

Chapter 4

Slide #8: Mendelian Inheritance

- Founder of genetics
- Austrian monk
- Formulated his laws on the creation of hybrids (laws of HEREDITY) in 1866.
- His work was only recognized in 1900.

Slide #9: Mendelian Inheritance

- Mendel's work was made with exemplary scientific rigour.
- The choice of the experimental material was judicious:
 - peas (many varieties available, possibility of crossbreeding, fairly cheap, generation time is short, descendants are plentiful. (see table 14.1)
- Abundant data and the use of mathematical analysis to verify his hypothesis.
- Mendel talks about "hereditary factors" (GENES were still unknown at that time)
- Had lots of data to prove his point

Slide #10: Mendelian Inheritance

- Variation of genetic traits is explained by the different shapes genes can have. These shapes are translated into various DNA sequence. Every distinct sequence is an allele
- Each gene occupies a specific locus on a given chromosome
- The DNA sequence of the locus can show variants (ALLELES).
- For example, the alleles for white flowers and the alleles for purple flowers are situated on one of the peas' chromosome.
- Allele may have different formats (DNA sequence (coding DNA sequence). End point is a protein. Sometimes an allele can produce a good protein but others may produce a bad protein).
- For example, white vs purple flowers.

Slide #11: Mendelian Inheritance

- All organisms inherit two copies of a gene (different or identical), one from the 'father' and the other from the 'mother'.
- Pair of homologous chromosomes
- Each copy is called an ALLELE.
- It is possible that two alleles can be the same or different

Slide #12: Hereditary Factors: Genetics

- An individual possesses two alleles from one gene (hereditary factor)
- 23 pairs of chromosomes in humans
- Two alleles: free earlobe/ attached earlobe
- Genes dispersed among chromosomes

Slide #13: Mendelian Inheritance

-If both alleles of a locus are different, one of them, the dominant allele determines the appearance of the organism; whereas the other, recessive allele, has no notable effect on the appearance.

-LAW OF UNIFORMITY OF HYBRIDS of the first generation.

-Pure individuals of purple flowers. If both alleles are present, the dominant allele has an extremely efficient way to make proteins so expressed in phenotype. The other allele not present is recessive. Some alleles are not functional and inefficient.

-Same case for peas that Mendel looked at.

-First generation, the dominant allele will show in the phenotype.

-FIRST LAW OF MENDEL

Slide #14: Hereditary Factors

-If both hereditary factors are different, one of them, the dominant one determines the appearance of the organism, whereas the other, recessive factor, has no notable effect on the appearance.

-Individual with two alleles, the dominant allele will express itself in the phenotype

Slide #15: Mendelian Inheritance

-Law of segregation:

-Two alleles for a heritable character SEGREGATE (separate from each other) during gamete formation and end up in different gametes.

-Second Law of Mendel

-All our cells have two copies of chromosomes except sex cells. MEIOSIS!!!

-Sex cells have one copy of chromosomes (HAPLOID)

-Zygote: new combination of genes

-Genotype: genetic makeup of species

-Cells that are formed with one independent allele

-In times of reproduction, all gametes separate independently (2nd LAW)

-A pool of independent alleles creates a flower (violet phenotype because it is dominant)

Slide #16: Mendelian Inheritance

-Understand these terms:

-phenotype: Physical expression of gene (based on genotype and contribution of environment) Ex. flowers have two phenotypes and 3 genotypes. In a population an individual can have two alleles. Number of alleles in a population indicate the genetic variation in a population. There can be 25 alleles in a population. It does not matter. Dominant allele vs recessive allele: one phenotype can be the result of two genotypes.

-genotype

-homozygous

-heterozygous

Slide #17: Mendelian Inheritance

-Testcross to identify the unknown genotype

- Homozygous dominant: PP vs pp → all flowers are dominant
- Genotype is heterozygous Pp vs pp → two purple vs two white (two dominant vs two recessive)

Slide #18: Mendelian Inheritance

- The law of independent assortment:
 - Every pair of allele separates INDEPENDENTLY from the other pairs when the gametes are formed
- Gametes will segregate independently.
- Two traits involved: round or wrinkled / yellow or green
- Are these traits united or linked or are they independent??? If they are linked, when round always yellow or vice versa, you will end up with the ratio 3:1. If they segregate independently (traits are not linked), the ratio will be 9:3:3:1. This means that every trait segregated independently.

Slide #19

- Father: free (non attached) earlobes (dominant).
- Mother: attached earlobes (recessive)
- Every pair of allele separates independently of the other pairs when the gametes are formed.
- The alleles of the earlobes and of the hairline separates independently when the gametes are formed.
- An individual may have two different traits: V shaped hairline vs straight hairline / attached earlobe vs not attached
- Behave independently.

Slide #20: Initial Impacts of Mendel's Theory

- Mendel's works were resurfaced by three geneticists (Coreens, Tschermak and Hugo De Vries) in early 1900s
- 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 discontinuous aspects of the traits associated with Mendel's ratios and rejected by the continued variation observed in nature by claiming that it was non-Mendelian and without any evolutionary importance.
- Maybe species arose randomly... opposed with Darwin's theory.

Slide #21: Initial Impacts of Mendel's Theory

- Furthermore, 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 major substantial morphological modifications.
- During the 1920s, it was discovered that mutations are generally harmful or neutral and that only a few seemed to influence, although lightly, an organism traits.
- Example: big field with yellow primrose when a random red rose appeared in the middle of the field. Concluded that maybe species arose like that by mutations.

Slide #22: Neo-Darwinism and Modern Synthesis

-The 1920s and the 1960s, genetics and the theory of natural selection were reconciled. It is the official creation of NEO-DARWINISM and the “modern evolutionary synthesis”. The main impacts of Neo-Darwinism were:

- Lamarckism was finally refuted.
 - We started to understand the effect of chance in the transmission of alleles from generation to generation (genetic drift). The effect of chance., of randomness (genetic drift). Population size: Population of plants that counts ten individuals. If a tree falls on the patch, maybe three individuals or five individuals die. Five individuals left. Genetics are greatly affected. Any random effect on a small population is very important.
 - The genetic basis of evolutionary changes was established. A lot of alleles in a population = lots of genetic variability.
 - The study of genetics shows the existence of an important and persistent variation (exception of the cheetah) (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. POLYGENISM. A trait is often under the influence of many genes.
- Mutations: rare, neutral, sometime harmful, very rarely positive
 - Need several mutations for a complex trait to be evolved.
 - Evolution: Genetic change from one population to other
 - No mutations = no genetic variations
 - Main impact of Neo-Darwinism: no more Lamarckism

Slide #23: Neo-Darwinism and Modern Synthesis

- 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 (chapter 23 of the book). Evolution at the population level.
- The biological and genetic basis of the formation of species (SPECIATION) and the study of evolution above the species level, (MACROEVOLUTION), (Chapter 24 of the book) including elaboration of the tree of life (PHYLOGENIES) (Chapter 26 of the book)
- Speciation: Process in which species are born
- Macroevolution: study of above the species level ex. Family / order
- Phylogenies: study of ancestry

Slide #24: Modern Additions to Mendel's Laws

- INCOMPLETE dominance
- Relationship between alleles might be different than dominant vs recessive type
- Incomplete dominance: In the first generation, if you have homozygous individuals (CC vs cc), instead of the offspring showing one colour or the other, they would show a mix. Meaning that it is dominant but not completely dominant.
- Every phenotype has a genotype

Slide #25: Modern Additions to Mendel's Laws

-INCOMPLETE dominance

-Example: chestnut gene (CC) crosses with white gene (cc) gives tan colour (Cc)

Slide #26: Modern Additions to Mendel's Laws

-CODOMINANCE

-Both alleles are dominant

-Black chicken x white chicken = black and white chicken

Slide #27: Modern Additions to Mendel's Laws

-POLYGENISM: When a phenotypic trait is under the combined action of two or multiple genes (very common)

-EPISTASIS: When the effect of a gene hides or blocks the expression of another gene.

-PLEIOTROPY: When a gene influences more than one trait

Slide #28: Modern Additions to Mendel's Laws

-Example of EPISTASIS

-Two colour traits: black and chocolate and the other character is the static gene E

-Black dominant trait and chocolate brown dominant.

-In labradors, there is an epistatic gene: hide the colour pattern dictated by the black and chocolate gene. Manifests itself only in the homozygous recessive state.

Slide #29: Modern Additions to Mendel's Laws:

-Certain PLEIOTROPIC (effects more than one trait) genes are lethal when homozygous.

-Manx cat: Mutation that occurred on the island. Characterized by the total absence of tail

-The Manx gene (M) shows an incomplete dominance compared to the normal gene (m) (with tail)

-Crossing between two cats that do not have a tail (mm a normal cat)

-Prevents proper development of vertebrate and organism dies when in homozygous dominant stage

-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

Slide #30: Modern Additions to Mendel's Laws

-POLYGENISM is a very common phenomena with regards to expression of the genes.

-We're all characterized by continuous traits (ex. Height, weight, skin colour)

-Many of our traits are the result of the action of several genes. That is why things seemed to be continuous.

Chapter 5

Slide #2: Hardy-Weinberg's Principle

-In 1908, a German biologist (Weinberg) and an English mathematician (Hardy) made the same discovery:

- They demonstrated that, under certain conditions, allele frequencies in a population stay constant from one generation to the next. Thus, NO EVOLUTION.

Slide #3: Hardy-Weinberg's Principle

- Selecting alleles at random from a gene pool
- Imagine population of alleles: 0.8 C and 0.2 c. From these alleles, we produce gametes. In each egg and sperm produced, there is an 80% chance of C and 20% chance of c.
- p= C (red) / q=c (white)
- p+q=1

Slide #4:

Number of plants	320	160	20	=500 plants
Number of alleles	640	320	40	=1000 alleles (each individual has two alleles)
Genotypes	$C^{(r)}C^{(r)}$	$C^{(r)}C^{(b)}$	$C^{(b)}C^{(b)}$	
Frequency of genotypes in a population	0.64	0.32	0.04	
Frequency of ALLELES in a population	0.64+0.16		0.16+0.04	
	0.8(p)	+	0.2(q)	=1
	$C^{(r)}$	gametes	$C^{(b)}$	

NOTES:

-0.16 is half of 0.32 because in 0.32, there is one $C^{(r)}$ and one $C^{(b)}$

Slide #5: Hardy-Weinberg's Principle

- Punnett square
- square one: 80% x 80% p^2
- square two: 80% x 20% pq
- square three: 20% x 80% pq
- square four: 20% x 20% q^2

Slide #6: Hardy-Weinberg's Principle

- p^2 = Expected frequency of genotype $C^{(r)}C^{(r)}$
- $2pq$ = Expected frequency of genotype $C^{(r)}C^{(b)}$
- q^2 = Expected frequency of genotype $C^{(b)}C^{(b)}$
- Adding three frequencies = 1

Slide #7: Hardy-Weinberg's Principle

- A population is in Hardy-Weinberg's equilibrium when:
 - The frequencies of alleles and genotypes within a population will remain constant (according to the equation $p^2+2pq+q^2=1$) from generation to generation as long as the following conditions are respected:

- There are no mutations
 - Mating is done randomly
 - The size of the population is extremely large
 - There is no genetic (gene) flow (no migration of alleles between populations).
 - There is no natural selection.
- Hardy-Weinberg's principle describes a hypothetical population that does not EVOLVE.

Slide #8: Hardy-Weinberg's Principle

- Imagine a population of 100 cats: 84 blacks and 16 white.
 - White cats: recessive homozygous (bb)
 - Black cats: homozygous (BB)+heterozygotes (Bb)
 - Phenotypic frequency: black = 0.84 (84%); white = 0.16 (16%)
- If p= frequency of allele B, q=frequency of allele b, and if we presume that our population is in H-W equilibrium, what are the genotypic frequencies in our cat population.
- Genotypic frequency: p^2 (BB); $2pq$ (Bb); q^2 (bb)
- $q^2=0.16$ thus $q=\sqrt{0.16}=0.4$ and $p=1-q=0.6$ =allele frequencies
- Thus genotypic frequency = $(0.6)^2$; $2(0.4 \times 0.6)$; $(0.4)^2$
- BB = 0.36; Bb = 0.48; bb = 0.16

Slide #9: Hardy-Weinberg Principle

- module

Slide #10: Mutation

- Mutation: changes in the DNA sequence of an organism
- THIS IS THE SOURCE OF GENETIC VARIABILITY. Mutations are:
 - Random (not directed by anyway)
 - Transmissible (only if they are in the gametes) (only the mutations in the sex cells are transmissible).
 - Frequent throughout the gene pool, but rare are at each locus. IF you have a mutation in gene pool, it might seem like a lot but in each locus it is very rare. Does not explain the variability from generation to generation. Doesn't change the allelic or genotypic frequency in a great factor. Weak evolutionary factory from one generation to generation (down below)
 - Will influence allele frequencies but is a weak evolutionary force from generation to generation, especially in large population.
- Variation from generation to generation
- Mutations - source of genetic variability

Slide #11: Mutation

- POINT mutations (addition, deletion or substitution of a base; A-C instead of A-T).
 - Negative effect (ex. Ehlers-Danlos Syndrome: Hyper elasticity to joints. Has an impact on connective tissue in blood vessels. Ex. Achondroplasia: Linked with dwarfism. Dominant heterozygous allele. Can still reproduce. Have an impact on growth of bones)

-Lethal effect (will cause death) (Ex. Achondroplasia. Babies do not survive when they have this condition because it has an impact on growth of bones. So babies that have it do not survive for a very long time... usually a few weeks).

-Neutral effect (Non-coding part of our genome, if there are mutations there, nothing particularly will happen. It might have a positive effect: when the effect enables the individual to be better adapted to their environment)

-Examples:

-Synonymy of codons for the for the formation of amino-acids; particularly in the third position.

-non-codons part (protein) of the genetic code

-Positive effect (when the effect enables the individual to be better adapted to their environment).

-Usually neutral

Slide #12: Mutation

-Sickle-cell anemia

-wild type vs sickle cell type: Change in morphology is linked to one base (A). Impacts the formation of protein. Has a greater impact on the nature of the amino acid. Changes the shape of the hemoglobin (has an impact on the final shape of the blood cell). Creates lots of health problems. Level of mortality was high a few years ago. Very dangerous because blood cells do not flow well as they would if they were round.

Slide #13: Mutation

-Point mutation can be chromosomal: might be DNA sequence lost, might be repetition of chromosome, might be repetition of chromosome, might remove chromosome.

Slide #14: Mutation

-Mutations can be chromosomal (DNA segment loss, repetition of DNA segments, addition of loss of chromosomes).

Slide #15: Mutation Rate

-Rates of mutations vary greatly according to groups of living beings or genes.

-Unit of measure; pair of basis per generation (pbg)

-Some environments may increase rate of mutations by the introduction of mutagen (ex. UV rays increase mutations in the skin)

-Mutation in humans:

-Human genome (DIPLOID (two copies of chromosomes): approx. 6.4×10^9 base pairs.

-Approx 2.5×10^{-8} mutations by pbg. Probability of mutation by base pairs.

-Baby: approx. 175 new mutations in his/her genome.

-If 2.5% of the genome contains coding genes, then 4.3 mutations by babies have the potential to alter proteins and influence the genotype

-Population of 500,000 humans: 2,000,000 mutations by generations.

- Even if a small portion of these mutations is advantageous, it offers a good genetic basis for evolution over millions of years.
- Not very strong genetic factor

Slide #16: Assortative Mating

- Random mating: panmixia (maintains H.W.)
- Panmixia- in a population, individuals do not happen very often. Extremely difficult to find in nature.
- American eel:
 - Species found in all large rivers and lakes on the Eastern coast of North America. Spawning ground: somewhere in the Sargasso Sea (PANMICTIC population?)
 - Grows in freshwater for several years and then migrate to a spot to salt water and reproduce. Populations will mate and reproduce there in that one spot. They seem to be coming out in the same genetic pool. Very little genetic variability between populations. What does that mean? There might be random mating. Individuals might be mating without any mating choice.

Slide #17: Assortative Mating

- 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)
 - If individuals that look alike have a high probability of mating by chance, means favours homozygosity. Homozygosity can have a negative impact (lose alleles in a population because you will allow some dominant recessive to show up)
 - Negative assortative mating: more frequent mating between individuals that do not look alike than expected by chance (Effect: increase HETEROZYGOSITY)
 - Increases heterozygosity is healthy because it favours genetic diversity in a population.

Slide #18: Assortative Mating

- Positive assortative mating:
 - Autogamy or selfing of plants (pure lineage of Mendel). Mendel would take the pollen of the plant and put in the piston (Created self mating).
 - Geographical proximity of individuals (ex. Population of mice in a barn: tendency of, mice to mate with individuals in the same barn that might be genetically related)
 - In humans: mating according to height and skin colour. There is mate choice being done. It is not random.

Slide #19: Assortative Mating

- NEGATIVE assortative mating
- Individuals that don't look alike that seem to mate with each other

-In general, there is very little probability that a plant self-fertilizes. Why? Timing of the maturity of the pollen does not match up with the maturity of the ovary. IF they do match up, the pistil rejects the pollen of the same flower.

-Some plants will have thrum flowers vs pin flowers (length of stamen) (Bee will only fertilize with style about the same height with the stamen in another plant). Insures that polymerization is done with a different flower. A lot of polymerization is done with insects (ex. Wasps: taken pollen from one flower to another flower. System favour the mating of individuals that are different).

Slide #20: Assortative Mating

-Assortative mating DOES NOT CHANGE allele frequencies; it changes genotypic frequencies (if there is no other evolutionary factors involved). Values of p and q will not change but genotypic frequencies will.

-Deck of card: 26 pairs that are red and black (heterozygous). In the event of a positive assortment mating, we only have pairs with the same colour. We still have the same number of cards but will change the genotype.

-Alleles will not change but will be distributed throughout.

-Negative assortment mating: black cards with red cards

Slide #21: Assortative Mating

-When paired with natural selection, positive assortative mating can lead to an increase in homozygosity and eventually mean the loss of allele in a population (there might be a dominant recessive gene that manifests itself in the population) and a loss of genetic variability:

1. Phenomena of endogamic depression (the fact that natural selection will purge the population from harmful alleles) 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.

Slide #22: Assortative Mating

-The "crazy" mailman and the mysterious quest of the black guppy (an example of artificial selection leading to a loss of genetic variability)

-A guy was breeding fish in his basement. He finds out that nobody succeeded in breeding a black guppy.

-Took fish with black spots and breed them together and take the progeny and breed them with darker fish. He eventually got black guppy.

-One morning he got up and he found one white spot in the fish which is a very small fungi. All the fish died.

-He had interbreeding for years and there was no genetic variability. He illuminated all genetic variability in the population. The entire population was wiped out.

-Comes back to the example of the cheetah. If there happens to be a disease, the entire population may be wiped out.

Slide #23: Gene Flow

-gene flow is migration between populations. If a species has one population, no gene flow. If a species has lots of populations, lots of gene flow.

-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.

-Example: One population has AA, Aa, and aa and second population AA only. Migration modifies the genetic makeup of the population. These immigrants bring new alleles and break the H-W equilibrium.

-Migration has the tendency to standardize the genetic makeup. The genetic variation of population x will equal the genetic variation of population y. If there are no migrants, both populations will evolve independently.

-REMEMBER: HOW TO USE POPULATION VS SPECIES

Slide #24: Gene Flow

-Example of gene flow

-birds are migrating from the mainland to the island (mainly occurs in the central part of the population not the eastern part of the population). Eastern population mainly composed of females that have been there for many generations. Central population mainly composed of migrants. Female success survival is much higher in the eastern population than the central population. Why? It is because females coming from the mainland and trying to establish nests in the central population are not adapted the environment life there. So, there's a high level of mortality there for the females. It takes a few generations for selection to act on them for the individuals to be well stable in the environment.

Slide #25: Genetic Drift

-Genetic drift: result of CHANCE

-Main idea of genetic drift is size of population and impact on the genotypic and allelic frequencies.

-You have a fairly small population (0.7 for red and 0.3 for white). Out of these ten, only five will have offspring. What happened to the other five? Maybe they randomly died. In the next generation, the allelic frequency is 0.5 and 0.5 (big change). Let's say that a cow went by and ate all the flowers except for two which happened to be the red ones. Only these plants will reproduce offspring. In the next generation, the allelic frequency is $p=1$ and $q=0$. Genetic drift, just by effect of chance, one allele will become fixed and all the other alleles will disappear. More rapid in small populations. In large populations, it's going to take much longer for the population to reach that point.

Slide #26: Genetic Drift

-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.

Slide #27: Genetic Drift

- The relationship between the size of a sample and sampling errors:
 - If we do one coin toss, the probability of obtaining tail is 0.5.
 - After one try: the frequency of tails = 0.5
 - After 10 tries, it would be surprising to obtain only tails. You might obtain 6 tails. Frequency = 0.6 (instead of the expected frequency of 0.5)
 - After 1000 tries, you might obtain 506 tails and 494 heads. Tail frequency = 0.506 (instead of expected 0.5)
 - Thus, the larger the sample, the SMALLER the differences will be between expected frequencies and observed frequencies.
 - We expect to see the same in a biological population.
 - The larger the population, the less effect of genetic drift.

Slide #28: The Genetic Drift

-Simulation

Slide #29: Genetic Drift

- If there are no other processes (mutation, migration, or selection) that will affect allelic 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 or genotypic frequencies, then the probability that an allele will become fixed is EQUAL TO ITS FREQUENCY.

Slide #30: Genetic Drift

- The population bottleneck:
 - In small populations, genetic drift can lead to the fixation of deleterious alleles and a loss of genetic variability. Thus, this correspond to an increase in the risk of EXTINCTION.
- An important reduction in population size. Because of environment impact, the population may be reduced to a few individuals. These individuals will always contain only a part of genetic variability of the large population from before. These behaviours of the small population that is more affected by genetic drift will create a new environment of the species. For example, small population means higher homozygosity (higher probability of individuals to mate with other individuals that look alike. Some bad allele might show up and change the phenotype. The genotypic variability will go down and the probability of extinction will increase).

Slide #31: Genetic Drift

- Consequences of a population bottleneck: the case of the Greater prairie chicken
- Greater Prairie chicken: Vary in population size. It is presumed that in 1820 they were distributed throughout illinois but in 1993, there were only two populations. Scientists studied the

preserved skin from the birds and they established genetic variability by establishing an average number of allele per locus. Population went through a bottleneck and lost genetic variability. Homozygous recessive allele might be expressed and affected the phenotype. Manifested itself in the reproductive success in these birds. Went from 93% eggs hatched in 1820 to less than 50% eggs hatched. That population went through bottleneck. Solution? Take individuals from a healthy population and introduce them in your population. Increases number of allele and increases reproductive success. The problem though is habitat. Sometimes you create the genetic variability but there is no habitat for the species. They reintroduced cougars in florida but at one point there was no habitat for them.

-Two populations, one species

-Has to be the same species

Slide #32: Genetic Drift

-FOUNDER EFFECT: when a few individuals from a large population create a new colony, the genetic makeup of the colony differs from the source population

-Myotonic dystrophy

-Charlevoix+Lake St-Jean regions in Quebec, Canada: 189 out of 100,000

-Europe: 4 out of 100,000

-Polydactyly in the Amish

-In northern Quebec, they were colonized by europeans. In that population, a few individuals that had the allele of myotonic dystrophy. There were few individuals, so the allele stayed in the population. There were interbreeding so the allele spread itself. The genetic makeup of the colonizer will have an impact on that small population.

-Amish. There were a lot of interbreeding within the population. Some of the german settlers just happened to have polydactyly.

Slide #33: Genetic Drift

-Canadian populations of several species show less genetic variability than more southern populations (founder effect).

-A couple of millions of years ago, Canada was covered in ice. Population that invaded canada came from some population of the US because they had access to it. Canadian population had lower genetic variability than the southern because of the founder effect. There is less genetic variability in Canada than the US.

Slide #34: Natural Selection

-A process by which the individuals with certain hereditary particularities (traits) SURVIVE AND REPRODUCE in larger numbers than other individuals.

-The alleles favored by selection are more abundant in offspring than in the parental generation. Has an effect of the genetic makeup of the population from generation to generation.

-The action of natural selection on the frequency of an allele can be cancelled by the action of mutation, genetic drift, and migration. Reminder that you can have NS acting on a trait in a small population but genetic drift can happen and wipe out the population.

- The only evolutionary mechanism that aids the survival and the reproduction of organisms in their environment.
- Natural selection is one of the many processes that we have to assess.
- Only one that creates adaptation.

Slide #35: Natural Selection

- Do not forget: only HEREDITARY variations constitute the basis of natural selection. Need to know if the traits you are studying can be inherited. Examples of non hereditary variability: butterflies the colour patterns are not linked to genetics but linked to their diet. Only linked with the environment.

Slide #36: Natural Selection

- How to know if NS acted on a population
- Variability in yarrow (plant) height according to altitude
 - GENETIC differences or environmental effect?
- These plants have different heights based on the altitude. Is result of NS or environment?
- Take seeds of all plants at different sides and put them in greenhouse (standard environment, same type of everything) than you look at them grow and measure the height after a few weeks. If they all have the same height, you will know that it is linked with the environment. If they have different heights that correspond to the altitude, you will know that there is a genetic basis to the trait. If it is inherited than you can talk about NS.

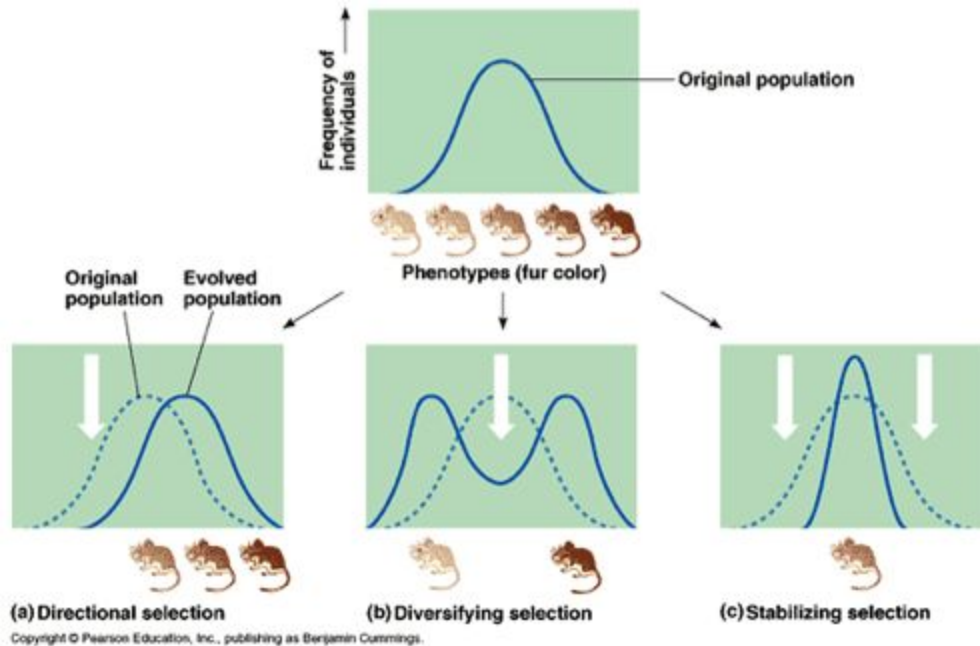
Slide #37: Natural Selection

- ADAPTIVE VALUE (selective value, fitness)
 - By definition, 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.
 - Ex. Three genotype in a population

Slide #38: Natural Selection

- Types of hereditary traits:
 - Qualitative (discrete variation: colour) Not something you can measure
 - Quantitative (continuous variation: height) Things that you can measure for which they have a genetic bases.
 - POLYMORPH populations showing distinct morphological types of genetic variability. There will be several morphology within the population. You will be able to categorize the population through traits.

Slide #39: The Natural Selection



-(b) is not diversifying selection but disruptive selection

-Directional Selection

-Most common type of selection

-Selection that will change the average value of the population

-Selection in one direction

-Disruptive selection

-the average does not change but there is selection against the average value but selection for the the extremes.

-Rare but might lead to speciation

-Stabilizing Selection

-Against the extremes.

-Favours individuals close to the average

Slide #40: Natural Selection

-Example of directional selection

-Impact of DDT on mosquitoes. DDT was found to be toxic on fauna and flora and birds so it was really harmful on the environment. It was an efficient after a few years. In the beginning, high mortality rate (95%). In a few years, the percentage of death would be less than 20%. What happened to the 5% that survived? Some mosquitoes, by chance, have a gene against the DDT. Allowed the population to survive. Same thing with antibiotics

Slide #41: Natural Selection

-Example of disruptive selection

-Pyrenestes species. Measured the width of the lower jaw. Seemed that the lower jaw is closely related to the seed that they are eating. There was selection against individual with average.

Why? Because there were no intermediate sized seeds. So the individuals that can only eat the medium size seeds vanished.

Slide #42: Natural Selection

- In the 1930's and 1940's NEWBORNS that weighed 8 pounds (3.6 Kg) had a higher rate of survival than smaller or larger newborn.
- Today, this stabilizing selection has almost disappeared in wealthiest countries.
- If babies were lighter or heavier, the survival rate would go down slightly.

Slide #43: Natural Selection

- All MAMMALS have seven cervical vertebrae (stabilizing selection)
- If you have more than seven or less than seven, the survival rate would go down and the probability of reproduction will decrease.
- When the embryo developing that has more than 7 cervical bones, meaning that it is connected to many other traits (polytropic).

Slide #44: Preservation of Genetic Variability in Nature

- Maintaining genetic variability in nature (POLYMORPHISM)
 - Diploid and genetic load
 - Advantage of heterozygotes
 - Frequency-dependent variability
 - Other mechanisms.

Slide #45: 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.
- In any diploid individual (have two copies of chromosomes), there is a lot of non expressed alleles that we have in our genome (Genetic load)

Slide #46: Preservation of Genetic Variability in Nature

- Balanced Polymorphism
- THE HETEROZYGOTE ADVANTAGE: When heterozygous individuals have more offspring than homozygous individuals.
- Ex. Sickle cell anemia
 - S dominant; s recessive
 - Homozygous ss=sickness (really acute disease); HIGH mortality before the reproductive age.
 - The allele frequency "s" is particularly high in regions where cases of malaria are high.
 - The heterozygote Ss is more resistant to malaria than SS

-Sickle cell anemia and malaria. Parasites invade red blood cells. It seems that if you are heterozygous (one allele of sickle cell anemia) will protect you against malaria. CO-DOMINANCE.

Slide #47: Preservation of Genetic Variability in Nature

-The selection-dependent on the inverse frequency in fishes that feed on scales. The RAREST phenotype is favoured by selection.

-Advantage of the rare

-One fish species coming from African lakes that feed on scales of other fish. The fish that is preyed upon wouldn't die and they would grow out their scales. The first species grew two populations. The first has mouth crooked to the right and the second population has mouth crooked to the left. Advantage of the rare is associated with the frequency of the attack on one side. If the frequency of attack is higher on one side, the prey would watch that side. The population with the opposite side will have the advantage because they can feed on the scales. The prey is not aware of their presence as much as the most abundant attackers. Both types are abundant in population but vary through time.

Slide #48: Preservation of Genetic Variability in Nature

-The selection depends on the positive frequency. The phenotype that is more ABUNDANT is always favoured.

-Selection leading to multiple stable equilibriums (adaptive landscape)

-Case of Mullerian mimicry: a case of mimicry between two toxic species.

-There are seven mountains that have different morphs (species number one). The second species live on the same mountain and they have the similar appearance as the first species. This is a case for Mullerian mimicry. One toxic species changes to look like it is more toxic than it is. There are several morphs that are stable which provides genetic variability in a species.

Slide #49: Preservation of Genetic Variability

-NEUTRAL variation

-A good portion of the genetic variability found in genes do not show selective advantages or is not affected by natural selection (ex. pseudogenes)

-PSEUDO gene -- quiet gene.

Slide #50: Preservation of Genetic Variability

-External mechanism (or ecological):

-The result of simultaneous impacts of different selective pressures.

-Temporal changes in selection pressure (selective pressures in the winter are different the selective pressures in the summer)

-Habitat mosaic (the habitat in which a species live will preserve genetic variability because they have different selective pressures according to each habitat)

-Non-assortative mating (tendency of an individual to mate with another individual that looks different)

Slide #51: 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.

-Females live much longer than males. Males have really big, colorful tails.

-An individual that has inherited traits are successful to find mates faster. Females will choose a male according to the amount of oscily in the males. Why? Because it is an indicator for the quality of the males. If you a lot of mating within that short time life, you have done your part.

Slide #52: Sexual Selection

-INTERSEXUAL selection (choice of sexual partners based on traits indicating the quality of the genetic baggage of the other sex):

-Selection between sexes

-Ex. Black Birds: females will choose individuals with longer stalk to maximize reproductive output. They took females and mated them with individuals with smaller stalk and the reproductive output turned out very bad.

-Ex. Long-tailed widowbird: males establish their territory. Why do females choose males? Based on the length of the tail. Males would display their tail to attract the female. They brought three of the birds and made three categories. They took one bird and cut off their tail, one bird and attached an extra tail, and a regular sized tail on the bird. The females chose the longer tail on a mail.

-The case of the widowbird: Do the females have a preference on the length of the tail feathers of males?

-Sexual dimorphism: differences in shape between sexes.

-If the males can't dance, females wouldn't choose them.

Slide #53: Sexual Selection

-INTRASEXUAL selection: selection between individuals of the same sex

-Confrontational behavior if often a ritualized combat.

-Some kind of confrontational behaviour between the same sex to compete for the other sex. Show of dominance.

-Ex. Size of antlers in Irish elf

-Ex. Polar bear ritualized combat

-Ex. Kangaroo

Slide #54: Sexual Selection

-PENIS BONE or baculum of a walrus. Structure is present in chimpanzees but absent in humans. Is it a case of sexual selection?

Chapter 6:

Slide #2: Adaptation

-Adaptations are the result of NATURAL SELECTION

-They are sometimes complex, have complex functions and a complex history (ex. Evolutionary compromises; symbiosis).

Slide #3: Adaptation

-Why is our species the only Primates choking on food? An EVOLUTIONARY COMPROMISE.

Slide #4: Adaptation

-Evolution of SPEECH: UNIQUE TO HUMANS

Slide #5: Adaptation

- The ultraviolet portion of the light spectrum attracts nocturnal insects

Slide #6: Adaptation

-Burying beetles transport mites.

-Symbiosis: MUTUALISM, COMMENSALISM, PARASITISM

Slide #7: Adaptation

-Parasitism in humans

Slide #8: Studying Adaptation

-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 (ex. 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 (ex. Carnivorous jaws vs herbivores jaws)

- Morpho-functional study of a trait (ex. Evolution of fur or feathers)

Slide #9: Studying Adaptations

-Mammals: Carnivores

Slide #10: Studying Adaptations: Comparative Method

-Carnivore: articulation connecting the lower jaw to the skull is AT THE SAME LEVEL as the row of teeth

-HINGED articulation.

Slide #11: Studying Adaptations

-Mammals: Herbivores

Slide #12: Studying Adaptations: Comparative Method

-Herbivores: Articulation connecting the lower jaw to the skull IS HIGHER than the row of teeth

-WEAK AND FLAT articulation

Slide #13: Studying Adaptations

- In the tyrannosauroidae the SMALLEST species tend to be the OLDEST species
- Species bear characteristics that have evolved in ancestral SPECIES

Slide #14: Studying Adaptations

- 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.

Slide #15: Humans: the Naked Truth

- Hair evolution
 - Adaptation or exaptation to CONSERVE HEAT?

Slide #16: Studying Adaptations

- Feathers: adaptation or exaptation for flight?

Slide #17: Evolution and Developmental Genes

- HETEROCHRONY
 - Changes in the speed or synchronization of the developmental phases.

Slide #18: Evolution and Developmental Genes

- Sometimes HETEROCHRONY alters the development speed of the reproductive organs
 - PAEDOMORPHOSIS: Faster development of reproductive organs than the somatic organs.
 - In the case of the axolotl salamander is sexually mature even though it still possesses larval characteristics (gills)

Slide #19: Evolution and Developmental Genes:

- Morphological form changes may arise from changes in the NUCLEOTIDE SEQUENCE of developmental genes (homeobox).

Slide #20: Evolution and Developmental Genes

- Morphological form changes may arise from changes in the REGULATION of developmental genes

Chapter 7

Slide #2: Inter-population Genetic Variation

-One species, two populations of caribou: the individuals of each population have a tendency to mate with members of their own population (positive ASSORTATIVE mating)

Slide #3: Geographical variation

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

Slide #4: Adaptive Value of Geographical Variation

-ECOGEOGRAPHIC rules: models of geographical variation that follows climatic gradients for many species within a group of vertebrates

-BERGMANN'S RULE:

-In endothermic animals in general, the populations living in northern regions of the geographic distribution of the species will generally have a LARGER size.

-72% of birds and 65% of mammals follow Bergmann's rule.

Slide #5: Adaptive Value of Geographical Variation

-Ecogeographic rules

-ALLEN'S RULE:

-In birds and mammals, the northern populations (or species) will generally have SHORT AND MASSIVE extremities, whereas the southern populations (species) will have LONGER AND THINNER extremities.

Slide #6: Adaptive Value of Geographical Variation

-Ecogeographic rules

-GUGLER'S RULE: DARKER pigments in more HUMID climates.

Slide #7: Adaptive Value of Geographical Variation

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

-6-7 Myr ago, the hominins (all human species) shared a common ancestor with the chimpanzee (PALE SKIN COVERED OF A DARK FUR)

Slide #8: Adaptive Value of Geographical Variation

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

-How many SPECIES of humans existed 2 Myr ago?

Slide #9: Adaptive Value of Geographical Variation

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

-A. afarensis

-Tropical forests

-Bipedal and ARBOREAL

-Diet of fruits, tubers and leaves.

-Sedentary way of life

Slide #10: Adaptive Value of Geographical Variation

- Evolution of the loss of fur and skin colour in humans
- As of 3 Myr
 - IMPORTANT COOLING
 - Droughts in East Africa
 - Formation of savannas
 - Impact on hominin species

Slide #11: Adaptive Value of Geographical Variation

- Evolution of the loss of fur and skin colour in humans
- Homo ergaster (= H. erectus) (1,2 Myr)
 - Less fruit available; meat added to the diet
 - Walks longer distances for prey and water.
 - Adapt to life on the 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 a more efficient THERMOREGULATION.

Slide #12: Adaptive Value of Geographical Variation

- Evolution of the loss of fur and skin colour in humans
- Furry animal glands: especially sebaceous and apocrine / OILY sweat / Perspiration
DIFFICULT
- Human Glands: especially ECCRINE/ WATERY sweat / EASY perspiration (10L)

Slide #13: Adaptive Value of Geographical Variation

- Evolution of the loss of fur and skin colour in humans
- Sweating Horse:
 - Sweating difficult / Few eccrine sweat glands (protein of eccrine and apocrine sweat glands: LATHERINE)
- Carnivore Thermoregulation:
 - panting and eccrine sweat glands found only on the PADS of paws.
- Human perspiration:
 - 10-12 litres per day (2-4 litres per hour) / a lot eccrine sweat glands (loss of FUR to facilitate sweat EVAPORATION)

Slide #14: Adaptive Value of Geographical Variation

- Evolution of the loss of fur and skin colour in humans
- Selection in favor of darker skin (1.2 Ma) AT THE SAME TIME as fur loss.
- Natural selection favored the individuals having thicker, darker and more acid skin (more melanosomes = more melanins).
- Protection against:
 - Ultraviolet rays (UV), drought, bacterial attacks and vitamin deficiencies.

Slide #15: Adaptive value of geographical variation

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

Slide #16: Adaptive Value of Geographical Variation

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

-For over 1 Myr (between 1,2 Myr to 100 000 years): the skin of ALL hominins species including Homo sapiens was dark.

Slide #17: Adaptive Value of Geographical Variation

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

Slide #18:

-Hypothesis to explain evolution of skin colour:

-Reminder: We need to find an INHERITED trait that gave those who had it a positive SURVIVAL AND REPRODUCTION DIFFERENTIAL (adaptation) from generation to generation compared to other members of the population.

Slide #19: Adaptive Value of Geographical Variation

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

- 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 REPRODUCTIVE SUCCESS OF THE INDIVIDUAL.

-Thus, we can say that DARK SKIN offers a protection against the UV rays that offers a survival and reproductive advantage (THAT'S AN ADAPTATION).

Slide #20:

-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 human population in areas of UV deficiency (ADAPTATION)

Slide #21: Adaptive Value of Geographical Variation

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

-The potential for synthesis of Vitamin D according to the UV radiation. The regions with the highest UV radiation are purple with a gradual decrease to red, orange, yellow, green and gray. Zone 1 (without strips): UV enough for the synthesis of Vitamin D. Zone 2 (vertically stripped) at

least one month without enough UV radiation to produce enough vitamin D, Zone 3 (quad): annual deficit UV radiation (Jablonski and Chapman, 2004, Annual Review of Anthropology).

Slide #22: Adaptive Value of Geographical Variation

- Evolution of the loss of fur and skin colour in humans
- Links between the quantity of UV rays reaching the Earth and human skin colour.

Slide #23: Adaptive Value of Geographical Variation

- Evolution of the loss of fur and skin colour in humans
- The great human migration that started 100,000 YEARS AGO has seen humans invade increasingly northern habitats more recently (especially in the last 40 000 years) and evolve paler skin to maximize UV absorption in areas where UV radiation is weak for adequate SYNTHESIS OF VITAMIN D3 by the skin.
- In areas where there is an important annual deficit of UV rays, colonization by humans (10 000 to 15 000 years) was made possible by the ability of humans to compensate for deficiencies in vitamin D3 through diet (hunting, fishing and domestication).

Slide #24: Adaptive Value of Geographical Variation

- Evolution of the loss of fur and skin colour in humans
- Conclusion:
 - Loss of fur in hominins is linked to LIFESTYLE changes due to climate change, more than 1,2 Myr years ago.
 - The skin color became DARK quickly after the loss of fur. The skin of human species remained dark during more than 1 Myr.
 - The appearance of pale skin in some human population is linked to the colonization of habitats further north in the last 100 000 years. This paler skin was an adaptation to maximize the absorption of UV rays in zones where radiation is low; this allowed the healthy synthesis of VITAMIN D3.
 - Note : individuals with darker skin in regions of high UV intensity synthesize Vitamin D3 at a much SLOWER RATE than individuals with pale skin.
 - A selective advantage of darker skin in regions of high UV intensity is to minimize the degradation of FOLIC ACID by UV rays.

Slide #25: Adaptive Value of Geographical Variation

- Evolution of the loss of fur and skin colour in humans
- The colour of skin is:
 - A variable POLYGENIC hereditary trait, which explains the variability of pigment intensity.
 - Only an adaptation to UV radiation.
 - Only an indicator of the ENVIRONMENT in which populations have lived.

Slide #26: Species

-MORPHOLOGICAL SPECIES CONCEPT:

- Consists in bringing together under one species name, individuals possessing SIMILAR MORPHOLOGICAL TRAITS
 - Specimens belong to a species if they morphologically resemble the “type” specimen (or holotype) of the species.
 - This type specimen is determined by the taxonomist as being at TYPICAL specimen showing all the unique feature of a species. It is a HOLOTYPE.
 - It is a concept that stems from the essentialism of Aristotle.
- Morphological variability (a Darwinian concept) of a species is documented through the description of other specimens (PARATYPES). These specimens usually represent the morphological variability observed in the species.

Slide #27: Species

-BIOLOGICAL SPECIES CONCEPT

- A group of populations whose members have the potential to INTERBREED in nature and produce VIABLE, FERTILE offsprings– but that do not produce viable, fertile offsprings with other such groups (there is a reproductive isolation mechanism in place that prevents interbreeding)
 - is only applicable to sexual organisms
 - Is only applicable in nature.
 - can only be checked in the an area of sympatry of potential species (area of overlap of two related species)

Slide #28: Species

-We can obtain INTERBREEDING HYBRIDS in a laboratory which are rarely or never found in NATURE (e.g. Mallard X Northern Pintail).

Slide #29: Species

- PREZYGOTIC 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)).

Slide #30: Species

-PREZYGOTIC reproductive barriers:

- b) TEMPORAL ISOLATION: non-synchronized mating or flowering (different seasons or a different time of day). Common mechanism in plants.
- c) ETHOLOGICAL ISOLATION (BEHAVIOURAL): absence of sexual attractiveness (distinct courtship). (e.g. Mallard and Northern pintail).

Slide #31: Species

-PREZYGOTIC reproductive barriers:

- 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.

Slide #32: Species

-POSTZYGOTIC reproductive barriers (lead to the loss of gametes)

- a)REDUCED HYBRID VARIABILITY: hybrids cannot develop or cannot reach sexual maturity. (e.g. cross between a goat and a sheep, the zygote quickly dies during the intrauterine development)

Slide #33: Species

-Postzygotic reproductive barrier

- b) STERILITY OF HYBRIDS: hybrids cannot produce functional gametes.

Slide #34: Species

-Postzygotic reproductive barriers

- c) HYBRID BREAKDOWN: hybrids can be viable and fertile (e.g. tigon and liger) but the offspring are susceptible to cancer and other illnesses.

Slide #35: Origin of Species

-Phyletic speciation (ANAGENESIS): Gradual evolution or "linear" succession of species in a way that the changing species shows different phenotypes through time.

Slide #36: Origin of Species

-Multiplication of species (CLADOGENESIS): creation of species by establishing a reproductive barrier between them.

-Cladogenesis: ONLY mechanisms responsible for the creation of biodiversity.

Slide #37: Origin of Species

-Evolution of a primate

Slide #38: Origin of Species

-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)

Slide #39: Origin of Species

-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. A genetic modification, under the combined effect of isolation and selective pressures, replaces a co-adapted system genes by another, more suitable to different ecological conditions.
 - 3. acquisition of reproductive isolation _____ the subsequent overlapping areas.
- Complete speciation: no viable hybrids in the contact zone (sympatric area) between species.

Slide #41: Origin of Species

-The dispersal capabilities of individuals is important in defining the probability of SPECIATION in some groups when compared to other groups.

Slide #42: Origin of Species

-The isthmus of panama (completed approx. 3 myr ago) has created a barrier between populations of ancestral species and created new species.

Slide #43: Origin of Species

-Eastern Meadowlark and Western meadowlark

-Minimal phenotypic differences (except for their song and behaviour that are very distinct)

Slide #44: Origin of Species

-Sympatric speciation: a new species APPEARS within populations (speciation WITHOUT geographic isolation):

- polyploidy (30 - 40% of plants): multiplying the normal number of chromosomes. This can happen when the chromosomes do not separate during the meiosis which produces diploid gametes (instead of haploids).
- Rare in animals.

Slide #45: Origin of Species

-Two morphs of *Rhagoletis Pomonella* in the process of sympatric speciation.

Slide #46: Hybrid Zones

-Hybrid Zone

Slide #47: Hybrid Zones

-Hybrid Zone

Slide #48: Hybrid Zones

-GROLAR Bear

-Rupture of reproductive isolation between grizzly and white bear. Exception?

Consequence of global warming?

Slide #49: Hybrid zones

- Enhancement of reproductive barriers in the contact area (hybrid zone)
 - CHARACTER DISPLACEMENT: the differences between two related species are often greater in sympatric areas. (e.g. 2 species of Galapagos finches)

Slide #50: Hybrid zones

- ENHANCEMENT of reproductive barriers in flycatchers.

Slide #51: Hybrid Zones

- Turbid water for 30 years: progressive FUSION gene pools (hybridization) of the two cichlid species.

Slide #52: Hybrid Zones

If the reproductive isolation is incomplete, there could be the creation of a STABLE of hybrid zone that containing hybrids. In these narrow zones from a geographical standpoint, there are genes or alleles of a species that pass freely into the gene pool of another species. (Gene introgression.)

Slide #53: Tempo of Speciation

- PUNCTUATED EQUILIBRIUM
- PHYLETIC GRADUALISM
- PROCESS OF SPECIATION: 4,000 years to 40 million years average: 6,500,000 years; rarely less than 500,000 years.