OCR (A) Biology A-level

Topic 6.2: Cloning and biotechnology

Notes

Biotechnology is the **industrial use of living organisms**, **or parts of living organisms**, to produce **food, drugs or other products**.

Natural cloning

An example of **plant natural cloning** is **vegetative propagation**. It is a form of **asexual reproduction** where the offspring is genetically identical to the parent. It occurs when a plant body part is **separated, and then develops into a new plant**. For instance, the **English Elm** is adapted to asexual reproduction in case of damage - it can be propagated by removing **suckers from the tree** during autumn and subsequently **growing them in a nursery bed**.

Plant cuttings are an example of a **simple cloning technique**. A section of the stem is cut **between the leaf and nodes**. The cut end is then **encouraged to grow with the use of plant hormones.**

Examples of **natural clones in animal species** include the **formation of twins by embryo splitting.**

Artificial cloning

An example of **artificial plant cloning** is **tissue culture** where an **explant** is taken from the shoot tip of the plant to be cloned and placed on a **nutrient rich growth medium**. The cells in the tissue divide by **mitosis** to form a **callus,** but do not differentiate. After a few weeks, single callus cells can be **re**moved and placed on a growth medium containing **plant hormones and plant regulators to stimulate shoot growth**. The shoots are then transferred to **growth medium** after another few weeks, and eventually the **growing plants are moved to a greenhouse** where they can be **acclimatised**.

Other examples of artificial plant cloning include micropropagation. Firstly, a **callus** is produced by **placing the explants in a nutrient rich medium**. Subsequently, the callus is transferred to another medium containing the **essential growth regulator**s. After a **plantlet** is formed, it is **acclimatised**. Micropropagation is **commercially used to produce plants** which are **difficult to grow from seed, or have been genetically modified.**

Advantages of artificial plant cloning include the fact that a large number of plants can be produced easily and independently of the season or weather. Disadvantages include the **lack of variation** as the plants are **genetically identical**, meaning that they wouldn't respond well to changes in conditions or attack of pathogen. Moreover, it **is harder to grow plants** this way than it is to sow seeds.

Methods of **artificial cloning in animals** include:

- **Nuclear transfer** where offspring **genetically identical** to the parent is produced. It occurs as following: a **differentiated cell is taken from the parent and fused with an enucleated egg cell** of another individual of the same species. The cell then divides and is **implanted into the womb of a surrogate mother**.

- **Embryo splitting** where **cells from a developing embryo are separated** to produce two genetically identical organisms

Advantages of artificial animal cloning include the fact that animals such as cows which are of benefit to humans can be **cloned quickly.** Moreover, artificial cloning can be used to **preserve an endangered species**. Disadvantages include the fact the **lack of genetic variation, uncertainty whether cloned animal will be of good health in the long term** and concerns about the **welfare of animals.**

The use of microorganisms

Microorganisms are used in biotechnological processes because of various reasons:

- They are **easy to grow as they grow rapidly**, grow well at low temperatures and are not climate dependent. Apart from this, they can be grown on materials which are otherwise of no use to humans
- They can **be genetically engineered to produce desired products**, which often are purer than those produced in chemical processes
- Microorganisms are used in processes such as **brewing, baking, cheese making, yoghurt production, penicillin production, insulin production and bioremediation**

Microorganisms can be grown in two types of culture, a **pure culture** which initially only contains a single microorganism, whereas a **mixed culture** is a mix of different species.

The growth curve of a microorganism in a closed culture has various distinct features:

- The first phase of microorganism growth is the **lag phase** where microorganisms are **adjusting to the environmen**t before starting to reproduce, thus meaning during the lag phase the population **remains constant**.
- The next part of the growth curve is the **log phase** where the population size grows **exponentially** meaning that **every round of division doubles the population size**, so long as the dividing organism has a **sufficient amount of nutrients**.
- The stationary phase is where the population size reaches its **maximum due to decreasing nutrient level**s and build of up **toxic substances**.
- The stationary phase is followed by a **decline phase** where lack of nutrients and increase in toxic products causes **death of organisms**.

Culturing microorganisms

In **batch culture**, the **fermentation** is carried out in a **closed fermenter**. The microorganisms and nutrients are added and then left to grow for a particular period of time. No further nutrients are added, and products are removed at the end of the period. Whereas continuous culture takes places in an open fermenter, where nutrients are c**ontinuously added and products are removed at a steady rate.** Even though the batch culture is easier to set up and maintain than the continuous culture, the growth rate isn't as fast.

However, in the case of **contamination of batch culture**, only a single batch is lost whereas in the case of continuous culture, it can lead to huge amount of product lost.

To **maximise the yield of product**, the t**emperature needs to be maintained at the optimum** with a **sufficient nutrient supply** and the **aerobic conditions** to prevent the formation of undesired products through anaerobic respiration. The **pH needs to be kept constant** to ensure that the **enzyme activity is not altered**.

It's important for the microorganisms to be manipulated under **aseptic conditions**, where **unwanted organisms are absent**. In the case where unwanted organisms are present, the medium is said to be contaminated. This is undesired as **contaminants compete with the culture for nutrients and spac**e, thus reducing the **product yield**. Some contaminants might produce **toxic chemicals**, thus **destroying the culture microorganisms and the products.**

Enzyme immobilisation

Methods of **enzyme immobilisation** include:

- **Adsorption** where enzyme bind to a support through **hydrophobic and ionic interactions**
- **Covalent bonding** where enzymes covalently bind to a support with the help of a **cross linking agent**
- **Entrapment** – enzymes are trapped in a **semi-permeable material** such as gel beads which allows the passage of substrate and product only
- **Membrane separation** – partially permeable membrane serves to **separate the enzymes from the substrate**

Examples of **immobilised enzymes in biotechnology** include: **glucose isomerase** for conversion of glucose to fructose, **penicillin acyclase** for the formation of semi-synthetic penicillins, **lactas**e for the hydrolysis of lactose to glucose and galactose, **am**inoacyclase for production of pure samples of L-amino acids, **glucoamylase** for the conversion of dextrins to glucoe, **nitrilase** for the conversion of acrylonitrile to acrylamide for use in the plastics industry.

Using immobilised enzymes can be advantageous due to the product not being contaminated with enzyme therefore removing the need for filtering/purification. The enzymes are also less susceptible to the effect of temperature.