Topic 6: Inheritance, variation and evolution

AQA GCSE Biology 8461 · spec 4.6 · sheets 6.1–6.5

Inheritance, variation and evolution: passing it on

- compare sexual and **asexual reproduction**, and describe **meiosis**;
- describe DNA, genes and the **genome**, and (HT) how proteins are made;
- use genetic terms and Punnett squares to predict inheritance, including inherited disorders and sex;

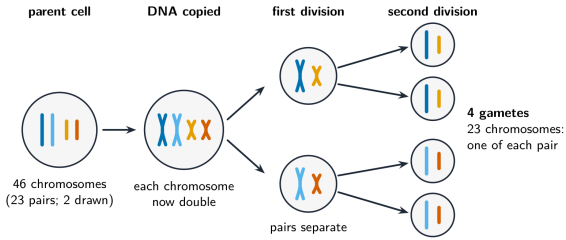
Inheritance, variation and evolution: passing it on (2)

- explain variation, **natural selection**, **selective breeding**, **genetic engineering** and (biology only) cloning;
- (biology only) describe the history of evolutionary theory, the evidence for evolution, and how living things are classified.

Reproduction and meiosis

- **Sexual reproduction** involves the joining of male and female sex cells, each called a **gamete** : sperm and egg cells in animals, pollen and egg cells in flowering plants.
- It mixes genetic information from two parents, so the offspring vary. **Asexual reproduction** involves only one parent and no gametes.
- Its offspring are genetically identical to the parent, a **clone** (apart from any mutations).
- In plants and animals it uses cell division by **mitosis** .

Figure: Reproduction and meiosis



- DNA is copied, the first division separates the **chromosome** pairs and the second separates the copies: four gametes with 23 chromosomes each; **fertilisation** restores 46.
- Match each part of the diagram to the text.

DNA, genes and the genome

- DNA is a **polymer** made of two strands twisted into a **double helix** .
- It is found in the nucleus, in structures called chromosomes.
- A **gene** is a small section of DNA that codes for a particular sequence of amino acids, which makes a particular protein.
- The **genome** is all the genetic material of an organism.

Genetic inheritance

- A **chromosome** is a long DNA molecule carrying many genes.
- An **allele** is a version of a **gene**.
- A **dominant** **allele** is expressed even if only one copy is present; it is shown with a capital letter, such as D.

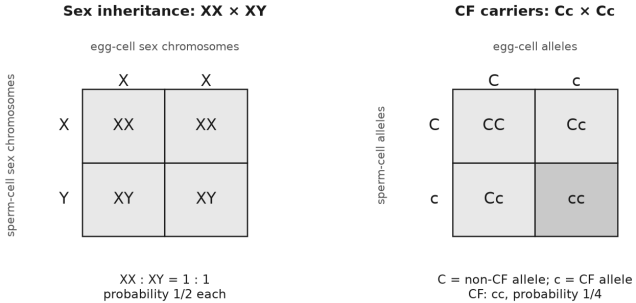
Genetic inheritance (2)

- A **recessive allele** is expressed only if two copies are present; it is shown with a small letter, such as d.
- **Homozygous** means having two identical alleles (DD or dd); **heterozygous** means having two different alleles (Dd).
- The **genotype** is the alleles present; the **phenotype** is the characteristic that results.

Genetic inheritance (3)

- **Polydactyly** , having extra fingers or toes, is caused by a **dominant allele**, so one copy is enough.
- **Cystic fibrosis** , a disorder of cell membranes that causes thick, sticky mucus in the lungs and gut, is caused by a **recessive** allele, so a person must inherit two copies. A carrier (Cc) does not have the disorder.

Figure: Genetic inheritance



- Punnett squares: XX × XY sex inheritance and Cc × Cc cystic-fibrosis carrier inheritance.
- Match each part of the diagram to the text.

Variation and evolution

- **Variation** is the difference between individuals of the same **species**.
- It can be caused by the genes they inherit (genetic), by the conditions in which they develop (environmental), or, most often, by both.
- All genetic variation comes from mutations.
- Most mutations have no effect on the **phenotype**, some change it slightly, and very few decide it completely.

Selective breeding, genetic engineering and cloning

- **Tissue culture** : small groups of cells from a plant are grown into new identical plants, to preserve rare **species** or to grow many plants for sale.
- **Cuttings** : a gardener cuts a piece of stem and grows it into a new plant.

Selective breeding, genetic engineering and cloning (2)

- **Embryo transplants** : cells are split apart from a young animal embryo before they specialise, and each one grows into an identical embryo, which is placed in a host mother.
- **Adult cell cloning** : the nucleus is removed from an unfertilised egg; the nucleus from an adult body cell is put in its place; an electric shock makes the egg divide into an embryo; the embryo is placed in the uterus of a host mother. Dolly the sheep, born in 1996, was cloned in this way.

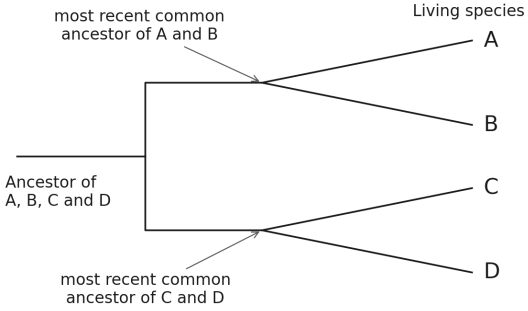
Evidence for evolution (biology only)

- when parts of an organism do not decay, because one of the conditions for decay is missing;
- when parts are replaced by minerals as they decay;
- as preserved traces such as footprints, burrows and root traces; such a mark is a **trace fossil** .

Classification

- **archaea** : primitive bacteria, often found in extreme places such as hot springs and salt lakes;
- bacteria: true bacteria;
- **eukaryota** : protists, fungi, plants and animals.

Figure: Classification



- An **evolutionary tree**: A and B share a more recent **common ancestor** than A and C; branch lengths are not a time scale
- Match each part of the diagram to the text.

Sources for this lesson

- AQA, *GCSE Biology (8461) specification*, section 4.6 Inheritance, variation and evolution.
- G. Mendel, "Versuche über Pflanzen-Hybriden" (Experiments on plant hybrids), *Verhandlungen des naturforschenden Vereines in Brünn* 4 (1866), pages 3 to 47.

Sources for this lesson (2)

- C. R. Woese, O. Kandler and M. L. Wheelis, "Towards a natural system of organisms: proposal for the domains **Archaea**, Bacteria, and Eucarya", *Proceedings of the National Academy of Sciences* 87 (1990), pages 4576 to 4579.
- AQA, *GCSE Biology* Paper 2 Higher (June 2024), the insecticide, **polydactyly** and GM soya questions, adapted.

Common errors

- Saying **meiosis** makes two cells, or cells with 46 chromosomes; it makes four gametes with 23.
- Saying "**dominant**" means more common or stronger.
- Writing a **gamete** as Dd; each gamete carries one allele.

Common errors (2)

- Thinking earlier children change the probability for the next child.
- Saying organisms mutate "because they need to" or evolve during their own lifetime.
- Mixing up **selective breeding** (humans choose) and **natural selection** (the environment chooses).

Common errors (3)

- Saying a **species** missing from one place is extinct.
- Reading branch lengths on an **evolutionary tree** as times when no scale is given.

Key terms

- **Meiosis**: cell division that makes four genetically different gametes with half the number of chromosomes.
- **Genome**: all the genetic material of an organism.
- **Allele**: a version of a **gene**.

Key terms (2)

- **Genotype**: the alleles an organism has.
- **Phenotype**: the characteristics that result from the **genotype** and the environment.
- **Natural selection**: the survival and reproduction of the individuals best suited to their environment.

Key terms (3)

- **Selective breeding**: humans choosing parents with useful characteristics to breed.
- **Genetic engineering**: adding a **gene** from one organism to the **genome** of another.
- **Speciation**: the formation of new **species** when populations can no longer interbreed.

Check yourself

- 1.
- How many gametes does **meiosis** make from one cell, and how many chromosomes does each human **gamete** have? 2.
- Give two advantages of **asexual reproduction**. 3.
- Define homozygous and heterozygous. 4.