6.3 Variation, breeding, engineering and cloning

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS variation • natural selection • vector • inbreeding

Objective

Explain variation and natural selection, selective breeding, genetic engineering and the four cloning methods. Original questions for spec statements 4.6.2.

1 Key knowledge and worked examples

Variation – differences between individuals of a population – has three causes: the **genes inherited** (genetic), the **conditions of development** (environmental), or a **combination**. All variants arise from **mutations**: most have no effect on the phenotype, some influence it, very few determine it. A mutation giving a **new phenotype** suited to a changed environment can change a species relatively rapidly.

Evolution by natural selection, step by step:

1. a population shows **extensive genetic variation**;
2. individuals whose phenotype is **best suited to the environment** survive and breed;
3. the useful alleles are **passed on** to the next generation, so the inherited characteristics of the population change over time;
4. if two populations become so different that they cannot interbreed to produce **fertile offspring**, two new species have formed (speciation).

Selective breeding (artificial selection): choose parents with the desired characteristic from a mixed population → breed them → select the best offspring → repeat for many generations. Uses: **disease-resistant crops**, animals with **more meat or milk**, dogs with **gentle natures**, **large/unusual flowers**. Risk: **inbreeding** – breeds prone to disease and inherited defects.

Genetic engineering modifies the genome by inserting a **gene from another organism** – GM crops (insect- or herbicide-resistant, increased yields) and bacteria making **human insulin**.

(HT) Steps: enzymes **isolate** the required gene → gene inserted into a **vector** (bacterial plasmid or virus) → vector inserts the gene into the required cells → transfer early in development so the organism develops with the desired characteristic.

(Bio) Cloning:

- **tissue culture** – small groups of plant cells grown into identical new plants (rare species, nurseries);
- **cuttings** – simple gardeners' method, many identical plants;
- **embryo transplants** – split an early animal embryo before specialisation, transplant identical embryos into host mothers;
- **adult cell cloning** – nucleus removed from an unfertilised egg → nucleus from an adult body cell inserted → **electric shock** starts division → ball of cells placed in the womb.

Worked example (4 marks). Explain how a population of bacteria became resistant to an antibiotic.

Random mutation produced a resistant variant; the antibiotic killed non-resistant bacteria – a selection pressure; the resistant bacteria survived and reproduced rapidly; so the resistant allele's frequency rose in the population over generations.

2 Practice

2.1 Give the three causes of variation in a population. [3]

2.2 Order the steps of selective breeding. [1]

2.3 *(HT)* In genetic engineering, what is the vector, and name two kinds used? [3]

3 Exam-style questions

3.1 Explain how evolution occurs by natural selection, using a population of rabbits in a cold winter. [4]

3.2 *(Bio)* Describe how adult cell cloning produces an animal, in order. [5]

3.3 *(HT)* Insulin for diabetes used to come from pigs. Describe how human insulin is now produced by genetic engineering of bacteria, and give one benefit and one concern. [6]

Solutions

2.1 Genes inherited; conditions in which the individuals developed; a combination of genes and environment.

2.2 Choose parents with the desired characteristic, breed them, select the best offspring and breed those – repeated over many generations.

2.3 The carrier that transfers the gene into the cells; a bacterial plasmid; a virus.

3.1 The rabbit population shows variation in fur thickness – a genetic variant; in the cold winter, rabbits with thicker fur are better suited to the environment and are more likely to survive to breed; they pass on the alleles for thicker fur; over generations the population's inherited characteristics change – evolution by natural selection.

3.2 The nucleus is removed from an unfertilised egg cell; the nucleus from an adult body cell (e.g. skin cell) is inserted into the egg cell; an electric shock stimulates the cell to divide and form an embryo; the embryo cells contain the same genetic information as the adult skin cell; once a ball of cells, the embryo is inserted into the womb of an adult female to develop.

3.3 The human insulin gene is cut out using enzymes; it is inserted into a vector – a bacterial plasmid or virus; the vector transfers the gene into bacterial cells; the bacteria are grown in large fermenters and produce human insulin, which is harvested and purified. Benefit – an exact match to human insulin, so it works better/no rejection, unlimited supply, no pigs needed. Concern – ethical objections to transferring genes between species; possible effects if engineered genes spread – accept a justified risk or objection.