Chapters 1-4 in Bio Notebook

Chapter 5: The Evolution of Populations

5.1 Hardy Weinberg's Principle

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

- Demonstrated that, under certain conditions, allele frequencies in a population stay constant from one generation to the next. Thus, no evolution.
- Selecting alleles at random from a gene pool.
- Ex of red, pink, and white flower and allele frequencies of each flower.
- If the gametes come together at random, the genotype frequencies of this generation are in Handy-Weinberg equilibrium;
  - 64% C^R +16% C^R = 80% C^R = 0.8 = p
  - 4% C^W + 16% C^W = 20% C^W = 0.2 = q
- With random mating, these gametes will result in the same mix of genotypes in the next generation.

A population is in Hardy-Weinberg's equilibrium when:

- The frequencies of alleles ($p + q = 1$) 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.

<u>More complicated example: Cats</u>

Imagine a population of 100 cats: **84 black and 16 white**

- White cats: recessive homozygotes (bb)
- Black cats: homozygotes (BB) + heterozygotes (Bb)

Phenotypic frequency: black= 84%, white = 16%

- p = frequency of allele (B)

- q = frequency of allele (b)

Genotypic frequency: p^2 (BB), 2pq (Bb), q^2 (bb)
$q^2 = 0.16$ thus $q = 0.4$ and $p = 1 – 0.4 = 0.6$ = allele frequencies
Thus, genotypic frequencies = $(0.6)^2$; 2(0.4 x 0.6); $(0.4)^2$ or (BB) = 0.36, (Bb) = 0.48, (bb) = 0.16

5.2 Mutation

Mutation: changes in the DNA sequence of an organism.

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

Point mutations: (addition, deletions, or substitutions of a base; A-C instead of A-T).

- Negative effect (e.g. Ehlers-Danlos Syndrome: disease that weakens connective tissues of body like tendons and ligaments that hold body together.)
- Lethal effect (cause death).
- Neutral effect:
    - Examples:
        - Synonymy of codons for the formation of amino acids; particularly in the third position.
        - Non-coding part (protein) of the genetic code
- Positive effect (when the effect enables the individual to be better adapted to their environment such as people of Tibetan plateau with higher conc of RBCs).

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

5.3 Assortative Mating

Random mating: panmixia

American eel: species found in all large rivers and lakes of the Eastern coast of North America, migrate from freshwater to ocean/sea water.
Spawning ground: somewhere in the Sargasso Sea; mate randomly when migrating to ocean water.

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 by chance. (Effect: increase homozygosity)

- Negative assortative mating: more frequent mating between individuals that do not look alike than expected by chance. (Effect: increase heterozygosity)

Positive Assortative Mating:

- Autogamy or selfing of plants (pure lineages of Mendel).
- Geographical proximity of individuals (e.g. population of mice in a barn).
- In humans: mating according to height and skin colour.

Negative Assortative Mating:

- Tendency for individuals to mate with other individuals that are different from them.
- Can cause rejection of sperm from ovules in flower during self-fertilization.

Assortative mating **does not change** allele frequencies; it changes genotypic frequencies.

- Like a deck of cards; alleles represent a card.
- Shuffing does not change the allele or the number of alleles, it changes the assortment of alleles.
- Thus, genotypic frequency is like shuffling a deck when assortment of alleles (cards) are dispersed from generation to generation.

When paired with natural selection, positive assortative mating can lead to an increase in homozygosity and a loss of genetic variability:

1. Phenomena of **endogamic depression** since the harmful alleles will express themselves.
2. Natural selection will purge the population of a portion of its harmful alleles.

Thus, a loss of genetic variability compared to panmixia (random mating).

The "**crazy**" mailman and the mysterious quest of the black guppy (an example of artificial selection leading to a loss of genetic variability). **Example of Positive Assortative Mating**

- Guppies; are small fishes that are found in freshwater and easy for them to reproduce in an aquarium
- Males have a small gonopodium on its abdomen to allow for female guppies to inseminate, and fertilize eggs in the female's oviduct, then grow into guppies.
- Very reproductive, reproduce at a high rate and easy to allow for reproduction.

There was a challenge of artificial selection where an individual would allow guppies to mate and produce a fully black guppy.

After 2 years of artificial selection, the individual ended up with a fully black guppy.

- Black guppy then reproduced another black guppy, he reached his goal.
- Eliminated genetic variability when he forced black guppies to mate since they were all homozygotes.
- Shows the result of endogamic depression.

5.4 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.

5.5 Genetic Drift

Genetic drift:

- Result of **chance**, assuming that it occurred under unpredictable events.
- Bigger impact when dealing with smaller populations.
- Cause changes in genotypic frequencies and allelic frequencies.
- Ultimate result of genetic drift is that only one allele will be preserved, the rest of the other alleles will be gone.
- In **small** populations, genetic drift will trigger a decrease in genetic variability and a decrease in heterozygosity.
- In a **large** population, genetic drift will cause little changes to the allelic or genotypic frequency of a population.

If there are no other processes (mutation, migration, or selection) that will affect allelic frequencies at a particular locus, genetic drift will eventually result in the **fixation** of an allele and the elimination of <u>**all**</u> 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 <u>**equal to its frequency**</u>.

Population bottleneck:

- In small populations, genetic drift can lead to fixation of deleterious alleles and a loss of genetic variability. Thus, increasing the risk of <u>**extinction**</u>.

Consequences of a population bottleneck:

- Ex; case of the Greater prairie chicken.
- Loss of habitat due to urbanization and agricultural expansion.
- Many chickens went extinct and the chickens that survived were a very small number (<50) and resulted in homozygosity.
- Since the population of chickens were small in Illinois, genetic drift had a greater toll on those chickens and their allele frequencies.

Founder effect: when a few individuals from a large population create a new colony, the genetic make-up of the colony differs from the source population.

- Negative alleles will have a greater impact in new colonies than in the source colony of which individuals came from.
- Resulted from mating in a small population with the negative allele.
- **Myotonic dystrophy:** gene disorder that affects muscle function
    - Charlevoix + Lake St-Jean regions in Quebec, Canada: 189 cases for 100,000.
    - Europe: 4 out of 100,000
- **Polydactyly** (6 toes, or 6 fingers) in the Amish.

5.6 Natural Selection

- A process by which individuals with certain hereditary particularities **survive and reproduce** in larger numbers than individuals.
- The alleles favored by selection are more abundant in the offspring than in the parental generation.
- The action of natural selection on the frequency of an allele can be cancelled by the action of mutation, genetic drift, and migration.
- The only evolutionary that aids the survival and the reproduction of organisms in their environment, in other words; **adaptation**.
- Natural selection is the only mechanism that allows for adaptation.
- **NOTE: only hereditary variations constitute the basis of natural selection.**

Variability in yarrow height according to altitude.

- Often linked with the mix of genetic make-up and environmental effect.
- Natural selection can only act upon genetic part of variability.

Adaptative value of a genotype: (selective value, fitness)

- By definition, **fitness** or the adaptative 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.
- Some genotypes have better adaptations when it comes to their phenotype, for example, a white flower is better adapted to an environment than the red or pink flower because they have the white pigmentation allele.
- The genotype that adapts better is known to have "**higher fitness**".

Directional selection: changes the value of the mean in a population.

- Ex: if an environment favours a darker colored mouse in terms of survival and reproduction, then the average would move slightly towards the darker mice since more darker mice become abundant.
- Ex: mosquitos exposed to DDT became adapted to it and after 1.5 years, DDT became less effective on mosquitos; resulted in a higher average of mosquitos with DDT adaptation.

Disruptive selection: (a rarer case) selection against the average value and in favor of the extreme.

- Ex: the palest mouse and the darkest mouse are favored, and the intermediate is selected against.
- Ex: birds with big peaks and small peaks, no birds had medium sized beaks.

Stabilizing selection: selection against the extreme and favors the mean.

- Ex: selection against the extreme (palest mouse and darkest mouse) the intermediate colored mouse will be favoured.
- Ex: in the 1930's and 1940's, newborns that weighed 8 pounds had a higher rate of survival than smaller or larger ones.

        - Another ex: all mammals have seven cervical vertebrae. Mammals with 6 or 8 cervical vertebrae would have issues with living and survival, thus mammals with 7 cervical vertebrae (the mean or middle) survive better and is favored.

5.7 Preservation of Genetic Variability in Nature

Diploidy

- A considerable portion of the genetic variability of diploid individuals is hidden from natural selection:
    - The mass of little expressed or unexpressed genes in heterozygotes (**genetic load**)
    - It is the cost associated with maintaining and storing genetic variation.
    - Helps in adapting to environment change.

Balanced Polymorphism

- **The heterozygote advantage**: when heterozygous individuals have more offspring than homozygous individuals.
    - Ex: Sickle cell anemia (point mutation)
        - S dominant (sickle cell anemia is a dominant allele); s recessive
        - Homozygote ss = sickness; high mortality before the reproductive age.
        - The allele frequency "s" is particularly high in regions when cases of malaria are high.
        - The heterozygote Ss is more resistant to malaria than SS.

The selection-dependent on the inverse frequency in fishes (can also be found in other organisms)

(Perissodus microlepis**) that feed on scales**.
The rarest phenotype is favored by selection; able to prey on other fishes and be more successful and results in a bigger reproductive output.

The selection depends on the positive frequency.

- The phenotype that is more **abundant** is always favored.
- Selection leading to multiple stable equilibriums. (adaptive landscape)
- Case of Mullerian mimicry: a case of mimicry between two toxic species.

Neutral Variation

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

External mechanism (or ecological):

- The result of simultaneous impacts of different selective pressures; an organism is not affected by one selective pressure rather it is affected by many).

- Temporal changes in selection pressure since we live on a planet that is extremely dynamic in terms of geology and climate.
- Habitat mosaic (same species can have different phenotype due to local selective pressures because they live in different environments).
- Non-assortative mating.

5.8 Sexual Selection

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

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

- The case of the widowbird: Do the females have a preference on the length of the tail feathers of males?
    - Length and quality of males' feather tails were preferred by the females.

Intrasexual selection:

- Selection between individuals of the same sex.
- Completely absent in widowbird.
- Found in polar bears
    - Confrontational behaviour is often a ritualized combat.
- Also found in kangaroos since there is competition with the mating of female kangaroos.
    - When kangaroos fight, if one kangaroos uses their hymn legs and "push" the abdomen of the other kangaroo
        - That's a sign that the kangaroo lost the battle and wants to get away.

Penis bone or baculum of a walrus (59 cm).

- Structure is present in chimpanzees but absent in humans.
- Is it a case of sexual selection?
    - A case of intrasexual selection.
- Presence of penis bone allows to inseminate females very efficiently; quickly and smoothly.
    - Since females are sexually receptive for a short period of time.
- Penis bone is usually found in males who are polygamists (males that mate with several females).
- Males have evolved a monogamist type of relationship, thus no need for a penis bone.
    - No usefulness of penis bone.

Chapter 6: Adaptation

6.1 Adaptation

6.2 Understanding Adaptations
6.3 Adaptations and Developmental Genes

6.1 Adaptations

- Adaptations are a result of **natural selection**.
- They are sometimes complex, have complex functions and a complex history (ex. evolutionary compromises; symbiosis)

6.2 Understanding Adaptations

Methods aimed at testing adaptive hypothesis:

- Direct study of natural selection (ex: peppered moth, medium ground finch, human adaptation to altitude.)
- Comparative approach + **knowledge of phylogenies:** allow to distinguish traits that have evolved independently (convergence) or that are the result of a common ancestor.
    - Ex; evolution of cheetah, carnivorous vs herbivorous jaws.
- Morphofunctional study of a trait: evolutionary trade-off and determination of exaptation vs adaptation
    - Ex: evolution locomotion, hair or feathers.

Why is our species the only Primates choking on food?

- An **evolutionary compromise**.
    - When chimpanzees swallow food the epiglottis flattens, and food is impossible to enter trachea.
    - In humans, we do not have that mechanism and possible for us to choke on food since there is space in the trachea for food to enter; epiglottis doesn't fully flatten out and cover trachea.
- Caused by the evolution of **speech: unique to humans**.
- Chimpanzees have short vertical tubes and long horizontal tubes.
    - Limits capacity to pronounce sound and not very articulated.
- While humans have long vertical tubes and short horizontal tubes.
    - Has a lot of nerves and muscle; very complex.
    - Allows for pronunciation of words and vowels.
    - Disadvantage is choking on food.

The ultra-violet portion of the light spectrum attracts nocturnal insects.

- Burying beetles (Nicrophorus sp.) transport mites (Poecilochirus sp.)
    - Mites found on the beetle.
    - Mites found on beetle since mites also reproduce in area of dead mice/rats.
    - Both mites and beetle reproduce in area of dead rodent burial.
    - Mites feed off dead rodents rather than beetles' competitor.
- **Symbiosis: mutualism, commensalism, parasitism**
    - **Mutualism: advantage for mites and beetle.**
    - **Parasitism in humans**

        - Flatworms when eating sushi
        - Eats what you eat and makes you more susceptible to disease and sickness
        - Increased when trend of eating sushi increased

Tyrannosauroidea

- In the Tyrannosauroidea, the **smallest** species tend to be the **oldest** species.
- Species bear characteristics that have evolved in ancestral **species**.

Exaptation: adaptation whose current function is not the one for which the structure initially evolved.

- 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 evolved from fins) are used to support body in an aerial environment.
    - The limbs of tetrapods are thus an **<u>exaptation</u>** for terrestrial mobility **(locomotion).**

Hair evolution: Elephants

- **Adaptation** or **exaptation** to **<u>conserve heat?</u>**
    - **Exaptation to conserve heat** since the coarse hairs on the elephant tend to actually lose more heat than areas with less hair.
    - Discovered by scientists in research
        - Regions with pin-like structures such as hairs on an elephant lose more heat than flat surfaces.
    - However, in most animals, fur or hair is used to conserve heat yet in elephants they have coarse hair to lose heat.
    - Cause not known for why elephants have hair to lose heat rather than conserve heat; most likely **exaptation**.

Feathers:

- **Adaptation** or **exaptation for flight?**
    - Possible evolution cause; sensory structures, sexual selection.

6.3 Adaptation and Developmental Genes

Heterochrony:

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

Sometimes **<u>heterochrony</u>** alters the development speed of the reproductive organs.

- <u>**Paedomorphosis**</u>: faster development of reproductive organs than somatic organs.
    - In the case of the axolotl, the salamander is sexually mature even though it still possesses larval characteristics (gills).

Chapter 7 – Geographic Variation and Speciation

7.1 Interpopulation Genetic Variability
7.2 Models of Geographic Variation
7.3 Adaptive value of Geographical Variation
7.4 Species
7.5 Origin of Species
7.6 Hybrid Zones
7.7 Tempo of Speciation

7.1 Inter-population Genetic Variation

One species, two populations of caribous:

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

7.2 Models of. Geographic 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).

- Same species but different forms (such as birds of same species having different crests).

7.3 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, the populations living in northern regions of geographic distribution of the species will generally have a **larger** size.
- 72% of birds and 65% of mammals follow Bergmann's rule.
- Reason why northern and southern animals of the same species have a difference in size
  - More north → larger, more south → smaller
- Relative to surface area-volume relationship
  - If surface area is lower compared to relative volume, then more heat can be conserved; larger animals in the north (need to conserve heat; climate is cold).
  - If surface area is higher compared to relative volume, then less heat can be conserved; smaller animals in the south (don't need to conserve heat; climate already hot).

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.

Gogler's rule:

- **Darker** pigments in more **humid** climates.

Evolution of the loss of fur and skin colour in humans

- 6-7 million years ago, the hominines (all human species) shared a common ancestor with the chimpanzee (**pale skin covered of a dark fur**).
    - To define species under hominin, vertebral column attaching into the skull (ventral column).
    - Any species with that trait can be considered as a hominine.
    - 25 species of hominin.
    - Humans lost their fur as hominines.
    - Many hominin species lost their fur 1.2 million yrs ago
    - Pinkish skin when fur is abundant in hominin species.
- How many species of humans existed 2 million years ago?
    - 6 species
- Many branches of hominine that lead to different forms and types of craniums.
- Not all hominines are linked to evolution of humans.

Australopithecus afarensis:

- Tropical forests.
- Bipedal and **arboreal (**big toes have same orientation as other toes, and also had very long fingers and toes; giving ability to climb trees).
- Diet of fruits, tubers and leaves.
- Sedentary way of life.

As of 3 million years ago

- **Important cooling**
- Droughts in East Africa
- Formation of savannas
- Impact on hominin species

Example: Homo ergaster (= H. erectus) (1.2 Ma)

- Less fruit available; meat added to 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**.

Furry animal glands vs human glands:

- Especially **sebaceous and apocrine** in furry animals; especially **eccrine** in humans.
- **Oily** sweat vs **watery** sweat.

- Perspiration **difficult** in furry animals' vs **easy** perspiration in humans (up to 10 litres a day)

Carnivore thermoregulation:
- **Panting** and eccrine sweat glands found only on the **pads** of paws.

Sweating horse:
- **Sweating difficult**
- **Few eccrine sweat glands**.
- (protein of eccrine and apocrine sweat glands: **latherine**).
- **Latherine will create a white moss** if apocrine sweat glands are covered by a pad.

Human Perspiration:
- Up to 10 litres per day.
- A lot of eccrine sweat glands (loss of **fur** to facilitate sweat **evaporation**).
- Very efficient system for sweating.
- Adopted after humans lost their fur.

Selection in favor of darker skin (1.2 Million yrs old) at the same time as fur loss.

Natural selection favored the individuals having thicker, darker, and more acidic skin (more melanosomes = more melanins).

Protection against:
- Ultraviolet rays (UV), drought, bacterial attacks and vitamin deficiencies.

Fur helped animals communicate
- For example; when scared, animals furs erect.

With the loss of fur in humans;
- Fur's role was transmitted to skin.
- Yet, means of communication was lost when fur was lost.
- Then we acquired other means of communication such as facial expressions (communicate some type of emotion).

For over 1 million years (between 1.2 million years to 100,000 years): the skin of **all** hominin's species including homo sapiens was dark.

Humans are the most successful hominins when it comes to their dispersal.

Hypothesis to explain evolution of skin colour:
- Note;

- We need to find **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.

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).

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**).

Links between quantity of UV rays reaching the Earth and human skin colour.
- More centre of earth → darker skin
- Further away from centre/ closer to the poles→ paler skin.

The great human migration that started **100,000 years ago** has seen Homo sapiens 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 with an important annual deficit of UV rays, colonization by Homo sapiens (10,000 to 15,000 years ago) was made possible because humans compensated for deficiencies in Vitamin D3 through **diet** (hunting, fishing and domestication).

Conclusion:
Loss of fur in hominins is linked to **lifestyle** changes due to climate change (cooling of climate), more than 1.2 million years ago.
The skin color became **dark** quickly after the loss of fur. The skin remained dark for more than 1 million yr.
A selective advantage of darker skin regions of high UV intensity is to minimize the degradation of **folic acid** by UV rays.
The evolution of pale skin in some human population is linked to the colonization of habitats further north during the last 100,000 years. This paler skin is an adaptation to maximize the

absorption of UV rays in zones where radiation is low; this allowed the healthy synthesis of **vitamin D3**.

- Individuals with darker skin in regions of high UV intensity synthesize vitamin D3 at a much **slower rate** than individuals with paler skin.

The colour of skin is:

- A variable **polygenic** trait which explains the variability of pigment intensity.
- An adaptation to UV radiation.
- Only an indicator of the **environment** in which populations have lived.

7.4 Species

pSpecies concept:

- Consists in bringing together under one species name, individuals possessing **similar and unique morphological traits.**
- Specimens belong to a species if they morphologically resemble the "type" specimen (or holotype) of the species.
- This type of specimen is determined by the taxonomist as being a **typical** specimen showing all the unique features of a species. It is a **holotype.**
- It is a concept that stems from the essentialism of Aristotle.

Holotype:

- Morphological variability (Darwinian Concept) of a species is now documented through the description of other specimens (**paratypes**).
- These specimens usually represent the morphological variability observed in the species.

Biological Species Concept:

- A group of populations whose members have the potential to **interbreed** in nature and produce **viable, fertile** offspring - but do not produce viable, fertile offspring 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 verified in the area of sympatry of potential species (area of overlap of two related species).
- We can obtain **interbreeding hybrids** in a laboratory which are rarely or never found in **nature** (e.g. Mallard X Northern Pintail).

Prezygotic Reproductive Barriers

- Prevent the formation of hybridized zygotes and thereby the loss of gametes.
  - **Ecological isolation:** populations on the same continent but live in different habitats (e.g. lion (Asian savannahs) and tiger (Asian forests)).

- **Temporal isolation:** non-synchronized mating or flowering (different seasons or a different time of day). Common mechanism in plants.
    - Different reproductive cycle; results in no hybrids of species.
- **Ethological isolation (behavioural)**: absence of sexual attractiveness (distinct courtship).
    - e.g. Mallard and Northern pintail.
- **Mechanical isolation:** mating or pollen transfer is impossible due to the incompatibility of genitals or different flower structures.
- **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 if not from the same species.

Postzygotic Reproductive Barriers

- imply loss of gametes; not favoured by natural selection.
    - **Reduced Hybrid Variability:** hybrids cannot develop or cannot reach sexual maturity.
        - **E.**g. crossbreed between a goat and a sheep, the zygote quickly dies during intrauterine development.
    - **Sterility of Hybrids:** hybrids cannot produce functional gametes.
        - Such as mule
    - **Hybrid breakdown:** hybrids can be viable and fertile, but the offspring are susceptible to cancer and other sicknesses.
        - **E.**g. tigon and liger

7.5 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.
- It's explained to be a partial process of cladogenesis.

Multiplication of Species (cladogenesis):

- Creation of species by establishing a reproductive barrier between them.
- Cladogenesis: **only** mechanisms responsible for the creation of biodiversity.
- One species can reproduce into a 'new' form of the same species.
    - E.g. of combing anagenesis and cladogenesis is the evolution of a primate called Pelycodus.

From a genetic standpoint, a premise for the multiplication of species or the establishment of a reproductive barrier is the **interruption** of migration or gene flow between populations.

- Models of speciation (cladogenesis) shows how the gene flow can be interrupted.
    - **Allopatric** speciation (almost universal process).

- **Sympatric** speciation (rarer).

Allopatric speciation: a population with continuous distribution divided in two or multiple populations by a geographical barrier. It allows for distinct characteristics to these species.

Steps:

1. Passive isolation of populations in space.
2. Genetic modifications, under the combined effect of isolation and selective pressures, replace a co-adapted system gene by another, more suitable to different ecological conditions.
3. Acquisition of reproductive isolation before the subsequent overlapping areas.

Complete speciation: no viable hybrids in the contact zone (sympatric area) between species.

- The dispersal capabilities of individuals are important in defining the probability of **speciation** in some groups when compared to other groups.

- The **Isthmus** of Panama (completed approx. 3 million yrs. ago) has created a barrier between populations of ancestral species and created new species. Land bridge split species and allowed for those species to obtain distinct characteristics.

Eastern Meadowlark (Sturnella Magna) and **Western Meadowlark** (Sturnella neglecta):

- Minimal phenotypic differences (except for their reproductive song and behaviour that are very distinct)
- Different songs allow for female to mate with the correct species.
- Range in all North America; but there is an overlap of these species in central North America.

Sympatric speciation: a new species **appears** within populations (speciation **without** geographical isolation):

- Polyploidy (many plants): accidental multiplication of the normal number of chromosomes during cell division.
- **Self-learning:** distinction between autopolyploidy vs allopolyploidy.
- Rare in animals.

7.6 Hybrid Zones

- Gene flow of a population can produce a genetic barrier and allow a small number of a population to diverge (isolate), then that small number can evolve in a certain fashion.
- And the rest of a population will evolve in a certain fashion.
- If they mate after they evolved, produce hybrids in the overlapping (hybrid) zone.
- There can be other possible outcomes;
    - Reinforcement

    - Fusion
    - Stability

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 the Galapagos finches.
    - **For example,** the same species may have different fur color in sympatric region but same color fur in allopatric region.

Turbid water for 30 years:

- Turbid water changed colour perspective of water; made male cichlid species look the same.
- Progressive **fusion** gene pools (hybridization) of the two different cichlid species.
- Mating of the two cichlid species resulted in hybrids and now the hybrids are the only ones present in the turbid water.

Grolar Bear:

- Rupture of reproductive isolation between grizzly and polar bear.
    - Grizzly bear specialized (adapted) in forest and mountain areas.
    - Polar bears specialized (adapted) in icy areas and feed on ice packs in the summer of the Arctic.
- Encounter of two species caused by global warming since arctic is melting while polar bears look for ice packs to feed on in the summer.
- They may have stopped looking for ice packs and went to feed on the mainland; may resulted in encounter with Grizzly bear.

Two species of toads (one from higher altitude and one from lower altitude) formed hybrid zones in regions in between their habitats.
Hybrids of those toad species turned out not to be successful since genes doesn't flow from both toads in the hybrids.
The hybrid zone may have features that are beneficial specifically to those hybrids.
Hybrid zone is stable since both parental toad species do not fuse in hybrids.

7.7 Tempo of Speciation
Process of speciation: 4,000 years to 40 million years.

- Average: 6,500,000 years; rarely less than 500,000.

Punctuated equilibrium: Morphology is changed with speciation, then remains same.
Phyletic gradualism: During speciation, morphology isn't changed. Over time, morphology of species gradually changes.
Both processes can occur, and also a mixture of these processes is possible.

Chapter 8 – Phylogenetics

8.1 Graphical Representation of Life
8.2 Homology and Homoplasy
8.3 Taxonomy and Classification
8.4 Phylogenetics: usefulness

Introduction

Systematics: A scientific discipline focused on naming, classifying organisms and determining their evolutionary relationships.

- **Phylogeny:** study of the evolutionary history of a species or a group of species.
- **Taxonomy:** a scientific discipline concerned with naming and classifying the diversity of life.
  - **Taxon (pl. taxa)**: a named taxonomic unit at any level of the phylogenetic hierarchy or classification.

8.1 Graphical Representation of Life

Representation of life and classification most resembles the modern model of the **spherical bush**:

- When the spherical bush is sliced in half, there is a core in the middle representing **all species common ancestor known as Luca**.
- The core (common ancestor) branches off into many species.
- The branches that reach the surface of sphere are the species living in our current time.
  - Such as homo sapiens, cheetahs, and archaea
- Branches that don't reach the spherical surface are species that survived in a period of time then went extinct.
- Species have a unique separate path, starting from core (or Luca) to the surface, that leads to their evolution and existence during this time.
- All current species are equal since all share 3.5 million yrs of history since **Luca**.

Three Domain of Life

- Eukarya
- Archaea
- Bacteria

Luca is not the middle of the Domain of Life diagram since Domain Eukarya and Domain Archaea have a common ancestor after Luca but Domain bacteria does not.

This signifies that Domain Eukarya and Domain Archaea are slightly more recent than Domain Bacteria.

8.2 Homology and Homoplasy

Homologous structures:

- Indicator of a common ancestor and data used to build phylogenies.

Homoplasy

- <u>Convergent evolution: indicate no common ancestor</u>
  - Makes phylogeny harder; it's a disturbance in study of phylogeny
  - Ex. ability to hover in sugar gliders vs flying squirrels.
  - Same type of adaptation in both species of squirrels but those squirrels are from different taxon groups.
  - Adaptation to fly is evidence of convergent evolution.
  - Obtained same adaptation separately from separate ancestors.
- <u>Evolutionary Reversion</u>
  - Ex. absence of fur in whales.
  - All mammals have fur except whales but that does not mean they are not mammals.
  - When investigating a whale, they have characteristics and traits that many mammals have.
  - Whales evolved from a quadruple mammal that may have been hairy; known as reversion because they went back to a state that is found in the ancestor of mammals that lived in water, usually don't have any hair.
  - Going back into a primitive state.

8.3 Taxonomy and Classification

Biologists use the binomial system to identify living organisms.

- **Homo** = name of **genus**
  - Signifies "**man**".
- **sapiens =** name of **species**
  - signifies: "**intelligent**, wise and reasonable".

Classification:

System of words used to group species into increasingly generalized categories.

- Hierarchical system (i.e., a sequential and orderly arrangement of categories).
- Taxonomic rank: taxon
- The classification needs to reflect the **phylogeny.**

Phylogenetic tree with dichotomous branches (cladogram)

- Bifurcation point (or branching point): common ancestor.
- **Cladogram** only shows a sequence of appearance of taxa.
- No time frame in cladogram.
- A classification reflects ramifications of the cladogram.
- Branching point, terminal nodes, sister taxa, and **polytomy**.
  - **Sister taxa**: species that share immediate common ancestor; most recent speciation in a group.
  - **Basal taxon**: shows traits allows us to define homologous traits.

- o **Branch point**: where lineages diverge (speciation event); also represents common ancestor of taxa groups.

Cladistics:

- Taxa should be based on **shared derived characters (**homology).
- **Not** shared ancestral characters (homoplasy).
- Only valid group: monophyletic group.

8.4 Phylogenetics: Usefulness

Monophyletic groups: contains all and only the descendants from an immediate common ancestor.

Non-monophyletic groups:

- **Paraphyletic group:** does not contain all the descendants from a common ancestor.
  - The class of Reptiles is an example of a **paraphyletic group**.
    - Birds has a common ancestor with reptiles, yet birds are not considered part of the reptile group.
    - **Rely on phylogeny to classify organisms since organisms with a common ancestor have similar traits**; thus, birds should be classified under reptiles.
    - **Phylogeny of fishes are also paraphyletic**.
      - **Fishes group are not monophyletic**; should not have their own classification.
- **Polyphyletic group:** contains descendants from several ancestors.

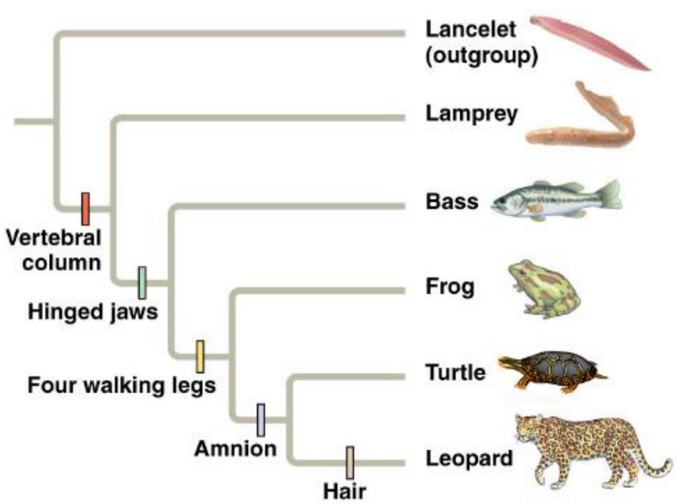
Reference group (outgroup, **fundamental group):**

- used to distinguish the shared **derived** character traits from shared **ancestral** character traits.

TAXA

CHARACTERS	Lancelet (outgroup)	Lamprey	Bass	Frog	Turtle	Leopard
Vertebral column (backbone)	0	1	1	1	1	1
Hinged jaws	0	0	1	1	1	1
Four walking legs	0	0	0	1	1	1
Amnion	0	0	0	0	1	1
Hair	0	0	0	0	0	1

(a) Character table



(b) Phylogenetic tree

Example: Vertebral column

- **Shared derived character** that define vertebrates as monophyletic.

OR

- **Common ancestral character** that does not define mammals (or any vertebrate taxa) as being monophyletic.

In case of conflicts in the distribution of traits in the cladograms:

- Principle of **parsimony**: the phylogeny must offer the simplest explanation **based on the facts**.
  - Hypothesis with the fewest evolutionary steps is considered the most parsimonious and this **hypothesis is presumed the best approximation of the true relationships.**

Branching point **age:** fossils or by an estimation of the rate of change from a molecular clock.

- Length of branches indicate time.

Dinosaurs have parental care like birds and crocodiles; since it's the most parsimony hypothesis.

- These organisms have a common ancestor that takes care of their offspring.

Chapter 9 – Ecology and Species Distribution

9.1 Ecology: Definitions, Concepts and Issues
9.2 The Climate
9.3 Terrestrial and Aquatic Biomes
9.4 Species Distribution

9.1 Ecology: Definitions, Concepts and Issues

Ecology: Scientific study of interactions between organisms, and between organisms and their environment.

- Objective: to discover how factors such as climate and interactions with other species influence the distribution and abundance of organisms.

Environment:

- **Abiotic** factors
- **Biotic** factors

Species distribution: the manner in which a species is spatially arranged.

Ecology can be divided into categories better understand different systems of ecology;

- **Organismal ecology:** interaction of individual organisms with the environment; with regards to organismal behaviour and their food resources.
- **Population ecology:** group of species that interact with their environment.
- **Community ecology:** interaction of species living in the same community.
- **Ecosystem ecology**: transfer of energy in a very trophic level.
- **Landscape ecology:** study of many ecosystems in a region; allows for species to move around within the region.
- **Global ecology:** global impact of environments due to humans, such as climate change and global warming.

Precautionary principle:

- Strategy to cope with possible risks where scientific understanding is yet incomplete.
- Scientists are uncertain about the truth (similar to the truth) yet it's not the truth nor they can affirm the truth; thus, this process is necessary.
- Such as climate change; politicians and scientists use safest, and most environmentally friendly procedures for the environment.
    - Since human activity is associated with climate change and global warming
    - Scientists want procedures to help maintain ecosystems.
- **Better be safe than sorry.**

Large Scale Abiotic Factors:

- Light
- Temperature
- Wind
- Precipitation

9.2 The Climate

In polar regions:

- The solar rays are slanted whereas they are vertical in equatorial regions.
    - Solar energy slanted in polar regions; **colder climate**
    - Solar energy vertical in equatorial regions; **warmer climate**
- The solar energy over a larger surface area.

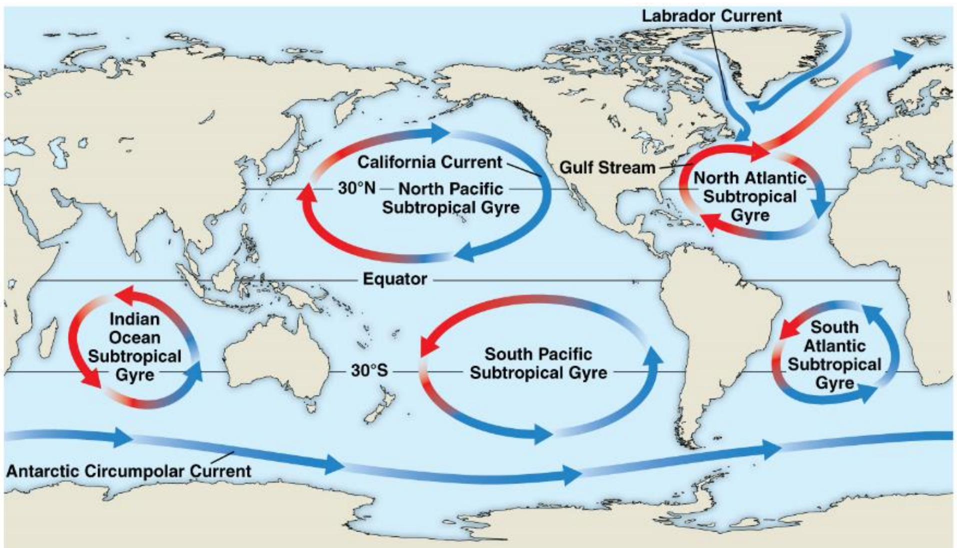
The earth is tilted on its axis at a 23.5 degree angle:

- The extratropical regions have seasons, whereas the tropical regions have very little differences between seasons and days.
- The closer you are to the equator; the faster earth rotates.
    - Closer to poles; slower earth rotates.
- At the equator, the earth rotates with a speed of 1,700 km/h

Air circulation and precipitations at a global scale.

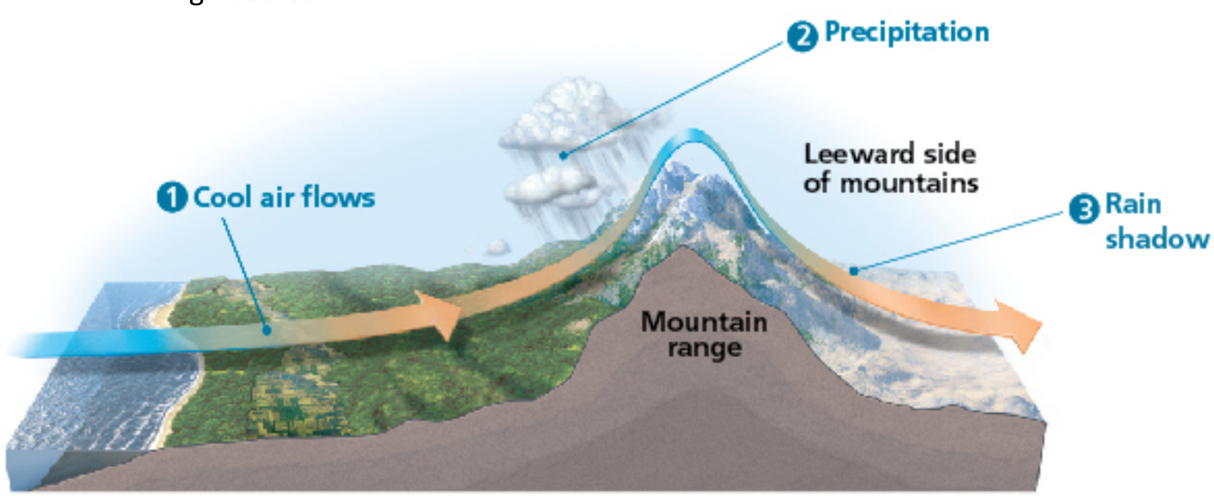
- In warm climates, water evaporates and condensates to form clouds and allow precipitation.

- Circulation of surface water in the ocean's influences **climate.**
    - Warm water circulates near mainland brings warmer temperature.
        - Alternates between the mainlands in which water circulates to warm them.



Planet is very dynamic; allows for development of speciation.

The effect of large **bodies** of water on the climate.

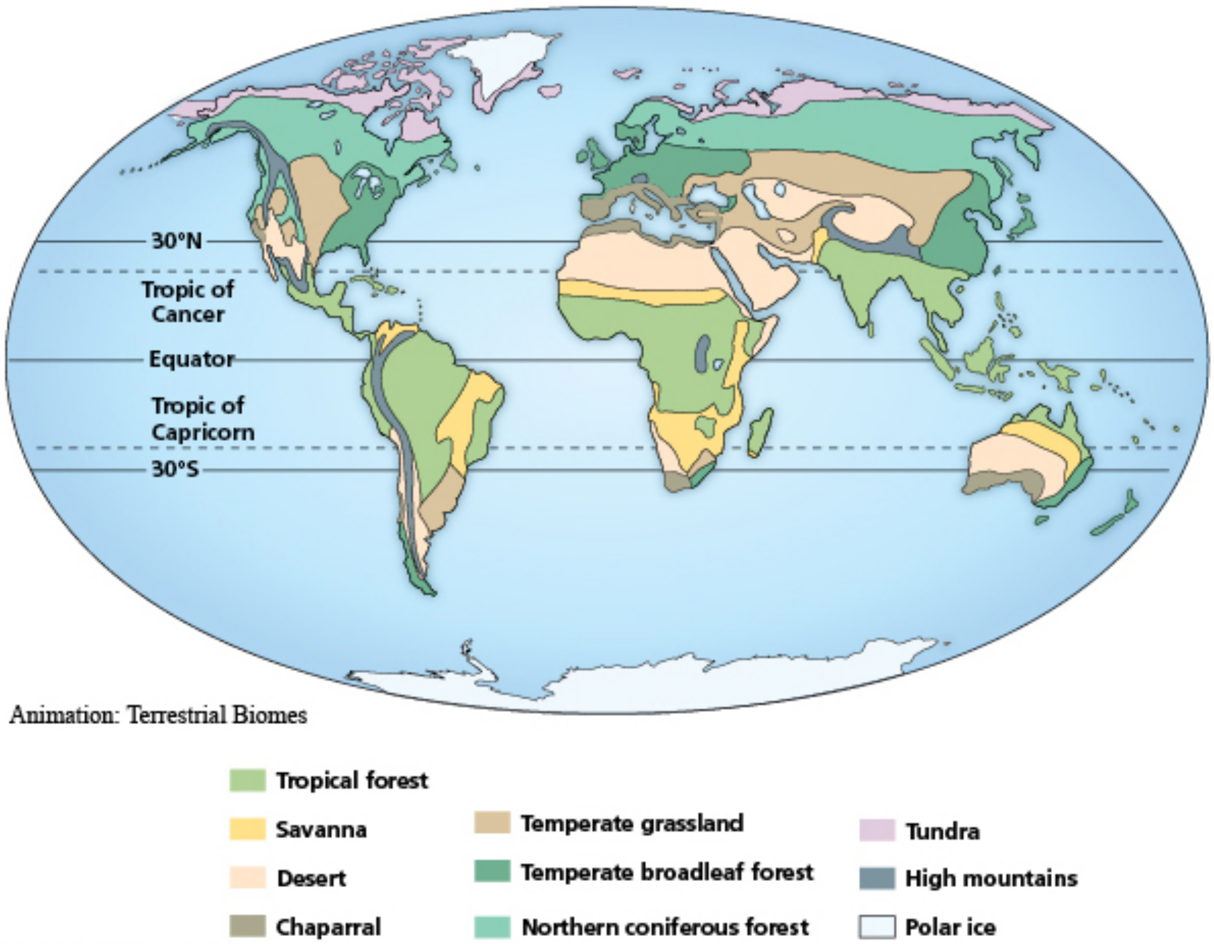


- Cool air from ocean moves to mainland.
- Solar energy causes forest to warm up; which then turn cool air to warm air.
- Warm air travels to high altitude in mountain; since mountain has colder, the warm air condensates and forms clouds causing precipitation.
- When air reaches the top of the mountain; loses most of its humidty.

- Then when it goes down, it absorbs most to all humidity.
    - An example of this procedure occurs in Costa Rica.

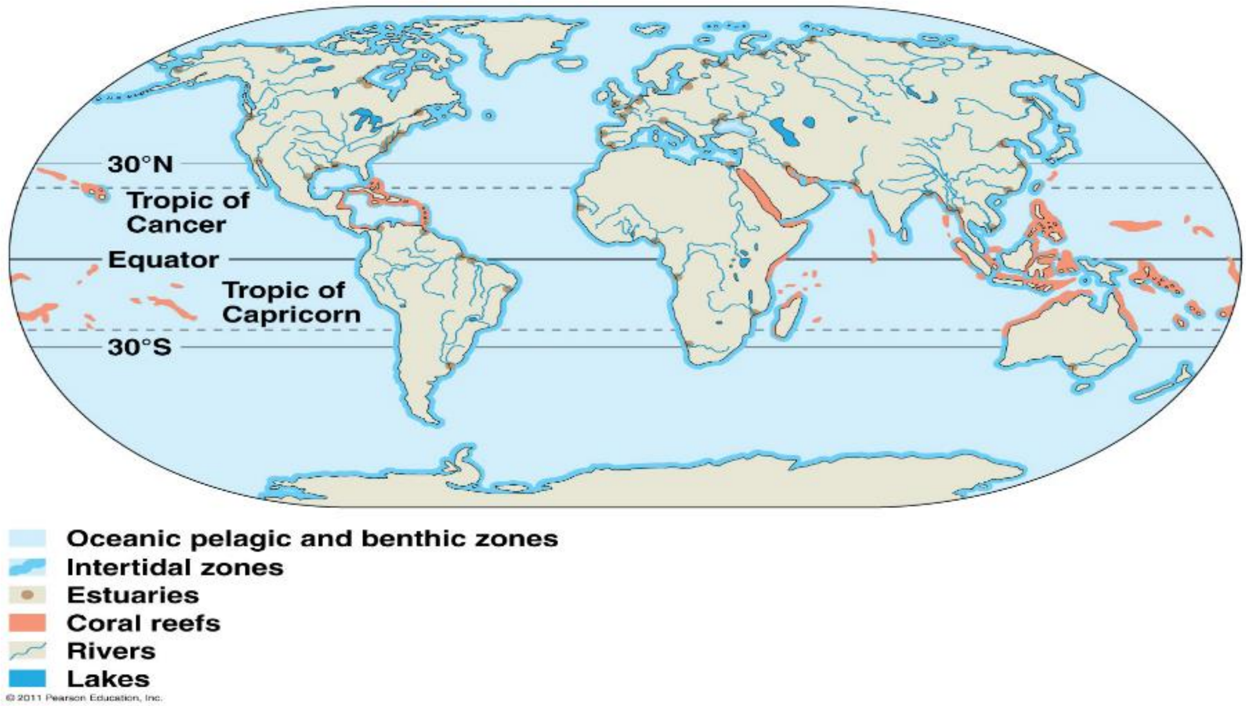
9.3 Terrestrial and Aquatic Biomes

- Types of terrestrial communities is known as **biomes**.



Animation: Terrestrial Biomes

- The climate has an important role in determining the geographic distribution and structures of **Biome;** as well as determining the species living in those region**s.**



Lakes:

- **Oligotrophic lakes:**
  - Poor in nutrients and **rich** in oxygen.
  - Very little vegetation and little life.
  - Can be considered the "desert" of lakes.
- **Eutrophic lakes:**
  - Rich in nutrients but **poor** in oxygen.
  - A lot of life and a lot of vegetation.
  - Poor oxygen can involve contamination of green algae.
  - Most of eutrophic lakes are human made; humans introduce nutrients into these lakes.
  - Allow for better life and diversity in eutrophic lakes.
  - Too much nutrients can make these lakes uninhabitable.
  - Naturally, eutrophic lakes take a long time to be rich in nutrients.
  - Humans accelerate this process and is unhealthy for the lake and species living within it.

Cycles of Lakes:

- Some lakes will maintain a specific temperature due to the water in the lake mixing.
  - Mixing of the water of the surface and bottom of the lake.
  - Caused by the wind.
- This is known as an **holomictic lake.**
- A **meromictic lake** is when the mixing of the water does not reach the bottom.
  - No mixing of water in the bottom.

- ○ **Thermocline** is the region of water where its temperature gets cooler the deeper you go.
- In winter, some eutrophic lakes can cause biodegradation if there is no influx of freshwater.
  - ○ Biodegradation then lowers influx of oxygen levels in water resulting in fish deaths in the winter.

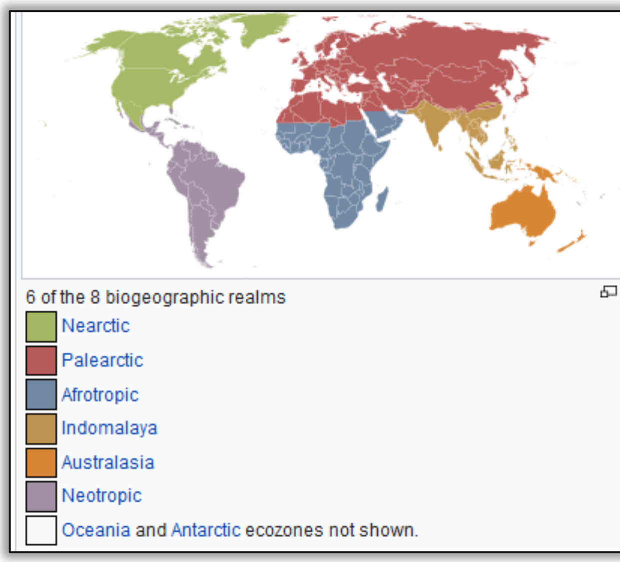
Coral reefs:
- Animals part of the group of Cnidaria (oldest Metazoan)
- Very diverse
- Most unique characteristic is that they form an exoskeleton.
- Inhabited by photosynthetic green algae (Zooxanthella)
  - ○ Provide for and nutrients and coral provide protection for algae.
  - ○ Good example of **symbiosis.**
- Warming of ocean makes coral expel algae from within it.
  - ○ Coral left on its own
  - ○ It can live for 2 more years; then dies.
- Very rich in environment.
- Green algae and corals is a good example of **mutualism** as well.

9.4 Species distribution

Study of **biogeography:**
- Study of species distribution.

Movement of tectonic plates allowed for the continents to separate from Pangaea.
- Only Pangaea in Paleozoic time period.
- Laurasia and Gondwana during Mesozoic period.
- In Cenozoic period, geological plates separated to from NA, SA, Africa, Australia, Antarctica, Eurasia.

Earth is dynamic (constantly changing) which is why this procedure has occurred over millions of years.



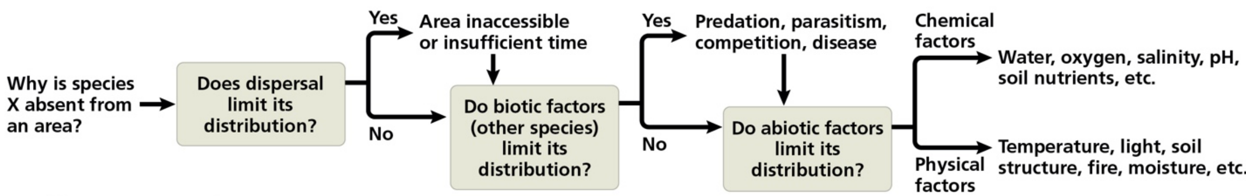
This process may have triggered speciation and extinction of many species.

Although it is based om geology, there is fossil evidence for the **continental drift.**
- fossils of dinosaurs are found in many continents; signifies that continents were closely packed and joined for this to occur.

- Finding fossils of the same species in many continents indicate that they were once one continent.

Why are species found in some areas and not in other places?

- Factors that may limit geographic distribution of species.



- Cyprinodon diabolis is a fish where they only live in a habitat called the Devil's Hole in Nevada. This a species with limited distribution; hence being an endangered species.
- Moose and White-tailed deer in Canada are both affected by parasitism as a limiting factor. Humans use the open land (moose and deers habitats) for agriculture and building homes which limit their distribution.
- The Wood turtle is an example of temperature limiting their distribution. The Atlantic Ocean and prairies are limiting its distribution. Temperature limits its northern distribution.
- Coyotes are currently expanding their range because humans have created new habitat for them (agricultural field and suburbs) and also because of the elimination of main competitor (wolves).

Abiotic factors (chemical or physical):

- Temperature
- Water
- Oxygen
- Salinity
- Sunlight

Climate Change:

Impact of Climate Change

Recent study of 4000 species

→50% on the move

- Land species: 10km per decade
- Marine species: 40 km per decade
    - Atlantic cod: 125 km per decade
- Frogs: reproductive cycle 8 days earlier/ decade
- Birds and butterfly: reproduction is 4 days earlier / decade
- New hybrid species: toads, sharks, butterflies, bears, trouts (species that are newly in contact)
- Pest and germs also moving

Southern **range** expansion of the long-spined urchin and its impact on kelp communities.

- Expanded from the coast of Australia to coasts of Tasmania (province of Australia).

- Global climate change: **adaptation** for dispersal
  - American beech is a plant species with very limited dispersal and their dispersal rate is very low and live on the east coast of the US.
  - According to some studies based on Climate Change temperature increase, the American beech will disperse itself more north since an increase in temperature in the south will be too humid/hot for it to survive.
  - Consequence is the shrinking of the distribution due to uninhabitable habitats in the south.

Predicted northern expansion of sugar maple distribution because of **global climate change.**

- Other factors than climate may affect northern expansion of distribution.
  - For example: **seed predation**
  - Other factors other than climate affect their distribution to the north which can cause the sugar maple species to go extinct.
  - If they go north due to climate change and the factor of seed predation in the north can cause the extinction of sugar maple.

Chapter 10 – Ecology of Populations

10.1 Definition
10.2 Density
10.3. Dispersion
10.4 Demography
10.5 Biological Cycles
10.6 Population Dynamics

10.1 Definition

- **Population:** a group of individuals of the same species living in a given geographical area.
- **Biological cycles:** characteristics that influence the survival and reproduction of individuals of a population.

10.2 Density

Density: is the number of individuals by unit area or volume. The density is the result of a dynamic interaction between;

- The processes of addition (**immigration and birth**)
- The process of elimination (**emigration and mortality**)

To define density, you need methods;

Determination density: direct counting

- By aerial surveys
- By their song (songs from birds of our forests)

Density (by sampling):

- Capture-recapture
- Estimation of the total population
    - N1/X=N2m/N2 or X=N1N2/N2m
    - X = estimation of the number of individuals in the population
    - N1 = captured individuals, marked and released;
    - N2 = individuals captured during the second sampling period
    - N2m = individuals with marks during the second sampling period.
- Conditions to respect:
    - Marking has no health effect on animal
    - Marked or non-marked individuals are distributed randomly in the population
    - No immigration or emigration in the population
    - Chances of catching marked or unmarked individuals are equal

Example of Capture and Recapture:

- Lake in Gatineau Park (monospecific lake; 2,3 hectares)
- Two days of sampling in 2009 (one week between dates):
    - Day 1: total number of captured, marked and released individuals (N1 = 170)
    - Day 2: total number of captured individuals (2^{nd} capture) (N2 = 120)
    - Day 2: number of captured individuals with a mark (N2m = 2)

X=(N1N2)/N2m = (170x120)/2 = 10200 fishes
Density: approx. 5000 per hectare

10.3 Dispersion

- Dispersion (spacing of individuals inside geographical limits of the population):
    - **Clumped (**aggregate in patches: feeding, mating, predation or defense); most common type
    - **Uniform** (competition for resources, territoriality)
    - **Random (**unpredictable spacing)

10.4 Demography
Demography:

- Quantitative study of populations and their variations over time (**Birth rate and death rate)**
- Quantitative demography
    - **Cohort** analysis (group of individuals of the same age):

        - **Survivorship** curve of a species

Types of survival curve:
- **Type 1:** low mortality rate during early and middle life and fast increased mortality in older individuals (big mammals: significant parental care)
- **Type 2:** constant death rate during the organism life span (multiple rodents, plants, invertebrates).
- **Type 3:** a high mortality rate for the young and life and a death rate that declines in the adults that survive (fishes with small eggs: absence of parental care).

Models of Population Growth:
- **Exponential growth** (curve shaped like a J)
    - (e.g. Often newly introduced species; no limit on resources)
- **Logistic growth** (sigmoid curve)
    - The plateau corresponds to the **carrying capacity of the environment.**
- **Human population growth (exponential growth)**
    - Slowly decreasing the pace at which we are increasing our population
    - Slowing down the increase of our population is in our hands (via birth control)
    - Stopping population growth and stabilizing the population is the best hope for quality of life for the next century (since human population increasing exponentially; too many humans)

10.5 Biological Cycles

Life History traits: traits that affect an organism's schedule of reproduction and survival.
- Life history traits are the result of **natural selection.**
- Examples of life history traits:
    - Age at first reproduction or age at maturity
    - Number of reproduction events
    - Number of offspring per reproductive event

Trade-off between reproduction and survival:
- Frequency of reproduction, number of offspring or investment in **parental care.**
    - Dandelion: millions of seeds in the wind with hope of germination and survival of a few.
    - Brazil nut Tree: fewer seeds but more volume per seed (with secretions to feed the embryo); thus, better chances of survival of offspring.
    - Seahorse: when father gives birth there is no more parental care for the babies since the father needs to recover from the birth and the female is ready to reproduce again. After birth, the babies are on their own for survival.

Examples of Biological Cycles:

- **Semelparity:** (ex. Pacific salmon, agave): one reproduction (unpredictable environment; many years of growth, massive production of seeds in one reproductive event then dies).
- **Iteroparity:** (ex. grizzlys; Bur oak; humans): several reproduction events.

- Experimental study of the **trade-off** between survival and reproduction:
  - A high investment of parents in the production of offspring can have a negative impact on the survival of the parents or offspring.

Population of Elders in Canada

- Female elders that produced more offspring were much less likely to survive to breed again the next year, demonstrating that reproduction had a significant cost.

10.6 Population Dynamics

- The study of population dynamics can be applied to **complex interactions between biotic and abiotic factors** responsible to the variation of population size.
  - Migratory locusts: tend to be solitary and shy insects but in certain conditions they modify their morphology and behaviour; become social, gregarious, and active insects.

Factors that regulate population growth can be density-dependent or density-independent:

- A birth rate (b) or death (m) **that does not change** with higher density, then the population is said to be **density independent**.
- If a death rate increases with population density or if a birth falls with rising density, the population growth is said to be **density dependent**.

Mechanisms of density-dependent regulation

- **Competition for resources**
  - When the density of Big horn rams or Sable Island horses is high. Lamb and foals survival during the winter is low.
- **Territoriality**
  - Organisms such as cheetah conquer territories and guards it. By guarding it, it regulates density within the territory.
- **Disease**
  - Such as COVID-19, more COVID cases in cities since there is high population density; more contact with people.
- **Predation**
- **Intrinsic factors**
- **Toxic wastes**

- **Fluctuation** of moose and wolf populations on the Isle Royale (Lake Superior).
    - Relationship between moose and wolf populations
        - Increase in wolf population lead to a decrease in moose population
        - Decrease in wolf population lead to an increase in moose population.
    - Occurred due to predation and since it consisted of small population of wolves and moose.
        - Wolf preyed on moose

Demographic cycles: lynx and snowshoe hare

- Experiments have shown that hares do not suffer from food limitation.
- Predation by lynx have a significant impact on hare population and is responsible for the decline in hare population.
- No explanation for the 10-year cycle.
- Exposure to predators causes hares to produce higher levels of **stress hormones**.
- Stressed hares are less likely to give birth to live offspring, and if they do, their offspring are smaller.
- Thus, predator stress contributes to the decline phase of hare populations.

Metapopulations: small local populations that occupy a particular area of an appropriate habitat (patches) for the survival of a population.

- Dynamics of emigration, immigration, extinction and recolonization of patches.
- Importance in **species conservation**.

Chapter 11 – Conservation Biology

11.1 The Three Levels of Biodiversity
11.2 Threats of Biodiversity
11.3 Conservation of Populations

11.1 The Three Levels of Biodiversity

Human activity threatens biodiversity.

- Threatens biodiversity in three levels:
    - **Human activity has an impact of genetic diversity**
        - When you reduce a population to a smaller number, you also reduce genetic diversity.
        - Eliminate the species resilience to the environment.
    - **Species diversity**
        - Species are born (through speciation) then go extinct according to their ecosystem and environment.
        - However, humans are accelerating the process of extinction for some species which is an very important issue.
    - **Community and ecosystem diversity across the landscape**

        - Preserving natural habitats; preserve a very large portion of land and water protects the biodiversity within those ecosystems.

Genetic diversity

- Importance of intra- and inter-populational genetic variation.
- Ex. cheetahs
    - Cheetahs lack genetic diversity making them an endangered species susceptible to extinction.
    - Lacking genetic diversity means cheetahs lose their resilience to environmental changes.

Species biodiversity:

- 99% of species that have existed on Earth are now extinct.
- Humanity has wiped out 60% of mammals, birds, fish and reptiles' populations since 1970 (WWF report 2018).
- 50% of animal and plant species might go extinct by the end of the 21st century.
- **Extirpation:** local disappearance of species.

Hot spots of biodiversity:

- Small areas containing a lot of **endemic** species and large number of endangered species. (1.5% of the land area, but 33% of animal and plant species)
- **Endemic species:** species of plant and animals that exist only in one geographical region.
    - Can be endemic to a continent or a region in a continent and some to a a single island.
    - Contain many different species in that particular region (hot spot).

Ecosystem Biodiversity

- **Dominant** species
- **Keystone** species in the ecosystem; are organisms that define the entire ecosystem (maintain biodiversity)
- Ecosystem **engineers**

Trophic Structure:

- Food chains

Bottom-up Control: plant eaten by primary consumer then by secondary and so on for energy transfer).

- Driven by food availability or **resource limited**

Trophic Structure:

- Food chains are embedded in a **food web (defines main component of an ecosystem).**
- **Energetic hypothesis**: the length of a food chain is limited by the inefficiency of energy transfer along the chain.

(About 10% of the energy stored in the organic matter of each trophic level is converted to organic matter at the next trophic level).

Top-down Model: the top carnivore dictates the food chain

- Driven by **predation**

11.2 Threats to Biodiversity

Destruction of habitats

- Responsible for 73% of species in danger of extinction
- Construction of infrastructure, deforestation and urbanization

Zoned reserves of Costa Rica

- Protected areas bordered by buffer zones