Part D: Applied Genetics

Selective breeding has been used for thousands of years to improve the characteristics of the organisms we find useful. Individual organisms with favourable characteristics have been bred together in the hope that the favourable characteristics are passed onto the next generation. Other individuals with less favourable characteristics are not encouraged to breed – resulting in fewer offspring with the less favourable characteristics being produced.

Selective breeding results in reduced genetic diversity in the selectively bred population and a greater incidence of favourable characteristics than would be expected.

e.g. milk cattle increased quality and quantity of milk
maize plants increased protein or oil content of their kernels.

Genetic Engineering involves the direct alteration of an organism's genetic material using that of another. The process is used to cause the organism to produce specific desirable proteins. Bacteria and yeasts are commonly used in genetic engineering, largely due to the ease with which their genetic information can be altered.

e.g. Human Insulin production in bacterial cells.

(1) The gene responsible for insulin production is identified in the genetic material of a human somatic cell.
(2) Identified insulin gene is removed from the chromosome using an enzyme.
(3) Plasmid is extracted from a bacterial cell and is cut open using an enzyme.
(4) Human insulin gene is inserted into the plasmid and sealed using an enzyme.
(5) Altered plasmid is re-inserted into a bacterial cell and is copied within the cell.
(6) Cell grows and divides, copying the altered plasmid each time.
(7) Many thousands of altered plasmid bacterial cells produce the proteins necessary for human insulin.
(8) Human insulin is extracted from the cells and is packaged for use.

When a bacterial cell has its chromosome altered, we say it has been reprogrammed. Reprogrammed microbes are used by the pharmaceuticial industry to produce many of the substances necessary for modern medicine. Insulin and Human Growth Hormone are produced using genetic engineering methods.

The use of reprogrammed microbes has reduced the risk of disease and infection for those people who require the proteins for their continued good health. Previously, substances such as Human Growth Hormone and Insulin were extracted from animals or dead bodies. Both sources carried huge risks of infection to humans.

Genetic engineering produces a wide range of products in a short period of time. However, genetic engineering is expensive and there is the danger of releasing genetically modified organisms into the local environment.

Selective breeding and genetic engineering have their advantages and disadvantages. In the future both processes could have a vital role to play in making various products necessary for human life to continue as we know it.

Selective Breeding	Genetic Engineering
Indirect modification of organism's genotype – element of chance.	Direct modification of organism's genotype – change genotype to produce a specific product
Many years for a breed of cattle.	A few days for a bacterial strain.
Improved version of an existing organism is produced.	Organism with a new genotype is produced, completely different to previous organisms.