Preparatory Notes Unit 4

(please go over these before our visit and have them at hand during our visit)

1. CHANGE IN POPULATIONS

A. VARIATION

The variations we see in the phenotypes of individuals of any single species or population can be quite spectacular. Look around a group of Homo sapiens and variation is evident immediately.

Remember PHENOTYPE = GENOTYPE + ENVIRONMENT

We can conclude that the genotype that is the DNA, of the individuals must be responsible for at least some of the variation we see.

TYPES OF VARIATION

Variation or diversity in a species increases the chances of a least some members of the species surviving environmental changes, natural disasters etc. The variation present in a population can be classified in several ways:

- Structural
- Behavioural
- Biochemical
- Developmental
- Physiological
- Geographical – different phenotypes in different locations - this variation can be due to environmental factors such as climate etc or genetic factors.

When members of a population show variation, the population is said to be polymorphic.

CAUSES OF VARIATION BETWEEN INDIVIDUALS

The sources of variation between individuals in a species or population can be due to genetic or environmental factors. In some cases, variation may be due to an interaction of both factors.

1. Inherited (genetic) factors

- **Recombination in meiosis**

The random assortment of homologous chromosomes during meiosis creates great variation. Every time gametes are produced from a parent diploid cell, new combinations of alleles are created. This is the greatest factor in variation. Crossing over and recombination of genetic material between homologous chromosomes also creates variation.

- **Random fusion of gametes**

With the large variation in gametes produced by both parents the random fusion of two adds to variation. This explains why brothers and sisters are not alike.

- **Mutations**

This is a process that produces new alleles of genes in various species. Point mutations occur when a nucleotide base and its pair are changed. This may cause the production of new and different proteins that affect the phenotype.

- **Changes in chromosome number**

Each species has a set number of chromosomes. Gain or loss can cause variation.

- **Variation due to one gene**

Example ABO blood groups. Discontinuous variation – members of a population can be arranged into a few discrete groups with respect to variation.

- **Variation due to polygenes.**

Example human height. Continuous variation – members of a population display a large amount of variation.

2. Environmental factors

External factors

- Nutrition
- Diseases
- Soil type
- Temperature
- Light
- Altitude

Internal factors

- Hormones
- Developing foetus

B. POPULATION GENETICS

A ***population*** of organisms is all the individuals of a species that live in a particular area at a particular time. There will be variation in the phenotypes of individuals within a population.

Population genetics is the study of allele frequencies in populations and the factors that change these frequencies.

Gene Pool

The gene pool can be defined as the total aggregate of genes, and all of their alleles, in a population at any one time. For a diploid individual, each gene locus is represented twice in the genome, and the two alleles may be the same (homozygous) or different (heterozygous). There may, however, be more than two alleles for a gene within a population's gene pool (eg the ABO blood groups in humans), although each individual can only have two of those alleles. Allele frequencies can vary from 0 (no one has the allele) to 1 (everyone has the allele). The total of all allele frequencies at one gene locus in a population is always 1.

Populations in Equilibrium

If a population of a species is stable and non-evolving, the composition of that population's gene pool is constant, since it is in equilibrium. This is known as the **Hardy-Weinberg Theorem** and it can be demonstrated mathematically to be true.
It is stated as follows:
No matter how many generations' alleles are segregated by meiosis and combined by fertilization, the frequencies of the alleles in the gene pool will remain constant unless acted on by other agents.

For this to be true, ***five conditions*** *must be met*:

1. The population must be very large.
2. The population must be isolated. There must be no migration of individuals into or out of the population.
3. There are no net changes to alleles due to mutations.
4. Mating is random.
5. All genotypes are equal in reproductive success.

Whilst these conditions can be approached in nature, they are never achieved for very long. Because the five conditions for Hardy-Weinberg equilibrium are seldom maintained for many generations, gene frequencies in gene pools do change. In other words the populations are evolving.

Factors affecting the gene pool equilibrium

Any factor, which upsets the equilibrium of a population, can cause variations in the predicted allele frequencies in later generations.

- **Genetic Drift**

Refers to random changes in allele frequencies in a population. This is due to chance. Occurs more when populations are small. Unpredictable.

- **Founder effect**

Occurs when a small population of individuals establishes in an area. The individuals in the new population are unlikely to have the same allele frequencies of the original parent population. The subsequent allele frequencies in the resulting new population can vary markedly from the original population provided they remain isolated.

- **Gene flow**

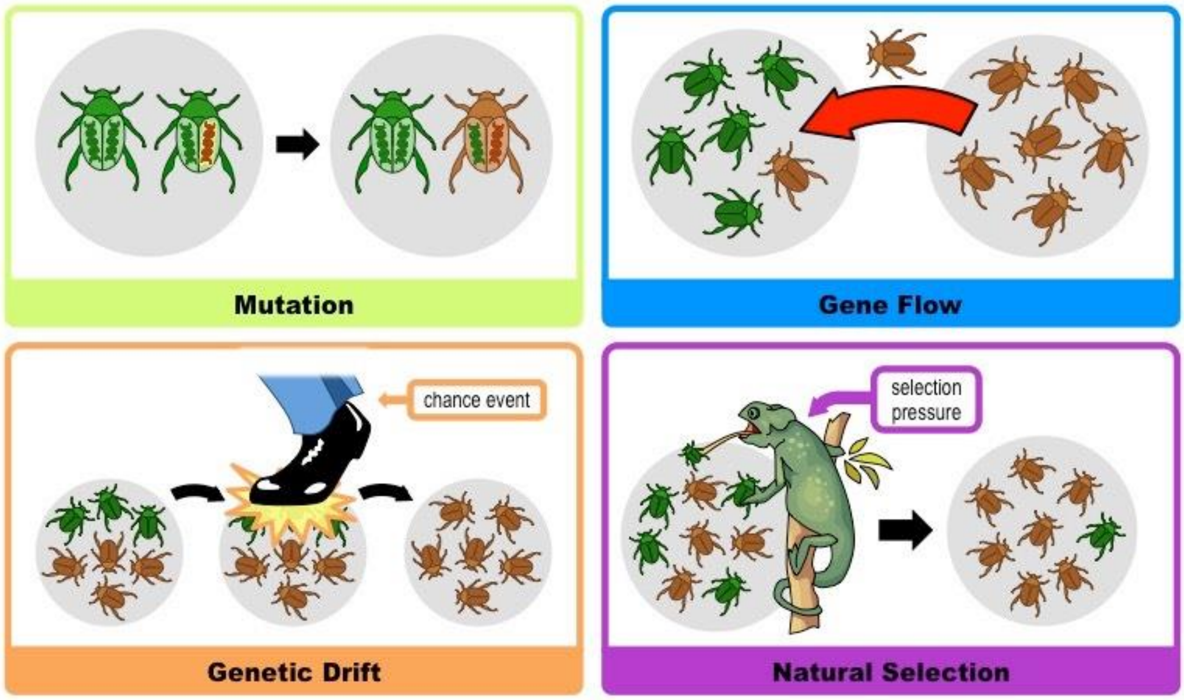
The movement of individuals into or out of a population can change allele frequencies. Migration refers to movement of individuals between populations. Since most populations are not entirely reproductively isolated, the population may gain or lose alleles by gene flow, the migration of fertile individuals or the transfer of gametes, between populations

- **Non - random mating**

The selection of mates is not random. Non-random matings are more common that one might first expect. In many populations, family groups stay within loose geographical boundaries within the larger group. This can lead to localised inbreeding and pockets of very different allele frequencies within the larger group.

- **Selection Pressures**

Allele frequencies can be changed by **natural selection**. Some phenotypes are better suited to particular environments so organisms that have the alleles for these phenotypes are better able to survive. Artificial selection in which organisms with particular traits are selected for breeding and others prevented from breeding changes allele frequencies.



2. NATURAL SELECTION

The genetic basis for natural selection is variation within population. Without variation within a population, there could be no natural selection - the population would either survive or die as minor environmental changes were encountered, since all members of the population would be genetically identical and all would be equally well or badly equipped to deal with the changes.

The frequency of an allele in a population can change as a result of a change in the environment. This is called natural selection. Darwin first proposed this and he stated that those organisms, which are best able to survive and breed, are most likely to pass on their characteristics to the next generation. This is often referred to as **Survival of the fittest**.

Natural selection is the differential success in reproduction of different phenotypes resulting from interaction of organisms with their environment. With time, natural selection causes changes in relative frequencies of alleles in the gene pool.

For Natural Selection to occur there must be:

1. Variation in the population
2. A selecting Factor
3. Survival of some individuals which are better suited i.e. survival of the fittest
4. Reproduction to pass on the characteristics to the next generation

STRUGGLE FOR SURVIVAL

All species have such great potential fertility that their population size would increase exponentially if all individuals born would eventually reproduce at their full potential. The fact is that populations are generally relatively stable in size, except for seasonal variation. A notable exception to this is the human population. We have all heard of the dire predictions facing Homo sapiens if population growth continues at the current world rate! What keeps populations constant? Why do some individuals survive? Why do many individuals die? The answers to these questions all help explain the struggle for survival, which occurs constantly in all populations of all species, including our own.

SELECTIVE PRESSURES

Selective pressures are those biotic and abiotic factors of the environment, which can influence the survival and reproduction of individuals, and ultimately of populations and species.

They include:

- **Competition for food, water, shelter, mates.**

The competition may be within the species or between species. The result is that not all individuals obtain equal shares of the resources, some survive, and some do not.

- **Migration.**

If populations outgrow or exhaust their resources, one solution for all or part of the group may be migration to a new location. This in itself may lead to many deaths during the journey, and may have a significant effect on population gene pools as previously discussed.

- **Geographical features.**

If natural events such as floods or earthquakes split a population, with or without killing many, the remaining population sub-groups may never recombine. This is a form of **reproductive isolation**. Over time, changes in the gene pools of each subgroup will occur, as described earlier. This can eventually lead to the evolution of new species.

SPECIATION

Species
A particular kind of organism; members of a species possess similar anatomical characteristics and have the ability to interbreed, producing vigorous (= healthy), virile (= able to reproduce sexually) offspring.

Two patterns of speciation can occur:

1. ***Phyletic evolution*** in which one population gradually changes over time to become a new species.
2. ***Branching evolution*** is when a population of one species splits, and one part of the population evolves separately to form a new species distinct from the original population. This usually involves **geographical isolation** and the populations may become **reproductively isolated** from each other.

Different selection pressures lead to different phenotypes being selected for and over time the two populations evolve different adaptations to these environments. As described earlier, this will almost certainly, over many generations, lead to changes in the gene pool of each sub-group. As these changes progress, random chance makes it highly likely that significant differences in phenotypes will develop in each group. For a while, breeding between groups will remain theoretically possible, if individuals were to meet and mate. Eventually, however, the accumulated changes in each group's gene pool would lead to a significant lack of homology at a number of gene loci. Viable offspring between the groups would now be impossible - the groups are no longer members of the same species and speciation has occurred.

When speciation occurs as a result of geographical isolation it is termed **allopatric speciation**.

Reproductive isolation can be due to:

- Differences in breeding seasons
- Differences in structure of genitalia
- Incompatible mating behaviours
- Gamete isolation

Speciation has been, and still is, occurring constantly since life began on Earth.

EXTINCTION

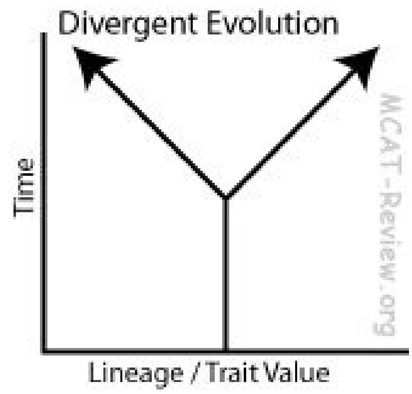
Sometimes environments change relatively rapidly. If the species, which live in those changing environments, are not lucky enough to already possess genes, which enable the species to survive in the face of such change, or if random mutations do not accumulate sufficiently quickly, all members of the unlucky species may die. This is extinction.

Extinction may be localised to one species in an ecosystem, often due to destruction of that species' habitat or it may widespread. The fossil record indicates that there have been at least twelve periods during the history of life on Earth where mass extinctions occurred. The two most extreme of these occurred about 250 million years ago (>90% of marine species died) and 65 million years ago (>50% of marine species, and many terrestrial species, including the dinosaurs died). Paleobiologists are still divided as to the explanations for these; asteroid collisions and global climate changes are currently the two leaders in the explanation stakes.

3. PATTERNS OF EVOLUTION

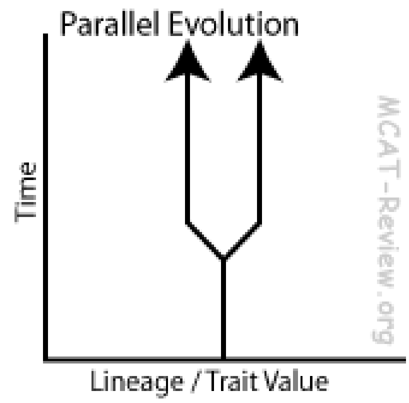
DIVERGENT EVOLUTION (ADAPTIVE RADIATION)

In DIVERGENT EVOLUTION one species (a common ancestor) splits into two, which become less and less alike over time due to different selection pressures. Evidence of descent from a common ancestor is often seen in homologous structures.



PARALLEL EVOLUTION

In PARALLEL EVOLUTION two related species arise from a common ancestor. The two species then evolve in much the same way over time, probably in response to similar environmental selection pressures.



CONVERGENT EVOLUTION

CONVERGENT EVOLUTION occurs when two groups that are not closely related come to resemble each other more and more as time passes. This is usually the result of occupation of similar habitats and similar environmental selection pressures.