

History of Biology Before Darwin

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Slide 4

- 1600s were the peak point of biology revolution

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- Treviranus 1802, had called biology has a discipline
 - NOT human biology
- No one heard the term of biology till 300 years ago did the term biology existed
 - Not many people were consider themselves as biologist within those 300 years

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- Many branches of biology has expanded over the years
 - Proteomics were discovered just over 4 years ago

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- 400 BCE - 450 CE: GREEK AND ROMAN AGES
 - First to travel
 - The Roman Empire went all the way from Rome to Northern Africa and all they way up to England not Ireland
 - This created a huge commerce zone
 - People identified minerals, plants, animals etc...
 - They catalogue the world they were exploring. They started to organize, put infrastructure, build durable road (some still used today). They shipped items everywhere

Transportation => Commerce => Successful => Culture => Wealth => Knowledge
=> Written down and catalogued

- Came crashed down when the Goth invaded the Roman Empire
 - Rome had expanded to the perimeters and could not protect that area well. The Goths came from the outside toward central Rome and destroyed everything
 - Many people had to live the way life was before the Roman Empire
 - END of knowledge sharing, transportation, communication

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Douglas Adams (1952-2001) describes the scientific revolution and the start of modern sciences as four ages of sand

- First - Telescope 1608
 - The beginning to be able to see the life from a far away distance
 - Astronomy, Physics, Geometry, Calculus was discovered
- Second - Microscope 1678
 - Being able to the smallest organisms
 - Has become advanced that we can see tissues, cells, and even now MRI are used to magnify
- Third - Computer Chip 1961
 - The use of binary code 0,1 created many things like color, alphabet, complex math and can be stored
- Fiber Optics - 1980s
 - Connectivity (wireless), sharing of resources, allow collaboration with other people
 - Placing GPS on insect and whales to see where they go

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Hippocrates - FATHER OF MEDICINE

- Medicine, Oath
- Known for assembling written records of every practice in human biology at the time
- He put all the knowledge of medicine in one place
 - His book -> Hippocratic corps

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Aristotle

- Was the first person to attempt to organize the living world and how the world works
- Organized the complexity of the world
- He ranked them by importance
 - Called *Scala Natura*

Slide 14

Theophrastus - ANCIENT FATHER OF TAXONOMY


Major events in the history of biology:

- Identify and understand the major events and findings in Biology.
- Be able to place the main findings of biology in a historical context.
- Explain how biology differs from the other sciences
- Understand how biology is done – scientific method in natural sciences.

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Success
of
Roman
Empire

Important stages in the history of Biology
400 BCE – 450: Greek and Roman ages



Hippocrates (460-370 BCE)

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Important stages in the history of Biology
400 BCE – 450: Greek and Roman ages



Aristotle (384-322 BCE)

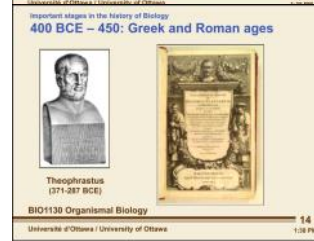
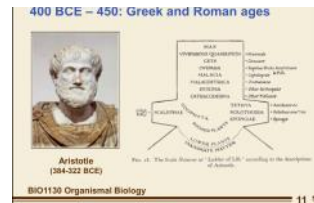
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- Called *Scala Natura*

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Theophrastus - ANCIENT FATHER OF TAXONOMY

- He took Aristotle organization and further organized the plant species for:
 - Medicine and healing
 - Agriculture exploration
 - Plant fibre
 - Cotton, wool, wood
- He is famous for his medicinal plants
 - 10 large books he wrote
 - 9 survived to this day
- Some plants are still classified the same way Theophrastus did



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- For the first time, things was being classified. It is human nature to organize complexity into groups with rules.
 - The Greek Philosophers made a set of rules on the organization that is called taxonomy

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- Aristotle and Theophrastus were using visual appearance
- Folk taxonomy
 - There is no written record.
 - There was an individual in a society that was the keep of all the information that was acquired.
 - There was also an apprentice that got the information passed down
- Artificial taxonomy
 - Information was written down
- There were about 600 items in a classification
 - 3-4 categories
 - The 600 terms were different in different parts of the world due to their location.
 - A place where there is a lot of ice, they would have many terms for ice, whereas a place with no ice has no terms relating to ice
- Aristotle and Theophrastus taking all the written work and getting them organized, and that was their biggest contribution.

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- Every organisms had a certain essence (ESSENTIALISM)
 - The pre-concept of genetics and natural selection

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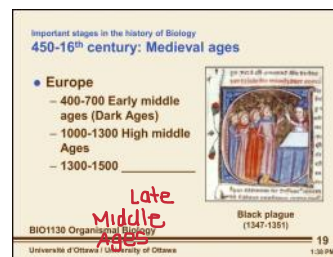
- No change to Aristotle's theory, only that one God was identified instead of multiple

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- 1600, towards the end of the Medieval Ages, was a guy named Usher
 - He takes the bible and put all the stories together. He works backwards and came to the conclusion that the world biodiversity on the planet was completed on October 23, 4004 BCE
 - 5600 years old the Earth

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- Medieval Ages were separated into 3 difference ages
 - Early Middle Ages
 - Complete collapse of the Roman World
 - High Middle Ages
 - Europe starts to be able to build
 - Comes crashing down again due to Black Plague
 - Celebrated by signing "Ring around the Rosy"
 - Late Middle Ages
 - 1492 Columbus sailed the ocean blue
- Medieval Ages were only about the Western culture
- Aristotle and Theophrastus works were translated and distributed around the world



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- While Europe was collapsing, the Islamic world and Byzantium were not affected yet they also had the knowledge of Aristotle and Theophrastus works
- It was consider the golden ages of Islam because this is when they take over as the knowledge base, commerce.

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- ⇒ IN KEY WORDS

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- As Europe begins to conquer again, it is driven by the church who wants to free the holy sites of Christianity, so they invade, kill & remove the Islamic world from those areas.
- Western culture clashes with Islamic world
- Knowledge comes back to the Western culture and scientific revolution continues

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- All funded by the Church
- Copernicus knew that if he made his theory about the sun being the center of the universe instead of Earth, he would be capital punishment. He talked to people about it but never made it public
 - He waited until he was on his death bed to tell people to publish his book
 - That was his last words
- Kepler builds on Copernicus ideas
- Galileo continues to prove Copernicus theory
 - He published a large amount of work
- Physical science and not natural science
 - BIG scientific revolution
 - Biology doesn't advance because everyone feared to disagree with anything the bible said

Important stages in the history of Biology:
16th-18th century: The scientific revolution and the start of modern sciences

- Copernicus (1473-1543) – earth not the center of the universe.
- Kepler (1571-1630) – planetary motion
- Newton (1643-1727) – laws of motion, gravity and thermal conduction
- Galileo (1564-1642) – further proof of earth revolving around the sun
- Boyle (1627-1691) – behaviour of gases
- Pascal (1623-1662) – geometry
- Descartes (1596-1650) – geometry
- Van Leeuwenhoek (1634) – first microscope
- Andrea Vesalius (1514) – Anatomy
- Harvey (1578-1633) – Systema naturae
- Linnaeus (1707-1778) – Systema naturae

origins of Calculus
anatomy & physiology

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- Douglas Adams first age of sand
- He made the first microscope
 - He never released how he made it and was sole control of producing them
 - When he died, so did the knowledge of the microscope
- He is important because he showed that there were a lot more organism that originally came

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Andrea Vesalius - FATHER OF ANATOMY

- He dissected many cadavers to learn the human body and drew the internal human body
- This was just advancement of human biology

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Harvey

- Figured out how the living body works
 - Find how the blood flows through the body
- Human biology is moving at a reasonable pace
 - Biology hasn't advanced much still Linnaeus

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Linnaeus - MODERN FATHER OF TAXONOMY

- His type of taxonomy called: mechanical
 - He groups organism based of description and then further organizes them into smaller groups
 - He groups the living world mostly right, but some were very wrong
- Binomial Nomenclature
- Hierarchy
 - Hierarchical Systems
 - He organized in a way that species would have the same characteristics as the higher level of the hierarchical system
 - Kingdom, Class, Order, Genus, Species
 - He didn't give phylum and family as a category

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- Autapomorphie defines a group
 - Animals have to ingest their food
 - Eukaryotes multicellular
 - Fungi secrete enzymes to ingest food

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- Linnaeus simplified the names of the organisms
- To name
 - First part = noun
 - Second part = adjective
- First term; Genus is always capitalized, but the second part isn't
- Using italics because it is part of a different language.

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- Physicalists
 - About physical science
 - Math, mechanical motion, behaviour of gases

- Believed that living things EXCEPT humans behave like very small machines
- Vitalists
 - Agreed with physicalist, but there is something special about living things
 - All organisms have some essence
 - Didn't know about the amino acids back then

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- Big difference b/w natural and physical science

Physical Science

- Describes inanimate objects
- Tries to explain them
- They can say that everything they say
- Predicating where things are going to be

Natural Science (Biology)

- Lots of variety, cannot explain why everyone was different
- Essence was genetics
- No math involved, but described what happened
- Make observation and try to see if the principal works on different situations
- It's a verbal explanation
- It is a narrative

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- Deduction (Physical Science)
 - Try to find these universal principles that explains everything; equations that is supposed to work on everything
 - If it doesn't work then they try to figure out why
 - Starts from the top and makes sure that it works for everything
- Induction (Natural Science)
 - Seen enough to make a prediction
 - Keep looking to confirm it
 - Need to make MULTIPLE observation

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- Proximate Cause - Physical Science
 - Something happens and the very next thing is the result
 - Ex. Hammers hit the knee and the reflex muscle activate
 - A directly causes B
- Ultimate Cause - Natural Science
 - The main tiny detail and WHY something
 - What is the impact?
 - The biological factor that explains why something happens; biomechanical mechanism

Proximate causes (Physical science-like biology)	Ultimate causes (Natural science-like biology)
<ul style="list-style-type: none"> ● Phenotype – morphology and behaviour ● Mechanical (predictable) ● Here and now ● Genes in action ● Experiments 	<ul style="list-style-type: none"> ● Genotype - Genes and history ● Variable (probabilistic) ● Evolutionary past ● Changes in genetic programs ● Historical narratives

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- Organicists
 - Emergence; swarm behaviour
 - Better when people work together than separate
 - The combination of Physicalist and Vitalists

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- Theory
 - Well-founded documented finding that can be seen and found in context. Explanation can be worked under multiple circumstances
 - General public thinks that theory can never be strong as a fact
 - In science, a theory is the strongest thing
- Fact
 - Nothing is very a fact because there is always a small doubt
- Hypothesis
 - Is how you can test something/theory. How do you check what you are saying is correct.
 - Explains a phenomenon
 - Null hypothesis
 - Counter point
- Law
 - Theories can become laws; become more prominent
 - Laws universal (applied everywhere) are mathematical proof/probability (Mendel Law)
 - Theory of evolution is still a theory not a law because no one has seen it in the universe
 - It's not universal; need a few more hundred years
- Prediction
 - Logical

- Having variables that make a prediction
- Chronological
 - Not based on much, making random assumptions

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- Controls
- Control of variables
- Sampling error
 - Every single time you take a measurement, not every time it will be the same
 - More measurements you take, the closer you are to the actual measurement (mean average)
 - Reduced the sampling error
- Repeat the test

Scientific method
Steps or stages

- A question that needs to be answered
- Gather information already known
- **Develop a hypothesis and test it**
- Interpret the results of the test
- Retest
- Publish results

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- Primary
 - Scientific papers from a journal
 - Articles in science
 - Written by the researcher
 - Has references
- Secondary
 - Someone currently in the field of study has written an article review
 - They review someone else's research
 - Has references
- Tertiary
 - Summary
 - Might be written by someone not in the field of study
 - No reference
 - Textbook, National Geography etc.

Slide 1

- What we have so far everything arrived on October 23, 4004 BCE and everything is different because of a special essence and the essence cannot be changed (fixed)
- This was the knowledge at the 1700s

Slide 2

- The naturalist (biologist term does come till 1802) were travelling around the world and seeing things
 - Travel is now happening and the European world is conquering the world
 - Some people are colonizing and some people are learning
- Georges-Louis Leclerc, Comte de Buffon
 - He goes on many journeys and a naturalist.
 - He notices there are a whole animals that were very similar
 - He studied the feline family
 - He sees big cats, small cats, tigers, lions, puma, jaguar...
 - He was wondering that if everything came on the same day, then why are there many variations of a cat or any organisms
 - He proposed that when everything came on the face on the planet in the Garden of Eden there was only one type of cat. Over time, the cats disperse and move away from the garden of Eden, they live in a different environment and when they adapt to that environment, their essence changes.
 - He said that essence changed due to environment change
 - Geography affects the appearance of organisms
 - His contribution was
 - The essence isn't fixed
 - Organisms changes over time

Slide 3

- Erasmus Darwin - Charles Darwin grandfather
 - It takes Linnaeus system natura and translate it in English language for people to understand
- He is a doctor
- He published two books
 - In one of the books, he published a poem that indicated the evolution sequence
 - He questioned the scala natura since not everything came on the same day

Slide 4

- George Cuvier - French Scientist
 - He was finding bones
 - The understanding were the bones were demons, dragons etc.
 - He systematically takes all the bones and pieces them together
 - He was the first one to do this
 - He found whole full organism
 - He found that those bones were animals that existed before
 - The concept he started was comparative biology because he could see all the bone and related them to modern day organisms
 - He comes to the conclusion there are relatives to the organism that have extinct. First person to use the term extinct to define how organisms are gone
 - He has a theory that a catastrophe happened and some of these organisms disappeared.
 - Catastrophic theory means when the incident occurred very quickly/suddenly
 - His student made link about the catastrophe in the bible
 - Noah's flood was the catastrophe and the animals that didn't make it to the arc disappeared

Slide 5

- He has a counterpart of the concept of extinction
- When you uncover the fossils there are different layers that you go through to uncover them
- Cuvier did not recognize this

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- Charles Lyell
 - A naturalist who is interested in mineral sciences and earth sciences
 - He noticed that cliff or a rock formation, there are strata and lines; characteristics of strata such as such as fossils in one layer and then vertebrate fossils in another layer
 - Different layers of rocks represent different periods of time
 - During his travel, he would look at different parts of the rocks and then he went to another location and found that some overlap
 - He was assembling the geological history of the earth
 - From this he creates stratigraphy which is the study of rock strata
 - He develops his concept about geological time
 - He describes the process as very slow as it takes a very long time for sedimentary rocks to form
 - No way the earth could have been made/happen in 4004 BCE
 - The planet is older than 6000 years
 - Instead of everything being catastrophe
 - He says you don't need a catastrophe event to occur for something to change
 - Things just change over a long period of time
 - Comet du Buffon counter argument to catastrophe events is Lyell's uniformitarian theory of geological change

Slide 7

- Rock Cycle
 - In rocks there are created by the plants has the magma core and the igneous rocks
 - The world is covered in ocean, where you get sediments and sedimentary rocks
 - The sedimentary rocks sits on top the original sediment rocks and build over time
 - Species get caught between these rock formation in which there fossils appear in different layers
 - This is Lyell is pointing out

Slide 8

- Lyell could not figure out why some parts of the fossils were found in one area and the other parts are located somewhere else on the earth
 - He did not know at the time about plate tectonics and that they are floating on magma

Slide 9

- In the oceans, there is a balance between CO2 in the air and in the water
- CO2 in carbon cycle in the ocean is important because it provides carbon for photosynthesis that is used build on nutrients for the plants in the ocean
 - The animals feed on the plants in which they expel CO2
 - So there is a sink of CO2 in the ocean
 - It is in equilibrium in the air

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- In an equilibrium, there is an important chemical reaction going on
- When you dissolve CO2 in water, you get carbonic acid and then it will ionized you get eh negative charged bicarbonate
- If there are any positively charge ions in the water, those two are going to react with each other
 - If calcium and bicarbonate you get calcium carbonate
 - Any salt, no matter what it is, doesn't stay in solution
 - It will precipitate out, so the molecules comes out of solution and falls to the bottom of the ocean
 - So constantly over time there is a rain of salt carbonate (biggest one is calcium) that constantly falling at the bottom of the ocean as a microscopic rain
 - There as an abundance that there are layers build up that make sedimentary rocks
- Lyell knew this process is extremely slow and no way it could have taken only 6000 years
- He notices that there are major changes in the composition of the organism over time

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- Lyell, Darwin, Buffon did not know the concept of the continental drift
- There was a time where all the continents were together called Pangea
- Continental drift was proven very recent, less than 100 years ago

Slide 13

- Jean-Baptiste Lamarck
 - Transmutation of species
 - He needed a mechanism that talked about how the organisms change
 - He knows that change occurs over time
 - He made the mistake in thinking that physical change over and the characteristic were passed down to the next generation
 - He didn't know that in animals, the reproductive cells gametes.

FOUND ERRORS IN SCALA NATURA

- Gametes are germ cells that are set aside when made when the organism are very young.
- The characteristics that have been developed are in somatic cells so it would not transfer to the next generation
- The concept of genetics was still confusing/unknown

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- Essence either changes quickly for slowly
 - Essence transmutation = slow essence change
 - Essence transformation = fast essence change
 - Dramatically change and new organisms occur
- Lamarck's transmutation of species is an example of environmental transformation of the essence
 - Either the essence changed from the environment - Buffon
 - There was a natural inheritance that automatically changed over time - finalist view

Slide 15

Wallace

- Young scientist that observed the change in population on organisms in the amazon
- Traits that are favourable were continued over time
- When he realizes natural selection on his end, he reaches out to Darwin and they publish their findings together

Darwin:

- Traveled on the HMS Beagle
 - Quit medical school and travelled
- Focused on population during his travel
- Reluctant to publish his work
- Wife was Emma Wedgewood
- Lyell was his mentor

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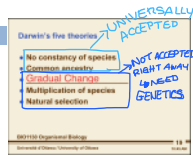
- Natural selection is changing organisms over time slowly
- Theory of natural selection

Slide 17/18

- Darwin
 - Everyone in the family is related
 - They are the same evolutionary history
 - Things that are the same probably share the same ancestors
- Linnaeus
 - He went by appearance

Slide 19

- Darwin DID NOT GIVE THE THEORY OF EVOLUTION
- Mayer
- Branching pattern, there is a common ancestor at the base of the patter
 - Luca is the universal lowest organism
- Organism that can reproduce more effectively have better fitness will have their trait passed down to the next generation



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- The theory of gradual change, multiplication of species and natural selection is not universally accepted right away because the underlying mechanism to explain those theories is genetics which has not been uncovered at the time
- Once the concept of genetics and heritability come in play, Darwin's 5 theories get grouped together to become the THEORY OF EVOLUTION.

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No Constancy of Species

- Darwin uses three evidence to proven his theory that was accepted universally
 - Fossils
 - Builds on Cuvier comparative anatomy
 - Extinction
 - Things have disappeared over time and occurred in his branching pattern
 - Transitional Forms
 - He did not have much information about this



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FOSSILS

- Fossilization is not an event that very occurs frequently
 - Only occurs under very special circumstances
- When living matter dies, it does not fossilize
 - It decomposed and everything gets recycled
- Only under unusual circumstance, you get fossils
 - Very hard to find
- Very special circumstance that generate fossils
 - Places where there is anaerobic where decomposition doesn't occur
 - Very rare and hard to find
- Soft body animals
 - Jellyfish, sponges... Last 30 years they were found
 - They were found in exploration, which with strata and the time period allowed people now to find where the rest of the fossils are
- Plate tectonic knowledge allows easier way to find fossil.
 - Uses logical predication to find more fossils
- There were a lot of gaps between one organism and the next
 - They could not find the transition organism
 - Called transitional fossils

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Example of transitional

- The evolution of the horse was
 - Stronger/faster legs to run away from predators
 - Teeth become more stronger so there weren't worn down from the plants



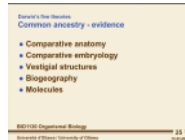
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- These evidence show that there is no constancy and that species changed over time

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Common Ancestry

- He was looking at a morphemically POV
- Things that looks structurally similar to each other even though they function differently
 - This indicated that they were related



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Comparative Anatomy

- Homology
 - They have the same underlying structure, but highly modified to perform different function
 - The structure diverge to different function
 - Somewhere in the base of the branching where the first animals that came on land had these structures and from there is structurally diverge

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Comparative Embryology:

- In animals, the 8 cell stage is the same in every organism
 - You have four cells that divide and 4 on the top and 4 on the bottom
 - The bottom 4 cells shift into a groove, and the different combination becomes many different organism

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Vestigial Structure

- Things that reflect functionality in the past that are not in use now
 - Example: Appendix
 - Though now the appendix is an important part of the body which plays into immunity and allergy. It is now a vital organ
 - So now it is not vestigial structure
 - Example: Goosebumps
 - Used for insulation and to make us look bigger and tougher
 - Not used like that anymore

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Molecules

- If you have a protein that changes and/or changes in composition and is found in a complete different species, then those species must be related

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- Homology
 - Homoplasy - Analogous
 - Convergence = same function but do not represent that same sequence to get to that structure
 - Different then, similar now
 - Homology - Divergent
 - Different now, similar then
 - The ancestor trait changes over time to other function

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Pasteur

- Life comes from life 200 years ago

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Schleiden

- Worked on plants

Schwann

- Worked on animals
- They found a common structure -> cell
 - All cells comes from division of cells
- With this information, people now understand that life is not spontaneous

Speciation

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- First attempt to formalize the concept of the biological species - 1942
- Morphological Species Concept
 - If you have a population with individuals that can interbreed and make viable offspring's makes them a species
 - Can be recognized by physical appearance
- Biological Species Concept
 - If members of two population interbreed and produce fertile offspring under natural conditions, they belong in the same species
 - If two populations do not interbreed in nature or fail to produce fertile offspring when they do, they belong in a different species
 - The most abundance organisms reproduce is bacteria
 - The whole prokaryotes world
- Phylogenetic Species Concept
 - Clusters of population that emerge from the same small branch
 - Comprises recent evolutionary history
 - Biologist can apply it to any group of organism including species that have been extinct and organisms that reproduce asexually

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Morphospecies Complex

- Things look so dramatically different that they are separate species
- All individuals of a species share measureable traits that distinguish them from individuals of other species

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- There are two process in which species can arrive
 - Anagenesis
 - Gradual change over time
 - Horse example
 - Human
 - Both species are present at the same time period
 - Linear sequence that goes slow over time
 - Cladogenesis
 - Divides a specie into 2
 - Both are present but there are sufficiently different that they become to species

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Parapatric Species

- Speciation arising between adjacent population
- May occur if hybrid offspring have low relative fitness
- Organisms one side of the discontinuity may interbreed freely with those on the other side, natural selection may favour different alleles on either side, limiting the gene flow

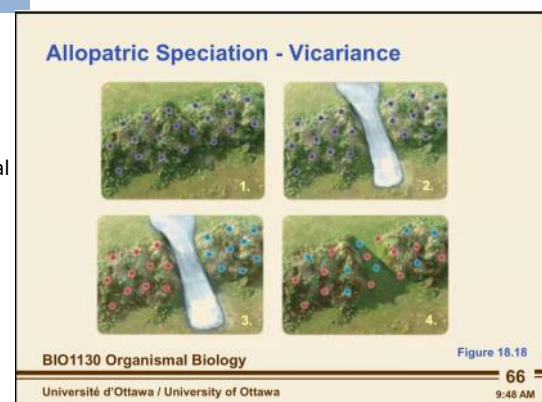
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Allopatric Vicariance

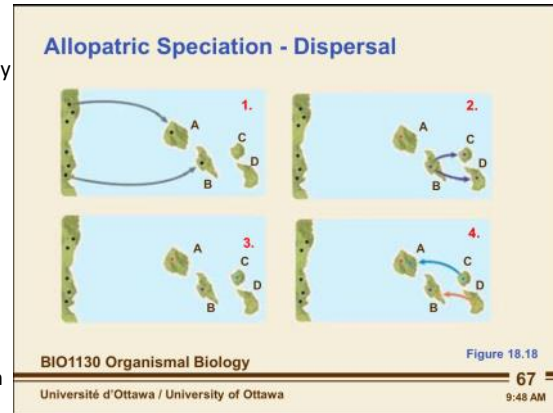
- May take place where a physical barrier subdivides a large population or when a small population becomes separated from a species' main geographic distribution
- Occurs in 2 stages
 1. Two populations become geographically separated, preventing gene flow
 2. The population experiences distinct mutations as well as different pattern of natural selection and genetic drift. They may accumulate genetic differences that isolate them reproductively.
- Most common mode of speciation in large animals
- Example
 - Population is distributes along the water
 - The water changes course and separates the population into two
 - The two population evolve independently
 - If the water changes back, the two species become secondary contact and cannot breed

Allopatric Dispersal

- Occurs in islands



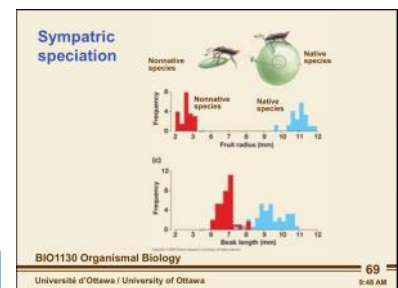
- One species on the mainland will travel to an island and colonize. Over time the species change in the island and may move to another island
- Then over time, these species on the various island will be different
 - This leads to a species cluster in which a group of species are closely related recently descended from a common ancestor
 - Example: Darwin's finch is the best example!!!
- Sometimes the allopatric population will reestablish contact when the geographical barrier is eliminated
 - This is called a secondary contact which provides a test whether or not the population have diverged into separate species
 - Hybrid zone is a narrow separation of the gene pool for the majority of individuals in both species
 - If there population can interbreed and produce viable offspring's, then the population can merge
 - ◆ If the offspring of the hybrid has low fitness, then natural selection will favour individuals who breed within their own population.
 - ◆ Called reinforcement that enhances reproductive isolation that had begun to develop while the populations were geographically isolated
 - If there are not able to interbreed, then they have become separate species



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Sympatric Speciation

- Reproductive isolation evolves between distinct subgroups that arise within one population
- Occurs in the same area - does not need geographic isolation
- Plants have a sympatric speciation called polyploidy in which individual has one or more extra copies of the entire haploid complement of chromosomes.



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Timing Relative to Fertilization	Mechanism	Mode of Action
Prezygotic ("pre-mating") mechanism	Ecological Isolation	Species occur in the same region, but occupy different habitats so rarely encounter each other
	Temporal Isolation	Species that breed during different times of day, different season, or different years cannot mix gametes
	Behavioural Isolation	Unique behaviour patterns & rituals isolate species ~Identifies members of species ~Attract mates of same species
	Mechanical Isolation	Morphological differences can prevent successful mating For many insects male and female sex organs of closely related species do not fit together preventing sperm transfer
Postzygotic ("post-mating") mechanism	Gametic Isolation	Sperm of one species may not be able to fertilize eggs of another species
	Hybrid in viability	Hybrid offspring cannot do not complete development
	Hybrid sterility	Hybrid offspring cannot produce gametes
	Hybrid breakdown	Hybrid offspring have reduced survival or fertility