https://cluesbook.com/

BT101 MERGED PPT

Slides Full Updated

Merged File date 2021

Regards: Team Cluesbook

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What is Ecosystem?

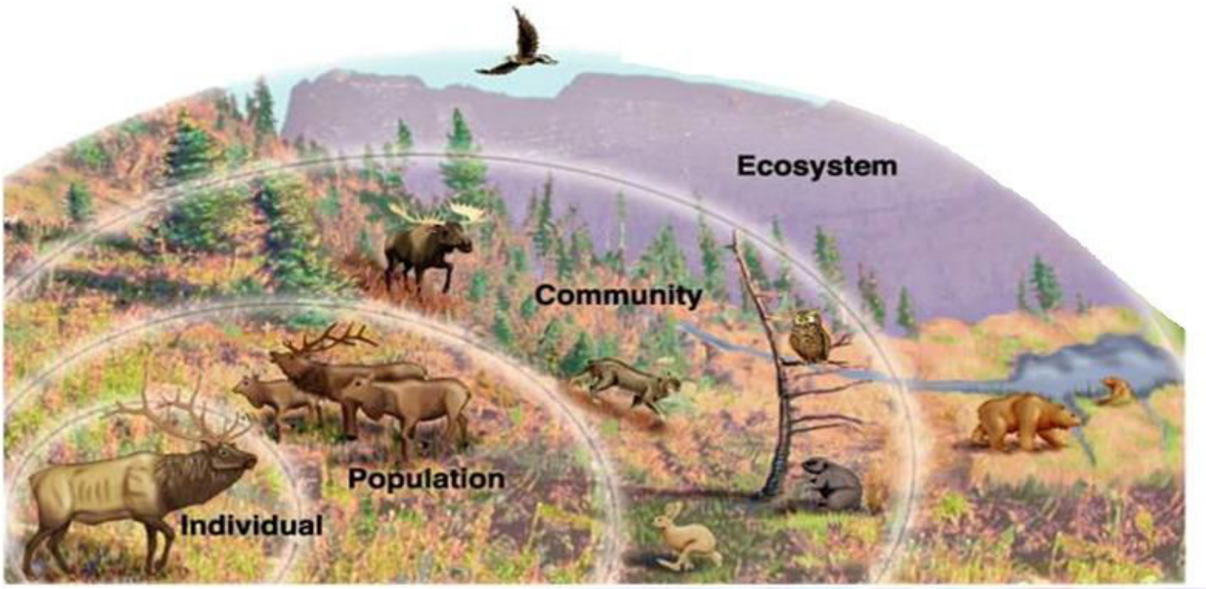
Ecosystem

- Community of living organisms in conjunction of its non-living components
- Non-living components
- Interaction as a system between both components

What is Ecosystem?

- **Population** is group of individuals belonging to same species occupying same space in particular time.
- **Community** is group of populations occupying same space in particular time.

What is Ecosystem?



https://socratic.org/questions/how-does-an-ecosystem-differ-from-a-community

What is Ecosystem?

Control of Ecosystem

- External

Climate, topography

- Internal

Types of species, population size, disease, gene pool, reproduction rate

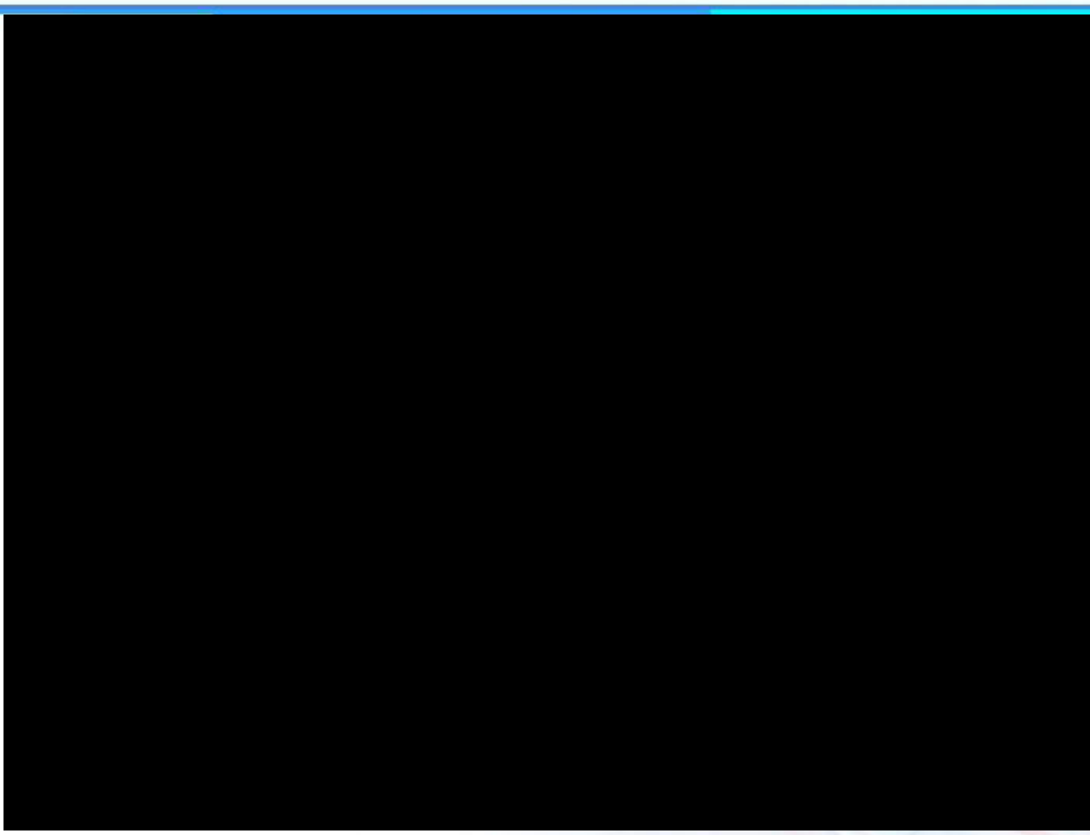
External factors are independent of internal factors.

What is Ecosystem?

Biome

- Distinct biological communities
- Formed in response to specific external factors in that environment

What is Ecosystem?



https://www.youtube.com/watch?v=hIy0ZlyPPDg

What is Ecosystem?

- Internal factors are controlled by feedback loop

Example:

Population size is controlled by availability of resources.

- Ecosystem – a dynamic entity

- Subjected to disturbances and recovery (succession)

END

Flow of Energy in Ecosystem

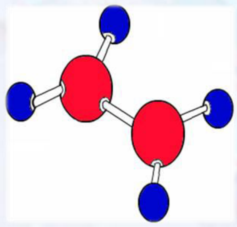
Learning Objectives

- Introduction of energy dynamics in ecosystem
- Use of energy by organisms
- Type of useable energy

Flow of Energy in Ecosystem

Energy

- Energy exists in several different forms
  - Light
  - Chemical-bond energy
  - Motion
  - Heat
- All organisms need energy to function

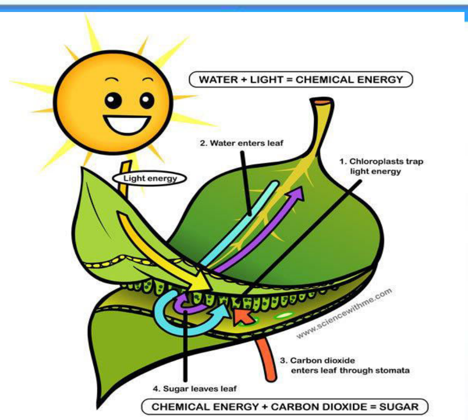


Flow of Energy in Ecosystem

Principles

- Energy is neither created nor destroyed in the biosphere.
- Organisms cannot convert heat to any of the other forms of energy.
- They only convert some chemical-bond or light energy to heat.

Flow of Energy in Ecosystem

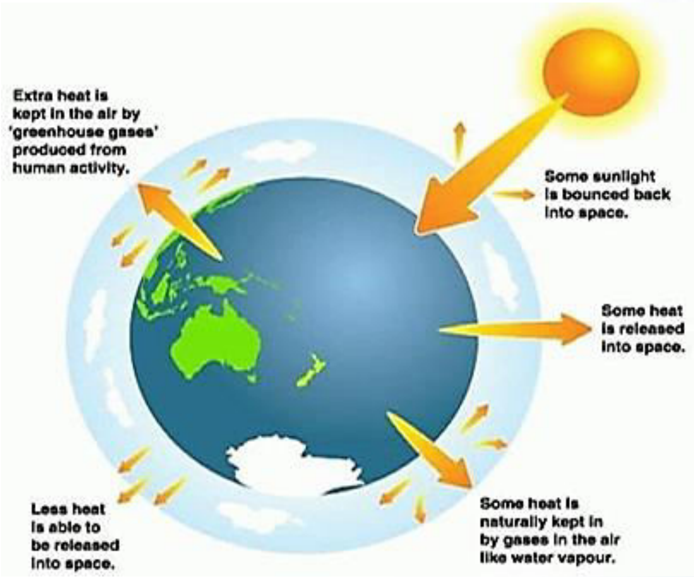


https://mayapeacockapbiology.weebly.com/energy-transfer.html

https://thetechjournal.com/science/plants-become-defensive-when-attacked.xhtml

- Earth is an open system having constant and equal exposure to light.
- Plants use light energy in photosynthesis.
- They convert light energy into chemical bond energy.
- Animals use chemical bond energy to make organic molecules.

Flow of Energy in Ecosystem



https://climatiquechange.weebly.com/

- Light and chemical-bond energy are partially converted to heat at every step.
- Heat is radiated into outer space at invisible infrared wavelengths.
- Earth's incoming and outgoing flows of radiant energy must be equal for global temperature to stay constant.

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Producers

Learning Objectives

- Concept of producers
- Types of producers
- Photosynthesis
- Chemosynthesis

Producers

Autotrophs

- Synthesis of the organic compounds of their bodies from inorganic precursors such as:

  - CO_2, H_2O, NO_3

- using energy from an abiotic source

  - Light
  - inorganic oxidation reactions

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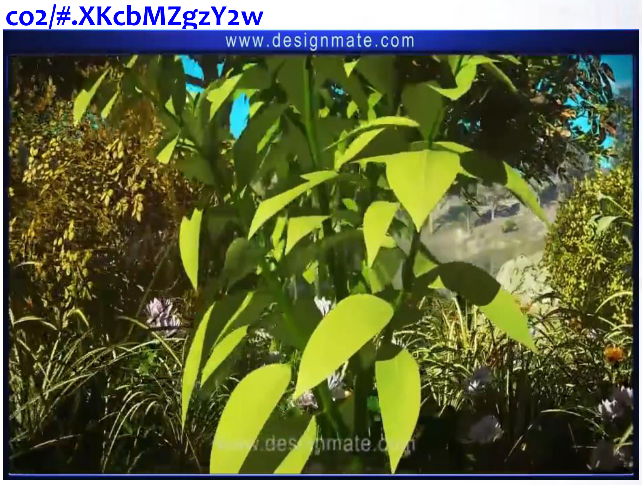
Producers

https://asknature.org/strategy/photosynthesis-makes-useful-organic-compounds-out-of-co2/#.XKcbMZgzY2w



Types of Autotrophs

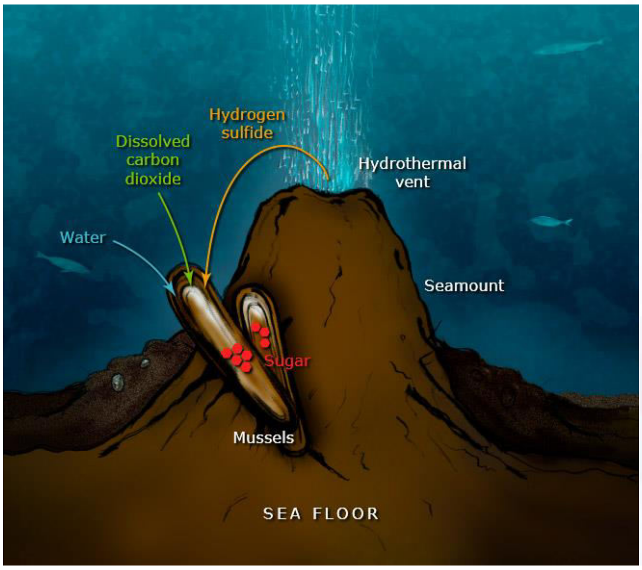
1. Photoautotrophs

- Photosynthetic organisms
- Examples: plants, algae, and cyanobacteria
- Photosynthesis

$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$

- Main input of free energy into the biosphere

Producers



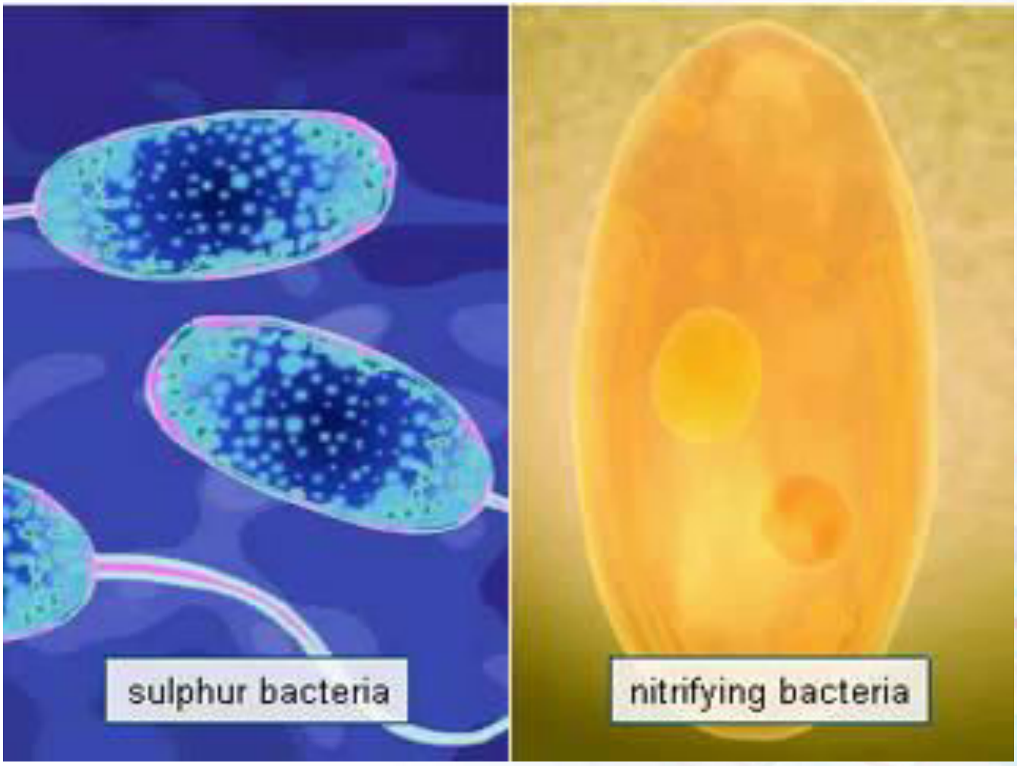
https://teara.govt.nz/en/diagram/8960/photosynthesis-and-chemosynthesishttps://teara.govt.nz/en/diagram/8960/photosynthesis-and-chemosynthesis

Types of Autotrophs

2. Chemoautotrophs

- Occurs in dark habitats
- They obtain energy by means of inorganic oxidation reactions.
- Convert toxic molicules into glucose
- Example: Microbes, mussels

Producers



https://www.youtube.com/watch?v=jcqYhM7gM0g

Consumers

Learning Objectives

- Concept of consumers
- Types of consumers

Consumers

Heterotrophs

- Cannot synthesize organic compounds from inorganic precursors.
- Eat organisms from a different population for energy
- Liberating chemical-bond energy for metabolic use in glycolysis, Kreb's cycle and electron transport chain

Example: Animals

Consumers

Types of Consumers

https://www.popsci.com/most-powerful-animals-ranked

1. Herbivore
2. Carnivore
3. Omnivore

Consumers

1. Herbivore

https://thevetisin.com/carnivores-omnivores-herbivores/

- Primary food source is plant-based.
- Examples: vertebrates as well as invertebrates
- Digestive systems capable of handling large amounts of plant material.
- There are eight types of herbivory depending upon different feeding habits.

Consumers

Feeding Strategy	Diet	Example
Algivores	Algae	krill, crabs, sea snail, sea urchin, parrotfish, surgeonfish, flamingo
Frugivores	Fruit	Ruffed lemurs
Folivores	Leaves	Koalas
Nectarivores	Nectar	Honey possum
Granivores	Seeds	Hawaiian honeycreepers
Palynivores	Pollen	Bees
Mucivores	Plant fluids	Aphids
Xylophages	Wood	Termites

Consumers

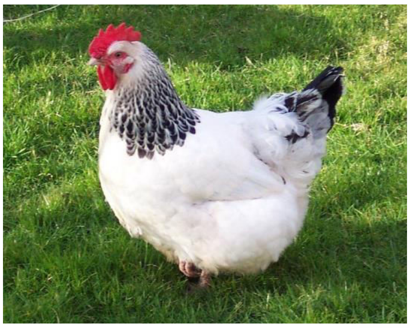
2. Carnivore

https://sco.wikipedia.org/wiki/Carnivora

- Primary food source is animal-based.
- Examples: vertebrates as well as invertebrates
- Digestive systems is more efficient in protein digestion.

Consumers

https://www.drcarney.com/blog/entry/omnivore



https://en.wikipedia.org/wiki/File:Light_sussex_hen.jpg

2. Omnivore

- Primary food source is both plant and animal-based.
- Examples: human, bear, cockroach, chicken
- Digest carbohydrates, protein, fat, and fiber, and metabolize the nutrients

Consumers

3. Omnivore

Types

- Frugivores: wolves and orangutans

- Insectivores: swallows and pink fairy armadillos

- Granivores: large ground finches and mice

END

Decomposers

Learning Objectives

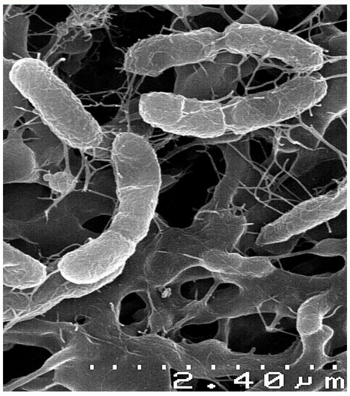
- Concept of decomposers
- Types of decomposers
- Process of decomposition

Decomposers

Heterotrophs

- Break down dead or decaying organisms
- Absorb nutrients directly through chemical and biological processes with out ingestion.

Decomposers



https://en.wikipedia.org/wiki/Chemosynthesis

http://fungiperth.org.au/

Heterotrophs

- Types

- Fungi
- Bacteria

Decomposers

Fungi

https://www.youtube.com/watch?v=i9T727tz7FA

- Primary decomposer
- Release digestive enzymes by their hyphae
- Absorb organic matter and release CO_2

Decomposers

Decomposition

1. **Autolysis**

Breaking down of tissues by the body's own internal chemicals and enzymes

2. **Putrefaction**

- Breakdown of tissues by bacteria.
- release compounds such as cadaverine and putrescine causing decaying odor

Decomposers

Decomposition

- Proteolysis releases nitrogen and phosphorous
- Carbohydrate breakdown
  - Aerobic by fungi and bacteria
  - Anaerobic by bacteria
- Anerobic degradation of lipids
- Nucleic acids and bones degradation

Decomposers

Decomposition

- Plays important role in nitrogen and carbon cycles

END

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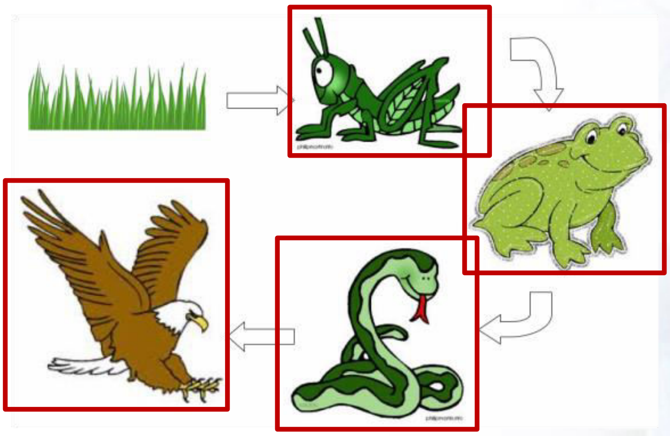
Flow of Energy in Ecosystem

Feeding Levels

Flow of Energy in Ecosystem

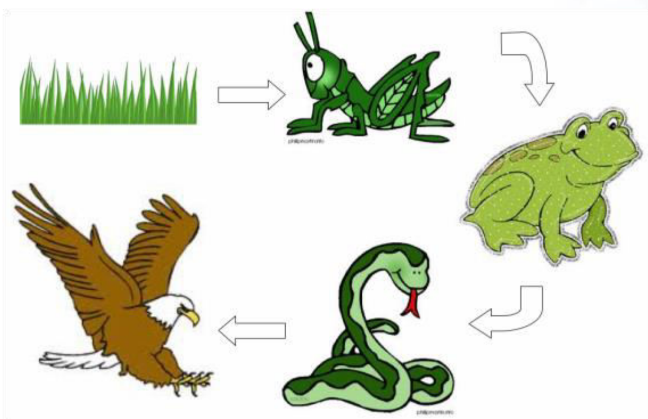


https://ecosystem300.weebly.com/food-chains.html

Feeding Levels

- Food energy passes through different sequence.
- Example: plants → grass hopper → frog → snake → hawk
- Many plant species eaten by insects
- Many insects species eaten by frogs

Trophic Level and Food Chain



https://ecosystem300.weebly.com/food-chains.html

Trophic Level

- Trophic level of an organism is position it occupies in a food chain.

Food Chain

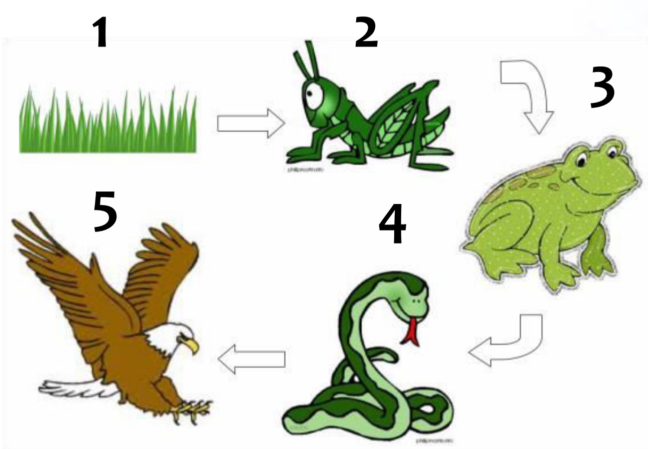
- Linear network of links to pass energy in form of food
- Simplified abstractions of real food webs, but complex in their dynamics

Flow of Energy in Ecosystem

Feeding Levels

- This complexity is organized by ecologists.
- Recognized limited number of feeding or trophic levels

Trophic Level and Food Chain



https://ecosystem300.weebly.com/food-chains.html

Food Chain

- Food energy passes through different sequence.
- Level 1: Primary producer

  Level 2: Primary consumer

  Level 3: Secondary consumer

  Level 4: Tertiary Consumer

  Level 5: Apex Predator

Trophic Level and Food Chain

A food chain also shows how the organisms are related with each other by the food they eat. Each level of a food chain represents a different trophic level. Food chain only follows a direct, linear pathway of one animal at a time.

Food Chain

- Detritivore and decomposers can be at trophic level as well.
- They return nutrients back in soil to be available for producers.

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Flow of Energy in Ecosystem

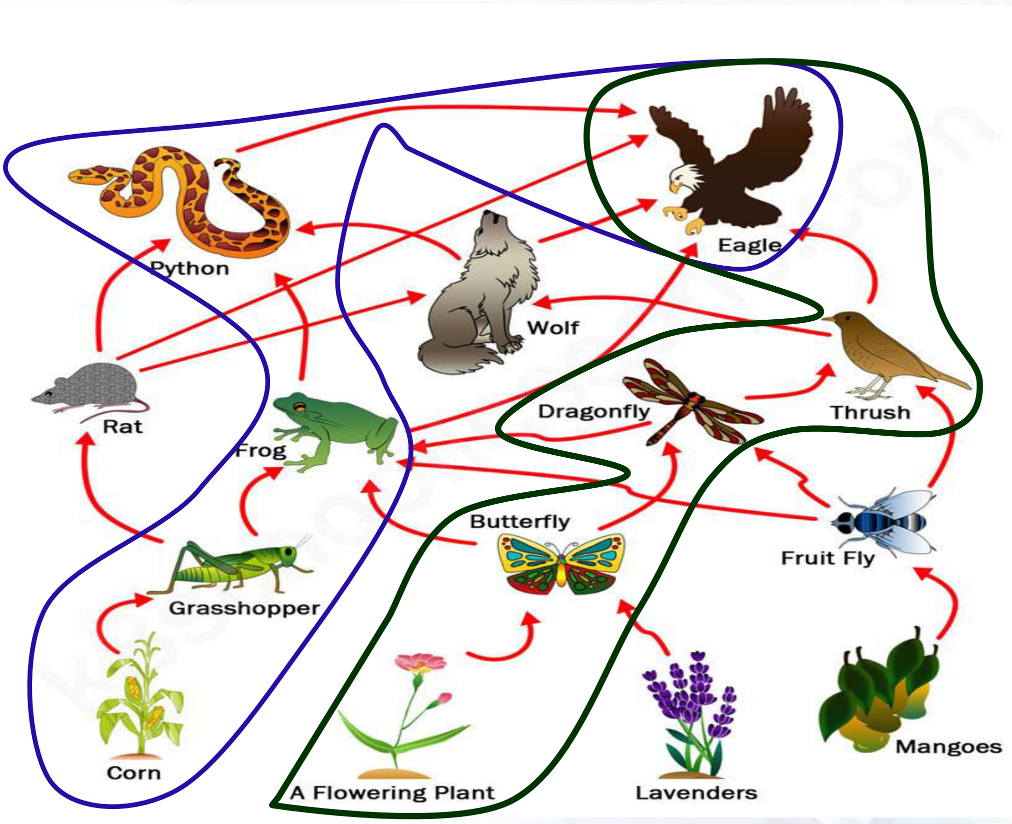
http://youtube.com/watch?v=0ZOvqYypOuo

Food Web

Food Web

- Complexly interconnected food chains in an ecological community
- Represent tiny portion of the complexity of real ecosystems

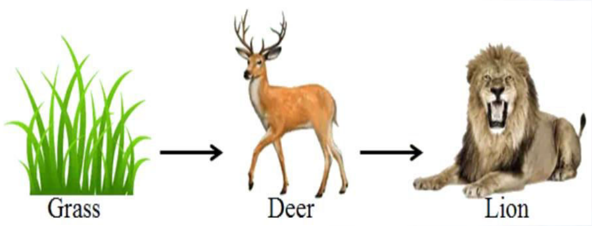
Food Web



https://k8schoollessons.com/food-chains-food-webs/

Food Web

Consumer-Resource system



https://www.doorsteptutor.com/Exams/NSTSE/Class-3/Questions/Topic-General-Science-1/Subtopic-Animals-Their-Food-and-Home-2/Part-15.html

- Direct or indirect balance between resources and consumption
- Predators indirectly increase plant growth.
- They prevent overgrazing by suppressing herbivores.
- The net effect of direct and indirect relations is called trophic cascades.

Food Web

Trophic Cascade

- Powerful indirect interactions that can control entire ecosystems
- Occurs when a trophic level in a food web is suppressed.

Food Web

Trophic Cascade

- Example: Removal of the top predator can alter the food web dynamics
- Impacts of climate and human activity on ecosystem

Food Web

Trophic Cascade

- Top-Down Effect

- Effect flows down through a trophic chain
- From apex predator to lower trophic levels

Food Web

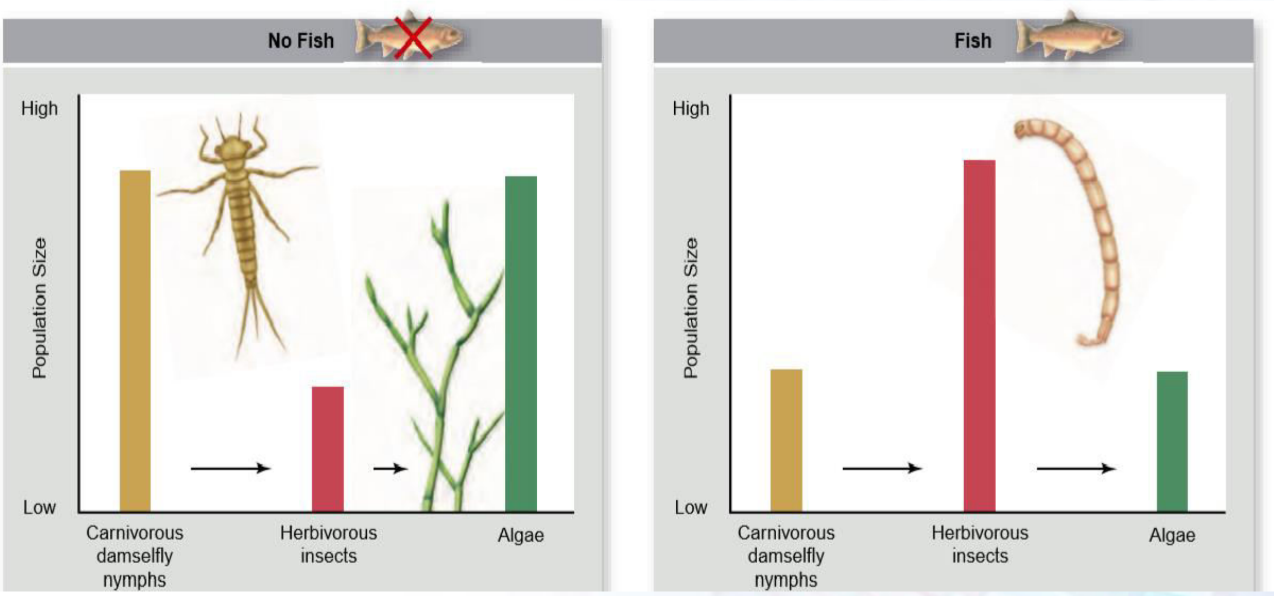
Trophic Cascade

- Bottom-Up Effect

- Effect flows up through a trophic chain
- From primary producers to higher trophic levels

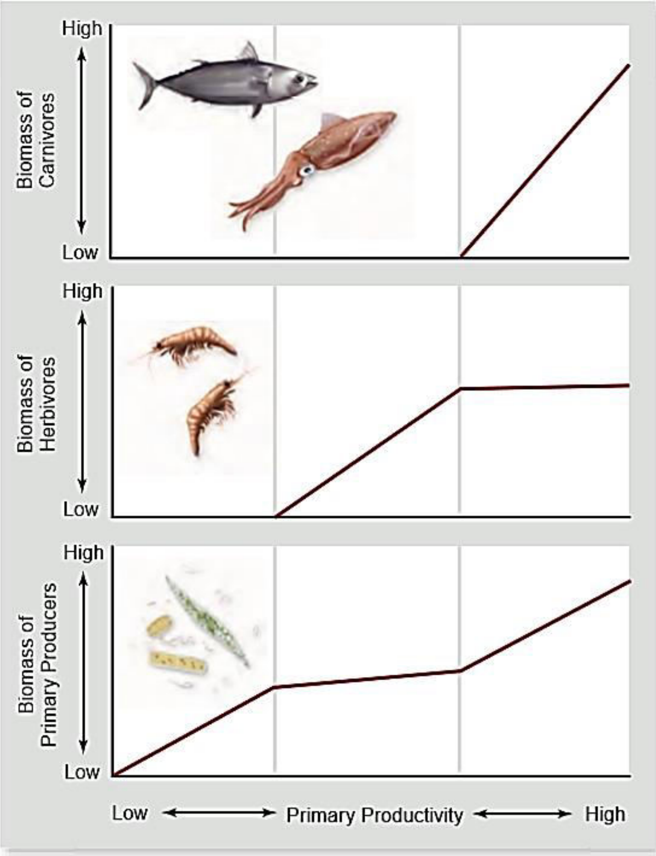
Food Web

Top-Down Effect



Biology Mason, Losos and Singer, 9th ed.

Food Web



Bottom-UP Effect

Biology Mason, Losos and Singer, 9th ed.

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Food Web

Trophic Cascades

- Species Level Cascade

Subset of the food-web dynamic is impacted by a change in population numbers

Food Web

Trophic Cascades

- Community Level Cascades

Change in population numbers has a dramatic effect on the entire food-web

Example: Distribution of plant biomass

END

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Trophic Level and Productivity

Productivity of trophic level

- Rate at which the organisms in the trophic level collectively synthesize new organic matter (new tissue substance)
- Energy is lost through respiration at every level.

Trophic Level and Productivity

Productivity of trophic level

1. Primary productivity (PP)

- Organic matter produced by photosynthesis
- Vascular plants; major contribution in PP
- Others; algae, mosses, liverworts
- PP is function of various factors; water, temperature, soil

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Trophic Level and Productivity

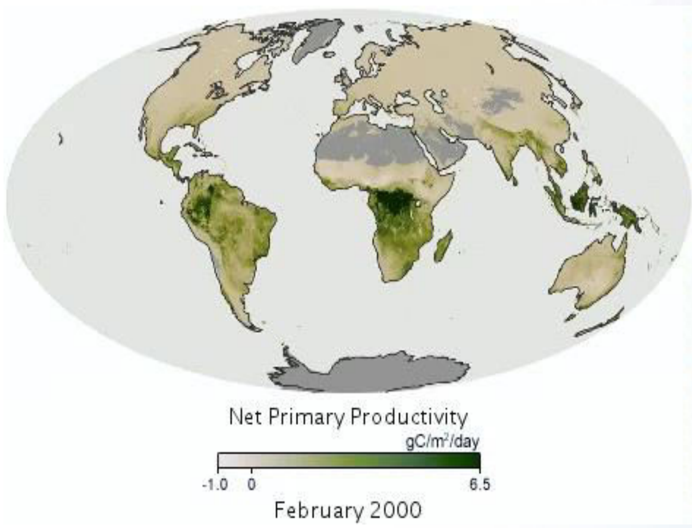
Productivity of trophic level

1 a . Gross primary productivity (GPP)

- Raw rate at which the primary producers synthesize new organic matter

Gross primary production (GPP) is the amount of chemical energy as biomass that primary producers create in a given length of time.

Trophic Level and Productivity



https://www.youtube.com/watch?v=URspHFp1u_k

Productivity of trophic level

1 b. Net primary productivity

= GPP – Respiration

- NPP varies with seasonal changes
- Measured in mass/unit area/year

Trophic Level and Productivity

Productivity of trophic level

1. Secondary productivity

- The rate that new organic matter is made by means of individual growth and reproduction in all the herbivores
- Each heterotroph trophic level has its own secondary productivity.

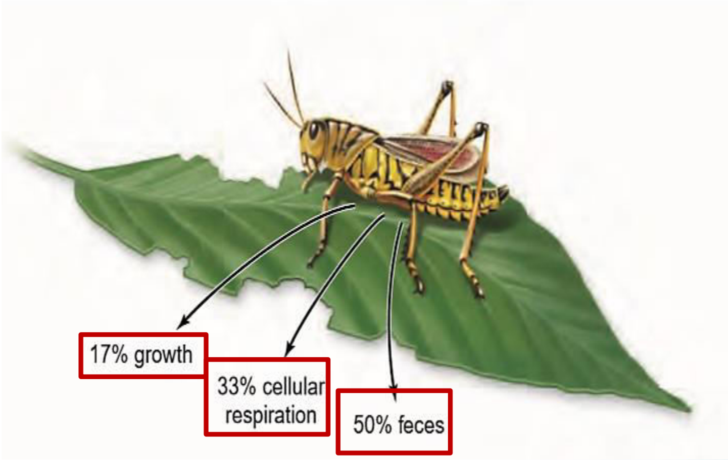
END

Some fraction of this fixed energy is used by primary producers for cellular respiration and maintenance of existing tissues (i.e., "growth respiration" and "maintenance respiration").[2][3] The remaining fixed energy (i.e., mass of photosynthate) is referred to as **net primary production.** Some fraction of this fixed energy is used by primary producers for cellular respiration and maintenance of existing tissues (i.e., "growth respiration" and "maintenance respiration"). The remaining fixed energy (i.e., mass of photosynthate) is referred to as **net primary production.**

How trophic levels process energy?

- **Small fraction of solar energy (1%) is consumed in photosynthesis**
- **Transformed into chemical-bond energy**
- **99% solar energy is converted into heat.**

How trophic levels process energy?



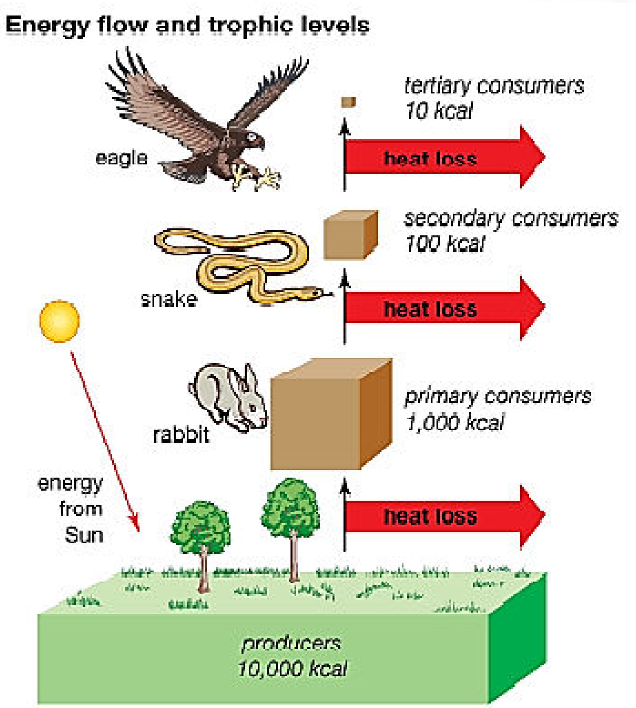
Biology Mason, Losos and Singer, 9th ed.

Synthesized chemical-bond energy is consumed:

- Absorption of nutrients
- Growth (tissue formation)
- Body functions
- Availability to consumers

- Tissues / Growth

How trophic levels process energy?



Encyclopedia Britannica, 2011

- Chemical-bond energy is passed from one heterotroph trophic level to the next.
- Loss of energy at every stage

1. Herbivore
2. Primary carnivore
3. Secondary carnivore

- Loss of 90% energy from one level to next

How trophic levels process energy?

Exponential decline of chemical-bond energy in a trophic chain limits:

- Lengths of trophic chains
- Number of top level carnivores

Top level carnivores have:

- large individual body sizes

- great individual energy needs

How trophic levels process energy?

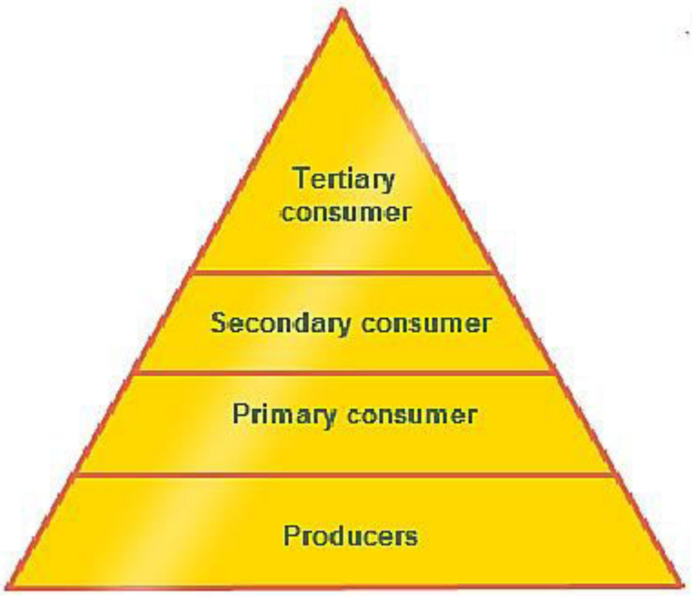
- Variability in Net Primary Productivity between ecosystems
- Wetlands and tropical rain forests: 2000 g/m^2/ year
- Temperate forests: 1200 - 1300 g/m^2/ year
- Savanna: 900 g/m^2/ year
- Deserts: 90 g/m^2/ year

END

Ecological Pyramids

Flow of energy and decline of chemical-bond energy is represented by pyramids.

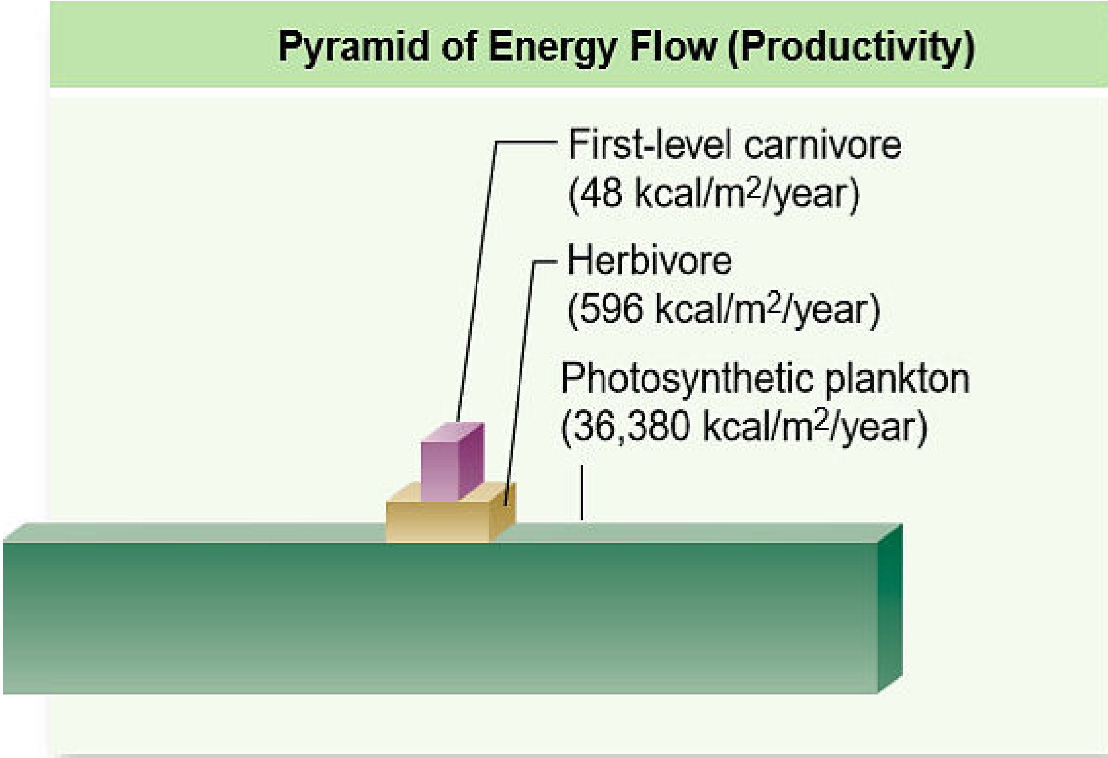
Ecological Pyramids



Flow of energy and decline of chemical-bond energy is represented by pyramids.

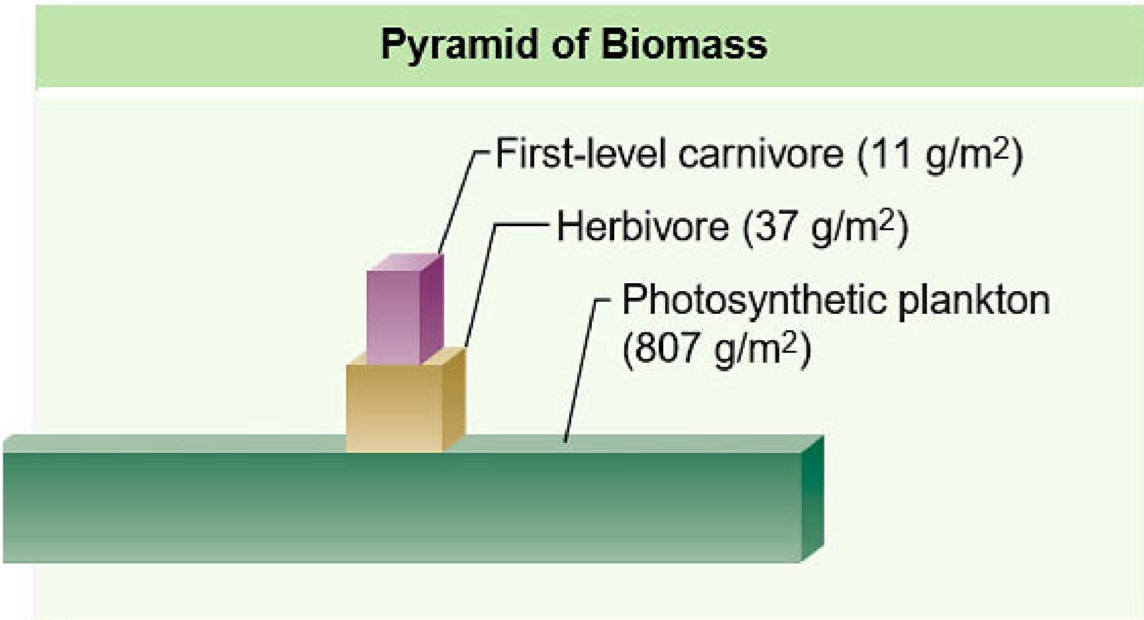
- Trophic levels are boxes stacked on top of each other.
- Width of box is proportional to productivity of that level.

Ecological Pyramids



Biology Mason, Losos and Singer, 9th ed.

Ecological Pyramids



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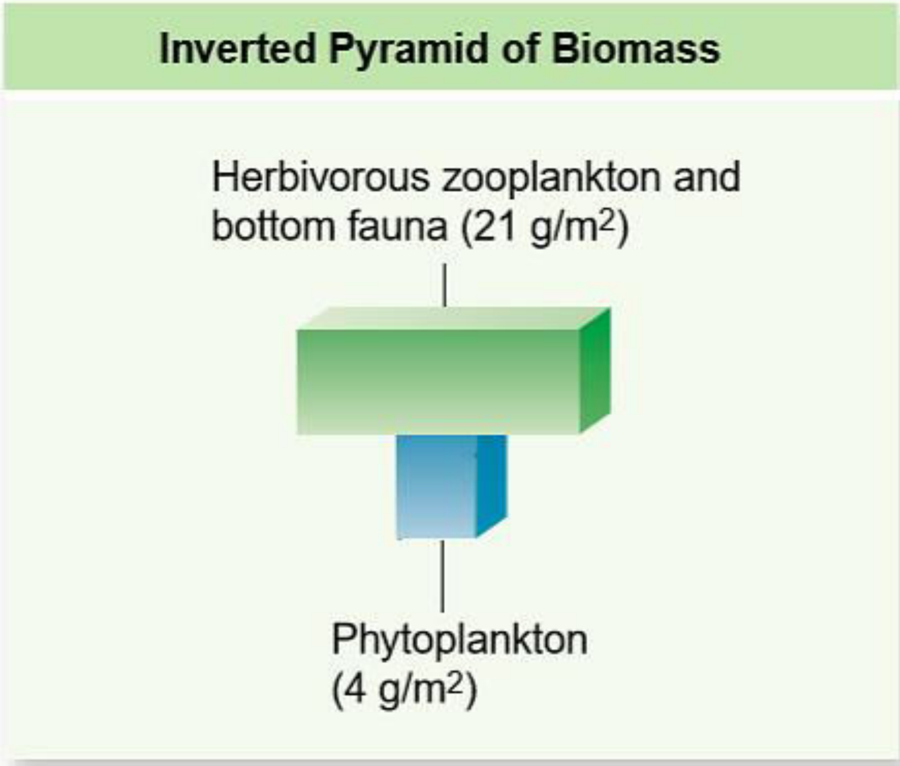
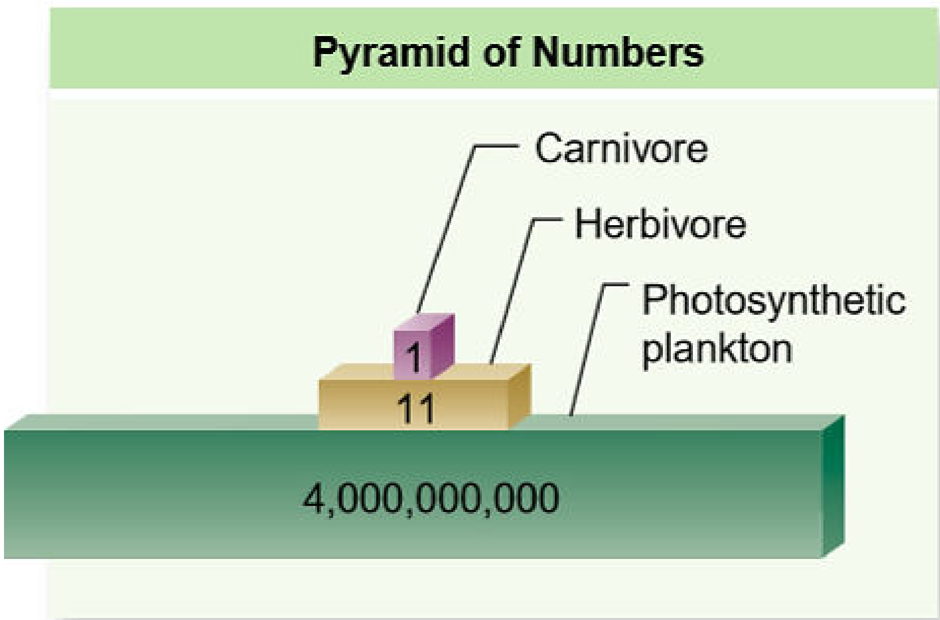
Ecological Pyramids



Biology Mason, Losos and Singer, 9th ed.

Ecological Pyramids



Biology Mason, Losos and Singer, 9th ed.

In a pyramid of numbers, the widths of the boxes are proportional to the numbers of individuals present in the various trophic levels. Such pyramids are usually, but not always, upright.

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Abiotic Factors in Environment

Habitat

- Natural environment where a species/organism lives
- Where they find:
- Food
- Shelter
- Protection
- Mates

Abiotic Factors in Environment

Habitat has two types of characteristics:

- Abiotic/Physical
- Biotic/Biological

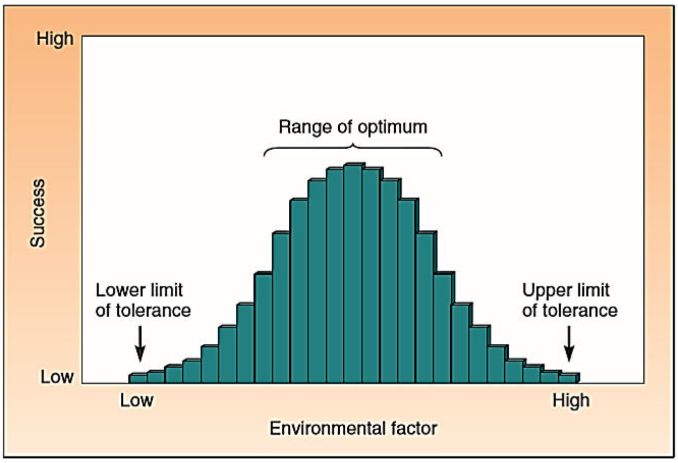
Abiotic Factors

- Temperature
- Water
- Light
- Soil

Abiotic Factors in Environment

https://www.youtube.com/watch?v=hIy0ZlyPPDg

Abiotic Factors in Environment



- Tolerance range

- At either limit, one or more essential functions cease
- - Range of optimum
- Highest success of animal
- - Limiting factor
- Factor out of tolerance range

- Taxis

Orientation towards a factor

Temperature

- Thermoregulation
- Inequality between heat loss and gain
- Harsh condition require adaptations
- Both ectothermic and endothermic animals have adaptations.

Temperature

https://www.sciencenewsforstudents.org/article/explainer-how-brief-can-hibernation-be

https://smbasblog.com/2016/11/15/do-mother-hummingbirds-sleep/

Torpor

- Decreased metabolism
- Lowered body temperature
- Examples:
  Bats, Humming birds
- Help in survival when not feeding

Temperature

http://thewildlife.wbur.org/2015/01/20/hibernating-animals-may-hold-secrets-for-fighting-alzheimers/

Hibernation

- Decreased metabolism
- Lowered body temperature
- May last for weeks or months
- Examples:

Rodents, Shrews

Temperature

https://bear.org/do-black-bears-hibernate/

Winter Sleep

- Occurs in large animals
- Large energy reserves
- Quick restoration of activity
- Examples:

Bears

Temperature

https://www.thinglink.com/scene/630237835143675906

https://www.worldatlas.com/articles/what-is-estivation-animals-that-estivate.html

Aestivation

- Survival in extended period of drying
- Avoid temperature damage and dehydration
- Examples:

Insects, frog, turtle

Temperature

http://youtube.com/watch?v=buQaIannwz0

Abiotic Factors - Water

- Water is critical factor in homeostasis.
- Animals lose water:
  - Evaporation
  - Excretion
- Lost water must be replaced.
  - Drinking
  - Eating
  - Avoiding dehydration

Abiotic Factors - Water

Adaptations

https://www.google.com/search?q=animals+hiding+in+burrows&rlz

To avoid dehydration:

- Behavioral

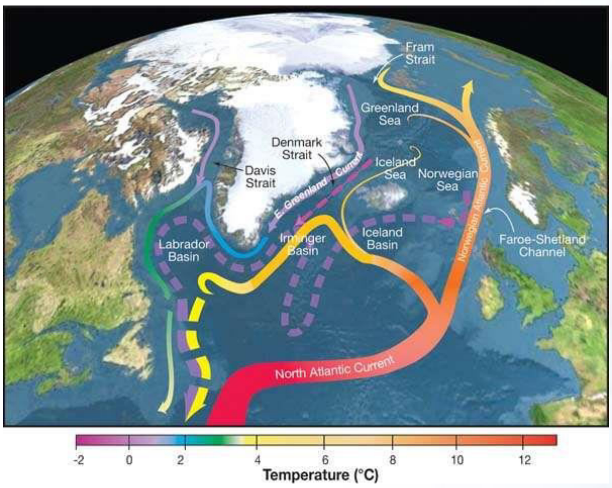
Nocturnal mode, burrows/hides

- Physiological

Osmoregulation

Abiotic Factors - Water

Water Currents



https://www.google.com/search?q=water+currents+in+ocean&rlz

- Affect animal distribution in water body.
- Generated by wind
- Convection currents
- Determine biodiversity and niche
- Movement of minerals and rocks

Abiotic Factors - Water

https://www.dailymail.co.uk/sciencetech/article-6728749/Protein-razor-sharp-teeth-inside-suckers-squid-replace-plastics.html

Adaptations

To cope with currents:

- Suckers
- Hooks / claws
- Body flattening
- Streamlining

Clues Book.com

Abiotic Factors - Light

- Discussed in "energy"
- Animal's response to light intensity
- Phototactic movement

 - positive (Euglena)

 - negative (Planaria, Earthworms)

Abiotic Factors - Light

Effects of Photoperiod

- Biological Clocks

  - Diurnal

Distribution, sleep-wake cycle

  - Annual

Reproduction, migration

http://idahoptv.org/sciencetrek/topics/bird_migration/facts.cfm

Abiotic Factors - Light

Effects of Light

- Increase metabolism
- Pigmentation

Sexual dimorphism, camouflage

- Sun as reference point in navigation during daily movement/migration

END

Population Growth

- Increase in the number of individuals in a population
- Reproduction

Population growth rate

- Rate at which the number of individuals in a population increases in a given time period.
- Species specific

Population Growth

Species	Rate of Reproduction
Bacteria	Every 20 minutes 3 million / 7 hours
House Fly	600 eggs / life time
Common Carp	300, 000 / year
Mouse	30 – 140 / year
Elephants	one / 5 – 6 years

Population Growth

Limiting factors regulate population size

- Rate of Birth
- Rate of Death/mortality
- Dispersal
- Food Resources
- Space to grow
- Environmental factors

Population Growth

Carrying Capacity (*K*)

- The maximum population size of the species that the environment can sustain indefinitely.
- Environment's maximal load
- Population size decreases above carrying capacity

Population Growth

Carrying Capacity

- Variable, may vary for different species
- May change over time due to a variety of factors including:
- food availability, water supply, environmental conditions and living space

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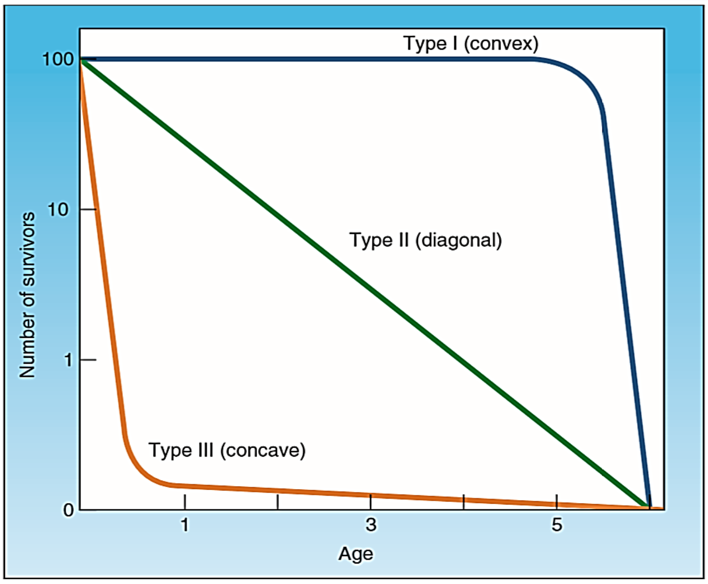
Population Growth

- Variety of tools to track the size of population
- Survivorship curve is one tool.
- It measures the proportion of individuals in a given species that are alive at different ages.

Population Growth

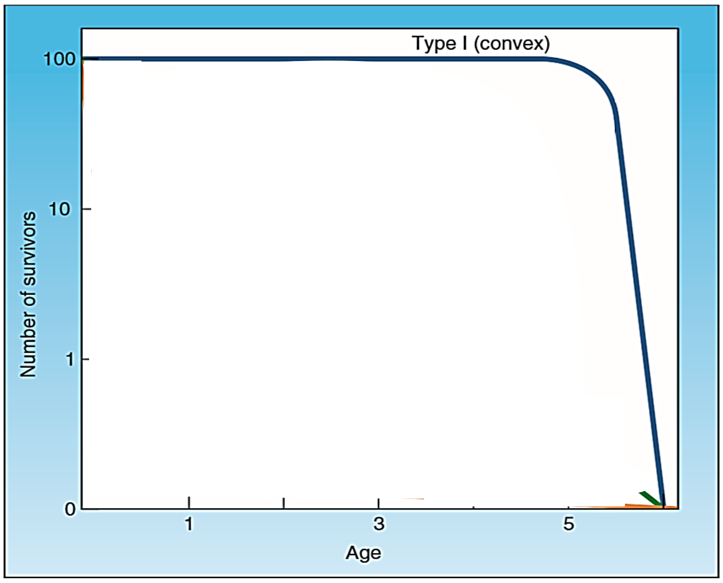


Zoology by Miller and Harley, 5th ed.

Survivorship Curve

- Y-axis is a logarithmic plot of numbers of survivors
- X-axis is a linear plot of age

Population Growth



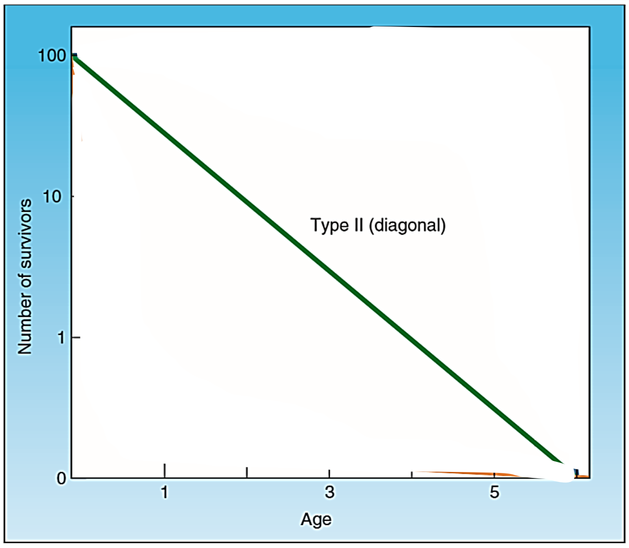
Zoology by Miller and Harley, 5th ed.

Kinds of Survivorship Curve

Type 1 (Convex)

- Populations survive to an old age, then die rapidly.
- Unimportance of environmental factors in influencing mortality
- Potential life span
- Example: Humans

Population Growth



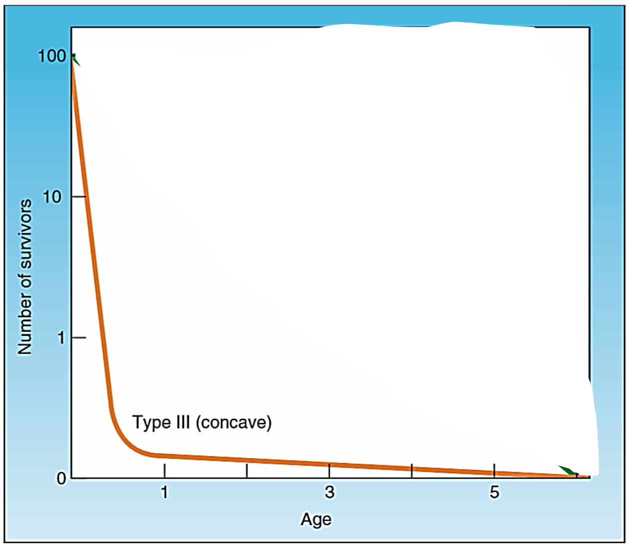
Zoology by Miller and Harley, 5th ed.

Kinds of Survivorship Curve

Type II (Diagonal)

- Constant probability of death throughout lives
- Influence of environmental factors on mortality
- Mortality independent of age
- Example: birds, rodents

Population Growth



Zoology by Miller and Harley, 5th ed.

Kinds of Survivorship Curve

Type III (Concave)

- High juvenile mortality
- Influence of environmental factors and less resistance of juveniles on mortality
- Lower mortality in adults
- Example: Fish

Exponential Population Growth

Types of Population growth

1. Exponential
2. Logistic

Exponential Population Growth

Exponential Growth

- Resources are abundant.
- Remarkable potential to increase in number
- Exponential addition in population size

Exponential Population Growth

The number of births minus the number of deaths per generation time

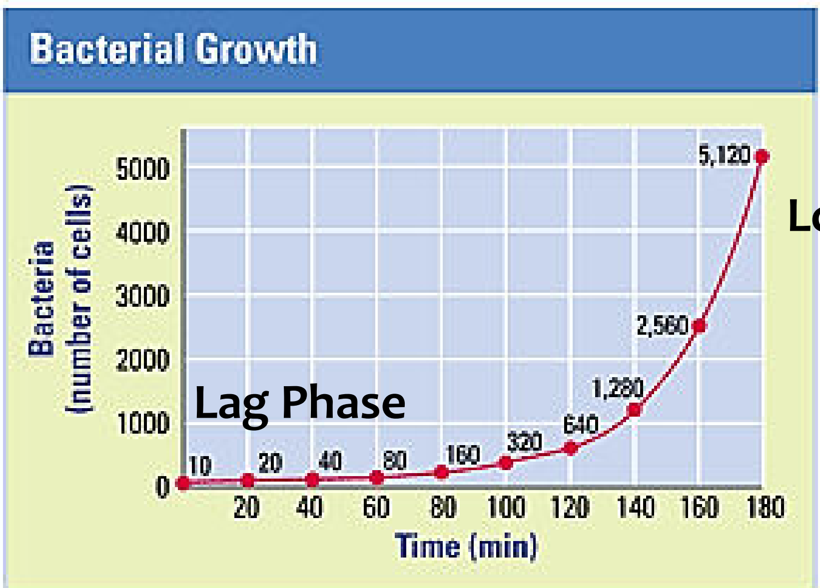
- Population may grow exponentially to certain time
- Ultimately limited by resource availability
- Formula of exponential growth

$\frac{dN}{dt} = rN$ N= Population size

r = intrinsic rate of natural increase

Exponential Population Growth

J – Shaped Curve



Log Phase

http://bodell.mtchs.org/OnlineBio/BIOCD/text/chapter16/review16.html

Exponential Population Growth

Factors affecting reproductive rate

END

- Number of offspring produced
- Likelihood of survival to reproductive age
- Duration of the reproductive period
- Length of time to reach maturity
- Environmental factors

Logistic Population Growth

- Carrying capacity of environment affect population growth.
- Environmental resistance
- Growth rate gets smaller as approaches the carrying capacity

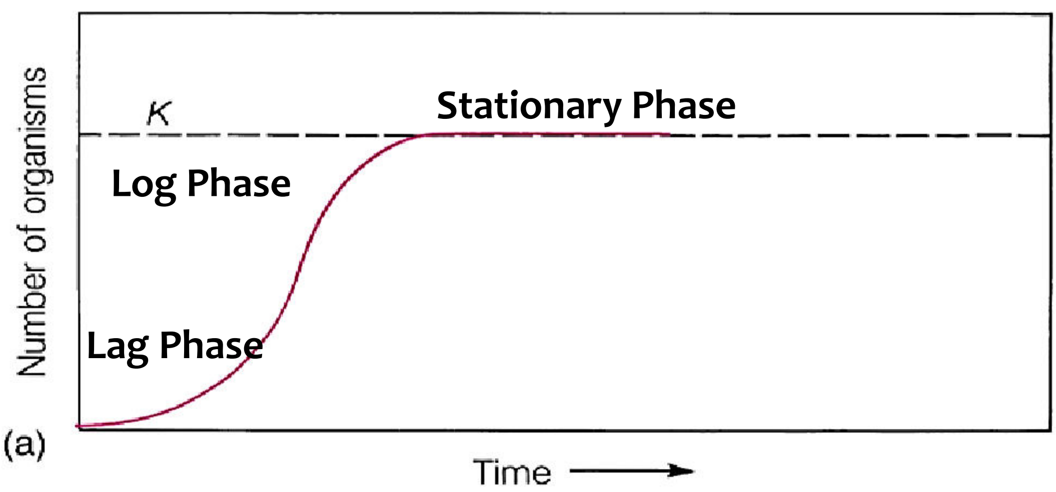
Logistic Population Growth

Environmental factors affect population growth.

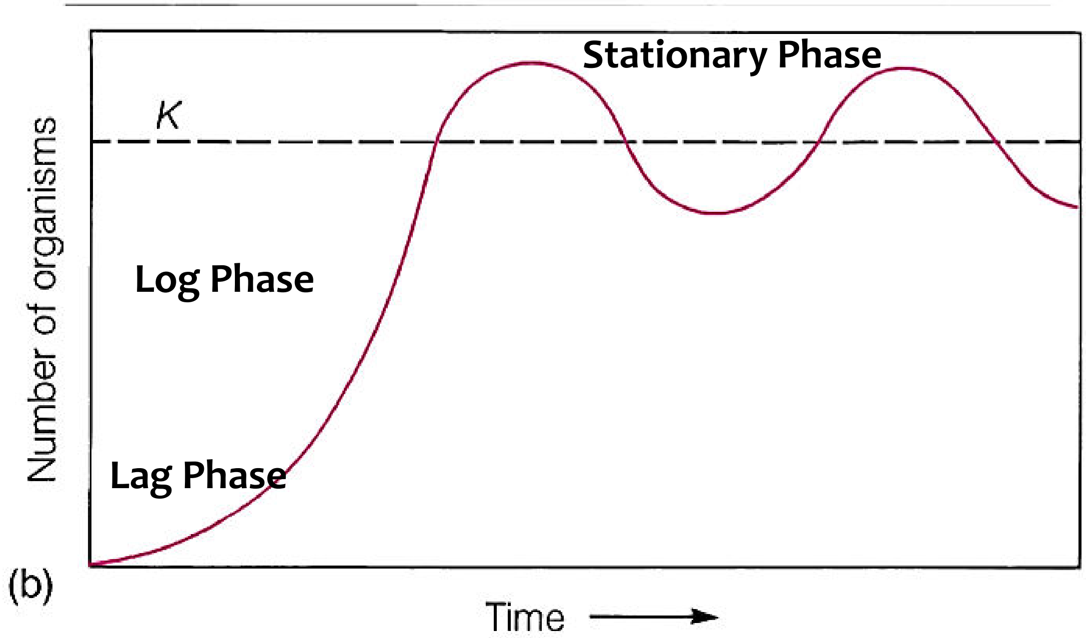
- Climate
- Food
- Space
- Competition

Logistic Population Growth

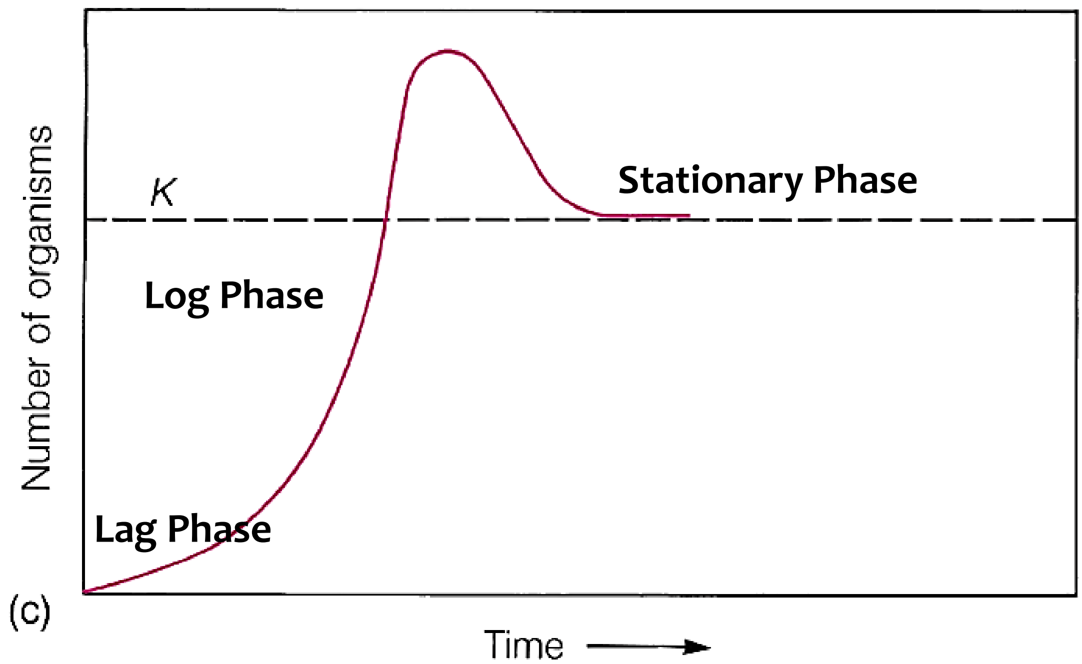
S - Shaped or Sigmoidal Curve



Logistic Population Growth



Logistic Population Growth



Logistic Population Growth

Formula

$$\frac{dN}{dt} = \frac{rN\,(K-N)}{K}$$

N = population size
dN / dt = change in population size per unit time
K = carrying capacity
r = intrinsic rate of natural increase

Logistic Population Growth

EXPONENTIAL GROWTH	LOGISTIC GROWTH
It occurs when resources are abundant.	It occurs when resources are limited.
Population passes well beyond the carrying capacity of the ecosystem.	Population doesn't grow beyond the carrying capacity of the ecosystem.
It produce J shaped curve.	It produce S shaped curve.
A stationary or stable phase is seldom achieved.	A stationary or stable phase is achieved.
It has two phases lag and log.	It has four phases lag, log, deceleration & steady .
It occurs in fewer organisms like lemmings, algal blooms, etc.	It is more common, example members of wildlife, yeast (a microscopic fungus), etc.

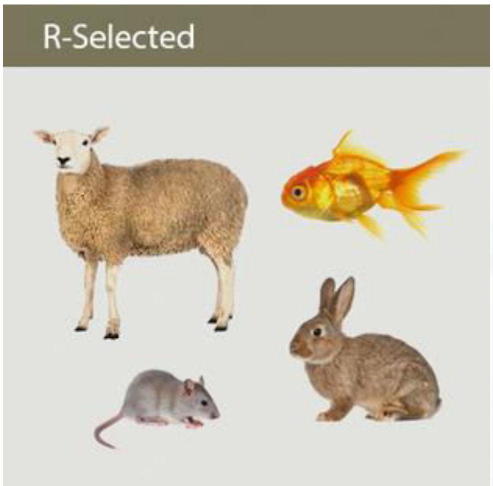
https://www.youtube.com/watch?v=LYoguW1Ha0w

r and k Selected Species

r-selected species

- High growth rates
- Typically exploit less crowded ecological habitats
- Produce many offspring
- Relatively low probability of surviving to adulthood

r and k Selected Species



https://steemit.com/animals/@reviewsatrandom/if-earth-was-an-mmo-growth-strats

r-selected species

- High reproductive rate supports their survival.
- Especially in unstable environment

r and k Selected Species

Traits of r-selected species

- High rate of reproduction
- Small body size
- Early maturity onset
- Short generation time
- Ability to disperse offspring widely
- Examples: bacteria, grasses, cephalopods, rodents

r and k Selected Species

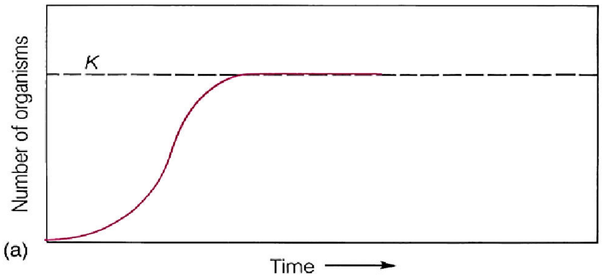
https://steemit.com/animals/@reviewsatrandom/if-earth-was-an-mmo-growth-strats

k-selected species

- Living at densities close to carrying capacity
- Typically are strong competitors in such crowded habitats.
- Invest more heavily in fewer offspring
- Relatively high probability of surviving to adulthood

r and k Selected Species

k-selected species



- Survive in stable environment
- Ability to compete successfully for limited resources is crucial
- Populations of k-selected organisms typically are very constant in number.
- Close to the maximum that the environment can bear

r and k Selected Species

Traits of k-selected species

- Large body size
- Long life expectancy
- Production of fewer offspring
- Often require extensive parental care until they mature
- Examples: humans, whales, parrots, eagles

END

Population Regulation

- No indefinite growth of any population
- Factors limit the population size and growth.

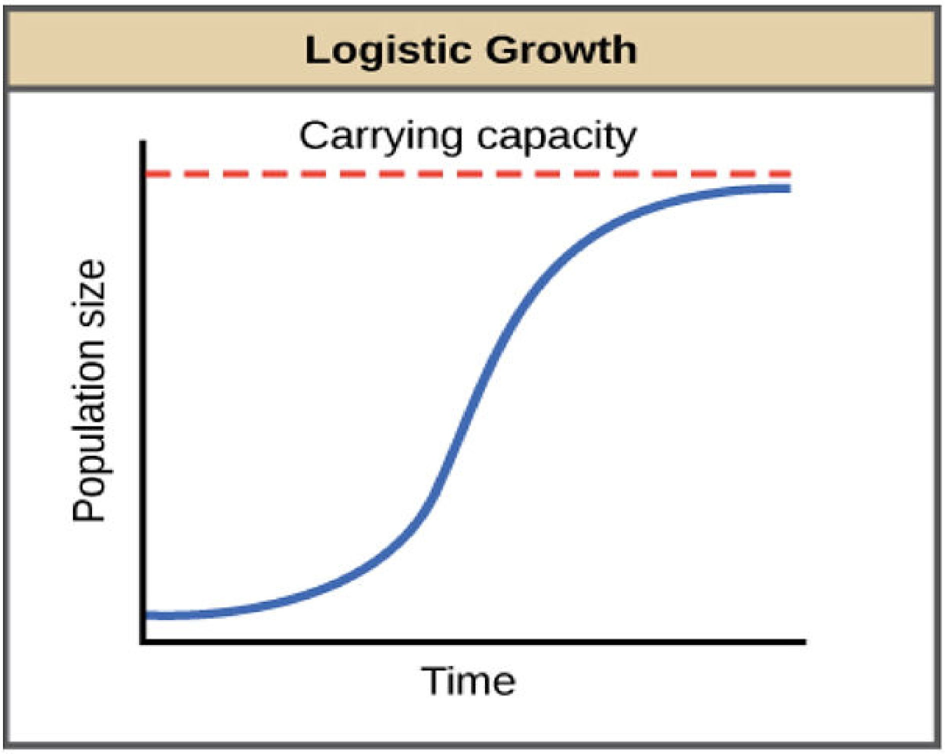
1. Density dependent factors
2. Density independent factors

Population Regulation

Density dependent factors

- Example: Food

Population Regulation



https://www.khanacademy.org/science/biology/ecology/population-growth-and-regulation/a/mechanisms-of-population-regulation

Population Regulation

Competition within the population

- When a population reaches a high density, there are more individuals trying to use the same quantity of resources.

Population Regulation

Competition within the population

- This can lead to competition for food, water, shelter, mates, light, and other resources needed for survival and reproduction.

Population Regulation

Predation

- Higher-density populations may attract predators who wouldn't bother with a sparser population.
- When these predators eat individuals from the population, they decrease its numbers but may increase their own.

Population Regulation

Disease and Parasites

- Disease is more likely to break out and result in deaths when more individuals are living together in the same place.

Population Regulation

Waste Accumulation

- High population densities can lead to the accumulation of harmful waste products that kill individuals or impair reproduction, reducing the population's growth.

Population Regulation

Density Independent Limiting Factors

Affect per capita growth rate independent of density of population

- Natural disasters
- Severe weather
- Pollution

Population Regulation

Density Independent Limiting Factors

Cannot regulate population at constant level

They are accidental.

Cause abrupt shift in population size

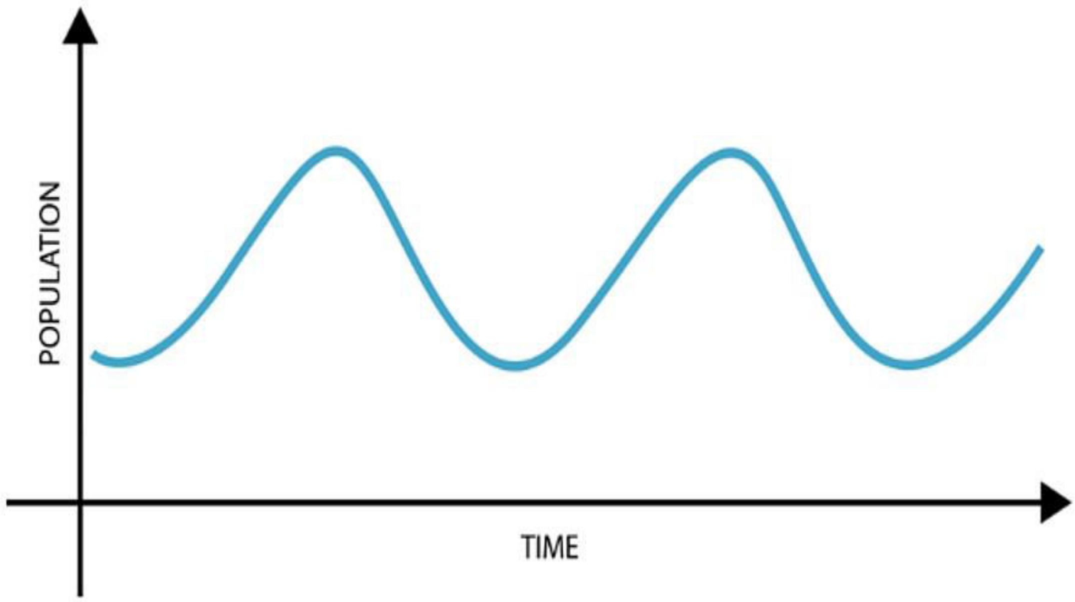
May wipe out small population by sporadic event

Population Regulation

- Collectively, density-dependant and independent factors create a different population growth curve.
- Cyclic oscillations

Population Regulation

Cyclic Oscillations in Population



https://www.khanacademy.org/science/biology/ecology/population-growth-and-regulation/a/mechanisms-of-population-regulation

Cyclical oscillations are repeating rises and drops in the size of the population over time. oscillations are produced by interactions between populations of at least two different species. For instance, predation, parasite infection, and fluctuation in food availability have all been shown to drive oscillations.

Communities

- Group of species living in a habitat
- Plants, animals, fungi, protists, and prokaryotes that occur at a locality
- Characterized by:

  - Species richness

  - Primary productivity

Communities

Biology Mason, Losos and Singer, 9th ed.

Communities

https://www.youtube.com/watch?v=9bQNRVyI4I0

Communities

Concept about complexity of communities

- Individualistic
- Holistic

Communities

Individualistic concept of communities

- Simple aggregation of species that happen to occur together at one place
- Species appear and disappear according to their ecological needs
- Structure of community varies with time

Communities

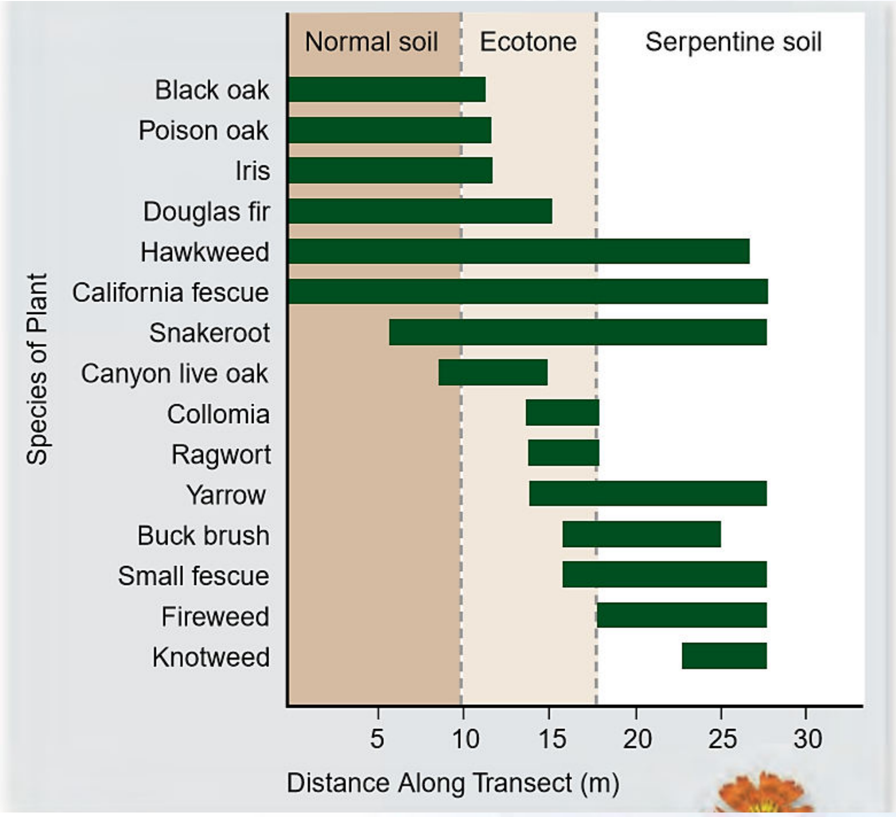
Hoslistic concept of communities

- Integrated and functioning as a whole unit
- Should stay the same through space or time
- Replaced by completely different communities with environmental changes

Communities

- Ecologists support individualistic concept.
- Community composition changes gradually across landscapes
- Some species appear and become more abundant.
- Others decrease in abundance and eventually disappear.

Communities



Biology Mason, Losos and Singer, 9th ed.

Change in community composition across an ecotone. The plant assemblages on normal and serpentine soils are greatly different, and the transition from one community to another occurs over a short distance. An ecotone is a transition area between two biomes. It is where two communities meet and integrate. Serpentine soil is an uncommon soil type produced by weathered ultramafic rock such as peridotite and its metamorphic derivatives such as serpentinite.

The Ecological Niche

- Each organism in a community confronts the challenge of survival in a different way.
- Occupies a specific functional role and place called its niche.
- The niche an organism occupies is the total of all the ways it uses the resources of its environment.

ClueśBook.com

The Ecological Niche

- A niche may be described in terms of:
- Space utilization
- Food consumption
- Temperature range
- Appropriate conditions for mating
- Requirements for moisture
- Other factors

The Ecological Niche

https://www.youtube.com/watch?v=p8NdASl4jY4

The Ecological Niche

- Sometimes species cannot utilize their entire niche.
- Due to presence of other species competing for resources
- Interspecific competition, occurs between two species to use the same resources

The Ecological Niche

Fundamental Niche

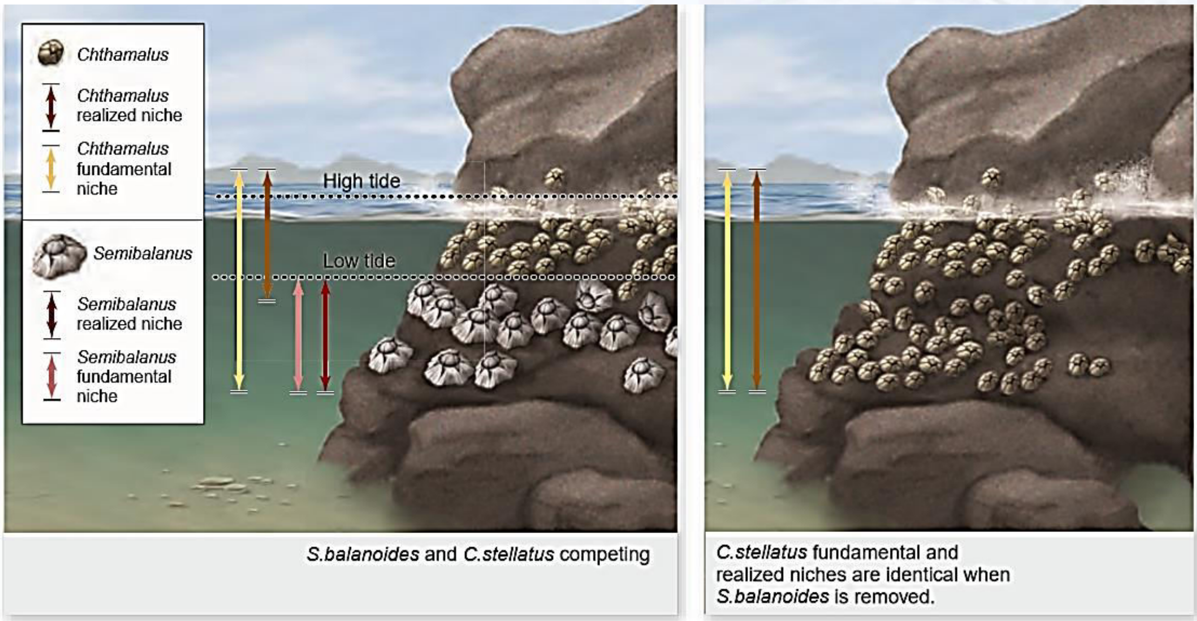
The entire niche that a species is capable of using, based on its physiological tolerance limits and resource needs.

The Ecological Niche

Realized Niche

The actual set of environmental conditions, including the presence or absence of other species, in which the species can establish a stable population.

The Ecological Niche



S.balanoides and C.stellatus competing

C.stellatus fundamental and realized niches are identical when S.balanoides is removed.

Biology Mason, Losos and Singer, 9th ed.

Community Stability

- Communities may begin in areas nearly devoid of life.
- The first community to become established in an area is called the **pioneer community**.
- Death, decay, new species and additional nutrients establish this community.

Community Stability

- Over thousands of years nutrients accumulate, communities established.
- Complex ecosystem becomes functional.
- Each successional stage is called a seral stage
- Entire successional sequence is a sere.

Community Stability

- Dominant life-forms of a sere gradually make the area less favorable for themselves due to consumption of resources.
- But more favorable for organisms of the next successional stage

Community Stability

- The final community is the climax community.
- It is different from the seral stages that preceded it because it can tolerate its own reactions.
- Complexity of ecosystem makes it more stable.

Community Stability

Types of Succession

- Primary

Occurring in an environment in which new substrate devoid of vegetation and other organisms usually lacking soil

- Secondary

An event reduces already established ecosystem.

Community Stability

http://youtube.com/watch?v=vt3eiaduSnw

ClluesBook.com

Community Stability

http://youtube.com/watch?v=jJ0zq010pv8

Interspecific Interactions

Herbivory

- Consumers of plants
- Anatomically and physiologically adapted to eating plant material
- Mutualistic gut flora e.g. cellulose digesting bacteria
- Important role in food chain

Interspecific Interactions

Herbivory

- Different feeding strategies

Major strategies:

1. Grazers
2. Browsers

Interspecific Interactions

Herbivory

https://en.wikipedia.org/wiki/File:Kangur.rudy.drs.jpg

1. Grazers

- Feeds on plants such as grasses, soft flowering plants (forbs) and algae
- Plants are not killed.
- Examples: Deer & Snails

ClauesBook.com

Interspecific Interactions

https://www.youtube.com/watch?v=7zYvIwDqhVU

Interspecific Interactions

Herbivory

Types of Grazing

1. Graminivory

- Feeding primarily on grass
- Specifically "true" grasses in family Poaceae

Examples: Horses, cattle, hippopotamus, grasshoppers

Interspecific Interactions

http://youtube.com/watch?v=AJbYCh3gbC8

Interspecific Interactions

Herbivory

Types of Grazing

1. Coprophagy

- Feeding on grass, forbs, leafy weeds, fruits, tree bark
- Heavy grazing for half an hour of grazing period
- Followed by half an hour of selective feeding

Interspecific Interactions

Herbivory

https://www.google.com/search?q=rabbits+eating+their+feces&rlz=1C1SQJL_enUS822US822&source=lnms&tbm=isch&sa=X&ved=0ahUKEwj4qtm72oviAhXHMewKHSPhAIIQ_AUIDygC&biw=1280&bih=529#imgrc=xc3YKg0G9e7kDM:

Types of Grazing

2. Coprophagy

- Later feeding in intervals
- Eat their or other species's soft feces (caecotrophs)

Example: Rabbit

Interspecific Interactions

Herbivory

2. Browsers

- Feed on non-grass plant material
- Leaves, soft shoots, twigs, fruits, woody plants such as shrubs

Examples: Goats, deer, giraffe, elephants

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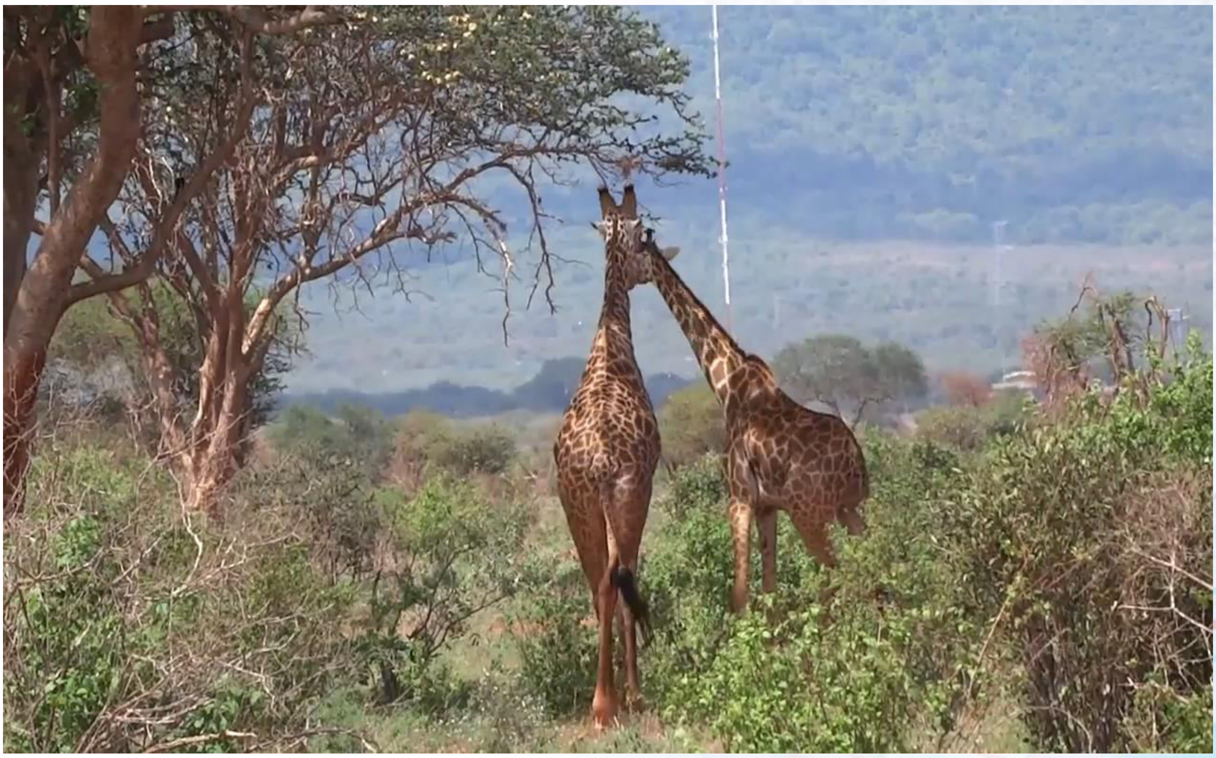
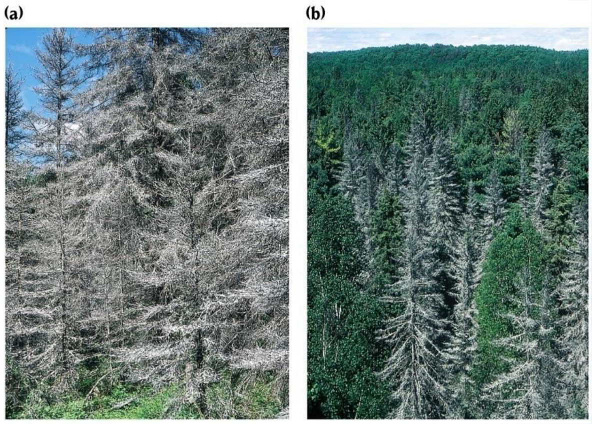
Interspecific Interactions



https://www.youtube.com/watch?v=HXLXq-ZRT-M

Interspecific Interactions

Herbivory



https://www.google.com/search?rlz=1C1SQJL_enUS822US822&biw=1280&bih=578&tbm=isch&sa=1&ei=cLHSXLWbBobUsAeV6JbYDQ&q=over+browsing&oq=over+browsing&gs_

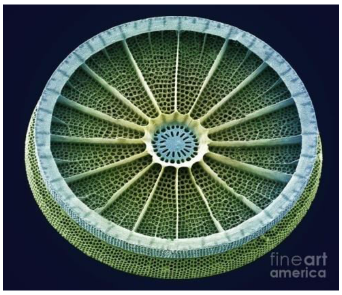
2. Browsers

- Over browsing

- Introduction of herbivores
- Low productivity of native plants
- Less predation pressure

Interspecific Interactions

Defense against Herbivory



https://en.wikipedia.org/wiki/Thorns,_spines,_and_prickles

1. Tolerance

2. Resistance

- Physical/Mechanical defense

Thorns, hair, resins, silica deposits in cell wall, resins make plants inedible

- Chemical defense

Interspecific Interactions

Defense against Herbivory

- Chemical defense
  - Terpenes, phenols, alkaloids
  - Give bitter taste to plants
  - Affect nervous system of herbivore

End

Physical, or mechanical, defenses are barriers or structures designed to deter herbivores or reduce intake rates, lowering overall herbivory. Thorns such as those found on roses or acacia trees are one example, as are the spines on a cactus. Smaller hairs known as trichomes may cover leaves or stems and are especially effective against invertebrate herbivores.[37] In addition, some plants have waxes or resins that alter their texture, making them difficult to eat. Also the incorporation of silica into cell walls is analogous to that of the role of lignin in that it is a compression-resistant structural component of cell walls; so that plants with their cell walls impregnated with silica are thereby afforded a measure of protection against herbivory.

Carbon-based defenses include terpenes and phenolics. Terpenes are derived from 5-carbon isoprene units and comprise essential oils, carotenoids, resins, and latex. They can have a number of functions that disrupt herbivores such as inhibiting adenosine triphosphate (ATP) formation, molting hormones, or the nervous system.[39] Phenolics combine an aromatic carbon ring with a hydroxyl group. There are a number of different phenolics such as lignins, which are found in cell walls and are very indigestible except for specialized microorganisms; tannins, which have a bitter taste and bind to proteins making them indigestible; and furanocumerins, which produce free radicals disrupting DNA, protein, and lipids, and can cause skin irritation.

Nitrogen-based defenses are synthesized from amino acids and primarily come in the form of alkaloids and cyanogens. Alkaloids include commonly recognized substances such as caffeine, nicotine, and morphine. These compounds are often bitter and can inhibit DNA or RNA synthesis or block nervous system signal transmission.

Interspecific Interactions

Predation

- One animal kills and eats another animal
- One is predator and other is prey
- Actively search for prey or sit and wait
- Examples: invertebrates such as jelly fish and insects
- Vertebrates such as lions

Interspecific Interactions

https://www.youtube.com/watch?v=ffcyVpqn9ng

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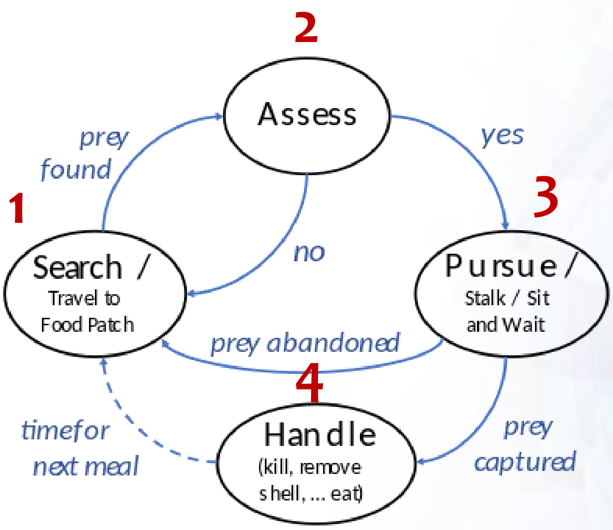
Interspecific Interactions



https://en.wikipedia.org/wiki/Predation

Predation

- **To feed, a predator must search for, pursue and kill its prey.**
- **These stages form a foraging Cycle.**

1. **Search**
2. **Assessment**
3. **Capture**
4. **Handling**

Interspecific Interactions

https://www.google.com/search?rlz=1C1SQJL_enUS822US822&biw=1280&bih=529&tbm=isch&sa=1&ei=DTTVXPmZM8O6aZi4vJgE&q=crocodiles+hunting&oq=crocodiles+hunting&gs

Foraging Cycle

1. Search

- Sit and Wait method

- Suitable if the prey are dense and mobile
- Low energy requirement
- Example: Crocodiles, spiders, aquatic invertebrates, praying mantises

Interspecific Interactions

https://www.google.com/search?q=sharks+hunting&rlz=1C1SQJL_enUS822US822&source=lnms&tbm=isch&sa=wluoElf6s5-PLM:

Foraging Cycle

1. Search

- Active foraging

- When prey is sedentary or sparsely distributed.
- Expends more energy.
- Examples: Sharks, sunfish, Insectivorous birds

Interspecific Interactions

Foraging Cycle

- Some switch between active foraging and sit & wait method.

Example: Plovers, shore birds, crappie fish

- Prey distributions are often clumped in form of patches.

Interspecific Interactions

Foraging Cycle

https://www.google.com/search?rlz=1C1SQJL_enUS822US822&biw=1280&bih=529&tbm=isch&sa=1&ei=mTXVXIqUErCelwTWyqjIAQ&q=black-browed+albatross+hunting&oq=black-browed+albatross+hunting&gs

- Predators respond by looking for patches.
- Albatross make foraging flights within the prey range of 700 – 3000 km.

Interspecific Interactions

Foraging Cycle

2. Assessment

- Decide to kill or keep searching
- Decision depends on the costs and benefits
- Too small prey does not worth spending energy in capture.

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Interspecific Interactions

Foraging Cycle

https://en.wikipedia.org/wiki/Predation

3. Capture

- Pursuit predation

Actively chasing fleeing prey

- Ambush

○ Sudden strike on nearby prey

○ Adjusts its attack according to how the prey is moving.

Interspecific Interactions

Foraging Cycle

https://en.wikipedia.org/wiki/Predation

3. Capture

- Ballistic interception
  - Predator observes the movement of a prey
  - Predicts its motion
  - Works out an interception path
  - Attacks the prey on that path

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Interspecific Interactions

Foraging Cycle

https://en.wikipedia.org/wiki/Predation

4. Handling

- Prey can be dangerous
- Sharp and poisonous spines
- Should be handled carefully
- Mostly predators tear the prey apart
- E.g. cat fish

Interspecific Interactions

Predation Strategies

- Solitary predation

e.g. hawks

- Group predation

e.g. wolves, hyenas

- Physical adaptations

Better vision, olfaction and auditory skills

Claws, sharp teeth, beaks, venom,

END

Interspecific Interactions

Competition

- Animals compete for same resources in ecosystem.
- Food
- Space
- Water
- Light
- Mates

Interspecific Interactions

https://en.wikipedia.org/wiki/Interspecific_competition

Types of Competition

- Intraspecific

Between members of same species

- Interspecific

Between members of different species

Interspecific Interactions

Intraspecific Competition

- Same choice of resource
- Limited resources
- Reduction in fitness for individuals
- Follows logistic population growth curve

Interspecific Interactions

Types of Intraspecific Competition

1. Direct

- Results in fighting, stealing and ritualistic combats
- Expelling weak competitors from territory make them vulnerable.

Interspecific Interactions

http://youtube.com/watch?v=d2phobqXrpg

Interspecific Interactions

https://www.pinterest.com/pin/231583605817014465/

Types of Intraspecific Competition

2. Indirect

- Exploitative competition
- One depleting a shared resource
- Both suffering a loss in fitness as a result

Example: Bears catching fish near mouth of river

Interspecific Interactions

Inter-specific Competition

- Competition between individuals of different species
- Comparatively variety of resources
- Logistic population growth curve
- Negative impact on each other

Interspecific Interactions

http://youtube.com/watch?v=M7EAKwrRXco

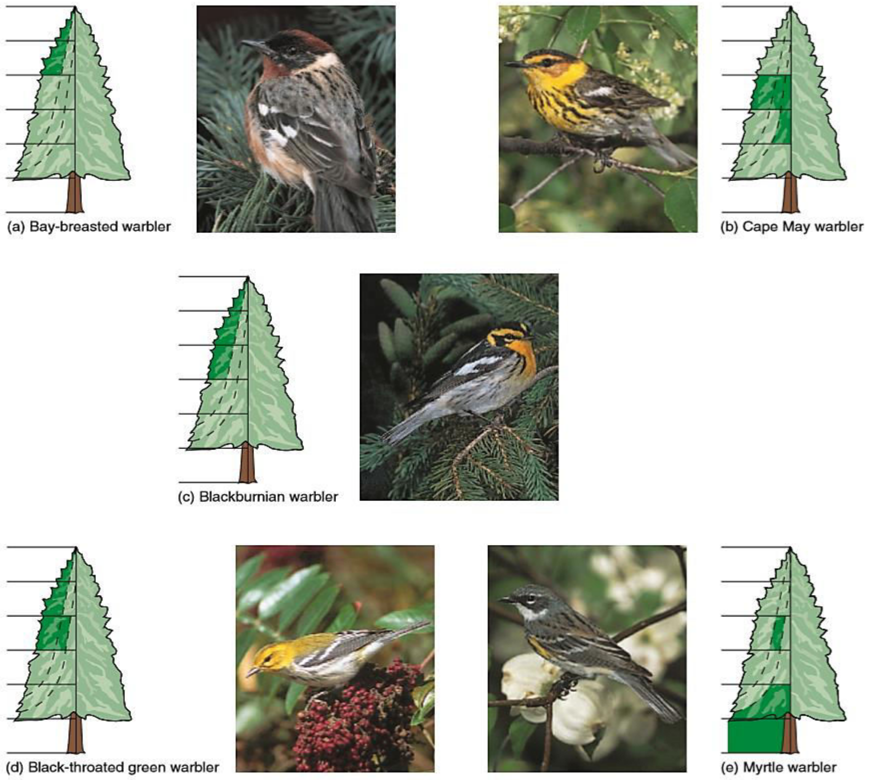
Interspecific Interactions

Types of Inter-specific Competition

- Direct
- Example: Lions and Leopards
- Indirect

Example: Aphid- *Fordinae geoica* out-compete *F. formicaria* by 84%

Interspecific Interactions



Zoology by Miller and Harley, 5th ed.

Interspecific Interactions

Coevolution

- Two or more species living in same habitat, reciprocally affect each other's evolution.
- One exerts elective pressures on the other.

Interspecific Interactions

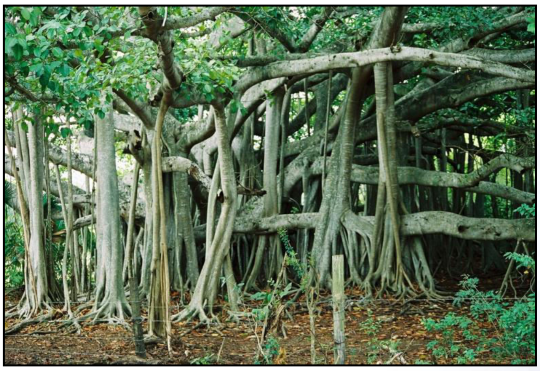
Coevolution

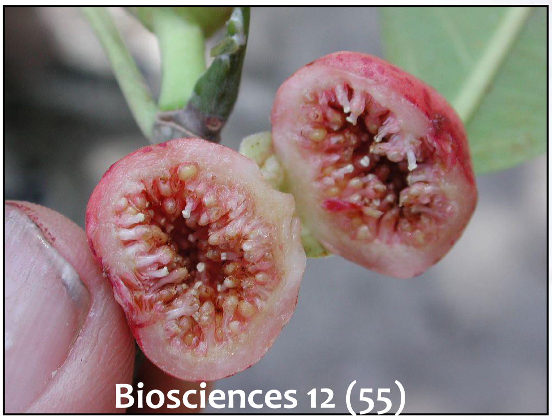
Mutualism

Both species coevolve to benefit each other in same habitat

- Fig – Wasp Relationship

Interspecific Interactions





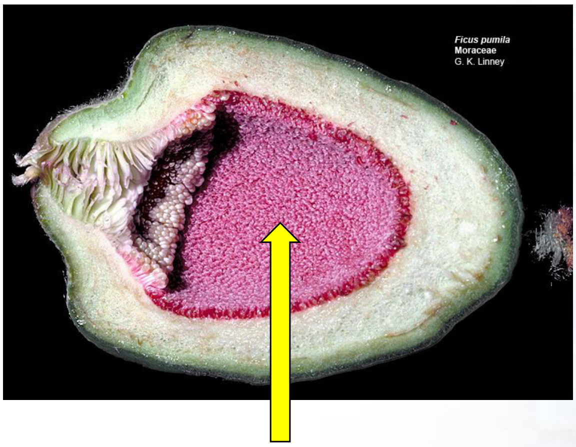
Biosciences 12 (55)

Coevolution

- ~750 tropical fig species
- All of which depend entirely on wasps for pollination
- Figs are not fruits, they are specialized inflorescences with hundreds of unisexual flowers.

Interspecific Interactions

Coevolution

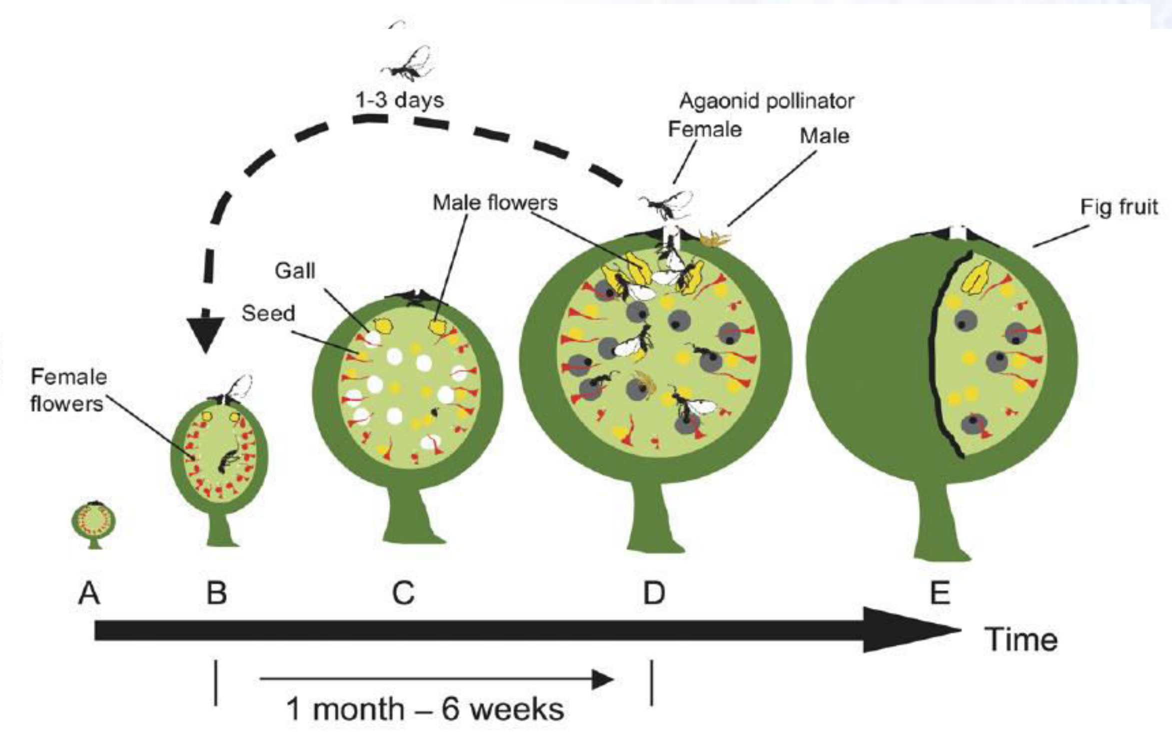


Female wasp enters via ostiole and oviposits in female flowers

Biosciences 12 (55)

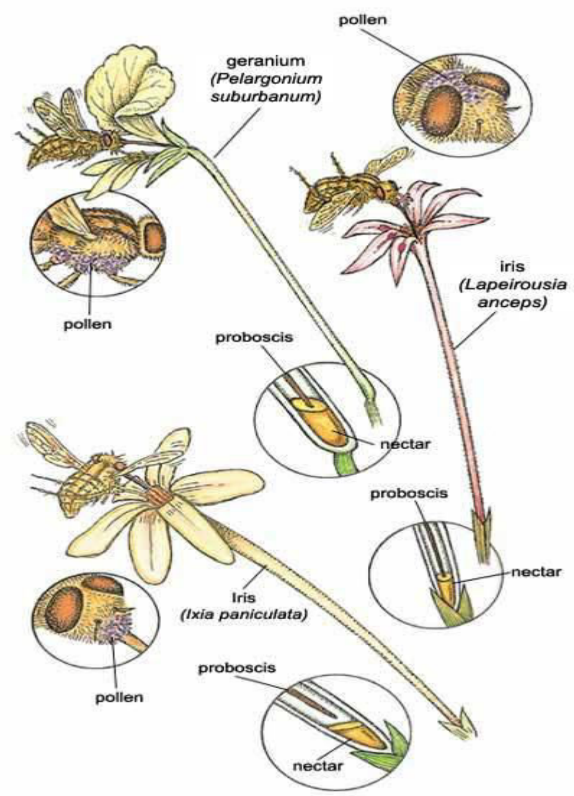
- Receptive figs produce scents that are specific to a particular pollinator species
- Shape of ostiole specific to head shape of particular wasp species (lock-and-key)
- Morphology of individual flowers specialized to a particular wasp species

Interspecific Interactions



Biosciences 12 (55)

Interspecific Interactions



Biosciences 12 (55)

Coevolution

- **Plant-pollinator coevolution**
- Flies and moths have outlandish proboscises
- Extract nectar from similarly outlandish flowers

Interspecific Interactions

Biosciences 12 (55)

Coevolution

- Attina Ants grow fungi in their colonies
- They provide leaves as food for fungi (yeasts) and eliminate competition for them.
- Fungi produce nutritional "gongylidia"
- These are hyphal swellings.

Interspecific Interactions

Coevolution

https://www.picsbud.com/images/fungal-symbionts-gongylidia-ant-mycelium-26.html

- Gongylidia are harvested by ants to feed their larvae.
- Coevolution exists from 50 million years.

ClutesBook.com

Interspecific Interactions

Coevolution

https://richsoil.com/antsandaphids/

- Ants protect aphids from parasites and predators.
- Aphids produce honeydew, source of nutrition for ants.
- Specifically coevolved for ants

Interspecific Interactions

Symbiosis

Relationship between two different species living together

- Obligate or facultative

Types

1. Mutualism
2. Commensalism
3. Parasitism

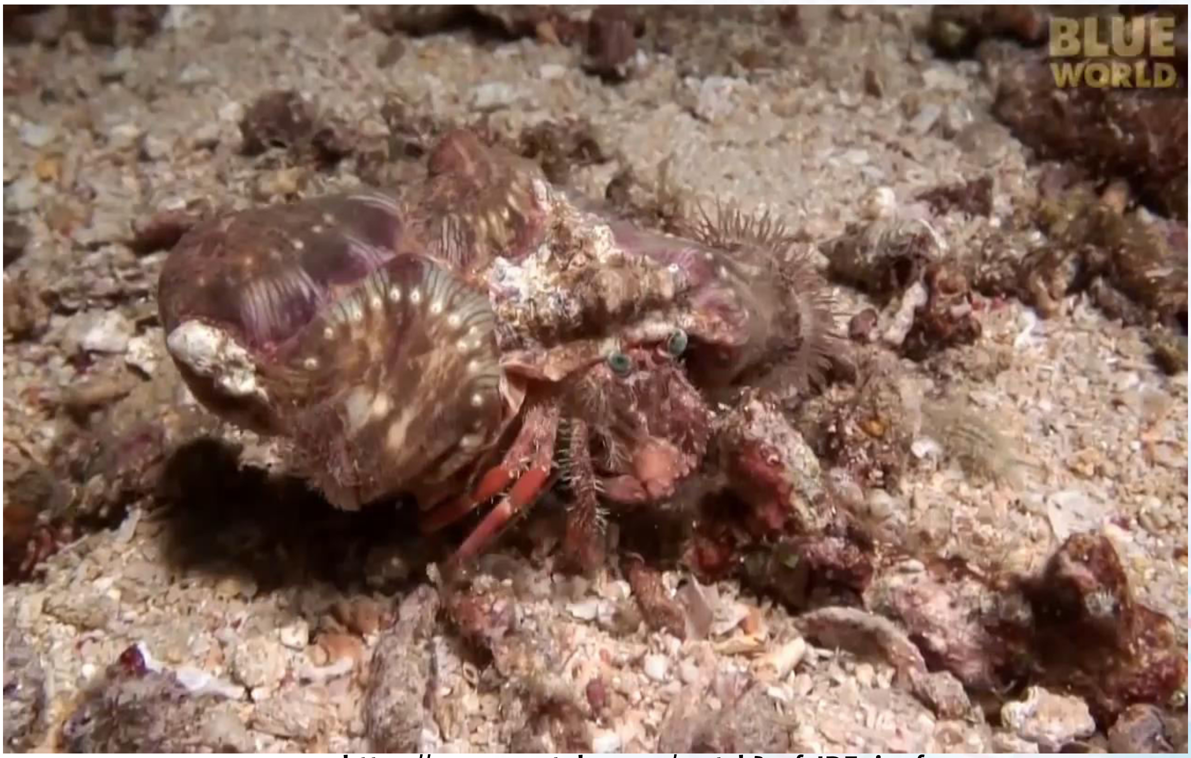
Interspecific Interactions

Mutualism

- Long-term relationship between individuals of different species
- Both individuals get benefit

Example: Hermit crab and sea anemone

Interspecific Interactions



https://www.youtube.com/watch?v=fzIDE0ippf4

Interspecific Interactions

Commensalism

- One species gain benefits while those of the other species is neither benefited nor harmed.

Example: Remora fish and Sharks

Interspecific Interactions

https://www.youtube.com/watch?v=fzIDE0ippf4

ClluesBook.com

Interspecific Interactions

https://en.wikipedia.org/wiki/Parasitism

https://extension.umd.edu/hgic/topics/parasitoid-wasps-hymenoptera

Parasitism

- One species gain benefits other species is harmed
- Intimate contact (feed off host)
- Usually do not kill host (parasitoids do)
- Enhances fitness of parasite but reduces fitness of host

Interspecific Interactions

Types of Parasites

1. Microparasites: reproduce inside host

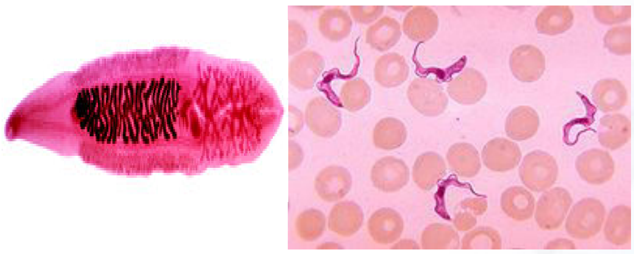
Bacteria, viruses

2. Macroparasites: release juvenile outside host

E.g. trematodes

Interspecific Interactions

Types of Parasites



https://en.wikipedia.org/wiki/Parasitism#Parasitic_castrators

3. Endo parasites

Examples: Liver fluke, tape worm, nematodes

4. Ectoparasites

Examples: Ticks, mites, fleas, mosquito, lice

Interspecific Interactions

https://en.wikipedia.org/wiki/Parasitism

https://extension.umd.edu/hgic/topics/parasitoid-wasps-hymenoptera

Parasitism

- One species gain benefits other species is harmed
- Host and Parasite
- Intimate contact (feed off host)
- Usually do not kill host (parasitoids do)
- Enhances fitness of parasite but reduces fitness of host

Interspecific Interactions

The parasitic castrator *Sacculina carcini* attached to its crab host.

https://en.wikipedia.org/wiki/Parasitism

Evolutionary strategies of Parasitism

1. Parasitic castrators

- Partly or completely damages the reproductive system of host
- Other systems are left intact
- Host's energy used for growth of parasites

Interspecific Interactions

Human head lice are directly-transmitted obligate ectoparasites.

https://en.wikipedia.org/wiki/Parasitism

Evolutionary strategies of Parasitism

2. Directly transmitted

- Do not need vector for transmission to host
- Single host life cycle

Interspecific Interactions

Trypanosoma among human red blood cells

https://en.wikipedia.org/wiki/Parasitism

Evolutionary strategies of Parasitism

3. Vector transmitted

- Need a vector for transmission to final host
- Life cycle involves an intermediate host.
- Do not sexually reproduce in intermediate hosts

Interspecific Interactions

Evolutionary strategies of Parasitism

4. Parasitoids

- Mostly are insects
- Sooner or later kill their host
- Types:

1. Idiobiont
2. Koinobiont

Interspecific Interactions

Idiobiont parasitoid wasps immediately paralyse their hosts for their larvae to eat.

https://en.wikipedia.org/wiki/Parasitism

Evolutionary strategies of Parasitism

- Idiobiont parasitoids
- Sting their prey on capture
- Either killing them outright or paralysing them immediately

Interspecific Interactions

Koinobiont parasitoid wasps like this braconid lay their eggs inside their hosts, which continue to grow and moult.

https://en.wikipedia.org/wiki/Parasitism

Evolutionary strategies of Parasitism

- Koinobiont parasitoids
- Flies as well as wasps
- Lay their eggs inside young hosts, usually larvae.
- Allowed hosts to grow
- Parasitoids emerge as adults, leaving the prey dead, eaten from inside

ClueBook.com

Interspecific Interactions

Mosquitoes are micropredators and important vectors of disease.

https://en.wikipedia.org/wiki/Parasitism

Types of Parasites

5. Micropredators

- Attacks more than one host
- Reducing each host's fitness
- Most micropredators are hematophagic, feeding on blood.

Interspecific Interactions

https://en.wikipedia.org/wiki/Parasitism#Parasitic_castrators

Types of Parasites

3. Endo parasites

Examples: Liver fluke, tape worm, nematodes

4. Ectoparasites

Examples: Ticks, mites, fleas, mosquito, lice

Interspecific Interactions

Camouflage

- Use of any combination of materials, coloration, or illumination
- Concealment from predators
- Also known as cryptic coloration

Interspecific Interactions

Principles of Camouflage

1. Crypsis

Objects hide and hard to see

2. Mimicry

Disguising them as something else

3. Motion dazzle

Using visual illusions

- Protect without hiding

Interspecific Interactions

http://youtube.com/watch?v=__ZvtiRVlpk

Interspecific Interactions

https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

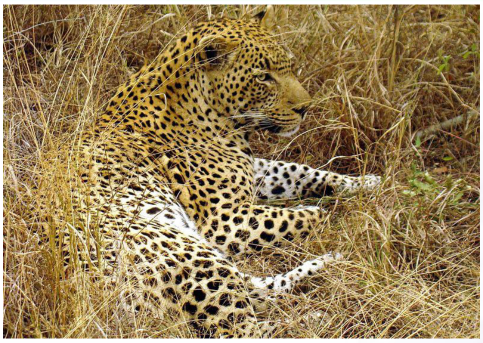
Crypsis

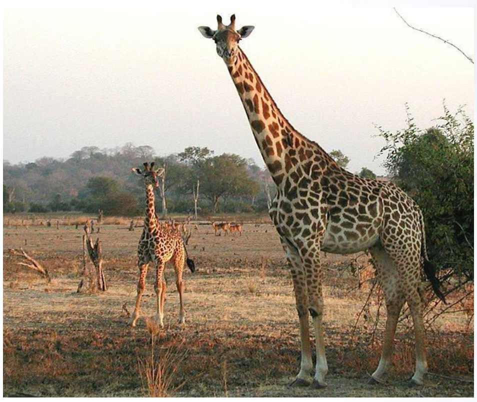
1. Resemblance to surroundings

- Colors and patterns resemble a particular natural background
- Change their color if environment changes
- Example: Egyptian nightjar, Parrot

ClluesBook.com

Interspecific Interactions





https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

Crypsis

2. Disruptive coloration

- Strongly contrasting, non-repeating markings such as spots or stripes
- It breaks up the outlines of an animal.
- Need other strategies for survival
- Example: Leopard, Giraffe

Interspecific Interactions

https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

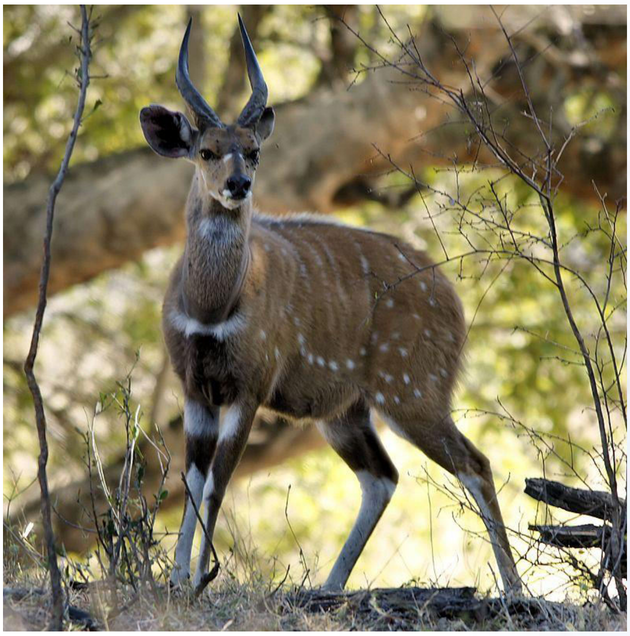
Crypsis

3. Eliminating shadow

- Flattened bodies
- Sides thinning to an edge
- Animals habitually press their bodies to the ground
- Sides are fringed with white scales
- Example: Horned Lizard

ClluesBook.com

Interspecific Interactions



https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

Crypsis

4. Distraction

- High-contrast markings which attract the predator's gaze
- Distract predator from recognizing whole prey
- Distract from identifying prey's outline
- Example: Bushbuck

Interspecific Interactions

Crypsis

https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

4. Self Decoration

- Decorating with materials such as twigs, sand, or pieces of shell
- Break up their outlines
- Conceal the features of their bodies
- Match their backgrounds
- Example: Decorator crabs

ClluesBook.com

Interspecific Interactions

Crypsis

https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

5. Changeable skin coloration

- Actively change their skin patterns and colours
- Change can be rapid or seasonal
- Chameleon rapidly changes its color.

Interspecific Interactions

http://youtube.com/watch?v=nHZNY5DSYeQ

Interspecific Interactions

Crypsis

5. Changeable skin coloration

- Arctic fox changes from brown or grey in the summer to white in the winter
- Use special chromatophore cells, fur molting to resemble their current background.

https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

Interspecific Interactions

https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

Crypsis

6. Countershading

- Shadow makes upper side darker and underside lighter
- Countershading graded color to counteract the effect of self-shadowing

Interspecific Interactions

http://youtube.com/watch?v=2yD5TDJV_no

Interspecific Interactions

Crypsis

6. Countershading

- Creating an illusion of flatness
- Makes animal darker below and lighter above

Example: gazelles, grasshoppers, sharks, dolphins

Interspecific Interactions

Crypsis

7. Counter-illumination

- Producing light to match a background that is brighter than an animal's body
- Light-producing organs (photophores) scattered all over its underside
- Example: hatchet fish, Firefly squid

Interspecific Interactions

Crypsis

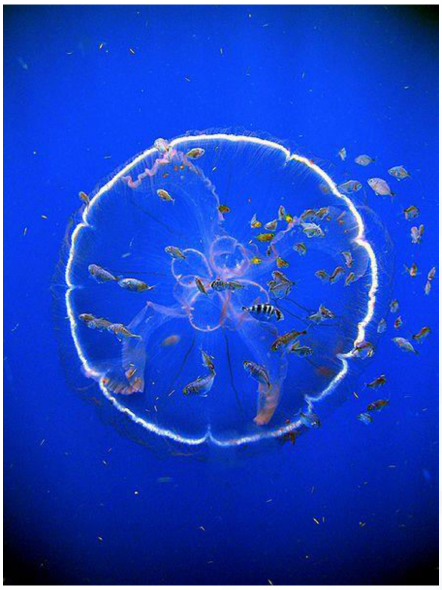
7. Counter-illumination

- Illumination makes them lighter in color from below
- Eliminates shadow
- Protect them from predator

Interspecific Interactions

http://youtube.com/watch?v=__ZvtiRVlpk

Interspecific Interactions



https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

Crypsis

8. Transparency

- Few marine animals float near the surface are highly transparent
- Makes them invisible to predators at certain distance
- More efficient in deeper water
- Example: Jellyfish

Interspecific Interactions

https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

Crypsis

9. Silvering

- Transparency can be imitated by silvering
- It makes body reflective
- Light comes from above reflected by mirror like body
- Make fish invisible from the side
- Example: Herring fish

Interspecific Interactions

https://en.wikipedia.org/wiki/Camouflage#Resemblance_to_surroundings

Motion dazzle

- Crypsis might be ineffective when animal moves
- Motion makes it visible to predator
- Rapidly moving bold patterns of contrasting stripes counteracts this risk
- Example: Zebra

Interspecific Interactions

Motion dazzle

- Due to optical illusion
- Motion dazzle may degrade predators' ability to estimate the prey's speed and direction accurately
- Giving the prey an improved chance of escape

Interspecific Interactions

https://www.youtube.com/watch?v=IISNFkRkSxI

Mimicry

- The resemblance of one species to another for protective or aggressive purposes
- Different from camouflage
- They imitate instead of hiding by camouflage strategies

Mimicry

Types of Mimicry

- On basis of adopting different models to mimic:

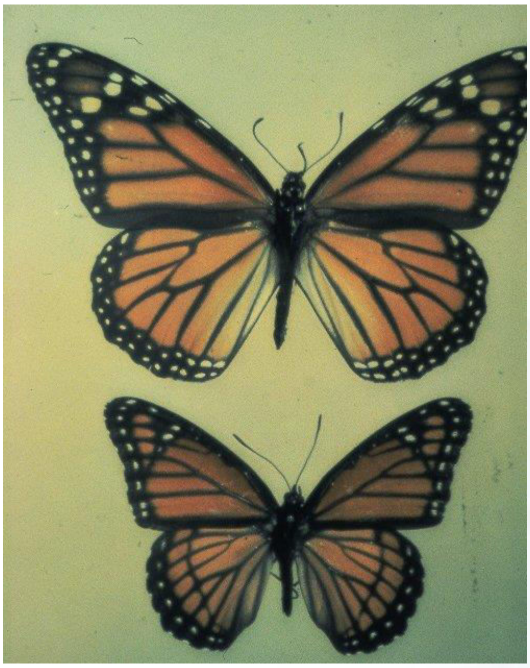
1. Batesian Mimicry
2. Mullerian Mimicry

Mimicry

Batesian Mimicry

- Association in which the members play two different roles
  1. Model
  2. Mimic
- Model – a species which possesses the inherent protection, e.g. poisonous chemicals in insects e.g. Butterflies

Mimicry



https://en.wikipedia.org/wiki/Mimicry

Batesian Mimicry

- The Mimic – a species which lacks the basic protection but through resembling the model superficially gains protection from predators
- Model: Monarch butterfly
- Mimic: Viceroy butterfly

Mimicry

Batesian Mimicry

- Mimics usually smaller than models
- Mimicry restricted to females
- One sex must stay the same to be recognizable
- Females do the choosing so males must be the original form

Mimicry

Batesian Mimicry

- Abundance of the mimic is limited by its effectiveness
- If too common then predators learn the wrong signal.
- Numbers increase to point of selective neutrality where benefit equals cost.

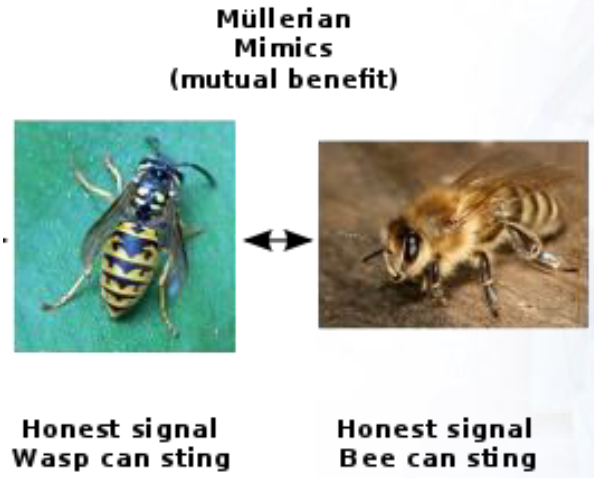
Mimicry

Batesian Mimicry

- Polymorphism is common
- If morph A is at selective neutrality
- New morph B, mimicking a different model, will be at a selective advantage

Mimicry

Mullerian Mimicry

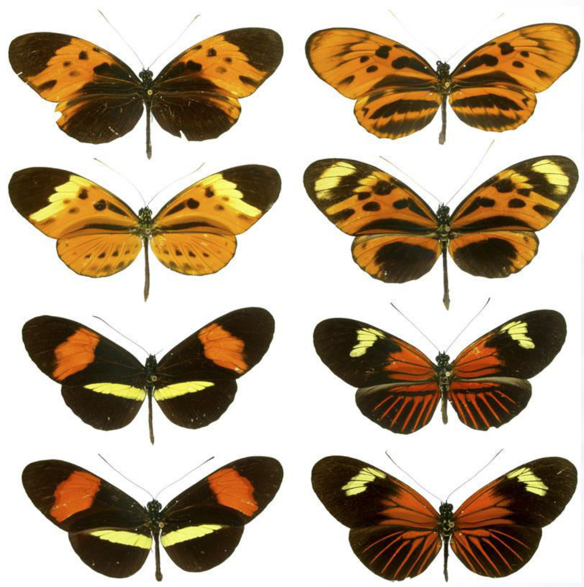


https://en.wikipedia.org/wiki/Mimicry

- Distasteful species, that may or may not be closely related
- Share one or more common predators
- Mimic each other's honest warning signals, to their mutual benefit
- Predators learn to avoid all of them

Mimicry

Mullerian Mimicry



https://en.wikipedia.org/wiki/Mimicry

- Polymorphism is infrequent
- Models tend to stay the same because there is a disadvantage in being different
- No limit to number of species participating

Mimicry

Mullerian Mimicry

- Different colors depend on location and visibility
- Groups at different levels in tropical forest have different colors due to different light levels

Aposematism

- Appearance of an animal that warns predators it is toxic, distasteful or dangerous.
- Advertisement of signals

1. Color
2. Odours
3. Sound
4. Aggression

Aposematism

- Function is to prevent attack.
- Beneficial for both predator and prey, saving them from harm.
- Types of Signals
- Primary: Easily detectable (colors)
- Secondary: invisible (ultrasonic noise for specific predator)

ClueBook.com

Aposematism

https://en.wikipedia.org/wiki/Aposematism#Defence_mechanism

- Primary Signals
- Bright and high contrast colors
- Patterns such as stripes
- Effective colors are red, yellow, black and white
- Colors resist changes in shadow and lighting.

Aposematism

Warning coloration evolves in response to:

- Background
- Light conditions
- Predator vision

Other visible signals

- Odour
- Sound
- Aggressive behavior

Aposematism

https://en.wikipedia.org/wiki/Aposematism#Defence_mechanism

Examples:

Tiger moth: Bitter taste and ultrasonic sounds

Skunk: Noxious odour

Dart frog: Poison

Velvet ant: Sting and noise

He honey badger's reverse countershadingmakes it conspicuous, honestly signalling its ability to defend itself through its aggressive temperament, and its sharp teeth and claws.

Aposematism

http://youtube.com/watch?v=WZqXfFgu9MQ

Aposematism

https://en.wikipedia.org/wiki/Aposem atism#Defence_mechanism

Examples:

Black widow spider: Neuro toxin

Honey badger: Aggressive

Aposematism

http://youtube.com/watch?v=v3WjnLn9p3U

Aposematism

https://en.wikipedia.org/wiki/Aposematism#Defence_mechanism

Prevalence

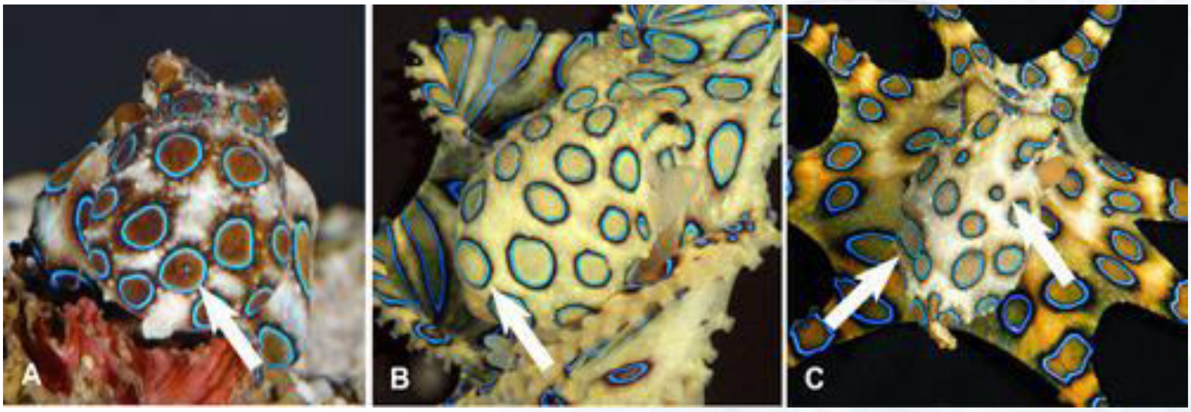
Both terrestrial and marine ecosystem

- Mostly insects

Marine animals

1. Nudibranch
2. Crown-of-thorns starfish

Aposematism



Iridescent blue rings on the mantles of the venomous octopus are considered by some to be aposematic

https://en.wikipedia.org/wiki/Aposematism#Defence_mechanism

Atmosphere and its Evolution

- Atmosphere of Earth is the layer of gases
- Commonly known as air
- Surrounds the planet Earth
- Retained by Earth's gravity

Atmosphere and its Evolution

Evolution

1. First Atmosphere

Composition of gases like solar nebula (disc of dirt and gases)

Aged 4 billion years ago

- Hydrogen
- Methane
- Helium
- Ammonia
- Water vapors

ClueBook.com

Atmosphere and its Evolution

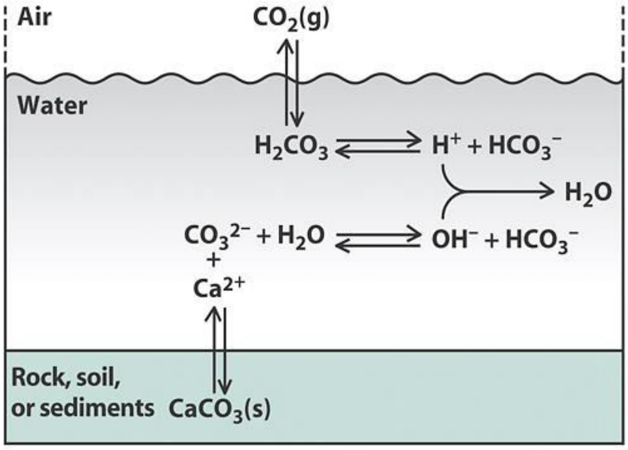
https://en.wikipedia.org/wiki/Types_of_volcanic_eruptions

Evolution

2. Second Atmosphere

- Outgassing from volcanism
- Supplemented by gases produced during heavy bombardment of Earth by huge asteroids
- Added N2, CO_2 and inert gases

Atmosphere and its Evolution



https://www.google.com/search?q=calcium+carbonate+formation+from+carbon+dioxide

Evolution

2. Second Atmosphere

- Carbon-dioxide emissions dissolved in water
- Reacted with metals such as calcium and magnesium
- Formed carbonates that were deposited as sediments.

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Atmosphere and its Evolution

Evolution

2. Second Atmosphere

- Water-related sediments have been found
- Dated from as early as 3.8 billion years ago
- 3.4 billion years ago, molecular nitrogen formed
- Earth temperature was warm.

Atmosphere and its Evolution

Evolution

2. Second Atmosphere

- 2.5 billion years ago, oxygen was developed
- Activity of photosynthesizing cyanobacteria
- Known as “Great Oxygenation Event”

Atmosphere and its Evolution

Evolution

https://en.wikipedia.org/wiki/Great_Oxygenation_Event

2. Second Atmosphere

- Activity of photosynthesizing cyanobacteria

Atmosphere and its Evolution

Evolution

2. Second Atmosphere

- Known as "Great Oxygenation Event"

Atmosphere and its Evolution

Evolution

3. Third Atmosphere

- Constant rearrangement of continental plates
- Inflow and outflow of CO_2 from large continental carbonate stores

Atmosphere and its Evolution

Evolution

3. Third Atmosphere

- O_2 synthesized in photosynthesis was being used in reducing materials
- Gradually, it was shifted to oxidizing atmosphere instead of reducing
- 541 million years ago, O_2 made stable 15% of atmosphere.

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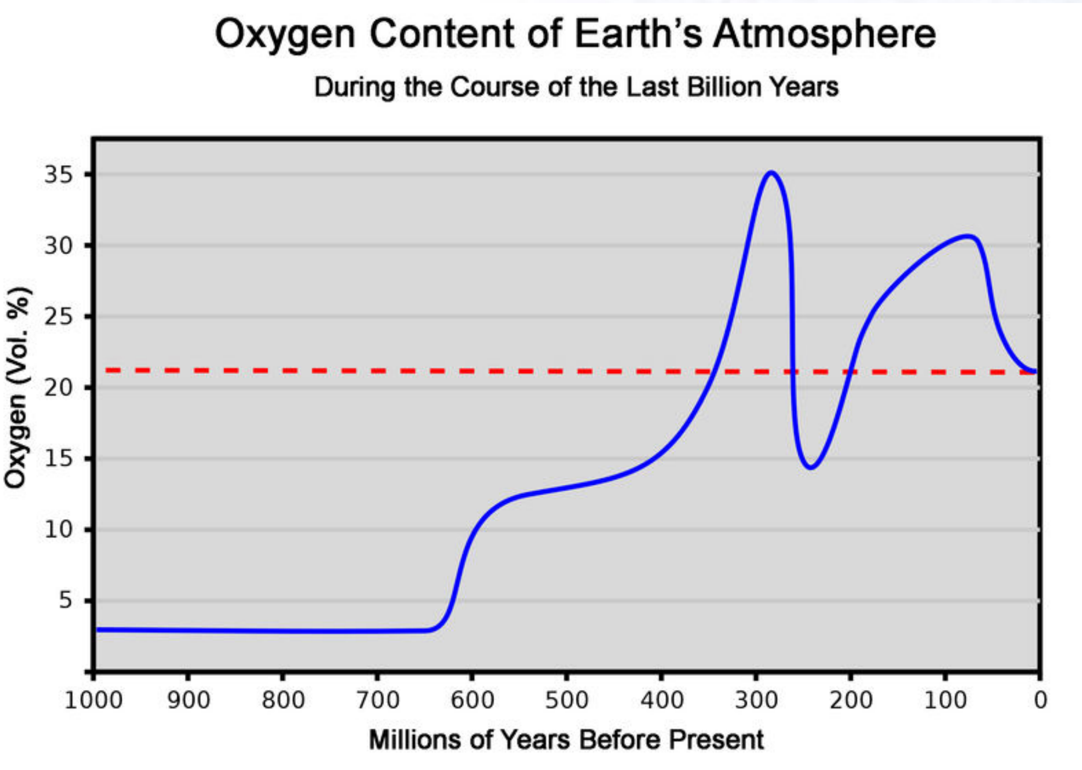
Atmosphere and its Evolution



https://en.wikipedia.org/wiki/File:Sauerstoffgehalt-1000mj2.png

Atmosphere and its Evolution

Evolution

3. Third Atmosphere

Reasons of fluctuations in O_2

- Plants produced oxygen and consumed CO_2
- Volcanic eruptions release sulfur into the atmosphere

Atmosphere and its Evolution

Evolution

3. Third Atmosphere

Reasons of fluctuations in O_2

- Sulfur oxidizes itself
- Reduces the amount of oxygen in the atmosphere
- Volcanic eruption also released CO_2
- Exact causes of fluctuations are unknow.

Atmosphere and its Evolution

http://youtube.com/watch?v=uCjmwcKeNaQ

Composition of Atmosphere

Comprised of a mixture of:

1. Invisible permanent gases
2. Variable gases
3. Suspended microscopic particles

Composition of Atmosphere

1. Permanent Gases

Form a constant proportion of the total atmospheric mass

2. Variable Gases

Distribution and concentration varies in space and time

3. Aerosols

Suspended particles and liquid droplets (excluding cloud droplets)

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Composition of Atmosphere

1. Permanent Gases

78% Nitrogen (N_2)

21% Oxygen (O_2)

<1% Argon (Ar)

- Relative percentages of the permanent gases remain constant up to 80 - 100km high.
- Turbulent mixing causes atmospheric composition to be fairly homogenous.
- Called as Homosphere

Composition of Atmosphere

2. Variable Gases

- Water vapor (H_2O): 0 to 4%
- Carbon Dioxide (CO_2): 0.038%
- Methane(CH_4): 0.00017%
- Ozone(O_3): 0.000004%

Composition of Atmosphere

Variable Water vapors

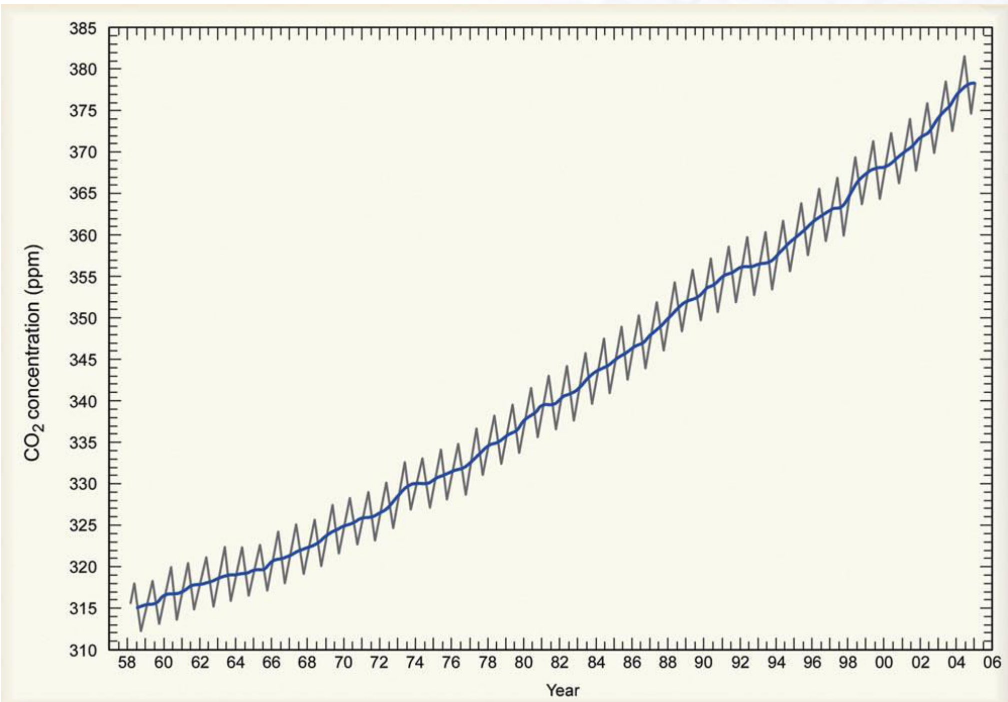
- Water vapor is invisible.
- Its not cloud droplets.
- 3rd major component
- Surface percentages vary between <1% in desserts to 4% in tropics.
- Typical mid-latitude value is about 1-2%.

Composition of Atmosphere

Variable Carbon Dioxide

- Small percentage of total atmosphere (380 ppm)
- But, very important green house gas

Composition of Atmosphere



Mauna Loa Observatory CO_2 trace
(annual variations embedded in the long-term record)

Composition of Atmosphere

Variable Ozone

- Near the surface, ozone concentrations about 0.04-0.15 ppm
- In the upper atmosphere ozone concentration can reach ~15 ppm
- Upper atmospheric ozone is vital to blocking harmful radiation
- Ozone near the surface, however, harmful to life

Composition of Atmosphere

Variable Methane

- Concentrations of about 1.7 ppm
- Extremely potent green house gas - 21 times more powerful by weight than carbon dioxide
- Unexpected increase in last 400,000 years
- Increase attributed to agriculture, industries, bio-mass and fossil fuel burning

Composition of Atmosphere

3. Aerosols

- Small (or "tiny") solid particles or liquid droplets (excluding clouds and rain)
- Aerosols can be man-made (anthropogenic) or naturally occurring (like ocean salt, dust, plant emissions)

Composition of Atmosphere

3. Aerosols

- Aerosols are not synonymous with pollution
- Some aerosols are very beneficial and, in fact, are required for precipitation processes to occur.

Composition of Atmosphere

Major constituents of dry air, by volume

Gas		Volume(A)	
Name	Formula	in ppmv(B)	in %
Nitrogen	N_2	780,840	78.084
Oxygen	O_2	209,460	20.946
Argon	Ar	9,340	0.9340
Carbon dioxide	CO_2	400	0.04[9]
Neon	Ne	18.18	0.001818
Helium	He	5.24	0.000524
Methane	CH_4	1.79	0.000179
Not included in above dry atmosphere:			
Water vapor(C)	H_2O	10–50,000(D)	0.001%–5%(D)

https://en.wikipedia.org/wiki/Atmosphere_of_Earth#Composition

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Layers of Atmosphere

- Air pressure and density decrease with altitude
- Temperature shows different patterns.
- It increases with altitude in some regions.
- Temperature is useful tool to distinguish atmospheric layers.

Layers of Atmosphere

- Atmosphere can be divided into five layers.
- Highest to lowest

Layers of atmosphere

1. Exosphere: 700 to 10,000 km (440 to 6,200 miles)
2. Thermosphere: 80 to 700 km (50 to 440 miles)[12]
3. Mesosphere: 50 to 80 km (31 to 50 miles)

Layers of Atmosphere

4. Stratosphere: 12 to 50 km (7 to 31 miles)
5. Troposphere: 0 to 12 km (0 to 7 miles)

Layers of Atmosphere

http://youtube.com/watch?v=1XtcqIv_EHs

Troposphere

- The lowest layer
- All weather conditions take place here.
- Conventional aviation takes place here.
- It contains:
- 75% of the atmosphere's mass
- 99% of the total mass of water vapor and aerosols

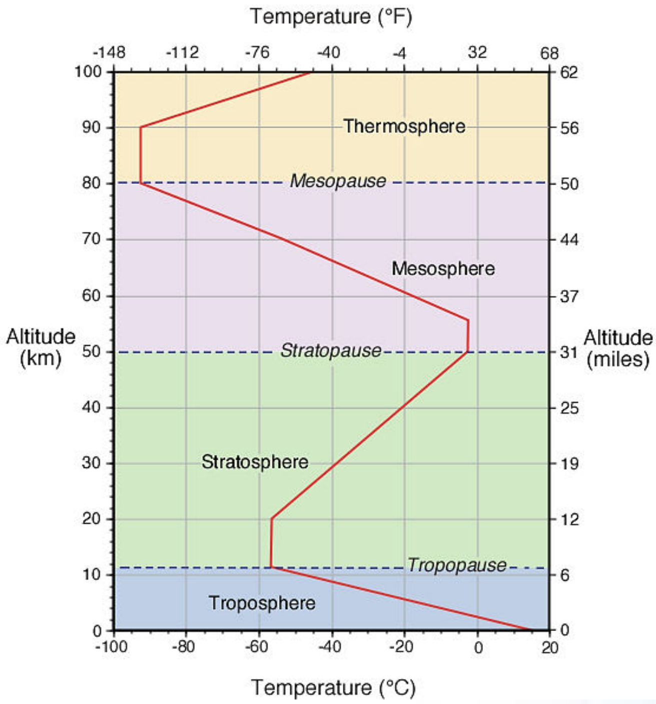
Troposphere

https://en.wikipedia.org/wiki/Troposphere#Pressure_and_temperature_structure

Height

- 18 km (11 mi; 59,000 ft) in the tropics
- 17 km (11 mi; 56,000 ft) in the middle latitudes
- 6 km (3.7 mi; 20,000 ft) in the polar regions in winter.
- The total average height of the troposphere is 13 km.

Troposphere



http://users.isp.com/retic/atmslayers.gif

Properties

- Composition of air is homogenous except water vapors.
- Temperature of the troposphere decreases with altitude.
- Ground absorbs most of the sun's energy
- It makes the lower levels of the atmosphere warm.

Troposphere

Properties

- Radiating of heat away from earth at the top of the atmosphere
- It results in the cooling of that part of the atmosphere.

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Troposphere

Properties

- Vapor pressure drops with decrease in temperature.
- Drop in vapor pressure is due to gravity.
- Pressure of the atmosphere is maximum at sea level and decreases with altitude.

Troposphere

Tropopause

- Boundary region between the troposphere and the stratosphere
- Temperature decrease with increase in altitude.

The orange layer is the troposphere, the white layer is the stratosphere, and the blue layer is the mesosphere.

https://en.wikipedia.org/wiki/Troposphere#Pressure_and_temperature_structure

ClluesBook.com

Troposphere

Tropopause

Height

- 17 kilometres (11 mi)above equatorial regions
- 9 kilometres (5.6 mi) over the polar regions

END

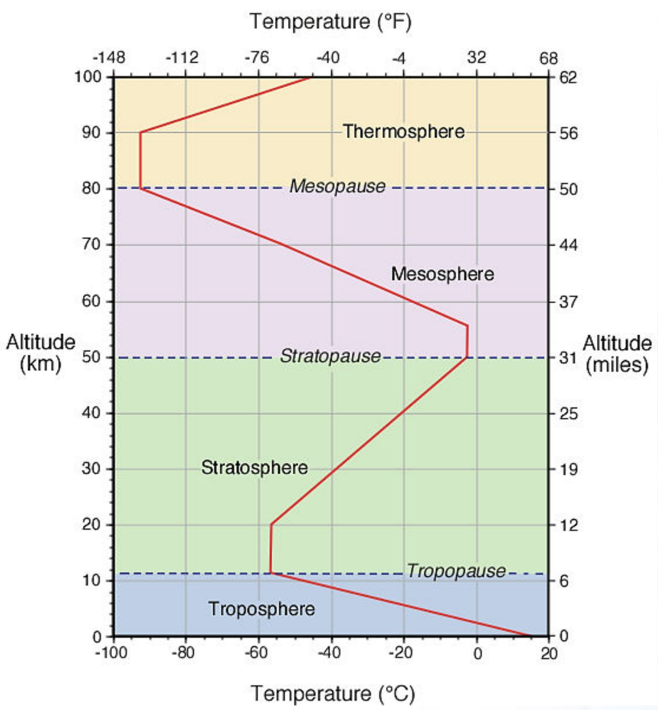
Stratosphere

- The second major layer of Earth's atmosphere
- Above the troposphere, and below the mesosphere

Height

- 20 km (66,000 ft; 12 mi) at equator
- 10 km (33,000 ft; 6.2 mi) at midlatitudes
- 7 km (23,000 ft; 4.3 mi) at the poles

Stratosphere



http://users.isp.com/retic/atmslayers.gif

Properties

- Low density/pressure of gases due to reduced gravity.
- Ozone is important gas.
- Temperature increases by increase in altitude.
- Temperatures range from −51 °C near the tropopause
- To an average of −15 °C near the mesosphere

Stratosphere

Ozone formation: $O_2 \xrightarrow{\text{UV light} < 200\text{nm}} 2\,O$

$$O + O_2 \longrightarrow O_3$$

http://www.itclamps.com/ozone.html

- Increase in temperature is a result of the absorption of the Sun's ultraviolet radiation by the ozone layer.
- Speed of wind far exceed those in the troposphere, reaching near 220 km/h.
- Aircrafts fly near lower troposphere to take benefit of low air density and temperature optimizing fuel efficiency.

Stratosphere

- Bacterial life survives in the stratosphere, making it a part of the biosphere.
- Few bird species have been observed in upper troposphere.
- Rüppell's vulture
- Bar-headed geese

Stratosphere

END

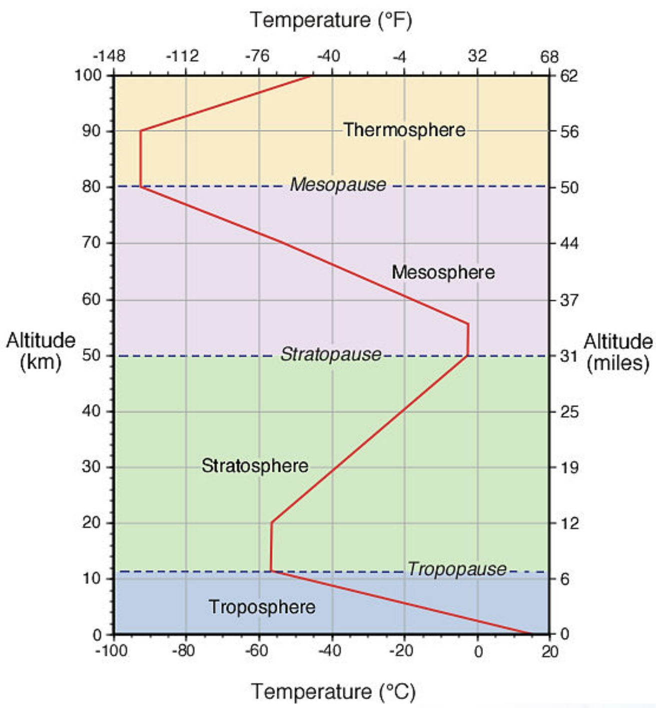
Stratopause

- Boundary between stratosphere and the mesosphere
- Height: 50 to 55 kilometres high above the Earth's surface
- Pressure: 1/1000 of the pressure at sea level
- Temperature: -15 degrees Celsius

Mesosphere

- Layer, directly above the stratosphere and directly below the thermosphere
- Lower boundary is 50 to 65 kilometres
- Upper boundary is around 85 to 100 kilometres
- It is called as "near space".

Mesosphere



http://users.isp.com/retic/atmslayers.gif

Properties

- Temperature decreases with increasing height
- Due to decreasing absorption of solar radiation
- Rarefied, low dense atmosphere
- Increasing cooling by CO_2 radiative emission

Mesosphere

https://en.wikipedia.org/wiki/Aurora

Properties

- Temperatures in the upper mesosphere fall as low as −101 °C varying according to latitude and season.
- Ionization starts here due to minimum gravity.
- Polar aurora is observed due to entry of solar winds.

Mesosphere

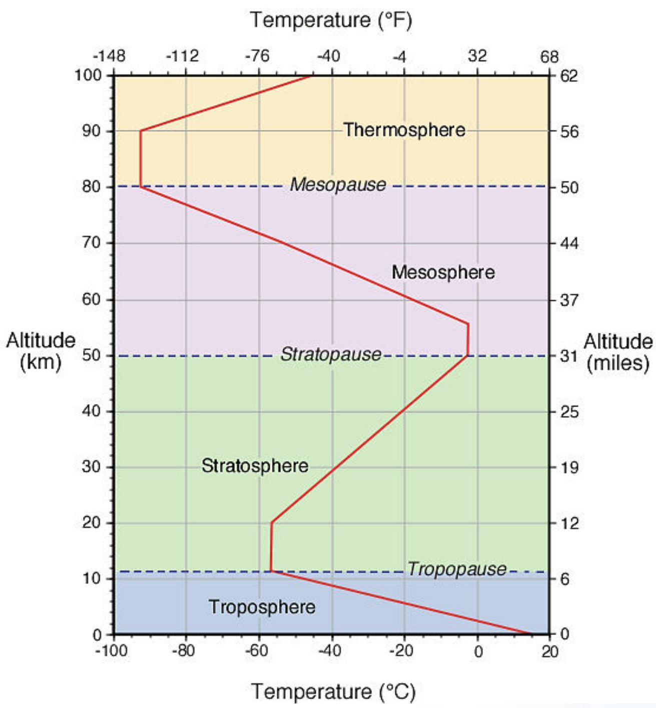
Mesopause

- Boundary between the mesosphere and the thermosphere
- Height: 85 – 100 km
- Temperature: 100 – 102 °C

Thermosphere

- Layer, directly above the mesosphere and below the exosphere
- Height: 80 km
- Extreme ultraviolet radiation causes photoionization/photodissociation of molecules, creating ions
- Known as ionosphere

Thermosphere



http://users.isp.com/retic/atmslayers.gif

Properties

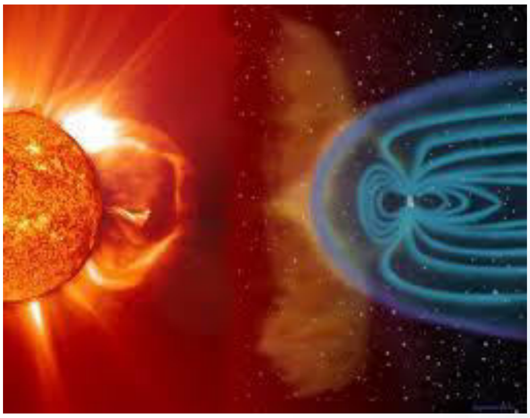
- Temperature increase with altitude due to absorption of highly energetic solar radiation.
- Temperature can raise 1700 °C or more.
- Highly diluted gas in this layer can reach 2,500 °C during the day.

Thermosphere

Properties

- Temperatures will significantly drop if solar activity is limited.
- Ions are far apart to transfer heat through conduction.
- Around 160 kilometres, the density is so low that molecular interactions are too infrequent to permit the transmission of sound.

Thermosphere



https://www.google.com/search?q
=solar+winds

- Solar winds, extreme UV storms and atmospheric waves are observed here.
- Bombardment of particles is too intense to weaken the magnetic field on opposite end.
- Difficult to distinguish the boundary between thermosphere and exosphere.

Exosphere

- It is located directly above the thermosphere.
- Thin, atmosphere-like volume surrounding a planet
- Molecules are gravitationally bound to that body
- Density is too low for them to behave as a gas by colliding with each other.

Exosphere

- Atmosphere thins out and merges with interplanetary space.
- Very little is known about it due to lack of research.

Benefits of Atmosphere

- Atmosphere is responsible for sustaining life on earth.
- Without it, earth will be barren like moon and mars.
- Atmosphere is key element in survival of life.

Benefits of Atmosphere

Temperature

- Maintains the Earth's temperature
- Molecules of air gases absorb heat energy from sun.
- Conduction of heat energy by mixing of air
- CO_2 , methane, nitrous oxide cause green house effect.

ClluesBook.com

Benefits of Atmosphere

https://www.shutterstock.com/image-vector/natural-human-enhanced-greenhouse-effect-diagram-656360482

Benefits of Atmosphere

Protection against Radiations

- Protective shield against radiation and cosmic rays
- Bombardment of UV rays and particles from sun
- Ozone filters most of the UV rays.
- Gases also absorb cosmic rays, gamma rays and x-rays
- Prevent mutations

Benefits of Atmosphere

Physical Protection

- Solar system is full of debris, small particles leftover from planetary creation or collisions in the asteroid belt.
- 100 tons of space debris strikes Earth every single day.
- Friction with atmospheric gases destroys them long before they reach the ground.

Benefits of Atmosphere

https://www.youtube.com/watch?v=jPu9DbstIDw

Benefits of Atmosphere

Weather and Water

- Atmosphere holds around 12,900 cubic kilometers of water at any given time.
- Responsible for water cycle
- Transfer water vapors from oceans to dry areas.
- Responsible for precipitation.
- Winds control weather.

END

Carbon Cycle

- Carbon is main component of living organisms.
- 20% of human body is carbon by weight.
- CO_2 is major source of carbon.
- Atmosphere contains about 750 billion metric tons of carbon in form of CO_2.

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Carbon Cycle

- Photosynthetic organisms take in CO_2 from the atmosphere
- Synthesize the carbon containing organic compounds
- This process is sometimes called carbon fixation.

Carbon Cycle

- Animals eat plants and make their own organic compounds.
- Production of energy by breakdown of these organic compounds in respiration.
- Respiration releases CO_2 in air.
- Decaying organisms also produce CO_2.

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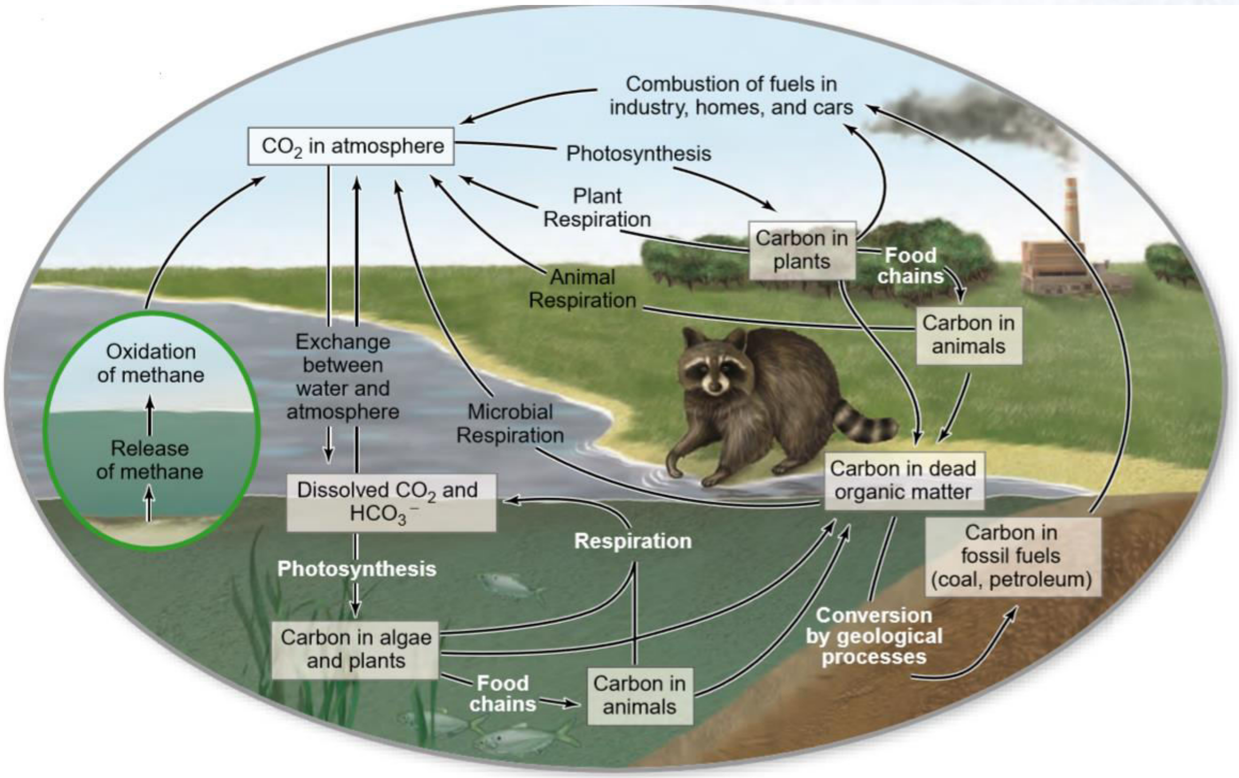
Carbon Cycle

- CO_2 released in air is again available for plants.
- In aquatic ecosystem, CO_2 reacts with the water to form bicarbonate ions.
- Dissolved CO_2 and bicarbonates are used by algae and aquatic plants in photosynthesis.

Carbon Cycle

- Methanogens, for example, are microbes that produce methane (CH_4) instead of CO_2.
- Methane released in air is oxidized into CO_2.
- Amount of CO_2 made by breakdown of organic compounds almost matches the amount of CO_2 used.
- Small mis-matches can have large consequences.

Carbon Cycle



Biology Mason, Losos and Singer, 9th ed.

Water Cycle

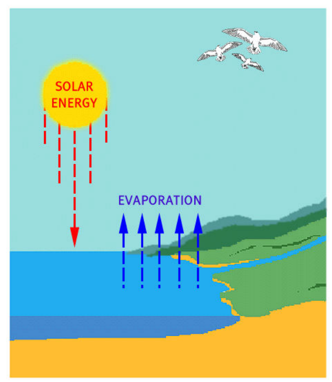
- Life depends on the presence of water.
- Adult human body contains 60% of water by weight.
- Water is compound which can be synthesized and broken.
- Synthesis in aerobic respiration
- Break down in photosynthesis

Water Cycle

- Rate of synthesis and breakdown is equal.

Evaporation

- In evaporation, water changes from its liquid state to a gaseous state.



https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Evaporation

- Some of the water in the oceans and freshwater bodies, such as lakes and rivers, is warmed by the sun and evaporates.

https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

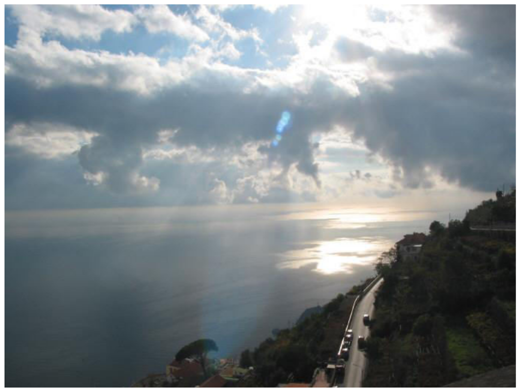
Evaporation

- During the process of evaporation, impurities in the water are left behind.
- As a result, the water that goes into the atmosphere is cleaner than it was on Earth.

Water Cycle

Condensation

- Opposite of evaporation
- Condensation occurs when a gas is changed into a liquid.



https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Condensation

- When the water droplets formed from condensation are very small.
- They remain suspended in the atmosphere.

https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Condensation

- These millions of droplets of suspended water form clouds in the sky or fog at ground level.

https://en.wikipedia.org/wiki/Water_cycle

ClueBook.com

Water Cycle

Precipitation

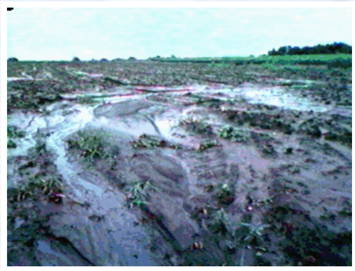
https://en.wikipedia.org/wiki/Water_cycle

- Under right temperature and atmospheric pressure conditions
- Small droplets of water in clouds form larger droplets and precipitation occurs.
- The raindrops fall to Earth.

Water Cycle

Surface Runoff

- Much of the water that returns to Earth as precipitation runs off the surface of the land
- Flows downhill into streams, rivers, ponds and lakes.



https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Surface Runoff

- Small streams flow into larger streams, then into rivers, and eventually the water flows into the ocean.

https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Surface Runoff

- Surface runoff is an important part of the water cycle.
- Much of the water returns again to the oceans, where a great deal of evaporation occurs.

https://en.wikipedia.org/wiki/Water_cycle

END

Water Cycle

Percolation (Infiltration)

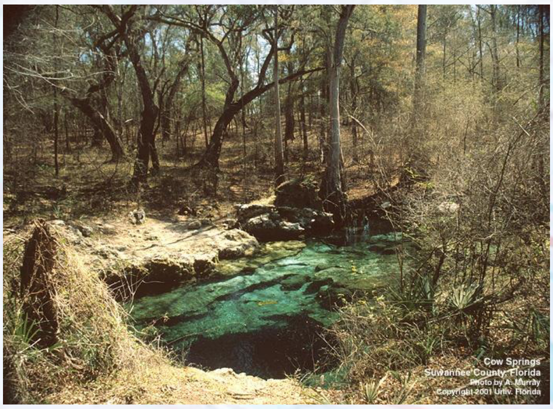
- Percolation is an important process.
- Rain water soaks into (infiltrates) the ground, into the soil and underlying rock layers.

https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Percolation (Infiltration)

- Some of this water ultimately returns to the surface at springs or in low spots downhill.



https://en.wikipedia.org/wiki/Water_cycle

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Water Cycle

Percolation (Infiltration)

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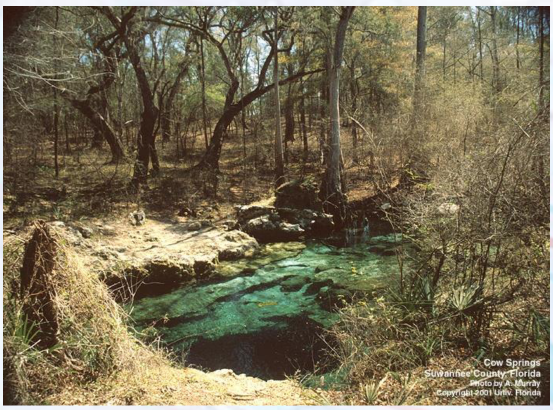
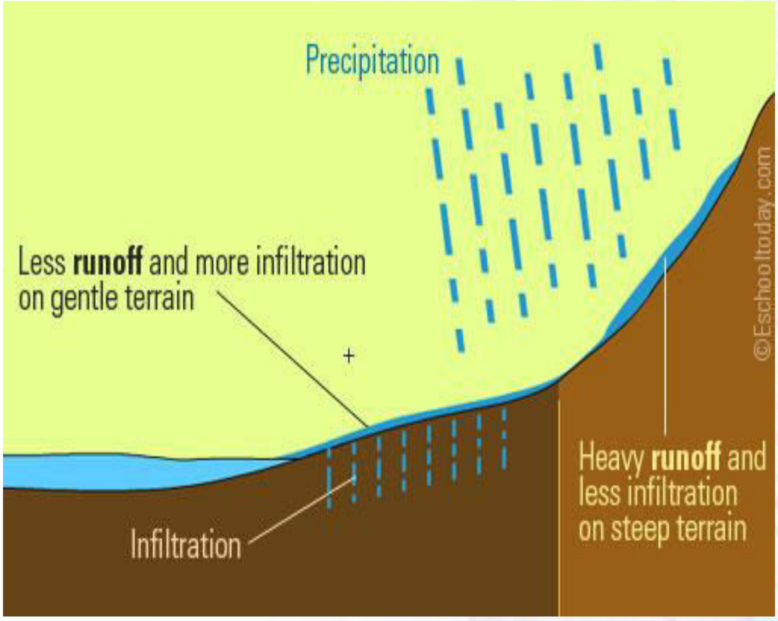


https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Percolation (Infiltration) & Surface Runoff



https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Percolation (Infiltration)

- Some of the water percolates underground
- It is called groundwater.

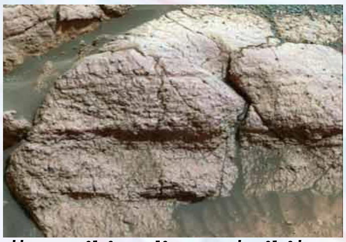
https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Groundwater

Water moves through the soil and rock layers.

- Many of the impurities in the water are filtered out.
- This filtering process helps clean the water.



https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Transpiration

- Plants absorb water from the soil.
- Water moves from the roots through the stems to the leaves.

https://en.wikipedia.org/wiki/Water_cycle

Water Cycle

Transpiration

- Water reaches the leaves.
- Some of it evaporates from the leaves, adding to the amount of water vapor in the air.

https://en.wikipedia.org/wiki/Water_cycle

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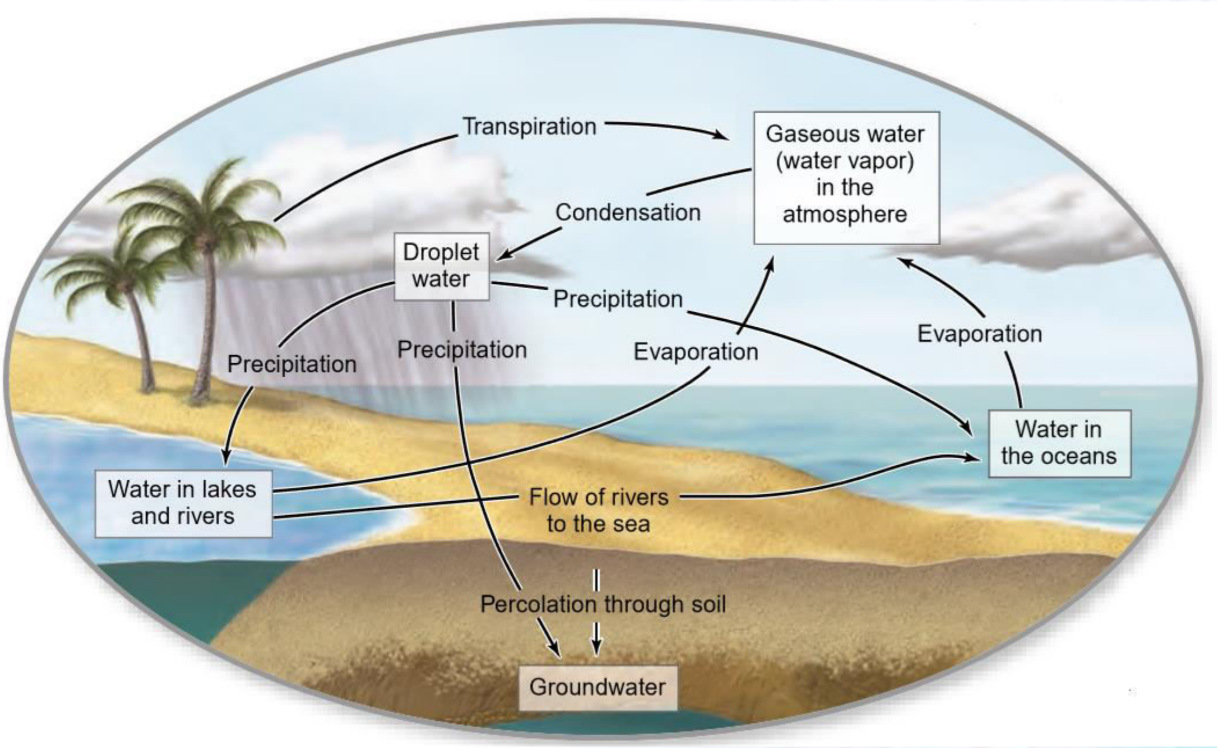
Water Cycle

Transpiration

- This process of evaporation through plant leaves is called transpiration.
- In large forests, an enormous amount of water will transpire through leaves.

Water Cycle



Biology Mason, Losos and Singer, 9th ed.

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Nitrogen Cycle - 1

- Nitrogen is a component of all proteins and nucleic acids.
- A living organism is 16% nitrogen by weight.
- Atmosphere is 78% nitrogen by volume.
- Atmospheric nitrogen is in its elemental form.
- It cannot be used in this form by living organism.

Nitrogen Cycle - 1

- Ultimate source of nitrogen is nitrogen containing organic compounds synthesized by plants or by algae or other microbes.
- Two commonly used nitrogen sources are ammonia (NH_3) and nitrate ions (NO_3–).

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Nitrogen Cycle - 1

- Prokaryotic microbes can synthesize ammonia and nitrate from N_2 in the atmosphere.
- It makes atmospheric nitrogen accessible to plants and algae.

Nitrogen Cycle - 1

- Other prokaryotes turn NH_3 and NO_3 into N_2, making the nitrogen inaccessible.
- These activities balance the amount of accessible of nitrogen.
- All these processes form nitrogen cycle.

Nitrogen Cycle - 1

Sources of Nitrogen

- Lightning
- Inorganic fertilizers
- Nitrogen Fixation
- Animal Residues
- Crop residues
- Organic fertilizers

Nitrogen Cycle - 1

Forms of Nitrogen

- Urea → $CO(NH_2)_2$
- Ammonia → NH_3 (gaseous)
- Ammonium → NH_4
- Nitrate → NO_3
- Nitrite → NO_2
- Atmospheric Dinitrogen → N_2
- Organic N

Nitrogen Cycle - 1

Global Nitrogen Reservoirs

Nitrogen Reservoir	Metric tons nitrogen	Actively cycled
Atmosphere	$3.9*10^{15}$	No
Ocean → soluble salts Biomass	$6.9*10^{11}$ $5.2*10^{8}$	Yes Yes
Land → organic matter → Biota	$1.1*10^{11}$ $2.5*10^{10}$	Slow Yes

https://en.wikipedia.org/wiki/Nitrogen_cycle

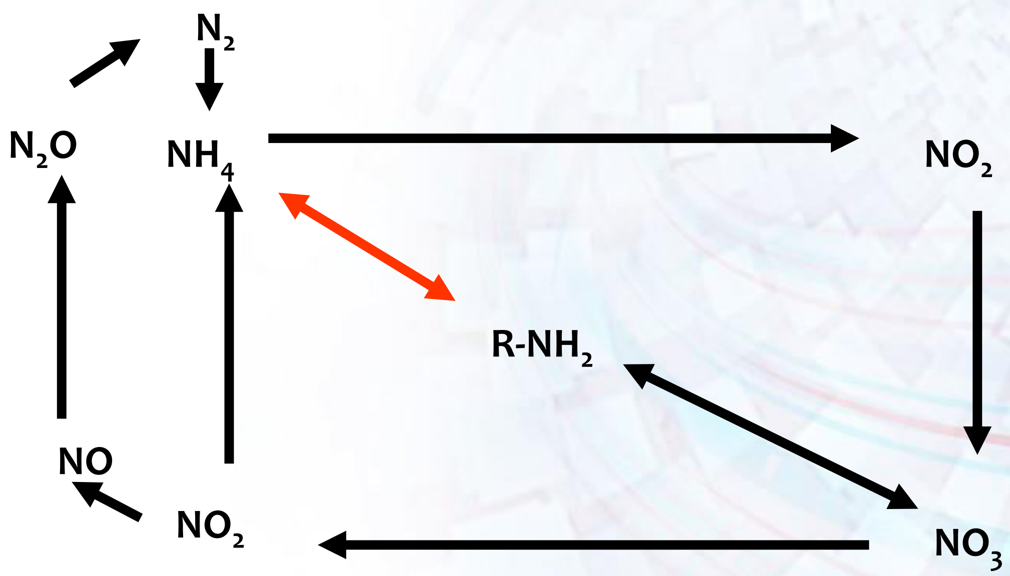
Nitrogen Cycle - 1

Phases of Cycle

1. Ammonification/mineral ization
2. Immobilization
3. Nitrogen Fixation
4. Nitrification
5. Denitrification

Nitrogen Cycle - 1

Ammonification or Mineralization



https://en.wikipedia.org/wiki/Nitrogen_cycle

Nitrogen Cycle - 1

Ammonification

- Decomposers: earthworms, termites, slugs, snails, bacteria, and fungi
- Uses extracellular enzymes to initiate degradation of plant polymers.

Nitrogen Cycle - 1

Ammonification

- Microorganisms use:

Proteases, lysozymes, nucleases to degrade nitrogen containing molecules

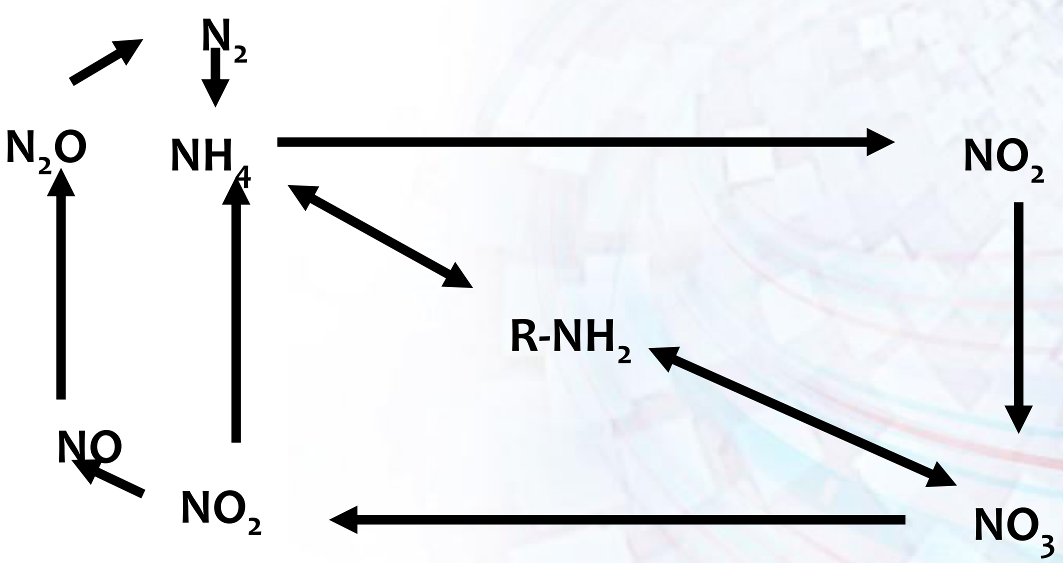
Nitrogen Cycle

Immobilization

- The opposite of mineralization
- Happens when nitrogen is limiting in the environment
- Nitrogen limitation is governed by C/N ratio
- C/N typical for soil microbial biomass is 20
- $C/N < 20 \rightarrow$ Mineralization
- $C/N > 20 \rightarrow$ Immobilization

Nitrogen Cycle

Nitrogen Fixation



Nitrogen Cycle

Nitrogen Fixation

- Energy intensive process :
- $N_2 + 8H^+ + 8e^- +$ 16 ATP = $2NH_3 + H_2 +$ 16ADP + 16 Pi
- Performed only by selected bacteria and actinomycetes
- Performed in nitrogen fixing crops

(ex: soybeans, legumes)

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Nitrogen Cycle

Microorganisms fixing Nitrogen

- *Azobacter*
- *Beijerinckia*
- *Azospirillum*
- *Clostridium*
- *Cyanobacteria*

- Require the enzyme nitrogenase
- Inhibited by oxygen
- Inhibited by ammonia (end product)

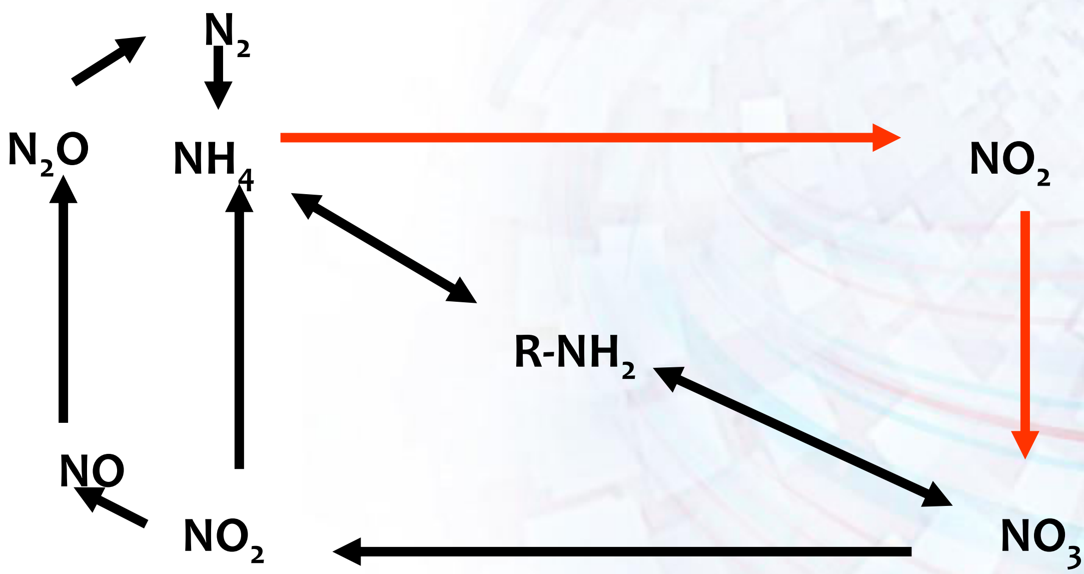
Nitrogen Cycle

Rates of Nitrogen Fixation

N_2 fixing system	Nitrogen Fixation (kg N/hect/year)
Rhizobium-legume	200-300
Cyanobacteria- moss	30-40
Rhizosphere associations	2-25
Free- living	1-2

Nitrogen Cycle

Nitrification



Nitrogen Cycle

Nitrification

Two step reactions that occur together :

- 1^{rst} step catalyzed by *Nitrosomonas*

  $2\ NH_4^+ + 3\ O_2 \rightarrow 2\ NO_2^- + 2\ H_2O + 4\ H^+$
- 2^{nd} step catalyzed by *Nitrobacter*
- $2\ NO_2^- + O_2 \rightarrow 2\ NO_3^-$

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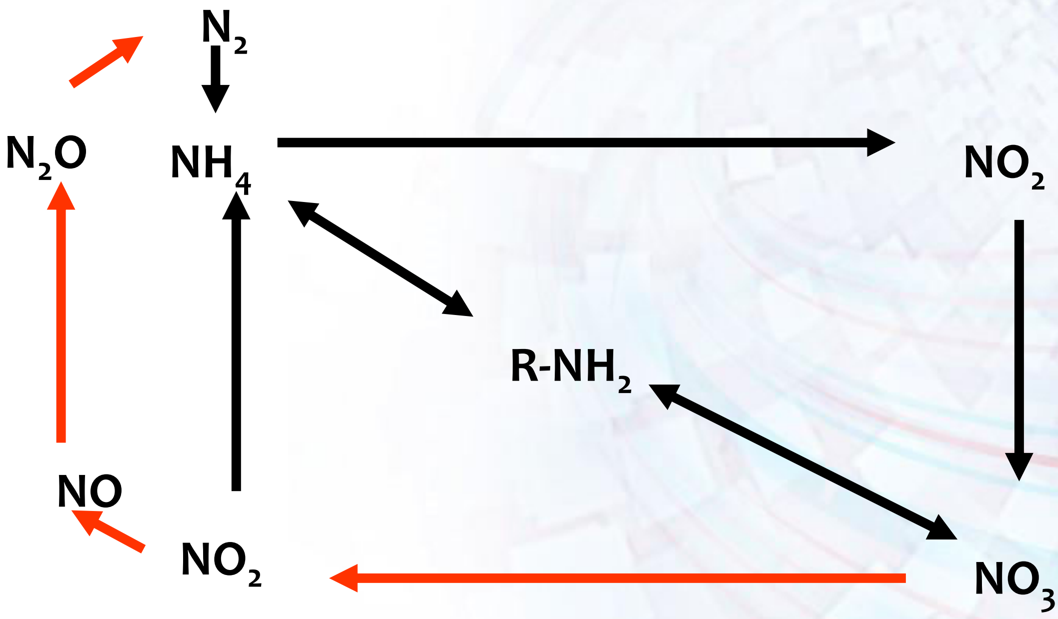
Nitrogen Cycle

Nitrification

- Optimal pH is between 6.6-8.0
- If pH < 6.0 → rate is slowed
- If pH < 4.5 → reaction is inhibited

Nitrogen Cycle

Denitrification



Nitrogen Cycle

Denitrification

- Removes a limiting nutrient from the environment
- Facultative anaerobic bacteria perform it.
- Oxidized nitrates are reduced.
- Glucose is electron donor.
- $4NO_3^- + C_6H_{12}O_6 \rightarrow 2N_2 + 6\ H_2o$
- Nitrate is the terminal electron acceptor

Nitrogen Cycle

Denitrification

- Inhibited by oxygen
- Not inhibited by ammonia

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Nitrogen Cycle

https://www.youtube.com/watch?v=LbBgPekjiyc

Phosphorus Cycle

Phosphorus is important component of:

1. Nucleic acids
2. Membrane phospholipids
3. ATP

- Phosphorus is mainly found in water, soil and rock in form of phosphates.

Phosphorus Cycle

- The phosphorus cycle is the movement of phosphorus to and from between environment and organisms.
- Unlike to carbon and nitrogen, Phosphorus cannot be found in air in the gaseous state.

Phosphorus Cycle

- Phosphate salts are released from rocks through weathering.
- Dissolve in soil water and will be absorbed by plants.
- This is the slowest cycle.

Phosphorus Cycle

- Animals absorb phosphates by eating plants or herbivores.
- When animals and plants die, phosphates will return to the soils or oceans again during decomposition.

Phosphorus Cycle

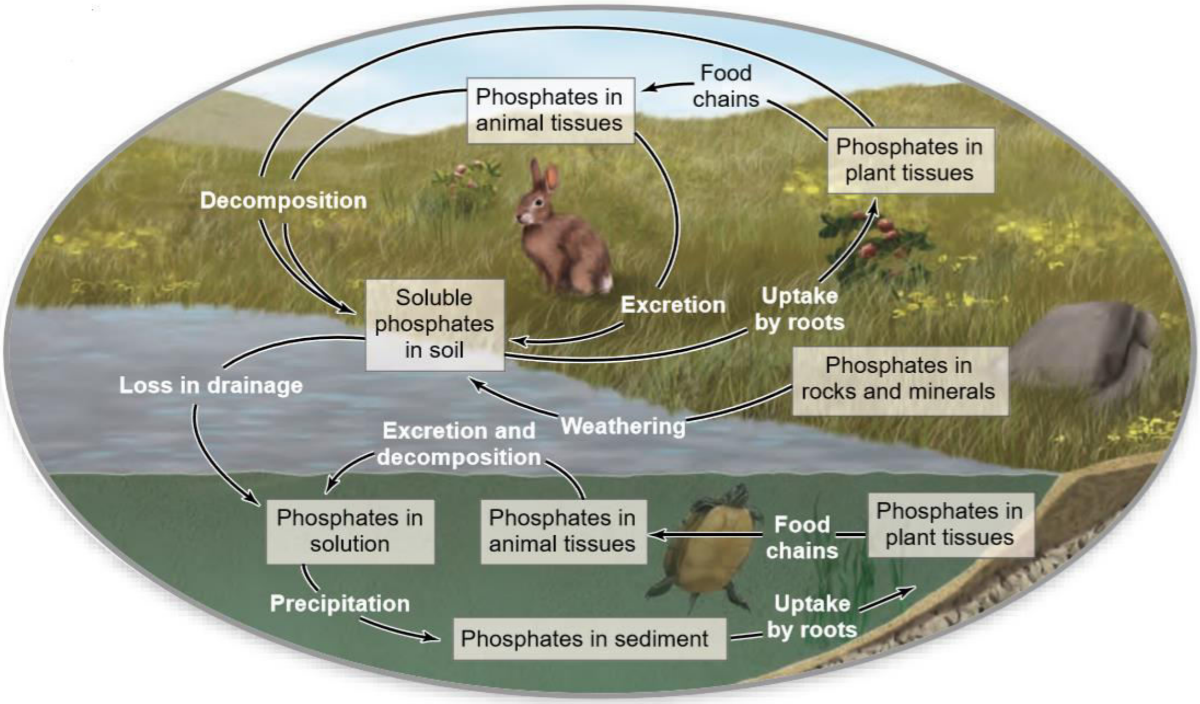
- After that, phosphorus will end up in sediments or rock formations again, remaining there for millions of years.
- Eventually, phosphorus is released again through weathering and the cycle starts over.

Phosphorus Cycle

- Like nitrogen, increased use of fertilizers increases phosphorus runoff into our waterways and contributes to eutrophication.

https://en.wikipedia.org/wiki/Phosphorus_cycle

Phosphorus Cycle



Biology Mason, Losos and Singer, 9th ed.

Extinction and Habitat Loss

Extinction

- Termination of an organism or of a group of organisms (taxon), usually a species
- Moment of extinction is death of the last individual of the species.
- Capacity to breed and recover may have been lost before this point.

Extinction and Habitat Loss

Extinction

- Variety of causes, independently or in concert, are responsible for extinctions.
- Disruption of habitat
- Loss of ecosystem interactions e.g. disrupted food chain or web, symbiosis, predation

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Extinction and Habitat Loss

Extinction

- Pollution
- Loss of genetic variation
- Catastrophic disturbances
- Natural or human-caused activities

Extinction and Habitat Loss

Extinction

- Disruption of ecosystem interactions is an important cause.
- One of the major disruptions is loss of habitat.

Extinction and Habitat Loss

Percentage of Extinction of Species

Group	Habitat Loss
E X T I N C T I O N S	
Mammals	19
Birds	20
Reptiles	5
Fish	35

Extinction and Habitat Loss

- Habitat loss is the most important cause of modern-day extinction.
- Human activities are negatively affecting all types of habitat, from rain forest to ocean floor.
- Natural habitats may be adversely affected by humans in three ways.

Extinction and Habitat Loss

1. Habitat destruction
2. Pollution
3. Habitat fragmentation

Extinction and Habitat Loss

http://youtube.com/watch?v=TP-V4VLLHNE

Habitat Destruction

- A process in which natural habitat becomes incapable of supporting its native species.
- Organisms inhabiting there are displaced or destroyed reducing biodiversity.
- Human activities are responsible for this.

Habitat Destruction

Causes

- Clearing habitats for agriculture and urban development
- Deforestation
- Mining
- Trawling
- Urbanization

Habitat Destruction

https://www.hunker.com/13406919/effects-of-land-clearing

Clearing habitats for agriculture and urban development

- Land clearing for agriculture is destructive.
- If extensive, it will bring irreversible changes.
- It will destroy whole ecosystem permanently.
- If 90% area is cleared, 50% of species will be lost.

Habitat Destruction

Clearing habitats for agriculture and urban development

- After clearing flora, fauna and topography, green house gas emissions, rise in soil salinity will damage it further.
- Land clearing should keep legislative regulation on its use.

Habitat Destruction

Deforestation

- About 31% of Earth's land surface is covered by forests.
- Removal of a forest or stand of trees from land which is then converted to a non-forest use.

Habitat Destruction

Deforestation

Reasons of deforestation

- Agriculture
- Fuel
- Timber for building
- Pastures & Plantation
- Urban development

Insufficient reforestation has resulted in habitat damage, biodiversity loss, and aridity.

ClusBook.com

Habitat Destruction

http://youtube.com/watch?v=Ic-J6hcSKa8

Habitat Destruction

Impacts of Deforestation

- Global warming
- Tropical deforestation is responsible for approximately 20% of world greenhouse gas emissions.
- Decay or burning of wood release carbon in atmosphere.
- Carbon store in soil is also released.

Habitat Destruction

https://en.wikipedia.org/wiki/Deforestation#Causes

Impacts of Deforestation

- Water cycle
- Rate of transpiration by trees is reduced.
- Drier climate
- Low moisture in soil
- Less water available for plants.
- More erosion, flooding and land sliding

Habitat Destruction

Impacts of Deforestation

- Decline in biodiversity
- Cause of extinction
- Loss of genetic variations
- Affect interspecific interactions e.g. symbiosis

Habitat Destruction

Impacts of Mining

https://www.google.com/search?q=mining&rlz

- Mining needs removal of everything to get access to mine.
- It involves land clearing, deforestation and digging.
- Habitat is permanently damaged.
- It leaks pollutants.

Habitat Destruction

Impacts of Mining

- Water bodies are exposed to heavy metals and toxic minerals
- Water is pumped out to allow miners to work.
- Water level shrinks.

Habitat Destruction

https://en.wikipedia.org/wiki/Trawling

Impacts of Trawling

Trawling

- Pulling a fishing net through the water behind one or more boats
- Heavy catch of fish from wild.
- Using trawlers
- All wanted and unwanted animals are caught.

Habitat Destruction

Impacts of Trawling

- Fishing gear towing at the bottom of sea damages sea bed.
- Including coral shattering, damage to habitats and removal of seaweed

Habitat Destruction

Impacts of Urbanization

- Population shift from rural areas to urban areas
- Gradual increase in the proportion of people living in urban areas

Negative Impacts

- Deforestation
- Habitat destruction
- Habitat fragmentation
- Pollution

Habitat Fragmentation

- Habitat needs to be an intact body.
- Least interference is required to protect niches of organisms.
- Many species are too sensitive to tolerate changes in their niches.
- e.g. insects

Habitat Fragmentation

- Breaking up of one patch of habitat into several smaller patches
- Reduction in the total area of the habitat
- Isolation of one habitat fragment from other areas of habitat
- Decrease in the average size of each patch of habitat

Habitat Fragmentation

https://en.wikipedia.org/wiki/Habitat_fragmentation#Natural_causes

Causes

- Fragmentation by different obstructions
- Volcanism, fire, climate change, deforestation, colonies, roads, water drains, noise, mining
- Population is divided into unconnected patches
- It affects biodiversity and population size in that habitat.

Habitat Fragmentation

http://youtube.com/watch?v=YMpMsSK3VPY

Habitat Fragmentation

Edge Effect

- Proportion of the habitat that occurs on the boundary or edge, increases.
- Edge effects can significantly degrade a population's chances of survival.
- Changes in microclimate in edges are more dangerous than fragmentation itself.

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Habitat Fragmentation

Rainforests of Manaus, Brazil, First monkeys needing large area disappeared., then insects followed by insectivorous birds.

Habitat Fragmentation

Edge Effect

- Population on edges are more exposed to sunlight.
- Parasites and predator effects can be more intense on edges.
- Plants are worst affected due to their immobility.

END

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Effects of Habitat Fragmentation

Effects of Fragmentation

- Loss of biodiversity
- Threatening or extinction of species
- Genetic diversity is also fragmented.
- Small populations having smaller pool of fitness maintaining alleles to survive

Effects of Habitat Fragmentation

Effects of Fragmentation

- Gene flow and migration are reduced.
- Species do not migrate to fragments.
- Reproductive isolation and inbreeding
- It causes inbreeding depression.

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Effects of Habitat Fragmentation

Effects of Fragmentation

- Inbreeding increases the level of homozygosity.
- Facilitating the expression of deleterious alleles that reduce the fitness
- It may result in local extinction.

Effects of Habitat Fragmentation

Effects of Fragmentation

- Genetic drift is increased.
- Random changes to the genetic make up of populations
- It leads to reductions in genetic diversity.

Effects of Habitat Fragmentation

Effects of Fragmentation

- Natural selection prefers large population size.
- Small population are weak in adaptations
- May be eliminated by the process of natural selection.

Effects of Habitat Fragmentation

END

Effects of Fragmentation

- Greatly affect the predator-prey dynamics of many species.
- By changing species diversity and population size
- Reduction in area of safe zones for prey making them vulnerable to predators
- It may increase their area of refuge on opposite

Invasive Species

- Colonization, a natural process by which a species expands its geographic range, occurs in many ways.

Examples:

- Seed dispersal by birds
- Lowering of sea levels join two isolated land masses
- Flooding

Invasive Species

- Migratory animals carrying other animals as symbiotic or parasitic partners
- Human activities are the major reason of invasion of species.

Invasive Species

- Exotic Species are species that occur outside of their natural ranges because of human activity.
- An exotic species becomes invasive when it becomes established in its new environment and out competes native species.

Invasive Species

- Types of invasive species

1. Animals
2. Plants
3. Pathogens

- They cause an imbalance in the natural environment.
- They outcompete the native species.

Invasive Species

https://en.wikipedia.org/wiki/Invasive_species

Zebra Mussel

- Originally from the Caspian and Black Sea.
- Accidentally introduced to the Great Lakes in 1988.
- Can harm other fresh water mussels
- Can block intake pipes for power plants
- Can cause problems for recreational activities.

Invasive Species

https://en.wikipedia.org/wiki/Invasive_species

Kudzu

- native to southern Japan and south east China.
- It occurs as an invasive species in the U.S.
- it is considered a noxious weed that climbs over trees or shrubs and grows so rapidly.
- It kills them by heavy shading.

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Invasive Species

https://en.wikipedia.org/wiki/Invasive_species

Asian Tiger Mosquito

- Originally from Asia.
- Introduced to Hawaii in the late 1800's.
- Continental United States in 1985.
- Can be a vector for disease.
- Ex. West Nile Virus

Invasive Species

Lionfish

https://en.wikipedia.org/wiki/Invasive_species

- Native to the Pacific Ocean
- Introduced to the water around the United States in 1992 through the aquarium trade.
- Preys on native species.
- Has poisonous spines.

Invasive Species

- Strategies and legislations about introduction of exotic species
- Protection of native species is of utmost priority.
- For purpose of conservation of native biodversity

END

Overexploitation

- Over harvesting
- Harvesting a renewable resource to the point of diminishing returns
- Risk of extinction appears even when the species is initially very abundant.

Examples:

1. Passenger pigeons
2. Bison

in N. America

Overexploitation

Cascade Effect

- Removal of apex predator in environment
- It leads to dramatic increase in their prey species.
- Unchecked prey can then overexploit their own food resources
- Shortage in food resources disturbs whole food web.

Overexploitation

Cascade Effect

- Cascade of overexploitation at different trophic levels
- Population numbers dwindle, possibly to the point of extinction.

Example:

- Overhunting of sperm whale; an apex predator

Overexploitation

http://youtube.com/watch?v=GIcoMDw6mRo

Overexploitation

Commercial Motivations

- International trade
- Furs
- Skin
- Bones
- Other body parts
- Trophy & Game hunting
- Hunting for food
- Medicines

Overexploitation

Threatened species

- Chinchilla, vicuña, otter, and many cat species for fur
- Elephants for tusk
- Cod, bluefin tuna and swordfish fishing in N. America
- Mahogany trees in West Indies
- Cedar forests of Lebanon

END

Land Pollution - 1

Pollution

- Introduction of contaminants into the natural environment that cause adverse change.
- Undesirable change in physical, chemical, or biological characteristics of any component of the environment.

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Land Pollution - 1

Pollution

Classified as:

1. Point source
2. Non point source

1. Point source

Single identifiable source of pollution

Example:

- Land fill
- Factory drain
- Sewages pipes

Land Pollution - 1

Pollution

Non Point source

Resulting from many diffuse sources

Example:

- Sediment
- Nutrients
- Toxic contaminants and chemicals
- Pathogens

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Land Pollution - 1

Types of Pollution

1. Land
2. Air
3. Water
4. Light
5. Noise

Land Pollution - 1

- Followed by industrial Revolution, natural habitats were destroyed and the environment was polluted.
- Common problem worldwide
- Direct result of the activities that humans engage in

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Land Pollution - 1

- Pollution of the Earth's natural land surface by industrial, commercial, domestic, and agricultural activities
- Includes visible litter and waste along with the soil
- The deposition of solid or liquid waste materials on land or underground can contaminate the soil and groundwater

Land Pollution - 1

http://youtube.com/watch?v=wt_siDmpfB0

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Land Pollution - 1

- Land pollution is comprised of:

1. Solid waste
2. Soil pollution

Land Pollution - 1

Solid Waste

- Semisolid or solid matter that are created by human or animal activities
- Disposed because they are hazardous or useless

Land Pollution - 1

Solid Waste

Sources of solid waste

- Wastes from agriculture
- Wastes from mining
- Wastes from industries
- Solids from sewage treatment
- Ashes
- Garbage

Land Pollution - 1

Solid Pollution

- Caused by chemicals in pesticides
- Results from unhealthy methods of soil management.
- Harmful practices of irrigation methods.
- Causes

END

Land Pollution - 2

Sources

- Littering
- Herbicides, insecticides, and pesticides
- Construction debris and waste
- Mining waste
- Overcrowded landfills
- Deforestation
- Chemical and nuclear plants

Land Pollution - 2

Sources

- Industrial factories
- Oil refineries
- Human sewage
- Oil and antifreeze leaking from motor vehicles

Land Pollution - 2

Causes

- Increase in urbanization
- Increase in agricultural land
- Domestic waste
- Agricultural activities
- Industrial activities

Land Pollution - 2

Effects

- Exterminates wild life
- Vegetation that provides food and shelter is destroyed
- It can seriously disrupt the balance of nature, and, in extreme cases, can cause human fatalities
- Most pesticides kill or damage life forms other than those intended.

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Land Pollution - 2

Effects

- Pesticides can damage crops; kill vegetation; and poison birds, animals, and fish
- Skin problems are often diagnosed due to land pollution.
- One of the leading causes for birth defects.

Land Pollution - 2

Effects

- Land pollution indirectly affects the respiratory system of human beings
- Can incur breathing problems and a number of diseases, which may affect the health of babies as well.

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Land Pollution - 2

Effects

- Impact it has on the surrounding environments
- Every form of land pollution kills off the habitats of land animals as well as aquatic life
- The more we deplete these habitats the more the ecosystem is thrown out of balance.

Land Pollution - 2

Preventions

- People should be educated and made aware about the harmful effects of littering.
- Items used for domestic purposes ought to be reused or recycled.
- Personal litter should be disposed properly.

Land Pollution

Preventions

- Organic waste matter should be disposed in areas that are far away from residential places
- Use of pesticides should be reduced.

Water Pollution - 1

- Any physical or chemical change in water that adversely affects the health of humans and other organisms
- Varies in magnitude by location
- Global issue
- Lack of disease-free water anywhere in the world

Water Pollution - 1

Categories

1. Sewage
2. Disease-causing agents
3. Sediment pollution
4. Inorganic plant and algal nutrients
5. Organic compounds
6. Inorganic chemicals
7. Radioactive substances
8. Thermal pollution

Water Pollution - 1

http://youtube.com/watch?v=Sp572udnPVg

Water Pollution - 1

Sewage

- The release of wastewater from drains or sewers
- Includes human wastes, soaps, and detergents

Causes serious environmental problems:

- Enrichment of nutrients

Water Pollution - 1

Sewage

- Fertilization of a body of water by high levels of plant and algal nutrients (nitrogen and phosphorus)
- Increase in Biological Oxygen Demand (BOD)

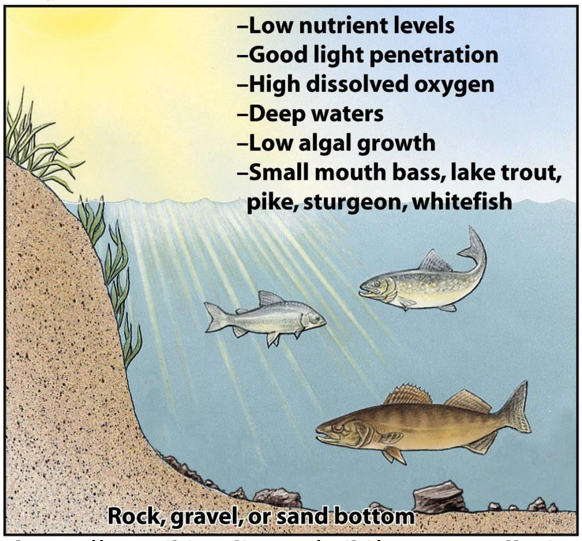
Water Pollution - 1

Sewage

- Amount of oxygen needed by microorganisms to decompose biological wastes
- As BOD increases Dissolve Oxygen (DO) decreases

Water Pollution - 1

Oligotrophic lake



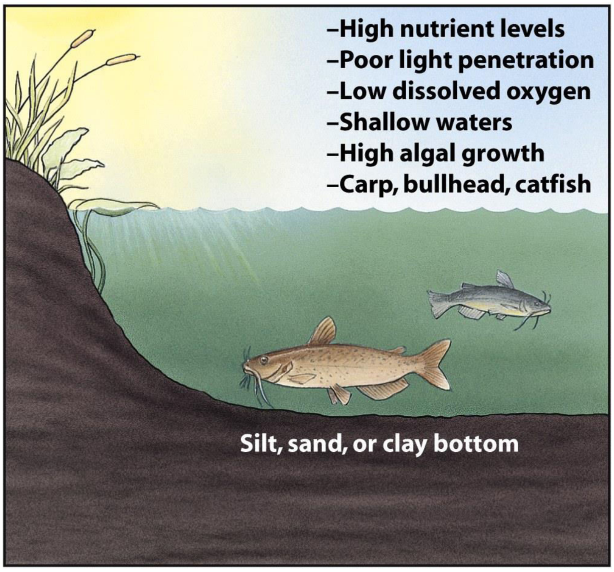
https://en.wikipedia.org/wiki/Water_pollution

Sewage

- Sewage- Eutrophication
- Oligotrophic
  - Unenriched, clear water that supports small populations of aquatic organisms

Water Pollution - 1

Eutrophic lake



https://en.wikipedia.org/wiki/Water_pollution

Sewage

- Sewage- Eutrophication
- Eutrophic-
  - Slow-flowing stream, lake or estuary enriched by inorganic plant and algal nutrients such as phosphorus
  - Often due to fertilizer or sewage runoff

Water Pollution - 1

Sewage

- Disease-causing Agents
- Infectious organisms that cause diseases
  - Originate in the wastes of infected individuals
- Common bacterial or viral diseases:
  - Typhoid, cholera, bacterial dysentery, polio, and infectious hepatitis

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Water Pollution - 1

Sewage

- Sediment Pollution
- Excessive amounts of suspended soil particles
  - Originates from

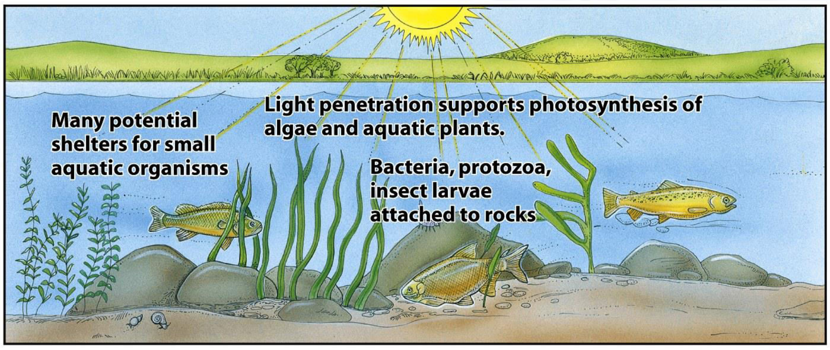
  Erosion of agricultural lands, forest soils exposed by logging, degraded stream banks, overgrazed rangelands, strip mines, and construction

Water Pollution - 1

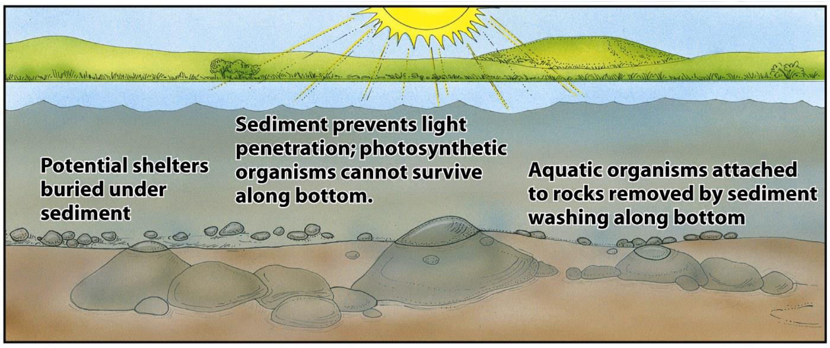
Sewage

- Sediment Pollution
- Problems
  - Limits light penetration
  - Covers aquatic animals and plants
  - Brings insoluble toxins into waterways

Water Pollution - 1



Stream ecosystem with low level of sediment



Same stream with high level of sediment

https://en.wikipedia.org/wiki/Water_pollution

Water Pollution - 2

Inorganic Plant and Algal Nutrients

- Chemicals such as nitrogen and phosphorus that stimulate the growth of plants and algae
  - Harmful in large concentrations

Water Pollution - 2

Inorganic Plant and Algal Nutrients

- Sources:
  - Human and animal wastes, plant residues, atmospheric deposition, and fertilizer runoff
- Causes:
  - Enrichment, bad odors, and a high BOD

Water Pollution - 2

Organic Compounds

- Chemicals that contain carbon atoms
  - Natural examples: sugars, amino acids, and oils
  - Human-made examples: pesticides, solvents, industrial chemicals, and PLASTICS

ClueslBook.com

Water Pollution - 2

Dead Zone; The Great Pacific Patch of Garbage

http://youtube.com/watch?v=QHK2Zg5OibI

Water Pollution - 2

Inorganic Chemicals

- Contaminants that contain elements other than carbon
  - Examples: acids, salts, and heavy metals
- Do not degrade easily
- Lead
  - Found in old paint, industrial pollutants, leaded gasoline

Water Pollution - 2

Inorganic Chemicals

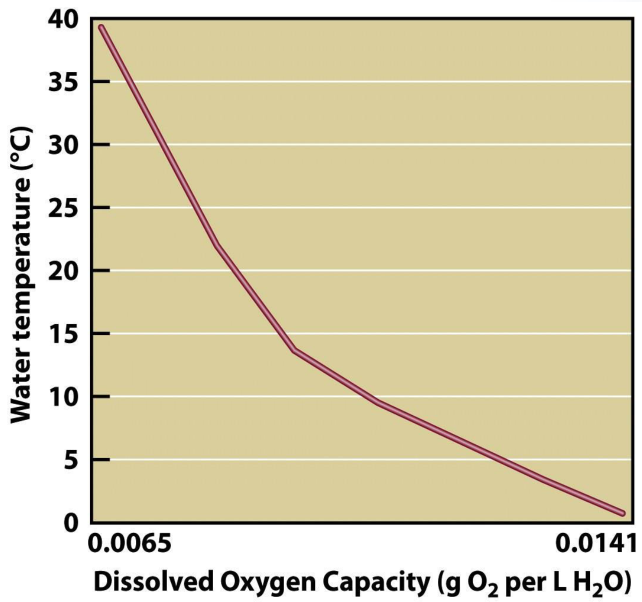
- Mercury
  - Mercury bioaccumulates in the muscles of top predators of the open ocean

Water Pollution - 2

Radioactive Substances

- Contain atoms of unstable isotopes that spontaneously emit radiation
- Sources
  - Mining
  - Processing radioactive materials
  - Nuclear power plants
  - Natural sources

Water Pollution - 2



https://en.wikipedia.org/wiki/Water_pollution

Thermal Pollution

- Occurs when heated water produced during industrial processes is released into waterways
- Organisms affected
  - Temperature affects reproductive cycles, digestion rates, and respiration rates
  - Warm water holds less DO than cold water

Water Pollution - 2

Water Pollution from Agriculture

- Agriculture is leading source of water pollution
  - Animal wastes and plants residues have high BOD
  - Chemical pesticides can leach into groundwater
- Almost all streams and rivers are polluted with agricultural pesticides.

Water Pollution - 2

Industrial & Municipal Wastes in Water

- Different industries generate different pollutants
  - Food processing plants- high BOD
  - Paper mills- High BOD and toxic compounds
- Few industries recover toxins before they go into the waste stream.

END

Air Pollution - 1

- Harmful or excessive quantities of substances including gases, particles, and biological molecules are introduced into Earth's atmosphere.
- It may cause diseases, allergies and even death of organisms.
- Both human and natural activities contribute.

Air Pollution - 1

Air Pollutants

- Chemicals added to the atmosphere by natural events or human activities in high enough concentrations to be harmful
- Two categories of air pollutants

1. Primary Air Pollutant
2. Secondary Air Pollutants

Air Pollution - 1

Primary Air Pollutant

- Harmful substance that is emitted directly into the atmosphere

Secondary Air Pollutant

- Harmful substance formed in the atmosphere
- Primary air pollutant reacts with substances normally found in the atmosphere or with other air pollutants.

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Air Pollution - 1

Major Classes of Air Pollutants

- Particulate Material
- Nitrogen Oxides
- Sulfur Oxides
- Carbon Oxides
- Hydrocarbons
- Ozone

Air Pollution - 1

http://youtube.com/watch?v=jSmmmYfO7pU

Air Pollution - 1

Particulate Material

- Thousands of different solid or liquid particles suspended in air
- Includes: soil particles, soot, lead, asbestos, sea salt, and sulfuric acid droplets

Air Pollution - 1

Particulate Material

Dangerous for two reasons

1. May contain materials with toxic or carcinogenic effects
2. Extremely small particles can become lodged in lungs

Air Pollution - 1

Nitrogen and Sulfur Oxides

- Nitrogen Oxides
  - Gases produced by the chemical interactions between atmospheric nitrogen and oxygen at high temperature
  - Problems
    - Greenhouse gases
    - Cause difficulty breathing

Air Pollution - 1

Nitrogen and Sulfur Oxides

- Sulfur Oxides
  - Gases produced by the chemical interactions between sulfur and oxygen
  - Causes acid precipitation

END

Air Pollution - 2

Carbon Oxides and Hydrocarbons

Carbon Oxides

- Gases carbon monoxide (CO) and carbon dioxide (CO_2)
- Greenhouse gases

Air Pollution - 2

Carbon Oxides and Hydrocarbons

- Hydrocarbons
  - Diverse group of organic compounds that contain only hydrogen and carbon (ex: CH_4- methane)
  - Some are related to photochemical smog and greenhouse gases

Air Pollution - 2

Ozone

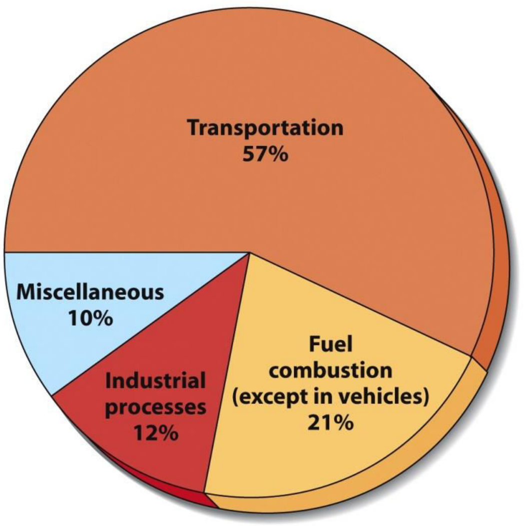
- Tropospheric Ozone
  - Man- made pollutant in the lower atmosphere
  - Secondary air pollutant
  - Component of photochemical smog

Air Pollution - 2

Ozone

- Stratospheric Ozone
  - Essential component that screens out UV radiation in the upper atmosphere
  - Man- made pollutants (ex: CFCs) can destroy it

Air Pollution - 2



https://en.wikipedia.org/wiki/Air_pollution

Sources of Outdoor Air Pollution

- Two main sources
  - Transportation
  - Industry
- Intentional forest fires is also high

Air Pollution - 2

https://en.wikipedia.org/wiki/Air_pollution

Urban Air Pollution

- Photochemical Smog
  - Brownish-orange haze formed by chemical reactions involving sunlight, particulate susoension, nitrogen oxide, and hydrocarbons

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Air Pollution - 2

http://youtube.com/watch?v=s2sHIyvN0aE

Air Pollution - 2

END

Effects of Air Pollution

- Low level exposure
  - Irritates eyes
  - Causes inflammation of respiratory tract
- Can develop into chronic respiratory diseases

Light Pollution

- Light pollution, also known as photo pollution
- Excessive, misdirected or obtrusive artificial light
- Major side-effect of urbanization
- It is blamed for compromising health, disrupting ecosystems and spoiling aesthetic environments.

Light Pollution

Nanthn Brandt Astrophotography, 2014

BBC, 2017

Light Pollution

https://www.youtube.com/watch?v=V_A78zDBwYE

Light Pollution

Impacts

- The degradation of photic habitat by artificial light.
- The alteration of natural light levels in the outdoor environment.
- The alteration of light levels in the outdoor environment due to man-made sources of light.

Light Pollution

Impacts

- Indoor light pollution is such alteration of light levels in the indoor environment
- Due to sources of light, which compromises human health.
- The introduction by humans, directly or indirectly, of artificial light into the environment.

Light Pollution

Effects

Humans

- Stress
- Headache
- Seasonal Affective Disorder

Ecosystem

- Ecosystem cycles of natural light

Light Pollution

Effects

Animals

- Negative impacts on plant and animal physiology
- Sleep
- Foraging behavior
- Predation
- Reproduction
- Animal navigation
- Alter competitive interactions
- Change predator-prey relations

Light Pollution

https://en.wikipedia.org/wiki/Light_pollution

Example

- Reptiles are strongly affected by light pollution.
- Sea turtles like to build their nests in remote and very dark beaches.
- Coastal lights interfere with their ability to find safe nesting areas for their eggs.

Light Pollution

Effects

- Artificial lights can confuse the baby turtles and take them to crawl away from the ocean into the roads or communities.

END

Noise Pollution

- Sound that is unwanted or disrupts one's quality of life is called as noise.
- When there is lot of noise in the environment, it is termed as noise pollution.
- Sound becomes undesirable when it disturbs the normal activities such as working, sleeping, and during conversations.

Noise Pollution

- It is an underrated environmental problem because of the fact that we can't see, smell, or taste it.
- World Health Organization stated that "Noise must be recognized as a major threat to human well-being"

Noise Pollution

Effects

- Noise pollution can damage physiological and psychological health.
- High blood pressure, stress related illness, sleep disruption, hearing loss, and productivity loss
- It can also cause memory loss, severe depression, and panic attacks.

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Noise Pollution

Sources

- Transportation systems are the main source of noise pollution in urban areas.
- Construction of buildings, highways, and streets cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers.

Noise Pollution

Sources

- Industrial noise also adds to the already unfavorable state of noise pollution.
- Loud speakers, plumbing, boilers, generators, air conditioners, fans, and vacuum cleaners add to the existing noise pollution.

Noise Pollution

http://youtube.com/watch?v=DdImG-jphkM

Acid Rain

- Form of precipitation that is unusually acidic.
- It has elevated levels of hydrogen ions (low pH).
- Deposition of a mixture

1. Wet (rain, snow, sleet, fog, cloud water and dew)
2. Dry (acidifying particles, dust and gases) acidic components

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Acid Rain

- Unpolluted rain has an acidic pH, but usually no lower than 5.7.
- This low pH is due to carbonic acid

$H_2O + CO_2 \rightleftharpoons H_2CO_3\,(aq)$

- Nitric acid is produced as result of lightening.

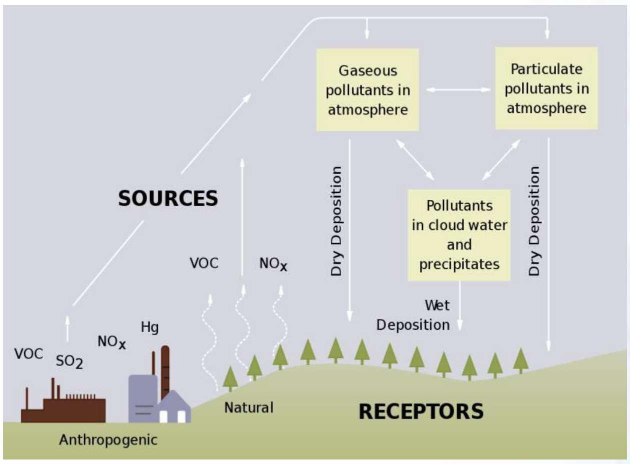
Acid Rain

Causes

- **Natural**
- Volcanic eruption releases SO_2 in air.
- Nitrogen fixation adds NO_2 in air.
- Electrical activity in the atmosphere such as lightning produces NO_2 .
- Acid deposits in glacial ice.

Acid Rain

Causes



https://en.wikipedia.org/wiki/Acid_rain

- **Human Activities**
- Sulfur and nitrogen compounds from human sources
- Electricity generation, factories, and motor vehicles
- Greatest contribution by burning coal in power plants

Acid Rain

Causes

- **Human Activities**
- Gases can be carried hundreds of kilometers in the atmosphere before they are converted to acids and deposited.
- Taller factories funnels disperse smoke even farther.

Acid Rain

Chemical Processes

- **Gas phase chemistry**
- In the gas phase sulfur dioxide is oxidized by reaction with
the hydroxyl radical via an intermolecular reaction

1. $SO_2 + OH \rightarrow HOSO_2$ (hydroxysulfonyl radical)

which is followed by:

2. $HOSO_2 + O_2 \rightarrow HO_2 + SO_3$

Acid Rain

Chemical Processes

- Chemistry in cloud droplets
- In the presence of water, sulfur trioxide (SO_3) is converted rapidly to sulfuric acid

  $SO_3 + H_2O \rightarrow H_2SO_4$ (aq)
- Nitrogen dioxide reacts with OH to form nitric acid
- $NO_2 + OH \rightarrow HNO_3$

Acid Rain

https://www.youtube.com/watch?v=1PDjVDIrFec

Acid Rain

Effects

- Not many things can grow in acidic conditions
- Low pH and high aluminum concentrations can damage or kill fish and aquatic populations
- At pH lower than 5 most fish eggs will not hatch and lower pH can kill adult fish.

Acid Rain

Effects

- Soils can be damaged by the hydronium ion, which mobilizes aluminum and encourages leaching of minerals such as magnesium essential for plant life.
- Forests suffer from soil damage, however most food crops are unharmed because the nutrients lost are replaced in fertilizer.

Acid Rain

Effects

- Monuments made of Calcium Carbonate (limestone and marble) will react with acid rain to form Gypsum
- Increases the oxidation rate of metals such as copper and bronze

Acid Rain

END

https://en.wikipedia.org/wiki/Acid_rain

Disruption of Water Cycle & Coastal Ecosystems

Stages of Water cycle

1. Evaporation
2. Transpiration
3. Condensation
4. Precipitation
5. Surface Run off
6. Infiltration

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Disruption of Water Cycle & Coastal Ecosystems

Deforestation

- Directly affects rate of transpiration
- Lesser volume of moisture in air by plants
- Increased rate of erosion due to weak support from root system.
- Making water in seas more muddy.

Disruption of Water Cycle & Coastal Ecosystems

Pollution (Smog & Acid rain)

- Precipitation brings all the toxic chemicals in air back into surface runoff.
- Releasing them into water bodies.
- Infiltration of these chemicals adds toxicity in underground water.
- Toxic chemicals are recycled in water cycle through evaporation.

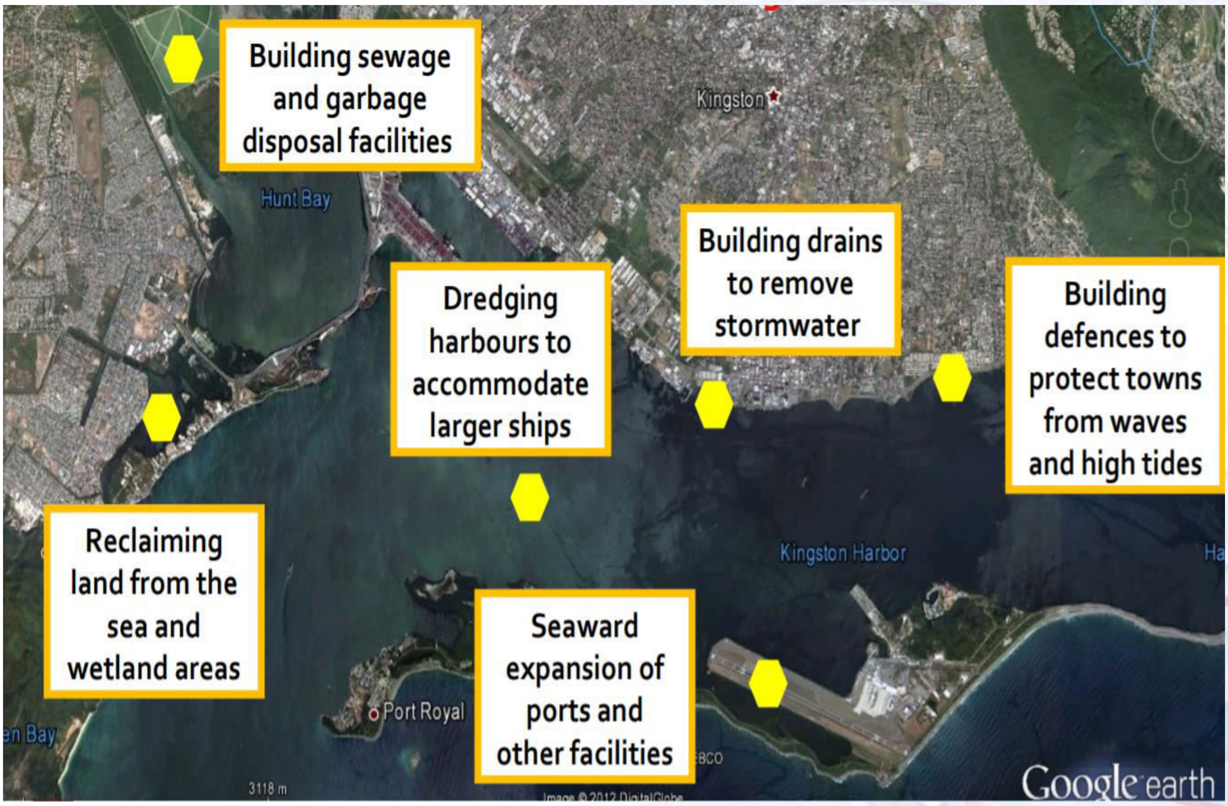
Disruption of Water Cycle & Coastal Ecosystems

Coastal Ecosystems

- 3 billion people now live in coastal areas
- 1 thousand migrate to coastal areas in China each day
- 14 of the world’s 17 largest cities are located along the coast

Disruption of Water Cycle & Coastal Ecosystems

Disruption of Water Cycle & Coastal Ecosystems



Disruption of Water Cycle & Coastal Ecosystems

Coastal Ecosystems

- To reclaim lands, mangroves and other wetland areas are destroyed.
- Coastal defences (dams and dykes) disrupt the natural function of waves and tides.
- Dredging of harbors damage reefs and produce sediments which also smother reefs

Disruption of Water Cycle & Coastal Ecosystems

Coastal Ecosystems

- Drains may deliver excess freshwater, solid waste and pollutants to coastal areas.
- Untreated sewage may be released in the sea causing pollution

Disruption of Water Cycle & Coastal Ecosystems

https://en.wikipedia.org/wiki/Eutrophication

Coastal Ecosystems

- Over enrichment of nutrients in water causes eutrophication.
- Especially in estuaries
- Excessive growth of algae
- Depletion of oxygen in water disturbing flora and fauna

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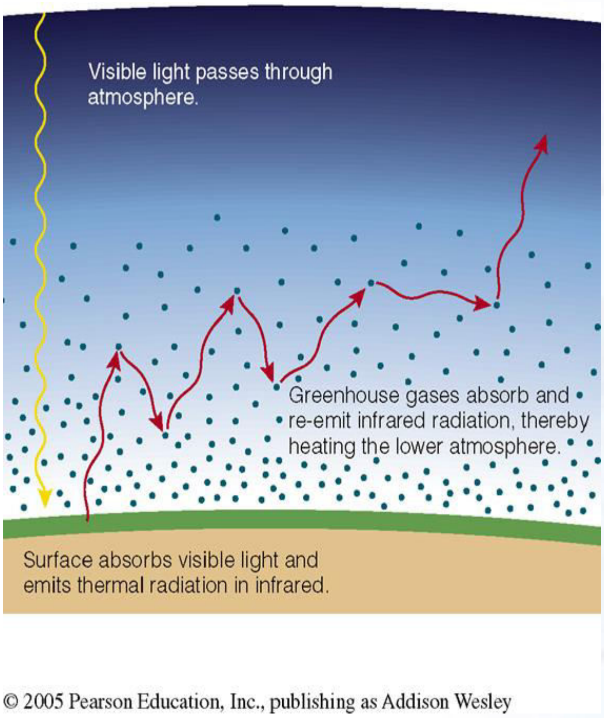
Greenhouse Effect

- The ground is heated by visible and (some) infrared light from the Sun.
- The heated surface emits infrared light.
- The majority of Earth's atmosphere (N_2 and O_2) are not good greenhouse gas.
- Carbon dioxide, methane, nitrous oxide and water vapors act as greenhouse gases.

Greenhouse Effect



- **The small amount of greenhouse gases (H_2O, CO_2, methane) traps (absorb and re-emit) the infrared radiation.**
- **Increasing the temperature of the atmosphere**

Greenhouse Effect

https://www.youtube.com/watch?v=G4H1N_yXBiA

Greenhouse Effect

Emission of Gases

– CO_2

- 40% of carbon dioxide emissions stem from the burning of fossil fuels for the purpose of electricity generation.
- 20% and 13 % of carbon dioxide emissions comes from the burning of gasoline in internal-combustion engines of cars and trucks.

Greenhouse Effect

Emission of Gases

– CO_2

- Aviation causes 3.5% of global warming, and the figure could rise to 15% by 2050.
- Buildings structure account for about 12% of carbon dioxide emissions.

Greenhouse Effect

Emission of Gases

– CO_2

- 25% of carbon emissions by the burning and cutting of about 34 million acres of trees each year

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Greenhouse Effect

Emission of Gases

– Water Vapors

- Causes about 36-70% of the greenhouse effect on Earth (not including clouds)

Greenhouse Effect

Emission of Gases

– Methane

- Methane is more than 20 times as effective as CO_2 at trapping heat in the atmosphere.
- 145% increase in the last 100 years
- From sources such as rice paddies, bovine flatulence, bacteria in bogs and fossil fuel production

Greenhouse Effect

Emission of Gases

– Methane

- In flooded fields, anaerobic conditions develop and the organic matter in the soil decomposes.

Greenhouse Effect

Emission of Gases

– Nitrous oxide (N2o)

- Naturally produced by oceans and rainforests

END

Man-made sources:

- Nylon and nitric acid production, the use of fertilizers in agriculture, cars with catalytic converters and the burning of organic matter

Ozone Depletion

- O_3
- Gas composed of three atoms of oxygen
- Bluish gas that is harmful to breathe.
- Nearly 90% of the Earth's ozone is in the stratosphere.
- Ozone absorbs a band of ultraviolet radiation called UVB.

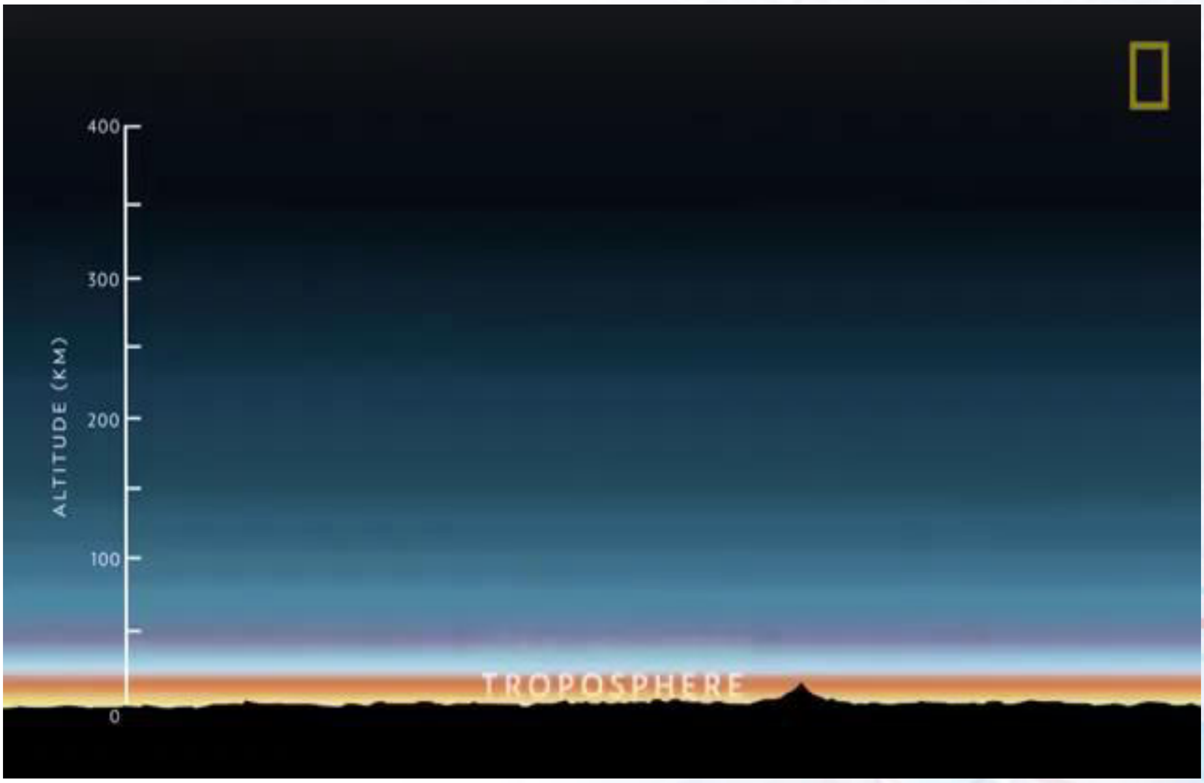
Ozone Depletion

EGEE 102 - Pisupati

Ozone Depleting Substances

- Halocarbon refrigerants
- Solvents
- Propellants in aerosols
- Chlorofluorocarbons
- Hydro chlorofluorocarbons
- Methyl bromide
- Carbon tetrachloride
- Methyl chloroform

Ozone Depletion



http://youtube.com/watch?v=aU6pxSNDPhs

Ozone Depletion

Effects

- Increased UV penetration
- Skin cancer in humans, basal and squamous cell carcinomas, have been strongly linked to UVB exposure.
- Malignant melanoma, lethal skin cancer related to UVA and UVB
- Cortical cataracts and UVB exposure

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Ozone Depletion

Effects

- Increased tropospheric ozone
- Increased production of vitamin D linked with UVB
- Cyanobacteria are sensitive to UV, indirectly affecting crops

- Ban on Use of CFCs since 1996

- Problem will be resolved by half of 21st century

END

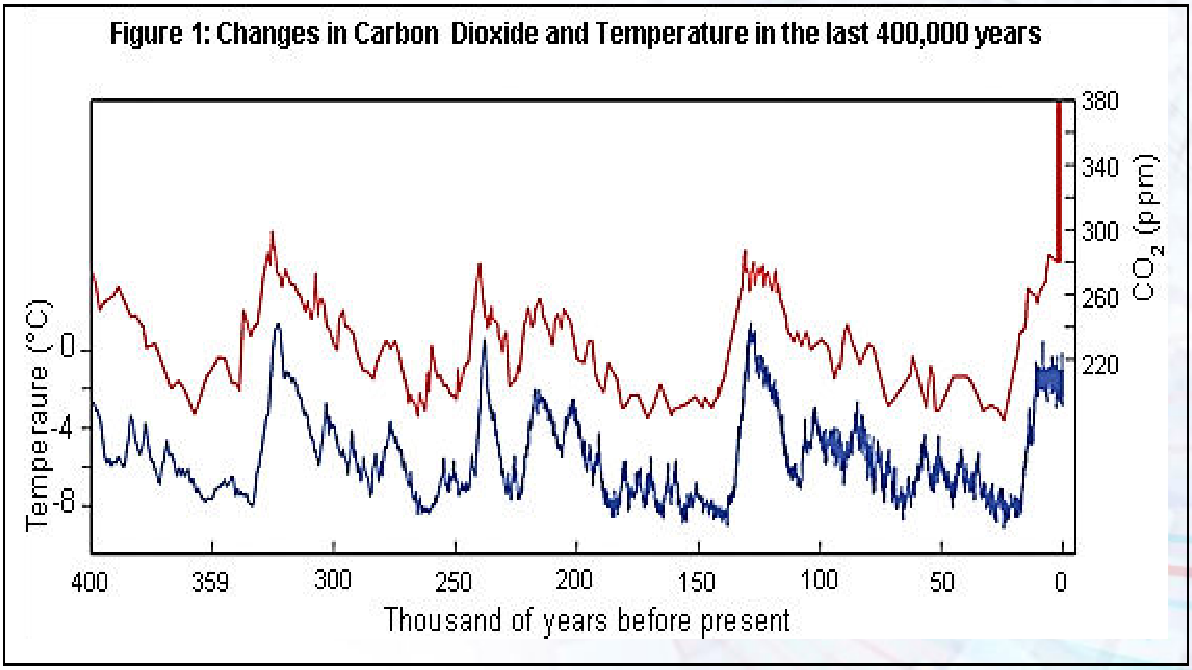
Global Warming

- There is a gradual increase in the average temperature of the Earth's atmosphere in the last 100 years.
- It has risen about 1°C since 1900.
- Sources: Greenhouse effect, pollution, deforestation

Global Warming

- The atmospheric concentration of CO_2 measured from Antarctic ice core data implies that Earth's climate has being pretty stable over the past 400,000 years.
- It also shows a rapid increase of about 30% in the past few centuries.
- From 270 ppm (parts per million) to 370 ppm

Global Warming



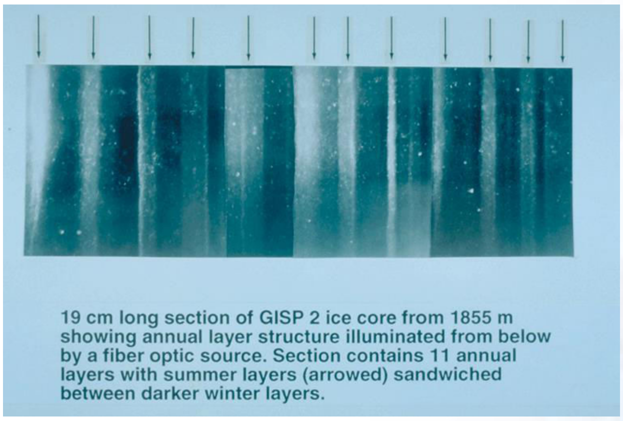
A. V. Fedorov et al. Science 312, 1485 (2006)17. 18.
Reproduced from EPA Climate Change Website

Global Warming

- Precise measurements of atmospheric CO_2 concentration is available only in the last few decade
- Information about atmospheric CO_2 concentration and temperatures in the past can be inferred by several different methods:

1. Tree-ring
2. Deep ocean sediment
3. Ice core records
4. Corals

Global Warming



NOAA Paleoclimatology Website

- Located high in mountains and in polar ice caps
- Ice has accumulated from snowfall over many millenia.
- Scientists drill through the deep ice to collect ice cores.
- These cores contain dust, air bubbles, or isotopes of oxygen, that can be used to interpret the past climate of that area.

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Global Warming

- An increase in atmospheric temperature will lead to the increase in the water vapor content of the troposphere.
- Because water vapor is a strong greenhouse gas, the increase in H_2O vapor in turn causes enhanced greenhouse effect.
- Raising the temperature more

Global Warming

- Higher atmospheric temperature will cause more evaporation of water.
- Which leads to even higher temperature.
- Clouds reflect sunlight
- They decrease the solar energy input into Earth's atmosphere during the day
- But they trap IR radiation from the Earth in night

Global Warming

- CO_2 cycle is thermostat of earth.
- If Earth warms up a bit, then:
- Carbonate minerals formation in the oceans at a higher rate.
- The rate at which the oceans dissolve CO_2 gas increases
- Pulling CO_2 out of the atmosphere

Global Warming

- The reduced atmospheric CO_2 concentration leads to a weakened greenhouse effect
- That counteracts the initial warming and cools the planet back down.

Global Warming

END

- If Earth cools a bit
- Carbonate minerals formation slows down in the oceans.
- The rate at which the oceans dissolve CO_2 gas decreases, allowing the CO_2 released by volcanism to build back up in the atmosphere.
- The increased CO_2 concentration strengthens the greenhouse effect and warms the planet back up

Effects of Global Warming - 1

- Physical Environmental Effects
- Effects on Biosphere
- Effects on Humans

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Effects of Global Warming - 1

https://www.youtube.com/watch?v=G4H1N_yXBiA

Effects of Global Warming - 1

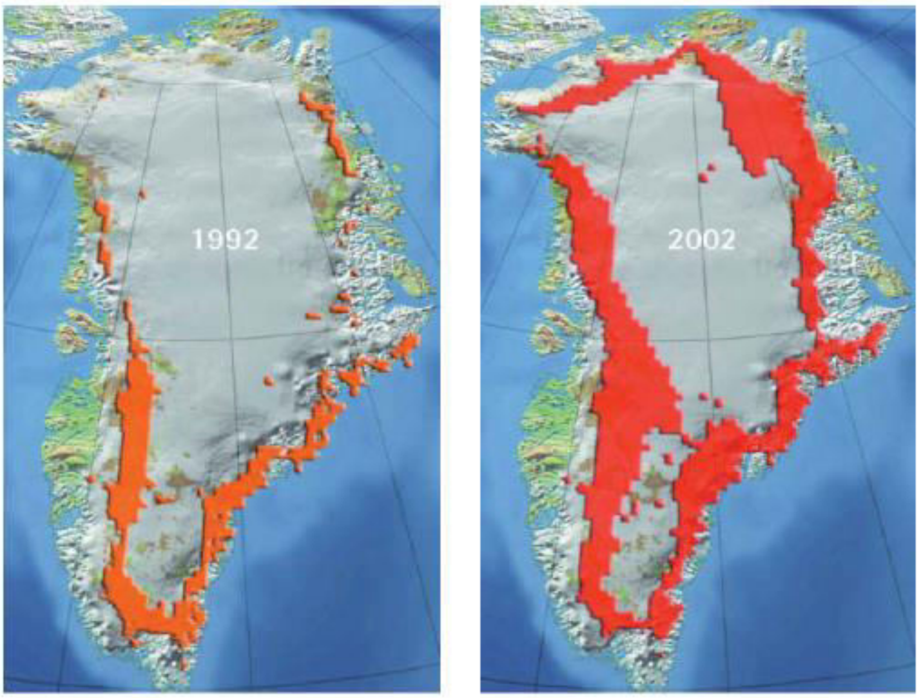
- Arctic sea ice shrinking

- Decrease in extent – 2.7% per decade since 1978

- Max. area of seasonally frozen ground decreased by 7% in Northern Hemisphere since 1900

Effects of Global Warming - 1

Figure 2.20 Seasonal melting of the Greenland Ice Sheet



Note: The areas in orange/red are the areas where there is seasonal melting at the surface of the ice sheet.

Source: Steffen and Huff 2005

Effects of Global Warming - 1

- Global sea level rise

- Average rate of 1.8 mm per year (1961-2003)
- Likely sea level rise during the 21st century - 5 mm per year
- Low lying areas, small island states may disappear, salt water intrusion into aquifers, floods
- Low-lying coastal cities will be at the forefront of impacts

Effects of Global Warming - 1

- Non-polar glaciers

Mt. Kilimanjaro-- February 17, 1993 Mt. Kilimanjaro-- February 21, 2000

https://en.wikipedia.org/wiki/Global_warming#Physical_environmental

- Widespread retreat during the 20th century

Effects of Global Warming - 1

END

- Continental Precipitation

- Significant increase in North & South America, northern Europe, north & central Asia
- Drying in Mediterranean, southern Africa, parts of South Asia

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Effects of Global Warming - 2

- Extreme Weather

- Frequency of drought, heat waves, typhoons, hurricanes and cyclones increased from 1960 until 2010.
- Extremely wet or dry events within the monsoon period have increased since 1980.

Effects of Global Warming - 2

- Changes in ocean properties
  - Increase in atmospheric CO_2 concentrations have led to an increase in dissolved CO_2
  - Increase in ocean acidity
  - Oxygen levels decrease because oxygen is less soluble in warmer water
  - An effect known as ocean deoxygenation

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Effects of Global Warming - 2

- Changes in Ecosystem
  - Earlier timing of spring events
  - Poleward and upward shifts in plant and animal ranges
  - Expansion of deserts
  - Ocean acidification threatens damage to coral reefs, fisheries, protected species, and other natural resources of value to society.

Effects of Global Warming - 2

- Impacts on Humans

- Changed precipitation patterns
- Warming of low latitudes
- Agricultural production
- Length of growing season will change.
- Droughts, extreme events will decrease yields
- Global economic inequality

Effects of Global Warming - 2

- Impacts on Humans

- Biodiversity shifts – changes in crop varieties
- New pests and diseases
- Food security
- Thermal stress – heat waves, cold spells
- Extreme events, weather disasters (personal injuries, damage & disruption to infrastructure)

Effects of Global Warming - 2

- Impacts on Humans
  - Infectious diseases (malaria, dengue)
  - Air pollution - impact of some air pollutants

Effects of Global Warming - 2

- Recent Climatic Trends in Pakistan (Department of Meteorology)
  - Rise in mean temperature of 0.6-1.0°C in arid coastal areas, arid mountains and hyper arid plains.
  - 0.5 to 0.7% Increase in solar radiation over southern half of country.
  - 3-5% decrease in cloud cover in central Pakistan with increase in sunshine hours.

Effects of Global Warming - 2

- Recent Climatic Trends in Pakistan

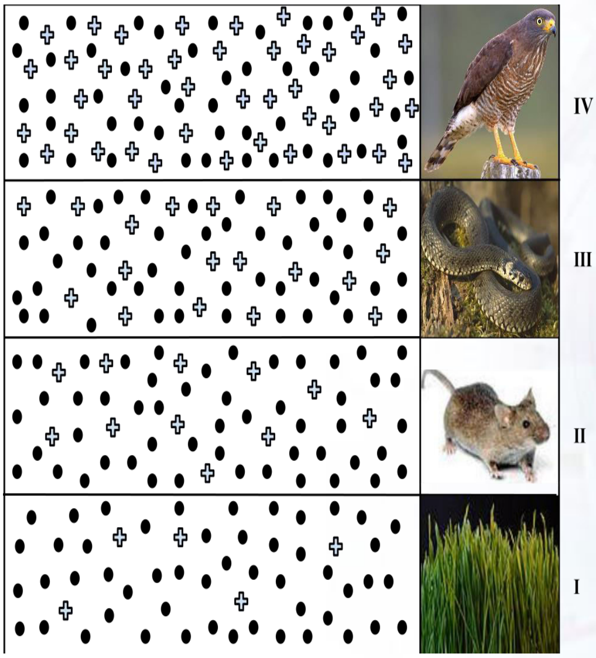
- 5% increase in net irrigation water requirement with no change in rainfall.

END

Biomagnification

- Increasing concentration of toxic substance
- In the tissues of tolerant organisms at successively higher levels in a food chain
- It occurs as result of three activities.

Biomagnification



https://en.wikipedia.org/wiki/Biomagnification

- Concentration of the persistent toxins increases higher up the food chain.

Biomagnification

- It occurs as result of three activities.

Biomagnification

1. Persistence

- Substance cannot be broken down by environmental processes

2. Food chain energetics

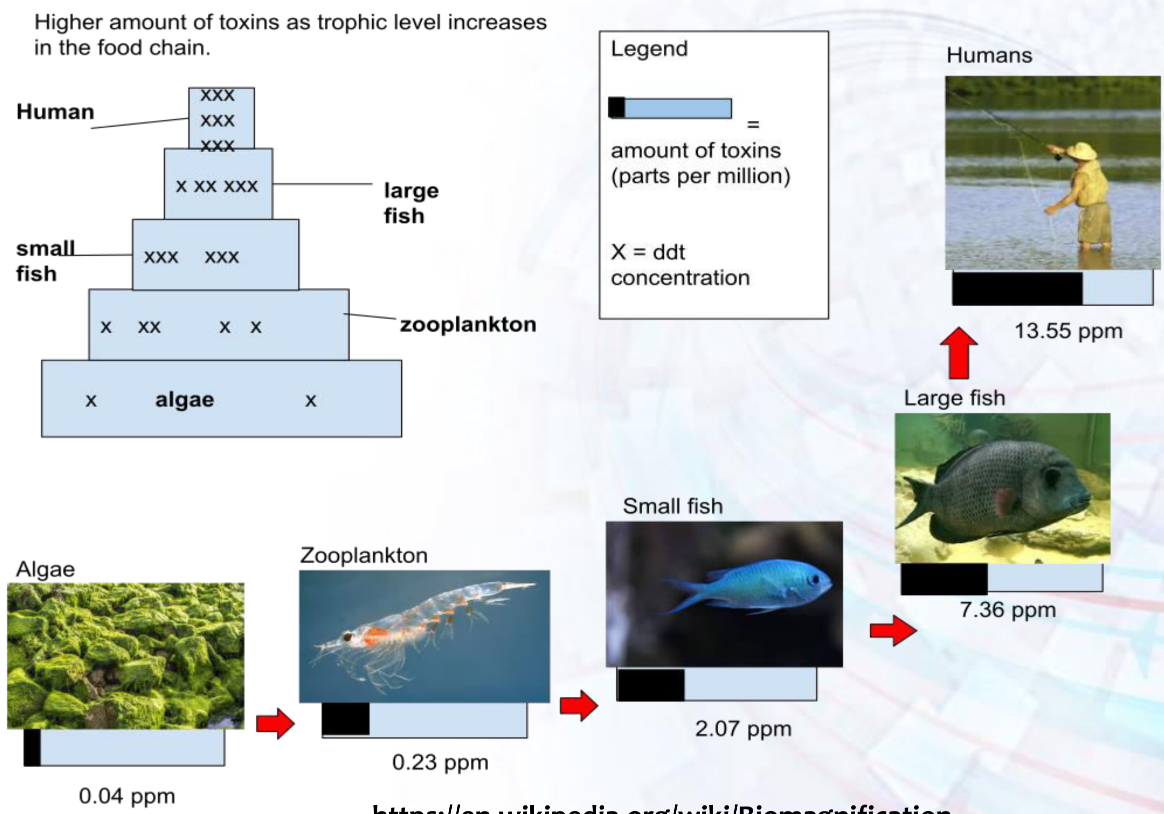
- Substance's concentration increases progressively as it moves up a food chain

Biomagnification

3. Low or non-existent rate of internal degradation or excretion of the substance

- often due to water insolubility

Biomagnification



https://en.wikipedia.org/wiki/Biomagnification

Biomagnification

- **Biomagnification**
- Occurs across trophic levels (food chain).
- **Bioaccumulation**
- Occurs within a trophic level
- Increase in the concentration of a substance in certain tissues of organisms' bodies due to absorption from food and the environment.

Biomagnification

- Bioconcentration
- Occurs when uptake from the water is greater than excretion

Biomagnification

Pollutants that undergo biomagnification

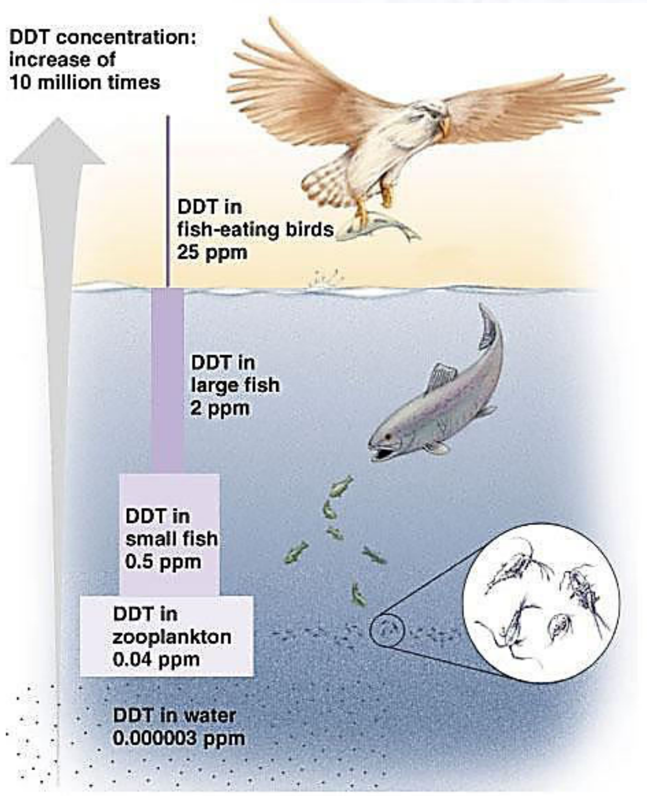
- DDT (dichlorodiphenyltrichloroethane)
- Hexachlorobenzene (HCB)
- PCBs (polychlorinated biphenyls)
- Toxaphene
- Monomethylmercury

Biomagnification

DDT (Case Study)

- Insecticide used to control malaria and typhus by killing mosquitoes and lice.
- Commonly used after WWII
- Inventor received Noble Prize
- Overused on crops as a pesticide
- Concentration of DDT increased 10 million times.

Biomagnification



http://www.cfkeep.org/html/stitch.php?s=89656982933378&id=34347859802049

Biomagnification

DDT (Problems)

- Egg shell thinning
- DDT interferes with metabolism of calcium
- Thin shells in predator birds such as osprey, bald eagles, brown pelicans
- Birds unable to incubate their eggs without breaking them.
- Acts as a hormone disrupter, mimics estrogen

Biomagnification

DDT (Problems)

- Has impacted sex ratio in some birds
- It has a half life of 15 year
- It takes 15yrs for its quantity to be ½ its original
- If we start with 100 kg, we will still have ~ 1 kg after 100 years.

Biomagnification

END

DDT (Problems)

- Banned in US in 1972
- Still used overseas to prevent malaria especially in Africa
- It saves millions of lives annually in Africa.

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Type of Wastewater

Wastewater

- Humans capture and divert a lot of the water for agriculture, industrial and municipal use.
- After the water is used, it is returned to the environment in a different condition, usually as dirty water (wastewater).

Type of Wastewater

- Wastewater is any water that has been affected by human use.
- Wastewater is "used water" from these sources:
- Domestic, industrial, commercial or agricultural activities
- Surface runoff
- Storm water
- Sewer inflow or sewer infiltration

Type of Wastewater

Components

- Pathogens
- Salts
- Acids
- Bases
- Metals
- Toxic inorganic compounds
- Organic matter
- Suspended solids

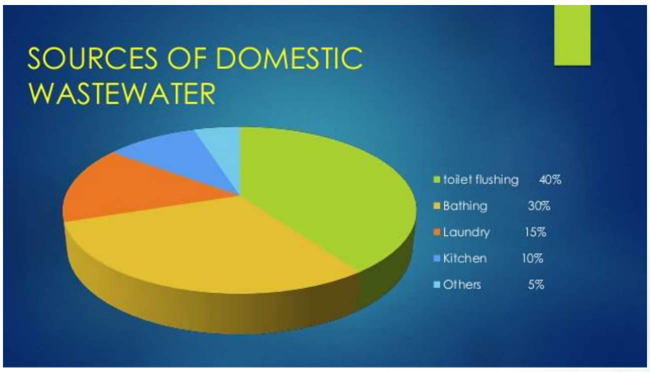
Type of Wastewater

- Types

1. Domestic wastewater from households
2. Municipal wastewater from communities (also called sewage)
3. Industrial wastewater from industrial activities
4. Agricultural wastewater from agricultural activities
5. Storm water

Type of Wastewater

Domestic wastewater



https://www.google.com/search?q=domestic+waste+water&rlz

- Flush toilets
- Sinks
- Dishwashers
- Washing machines
- Bath tubs
- Showers

Type of Wastewater

Municipal wastewater

- Residential
- Shops
- Houses
- Offices
- Schools
- Hospitals
- Motor service stations
- Others

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Type of Wastewater

https://en.wikipedia.org/wiki/Wastewater

Industrial wastewater

- Huge water use in industrial activities
- Every industry uses water for chemical or physical processes.
- Quantity and quality depends on the type of industry.

Industrial waste is the **waste** produced by **industrial** activity which includes any material that is rendered useless during a manufacturing process such as that of factories, **industries**, mills, and mining operations.

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Type of Wastewater

https://en.wikipedia.org/wiki/Wastewater

Agricultural wastewater

- Irrigation
- Livestock watering and cleaning
- Aquaculture
- 69% to 90% of global fresh water use in agriculture
- Bulk of it is returned to the soil, waterways or discharged with added nutrients and contaminants

Type of Wastewater

https://en.wikipedia.org/wiki/Wastewater

Storm wastewater

- Rainfall that flows over the ground surface
- It is created when rain falls on roads, driveways, parking lots, rooftops and other paved surfaces that do not allow water to soak into the ground.
- Stormwater runoff is the number one cause of stream impairment in urban areas.

Type of Wastewater

Classification on basis of contamination

- Gray water
- Black water

Black Water: This is wastewater that originates from toilet fixtures, dishwashers, and food preparation sinks. It is made up of all the things that you can imagine going down the toilets, bath and sink drains. They include poop, urine, toilet paper and wipes; body cleaning liquids, anal cleansing water and so on. They are known to be highly contaminated with dissolved chemicals, particulate matter and is very pathogenic

Gray Water: This is wastewater that originates from non-toilet and food fixtures such as bathroom sinks, laundry machines, spas, bathtubs and so on. Technically it is sewage that does not contain poop or urine. Gray water is treated very differently from Black water and is usually suitable for re-use.

Yellow Water: This is basically urine collected with specific channels and not contaminated with either black water or gray water.

Type of Wastewater

Gray water

- Generated in households or office buildings from streams other than toilets
- Contains fewer pathogens
- Easier to treat and reuse onsite for:
- Toilet flushing
- Landscape or crop irrigation
- Other non-potable uses

Type of Wastewater

Black water

- Generated in toilets
- Contains pathogens
- Contain feces, urine, water and toilet paper from flush toilets
- Difficult to treat and recycle

END

Impacts of Wastewater on Environment

- All types of wastewater act as pollutant.
- Negative impacts on environment
- Industrial effluents may contain acids, alkalis, salts, poisons, oils and in some cases harmful bacteria.
- Mines, especially gold and coal mines, are responsible for large quantities of acid water.

Impacts of Wastewater on Environment

- Agricultural pesticides, fertilizers and herbicides may wash into rivers and stagnant water bodies.
- Sewage as well as domestic and farm wastes were often allowed to pollute rivers and dams.

Impacts of Wastewater on Environment

http://youtube.com/watch?v=fzRQkPPkuLU

Impacts of Wastewater on Environment

Non-persistent (degradable) Pollutants

- Domestic sewage
- Fertilizers
- Some industrial wastes
- Disease causing microbes
- These can be broken down by chemical reactions or by natural bacteria.

Impacts of Wastewater on Environment

Non-persistent (degradable) Pollutants

- Product of break down will be non-polluting substances such as carbon dioxide and nitrogen.
- If the pollution load is high, this process can lead to low oxygen levels and eutrophication.
- This damage is reversible.

Impacts of Wastewater on Environment

Persistent Water pollutants

- Some pesticides (DDT, dieldrin)
- Some leachate components from landfill sites (municipal, industrial)
- Petroleum and petroleum products (oil pollution)
- Heavy metals such as lead, mercury, cadmium

Impacts of Wastewater on Environment

Persistent Water pollutants

- Radioactive materials such as strontium-90, cesium-137, radium-226, and uranium
- High risk to the health of organisms
- Disturbance of food chain by affecting certain trophic levels

Impacts of Wastewater on Environment

Persistent Water pollutants

- This includes substances that degrade very slowly or cannot be broken down at all.
- They may remain in the aquatic environment for years or longer periods of time.
- The damage they cause is either irreversible or repairable only over decades or centuries.

END

Treatment of Wastewater - 1

Septic Tanks

- Bacteria in sewage degrade organic matter
- Tank buried in ground to treat sewage from an individual home
- Wastewater flows into tank
- Solid material ("sludge") settles to bottom of tank

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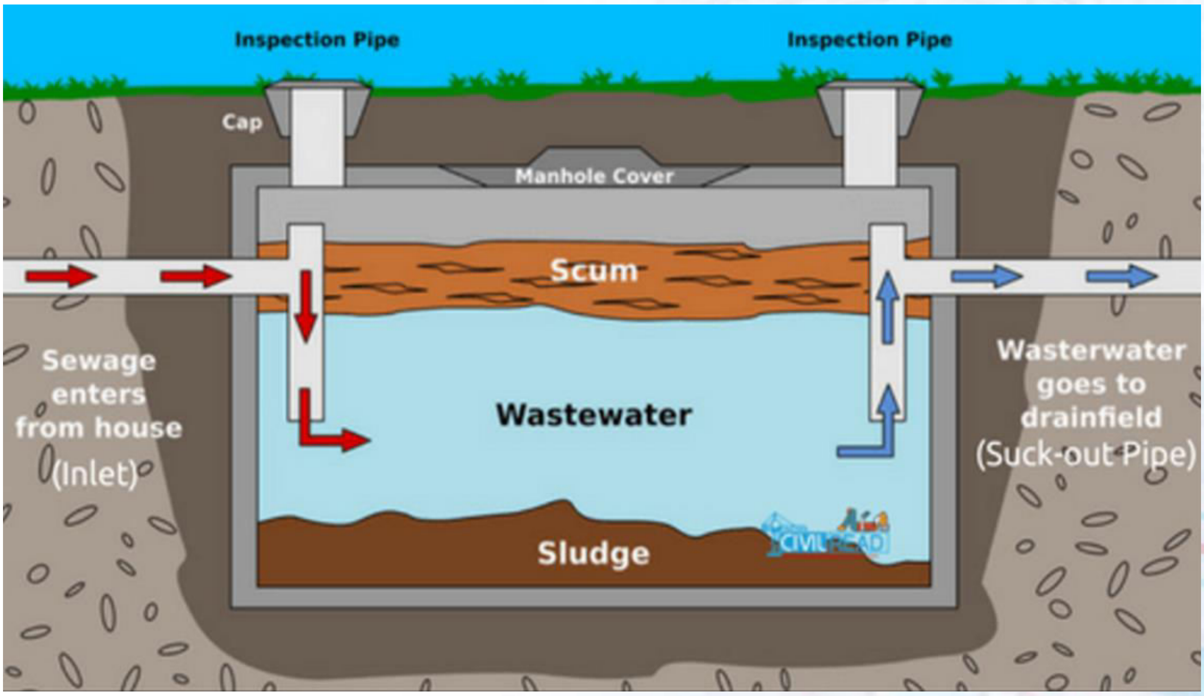
Treatment of Wastewater - 1

Septic Tanks

- Clean water flows out of tank into ground through subsurface drains

Treatment of Wastewater - 1



http://www.watsantraining.com/blog/106-components-and-design-of-a-septic-tank

Treatment of Wastewater - 1

Lagoons (Stabilization Ponds)

- 3-5’ deep
- Sunlight, algae, oxygen interact to clean wastewater

Conventional Sewage Treatment

- Processes

1. Collection
2. Treatment

Treatment of Wastewater - 1

Conventional Sewage Treatment

Collection

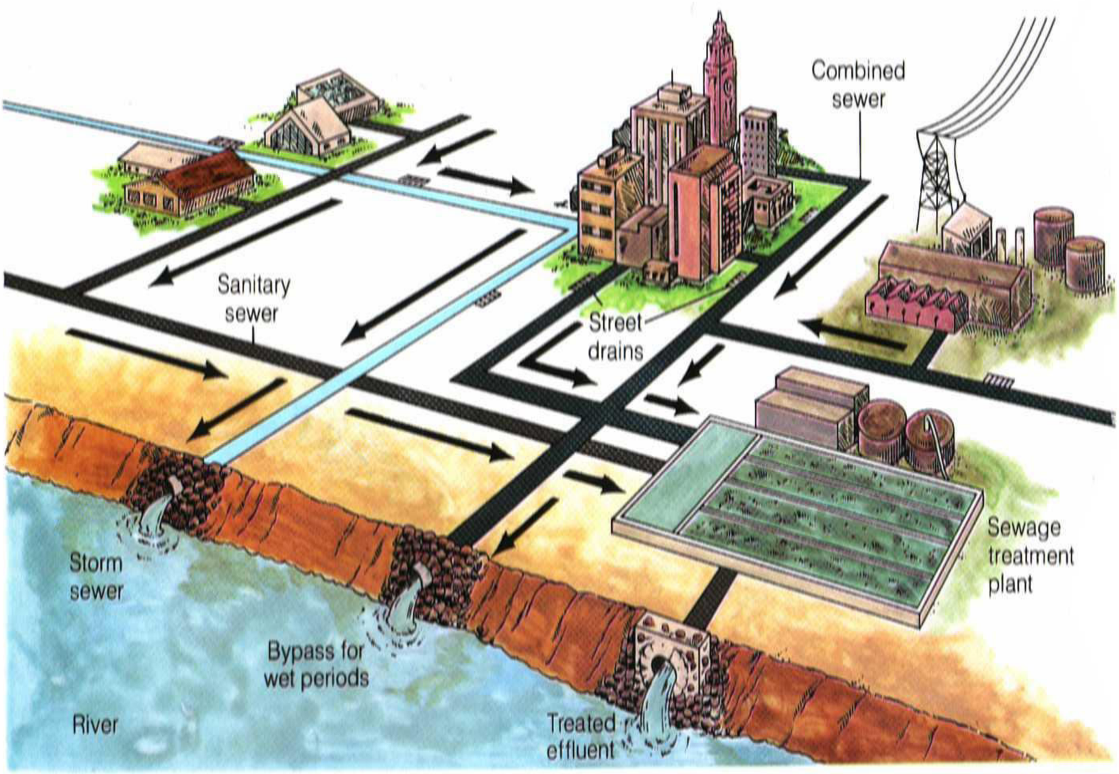
- Combined Sewers

Carry stormwater and wastewater

- Separated Sewers

1. Sanitary Sewers
2. Storm Sewers

Treatment of Wastewater - 1



Treatment of Wastewater - 1

Conventional Sewage Treatment

Processes

1. Primary
2. Secondary
3. Advanced

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Treatment of Wastewater - 1

Primary Treatment

- Mechanical process
- Screening
- Grinding
- Grit Chamber (heavy particles - “grit”)
- Sedimentation Tank (suspended solids - “sludge”)
- Chlorination of effluent

Treatment of Wastewater - 1

Secondary Treatment

- Biological process
- Uses bacteria to remove organic matter dissolved in water (ODW) and lower BOD

Types

- Trickling Filter
- Activated Sludge

Treatment of Wastewater - 1

http://youtube.com/watch?v=QoBLswO6xhk

Treatment of Wastewater - 1

Secondary Treatment

- Secondary Treatment With Trickling Filters
- Effluent leaves sedimentation tank and flows through trickling filters
- Bed of stones 3-10’ deep through which sewage passes

Treatment of Wastewater - 1

Secondary Treatment

- Bacteria gather on stones and multiply, consuming ODW
- Cleaner water trickles through pipes at bottom of filter for additional treatment

END

Treatment of Wastewater

Secondary Treatment

- Secondary Treatment With Activated Sludge
- Effluent leaves sedimentation tank and is pumped to an aeration tank
- Effluent is mixed with air and sludge loaded with bacteria ("activated sludge")

Treatment of Wastewater

Secondary Treatment

- Sludge contacts with raw sewage, and bacteria in the sludge then decompose the raw sewage, lowering ODW and BOD

Treatment of Wastewater

Secondary Treatment

- Activated sludge-sewage mixture is called mixed liquor
- Mixed liquor leaves aeration tank
- Flows to another sedimentation tank where suspended solids settle out for reuse as activated sludge

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Treatment of Wastewater

Secondary Treatment

- Effluent is chlorinated
- Activated sludge in sedimentation tank is reused

Treatment of Wastewater

Advanced Tertiary Treatment

- Physical and chemical processes that specific pollutants left in wastewater after primary and secondary treatment
- Extremely costly
- It cost twice as much to build a secondary treatment plant

Treatment of Wastewater

Advanced Tertiary Treatment

- Bleaching to remove coloration
- Disinfection to kill pathogens
- Coagulation-sedimentation with alum
- Adsorption using activated charcoal
- Electrodialysis for salt removal

Treatment of Wastewater

http://youtube.com/watch?v=20Xk2XfDhuY

Conservation of Endangered Species

- Preserving populations and species in danger of decline or extinction
- There should be something left to be conserved.

Conservation of Endangered Species

Pristine Restoration

- In ecosystems where all species have been effectively removed
- Conservationists might attempt to restore the plants and animals that are the natural inhabitants of the area
- If these species can be identified.

Conservation of Endangered Species

Pristine Restoration

- Focus is on reconstructing the processes that operated in the natural habitat.

Conservation of Endangered Species


a.


b.

The University of Wisconsin–Madison Arboretum has pioneered restoration ecology.

a. The restoration of the prairie was at an early stage in November 1935.

b. The prairie as it looks today. This picture was taken at approximately the same location as the 1935 photograph

Conservation of Endangered Species

Removing introduced species

- Sometimes the habitat has been destroyed by a single introduced species.
- In such a case, habitat restoration involves removing the introduced species.
- It is important to act quickly if an introduced species is to be removed.

Conservation of Endangered Species

Cleanup and Rehabilitation

- Habitats are seriously degraded by chemical pollution.
- They cannot be restored until the pollution is cleaned up.
- Example: Nashua River in New England
- Cleaned up after being heavily polluted by dye plants.

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Conservation of Endangered Species

Captive Breeding Programs

- Recovery programs
- Particularly focused to on one or a few species
- Sometimes involve direct intervention in natural populations to avoid an immediate threat of extinction.
- It might be successful or failed effort.

Conservation of Endangered Species

State Symbols USA

Captive Breeding Programs

- The Hawaiian goose was practically extinct in the wild
- 12 birds were taken into captivity
- A population of 9000 was released back into the wild
- The rats eat the eggs and the nestlings of the geese.

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Conservation of Endangered Species

America Zoo

Captive Breeding Programs

- Pere David's deer was a native species of China
- In 1865, 18 were taken into zoological collections
- Meanwhile it became extinct in the wild
- By 1981 there were 994 individuals scattered through zoological collections.

Conservation of Endangered Species

National Parks

- First the area that is suitable for the creation of a reserve has to be identified and delimited.
- This requires surveys to collect data on key species.
- Property may have to be expropriated.
- A legal framework may need to be set up to control human activities in the area.

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Conservation of Endangered Species

National Parks

- If part of the area has been degraded due to bad land use it may need restoring.
- Alien species that have penetrated the area may need excluding or eliminating.

Conservation of Endangered Species

National Parks

- Constant management will be needed to maintain the habitat of the species being conserved.
- This may mean arresting natural succession.
- Examples in Pakistan

1. Hingol national park
2. Kirthar national park
3. Chitral national park

Conservation of Endangered Species

Hingol National Park

http://youtube.com/watch?v=56SXB2sScAE

Evolution

- Change in the heritable characteristics of biological populations over successive generation
- These characteristics are the expressions of genes.
- Which are passed on from parent to offspring during reproduction.
- Variations come from evolution and causes biodiversity.

Evolution

History of Evolution

1. Classical
2. Medieval
3. Pre-Darwinian
4. Darwinian Revolution
5. Modern Synthesis

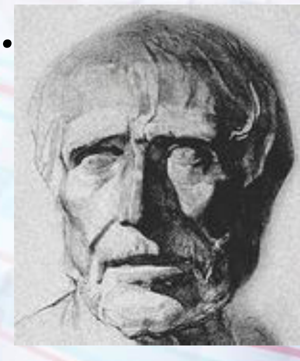
Evolution

History of Evolution

1. Classical

- All living things were related and that they had changed over time.
- One type of organism could descend from another type.

Lucretius



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Evolution

History of Evolution

2. Medieval

- Fixed natural possibilities
- Life forms are fixed
- Aristotle added that new types of living things could come to be.

Aristotle

Evolution

History of Evolution

3. Pre-Darwinian Period

- Began in 17th century
- Explanation of natural phenomena in terms of physical laws
- John Ray introduced the term "Species"
- Linnaeus in 1735 explicitly recognized the hierarchical nature of species relationships.

Evolution

Buffon

Linnaeus

Lamarck

https://en.wikipedia.org/wiki/Evolution#History_of_evolutionary_thought

History of Evolution

3. Pre-Darwinian Period

- Introduction of five kingdom classification
- Buffon suggested that species could degenerate into different organisms.
- Erasmus Darwin proposed that all warm-blooded animals could have descended from a single microorganism.

Evolution

History of Evolution

3. Pre-Darwinian Period

- First evolutionary scheme was proposed by Jean-Baptiste Lamarck in 1809.
- He proposed the theory of changes/mutations over the time.
- It was a break from the concept of fixed creation but faced strong resistance.

Evolution

Malthus

Darwin

https://en.wikipedia.org/wiki/Evolution#History_of_evolutionary_thought

History of Evolution

4. Darwinian Revolution

- Malthus (1798) proposed that population growth creates a struggle for resource.
- Darwin influenced by Malthus's ideas, proposed the ground breaking "Theory of natural selection" in 1859.

Evolution

History of Evolution

4. Darwinian Revolution

- Huxley applied Darwin's ideas to humans, using paleontology and comparative anatomy.
- Gregor Mendel proposed the laws of genetics in 1865.
- Weismann made the important distinction between germ cells and somatic cells.

Evolution

History of Evolution

4. Darwinian Revolution

- He demonstrated that heredity passes through the germ line only.
- De Vries proposed that hereditable material is in nucleus and transferred to cytoplasm.

Evolution

History of Evolution

5. Modern Synthesis

- It connected natural selection and population genetics, based on Mendelian inheritance, into a unified theory that applied generally to any branch of biology.
- Watson & Crick model of DNA in 1953.

Evolution

- Evidences of evolution are based upon:

1. Biogeography
2. Paleontology
3. Comparative Anatomy
4. Molecular Biology

END

Evolution

Biogeography

- Study of the geographic distribution of plants and animals
- Study the life-forms in different parts of the world have distinctive evolutionary histories
- Geographical regions have characteristic biotas.

Evolution

Biogeography

- Closely related taxa tend to be closer together than more distantly related groups.
- Similar environments are found in different areas but the same species may not be found in all places where they could be

Evolution

Biogeography

- Not closely related species in similar environments may appear similar due to convergence.

Evidences

1. Regions with identical climate have different floras and faunas (Buffon's Law).

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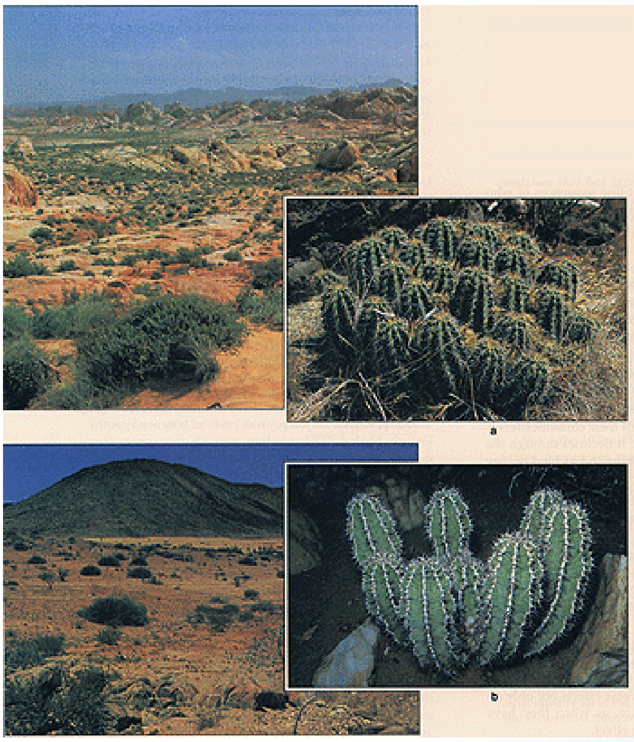
Evolution

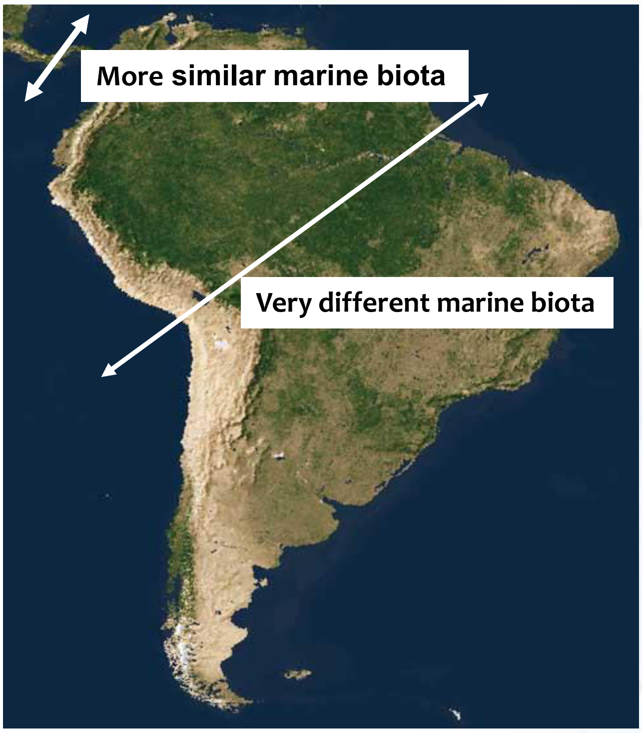


Courtesy of K.J. Sytsma

Cactaceae in North American deserts

Euphorbiaceae in southern African deserts

Evolution

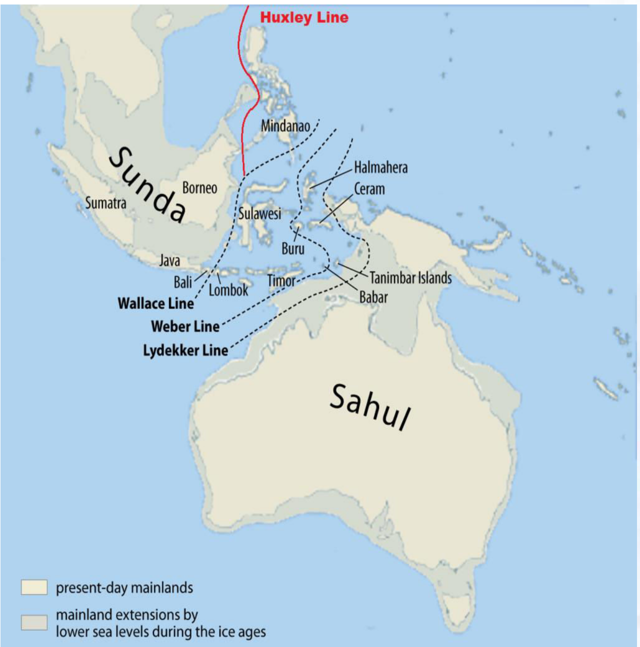


https://en.wikipedia.org/wiki/Biogeography

Biogeography

2. Geographic barriers closely associated with breaks between taxonomic groups.

Evolution



https://en.wikipedia.org/wiki/Wallace_Line

Biogeography

3. Within a region, organisms are often closely related

- Across environmental gradients and lower taxonomic groups often show narrower distributions than higher.

Evolution

Biogeography

Disjunct Distribution

- A taxon with a disjunct distribution is one that has two or more groups that are related but considerably separated from each other geographically.
- Barriers

Evolution

Biogeography

Disjunct Distribution

- Physical barriers
- Climatic barriers
- Biological barriers

Evolution

Biogeography

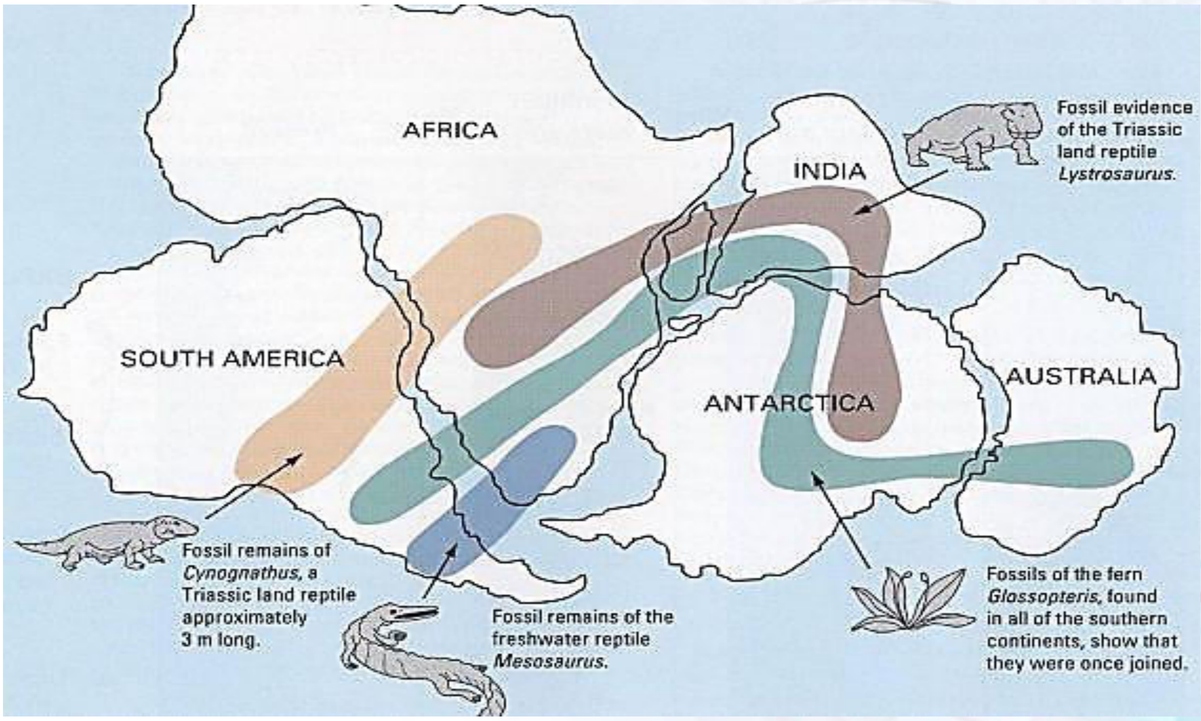
Plate Tectonics

Glossopteris Permian – "fern"
Mesosaurus – Freshwater Permian Reptile

Cynognathus – Triassic land reptile

Lystrosaurus – Triassic land reptile

Evolution



https://www.google.com/search?q=plate+tectonics+and+dinosaurs+distribution

Evolution & Paleontology

- Paleontology is the study of fossils.
- It provides some of the most direct evidence for evolution.
- Fossils (to dig) are evidence of plants and animals that existed in the past and have become incorporated into the earth's crust.

ClluesBook.com

Evolution & Paleontology

- Nicolas Steno (1638-86) Father of geology and stratigraphy

https://en.wikipedia.org/wiki/Nicolas_Steno

Evolution & Paleontology

James Hutton

- Evolution of earth must be old .
- Observable processes produce small changes that accumulate over time

William Smith

- Different rock layers contain distinct fossils

Evolution & Paleontology

https://en.wikipedia.org/wiki/Fossil

Fossil

- Any preserved remains, impression, or trace of any once-living thing from a past geological age.

Examples: Bones, shells, exoskeletons, stone imprints of animals or microbes, objects preserved in amber, hair, petrified wood, oil, coal, and DNA remnants

Evolution & Paleontology

- Emerging field of geology lead to a new concept of the age of the Earth.
- The history of the earth extends back through vast time periods.
- The processes at work today are the same as those that have been operating throughout the entire history of Earth.

Evolution & Paleontology

These concepts became known as:

Uniformitarianism or Actualism

- Georges Cuvier (1769-1832) proposed that:
- Fossils resemble but are not exactly the same as modern species
- Many past species are extinct

Evolution & Paleontology

- Mary Anning (1799 – 1847) discovered several marine fossils of Jurassic period.
- Darwin proposed his theory of natural selection based upon evidences from fossil record.
- Fossils provide the missing links between ancestor and descendants.

ClusBook.com

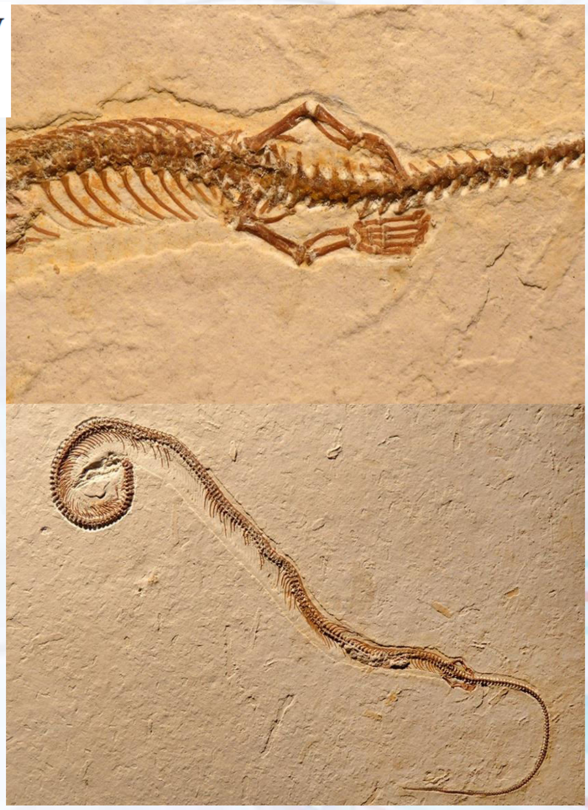
Evolution & Paleontology

A four-legged snake from the Early Cretaceous of Gondwana

David M. Martill,[1] Helmut Tischlinger,[2] Nicholas R. Longrich[3]

24 JULY 2015 • VOL 349 ISSUE 6246
sciencemag.org SCIENCE

Finding Missing Links in the Fossil Record



Evolution & Comparative Anatomy

- Comparative anatomy is the study of similarities and differences in the anatomy of different species.
- It is closely related to evolutionary biology and phylogeny (the evolution of species).

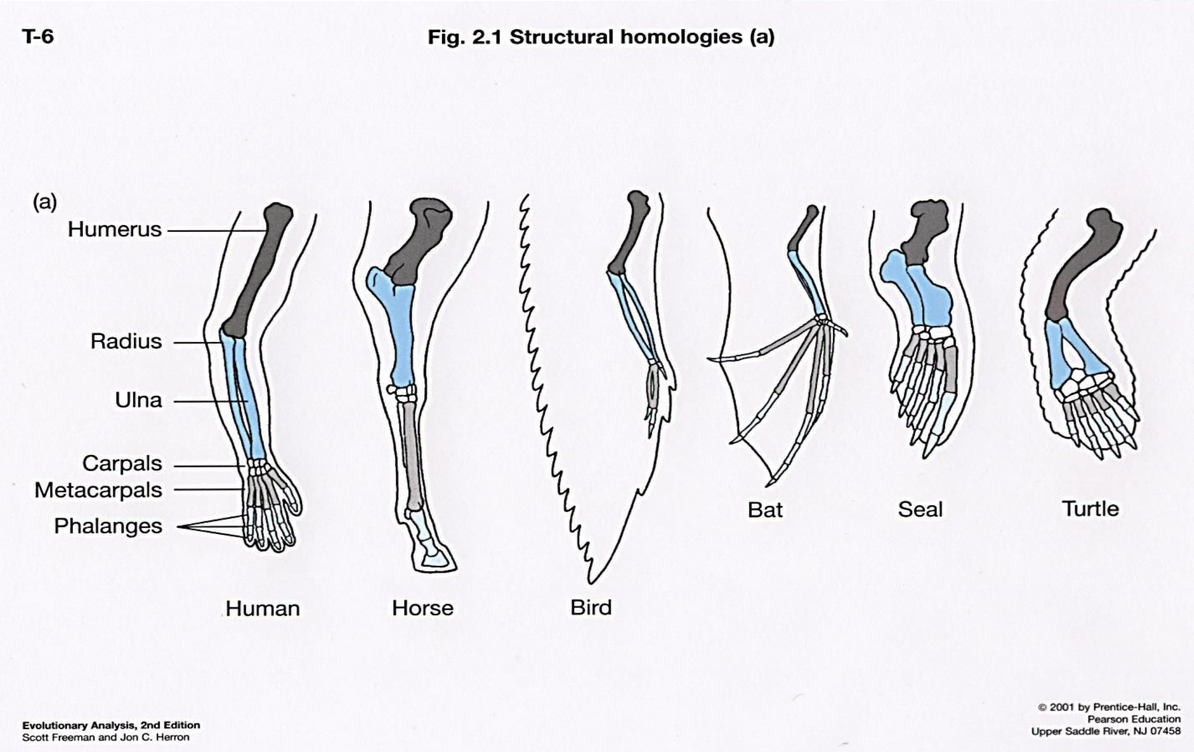
ClluesBook.com

Evolution & Comparative Anatomy

Homology and Common Descent

- Divergent evolution
- Existence of shared ancestry between a pair of structures, or genes, in different taxa
- Once related lineages are reproductively isolated, evolution can lead to modifications of the basic plan.
- Forelimbs of vertebrates

Evolution & Comparative Anatomy



https://en.wikipedia.org/wiki/Homology_(biology)

Evolution & Comparative Anatomy

Homology and Common Descent

- Evolution can be viewed as a series of bifurcations in a phylogenetic tree.
- All life can be traced back to a common ancestor.

Evolution & Comparative Anatomy

Analogy

- Convergent Evolution
- Independent evolution of similar features in species of different lineages
- Creates analogous structures that have similar form or function but were not present in the last common ancestor of those groups

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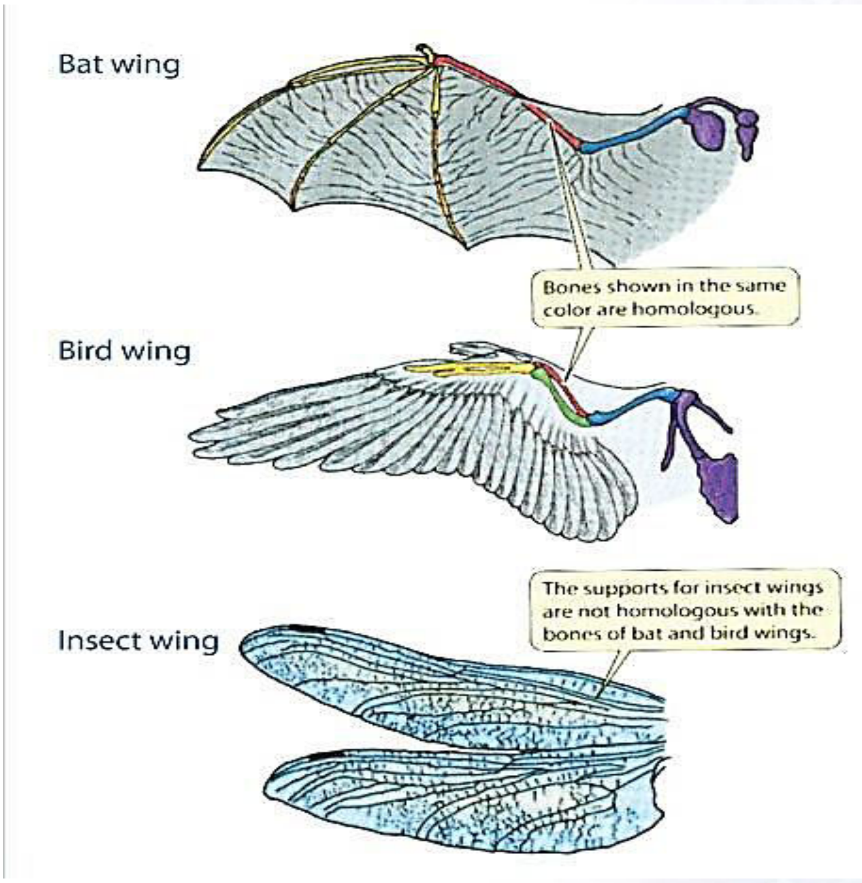
Evolution & Comparative Anatomy



https://en.wikipedia.org/wiki/Convergent_evolution#Flight

Evolution & Comparative Anatomy

Vestigial Organs

- Retention during the process of sexual reproduction of genetically determined structures or attributes
- That have lost some or all of their ancestral function in a given species.

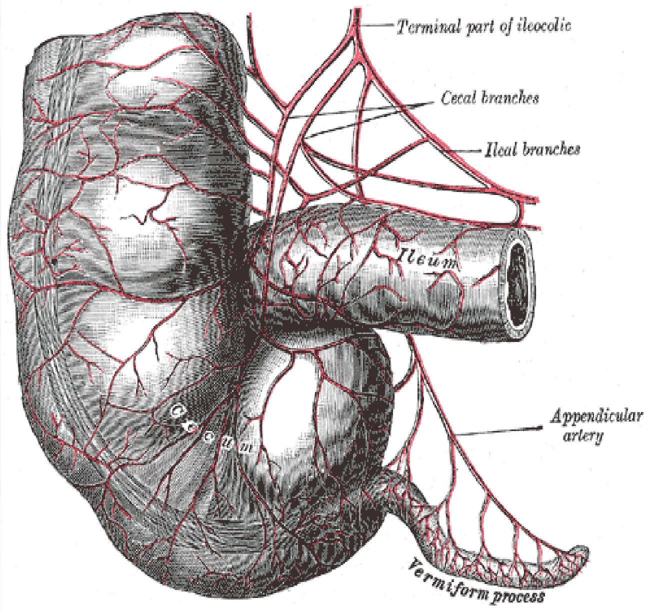
Evolution & Comparative Anatomy

Vestigial Organs

- Vestigiality is loss of feature due to loss of its value in changed environment.

Evolution & Comparative Anatomy

- The human vermiform appendix on the vestigial caecum.



https://en.wikipedia.org/wiki/Human_vestigiality#/media/File:Gray536.png

Evolution & Comparative Anatomy

- Vestigial hind limbs in boa constrictor

https://en.wikipedia.org/wiki/Vestigiality#/media/File:Rudimentary_hindlegs_spurs_in_Boa_constrictor_snake.jpg

Evolution & Comparative Anatomy

- Blind cave fish has no eye
- Genes for functional eyes are still in their DNA

https://www.google.com/search?q=blind+cave+fish

END

Evolution & Molecular Biology

- Molecular biology has yielded a wealth of information on evolutionary relationships.
- Related animals have similar DNA derived from their common ancestor.
- Molecular biologists can estimate the elapsed time since divergence from a common ancestral molecule by looking for:

Evolution & Molecular Biology

1. Extraction and analysis of the structure of proteins from animal tissue, and compare the DNA of different animals
2. Dissimilarities in the structure of related proteins and DNA
3. By assuming relatively constant mutation rates

Evolution & Molecular Biology

Second letter

First letter	U	C	A	G	Third letter
U	UUU UUC } Phe UUA UUG } Leu	UCU UCC UCA UCG } Ser	UAU UAC } Tyr **UAA Stop** **UAG Stop**	UGU UGC } Cys **UGA Stop** UGG Trp	U C A G
C	CUU CUC CUA CUG } Leu	CCU CCC CCA CCG } Pro	CAU CAC } His CAA CAG } Gln	CGU CGC CGA CGG } Arg	U C A G
A	AUU AUC AUA } Ile **AUG Met**	ACU ACC ACA ACG } Thr	AAU AAC } Asn AAA AAG } Lys	AGU AGC } Ser AGA AGG } Arg	U C A G
G	GUU GUC GUA GUG } Val	GCU GCC GCA GCG } Ala	GAU GAC } Asp GAA GAG } Glu	GGU GGC GGA GGG } Gly	U C A G

https://www.google.com/search?q=genetic+code&rlz

Genetic code of mRNA is universal.

Evolution & Molecular Biology

END

- Sequencing of DNA and proteins help to accurately locate the similarities between different taxa.
- Transplantation of lost genes and other techniques like cloning help to understand evolution better.

Lamarckism

- Jean Baptiste LAMARCK 1744 – 1829
- Lamarck rejected fixity
- He proposed a theory of evolution which is attractive.

https://en.wikipedia.org/wiki/Lamarckism

Lamarckism

- However, it was eventually rejected because of the way inheritance works.
- But it is still considered a breakthrough.
- Theory of “inheritance of acquired characteristics or soft inheritance”

Lamarckism

- Lamarck noticed that organisms adapted to a particular niche had well developed specialized organs
- For example a carnivore will have long canine teeth to grip its prey.
- Small non-functional organs (vestigial organs)

Lamarckism

- e.g. the appendix in humans, the internal hind limbs of whales and the internal legs of some species of snakes
- Comparative anatomy showed that these organs resembled those which were much more developed, with particular functions, in other species

Lamarckism

The Law of Use and Disuse

- He proposed that if an organ is used a lot it will develop and strengthen.
- If it is not used it will atrophy.
- He called this the law of use and disuse.

Lamarckism

The Inheritance of Acquired Characteristics

- If an organism developed a characteristic feature through adapting to a new way of life during its lifetime, it would pass this on to its offspring
- The classic example given is that of the giraffe's neck.

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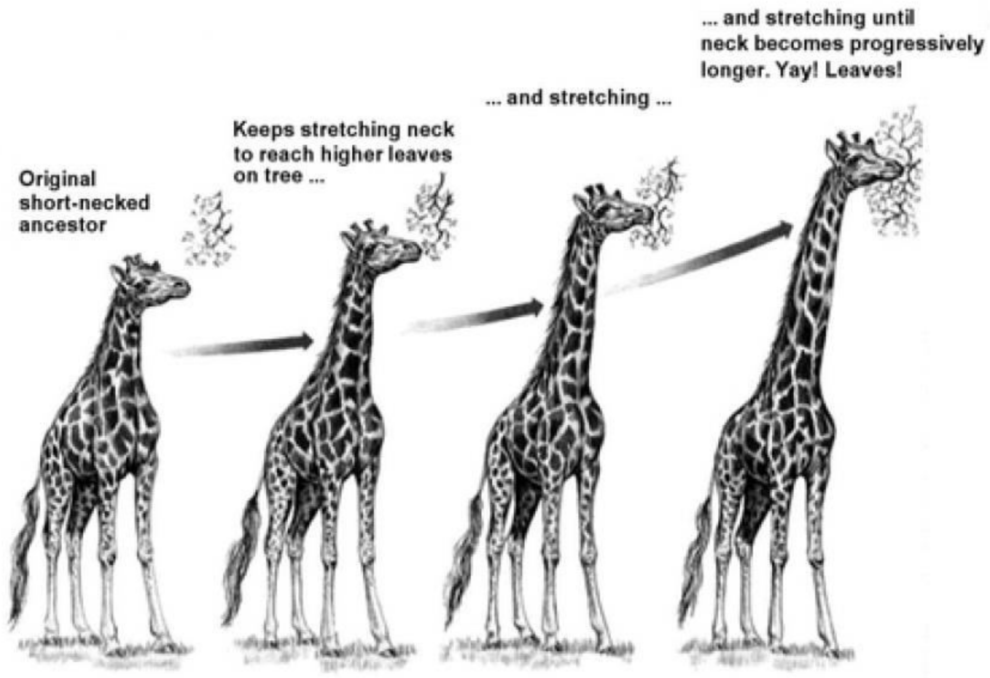
Lamarckism

The Inheritance of Acquired Characteristics

- As the giraffe's ancestors searched for a richer food supply they stretched to reach higher branches in trees.
- Thus their stretched bodies were passed onto their offspring.

Lamarckism

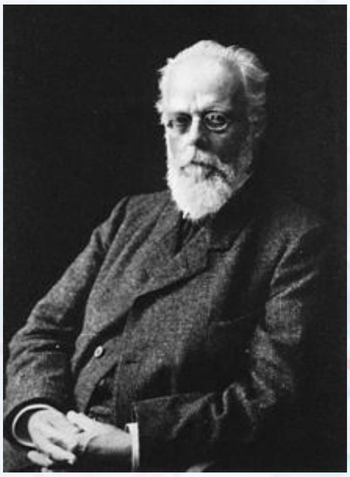


https://en.wikipedia.org/wiki/Lamarckism Lamarck's Giraffe

Lamarckism

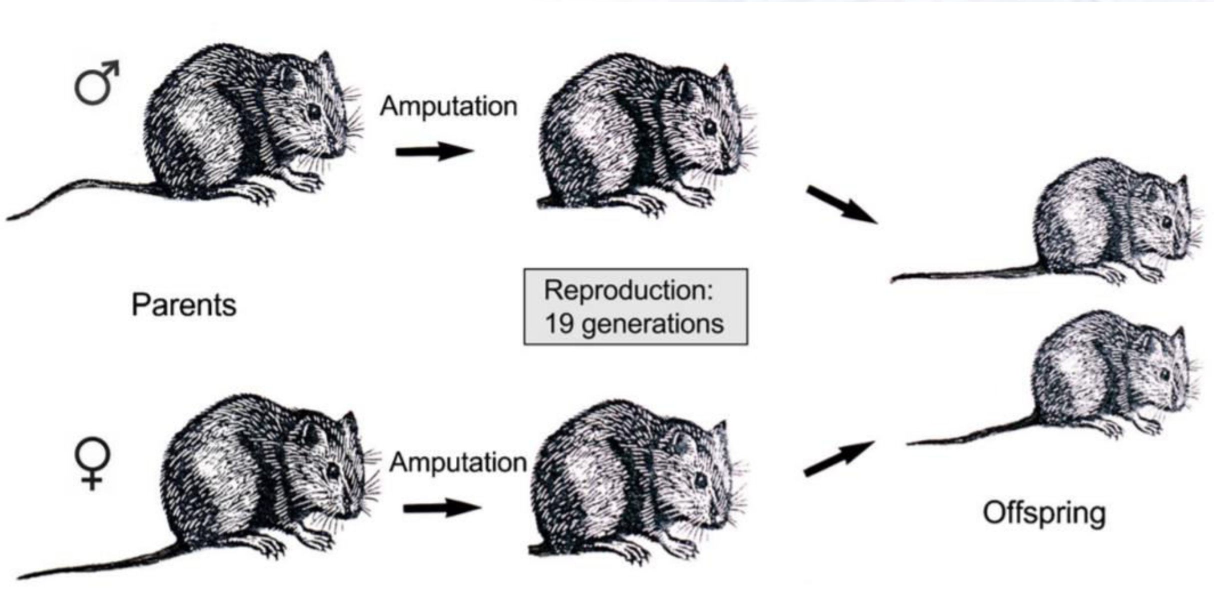
Rejection of Lamarckism

- Weismann's theory of germ plasm (1896–1910)



https://en.wikipedia.org/wiki/August_Weismann

Lamarckism



https://en.wikipedia.org/wiki/August_Weismann

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Lamarckism

Rejection of Lamarckism

- Characteristics acquired during the lifetime of a parent are not passed onto the offspring.
- Changes only in the germ cells/DNA are transferred to next generation.
- Modern genetics confirmed germ plasm theory.

END

History of Darwin & Voyage

- Charles Robert Darwin (1809–1882) in England.

https://en.wikipedia.org/wiki/Natural_selection

History of Darwin & Voyage

- He joined school of medicine, Scotland in 1825 but he was not interested in being physician.
- Later he joined, Christ's College in Cambridge and graduated with honors in 1831.

History of Darwin & Voyage

- Instead of clergy training, he had been more involved in work of Cambridge's scientists, especially taxonomists.
- He made valuable contributions to beetle taxonomy.
- John Henslow nominated Darwin to serve as a naturalist on a mapping expedition that was to travel around the world.

ClueBook.com

History of Darwin & Voyage

http://youtube.com/watch?v=sOcQiljuTdg

History of Darwin & Voyage

- HMS Beagle set sail on December 27, 1831 on a 5-year voyage.
- Darwin helped with routine seafaring tasks and made numerous collections.
- Opportunity to explore tropical rain forests, fossil beds, the volcanic peaks of South America, and the coral atolls of the South Pacific.

ClueBook.com

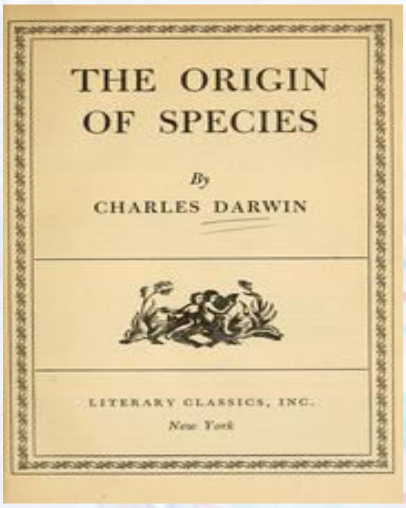
History of Darwin & Voyage

- Most importantly, Darwin spent 5 weeks on the Galápagos Islands.
- A group of volcanic islands 900 km off the coast of Ecuador
- Most revolutionary ideas came from his observations of plant and animal life on these islands.

History of Darwin & Voyage

END

- On his return, it took " him 22 years to publish his history changing book " Origin of Species" in 1859.



Evidences of Theory of Natural Selection - 1

- Darwin based his theory on many solid evidences from his observations and collected samples.
- Three major evidences:

1. Geology
2. Fossil Evidences
3. Galápagos islands

Evidences of Theory of Natural Selection - 1

Geology

- Darwin was impressed by Charles Lyell and James Hutton' s ideas of geology.
- Theory of uniformitarianism

Theory states:

- Changes in the earth's crust throughout history have resulted from the action of uniform, continuous processes.

Evidences of Theory of Natural Selection - 1

Geology

- Theory of uniformitarianism planted two ideas in Darwin's mind:

(1) The earth could be much older than 6,000 years.

(2) If the face of the earth changed gradually over long periods, living forms also change during that time?

Evidences of Theory of Natural Selection - 1

Geology

- Gradual changes over the time with changing environment was foundation of theory of natural selection.

END

Evidences of Theory of Natural Selection - 2

Fossil Evidences

- Digging in riverbed of Pampas in Argentina
- Most of evidences of theory came from fossils
- He found fossil of:
- Extinct hippopotamus like animal, now called Toxodon
- Horselike animal, Thoantherium

Evidences of Theory of Natural Selection - 2

Toxodon

Thoantherium

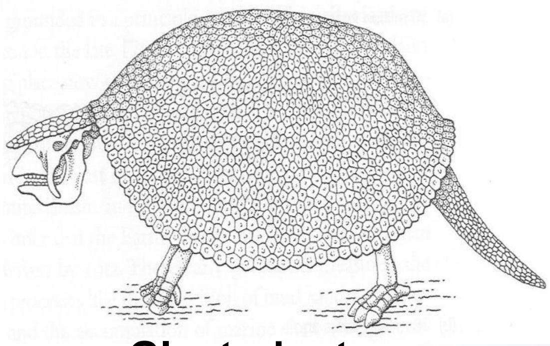
https://www.khanacademy.org/partner-content/amnh/human-evolutio/

- Extinct hippopotamus like animal, now called Toxodon
- Horselike animal, Thoantherium

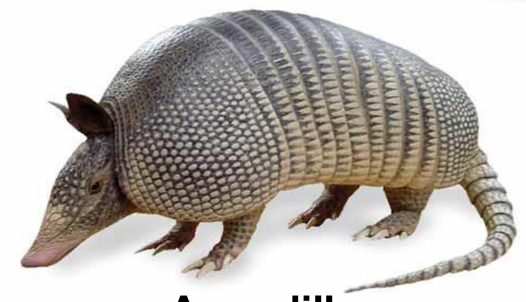
Evidences of Theory of Natural Selection - 2

- Horses had been present and had become extinct long ago in S. America.
- They were introduced in 1500.
- There was sudden extinction without leaving descendant species.

Evidences of Theory of Natural Selection - 2



Glyptodonts



Armadillo

https://www.khanacademy.org/partner-content/amnh/human-evolutio/

- Giant extinct armadillo and present descendants
- Except for their large size, these fossils were very similar to forms Darwin found living in the region.
- Why would fossil remains and modern species found on the same continent resemble each other so closely?

Evidences of Theory of Natural Selection - 2

Greater Rhea

Darwin's Rhea

https://en.wikipedia.org/wiki/Darwin%27s_rhea

- One species is replaced by an "allied" species geographically.
- Rhea in N. Argentina
- Replaced in south of the Rio Negro by a smaller, browner Rhea.

Evidences of Theory of Natural Selection - 2

He concluded:

- Some species became extinct without leaving any descendants.
- Others became extinct, but not before giving rise to new species.
- Recent fossils are closely related to extant species.
- Adjacent layers in the fossil record contain similar organisms.

END

Evidences of Theory of Natural Selection - 3

Galápagos Islands

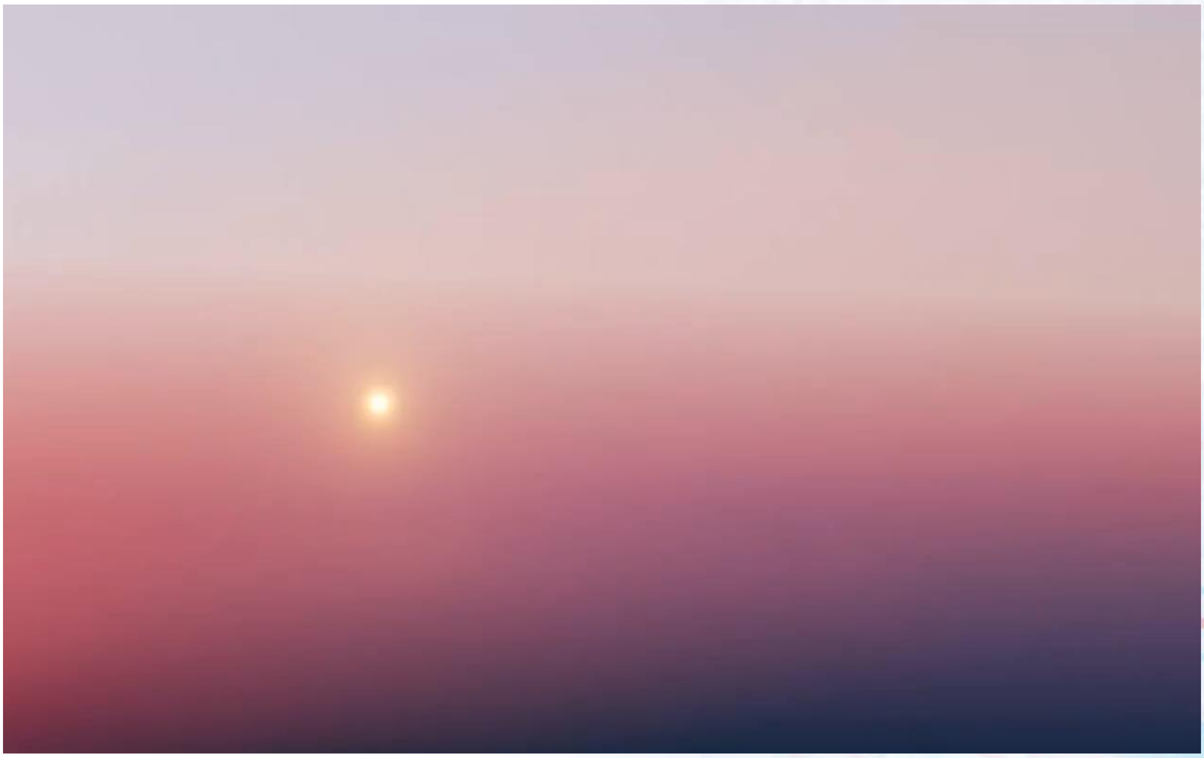
- Which are named after the large tortoises that inhabit them (Sp. galápago, tortoise)
- Darwin noticed that shapes of the tortoise shells from different parts of same Island differed.

Evidences of Theory of Natural Selection - 3

Galápagos Islands

- **Tortoises from the drier regions had longer necks than tortoises from wetter habitats.**
- **However, Islands's tortoises were quite similar to each other and to the tortoises on the mainland of South America.**

Evidences of Theory of Natural Selection - 3



http://youtube.com/watch?v=ZbITQ0dqxCQ

Evidences of Theory of Natural Selection - 3

Galápagos Finches

- Their similarities suggestive of common ancestry
- Chance arrival of a few finches probably set up the first bird populations on the islands.
- Early finches encountered habitat without other birds or predators.

Evidences of Theory of Natural Selection - 3

Galápagos Finches

- They were seed eaters and filled seed bearing habitats.
- 14 species of finches arose from this ancestral group.
- Each species is adapted to a specific habitat on the islands.

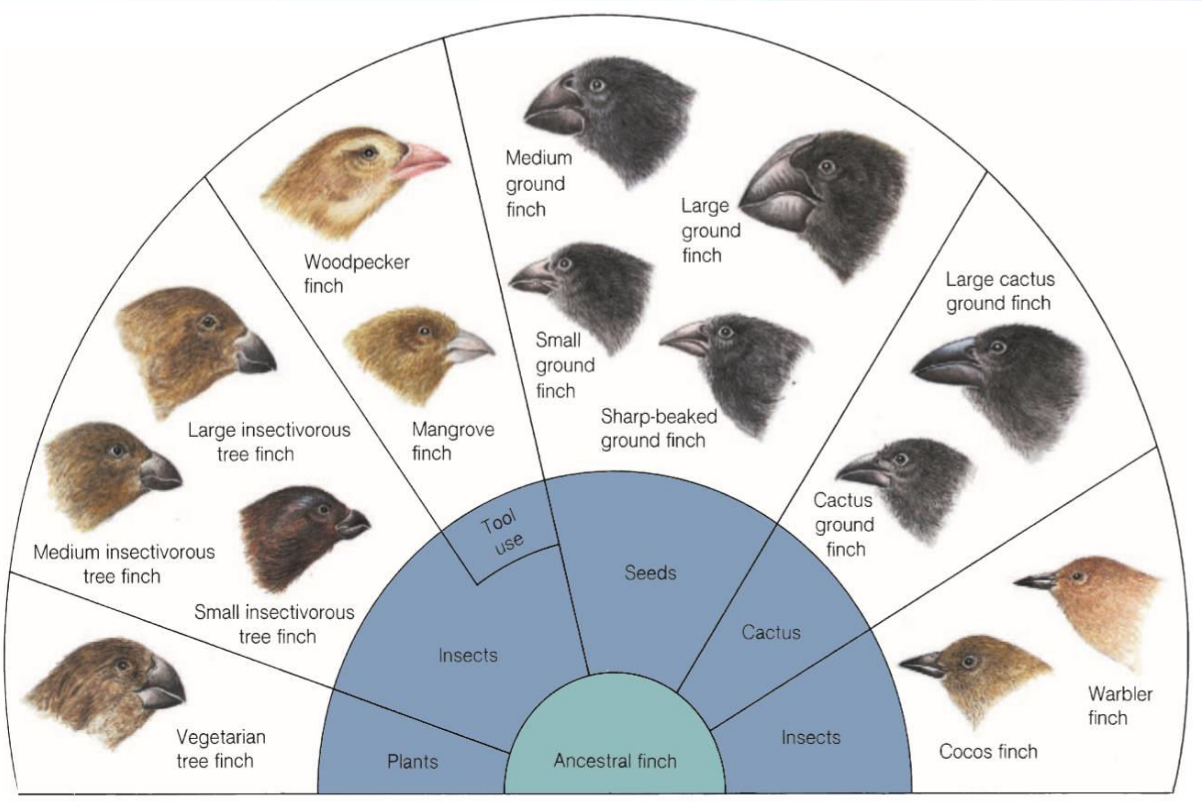
Evidences of Theory of Natural Selection - 3

Galápagos Finches

- The most obvious differences were in

1. Dietary habits
2. Shape and size of bill

Evidences of Theory of Natural Selection - 3



Zoology by Miller and Harley, 5th ed.

Evidences of Theory of Natural Selection - 3

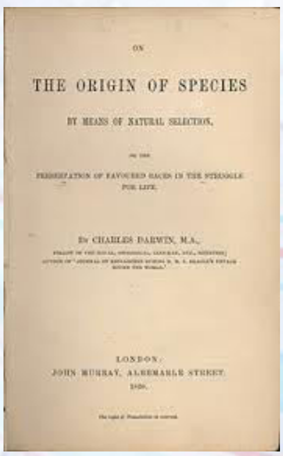
Galápagos Finches

- **Formation of new forms from an ancestral species, usually in response to the opening of new habitats.**
- **It is called adaptive radiations.**

END

Theory of Natural Selection - 1

- **Based on his observations and collected data, Darwin proposed his theory of natural selection in form of "Origin of Species" in 1859.**


ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

LONDON:
JOHN MURRAY, ALBEMARLE STREET.

https://www.google.com/search?q=origin+of+species

Theory of Natural Selection - 1

- Theory has four major postulates.
- Each postulate describes the driving force behind evolution.

Theory of Natural Selection - 1

1. Competition

- All organisms have a far greater reproductive potential than is ever realized.
- Example: Female sea star releases about 1 million eggs each season.
- What if all of these eggs were fertilized and developed to reproductive adults by the following year?

Theory of Natural Selection - 1

- Drastic increase in population size of each species
- Unimaginable resource problems in just a few years
- Limited resources and increasing population sizes create competition between individuals at:

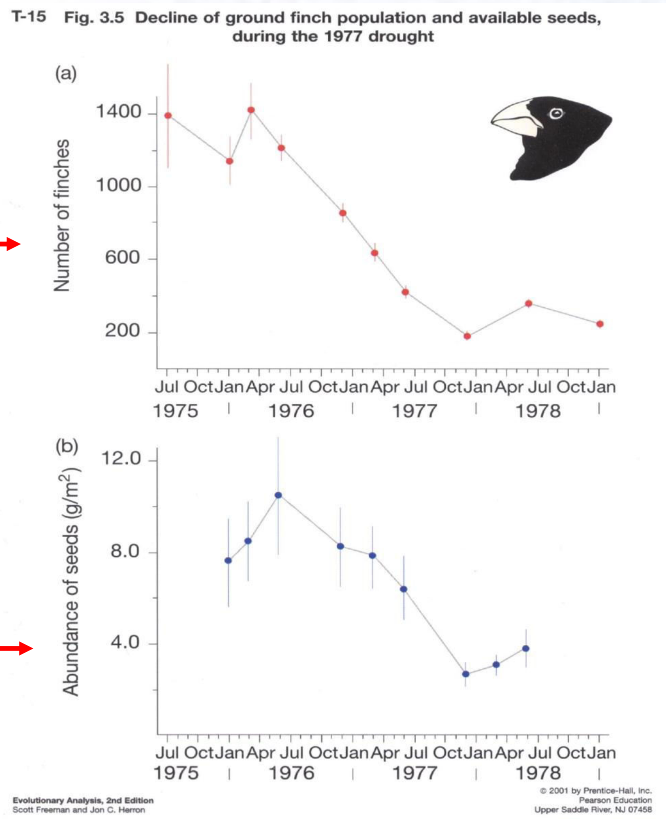
1. Intraspecific
2. Inter specific

Theory of Natural Selection - 1

COMPETITION

Decline in population size

Change in environment (Resources)



Theory of Natural Selection - 2

2. Variations

- Individuals vary in traits directly related to their ability to survive and reproduce
- Inherited variations arise by random mutation.
- Seldom are any two individuals exactly alike.
- Variations can be advantageous or harmful.

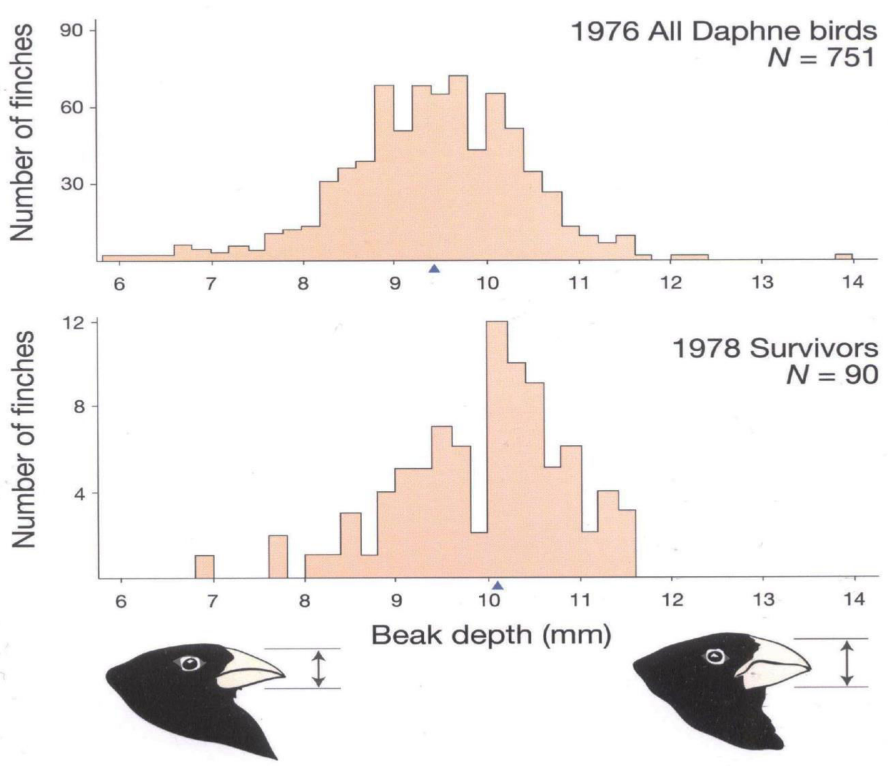
Theory of Natural Selection - 2

- May be neither helpful nor harmful
- Variations can be passed on to offspring.

Theory of Natural Selection - 2

DIFFERENTIAL SURVIVAL

Fig. 3.6 Beak depth before and after natural selection

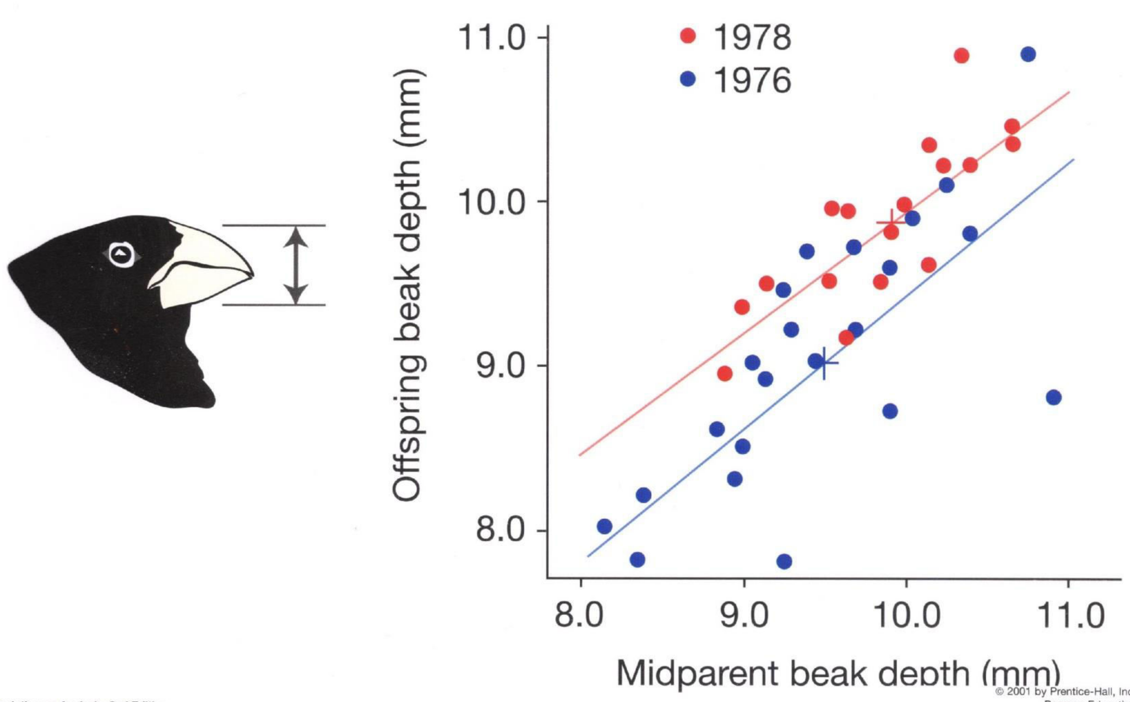


Theory of Natural Selection - 2

VARIATION & HERITABILITY

T-14

Fig. 3.4 Heritability of beak depth in Geospiza fortis



Evolutionary Analysis, 2nd Edition
Scott Freeman and Jon C. Herron

Theory of Natural Selection - 2

END

- Mendel later suggested that genes are responsible for traits.
- Inheritance is carried out by transfer of genes.
- Independent assortment of alleles and crossing over bring variations.
- This confirmed the second postulate of Darwin.

Theory of Natural Selection - 3

3. Survival of the Fittest

- Because resources are limited, existence is a constant struggle.
- Higher rate of population growth causes depletion of resources.
- Therefore, many individuals die.

Theory of Natural Selection - 3

- Darwin reasoned that the individuals that die are those with the traits (variations) that make survival and successful reproduction less likely.
- Traits that promote successful reproduction are said to be adaptive.
- Survival of the fittest

Theory of Natural Selection - 3

4. Transfer of adaptive traits to next generation

- Adaptive traits are perpetuated in subsequent generations.
- Organisms with maladaptive traits are less likely to reproduce
- Maladaptive traits become less frequent in a population and eventually are eliminated.

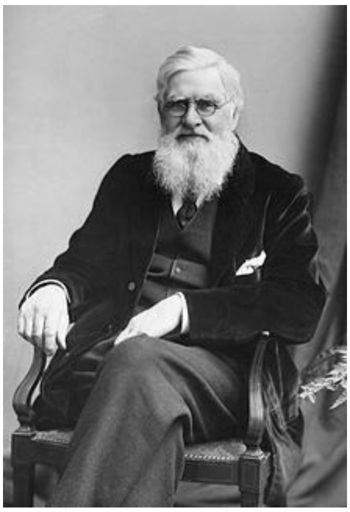
Theory of Natural Selection - 3

4. Transfer of adaptive traits to next generation

- Process of selection is called as "Natural Selection".
- Change in environment (climate, food shortage, other stressors) lead to extinction of ill-adapted species.

ClueBook.com

Theory of Natural Selection - 3



https://en.wikipedia.org/wiki/Alfred_Russel_Wallace#Natural_selection_and_Darwin

Alfred Russel Wallace (1823-1913)

- Co-discoverer of theory of natural selection
- Collection of data and specimens from amazon and Malay archipelago
- **He proposed:**
- Population pressure on resources
- Variations in response to environmental changes

Theory of Natural Selection - 3

Both Wallace's and Darwin's papers were published in the Journal of the Proceedings of the Linnean Society in 1859.

END

Differences from Darwin's theory

- Every evolutionary modification was a product of selection.
- Therefore, had to be adaptive for the organism.
- However, Darwin did not insist on finding adaptive significance for every modification.

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Adaptations

- Adaptations are defined as:
- Characteristics that increase the potential of an organism or species to successfully reproduce in a specified environment.

Adaptations

- Adaptation occurs when a change in a phenotype increases an animal's chance of successful reproduction.
- Change in environment is the force behind adaptations.
- It may result in the evolution of multiple new groups.
- To exploit the changed environment

Adaptations

- Adaptation is confused with fitness or adaptedness.
- **Adaptedness or fitness:**

is a measure of the capacity for successful reproduction in a given environment.

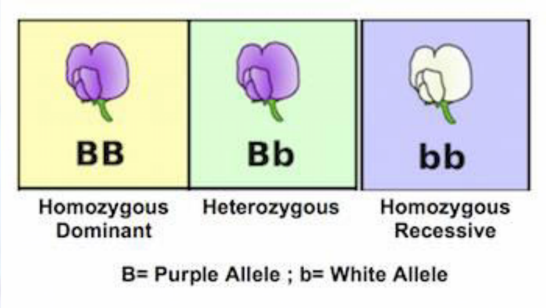
- Not every characteristic is an adaptation to some kind of environmental situation.
- Neither adaptations lead to perfection.

END

Population Size, Genetic Drift & Neutral Selection

- Genes of all traits are present in a population in form of alleles.

Example:



https://www.google.com/search?q=example+of+allele

Population Size, Genetic Drift & Neutral Selection

- Stock of different genes in an interbreeding population is called as gene pool.
- This gene pool is transferred to next generation.
- But there can be outflow or inflow of genes in gene pool.
- This change in gene frequency is called as genetic drift.

Population Size, Genetic Drift & Neutral Selection

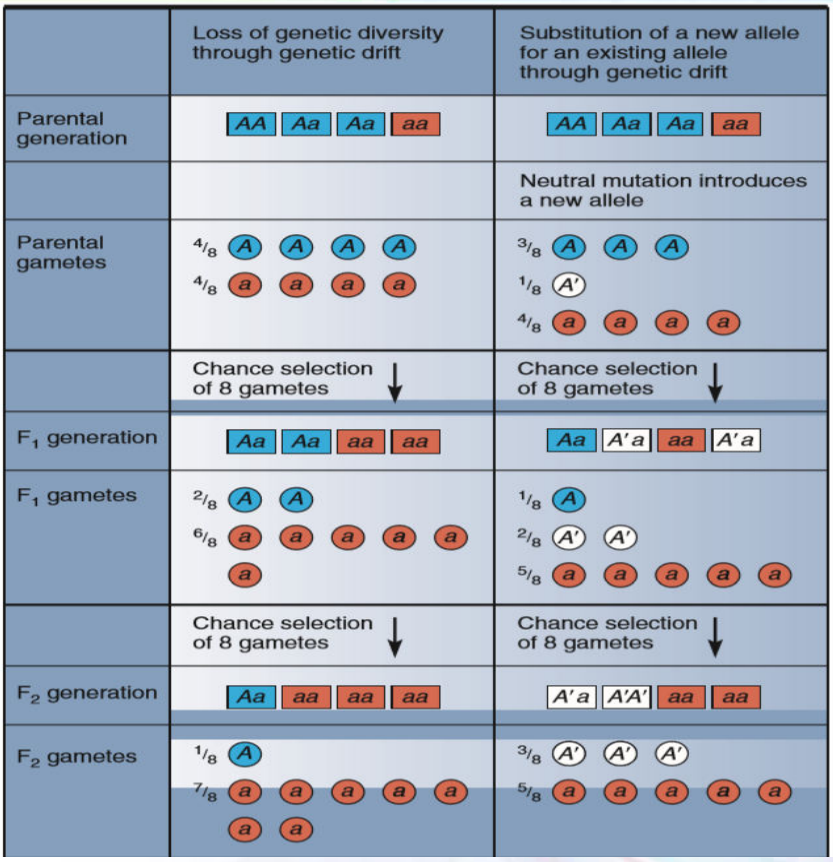
- The process of genetic drift is analogous to flipping a coin.
- Higher the number of trials, closer to ratio of 50:50.
- Smaller the number, disproportionate ratio like 70:30.
- Chances of incorporation of two adaptive alleles into gametes is equal.

Population Size, Genetic Drift & Neutral Selection

- Gamete sampling from small population may show unusual proportions of alleles in next generation.
- This is due to chance event like meiosis.
- These chance events may result in increasing or decreasing the frequency of alleles.

Population Size, Genetic Drift & Neutral Selection

Zoology by Miller and Harley, 5th ed.



Population Size, Genetic Drift & Neutral Selection

- In small populations, inbreeding is also common.
- Genetic drift and inbreeding are likely to reduce genetic variation within a population.

END

Types of Genetic Drift

- Two special cases of genetic drift have influenced the genetic makeup in a population.

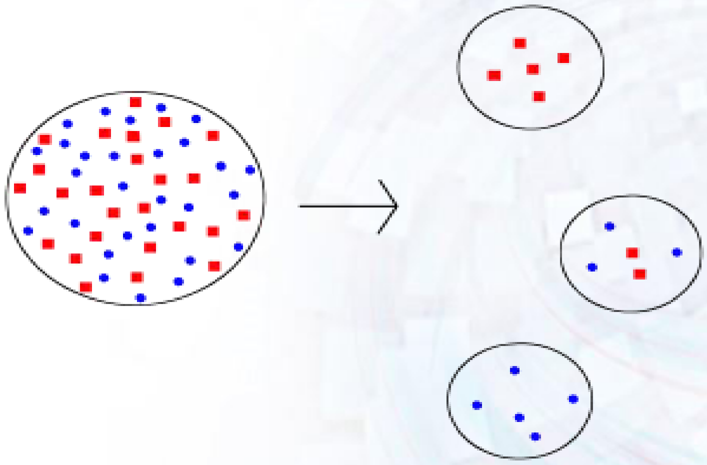
1. Founder Effect
2. Bottleneck Effect

Types of Genetic Drift

Founder Effect

- When a few individuals from a parental population colonize new habitats.
- The new colony that emerges from the founding individuals is likely to have a distinctive genetic makeup
- Far less variation than the larger population

Types of Genetic Drift



Founder effect: The original population (left) could give rise to different founder populations (right).

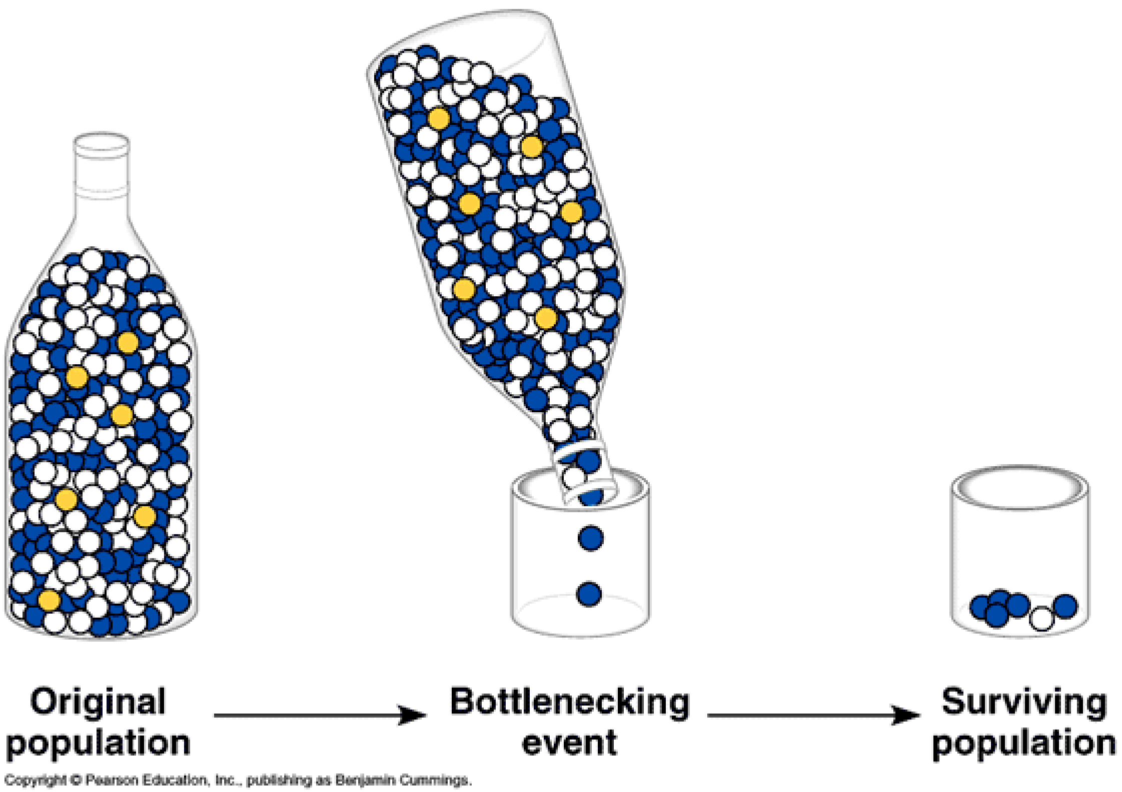
ClluesBook.com

Types of Genetic Drift

Bottleneck Effect

- It occurs when number of individuals in a population is drastically reduced.
- Mostly by any disaster e.g. natural catastrophy, over hunting, habitat damage
- Survivors have gene pool not representing the initial population.

Types of Genetic Drift



Types of Genetic Drift

- Decreases in genetic diversity make populations less likely to withstand environmental stress.
- More susceptible to extinction

END

Conditions of Natural Selection

Conditions of natural selection

- Three conditions must be met for natural selection to occur.

1. Variation must exist among individuals in a population.

ClluesBook.com

Conditions of Natural Selection

- Natural selection works by favoring individuals with some traits over individuals with alternative traits.
- If no variation exists, natural selection cannot operate.

Conditions of Natural Selection

2. Variation among individuals must result in differences in the number of offspring surviving in the next generation.

- Because of their phenotype or behavior
- Some individuals are more successful than others in producing offspring.

Conditions of Natural Selection

- Although many traits are phenotypically variable, individuals exhibiting variation do not always differ in survival and reproductive success.

3. Variation must be genetically inherited.

- For natural selection to result in evolutionary change, the selected differences must have a genetic basis.

Conditions of Natural Selection

END

- Not all variations has a genetic basis. It can be environmental.
- Even genetically identical individuals may be phenotypically quite distinctive if they grow up in different environments.
- When phenotypically different individuals do not differ genetically, no evolutionary change will have occurred.

Selection for Surviving Adaptations

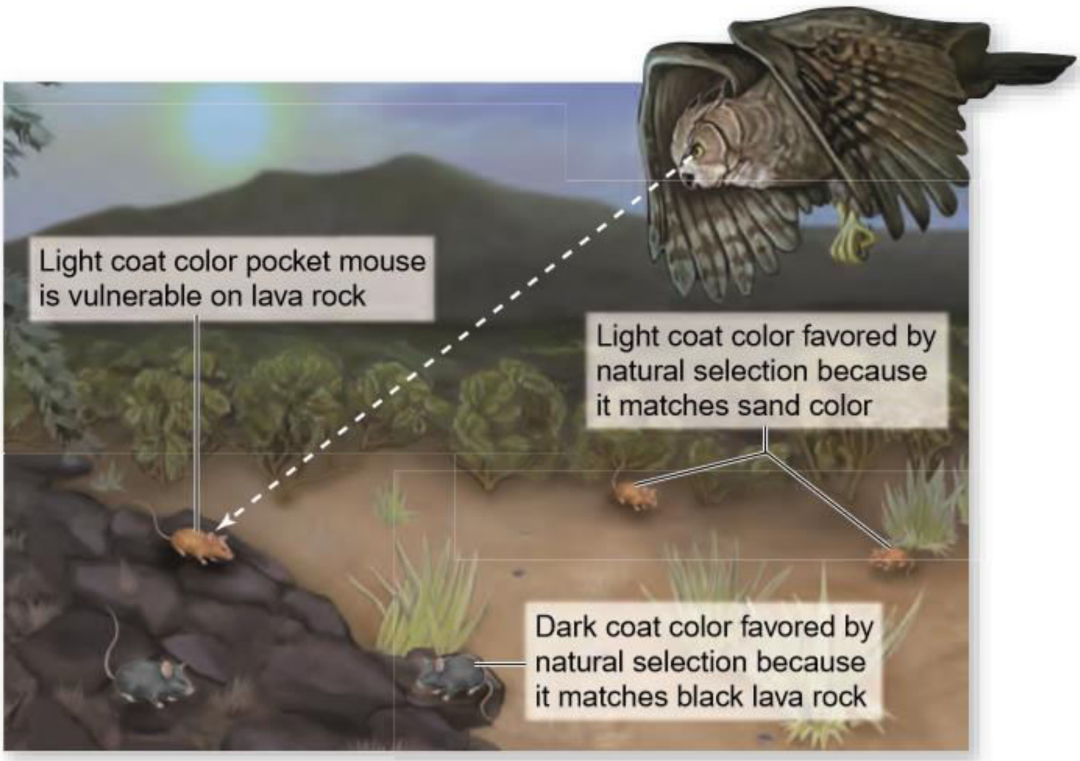
- The result of evolution driven by natural selection is that:
- Populations become better adapted to their environment.
- Many instances of adaptation involve genetic changes that decrease the probability of capture by a predator.

Selection for Surviving Adaptations

Example:

- Black rocks formation in America South-west
- Black coat color supports animal to mimic the background.
- Lizards, rodents, and a variety of insects dwelling there are dark in color.

Selection for Surviving Adaptations



Biology Mason, Losos and Singer, 9th ed.

Selection for Surviving Adaptations

- Natural selection helps to adapt in different climate.
- Same trait but different intensity of expression

Example:

- Enzyme lactate dehydrogenase
- Catalyzes the conversion of pyruvate to lactate
- Different allele frequency in mummichog fish population in North and South.

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Selection for Surviving Adaptations

- Form of enzyme in mummichog populations in North are better catalyst at low temperatures.
- As compared to south
- At low temperatures, individuals with the northern allele swim faster
- Survive better, than individuals with the alternative allele.

Selection for Surviving Adaptations

- Pesticide and microbial resistance
- The widespread use of insecticides has led to the rapid evolution of resistance in more than 500 pest species.

Example: Housefly

- Resistance allele at the *pen* gene decreases the uptake of insecticide.

Selection for Surviving Adaptations

- Alleles at the *kdr* and *dld-r* genes decrease the number of target sites, thus decreasing the binding ability of the insecticide.
- That's how natural selection helps to survive better in environment.

END

Fitness and its Measurement

Fitness

- Fitness is quantified as reproductive success
- The number of surviving offspring left in the next generation.
- The most fit phenotype is simply the one that produces, on average, the greatest number of offspring.

Fitness and its Measurement

Example:

Two phenotypes of toads

1. Green
2. Brown

- Green leave average 4 offsprings
- Brown leave average 2.5 offsprings
- By custom, the most fit phenotype is assigned a fitness value of 1.0.

Fitness and its Measurement

- Fitness of the green phenotype would be 4.0/4.0 = 1.000
- Fitness of the brown phenotype would be 2.5/4.0 = 0.625.
- The difference in fitness would therefore be

1.000 – 0.625 = 0.375

Fitness and its Measurement

- Difference in fitness of 0.375 is quite large
- Natural selection in this case strongly favors the green phenotype.

Components of Fitness

- Survival
- Mating success
- Number of offspring per mating

Fitness and its Measurement

- Predicting fitness from a single component can be tricky.
- As traits favored for one component of fitness may be at a disadvantage for others.

Example:

- In water strider (fish), larger females lay more eggs than smaller females.

Fitness and its Measurement

- Larger females are supported by natural selection.
- But larger females die at younger age.
- Having fewer opportunities to reproduce than smaller females.

END

Interactions Among Evolutionary Forces

- The amount of genetic variation in a population may be determined by the relative strength of different evolutionary processes.
- Sometimes these processes act together, and in other cases they work in opposition.

Interactions Among Evolutionary Forces

Mutation and genetic drift may counter selection

- Both genetic drift and natural selection remove alleles from population.
- Natural selection is non random
- It operates to increase the representation of alleles that enhance survival and reproductive success.

Interactions Among Evolutionary Forces

- Genetic drift is random.
- In which any allele may increase or depart the population.
- Sometimes, drift may lead to a decrease in the frequency of an allele that is favored by selection.
- Mutation may also counter natural selection.
- It may randomly decrease or increase the frequency of alleles.

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Interactions Among Evolutionary Forces

Gene flow may promote or constrain evolutionary change

- Gene flow can be either a constructive or a constraining force.
- It can spread a beneficial mutation that arises in one population to other populations.

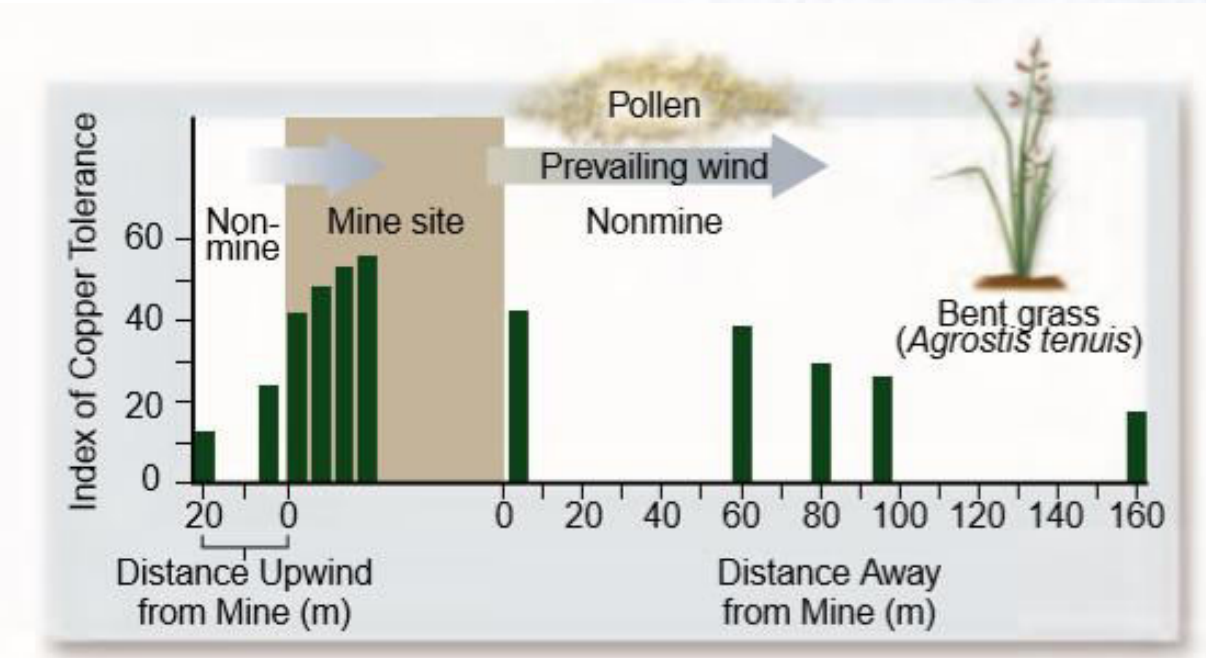
Interactions Among Evolutionary Forces

- Gene flow can impede adaptation within a population by the continual flow of inferior alleles from other populations.
- Natural selection is removing inferior alleles while gene flow can bring them back.

Example:

- Heavy metals tolerance

Interactions Among Evolutionary Forces



Biology Mason, Losos and Singer, 9th ed.

Maintenance of Variation - 1

- Natural selection removes variation from a population by favoring one allele over others at a gene locus.
- However, in some circumstances, selection can do exactly the opposite.
- It actually maintains population variation.

Maintenance of Variation - 1

Frequency dependent selection

- This type of selection favors certain phenotypes depending on how commonly or uncommonly they occur.
- It has two types:

1. Negative
2. Positive

Maintenance of Variation - 1

Negative frequency dependent selection

- Rare phenotypes are favored by selection
- Making them more common thus maintaining variation.

Reason:

- Commonly abundant animals are easy and recognized prey for predators.

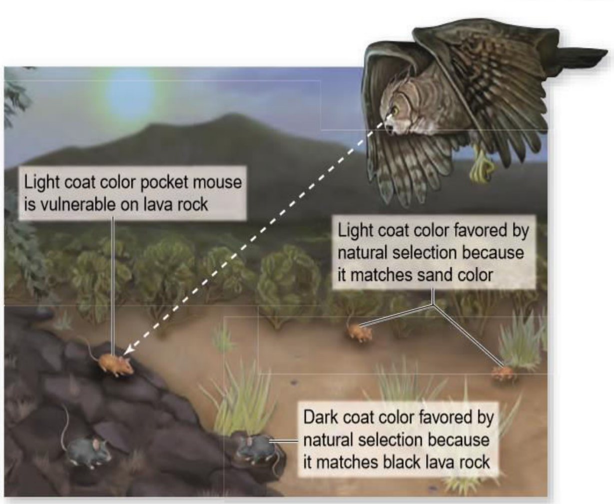
Maintenance of Variation - 1

- Animals having rare alleles for that trait will have higher chances to survive.

Example:

- Fish predation on an insect, the water boatman, which occurs in three different colors.
- Experiments indicate that each of the color types is preyed upon disproportionately.

Maintenance of Variation - 1



Biology Mason, Losos and Singer, 9th ed.

- Fish eat more of the common-colored insects than uncommon colors.

Positive frequency-dependent selection

- Favours common forms
- It tends to eliminate variation from a population.
- Example:
- Predators don't always select common individuals.

Maintenance of Variation - 1

- Both positive and negative frequency dependent selections play their role in evolutionary processes.
- There cannot be a standard rule of selection around the globe for one trait.

END

Maintenance of Variation - 2

Oscillating Selection

- In some cases, selection favors one phenotype at one time and another phenotype at another time.
- Example: Medium ground finches of the Galápagos Islands
- In times of drought, the supply of small, soft seeds is depleted.

Maintenance of Variation - 2

Oscillating Selection

- But there are still enough large seeds around.
- Consequently, birds with big bills are favored.
- However, when wet conditions return, the ensuing abundance of small seeds favors birds with smaller bills.

Maintenance of Variation - 2

Difference between oscillating and Frequency dependent selection

- **In oscillating selection, the fitness of a phenotype does not depend on its frequency.**
- **Rather, environmental changes lead to the oscillation in selection.**

Maintenance of Variation - 2

- **In frequency dependent selection, it is the change in frequencies themselves.**
- **Fitness of the different phenotypes can vary according to their frequencies and environment.**

Maintenance of Variation - 2

Heterozygotes may exhibit greater fitness than homozygotes

- Fitness favors individuals with copies of both alleles
- Works to maintain both alleles in the population

END

Kinds of Selection

- Traits are affected by more than one gene.
- Selection operates on all the genes.
- Influencing most strongly those that make the greatest contribution to the phenotype.
- Three kinds of Selection

Kinds of Selection

1. Disruptive Selection
2. Directional Selection
3. Stabilizing Selection

Disruptive Selection

- Selection acts to eliminate intermediate types

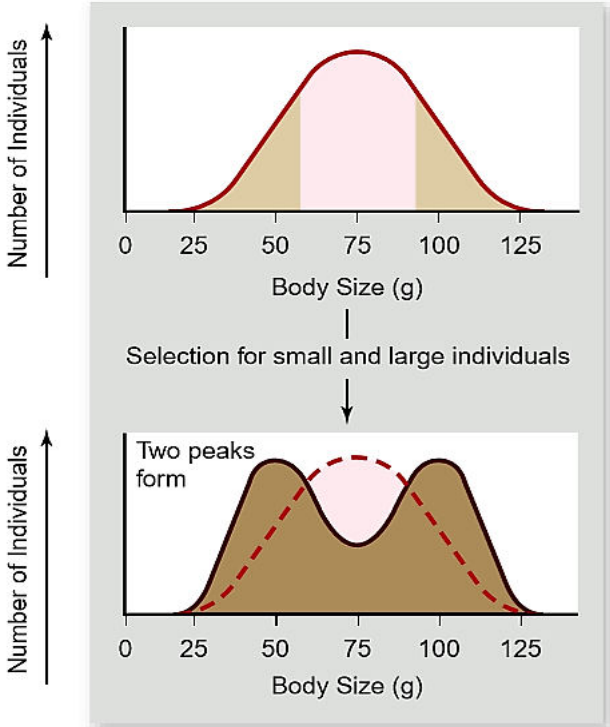
Example:

Different beak sizes of seed cracker finches

Kinds of Selection

- Populations of these birds contain individuals with large and small beaks
- Very few individuals with intermediate-sized beaks
- Large beaked birds can open the tough shells of large seeds.
- Birds with the smaller beaks are more adept at handling small and soft seeds.

Kinds of Selection

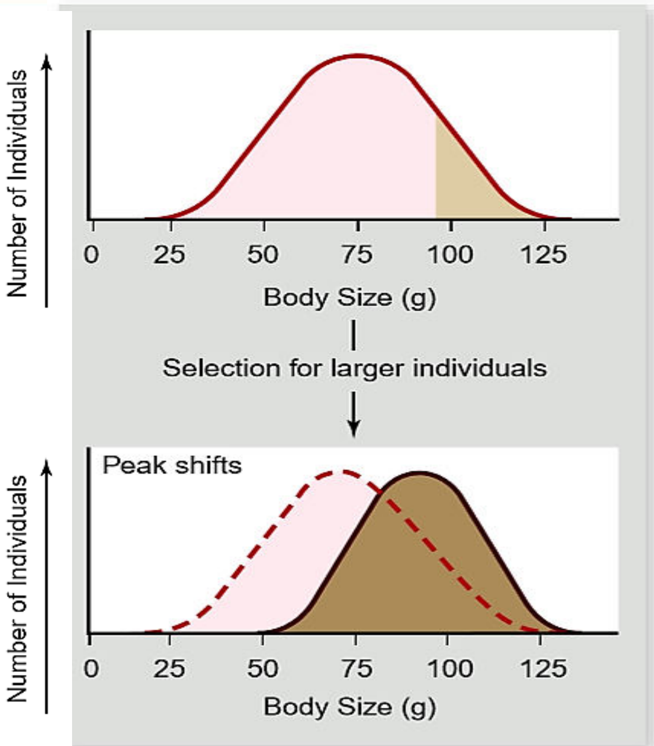


a. Disruptive selection

Biology Mason, Losos and Singer, 9th ed.

- Birds with intermediate-sized beaks are unable to open large and small seeds properly.
- Selection eliminates birds with intermediate-sized beaks.
- Disrupting the population into two phenotypically distinct groups; large and small.

Kinds of Selection



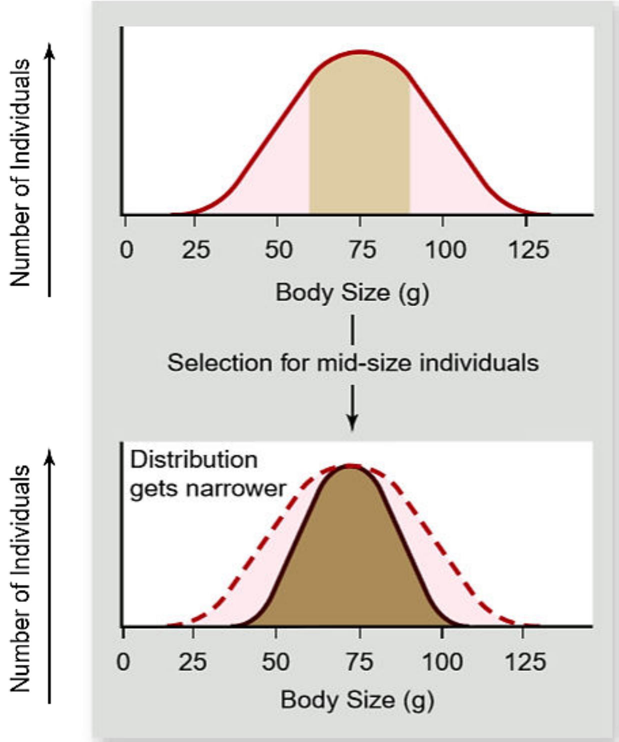
ᵢ. Directional selection

Biology Mason, Losos and Singer, 9th ed.

Directional Selection

- Elimination of one extreme from an array of phenotypes
- Genes promoting this extreme become less frequent in the population
- Eventually disappear

Kinds of Selection



c. Stabilizing selection

Biology Mason, Losos and Singer, 9th ed.

Stabilizing Selection

- Elimination of both extremes from an array of phenotypes
- Increase in frequency of the already common intermediate type
- No change in the most common phenotype of the population
- Making it even more common by eliminating extremes.

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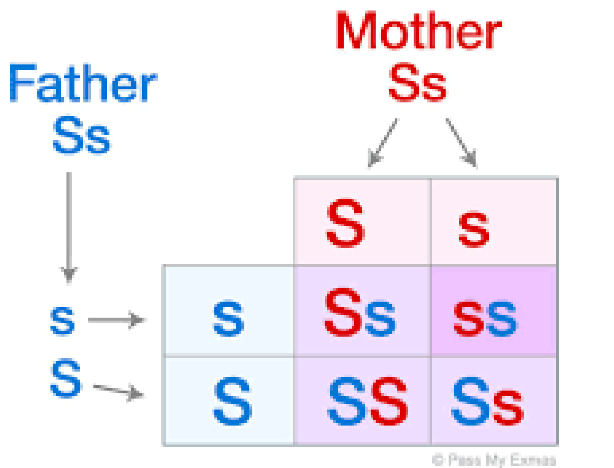
Polymorphism

- Polymorphism occurs in a population when two or more distinct forms exist
- Without a range of phenotypes between them.

Balanced Polymorphism

- It occurs when different phenotypes are maintained at relatively stable frequencies in the population.

Polymorphism



https://www.google.com/search?rlz=1C1SQJL_

- Resemble a population in which disruptive selection operates.

Example:

- Sickle cell anemia is homozygous recessive trait.
- Most common in Africa where malaria is common as well.
- Heterozygous alleles carriers are less more susceptible to malaria.

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Polymorphism

- Homozygous dominant alleles carriers are more susceptible to malaria.
- Homozygous recessive alleles carriers have low survival due to anemia.
- Therefore, heterozygous are more successful in survival and reproductive potential than two others.
- Heterozygote superiority

Polymorphism

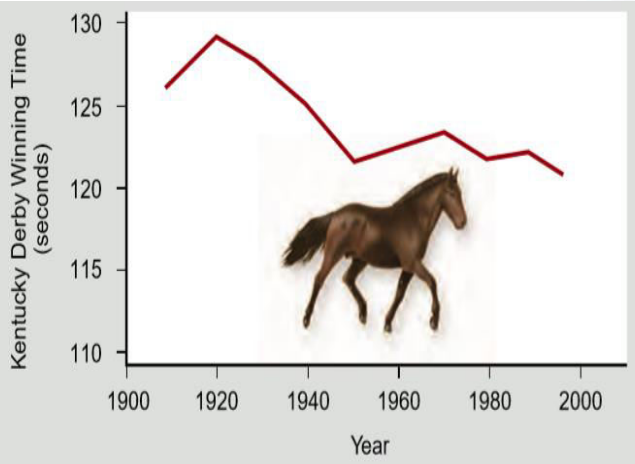
END

- It leads to balanced polymorphism
- Because perpetuation of the alleles in the heterozygous condition maintains both alleles at a higher frequency
- Frequency of homozygous phenotypes will be lower than heterozygous.
- This is Balanced polymorphism.

The Limits of Selection

- Natural selection is the most powerful of the principal agents of genetic change.
- There are limits to what it can accomplish.

The Limits of Selection



Biology Mason, Losos and Singer, 9th ed.

1. Evolution requires genetic variation

Example:

- Racing horses breeds by artificial breeding
- Performance has not much improved from 50 years.
- Artificial breeding might have removed variation from the population.
- Rate of mutation is slower to replenish it.

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The Limits of Selection

- Little genetic variation now remains
- Variations in phenotype
- No variation in genotype
- No variation means no evolutionary change

2. Gene interactions affect fitness of alleles

- Effect of one gene is dependent on the presence of one or more genes.

The Limits of Selection

- Interaction between genes
- Gene encoding the enzyme that synthesizes penicillin cannot work alone.
- Gene encoding the enzymes that synthesize the necessary precursors in the metabolic pathway.
- One gene interacts with the other.

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The Limits of Selection

- Natural selection cannot favour one gene to over other

3. Genes have multiple effects

- Alleles often affect multiple aspects of a phenotype.
- Selecting for large clutch size in chickens eventually leads to eggs with thinner shells that break more easily.

The Limits of Selection

END

- That's why we could never produce chickens that lay eggs twice as large as the best layers do now.
- Likewise, we cannot produce gigantic cattle that yield twice as much meat as our leading breeds.
- There are limits in selection (natural & artificial) due to genes interactions.

Species & Speciation - 1

- Species is a group of populations in which genes are actually, or potentially, exchanged through interbreeding.
- This definition has problems.
- Taxonomists depend upon:

1. Morphological
2. Ecological information

- Especially in case of fossils

Species & Speciation - 1

- Reproductive criteria are not fully examined.
- Not all organisms reproduce sexually.
- Different populations of same species are geographically isolated.
- It is not easy to assess if they can interbreed.
- Other criteria need to be applied in these cases.

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Species & Speciation - 1

- In describing species, taxonomists use following criteria:

1. Morphological
2. Physiological
3. Embryological
4. Behavioral
5. Molecular
6. Ecological

- Realizing that all of these have a genetic basis.

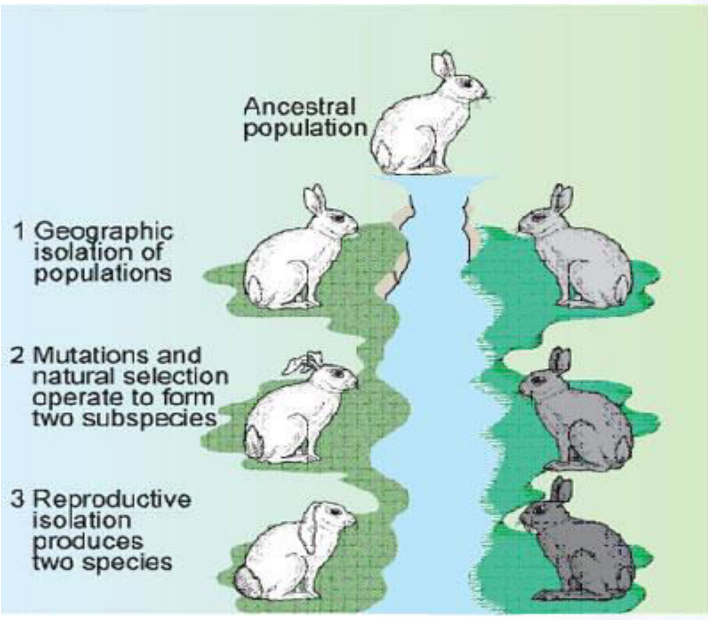
Species & Speciation - 1

Speciation

- Formation of new species.
- A requirement of speciation is that subpopulations are prevented from interbreeding.
- This is called reproductive isolation.
- No gene flow in case of reproductive isolation.

Species & Speciation -1

- Natural selection and genetic drift result in evolution in each sub population.



Zoology by Miller and Harley, 5th ed.

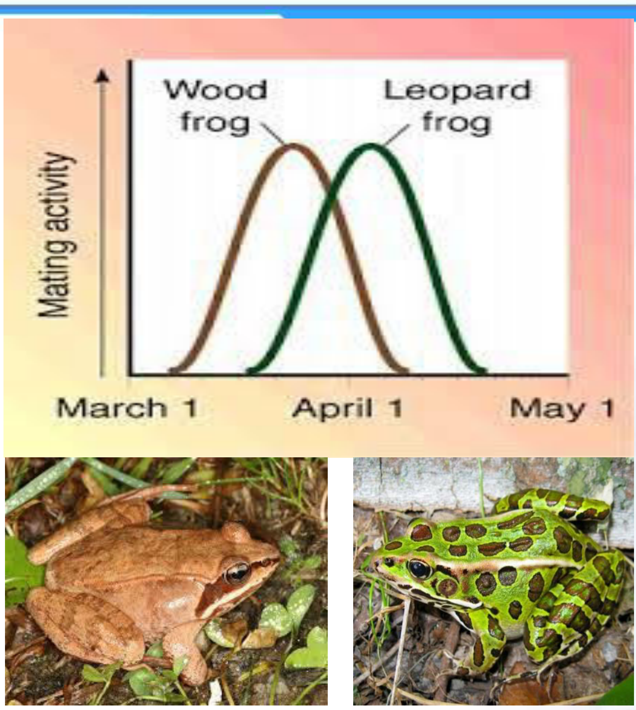
Species & Speciation

Ways of Reproductive Isolation

1. Premating isolation

- Geographical Isolation - prevents mating from taking place
- Barriers, such as rivers or mountain ranges, may separate subpopulations.

Species & Speciation



Zoology by Miller and Harley, 5th ed.

- Mechanical Isolation - If courtship behavior patterns of two animals are not mutually appropriate for each other.
- Mating does not occur.
- Temporal Isolation – type of reproductive isolation due to reproducing at different times.

Species & Speciation

Zoology by Miller and Harley, 5th ed.

- **Behavioral Isolation** – reproductive isolation due to differences in mating or courtship behavior.
- Even though they are able to physically interbreed.
- Example: Different ways to decorate nests to attract females.
- Satin bowerbird & MacGregor's Bowerbird

Species & Speciation

- **Ecological Isolation** – reproductive isolation due to living in different parts of the habitat (microhabitats)
- Rarely come in contact with each other
- Two closely-related birds of the Turdus genus
- Blackbird (*Turdus merula*)
- Ring ouzel (*Turdus torquatus)*

Species & Speciation

Ring ouzel (Turdus torquatus)

Blackbird (Turdus merula)

https://biologywise.com/ecological-isolation-explained-with-examples

- Population of the blackbird is a woodland species.
- Ring ouzel is a moorland breeding species.
- Both are ecologically isolated and developed into two different species.

Species & Speciation

2. Postmating isolation

- Prevents successful fertilization and development
- Even though mating may have occurred.

Example:

- Conditions in the reproductive tract of a female may not support the sperm of male.
- Though successful fertilization

Species & Speciation

Other kinds of postmating isolation:

- Developmental failures of the fertilized egg or embryo
- Hybrids produced after rare mating of two different species

Example:

- Mule produced from a mating of a male donkey and a mare is a sterile hybrid.

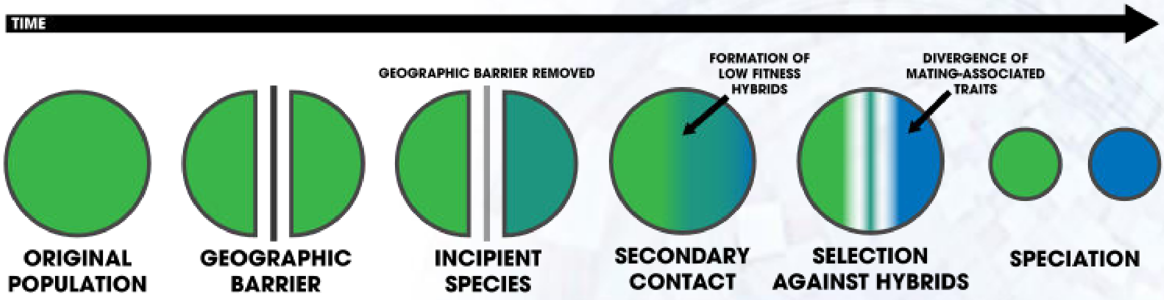
END

Allopatric Speciation

- Geographical isolation of subpopulations from one another

https://en.wikipedia.org/wiki/Allopatric_speciation

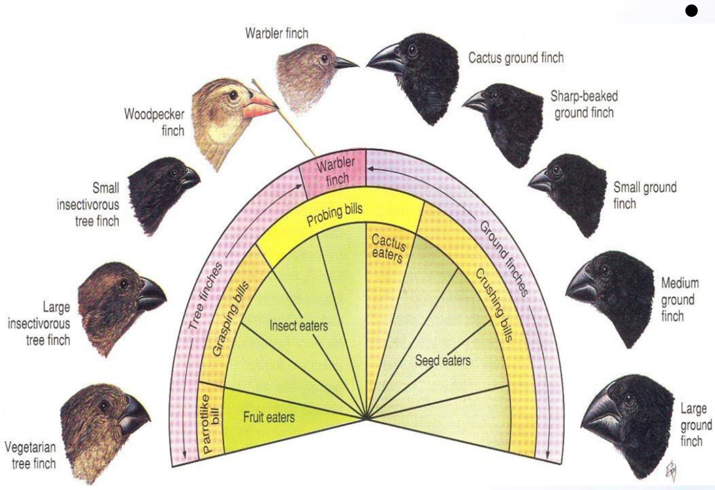
Allopatric Speciation



In allopatric speciation, a species population becomes separated by a geographic barrier, whereby reproductive isolation evolves producing two separate species. From this, if a recently separated population comes in contact again, low fitness hybrids may form, but reinforcement acts to complete the speciation process.

https://en.wikipedia.org/wiki/Allopatric_speciation

Allopatric Speciation



https://www.mun.ca/biology/scarr/Adaptation_in_Darwins_Finches.html

- Classical example are Darwin's finches on the Galápagos Islands

  14 species of finches evolved from the original seed eater finches from mainland.

  Populations became isolated on various islands over time

- Adapted to new habitats and available food resources

Allopatric Speciation

- Evolved into new species due to geographical isolation
- Mutations further increased variations.
- Natural selection favored the retention of the variations that promoted successful reproduction.

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Allopatric Speciation

- Combined forces of isolation, mutation, and natural selection
- Allowed the finches to diverge into a number of species with specialized feeding habits.

Allopatric Speciation

About 800 species of drosophilid flies in Hawaiian islands

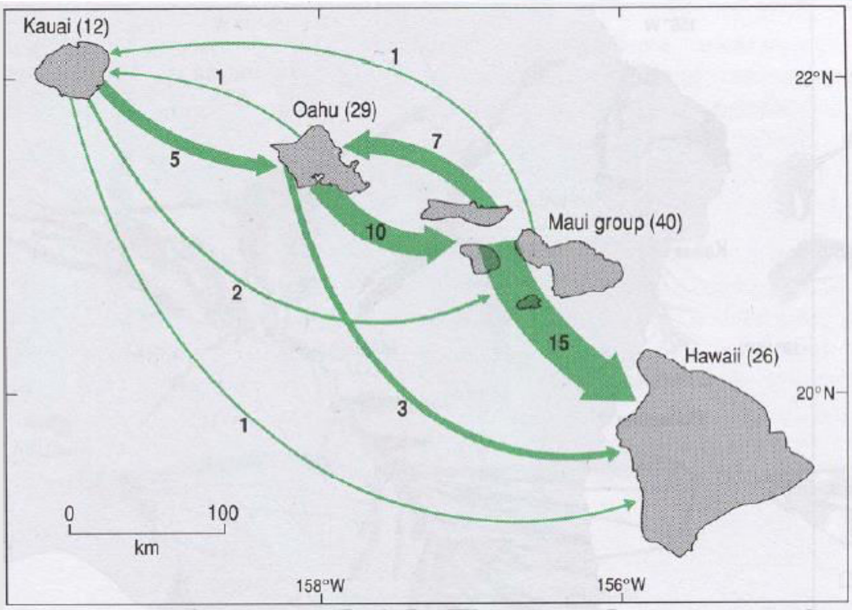

Figure 9.15 *Summary of the hypothetical founder events invoked to account for the origin of the picture-winged group of* Drosophila *in the Hawaiian islands. The width of the arrows is proportional to the number of proposed founder events; the number of species found on each island is given in brackets.*

from Skelton, Evolution

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Parapatric Speciation

- **Occurs in small, local populations, called demes.**
- **All of the frogs in a particular pond or all of the sea urchins in a particular tidepool make up a deme.**
- **Individuals of a deme are more likely to breed with one another than with other individuals in the larger population.**

Parapatric Speciation

- They experience the same environment.
- They are subject to similar selection pressures.
- Demes are not completely isolated from each other.
- Individuals, gametes can move among demes of a population.
- Exchange of genes continues.

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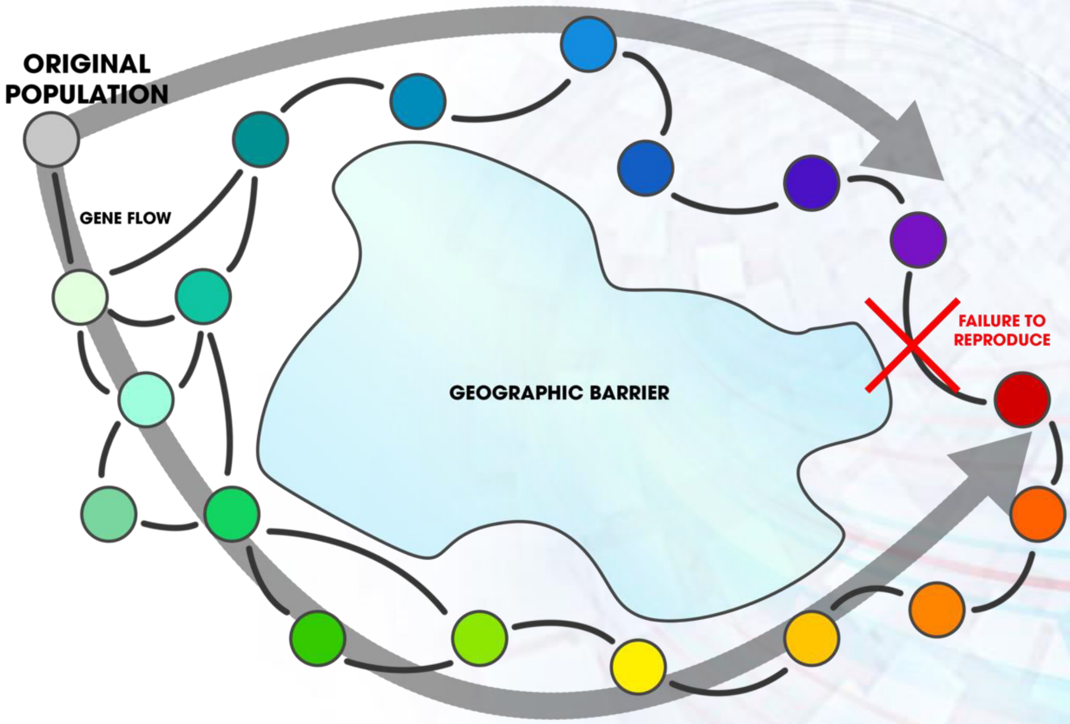
Parapatric Speciation



https://en.wikipedia.org/wiki/Parapatric_speciation#Ring_species

Parapatric Speciation

- No certain cases of parapatric speciation are known.
- Therefore considered of less importance in the evolution of animal groups than allopatric speciation.

END

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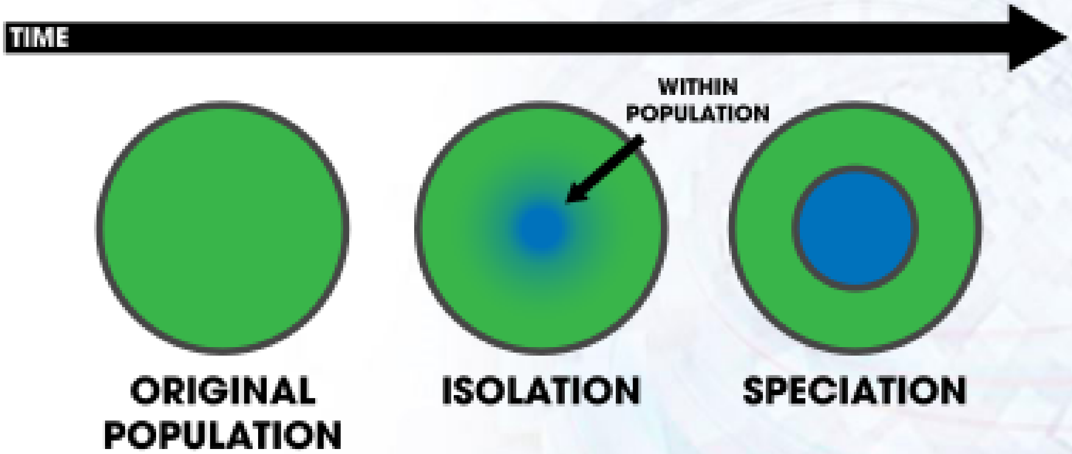
Sympatric Speciation

- This speciation, occurs within a single population.
- Evolution of a new species from a surviving ancestral species
- While both continue to inhabit the same geographic region.
- Rarely occurs in plants.
- Uncommon in animals

Sympatric Speciation



https://en.wikipedia.org/wiki/Sympatric_speciation

Sympatric Speciation

- Sometimes hybrids between two parental flowering plants are formed.
- This can happen because plants can't choose their mate and way of pollination.
- Hybrids may be sterile if paternal and maternal chromosomes are incompatible and cannot pair in meiosis.

Sympatric Speciation

- But sometimes, chromosome sets "accidentally" double (polyploidy).
- This doubling results in compatible partners.
- Plants can self-pollinate, produce seeds, and so propagate: a new species has formed.
- Between 30 and 50% of angiosperm plant species may have formed in this way.

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Sympatric Speciation

Mimulus lewisii line LF10 *Mimulus cardinalis* line CE10

https://www.google.com/search?q=Sympatric+speciation+in+Mimulus&rlz

- Examples: wheat, tobacco, cotton, bananas, potatoes

Sympatric speciation in Mimulus flowers

- The two closely related flower species.
- One species is best adapted to bumblebee pollination
- Other to hummingbird pollination

Sympatric Speciation

- Differences
- Morphology
- Placement of reproductive organs
- Colour
- Nectar content

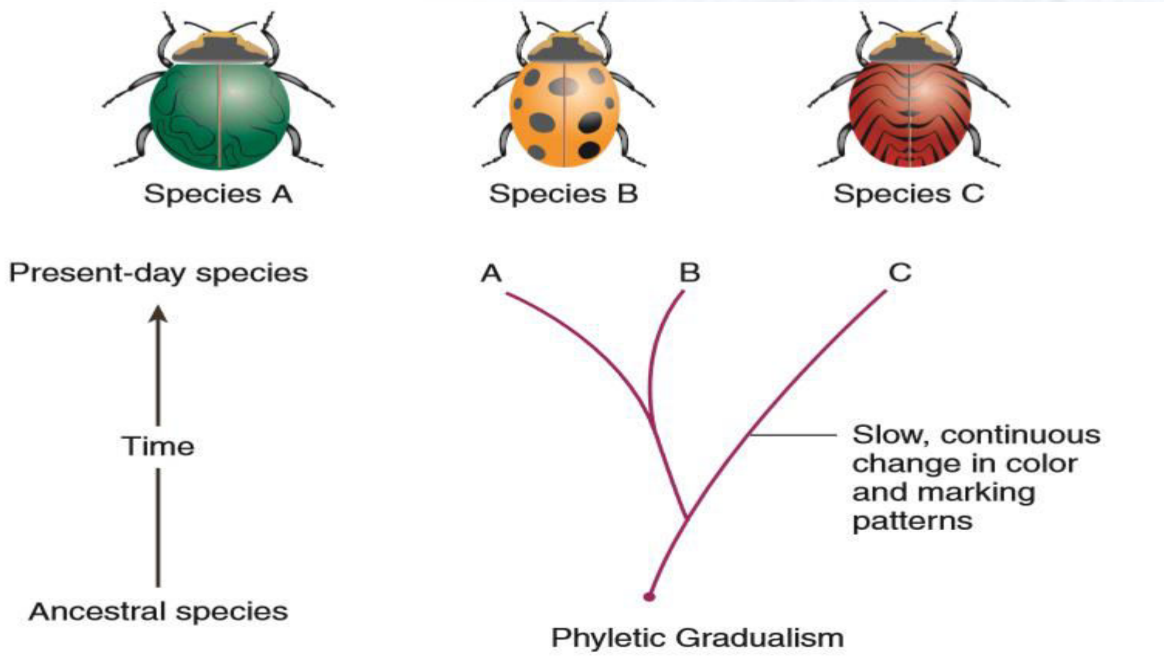
END

Rates of Evolution

- Evolutionary changes are occurring gradually over millions of years.
- This concept, called phyletic gradualism.
- It has been the traditional interpretation of the tempo, or rate, of evolution.
- Species do not change significantly over millions of years.

Rates of Evolution

- Periods of stasis or equilibrium



Zoology by Miller and Harley, 5th ed.

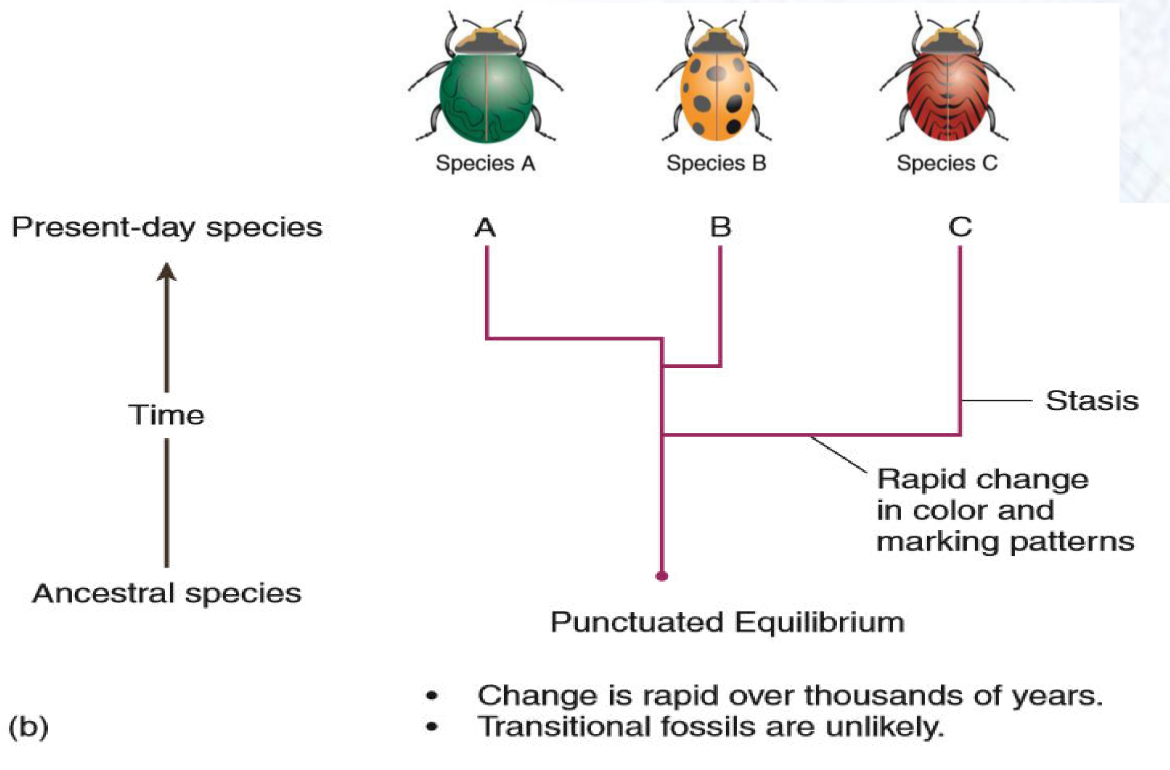
Rates of Evolution

- Stasis is interrupted by ecological crisis, such as a change in climate or a major geological event.
- At this interruption, variation that previously was selectively neutral or disadvantageous might now be advantageous.
- Geological events might result in new habitats becoming available.

Rates of Evolution

- Brief period of interruption punctuates long periods of stasis.
- It is called as punctuated equilibrium model of evolution.
- Stabilizing selection characterizes the periods of stasis.
- Directional or disruptive selection characterizes the periods of change.

Rates of Evolution



Zoology by Miller and Harley, 5th ed.

Rates of Evolution

- Rapid evolutionary changes in small populations.
- Example: rapid pesticide and antibiotic resistance
- Galapagos islands finches
- A long, dry period from the middle of 1976 to early January 1978 resulted in birds with larger, deeper bills.
- Over one year time period

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Rates of Evolution

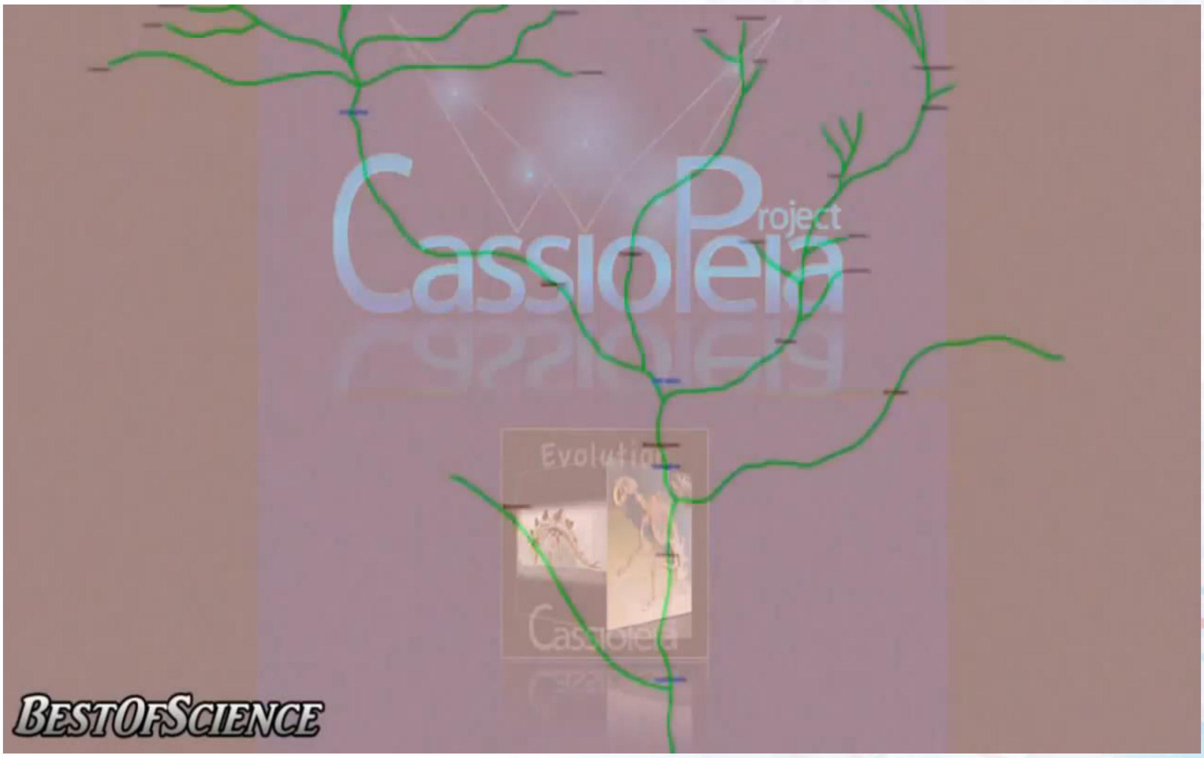
- Initially, birds consumed smaller seeds.
- After depletion of small seeds, they had to eat large seeds.
- Small beaks developed into large beaks.
- This period of rapid change is followed by stasis again.
- It explains missing transitional stages in fossil record.

END

Molecular Evolution

- Evolutionary changes whether over long period or rapid are result of change in genetic make up.
- DNA
- Changes in the base sequences in DNA and amino acids in proteins

Molecular Evolution



http://youtube.com/watch?v=nvJFI3ChOUU

Molecular Evolution

- *Cytochrome c* is a protein present in the cellular respiration pathways in all eukaryotic organisms.
- Closely related organisms have similar *cytochrome c* molecules.
- Structure of *cytochrome c* has changed so little during hundreds of millions of years.
- It is said to have been conserved evolutionarily.

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Molecular Evolution

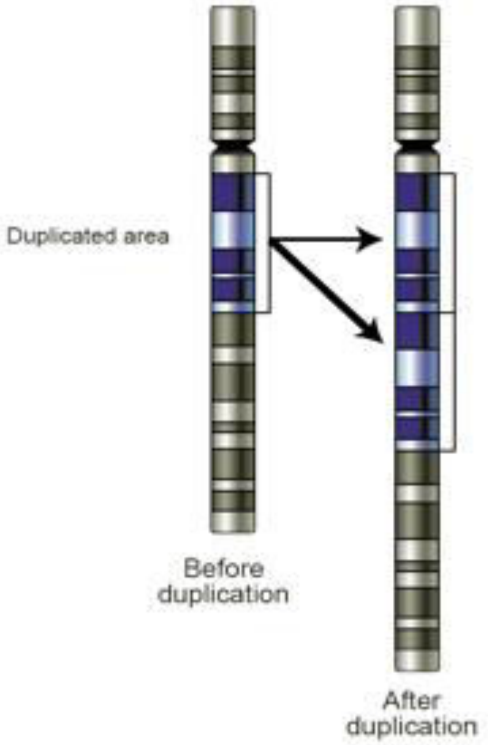
- Highly conserved proteins can help establish evolutionary relationships among distantly related organisms.
- Not all proteins are conserved as rigorously as *cytochrome c*.
- Less conserved proteins are useful for looking at relationships among more closely related animals.

END

Gene Duplication

- Major mechanism through which new genetic material is generated during molecular evolution.
- Duplication of a region of DNA that contains a gene.
- Products of several types of errors in DNA replication and repair machinery

Gene Duplication



https://en.wikipedia.org/wiki/Gene_duplication

- Duplication of gene or whole genome

Examples:

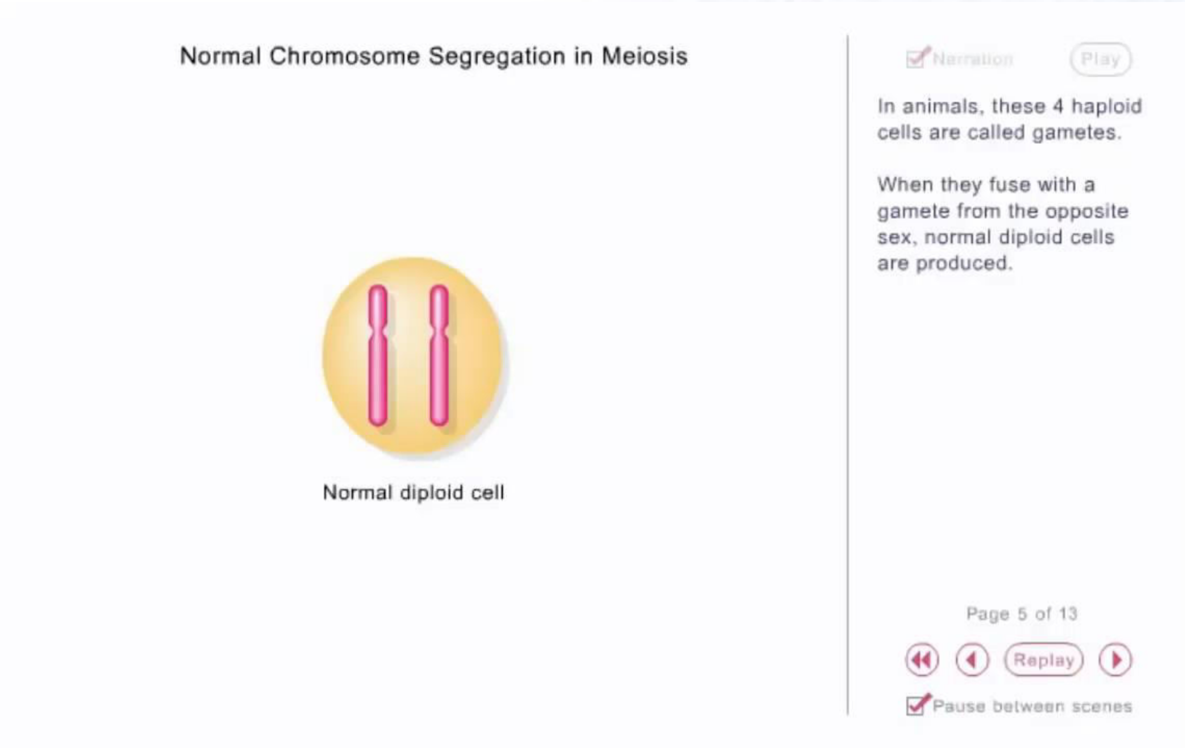
1. Aneuploidy

- Nondisjunction at a single chromosome results in an abnormal number of chromosomes.

2. Polyploidy

- Product of nondisjunction during meiosis which results in additional copies of the entire genome.

Gene Duplication



http://youtube.com/watch?v=4bzY9e-YQqI

Gene Duplication

3. Replication Slippage

- Error in DNA replication that can produce duplications of short genetic sequences.
- There are other mutations as well.

END

Mosaic Evolution

- A species is a mosaic of different molecules and structures that have evolved at different rates.
- Some molecules or structures are conserved in evolution.
- Others change more rapidly.
- The basic design of a bird provides a simple example.

Mosaic Evolution

- All birds are easily recognizable as they because of highly conserved structures

1. Feathers
2. Bills
3. Body form

- Particular parts of birds, however, are less conservative and have a higher rate of change.

Mosaic Evolution

Hovering

Soaring

https://en.wikipedia.org/wiki/Bird_flight#Soaring_wings_with_deep_slots

- Wings have been modified for:

1. Hovering (humming bird)
2. Soaring (eagle, vulture)
3. Swimming (swans, ducks)

Swimming

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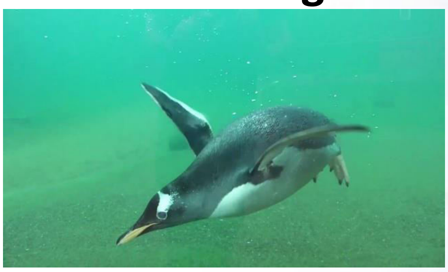
Mosaic Evolution

Wading



Swimming

https://en.wikipedia.org/wiki/Bird_flight#Soaring_wings_with_deep_slots

- Legs have been modified for:

1. Wading (stork, heron)
2. Swimming (penguin, duck)
3. Perching (sparrow, parrot)

Perching

Systematics & Five Kingdom System

- Rich biodiversity
- Millions of animals, plants and microbes
- Need of a naming them
- Classification system
- In 1735, Carl Linnaeus, presented the criteria of classification:

1. Similarities
2. Degree of evolutionary relatedness

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Systematics & Five Kingdom System

- In 1736, Linnaeus published a system of binomial nomenclature, still in use today.
- Father of taxonomy

https://en.wikipedia.org/wiki/Carl_Linnaeus

Systematics & Five Kingdom System

Classification

Systematists develop classifications based on evolutionary relationships.

They tend to look at:

1. Anatomy - a traditional method.
2. Molecular data - to examine genetic similarities and differences.

Systematics & Five Kingdom System

Old System of Classification

- Three Kingdoms of nature:

1. Plants
2. Animals
3. Minerals

Systematics & Five Kingdom System

Two Kingdom System

- Linnaeus divided all living things into two kingdoms:

1. Plants
2. Animals

Systematics & Five Kingdom System

Two Kingdom System

- Up until the 1960's, textbooks used the 2 Kingdom System to describe the living world.
- Linnaeus developed his system at a time when the microbial world was a new discovery.

Systematics & Five Kingdom System

Two Kingdom System

Moves, consumes food = animal-like

Has chloroplasts, photosynthesizes = plant-like

- Many one-celled organisms, such as Euglena, don't fit well in a 2 Kingdom system.

Systematics & Five Kingdom System

<u>Analogous structures</u>:

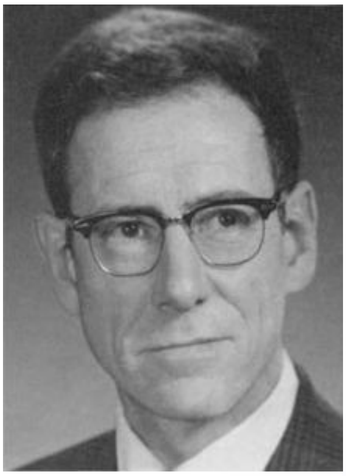
Solutions to a common challenge

<u>Homologous structures</u>:

Inherited similarities

http://www.biologydiscussion.com/biology/kingdom-classification-of-living-organism/5542

Systematics & Five Kingdom System



https://en.wikipedia.org/wiki/Robert_Whittaker

Three Kingdom System

- Robert Whittaker, working in the 1940s-70s, was dissatisfied with the old 2-kingdom systems.
- Developed first a 3-kingdom system

1. Fungi
2. Plants
3. Animals

- Later a 5-kingdom system

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Systematics & Five Kingdom System

Five Kingdom System

1. Bacteria
2. Protists
3. Fungi
4. Plants
5. Animals

- This system is in use now.

Systematics & Five Kingdom System

Three Domain System

1. Archaea
2. Bacteria
3. Eukarya

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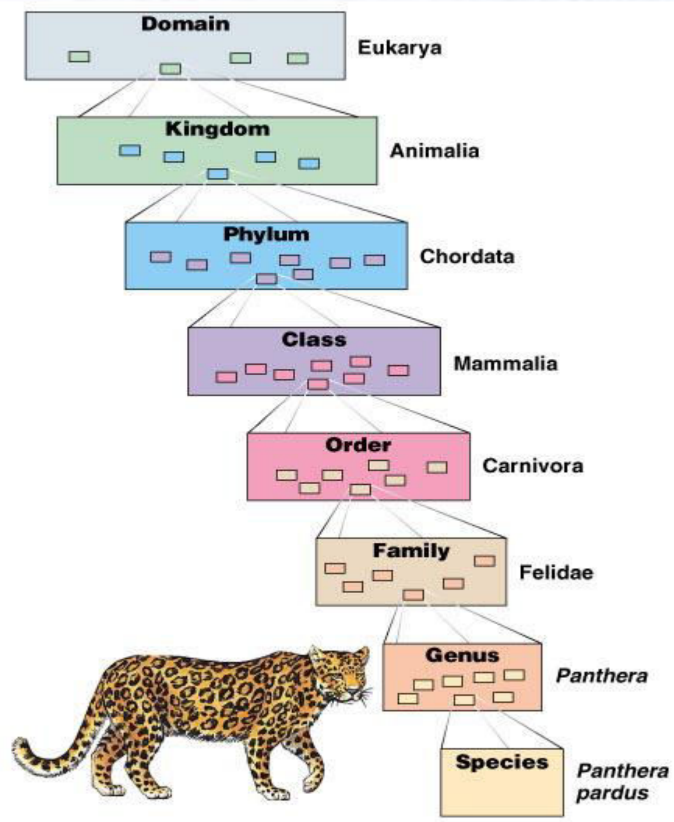
Systematics & Five Kingdom System



Systematics & Five Kingdom System

Binomial Nomenclature

- The binomial system of nomenclature brings order to a chaotic world of common names.
- Common names vary from country to country, and from region to region within a country.
- There was need of globally recognized names.

Systematics & Five Kingdom System

Binomial Nomenclature

- In binomial system, no two kinds of animals have the same binomial name.
- Every scientific name has two parts:

1. First from genus
2. Second from species

- Names are written in italics

Systematics & Five Kingdom System

END

Binomial Nomenclature

Example:

Common name: Indian frog

Genus name: Rana

Species name: tigrina

Scientific name: *Rana tigrina*

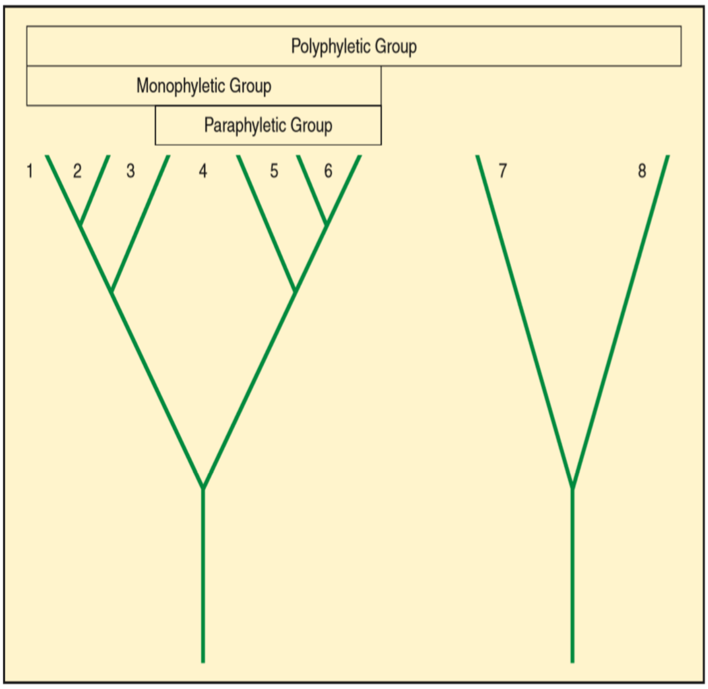
- This scientific name is universally accepted.

Cladistics

Systematics

- It is to arrange animals into groups that reflect evolutionary relationships.
- Three types of groups

Cladistics

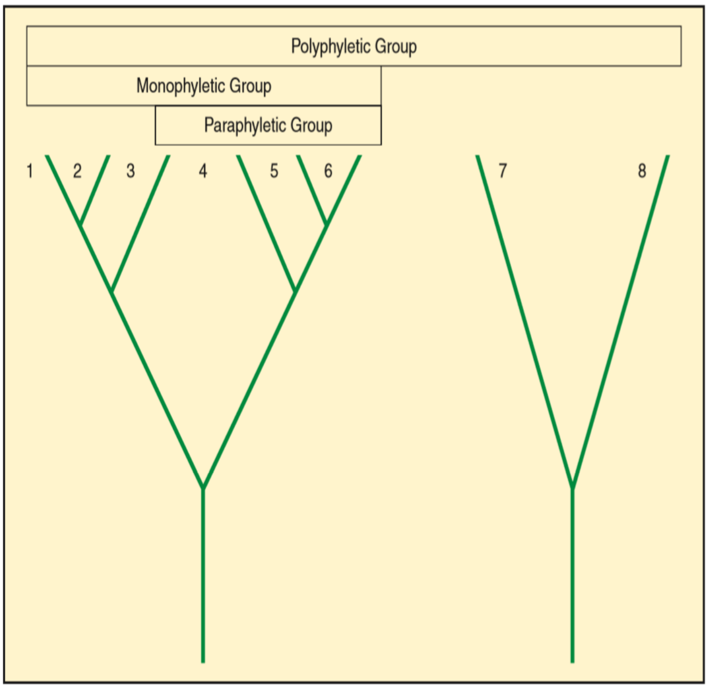


Zoology by Miller and Harley, 5th ed.

1. Monophyletic Groups

- These groups should include a single ancestral species and all of its descendants.

Cladistics

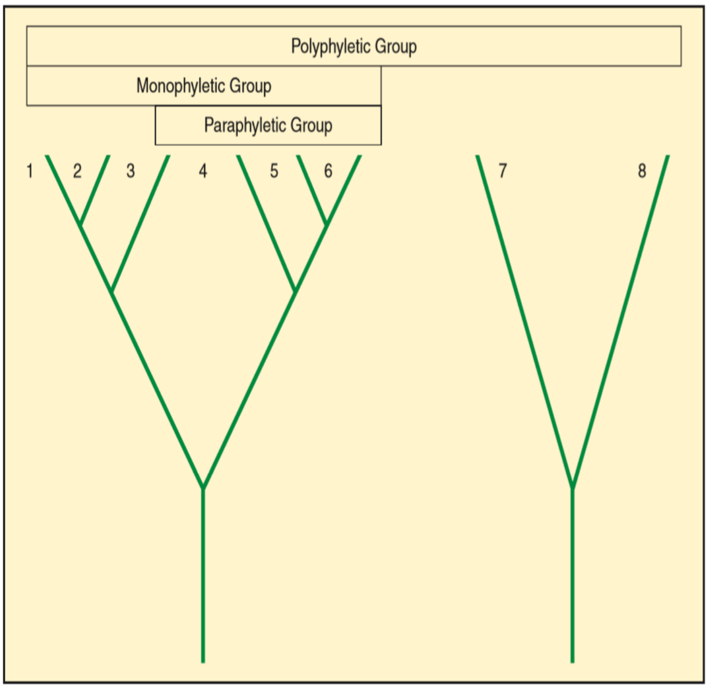


Zoology by Miller and Harley, 5th ed.

2. Polyphyletic groups

- These have members that can be traced to separate ancestors.
- Since each group should have a single ancestor, a polyphyletic group reflects insufficient knowledge of the group.

Cladistics



Zoology by Miller and Harley, 5th ed.

3. Paraphyletic Group

- They include some, but not all, members of a lineage.
- Paraphyletic groups also result when knowledge of the group is insufficient.

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Cladistics

Phylogenetic systematics (cladistics)

- Cladists differentiate between homologies and analogies.
- Homologies of recent origin are most useful in phylogenetic studies.
- Characters that all members of a group share are referred to as symplesiomorphies.

Cladistics

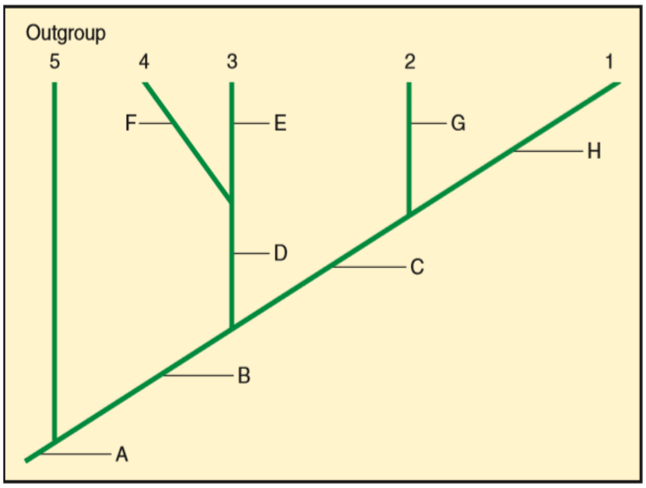

FIGURE 7.5

Interpreting Cladograms. This hypothetical cladogram shows five taxa (1–5) and the characters (A–H) used in deriving the taxonomic relationships. Character A is symplesiomorphic for the entire group. Taxon 5 is the outgroup because it shares only that ancestral character with taxa 1–4. All other characters are more recently derived. What single character is a synapomorphy for taxa 1 and 2, separating them from all other taxa?

Zoology by Miller and Harley, 5th ed.

- To decide what character is ancestral for a group of organisms, cladists look for a related group of organisms, called an outgroup.
- Characters that have arisen since common ancestry with the outgroup are called derived characters or synapomorphies.

Cladistics

- The hypothetical lineage shown in figure is called a cladogram.
- Cladograms depict a sequence in the origin of derived characters.

END

Domain Archaea

- "ancient" bacteria
- Some of the first archaebacteria were discovered in Yellowstone National Park's hot springs and geysers.

https://www.google.com/search?q=yellowstone+geysers

Domain Archaea

- They live in extreme environments (like hot springs or salty lakes).
- or normal environments (like soil and ocean water).
- All are unicellular.
- No peptidoglycan in their cell wall.
- Some have a flagella that aids in their locomotion.

Domain Archaea

- Most don’t need oxygen to survive
- They can produce ATP from sunlight
- They can survive enormous temperature and pressure extremes.
- They can survive high doses of radiation
- They can survive under rocks and in ocean floor vents deep below the ocean’s surface.

Domain Archaea

Types

1. Methanogens
2. Thermoacidophiles
3. Halophiles

Domain Archaea

1. Methanogens

- They release methane (CH4) as a waste product
- Many live in mud at the bottom of lakes and swamps because it lacks oxygen
- Some live in the intestinal tracts of animals to help break down food.
- They could play a role in garbage/sewage cleanup by eating garbage.

Domain Archaea

2. Thermoacidophiles

- Live in the dark
- Live without oxygen
- Like to live in superheated water with temperatures reaching 750°F
- Prefer environments that are very acidic (between pH of 1-3)
- Live in a chemical soup of hydrogen sulfide (H_2S) and other dissolved minerals.

Domain Archaea

https://www.google.com/search?rlz=1C1SQJL

3. Halophiles

- Halo = salt

  phil = loving
- Can live in water with salt concentrations exceeding 15%.
- The ocean's concentration is roughly 4%.
- One habitat of halophils is Great Salt Lake.
- actually three to five times saltier than the ocean.

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Domain Archaea

3. Halophiles

- Great Salt Lake is actually three to five times saltier than the ocean.
- 2.5 million tons of sodium chloride is extracted from the lake.

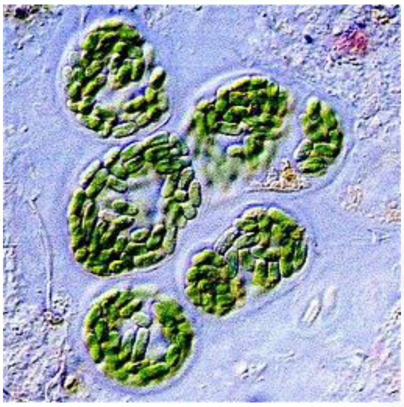
END

Domain Bacteria

- Prokaryote
- No membranous organelles
- Classified in three types:

1. Cyanobacteria
2. Spirochaetes
3. Actinobacteria

Domain Bacteria



https://en.wikipedia.org/wiki/Cyanobacteria#Nitrogen_fixation

Cyanobacteria

- Photosynthesizing bacteria that are related to the chloroplasts of eukaryotic plants and algae
- Also known as blue green algae
- Produce energy by photosynthesis
- They have flattened sacs called thylakoids where photosynthesis is performed.

Domain Bacteria

Symbiotic Relationships

https://en.wikipedia.org/wiki/Cyanobacteria#Nitrogen_fixation

- Cyanobacteria can fix atmospheric nitrogen in anaerobic conditions.
- Symbiotic relationship with leguminous plants roots.
- Nitrogen gas is converted into ammonia (NH_3), nitrites (NO_2) or nitrates (NO_3) to be available for plants.

Domain Bacteria

Spirochaetes

- Gram-negative bacteria that include those causing syphilis and Lyme disease
- Double membrane bacteria, most of which have long, helically coiled.
- Chemoheterotrophic ; obtaining energy from oxidation

https://www.google.com/search?q=Spirochaete

Domain Bacteria

Actinobacteria

- Gram-positive bacteria
- Great economic importance
- Decompose the organic matter of dead organisms
- Cause diseases
- Streptomyces species, are recognized as the producers of many bioactive metabolites:

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Domain Bacteria

Actinobacteria

- Antibacterials
- Antifungals
- Antivirals
- Antithrombotics
- Immunomodifiers
- Antitumor drugs
- Enzyme inhibitors
- In agriculture, including insecticides, herbicides, fungicides

END

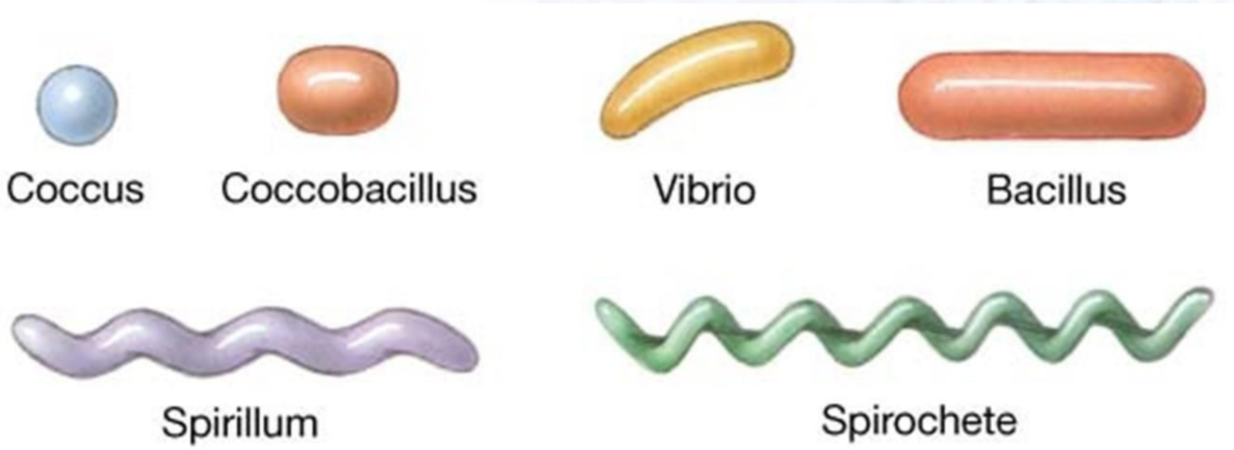
Structure & Function of Prokaryotic Cell-1

Bacteria

- Average bacteria 0.5 - 2.0 µm in diameter.
- Surface Area ~12 µm^2
- Volume is ~4 µm
- Surface Area to Volume is 3:1

Structure & Function of Prokaryotic Cell-1

Shapes of Bacteria



https://www.google.com/search?q=sHapes+of+bacteria

Structure & Function of Prokaryotic Cell-1

Bacteria

- Gel-like matrix of water, enzymes, nutrients, wastes and gases and contains cell structures like numerous ribosomes and polysomes.
- No endoplasmic reticulum and no membrane bound organelles.
- Location of growth, metabolism, and replication.

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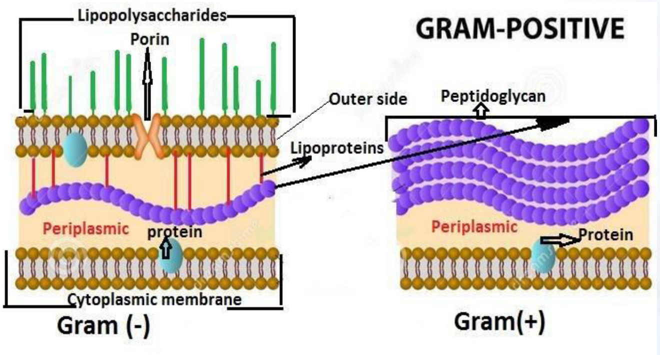
Structure & Function of Prokaryotic Cell-1

https://www.youtube.com/watch?v=c-rtadlcZjs

Structure & Function of Prokaryotic Cell-1

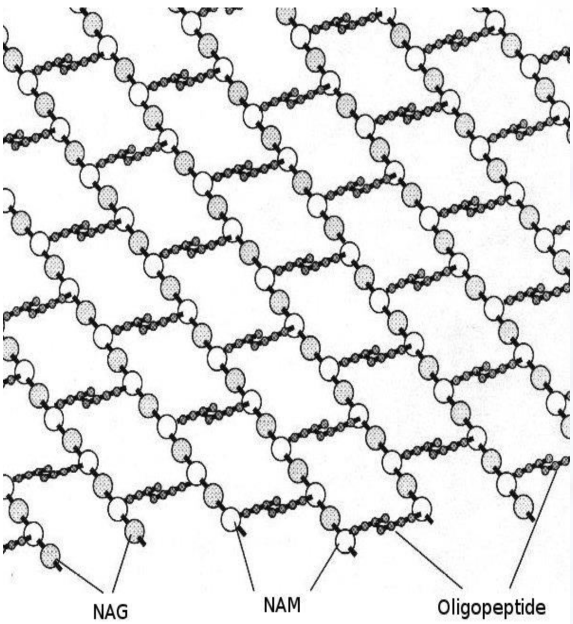


https://www.google.com/search?rlz=1C1SQJL_

Plasma Membrane

- Protection of cell contents
- Thin and elastic semipermeable membrane
- Made up of proteins embedded in two layers of lipids (lipid bilayer model)
- Cell motility
- Exchange of materials

Structure & Function of Prokaryotic Cell-1



https://www.google.com/search?q=cell+wall+of+bacteria

Cell Wall

- Peptido-glycan Polymer (amino acids + sugars)
- Unique to bacteria
- Sugars; NAG & NAM

1. N-acetyl glucosamine
2. N-acetyl muramic acid

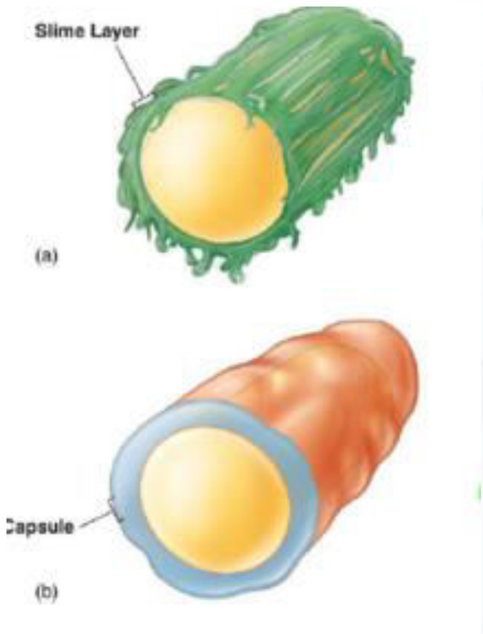
- Hard to break down
- Amino acids cross link NAG & NAM

Structure & Function of Prokaryotic Cell-1

Ribosomes

- Involved in protein synthesis
- Different from host cell ribosomes in SR.
- 3 types of RNAs:
- Ribosomal, transfer , mRNA
- Found within cytoplasm or attached to plasma membrane

Structure & Function of Prokaryotic Cell



https://www.google.com/search?rlz=1C1SQJL

Glycocalyx

- Polysaccharides firmly attached to the cell wall.
- It exists either as capsule or slime layer.
- Capsules adhere to solid surfaces and to nutrients in the environment.
- Capsule also protect bacteria from being phagocitized by cells of the hosts immune system.

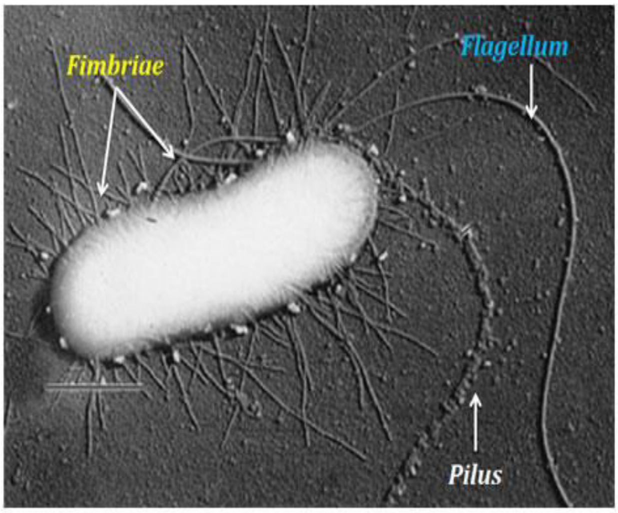
Structure & Function of Prokaryotic Cell-2

Flagella

- Motility - movement
- Arrangement basis for classification

Structure & Function of Prokaryotic Cell-2

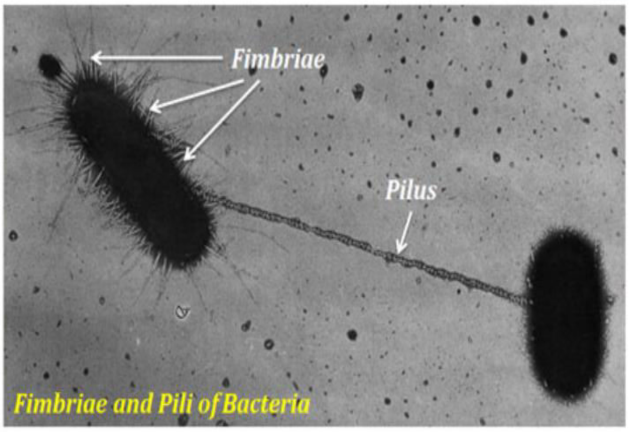
Flagella



https://www.google.com/search?rlz=1C1SQJL

1. Monotrichous; one flagella
2. Lophotrichous; tuft at one end
3. Amphitrichous; both ends
4. Peritrichous; all around bacteria.

Structure & Function of Prokaryotic Cell-2



https://www.google.com/search?rlz=1C1SQJL

Pilli

- Short protein appendages smaller than flagella
- Made up of protein pilin
- Length is 0.5 – 2 µm.
- Number is 1 – 10 per cell.
- Used in conjugation for exchange of genetic material.

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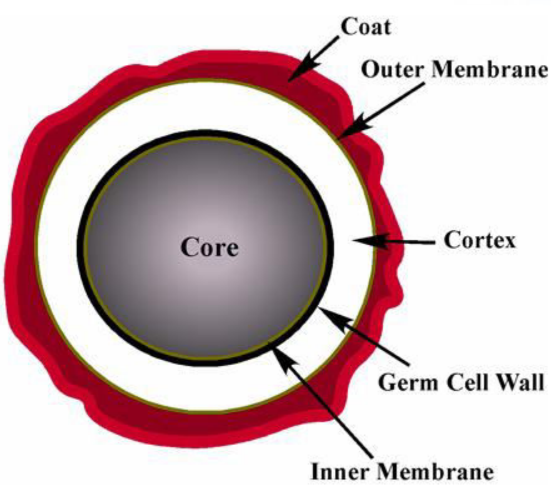
Structure & Function of Prokaryotic Cell-2



https://en.wikipedia.org/wiki/Bacteria#Endospores

Endospores

- Dormant, tough, and non-reproductive structure produced by some bacteria
- Do not need nutrients to survive, may survive millions of years
- Resistant to heat, irradiation and cold
- Boiling > 1 hour still viable
- Takes time and energy to destroy spores

Structure & Function of Prokaryotic Cell-2

Reproduction

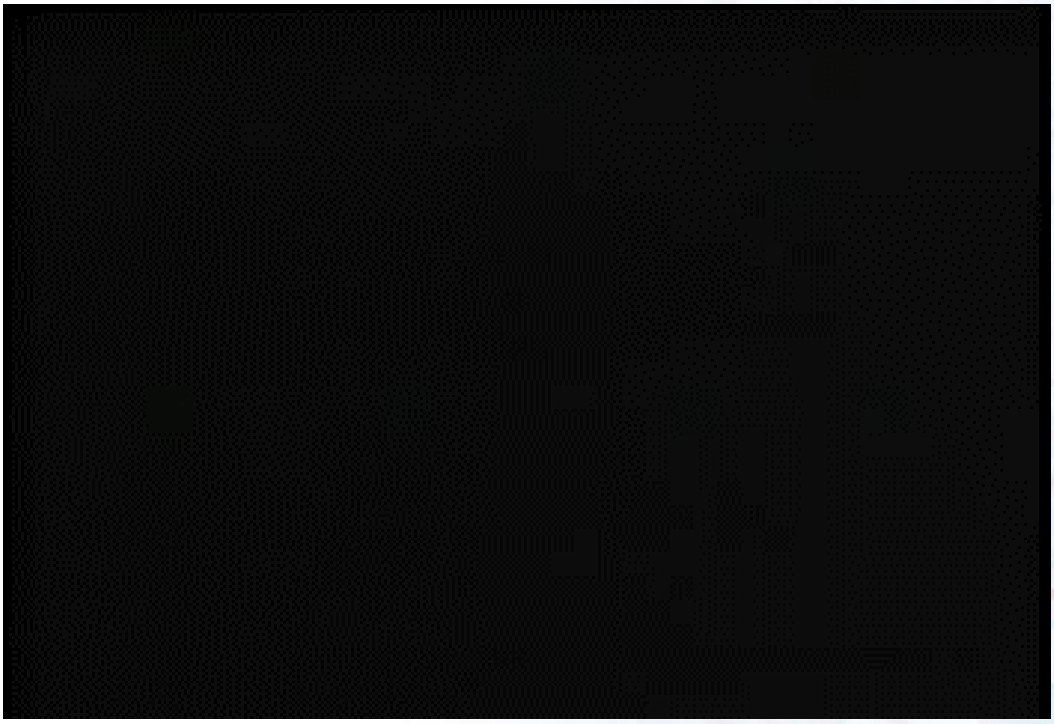
- Asexual reproduction

1. Binary fission
2. Multiple fission

- Sexual reproduction

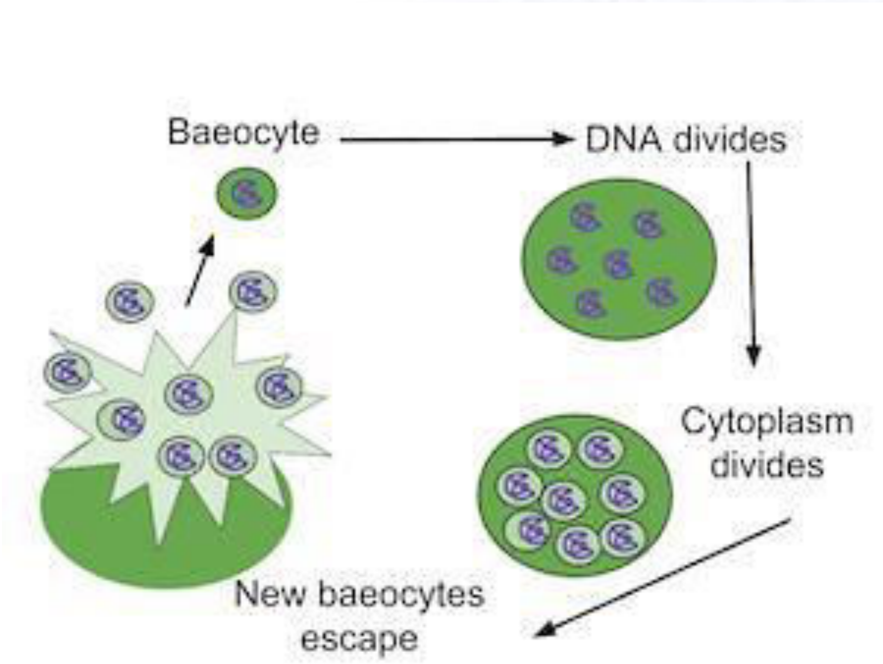
1. Conjugation

Structure & Function of Prokaryotic Cell-2



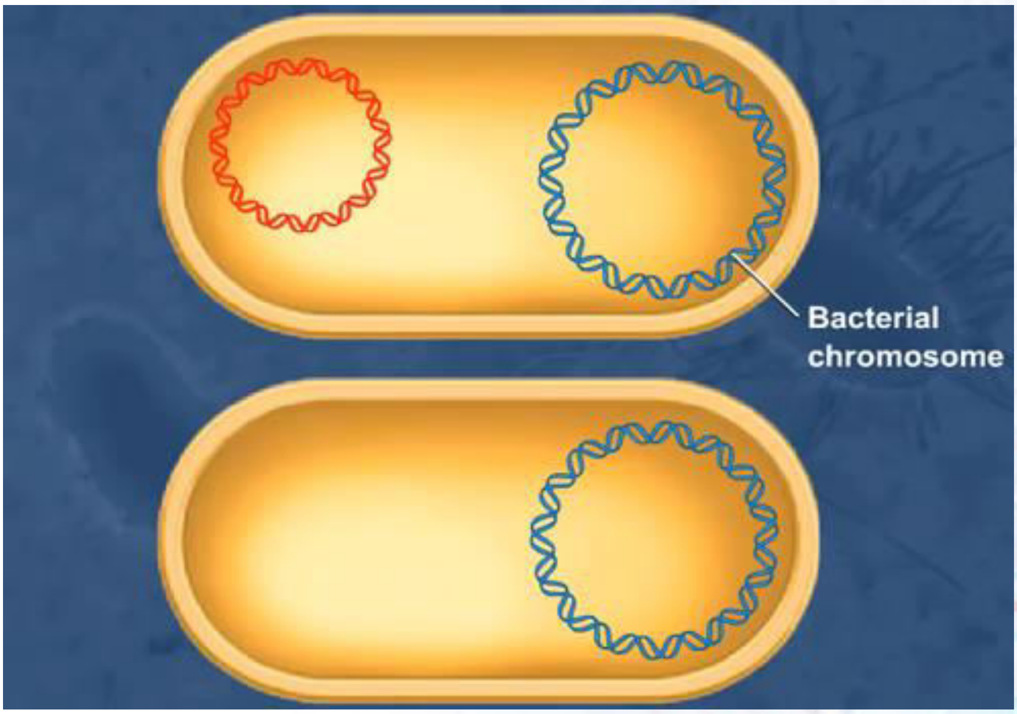
https://www.youtube.com/watch?v=DY9DNWcqxI4

Structure & Function of Prokaryotic Cell-2



https://en.wikipedia.org/wiki/Bacteria#Growth_and_reproduction

Structure & Function of Prokaryotic Cell



https://www.youtube.com/watch?v=hm8SZaFmlWg

Domain Eukaryota

- Organisms whose cells have a nucleus enclosed within membranes.
- Contain other membrane-bound organelles such as mitochondria and the Golgi apparatus.
- Can be multicellular unlike to other domains.
- Cells make different types of tissues and systems
- Animals and plants are common examples.

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Domain Eukaryota

- Evolved 2.7 billion years ago

Classification

1. Kingdom Protista (unicellular eukaryotes)
2. Kingdom Plantae
3. Kingdom Fungi
4. Kingdom Animalia

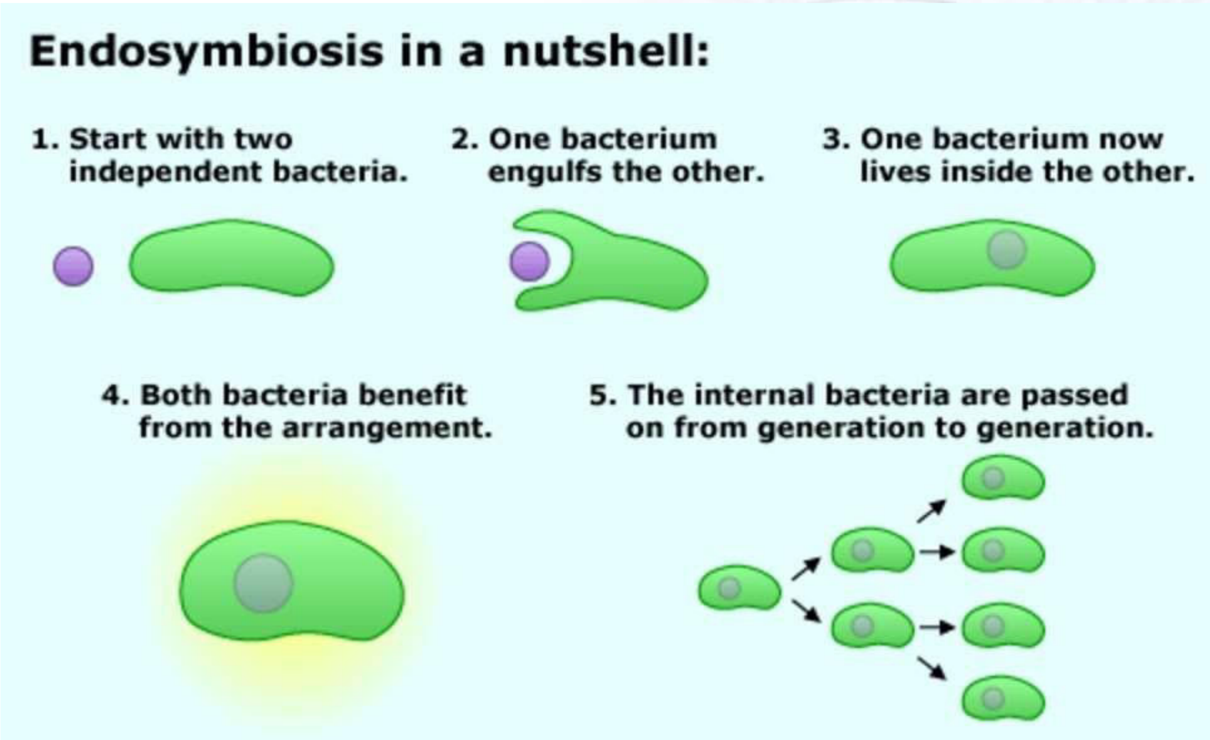
Domain Eukaryota

Origin of Eukaryotic Cells

Endosymbiotic Theory

- Chloroplasts and Mitochondria evolved from symbiotic bacteria that lived inside of a larger prokaryote.
- Also known as Symbiogenesis

Domain Eukaryota



https://en.wikipedia.org/wiki/Symbiogenesis

Domain Eukaryota

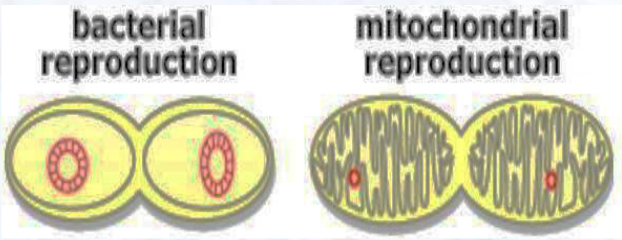
- Chloroplasts evolved from endocytosis of cyanobacteria
- Mitochondria evolved from endocytosis of aerobic bacteria.

Evidence of evolution of mitochondria

- Membranes- Have double cell membranes
- DNA- Have circular DNA, like bacterial genome

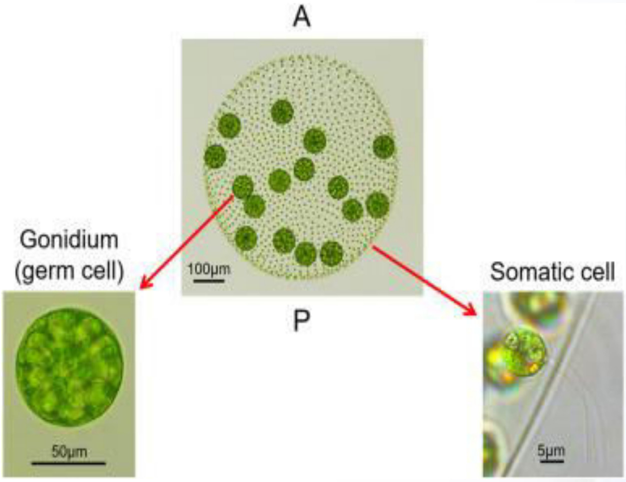
Domain Eukaryota

- Reproduction- via budding, just like bacteria
- Size- similar size to bacteria (1-10 microns)



https://en.wikipedia.org/wiki/Symbiogenesis

Domain Eukaryota



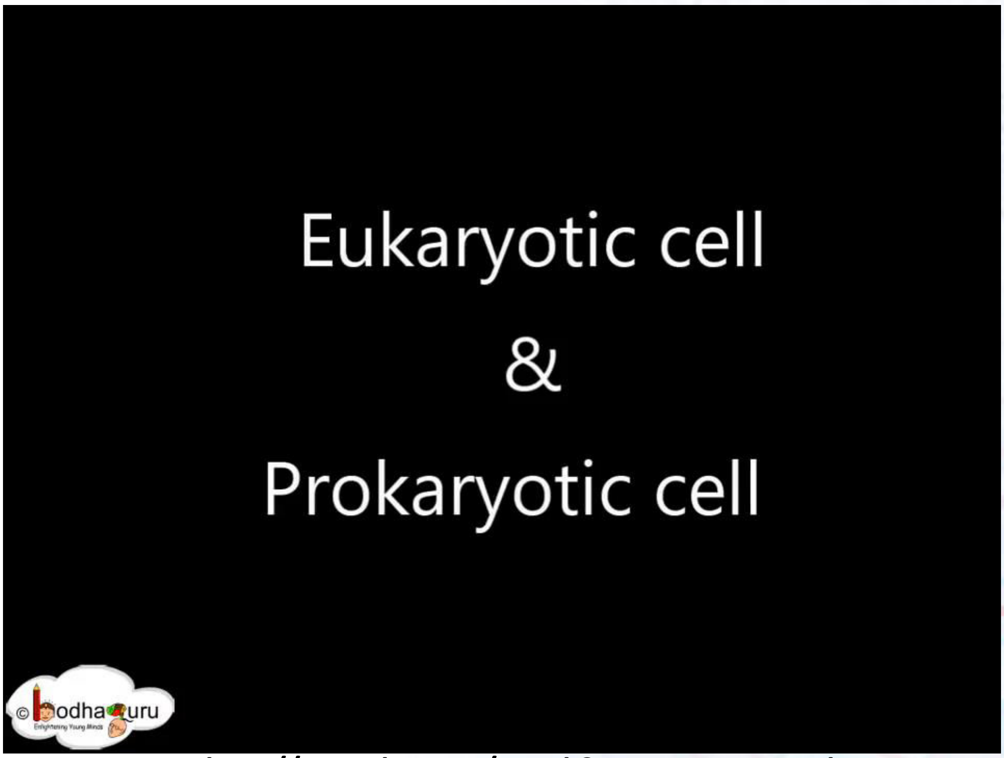
https://www.google.com/search?q=types+of+cells+in+volvox

- Multicellularity
- Cell specialization, larger size, more complexity
- Volvox algae with division of labor
- Two types of cell functions

1. Swimming (somatic cells)
2. Reproduction (gonidium)

- Multicellularity became more complex in kingdom animalia and plantae.

Domain Eukaryota



http://youtube.com/watch?v=2ZBmmQN6nLk

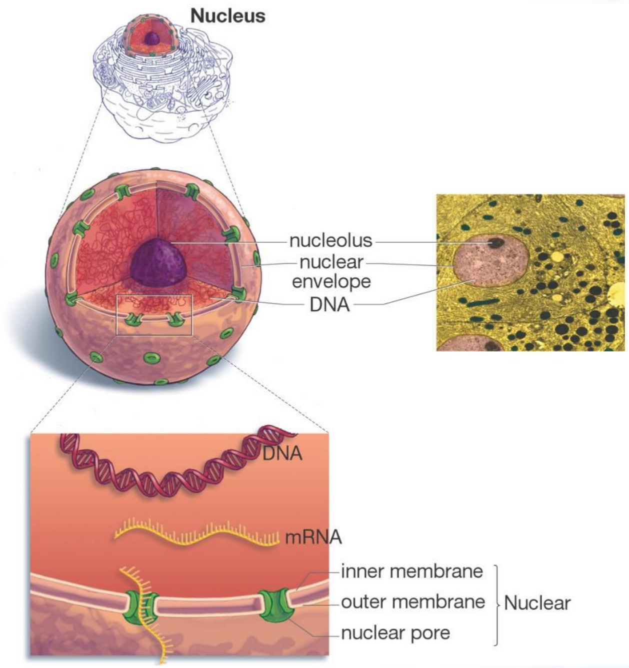
Nucleus

Nucleus

- The nucleus is an organelle found in eukaryotic cells.
- Inside its fully enclosed nuclear membrane, it contains the majority of the cell's genetic material.
- This material is organized as DNA molecules, along with a variety of proteins, to form chromosomes.

Nucleus

What is nucleus made up of?



https://www.google.com/search?q=nucleus

1. The nuclear envelope
2. Nucleoplasm and Chromatin (two major types of material)
3. The nucleolus
4. DNA

Two meters of human DNA fits into a nucleus that’s 0.000005 meters across.

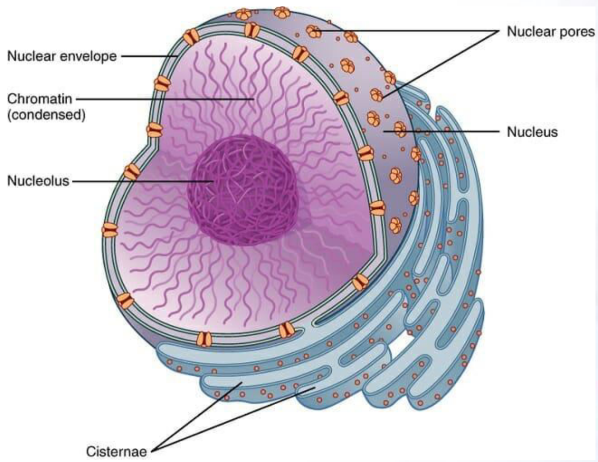
Structure of **Nucleus**. **Nucleus** is a membrane bound structure that contains the **cell's** hereditary information and controls the **cell's** growth and reproduction. ... It is the command center of a eukaryotic **cell** and is commonly the most prominent organelle in a **cell**.

Think of the nucleus as the cell's control center, mainly genetic control center of a eukaryotic cell.

In most cells, there is only one nucleus. It is spherical, and the most prominent part of the cell, making up 10% of the cell's volume.

The **nucleus is known** as the '**brain of the cell**' because the **nucleus** coordinates all the **cell's** activities

Nucleus



https://www.google.com/search?q=nucleus

Nuclear Envelope or Membrane

- **The nuclear envelope is a double-layered membrane**
- **Perforated with pores, which control the flow of material going in and out of the nucleus.**

Nucleus

- The outer layer is connected to the endoplasmic reticulum, communicating with the cytoplasm of the cell.
- The exchange of the large molecules (protein and RNA) between the nucleus and cytoplasm happens here.

Nucleus

Nucleoplasm

- A jelly-like (made mostly of water) matrix within the nucleus
- All the other materials "float" inside
- Helps the nucleus keep its shape and serves as the median for the transportation of important molecules within the nucleus

Nucleus

Nucleolus

- Site of ribosome synthesis
- Compartment in the nucleus where ribosomes are assembled.
- Ribosomes are then moved out into cytoplasm through nuclear pores.
- Ribosomes and RNA work together outside the nucleus, to build all the proteins in the cell.

Every nucleus has at least one nucleolus.

- **It appears as a darker globular mass which is responsible for producing the large and small subunits of ribosomal RNA.**
- **Subunits do not join together until shipment out of nucleus**
- **One large and one small subunit join as an intact ribosome during protein synthesis.**

Chromatin = all the chromosomes, which are long strands of the molecule DNA
DNA regulates all cell activities, yet never leaves the nucleus; how is this possible?

produces **RNA**, short messenger molecules that exit through nuclear pores

RNA carries instructions out into the cytoplasm

Nucleus

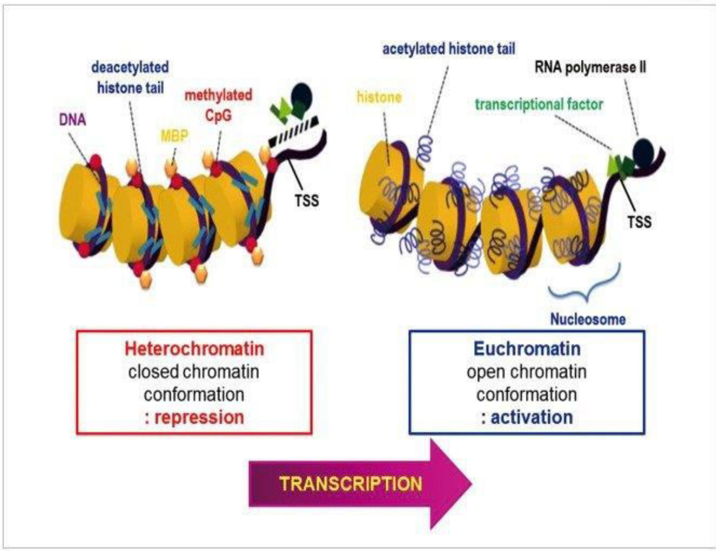
Only the cells of advanced organisms, known as eukaryotes, have a nucleus. The **nucleus** is the most **important** organelle in the cell. It contains the genetic material, the DNA, which is responsible for controlling and directing all the activities of the cell. All the RNAs needed for the cell are synthesized in the **nucleus**.

Chromatin & Chromosomes

- **Chromosomes contain double stranded DNA molecules in a condensed form attached to a histone protein.**
- **Chromatin is comprised of DNA.**
- **There are two types based on function.**

Nucleus

Chromatin & Chromosomes



https://www.google.com/search?rlz=1C1SQJL_enUS822US822

- **Heterochromatin: highly condensed, transcriptionally inactive mostly located adjacent to the nuclear membrane**
- **Eurochromatin: delicate, less condensed organization of chromatin, located in a transcribing cell**

Nucleus

DNA or Deoxyribonucleic acid

- Contains the information needed for the creation of proteins
- In the form of chromatin or chromosomes
- The nucleus is the site of DNA duplication, which is needed for cell division (mitosis) and organism reproduction and growth.

Nucleus

The Nucleus and Cell Control

- The nucleus is the leader of the eukaryotic cell
- It contains the direction to make proteins.
- Every part of the cell depends on proteins, so by containing blueprint to make proteins, the nucleus controls the activity of the organelles.

Nucleus

Major Functions of the nucleus

- It stores the cell's hereditary material, or DNA
- Coordinates the cell's activities, which include growth, intermediary metabolism, protein synthesis, and reproduction (cell division).

Nucleus

- Nucleus is the brain of the cell and controls most of its functions. ...
- The nucleus oversees cells' functions and regulatory mechanisms for keeping the cell healthy and alive.
- The nucleus controls growth of the cell through the synthesis of structural proteins, energy and nutrient metabolism.
- Without a nucleus, the cell will not know what to do and there would be no cell division. Protein synthesis would either cease or incorrect proteins would be formed. All this would result in cell death.

Major Functions of the Nucleus

- Keep the DNA from getting tangled with cytoplasmic machinery
- Isolates DNA from potentially damaging interactions
- Cells control the movement of substances to and from the cytoplasm

END

Ribosomes

- First isolated from cell cytoplasm by Claude (1943)
- Term ribosomes was coined by Palade (1955).
- Also called 'palade particles'

Found in both prokaryotes & eukaryotes(except sperm & RBC)
Reported inside the matrix of mitochondria & plastids also.
No. of ribosomes depend upon the RNA contents & basophilic nature of the cell.
Sites of protein synthesis so called protein factories.

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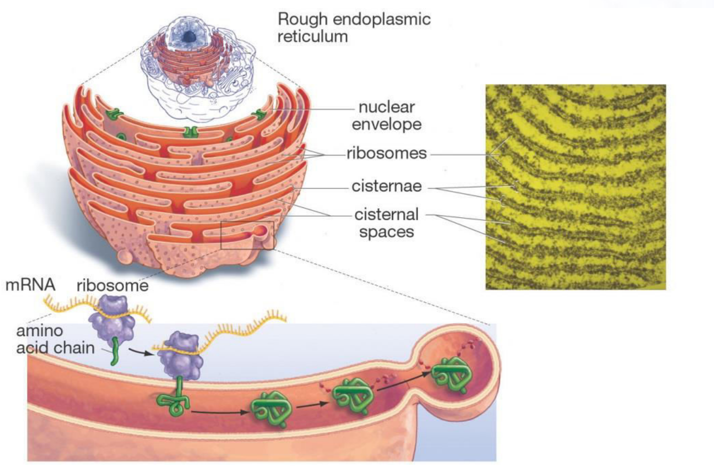
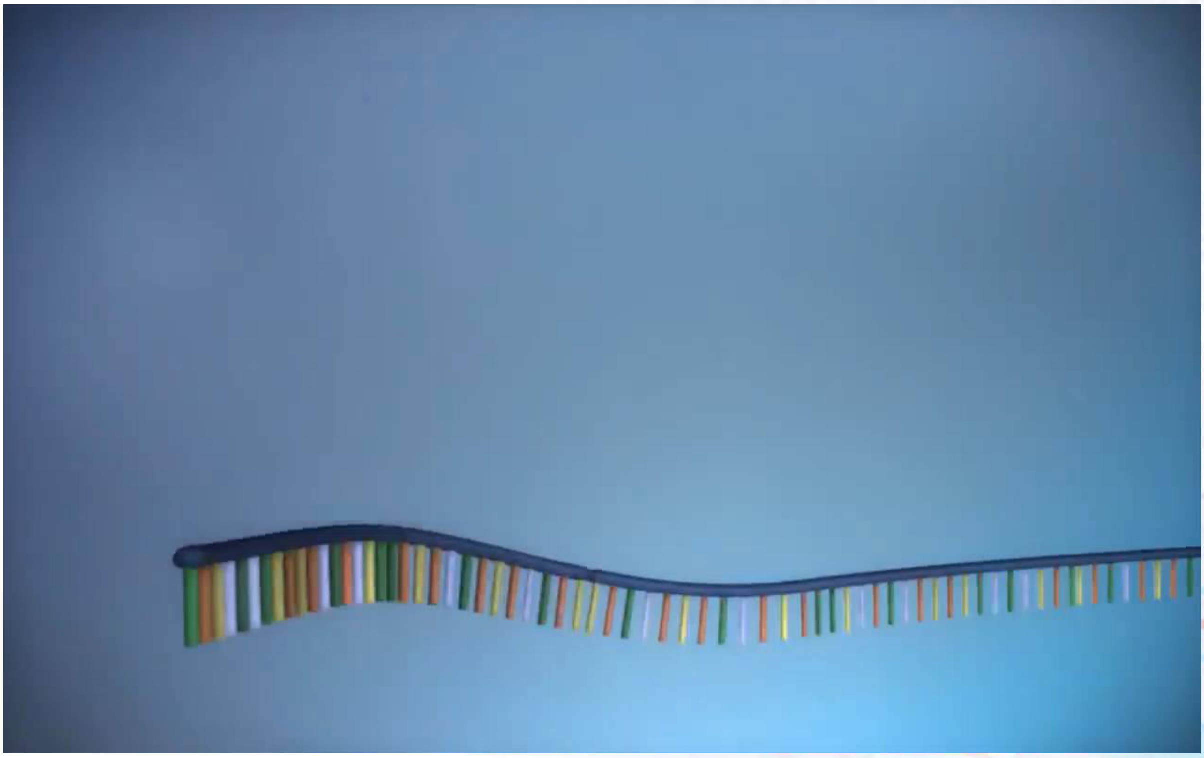
Ribosomes



https://en.wikipedia.org/wiki/Ribosome

- Ribosomes are the protein builders or the protein synthesizers of the cell.
- They connect one amino acid at a time and build long chains.
- Ribosomes are special because they are found in both prokaryotes and eukaryotes.

Ribosome



http://youtube.com/watch?v=gG7uCskUOrA

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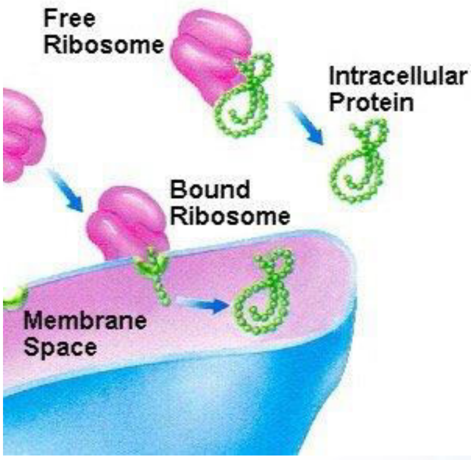
Ribosomes are a cell structure that makes protein.

Protein is needed for many cell functions such as repairing damage or directing chemical processes. Ribosomes can be found floating within the cytoplasm or attached to the endoplasmic reticulum.

In each ribosomal subunit rRNA is in the form of highly folded filament, different types of proteins are adhered to it. 60% rRNA is in double helix form. Most abundant nitrogen bases are guanine & cytosine.

Ribosome



https://www.google.com/search?q=membrane-bound+ribosomes

Type of Ribosome

Classified according to their location

1. Membrane-Bound Ribosomes

- Synthesize proteins for membranes and exocytosis (used outside the cell).
- Attached to endoplasmic reticulum

Ribosome

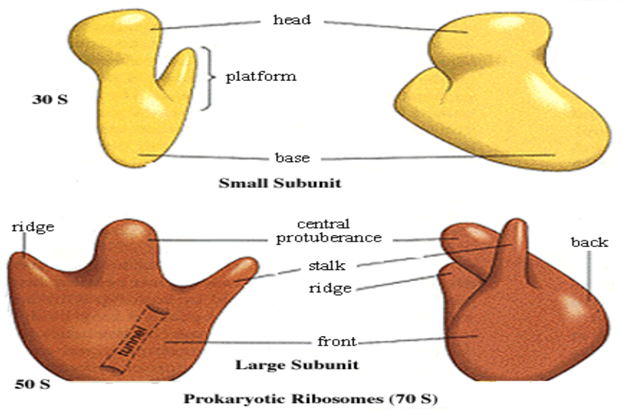
Type of Ribosome

Classified according to their location

2. Free Ribosomes

- Found freely in fluid cytoplasm
- Synthesize proteins that function inside the cytosol

Ribosome



https://en.wikipedia.org/wiki/Ribosome

Type of Ribosome

- On the basis of sedimentation coefficient, ribosomes are of 2 types:
- (A) 70S Ribosomes:
- Found in prokaryotes.
- (B) 80S Ribosomes:
- Found in cytoplasm of eukaryotes.

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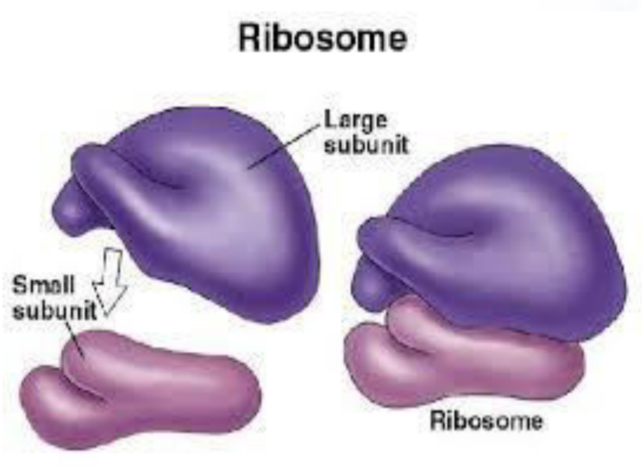
Ribosome



https://en.wikipedia.org/wiki/Ribosome

Chemical Composition

- 60-65% r-RNA
- Proteins
- 70S ribosome: 35-40%
- 80S ribosome: 55%

Ribosome

Function of the Ribosome

Ribosomes = site of protein synthesis

•Assembles peptides in the nucleolus

•Exported into cytoplasm

•Wrapped inside vesicles

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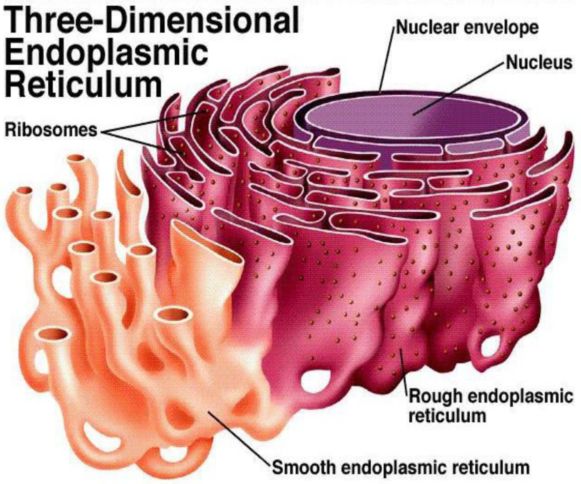
Endoplasmic Reticulum

Endoplasmic Reticulum (ER)

- Discovered in 1945 by albert claude
- It was first noticed in the cytoplasm of chick embryo cells.

Endoplasmic Reticulum



https://en.wikipedia.org/wiki/Endoplasmic_reticulum

- **ER is a system of membranous channels and saccules.**
- **ER is an organelle found in the cells of eukaryotic organisms.**
- **These membranes are continuous, joining with the outer membrane of the nuclear membrane.**

It is an interconnected network of flattened sacs or tubes encased in membranes.

Some organelles are bounded by a **single membrane**. For example, vacuole, lysosome, Golgi Apparatus, **Endoplasmic Reticulum** etc. They are present only in a eukaryotic cell. **Double membrane**-bound: Cell organelles like mitochondria and chloroplast are **double membrane**-bound organelles.

Rough **ER** is found throughout the cell but the density is higher near the nucleus and the Golgi apparatus. Ribosomes on the rough **endoplasmic reticulum** are called 'membrane bound' and are responsible for the assembly of many proteins. This process is called translation.

Endoplasmic Reticulum

Types of Endoplasmic reticulum

1. Rough ER (RER)
2. Smooth ER (SER)

Endoplasmic Reticulum

RER

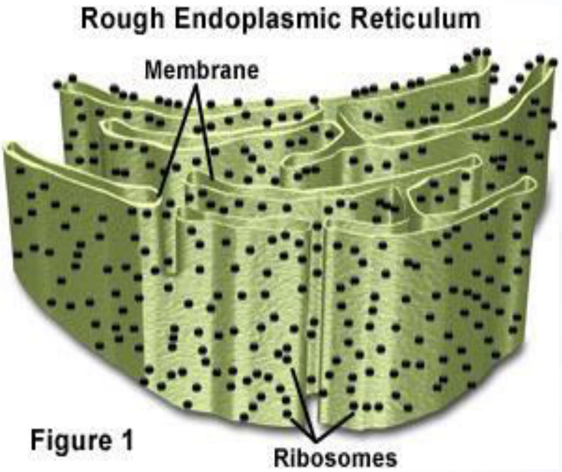


Figure 1

https://en.wikipedia.org/wiki/Endoplasmic_reticulum

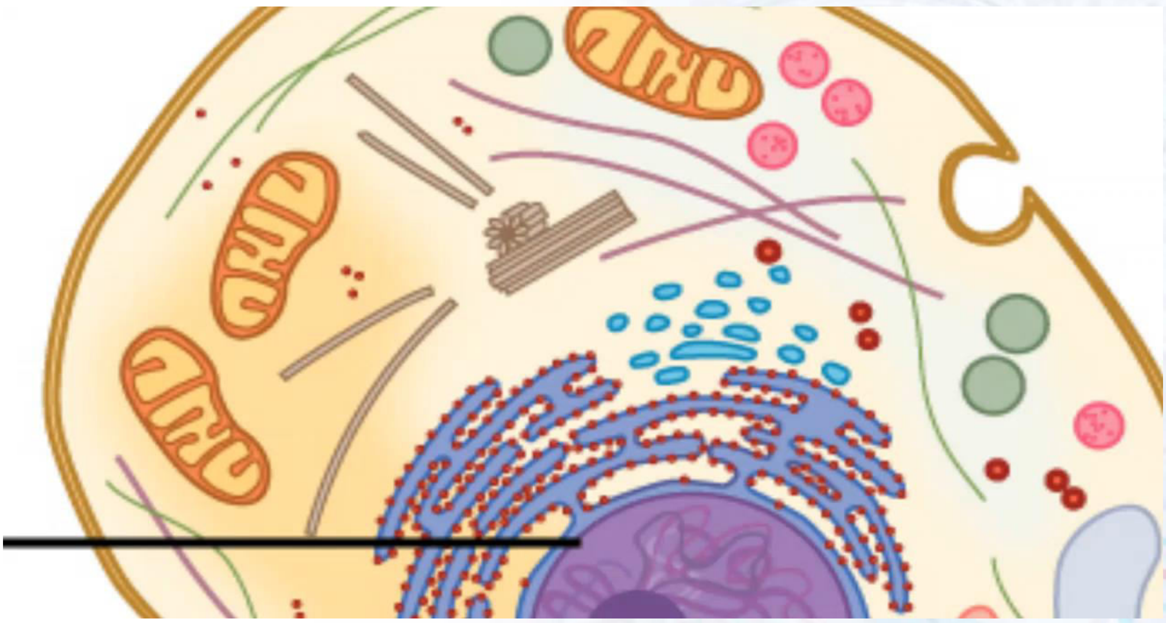
- RER has ribosomes attached.
- Involved with protein production, protein folding, quality control and dispatch.
- Synthesis of proteins.
- They produce and process specific proteins at ribosomal sites like glycosylation.

Endoplasmic Reticulum

RER

- Often interact with Golgi complex.
- Consists of network-like tunnels with tubules and vesicles
- which is held together by the cytoskeleton of the cell.

Endoplasmic Reticulum



http://youtube.com/watch?v=aan7tpWR16mo

Endoplasmic Reticulum

SER

- SER is more tubular then RER
- Forms a separate interconnecting network. (Is found evenly distributed among the Cytoplasm.)
- SER has no ribosomes on it.
- SER manufactures lipids and in some cases the metabolism of them and associated products.

ClueBook.com

Endoplasmic Reticulum

SER

- Storage of carbohydrates
- Detoxification reactions in liver
- Synthesizes much of the new membrane material
- Modification of existing molecules

END

Golgi Apparatus

Golgi Body

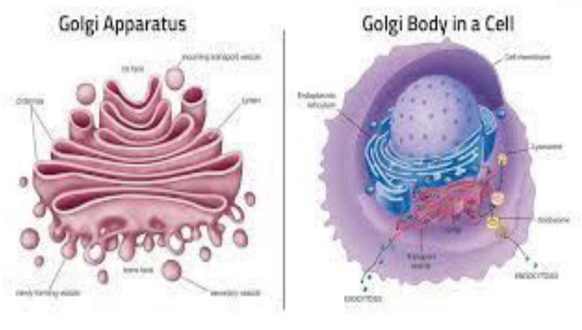
- Named after Camillo Golgi
- An Italian biologist who discovered the organelle with a light microscope in 1897.

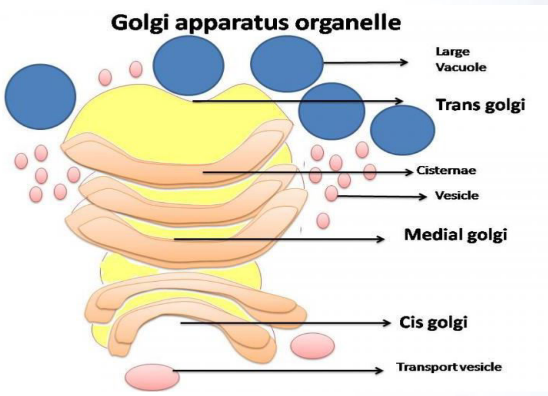
He **Golgi apparatus** is an organelle present in most eukaryotic cells. It is made up of membrane-bound sacs, and is also called a **Golgi** body, **Golgi** complex, or dictyosome. The job of the **Golgi apparatus** is to process and bundle macromolecules like proteins and lipids as they are synthesized within the cell.

https://en.wikipedia.org/wiki/Golgi_apparatus

ClluesBook.com

Golgi Apparatus





https://en.wikipedia.org/wiki/Golgi_apparatus

Structure

- Located near the end of the ER close to the nucleus
- Composed of several layers of cisternae (fluid-filled sacs)
- Has three different parts:

1. cis-Golgi
2. medial-Golgi
3. trans-Golgi

Golgi Apparatus

ER and Golgi often adjacent in cytoplasm of cell.

Both are membrane producers

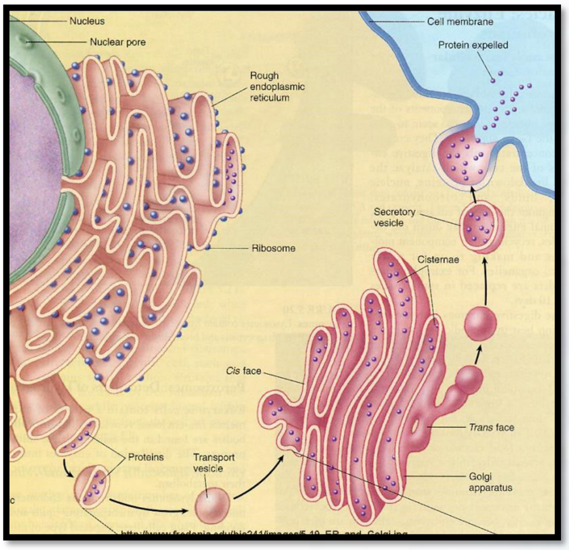
- Membrane has sides
- Vesicles are produced inside out
- Vesicle fuses with surface and excreted proteins are released and integral proteins are added along with membrane

ER often performs first steps of modification that is later finished in Golgi

Functions

- ***cis*** **is first cisternae.**
- ***trans*** **is final cisternae.**
- **From trans, proteins are packaged into vesicles destined to lysosomes, secretory vesicles, or the cell surface.**

Golgi Apparatus



https://en.wikipedia.org/wiki/Golgi_apparatus

Functions

- **Transport vesicles are used to move back and forth between the ER and Golgi bodies**
- **One side of the Golgi body receives transport vesicles produced by the ER.**
- **This side is called cis face.**
- **Opposite side releasing vesicle is trans face.**

The Golgi body Responsible for secretion.

The **Golgi apparatus** receives proteins and lipids (fats) from the rough endoplasmic reticulum. It modifies some of them and sorts, concentrates and packs them into sealed droplets called vesicles.

- **Very prominent in cells that serve secretory functions-such as epithelial cells**

Modifies structures previously synthesized in the ER

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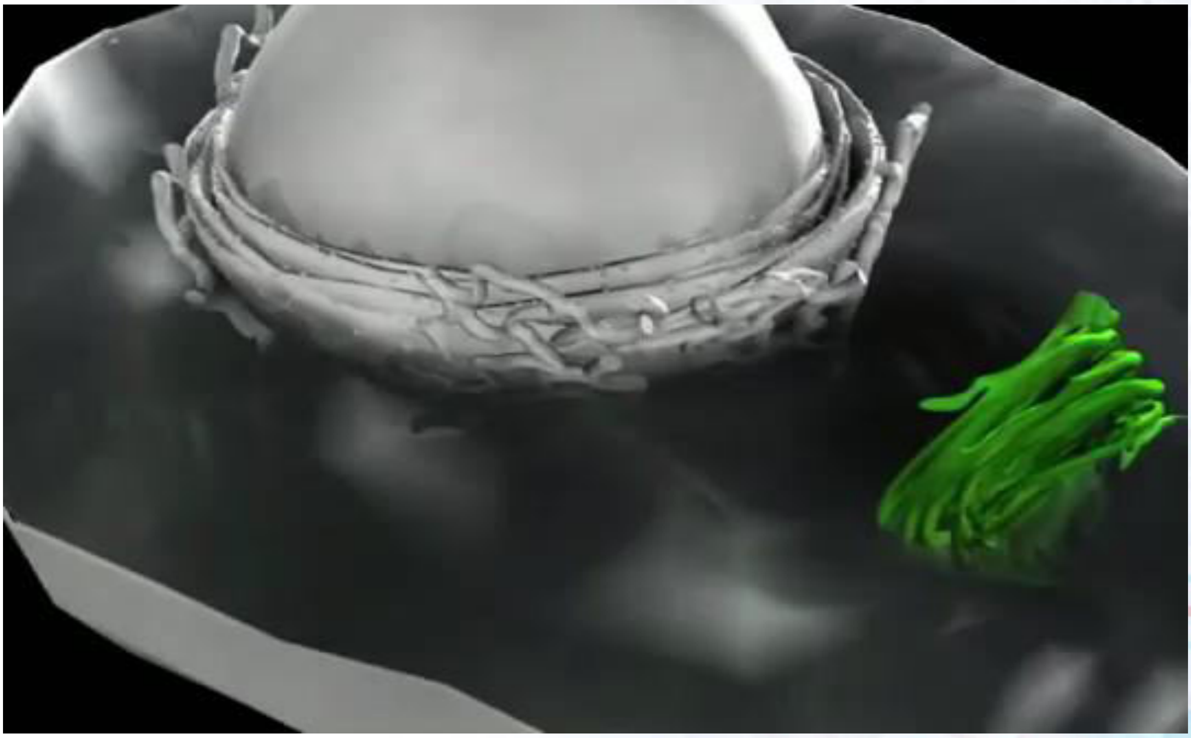
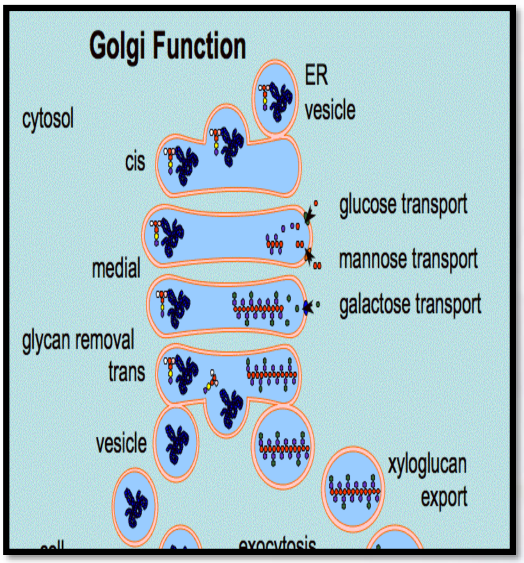
Golgi Apparatus



https://en.wikipedia.org/wiki/Golgi_apparatus

Golgi Apparatus



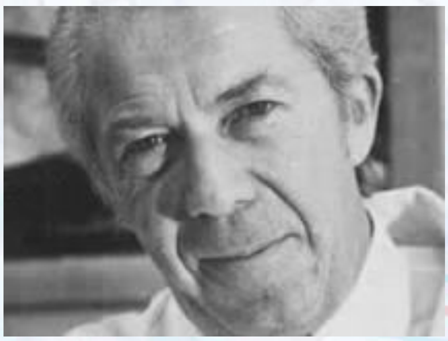
https://en.wikipedia.org/wiki/Golgi_apparatus

Functions

- The Golgi body marks and sorts the molecules into different groups.
- These groups are sent in secretory vesicles inside or outside of the cell.
- Proteins are modified before sending by adding specific sugar molecules are added to a core oligosaccharide that is attached to a protein.

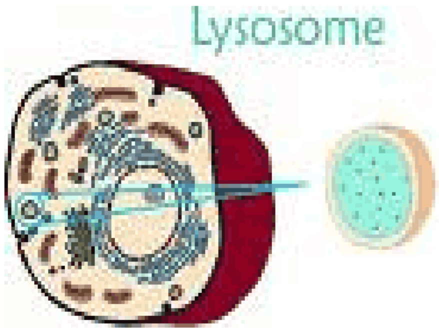
Lysosome

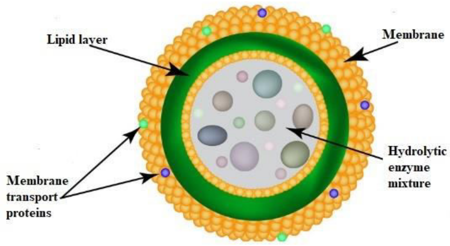
- Lysosomes were discovered by the Belgian cytologist de Duve in the 1950s.



https://en.wikipedia.org/wiki/Lysosome

Lysosome





Lysosome

https://en.wikipedia.org/wiki/Lysosome

- Lysosomes are vesicles produced by the Golgi apparatus.
- Present in cytoplasm of eukaryotic cells.
- It contains degradative enzymes enclosed in a membrane.
- Internal environment is acidic (pH: 7)

Lysosomes are spherical bodies, or vacuoles that are enclosed by a single membrane. ... **Lysosomes** are membrane-enclosed organelles that help eukaryotic cells obtain nourishment from macromolecular nutrients. **The lysosomes**contain many hydrolytic enzymes such as proteases, nucleases, and lipases)

Lysosomes are analogous to the human stomach; the pH within a lysosome is very acidic & the enzymes within work most effectively in this environment.

How are they structured?
Enzyme-filled sacs
-Generally spherical
-Surrounded by single membrane

Lysosome

Functions

- **Lysosomes are known to contain:**

1. **More than 60 different enzymes**
2. **More than 50 membrane proteins**

The Lysosome functions:

Digesting food or cellular invaders

Recycling cellular components

Cell suicide (suicide is bad for cells, but good for us!)

The lysosome is not found in plant cells)

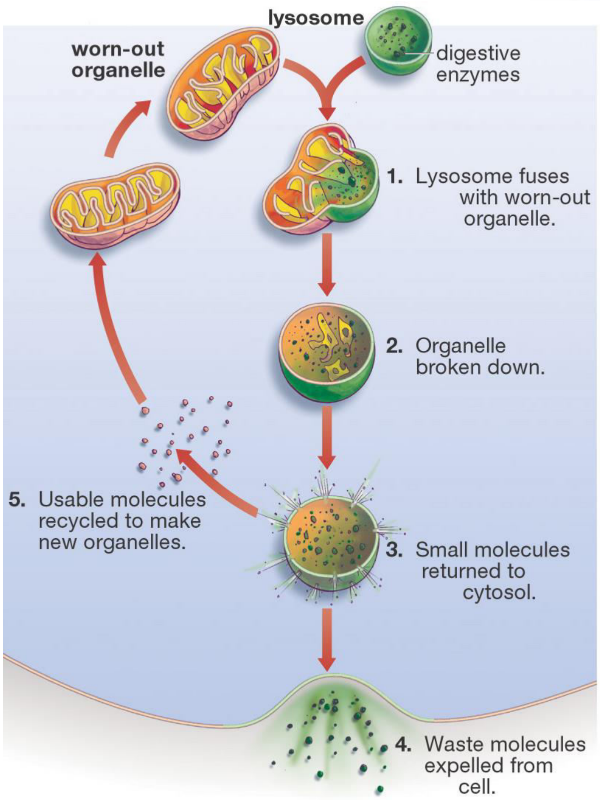
Lysosome

Functions

- **Wide variety of hydrolytic enzymes (acid hydrolases) that break down macromolecules such as**

1. **Nucleic acids**
2. **Proteins**
3. **Polysaccharides**

Lysosome



Functions:

- Carrying out digestion
- Recycling of cellular organelles
- The breakdown of viruses and other cellular invaders
- Single-celled organisms, such as amoebas, use lysosomes to digest their food since they have no process for extracellular digestion.

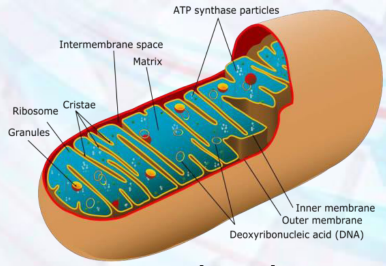
Lysosome

https://www.youtube.com/watch?v=cA-Ou_t2sag

Mitochondria - 1

These were identified as organelles by the Belgian cytologist Christian **de Duve** in **1967** after they had been first described by a Swedish doctoral student, **J. Rhodin** in **1954**.

- **Mito – thread**
- **Chondrion – granule like**
- **First observed by Richard Altman (1894)**
- **Term mitochondria was coined by Carl Benda (1898).**

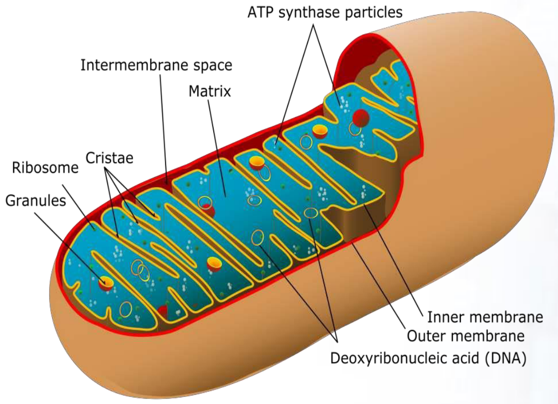


https://en.wikipedia.org/wiki/Mitochondrion

Mitochondria - 1

- **Size: 0.05 – 1.0 µm**
- **Length: 1 – 10 µm long**
- **Shape: Bean shaped , in fibroblast it is elongated and thread like.**
- **Number: Depends on type, size and functional state of cell.**
- **Example: average liver cell contain around 1500 mitochondria.**

Mitochondria - 1



https://en.wikipedia.org/wiki/Mitochondrion

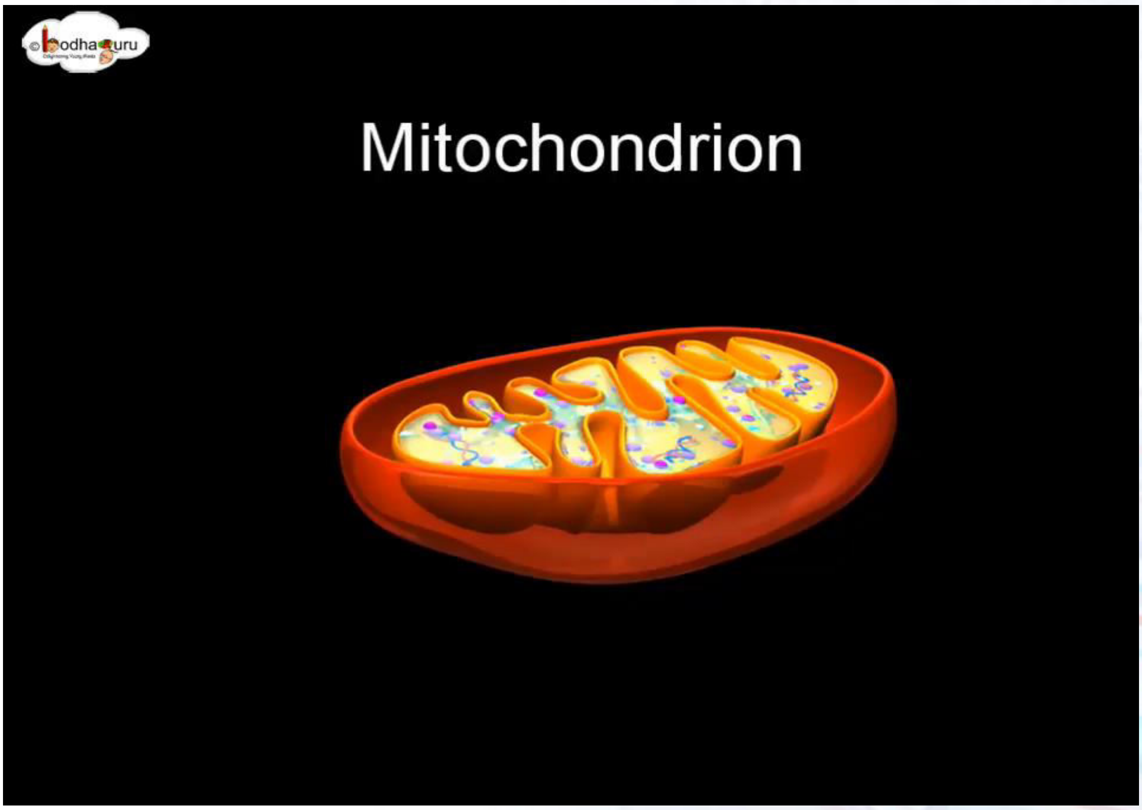
Structure

- **Outer Membrane**
- **Intermembrane Space**

(Perimitochondrial space)

- **Inner Membrane**
- **Cristae**
- **Matrix**

Mitochondria - 1



http://youtube.com/watch?v=_XqBIGRlkg8

Mitochondria - 1

Outer Membrane

- Simple phospholipid bilayer.
- Contain large number of integral protein structures called porins.
- Porins allow molecules to freely diffuse from one side of the membrane to the other.
- Easy transport of ions, nutrient molecules, ATP, ADP.

Mitochondria - 1

Inner Membrane

- Permeable only to oxygen, CO_2 , H_2O.
- Contains proteins that perform redox reactions in :
- Cellular respiration
- Transport of proteins
- Exchange of anions between the cytosol and the mitochondria

Mitochondria - 1

Intermembrane Space

- It has high proton concentration.
- Because the outer membrane is freely permeable to small molecules, the concentration of small molecules such as ions and sugars in the intermembrane space is same as that of the cytosol.

Mitochondria - 1

Cristae

- Folds of inner mitochondrial membrane
- Expand its surface area , enhancing its ability to produce ATP
- Contains stalked particles on inner side called as F_1 particles.

END

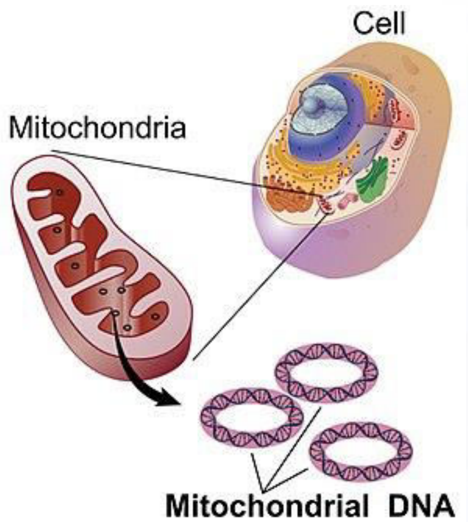
Mitochondria - 2

Matrix

- Enclosed in inner membrane
- Gel like consistency ,Dense , homogenous.
- Contains 2/3 rd of total protein of mitochondria.
- Contains enzymes, DNA genome, ribosomes, tRNA, granules, fibrils and tubules.

Mitochondria - 2

Mitochondrial DNA



https://en.wikipedia.org/wiki/Mitochondrial_DNA

- Own circular DNA, mostly attached to inner membrane
- Own ribosomes
- The DNA in the cell nucleus does not code for the construction of mitochondria.
- Stores biological info required for growth and multiplication of mitochondria.

Mitochondria - 2

Mitochondrial DNA

- Encode RNAs and proteins that are essential for mitochondrial function.
- It codes 2 rRNAs , 22 tRNAs and 13 mitochondrial membrane proteins.
- It can undergo replication and duplication.

Mitochondria - 2

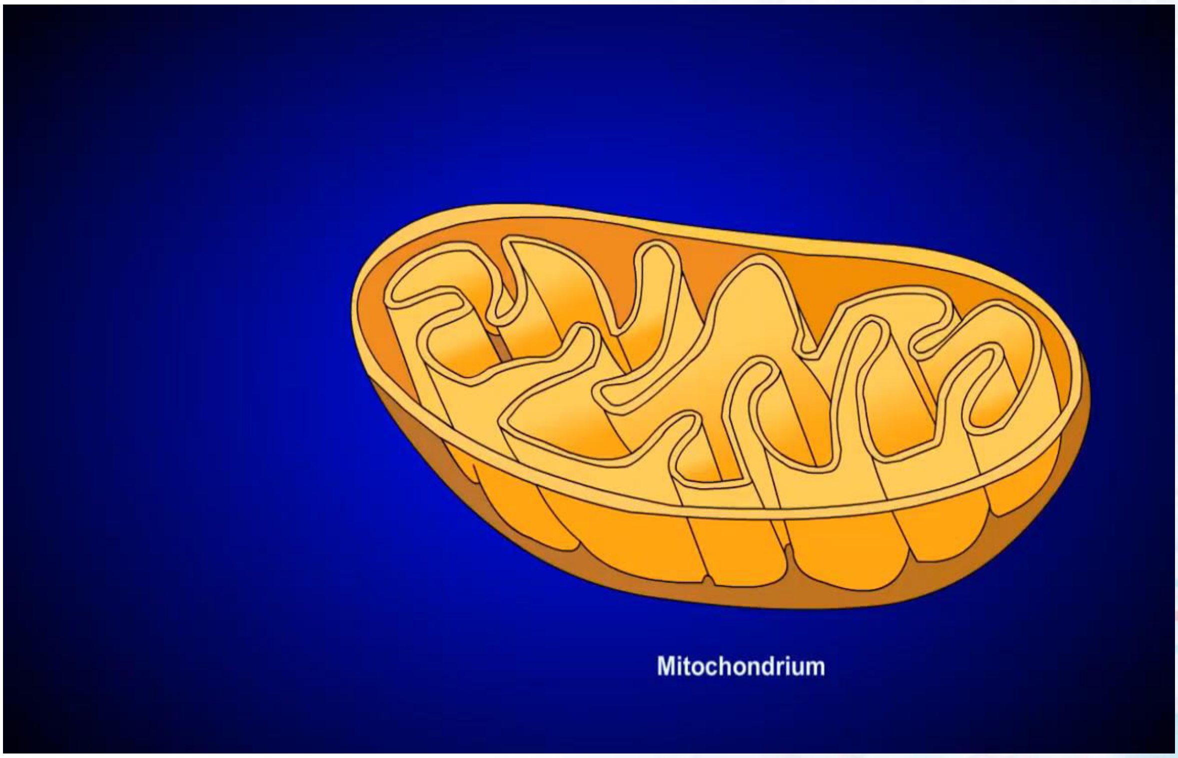
Functions

- Aerobic respiration
- Mitochondria uses complex molecules and oxygen to produce a higher energy molecule known as ATP.
- Synthesis of mtDNA , RNA, protein.
- Storage of calcium ions

Mitochondria - 2

- **OUTER MEMBRANE**
  Oxidation of epinephrine
  Degradation of tryptophan
  Elongation of fatty acid
- **INNER MEMBRANE**
  Oxidative phosphorylation
- **MATRIX**
  Kreb' s Cycle
  Beta oxidation
  Detoxification of ammonia

Mitochondria - 2

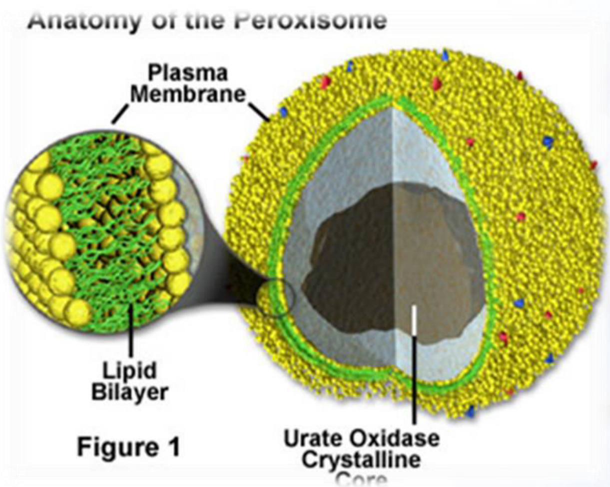


https://www.youtube.com/watch?v=eBl3U-T5Nvk

Peroxisomes

- First observed by electron microscopy in animal cells (195s), then in plant cells (1960)
- Christian deDuve (1967)
  - Isolated from liver cells by centrifugation
  - Called them peroxisomes because they generate and destroy H_2O_2

Peroxisomes



https://en.wikipedia.org/wiki/Peroxisome

- Peroxisome, membrane-bound organelle occurring in the cytoplasm of eukaryotic cells.

These (**also called microbodies**) are organelles found in virtually all eukaryotic cells Called **Peroxisomes** because of their ability to produce or utilize Hydrogen peroxide. They are small, oval or spherical in shape. They have a fine network of tubules in their matrix. About 50 enzymes have been identified. The number of enzymes fluctuates according to the function of the cells.

Peroxisomes

Functions

- Contains oxidative enzymes
- Break down fatty acids and amino acids by oxidation.
- Long fatty acids are converted to medium chain fatty acids
- Which are subsequently shuttled to mitochondria to be broken down to carbon dioxide and water.

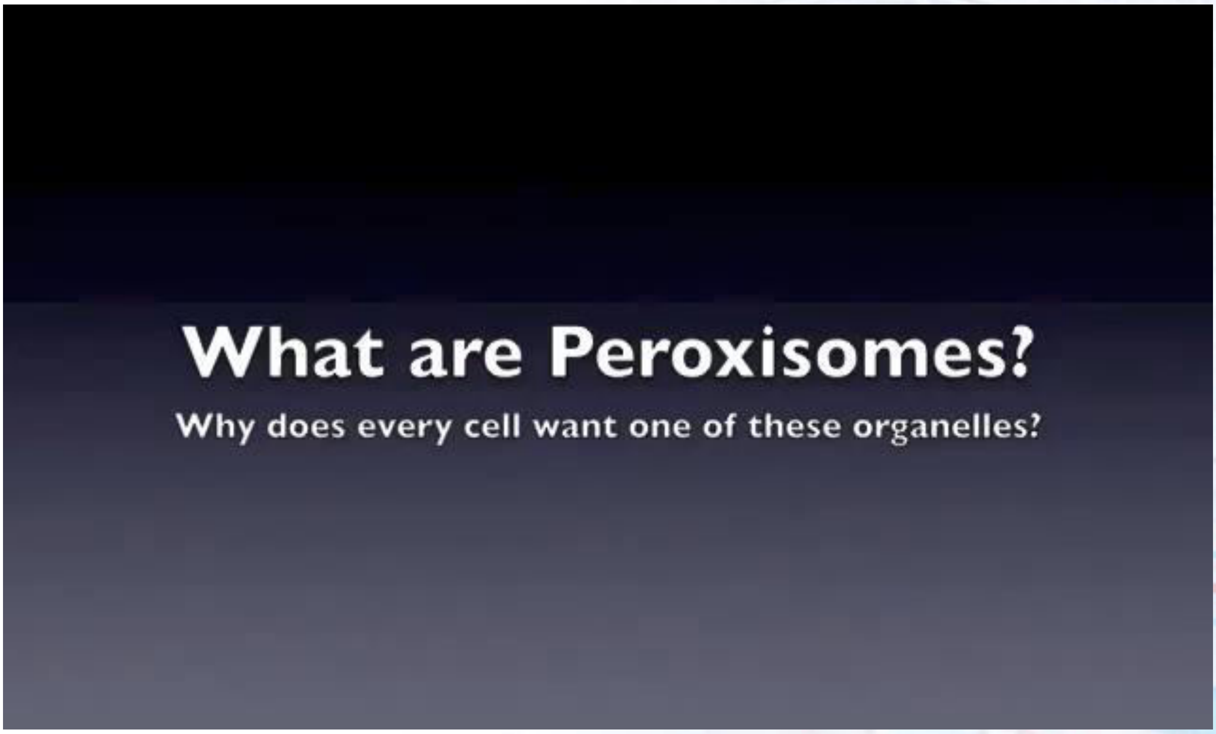
Peroxisomes

Functions

- In yeast and plant cells, this process is carried out exclusively in peroxisomes.
- B-Oxidation of fatty acid
- Glyoxylate cycle
- Photorespiration (Glycolate pathway)
- Degradation of purines
- Decomposition of hydrogen peroxide

However, peroxisomes bud off from the endoplasmic reticulum, not the Golgi apparatus (that is the source of lysosomes). The enzymes and other proteins destined for peroxisomes are synthesized in the cytosol. Each contains a peroxisomal targeting signal (PTS) that binds to a receptor molecule that takes the protein into the peroxisome and then returns for another load.

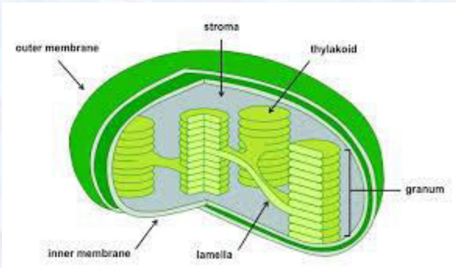
Peroxisomes



http://youtube.com/watch?v=1YluxTDJsRU

Chloroplast

- Chloroplast was first isolated and named in 1817.
- Only photosynthetic organisms have chloroplasts.



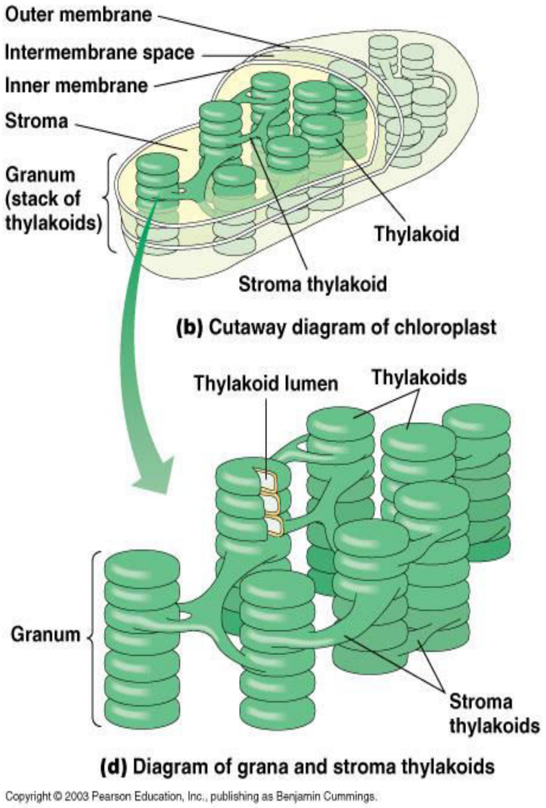
https://en.wikipedia.org/wiki/Chloroplast

Chloroplast

Structure

- Chloroplasts are a type of plastids.
- They are round, oval, green, disk-shaped body that is involved in the synthesis and storage of foodstuffs.
- Presence of two pigments, chlorophyll a and chlorophyll b.

Chloroplast



Structure

- Outer membrane
- Inner membrane
- Stroma
- Thylakoids

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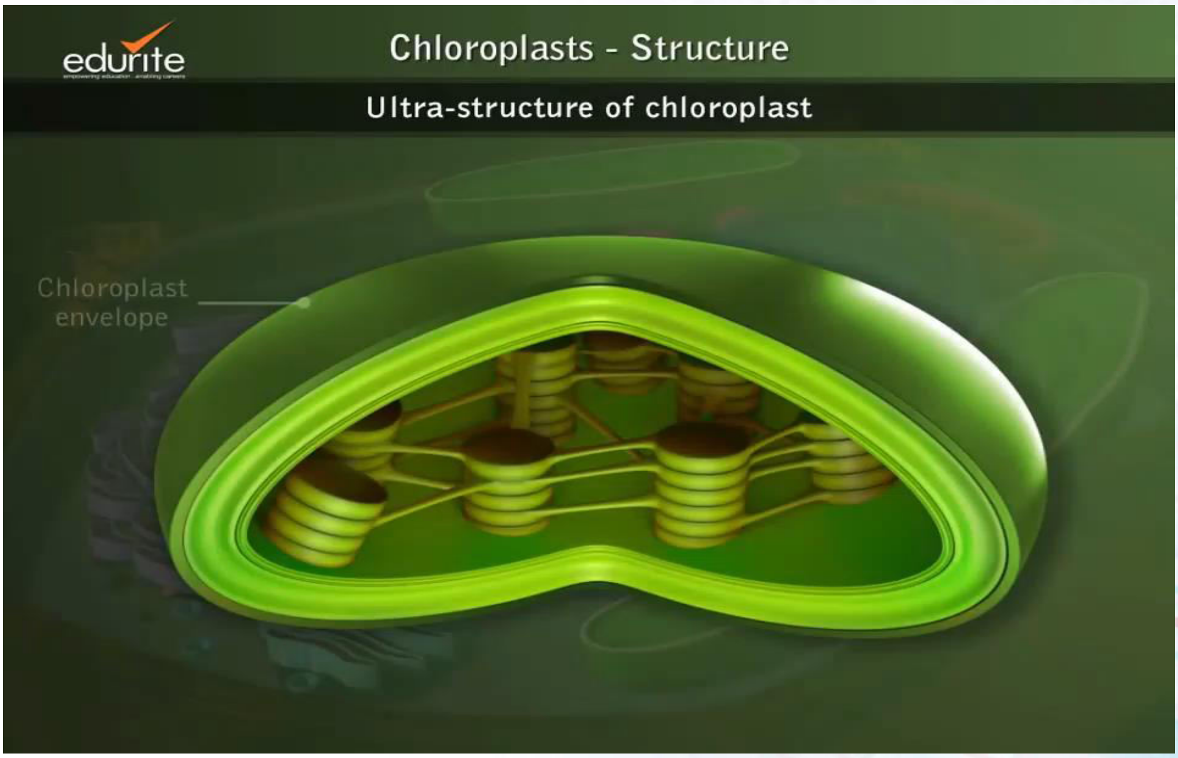
Chloroplast



http://youtube.com/watch?v=eOPEn2qYff4

Chloroplast

Function

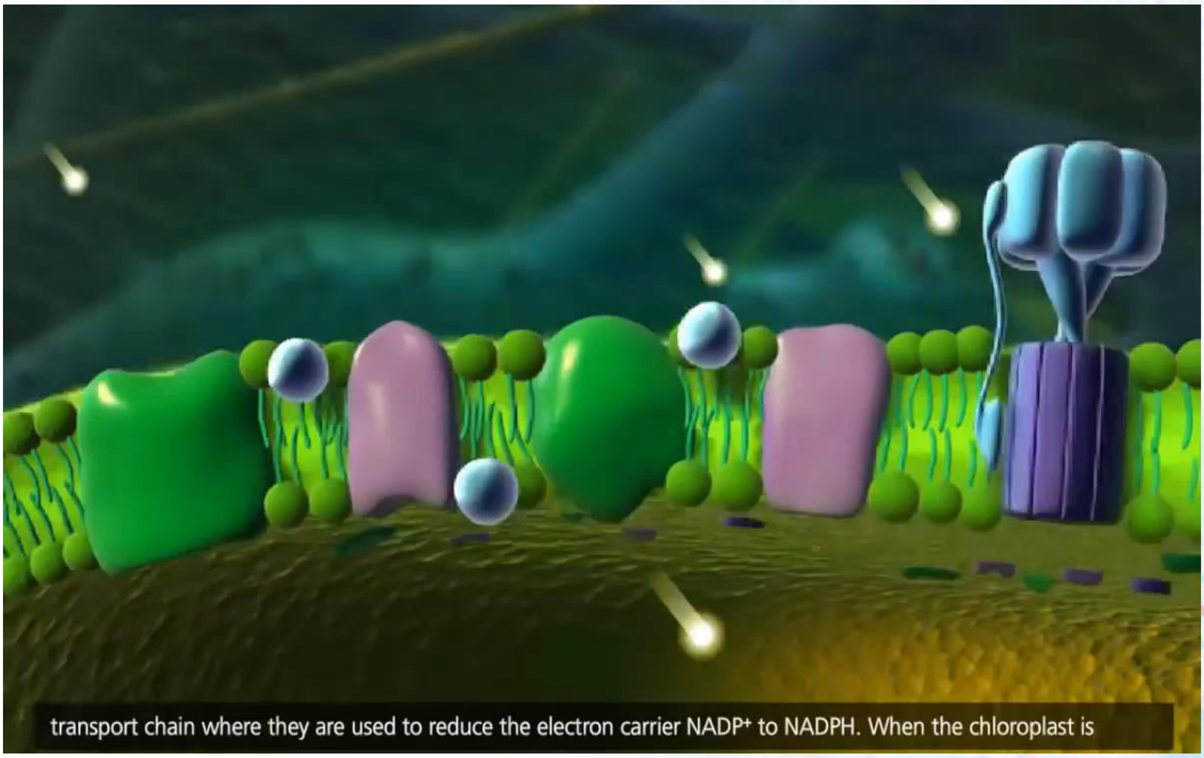
- Chlorophyll absorbs energy from light in form of photons.
- Transfer this energy to Photosystems present in thylakoid membrane.
- Photosystems convert light energy into chemical energy i.e. ATP and NADPH.

Chloroplast

Function

- ATP and NADPH are released into stroma.
- They are used to provide energy to run Calvin cycle in stroma to produce glucose.
- CO_2 and water are used as raw material for glucose synthesis.

Chloroplast



http://youtube.com/watch?v=PiAUPg4UrrE

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Chloroplast

Function

- Synthesis of glucose and other oligosaccharides.
- Synthesis of structural carbohydrates like cellulose and starch.

END

Cytoskeleton & Cell Movement - 1

- Cytoskeleton provides support and shape to cell
- Present in both eukaryotic and prokaryotic cell.
- It is a network of protein fibers
- Supporting cell shape
- Anchoring organelles within the cell

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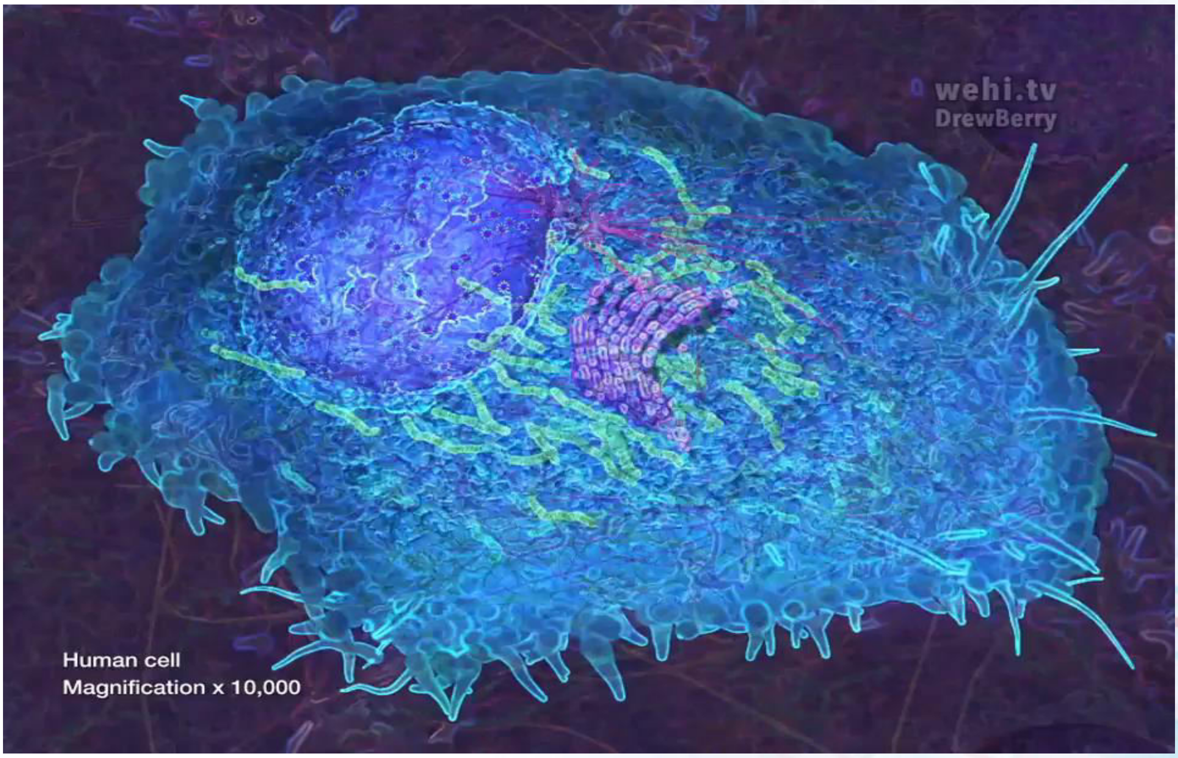
Cytoskeleton & Cell Movement - 1



http://youtube.com/watch?v=tO-W8mvBa78

Cytoskeleton & Cell Movement - 1

The **cytoskeleton** is a structure that helps cells maintain their shape and internal organization, and it also provides mechanical support that enables cells to carry out essential functions like **division** and **movement.**

Structure

Cytoskeleton is made up of three kinds of protein filaments:

1. Microtubules

(formed by tubulins)

2. Microfilaments

(formed by actins)

3. Intermediate Filaments

Cytoskeleton & Cell Movement - 1

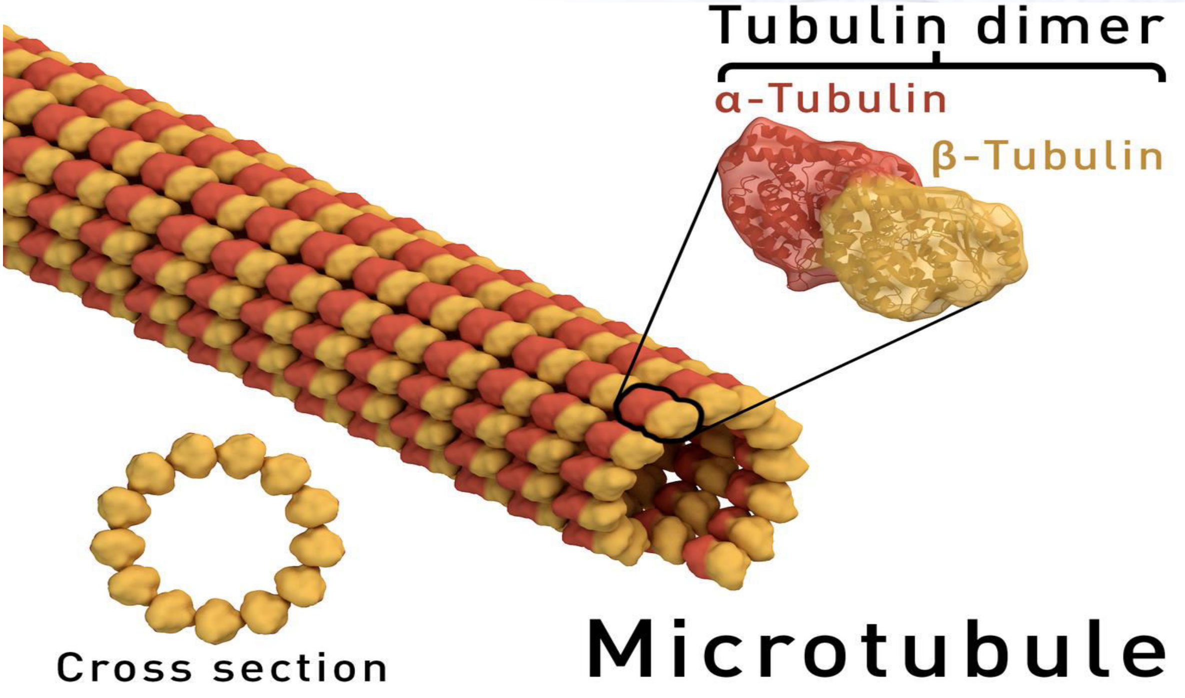
Microtubules control the beating of **cilia** and **flagella**, locomotor appendages of some cells

Cilia and flagella differ in their beating patterns

1. Microtubules

- Thickest fiber
- Hollow rods 25 nm in diameter
- Constructed of protein, tubulin
- Dimer of alpha and beta tubulin
- Grow or shrink as more tubulin molecules are added or removed.

Cytoskeleton & Cell Movement - 1



https://en.wikipedia.org/wiki/Microtubule

Cytoskeleton & Cell Movement - 1

Functions

- Structural support and cell movement
- Centriole
- Spindle formation in cell division
- Transport of materials
- Motility of cell by flagella and cilia

Cytoskeleton & Cell Movement - 1

http://youtube.com/watch?v=tO-W8mvBa78

Cytoskeleton & Cell Movement - 2

2. Microfilaments

(actin filaments)

Structure

- Thinnest class of fibers
- Solid rods of protein, actin
- Twisted double chain of actin subunits
- About 7 nm in diameter

Cytoskeleton & Cell Movement - 2

2. Microfilaments

Functions

- 3-D network inside cell membrane
- In muscle cells, actin filaments interact with myosin filaments to create muscle contraction.
- Cell movement
- Intracellular transport/trafficking

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Cytoskeleton & Cell Movement - 2

2. Microfilaments

Functions

- Maintenance of eukaryotic cell shape
- Cytokinesis
- Cytoplasmic streaming

Cytoskeleton & Cell Movement - 2

http://youtube.com/watch?v=YTv9ItGd050

Cytoskeleton & Cell Movement - 2

3. Intermediate Filaments

Structure

- Specialized for bearing tension
- Built from keratin proteins
- Same protein as hair
- Intermediate in size 8-12 nm

Cytoskeleton & Cell Movement - 2

3. Intermediate Filaments

Functions

- Hold “things” in place inside cell
- More permanent fixtures of cytoskeleton
- Reinforce cell shape and fix organelle location
- Movement of cell and movement of organelles
- Phagocytosis and Endocytosis

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Cytoskeleton - 2

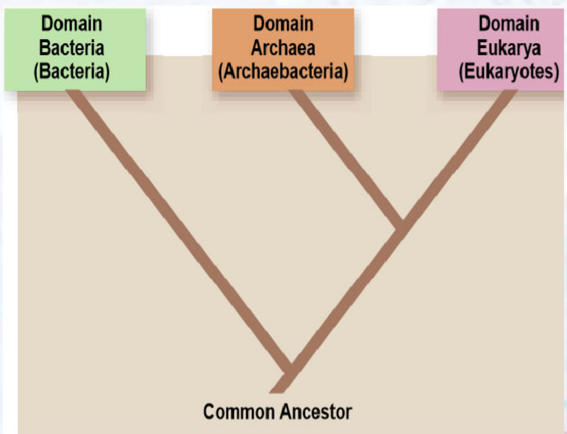
http://youtube.com/watch?v=YTv9ItGd050

Protists

- Genomic DNA sequences of an archaean and a bacterium were first compared in 1996.
- Archaea are very different from bacteria.
- Both are different from eukaryotes.
- Three domain classification is authentic.

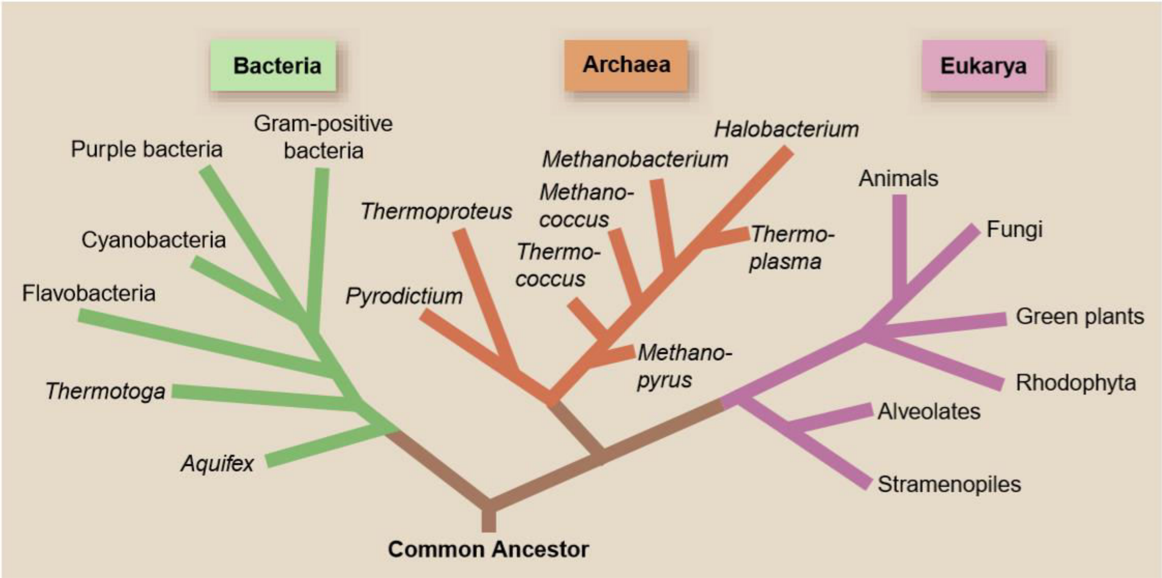
Protists

The three domains probably are monophyletic.



Biology Mason, Losos and Singer, 9th ed.

Protists



Biology Mason, Losos and Singer, 9th ed.

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Protists

- Protists are unicellular.
- It cannot be implied that they are simple.
- Often they are more complex than any particular cell in multicellular organism.
- Organelles that are similar to the organelles of other eukaryotic cells carry out specific functions in protists.

Protists

- Some protozoan organelles, however, reflect specializations for unicellular lifestyles.
- Too complex to be classified into seven phyla.

1. Sarcomastigophora
2. Labyrinthomorpha
3. Apicomplexa
4. Microspora

Protists

4. Acetospora
5. Myxozoa
6. Ciliophora

END

Phylum Mastigophora - 1

- Unicellular or colonial
- Locomotion by flagella, pseudopodia, or both
- Autotrophic (self-nourishing), saprozoic (living in decaying organic matter), or heterotrophic (obtains energy from organic compounds)

Phylum Mastigophora - 1

- Single type of nucleus
- Sexual reproduction (usually)
- Phylum Mastigophora has two classes.

1. Phytomastigophora
2. Zoomastigophora

Phylum Mastigophora - 1

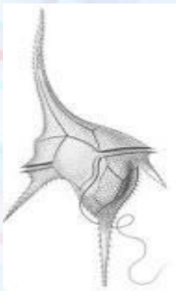
1. Phytomastigophora

- Have flagella for locomotion
- Posses chlorophyll
- Mainly autotrophs
- Some heterotrophs
- Produce a large portion of the food in marine food webs

Phylum Mastigophora - 1

1. Phytomastigophora

- Much of the oxygen used in aquatic habitats comes from photosynthesis by these marine organisms.
- Common marine phytomastigophore are dinoflagellates.
- They contain two flagella. https://en.wikipedia.org/wiki/Dinoflagellate



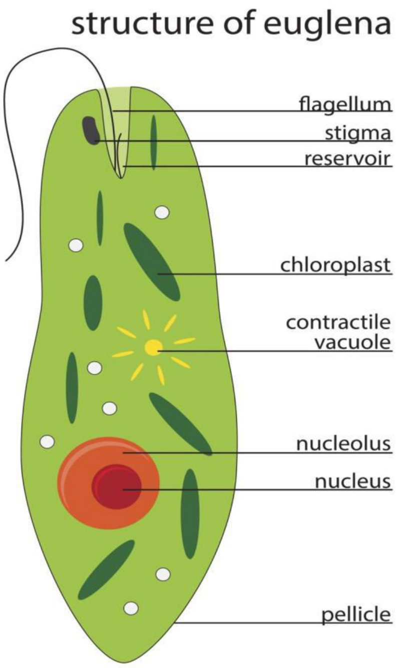
Phylum Mastigophora - 1

https://www.google.com/search?q=dinoflagellates+red+tide&rlz

1. Phytomastigophora

- Contain chlorophyll, xanthophyll pigments, which gives golden brown color
- Chloroplasts change coloration of water
- Gymnodinium produce toxins – "red tides"
- Algal blooms, consume most of O_2 in water.

Phylum Mastigophora - 1

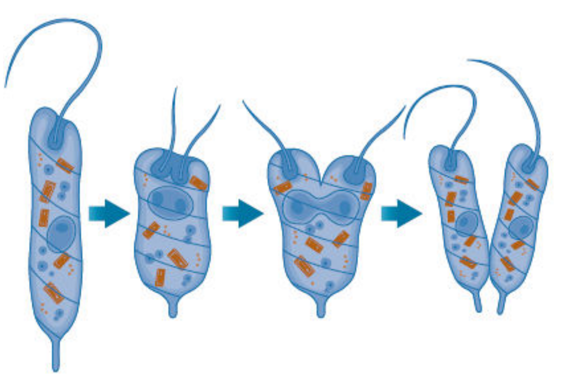


https://biologywise.com/euglena-movement

Euglena

- Freshwater
- Chloroplast has a pyrenoid
- Involved in carbon fixation and starch formation and its storage
- Orients towards light
- Stigma covers photoreceptors at base of flagellum
- Stigma permits light in one direction

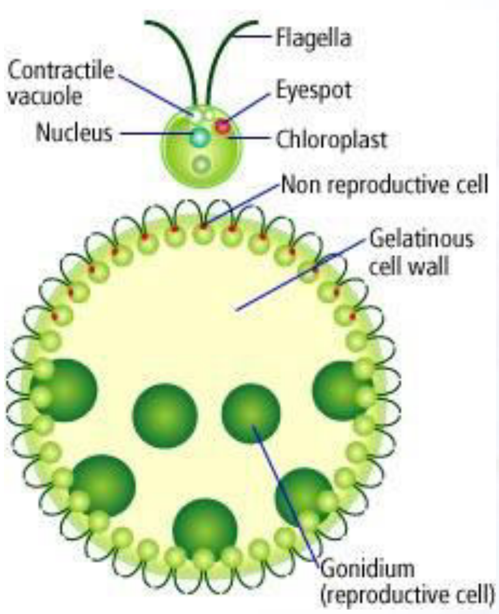
Phylum Mastigophora - 1



Zoology by Miller and Harley, 5th ed., 2011.

- Euglena flagella are haploid
- Flagella reproduce by binary fission-longitudinal
- Sexual reproduction is still unknown

Phylum Mastigophora - 1



https://www.lucia-umami.de/volvox-diagram.html

Volvox

- Colonial flagellate
- Embedded in a spherical, gelatinous matrix
- Individual cells posses two flagella
- Asexual reproduction occurs in spring and summer.
- Sexual reproduction occurs in autumn.

Phylum Mastigophora - 1

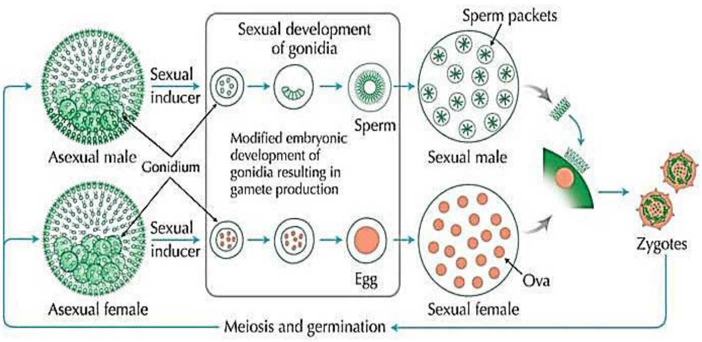
Many prey animals have conspicuous high-contrast markings which paradoxically attract the predator's gaze.[d][44] These distractive markings serve as camouflage by distracting the predator's attention from recognising the prey as a whole, for example by keeping the predator from identifying the prey's outline. Experimentally, search times for blue tits increased when artificial prey had distractive markings.

- Some species of Volvox which reproduce in summer has:

1. Dioecious
2. Monoecious

- Specialized cells differentiate into macrogametes or microgametes.
- Macrogametes are large, filled with nutrient reserves, and nonmotile.

Phylum Mastigophora - 1



https://www.google.com/search?q=gametes+of+volvox

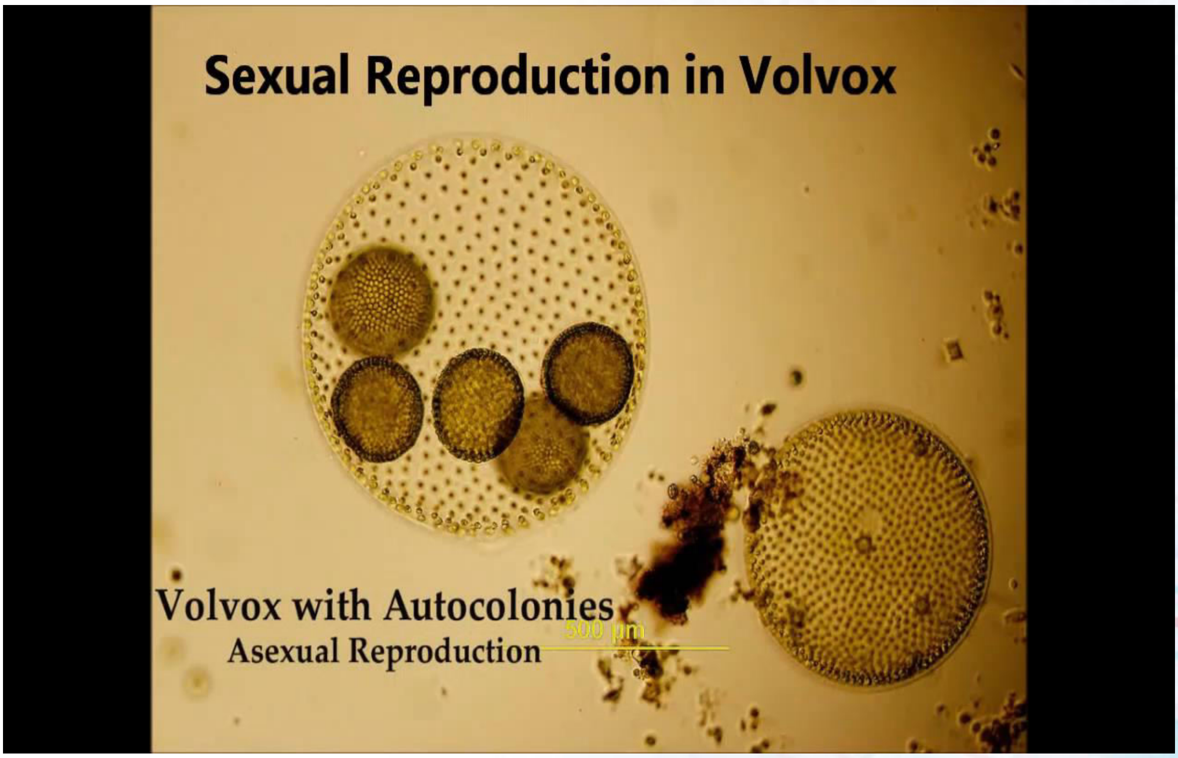
- Microgametes form a packet of flagellated cells (sperms).
- That leaves the parental colony and swims to a colony containing macrogametes.
- Syngamy occurs.
- Zygote undergoes meiosis to retain haploidy.

Phylum Mastigophora - 1

- Product of meiosis undergoes mitotic division.
- Daughter colonies are released from zygotic capsule.

ClluesBook.com

Phylum Mastigophora - 1



http://youtube.com/watch?v=cmSs157KvTg

Phylum Mastigophora - 2

2. Zoomastigophora

- Lack chloroplast
- Heterotrophic or saprozoic
- Parasites of humans

Examples:

1. *Trypanosoma brucei*

- It has three sub species.

Phylum Mastigophora - 2

Trypanosoma brucei

- *T. b. brucei*
- *T. b. gambiense*
- *T. b. rhodesiense*

Phylum Mastigophora - 2

1. *T. b. brucei*

- Parasite of non human
- Common host are mammals of Africa

https://www.google.com/imgres?imgurl=https%3A%2F%2Fwww.yourgenome.org%2

Phylum Mastigophora - 2

2. *T. b. gambiense*

- Causes sleeping sickness in humans

3. *T. b. rhodesiense*

- Causes sleeping sickness in humans.

Phylum Mastigophora - 2

- Tsetse flies is the intermediate host for all three sub species.

https://www.google.com/search?q=ytestes+fly

Phylum Mastigophora - 2

- Trypanosoma reproduce asexually.
- In gut of fly for 10 days
- Migrate to salivary glands
- Transform into fly after 15 to 35 days.
- Infected Tsetse fly bites another host
- Parasite travel with salivary secretion

Phylum Mastigophora - 2

- Enter into blood of human
- Multiply asexually
- Inside host, they live in the blood, Lymph, spleen, central nervous system and cerebrospinal fluid

ClueBook.com

Phylum Mastigophora - 2

- When parasite enters into central nervous system
- Symptoms includes apathy, mental dullness, and lack of coordination.
- May be fatal

END

Subphylum Sarcodinia

- Members of the subphylum Sarcodina are the amoebae.
- Cells are naked or with shell.
- Mostly free living
- When feeding and moving, they form temporary cell extensions called pseudopodia.

Subphylum Sarcodinia

http://youtube.com/watch?v=mv6Ehv06mXY

Subphylum Sarcodinia

Types of pseudopodia

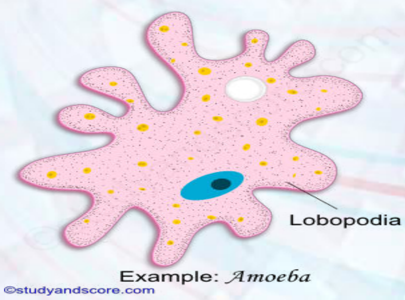
- Majorly amoeba has four types

1. Lobopodia
2. Filopodia
3. Reticulopodia
4. Axopodia

Subphylum Sarcodinia

1. Lobopodia

- Contain ectoplasm and endoplasm
- Used for locomotion
- Used for engulfing feed

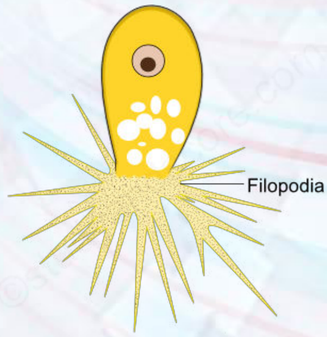


https://www.google.com/search?q=lobopodia+

Subphylum Sarcodinia

2. Filopodia

- Only ectoplasm in pseudopodia
- Two-way streaming
- Provides food in conveyor belt fashion



https://www.google.com/search?tbm=isch&q=filopodia

Subphylum Sarcodinia

3. Reticulopodia

- Similar to filopodia
- Branch and rejoin to form net like series of cell extensions

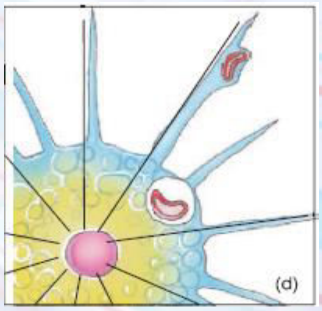
https://www.google.com/search?biw=1366&bih=625&tbm=isch&sa=1&ei=fLX6XN6QMtKbkwXc1KeYAw&q=Reticulopodia

Subphylum Sarcodinia

4. Axopodia

- These are thin filamentous supported by central axis of microtubules.
- Food caught on axopodia delivered to the central cytoplasm of amoeba.

Zoology by Miller and Harley, 5th ed., 2011

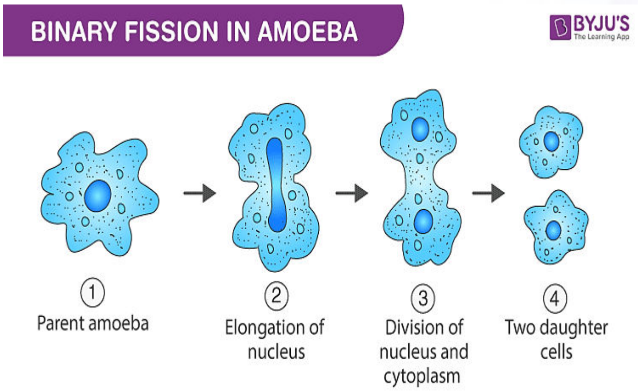


END

Superclass Rhizopoda, Class Lobosea

- Belong to Subphylum Sarcodinia
- Most familiar amoeba belong to these classes
- About 4000 species
- Mostly amoeba are naked without shell.
- Found in shallow water substrates of freshwater ponds, lakes, and slow-moving streams

Superclass Rhizopoda, Class Lobosea



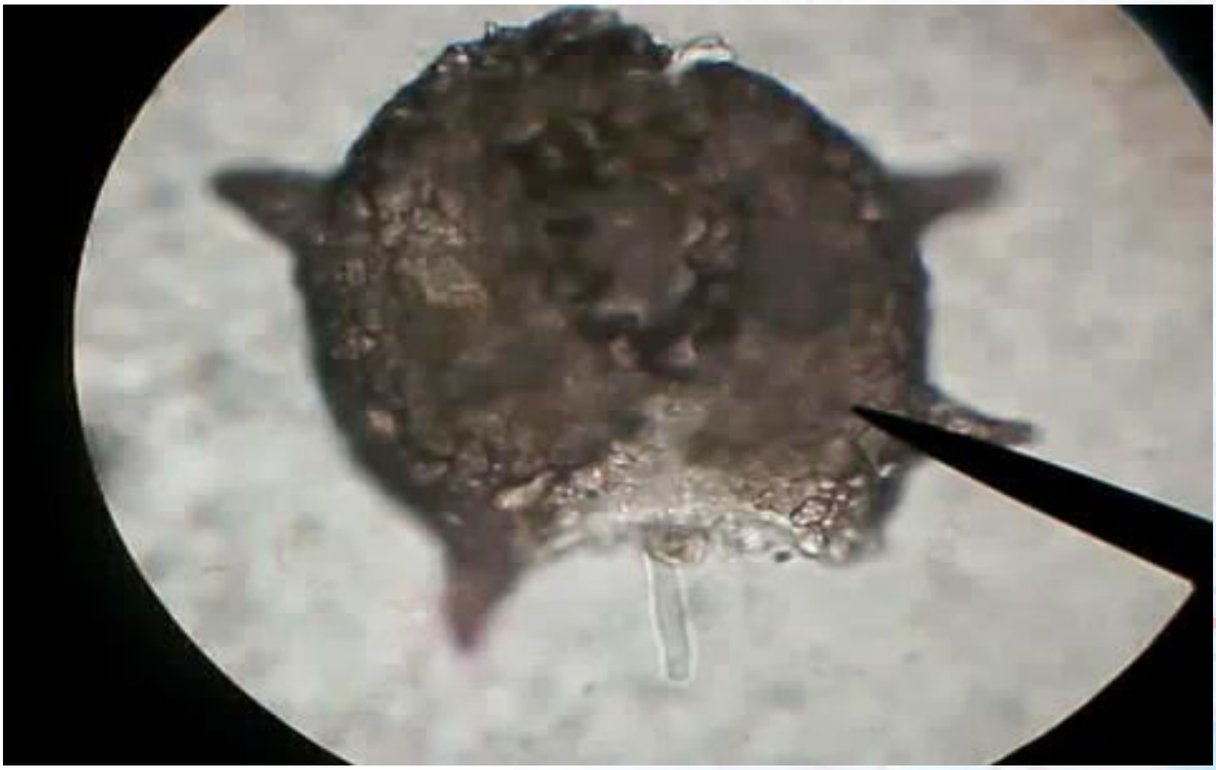
https://www.google.com/search?q=binary+fission+in+amoeba

- Feed on other protists and bacteria
- They engulf food by phagocytosis using pseudopodia.
- Reproduction by binary fission

Superclass Rhizopoda, Class Lobosea

- Superclass rhizopoda possess a test or shell
- Protective structures which cytoplasm secrete
- Pseudopodia extruded from opening in test

Superclass Rhizopoda, Class Lobosea



http://youtube.com/watch?v=5osbVB5w0qs

Superclass Rhizopoda, Class Lobosea

Shell Composition

- Calcareous
- Proteinaceous
- Siliceous
- Chitins
- Sand
- Other debris

Superclass Rhizopoda, Class Lobosea

Modes of Life

1. Free Living Amoeba

- Difflugia
- Arcella

2. Parasites

- Entamoeba

Superclass Rhizopoda, Class Lobosea

Entamoeba

- Causes dysentery in humans
- Inflammation and ulceration of the lower intestinal tract
- Debilitating diarrhea
- Lives in intestinal wall
- Pass to other host in the form of cyst

Superclass Rhizopoda, Class Lobosea

http://youtube.com/watch?v=FAPtIPOWQVQ

Subphylum Actinopoda

- Mostly marine
- Spherical, planktonic
- Axopodia supported by microtubules
- Includes marine radiolarians with siliceous tests
- About 3,000 species.

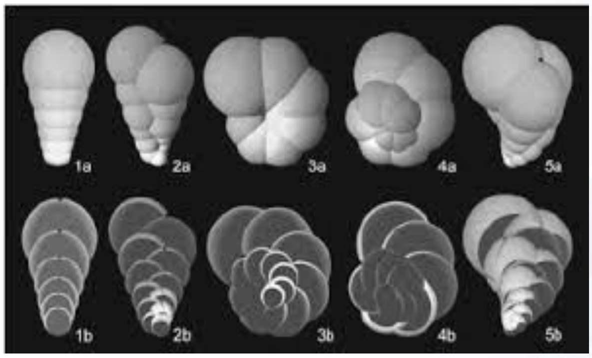
Subphylum Actinopoda

Classified into further three super classes.

1. Foraminiferans
2. Heliozoans
3. Radiolarians

ClueBook.com

Subphylum Actinopoda



https://www.google.com/imgres?imgurl=https%3A%2F%2Fwww.researchgate.net%

1. Foraminiferans

- Primarily a marine group of amoebae
- Possess reticulopodia and secrete a test that is primarily calcium carbonate
- As they grow, they secrete new, larger chambers that remain attached to the older chambers.

Subphylum Actinopoda

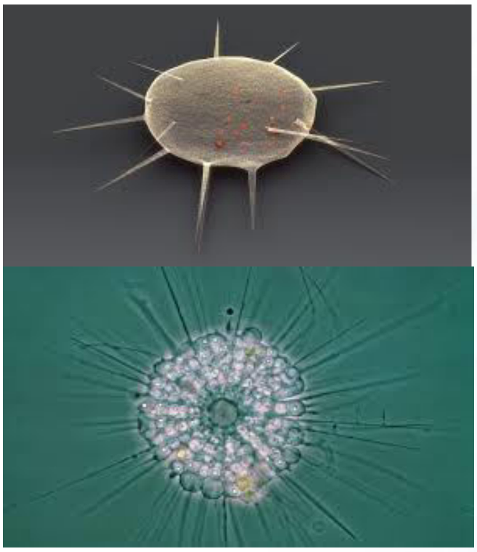
1. Foraminiferans

- Foram tests are abundant in the fossil record since the Cambrian period.
- Make up a large component of marine sediments
- Resulted in limestone and chalk deposits at sea bottom.

Subphylum Actinopoda

http://youtube.com/watch?v=q0WbN34Mh7k

Subphylum Actinopoda



https://www.google.com/search?rlz=1C1SQJL_

2. Heliozoans

- Aquatic amoebae that are either planktonic or live attached by a stalk to some substrate.
- Either naked or enclosed within a test that contains openings for axopodia.

ClluesBook.com

Subphylum Actinopoda

https://www.google.com/search?q=Radiolarians+shells

3. Radiolarians

- Planktonic marine and freshwater amoebae
- They are relatively large; some colonial forms may reach several centimeters in diameter.
- They possess a test (usually siliceous) of long, movable spines and needles or of a highly sculptured and ornamented lattice.

Subphylum Actinopoda

3. Radiolarians

- After death, tests drift to the ocean floor.
- Some of the oldest known fossils of eukaryotic organisms are radiolarians.

END

Phylum Apicomplexa - 1

- Parasitic
- Having apical complex used for penetrating host cells
- Cilia and flagella are lacking, except in certain reproductive stages.
- About 5, 500 species
- Single type of nucleus
- Sexual and asexual phases in life cycle

Phylum Apicomplexa - 1

Class Sporozoea

- Name derived from most sporozoeans producing a resistant spore or oocyst following sexual reproduction
- Some species cause a variety of diseases in domestic animals and humans.
- Example: plasmodium, coccidians

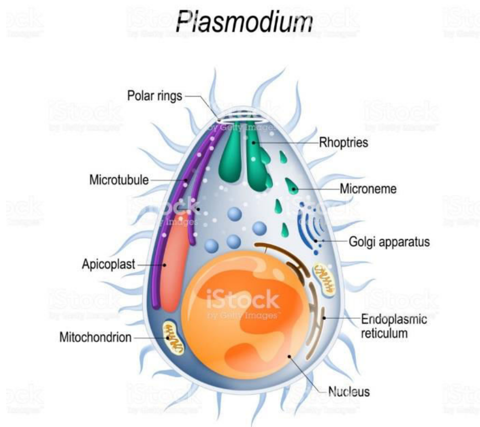
Phylum Apicomplexa - 1

Life cycle of sporozoeans

- Three stages of life:

1. Schizogony
2. Merogony
3. Gametogony

Phylum Apicomplexa - 1



https://www.google.com/search?q=merozoites

Schizogony and Merogony

- Multiple fission of an asexual stage in host cells to form many more (usually asexual) individuals
- Which are called merozoites.
- They leave the host cell and infect many other cells.

Phylum Apicomplexa - 1

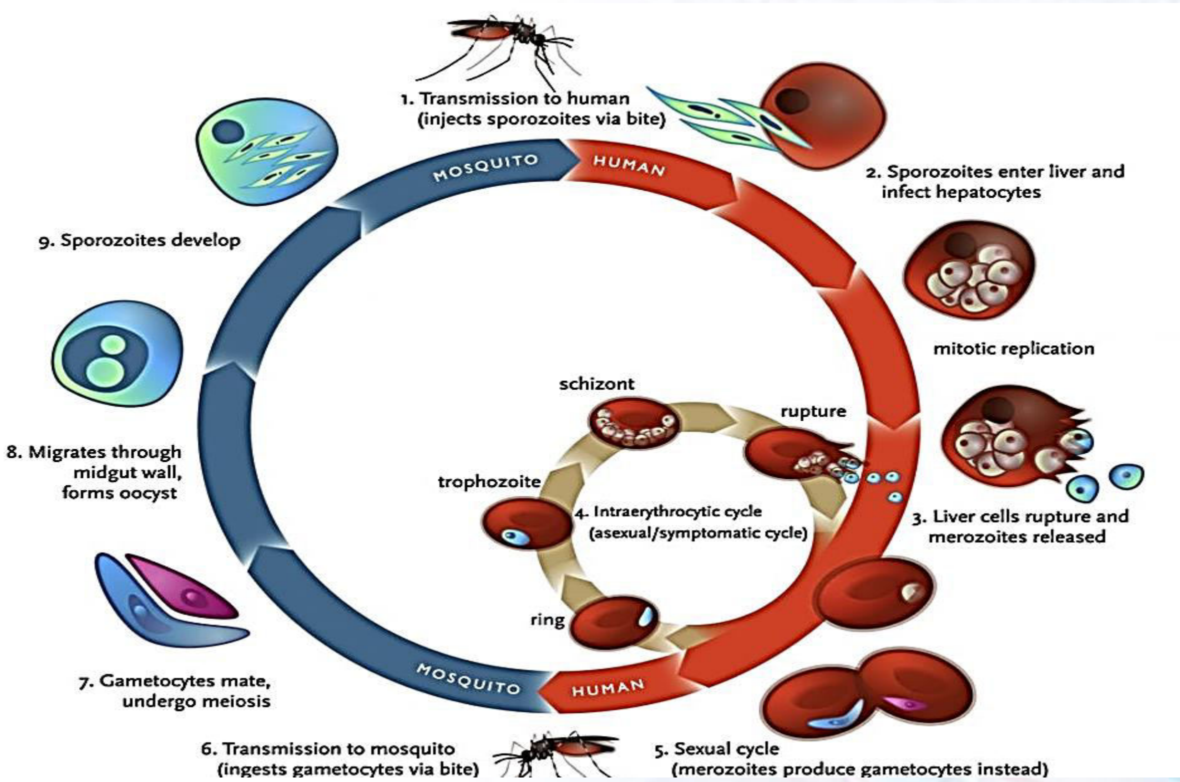
- Merozoites undergo gametogony
- Begins the sexual phase of the life cycle
- The parasite forms either microgametocytes or macrogametocytes.
- Microgametocytes undergo multiple fission to produce biflagellate microgametes

Phylum Apicomplexa - 1

- That emerge from the infected host cell.
- The macrogametocyte develops directly into a single macrogamete.
- A microgamete fertilizes a macrogamete to produce a zygote
- That becomes enclosed and is called an oocyst.

ClüesBook.com

Phylum Apicomplexa - 1



https://www.google.com/search?rlz=1C1SQJL_enUS822US822&biw

Phylum Apicomplexa - 1

- Zygote undergoes meiosis.
- The resulting cells divide repeatedly by mitosis.
- This process, called sporogony, produces many rod-like sporozoites in the oocyst.

END

Phylum Apicomplexa - 2

Plasmodium

- Causes malaria in humans
- Very common apicomplexan.
- Globally, an estimated 3.4 billion people in 92 countries are at risk of being infected with malaria.

Phylum Apicomplexa - 2

http://youtube.com/watch?v=qMz8B0nVZ4M

Phylum Apicomplexa - 2

Coccidiosis

- Disease of poultry, sheep, cattle, and rabbits
- Two genera, Isospora and Eimeria have important parasites.

https://www.pinterest.com/pin/224476362655521924/

Phylum Apicomplexa - 2

Cryptosporidium (coccidian)

- Chronic diarrhea in AIDS patients
- Only known protozoan to resist chlorination
- Virulent in immunosuppressed individuals

https://www.cdc.gov/parasites/crypto/index.html

Phylum Apicomplexa - 2

Toxoplasmosis

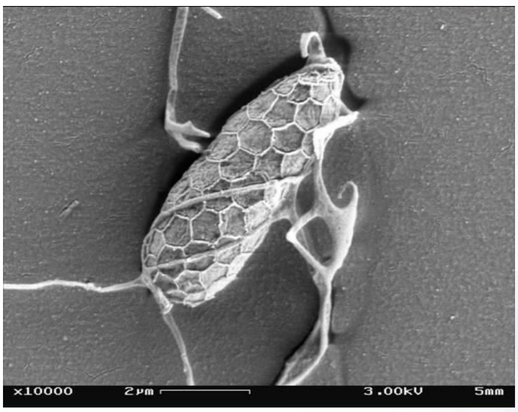
- Caused by Toxoplasma
- Virulent in immunosuppressed individuals as in AIDS
- major cause of stillbirths and spontaneous abortions.
- Fetuses that survive frequently show signs of mental retardation and epileptic seizures

END

Phylum Labyrinthomorpha

- Very small phylum
- Consists of protozoa with spindle-shaped, nonamoeboid, vegetative cells.
- In some genera, amoeboid cells use a typical gliding motion to move within a network of mucous tracks.

Phylum Labyrinthomorpha



https://en.wikipedia.org/wiki/Labyrinthulomycetes#/media/File:Aplanonet3.jpg

- Most members are marine
- Either saprozoic or parasitic on algae or seagrass
- Or as decomposers on dead plant material
- Organisms are uninucleated
- Typically ovoid in shape

Phylum Labyrinthomorpha

- Move back and forth with help of ectoplasmic projections
- This class has usually two orders.

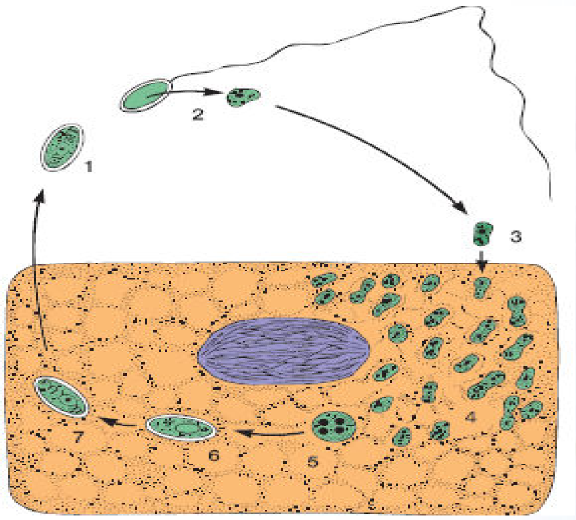
1. Labyrinthulales
2. Thraustochytriales

END

Phylum Microspora

- Members of the phylum are commonly called microsporidia
- Small, obligatory intracellular parasites
- Several species that parasitize beneficial insects.

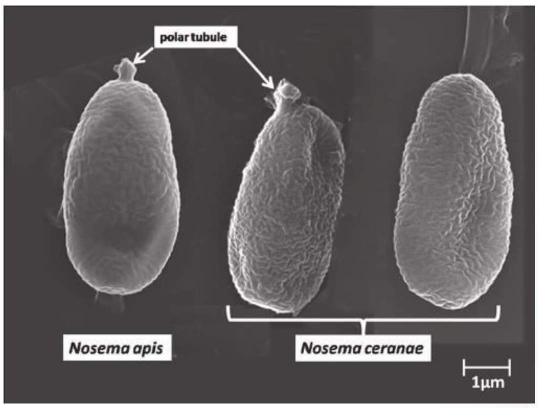
Phylum Microspora



https://images.slideplayer.com/24/7574724/slides/slide_24.jpg

- *Nosema bombicus* parasitizes silkworms
- Causing the disease pebrine or pepper disease
- Worms hatching from the infected eggs will die in their larva stage

Phylum Microspora



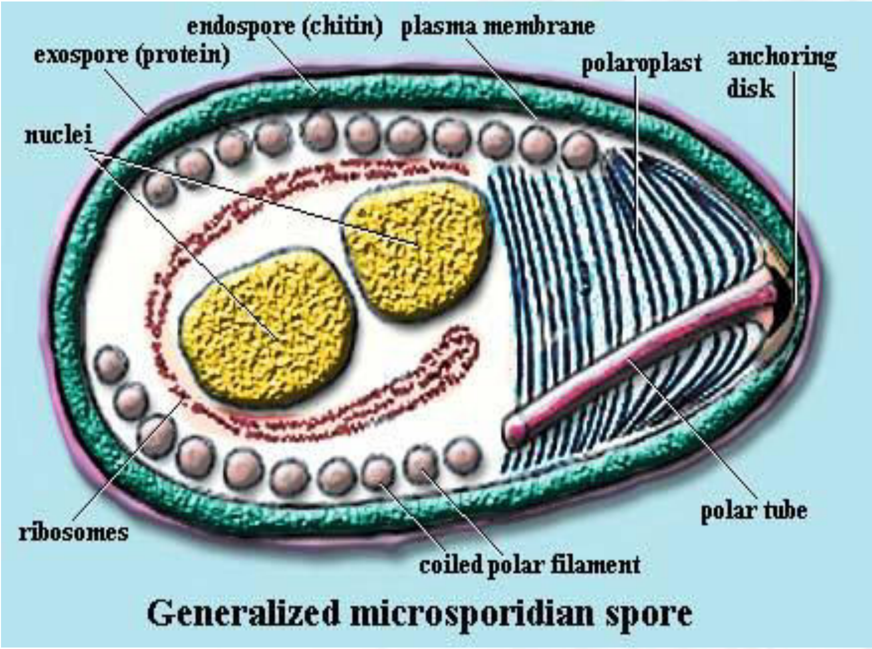
https://www.researchgate.net/figure/Nosema-apis-and-N-ceranae-spores-observed-under-SEM-Arrows-indicate-the-start-of_fig1_233808987

- *N. apis* causes serious dysentery in honeybees.
- These parasites have a possible role as biological control agents for insect pests.

Example:

- U.S. Environmental Protection Agency has approved and registered *N. locustae* for use in residual control of rangeland grasshoppers.

Phylum Microspora



https://web.stanford.edu/group/parasites/ParaSites2006/Microsporidiosis/microsporidia1.html

Phylum Microspora

- Recently, four microsporidian genera have been implicated in secondary infections of immunosuppressed and AIDS patients.

END

Phylum Acetospora & Myxozoa

Phylum Acetospora

- Acetospora is a relatively small phylum.
- That consists exclusively of obligatory extracellular parasites
- Characterized by spores lacking polar caps or polar filaments

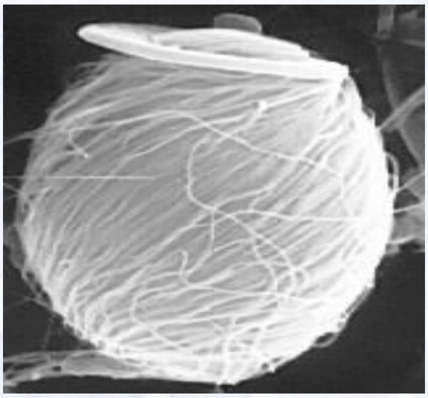
ClueBook.com

Phylum Acetospora & Myxozoa

Phylum Acetospora

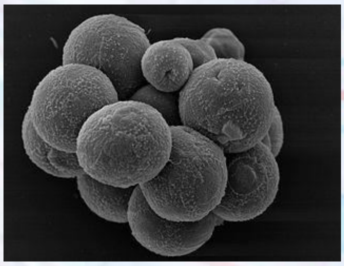
- They primarily are parasitic in the cells, tissues, and body cavities of molluscs.

Phylum Acetospora & Myxozoa



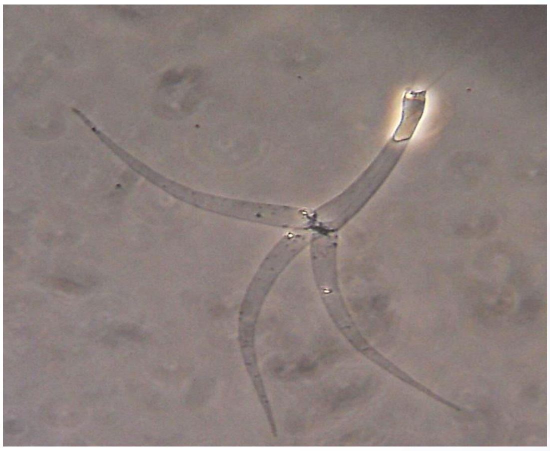
http://research.amnh.org/users/siddall/haplosporidia/morph.html

https://wikivividly.com/wiki/Ascetosporea



ClueSBook.com

Phylum Acetospora & Myxozoa



https://fishpathogens.net/pathogen/myxobolus-cerebralis

Phylum Myxozoa

- Commonly called myxosporeans
- All obligatory extracellular parasites in freshwater and marine fish.
- They have a resistant spore with one to six coiled polar filaments.

Phylum Acetospora & Myxozoa

https://fishpathogens.net/pathogen/myxobolus-cerebralis

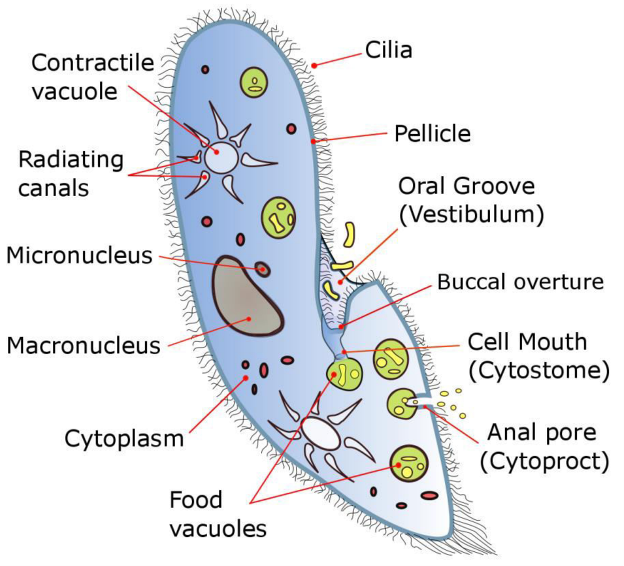
Phylum Myxozoa

- The most economically important myxosporean is *Myxosoma cerebralis*.
- Which infects the nervous system and auditory organs of trout and salmon.
- Causing whirling or tumbling disease

Phylum Ciliphora - 1

- About 9,000 species
- Some of the most complex protozoa
- Ciliates are widely distributed in freshwater and marine environments.
- A few ciliates are symbiotic.

Phylum Ciliphora - 1



https://en.wikipedia.org/wiki/Paramecium

- Cilia for locomotion and for the generation of feeding currents in water
- Relatively rigid pellicle and more or less fixed shape
- Distinct cytostome (mouth) structure
- Dimorphic nuclei, macronucleus and micronuclei

ClueBook.com

Phylum Ciliphora - 1

Cilia and Other Pellicular Structures

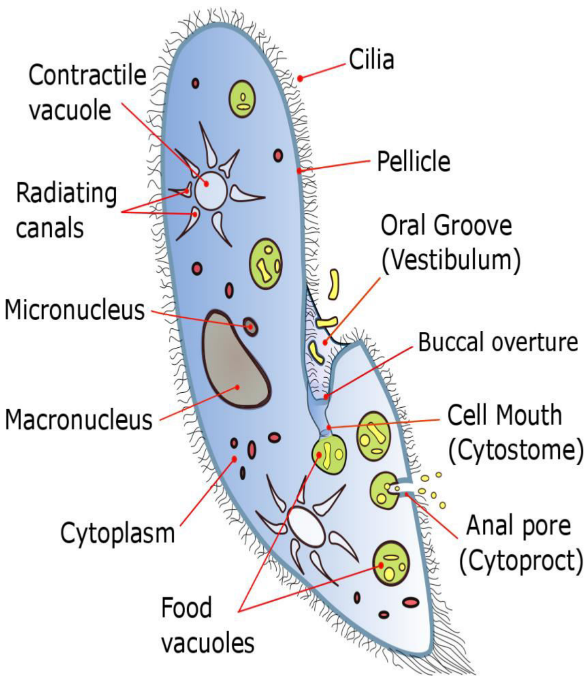
- Shorter
- Widely distributed
- Similar like flagella
- Coordinated movement
- Connected basal bodies
- Give shape to organism

Phylum Ciliphora - 1

Cilia and Other Pellicular Structures

- Trichocysts are pellicular structures primarily used for protection.
- They are rodlike or oval organelles
- Oriented perpendicular to the plasma membrane
- Pellicle can discharge trichocysts, which then remain connected to the body by a sticky thread

Phylum Ciliphora - 1



https://upload.wikimedia.org/wikipedia/commons/f/f7/Paramecium_diagram.png

Nutrition

- Ciliates like paramecium have oral groove on one side
- Cilia sweep small food particles toward the cytopharynx
- Food vacuole forms
- Break and circulate in endoplasm

Phylum Ciliphora - 1

Nutrition

- Free living ciliates prey upon protists and small animals
- Prey capture by fortuitous contact
- Ciliate *Didinium* feeds principally on Paramecium

Zoology by Miller and Harley, 5th ed., 2011

Phylum Ciliphora - 1

https://www.youtube.com/watch?v=gN42ggEgO8g

Phylum Ciliphora - 2

Excretion

- Excretion of waste material by contractile vacuole.
- Exchange of gases through plasma membrane

ClueBook.com

Phylum Ciliphora - 2

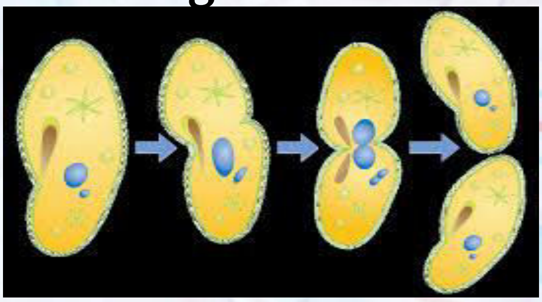
Genetic Material

- A large, polyploid macronucleus regulates daily metabolic activities.
- One or more smaller micronuclei are the genetic reserve of the cell.

Phylum Ciliphora - 2

Reproduction

- Asexually reproduction is common.
- Cell divided into two by mitosis through:
- Binary fission
- Budding



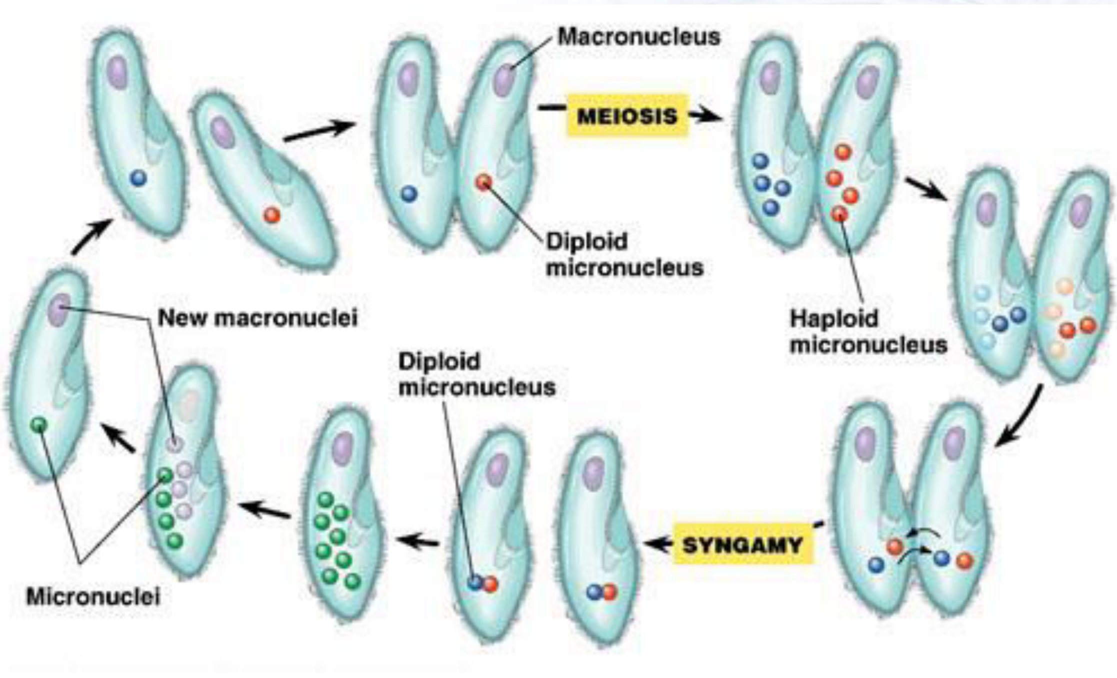
https://en.wikipedia.org/wiki/Paramecium

Phylum Ciliphora - 2

Reproduction

- Sexual reproduction
- Occurs when placed under stress
- Paramecia may engage in a process known as conjugation
- Exchange genetic material with other individuals
- Process may take many hours

Phylum Ciliphora - 2



https://en.wikipedia.org/wiki/Paramecium

Phylum Ciliphora - 2

Symbiotic Ciliates

- Most ciliates are free living.
- Some are commensalistic or mutualistic
- A few are parasitic.
- Large numbers of different species of ciliates also inhabit the rumen of many ungulates.

Phylum Ciliphora - 2

Symbiotic Ciliates

- These ciliates contribute to the digestive processes of their hosts.

END

Kingdom Animalia - 1

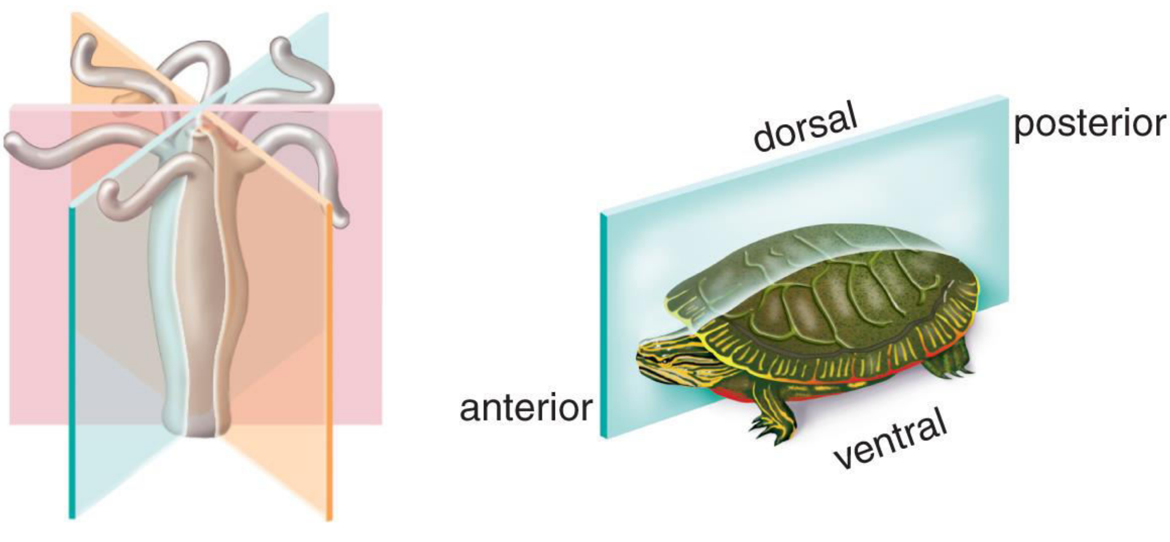
- Multicellular with extensive specialization
- Eukaryotic Animal Cells (no cell wall)
- Heterotrophic
- Sexual reproduction
- Advanced nervous systems

Kingdom Animalia - 1

- Cells →Tissues →Organs →Organ Systems →Organism
- Symmetry of body plan

1. Asymmetry
2. Radial
3. Bilateral

Kingdom Animalia - 1



radial symmetry bilateral symmetry

a. b.

Kingdom Animalia - 1

Classification

1. Phylum Invertebrata
2. Phylum Chordata

- Notochord
- Invertebrates are without notochord.
- Chordates have notochord.

Kingdom Animalia - 1

Invertebrates

- Fresh water, saltwater, on land and as parasites in other animals
- Lack of vertebral column
- Soft bodies
- Mostly exoskeleton
- Both sexual and asexual reproduction

Kingdom Animalia - 1

Classification of Invertebrata

1. Porifera
2. Cnidaria
3. Echinodermata
4. Platyhelminthes
5. Nematoda
6. Annelida
7. Arthropoda
8. Mollusca

END

ClueBook.com

Kingdom Animalia - 2

Chordata

- Fresh water, saltwater, on land
- Bilaterally symmetrical,
- Four unique characteristics present at some stage in development:
- Notochord, pharyngeal slits or pouches, dorsal tubular nerve cord, and postanal tail

Kingdom Animalia - 2

Chordata

- Presence of an endostyle or thyroid gland
- Complete digestive tract
- Ventral, contractile blood vessel (heart)

Kingdom Animalia - 2

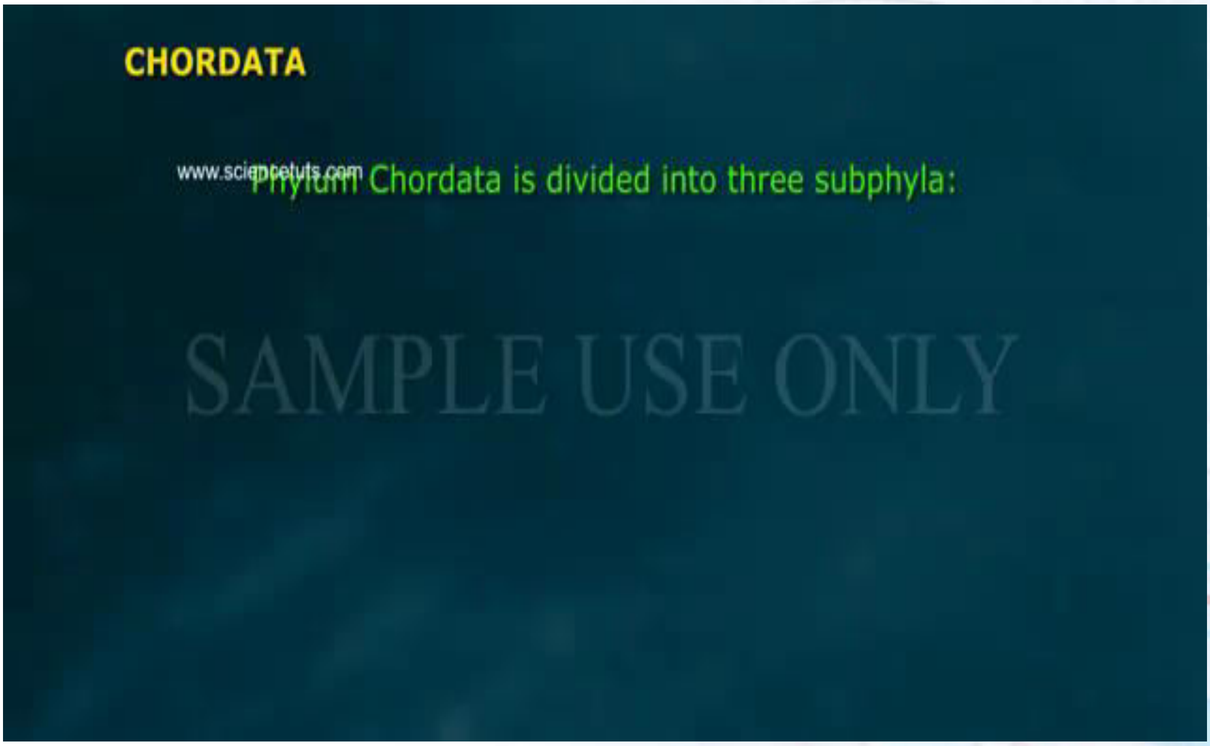
https://www.youtube.com/watch?v=yT5iR32Sq90

Kingdom Animalia - 2

Classification of Chordata

1. Subphylum Urochordata
2. Subphylum Cephalochordata
3. Subphylum Vertebrata

Kingdom Animalia - 2



https://www.youtube.com/watch?v=yT5iR32Sq90

Kingdom Animalia - 2

Classification of Vertebrata

Classes:

1. Pisces
2. Amphibia
3. Reptilia
4. Aves
5. Mammalia

END

Phylum Porifera

- Sponges
- Marine animals
- Loose organized cells
- Colonies of individual cells
- Asymmetrical or radially symmetrical

Phylum Porifera

- Three cell types:

1. Pinacocytes
2. Mesenchyme cells
3. Choanocytes

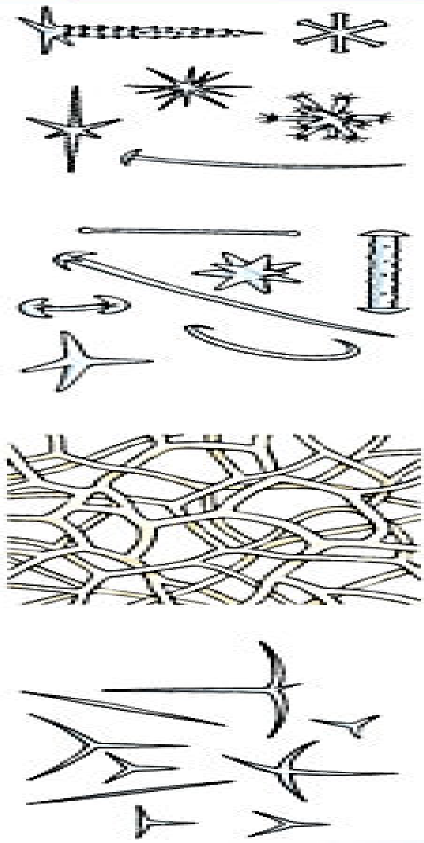
- Central cavity, or a series of branching chambers
- No tissues or organs

Phylum Porifera

https://www.youtube.com/watch?v=DfROrUE-xEE

Phylum Porifera

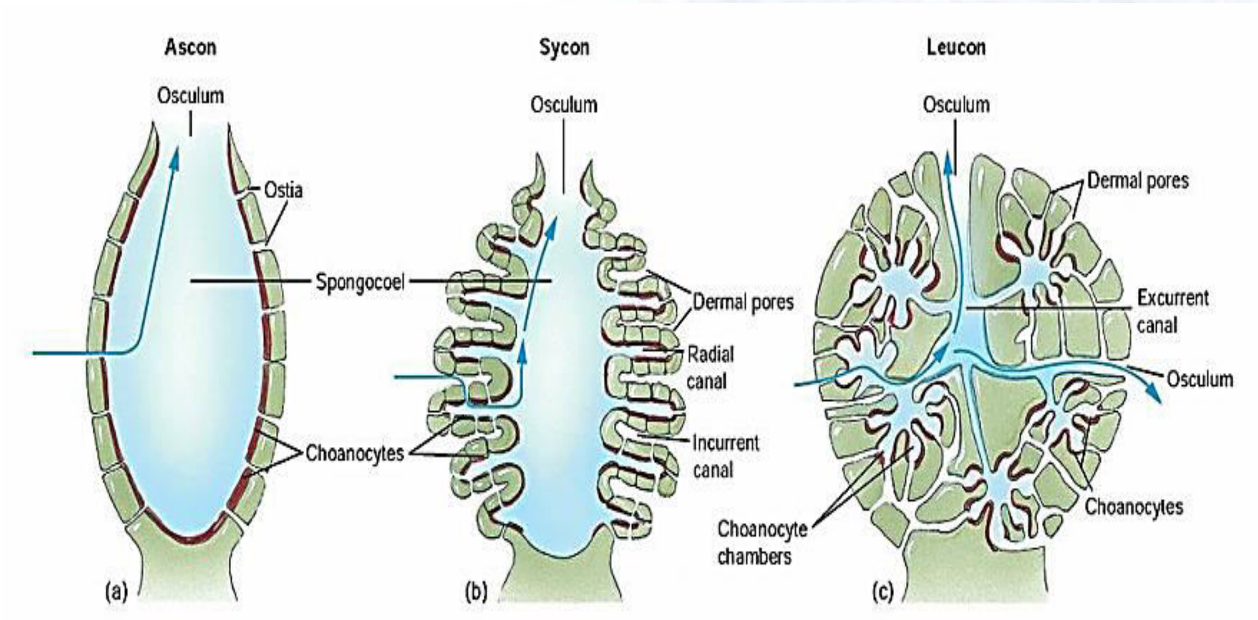
https://www.google.com/url?sa=i&source=images&cd=&ved



Skeleton

- Microscopic needlelike spikes called spicules.
- Formed by amoeboid cells
- Made of calcium carbonate or silica
- May be made of spongin

Phylum Porifera



http://swaggology.weebly.com/uploads/2/6/3/1/26313285/4677105.jpg?1392256087

Phylum Porifera

Maintenance

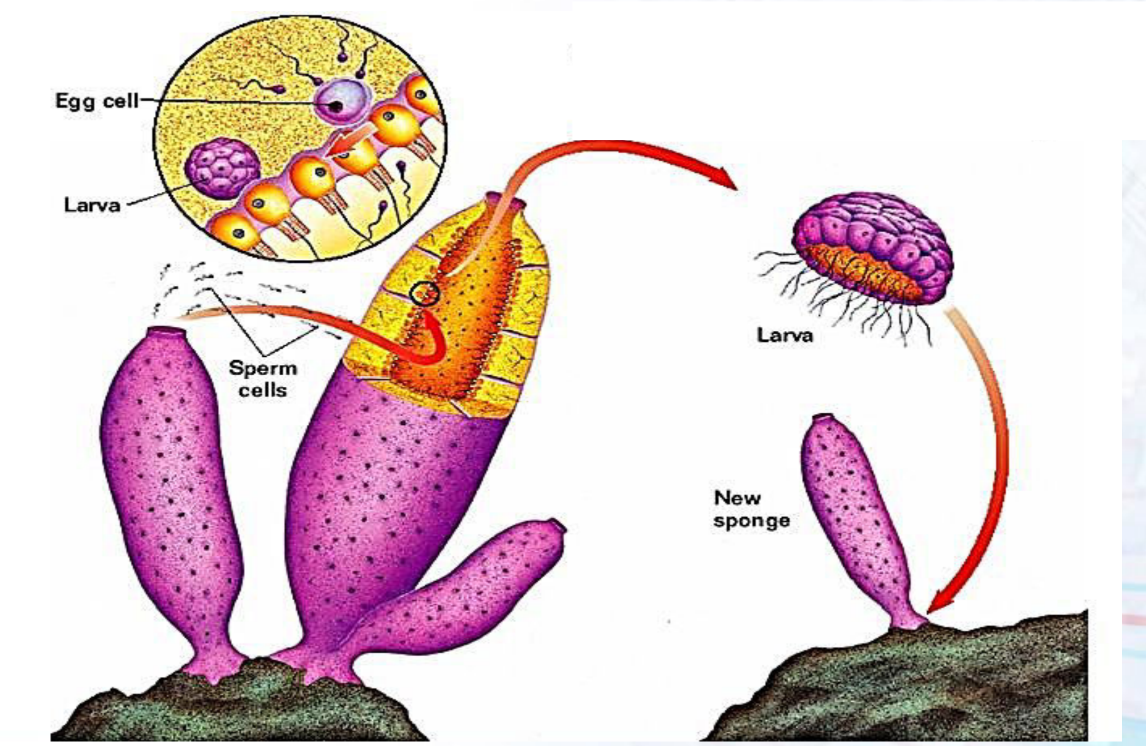
- Feed on particles that range in size from 0.1 to 50 µm.
- Nitrogenous waste removal and gas exchange occur by diffusion
- No nerve cells

Phylum Porifera

Reproduction

1. Asexual
- Budding
- Regeneration
2. Sexual
- Monoecious
- Choanocytes undergo meiosis to form flagellated sperm
- Other choanocytes form eggs by meiosis

Phylum Porifera



https://www.google.com/url?sa=i&source=images&cd=&ved

Phylum Porifera

Reproduction

- Cleavage of a zygote results in the formation of flagellated larva
- Larva is released and develops into adult.

END

Phylum Coelenterata

- Radial or biradial symmetry
- Diploblastic, tissue-level organization
- Gelatinous mesoglea between the epidermal and gastrodermal
- Gastrovascular cavity
- Specialized cells, called cnidocytes

Phylum Coelenterata

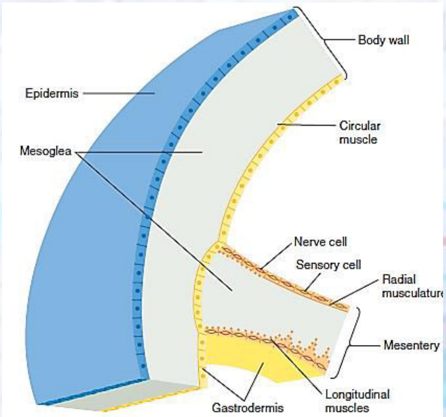
Classification

1. Class Hydrozoa
2. Class Scyphozoa
3. Class Cubozoa
4. Class Anthozoa

Phylum Coelenterata

- Cells derived from embryological layers
- Epidermis
- Gastrodermis
- Mesoglea

Zoology by Miller and Harley, 5th ed., 2011



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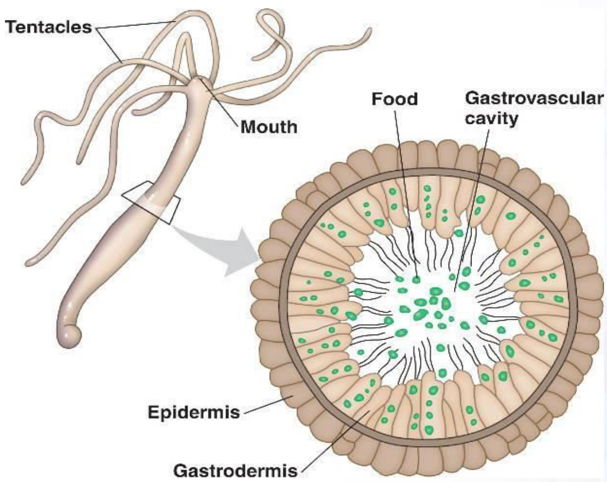
Phylum Coelenterata



http://bio1152.nicerweb.com/Locked/media/ch41/hydra_digestion.html

- Gastrovascular cavity
- Cnidarians food consists of small crustaceans, small fish
- Nutritive-muscular cells
- Hydrostatic skeleton
- Nervous system in the form of a nerve net

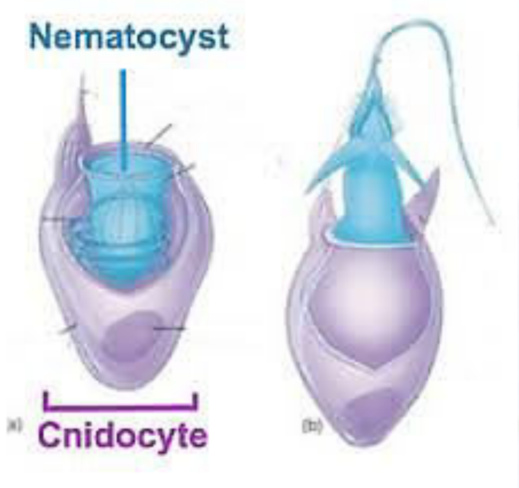
Phylum Coelenterata

Nematocysts

- Fluid-filled, intracellular capsule enclosing a coiled, hollow tube
- A lidlike operculum caps the capsule at one end

Phylum Coelenterata

Nematocysts



https://blogs.ubc.ca/mrpletsch/2019/01/23/phylum-cnidaria/

- The cnidocyte has a modified cilium called a cnidocil
- On stimulation, cnidocil discharge a coiled tube

Phylum Coelenterata

https://www.youtube.com/watch?v=EKQDKqfvQew

ClueBook.com

Phylum Coelenterata

Alternation of Generation

1. **Polyp**

- Asexual and sessile
- Attaches to a substrate at the aboral end
- Cylindrical body called column

2. **Medusa**

- Dioecious and free swimming
- Tentacles dangle from its margins

Phylum Coelenterata

https://www.youtube.com/watch?v=Dgre5EBQLaM

Phylum Platyhelminthes

- Usually flattened dorsoventrally
- Triploblastic
- acoelomate
- Bilaterally symmetrical
- Unsegmented worms
- Beginning of cephalization with an anterior cerebral ganglion

Phylum Platyhelminthes

- Longitudinal nerve cords
- Protonephridia as excretory structures
- Hermaphroditic
- Complex reproductive systems

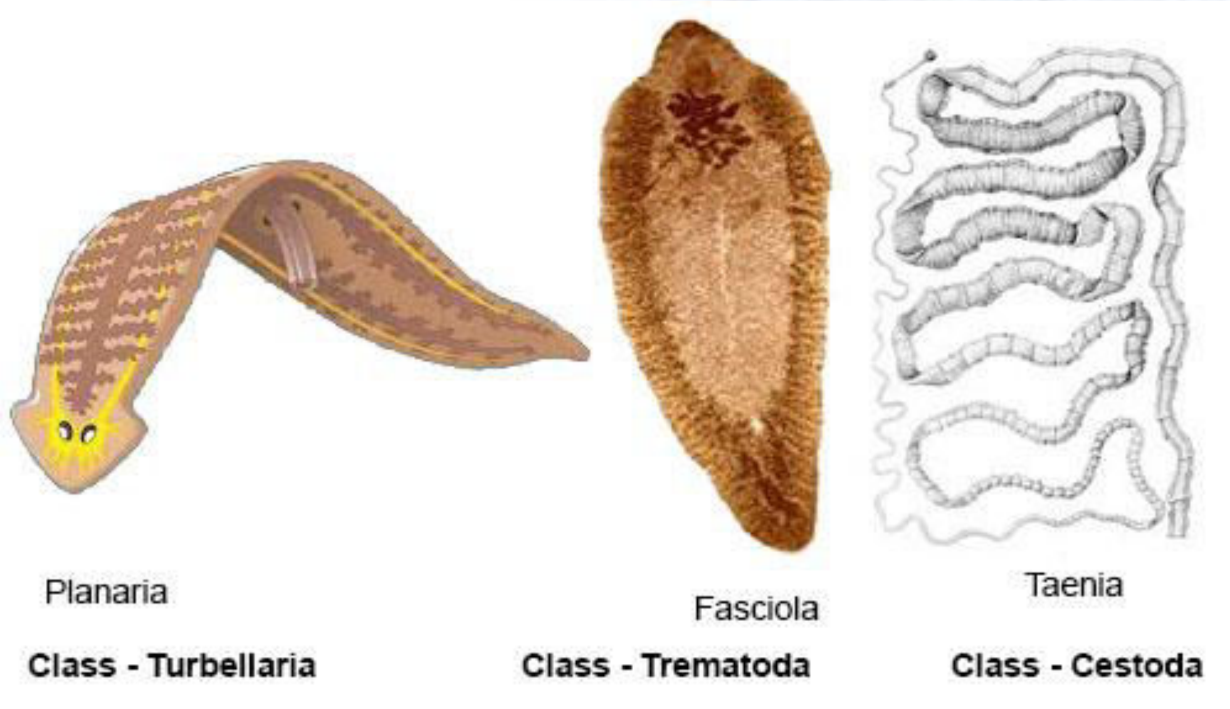
ClluesBook.com

Phylum Platyhelminthes

Classification

1. Class Turbellaria (Free-Living Flatworms)
2. Class Monogenea
3. Class Trematoda (Flukes)
4. Class Cestoidea (Tapeworms)

Phylum Platyhelminthes



https://www.kullabs.com/uploads/62.jpg

Phylum Platyhelminthes

Locomotion

- Bilaterally symmetrical animals
- Bottom dwellers
- Glide over the substrate
- Cilia and muscular undulations
- Sheet of mucus
- Aids in adhesion and helps the cilia gain traction

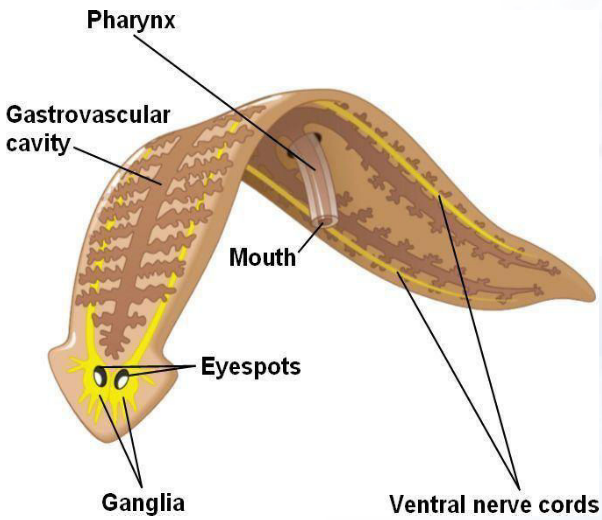
Phylum Platyhelminthes

Digestion and Nutrition

- Marine turbellarians lack the digestive cavity
- Other turbellarians have digestive tracts that are lobed

ClueBook.com

Phylum Platyhelminthes



http://digestivemack.weebly.com/uploads/1/1/5/1/11517135/151459512.gif

Digestion and Nutrition

- Food digestion is partially extracellular

Phylum Platyhelminthes

Digestion and Nutrition

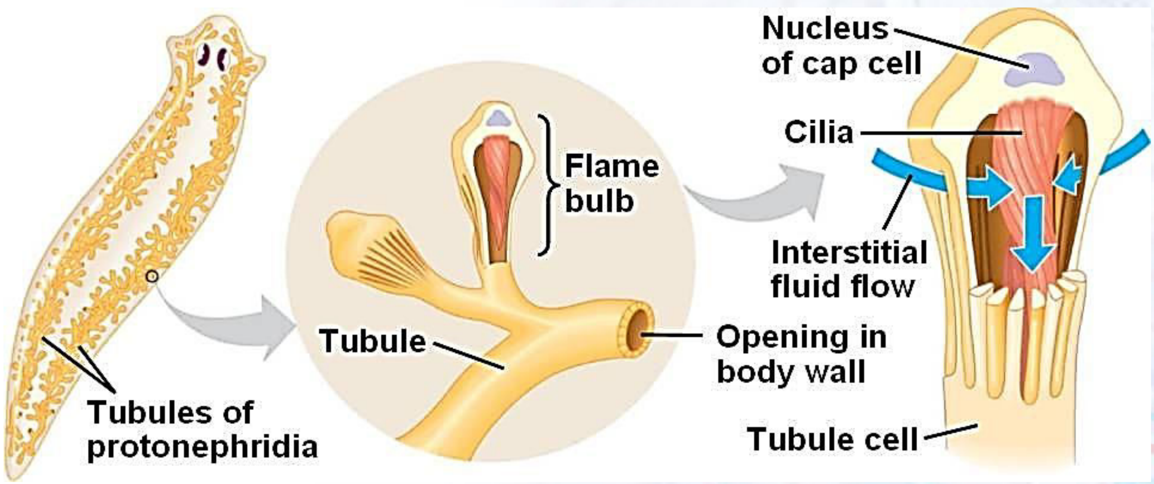
- Pharyngeal glands secrete enzymes that help break down food into smaller units
- Digestion is completed in intracellular vesicles

Excretion

- Protonephridia or Flame cells

ClluesBook.com

Phylum Platyhelminthes



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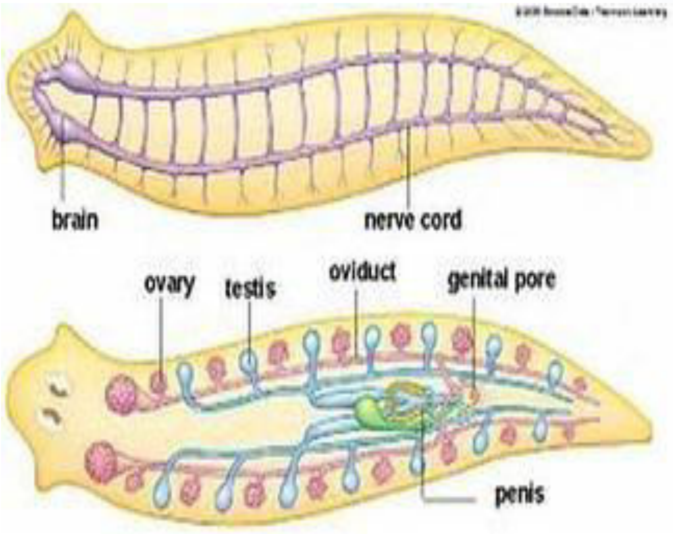
Phylum Platyhelminthes



http://reproductivesys.weebly.com/uploads/2/9/7/7/29775075/612451016.jpeg?325

Reproduction

- Reproduce asexually by transverse fission
- Monoecious
- Cross-fertilization
- reproductive systems arise from the mesodermal tissues in the parenchyma
- Female system has one to many pairs of ovaries
- Eggs are laid with or without a gel-like mass

Phylum Platyhelminthes

- A hard capsule called a cocoon
- A few turbellarians have a free-swimming stage called a Müller's larva

http://www.biologydiscussion.com/invertebrate-zoology/phylum-platyhelminthes/platyhelminthes-habitat-structure-and-development/32822

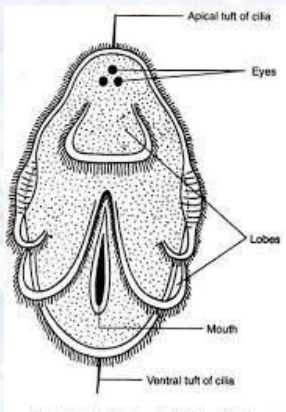


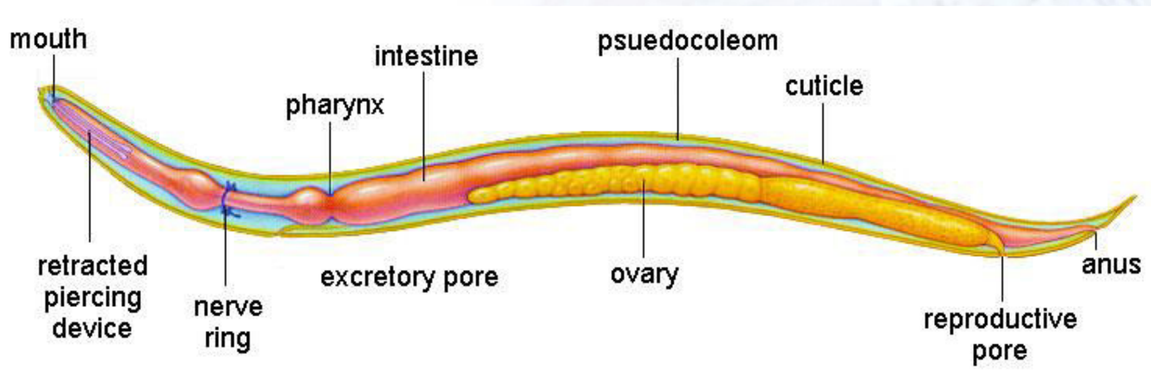
Fig. 14.29: Muller's larva (after Borradaile).

END

Phylum Nematoda

- Triploblastic
- Bilateral
- Vermiform
- Unsegmented
- Pseudocoelomate
- Complete digestive tract
- Unique execratory system comprised of two or more renette cell

Phylum Nematoda

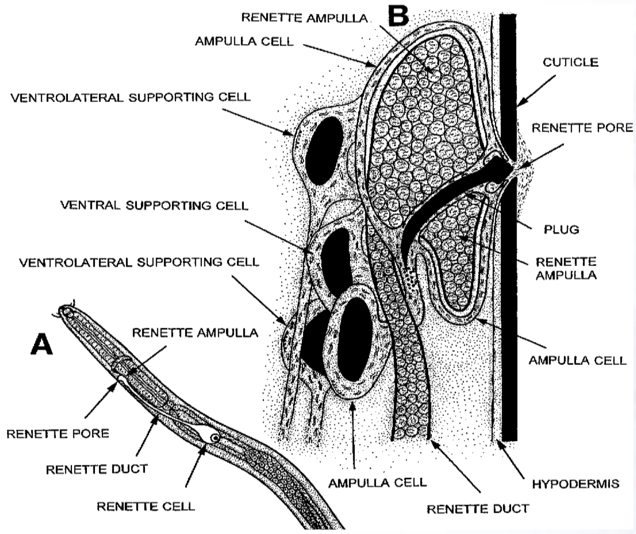


https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact

Phylum Nematoda

- Body wall has only longitudinal muscles
- Cuticle may contain spines, bristle papillae and ridges
- Pseudocoelom is a spacious fluid filled cavity
- Visceral organs
- Form hydrostatic skeleton

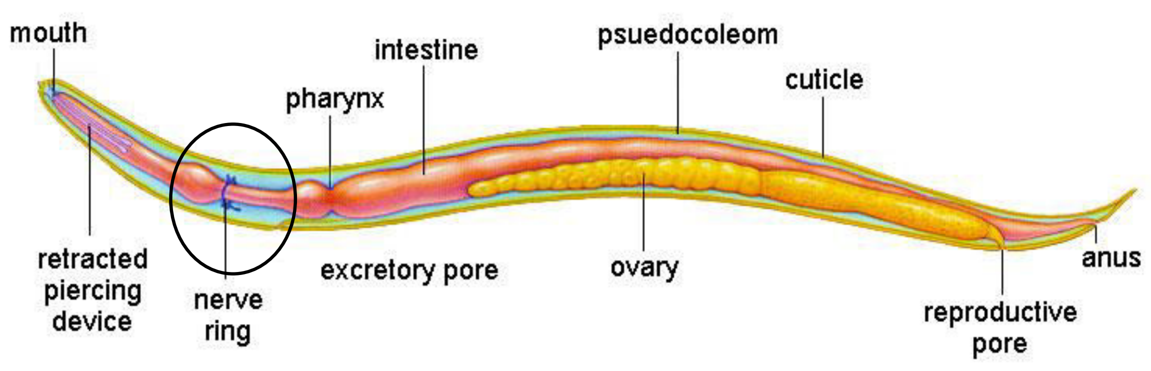
Phylum Nematoda



https://www.google.com/url?sa=i&source=images&cd=&ved=2ahUKEwja_4_

- May be herbivores, carnivores, omnivores and saprotrophs
- Feed on blood and tissue fluid of their hosts
- Complete digestive tract
- Excretion of nitrogenous waste
- Ventral gland cells, called renette
- Nervous system consist of anterior nerve ring

Phylum Nematoda



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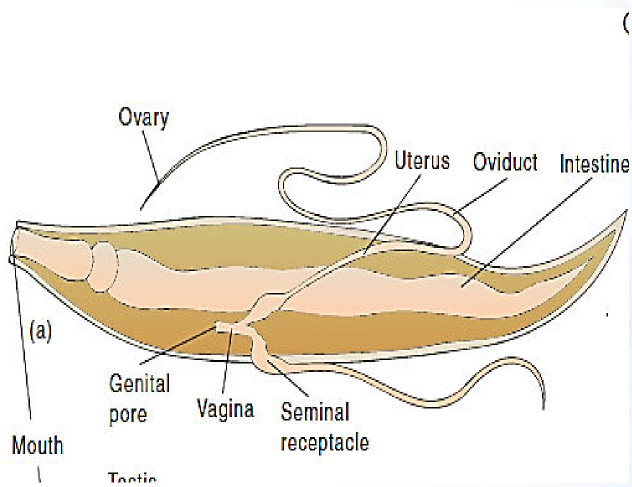
Phylum Nematoda



https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact=8&ved=

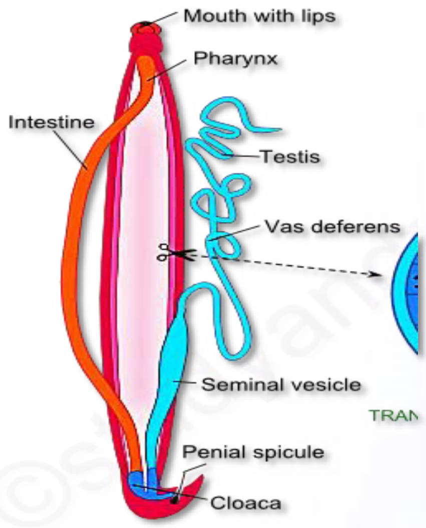
Reproduction

- Dioecious and dimorphic
- Males are smaller than female

Female System

- Pair of convoluted ovaries
- Two uteri unite to form a vagina

Phylum Nematoda



https://www.studyandscore.com/images_all/1_Study%20material/Life%20sciences/Zoology/Nematyhelminthes/Ascaris_male_reproductive_system.png

Reproduction

- **Male System**
- Single testis
- Present vas deferens
- Seminal vesicles connect to the cloaca
- Posterior flap of tissue called bursa
- Help in copulation

ClluesBook.com

Phylum Nematoda

- Parasites
- Parasitic adaptations

Examples

- Ascaris
- Roundworms
- Hookworms
- Heartworms

END

Phylum Annelida - 1

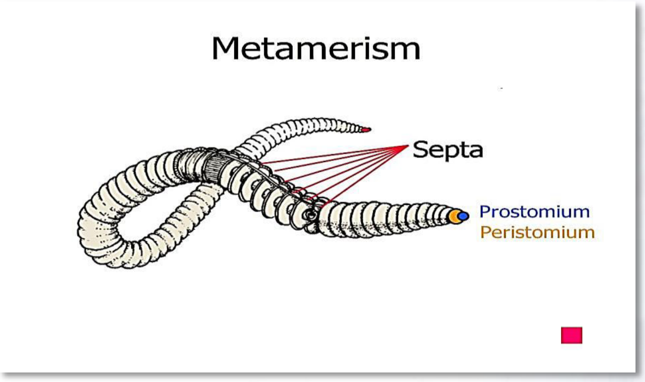
- Segmentation
- Metameric segmented
- Bilaterally symmetrical or wormlike
- Protostome characteristic
- Spiral cleavage, Trochophore larvae
- Paired epidermal setae

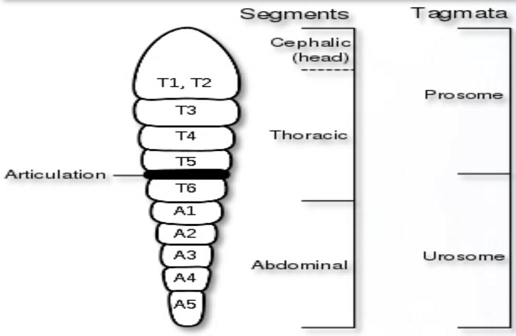
Phylum Annelida - 1

- Closed circulatory system
- Metanephridia or protonephidia

http://4.bp.blogspot.com/PlbYPxxBee8/Uj6OWsDsw5I/AAAAAAAAACY/Y2xNj6wvT-s/s1600/eisenia-veneta-51_005crop_compost.jpg

Phylum Annelida - 1





https://slideplayer.com/slide/9387936/28/images/28/Metamerism+Prostomium+Peristomium.jpg

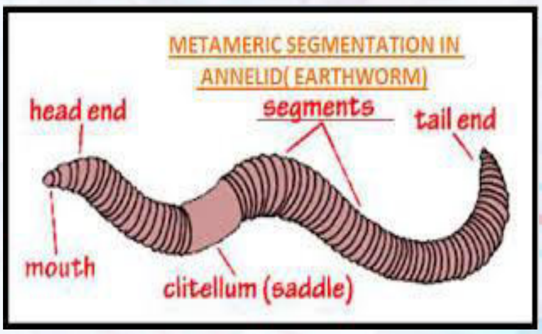
Metamerism

- Segmented arrangement of body parts in an animal is called Metamerism.
- Each segment having its own excretory, nervous and circulatory system.

Phylum Annelida - 1

Tagmatization

- Organization of segments into functional units (e.g. head, thorax and abdomen)



https://www.google.com/imgres?imgurl=x-raw-image

Phylum Annelida - 1

Locomotion

Capable of walking, fast crawling or swimming

1. Parapodia

- Paired muscular bristle-bearing appendages used in locomotion, sensation and respiration.

https://www.google.com/imgres?imgurl=https%3A%2F%2Fc8.alamy.com%2Fcomp%

2. Setae

- Bristle secreted from invaginations of the distal ends of Parapodia.

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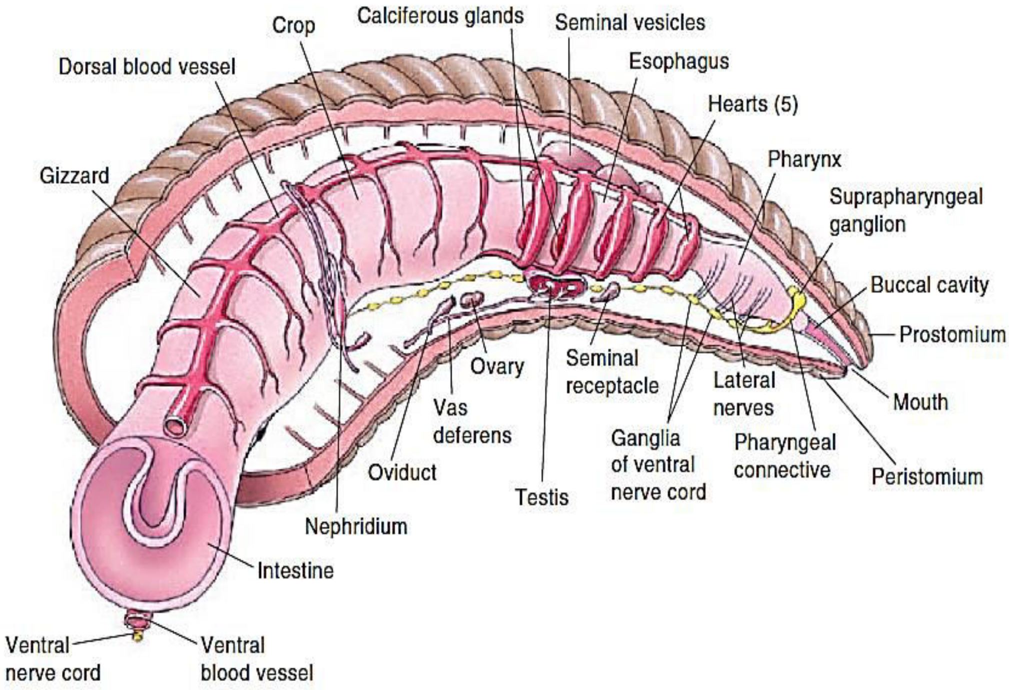
Phylum Annelida - 1

Feeding

- Oligochaetes are scavengers.
- Feed primarily on fallen and decaying vegetation
- Polychaetes are herbivores and scavengers
- Use jaws for tearing food
- Oligochaetes feed on body fluid of other vertebrates

Phylum Annelida - 1



Zoology by Miller and Harley, 5th edition.

Phylum Annelida - 1

Classification

1. Class Polychaeta (marine habitat)
2. Class Oligochaeta (marine and terrestrial habitat)
3. Class Hirudinea (marine, freshwater and terrestrial habitat)

END

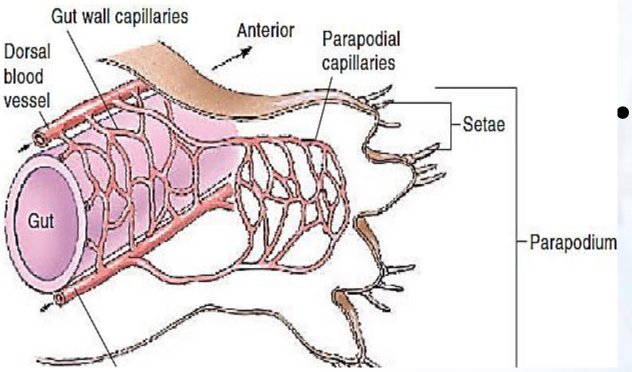
Phylum Annelida - 2

Circulation

- Segmented vessels expand and may be contractile
- Expanded segmented vessels surround the esophagus

Phylum Annelida - 2

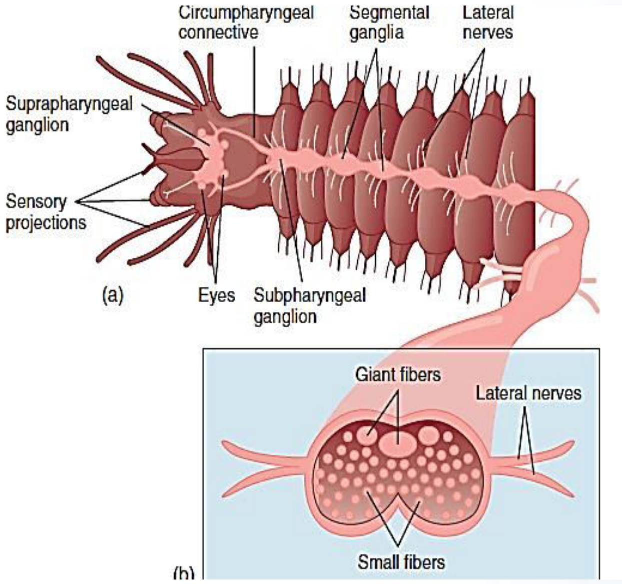
Circulation



Zoology by Miller and Harley, 5th edition.

- Propel blood between dorsal and ventral blood vessels
- Branches from the ventral vessels supply the intestine and body wall.

Phylum Annelida - 2

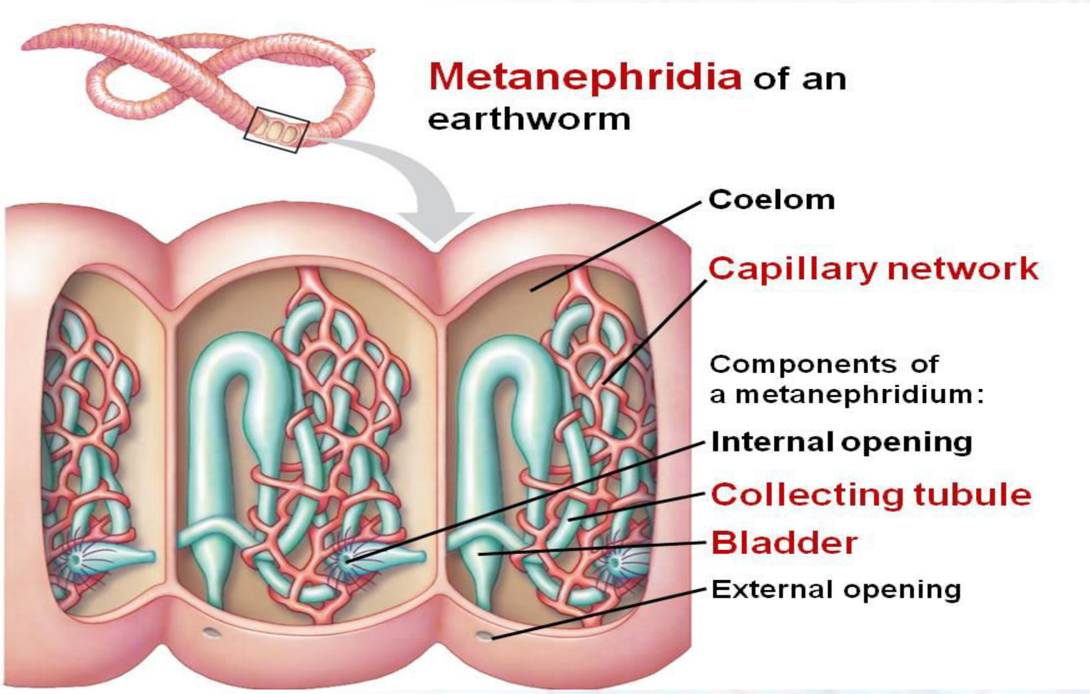


Zoology by Miller and Harley, 5th edition.

Nervous System

- **Ventral nerve cord and all ganglia fused**
- **Giant fibers mediates escape response (Oligochaetes and Polychaetes)**
- **Ventral nerve cord are unfused, except at the ganglia (Leech)**
- **Sense organs are widely scattered over the body**

Phylum Annelida - 2



https://www.google.com/search?hl=en&biw=1280&bih=578&tbm=isch&sxsrf=

Phylum Annelida - 2

Reproductive System

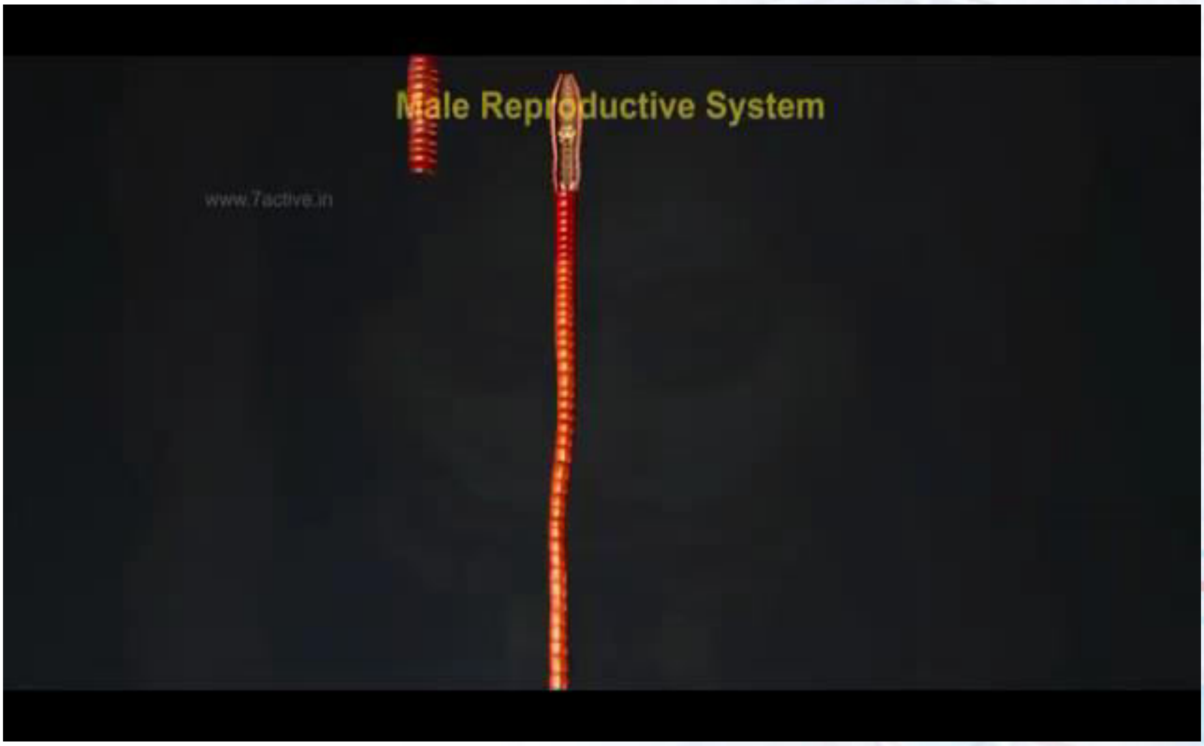
- Power of regeneration
- Reproduce asexually by budding, transverse fission
- Dioecious and monoecious
- Three pairs of seminal vesicles
- Seminal receptacles receptacles receive sperm during copulation

Phylum Annelida - 2

Reproductive System

- Cocoon is released.
- Contains many juveniles.

Phylum Annelida - 2



http://youtube.com/watch?v=J_f55aO_cu0

Phylum Annelida - 2

https://www.youtube.com/watch?v=fLq-JjWij-8

Phylum Annelida - 2

Reproductive System

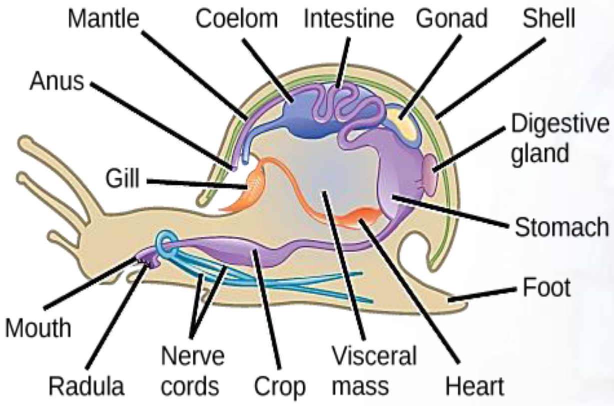
- Spiral cleavage
- No larva form
- Hatching occur in one to few weeks

END

Phylum Mollusca

- Body divided into three parts
- Head-foot, visceral mass and mantle
- Mantle secretes a calcareous shell
- Bilateral symmetry
- Coelom reduced to cavities surrounding the heart, nephridia and gonads

Phylum Mollusca



https://s3uswest2.amazonaws.com/coursesimages/wpcontent/uploads/sites/1223/2017/02/03223340/F igure_28_03_08.png

1. Head-foot

- Elongate with an anterior head
- Containing mouth, nervous and sensory structure
- Elongate foot
- Used for attachment and locomotion

2. Visceral mass

- Contains the organ for:

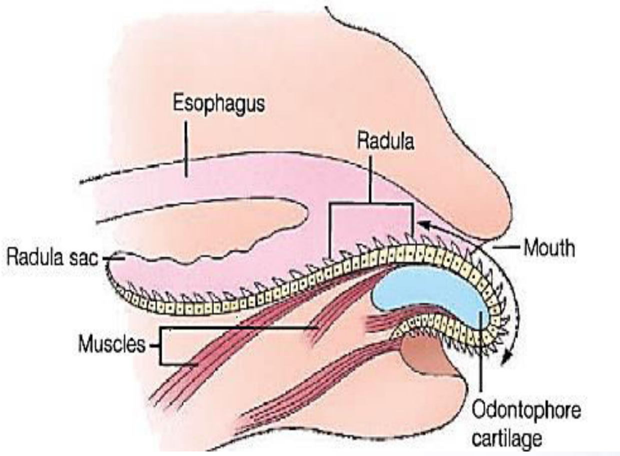
Phylum Mollusca

- Digestion
- Circulation
- Reproduction
- Excretion

3. Mantle

- Attach to the visceral mass
- Secrete a shell
- Between the mantle and foot is a space called mantle cavity.

Phylum Mollusca



Zoology by Miller and Harley, 5th edition.

3. Mantle

- Mantle cavity open to the outside

4. Radula

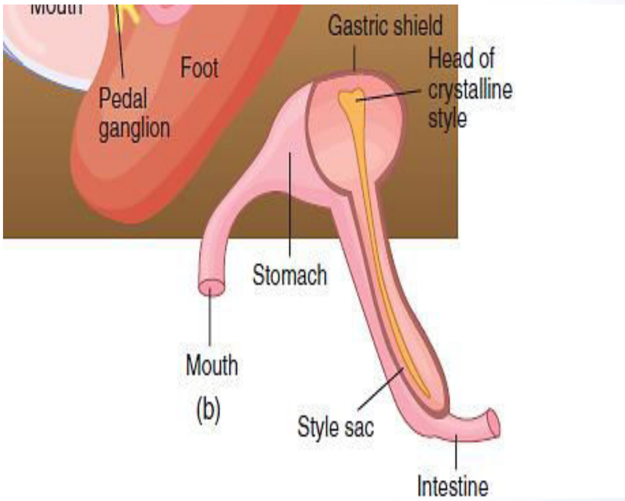
- Rasping structure called radula
- Consist of Chitinous belts
- Curved teeth
- Fleshy tongue like structure called odontophore

ClluesBook.com

Phylum Mollusca

https://www.youtube.com/watch?v=mLVDwlrSq5U

Phylum Mollusca



Zoology by Miller and Harley, 5th edition.

- Digestive tract is ciliated
- Food is trapped in mucous strings
- Mucoid mass, called the protostyle
- Extend to the stomach and rotated by cilia
- Digestive gland releases enzymes and acids into stomach

Phylum Mollusca

- Food trap on the protostyle
- Wastes form fecal pellets move into intestine

Reproduction

- Both dioecious and monoecious
- Gonads lie in spirals of the visceral mass
- External fertilization

Phylum Mollusca

- Internal, cross fertilization
- In gastropods, spiral cleavage results in Trochophore larva
- This develop into another larva called veliger larva

Phylum Mollusca

Classification

1. Class Gastropoda (snails and slugs)
2. Class Bivalvia (oysters, mussels)
3. Class Cephalopoda (octopuses and cuttle fish)

END

Phylum Arthropoda - 1

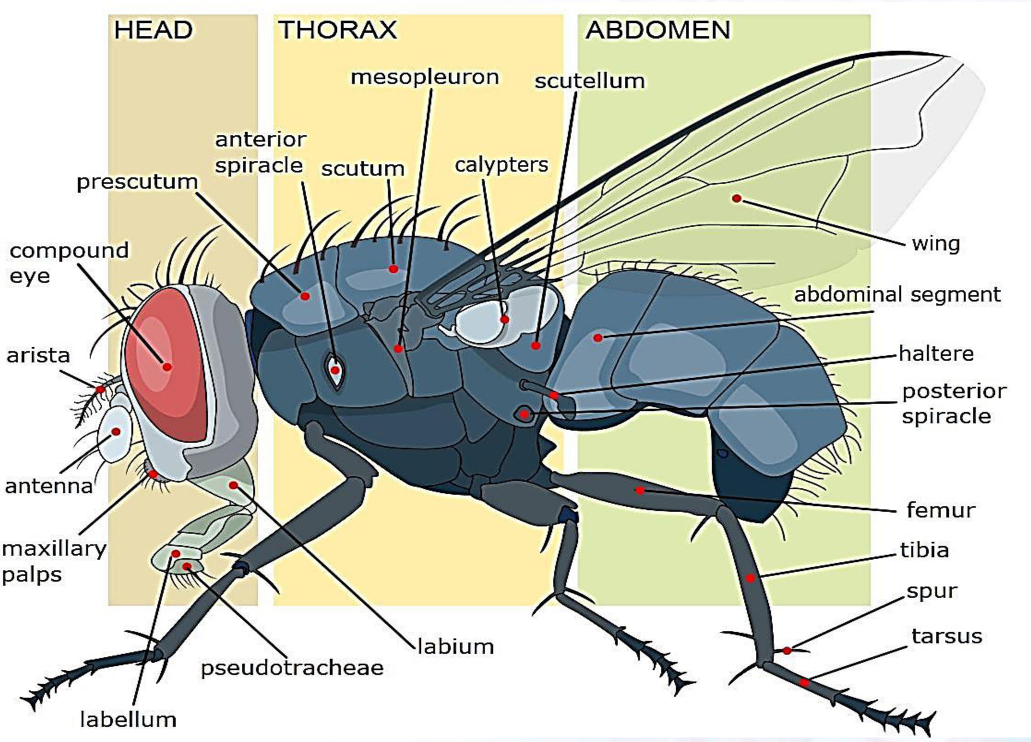
- Metamerism and Tagmatization
- Chitinous exoskeleton that provides support and protection
- Paired, joined appendages
- Growth accompanied by Ecdysis and molting
- Ventral nervous system

ClueBook.com

Phylum Arthropoda - 1

- Open circulatory system in which blood is released into tissue spaces
- Complete digestive tract
- An external, jointed skeleton called exoskeleton or cuticle
- Non-living and secreted by single layer of epidermis

Phylum Arthropoda - 1



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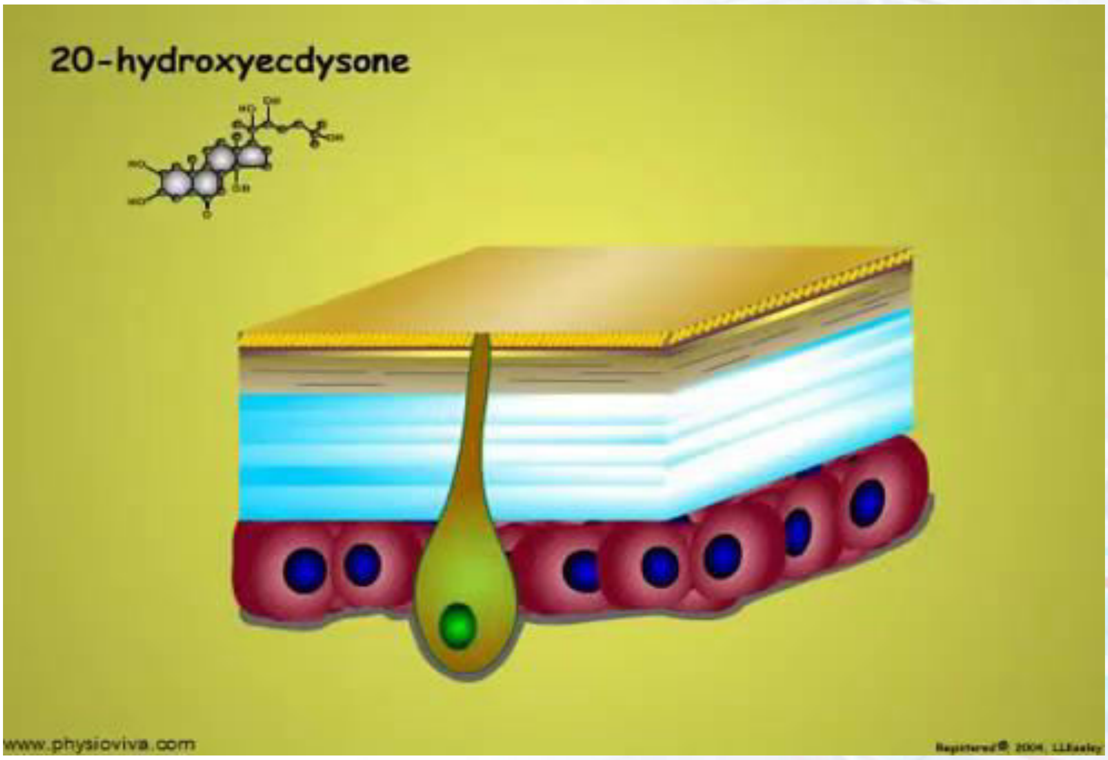
ClueSBook.com

Phylum Arthropoda - 1

Exoskeleton

- Provides structural support
- Protection
- Impermeable surfaces for the prevention of water loss
- Muscle attachment and movement
- It is shed off at the time of growth, called ecdysis.

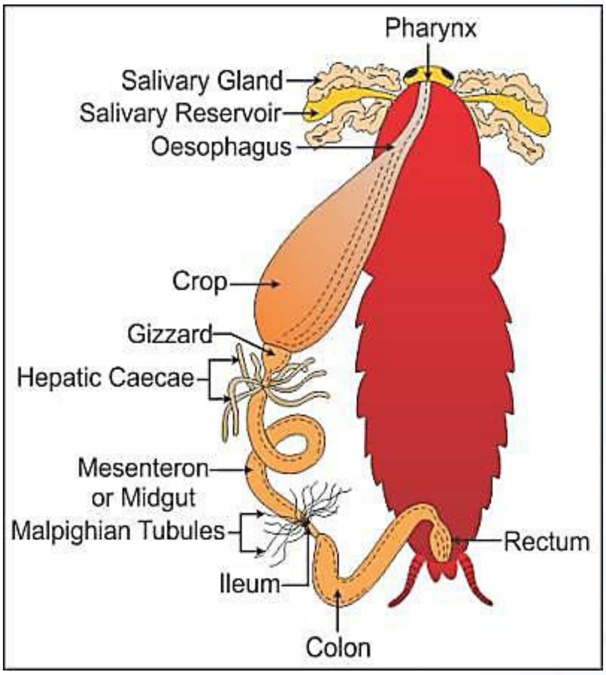
Phylum Arthropoda - 1



https://www.youtube.com/watch?v=QfeEZI0VGs0

ClueBook.com

Phylum Arthropoda - 1



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Digestion

- Herbivore, carnivore, parasites
- Complete gut
- Three parts of gut
- Gizzard may be present.
- Gut receives nitrogenous wastes for excretion

Phylum Arthropoda - 2

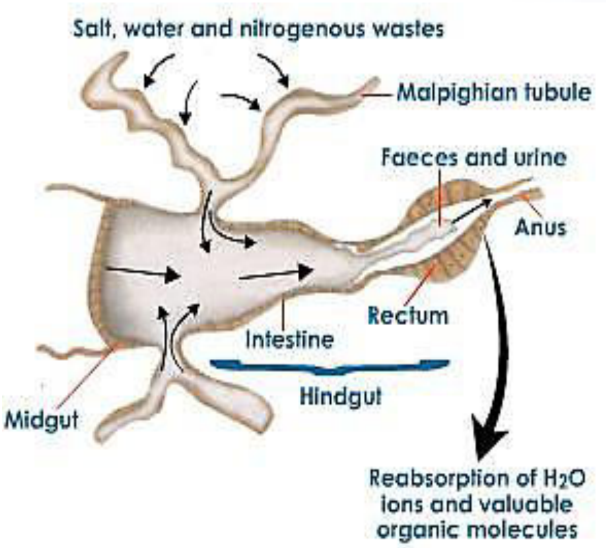
Excretion

1. Coxal glands
2. Malphigian Tubules

1. Coxal glands

- Paired
- Thin walled
- Absorb nitrogenous waste and excrete through excretory pore

Phylum Arthropoda - 2



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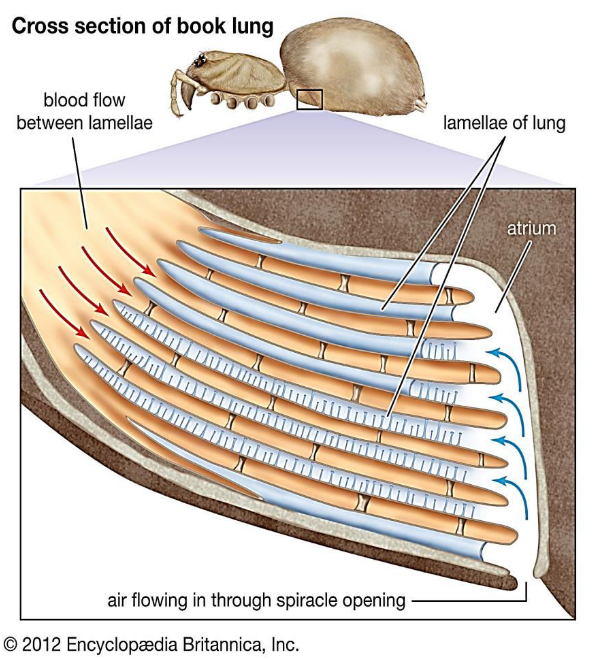
2. Malpighian tubules

- Absorb waste material from the blood and empty them into the gut tact
- Major excretory product is uric acid
- Uric acid is excreted as a semisolid with little water loss

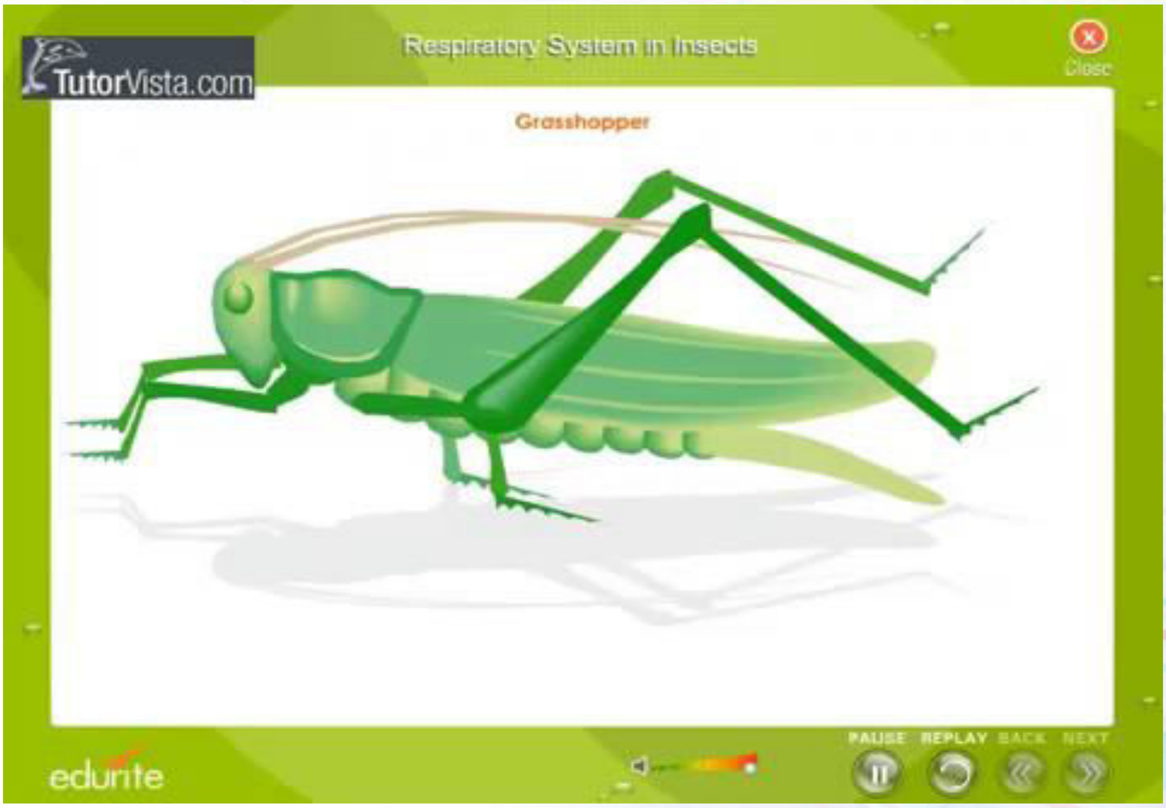
Phylum Arthropoda - 2



Respiration

- Gas exchange occurs through minimal water loss
- Arachnids possess structures, called book lungs
- Insects have tracheal system

Phylum Arthropoda - 2



http://youtube.com/watch?v=HV60yTvy3Mk

Phylum Arthropoda - 2

Circulatory System

- Open circulatory system
- Blood pump into blood spaces
- Large tissue spaces are called hemocoel
- Blood bath the tissues and than return into the dorsal aorta, through an opening called ostia

END