Edexcel IGCSE Biology

Topic 3: Reproduction and inheritance

Notes

(Biology only in bold)

Reproduction

Sexual and asexual reproduction (3.1 and 3.2)

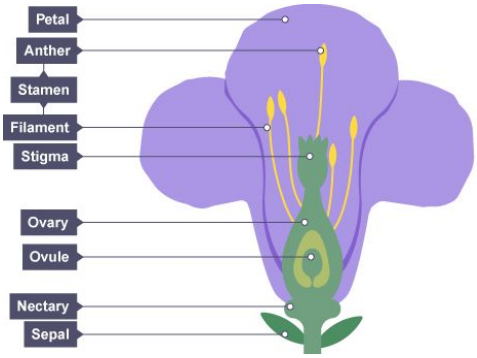
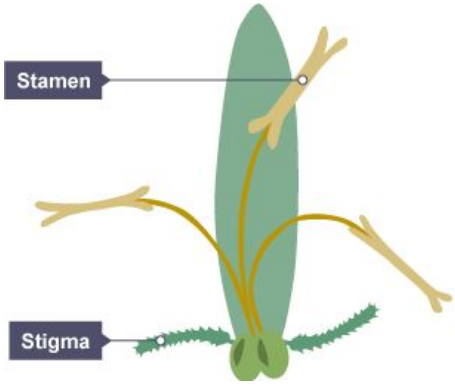
Advantages of sexual reproduction	Advantages of asexual reproduction
Produces variation in offspring. • This means that if the environment changes it is likely that an organism in the species will have a characteristic that allows them to survive (called a survival advantage). • Although some individuals may die, variation decreases the chance of the whole species becoming extinct.	Only one parent is needed.
It allows us to use selective breeding. • This type of reproduction mixes the genetic information from two organisms • Organisms with different desirable characteristics can be bred to produce offspring with even more desirable characteristics. • This speeds up natural selection. • An example is to increase food production by breeding two animals with lots of meat.	Uses less energy and is faster as organisms do not need to find a mate.
	In favorable conditions, lots of identical offspring can be produced.

Fertilisation involves the fusion of a male and female gamete to produce a zygote that undergoes cell division and develops into an embryo.

Reproduction in plants (3.3-37)

Adaptations of different types of plants

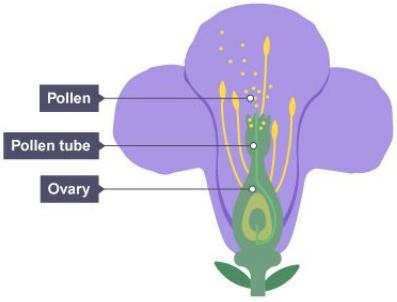
Feature	Insect-pollinated	Wind-pollinated
Petals	Large and bright to attract insects	Small and dull - usually green or brown
Nectar	Scented with nectar to attract insects	No scent or nectar
Pollen grains	Sticky and in moderate amounts	Smooth and light so they can be easily carried in the wind and in large amounts

		to make sure some reach other flowers
Anthers	Inside flower, stiff and attached so that insects can brush past	Outside flower, loose on long filaments so that pollen can be released easily
Stigma	Inside flower, sticky so pollen grains stick to it when an insect brushes past	Outside flower, feathery so it is easier to catch pollen grains drifting in the wind
		

Seed and fruit formation

- Pollen grains are the male gamete in plants
- The ovule is the female gamete in plants

1) Pollen grains land on stigma (via insect or wind pollination)
2) Pollen tube grows out of the pollen grain and down the style into the ovary and then to the ovule
3) The male nucleus travels down the pollen tube from the pollen grain to fuse with the female egg nucleus in the ovule, forming a zygote
4) The zygote undergoes mitosis to form a seed
5) The ovule will become the seed and the ovule wall will become the seed coat
6) The ovary will become the fruit of the plant.



Practical: understand the conditions needed for seed germination

Germination is the process in which seeds begin to develop into a new young plant.

- Water: needed to activate enzymes to break down the starch food reserves in the seeds
- Oxygen: needed for aerobic respiration to release energy for growth
- Warmth: optimum temperature for enzymes will increase growth rate

Method:

1) Set up 4 boiling tubes with 10 cress seeds in each, sitting on cotton wool
2) Tube A should have dry cotton wool and kept at 20°C
3) Tube B should have moist cotton wool and kept at 20°C
4) Tube C should have boiled water that has been cooled, covered with a layer of oil and kept at 20°C
5) Tube D should have moist cotton wool but is kept at lower temperature (4°C)

The results will show that seeds germinate in test tube B only because it has the water, temperature and oxygen required for germination. Tube A does not have water, the oil in tube C does not allow for oxygen and tube D is not kept at optimum temperature.

Germinating seeds

Structure	Description
Embryo	Young root and shoot become the adult plant
Food store	Starch for the plant to use until it is able to carry out photosynthesis
Seed coat	A protective covering

Asexual reproduction

- Asexual reproduction produces clones as it only involved on parent, unlike sexual reproduction.
- Natural: Runners
    - E.g. strawberry plants
    - Grow horizontally over soil surface and put down roots to form new plants
- Artificially: Cuttings
    - Tissue samples scraped from parent plant and then placed in agar growth medium with nutrients and auxins
    - The sample develop into plantlets and these are planted into compost to grow further

Human reproduction (3.8-3.13)

Male reproductive system

Structure	Description
Sex gland	Produces semen that contains sperm cells
Sperm duct	Sperm passes through this
Testis	Contained in scrotum (bag of skin) and produces sperm and testosterone

Penis	Passes urine and semen out of the body
Urethra	Tube inside the penis to carry urine or semen. A ring of muscle inside stops the two mixing.

Female reproductive system

Structure	Description
Ovary	Contains ova (female gametes) which develop when FSH is released
Oviduct	Connects ovary to the uterus and is lined with ciliated cells that push the ovum towards the uterus for fertilisation
Uterus	Has a thick lining so that fertilised eggs can be implanted
Cervix	Ring of muscle at lower end of uterus to ensure foetus remains in place during pregnancy
Vagina	Muscular tube that leads to the inside of the body

Secondary sexual characteristics

Females: oestrogen

- Breast development
- Menstrual cycle begins
- Growth of body hair
- Widening of hips
- Increased height

Males: testosterone

- Growth of penis and testes
- Production of sperm
- Growth of facial and body hair
- Muscle development
- Voice lowering and breaking

Menstrual cycle

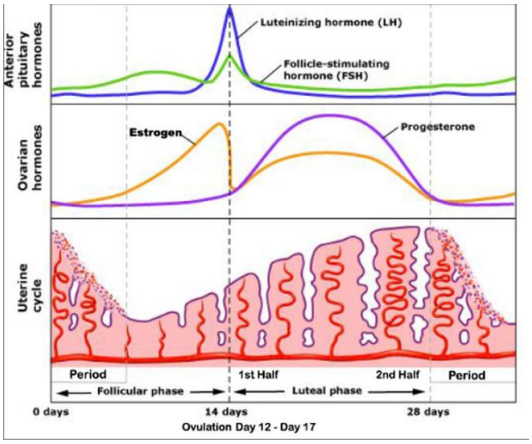
The menstrual cycle last 28 days and the egg is usually released on day 14 (ovulation).

Oestrogen

- Oestrogen causes thickening of the uterus in preparation for implantation of an egg
- Levels peak on day 10 and then begin to fall

Progesterone

- Progesterone maintains the thick lining of uterus
- Inhibits the release of LH and FSH
- The egg matures on day 14 and progesterone starts increasing after this until it reaches its peak 3 days later



If the egg is not fertilised, progesterone levels fall and the uterus lining breaks down in a period that lasts for around 5 days

FSH and LH

- **FSH (follicle stimulating hormone) causes maturation of the egg within the ovary**
- **LH (luteinising hormone) stimulates the release of the egg during ovulation**
- **A decrease in oestrogen causes LH and FSH to start increasing**
- **Ovulation (the release of an egg cell from one of the ovaries) occurs when LH and FSH levels peak**

Developing embryo

The placenta allows diffusion of glucose, oxygen and amino acids from the mother's blood to the developing foetus for growth. Carbon dioxide and urea from the foetus are passed into the mother's blood to be removed. It also takes over the production of progesterone.

Amniotic fluid is a liquid contained in a bag (amnion) in the uterus that surrounds the foetus. It protects the foetus and cushions any rough movement. When labour begins, the amnion breaks and the fluid comes out - often known as a woman's 'water breaking'.

Inheritance

Genetic definitions (3.14-3.15, 3.19-3.21B, 3.23)

Key genetic definitions

Gamete	An organism's reproductive cell (egg in female and sperm in males), which has half the number of chromosomes (23).
Genome	The entire DNA of an organism
Chromosome	A structure found in the nucleus which is made up of a long strand of DNA.
Gene	A short section of DNA that codes for a protein, and therefore contribute to a characteristic. Some characteristics are controlled by a single gene, such as fur colour in mice and red-green colour blindness in humans. However, most characteristics are the result of many different genes interacting.
Allele/variant	The different forms of the gene - humans have two alleles for each gene as they inherit one from each parent.
Dominant allele	Only one (out of the two alleles) is needed for it to be expressed and for the corresponding phenotype to be observed.
Recessive allele	Two copies are needed for it to be expressed and for the corresponding the phenotype to be observed.

Homozygous	When both inherited alleles are the same (i.e. two dominant alleles or two recessive alleles).
Heterozygous	When one of the inherited alleles is dominant and the other is recessive.
Genotype	The combination of alleles an individual has, e.g. Aa
Phenotype	The physical characteristics that are observed in the individual, e.g. eye colour. Phenotypic features are the result of polygenic (multiple genes) inheritance rather than single genes
Codominance	**When neither allele is dominant over the other, so both contribute to the phenotype E.g. a white chicken and a black chicken can have offspring that are speckled so the hen is codominant**

DNA (3.16B-3.18B)

DNA structure

- **DNA stands for deoxyribonucleic acid**
- **It is a double helix made from 2 strands that have twisted around each other.**
- **It is a polymer, meaning that it is made of many different molecules that join up to make a long strand: in the case of DNA, these molecules are called nucleotides.**
- **Each nucleotide is made from one sugar molecule, one phosphate group (which forms the backbone) and one of the four different organic bases**
    - **The 4 bases are A, C, G, T.**
    - **These nucleotides pair by complementary base pairing, meaning that only certain bases can join together: C joins to G and A joins to T**
- **Each group of three bases codes for an amino acid and these then join together to make a protein**
- **Chromosomes are structures made up of long molecules of DNA.**

Protein synthesis

DNA is too large to leave the nucleus. Hence, in order to make the proteins, a series of steps must be taken to copy and transport the genetic information.

1) **DNA helix is unwound and unzipped**
2) **mRNA nucleotides (messenger RNA: a different type of nucleotide) match to their complementary base on the strand.**
3) **The mRNA nucleotides are then joined together, creating a new strand called a template strand of the original DNA. This process is called transcription.**
4) **The strand of mRNA then moves out of the nucleus to the cytoplasm and onto structures called ribosomes.**

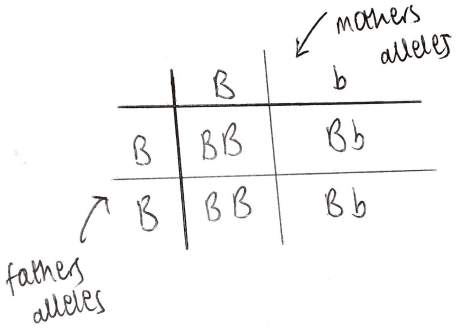
5) **At the ribosomes, the bases on the mRNA are read in threes to code for an amino acid (the first three bases code for one amino acid, the second three bases code for another etc). This is called translation.**
6) **The corresponding amino acids are brought to the ribosomes by carrier molecules.**
7) **These amino acids connect together to form a protein. It is therefore the triplet code of bases that determines which protein is produced and therefore expressed.**
8) **When the chain is complete the protein folds to form a unique 3D structure.**

Genetic inheritance (3.24-3.27)

Punnett square diagrams

A single gene cross looks at the probability of the offspring of two parents having certain genotypes and phenotypes. This is done using the gene alleles of the two parents and a Punnett square diagram. You should be able to draw and use a Punnett square diagram in order to describe monohybrid inheritance (looking at only one characteristic, e.g. eye colour). However, it is important to remember that most phenotypic features are the result of multiple different genes interacting rather than a single gene inheritance.

Uppercase letters are used to represent dominant characteristics. Lowercase letters represent recessive characteristics. You can choose any letter but usually either A or B is used for simplicity.



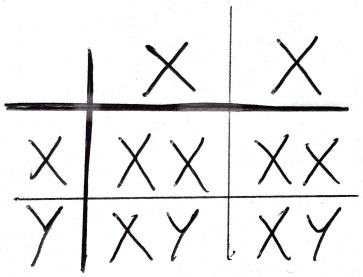
Sex determination

Human body cells have 23 pairs of chromosomes.

- 22 control characteristics, and the chromosomes in each pair look very similar
- The 23rd pair carries sex determining genes, and the two chromosomes can look different to each other (Y chromosomes are much smaller than X chromosomes)

The two possible chromosomes in the 23rd pair are X chromosomes and Y chromosomes. When cells undergo meiosis to form a gamete, one sex chromosome goes into each gamete.

- Females have two X chromosomes, so therefore only pass on X chromosomes in their eggs.
- Males have one X chromosome and one Y chromosome, so therefore can pass on X or Y chromosomes in their sperm.



In a similar way as above, we can show that there is a 50% chance of babies being born as either a boy or a girl using a Punnett square.

Mitosis (3.28 and 3.29)

Mitosis is a type of cell division where one cell divides to form two identical daughter cells. The cell cycle is a series of steps that the cell has to undergo in order to do this.

Stage 1 (Interphase)

- The cell grows as organelles (such as ribosome and mitochondria) grow and increase in number
- The synthesis of proteins occurs
- All 46 chromosomes are replicated (forming the characteristic 'X' shape)
- Energy stores are increased

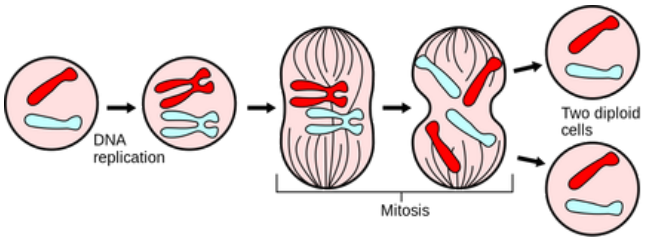
Stage 2

- The chromosomes line up at the equator of the cell
- Spindle fibres pull each chromosome of the 'X' to either side (poles) of the cell.

Stage 3

- Two identical daughter cells form when the cytoplasm and cell membranes divide, each containing the same 46 chromosomes as the original cell.

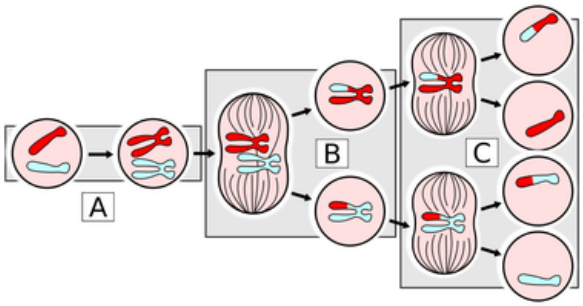
Cell division by mitosis occurs during growth and development, replacing damaged cells and also cloning. Mitosis is also a vital part of asexual reproduction, as this type of reproduction only involves one organism. So, to produce offspring, it simply replicates its own cells.



Meiosis (3.30 and 3.32)

Meiosis is the formation of four non-identical cells from one cell. Cells in the reproductive organs divide by meiosis to form gametes. Gametes only have one copy of each chromosome.

1) The cell makes copies of its chromosomes, so it has double the amount of genetic information.
2) The cell divides into two cells, each with half the amount of chromosomes, giving the normal amount of 46 chromosomes (diploid).
3) Each cell divides into two again to produce four cells, each with 23



chromosomes. As they have half of the normal amount of chromosomes, they are called haploid.

These cells are called gametes and they are all genetically different from each other because the chromosomes are shuffled during the process, resulting in random chromosomes ending up in each of the four cells.

Variation (3.31-3.33)

Genetic variation is the difference in DNA sequences of individuals within the same species.

Random fertilisation increases genetic variation between offspring as each gamete has variation due to meiosis and the fusing of the egg and sperm is random.
Variation within a species can be genetic, environmental or a mixture of both:

- Genetic variation would be eye colour, blood type etc as these phenotypes are dependent on inheriting alleles from parents.
- Environmental variation is caused by differences in lifestyle, diet, climate etc. which could lead to organisms to adapt. An example of this would be how white moths adapted to be darker in more polluted areas.
- Genetics and environment can interact, such as height. A child might have the potential to grow tall, due to their genetics, but if they are malnourished and do not eat well or enough, then they will not grow as much.

Mutations (3.34-3.39)

Mutations are rare, random change in genetic material that can be inherited.

Phenotype and mutations

A change in DNA can affect the phenotype by altering the sequence of amino acids in a protein.
Each gene acts as a code for making a specific protein

- **Each gene codes for the order in which the bases (A,T, C and G) link together**
- **Each triplet of bases codes for a specific amino acid**
- **The series of amino acids codes for a protein**
- **Therefore, a mutation in the bases can change the entire protein.**

All variants (alleles) are caused by mutation. Most of these mutations have no effect on the phenotype, as most of DNA is non-coding and therefore does not cause a change in any proteins. However, some do have a small influence on phenotype and very few can have a significant effect if they are in coding regions.

Mutations can occur more frequently due to:

- **Exposure to ionising radiation (for example, gamma rays, x-rays and ultraviolet rays)**
- **Exposure to chemical mutagens (e.g. chemicals in tobacco)**

These mutations can lead to uncontrollable growth, which causes a tumour. Therefore, mutagens like chemicals in tobacco are called carcinogens (cancer-causing).

Darwin

Evolution: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.

- Mutations occur which provide variation between organisms.
- If a mutation provides a survival advantage, the organism is more likely to survive to breeding age (survival of the fittest)
- The mutation will then be passed onto offspring.
- Over many generations, the frequency of the mutation will increase within the population

There is usually a large amount of genetic variation between individuals of the same species within a population. This natural variation occurs through small mutations that have occurred throughout time. For example, we can see that within a particular breed of dog, there are slightly different coat colours and patterns due to random mutations.

This may cause one population of a species to become so different that they can no longer interbreed to produce fertile offspring. This means they have become a new species. This is called speciation.

Antibiotic resistance in bacteria

Bacteria are organisms that reproduce at a very fast rate and therefore advantageous genes, such as those for antibiotic resistance, can become prominent within a population very quickly.

Exposure to antibiotics creates a selection pressure, as those with antibiotic resistant genes survive and those without die. As a result, those with antibiotic resistance can reproduce and pass on the advantageous gene to their offspring and so the population of antibiotic resistant bacteria increases.

An example is the MRSA ‘superbug’ that is resistant to many different types of antibiotics. It is found in hospitals as it spreads when doctors and nurses move between different patients.