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A2 Biology Unit 5

Genetics

Some important terms

Using the example of tall (T) and short (t) pea plants, explain the meaning of the following terms:

- Gene
- Allele
- Phenotype
- Genotype
- Homozygous
- Heterozygous
- Gamete

Draw a diagram to illustrate the inheritance of height from a cross between a pure breeding tall plant and a pure breeding short plant. Trance two generations (F1 and F2)

Sex Linkage

When alleles are carried on the sex chromosomes they are said to be sex linked. Sex is inherited by whole chromosomes, not alleles. Complete the diagram below

	Male	female
	XY	XX
Gametes	X Y	X X
Offspring		

Example:

Haemophilia is caused by a recessive allele X^h which occurs only on the X chromosome. In the heterozygous condition X^HX^h the female is said to be a carrier. Queen Victoria was a carrier. Her husband Albert was normal. Draw a genetic diagram to show the possibilities of a normal, haemophiliac or carrier child being born to them.

Co-dominance and multiple alleles

- The human blood groups A, B, AB and O are determined by three alleles, I^O, I^A, and I^B. (multiple alleles)
- Alleles I^A and I^B are co-dominant, allele I^O is recessive.

Bearing in mind that a person can only inherit two alleles for the blood group gene, one form each parent.

a) list all the possible genotypes for these blood groups

b) draw a genetic diagram to show the possible results of a cross between parents of blood groups A and B.

Hardy-Weinberg principle of allelic frequencies.

Example cystic fibrosis

Allelic frequency = the number of times an allele occurs within the gene pool i.e. amongst all the genes of all the individuals of a population.

Each individual carries two alleles for each gene (one from either parent) so the total number of alleles of any gene in the population is 2 times the total no. of individuals.

The cystic fibrosis gene has three possible genotypes:
FF (unaffected), Ff (unaffected) ff (cystic fibrosis sufferer)

Hardy-Weiberg equations assume

- No mutations
- No transfer of alleles in or out of the population
- Completely random mating (no selection)
- The population is large

In any population, the total number of alleles is taken to be 1.0
Taking a gene with two alleles A and a, where the frequency of allele A is p and the frequency of allele a is q

$$p + q = 1.0$$

$$AA + Aa + aA + aa = 1.0$$

or $$p^2 + 2pq + q^2 = 1.0$$

Suppose 1 person in 20,000 individuals has the condition aa

What is the value of q?

What is the value of p? (you know that $p + q = 1.0$)

So how many carriers of allele a are there in the population?

Selection

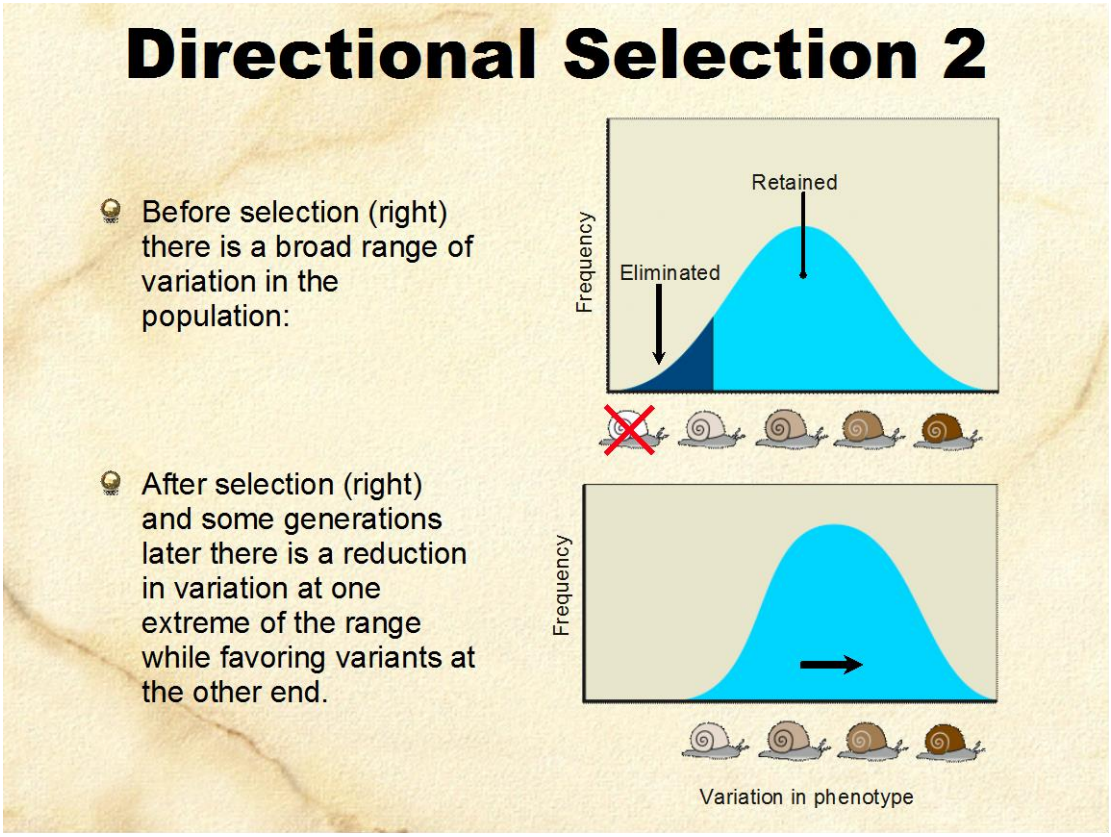
In practice, matings are not random and various environmental factors affect the success or failure of different alleles. Selection is any process which affects the **allelic** frequencies in a population.

Natural selection

- organisms produce many more offspring than ever survive to maturity
- within a population there is a **variety** of form (we now know that this is a product of random **mutations**)
- those organisms which survive to reproduce do so because they possess features which fit them better to survive predators, disease, extremes of climate, food shortage etc.
- offspring resemble their parents so tend to **inherit** the adaptive features and pass them on in turn to the next generation
- environmental (natural) factors thus select the fittest individuals from a population varying in form

Artificial selection occurs when the selective pressure and breeding process is controlled by humans e.g. farm animals, dogs and face horses.

Directional or stabilising selection?



Stabilising selection

Those individuals closest to the mean values of a particular characteristic are favoured by the selective pressures of the environment.

e.g. fur length in mammals. In hot seasons, the shortest fur length is favoured, in cold it is the reverse, but in average conditions selection favours an intermediate length.

Speciation

Definition: Speciation is the process by which new species arise from a common ancestor.

- The raw material for variation = **GENE MUTATION**
- This produces new **ALLELES** (variant of a gene, often due to a single base sequence change in the DNA code)
- The **GENE POOL** of a population is constantly expanding in this way as long as there is sufficient opportunity for outbreeding.

It is subject to the following two influences:

- **Natural selection:** (see earlier section) Different environmental pressures will tend to select individuals best suited to the changing conditions.
- **Genetic drift:** An entirely random process of genetic change over a number of generations due to the chance recombination of genes in the process of fertilisation.

Speciation depends on the different varieties within a population becoming isolated

Geographic isolation

Both of these processes operate most strikingly when an interbreeding population becomes separated by a river, mountain range or other natural barrier. The two isolated groups diverge from eachother over hundreds and thousands of generations to produces very different features.

Give three examples of geographic isolation

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Reproductive isolation

If the differences prevent interbreeding between the two groups then **speciation** occurs. Factors preventing reproduction include

- Changes in breeding season
- Changes in courtship behaviour
- Physiological changes preventing fertilisation, conception or implantation
- Structural / anatomical changes

Example:

The courtship behaviour of male fruitflies has several components. The diagram shows the courtship sequences of males from two closely related species of fruitfly.

Species A

Faces female - scissor swings - vibrates wings - licks female - mates

Species B

Faces female - scissor swings - licks female - mates

Suggest how the sequences provide evidence that

1. the fruit flies are separate species

2. the species are closely related