AS90163 Biology Describe the transfer of genetic information

Part 3 - Applications of genetics

Reproduction

There are two forms of reproduction:

- **sexual** reproduction - joining (fusion) of male and female gametes
- **asexual** reproduction - no fusion of cells - only one individual is needed (single parent).

Asexual reproduction gives rise to individuals genetically identical to the parent. These genetically identical individuals are known as a **clone**.

Sexual reproduction results in individuals with a mixture of genetic information from two parents. These individuals show more variation than offspring from asexual reproduction. Sexual reproduction gives rise to variation because:

- the gametes are produced by meiosis
- when gametes fuse, one of each pair of alleles comes from each parent
- the alleles in a pair may vary and therefore produce different characteristics

New plants or animals may be produced by cloning or sexual reproduction. There are biological advantages and disadvantages to each of these methods.

Cloning	**Sexual reproduction**
Single parent	Two parents
Cloning makes copies with the same genetic information using mitosis / asexual reproduction	Uses meiosis / sexual reproduction to form offspring that are different
No variation in the offspring. Cloning produces large numbers of identical offspring quickly.	Variation in offspring**.** It takes time to produce large numbers of offspring.
Since the offspring are genetically identical any desirable characteristics are retained. BUT since the offspring are genetically identical, any undesirable characteristics or weakness will be seen in <u>all</u> offspring, eg lack of disease survivability.	Since the offspring are genetically different, some desirable characteristics may be lost BUT since the offspring are genetically different, new desirable characteristics may arise, eg. They might have different disease survivability.

Genetic engineering

Genetic engineering involves the transfer of foreign genes into the cells of animals or plants at an early stage in their development so that they develop with desired characteristics.

Genes from human chromosomes can be ‘cut out’ using enzymes and transferred to bacterial cells. The transferred gene continues to be expressed in the bacterial cell making the same protein in a bacterial cell. By culturing the genetically engineered bacteria on a large scale, commercial quantities of the protein can be produced. This process is used in the manufacture of vaccines, drugs and hormones, including human insulin.

Some genetic diseases may be treated by genetic modification of human cells. Non-reproducing, genetically-engineered viruses may be used to introduce a functional gene into such cells, e.g. the treatment of cystic fibrosis.

Genes can also be transferred to the cells of animals or plants at an early stage in their development so that they develop with desired characteristics.

Transgenic animals are animals which carry genes from humans and other species. New drugs can be developed by creating transgenic sheep and cattle that carry genes for human proteins that are produced in their milk. **Transgenic plants** may carry genes introduced from fish living in Artic waters, introduced to help the plants be frost resistant.

Applications of genetic engineering include making human **growth hormone**, producing varieties of pest **resistant crop** and making blood clotting factor (for treating **haemophiliacs)**.

There may be **economic**, **social** and **ethical issues** concerning cloning and genetic engineering, eg long-term evolutionary problems such as production of seedless fruits. Genetic engineering (also known as *genetic manipulation* / *GM* is not the same as **cloning**. Cloning techniques are after genetic engineering to produce more copies of the GM individual.

Selective breeding

Selective breeding involves selecting the parents with desired traits, crossing them, selecting from their offspring, and then repeating the process over several generations.
We can use artificial selection to produce new varieties of organisms. We choose individuals which have characteristics useful to us and breeding from them. Selective breeding has resulted in varieties of plants and breeds of animals that have increased yields (eg cow producing more milk, or a sheep producing more wool) or better qualities (eg cow with leaner meat).

Disadvantages: Selective breeding greatly reduces the number of alleles in a population. Widespread use of clones in agriculture also reduces the number of alleles available for further selective breeding. Selective breeding to produce new varieties for changed conditions may not then be possible.

How selective breeding be used to produce a new pure-breeding variety of dog.

The desired characteristic is selected. Individuals with this characteristic are bred together. Any offspring with the desired characteristic are chosen to breed. Breeding is done over many generations until population is pure breeding – that is, only homozygous dogs are born.

Cloning

A clone is a large number of cells which all originate by division of a single parent cell. All the cells in a clone are genetically identical.

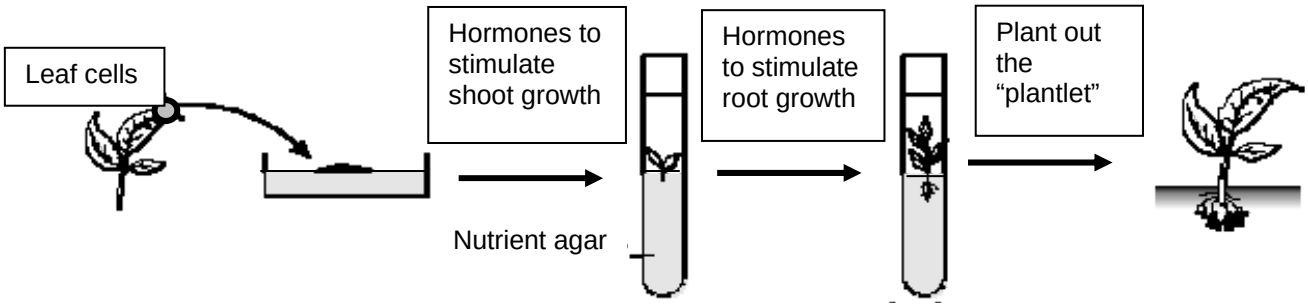
Cloning is a process whereby plants or animals can be copied exactly. Cloning can make genetically identical plants or animals. Usually only identical twins in animals, or cuttings in plants, are genetically identical.

New plants can be produced quickly and cheaply by taking cuttings from older plants. These new plants are genetically identical to the parent plant.

Cloning may be used for the mass production of genetically-engineered cells in fermenters.

Modern cloning techniques include:

- **tissue culture,** Small samples of plant tissue (called "explant") are grown on agar plates. The plant tissue is separated into individual cells, each grow into a mass of cells called a callus. If the correct plant hormones are added these can develop into whole plantlets, which can eventually be planted outside, where they will grow into normal-sized plants. Conditions must be kept sterile to prevent infection by microbes.



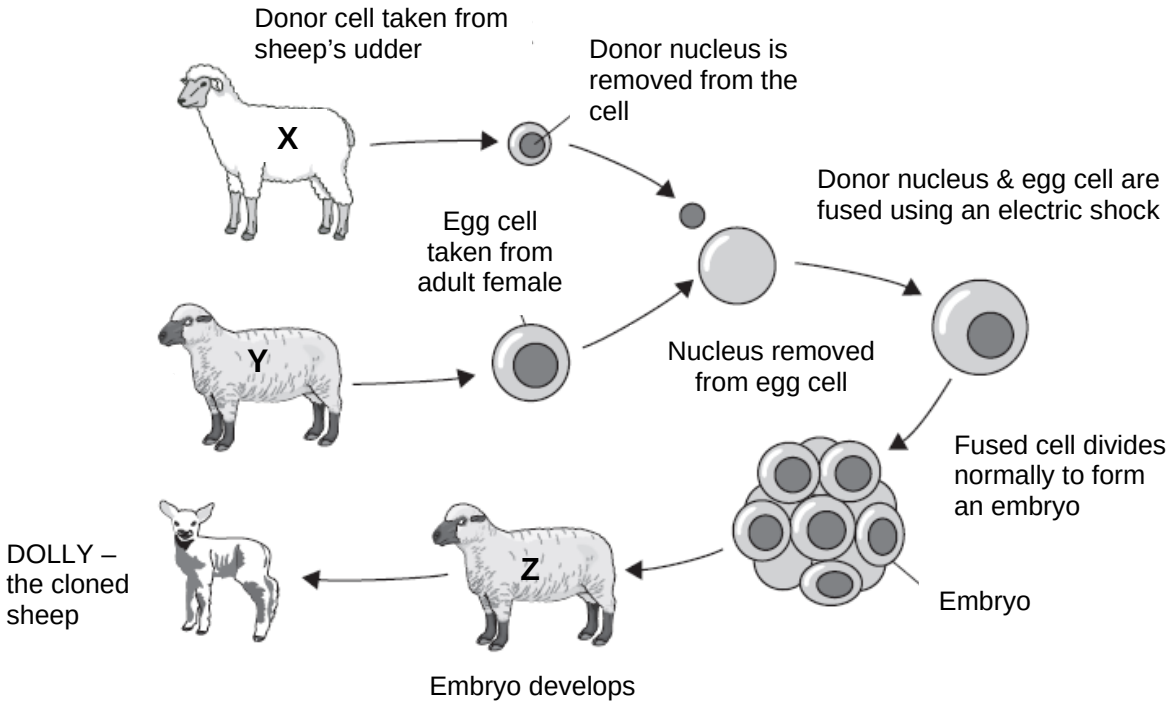
Advantages of tissue culture

- grow many new plants quickly
- don't need much space & can easily control the environment
- all offspring inherit the same desirable characteristics

Disadvantages of tissue culture

- no new beneficial characteristics will occur by chance
- gene pool (genes and gene variations in a population) is reduced
- all plants have same genes and so are equally susceptible to same diseases or pests

- **embryo transplants** - splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers.
- **transplanting a donor cell** (eg from sheep X) into an evacuated* egg cell (from sheep Y) and transplanting it to a surrogate mother (sheep Z). Dolly, is a clone of sheep X.



*evacuated – nucleus removed from cell

There are many "fors" and "againsts" especially for cloning animals – these may be **economic, social** and/or **ethical issues.**