LS2201

Evolutionary Biology

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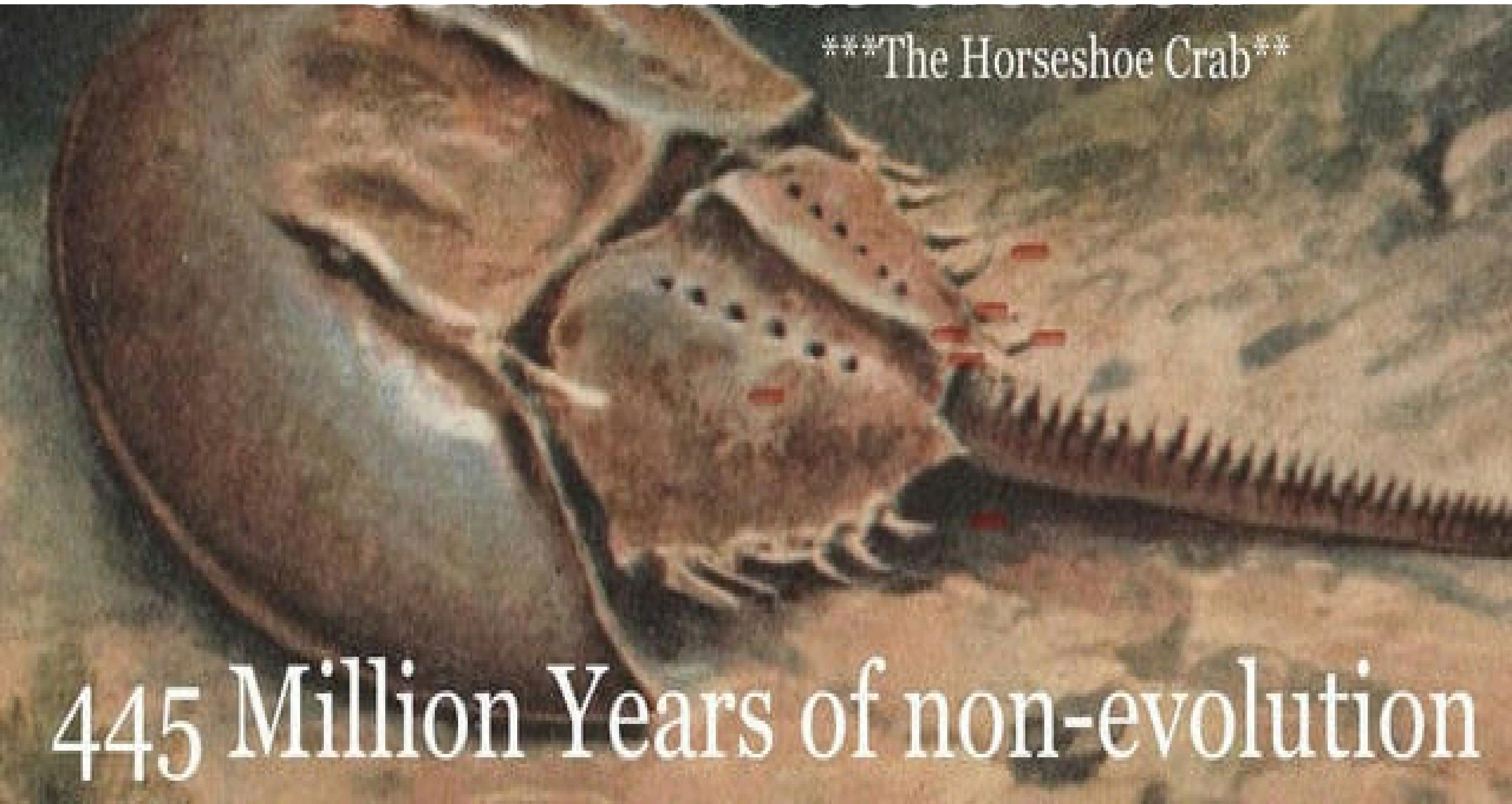

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1. Variation

Types of Variation

The genetic changes accumulated as a result of mutations and recombination give rise to genetic differences between the members of a population or species. This genetic variation leads to evolution, and small variations within a species often accumulate and give rise to large diversifications.

- What is phenotype?
  Phenotype refers to the pbservable characteristics or features in an individual, or a group of organisms that are similar (species).
- WHat leads to phenotypic variations?
  It is often the result of genetic variations(dfferent alleles at a single locus), or even environmental effects during development.

To determine the source of phenotypical variations, we usually use **crosses**:
Phenotypes can be experimentally crossed to produce Fl , F2 and backcross progeny. Mendelian ratios among the phenotypes of the progeny (e.g., 3:1 or 1:2:1) are taken as evidence of simple genetic control.
This is also what we usually refer to as *morphological variation*.

1.1.1.1 Continuous Variation

Variations are often classified as either *continuous* or *discrete*. WHat exactly do we mean by continuous variation? Essentially, continuous means, refers to a quantitative measure, as in individuals can range anywhere between the two extremes of populatio, with the majority of individuals faring in the centre.
Height is a classic example of continuous variation. Humans do not come in set heights; instead, there is a wide range of heights that people can be, from very short to very tall. It thus refers to a rane of small differences in a trait among individuals.

1.1.1.2 Discrete Variation

Discrete variation on the other hand, is seen in case of traits that are not *quantitative* in the sense, that they come in fixed classes. Human blood groups would be a good example of this kind of variation, as they are usually A, B, O, or AB, and never something in between.

1.1.1.3 Variation at the cellular level

Variations in an organism, at the cellular level can occur in three ways:

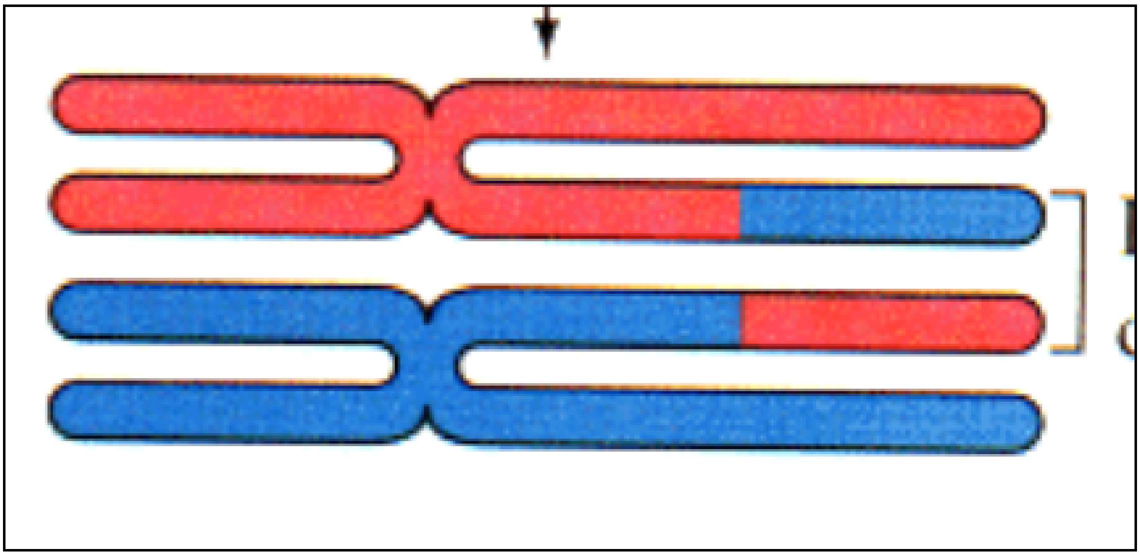
- Change in the number of chromosomes
- Changes in banding patterns (using Giesma stain, can be used to detect structural abnormalities in chromosomes)
- Changes in DNA sequences due to various sorts of mutations

Sources of Variation

Recombination, migration and mutation are the three sources of variation, broadly.

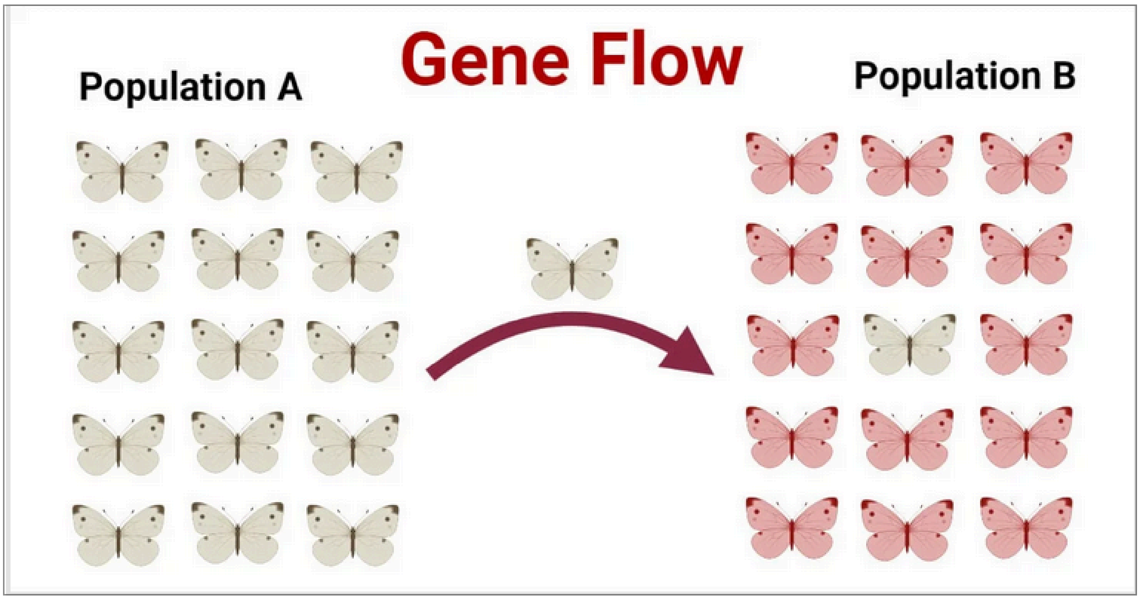
Recombination

1.During prophase I, homologous chromosomes pair up with non-sister chromatids to form a tetrad.
2. During pachytene, recombination happens when the breakage and rejoining happens between the non-sister chromatids at the chiasma.
3. This leads to changes in the chromosomes, forming recombinant chromatids.



Migrations

Gene flow – also called migration – is any movement of individuals, and/or the genetic material they carry, from one population to another. If genetic variants are carried to a population where they previously did not exist, gene flow can be an important source of genetic variation.



When the migrating individuals interbreed with the new population, they contribute their genes to the gene pool of the local population. This establishes gene flow in the population.

Mutations

Mutation is the only original source of variation in populations.
A **mutation** is a heritable change in the nucleotide sequence of an organism's DNA that ultimately serves as a source of genetic diversity.

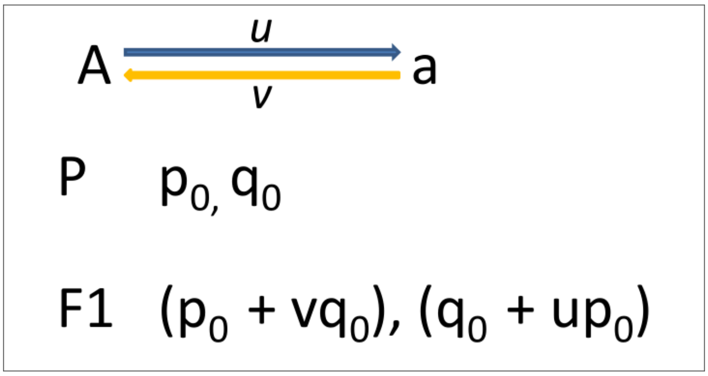
Mutations are Random

Mutations themselves, are random, and are caused due to inaccuracies in copying mechanisms of the cell; it is *natural selection* that selects cetain mutations for their advantages, and impose a direction on evolutionary change.

Gene frequency can be affected by the frequency of mutation.

Mutation Rates

Let us consider this case:



Gene exchange occurs between A and a, at rates *u* and *v* respectively.
As a result, change in the frequency of *a*:

$$\Delta q = up_0 - vq_0 \tag{1.1}$$

We conclude, that, if p_0 is high, Δq increases, **q increases rapidly**, and if q_o is high, Δq decreases and **q does not increase as fast**.

Mutational Equilibrium

The point at which Δq is zero, p and q are balanced in their mutation frequencies. This is called **mutational equilibrium**.

$$\begin{aligned} \Delta q = up - vq = 0 \\ \Rightarrow up = vq \text{ for some } q = q' \\ \wedge\ p = (1 - q), \Rightarrow u(1 - q`) = vq` \\ \Rightarrow q` = \frac{u}{u + v} \end{aligned} \tag{1.2}$$

Mutation and Evolution

All the genes within a species descended from a single ancestral lineage, which traces back into the distant past. Thus the rate at which two species diverge over time is equal to the rate at which their two ancestral lineages accumulate mutations.

1.2.3.2 Effects of Mutations

Neutral Mutations

Mutations in which natural selection does not affect the spread of the mutation in a species are termed neutral mutations.
Neutral mutations have no consequence in natural evolution, and do not cause any effect in the individual's survival.
One example of this is the degeneracy of amino acid codons.
Glutamine is coded for by both GAA and GAG – this is an example of neutral mutation. Most mutations that occur in organisms are not important in natural selection, but they can accumulate in populations due to random genetic drift.
For example, having two different colored eyes does not help or harm the organism's chance of survival so it would be considered a neutral mutation.

Founder Effect

Founder effect refers to the reduction in genomic variability that occurs when a small group of individuals becomes separated from a larger population. Over time, the resulting new subpopulation will have genotypes and physical traits resembling the initial small, separated group, and these may be very different from the original larger population.

For example, the 250 people making up the human population on the island of Tristan da Cunha, are mostly descended from one Scottish family who arrived in 1817.

Genetic Bottleneck

A small fraction of the original population survives due to a natural (or anthropogenic) disturbance. The surviving population grows and the final population has a different genetic distribution from the original population.

Both founder effect and genetic bottleneck leads to **genetic drift**, which is a random change in allele frequencies from one generation to another.