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EVOLUTION BY NATURAL SELECTION

Introduction

Key Terms

biological evolution	any genetic change in a population that is inherited over several generations
biological species	a group of organisms with similar characteristics that interbreed with one another to produce fertile offspring
population	a group of individuals of the same species occupying a particular habitat
punctuated equilibrium	evolution characterised by long periods of little or no change followed by short periods of rapid change
natural selection	mechanism of evolution - organisms survive if they have characteristics that make them suited to the environment
artificial selection	human-driven selective force, e.g. breeding of plants and animals to produce desirable traits
inbreeding	mating of individuals that are closely related
outbreeding	mating of individuals that are not closely related
speciation	the formation of a new species
geographic speciation	formation of a new species when the parent population separated by a geographical barrier
reproductive isolation	a mechanism that prevents two species from mating with one another and making fertile hybrids

Theory And Hypothesis

***A **theory** is an explanation of something that has been observed in nature which can be supported by facts, generalisations, tested hypotheses, models and laws.

***A **hypothesis** is a possible solution to a problem.

Evidence for evolution

Fossils	covered in Grade 10 • Different fossils are found in different rock layers with the oldest fossils in the oldest rock layers with transitional fossils present. • This systematic change through time is termed descent with modification. • The evidence shows characteristics that make organisms similar to one another largely from the study of fossils
Biogeography	covered in Grade 10 • Biogeography is the study of where species are found and why they are found there. • There are many different collections of plants and animals in regions of the same line of latitude, with similar climates and conditions, suggesting such organisms have a shared ancestor.
Genetics	new concept for Grade 12 – see below □ Species that are closely related have a greater genetic similarity to each other than distant species and therefore share a more recent common ancestor.
Homologous structures (modification of descent)	There is a similarity in the structure of the pentadactyl limb e.g. the flipper of a dolphin, the wing of a bird and the human arm. The bones, muscles and nerves are arranged in a similar way

VARIATION

*****Biological species**---- a group of organisms with similar characteristics that are able to interbreed and produce fertile offspring.

*****Population**---- a group of organisms of the same species found in the same habitat at the same time.

Causes of variation:

a) Meiosis

- **Crossing over** during Prophase I of meiosis involves an exchange of genetic material, leading to new combinations of maternal and paternal genetic materials in each new cell / gamete resulting from meiosis.
 - **Random arrangement of maternal and paternal chromosomes at the equator** during metaphase allows different combinations of chromosomes / chromatids to go into each new cell / gamete resulting from meiosis, making them different.
- b) A **mutation** changes the structure of a gene or chromosome and therefore the organism's genotype. Since the genotype influences the phenotype, it creates organisms with new, different characteristics from one generation to the next
- c) **Random fertilisation** between different egg cells and different sperm cells formed by meiosis result in offspring that are different from each other.
- d) **Random mating** between organisms within a species leads to a different set of offspring from each mating pair.

Continuous and Discontinuous Variation

Continuous variation	Discontinuous variation
1) Genetic features vary widely across a wide range e.g genes for height & skin colour	1) There are definite differences between characteristics with no stages in between e.g blood groups A, B, O & AB
2) There is an average value that is most common	2) There are no values in between e.g tongue rolling or non-tongue rolling

ORIGIN OF AN IDEA ABOUT ORIGINS/THEORIES OF EVOLUTION

NB: Ideas of evolution in the order of their origin are as follows:

- Lamarckism
- Darwinism
- Punctuated Equilibrium

LAMARCKISM (JEAN BAPTISTE de LAMARCK- 1744 – 1829)

NB: Lamarck used 2 'laws' to explain evolution:

- 'Law' of use and disuse
- 'Law' of the inheritance of acquired characteristics

The Law of use and disuse of organs/limbs/appendages

- An organ/limb which is used often, develops longer and stronger
- But one that is not in use any more (disused) will become vestigial (start to disappear)/reduced in size/less developed

The law of inheritance of acquired characteristics

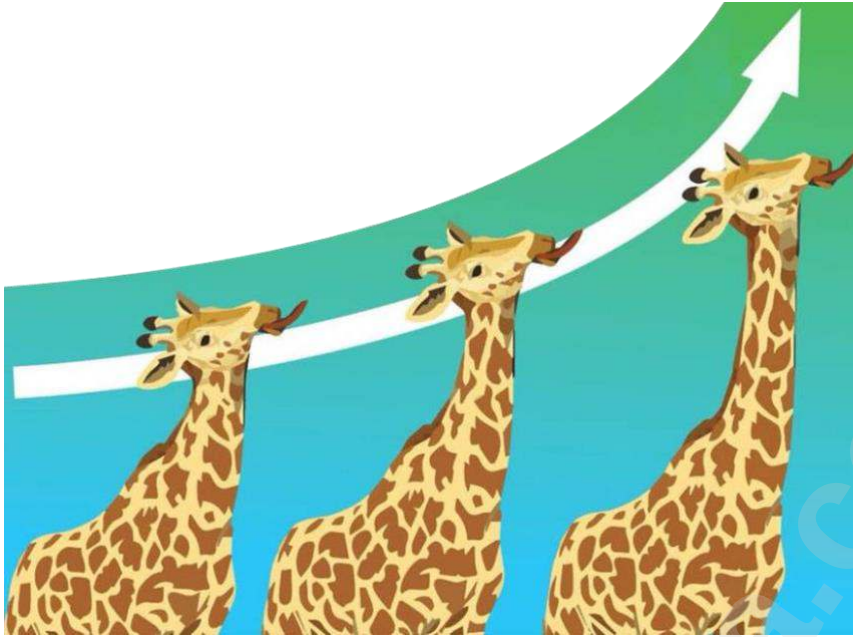
- Characteristics developed during the life of an individual (acquired characteristics) could be passed on to its offspring.

Why Lamarck's Theory was Rejected

- There is no evidence that an organism can pass on an evolved characteristic to the next generation

Lamarck's theory on giraffe necks:

- All giraffes had short necks originally
- Giraffes frequently stretched/used their necks to reach leaves of tall trees
- Necks became longer
- The long necks acquired this way
- were passed on the next generation/were inherited



Darwinism (Charles Darwin 1809 – 1882) --- Darwin's Theory of Evolution by Natural Selection

- Organisms produce a large number of offspring
- There is a great deal of variation amongst organisms
- Some have favourable characteristics and some do not
- When there is a change in the environmental conditions or if there is competition
- then organisms with characteristics that make them more suited, survive
- whilst organisms with unfavourable characteristics, which make them less suited die
- The organisms that survive, reproduce
- And thus pass on the allele/gene for the favourable characteristic to their offspring
- The next generation will therefore have a higher proportion of individuals with the favourable characteristic
- In this way, the characteristics of a population gradually change over a long period of time

Use of giraffe as an example:

- As a result of genetic variation in the giraffe population
- some giraffes have long necks
- while others have short necks
- Environmental change/ competition for resources occurred

- causing those with longer necks to survive
- While those with short necks die
- This is natural selection/ survival of the fittest
- The genes/ genotype for longer necks
- were passed on to subsequent generations most of which now have long necks

Punctuated Equilibrium (Eldredge and Gould 1972)

*Punctuated Equilibrium explains the speed at which evolution takes place

- Evolution involves long periods of time where species do not change or change gradually through natural selection (known as equilibrium)
- This alternates with (is punctuated by) short periods of time where rapid changes occur through natural selection
- during which new species may form in a short period of time

	Lamarckism	Darwinism
make-up of a population	members of population are all the same	members have similar characteristics with a measure of variation
transformation of a species/population	individuals are able to transform during a life time	populations, not individuals, transform over time and only through genetic means
mechanism of change	individual chooses which traits to pass on to offspring changes are directed to meet survival	natural selection – the environment exercises selective pressure causing change variation exists regardless of organisms needs.

FORMATION OF NEW SPECIES (SPECIATION)

*** Allopatric/ Geographic Isolation ---- is when part of a population becomes isolated from the parent population by geographical or physical barriers.

Speciation through Geographic Isolation

- If a population of a single species
 - becomes separated by a geographical barrier (sea, river, mountain, lake)
 - then the population splits into two.
 - There is now no gene flow between the two populations.
 - Since each population may be exposed to different environmental conditions/the selection pressure can be different
 - natural selection occurs independently in each of the two populations
 - such that the individuals of the two populations become very different from each other
 - genotypically and phenotypically.
 - Even if the two populations were to mix again
 - they will not be able to interbreed'
 - The two populations are now different species
- NB: Use Galapagos finches, Galapagos tortoises and plants on different land masses as examples

NB: Speciation increases biodiversity

*** Extinction ----- the permanent disappearance/loss of a species from earth

NB: Extinction results in loss of biodiversity because it reduces the number of species.

ARTIFICIAL SELECTION

In artificial selection, specific characteristics in an organism are selected to breed with.

Artificial selection e.g production of improved fruit/meat production

- Humans select organisms
- With a particular desirable characteristic
- And interbreed them

- With other organisms that also have the same desirable characteristics
- To improve this characteristic further in the offspring
- They may also choose organisms with different characteristics
- To get offspring with a combination of desirable characteristics

Differences between Natural Selection and Artificial Selection

Natural selection	Artificial selection
The environment or nature is the selective force	Humans represent the selective force
Selection is in response to suitability to the environment	Selection is in response to satisfying human needs
Occurs within a species	May involve one or more species (as in cross breeding)