BIO MIDTERM 2

What is a Cheetah?

- A mammal characterized by a few derived traits (evolutionary innovations) that distinguished it from other feline species
- Result of 3500 million years of evolution
- More than 99% of its characteristics were evolved in species that are now extinct
- Less than 1% of its features are unique
- Result of history of its ancestors than of its own history
- Humans are the same as cheetahs (evolved most of the traits from extinct species)

Inductive Reasoning

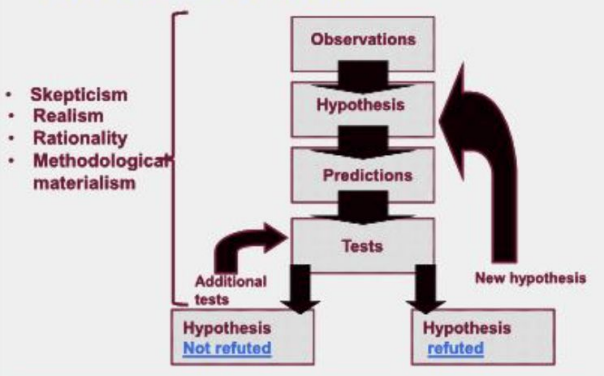
- Description based
- Making a generalization often based on multiple specific observations

Deductive Reasoning

- Hypothesis based
- Involves stating a hypothesis
- Drawing a conclusion after observation from hypothesis

Scientific Process

- A scientific hypothesis must be:
  - Verifiable
  - Refutable
  - Reproducible



Contract between Science and Knowledge

1. Initial Skepticism on facts
- Honest questions on facts and hypothesis
- Always retest what has been found
2. Realism
- World exists independently from our perception of it
- Realm of ideas does not have priority over the real world
3. Rationality
- Logic: demonstrates from a scientist must be result of coherent steps
- Parsimony: methodological principle, states that acceptable theories are hypothetically the most economical in assumptions
4. Methodological Materialism
- All that is experimentally accessible in real world is material or has a material origin

Evolution and Natural Selection

- Darwin notes that species show resemblance to other species because they share a **common ancestor**
- Finches show morphological similarities because they share a common ancestor
- 99% of species that have lived on earth are extinct
- Most of evolutionary branches finish in a dead end which represents a extinct species
- Darwin read an essay by Malthus
- The essay helped inspire him to formulate his theory of natural selection
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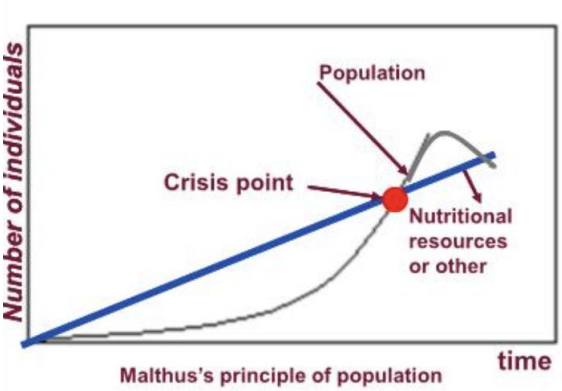


Malthus: Essay on the Principle of Population

- Population has tendency to increase geometrically
- Available resources to feed populations increase arithmetically (linear)
- Human population increases faster than its capacity to feed everyone
- Leads to chaos
    - Famine
    - Sickness
    - War
- Eventually a substantial reduction in population size
- Not enough resources for everyone

Darwin's observations:

- All species produce more offspring than their environment can sustain
    - Most offspring fail to survive and reproduce
- Members of a population often vary in their inherited traits

Darwin's Conclusions on Natural Selection:

- Individuals whose inherited traits gives them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals
- From generation to generation, this unequal capacity of survive and reproduce (differential reproductive success) results in an accumulation of favourable traits in a population
- Enables emergence of adaptations

Important notions linked with natural selection:

- Individuals do not evolve, populations evolve
- Only hereditary traits are subject to natural selection
- Genetic variability is required for evolution
- Corresponds to differential reproductive success within a population from generation to generation
- Enables individuals to become better adapted to their environment

- Selective forces are variable
- Traits in populations will change and can modify a species

For Darwin's Mechanism to be Valid:

- Respects principle of uniformity
- Results of natural selection are visible in nature
- Can be verified on current populations
- Materialistic concept
    - Not random
    - Enables individuals that are better adapted to the environment to be more successful than those who aren't
    - Not a quest for perfection
    - Organisms adapt to environment

Artificial Selection:

- Finalized because the goal
- Fixed well in advance
- Precedes the causes
- End result can be obtained in a few generations

Natural Selection:

- Not finalized
- Can take long time to see changes
- Geological time scale

Example 1 of Natural Selection: Peppered Moths

- Colouration is a hereditary trait
- Both coloured moths lie on dark surface
    - Predators see the grey (lighter coloured) morph moths easily
    - Dark moths blend in with environment
    - More dark moths survive than lighter ones
- Moths lie on the tree
    - Grey morphs survive
    - Predators attack dark morphs

Example 2 of Natural Selection: Finches

- Drought in 1977 in Galapagos islands
- Caught birds and marked them
- Found that there were more birds with bigger beaks
- Environment favoured birds with big and stronger beaks (in order to eat seeds)
- Trait was inherited trait from both parents

Example 3 of Natural Selection: Adaptations to Altitude

- Everyone's bodies are adapted to live at a certain altitude
- If your body doesn't move gradually into a new altitude, could cause altitude sickness
- Body needs to adapt to new altitude (acclimatization)
    - Body compensates the low partial pressure of oxygen by increasing the concentration of red blood cells
    - Can cause health risks
- A 2000 m body needs to acclimatize, partial pressure of oxygen is insufficient for normal saturation of hemoglobin
- Altitude sickness is caused by rapid exposure to low amounts of oxygen at high elevations
- Altitude sickness can cause shortness of breath
- If you increase the number of red blood cells, there could be serious health risks
- Mutations can occur because of environmental needs
- To acclimatize the body increases the number/ concentration of red blood cells
- Adaptations in andes
    - Increase in concentration of hemoglobin (red blood cells)
    - 550 generations
- Adaptations in Qinghai- Tibet Plateau
    - Deeper breath
    - Larger pulmonary capacity
    - Increased blood flow
    - 1000+ generations
- Natural selection favours those with genetic traits that allow adaptation to high altitude
- Those with this mutation are at an advantage to survive and reproduce (produce offspring)

Evolution and Natural Selection

- Hereditary traits that give a reproductive advantage (an adaptation) to individuals in a population are favoured
- From generation to generation, there's a higher percentage of individuals with the adaptation
- Examples of natural selection
- Adaptations can redefine species or define a new species

Fossils

- Terrestrial animals gradually changed
- Most animals share a common ancestor with whales
- Homologous structures were toes
- Whales (aquatic) evolved from tetrapods (terrestrial)
- Progressive transformation of homologous structures
    - Goes from being able to walk to swim
- If a fossil is found in the wrong geological zone

    - Sufficient to refute our concept of evolution
    - Would need to rethink theories

Vestigial Structures:

- Structure remains in flesh
- Structure doesn't have a specific function
- Was useful at one point
- Comes from a common ancestor
- Humans have a number of vestigial structures
- Lost all of or almost all of its initial structure

Third eyelid:

- Found in chickens
- Humans have a remnant of a 3rd eye
- Does Not have a function
- Used for protection in chickens
- Humans lost the function of the 3rd eyelid
    - Had no function
    - Wasn't useful

Appendix:

- No function in humans
- Contains bacteria
- Ancestors were herbivores
- We don't have enzymes to break down plant cells
- Humans use microorganisms to break down plant cells
- Caecum holds substances for plant cell digestion
- Digestion of vegetation does not happen in the caecum for humans
- Caecum is reduced and appendix shrunk
- Ancestors had a large caecum for digestion

Goose bumps and hair:

- Our hair stand up when cold and scared
- In cats/ other animals
    - Each hair has muscles
    - Hair contracts
    - Seaks a layer of air between hair and skin
    - Seals warm air to help animals stay warm
- Very efficient in animals
- Reflex for hair to stand up
- Our hair is not dense enough to preserve heat
- Chills are a reflex of hair muscles
- Hair didn't become sparse because of clothes

- Minimal function in humans

Hiccups:

- From fish and amphibians
- Contraction of diaphragm
- Phrenic nerve goes near lungs and heart, connected to diaphragm
- Cause of hiccups is the phrenic nerve getting squeezed
- Considered a nervous reaction
- To cure hiccups
    - Move to displace area of where nerve is getting squeezed
- Why does the nerve have a long path?
    - Respiratory system moved down
    - Got longer over time
- Consequence from a common ancestor

Gregor Mendel:

- Father of genetics
- Discovered fundamental laws of inheritance
- Has abundant data and math to verify his hypothesis
- Talks about hereditary factors (genes)
- Variation in genetic traits is explained by different shapes a gene can have

Mendel's Laws:

1. Law of segregation

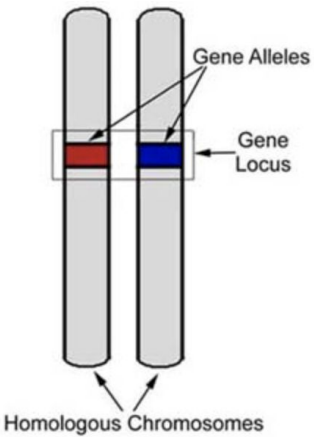
- Each inherited trait is defined by a gene pair.
- Parental genes are randomly separated to the sex cells so that sex cells contain only one gene of the pair.
- Offspring therefore inherit one genetic allele from each parent when sex cells unite in fertilization

2. Law of Independent Assortment

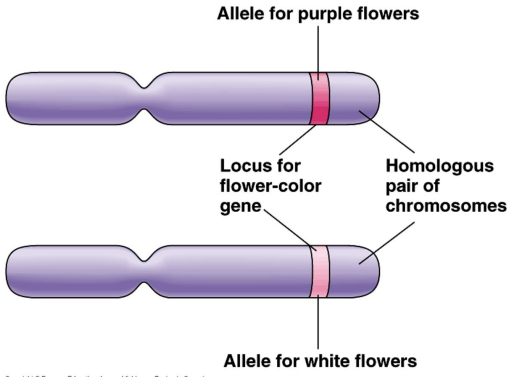
- Genes for different traits are sorted separately from one another so that the inheritance of one trait is not dependent on the inheritance of another

3. Law of dominance

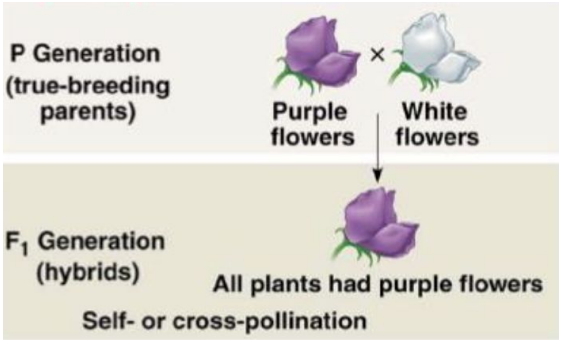
- An organism with alternate forms of a gene will express the form that is dominant



- Variation in genetic traits is explained by different shapes a gene can have
- Each gene occupies a specific locus on a chromosome
- The DNA sequence of a locus can show variants (alleles)



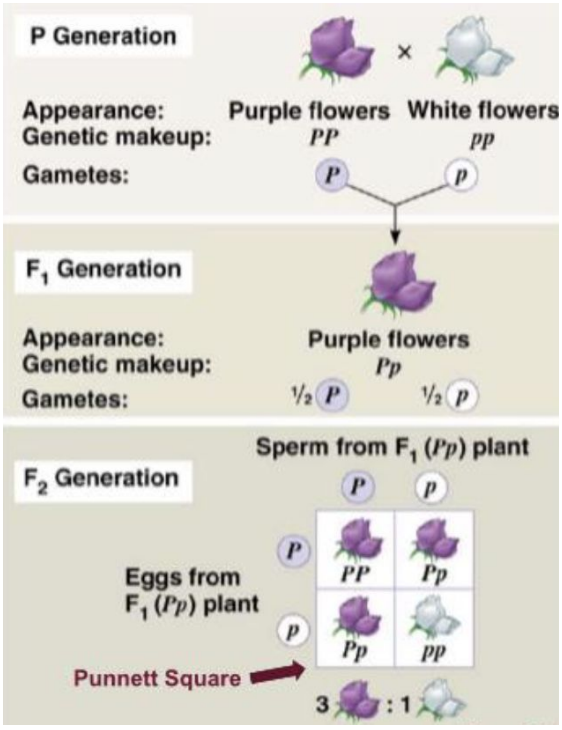
- All organisms inherit 2 copies of a gene
  - They can be different or identical
  - One comes from the father
  - One comes from the mother
  - Each copy of a gene is called an **allele**



If both alleles of locus are different
- One is **dominant** allele
- One is **recessive** allele

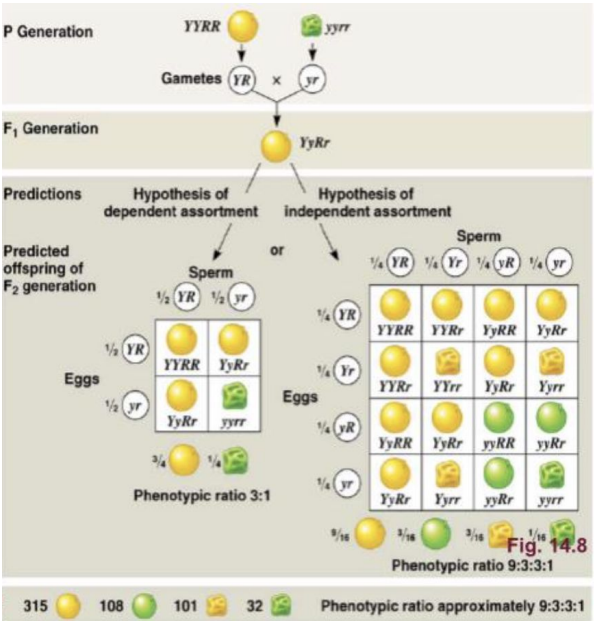
This describes the **law of uniformity of hybrids**

- For plants to be white, both parents need the **recessive** trait

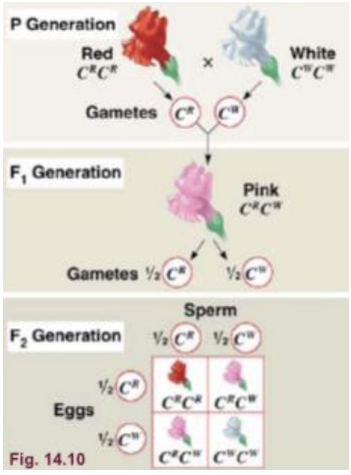


Law of Segregation:

- 2 alleles for a heritable character **segregates** (separated) from each other during gamete formation and up in different gametes
- Flowers get one allele from each parent
- Punnett squares can be used to determine the probabilities of possible followers in F2 generation

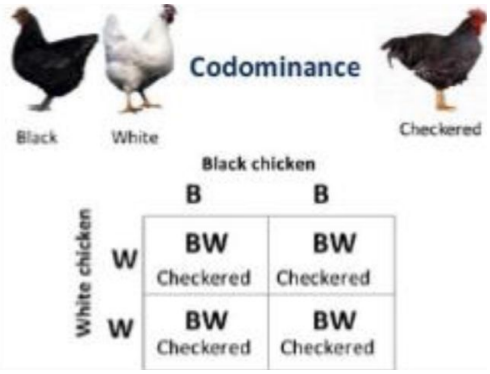


Law of independent assortment:
Every pair **separates independently** from other pairs when the gametes are formed



Incomplete dominance

- Traits mix together
- Dominant/ recessive trait is never perfect
- Results in expression of both genes in phenotype



Codominance

- Shows both traits

Initial Impacts of Mendel's Theory

- His work was resurfaced by 3 geneticists
- Initially had a negative impact on the theory of natural selection
- Hugo de Vries formulated the theory of mutation
    - New species can be formed in multiple steps (saltationism) through mutations
    - Causes morphological modifications
    - Attempts to prove evolution wrong
    - Thought mutations were the source of everything
- Some mutations affect an organism's traits
- Most mutations are harmful or neutral

Neo-Darwinism and Modern Synthesis

- Genetics and natural selection are put together
- Creation of neo-darwinism and modern evolutionary synthesis
- Main impacts of Neo-Darwinism:
    - Transmission of alleles from generation to generation (genetic drift)
    - Genetic basis of evolution was established
    - Everything began to be quantified
    - Shows importance of natural selection with math
    - Quantifies genetic variabilities
- Population genetics and microevolution gave new perspective to factors producing evolutionary changes in populations
- Biological and genetic bases:
    - Formation of species (speciation)
    - Study of evolution above species level (macroevolution)
    - Elaboration of tree of life (phylogenies)

Modern Additions to Mendel's Laws

- Polygenism: when a phenotype trait is under the combined action of 2 or more genes
- Epistasis: when the effect of a gene hides or blocks the expression of another gene (can be explained through crossing)
- Pleiotropy: when a gene influences more than 1 trait

Example of Polygenism

- Common with gene expression
- Trait can be under influence of multiple genes
- Combined effect of all genes
- Causes genetic variability
- Skin colouration is influenced by up to 20 genes

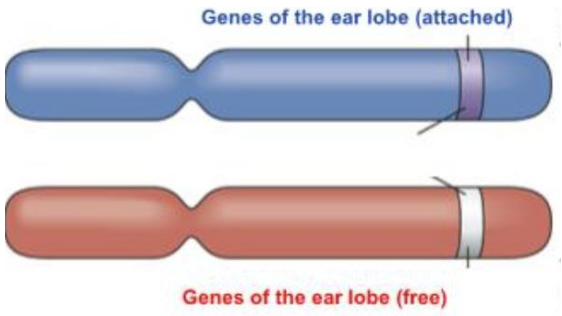
Example of Epistasis

- Crossing same type of dog with same traits
- 3 possible outcomes
- Stacking gene is in recessive state
- Hides expression of other genes
- Hides expression of pigment

Example of Pleiotropy

- M gene shows incomplete dominance (no tail)
- m is normal gene (tail)
- Gene that causes no tail is lethal when homozygous
- Homozygous dominant (MM) doesnt get born

- An individual possesses 2 alleles for one allele (called a **hereditary factor)**
- Humans have 23 pairs of chromosomes (46 chromosomes in total)
- Mother has attached earlobes (**recessive allele**)
- Father has free earlobes (**dominant allele**)



- If both hereditary factors are different
    - The dominant allele **determines the appearance** of the organism
    - The recessive allele has **no noticeable effect**
- The child would get the **dominant trait** (free earlobes)

Hardy Weinberg's Principle:

- Under certain conditions allele frequencies in a population stay constant
- Describes a population that doesn't evolve
- Population genetics

$$p^2 + 2pq + q^2 = 1$$

p = the frequency of “A” allele
q = frequency of “a” allele
p^2 = the frequency of the “AA” homozygous genotype
q^2 = the frequency of “a” homozygous genotype
pq = the frequency heterozygous genotype “Aa”

- States the amount of genetic variation in a population will remain constant from generation to generation
- p + q = 1
- If p and q are known, frequencies of the 3 phenotypes can be calculated

Conditions for Hardy-Weinberg's Principle:

- There are no mutations
- Mating is random
- Population is large
- No gene flow (no migration)
- No natural selection

Mutations:

- Changes in the DNA sequence of an organism
- mutation s are the source of genetic variability
- Can be chromosomal
    - DNA sequence loss
    - Repetition of DNA segments

    - Addition or loss of chromosomes

Characteristics of mutations:

- Random
- Transmissible
- Frequent in gene pool
- Rare at each locus
- Influences allele frequencies
- Weak evolutionary force in large populations

Point Mutations:

- Addition, deletion or substitution of base
- Can have different effects
    - Lethal effect
    - Neutral effect (can code for same codon)
    - Positive effect (helps individuals adapt better)

Mutation Rate:

- Rates vary according to groups of species or genes
- Unit of measure: pairs of bases per generation (pbg)
- Mutations offer good genetic basis for evolution

Random Mating:

- Maintains Hardy-Weinberg equilibrium
- Also known as : **panmixia**

Assortative Mating:

- Choice of partners in relation to the phenotype
- Modifies Hardy-Weinberg equilibrium
- Does Not change allele frequencies
- Changes genotypic frequencies
- Causes a greater decrease in genetic variability compared to random mating

Positive Assortative Mating:

- More frequent mating between similar individuals than expected chance
- Increase in homozygosity
- Examples of positive assortative mating
    - Autogamy / selfing of plants
    - Geographical proximity of individuals
    - Mating by height or skin colour (humans)
- Can increase homozygosity
- Decreases genetic variability

Negative Assortative Mating:

- Organisms avoiding mating with organisms similar to themselves

Gene Flow:

- Migration
- Exchange or genes between populations
- Tendency to standardize the genetic pool of populations involved
- Plays a similar role as mutations by introducing new genes in one of the populations

Genetic Drift:

- Result of chance
- Increases impact on a population as the size of population gets smaller
- In small populations, it causes:
    - Decrease in genetic variability
    - Decrease in heterozygosity
- In large populations, it causes:
    - Little changes to allelic / genotypic frequency of a population
- If no other processes are affecting allelic frequencies at a particular locus
    - Genetic drift will result in fixation of an allele
    - Elimination of all others on this locus
- Probability that an allele will become fixed s equal to its frequency

Population Bottleneck:

- Small populations
- Genetic drift can lead to fixation of alleles
- Loss of genetic variability
- Increases the risk of extinction

Founder Effect:

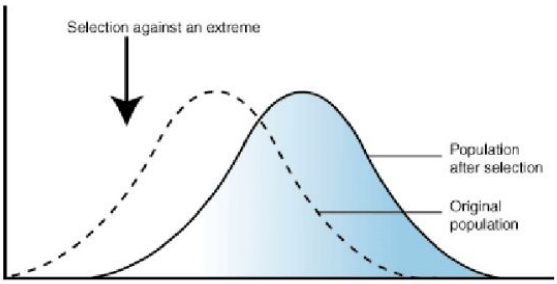
- Few individuals form a large population and create a new colony
- Can lead to birth defects
- Causes a loss of genetic variability
- Causes speciation
- Leads to evolution of new species
- Increases inbreeding
- ExL Myotonic dystrophy and Polydactyly

Natural Selection in Genetics:

- Survive and reproduce in larger numbers than other individuals if they have certain hereditary genes or traits
- Alleles are favoured by selection
- Natural selection on the frequency of an allele can be cancelled by the action of mutation, genetic drift and migration

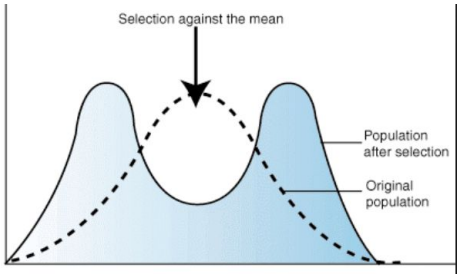
- Only evolutionary mechanism that helps survival and reproduction of organisms in their environment
- Adaptive value (selected value, fitness)
    - Fitness or adaptive value of a genotype corresponds to the contribution of an individual to the genetic pool of the next generation when compared with the contribution of other individuals
- Types of hereditary traits
    - Qualitative (discrete variation: colour)
    - Quantitative (continuous variation: height and weight)
- Polymorph
    - Populations showing morphological types of genetic variability

Directional Selection:



- Extreme phenotype is favored over other phenotypes
- Causes allele frequency to shift over time in the direction of that phenotype

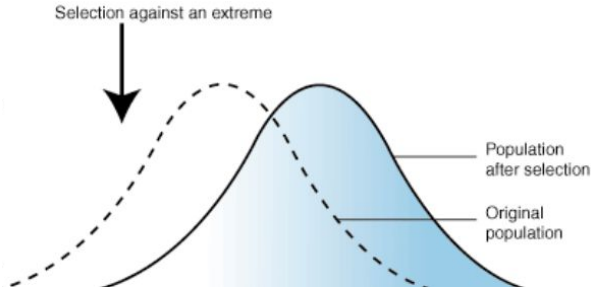
Disruptive Selection:



- Also called diversifying selection
- describes changes in population genetics in which extreme values for a trait are favored over intermediate values
- Variance of the trait increases and the population is divided into two distinct groups

Stabilizing Selection:

- The population mean stabilizes on a particular non-extreme trait value.



Preservation of Genetic Variability in Nature:

- Maintaining genetic variability in nature (aka polymorphism)

    - Diploid and genetic load
    - Advantage of heterozygotes
    - Frequency dependant selection
    - Neutral genetic variability
    - Other mechanisms
- Diploidy
    - Considerable portion of genetic variability of diploid individuals is hidden from natural selection
    - Mass of little expressed or unexpressed genes in heterozygotes (genetic load)
    - It is cost associated with maintaining and storing genetic variation
- Balanced Polymorphism
    - The heterozygote advantage: when heterozygous individuals have more offspring than homozygous individuals
    - Example: sickle cell anemia
        - S is dominant
        - s is recessive
        - Homozygous (ss) results in sickness
        - High morality before the reproductive age
        - Allele frequencies" is particularly high in regions where cases of malaria are high
        - Heterozygotes) is more resistant to malaria than homozygous dominant (SS)
          Selection dependant
- Selection dependant
    - The selection dependant on the inverse frequency in fishes that feed on scales
    - The rarest phenotype is favored by selection
    - Depends on positive frequency
    - Phenotype that is more abundant is always favoured
    - Selection leading to multiple stable equilibriums
    - Case of mullerian mimicry: 2 toxic species
- Neutral variation
    - Most of the genetic variability found in genes don't show selective advantages or aren't affected by natural selection
    - Example: pseudogenes
- External mechanism (or ecological)
    - Result of simultaneous impacts of different selective pressures
    - Temporal changes in selection pressure
    - Habitat mosaic
    - Non- assortative mating

Sexual Selection:

- Charles darwin initially formulated this concept

- Form of evolution where individuals that posses some specific hereditary traits are more susceptible than others to find partners

Intersexual Selection:

- Choice of secual partners based in traits indicating the quality of genetic baggage of the other sex

Intrasexual Selection:

- Selection between individuals of the same sex

Adaptations:

- Result of natural selection
- Change frequencies
- Can sometimes be complex and have complex history
    - Can come from evolutionary comprises or symbiosis

Why is our species the only primates that can choke on food?

- Evolutionary compromise (in order to be able to speak)
- Humans and chimpanzees share the closest common ancestor
- Chimpanzees have long mouths and long necks
- Humans have shorter mouths and large tongues
- Soft palate covers the trachea in chimpanzees
- Food pushes against the epiglottis and the throat closes
- Chimpanzees can't choke, the throat closes in order to block the food from going to the wrong place
- Humans have small jaws because we spend less time than chimpanzees eating and chewing
- This adaptation made it easier for humans
- Humans have space between their soft palate and the epiglottis
- The throat doesn't close when humans are swallowing food
- Food can enter the trachea when we swallow since the throat doesn't close

Evolution of Speech:

- Unique to humans
- Evolutionary compromise: risk of choking in order to speak
- Chimpanzees have
    - Long horizontal tubes
    - Amplifying area for sound
- Humans have
    - Long vertical tubes
    - Sounds generated from area underneath vertical tube
    - Vertical tube allows us to speak
    - Vulnerable to choking because of this tube

    - Long space cones from the ability to speak

Example of Adaptation: Burying Beetles

- Example of symbiosis: mutualism, commensalism and parasitism
- Mite migrates into corpse
- Use beetles as a method of transportation
- Symbiosis of 2 species
- Coevolution of both species since they adapt to each other, both closely correlated
- Advantages for beetle:
    - Mite gets transportation
    - Mite gets rid of some competitors of the beetle on corpse
    - Gets rid or larvae of other species
    - Reduces competition

Example of Adaptation: Parasitism in Humans

- Rare case
- Commonly found in sushi and fish products
- Salmon and large fish can be affected
- Advantage for one species but not for the other

Studying Adaptations:

- All traits of a living being are not adapted to the current environment
    - Concept of exaptation
- Our traits are adapted to previous environment (common ancestors)
- Features evolved for different reasons
- Ways to approve or refute an adaptive hypothesis
    - Study of natural selection
    - Comparative approach with knowledge of phylogenies
    - Morpho-functional study of a trait

Studying Adaptation: Comparative Method

- Mammals (carnivores)
    - Evolved from common ancestor
    - Has same function, hasn't changed
    - Articulation connecting lower jaw and skill is at same level as row of teeth
    - Hinged articulation
- Herbivores
    - Trait of jaw
    - Only way a herbivore can work
    - Comes from common ancestors
    - Articulation connecting the lower jaw to the skull is higher than row of teeth
    - Weak and flat articulation

Tyrannosauroidea Example:

- Smallest and oldest species
- Evolved from a small species
- Same morphology in small as big
- Adaptations are to lifestyle of small dinosaurs
- No selection against features like small arms
- Characteristics evolved from ancestral species

Adaptation of limbs:

- Initial function of fins were to stabilize a fish's body (adaptation)
- Tetrapods evolved limbs from fins
- Used to support the body in aerial environment
- Limbs are an **exaptation**
- Helps with terrestrial mobility or **locomotion**

Hair Evolution:

- Exaptation to conserve heat
- Relates mammals together
- Elephants have irregular hair, dont have fur
- They lose heat but not in a homozygous pattern
- Where skin is thinner, they lose more heat and energy
- Having sparse hair is more efficient at losing heat than no hair at all
- Flat surface isnt as good to lose heat
- Sensory structure
- Elephants can maintain heat

Adaptation of feathers:

- Neither an adaptation or exaptation
- Didn't evolve for flight
- Didn't evolve for thermoregulation
- Evolved for other functions
- Large dinos had feathers too

Heterochrony:

- Changes in speed or synchronization of the development phases
- Morphological results
- Proportions change
- Genes express themselves when babies are developing
- Slight changes in genes
- Small changes to elements
- Chimpanzee and human fetus are very similar
    - As they grow up, they have different jaw shapes
- Size of homologous structures

    - Evolution is not the function of structure
    - Evolution is gene used to develop size of structure
- Can alter the development of the reproductive organs
    - Paedomorphosis
    - Faster development of reproductive organs than somatic organs
    - Salamander si sexually mature even though it still has larval characteristics (gills)
    - Fully functioning reproduce organisms
    - Aquatic salamander able to reproduce
    - No terrestrial phase
    - Development of animal

Interpopulation Genetic Variation:

- One species, two populations
- Individuals from each population have a tendency to mate with members of their own population
- Example of positive assortative mating

Polymorphic Species:

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

Ecogeographic Rules:

- Models of geographical variation that follows climatic gradients for many species within a group of vertebrates
- Gloger's rule
    - Pigments in more humid climates
- Bergmann's rule
    - In endothermic animals, populations living in northern regions of the geographic distribution of the species will generally have a larger size
    - 72% of birds follow this rule
    - 65% of mammals follow this rule
- Allen's rule
    - In birds mammals, the northern populations will generally have short and massive extremities
    - Southern populations will have longer and thinner extremities

Evolution of the loss of fur and skin colour in humans:

- 6-7 million years ago, hominids (all human species) shared a common ancestor with the chimpanzee
    - Pale skin covered in dark fur
- Homo ergaster (H. erectus)
    - 1,2 million years ago
    - Less fruit available, meat was added to diet

- Walks longer distances for prey and water
- Adapt to life on plains
- More active lifestyle (hunter gatherer)
- Natural selection acts on the shape of the body (ability to run
    - Abundance of sweat glands and less fur to have more efficient thermoregulation

Human vs Animal Sweat Glands:

- Durry animal glands
    - Especially sebaceous and apocrine
    - Oily sweat
    - Perspiration difficult
- Human glands
    - Especially eccrine
    - Watery sweat
    - Easy perspiration (up to 10 L a day)

Sweating Horse:

- Sweating difficult
- Few eccrine sweat glands
- Protein of eccrine and apocrine sweat glands: katherine

Carnivore Thermoregulation:

- Panting
- Eccrine sweat glands found only on pads of paws

Human Perspiration:

- Up to 10 L a day
- A lot of eccrine sweat glands
- Loss of fur to facilitate sweat evaporation

- Selection in favour of darker skin at the same time as fur loss
- Natural selection favoured the individuals having thicker, darker and more acidic skin
    - more melanosomes =more melanins
- Protection against
    - UV rays
    - Fraught
    - Bacterial attacks
    - Vitamin deficiencies s
- For over 1 million years
    - Skin of all hominins species including Homo sapiens was dark
- Hypothesis to explain evolution of skin colour
    - Find an inherited trait

- Inherited trait gave those who had it positive survival and production differential (adaptation) from generation to generation compared to other members of the population

Folic Acid and Dark Skin:

- Folic acid is vitamin B9
- Destroyed in skin by excessive UV rays
- Deficiency of B9
    - Serious and possibly lethal; development malformations
    - Poor wound healing
    - Disturbed immune system
    - Sperm malformation
- At young age and pregnant woman
    - Direct impact on survival and reproductive success of the individual
- Dark skin offers a protection against UV rays
    - Offers survival and reproduction advantage
    - Adaptation

Vitamin D3 and pale skin:

- Synthesized in the skin by UV rays
- Helps in absorption of calcium in the gut
- Deficiency in vitamin d3
    - Have a direct impact on reproductive success of affected individuals
- Pale skin in low UV radiation would
    - Maximize the absorption of UV rays
    - Survival of human population in areas of UV deficiency
    - Adaptation

- Links between the quantity of UV rays reaching the earth and human skin colour
- Great human migration
    - Started 100 000 years ago
    - Humans invade increasingly northern habitats more recently
    - Evolve paler skin to maximize UV absorption in areas where UV radiation is weak
    - For synthesis of vitamin D3 by the skin
- In ares with an important annual deficit of UV rays
    - Colonized by humans
    - Was made possible because humans could compensate for deficiencies in vitamin D3 through diet
        - Hunting
        - Fishing
        - Domestication

Conclusions for evolution of the loss of fur and skin colour in humans:

- Loss of fur in hominids because of lifestyle changes from climate change
- Skin colour became dark quickly after fur loss
- Skin remained dark for more than i million years
- The evolution of pale skin is linked to colonization of habitats
    - Further north
    - Adaptation to maximize the absorption of UV rays in zones where radiation is low
    - Allowed healthy synthesis of vitamin D3
- Selective advantage of darker skin in regions with high UV
- Minimize the degradation of folic acid by UV rays
- Skin colour is a
    - Variable polygenic trait (explains variability of pigment intensity)
    - An adaptation to UV radiation
    - Only an indicator of the environment in which populations have lived

Morphological species concept:

- Consists in bringing together under one species name
- Individuals that have similar and unique morphological traits
- Specimen belong to a species if they morphologically resemble the “type” of specimen of the species
- Specimen is determined by taxonomist
- Typical specimen shows all unique features of a species **(holotype)**
- Concept comes from the essentialism of Aristotle
- Morphological variability of a species is now documented through the description of other specimens **(paratypes)**
- Specimens usually represent the morphological variability observed in the species