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A2 Biology OCR

Unit F215: Control, genomes and environment

Module 2.1 Cloning in plants and animals

Notes & Questions

Outline the differences between reproductive and non-reproductive cloning.

- **A Clone**
 - A cell or an entire organism that is genetically identical to another. Usually derived from the same DNA.
 - Derived from mitosis
 - Produced by asexual reproduction

- **Reproductive Cloning**
 - Reproductive cloning is a technology used to generate an animal that has the same nuclear DNA as another currently or previously existing animal.
 - Dolly was created by reproductive cloning technology.

- **Non-reproductive Cloning (Therapeutic cloning)**
 - Therapeutic cloning is the production of human embryos for use in research. The goal of this process is not to create cloned human beings, but rather to harvest stem cells that can be used to study human development and to treat disease.
 - Stem cells are important to biomedical researchers because they can be used to generate virtually any type of specialized cell in the human body.
 - Many researchers hope that one day stem cells can be used to serve as replacement cells to treat heart disease, Alzheimer's, cancer, and other diseases.

- **Cell potency**
 - Totipotent
 - Cells that can divide into all types of cells
 - Can form a new organism from totipotent cells
 - Pluripotent
 - Cells that can divide into many types of cells
 - Can produce any adult cell but not a new organism
 - Multipotent
 - Cells that can divide into a few types of cells
 - E.g. Hematopoietic cell can become any type of blood cell
 - Unipotent
 - Cells that can only divide into one type of cell

Describe the production of natural clones in plants using the example of vegetative propagation in elm trees.

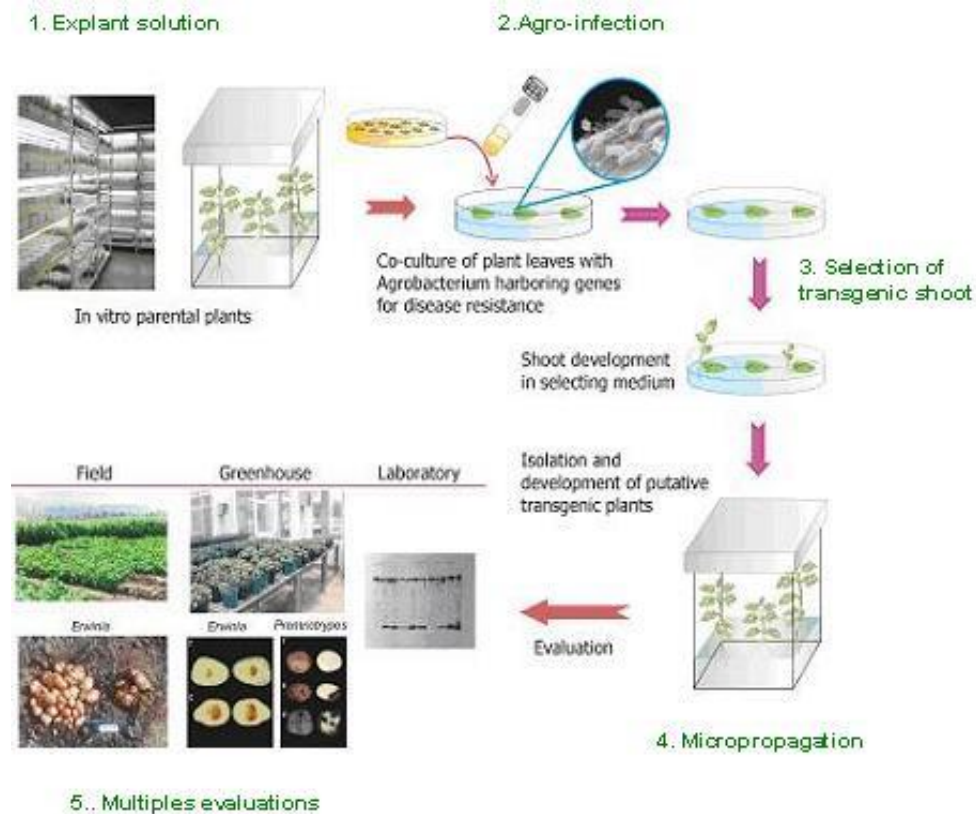
- **Vegetative propagation**
 - Production of structures which grow into new individuals = clones
 - Examples: strawberry plant runners, spider plant runners & English Elm tree basal sprouts.
 - The English Elm tree (*Ulmus procera*)
 - New elm trees grow from root suckers (basal sprouts) in an area called a clonal patch



- **Benefits**
 - Root suckers allow faster growth of new elm tree in habitat after felling/death of parent tree
 - Out competes competition from other species as a good root system is already established
- **Drawbacks**
 - No genetic variation
 - Problem when faced with Dutch Elm Disease
 - Fungal disease that withers leaves and kills trunk and branches
 - Carried on beetles.

Describe the production of artificial clones of plants from tissue culture.

- **Vegetative propagation**
 - **Cuttings**
 - Cut a growing shoot 5cm from tip at an angle
 - Dip into rooting powder and plant
 - Make new established plants quickly
 - **Grafting**
 - Taking a cutting from one plant and grafting it onto the stem of another.
 - Allows the features of both plants to be available
- **Micro-propagation (Tissue Culture)**
 - Large scale cloning by separating cells and growing them on a growth medium
 - **Tissue culture procedure**
 - meristematic/pluripotent/totipotent/cambial/undifferentiated, tissue;
 - Explant cut from growing shoot
 - sterile conditions;
 - aseptic technique;
 - prevent, growth of / contamination by, bacteria / fungi;
 - could overwhelm / grow faster than / compete with, plant tissue;
 - nutrient medium to encourage, division/mitosis;
 - sucrose ; amino acids ; vitamins ; ions / named ions ; water ; agar ;
 - produces callus;
 - callus subdivided;
 - different (nutrient) medium to encourage differentiation;
 - cytokinins stimulate, shoot / stem, growth / many branches;
 - detail of either medium;
 - auxins stimulate growth of, root / root hairs;
 - grows to plantlet;
 - hardening medium/sterile soil;



Discuss the advantages and disadvantages of plant cloning in agriculture.

- **Advantages**

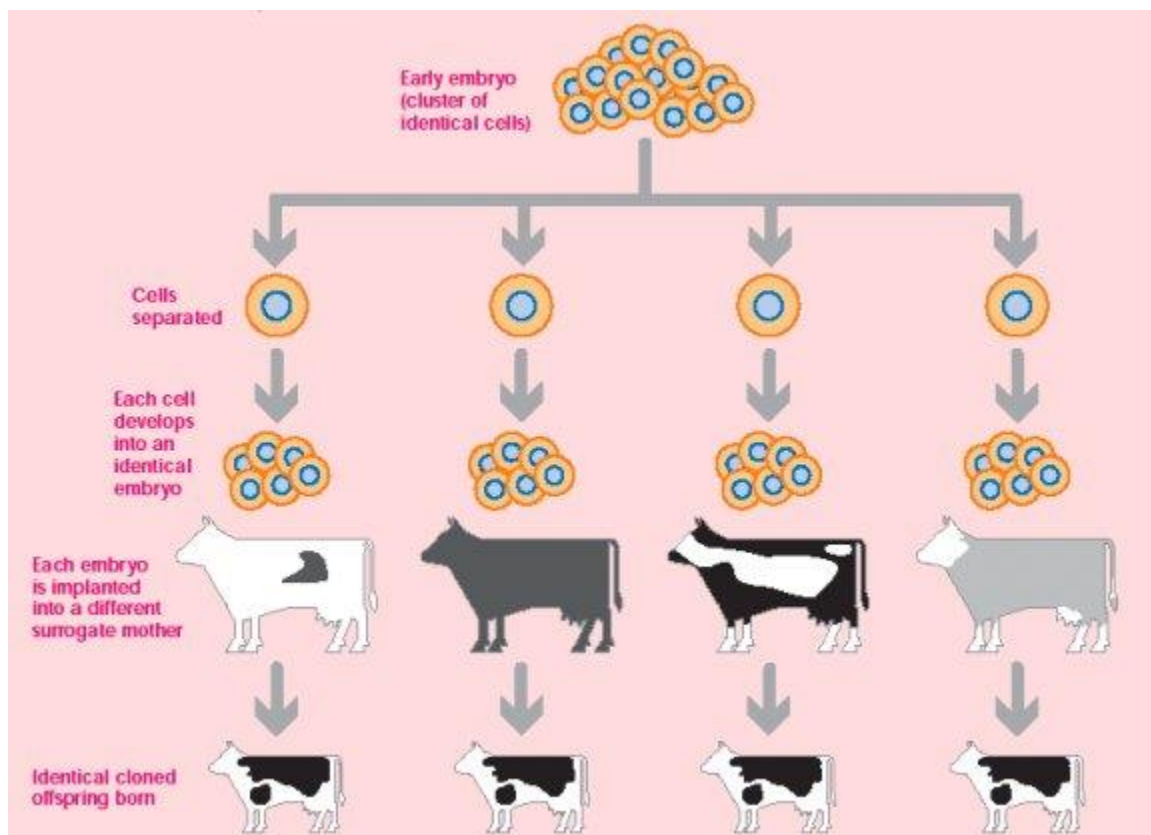
- Many plants with desired feature, do not need to keep genetically manipulating plants each time
 - Pest, drought, weed resistance etc
- Shorter generation time
- Only requires small parts of plants

- **Disadvantages**

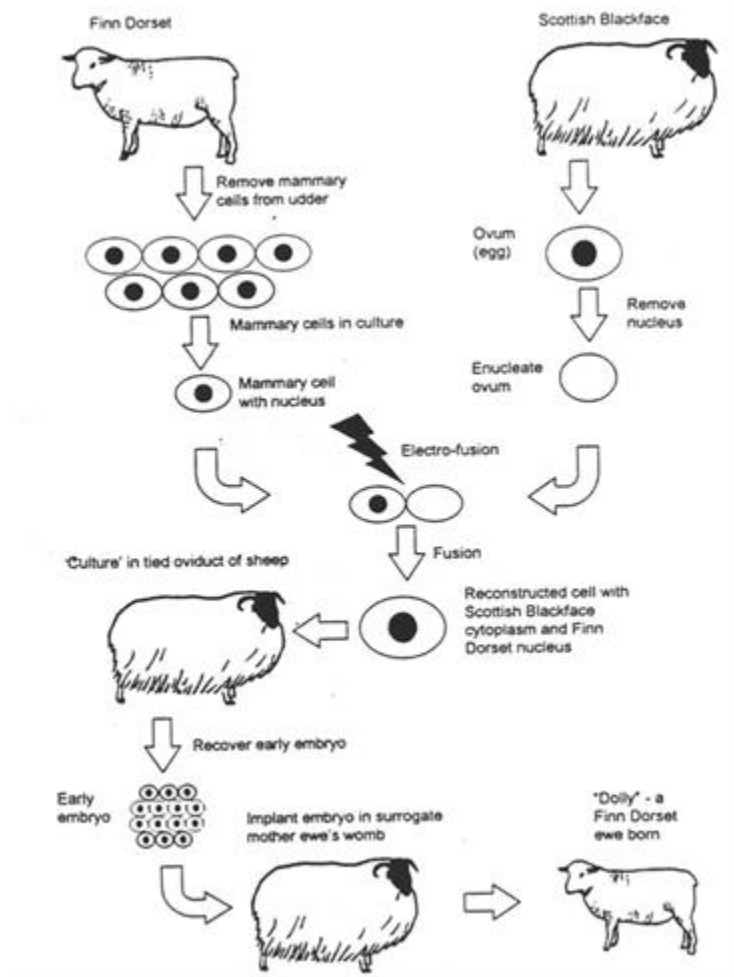
- Genetic uniformity
- Requires lots of skilled staff & Labour intensive
- Requires sterile conditions
- Requires expensive equipment

Describe how artificial clones of animals can be produced.

- **Artificial Animal Clones**
 - There are two methods of cloning animals
 - **Splitting embryos** – Artificial identical twins
 - Sperm & eggs collected
 - In vitro fertilisation
 - 16 celled embryo cells (totipotent) is split into several separate segments
 - Implant each cell bundles into a separate surrogate mother.



- **Nuclear transfer** – using enucleated egg
 - Adult cells removed
 - Nucleus removed and inserted into a donor enucleated egg cell using electrofusion
 - The recombinant egg cell is inserted into the uterus of a surrogate mother
 - After a few stages of development the early embryo is removed and inserted into a second surrogate mother
 - Embryo develops into a fetus is born
 - The new born is genetically identical to the nuclear DNA of the original adult
 - It is important to note that the mitochondrial DNA will not be the same and will in fact be the same as the donor who donated the egg cell.



Discuss the advantages and disadvantages of cloning animals.

- **Advantages**
 - High value animals can be produced in large numbers
 - Rare species can be cloned to preserve the species
 - Genetically modified animals can increase in numbers quickly
 - E.g sheep that produce pharmaceuticals in their milk

- **Disadvantages**
 - Genetic uniformity
 - May overlook animal welfare
 - Long term health effects unknown

- **Advantages of therapeutic cloning**
 - No rejection of transplanted organs
 - No waiting on donor lists
 - Can replace tissues/organs currently not possible
 - E.g. spinal cord/nerves/heart
 - Less traumatic than major surgery

Questions

1.

Plants from a different species of coffee plant, *C. canephora*, have been genetically engineered to have a low caffeine content by suppressing the activity of caffeine synthase.

Describe **one** advantage and **one** disadvantage of producing coffee plants with inactive caffeine synthase by genetic engineering rather than by selective breeding.

advantage

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[2]

disadvantage

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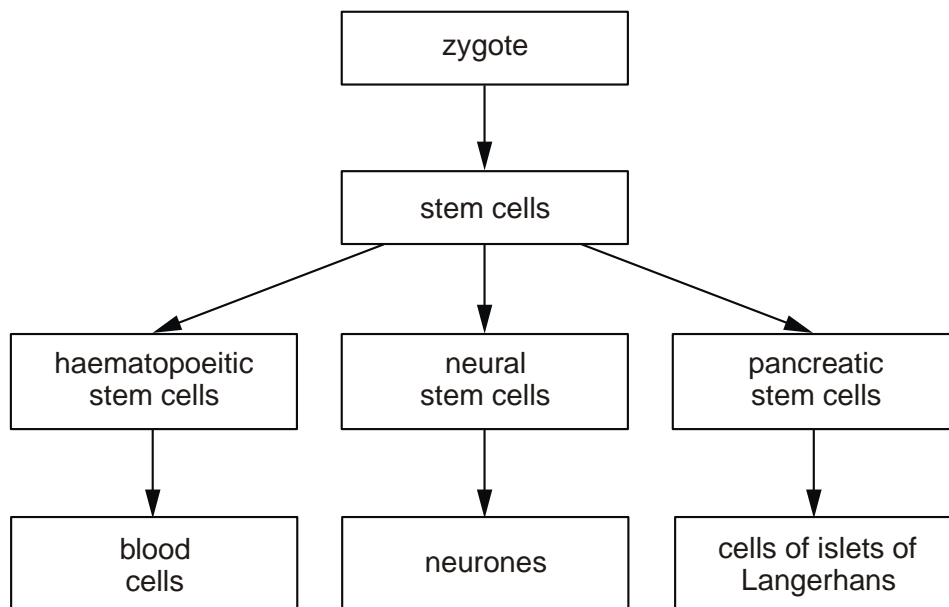
[2]

[Total 4 marks]

2

A human zygote divides to produce stem cells. Stem cells have the ability to develop into any cell type, in a similar way to meristematic cells in plants.

The figure below shows development of three cell types from human stem cells.



5.2.1

There are many potential medical uses of stem cells from human embryos. One potential use is to make cells of the islets of Langerhans for transplantation, as a treatment for diabetes mellitus.

(i) Suggest **one** ethical objection to the use of stem cells from human embryos.

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[1]

(ii) Suggest **two** other medical conditions which could be treated using the embryonic stem cells shown in the figure.

1

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2

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[2]

[Total 3 marks]

3

In 2004, researchers at the coffee gene bank in Brazil found three plants of *C. arabica* from Ethiopia with a very low caffeine content thanks to a mutation in the gene for caffeine synthase. It is hoped that the three plants may be cultivated to produce a commercial variety. This process might be speeded up by the use of cloning using tissue culture.

Outline the main steps involved in cloning plants using tissue culture.

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[Total 5 marks]

- (a) A great deal of tropical rainforest has been destroyed as trees are cut down to make way for agriculture and also for the wood that they yield. Replanting the rain forests might take 100 years so scientists are using other techniques to speed the process.

They are able to take cuttings from rainforest trees and then to clone them. The clones are from trees best suited to restore the rainforest and are attractive to foresters because of their rapid growth. Cloned trees are planted and grow far more quickly than saplings grown from seed.

- (i) Explain the meaning of the term *clone*.

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[2]

- (ii) State **two** advantages of using clones instead of saplings grown from seed.

1

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2

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[2]

- (iii) Each cutting is given a coating of auxin on its cut surface before it is planted in a rooting medium. This encourages the rooting process.

State **two other** commercial uses of auxin.

1

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2

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[2]

- (iv) Auxin stimulates the growing roots to develop root hairs. These are projections from specialised epidermal cells.

Explain in detail why it is important for the cuttings to develop root hairs.

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[4]

- (b) Micropropagation has been used to produce clones of some pine trees. New plants are grown by culturing tissues from trees with high productivity. The tissues from the trees are grown in artificial conditions in a culture medium.

List **three** constituents of the culture medium.

1
2
3

[3]

- (c) One disadvantage of micropropagation is that it can be more expensive than traditional methods.

Suggest **three** factors which may contribute to this extra cost.

1
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2
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3
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[3]

- (d) Name **one** technique for producing clones of trees, other than taking cuttings, or micropropagation.

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[1]

[Total 17 marks]