BIO 1130 Midterm 2 Review
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Introduction chapter: Slide 29

- A cheetah is a mammal characterized by few derived traits (evolutionary innovations) that distinguishes it from other feline species
  - The species is the result of 3,500 Myr of evolution. Why?
  - More than 99% of its characteristics have evolved in species that are now extinct
  - Less than 1 % of its features are unique
- So the cheetah is more the result of the history of its ancestors than of its own history
- This applies to all living species, including humans

Chapter 1

Slides 3-4

- Inductive reasoning (linked to a descriptive-based approach)
  - Making a generalization often based on numerous specific observations
  - Particular → general
  - E.g. obs: this orange is sweet → gen: all oranges are sweet
- Deductive reasoning (linked to a hypothesis-based approach)
  - Involves stating a hypothesis and drawing conclusions (after experimentation or observation) from this hypothesis
  - General → particular

Slides 6-7

- Scientific hypotheses must be verifiable, refutable, reproducible
  - From a hypothesis you can make a prediction
  - Predictions must be testable and give a clear result
    - If… then… statement
  - Hypothesis can be falsified or not falsified
  - We can never prove that a hypothesis is the scientific truth
  - If a hypothesis has survived multiple falsification attempts = theory

Slides 9-11

- E.g. of the scientific process
  - Obs: this orange is sweet
  - Hyp: all oranges are sweet
  - Pred: If I taste all kinds of oranges, then they will always be sweet
  - Tests: tasting all kinds of different oranges
    - Travelled to Madagascar and tasted a very sour orange
    - Hypothesis is refuted/ falsified and a new hypothesis is formed: all oranges are sweet except those from Madagascar
    - If hypothesis was not refuted/ accepted, more tests are to be performed
- Contract between science and knowledge
  - Initial skepticism on facts

        - Asing honest questions on facts and hypothesis (tangible, real things) and always retest findings (there's always uncertainty)
            - → E.g. Viceroy butterfly initially thought to be nontoxic until retested
    - Realism
        - Must ignore preconceived ideas and ideologies when performing experiments (the realm of ideas does not have priority over the real world)
    - Rationality
        - Logic: demonstrations from a scientist must be the result of coherent steps (evidence based)
            - → Steps to arrive to a conclusion/ hypothesis
        - Parsimony: methodological principle which states that acceptable theories are hypothetically the most economical in assumptions
            - → E.g. crop circles (most probable assumptions)
    - Methodological materialism
        - All that is experimentally accessible in the real world is material or has material origin (everything must be evidence based)

Chapter 3

<u>Slides 10-19</u>

- Darwin was the first to come to the conclusion that species have similar traits because they share a common ancestor, not a common environment
        - E.g. Galapagos island finches
    - This rejects the fixity of species and accepts the concept of descent with modification (evolution)
    - Rejects Lamarck's evolutionary mechanism (environmental determinism)
- 99% of species that lived on Earth are extinct
    - Species have an existence, they go through a change in morphology, then go extinct
    - Most evolutionary branches finish in a dead-end (extinction)
- "An essay on the principle of population" by Thomas R. Malthus
    - Every human population has a tendency to increase geometrically, but the available resources increase arithmetically
    - The human population increases faster than its capacity to feed itself
        - Leads to chaos (crisis point; famine, sickness, war) and an eventual decrease in population size
- Darwin's first observation
    - All species can produce more offspring than their environment can sustain and many of these offspring fail to survive and reproduce
- Darwin's second observation
    - Members of a population often vary in their inherited traits
- From these observations we can make two inferences
    - Individuals whose inherited traits gives them a higher chance of surviving and reproducing in a given environment tend to leave more offspring

- From generation to generation, this unequal capacity to survive and reproduce (differential reproductive success) leads to an accumulation of favourable traits in a population
    - This is NATURAL SELECTION (enables the emergence of adaptations)

<u>Slides 22-37</u>

- Important notions linked with natural selection
  - Individuals do not evolve, populations evolve
  - Only hereditary traits with variability can evolve
  - Individuals with traits that lead to higher survival and reproductive success are "fitter"
  - If a trait is well adapted to its environment, it confers to a higher relative fitness
  - Environmental factors vary in time and space
    - Selective forces are variable and a trait that increases fitness in a specific environment might lose this fitness in a changed environment
      - E.g. blue fish in a blue pond, light vs dark moth
      - Selective pressures can change
      - Genetic variability increases resiliency to change in selective pressure in the environment to prevent species extinction
  - Traits in populations may change and may modify the species
- Artificial selection
  - Can be finalized as there is a fixed goal
  - End result can be achieved in a few generations
- Natural selection
  - Never finalized
  - Can take a long time for changes to occur
- Humans and Altitude
  - At over 2,000 m, the partial pressure of O2 is insufficient for normal saturation of hemoglobin for a traveller in high altitudes causing shortness of breath and altitude sickness
  - Causes the body to have a physiological response (acclimatization)
    - Increases concentration of red blood cells in the blood
  - E.g. Qinghai–Tibet Plateau (3,500 m) and Andes
    - After 150 generations and 550 generations (respectively) the majority of the population settled in these areas have adaptations have the genetic traits allowing for survival and reproduction in high altitudes
      - Qinghai–Tibet Plateau: deeper breath, faster breathing cycle; larger pulmonary capacity and increased blood flow; lower hemoglobin concentration
      - Andes: higher alveolar surface in lungs, same hemoglobin concentration in blood but each molecule has a higher oxygen capacity
  - ✳ Mutations are FAVOURED not CAUSED by environments

Slide 43

- Life is organized as a tree
    - Phylogenetic tree shows relationships between species and organizes them based on homologous structures
    - Shows that many species from the same family lived at the same time
    - Linear evolution is far from reality
    - Species did not replace one another

Slides 46-48

- Vestigial structures
    - Anatomic structure that has lost (almost) all its initial function
    - E.g. whale evolved from quadrupedal species which is evident based on the presence of a pelvic bone
    - E.g. nictitating membrane/ third eyelid, appendix, hiccups, and goosebumps and hair all provide evidence of evolution from a common ancestor which used these structures
        - We had vegetarian ancestors; rabbits and horses have large caecum, whereas our caecum is small (but functional) → the appendix is the remanence of a large caecum that we didn't need
        - Goosebumps and hair came from our ancestors who had lots of hair which they used to trap heat under their fur
            - We lost the density of our fur but we still have the reflexes for goosebumps
            - Also linked to emotion which increases appearance of size in animals when angry/ scared
        - The hiccups are a heritage from our fish and amphibian ancestors
- Discovery of a fossil in the wrong place in the geological archives would be sufficient to refute our concept of evolution

Chapter 4 Genetics, Neo-Darwinism and Modern Synthesis

4.2 Mendelian Inheritance

- Gregor Mendel; founder of genetics, Austrian monk, formulated laws on creation of hybrids (laws of heredity)
- He used peas which was judicious as there are many varieties available, possibility of crossbreeding, fairly cheap, generation time is short, descendants are plentiful
  - Talks about "heredity factors" as genes were not discovered yet
- Variation of genetic traits is explained by the different shapes genes can have
- Each gene occupies a specific locus on a given chromosome
    - ➢ Locus is is the area on a chromosome where a gene is located
  - The DNA sequence of the locus can show variants (alleles)
  - E.g. the alleles for white flowers and the alleles for purple flowers are situated on one of the peas' chromosome.
- All organisms inherit two copies of a gene (different or identical), one from the "father" and the other from the "mother"
  - Each copy is called an allele
- An individual possesses two alleles for one gene (hereditary factor)
  - There are 23 pairs of chromosomes in humans
- If the alleles are different, the dominant one determines the trait and the recessive allele has no notable effect
  - Laws of uniformity of hybrids of the first generation
- Important terms
  - Law of segregation
    - Two alleles for a heritable character segregate (separate from each other) during gamete formation and end up in different gametes
  - Phenotype
    - Physical constitution of an organism
  - Genotype
    - Genetic constitution of an organism
  - Heterozygous
    - Possessing two different alleles for a trait
  - Homozygous
    - Possessing two identical alleles for a trait
- The law of independent assortment
  - Every pair of allele separates independently from the other pairs when the gametes are formed
    - E.g. colour and texture alleles in peas, earlobes and hairline in humans

4.3 Initial Impacts of Mendel's Theory

- The discovery of Mendel's work had, initially, a negative impact on the theory of natural selection

    - Why? The first geneticists put the emphasis on the discrete or discontinuities aspects of the traits associated with Mendel's ratios and rejected the continued variation observed in nature by claiming that it was non-Mendelian and without any evolutionary importance
- Hugo de Vries (1838-1935) formulated a "Theory of mutations" which indicated that new species can be formed in one or multiple steps (saltationism) through mutations that would cause substantial morphological modifications
    - It was discovered that mutations are generally harmful or neutral and that only a few seemed to influence, although lightly, an organism traits

<u>4.4 Neo-Darwinism and Modern Synthesis</u>

- The main impacts of Neo-Darwinism were:
    - Lamarckism was refuted
    - We started to understand the effect of chance in the transmission of alleles from generation to generation (genetic drift)
    - The genetic basis of evolutionary changes was established
    - The study of genetics shows the existence of an important and persistent variation (continuous or discrete) which creates the hereditary material on which evolution can act
    - This continuous variation has a Mendelian basis, that is to say that it implies the segregation of hereditary particles having a minimal phenotypic effect
- The emergence of population genetics and of microevolution offered a new perspective in regards to the relative significance of the factors producing evolutionary changes in populations
- The biological and genetic basis of the formation of species (speciation) and the study of evolution above the species level (macroevolution), including elaboration of the tree of life (phylogenies)

<u>4.5 Modern Additions to Mendel's Laws</u>

- Incomplete dominance
    - Both dominant alleles are partially expressed
        - All alleles (dom. and rec.) produce enough proteins to have an effect on the phenotype
        - E.g. red flower (RR) + white flower (WW) = pink flower (RW)
    - Recessive gene is partially expressed
        - E.g. cream horse (cc) + chestnut horse (CC) = palomino (Cc)
- Codominance
    - Both dominant genes are fully expressed
        - Black chicken (BB) + white chicken (WW) = checkered chicken (BW)
- Polygenism
    - When a phenotypic trait is under the combined action of two or multiple genes (very common)
    - E.g. colour of skin

- Epistasis
    - When the effect of a gene hides or blocks the expression of another gene
    - E.g. Labrador retrievers
        - When a dominant B allele is present with a dominant E = black
        - Homozygous recessive B with dominant E = chocolate
        - Homozygous recessive E = yellow
            - B gene is not expressed as ee blocks B
- Pleiotropy
    - When a gene influence more than one trait
    - Certain pleiotropic genes are lethal when homozygous
    - E.g. Manx cat
        - The Manx gene (M) shows an incomplete dominance compared to the normal gene (m) (with tail)
        - The gene responsible for the lack of tail is lethal (embryo reabsorbed) when homozygous
        - The heterozygous cat do not have tails or have short tails

Chapter 5 The Evolution of Populations

<u>5.1 Hardy-Weinberg's principle</u>

- German biologist (Weinburg) and english mathematician (Hardy) made the same discovery
    - They demonstrated that, under certain conditions, allele frequencies in a population remain constant from one generation to the next, thus, no evolution
- A population is in Hardy-Weinburg equilibrium when the frequencies of alleles and genotypes within a population will remain constant ($p^2 + 2pq + q^2 = 1$) from generation to generation as long as the following conditions are respected
    - There are no mutations
    - Mating is random
    - Size of population is extremely large
    - There is no genetic (gene) flow (no migration of alleles between populations)
    - No natural selection
- Hardy-Weinberg's principle describes a hypothetical population that does not evolve

<u>5.2 Mutation</u>

- Mutations are changes in the DNA sequence of an organism
- This is the source of genetic variability, mutations are
    - Random
    - Transmissible (only if they are in the gametes)
    - Frequent throughout the gene pool, but rare at each locus
    - Rates of mutations vary greatly among groups of living beings
    - Will influence allele frequencies but is a weak evolutionary force from generation to generation, especially in large population

- Point mutations (addition, deletions or substitution of a base; A-C instead of A-T)
    - Negative effect
    - Lethal effect
    - Neutral effect
        - E.g. Synonymy of codons for the formation of amino-acids; particularly in the 3rd position (fig 17.5)
        - E.g. Non-coding part (protein) of the genetic code
    - Positive effect
        - When the effect enables the individual to be better adapted to their environment
- Mutations can be chromosomal (DNA segment loss, repetition of DNA segments, addition or loss of chromosomes)

<u>5.3 Assortative Mating</u>

- Random mating: panmixia (maintains H.W)
    - E.g. American eel
- Assortative mating: Choice of partners in relation to the phenotype (modifies H.W. equilibrium)
    - Positive assortative mating: more frequent mating between similar individuals than expected chance (Effect: increase homozygosity)
    - Negative assortative mating: More frequent mating between individuals that do not look alike than expected by chance. (Effect: increase heterozygosity)
- Positive assortative mating
    - Autogamy or selfing of plants (pure lineage of Mendel: ultimate positive assortative mating)
    - Geographical proximity of individuals (e.g. population of mice in a barn)
    - In humans: mating according to height and skin colour
- Negative assortative mating (fig 38.4)
- Assortative mating does not change allele frequencies; it changes genotypic frequencies
- When paired with natural selection, positive assortative mating can lead to an increase in homozygosity and a loss of genetic variability:
    1. Phenomena of endogamic depression since the harmful alleles will express themselves
    2. Natural selection will purge the population of a portion of its harmful alleles
        - ➢ Thus, a loss of genetic variability compared to panmixia

<u>5.4 Gene flow</u>

- Migration: exchange of genes between populations
- Has a tendency to standardize the genetic pool of the populations involved
- Can play a similar role as mutations by introducing new genes in one of the populations

<u>5.5 Genetic Drift</u>

- Genetic drift is a result of chance

    - Chance will have increasingly more impact on a population as the size of the population gets smaller
    - In small populations, genetic drift will trigger a decrease in genetic variability and a decrease in heterozygosity
    - In a large population genetic drift will cause little changes to the allelic or genotypic frequency of a population
- If there are no other processes (mutation, migration, or selection) that will affect allele frequencies at a particular locus, genetic drift will eventually result in the fixation of an allele and the elimination of all others for this locus
- If no other evolutionary processes are acting on allelic of genotypic frequencies, then the probability that an allele will become fixed is equal to its frequency
- Population bottleneck
    - In small populations, genetic drift can lead to the fixation of deleterious alleles and a loss of genetic variability
    - Increases the risk of extinction
    - E.g. cheetahs and greater prairie chicken
- Founder effect: when a few individuals from a large population create a new colony, the genetic make-up of the colony differs from the source population
    - Opposite of a bottleneck
    - E.g. Myotonic dystrophy and Polydactyly in the Amish

<u>5.6 Natural Selection</u>

- A process by which individuals with certain hereditary particularities survive and reproduce in larger numbers than other individuals
- The alleles favored by selection are more abundant in offspring than in the parental generation
- The action of natural selection on the frequency of an allele can be cancelled by the action of mutation, genetic drift, and migration
- The only evolutionary mechanism that aids the survival and reproduction of organisms in their environment
- No not forget: only hereditary variations constitute the basis of natural selection
    - E.g. Map butterflies is an example of non hereditary variability
    - E.g. variability in yarrow height according to altitude
        - Genetic differences or environmental effect?
- Adaptive value (selective value, fitness)
    - Fitness or the adaptive value of a genotype corresponds to the contribution of an individual to the genetic pool of the next generation when compared with the contribution of other individuals
- Types of hereditary traits:
    - Qualitative (discrete variation: colour)
    - Quantitative (continuous variation: height, weight)
- Polymorph populations showing distinct morphological types of genetic variability
- Directional selection

    - Average changes
    - Common
    - E.g. medium ground finch
    - E.g. mosquitoes becoming resistant to DDT
- Disruptive selection
    - Favours both extremes/ average is selected against
    - E.g. Pyrenestes ponceau birds → very small and very large beak sizes survive
- Stabilizing selection
    - Selection against extreme
    - E.g. newborn baby weight
    - E.g. all mammals have seven cervical vertebrae

5.7 Preservation of Genetic Variability in Nature
- Diploidy
    - A considerable portion of the genetic variability of diploid individuals is hidden from natural selection
        - The mass of little expressed or unexpressed genes in heterozygotes (genetic load)
            - It is the cost associated with maintaining and storing genetic variation
- Balanced polymorphism
    - The heterozygote advantage
        - When heterozygous individuals have more offspring than homozygous individuals
            - E.g. sickle cell anemia and Perissodus microlepis fish
- The selection depends on the positive frequency. The phenotype that is more abundant is always favoured
- Selection leading to multiple stable equilibriums (adaptive landscape)
    - E.g. Case of müllerian mimicry: a case of mimicry between two toxic species.
- Neutral variation
    - A good portion of the genetic variability found in genes do not show selective advantages or is not affected by natural selection (e.g. pseudogenes)
- External mechanism (or ecological):
    - The result of simultaneous impacts of different selective pressures
    - Temporal changes in selection pressure
    - Habitat mosaic
    - Non-assortative mating
    - E.g. climate change

5.8 Sexual Selection
- Initial formulation of the concept: Charles Darwin
- A form of evolution in which individuals that possess some specific hereditary traits are more susceptible than others to find partners

        - E.g. peacocks
- Intersexual selection (choice of sexual partners based on traits indicating the quality of the genetic baggage of the other sex)
    - E.g. The widowbird: Do the females have a preference on the length of the tail feathers of males?
        - Experiment of glueing/ cutting tails proved long tails are preferred
- Intrasexual selection
    - Selection between individuals of the same sex
        - E.g. fighting over a mate (confrontational behavior is often a ritualized combat)
        - E.g penis bone or baculum of a walrus. Structure is present in chimpanzees but absent in humans. Is it a case of sexual selection?
            - Hypothesis I: quality of erection
            - Hypothesis II: making sure other males don't mate/ fertilize females (polygamy)
                - ➢ Humans are monogamous therefore don't need to compete

Chapter 6 Adaptations

<u>6.1 Adaptation</u>

- Adaptations are the result of natural selection
    - They are sometimes complex, have complex functions and a complex history (ex. evolutionary compromises; symbiosis)
    - Barely keep up with change in environment → can never be perfectly adapted to the environment since it is constantly changing
        - Species try to keep up but only ~1% succeed
- Why is our species the only Primate that can choke on food?
    - An evolutionary compromise
    - Evolution of speech: unique to humans
        - Humans have some parts same as chimps (epiglottis, soft palate) but we have smaller mouths and a space between the palate and epiglottis due to our evolution for speech
            - We have longer pharynx and dynamic nervous system in that area
- Burying beetles transport mites. Symbiosis: mutualism, commensalism, parasitism
    - Symbiosis
        - Need to understand both species to understand it
    - Mutualism
        - Advantage for both species
    - Commensalism
        - Advantage for one but not the other (other is not harmed though)

<u>6.2 Studying Adaptations</u>

- All traits of a living being are not necessarily adaptations to the current environment: concept of exaptation
- Methods aimed at corroborating or refuting an adaptive hypothesis:
    - Direct study of natural selection (e.g. peppered moth, Medium ground finch, human adaptation to altitude)
    - Comparative approach + knowledge of phylogenies: indicator that traits have evolved independently or are the result of a common ancestor
        - E.g. evolution of the cheetah, carnivorous jaws
    - Morpho-functional study of a trait
        - E.g. evolution of fur or feathers
- E.g. In the Tyrannosauroidea, the smallest to be the oldest species
    - Species bear characteristics that have evolved in ancestral species
    - To understand larger species, we must understand small ones
- E.g. The initial function of fins was to stabilize the fish body in its environment; it is an adaptation
    - In terrestrial animals (tetrapods), the limbs (that have evolved from fins) are used to support the body in an aerial environment
        - The limbs of the tetrapods are thus an exaptation for terrestrial mobility (locomotion)
    - Exaptation: Adaptation whose current function is not the one for which the structure initially evolved. (p.567)
- Recycling structure from something else
    - E.g. Hair evolution
        - Adaptation or exaptation to conserve heat?
            - Elephants have areas of hair to allow for dissipation of heat
                - ➢ Hypothesis: thermoregulation, helps heat to dissipate, areas with hair is 25% more efficient at losing heat
            - Hair may have evolved to lose heat but is now used to also preserve heat
                - ➢ May have also evolved for sensory reception (whiskers)
    - E.g. Feathers: adaptation or exaptation for flight?
        - Dinosaurs had feathers but couldn't fly → sexual selection?

<u>6.3 Evolution and Developmental Genes</u>

- Heterochrony
    - Changes in the speed or synchronization of the developmental phases ***
- Heterochrony can alter development speed of reproductive organs
    - Paedomorphosis
        - Faster development of reproductive organs that somatic organs
        - E.g. axolotl becomes sexually mature despite having larvae characteristics

→ Compromise, coevolution, recycled adaptation, more complex

Chapter 7 Geographic Variation and Speciation

<u>7.1 Inter-population Genetic Variation</u>

- Individuals of each population have a tendency to mate with members of their own population
    - Positive assortative mating

<u>7.2 Models of geographic variation</u>

- Polymorphic species
    - Species formed of several geographic groups which differ from each other by traits that are easy to recognize
        - Also called morphs, forms or subspecies

<u>7.3 Adaptive value of geographical variation</u>

- Ecogeographic rules
    - Models of geographical variation that follows climatic gradients for many species within a group of vertebrates
    - Bergmann's rule
        - Populations of animals living in northern regions of the geographic distribution of the species will generally have a larger size
            - ➢ E.g. hairy woodpecker; largest comes from Yukon, smallest comes from Mexico
                - Thermoregulation → surface to volume ratio; high in south, low in north
    - Allen's rule
        - Northern populations of birds and mammals generally have short and massive extremities
        - Southern populations have longer, thinner extremities
            - ➢ Arctic hare and jackrabbit; Arctic fox and the fennec fox
                - ➢ Thermoregulation
    - Gogler's rule
        - Darker pigments is found in more humid climates
- Evolution of the loss of fur and skin colour in humans
    - 7 Million years (Myr) ago, the hominins (all human species) shared a common ancestor with the chimpanzee
        - Pale skin covered by dark fur
    - Australopithecus afarensis (Lucy)
        - Lived in tropical forests
        - Bipedal AND arboreal
        - Diet of fruits, tubers and leaves
        - Sedentary way of life

- 3 Myr → important global cooling causing droughts in East Africa, forming savannas
- Homo ergaster
  - Since less fruit was available, meat was added to the diet
  - Walk long distances for prey and water
  - Adapt to life on the plains
  - More active lifestyle (hunter-gatherer)
    - ➢ Brain size began to increase due to hunter-gatherer lifestyle
- Natural selection acts on the shape of the body, favouring those able to run
  - Abundance of sweat glands and less fur for efficient thermoregulation
    - ➢ Wet fur loses its abilities to help with thermoregulation
- Fury animal sweat glands
  - Especially sebaceous and apocrine; oily sweat; perspiration difficult
- Human sweat glands
  - Especially eccrine; watery sweat; easy perspiration
- Natural selection in favour of darker skin at the same time as fur loss
  - Favored individuals with thicker, darker, more acidic skin (more melanosomes = more melanins
    - ➢ Offered protection against Ultraviolet rays (UV), drought, bacterial attacks and vitamin deficiencies
  - Due to lack of hair to demonstrate emotions, humans evolved very intricate and intense facial expressions
- Hypothesis to explain evolution of skin colour: we need to find an inherited trait that provides an advantage for reproduction and survival
  - Folic acid and dark skin
    - Folic acid (vitamin B9) is destroyed in skin by excessive UV rays
    - B9 deficiency: serious and possibly lethal developmental malformations (spina bifida), poor wound healing, disturbed immune system, sperm malformation
    - A vitamin deficiency at a young age and, particularly, in pregnant women would have a direct impact on the survival and reproduction success of the individual
    - Therefore we can say that dark skin offers a protection against the UV rays that offers a survival and reproductive advantage (adaptation)
  - Vitamin D3 and pale skin
    - Vitamin D3 is synthesized in the skin by UV rays. It helps in the absorption of calcium in the gut. (Deficiency: rickets, plus several other diseases)
    - A deficiency in vitamin D3 would have a direct impact on the reproductive success of affected individuals

        - Pale skin in low UV radiation would maximize the absorption of UV rays and the survival of the human population in areas of UV deficiency (adaptation)
  - The colour of skin is:
    - A variable polygenic trait which explains the variability of pigment intensity
    - An adaptation to UV radiation
    - Only an indicator of the environment in which populations have live

<u>7.4 Species</u>

- Morphological species concept
  - Consists in bringing together under one species name, individuals possessing similar and unique morphological traits
  - Specimens belong to a species if they morphologically resemble the "type" specimen (holotype) of the species
  - The holotype specimen is determined by the taxonomist as being a typical specimen showing all the unique features of a species
    - Stems from the essentialism of Aristotle
  - Morphological variability (a Darwinian concept) of a species is now documented through the description of other specimen
    - Paratypes
- Biological species concept
  - A group of populations whose members have the potential to interbreed in nature and produce viable, fertile offspring– but that do not produce viable, fertile offspring with other such groups
    - There is a reproductive isolation mechanism in place that prevents interbreeding
      - Is only applicable in nature and sexual organisms
      - Can only be verified in an area of sympatry of potential species (area of overlap of two related species)
- Prezygotic reproductive barriers
  - Prevent the formation of hybridized zygotes and thereby the loss of gametes
    a. Ecological isolation: populations on the same continent, but live in different habitats
      - ➢ E.g. lion (Asian Savannas) and tiger (Asian forests)
    b. Temporal isolation: non-synchronized mating or flowering (different seasons or a different time of day)
      - ➢ E.g. eatern and western spotted skunks mate at different times of year
    c. Ethological isolation (behavioural): absence of sexual attractiveness (distinct courtship)
      - ➢ E.g. Mallard and Northern pintail
    d. Mechanical isolation: mating or pollen transfer is impossible due to the incompatibility of genitals or different flower structures

        e. Gametic isolation: the male and female gametes cannot meet or the sperm and pollen cannot survive in the genital tract of the animal or in the flowers stigmas

- Postzygotic reproductive barriers
    - Imply loss of gametes
        a. Reduced hybrid viability: hybrids cannot develop or cannot reach sexual maturity
            - ➢ E.g. crossbreed between a goat and a sheep, the zygote quickly dies during intrauterine development
        b. Sterility of hybrids: hybrids cannot produce functional gametes
            - ➢ E.g. mules are infertile
        c. Hybrid breakdown: hybrids can be viable and fertile but the offspring are susceptible to cancer and other sickness
            - ➢ Doesn't make sense to spend energy producing unhealthy offspring
            - ➢ E.g. tigon and liger

<u>7.5 Origin of Species</u>

- Phyletic speciation (anagenesis)
    - Gradual evolution or "linear" succession of species in a way that the changing species shows different phenotypes through time
- Multiplication of species (cladogenesis)
    - Creation of species by establishing a reproductive barrier between them
    - Cladogenesis: only mechanisms responsible for the creation of biodiversity
- From a genetic standpoint, a premise for the multiplication of species or the establishment of a reproductive barrier is the interruption of migration or gene flow between populations
- Models of speciation (cladogenesis) shows how the gene flow can be interrupted
    - Allopatric speciation (almost universal process)
    - Sympatric speciation (rarer)
- Allopatric speciation: a population with continuous distribution divided in two or multiple populations by a geographical barrier
    - Steps:
        1. Passive isolation of populations in space
        2. Genetic modifications, under the combined effect of isolation and selective pressures, replace a co-adapted system genes by another, more suitable to different ecological conditions
        3. Acquisition of reproductive isolation before the subsequent overlapping areas
    - Complete speciation: no viable hybrids in the contact zone (sympatric area) between species
    - E.g. Eastern Meadowlark and Western meadowlark

        - Minimal phenotypic differences (except for their song and behaviour that are very distinct)
- Sympatric speciation: a new species appears within populations (speciation without geographical isolation)
    - Polyploidy (30 - 40% of plants): multiplying the normal number of chromosomes. This can happen when the chromosomes do not separate during meiosis which produces diploid gametes (instead of haploids)
    - Rare in animals