AQA Separate Biology

Inheritance, Variation and Evolution Revision Booklet

Name: _____

4.6 Inheritance, Variation and Evolution

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4.6 Inheritance, Variation and Evolution Pupil Checklists

4.6.1 Reproduction	
4.6.1.1 Sexual and asexual reproduction	**Review**
Understand that meiosis leads to non-identical cells being formed while mitosis leads to identical cells being formed.	☺ 😐 ☹
Recall that sexual reproduction involves the joining (fusion) of male and female gametes: • sperm and egg cells in animals • pollen and egg cells in flowering plants.	☺ 😐 ☹
Recall that in sexual reproduction there is mixing of genetic information which leads to variety in the offspring. The formation of gametes involves meiosis.	☺ 😐 ☹
Recall that asexual reproduction involves only one parent and no fusion of gametes. There is no mixing of genetic information. This leads to genetically identical offspring (clones). Only mitosis is involved.	☺ 😐 ☹
4.6.1.2 Meiosis	**Review**
Explain how meiosis halves the number of chromosomes in gametes and fertilisation restores the full number of chromosomes.	☺ 😐 ☹
Recall that cells in reproductive organs divide by meiosis to form gametes.	
Understand that when a cell divides to form gametes: • copies of the genetic information are made • the cell divides twice to form four gametes, each with a single set of chromosomes • all gametes are genetically different from each other.	☺ 😐 ☹
Recall that gametes join at fertilisation to restore the normal number of chromosomes. The new cell divides by mitosis. The number of cells increases. As the embryo develops cells differentiate.	☺ 😐 ☹

4.6.1 Reproduction	
4.6.1.3 Advantages and disadvantages of sexual and asexual reproduction	**Review**
Recall the advantages of sexual reproduction: • produces variation in the offspring • if the environment changes variation gives a survival advantage by natural selection • natural selection can be speeded up by humans in selective breeding to increase food production.	☺ 😐 ☹
Recall the advantages of asexual reproduction: • only one parent needed • more time and energy efficient as do not need to find a mate • faster than sexual reproduction • many identical offspring can be produced when conditions are favourable.	☺ 😐 ☹
Understand that some organisms reproduce by both methods depending on the circumstances, limited to: • Malarial parasites reproduce asexually in the human host, but sexually in the mosquito. • Many fungi reproduce asexually by spores but also reproduce sexually to give variation. • Many plants produce seeds sexually, but also reproduce asexually by runners such as strawberry plants, or bulb division such as daffodils.	☺ 😐 ☹
Explain the advantages and disadvantages of asexual and sexual reproduction for any organism if given appropriate information.	☺ 😐 ☹
4.6.1.4 DNA and the genome	**Review**
Describe the structure of DNA and define genome.	☺ 😐 ☹
Recall that the genetic material in the nucleus of a cell is composed of a chemical called DNA. DNA is a polymer made up of two strands forming a double helix. The DNA is contained in structures called chromosomes.	☺ 😐 ☹
Describe a gene as a small section of DNA on a chromosome. Recall that each gene codes for a particular sequence of amino acids, to make a specific protein.	☺ 😐 ☹
Understand that the genome of an organism is the entire genetic material of that organism. The whole human genome has now been studied and this will have great importance for medicine in the future.	☺ 😐 ☹
Discuss the importance of understanding the human genome. This is limited to the: • search for genes linked to different types of disease • understanding and treatment of inherited disorders • use in tracing human migration patterns from the past.	☺ 😐 ☹

4.6.1 Reproduction	
4.6.1.5 DNA structure	**Review**
Describe DNA as a polymer made from four different nucleotides. Recall that each nucleotide consists of a common sugar and phosphate group with one of four different bases attached to the sugar.	☺ 😐 ☹
Recall that DNA contains four bases, A, C, G and T.	☺ 😐 ☹
Understand that a sequence of three bases is the code for a particular amino acid. The order of bases controls the order in which amino acids are assembled to produce a particular protein.	☺ 😐 ☹
Recall that the long strands of DNA consist of alternating sugar and phosphate sections. Attached to each sugar is one of the four bases.	☺ 😐 ☹
Recall that in mitosis one set of chromosomes is pulled to each end of the cell and the nucleus divides. Finally the cytoplasm and cell membranes divide to form two identical cells.	☺ 😐 ☹
Recall that he DNA polymer is made up of repeating nucleotide units.	☺ 😐 ☹
(HT only) Be able to: • recall a simple description of protein synthesis • explain simply how the structure of DNA affects the protein made • describe how genetic variants may influence phenotype: a) in coding DNA by altering the activity of a protein: and b) in non-coding DNA by altering how genes are expressed.	☺ 😐 ☹
(HT only) Recall that In the complementary strands a C is always linked to a G on the opposite strand and a T to an A.	☺ 😐 ☹
(HT only) Explain how a change in DNA structure may result in a change in the protein synthesised by a gene.	☺ 😐 ☹
(HT only) Understand that proteins are synthesised on ribosomes, according to a template. Carrier molecules bring specific amino acids to add to the growing protein chain in the correct order.	☺ 😐 ☹
(HT only) Understand that when the protein chain is complete it folds up to form a unique shape. This unique shape enables the proteins to do their job as enzymes, hormones or forming structures in the body such as collagen.	☺ 😐 ☹
(HT only) Recall that mutations occur continuously. Understand that most do not alter the protein, or only alter it slightly so that its appearance or function is not changed.	
(HT only) Recall that a few mutations code for an altered protein with a different shape. Understand that an enzyme may no longer fit the substrate-binding site or a structural protein may lose its strength.	
(HT only) Recall that not all parts of DNA code for proteins. Understand that non-coding parts of DNA can switch genes on and off, so variations in these areas of DNA may affect how genes are expressed.	

4.6.1 Reproduction	
4.6.1.6 Genetic inheritance	**Review**
Explain the following terms Gamete, chromosome, gene, allele, dominant, recessive, homozygous, heterozygous, genotype, phenotype.	☺ 😐 ☹
Recall that some characteristics are controlled by a single gene, such as: fur colour in mice; and red-green colour blindness in humans.	☺ 😐 ☹
Recall that each gene may have different forms called alleles.	☺ 😐 ☹
Understand that the alleles present, or genotype, operate at a molecular level to develop characteristics that can be expressed as a phenotype.	☺ 😐 ☹
Understand that a dominant allele is always expressed, even if only one copy is present. A recessive allele is only expressed if two copies are present (therefore no dominant allele present).	☺ 😐 ☹
Describe that If the two alleles present are the same the organism is homozygous for that trait, but if the alleles are different they are heterozygous.	☺ 😐 ☹
Understand that most characteristics are a result of multiple genes interacting, rather than a single gene.	☺ 😐 ☹
Understand the concept of probability in predicting the results of a single gene cross, but recall that most phenotype features are the result of multiple genes rather than single gene inheritance.	☺ 😐 ☹
Use direct proportion and simple ratios to express the outcome of a genetic cross.	☺ 😐 ☹
Complete a Punnett square diagram and extract and interpret information from genetic crosses and family trees.	☺ 😐 ☹
(HT only) Construct a genetic cross by Punnett square diagram and use it to make predictions using the theory of probability.	☺ 😐 ☹

4.6.1 Reproduction	
4.6.1.7 Inherited disorders	**Review**
Recall that some disorders are inherited. These disorders are caused by the inheritance of certain alleles. • Polydactyly (having extra fingers or toes) is caused by a dominant allele. • Cystic fibrosis (a disorder of cell membranes) is caused by a recessive allele.	☺ 😐 ☹
Make informed judgements about the economic, social and ethical issues concerning embryo screening, given appropriate information.	☺ 😐 ☹
4.6.1.8 Sex determination	**Review**
Recall that ordinary human body cells contain 23 pairs of chromosomes.	☺ 😐 ☹
Understand that 22 pairs control characteristics only, but one of the pairs carries the genes that determine sex. • In females the sex chromosomes are the same (XX). • In males the chromosomes are different (XY).	☺ 😐 ☹
Complete a genetic cross to show sex inheritance.	☺ 😐 ☹
Understand and use direct proportion and simple ratios in genetic crosses.	☺ 😐 ☹

4.6.2 Variation and evolution	
4.6.2.1 Variation	**Review**
Describe simply how the genome and its interaction with the environment influence the development of the phenotype of an organism. .	☺ 😐 ☹
Understand that differences in the characteristics of individuals in a population is called variation and may be due to differences in: • the genes they have inherited (genetic causes) • the conditions in which they have developed (environmental causes) • a combination of genes and the environment.	☺ 😐 ☹
Be able to: • state that there is usually extensive genetic variation within a population of a species • recall that all variants arise from mutations and that: most have no effect on the phenotype; some influence phenotype; very few determine phenotype.	☺ 😐 ☹
Recall that mutations occur continuously. Understand that very rarely a mutation will lead to a new phenotype. If the new phenotype is suited to an environmental change it can lead to a relatively rapid change in the species.	☺ 😐 ☹
4.6.2.2 Evolution	**Review**
Describe evolution as a change in the inherited characteristics of a population over time through a process of natural selection, which may result in the formation of a new species.	☺ 😐 ☹
Understand that the theory of evolution by natural selection states that all species of living things have evolved from simple life forms that first developed more than three billion years ago.	☺ 😐 ☹
Explain how evolution occurs through natural selection of variants that give rise to phenotypes best suited to their environment.	☺ 😐 ☹
Understand that if two populations of one species become so different in phenotype that they can no longer interbreed to produce fertile offspring they have formed two new species.	☺ 😐 ☹

4.6.2 Variation and evolution	
4.6.2.3 Selective breeding	**Review**
Explain the impact of selective breeding of food plants and domesticated animals.	☺ 😐 ☹
Understand that selective breeding (artificial selection) is the process by which humans breed plants and animals for particular genetic characteristics. Humans have been doing this for thousands of years since they first bred food crops from wild plants and domesticated animals.	☺ 😐 ☹
Understand that selective breeding involves choosing parents with the desired characteristic from a mixed population. They are bred together. From the offspring those with the desired characteristic are bred together. This continues over many generations until all the offspring show the desired characteristic.	☺ 😐 ☹
Recall that characteristics can be chosen for usefulness or appearance: • Disease resistance in food crops. • Animals which produce more meat or milk. • Domestic dogs with a gentle nature. • Large or unusual flowers.	☺ 😐 ☹
Recall that selective breeding can lead to ‘inbreeding’ where some breeds are particularly prone to disease or inherited defects.	☺ 😐 ☹

4.6.2 Variation and evolution	
4.6.2.4 Genetic engineering	**Review**
Describe genetic engineering as a process which involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic.	☺ 😐 ☹
Recall that plant crops have been genetically engineered to be resistant to diseases or to produce bigger better fruits.	☺ 😐 ☹
Recall that bacterial cells have been genetically engineered to produce useful substances such as human insulin to treat diabetes.	☺ 😐 ☹
Explain the potential benefits and risks of genetic engineering in agriculture and in medicine and that some people have objections.	☺ 😐 ☹
Understand that in genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' and transferred to cells of other organisms.	☺ 😐 ☹
Recall that crops that have had their genes modified in this way are called genetically modified (GM) crops. GM crops include ones that are resistant to insect attack or to herbicides. GM crops generally show increased yields.	☺ 😐 ☹
Recall that concerns about GM crops include the effect on populations of wild flowers and insects. Some people feel the effects of eating GM crops on human health have not been fully explored.	☺ 😐 ☹
Understand that modern medical research is exploring the possibility of genetic modification to overcome some inherited disorders.	☺ 😐 ☹
(HT only) Describe the main steps in the process of genetic engineering. • enzymes are used to isolate the required gene; this gene is inserted into a vector, usually a bacterial plasmid or a virus • the vector is used to insert the gene into the required cells • genes are transferred to the cells of animals, plants or microorganisms at an early stage in their development so that they develop with desired characteristics.	☺ 😐 ☹

4.6.2 Variation and evolution	
4.6.2.5 Cloning	**Review**
Understand the process of tissue culturing: using small groups of cells from part of a plant to grow identical new plants. This is important for preserving rare plant species or commercially in nurseries.	☺ 😐 ☹
Understand the process of taking a cutting: an older, but simple, method used by gardeners to produce many identical new plants from a parent plant.	☺ 😐 ☹
Understand the process of embryo transplanting: splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers.	☺ 😐 ☹
Explain the process of adult cell cloning: • The nucleus is removed from an unfertilised egg cell. • The nucleus from an adult body cell, such as a skin cell, is inserted into the egg cell. • An electric shock stimulates the egg cell to divide to form an embryo. • These embryo cells contain the same genetic information as the adult skin cell. • When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development.	☺ 😐 ☹

4.6.3 The development of understanding of genetics and evolution	
4.6.3.1 Theory of evolution	**Review**
Understand that Charles Darwin, as a result of observations on a round the world expedition, backed by years of experimentation and discussion and linked to developing knowledge of geology and fossils, proposed the theory of evolution by natural selection. • Individual organisms within a particular species show a wide range of variation for a characteristic. • Individuals with characteristics most suited to the environment are more likely to survive to breed successfully. • The characteristics that have enabled these individuals to survive are then passed on to the next generation.	☺ 😐 ☹
Recall that Darwin published his ideas in *On the Origin of Species* (1859). There was much controversy surrounding these revolutionary new ideas.	☺ 😐 ☹
Recall that the theory of evolution by natural selection was only gradually accepted because: • the theory challenged the idea that God made all the animals and plants that live on Earth • there was insufficient evidence at the time the theory was published to convince many scientists • the mechanism of inheritance and variation was not known until 50 years after the theory was published.	☺ 😐 ☹
Understand that other theories, including that of Jean-Baptiste Lamarck, are based mainly on the idea that changes that occur in an organism during its lifetime can be inherited. We now know that in the vast majority of cases this type of inheritance cannot occur.	☺ 😐 ☹
4.6.3.2 Speciation	**Review**
Describe the work of Darwin and Wallace in the development of the theory of evolution by natural selection. Explain the impact of these ideas on biology.	
Recall that Alfred Russel Wallace independently proposed the theory of evolution by natural selection. He published joint writings with Darwin in 1858 which prompted Darwin to publish *On the Origin of Species* (1859) the following year.	
Recall that Wallace worked worldwide gathering evidence for evolutionary theory. He is best known for his work on warning colouration in animals and his theory of speciation.	
Recall that Alfred Wallace did much pioneering work on speciation but more evidence over time has led to our current understanding of the theory of speciation.	
Describe the steps which give rise to new species.	

4.6.3 The development of understanding of genetics and evolution	
4.6.3.3 The understanding of genetics	**Review**
Describe the development of our understanding of genetics including the work of Mendel	☺ 😐 ☹
Understand why the importance of Mendel's discovery was not recognised until after his death.	☺ 😐 ☹
Recall that in the mid-19th century Gregor Mendel carried out breeding experiments on plants. One of his observations was that the inheritance of each characteristic is determined by 'units' that are passed on to descendants unchanged.	☺ 😐 ☹
Recall that in the late 19th century behaviour of chromosomes during cell division was observed.	☺ 😐 ☹
Recall that in the early 20th century it was observed that chromosomes and Mendel's 'units' behaved in similar ways. This led to the idea that the 'units', now called genes, were located on chromosomes.	☺ 😐 ☹
Recall that in the mid-20th century the structure of DNA was determined and the mechanism of gene function worked out.	☺ 😐 ☹
Understand that his scientific work by many scientists led to the gene theory being developed.	☺ 😐 ☹
4.6.3.4 Evidence for evolution	**Review**
Describe the evidence for evolution including fossils and antibiotic resistance in bacteria.	☺ 😐 ☹
Understand that the theory of evolution by natural selection is now widely accepted.	☺ 😐 ☹
Understand that evidence for Darwin's theory is now available as it has been shown that characteristics are passed on to offspring in genes. There is further evidence in the fossil record and the knowledge of how resistance to antibiotics evolves in bacteria.	☺ 😐 ☹

4.6.3 The development of understanding of genetics and evolution	
4.6.3.5 Fossils	**Review**
Recall that fossils are the 'remains' of organisms from millions of years ago, which are found in rocks.	☺ 😐 ☹
Understand that fossils may be formed: • from parts of organisms that have not decayed because one or more of the conditions needed for decay are absent • when parts of the organism are replaced by minerals as they decay • as preserved traces of organisms, such as footprints, burrows and rootlet traces.	☺ 😐 ☹
Recall that many early forms of life were soft-bodied, which means that they have left few traces behind. What traces there were have been mainly destroyed by geological activity. This is why scientists cannot be certain about how life began on Earth.	☺ 😐 ☹
Understand that we can learn from fossils how much or how little different organisms have changed as life developed on Earth.	☺ 😐 ☹
Extract and interpret information from charts, graphs and tables such as evolutionary trees.	☺ 😐 ☹
4.6.3.6 Extinction	**Review**
Recall that extinctions occur when there are no remaining individuals of a species still alive.	☺ 😐 ☹
Describe factors which may contribute to the extinction of a species.	☺ 😐 ☹
4.6.3.7 Resistant bacteria	**Review**
Recall that bacteria can evolve rapidly because they reproduce at a fast rate.	☺ 😐 ☹
Recall that mutations of bacterial pathogens produce new strains. Understand that some strains might be resistant to antibiotics, and so are not killed. They survive and reproduce, so the population of the resistant strain rises. The resistant strain will then spread because people are not immune to it and there is no effective treatment.	☺ 😐 ☹
Recall that MRSA is resistant to antibiotics.	☺ 😐 ☹
Describe how to reduce the rate of development of antibiotic resistant strains: • doctors should not prescribe antibiotics inappropriately, such as treating non-serious or viral infections • patients should complete their course of antibiotics so all bacteria are killed and none survive to mutate and form resistant strains • the agricultural use of antibiotics should be restricted.	☺ 😐 ☹
Understand that the development of new antibiotics is costly and slow. It is unlikely to keep up with the emergence of new resistant strains.	☺ 😐 ☹

4.6.4 Classification of living organisms	
	Review
Understand that traditionally living things have been classified into groups depending on their structure and characteristics in a system developed by Carl Linnaeus.	☺ 😐 ☹
Recall that Linnaeus classified living things into kingdom, phylum, class, order, family, genus and species. Organisms are named by the binomial system of genus and species.	☺ 😐 ☹
Use information given to show understanding of the Linnaean system.	☺ 😐 ☹
Describe the impact of developments in biology on classification systems.	☺ 😐 ☹
Understand that as evidence of internal structures became more developed due to improvements in microscopes, and the understanding of biochemical processes progressed, new models of classification were proposed.	☺ 😐 ☹
Recall that due to evidence available from chemical analysis there is now a 'three-domain system' developed by Carl Woese. In this system organisms are divided into: • Archaea (primitive bacteria usually living in extreme environments) • Bacteria (true bacteria) • Eukaryota (which includes protists, fungi, plants and animals).	☺ 😐 ☹
Recall that evolutionary trees are a method used by scientists to show how they believe organisms are related. They use current classification data for living organisms and fossil data for extinct organisms.	☺ 😐 ☹

4.6 Inheritance, Variation and Evolution Knowledge

4.6.1 Reproduction

4.6.1.1 Sexual and asexual reproduction

Asexual reproduction

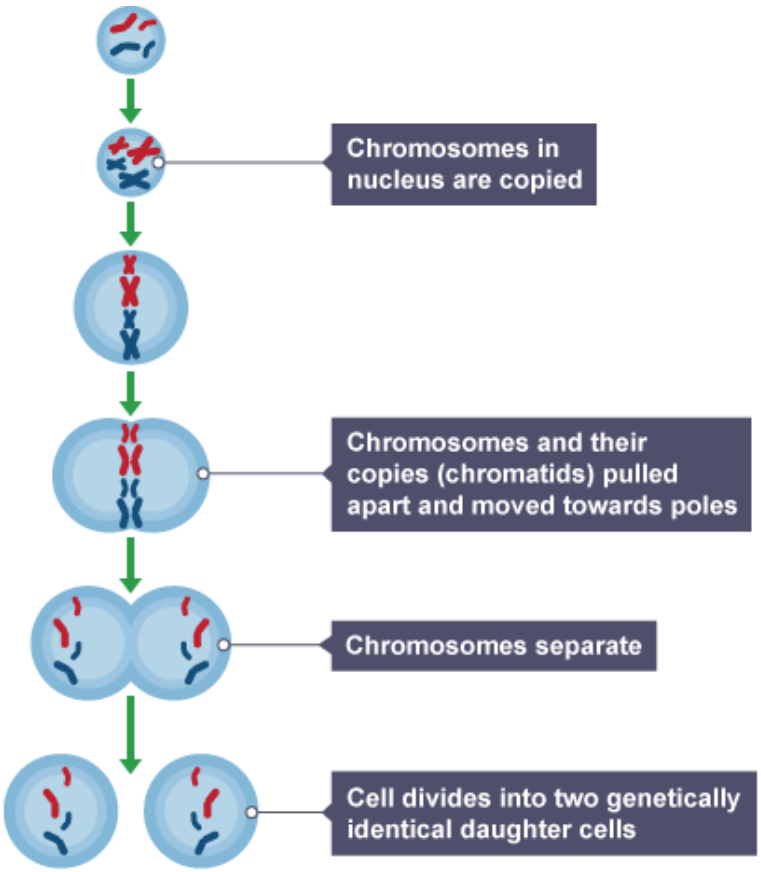
Only one parent is needed in asexual reproduction. There is no fusion of gametes so genetic material does not mix, which means that the offspring produced through this process are genetically identical clones to the parent.

Examples of organisms that use asexual reproduction include:

- bacteria
- production of spores by fungi
- some plants, such as strawberries, use runners
- formation of tubers in potatoes and bulbs in daffodils

Mitosis

Asexual reproduction uses the process of mitosis to create the identical copies (clones) of the parent cell.



Mitosis is part of the cell cycle, which involves:

- cell growth, and the increase of the number of structures in the cell (mitochondria, ribosomes)
- genetic material is copied
- mitosis occurs leading to chromosomes separation and cell division

Mitosis is also used for:

growth

repair to damaged tissue

replacement of worn-out cells

Sexual reproduction

Two parents are needed in sexual reproduction. During this process the nuclei of the male and female gametes are fused in order to create a zygote. This process is known as fertilisation. The gametes contain half the number of chromosomes in each (haploid). When the male and female gametes combine they create the full complement of chromosomes (diploid) in order to create a human embryo.
The gametes in:

- animals are sperm and eggs
- flowering plants are pollen and eggs

The offspring produced in sexual reproduction are genetically different to each other and the parents. This process results in variation as it involves the mixing of genetic information.

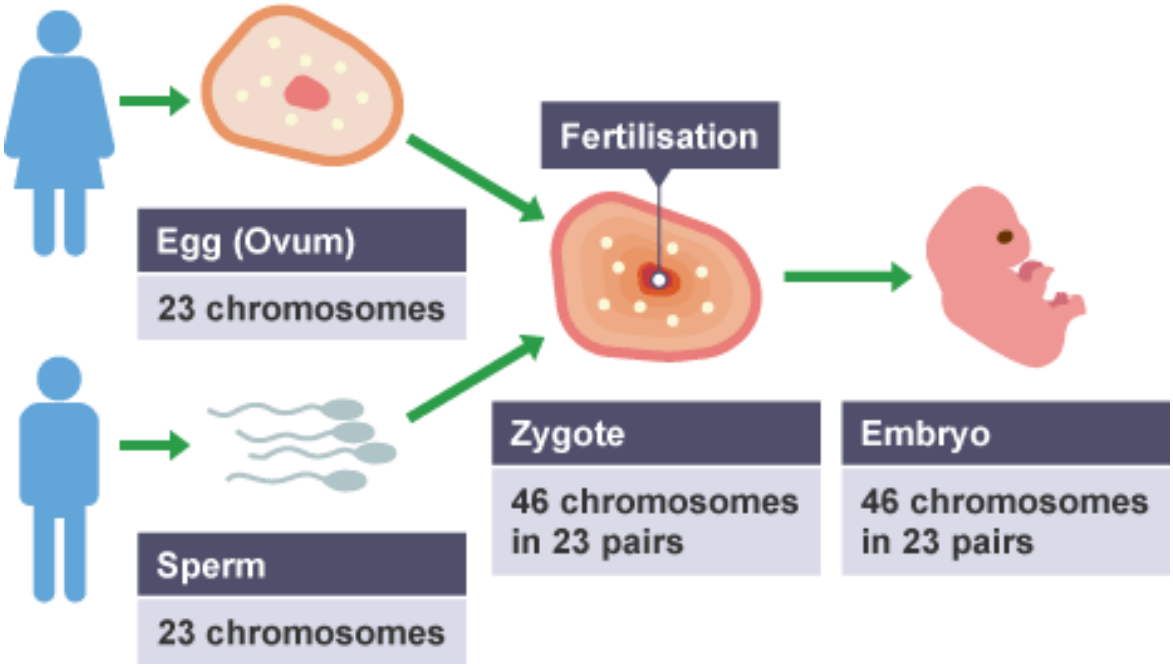
4.6.1.2 Meiosis

Sexual reproduction uses the process of **meiosis**, which creates gametes. The process of meiosis happens in the male and female reproductive organs. As a cell divides to form gametes:

- copies of the genetic information is made
- the cell divides twice to form four gametes, each with a single set of chromosomes (haploid)
- all gametes are genetically different from each other

Fertilisation

Fertilisation is the fusion of the **nucleus** of a male **gamete** with the nucleus of a female gamete. In humans, each gamete has half the number of the total 46 chromosomes that the body requires. Twenty three chromosomes within a gamete are referred to as a haploid. When the two gametes combine, they merge the two sets of chromosome to have 46, which are referred to as diploid.
This produces a new cell called a zygote, which will mature into an embryo. The number of cells increase by mitosis, and as the embryo develops, the cells begin to differentiate (or specialise).



4.6.1.3 Advantages and disadvantages of sexual and asexual reproduction (biology only)

There are two types of reproduction - **sexual reproduction** and **asexual reproduction.**

Two parents are needed in **sexual reproduction**, and the offspring produced are genetically different to the parents.

Only one parent is needed in **asexual reproduction**, and the offspring produced are genetically identical, eg reproduction in bacteria, production of spores by fungi, and the formation of tubers in potatoes and bulbs in daffodils.

Sexual reproduction

These are some of the **advantages** of sexual reproduction:

- introduces variation into a population
- the species can adapt to new environments
- a disease is less likely to affect all the individuals in a population

These are some of the **disadvantages** of sexual reproduction:

- time and energy are needed to find a mate
- not possible for an isolated individual

Asexual reproduction

The **advantages** of asexual reproduction include:

- population can increase rapidly
- can exploit a suitable habitat quickly

The **disadvantages** include:

- does not lead to variation in a population
- the species may only be suited to one habitat
- disease may affect all the individuals in a population

4.6.1.4 DNA and the genome

DNA

The genetic material in the nucleus of a cell is composed of a chemical called **DNA**. DNA is a polymer, a large and complex molecule. It is made up of two strands forming a twisted ladder structure called a **double helix**. It carries the **genetic code**, which determines the characteristics of a living **organism**.

Except for identical twins, each person's DNA is unique. This is why people can be identified using DNA fingerprinting. DNA can be cut up and separated, which can form a 'bar code' that is different from one person to the next.

Chromosomes

The cell's **nucleus** contains chromosomes. These are long threads of DNA, which are made up of many genes.

Genes

A gene is a small section of DNA in a chromosome. Each gene codes for a particular sequence of amino acids in order to make a specific protein. It is the unit of **heredity**, and may be copied and passed on to the next generation.

The diagram shows the relationship between the cell, its nucleus, chromosomes in the nucleus, and genes.

The human genome

The **genome** of an organism is the entire genetic material of that organism. The whole human genome has been studied, and this has great importance for medicine.

In order to exploit its secrets, it is vital that the human genome is fully understood.

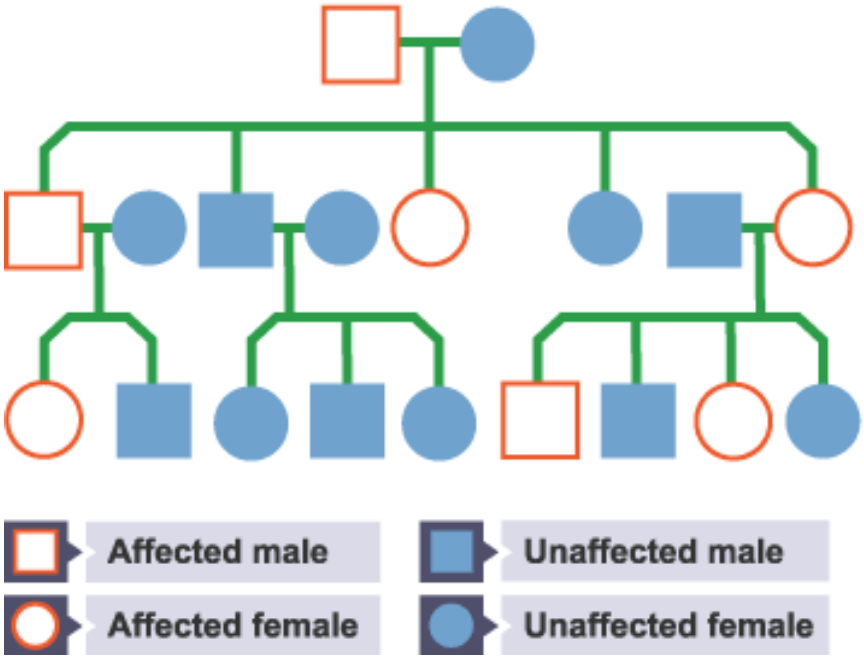
It enables us to:

- search for genes linked to different types of disease
- understand inherited disorders and their treatment
- trace human migration patterns from the past

Scientists are searching for disease associated genes. One example was those that can contribute to breast cancer, which are known as *BRCA1* and *BRCA2*. Mutations in these genes account for approximately 10% of all inherited breast cancer cases detected.

Scientists detected *BRCA1* and *BRCA2* genes by studying families where breast cancer was known to have been inherited between individuals. They were able to create a pedigree

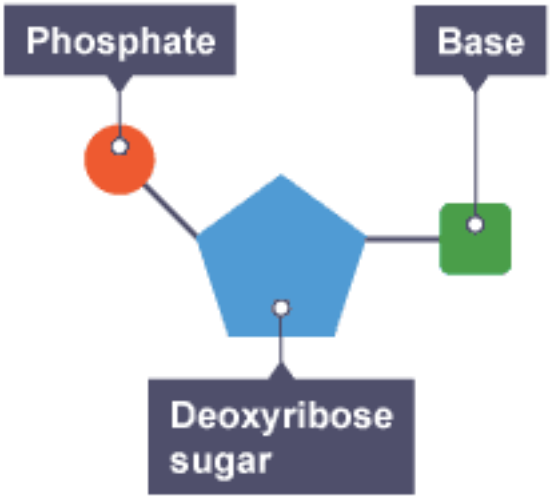
analysis, which is similar to a family tree diagram that showed the close relationship of those affected and unaffected within the family.
The pedigree analysis illustrates the inheritance pattern of the disease to be determined. This enabled scientists to test DNA of the affected and unaffected individuals to identify differences. It is now possible to detect the presence of the genes by having a simple blood test.



4.6.1.5 DNA Structure (Biology only)

DNA is the molecule that holds the instructions for growth and development in every living thing. Its structure is described as a double-stranded helix held together by complementary base pairs.

The basic units of DNA are nucleotides. These nucleotides consist of a deoxyribose sugar, phosphate and base.

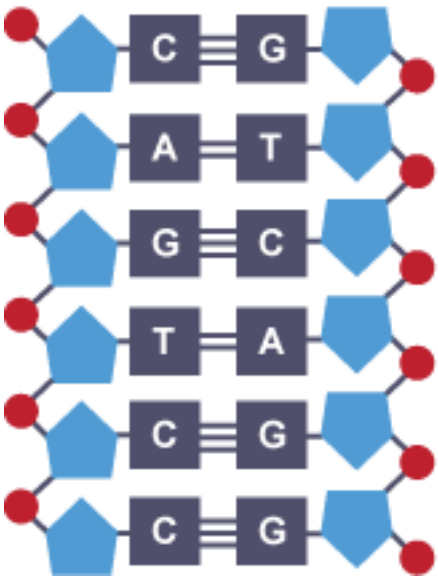


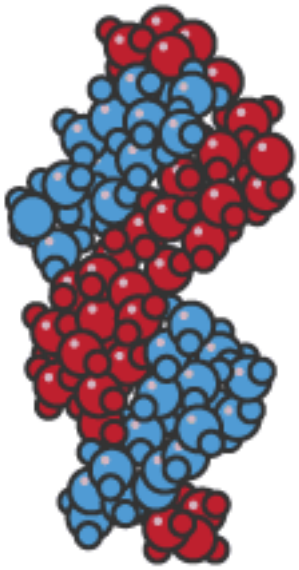
The nucleotides are identical except for the base, which can be an adenine, thymine, guanine or cytosine. There are chemical cross-links between the two strands in DNA, formed by pairs of bases held together by hydrogen bonds. They always pair up in a particular way, called complementary base pairing:

- thymine pairs with adenine (T-A)
- guanine pairs with cytosine (G-C)

These basic units are linked together to form strands by strong bonds between the deoxyribose sugar of one **nucleotide** and the phosphate of the next nucleotide. These strong bonds form a sugar-phosphate backbone.

The ends of the DNA strand are called the 5' end (said as "5 prime end") at the phosphate end, and the 3' end at the deoxyribose end. The two strands of DNA are antiparallel which means that one strand runs in a 5' to 3' direction and the other runs in a 3' to 5' direction. This creates the twisting double helix structure of DNA.





All cells store their genetic information in the base sequence of DNA, and it is this base sequence which forms the genetic code. The **genotype** is determined by the sequence of bases.

Organisation of DNA

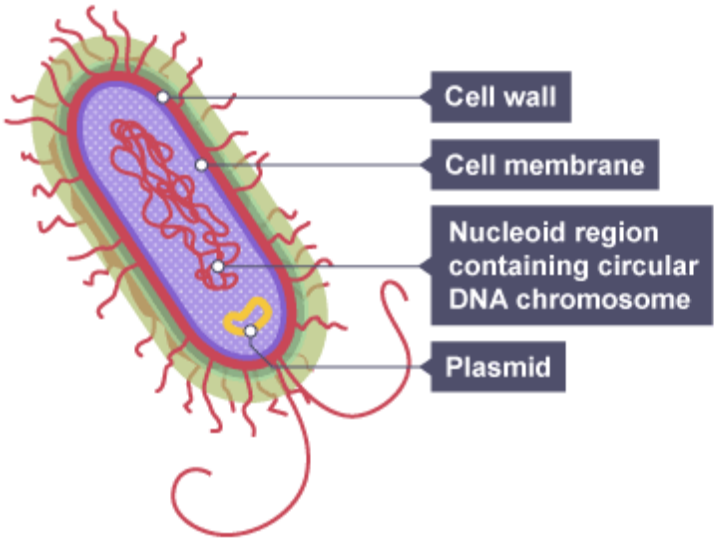
DNA is present in the cells of every living thing. However, the DNA is organised differently in different types of organism.

We can divide cells into two groups based on how they organise their DNA eukaryotes and prokaryotes.

Prokaryotes

Bacteria are prokaryotes. They do not have a membrane-bound nucleus and their DNA is free in the **cytoplasm**.

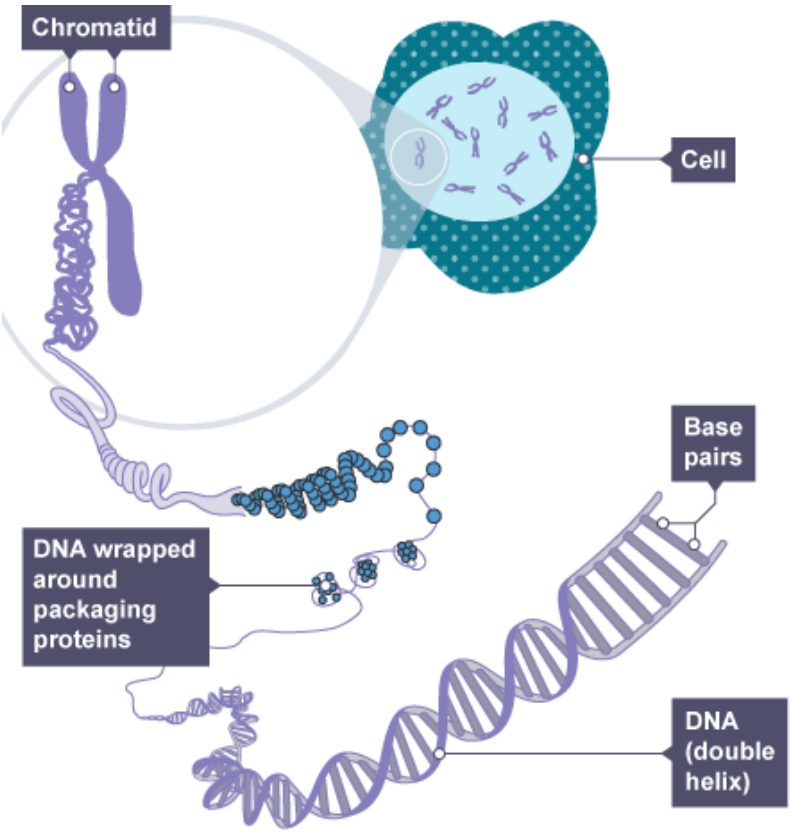
Bacteria have a single circular chromosome in the centre of the cell that holds all the genes needed for that bacterium. Bacteria also have extra circles of DNA called plasmids. These plasmids contain additional genes, such as for antibiotic resistance, which may increase a bacterium's chance of survival.



Eukaryotes

Animals, plants and fungi are eukaryotes. They have a membrane-bound nucleus and their chromosomes are linear rather than circular.

The DNA found in the linear chromosomes within the nucleus is tightly coiled and packaged around special proteins called histones - as shown below.



Interestingly, circular chromosomes are also found in **mitochondria** and chloroplasts. They both use their own DNA to make some proteins needed for their function. This gives evidence for the theory that mitochondria and chloroplasts originated from prokaryotic cells that were engulfed by a larger cell.

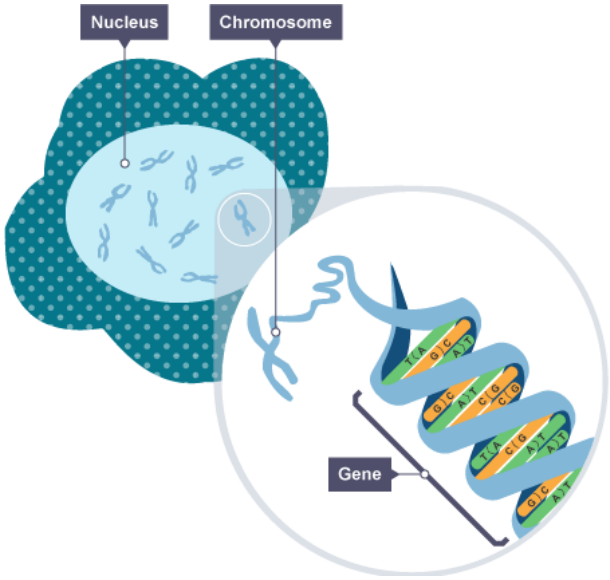
4.6.1.6 Genetic inheritance

Genetic key terms

- A **gamete** is a sex cell. In humans, gametes are sperm and eggs (ovums). **DNA** is a large and complex polymer, which is made up of two strands forming a double helix. DNA determines the characteristics of a living organism. With the exception of identical twins, each person's DNA is unique.
- **Chromosomes** are contained inside the cell's **nucleus**. These are long threads of DNA, which are made up of many genes.
- A **gene** is a small section of DNA on a chromosome, that code for a particular sequence of amino acids, to make a specific protein. It is the unit of heredity, and may be copied and passed on to the next generation.

Some characteristics are controlled by a single gene, such as fur in animals and red-green colour blindness in humans. Each gene might have different forms, and these are called

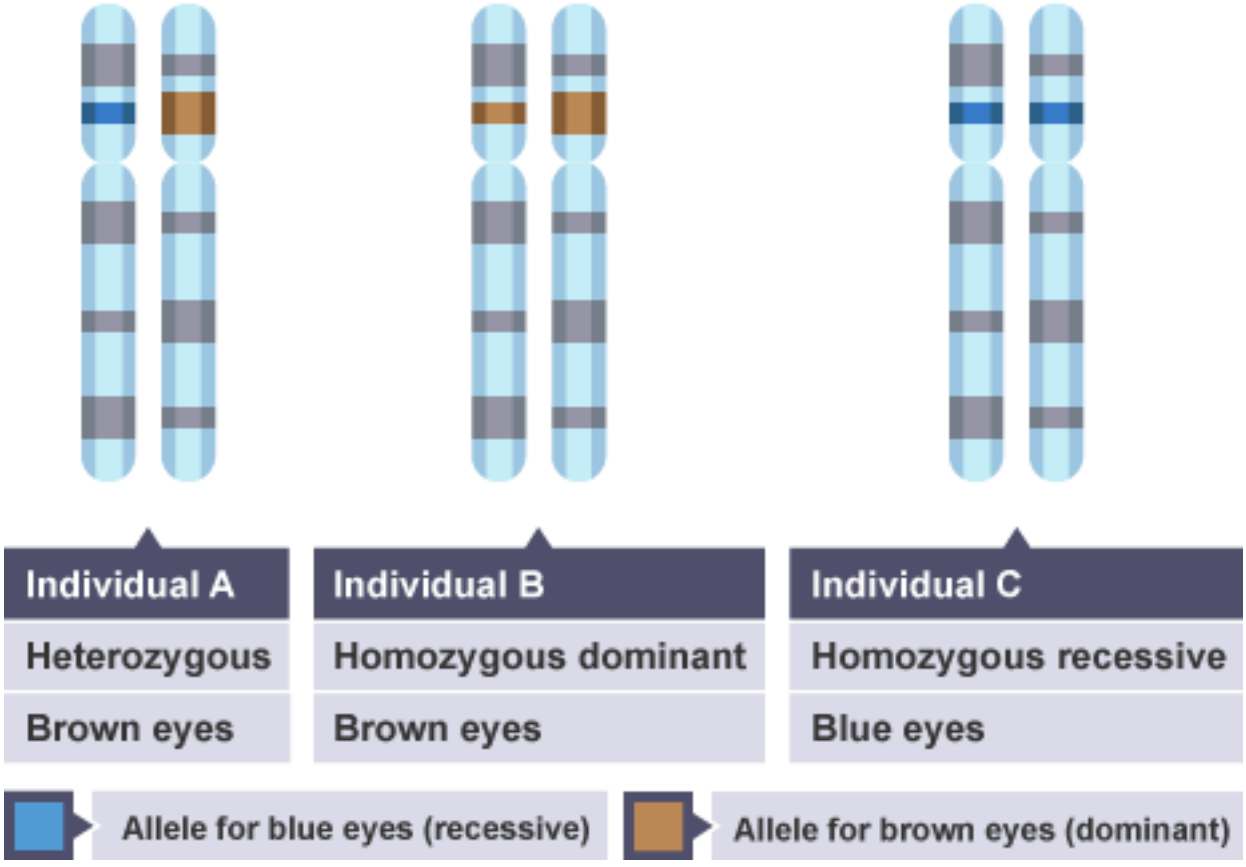
alleles. The diagram shows the relationship between the cell, its nucleus, chromosomes in the nucleus, and genes.



- Chromosomes are found in the nucleus of a body cell in pairs. One chromosome is inherited from the mother and one is inherited from the father. The chromosome in each pair carries the same gene in the same location. These genes could be the same, or different versions.

- **Alleles** are **different versions** of the same gene. For example, the gene for eye colour has an allele for blue eye colour and an allele for brown eye colour. For any gene, a person may have the same two alleles, known as homozygous or two different ones, known as heterozygous.

The **genotype** is the collection of alleles that determine characteristics and can be expressed as a **phenotype**. The **genotype** is the collection of alleles that determine characteristics and can be expressed as a **phenotype**.



Alleles may be either dominant or recessive:

- A **dominant allele** is always expressed, even if one copy is present. Dominant alleles are represented by a capital letter, for example, A. The allele for brown eyes is dominant. You only need **one copy** of this allele to have brown eyes. Two copies will still give you brown eyes.
- A **recessive allele** is only expressed if the individual has two copies and does not have the dominant allele of that gene. Recessive alleles are represented by a lower case letter, for example, a. The allele for blue eyes is recessive. You need **two copies** of this allele to have blue eyes.
- **Homozygous** alleles are both identical for the same characteristic, for example AA or aa.
- **Heterozygous** alleles are both different for the same characteristic, for example Aa.

Most characteristics are a result of multiple genes interacting, rather than a single gene.

Carrying out a genetic cross

Monohybrid crosses

Genetic crosses of single gene combinations (monohybrid inheritance) can be shown and examined using Punnett squares. This shows the possible offspring combinations could be produced, and the probability of these combinations can be calculated.

In this genetic cross, the female alleles are Dd and the male alleles are dd.

	D	d
d	Dd	dd
d	Dd	dd

Half of the possible offspring have the same allele combination; Dd and the other half have the dd combination.

These examples are single gene combinations, but remember that most phenotypes are controlled by multiple genes.

How to construct Punnett squares - Higher

Method to use:

1. Determine the parental genotypes - the allele combinations for the male and female. You can use any letter you like but select one that has a clearly different lower case, for example: Aa, Bb, Dd.
2. Split the alleles for each parental type and add them into your Punnett square around the edges.
3. Work out the new possible genetic combinations inside the Punnett square.
4. Use this to answer the question. You may be asked to comment on the proportion of different allele combinations in the offspring, calculate a probability ratio or just determine the phenotypes of the offspring.

Worked example

The inheritance of fur colour in mice is controlled by a single gene. White fur is recessive. Grey fur is dominant. Two mice that are heterozygous for the fur colour gene mate. Determine the probability that the offspring will have grey fur.

Step 1:

Female: Aa Male: Aa

Step 2:

	A	a
A		
a		

Step 3:

	A	a
A	AA	Aa
a	Aa	aa

Because the genotypes Aa and AA both result in the grey fur phenotype, there is a 75% probability that the offspring will have grey fur. Because the genotype aa results in the white fur phenotype, there is a 25% probability that the offspring will have white fur.

4.6.1.7 Inherited disorders

Cystic fibrosis is an inherited disorder of cell membranes that mainly affects the lungs and digestive system. They can become clogged with lots of thick, sticky mucus as too much is produced. Over many years, the lungs become increasingly damaged and may eventually stop working properly. A number of treatments are available to help reduce the problems caused by the condition, but unfortunately average life expectancy is reduced for people who have it.

It is caused by a faulty **recessive allele** on chromosome 7. To be born with cystic fibrosis, a child has to inherit two copies of this faulty gene - one from each of their parents. Their parents will not usually have the condition themselves, because they will only carry one faulty gene and one that works normally.
In the diagram below cystic fibrosis involves:

- the recessive allele (lower case), which can be shown as f
- the dominant allele (capital letter), which can be shown as F

An individual who is **homozygous** (ff) with the recessive allele will develop cystic fibrosis. Someone who is **heterozygous** (Ff) will be a carrier of the recessive allele, but will not develop cystic fibrosis and have no symptoms. Someone who is homozygous with the **dominant** allele (FF) will not develop cystic fibrosis, as you need two faulty alleles (ff) for the condition. In this combination, no faulty alleles are present.

Example 1

In example 1, both parents are heterozygous, Ff. The chance of them producing a child with cystic fibrosis is 1 in 4, or 25%. The parents are **carriers** of the disorder, and it is possible for them to produce a child with cystic fibrosis, without having it themselves. Carriers have no symptoms and are usually unaware they are carrying the recessive allele.

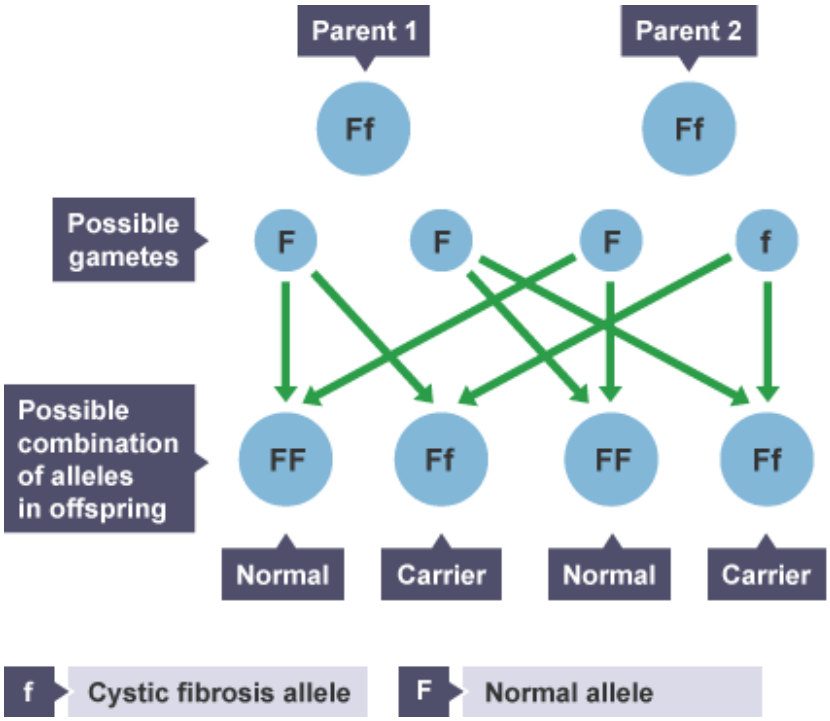
		Mother	
		F	**f**
Father	**F**	FF	Ff
	f	Ff	ff

Example 2

In example 2, only one parent (the father) has a copy of the recessive allele (Ff). There is no chance of them producing a child with cystic fibrosis. However, half the possible offspring will be homozygous, FF, and be unaffected, and half will be heterozygous, Ff and carry the recessive allele. The ratio of FF to Ff is 1:1 or 50%.

		Mother	
		F	F
Father	F	FF	FF
	f	Ff	Ff

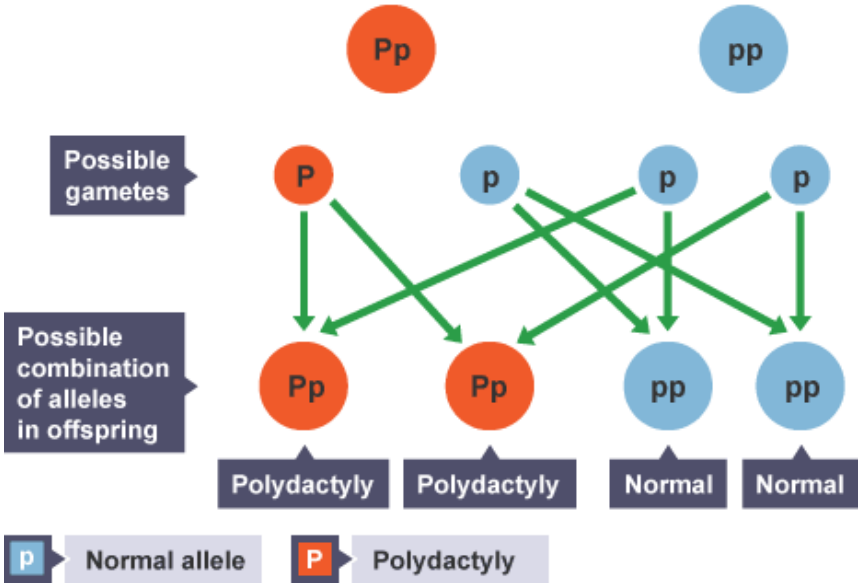
This genetic diagram shows how cystic fibrosis is inherited.



Polydactyly

Polydactyly is an inherited condition in which a person has extra fingers or toes. It is caused by a **dominant** allele of a gene. This means it can be passed on by just one allele from one parent if they have the disorder.

Someone who is homozygous (PP) or heterozygous (Pp) for the dominant allele will develop Polydactyly.



Offspring need to carry just one dominant allele from their parents to inherit the polydactyl condition.

The probability of the offspring having polydactyly is 50% (2 of the 4) and 50% not having it (normal). This can be expressed as a ratio, 2:2 which can be simplified to 1:1.

Genetic tests

Genetic testing involves analysis of a person's **DNA** to see if they carry alleles that cause genetic disorders. It can be done at any stage in a person's life.

- **Antenatal** testing is used to analyse an individual's DNA or chromosomes before they are born. This testing is offered to couples who may have an increased risk of producing a baby with an inherited disorder, but it can't detect all the risks of inherited disorders.
- Neonatal testing known as the new born blood spot test involves analysing a sample of blood that is taken from pricking a baby's heel. It detects genetic disorders in order to treat them early.
- **Pre-implantation genetic diagnosis** (PGD) is used on embryos before implantation. Fertility drugs stimulate the release of several eggs.The eggs are collected and fertilised in a Petri dish. This is known as in vitro fertilisation (IVF). Once the embryos have reached the eight-cell stage, one cell is removed.The cells are tested for the disorder causing alleles. Embryos that don't contain the disorder allele are implanted into the uterus.

Limits of genetic testing

Genetic tests are not available for every possible inherited disorder, and are not completely reliable. They may produce false positive or false negative results, which can have serious consequences for the parents involved.

False positives

A false positive is a genetic test that wrongly detected a certain allele or faulty chromosome. The individual could believe something is wrong, when it is actually fine.

False negatives

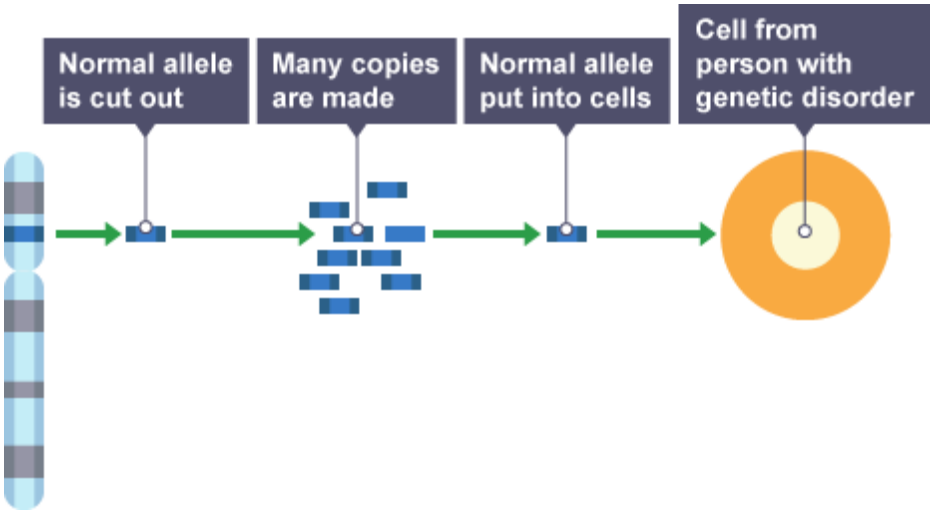
A false negative is a genetic test has failed to detect a certain allele or faulty chromosome. The parents may be wrongly reassured. These results can have a major impact on the lives of individuals, through pregnancy termination, future decisions and planning the level of care needed for children with inherited disorders.

Gene therapy

Gene therapy involves inserting copies of a normal allele into the chromosomes of an individual who carries a faulty allele. It is not always successful, and research is continuing to try and develop this possible treatment further.

Gene therapy involves these basic steps:

- identify the gene involved in the genetic disorder
- restriction enzymes cut out the normal allele
- many copies of the allele are made
- copies of the normal working allele are put into the cells of a person who has the genetic disorder due to a mutated or faulty copy of an allele



Problems in the process

The problems involved in the process:

- the alleles may not go into every target cell, which are cells that need the new non-faulty cell

- the alleles may be inserted into the chromosomes in random places, rather than in the required position, so they do not work properly
- some treated cells may be replaced naturally by the patient's own untreated cells, as cells are frequently replaced through the process of mitosis during growth and repair

Different methods

Different methods are used to get the alleles into the patient's cells, including:

- using nose sprays, which allow a patient to introduce the working allele up their nose and it will be taken into their body and incorporated
- using cold viruses that are modified to carry the allele - the viruses go into the cells and infect them
- the direct injection of DNA

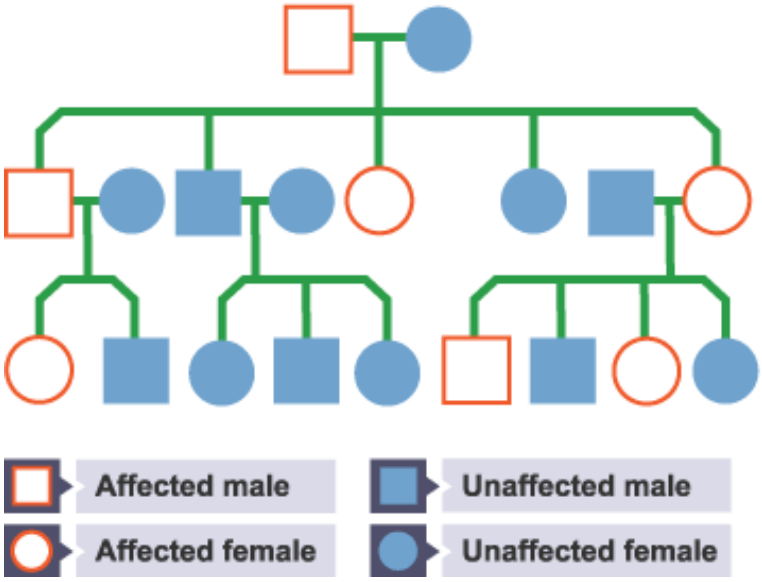
Gene therapy can have major ethical implications in society as people disagree with gene alteration in people, as they believe it is unnatural.

Other people think that gene therapy is a good idea, as it prevents unnecessary suffering in affected individuals. Gene therapy only affects the individual involved in the process and not any future generations who would be likely to inherit similar diseases.

Family trees

Pedigree analysis

Doctors can use a **pedigree analysis chart** to show how genetic disorders are inherited in a family. They can use this to work out the probability (chance) that someone in a family will inherit a condition. A pedigree analysis is usually undertaken if families are referred to a genetic counsellor following the birth of an affected child.



The pedigree analysis diagram is used to show the relationship within an extended family. Males are indicated by the square shape and females are represented by circles. Affected individuals are red and unaffected are blue. Horizontal lines between males and females show that they have produced children.
This analysis shows both male and female are affected, and every generation has affected individuals. There is one family group that has no affected parents or children, but the remaining two families have one affected parent and affected children too.

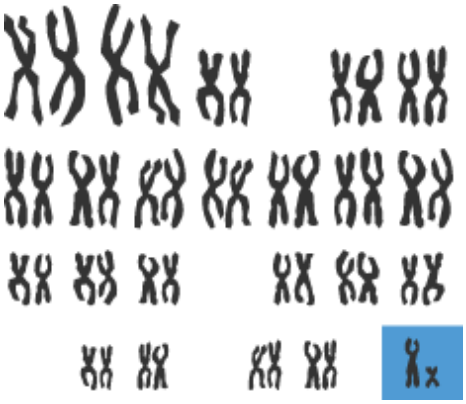
4.6.1.8 Sex determination

Human body cells have 23 pairs of **chromosomes** in the nucleus. Twenty two pairs are known as autosomes, and control characteristics, but one pair carries genes that determine sex - whether offspring are male or female:

- males have two different sex chromosomes, X Y
- females have two X chromosomes, XX

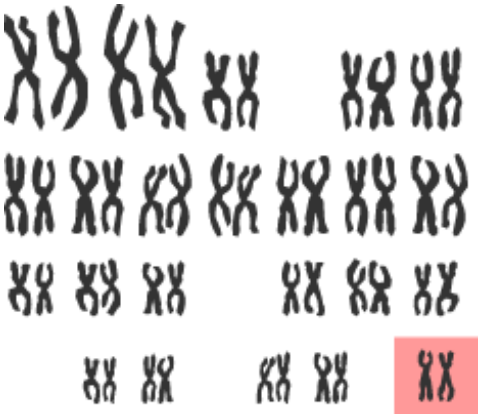
Chromosomes from a male

These diagrams are known as human karyotypes, and show all the chromosomes aligned in pairs. The blue box shows the two sex chromosomes - these are different sizes, therefore an X (larger chromosome) and a Y (smaller one).



Chromosomes from a female

The red box shows the two sex chromosomes - these are the same size, both two X larger chromosomes.



Genetic diagram

A **genetic diagram**,like a Punnett square, shows how alleles may combine in **zygotes**. The diagram below shows how biological sex is inherited.

		Mother	
		X	X
Father	X	XX	XX
	Y	XY	XY

Mothers/female alleles - XX and the fathers/male alleles - XY

The two possible combinations are:

- an X chromosome from the mother and an X chromosome from the father - producing a girl (female phenotype from the XX genotype)
- an X chromosome from the mother and a Y chromosome from the father - producing a boy (male phenotype from the XY phenotype)

The ratio of female to male offspring is 1:1 - on average, half of the offspring will be girls and half will be boys. This can also be converted into a probability of 50% (XX) and 50% (XY).

4.6.1 Reproduction PPQ's

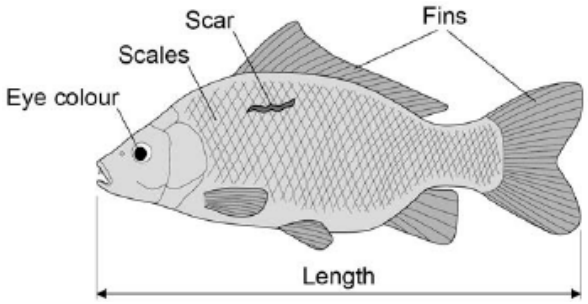
Low demand

PPQ 1

Q1.

Figure 1 shows a fish called a carp.

Figure 1



The characteristics of an animal can be a result of:

- only genetic causes
- only environmental causes
- both genetic **and** environmental causes.

(a) Give **one** characteristic shown in **Figure 1** for each different cause.

Only genetic causes _____

Only environmental causes _____

Both genetic **and** environmental causes _____

_____ **(3)**

(b) Two alleles control the body colour of carp:

- brown (**B**)
- blue (**b**).

The brown allele is dominant to the blue allele.

The genetic cross from breeding two carp is shown in **Figure 2**.

Figure 2

	B	b
b	Bb	
b		

Complete **Figure 2**.

(2)

(c) Draw a ring around **one** blue offspring shown in **Figure 2**.

(1)

(d) What is the probability that the offspring from this genetic cross will be brown?

Tick **two** boxes.

- 0 ☐
- 0.25 ☐
- 0.5 ☐
- 1.0 ☐

(1)

(e) Carp can produce large numbers of offspring. The two carp crossed in **Figure 2** had 260 000 offspring.

Approximately how many offspring are expected to be brown?

_____

Brown carp offspring = _____

(1)

(f) A pond contains carp used for breeding.

The carp for breeding are brown or blue. A red carp has been seen.

The red carp was **not** added to the pond.

Suggest what might have caused the red carp to appear.

_____

_____

(1)

(Total 9 marks)

PPQ 2

Q2. In sexual reproduction, an egg fuses with a sperm.

(a) (i) Draw a ring around the correct answer to complete the sentence.

An egg and a sperm fuse together in the process of

cloning.
fertilisation.
mitosis.

(1)

(ii) Egg cells and sperm cells each contain the structures given in the box.

chromosome	**gene**	**nucleus**

List these three structures in size order, starting with the smallest.

1 _____ (smallest)

2. _____

3 _____ (largest) **(2)**

(iii) The egg and the sperm contain genetic material.

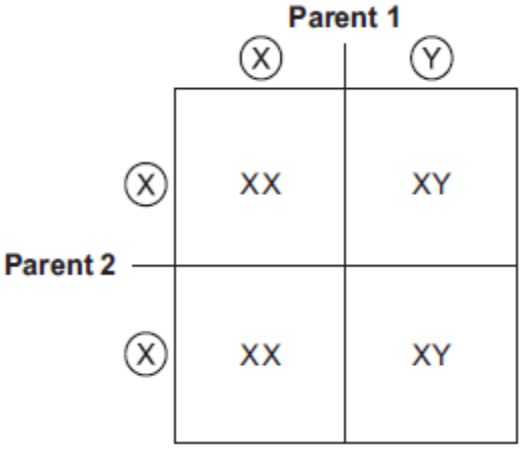
Draw a ring around the correct answer to complete the sentence.

The genetic material is made of

carbohydrate.
DNA.
protein.

(1)

(b) The diagram below shows the inheritance of **X** and **Y** chromosomes.



(i) Draw a tick (✓) on the part of the diagram that shows a sperm cell.

(1)

(ii) What is the chance of having a female child?

Give the reason for your answer.

_____

_____

_____

_____

(2)

(Total 7 marks)

PPQ 3

Q3. Humans reproduce sexually.

(a) Draw a ring around the correct answer to complete each sentence.

(i) At fertilisation | chromosomes / genes / gametes | join together.

(1)

(ii) At fertilisation a single cell forms. The cell has new pairs of | chromosomes. / nuclei. / gametes. |

(1)

(b) A child inherits cystic fibrosis. The child's parents do **not** have cystic fibrosis.

(i) What does this information tell us about the cystic fibrosis allele?Tick (✓) **one** box.

The allele is dominant. ☐

The allele is recessive. ☐

The allele is strong. ☐

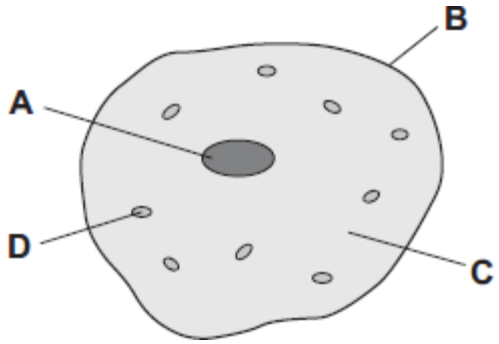
(1)

(ii) How many copies of the cystic fibrosis allele does the child have? Draw a ring around your answer.

one **two** **four**

(1)

(c) The diagram shows a human body cell.



Which part of the cell, **A**, **B**, **C** or **D**:

(i) contains the allele for cystic fibrosis ☐

(1)

(ii) is affected by cystic fibrosis? ☐

(1)

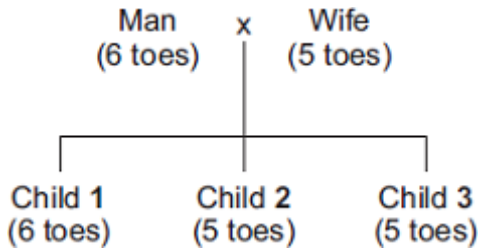
(Total 6 marks)

PPQ 4

Q4. Polydactyly is an inherited condition. Polydactyly is controlled by a dominant allele. The photograph shows the foot of a baby with polydactyly.

A man and his wife have three children. The man has polydactyly.

The diagram shows the inheritance of polydactyly in this family.
The diagram also shows the number of toes each person has on each foot.



In the rest of this question, the following symbols are used to represent alleles.

D = allele for polydactyly (6 toes on each foot)
d = allele for 5 toes on each foot

(a) (i) How many alleles for the number of toes will there be in **one** sperm cell? ☐

(1)

(ii) Complete the sentence.

A sperm cell joins with an egg cell in a process called _____

(1)

(b) (i) What combination of alleles does the man have?

Tick (✓) **one** box.

DD ☐

Dd ☐

dd ☐

(1)

(ii) What combination of alleles does the man's wife have?

Tick (✓) **one** box.

DD ☐

Dd ☐

dd ☐

(1)

(c) Draw a ring around the correct answer to complete each sentence.

(i) The man and his wife plan to have a fourth child.

The probability that this child will have 6 toes on each foot is

1 in 2.

1 in 3.

1 in 4.

(1)

(ii) When Child **2** grows up, he marries a woman with 5 toes on each foot.

The probability that their first child will have 6 toes on each foot is

0.

1 in 2.

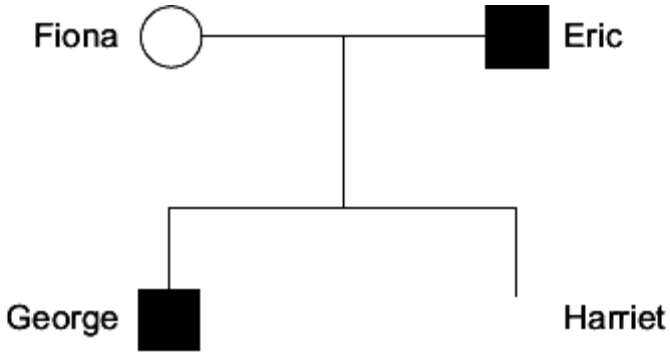
1 in 4.

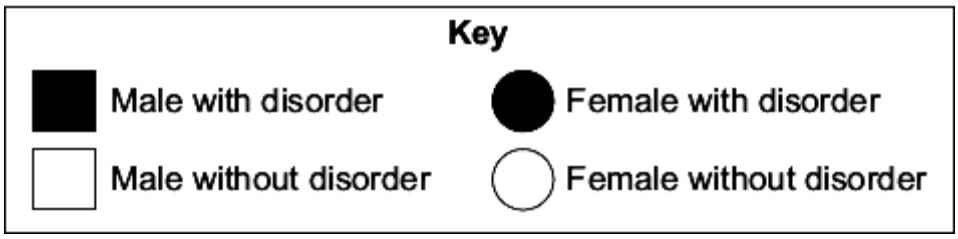
(1)

(Total 6 marks)

PPQ 5

Q5. The family tree shows the inheritance of a disorder caused by a dominant allele. Fiona and Eric have two children George and Harriet.





(a) The son, George, has the disorder.

The daughter, Harriet, does **not** have the disorder.

(i) Use the key to draw the symbol for Harriet next to her name **on the family tree**.

(2)

(ii) The symbol **D** represents the dominant allele for the disorder.
The symbol **d** represents the recessive allele.

Fiona has the pair of alleles **dd**.

Write the correct pairs of alleles in the boxes.

Harriet has the pair of alleles ☐

A person with the disorder could have

the pair of alleles ☐ or the pair of alleles ☐

(3)

(b) Before Harriet was born, a doctor suggested that Fiona should have the embryo 'screened'.

(i) Give **one** reason why the doctor suggested screening.

Tick (✓) **one** box.

To check for the **D** allele	☐
To check the sex of the embryo	☐
To cure the disorder	☐

(1)

(ii) Why do some people believe that embryos should **not** be screened?

_____

_____

(1)

(Total 7 marks)

Standard demand

PPQ6

Q6. Some genetic disorders are caused by alleles inherited from the parents.

(a) What are **alleles**?

_____

_____ **(1)**

(b) Describe how embryos can be screened for the alleles that cause genetic disorders.

_____

_____

_____

_____

_____

_____

_____

_____ **(4)**

(c) Polydactyly is a genetic disorder that leads to extra fingers or toes.

Polydactyly is caused by a dominant allele, **D**.

The photograph shows the hand of a person with polydactyly.

A man has polydactyly. His wife does not have polydactyly.

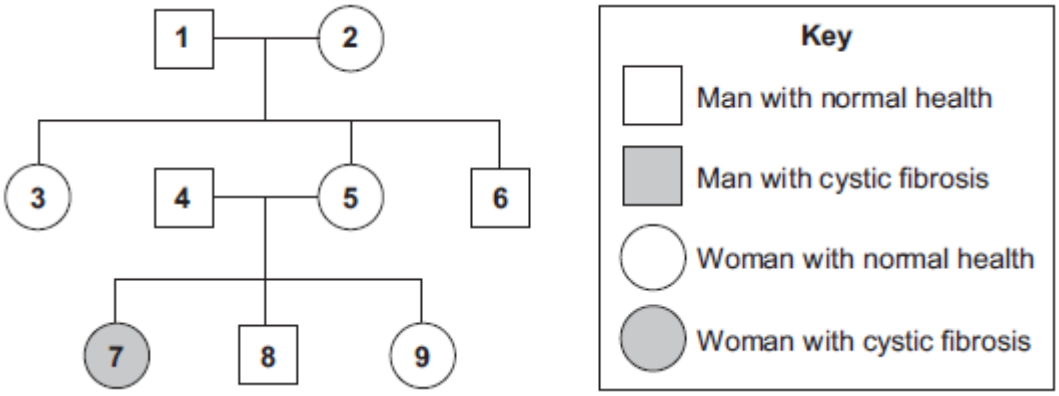
This couple's children have a 50% chance of having polydactyly.

Draw a genetic diagram to explain why.

(3)

(d) Cystic fibrosis is another genetic disorder. It is caused by a recessive allele.

The diagram shows the inheritance of cystic fibrosis in one family.



Woman **5** is pregnant with her fourth child.

What is the probability that this child will have cystic fibrosis?

Draw a genetic diagram to explain your answer.

Use the following symbols.

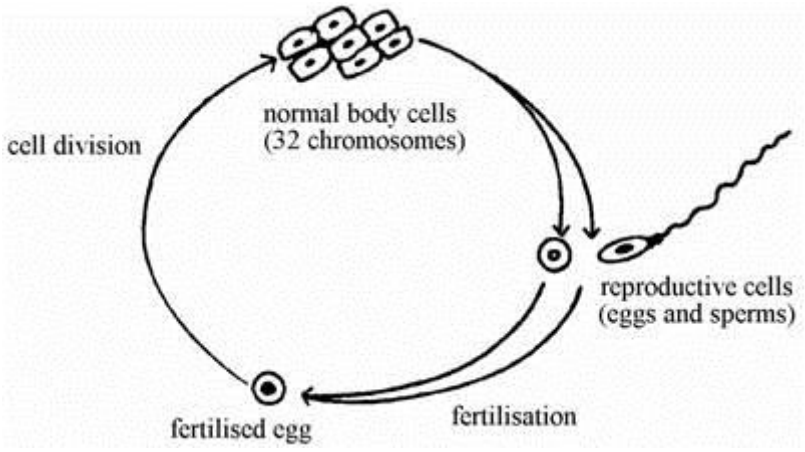
N = allele for normal health
n = allele for cystic fibrosis

(4)
(Total 12 marks)

PPQ7

Q7.

The diagram shows three types of cells in a life history of a simple animal.



(a) How do the chromosomes of the body cells compare with the chromosomes in the fertilised egg from which they came?

_____

_____

(1)

(b) Describe what happens to chromosomes in the nucleus of a body cell when it forms reproductive cells.

_____

_____

_____

_____

_____

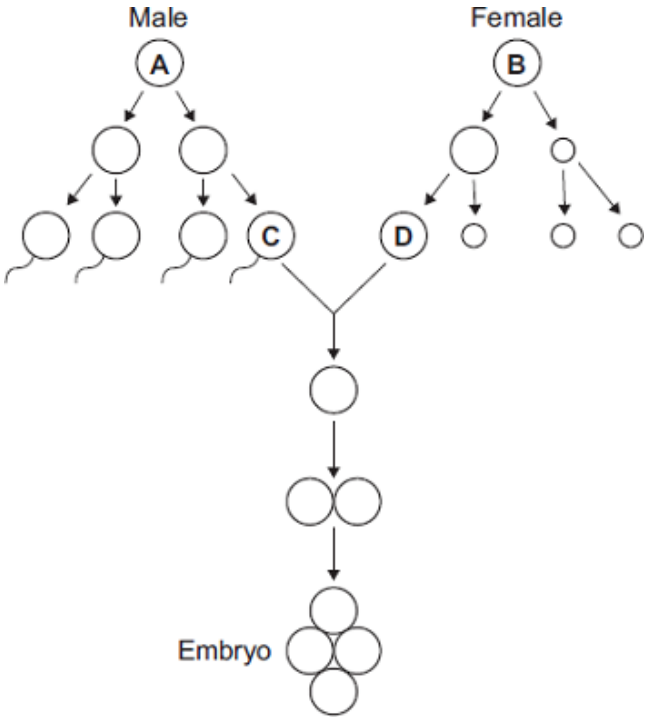
(4)

(Total 5 marks)

PPQ8

Q8.

The diagram shows some of the cell divisions that occur during human reproduction.



(a) (i) Name the type of cell division that produces cell **D** from cell **B**.

_____

(1)

(ii) Which organ in the male body produces cell **C** from cell **A**?

_____

(1)

(b) (i) Cells **A** and **B** each contain 46 chromosomes.

How many chromosomes would there be in the nucleus of cell **C**? ☐

(1)

(ii) Why is it important that cell **C** has this number of chromosomes?

_____

_____

_____

_____

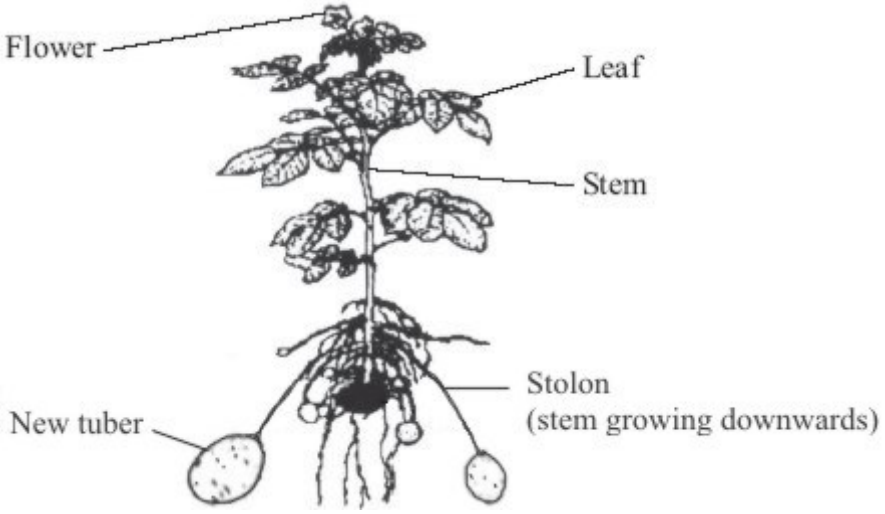
(2)

(Total 5 marks)

PPQ9

Q9.

The drawing shows a potato plant producing new tubers (potatoes). Buds on the stem of the parent plant produce stolons. The new tubers are formed at the ends of the stolons (stems that grow downwards).



(a) Explain why the new tubers are genetically identical to each other.

_____

_____

_____

_____

(2)

(b) Some of the tubers are used to produce potato plants. These new potato plants will not all grow to the same height.

Give **one** reason why.

_____

_____

(1)

(Total 3 marks)

PPQ10

Q10.

DNA is the genetic material of human cells.

Figure 1 shows the structure of part of a DNA molecule.

Figure 1

(a) (i) Describe where DNA is found in a human cell.

_____

_____

_____ **(2)**

(ii) When a cell divides by mitosis the new cells are genetically identical.

What causes the cells to be genetically identical?

_____

_____ **(1)**

(b) Many genes have different forms called alleles.

(i) A person has polydactyly (extra fingers or toes). Polydactyly is caused by a dominant allele.
What is the smallest number of copies of the dominant allele for polydactyly that could be found in a body cell of this person?

_____

(1)

(ii) Another person has cystic fibrosis. Cystic fibrosis (CF) is caused by a recessive allele.
How many copies of the recessive CF allele are there in a body cell of this person?

_____

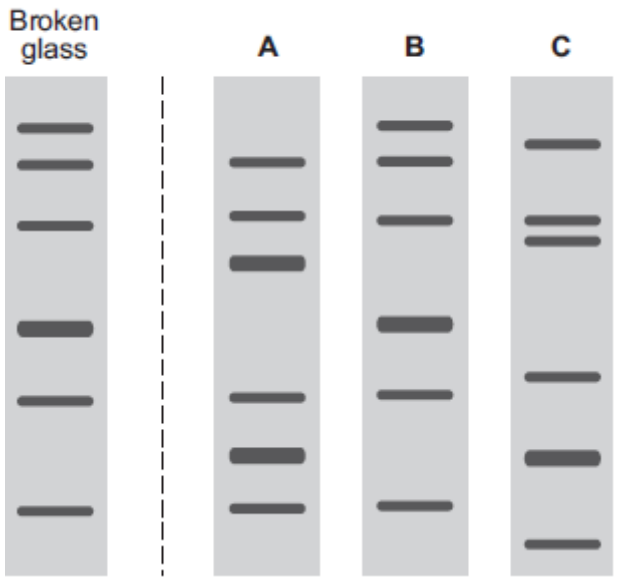
(1)

(c) A burglar broke into a house. The burglar cut his hand on some broken glass. Scientists extracted DNA from the blood on the broken glass.

The scientists analysed the DNA from the glass and DNA from three suspects, **A**, **B** and **C**. The scientists used a method called DNA fingerprinting.

Figure 2 shows the scientists' results.

Figure 2



Which suspect, **A**, **B** or **C**, is most likely to have been the burglar?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

(1)

(Total 6 marks)

High demand

PPQ11

Q11. Phenylketonuria (PKU) is an inherited condition. PKU makes people ill.

(a) PKU is caused by a recessive allele.

(i) What is an allele?

_____

_____

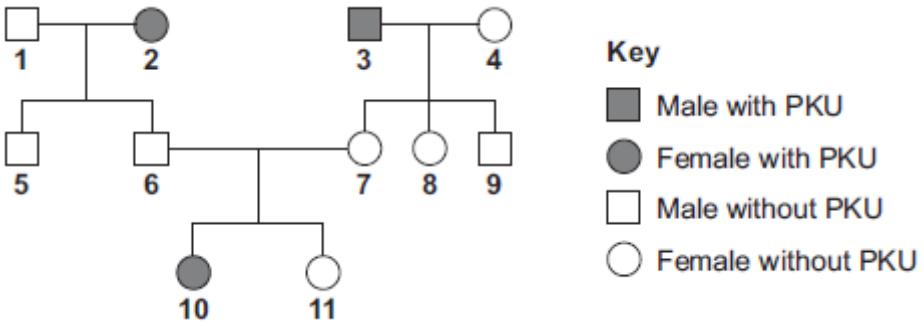
(1)

(ii) What is meant by recessive?

_____

_____ **(1)**

(b) The diagram below shows the inheritance of PKU in one family.



(i) Give **one** piece of evidence from the diagram that PKU is caused by a recessive allele.

_____

_____

(1)

(ii) Persons **6** and **7** are planning to have another child.
Use a genetic diagram to find the probability that the new child will have PKU.

Use the following symbols in your answer:

N = the dominant allele for **not** having PKU

n = the recessive allele for PKU.

Probability = _____

(4)

(c) Persons **6** and **7** wish to avoid having another child with PKU.

A genetic counsellor advises that they could produce several embryos by IVF treatment.

(i) During IVF treatment, each fertilised egg cell forms an embryo by cell division.

Name this type of cell division.

_____

(1)

(ii) An embryo screening technique could be used to find the genotype of each embryo.

An unaffected embryo could then be placed in person **7**'s uterus.

The screening technique is carried out on a cell from an embryo after just three cell divisions of the fertilised egg.

How many cells will there be in an embryo after the fertilised egg has

divided three times? ☐

(1)

(iii) During embryo screening, a technician tests the genetic material of the embryo to find out which alleles are present.

The genetic material is made up of large molecules of a chemical substance.

Name this chemical substance.

_____

(1)

(d) Some people have ethical objections to embryo screening.

(i) Give **one** ethical objection to embryo screening.

_____

(1)

(ii) Give **one** reason in favour of embryo screening.

_____

(1)

(Total 12 marks)

PPQ12

Q12. People with cystic fibrosis make large amounts of thick, sticky mucus in their lungs Cystic fibrosis is caused by the inheritance of recessive alleles.

(a) What do each of the following mean?

(i) Alleles

_____

_____ **(1)**

(ii) Recessive

_____

_____ **(1)**

(b) Mr and Mrs Brown have a child with cystic fibrosis. They hope to have another child. They want to know the probability that their next child will have cystic fibrosis. They visit a genetic counsellor who explains, "You are both heterozygous for cystic fibrosis. There is a 1 in 4 (25%) chance that your next child will have cystic fibrosis."

Use the following symbols in answering the questions.

N = allele for being unaffected by cystic fibrosis
n = allele for cystic fibrosis

(i) Mr and Mrs Brown both have the same genotype.

What is their genotype? _____ **(1)**

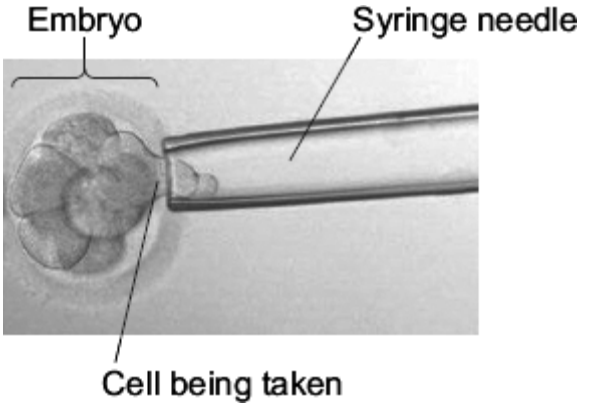
(ii) There is a 1 in 4 chance that Mr and Mrs Brown's next child will have cystic fibrosis. Use a genetic diagram to explain why.

(3)

(c) Mr and Mrs Brown do **not** want to have another child with cystic fibrosis. The genetic counsellor explains two different methods for finding out whether an embryo has cystic fibrosis. The methods are:

- pre-implantation genetic diagnosis (**PGD**)
- chorionic villus sampling (**CVS**).

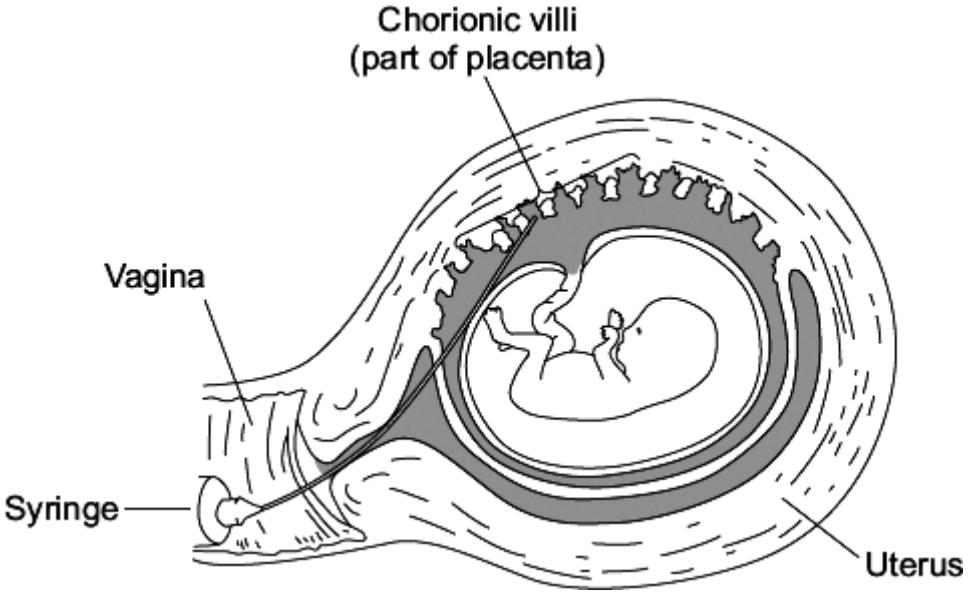
In **PGD**, eggs are fertilised in dishes and allowed to grow into embryos. A cell is taken from each embryo when the embryo is 3 days old. The photograph shows how the cell is taken.



Photograph:© Pascal Goetgheluck/
Science Photo Library

The DNA in the cell can then be tested. The possibility of a false positive result is about 1 in 6. An unaffected embryo can then be placed in the woman's uterus. The procedure costs about £6000.

CVS can only be done after 9 weeks of pregnancy. A tiny piece of the placenta is taken out using a tube attached to a syringe. This is grown in tissue culture for about 7 days. The diagram below shows how **CVS** is done.



The DNA in the cells can then be tested. About 2 in every 100 women have a miscarriage because of **CVS**. The possibility of a false positive result is about 1%. The procedure costs about £600. Following a positive result, the parents must then decide whether to terminate the pregnancy.

The genetic counsellor thinks that **PGD** is a better method than **CVS** for detecting cystic fibrosis in an embryo.

Evaluate this opinion.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 10 marks)

PPQ13

Q13. The table shows the number of chromosomes found in each body cell of some different organisms.

Animals		**Plants**	
Species	**Number of chromosomes in each body cell**	**Species**	**Number of chromosomes in each body cell**
Fruit fly	8	Tomato	24
Goat	60	Potato	44
Human	46	Rice	24

(a) Nearly every organism on earth has an even number of chromosomes in its body cells.

Suggest why.

_____

_____ **(1)**

(b) Chromosomes contain DNA molecules.

Describe the function of DNA.

_____

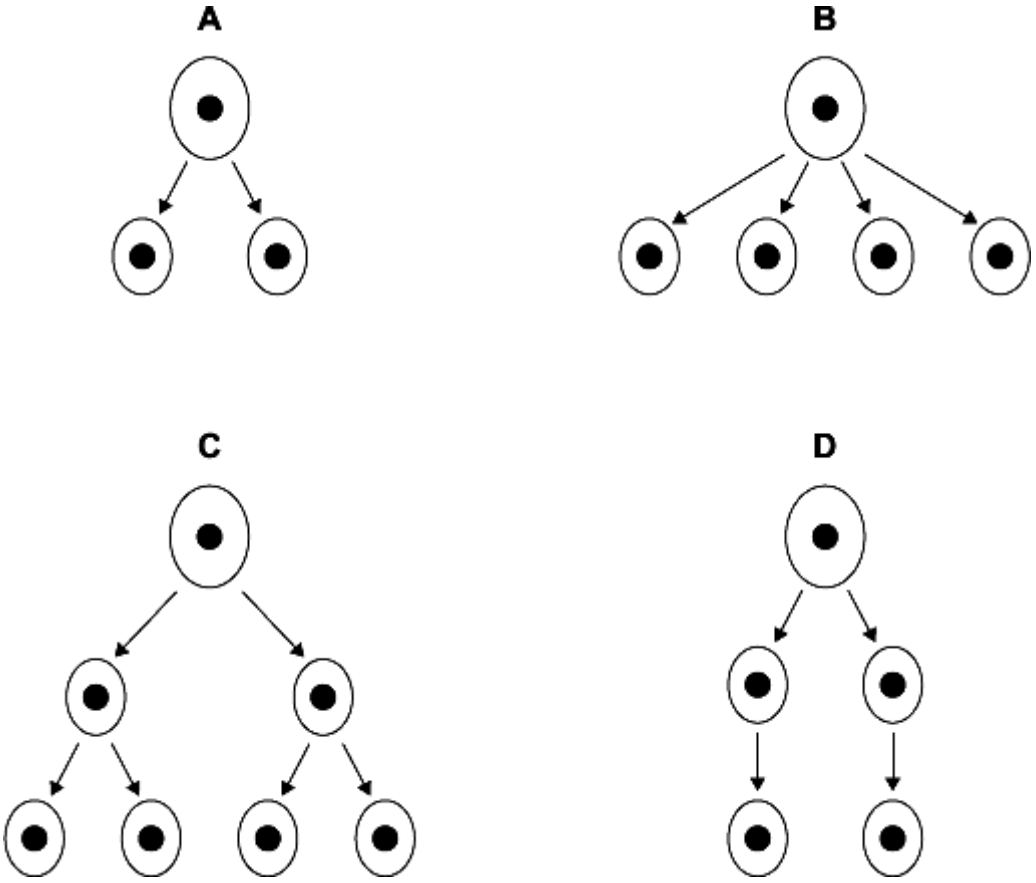
_____

_____

_____**(2)**

(c) Gametes are made in the testes by meiosis.

(i) Look at the diagrams.



Which diagram, **A**, **B**, **C** or **D**, represents how cell division by meiosis produces gametes in the testes? ☐

(1)

(ii) How many chromosomes will each goat gamete contain?

_____ **(1)**

(d) Body cells divide by mitosis.

(i) Why is the ability of body cells to divide important?

_____

_____ **(1)**

(ii) When a body cell of a potato plant divides, how many chromosomes will each of the new cells contain?

_____ **(1)**

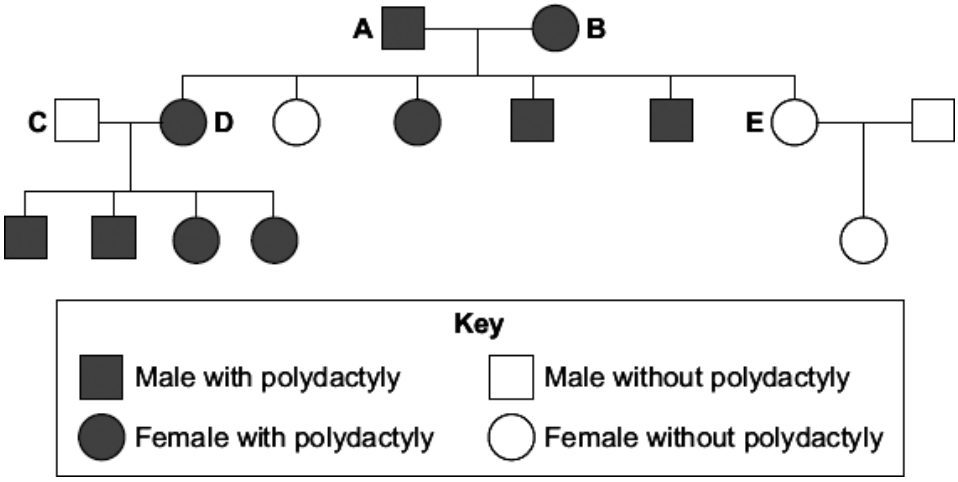
(Total 7 marks)

PPQ14

Q14. Cats normally have four toes on each back paw. The picture shows the back paw of a cat with an inherited condition called polydactyly.

By Onyxrain (Own work) [Public domain], via Wikimedia Commons

The family tree shows the inheritance of polydactyly in three generations of cats.



(a) What combination of alleles did the original parents, **A** and **B**, have?

Explain how you work out your answer. You may use a genetic diagram in your answer.

Use the symbol **H** to represent the dominant allele. Use the symbol **h** to represent the recessive allele.

_____

_____

_____

_____

_____

_____

A = _____ **B =** _____

(4)

(b) (i) Give **two** possible combinations of alleles for cat **D**.

1. _____ 2. _____

(1)

(ii) You cannot be sure which one of these two is the correct combination of alleles for cat **D**.

Why?

_____

_____

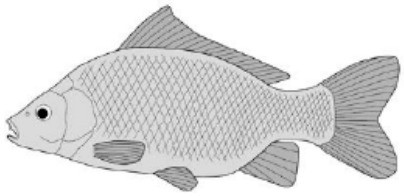
_____

(1)

(Total 6 marks)

PPQ15

Q15. The figure below shows a carp.



(a) A mutation causes a blue colour in some carp.

What is a mutation?

_____

_____ **(1)**

(b) Suggest how a mutation could cause a different colour in carp.

_____

_____**(1)**

(c) Two alleles control the body colour of carp:

- brown (**B**)
- blue (**b**).

The brown allele is dominant to the blue allele. Two carp that are heterozygous for colour are crossed and produce 2.6×10^5 offspring.

Approximately how many of the offspring are expected to be blue?

Draw a genetic diagram to explain your answer. Give your answer in standard form.

Number of offspring expected to be blue = _____**(5)**

(d) A scientist wanted to find out whether a brown carp has the genotype **BB** or **Bb**.

Describe what genetic cross a scientist could do to determine this.

_____

_____

_____

_____

_____

_____**(2)**

(Total 9 marks)

PPQ16

Q16. Cell division is needed for growth and for reproduction.

(a) The table below contains three statements about cell division. Complete the table. Tick **one** box for each statement.

	Statement is true for		
Statement	**Mitosis only**	**Meiosis only**	**Both mitosis and meiosis**
All cells produced are genetically identical			
In humans, at the end of cell division each cell contains 23 chromosomes			
Involves DNA replication			

(2)

Bluebell plants grow in woodlands in the UK.

- Bluebells can reproduce sexually by producing seeds.
- Bluebells can also reproduce asexually by making new bulbs.

(b) One advantage of asexual reproduction for bluebells is that only **one** parent is needed. Suggest **two** other advantages of asexual reproduction for bluebells.

1. _____

_____

2. _____

_____ **(2)**

(c) Explain why sexual reproduction is an advantage for bluebells.

_____

_____

_____

_____

_____

_____

_____

_____

_____**(4)**

(Total 8 marks)

PPQ17

Q17.

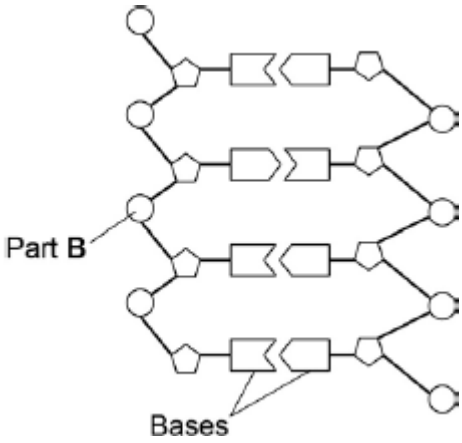
Figure 1 shows an image of a small section of DNA.

Figure 2 shows the structure of a small section of DNA.

Figure 1

© Svisio/iStock/Thinkstock

Figure 2



(a) What is Part **B**?

_____

_____

(1)

(b) In **Figure 1** the structure of DNA shows four different bases.

There are four different bases and they always pair up in the same pairs.

Which bases pair up together?

_____

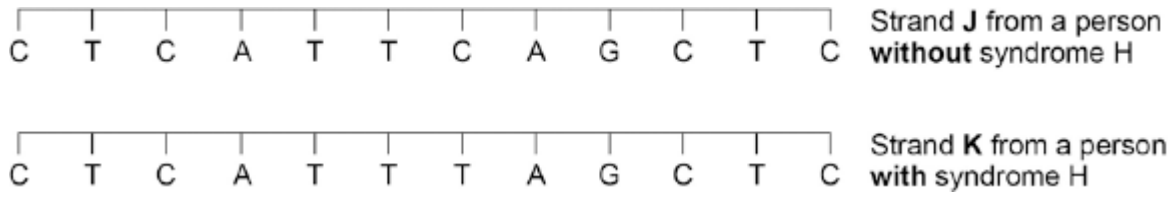
(1)

(c) Syndrome H is an inherited condition.

People with syndrome H do **not** produce the enzyme IDUA.

Figure 3 shows part of the gene coding for the enzyme IDUA.

Figure 3



Strand **K** shows a mutation in the DNA which has caused syndrome H.

The enzyme IDUA helps to break down a carbohydrate in the human body.

The enzyme IDUA produced from Strand **K** will not work.

Explain how the mutation could cause the enzyme **not** to work.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(d) A recessive allele causes syndrome H.

A heterozygous woman and a homozygous recessive man want to have a child.

Draw a Punnett square diagram to determine the probability of the child having syndrome H.

Identify any children with syndrome H.

Use the following symbols:

A = dominant allele

a = recessive allele

Probability = _____ %

(5)

(Total 12 marks)

4.6.1 Reproduction PPQ Answers

Low demand

PPQMS1

Q1.

(a) **only genetic causes**
any **one** from:

- pattern of scales
- number of fins
- eye colour

1

only environmental causes:

- scar

1

both genetic and environmental causes:

- length

1

(b)

	B	**b**
b		bb
b	Bb	bb

*allow 2 correct for **1** mark*

2

(c) any bb circled

1

(d) 0.5

*allow ecf from **04.2***

1

(e) (260 000 / 2 =) 130 000

*allow ecf from **04.4***

1

(f) mutation

allow change in diet / hormones / DNA

1

[9]

PPQMS2

Q2.

(a) (i) fertilisation

1

(ii) in sequence:

accept 1 next to gene, 2 next to chromosome and 3 next to nucleus in box

1 gene
2 chromosome
3 nucleus

*allow 1 mark for smallest **or** largest in correct position*

2

(iii) DNA

1

(b) (i) On diagram:

tick drawn next to **X** and / or **Y** from Parent 1

tick(s) must be totally outside grid squares
allow ticks around "parent "
extra ticks elsewhere cancel

1

(ii) 0.5 / ½ / 50% / 1:1 / 50:50 / 1 in 2

allow 2/4 / 2 in 4 / 2 out of 4 / 'even(s)' / 'fifty – fifty'
*do **not** allow 1:2 or '50 / 50' or '50 – 50'*

1

2 (out of 4) boxes are **XX**

or

half of the sperm contain an **X**-chromosome

*allow **XY** is male and 2 (out of 4) boxes are **XY***

1

[7]

PPQMS3

Q3.

(a) (i) gametes

apply list principle

1

(ii) chromosomes

apply list principle

1

(b) (i) The allele is recessive

no mark if more than one box is ticked

1

(ii) two

apply list principle

1

(c) (i) **A**

apply list principle

1

(ii) **B**

apply list principle

1

[6]

PPQMS4

Q4.

(a) (i) 1

1

fertilisation / fusion

allow sexual reproduction

allow fertilise / fuse

ignore joining

1

(b) (i) **Dd**

1

(ii) **dd**

1

(c) (i) 1 in 2

1

(ii) 0

1

[6]

PPQMS5

Q5.

(a) (i) circle

mark independently

1

unshaded

could be in body of script

1

(ii) (Harriet) dd

in first box

1

DD

if another letter is chosen it must be used throughout and upper or lower case must be clear

1

Dd

1

(b) (i) to check for the D allele.

1

(ii) any **one** from:

- may harm / kill foetus / embryo / baby / mother
  allow could affect the baby
- immoral / unethical / religion
  ignore playing God
  ignore references to unnatural
  ignore wrong unqualified
  ignore expense / prejudice unqualified
  ignore lack of permission
  ignore results are unreliable

1

[7]

Standard demand

PPQMS6

Q6.

(a) (different / alternative) forms of a gene
*do **not** accept types of genes*

1

(b) DNA isolated from embryo

1

(fluorescent) probe mixed with embryo DNA

1

probe (then) binds with embryo DNA

1

(UV light) to show alleles / gene for disorder

1

(c) genotypes of parents and gametes correct (Man **D** and **d**, Wife **d** and **d**)
*allow half-size genetic diagram with only one **d** from wife*

1

offspring genotypes correct (½ = **Dd** and ½ = **dd**)
allow ecf if parental genotypes are wrong

1

offspring phenotypes correctly assigned to genotypes

1

(d) genotypes of parents and gametes correct (**N** and **n**)
allow ecf if parental genotypes are wrong

1

offspring genotypes correct (**NN**, 2 × **Nn**, and **nn**)

1

offspring phenotypes correctly assigned to genotypes;

1

correct probability = 0.25 / ¼ / 25% / 1 in 4 / 1:3, only;
*do **not** allow '3:1' / '1:4'*

1

[12]

PPQMS7

Q7.

(a) *idea*

identical (do not allow simply "the same number")
for 1 mark

1

(b) *idea*

chromosomes double/duplicate/copies made
for 1 mark

separate into 2 sets/divide*
gains 1 mark

but
separate into 4 sets/divide twice*
gains 2 marks

number halved compared to bodycell
or
single set (only) 16
accept in terms of cells but only if chromosomes referred to in first and/or last items)
for 1 mark

4

[5]

PPQMS8

Q8.

(a) (i) meiosis
allow mieosis

1

(ii) testis / testes
allow testicle

1

(b) (i) 23

1

(ii) fuses / joins with cell D / with egg cell **or** used in fertilisation
allow fuse with another cell

1

prevents doubling of chromosome number / restores original no. / 46 / diploid no. / normal no. / full no.

accept 23 from each parent / from each gamete

1

[5]

PPQMS9

Q9.

(a) grow from parents,
by vegetative reproduction/asexual reproduction/
no sexual reproduction

for 1 mark each

2

(b) e.g. different environmental conditions/named condition

for 1 mark

1

[3]

PPQMS10

Q10.

(a) (i) in the chromosome(s)

ignore genes / alleles

1

in the nucleus

allow nuclei

allow mitochondria

1

(ii) the DNA / chromosomes / genes are replicated / copied / multiplied / doubled / duplicated

allow DNA is cloned

ignore same DNA / chromosomes / genes if unqualified

1

(b) (i) 1 / one

1

(ii) 2 / two

1

(c) **B**

1

[6]

High demand

PPQMS11

Q11.

(a) (i) one form of a / one gene

*do **not** allow 'a type of gene'*

allow a mutation of a gene

1

(ii) not expressed if dominant / other allele is present / if heterozygous

or

only expressed if dominant allele not present / or no other allele present

allow need two copies to be expressed / not expressed if only one copy / only expressed if homozygous

1

(b) (i) two parents without PKU produce a child with PKU / **6** and **7** → **10**

allow 'it skips a generation'

1

(ii) genetic diagram including:

accept alternative symbols if defined

Parental gametes:

6: **N** and **n**
and 7: **N** and **n**

1

derivation of offspring genotypes:

NN **Nn** **Nn** **nn**

allow genotypes correctly derived from student's parental gametes

1

identification: **NN** and **Nn** as non-PKU

OR nn as PKU

allow correct identification of student's offspring genotypes

1

correct probability only: 0.25 / ¼ / 1 in 4 / 25% / 1 : 3

*do **not** allow 3 : 1 / 1 : 4*

*do **not** allow if extra incorrect probabilities given*

1

(c) (i) mitosis

correct spelling only

1

(ii) 8

1

(iii) DNA

allow deoxyribonucleic acid

*do **not** allow RNA / ribonucleic acid*

1

(d) (i) may lead to damage to embryo / may destroy embryos / embryo cannot give consent

allow avoid abortion

allow emotive terms – eg murder religious argument must be qualified

allow ref to miscarriage

allow idea of avoiding prejudice against disabled people

allow idea of not producing designer babies

1

(ii) any **one** from:

- prevent having child with the disorder / prevent future suffering / reduce incidence of the disease

  ignore ref to having a healthy child

  ignore ref to selection of gender
- embryo cells could be used in stem cell treatment

  allow ref to long term cost of treating a child (with a disorder)

  allow ref to time for parents to become prepared

1

[12]

PPQMS12

Q12.

(a) (i) (alternative) forms / types of a / the same gene

1

(ii) only expressed if 2 copies inherited
or not expressed if other allele present

allow over ruled / over powered by the other allele

1

(b) (i) **Nn**

ignore heterozygous

1

(ii) genetic diagram including:

accept alternative symbols, if defined

gametes: **N** and **n** from both parents

accept alternative symbols if correct for answer to (b)(i)

1

correct derivation of offspring genotypes:
NN Nn Nn nn

allow if correct for candidate's parental genotypes / gametes

1

identification of **nn** as having cystic fibrosis

1

(c) **Argued evaluation**

any **four** from:

- PGD higher financial cost

accept CVS only costs £600

- PGD occurs before pregnancy / implantation
  accept detected at earlier stage so less unethical / less trauma
- PGD does not involve abortion so less trauma / less pain / ethical

PPQ MS13

Q13. (a) any **one** from

- chromosomes in pairs
- inherited one of each pair from each parent
- one of each pair in egg **and** one of each pair in sperm
- so sex cells / gametes can have half the number
  allow need to pair during cell division / meiosis

1

(b) any **two** from:

- code
- combination / sequence of amino acids
- forming specific / particular proteins / examples
  *If **no other mark** gained allow reference to controlling characteristics / appearance for **1** mark*

2

(c) (i) C

1

(ii) 30

1

(d) (i) for growth / repair / replacement / asexual reproduction
*do **not** accept incorrect qualification, eg growth of cells **or** repair of cells*
they equals cells therefore do not accept they grow etc

1

(ii) 44 **or** 22 pairs

1

[7]

PPQ MS14

Q14. (a) **A** = Hh **B** = Hh

may not be in answer space
accept heterozygous or description

1

(allele for) polydactyly is dominant **or** polydactyly is H,
for marking points 1, 2 and 3 accept evidence in clearly labelled / annotated genetic diagram

1

cats with polydactyly have H

accept if polydactyly was recessive all offspring would have polydactyly

1

E or (some) offspring of **A** and **B**, does not have polydactyly,
so **A** and **B** must both have h

1

(b) (i) HH **and** Hh **or**
homozygous dominant **and** heterozygous

both required, in either order

allow description

1

(ii) any **one** from:

accept annotated genetic diagram to explain answer

- polydactyly is dominant
- parents are both Hh
- if D is Hh all offspring could inherit H

1

[6]

PPQ MS15

Q15. (a) a change in the DNA / gene

1

(b) produces a different protein / enzyme that is responsible for colour

1

(c) parents genotype both Bb

allow correctly derived gametes

1

offspring genotypes correctly derived

1

bb identified as blue

allow ring around bb only

1

65 000

allow ecf or 260 000 × 0.25

1

6.5×10^4

1

(d) cross with **bb** / blue carp

*allow annotated Punnett square diagram(s) of cross with **bb** carp*

1

if any offspring are blue, the parent was **Bb** / heterozygous

allow converse

1

*allow cross with known **Bb** carp*

*if any offspring are blue, other parent was **Bb** / heterozygous*

[9]

PPQ MS16

Q16.

(a)

	statement is true for		
	mitosis only	**meiosis only**	**both mitosis and meiosis**
all cells produced are genetically identical	✓		
in humans, at the end of cell division each cell contains 23 chromosomes		✓	
involves DNA replication			✓

*3 correct = **2** marks*
*2 correct = **1** mark*
*0 or 1 correct = **0** marks*

2

(b) any **two** from:

ignore references to one parent only

- many offspring produced
- takes less time

allow asexual is faster

- (more) energy efficient
- genetically identical offspring

allow offspring are clones

- successful traits propagated / maintained / passed on (due to offspring being genetically identical)
- no transfer of gametes or seed dispersal

allow no vulnerable embryo stage
allow no need for animals

- not wasteful of flowers / pollen / seeds
- colonisation of local area

must imply local area

2

(c) genetic variation (in offspring)

1

(so) better adapted survive

allow reference to natural selection or survival of the fittest

1

(and) colonise new areas by seed dispersal
or
can escape adverse event in original area (by living in new area)

must imply new area

1

many offspring **so** higher probability some will survive

1

*allow bluebell example described (**max 3** if not bluebell)*

[8]

PPQ MS17

Q17.

(a) phosphate

1

(b) A / adenine and T / thymine
and C / cytosine and G / guanine

1

(c) (mutation) changes from C to T DNA code
or
there is a change in the three bases / triplet from CAG to TAG

1

(mutation) changes the amino acid

1

(this could) change the protein

1

(so it) forms a different shape / changed active site

1

(therefore) the enzyme no longer fits the substrate / carbohydrate

1

(d) mother / woman's gametes correct: A a

1

father / man's gametes correct: a a

1

correct derivation of offspring

1

identification of child with syndrome H or genotype aa

1

0.5

allow 50% / 1 / 2 / 1 in 2 / 1:1

1

*do **not** accept 1:2*

[12]

4.6 Inheritance, Variation and Evolution Knowledge

4.6.2 Variation and Evolution

4.6.2.1 Variation

Individuals in a population are usually similar to each other, but not identical. Some of the **variation** within a **species** is **genetic**, some is environmental - the conditions in which they have developed and some is a combination of both.

Genetic causes of variation

Children generally look a little like their mother and their father, but are not identical to either. They inherit their features from each parent's DNA.
Every sperm and egg cell contains half of the genetic information needed for an individual. Each sex cell is known as **haploid**, which has half the normal number of **chromosomes**. When the chromosomes fuse during **fertilisation**, a new cell is formed, which is known as a **zygote**. It has all the genetic information needed for an individual, which is known as **diploid** and has the full number of chromosomes.

Examples of genetic variation in humans include blood group, skin colour and natural eye colour.
Whether you have lobed or lobeless ears is due to genetic causes.

Biological sex is also an inherited variation - whether you are male or female is a result of genes you inherited from your parents.

Environmental causes of variation

Characteristics of animal and plant species can be affected by factors such as climate, diet, accidents, culture and lifestyle. For example, if you eat too much you will become heavier, and if you eat too little you will become lighter. A plant in the shade of a big tree will grow taller to reach more light.
Other examples of features that show environmental variation include:

- scars
- language and accent
- flower colour in hydrangeas as these plants produce blue flowers in **acidic** soil and pink flowers in **alkaline** soil

Genetic and environmental causes together

Some features vary because of a combination of genetic and environmental causes. For example, tall parents will pass genes to their children for height. Their children have the genetic potential to also be tall. However, if their diet is poor then they will not grow very well: their environment also has an impact on their height.

Mutation and variation

Extensive genetic variation is contained within any species. This is clearly visible in the domestic dog species.

Variation within genes leads to different **genotypes**, and this can be seen by a different **phenotype**. Genetic and environmental variation combine together to produce these different phenotypes. All variants arise from **mutations** and most have no effect on the phenotype.

A **mutation** is a change in a **gene** or **chromosome**. Mutations arise spontaneously and happen continually. A mutation rarely creates a new phenotype, but if the phenotype is suited to a particular environment, it can lead to rapid change in a species.

For example, if a mutation leads to a change, such as feather colouring in birds, this new change may allow those individuals to reproduce more frequently, due to them being more attractive and seen as a more desirable mate. This would result in this phenotype being passed on more successfully than the birds of the same species without the new phenotype.

4.6.2.2 Evolution

Natural selection is a process where organisms that are better adapted to an environment will survive and have more offspring. This means their genes are passed on to the future generations. This process is fundamental to the process of **evolution**.

Charles Darwin was a famous English naturalist, who during his life came up with a theory of evolution. He is associated with the term 'survival of the fittest' which describes how natural selection works, by selecting the best examples of an organism to survive. For example, individuals that are best adapted to their environments are more likely to survive and therefore reproduce.
A famous example of this is the peppered moth.

Light peppered moths camouflage themselves against light lichens on trees
During the nineteenth century, pollution killed off some of the **lichens** and soot deposits caused the bark on trees to appear darker. Light coloured moths were no longer **camouflaged** and were eaten by birds. The dark moths had a better camouflage.
As a result, dark moths had a greater chance of reproducing and passing on the **phenotypes**, and through this the **alleles** that made them dark. This led to a gradual increase in the proportion of dark moths until light moths became very rare in industrial areas.
Note that this change was not due to pollution making the moths darker. The dark variety had always existed, but had an advantage when the environment changed.

4.6.2.3 Selective breeding

Selective breeding or artificial selection is when humans breed plants and animals for particular genetic characteristics. Humans have bred food crops from wild plants and domesticated animals for thousands of years.

Main steps involved

Selective breeding takes place over many generations. These are the main steps for both plants and animals involve:

- Decide which characteristics are important enough to select.
- Choose parents that show these characteristics from a mixed population. They are bred together.
- Choose the best offspring with the desired characteristics to produce the next generation.
- Repeat the process continuously over many generations, until all offspring show the desired characteristics.

Farmers selectively breed different types of cows with highly desirable characteristics in order to produce the best meat and dairy.
Characteristics can be chosen for usefulness or appearance:
Desired characteristics in plants:

- disease resistance in food crops

- wheat plants that produce lots of grain
- large or unusual flowers

Desired characteristics in animals:

- animals that produce lots of milk or meat
- chickens that lay large eggs
- domestic dogs that have a gentle nature

The new varieties may be economically important. For example, they may provide more or better quality food, or allow farmers to feed more people.

Benefits and risks of selective breeding

Because of **selective breeding**, future generations of selectively bred plants and animals will all share very similar genes which will reduce variation. Genes and their different **alleles** within a population are known as its gene pool. Inbreeding can lead to a reduced gene pool, making it more difficult to produce new varieties in the future. This also makes organisms prone to certain diseases or inherited defects.

Benefits of selective breeding include:

- new varieties may be economically important, by producing more or better quality food
- animals can be selected that cannot cause harm, for example cattle without horns

Risks of selective breeding include:

- reduced genetic variation can lead to attack by specific insects or disease, which could be extremely destructive
- rare disease genes can be unknowingly selected as part of a positive trait, leading to problems with specific organisms, eg a high percentage of Dalmatian dogs are deaf
- can create physical problems in specific organisms, eg large dogs can have faulty hips due to not being formed correctly

4.6.2.4 Genetic engineering

Genetic engineering is also called genetic modification or GM. It involves modifying the genome of an organism by introducing a gene from another organism to result in a desired characteristic.

Genetic engineering involves these steps:

1. selection of the desired characteristic
2. the gene responsible for the characteristic is 'cut out' of the chromosome
3. the gene is transferred and inserted into another organism

4. replication of the modified organism.

Plant crops have been genetically engineered to be disease resistant or to produce bigger fruits.

Current uses of genetic engineering

Diabetes is a disorder in which the body's blood glucoselevels remain too low or too high. It can be treated by injecting insulin. The extra insulin allows the glucose to be taken up by the liver and other tissues, which results in cells receiving the glucose they need, and blood glucose levels stay normal.

Bacterial cells have been genetically modified to produce substances such as human insulin.

Genetically modified crops

Current genetically modified crops include those that are resistant to insect attack or are herbicide resistant, this produced increased yields. Herbicide resistant crops allow them to tolerate the herbicide, but the weeds are killed by it, thus overall less herbicide is needed.

Golden rice

Scientists have added a gene to wild rice that makes it produce beta carotene. This changes the colour of the wild rice to a golden colour. Beta carotene is needed by humans in order to make vitamin A - which is essential for good vision.

The advantage of golden rice is that it can be used in areas where vitamin A deficiency is common, so it can help prevent blindness. In many countries golden rice is not being grown commercially over fears associated with genetically modified crops.

There are ethical issues involved in genetic modification, as well as concerns about the possible health risks of genetically modified food. For example, a GM food might contain a substance that causes an allergic reaction in some people, or higher levels of a toxin naturally found in the food. Others think it is ethically wrong to create new life forms, or to move genes between different species.

Future uses

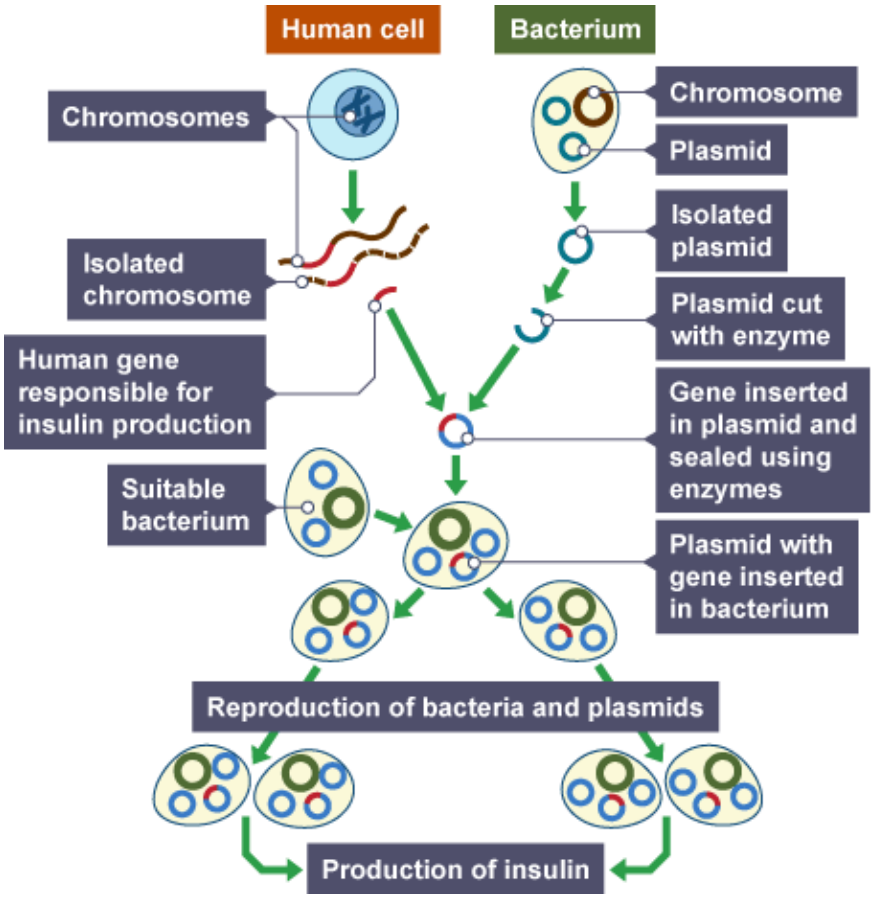
In the future researchers are hoping to use genetic engineering to be able to overcome some inherited disorders, such as cystic fibrosis and Huntington's disease amongst others.

The process of genetic engineering - Higher

The main steps of genetic engineering:

- Enzymes are used to isolate the required **gene**, this gene is inserted into a **vector**, which is usually a bacterial **plasmid** or a virus.
- The vector inserts the gene into required cells.
- The genes are transferred to animal, plant or microorganism cells, during early development. This allows them to develop with the desired characteristics.

This diagram shows how the genetic engineering of the insulin works:



Potential benefits and risks of genetic engineering

There are many benefits to using genetic engineering. It is used in agriculture to do things such as, improve the yields of important economic crops, and provide insect or pest resistance. It is also used in the medical field to create insulin, which can be used for treating diabetes. But, as with most new technology, it also carries potential risks.

Benefits of genetic engineering

- Genetic modification is a faster and more efficient way of getting the same results as selective breeding.
- Improve crop yields or crop quality, which is important in developing countries. This may help reduce hunger around the world.

- Introduce herbicide resistance, which results in less herbicides being used, as weeds are quickly and selectively killed.
- Insect and pest resistance can be developed and inserted into the plants. The plant produces toxins, which would discourage insects from eating the crop.
- Sterile insects could be created such as a mosquito. They would breed, which would lead to infertile offspring. This may help with spread of diseases, such as malaria, dengue fever and the Zika virus.

Risks of genetic engineering

- Transfer of the selected gene into other species. What benefits one plant may harm another.
- Some people believe it is not ethical to interfere with nature in this way. Also, GM crop seeds are often more expensive and so people in developing countries cannot afford them.
- GM crops could be harmful, for example toxins from the crops have been detected in some people's blood.
- GM crops could cause allergic reactions in people.
- Pollen produced by the plants could be toxic and harm insects that transfer it between plants.

4.6.2.5 Cloning (biology only)

Cloning in plants

Clones are genetically identical individuals. The cloning of plants has many important commercial implications. It allows a variety of a plant with desirable characteristics to be produced cheaply, quickly and on a large scale. Cloning often follows **genetic modification**. It allows many copies of the GM organism to be produced.

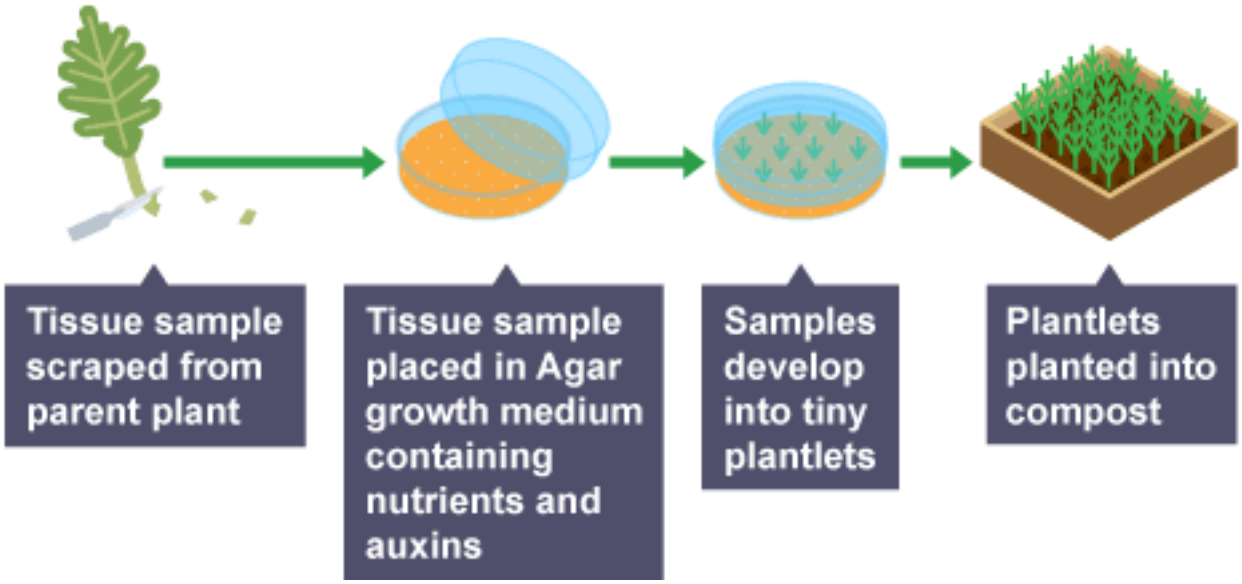
Cuttings

The simplest way to clone a plant involves taking a **cutting**. This is an old but simple technique, used by gardeners. A branch from the parent plant is cut off, its lower leaves are removed, and the stem is planted in damp compost. Plant hormones are often used to encourage new roots to develop. The cutting is usually covered in a clear plastic bag to keep it moist and warm. After a few weeks, new roots develop and a new plant grows.

Tissue culture

Another way of cloning plants is by **tissue culture** also called **micropropagation**. It works with small pieces of plants, called **explants**. These are grown **in vitro** using

sterile **agar jelly** that contains plant hormones and nutrients. This makes tissue culture more expensive and difficult to do than taking cuttings. This is an important way to preserve rare plant species or grow commercially in larger nurseries.

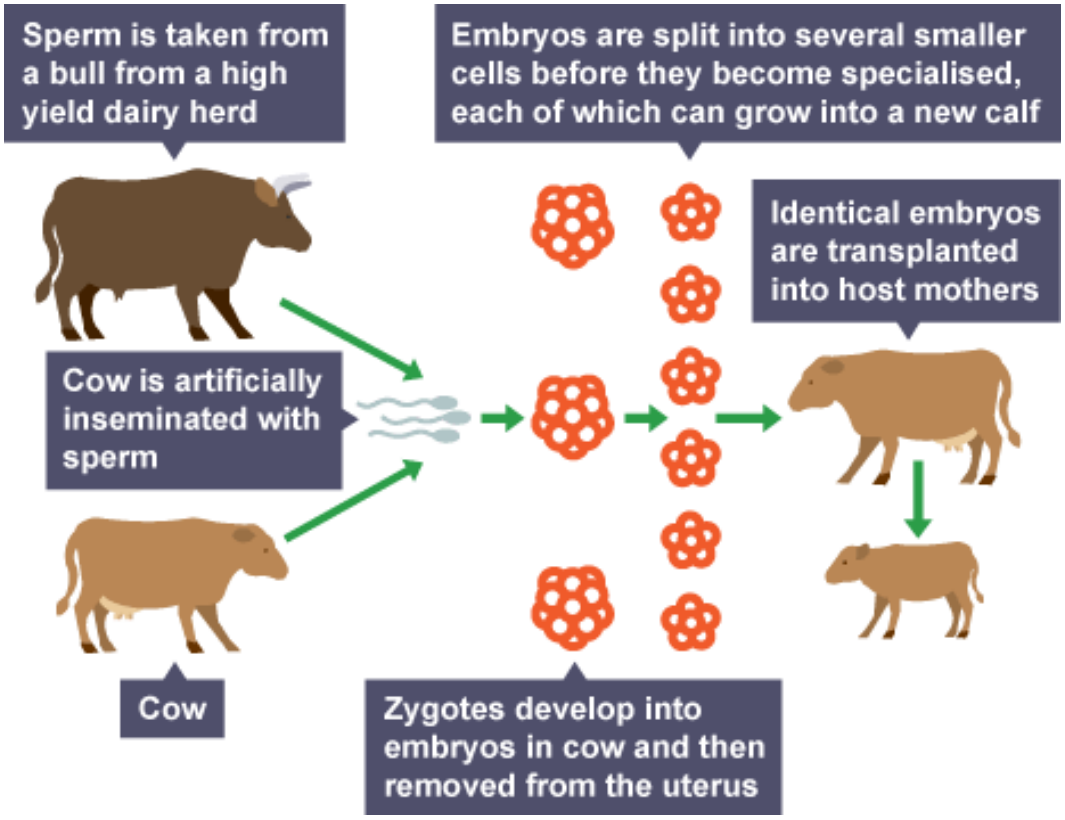


Cloning expensive food crops has been carried out for many years, and causes the public fewer ethical and moral concerns than animal cloning.

Cloning in animals

Embryo transplants

The most basic technique of animal cloning is shown in the diagram below.

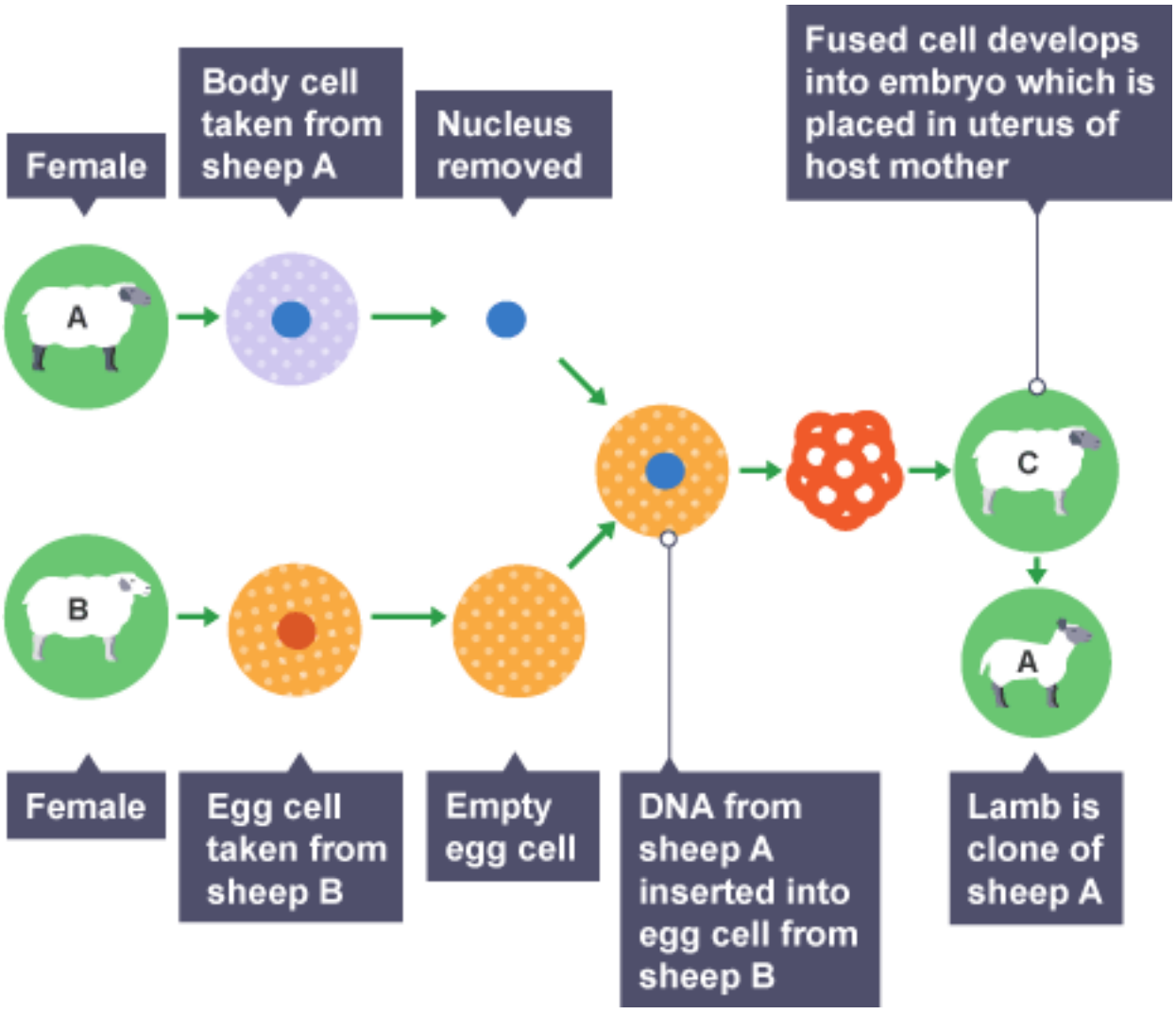


Adult cell cloning

Dolly the sheep was the first mammal to be cloned. She was born in the UK in 1996 and died in 2003. She was produced using the **nucleus** from an udder cell, although other cells such as skin cells may also be used.

The method for adult cell cloning is:

- The nucleus is removed from an unfertilised egg cell.
- The nucleus from an adult body cell, such as a skin cell, is inserted into the egg cell.
- An electric shock stimulates the egg cell to divide to form an embryo.
- These embryo cells contain the same genetic information as the adult skin cell.
- When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development.



4.6.2 Variation and Evolution PPQ's

Low demand

PPQ1

Q1.

A person's characteristics can be due to:

- environmental causes
- genetic causes
- both environmental and genetic causes.

(a) Complete **Table 1**.

Put a tick to show what each characteristic is due to.

Table 1

Characteristic	Characteristic due to		
	Environmental causes	**Genetic causes**	**Both environmental and genetic causes**
Eye colour			
A scar			
Weight			

(3)

(b) Draw **one** line from each key term to the correct definition.

Key term	Definition
	The set of alleles for a characteristic
Genotype	The genus of an organism
	The inheritance of chromosomes
Phenotype	The mutation of genes
	The physical characteristic of an organism

(2)

(c) Farmers use selective breeding to control the characteristics in cows.

Table 2 shows the stages of selective breeding in cows.

Complete **Table 2** to show the correct order of the stages.

The first stage has been numbered for you.

Table 2

Stage in selective breeding	Order of stage
Cows are bred over many generations	
Parents are bred together	
Cows with the desired characteristics are chosen	1
Calves with the most desired characteristics are bred together	

(2)

(d) Farmers selectively breed cows for many different reasons.

Suggest **two** characteristics that cows may be bred for.

Do **not** suggest coat colour.

1. _____

_____

2. _____

_____

(2)

(e) Selective breeding can lead to problems.

Suggest how problems caused by selective breeding in cows can have negative financial effects for the farmer.

_____

_____

_____

_____

(2)

(Total 11 marks)

PPQ2

Q2.

Scientists have produced many different types of GM (genetically modified) food crops.

(a) Use words from the box to complete the sentence about genetic engineering.

clones	chromosomes	embryos	genes

GM crops are produced by cutting _____ out of the

_____ of one plant and inserting them into the cells of a crop plant.

(2)

(b) Read the information about GM food crops.

- Herbicide-resistant GM crops produce higher yields.
- Scientists are uncertain about how eating GM food affects our health.
- Insect-resistant GM crops reduce the total use of pesticides.
- GM crops might breed naturally with wild plants.
- Seeds for a GM crop can only be bought from one manufacturer.
- The numbers of bees will fall in areas where GM crops are grown.

Use this information to answer these questions.

(i) Give **two** reasons why some farmers are in favour of growing GM crops.

1. _____

_____

2. _____

_____

(2)

(ii) Give **two** reasons why many people are against the growing of GM crops.

1. _____

_____

2. _____

_____

(2)

(Total 6 marks)

PPQ3

Q3.

The photographs show two breeds of cow.

Friesian cow

By Keith Weller/USDA (www.ars.usda.gov: Image Number K5176-3) [Public domain], via Wikimedia Commons

Jersey cow

By Jamain (Own work) [CC-BY-SA-3.0-2.5-2.0-1.0], via Wikimedia Commons

In parts (a) and (b) draw a ring around the correct answer to complete each sentence.

(a) Cows produce their young (calves) by

asexual reproduction.
cloning.
sexual reproduction.

(1)

(b) Cows and their calves have many similar characteristics.

(i) The information for characteristics is carried by

clones.
embryos.
genes

(1)

(ii) The information for characteristics is passed to the next generation in cells called

body cells.
gametes.
neurones.

(1)

(c) Friesian and Jersey cows can both be used for meat or to produce milk.

The information shows features of Friesian and Jersey cows.

Friesian cows	Jersey cows
Body mass up to 600 kg	Body mass up to 400 kg
Milk contains 3.4% protein	Milk contains 3.8% protein
Can be milked for 325 days after giving birth	Can be milked for 250 days after giving birth
Produce no milk for 55 days before having a calf	Produce no milk for 45 days before having a calf
Produce > 30 litres of milk per day	Produce < 30 litres of milk per day

Use **only** the information above to answer these questions.

In your answers you must make comparisons between the two breeds of cow.

(i) Give **two** advantages of a farmer keeping Friesian cows and **not** Jersey cows.

1. _____

_____

2. _____

_____

(2)

(ii) Give **two** advantages of a farmer keeping Jersey cows and **not** Friesian cows.

1. _____

_____

2. _____

_____

(2)

(d) Cow's milk is different from human milk. Cow's milk should **not** be given to young human babies.

Scientists in China have *genetically engineered* cows to produce human milk. Milk from these cows can be fed to young human babies.

(i) What is *genetic engineering* ?

Tick (✓) **one** box.

Genes from one organism are transferred to a different organism ☐

Cells are separated from an embryo and are transferred to host mothers ☐

The nucleus from a body cell is transferred to an egg cell ☐

(1)

(ii) Some people are worried about using milk from genetically engineered cows, to feed human babies.

Give **one** reason why.

_____

_____

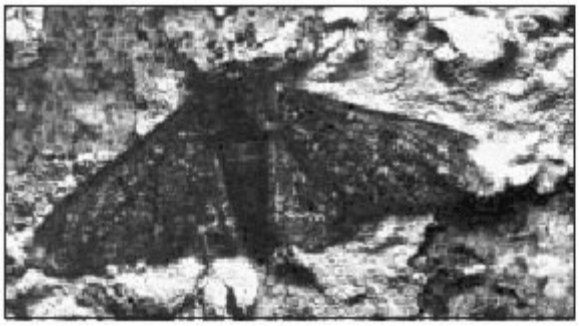
(1)

(Total 9 marks)

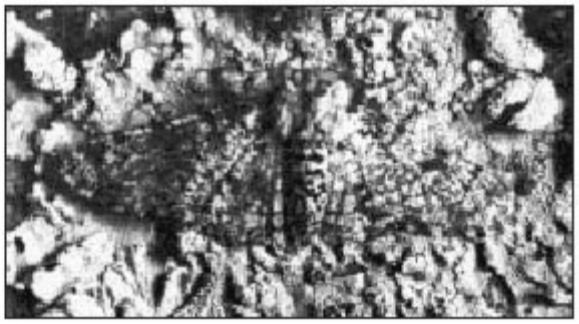
PPQ4

Q4.

The photographs show two varieties of moths, **X**and **Y**. The moths belong to the same species. The moths are resting on a tree trunk in open countryside.



Moth **X**



Moth **Y**

(a) Which variety of moth, **X** or **Y**, is more likely to be killed by insect-eating birds? Give a reason for your answer.

Variety of moth: _____

Reason _____

_____

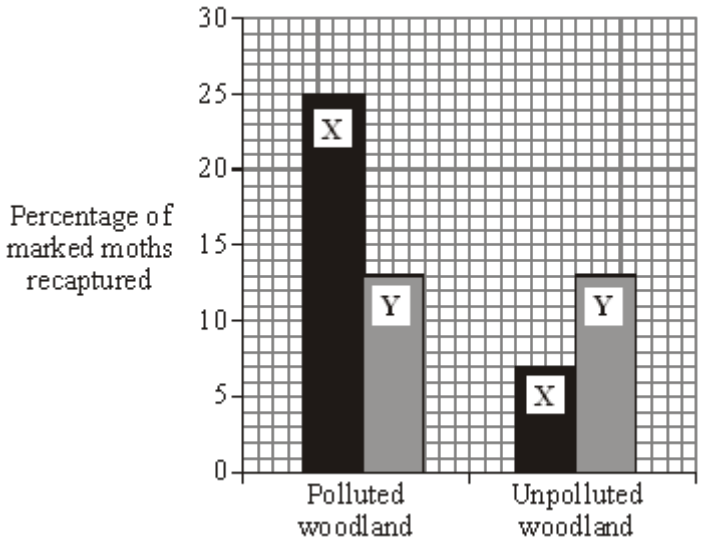
(1)

(b) In an experiment, large numbers of each variety of moth were caught in a trap.

- They were marked with a spot of paint on the underside of one wing and then released.
- A few days later, moths were again trapped and the number of marked moths was counted.
- The experiment was carried out in a woodland polluted by smoke and soot, and also

in an unpolluted woodland.

The results are shown in the bar graph.



(i) When the moths were being marked, suggest why the paint was put on the underside of the wing and not on the top.

_____

(1)

(ii) What percentage of moths of type **X** was recaptured in:

the polluted woodland; _____

the unpolluted woodland? _____

(2)

(iii) In each woodland, only a small number of marked moths of both varieties were recaptured. Suggest **one** reason for this.

_____

_____

(1)

(c) (i) The colour of the moths is controlled by a gene. The dark form was first produced by a mutation in the gene.

What chemical, found in a gene, is changed by a mutation? Draw a ring around your answer.

carbohydrate **DNA** **fat** **protein**

(1)

(ii) Some of the offspring from the original dark moth were also dark. What caused this?

_____

_____

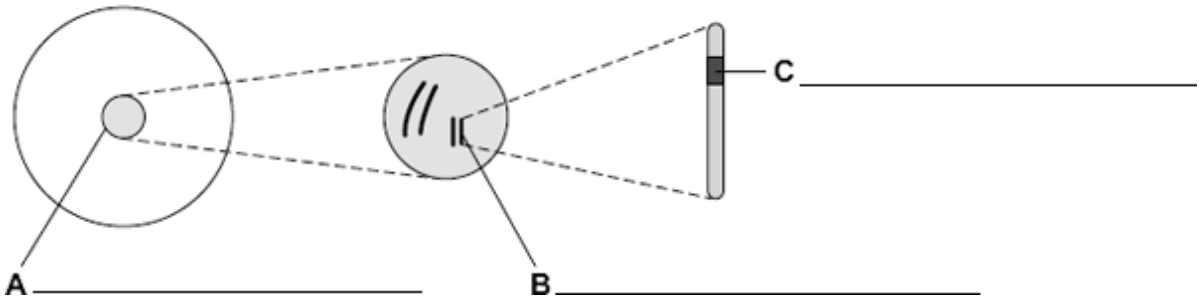
(1)

(Total 7 marks)

PPQ5

Q5. **Diagram 1** shows an animal cell and some of the structures inside the cell.

Diagram 1



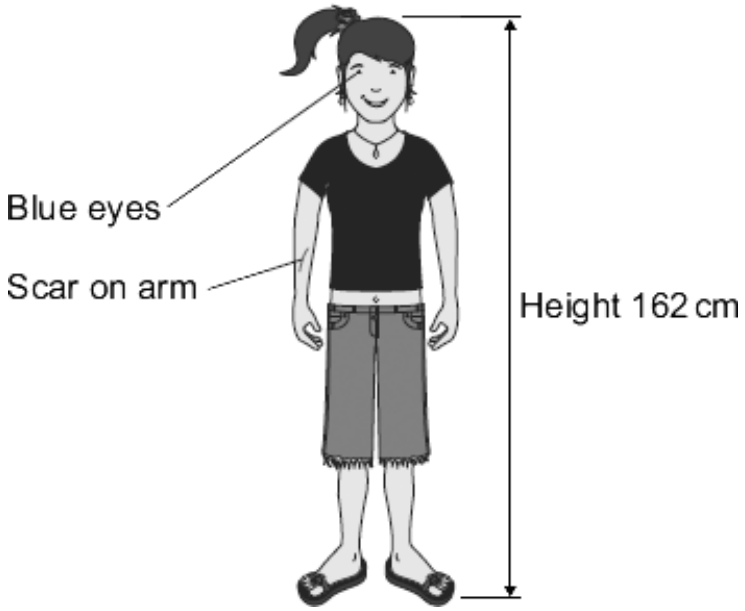
(a) Use words from the box to label structures **A**, **B** and **C**, on **Diagram 1**.

Characteristic	**Chromosome**	**Gamete**	**Gene**	**Nucleus**

(3)

(b) Factors that may affect characteristics include genes and the environment. **Diagram 2** shows some of the characteristics of a girl.

Diagram 2



Draw **one** line from each characteristic in **List A** to the factor(s) that affect the characteristic in **List B**.

List A **Characteristic**	**List B** **Factor(s) that affect the characteristic**
	Affected by genes only
Blue eyes	
	Affected by environment only
Height 162 cm	
	Affected by both genes and the environment
Scar on arm	
	Affected by neither genes nor the environment

(3)

(Total 6 marks)

Standard demand

PPQ6

Q6.

A particular species of snail has a shell which may be pink, yellow or brown. It may also be plain or have bands running round it.

The snails are eaten by song thrushes.

Explain why snails with plain brown shells are the most common in hedgerows.

_____

_____

_____

_____

_____

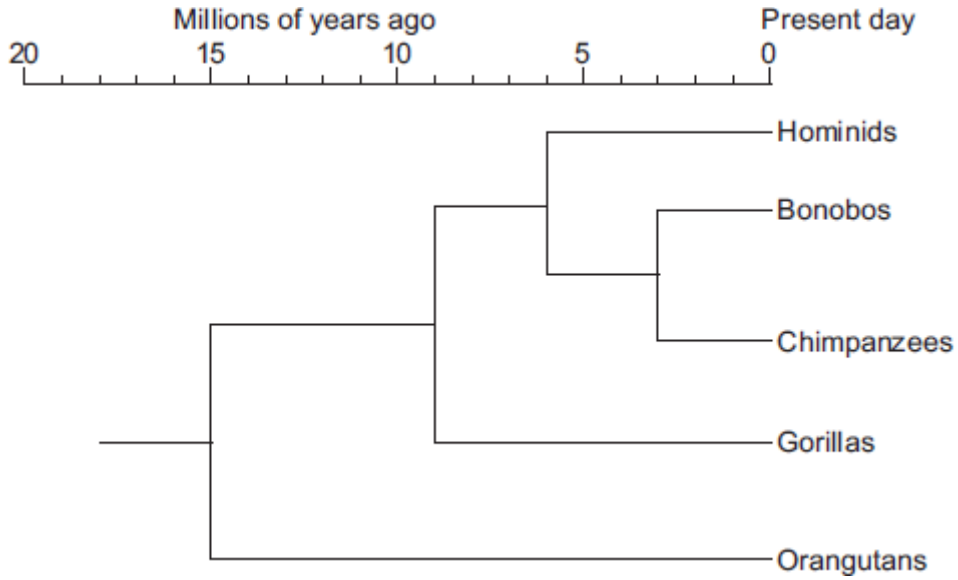
_____

(Total 4 marks)

PPQ7

Q7.

The diagram shows an evolutionary tree for the great apes.



(a) (i) How many years after gorillas did hominids evolve?

_____ millions of years

(1)

(ii) Which animal in the diagram is the most distant relative of chimpanzees?

_____

(1)

(b) Charles Darwin is well known for his theory of evolution.

Complete the sentence.

Darwin's theory states that evolution happens by a process called

_____

(1)

(Total 3 marks)

PPQ8

Q8. (a) Use words from the list to complete the sentences.

alleles **chromosomes** **gametes** **genes** **mutations**

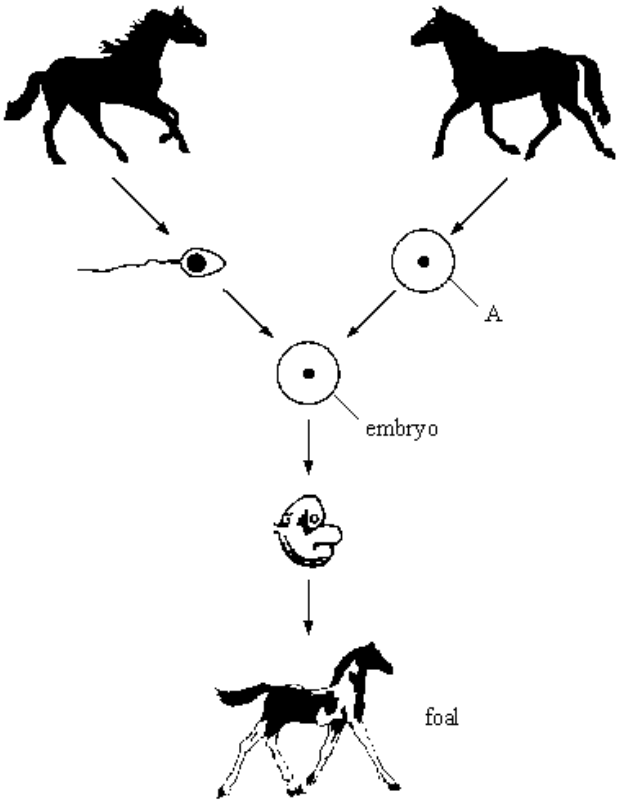
The nucleus of a cell contains thread-like structures called _____ .

The characteristics of a person are controlled by _____

which may exist in different forms called _____ .

(3)

(b) The drawing shows some of the stages of reproduction in horses.



(i) Name this type of reproduction _____

(1)

(ii) Name the type of cell labelled **A** _____

(1)

(c) When the foal grows up it will look similar to its parents but it will **not** be identical to either parent.

(i) Explain why it will look similar to its parents.

_____

_____

(1)

(ii) Explain why it will **not** be identical to either of its parents.

_____

_____

_____

_____

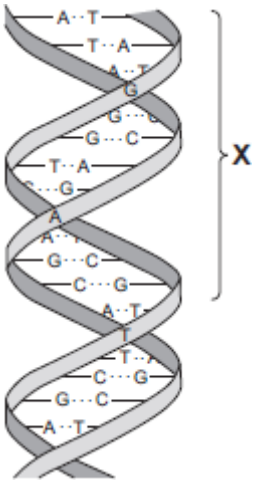
(2)

(Total 8 marks)

PPQ9

Q9.

The diagram shows part of a DNA molecule.



(a) (i) In which part of an animal cell is DNA found?

_____

(1)

(ii) Complete the following sentence.

The letters **A**, **C**, **G** and **T** in the diagram represent four different compounds

called _____ .

(1)

(iii) One strand of the DNA, in the section labelled **X**, contains the following sequence of these compounds:

T A T G G G T C T T C G

How many amino acids would this section of the DNA code for? ☐

(1)

(iv) The section of DNA described in part **(a) (iii)** is a small part of a gene.

The sequence of compounds **A**, **C**, **G** and **T** in the gene is important.

Explain why.

_____

_____

_____

_____ **(2)**

(b) *Read the following information about genetic engineering.*

The caterpillar of the European Corn Borer moth feeds on the fruits of maize (sweet corn). There is a chemical called Bt-toxin which is poisonous to the corn borer caterpillar but not to humans.

Scientists carried out the following steps.

1. The Scientists made a bacterial plasmid to which they added two genes:
   - **Bt** gene, which coded for production of the Bt-toxin
   - **kan^r** gene, which coded for resistance to an antibiotic called kanamycin.

2. They used this plasmid to produce genetically modified bacteria which could invade plant cells.

3. They mixed these genetically modified bacteria with pieces cut from maize leaves.

4. They placed the pieces of maize leaf on agar jelly in a Petri dish. The agar jelly contained the antibiotic, kanamycin. The kanamycin killed most of the pieces of maize leaf, but a few survived.

5. They took some cells from the surviving pieces of maize leaf and grew them in tissue culture.

The result was maize plants that now contained the **Bt** gene, as well as the **kan^r** gene, in all of their cells.

(i) What is a **plasmid** (Step 1)?

_____

_____

_____

_____ **(2)**

(ii) Why did the scientists add **kanamycin** to the agar jelly (Step 4)?

_____

_____

_____

_____ **(2)**

(iii) The scientists grew each Bt-maize plant from a single cell which contained the **Bt** gene.

Explain why **all** the cells in the Bt-maize plant contained the **Bt** gene.

_____

_____

_____

_____

(2)

(iv) Kanamycin is an antibiotic.

Some scientists are concerned that the gene for kanamycin resistance has been put into maize.

Suggest why.

_____

_____

_____

_____

_____

_____

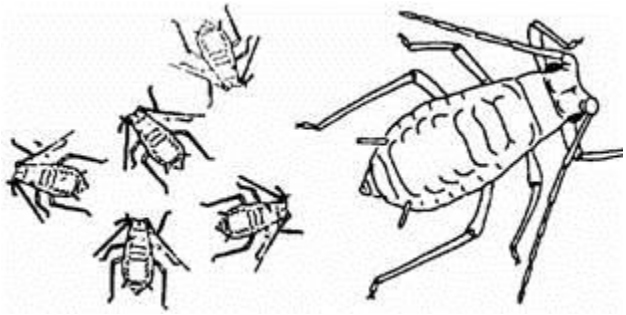
(2)

(Total 13 marks)

PPQ10

Q10.

The bean aphid is a type of black-fly which lives on broad bean plants in summer.
In the autumn, males and females mate and produce eggs.



(a) Name the type of reproduction which produces the eggs.

_____

(1)

(b) In spring these eggs hatch. The young aphids are all female.
Explain why they are all similar but not identical to each other.

_____

(1)

(c) These females are then able to produce offspring without needing any males.

(i) Name the type of reproduction where females do **not** need males to produce offspring.

_____ **(1)**

(ii) How will the offspring from one of these females:

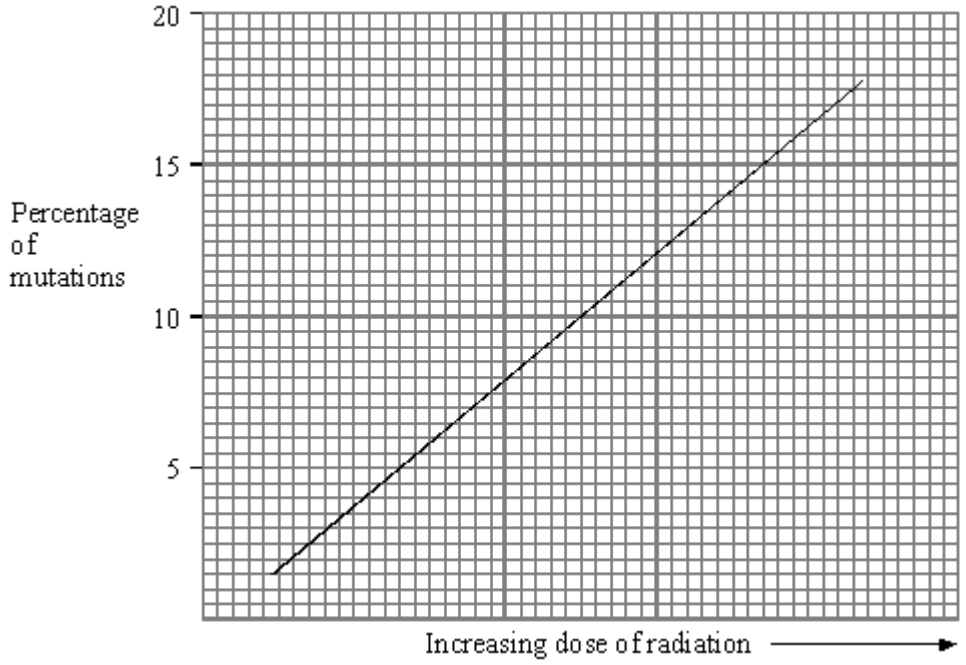
A compare with each other

_____

B compare with the offspring from other females?

_____ **(2)**

(d) Some scientists investigated mutations in these aphids. They exposed the aphids to X-rays.
They plotted their results.



(i) What was the connection between the dose of X-rays and the percentage of mutations?

_____

(1)

(ii) Name **one** other possible cause of mutations.

_____

(1)

(Total 7 marks)

High demand

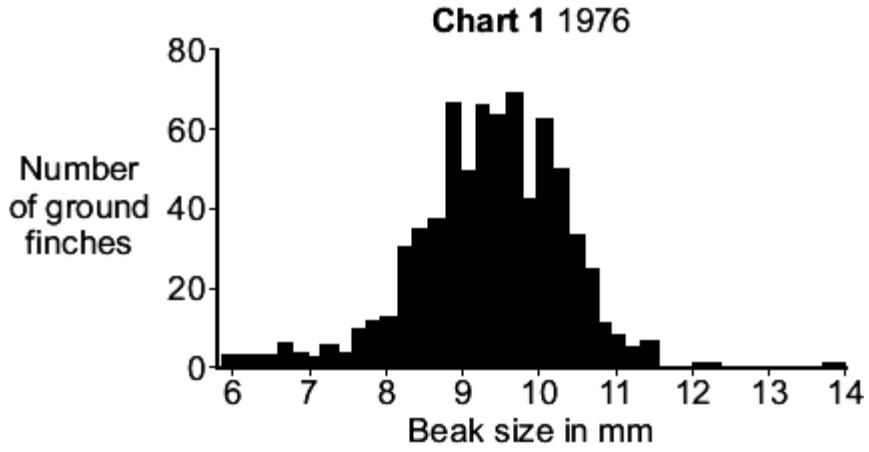
PPQ11

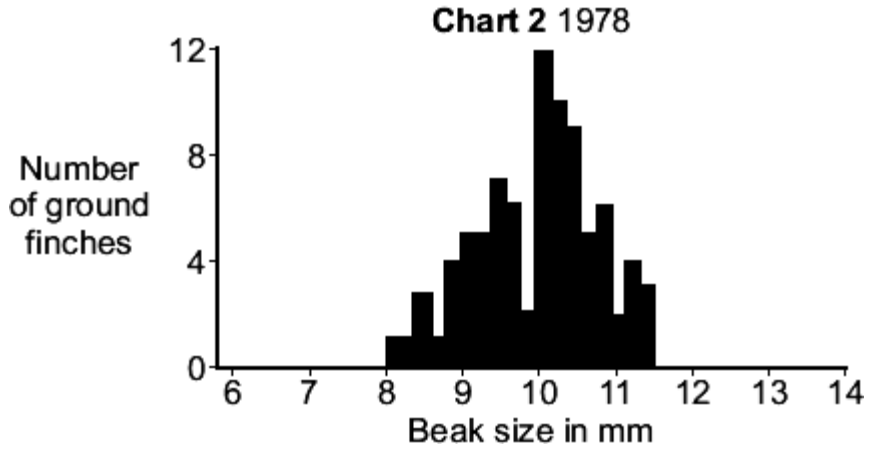
Q11.

The Galapagos Islands are in the Pacific Ocean, 1400 km from South America.
A type of bird called a ground finch lives on the islands.
The picture shows a ground finch.

By Charlesjsharp (Own work) [CC-BY-SA-3.0], via Wikimedia Commons

The size of the seeds the ground finch can eat depends upon the size of the beak.
To eat large seeds, a large beak is needed.
The bar charts show the sizes of the beaks of ground finches on **one** island, in 1976 and in 1978.





(a) The population of the ground finches and their beak sizes changed between 1976 and 1978.

Describe these changes.

_____

_____

_____

_____

_____

_____

(3)

(b) In 1977 there was very little rain on the island. The lack of rain affected the seeds that the finches ate.
The table shows how the seeds were affected.

Year	Mean number of seeds per m^2	Mean mass of each seed in mg
1976	8.5	3.5
1978	2.8	4.2

Suggest an explanation for the changes in beak sizes between 1976 and 1978.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 7 marks)

PPQ12

Q12.

The vole is a small, mouse-like animal. Voles found on some cold islands to the north of Scotland are much larger than voles found in warmer areas such as southern France. Explain how natural selection may have caused the northern voles to be larger in size.

_____

_____

_____

_____

_____

_____

_____

_____

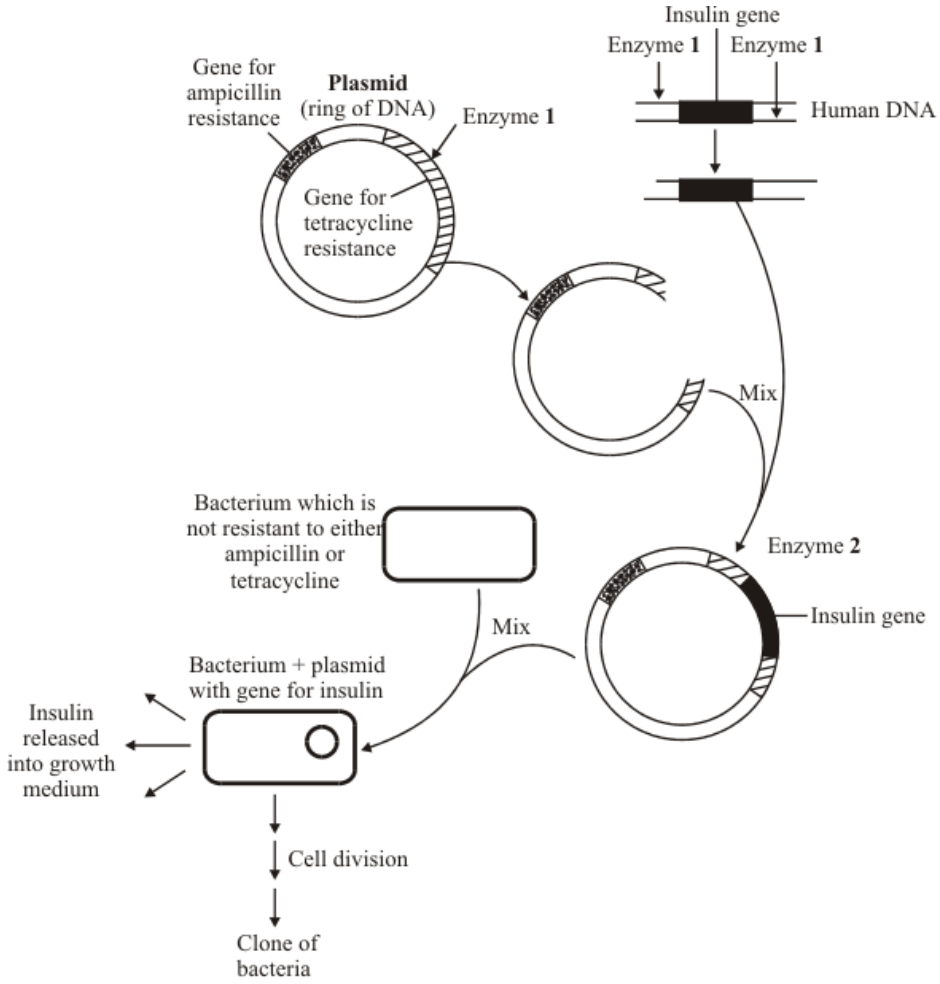
_____

_____

(Total 5 marks)

Q13.

The diagram shows how genetic engineering can be used to produce human insulin from bacteria. Ampicillin and tetracycline are two types of antibiotic. Study the diagram carefully and answer the questions.



In experiments like these, some bacteria take up the plasmid (ring of DNA) containing the insulin gene. Other bacteria fail to take up a plasmid, or they take up an unmodified plasmid (a ring of DNA which has not been cut open and which does not contain the insulin gene).

(a) Complete the table by putting a tick (✓) in the correct boxes to show which bacteria would be able to multiply in the presence of ampicillin and which bacteria would be able to multiply in the presence of tetracycline.

	Bacterium can multiply in the presence of	
	Ampicillin	**Tetracycline**
Bacterium + plasmid with the insulin gene		
Bacterium without a plasmid		
Bacterium with an unmodified plasmid		

(3)

(b) The bacterium with the plasmid containing the insulin gene multiplies by cell division to form a clone of bacteria.

Will **all** the bacteria in this clone be able to produce insulin? Explain your answer.

_____

_____

_____

_____

_____

_____

(3)

(Total 6 marks)

PPQ14

Q14. The Blue-moon butterfly lives on a small island called Samoa, in the Pacific Ocean.

In 2006 Blue-moon butterflies almost became extinct.

Wolbachia bacteria killed males before they could hatch from eggs. Only females were resistant to the bacteria.

In 2006 the number of male Blue-moon butterflies had decreased to only 1 per cent of the population. Two years later, the number of males was equal to the number of females.

(a) Scientists believe that a change in a gene suddenly occurred to make some males resistant to the bacteria.

What scientific term describes a change in a gene?

_____ **(1)**

(b) The numbers of male Blue-moon butterflies in the population increased quickly after the new form of the gene had appeared.

Suggest why.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 5 marks)

PPQ15

Q15.

The drawings show two different species of butterfly.

Amauris

Hypolimnas

- Both species can be eaten by most birds.
- *Amauris* has an unpleasant taste which birds do **not** like, so birds have learned **not** to prey on it.
- *Hypolimnas* does **not** have an unpleasant taste but most birds do **not** prey on it.

(a) Suggest why most birds do **not** prey on *Hypolimnas*.

_____

_____

_____

_____

(2)

(b) Suggest an explanation, in terms of natural selection, for the markings on the wings of *Hypolimnas*.

_____

_____

_____

_____

_____

_____

(3)

(Total 5 marks)

PPQ16

Q16.

Scientists have recently cloned a mouse that had died and been frozen for 16 years.

(a) Explain what is meant by a clone.

_____

_____

_____

_____

(2)

(b) The scientists used an egg cell from a living mouse and the genetic material from a brain cell of the frozen mouse.

Describe how the process of adult cell cloning could be used to clone the frozen mouse.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(c) People could ask scientists to use this technique to clone long-dead relatives, whose bodies have been deep-frozen.

Most people would be opposed to cloning a human from a deep-frozen, long-dead relative.

Give **one** reason why.

_____

_____

(1)

(Total 6 marks)

PPQ17

Q17. The use of cloned animals in food production is controversial. It is now possible to clone 'champion' cows. Champion cows produce large quantities of milk.

(a) Describe how adult cell cloning could be used to produce a clone of a 'champion' cow.

(4)

(b) Read the passage about cloning cattle.

> The Government has been accused of 'inexcusable behaviour' because a calf of a cloned American 'champion' cow has been born on a British farm. Campaigners say it will undermine trust in British food because the cloned cow's milk could enter the human food chain.
>
> But supporters of cloning say that milk from clones and their offspring is as safe as the milk we drink every day.
>
> Those in favour of cloning say that an animal clone is a genetic copy. It is not the same as a genetically engineered animal. Opponents of cloning say that consumers will be uneasy about drinking milk from cloned animals.

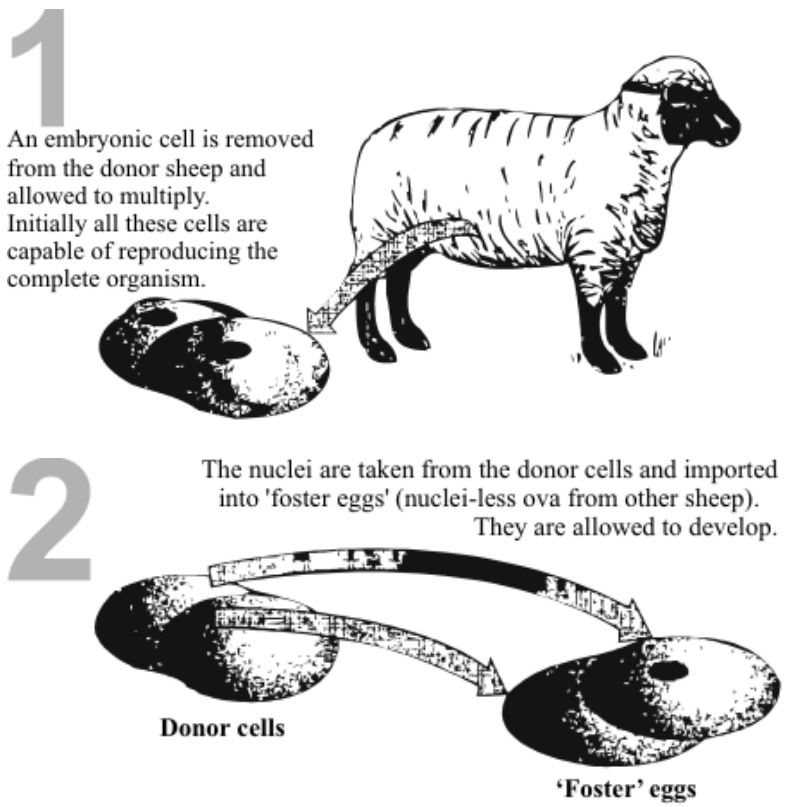
Use the information in the passage and your own knowledge and understanding to evaluate whether the government should allow the production of milk from cloned 'champion' cows. Remember to give a conclusion to your evaluation.

(5)

(Total 9 marks)

PPQ18

Q18. The diagram shows one method of cloning sheep.



(a) Explain why the lambs produced by this technique are identical to each other.

_____

_____

_____

_____ **(2)**

(b) Explain why the lambs are **not** genetically identical to the sheep which produced the 'foster' eggs.

_____

_____

_____

_____ **(2)**

(c) Explain the drawback of widespread use of just a few clones of sheep.

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

4.6.2 Variation and Evolution PPQ Answers

Low demand

PPQ MS1

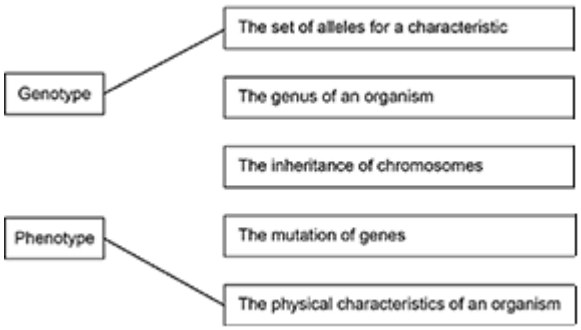
Q1.

(a)

Characteristic	Environmental	Genetic	Both
Eye colour		✔	
A scar	✔		
Weight			✔

3

(b) **Key term** **Definition**



extra lines from the left negate the mark

2

(c)

Stage in selective breeding	Order of stage
Cows are bred over many generations	4
Parents are bred together	2
Cows with the desired characteristics are chosen	1
Calves with the most desired characteristics are bred together	3

*all 3 correct for **2** marks*
*1 or 2 correct for **1** mark*

max. 2

(d) beef / meat

allow hardiness, disease resistance

1

milk yield

1

(e) higher veterinary costs

1

less income from sale of (milk and meat) products

1

[11]

PPQ MS2

Q2.

(a) genes

1

chromosomes

1

(b) (i) higher yield

1

less use of pesticides

1

(ii) any **two** from:

- uncertain about effects on health
- fewer bees
- might breed with wild plant
- seeds only from one manufacturer

2

[6]

PPQ MS3

Q3.

(a) sexual reproduction

1

(b) (i) genes

1

(ii) gametes

1

(c) (i) any **two** from:

answers must be comparative

- more meat (per cow)
  ignore bigger unqualified
- more milk each day
- can be milked for more time after giving birth / greater proportion of time
  *accept '(produce) more milk', for **1** mark, if neither more milk each day nor can be milked for more time after giving birth are given*

2

(ii) (milk contains) more protein

answers must be comparative

1

less time before having a calf when no milk produced

1

(d) (i) genes from one organism are transferred to a different organism

1

(ii) (possible) harm to babies' long term health

allow don't know long-term / side effects (on baby)

accept idea that there may be other things in (genetically engineered) cow's milk that might harm babies' health e.g. bacteria

ignore ethical / religious arguments

1

[9]

PPQ MS4

Q4.

(a) **X** (no mark)

X is more visible **or Y** is more camouflaged

1

(b) (i) so camouflage not changed **or** so not easier to see

1

(ii) 25

1

7

1

(iii) any **one** from:

- eaten (by birds) / died
- mixed in with large number of unmarked moths
- moved away

1

(c) (i) DNA

1

(ii) the gene / allele for being dark / dominant

1

[7]

PPQ MS5

Q5.

(a) A – nucleus

1

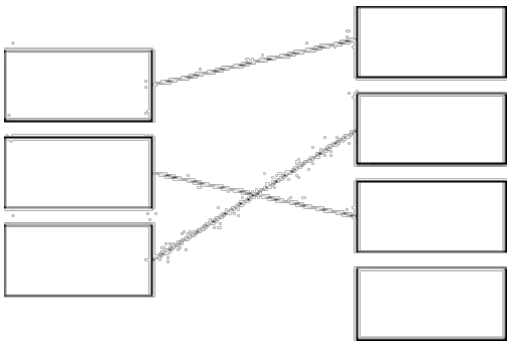
B – chromosome

1

C – gene

1

(b)



extra line from statement cancels the mark

3

[6]

Standard demand

PPQ MS6

Q6.

idea brown colour/plain shell inconspicuous
for 1 mark

less likely to be eaten
gains 1 mark

but
less likely to be eaten before breeding
gains 2 marks

so alleles (genes) passed on
for 1 mark
(N.B accept inverse of any of the above)

[4]

PPQ MS7

Q7.

(a) (i) 3 (millions of years)

1

(ii) orangutans

1

(b) natural selection
ignore survival of the fittest

1

[3]

PPQ MS8

Q8.

(a) chromosomes
genes (*reject* alleles)
alleles
for 1 mark each

3

(b) (i) sexual / sex
for one mark

1

(ii) egg / gamete / sex cell / ovum (*reject* ovule)
for one mark

1

(c) (i) information / genes / DNA passed from parents (*reject* chromosomes)
for one mark

1

(ii) genes / genetic information / chromosomes from two parents

alleles may be different
environmental effect / named may have been mutation
any two for 1 mark each

2

[8]

PPQ MS9

Q9.

(a) (i) nucleus
correct spelling only
accept mitochondrion
ignore genes / genetic material / chromosomes

1

(ii) base(s)
Accept all four correct names of bases
ignore nucleotides and refs to organic / N-containing

1

(iii) 4

1

(iv) codes for sequence / order of amino acids
ignore references to characteristics

1

codes for a (specific) protein / enzyme

or

the sequence / order of three bases / compounds / letters

codes for a specific amino acid

or

the sequence / order of 3 bases / compounds / letters

codes for the order / sequence of amino acids

1

(b) (i) DNA

1

circular / a ring **or** a vector / described

1

(ii) kills any cells not having **kan^r** gene / so only cells with **kan^r** gene survive

1

hence surviving cells will also contain **Bt** gene / plasmid

1

(iii) cells divide by mitosis
ignore ref to asexual reproduction
correct spelling only

1

genetic information is copied / each cell receives a copy of (all) the gene(s) /

all cells produced are genetically identical / form a clone

1

(iv) any **two** from:

- gene may be passed to pathogenic bacteria
- cannot then kill these pathogens with kanamycin
  or
  cannot treat disease with kanamycin
- may need to develop new antibiotics
- gene may get into other organisms
- outcome unpredictable

2

[13]

PPQ MS10

Q10.

(a) sexual / sex

for 1 mark

1

(b) *idea that*
sexual reproduction brings about a mixture of genes
or similar / different genes / parents / gametes / DNA /
characteristics / chromosomes (*not* features)

for 1 mark

1

(c) (i) asexual / cloning (*allow* vegetative)

for 1 mark

1

(ii) (A) *idea that* (they are exactly the same). *Do not allow*
similar or just <u>one</u> named feature.

for 1 mark

2

(B) different (*allow* similar but *do not allow* same).
Allow any one named difference

for 1 mark

(d) (i) greater the X-ray dose, greater the % of mutations
or % of mutations increases steadily / in proportion to X-ray dose

for 1 mark

1

(ii) ionising radiations / ultra-violet light / alpha particles / beta particles
/ gamma rays / radio activity / chemicals / drugs / smoking / natural
in meiosis / spontaneous / cell replication / toxic waste / pollution

1

Accept radioactivity but not radiations alone.

for 1 mark

[7]

High demand

PPQ MS11

Q11.

(a) in 1978
fewer finches **or** population smaller

1

any **two** from:

- no beaks less than 8mm
- no beaks greater than 11.5 / 12mm
  *if these points not given allow smaller range of beak sizes for **1** mark*
- mean / average beak size higher

2

(b) variation or range or mutation of beak sizes
*do **not** accept idea that drought / seed size caused mutation*

1

birds with larg(er) beaks are better adapted for feeding
accept idea of competition for food / seeds amongst finches

1

birds with larg(er) beaks survive
accept (only / more) birds with large beaks were better competitors

1

birds with larg(er) beaks breed **or** gene / allele for large beak passed on
*do **not** accept large beak passed on*

1

[7]

PPQ MS12

Q12.

any **five** from:

- genetic variation exists in a population **or**
  variation caused by mutation / change in gene / in DNA
- larger voles have smaller $\frac{\text{S.A.}}{\text{Vol.}}$
  or have more fat
  'they' accept as larger voles
- larger voles lose less heat / are better insulated **or** more energy stored
- larger voles survive
- larger voles breed
- larger voles pass on (beneficial) gene / allele / mutation / DNA

ignore characteristic

[5]

PPQ MS13

Q13.

(a)

Ampicillin	Tetracycline
✓	–
–	–
✓	✓

*accept blank **or** cross **or** –*
*1 st: mark by rows to maximum **3** marks*
*2 nd: if no marks by rows, mark by columns to maximum **1** mark*
*table completely blank = **0** marks*

3

(b) 1st: Yes (no mark)
*if 'no' - read on for logical argument e.g. loss of plasmid **or** gene mutation*

2nd: all formed from same original cell
must be one cell i.e. bacterium

1

by asexual reproduction / no fusion / not sexual
allow reference to 'mitosis'

1

offspring cells are genetically identical **or**
all have a copy of the insulin gene / of the plasmid

1

[6]

PPQ MS14

Q14.

(a) mutation
correct spelling only
ignore other adjectives eg random / spontaneous

1

(b) *ignore references to X / Y chromosomes*

idea of mutant gene / new form / this allows hatching (of males)

1

(individual with advantage) (more) survive / (more) live / (more) don't die
allow immunity rather than resistance throughout

1

(so survivors) breed / reproduce

1

mutation / gene passed (from survivors) to offspring / next generation

allow resistance / characteristic for gene
'gene passed on' is insufficient

1

[5]

PPQ MS15

Q15.

(a) wing pattern similar to *Amauris*

allow looks similar to Amauris

1

birds assume it will have an unpleasant taste

1

(b) mutation / variation produced wing pattern similar to *Amauris*

*do **not** accept breeds with Amauris*
*do **not** accept idea of intentional adaptation*

1

these butterflies not eaten (by birds)

1

these butterflies breed **or** their genes are passed to the next generation

1

PPQ MS16

Q16.

(a) genetically identical / same DNA / same chromosomes

gains 2 marks
*accept identical without reference to genetic material for **1** mark*

2

(b) remove nucleus from egg

allow use empty egg cell

1

insert genetic material / nucleus /DNA / chromosomes from frozen mouse

*do **not** allow if reference to sperm*

1

electric shock **or** allow to divide **or** insert into womb / uterus

1

(c) ethical / religious / emotional reasons

or

not known if it is safe / long term effects not known

ignore playing God / unnatural / immoral

1

[6]

Q17.

(a) any **four** from:

- nucleus / DNA / chromosomes / genetic material removed (from egg)
- from (unfertilised) egg / ovum
  *linked to second point allow 'empty egg cell' for first **two** marks*
  *do **not** allow fertilised egg allow egg from champion cow*
- nucleus from body cell of champion (cow)
- inserted into egg / ovum
- electric shock
- to make cell divide **or** develop into embryo
- (embryo) inserted into womb / host / another cow
  allow this point if wrong method eg embryo splitting

4

(b) any **four** from:

Pros: Max 3 marks

- economic benefit eg increased yield / more profit
- clone calf not genetically engineered
- genetic material not altered
- milk safe to drink / same as ordinary milk

Cons: Max 3 marks

- consumer resistance
- caused by misunderstanding process
- not proved that milk is safe
  *ignore 'God would not like it' **or** 'it's not natural'*
- ethical / religious argument
- reduce gene pool / eg

4

Conclusion:

sensible conclusion for or against, substantiated by information from the passage and / or own knowledge
conclusion at end

1

[9]

Q18.

(a) contain the same genes, because they are formed by division of identical nucleus

for 1 mark each

2

(b) genes located in nucleus, nucleus comes from donor cells

for 1 mark each

2

(c) number of alleles in population reduced, therefore less chance of successfully breeding, to cope with changed conditions

for 1 mark each

3

[7]

4.6.3 The development of understanding of genetics and evolution Knowledge

4.6.3.1 Theory of evolution (biology only)

The idea behind the theory of evolution through the process of natural selection is that all species of living things have evolved from simple life forms over a period of time. The Earth is about 4.5 billion years old and there is scientific evidence to suggest that life on Earth began more than three billion years ago.

The accepted theory of **evolution** explains that it happens by natural selection. The key points are:

- Individuals in a species show a wide range of variation and this variation is because of differences in their genes.
- Individuals with characteristics most suited to their environment are more likely to survive and reproduce. This is commonly known as 'survival of the fittest'. The genes that allow these individuals to be successful within their environment are passed on to their offspring, which results in these specific genes becoming more common.
- Those that are poorly adapted to their environment are less likely to survive and reproduce. Their genes are less likely to be passed on to the next generation.
- Over a period of time, a species will gradually evolve.
- Both genes and the environment can cause variation, but only genetic variation can be passed on to the next generation.
- If two populations of one species become increasingly different in phenotype that they can no longer interbreed to form fertile offspring, this can result in the formation of two species.

A simple example can be seen in peacocks:

- females choose a mate based on their colourful tail feathers
- the more colourful the tail of a peacock, the more likely they are to mate and pass on these genes
- over time, the tails of peacocks have become more colourful

Charles Darwin is recognised as the scientist most associated with the theory of evolution, however, a number of other scientists were influential in this field.

Lamarck's theory

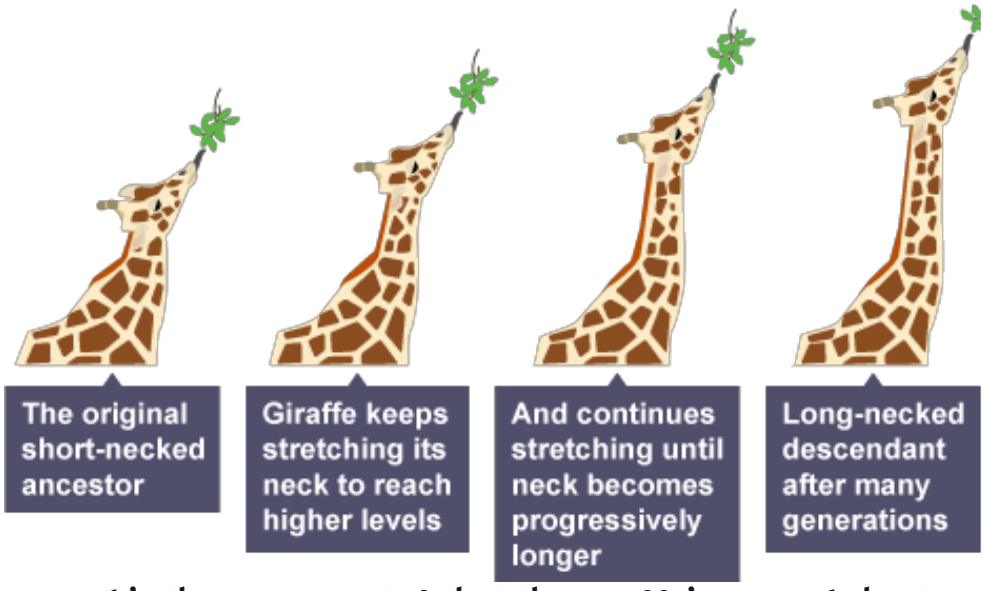
At the beginning of the 19th century Jean-Baptiste Lamarck was a French scientist who developed an alternative theory of **evolution** before Charles Darwin.

Lamarck's theory involved two ideas:

- a characteristic which is used more and more by an organism becomes **bigger and stronger**, and one that is not used eventually **disappears**
- any feature of an organism that is improved through use is **passed to its offspring**

However, through modern science we now know that in the vast majority of cases this type of inheritance cannot occur.

Lamarck's theory cannot account for all the observations made about life on Earth. For instance, his theory implies that all organisms would gradually become complex, and simple organisms disappear.



Lamarck's theory suggested that the giraffe's original short-necked ancestor repeatedly stretched its neck to reach the higher branches to eat. Lamarck believed that the stretching elongated the giraffe's neck, which became a useful characteristic and was passed onto future generations. This resulted in the length of the giraffe's neck increasing over time.

It is now commonly accepted that Lamarck's ideas were wrong. For example, simple organisms are still detected in all varieties of life, plus it is now known that mutations can create variation such as neck length.

Darwin's theory of evolution

Charles Darwin was an English naturalist who studied variation in plants, animals and fossils during a five-year voyage around the world in the 19th century. Darwin visited four continents on the ship HMS Beagle.

Darwin observed many organisms including finches, tortoises and mocking birds, during his five week visit to the **Galapágos Islands**, near Ecuador in the Pacific Ocean. He continued to work and develop his ideas once he returned from his voyages.
Darwin's theory of evolution challenged the idea that God made all the animals and plants that live on Earth, which contradicted the commonly held Christian views of his era. He did not publish his scientific work and ideas until 28 years after his voyage.
Finally, as a result of Darwin's world expedition and observations, which were backed by many years of experimentation; his discussions with like-minded scientists and his developing knowledge of geology and fossils; he proposed the theory of evolution by natural selection.
Darwin proposed that:

- individual organisms within a particular species show a wide range of variation for a characteristic
- individuals with characteristics most suited to the environment are more likely to survive to breed successfully
- the characteristics that have enabled these individuals to survive are then passed on to the next generation

This theory is called natural selection.

Darwin ideas were documented in the book *On the Origin of Species*, which was published in 1859. The naturalist's ideas created controversy in Victorian society.

The theory of evolution through the process of natural selection was only gradually accepted because:

- the theory challenged the idea that God made all animals and plants that live on Earth (creationism)
- there was insufficient evidence when the theory was published to convince many scientists
- the mechanism of inheritance and variation was not known until 50 years after the theory was published

Some scientists were reluctant to change their minds about the ideas of creationism, even when new evidence was discovered that contradicted their ideas.

Darwin's book, *On the Origin of Species*, was a world best seller and is still in print today. With every new edition of his book, more evidence was discovered to support Darwin's ideas. This led to the development of his theory over time. In a later edition, he introduced the famous term 'Survival of the fittest'.

4.6.3.2 Speciation (biology only)

Darwin and Wallace

Alfred Russel Wallace was a great admirer of Darwin and a fellow naturalist, who independently proposed the theory of evolution by natural selection. Wallace produced scientific journals with Darwin in 1858, which prompted Darwin to publish On the Origin of Species the following year.

Wallace worked around the world gathering evidence to support his evolutionary theory. He is best known for studying warning colouration in animals, and examples include the Golden Birdwing Butterfly *(Ornithoptera croesus)* and his theory of **speciation**.
After a variety of zoological discoveries Wallace proposed a theory of evolution, which matched Darwin's unpublished ideas that he had kept secret for nearly 20 years. This encouraged Darwin to collect his scientific ideas and collaborate with Wallace. They published their scientific ideas jointly in 1858.

Alfred Russel Wallace created pioneering work in speciation; however, additional evidence over time has led to our current understanding of the theory of **speciation**.
A **species** is a group of organisms able to interbreed and produce fertile offspring.
New species can arise as a result of the following things:

- **genetic variation** - each population has a wide range of **alleles** that can control their characteristics
- **natural selection** - the alleles which help an **organism** to survive are selected in each population
- **speciation** - the populations become extremely varied and successful interbreeding cannot happen anymore

New species can also arise as a result of **isolation**:

two populations of a species can become geographically separated because of the environment

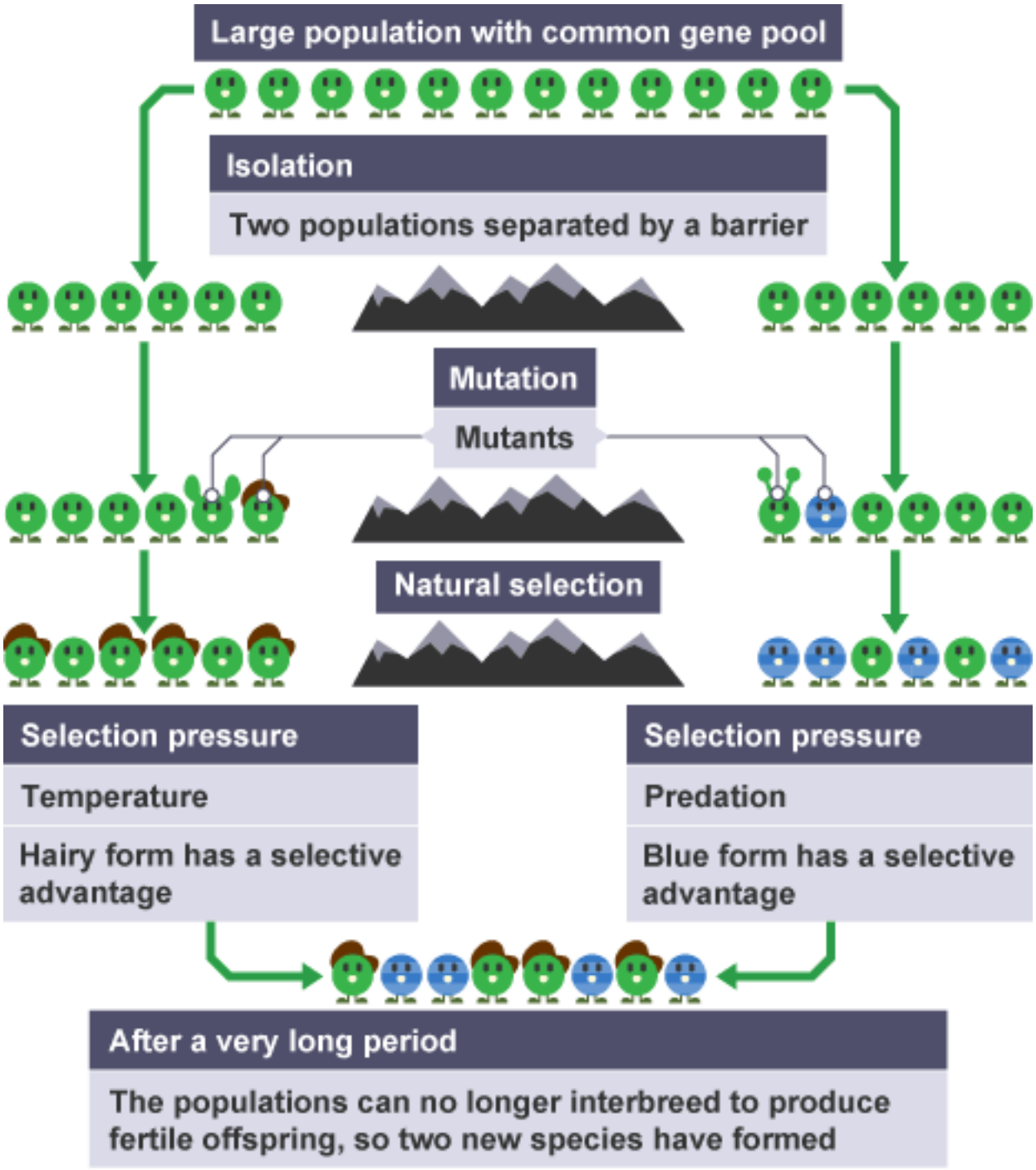
isolation can prevent interbreeding and the combination of genes within a species

different mutations can take place in the isolated groups and create different

phenotypes within a particular location

over time species may evolve to be different to each other, and they will not be able to interbreed

The diagram illustrates what could happen to an animal population, which is separated into two isolated groups by a geographical feature, such as a mountain or river.



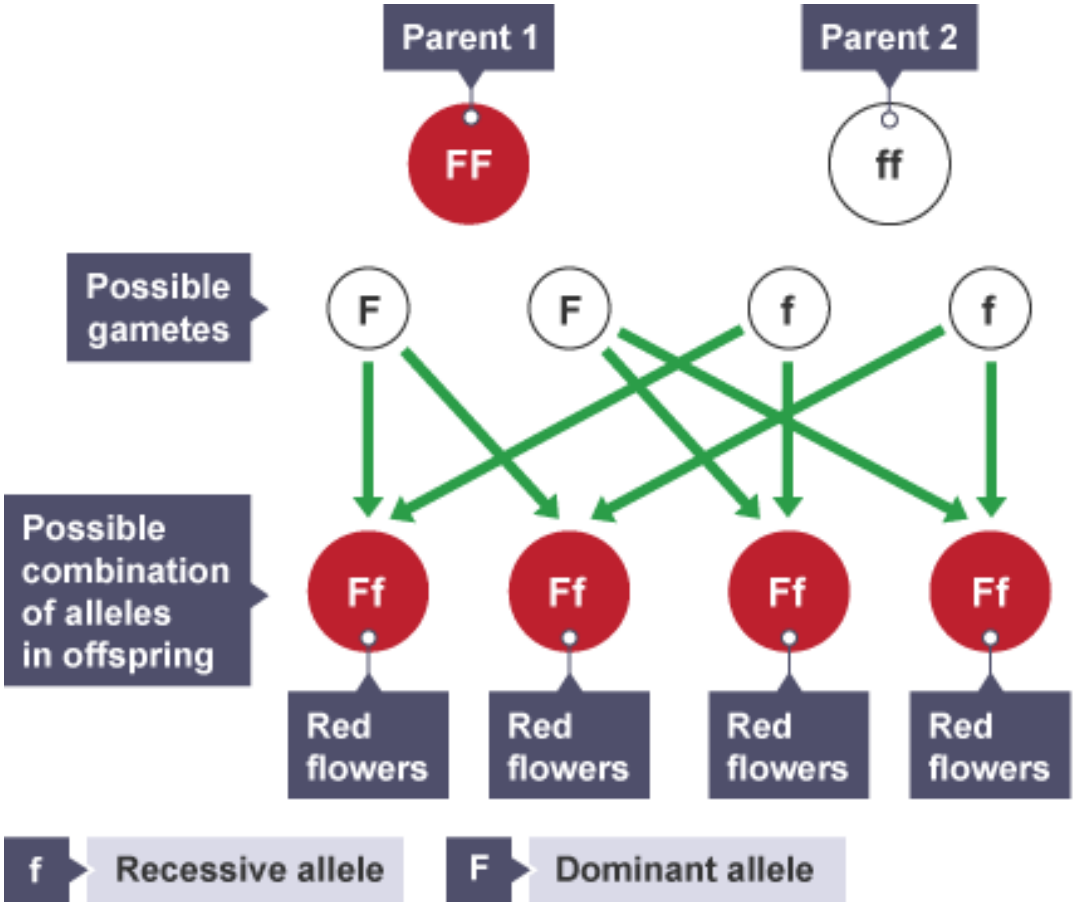
Charles Darwin described the speciation of finches after his studies of the birds on the Galapágos Islands, which are a group of islands roughly 1,000 km off the coast of Ecuador. Darwin noticed that the finches on the different islands were similar to each other.

However, Darwin's studies revealed that the finches had wide variations in their size, beaks and claws from island to island. The finches' beaks differed depending on the local food source. Darwin concluded that because the islands were distant from the mainland, the finches that had arrived there had changed over time.

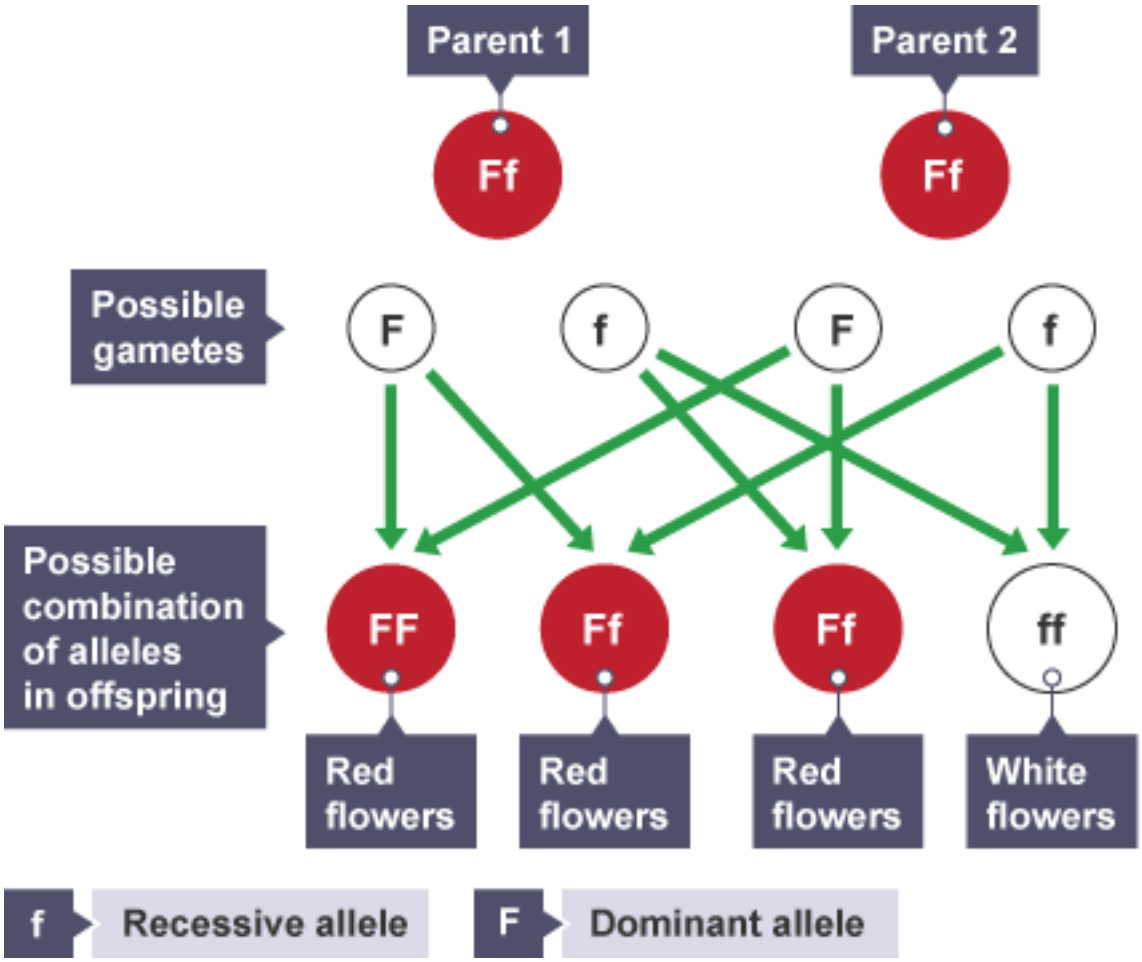
4.6.3.3 The understanding of genetics (biology only)

In the mid-19th century Gregor Mendel (1822-1884) studied the inheritance of different characteristics in pea plants. He found that when he bred red-flowered plants with white-flowered plants, all the offspring produced red flowers. If he bred these plants with each other, most of the offspring had red flowers, but some had white. This was because the allele for red flowers is **dominant**, and the allele for white flowers is **recessive**. One of Mendel's observations was that the inheritance of each characteristic is determined by 'units' that are passed on to descendants unchanged.

The genetic diagram shows all of the possible alleles for a particular characteristic. Dominant alleles are capital letters, while the recessive alleles are lower-case letters.



This genetic diagram shows the outcome of Mendel's first cross. All the offspring have red flowers (100%), even though they are heterozygotes and carry the recessive allele for white flowers (Ff).



Three-quarters (75%) of the offspring have red flowers (FF and Ff) and a quarter (25%) have white flowers (ff).

It can be shown as:

FF : Ff : ff

1 : 2 : 1

Mendel's work expanded the knowledge of genetic inheritance before DNA had even been discovered. Mendel's work was not accepted by most scientists when he was alive for three main reasons:

- when he presented his work to other scientists he did not communicate it well so they did not really understand it
- it was published in a scientific journal that was not well known so not many people read it
- he could not explain the science behind why characteristics were inherited

The idea that genes were located on chromosomes emerged in the late 19th century when better microscopes and staining techniques allowed the visualization and behaviour of chromosomes during cell division.

In the early 20th century, it was observed that chromosomes and Mendel's 'units' behaved in similar ways. This led to the theory that the 'units', now called genes, were located on chromosomes.

In the mid-20th century two scientists, James Watson and Francis Crick worked out the structure of DNA. By using data from other scientists Rosalind Franklin and Maurice Wilkins, they were able to build a model of DNA. They showed that bases occurred in pairs, and x-ray data showed that there were two chains wound into a double helix. This model was used to work out how genes code for proteins.
Many years of work from different scientists' focusing on DNA, chromosomes and genes, has led us to the possibility of treating genetic conditions using gene therapy.

4.6.3.4 Evidence for evolution

The idea behind the theory of evolution through the process of natural selection is that all species of living things have evolved from simple life forms over a period of time. The Earth is about 4.5 billion years old and there is scientific evidence to suggest that life on Earth began more than three billion years ago.

The accepted theory of **evolution** explains that it happens by natural selection. The key points are:

- Individuals in a species show a wide range of variation and this variation is because of differences in their genes.
- Individuals with characteristics most suited to their environment are more likely to survive and reproduce. This is commonly known as 'survival of the fittest'. The genes that allow these individuals to be successful within their environment are passed on to their offspring, which results in these specific genes becoming more common.
- Those that are poorly adapted to their environment are less likely to survive and reproduce. Their genes are less likely to be passed on to the next generation.
- Over a period of time, a species will gradually evolve.
- Both genes and the environment can cause variation, but only genetic variation can be passed on to the next generation.
- If two populations of one species become increasingly different in phenotype that they can no longer interbreed to form fertile offspring, this can result in the formation of two species.

A simple example can be seen in peacocks:

- females choose a mate based on their colourful tail feathers
- the more colourful the tail of a peacock, the more likely they are to mate and pass on these genes
- over time, the tails of peacocks have become more colourful

4.6.3.5 Fossils

A **fossil** is the preserved remains of a dead organism from millions of years ago. Fossils are found in rocks and can be formed from:

- hard body parts, such as **bones and shells**, which do not decay easily or are replaced by minerals as they decay
- parts of organisms that have not decayed because one or more of the conditions needed for decay are absent. For example, **dead animals and plants** can be preserved in amber, peat bogs, tar pits, or in ice
- preserved traces of organisms, such as **footprints**, **burrows**and rootlet traces - these become covered by layers of sediment, which eventually become rock

The fossil record

Fossil remains have been found in rocks of all ages. Fossils of the simplest organisms are found in the oldest rocks, and fossils of more complex organisms in the newest rocks. This supports **Darwin's theory of evolution**, which states that simple life forms gradually evolved into more complex ones.

Evidence for early forms of life comes from fossils. By studying fossils, scientists can learn how much (or how little) organisms have changed as life developed on Earth.
There are gaps in the fossil record because many early forms of life were soft-bodied, which means that they have left few traces behind. What traces there were may have been destroyed by geological activity. This is why scientists cannot be certain about how life began.
Fossils provide a snap shot of the past and allow us to study how much or how little organisms have changed as life developed on Earth.

Evolutionary trees

Evolutionary trees are used to represent the relationships between organisms. Branches show places where speciation has occurred, and a new species has evolved.

Under certain conditions fossils might not have been created. Parts of organisms do not always decay because the conditions needed might be absent, and so they may be preserved in different ways. For example, **dead animals and plants** can be preserved in amber, peat bogs, tar pits, or in ice.
Amber is a substance that is formed from hardened tree sap or resin. This allows the whole organism to be seen clearly.

Britain's most famous peat bog body is known as the Lindow man. The acidic, oxygen-free conditions in the peat bog meant that the man's skin, hair and many of his internal organs were extremely well preserved, which is very unusual, as this does not occur with rock fossils. As more the of the Lindow man's DNA is preserved, it enables scientists to learn more about that era and how we may have evolved from the time that the man was alive. Another well-known example of a body preserved in ice is Oetzi. He was a mummified ancient man found in 1991, near the Austrian Italian border. Detailed analysis of his body indicated that he was approximately 5,000-years-old. His body has been extensively examined, including his gut bacteria and pollen contained on some clothes.

4.6.3.6 Extinction

Extinction occurs when there are no remaining individuals of a species alive.
Animals that have not adapted well to their environment are less likely to survive and reproduce than those that are well adapted. The animals that have not adapted to their environment may become extinct. Extinction has a role in evolution as some species disappear. Others survive and continue to evolve.

Several factors can cause a species to become extinct. They include:

- new diseases
- new predators
- new, more successful competitors
- changes to the environment over geological time, such as climate change
- a single catastrophic event, such as a massive volcanic eruption or a collision between an asteroid and the Earth

A species may also become extinct through speciation.

The fossil record shows that many species have become extinct since life on Earth began. Extinction is still happening and often, it is due to human activities. Humans compete with other living organisms for space, food and water - humans are very successful predators.

The dodo was a heavily-built flightless bird, roughly the size of a swan. It became extinct following the introduction of new predators by people.
Dodos lived on Mauritius, an island in the Indian Ocean. The island was uninhabited and the birds had no natural predators.

When Mauritius was colonised by the Dutch in 1638, dodos were hunted for food. They were easy to catch and new competitors were brought onto the island, including pigs, cats and rats. They ate the dodos' eggs and their young. Within 80 years, the dodo was extinct.

4.6.3.7 Resistant bacteria

Antibiotic resistance

Bacteria can evolve quickly because they reproduce at a fast rate. Mutations of bacteria produce new strains. Some bacteria might become **resistant** to certain antibiotics, such as penicillin, and cannot be destroyed by the antibiotic. The evolution of the bacteria is an example of natural selection.

Development of resistance

The main steps in the development of resistance are:

1. random mutations occur in the genes of individual bacterial cells
2. some mutations protect the bacterial cell from the effects of the antibiotic
3. bacteria without the mutation die or cannot reproduce when the antibiotic is present
4. resistant bacteria can reproduce with less competition from normal bacterial strains

MRSA

The number of resistant strains has increased, partly due to the misuse of antibiotics. This has resulted in more infections that are difficult to control.

MRSA is methicillin-resistant *staphylococcus aureus*, and it is very dangerous because it is resistant to most antibiotics.

In order to reduce the rate of development of antibiotic resistant strains:

- doctors should not prescribe antibiotics inappropriately, such as for the treatment of non-serious infections
- patients should always complete the full course of antibiotics to ensure all bacteria are killed and none do not survive to mutate and form resistant strains
- the agricultural use of antibiotics should be restricted

Many new types of antibiotics were discovered during the 1950s and 1960s, but more recently, this has slowed greatly. Many scientists even stopped looking for new antibiotics, as they felt it was unnecessary.

Recent concerns of increasing resistance have created the need for new antibiotics, but they are costly and very slow to develop. Some scientists fear that we are fighting a losing battle against resistant bacteria, which may ultimately lead to people dying from simple infections, for example following operations.

4.6.3 The development of understanding of genetics and evolution PPQ's

Low demand

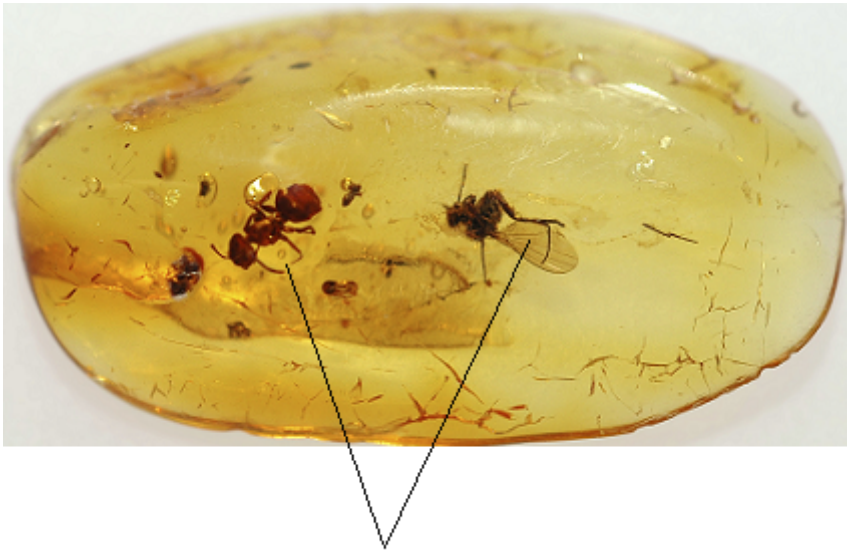
PPQ1

Q1.

Fossils give us information about organisms from a long time ago.

(a) Amber is a solid, glass-like material. Amber is formed from a thick, sticky liquid which oozes out of pine trees.

The image shows two fossil insects in amber.



(i) Suggest how the insects came to be preserved in the amber.

_____

_____

_____

_____

(2)

(ii) Give **two** other ways fossils are formed.

1. _____

_____

2. _____

_____

(2)

(b) The fossil record shows that many organisms, including the dinosaurs, became extinct 65 million years ago.

One theory was that volcanic activity might have caused this mass extinction. Many scientists believe that this extinction was caused when an asteroid collided with the Earth.

(i) A new scientific theory may replace an old theory.

Why might this happen?

Tick (✓) **one** box.

Evidence from amber is unreliable.	☐
Internet evidence is more reliable than fossil evidence.	☐
New technology provides more valid evidence.	☐

(1)

(ii) Give **three** reasons, other than volcanic activity and collision with an asteroid, why a species may become extinct.

1. _____

_____

2. _____

_____

3. _____

_____

(3)

(Total 8 marks)

PPQ2

Q2. Evolution is the development of new species over time.
Evidence for evolution comes from *fossils*.

(a) (i) What is a *fossil*?

_____

_____

_____

_____

(2)

(ii) How can fossils give evidence for evolution?

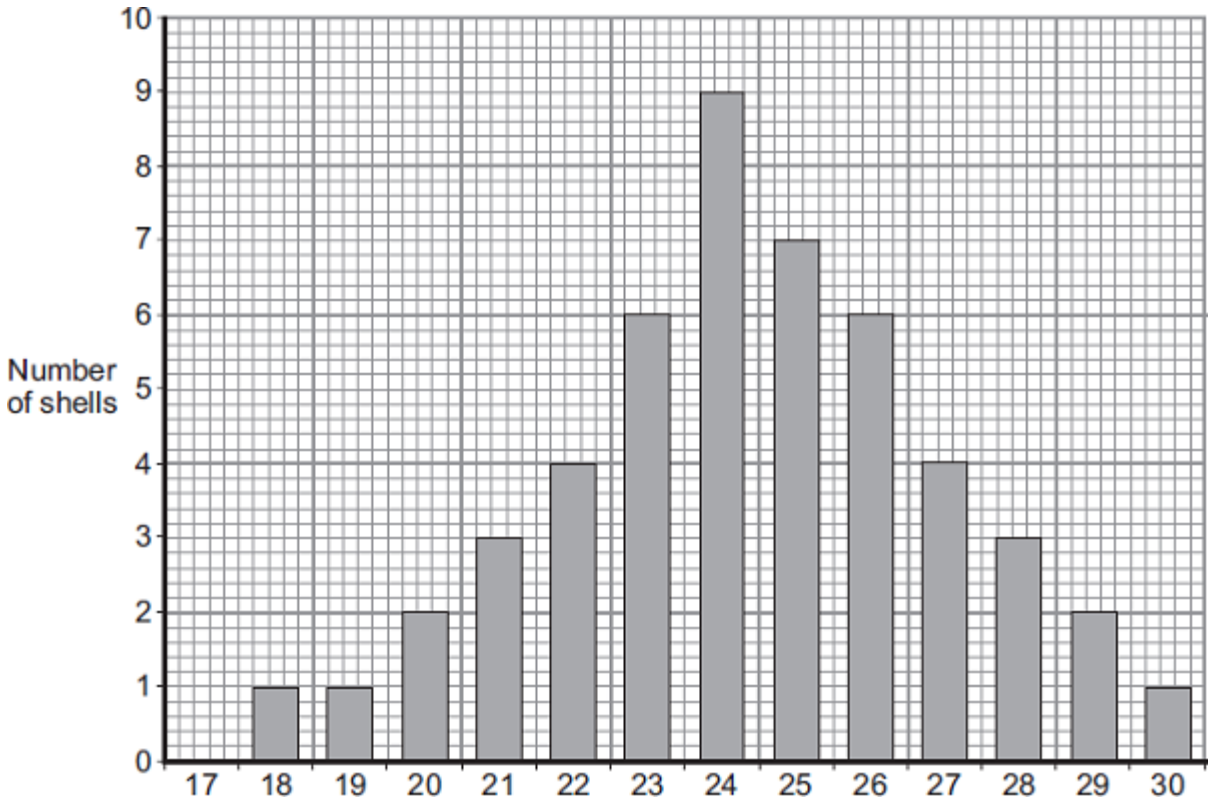
_____

_____

(1)

(b) A species of snail lived 400 million years ago.
Scientists measured the width of 49 fossil shells of this snail.

The bar chart shows the scientists' results.



(i) What is the range of the values for the width of the fossil shells for this species?

From _____ to _____

(1)

(ii) The scientists **cannot** be sure that this is the full range of fossil shell widths for this species.

Why?

_____

_____

(1)

(c) This species of snail became extinct 380 million years ago.

Give **one** possible reason why species become extinct.

_____

_____

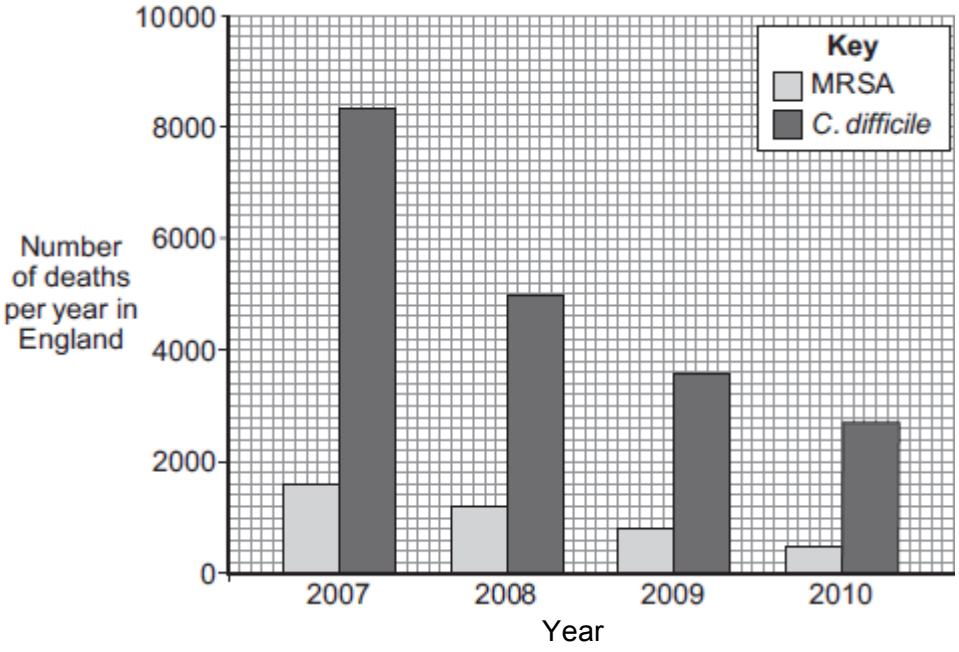
(1)

(Total 6 marks)

Standard demand

PPQ3

Q3. Infections by antibiotic resistant bacteria cause many deaths. The bar chart below shows information about the number of deaths per year in England from *Methicillin-resistant Staphylococcus aureus* (MRSA) and from *Clostridium difficile* (*C.difficile*) over 4 years.



(a) (i) Describe the trend for deaths caused by *C.difficile*.

_____

_____

_____

_____

(2)

(ii) Suggest a reason for the trend you have described in part **(a)(i)**.

Explain your answer.

_____

_____

_____

_____

(2)

(iii) Calculate the percentage change in deaths caused by MRSA from 2009 to 2010.

_____

_____

_____

Percentage change in deaths caused by MRSA = _____ %

(2)

(iv) Numbers have not yet been published for 2011.

When the numbers are published, scientists do **not** expect to see such a large percentage change from 2010 to 2011 as the one you have calculated for 2009 to 2010.

Suggest **one** reason why.

_____

_____

(1)

(b) Before 2007 there was a rapid increase in the number of deaths caused by MRSA.

Describe how the overuse of the antibiotic methicillin led to this increase.

_____

_____

_____

_____

_____

_____

(3)

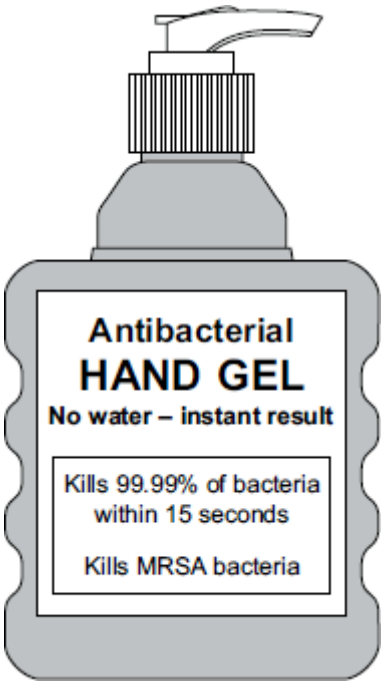
(Total 10 marks)

PPQ4

Q4.

MRSA strains of bacteria are causing problems in many hospitals.

(a) The diagram shows a hand-gel dispenser.



Hand-gel dispensers are now placed at the entrance of most hospital wards.

Explain why.

_____

_____

_____

_____

(2)

(b) Explain, as fully as you can, how MRSA strains of bacteria became difficult to treat.

_____

_____

_____

_____

_____

_____

(3)

(Total 5 marks)

PPQ5

Q5.

Doctors give antibiotics to patients to kill bacteria in their bodies.

Explain how the overuse of antibiotics has led to the evolution of antibiotic-resistant bacteria.

To gain full marks in this question you should write your ideas in good English.
Put them into a sensible order and use the correct scientific words.

_____

_____

_____

_____

_____

_____

(Total 3 marks)

High demand

PPQ6

Q6. Head lice live on people's heads and feed on their blood. Head lice cause itching and people may develop open wounds from scratching.

A poisonous chemical has been used to kill head lice for many years.
Recently, the chemical has not been as successful at killing head lice. Many head lice now survive treatment with the chemical.

Explain in terms of **natural selection** why most head lice are no longer killed by the chemical.

_____

_____

_____

_____

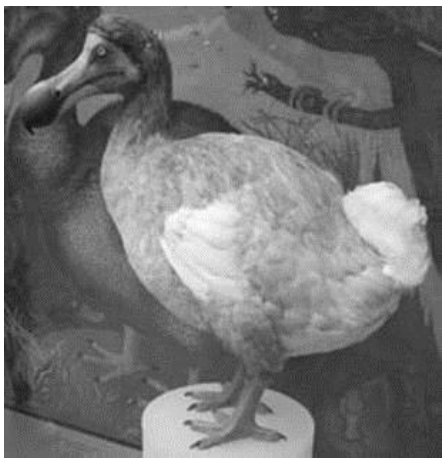
_____

_____

(Total 3 marks)

PPQ7

Q7. The dodo is an extinct bird. The drawing shows an artist's impression of the bird.



The dodo lived on a small island in the middle of the Indian Ocean. Its ancestors were pigeon-like birds which flew to the island millions of years ago. There were no predators on the island. There was a lot of fruit on the ground. This fruit became the main diet of the birds. Gradually, the birds became much heavier, lost their ability to fly and evolved into the dodo.

(a) Suggest an explanation for the evolution of the pigeon-like ancestor into the flightless dodo.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(b) The dodo became extinct about 80 years after Dutch sailors first discovered the island in the eighteenth century.

Scientists are uncertain about the reasons for the dodo's extinction. Suggest an explanation for this uncertainty.

_____

_____

(1)

(Total 5 marks)

PPQ8

Q8.

Figure 1 is a map showing a group of islands in the Pacific Ocean, near the coast of California, USA.

Figure 1

A species of fox, called the Island Fox, lives on each of the six islands shown in **Figure 1**.

Figure 2 shows an Island Fox.

Figure 2

© GaryKavanagh/iStock

The foxes on each island are slightly different from those on the other islands.

The Island Foxes are similar to another species of fox, called the Grey Fox.

The Grey Fox lives in mainland California.

(a) Suggest how scientists could prove that the six types of Island Fox belong to the same species.

_____

_____

_____

_____

(2)

(b) Scientists believe that ancestors of the modern Island Fox first colonised what is now Santa Cruz Island during the last Ice Age, approximately 16 000 years ago. At that time, lowered sea levels made the three northernmost islands into a single island and the distance between this island and the mainland was reduced to about 8 km.

(i) How could the Island Fox have developed into a completely different species from the mainland Grey Fox?

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(ii) Suggest why the Island Foxes have developed into different varieties of the same species instead of six different species.

_____

_____

_____

(1)

(Total 8 marks)

PPQ9

Q9.

In the 1850s an Austrian monk, called Gregor Mendel, carried out a series of investigations on heredity.

(i) What plants did he use for his investigations?

_____

(1)

(ii) In his work he assumed that one gene controlled one characteristic. He started his investigations with pure breeding parents. Use a genetic diagram to show how he explained the following result.

Parental phenotypes	
Yellow seeds	Green seeds

↓

F2 phenotype	
6022 yellow seeds	2001 green seeds

(4)

(Total 5 marks)

PPQ10

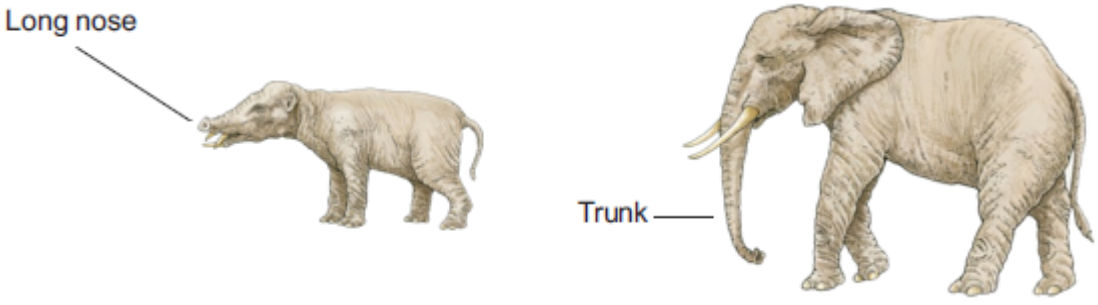
Q10.

The image below shows:

- *Phiomia*, an ancestor of elephants
- a modern African elephant.

Phiomia lived about 35 million years ago.

Phiomia **African elephant**



Both *Phiomia* and the African elephant reach up into trees to get leaves.

In the 1800s, Darwin and Lamarck had different theories about how the long nose of *Phiomia* evolved into the trunk of the African elephant.

(a) (i) Use Darwin's theory of natural selection to explain how the elephant's trunk evolved.

_____

_____

_____

_____

_____

_____

_____

_____ **(4)**

(ii) Lamarck's theory is different from Darwin's theory. Use Lamarck's theory to explain how the elephant's trunk evolved.

_____

_____

_____

_____**(2)**

(b) (i) In the 1800s, many scientists could **not** decide whether Lamarck's theory or Darwin's theory was the right one.

Give **two** reasons why.

1. _____

_____

2. _____

_____

(2)

(ii) Before the 1800s, many people had a different idea to explain where all the living things on Earth came from. What idea was this?

_____

_____

(1)

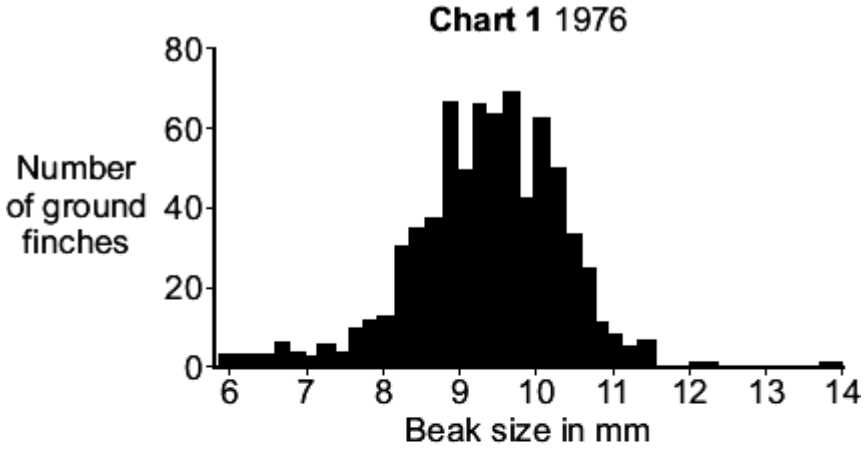
(Total 9 marks)

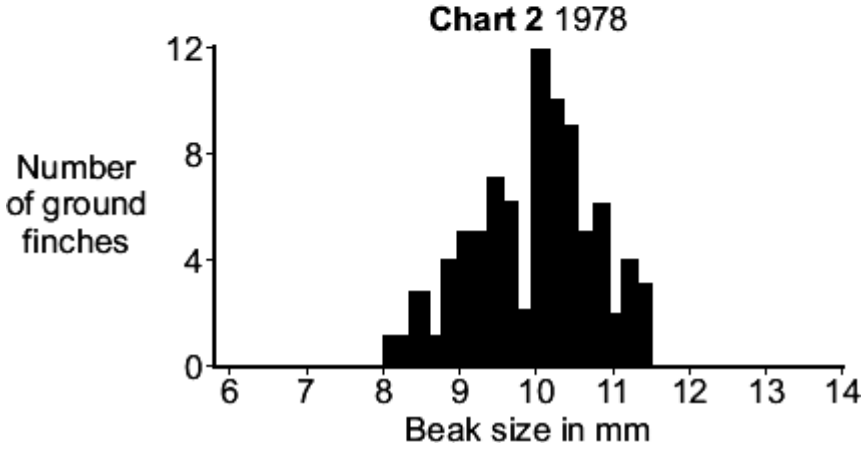
Q11.

The Galapagos Islands are in the Pacific Ocean, 1400 km from South America.
A type of bird called a ground finch lives on the islands.
The picture shows a ground finch.

By Charlesjsharp (Own work) [CC-BY-SA-3.0], via Wikimedia Commons

The size of the seeds the ground finch can eat depends upon the size of the beak.
To eat large seeds, a large beak is needed.
The bar charts show the sizes of the beaks of ground finches on **one** island, in 1976 and in 1978.





(a) The population of the ground finches and their beak sizes changed between 1976 and 1978.

Describe these changes.

_____

_____

_____

_____

_____

_____

(3)

(b) In 1977 there was very little rain on the island. The lack of rain affected the seeds that the finches ate.
The table shows how the seeds were affected.

Year	Mean number of seeds per m^2	Mean mass of each seed in mg
1976	8.5	3.5
1978	2.8	4.2

Suggest an explanation for the changes in beak sizes between 1976 and 1978.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 7 marks)

4.6.3 The development of understanding of genetics and evolution PPQ answers

Low demand

PPQ MS1

Q1.

(a) (i) any **two** from:
- trapped / held (since sticky)
- engulfed / covered by resin

allow engulfed / covered by amber
- prevented decay.

2

(ii) any **two** from:
- animal / plant (dies and) body covered in sediment / mud

ignore ref to rock

allow covered in tar / ice
- bones / shells / hard parts do not decay
- minerals enter bones / parts are replaced by other materials / mineralisation
- preserved traces / footprints / burrows / rootlet traces / impressions / casts.

2

(b) (i) New technology provides more valid evidence.

1

(ii) any **three** from:
examples of physical factors, e.g.

accept 3 physical factors or 3 biological factors or some of each for full marks

- flooding
- drought
- ice age / temperature change.

ignore pollution

examples of biological factors, e.g.
- (new) predators (allow hunters)
- (new) disease / named pathogen
- competition for food
- competition for mates

competition must be qualified
- cyclical nature of speciation
- isolation
- lack of habitat or habitat change.

***if no other answers given allow** natural disaster / weather change / catastrophic event / environmental change / climate change for **1** mark*

3

[8]

PPQ MS2

Q2.

(a) (i) (remains of) an organism / a bone / a shell / hard part of an organism / part of organism that does not decay / impression of an organism / footprint / burrow / rootlet trace

1

further detail – eg in rock / ice / amber / mineralisation

or

from a long time ago / many years ago

if number, > 1000 years

ignore hundreds

1

(ii) older fossils are simple(r)

must make ref to change and time

allow deeper fossils are simple(r)

or

fossils show change / adaptation with time

1

(b) (i) 18 to 30

allow 30 to 18

allow 12

ignore units

1

(ii) small sample

allow only 49 shells / not representative / not enough evidence

allow not all fossils found

1

(c) example of a physical factor such as flooding, volcanic activity (allow volcanoes) asteroid collisions, drought, ice age / temperature change

allow natural disaster / climate change / weather change / catastrophic event / environmental change

or

example of a biological factor such as predators / disease / competition / lack of food or mates / cyclical nature of speciation / isolation / lack of habitat or habitat change

ignore human factors eg hunting / pollution

1

[6]

Standard demand

PPQ MS3

Q3.

(a) (i) decrease

1

rate of decrease slows

1

(ii) any **one** from:

- more use of disinfectant

  allow any reasonable increase in hygiene or sterilisation precautions
- more use of hand washing
- more careful / more often cleaning of patient facilities
- raised awareness / education about hygiene

1

Explanation:
stops / reduces the bacteria being transferred / spreading

1

(iii) 800 – 500 / 800 × 100 =

1

37.5 (%)

*correct answer with or without working gains **2** marks*

1

(iv) any **one** from:

- numbers quite low now so hard to reduce further
- was a big campaign / much publicity (in 2009) so more people already doing it
- hygiene / cleaning now good so hard to improve
- hospitals short of money so less staff to clean

1

(b) mutation occurred giving resistance (to methicillin)

*do **not** accept overuse caused mutation*

1

resistant bacteria not able to be treated / not killed

1

these bacteria multiplied / reproduced / spread quickly

1

[10]

PPQ MS4

Q4.

(a) kills / destroys bacteria / MRSA

*do **not** allow germs*

1

prevents / reduces transfer

allow stops MRSA entering ward

1

(b) mutation

*do **not** accept antibiotics causes mutation*

1

(causes) resistance

allow not effective

ignore immunity

1

to antibiotics

1

[5]

PPQ MS5

Q5.

Quality of written communication

*for correct use of at least **two** scientific terms eg mutation, resistant (**not** just 'antibiotic-resistant', **not** 'immune') / selection / natural selection / survival / reproduction / gene / allele / DNA*

1

any **two** from:

mutation occurs in bacteria or change in DNA / gene occurs

cancel if mutation 'caused by' antibiotic

(when antibiotic used) only resistant bacteria survive **or** non-resistant bacteria are killed **or** reference to 'natural selection'

resistant bacteria pass on the gene / allele

allow pass on the mutation

*do **not** accept just 'pass on resistance'*

2

[3]

High demand

PPQ MS6

Q6.

variation exists in the population / a mutation occurred
ignore adaptation

1

so some head lice resistant to chemical / not killed by it
ignore immune

1

these survive and breed
or
pass on gene / allele / DNA (for resistance) to next generation
ignore characteristic / chromosome

1

[3]

PPQ MS7

Q7.

(a) any **four** from:

- mutation / variation
- produces smaller wings / fatter body
  must be linked to mutation / variation
- wings no longer an advantage since no predators
  allow wings / flight not needed as no predators
- wings no longer an advantage since food on ground
  allow wings / flight not needed as food on ground
- fatter body can store more energy when fruit scarce
- successful birds breed / pass on genes

4

(b) any **one** from:

- evidence has all gone
- no scientists on island at time to record evidence
- no records (from sailors)

1

[5]

PPQ MS8

Q8.

(a) reference to interbreeding

1

successfully between Island types

allow ref. to production of fertile offspring

allow ref. to DNA analysis / comparison for 1 mark

ignore ref. to grey fox

1

(b) (i) (two ancestral populations) separated / isolated (by geographical barrier / sea)

1

and genetic variation (in each population) **or** different / new alleles **or** mutations occur

1

under different environment / conditions

allow abiotic or biotic example

allow different selection pressures

1

natural selection occurs **or** better adapted survived to reproduce

1

so (favourable) alleles / genes / mutations passed on (in each population)

ignore they adapt to their environment

1

(ii) any **one** from:

- continued to mate with one another
- few beneficial mutations (between island varieties)
- similar conditions on each island so similar adaptations/features fit

1

[8]

PPQ MS9

Q9.

(i) (sweet) peas

1

(ii) homozygous parents crossed [1]

heterozygous (F1) offspring crossed [1]

recognition of yellow dominant over green [1]

recognition that results support 3:1 **or**
0.75 to 0.25 ratio

*up to **4** marks awarded for an understanding of the monohybrid cross and the expected outcome*

4

[5]

Q10.

(a) (i) variation (in population) / mutation

1

longer nosed individuals get more food / leaves

allow longer nosed individuals more likely to survive

1

(these) survivors breed (more)

1

pass on genes / alleles / DNA (for long nose)

allow pass on mutation

1

(ii) Phiomia / ancestor stretched its nose (during its lifetime) to reach food / leaves

1

passed on (stretched nose) to offspring

allow offspring inherit (stretched nose)

*do **not** allow ref to genes*

1

(b) (i) insufficient evidence / no proof

ignore other theories, eg religion

*do **not** allow no evidence*

1

mechanism of inheritance not known

allow genes / DNA not discovered

1

(ii) God made all living things / them

allow creationism

ignore religion

1

[9]

Q11.

(a) in 1978
fewer finches **or** population smaller

1

any **two** from:

- no beaks less than 8mm
- no beaks greater than 11.5 / 12mm
  *if these points not given allow smaller range of beak sizes for **1** mark*
- mean / average beak size higher

2

(b) variation or range or mutation of beak sizes
*do **not** accept idea that drought / seed size caused mutation*

1

birds with larg(er) beaks are better adapted for feeding
accept idea of competition for food / seeds amongst finches

1

birds with larg(er) beaks survive
accept (only / more) birds with large beaks were better competitors

1

birds with larg(er) beaks breed **or** gene / allele for large beak passed on
*do **not** accept large beak passed on*

1

[7]

4.6.4 Classification of living organisms knowledge

Linnaean system of classification

Living organisms are classified into groups depending on their structure and characteristics. This system was developed in the eighteenth century by Carl Linnaeus. The classification of species allows the subdivision of living organisms into smaller and more specialised groups.

Kingdoms

The first division of living things in the classification system is to put them into one of five **kingdoms.**

The five kingdoms are:

- animals (all multicellular animals)
- plants (all green plants)
- fungi (moulds, mushrooms, yeast)
- protists (Amoeba, Chlorella and Plasmodium)
- prokaryotes (bacteria, blue-green algae)

Further divisions

Living things can then be ranked according to:

- phylum
- class
- order
- family
- genus
- species

Phylum follows Kingdoms and has many different organisms, including three examples below:

- Chordata, which have backbones
- Arthropod, which have jointed legs and an exoskeleton
- Annelids, which are segmented worms

Class is an additional sub-division, which for example, results in the Chordata phylum being divided into:

- Mammals
- Birds
- Amphibians
- Fish
- Reptiles

Order follows class and as an example, mammals can be further sub-divide into a variety of different groups such as:

- Carnivores
- Primates

Orders are broken down into families. Here are a few examples of which carnivores can be divided into:

- Canidae - dogs
- Felidae - cats

Genus, the Felidae family can be further sub-divided into four genus examples:

- Acinonyx - cheetah
- Panthera - lion and tiger
- Neofelis - clouded leopard
- Felis - domestic cats

Species is the final classification stage, and the genus Panthera can be divided into:

- Panthera leo (lion)
- Panthera tigris (tiger)

As an example, the complete breakdown of the classification of lions:

- kingdom - animal
- phylum - vertebrate
- class - mammal
- order - carnivorous
- family - cat
- genus - big cat
- species - lion

There are many ways to remember this order, for example using the mnemonic:

Kids prefer candy over fresh green salad

The binomial system of naming species uses Latin words. Each name has two parts, the genus and the species. For example, human beings belong to the genus *Homo*, and our species is sapiens - so the scientific name is *Homo sapiens*.

The binomial system is important because it allows scientists to accurately identify individual species. For example, the European robin is *Erithacus rubecula*. It is much smaller than the American robin, *Turdus migratorius*, which belongs to a different genus.

The grouping of families was added to allow the large number of new species to be included in this system. Linnaeus' original ideas have been adapted, but continued to be accepted and as new species are identified they can be fitted into the current classification system.

Originally, Linnaeus couldn't distinguish between different types of organisms such as algae, lichens, fungi, mosses and ferns. The inability to examine such organisms in detail made separation of these difficult at the time.

As more scientific equipment became available it allowed scientists to examine organisms in more detail and note important features, such as the identification of sex organs. This allowed more divisions to be created, and with the advancement of technology, this allowed the development of Linnaeus's classification system.

Impact of modern developments of classifying systems

Technology associated with biology has advanced throughout the years, which has allowed the current classification system to be enhanced by using microscopes, biochemistry and DNA evidence.

Different types of microscope
Originally Linnaeus's system relied purely on human judgement in order to compare the characteristics of various organisms.
The development of microscopes allowed cells to be examined in far more detail.
Organelles within the individual cells could be distinguished and this allowed a more scientific approach of classification.

The development and study of biochemistry and the processes undertaken inside the cells, in some cases, have allowed any ambiguities within this classification system to be clarified.

The comparisons of DNA sequences have allowed the relationship of organisms to be explored further. In some cases, species that are more closely related may have fewer differences contained within the DNA sequences.
DNA sequences can highlight the differences and similarities between species from the DNA molecules they share

Three-domain system

Classification systems have continued to be developed by other scientists, such as Carl Woese who developed the three-domain system. This is based on evidence now available from chemical analysis.

The updated system divides organisms into:

- Archaea (primitive bacteria usually living in extreme environments)
- Bacteria (true bacteria)
- Eukaryota (including protists, fungi, plants and animals)

Evolutionary trees

Evolutionary trees are a method used by scientists to represent the relationships between a set of organisms. The tips of the tree often represent different species and where two branches join, this represents a common ancestor for those two species. They can be created from current data such as DNA analysis and existing fossil data.

4.6.4 Classification of living organisms PPQ's

Low demand

PPQ1

Q1. Living things can be classified into groups.

(a) Scientists look at structures inside cells to classify living things.

Suggest **one** structure found in cells that can be used to classify living things.

_____

(1)

(b) The table below shows one system for classifying humans.

X	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates
Family	Hominidae
Genus	*Homo*
Species	*Sapiens*

Who devised this system of classification?

Tick **one** box.

Darwin ☐

Linnaeus ☐

Wallace ☐

Woese ☐

(1)

(c) Look at the table above.

X is the largest category in this classification.

Name category **X**.

_____

(1)

(d) Give the **binomial name** of humans.

Use information in the table above.

_____ **(1)**

(e) Suggest **one** way that classification systems are useful to scientists.

_____ **(1)**

(Total 5 marks)

High demand

PPQ2

Q2. In the 18th century a binomial system of grouping similar organisms was developed. Before the binomial system was developed the common briar rose had the following names:

- *Rosa sylvestris inodora seu canina*
- *Rosa sylvestris alba cum rubore folio glabro*.

In the binomial system, the same rose is called *Rosa canina*.

(a) One advantage of the binomial system is that the name is shorter than the names used before this system.

Suggest **two other** advantages of the binomial system.

1. _____

_____

2. _____

_____ **(2)**

(b) Classification systems have changed in the last 50 years.

Give **one** reason why we now have more information to classify organisms.

_____

_____ **(1)**

(c) 'Archaea' is one of the groups in the three-domain system of classification. Give **two** features of the domain Archaea.

1. _____

_____

2. _____

_____ **(2)**

(Total 5 marks)

4.6.4 Classification of living organisms PPQ answers

Low demand

PPQ MS1

Q1.

(a) Relevant organelle found in cells such as nucleus, mitochondria

1

(b) Linnaeus

1

(c) Kingdom

1

(d) *Homo Sapiens*

ignore underlining, italics or not, capitals or not

1

(e) Any **one** from:

- to know which species are closely related
  or
  study evolution
- to monitor biodiversity
- to identify different organisms such as two different species

1

[5]

High demand

PPQ MS1

Q2.

(a) same name to everyone

1

(genus) part gives information on ancestry

1

(b) any **one** from:

- DNA / RNA analysis
- improvements to (electron) microscopes
- improved understanding of biochemical processes
- evidence of internal structures being more developed

1

(c) primitive bacteria / prokaryotes

1

(often) from extreme environments / extremophiles

1

[5]