.

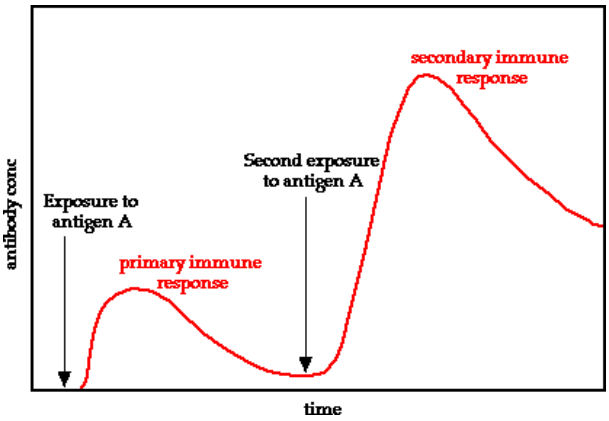
The lymphocyte now produces antibodies specific to the foreign antigen. They are released into the blood and attach to the antigen on the pathogen, and destroys the pathogen.

Vaccination.

Edward Jenner was born in 1749 in Gloucestershire. Deadly diseases were common at this time. Smallpox was one such disease. Dr. Jenner noticed that milkmaids seemed to be able to resist smallpox, but often caught a milder form called cowpox. Jenner thought that if people were infected with cowpox, then they could not get smallpox. Dr. Jenner was able to take some of the puss from cowpox sores and inject it into a boy who caught cowpox. Dr. Jenner then injected the boy with the puss from a smallpox sore. He did not get the disease. He had become immune to smallpox. This was the first time someone had been given an injection which stopped them getting a disease. This process is now common and it is called vaccination. This technique is now used to protect humans from infectious diseases caused by bacteria or viruses.

How Vaccination Works. (HT only)

- **A small quantity of dead or inactive pathogen, or parts of their antigens are injected.**
- **This is called a *vaccine*.**
- **The antigens on the pathogens stimulate the lymphocytes to produce antibodies.**
- **Some of these lymphocytes are retained and known as memory cells.**
- **These can quickly produce the same type of antibody again if the same antigen is encountered again.**
- **This quickly destroys the live pathogen.**



This process is called *vaccination* or *immunisation*. Vaccines can be produced to protect against bacteria and viruses.

Natural Immunity

- **Following a normal infection, some of the activated lymphocytes are retained.**
- **These can also quickly produce the same type of antibody again, if the same antigen is encountered.**
- **This quickly destroys the same pathogen.**

This response is highly specific. This is because the shape of the antigen will only trigger one type of lymphocyte. This in turn can only make the one specific type of antibody, which destroys the pathogen containing that antigen. So one vaccination will only protect against one type of pathogen, e.g. measles. However, some viral diseases like the flu are able to constantly change their antigens by mutations. Therefore, the body does not recognise the same pathogen in a later infection, so we can catch flu many times.

Making Decisions about Vaccinations.

Parents need to make decisions about whether to have their children vaccinated or not. They may be affected by public opinion and scare stories in the media. They need sound scientific evidence to make their decisions. Scientists can only provide a statistical analysis about the probabilities of catching a disease or suffering from any side effects caused by the vaccine.

Drugs and Medicines to Treat Disease.

Scientists try to improve people's health. This can be done in a number of ways, e.g. the development of vaccines, treatments such as radiotherapy or physiotherapy, and also the development of drugs. When we have an infection, we feel unwell. We take medicines to deal with two problems the body has:

- Antibiotics – to kill the infectious micro-organism in the body.
- Painkillers – to treat the symptoms produced.

Some conditions can be prevented by treatment with drugs or other therapies e.g. statins which prevent cholesterol build up in artery walls, reducing the risk of heart disease.

Antibiotics.

The immune system takes about a week to make the antibodies needed to kill the pathogen. In some cases this would be too long. It is possible to use drugs which damage the bacterial cell wall, or which bacteria can ingest, and thus poison them. These drugs are called *antibiotics*, e.g. *penicillin*. (Penicillin produced by a living fungal organism, and was first discovered by A. Fleming in Paddington in 1928.) Antibiotics can quickly kill the bacteria.

Since viruses have no real cell structure, and live mainly inside other cells, it is difficult to develop drugs, which kill viruses, without also damaging the body's tissues. One anti-viral drug is Zovirax, which is used to treat cold sores.

When scientists develop new drugs, they follow a sequence of events:

Step 1 ~ new drugs are developed by scientists to treat a disease.
Step 2 ~ laboratory trials, on cells, tissues, and eventually live animals. This will check for toxicity, and whether the drug works.
Step 3 ~ clinical trials. Here the drugs are tested on human volunteers. Step 2 & 3 look for possible side effects, these are unintended effects on the user.
Step 4 ~ if successful the drug is marketed.

This process is expensive. Following testing scientists would evaluate the benefits and drawbacks of the use of the drug. This is called a *risk-benefit assessment*.

Ethical Issues Related to Drugs.

- Many drugs are expensive so decisions have to have made regarding which treatments are cost effective.
- Some drugs are so expensive other treatments in the NHS cannot be afforded.
- Some drugs are only effective in a small number of people, which means that you pay for drugs which have little effect in the population.
- New drugs may be only slightly more effective than old drugs, but more expensive.

Ethical issues of Drug Testing.

Arguments for Animal Testing	Arguments Against Animal Testing
Research develops new drugs which benefit humans.	Benefits to humans are not proved. The reactions of animals may be different to humans.
Licensed scientists try to minimise suffering of the animals.	The animals will suffer, experiments may be painful and reduce quality of life.
Animals are generally well looked after.	Alternative methods such as: computer models, tissue or cell cultures, or statistical studies could be used.

The Development of Antibiotic Resistance.

The development of antibiotic resistance by bacteria results from the overuse of antibiotics. This happens in a series of steps

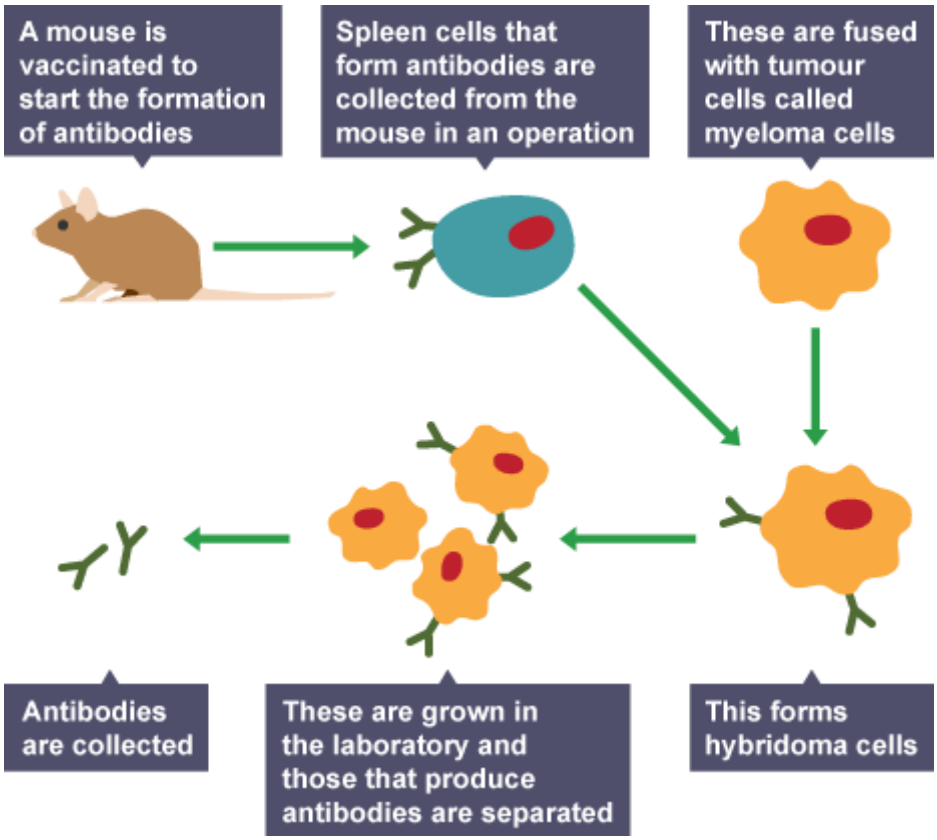
1. A mutation occurs in some bacteria, which gives them resistance to the antibiotic. (Here the resistant bacteria are shown in pale grey)
2. Treatment with the antibiotic kills the bacteria that do not have this mutation, so are not resistant.
3. The bacteria with the resistance survive.
4. The surviving bacteria reproduce, passing on the gene for resistance.

5. Eventually the whole population becomes resistant.

An example of antibiotic resistance is seen in MRSA, which is a bacteria which is now resistant to most antibiotics. This bacterium cannot be treated by our common antibiotics. The best way to control it in hospitals is good hygiene, using antibacterial hand-washes and cleaning the surfaces in wards.

Monoclonal Antibodies. (HT only)

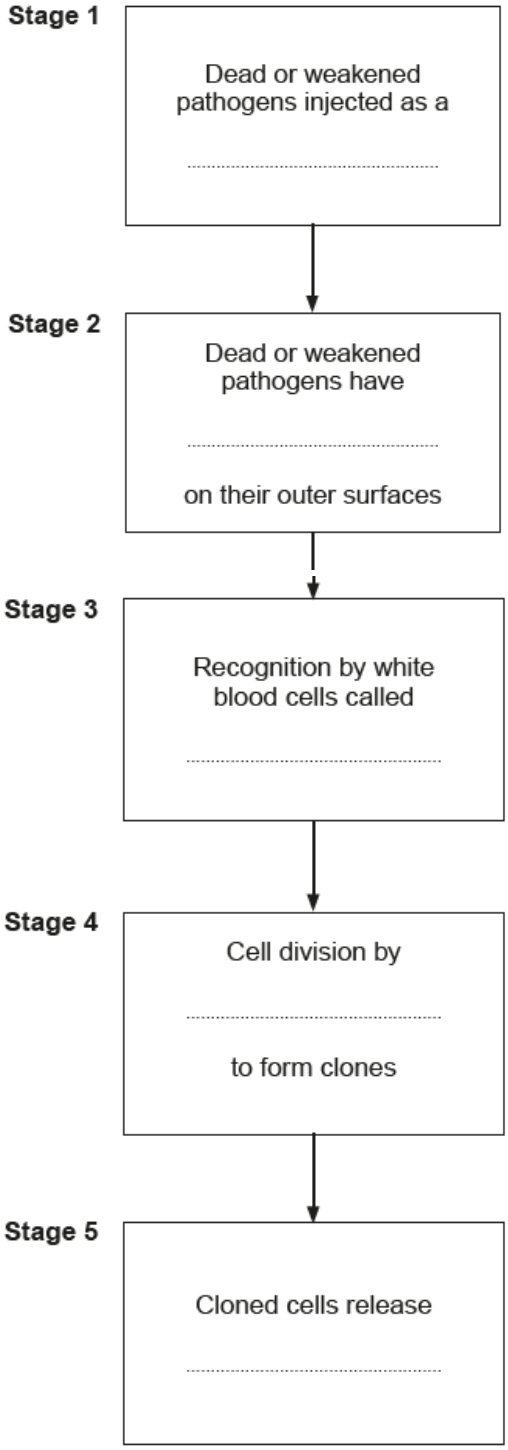
Monoclonal antibodies are antibodies of one type. They are produced from activated lymphocytes, which are able to divide continuously. This produces large numbers of identical antibodies, specific to one antigen.



Monoclonal antibodies have many medical applications.

- **Diagnosis of diseases including Chlamydia and HIV – a patients blood is mixed with the monoclonal antibodies. If they attach to an antigen, it suggests the patient is infected.**
- **Tissue typing for transplants – the monoclonal antibodies are added to a sample of tissue from a donor. If they attach it indicated the presence of certain antigens.**
- **Monitoring the spread of malaria – there are several different strains of malaria which can be distinguished using monoclonal antibodies.**
- **Supporting chemotherapy for cancers – the toxic drugs are attached to monoclonal antibodies which will attach in turn to the antigen on the tumour cell. This will deliver the drug to the cancer cell only. They are sometimes called 'magic bullets'.**
- **Pregnancy test kits to identify the small levels of a hormone called human chorionic gonadotrophin, which is present in the urine of pregnant women.**
- **They can also be used to locate blood clots as they bind to clots.**

8. The incomplete flow chart below shows the stages that occur after a person has been given an injection for protection against a disease caused by a pathogen.
Complete the flow chart by adding the most appropriate words. [5]



9. The World Health Organisation (WHO) collects data on the disease, tuberculosis (TB) which is caused by a bacterium. The WHO used the data shown in the table below to estimate:

- the total number of people with the disease in each region;
- the number of deaths from TB in each region.

Region	Number of people with TB per 100 000	Number of deaths from TB per 100 000
Africa	345	78
USA	43	6
Eastern Mediterranean	122	28
Europe	50	8
South East Asia	190	38
Western Pacific	112	19

(a) (i) Give **one** reason why it is necessary to express the number of people as per 100 000. [1]

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(ii) Calculate the percentage of those with TB in Europe who survive the disease. Show your working. [2]

percentage who survive ..... %

(iii) How does the data show that Africa is less successful at treating TB than Europe? [1]

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(b) A vaccine against TB has existed since 1921. Explain how a vaccine can protect the body from a disease caused by a bacterium. [4]

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(c) The number of cases of TB decreased considerably in many countries during the 20th century. Over the past 15 years, the number of cases worldwide has greatly increased. Suggest why this has happened. [1]

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