


Biology, biologists and Bioscience

Biology, Biologists, and Bioscience

The dead dudes lecture



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- History of Greek Philosophers
 - "naturalist thinking" - laws of nature exist only in our natural universe, no point in nature, ghosts don't exist, etc.
 - science, big events (modern science) after 1850 to the 20th century
 - importantly the 19th century!
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In this lecture:

- History of biology, a natural science, compared to that of the physical sciences.
- Misconceptions about "facts" of biology
- How biology is done – scientific method in natural sciences.

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- 400 BCE - Medieval ages - Fall of Rome 450 CE
 - Medieval and Christian European time there is no progress in science
 - Muslim world, Greeks, Romans make advances in science
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-
-

Defining biology (Treviranus 1802)

The subject matter of our investigations will be the various forms and manifestations of life, the conditions and laws controlling their existence, and the causes by which this is effected. The science, which occupies itself with these subjects, we shall designate by the name biology, or science of life.

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- Biology: study of life, divided and classified.
 - how life started, conditions and laws controlling their existence.
 - how they are effected.
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Important stages in the history of Biology

- 400 BCE – 450CE: Greek and Roman ages
- 450 – 16th century: Medieval ages
- 16th-18th century: Renaissance and the scientific revolution
- 19th century
- 20th century
- 21st century

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World existed forever never changed
Zoology - study of behaviour, structure, anatomy, distribution of animals.

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



Hippocrates (460-370 BCE) (384-322 BCE) Theophrastus (371-287 BCE)

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Hippocrates - medicine and human biology
Aristotle - student of Plato, field of zoology
Theophrastus - Botanist(plants), student of Aristotle, father of taxonomy

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

- *Scala naturae* the great chain of being
- Essentialism




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Chain of Being (image to the left).
Aristotle - *scala naturae*, Hierarchy in Chain of Being.
Essentialism - believed Plato's ideal, all organisms are unchanged, "same".

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Important stages in the history of Biology
450-16th century: Medieval ages

- **Europe**
 - 400-700 Early middle ages (Dark Ages)
 - **800 - 900** High middle Ages
 - 1300-1500 Late middle ages



Black plague (1347-1351)

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- Fall of Rome under attack from the Germanic Goths

- Europe: exploration, golden age of science

- Black plague: dense populations caused people to die faster, commerce collapse, "Ring around the Rosie"

Important stages in the history of Biology
450-16th century: Medieval ages

- **Byzantium**
 - Al-Jahiz (781-869)
 - Al-Dinawari (826-896)
 - Avicenna (980-1037)
 - Al-Baitar (d. 1248)
 - Abu al-Abbas al Nabati (13th century)



Avicenna

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Breeding, agricultural improvements - food chain, evolution

studied growth, embryo of plants, relationship between plants, cataloged plants.

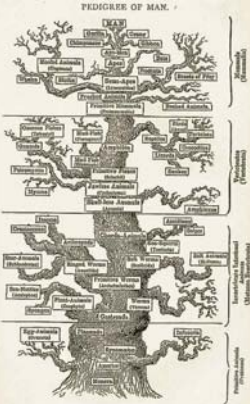
plant compendium, medical catalog, used until end of 1600s

adds 1400 plants, creates dosages, creates dosages, pharmacology

experiments on plants

Special creation

- **Pattern**
 - Species don't change
 - Each species created on Oct 23, 4004 BCE
 - Species are not old
- **Process**
 - A designer of some sort



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-Superior-Inferior Chain

-species do not change

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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 (1561-1626) – further proof of earth revolving around the sun
- Boyle (1627-1691) – behaviour of gases
- _____ (1623-1662) – origins of calculus
- Descartes (1596-1650) – geometry
- Van Leeuwenhoek (1673) – first microscope,
- _____ (1650's) – Anatomy and physiology
- Linnaeus (1735) – Systema naturae.

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-Organized organisms, nested hierarchy "folder in folder"
-scientific names

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



Van Leeuwenhoek
(1632-1723)



Harvey
(1578-1657)

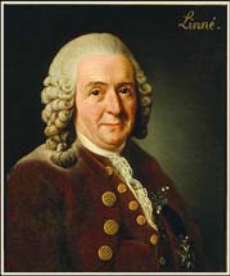
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European explorers changed ideas of Essentialism
-brought back items and species
-organized them

The "scientific revolution" 16th – 18th century
Linnaeus – Systema naturae, 1735



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- Taxonomic hierarchy
- Binomen and binomial nomenclature

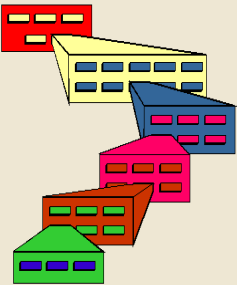
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Binomen - genus and species

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The "scientific revolution" 16th – 18th century
Linnaeus – Taxonomic hierarchy



Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Rodentia
Family: Castoridae
Genus: *Castor*
Species: *canadensis*




Figure 18.8

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Apis pubescens, thorace subgriseo, abdominae fusco, pedibus utrinque margine ciliatis




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Binomial nomenclature



Apis mellifera
(Honey bee)

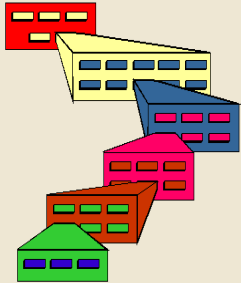
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The "scientific revolution" 16th – 18th century
Linnaeus – Taxonomic hierarchy



- Kingdoms
 - Animalia
 - Plantae
 - Fungi
 - Protista
 - Monera


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-cell junctions, cell communication
-multi-cells, muscle, bone, organ cells
- No differentiation, reproductive cells maybe, no cell to cell communication



Kingdom Monera
(includes all prokaryotes)

5 μm




Kingdom *Protista*
(includes several groups of unicellular eukaryotes)

20 μm


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Prokaryotes - cytoplasm everything happens there
- don't all need oxygen
Eukaryotes - double membrane, replication, transcription
-Mitochondria came first
-Mitochondria makes energy as NADH, not ATP
-Chloroplasts can't make ATP, no fuel to cells




Kingdom Plantae

3 cm



Kingdom Fungi



Kingdom Animalia

1 mm

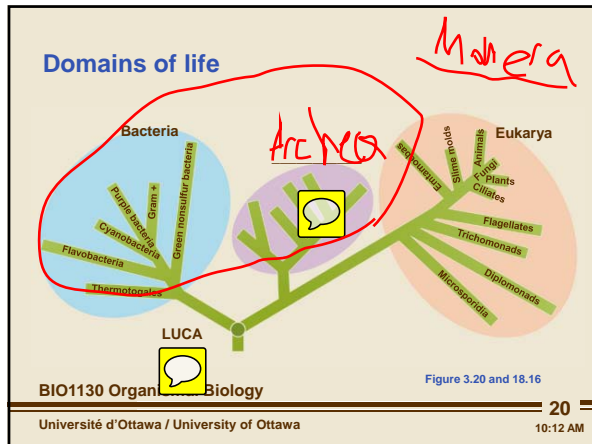
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- cellulose
- chitin

external digestion, absorb nutrients

consume products internally, break down foods

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Georges-Louis Leclerc, Comte de Buffon (1707-1788)



- Common ancestor
- Biogeography

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-Geography shaped species
-bodies match to environment
-species change, defines scala naturae, no change

Erasmus Darwin (1731-1802)



- Translated Linnaeus into English
- The temple of nature

By firm immutable immortal laws Impress'd on Nature by the GREAT FIRST CAUSE, Say, MUSE! how rose from elemental strife Organic forms, and kindled into life

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Common Origin, studies bones, etc
- Epic poem "temple of nature"
- Gradual change over time
- stated in poem

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Georges Cuvier
(1769-1832)



- Catastrophic theory
- Extinction



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- found bones, thought of dragons, monsters
- get full organism from bones
- concept of "Lost World", not found to day
- Badly designed animals become extinct
- catastrophism: world event killed species, Noah's arc because of flooding, etc.

Charles Lyell
(1797- 1875)



- Uniformitarian theory of geological change
- Stratigraphy and the geological time scale


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- Notices strata, lines on rocks
- travels world finds micro fossils from everywhere that make up whole world
- world is extremely old, slow change gradual

Jean-Baptiste Lamarck
(1744-1829)



- Transmutation of species

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- Explain where changes came from
- "use it or lose it". passed on traits, favourable abilities
- environmental pressure to change
- genetics?
- Transmutation of species - species change into each other based on environmental influences
- Basis of evolution, use it or lose it theory, ex: giraffes having long necks, they would grow longer to reach plants high up and then pass this trait onto their offspring so they could reach high to
- Organisms gained complexity during their lifetime

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species essence changes to become another species ex: black bear to a polar bear

Essentialist explanation of change

- **Transmutation** (not Lamarck)
- **Transformation**
 - *Finality*
 - **Environmental** (this is Lamarck)

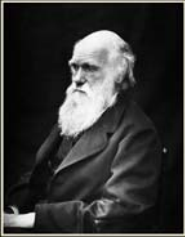
Neck stretching
-slow transformation
Environment
-final species form

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Genetics (DNA) for change

- two meanings to transmutation (Lamarck or Genetics)
- Lamarck believes organisms change because of the environment
- Genetics - massive changes to essence to cause dramatic changes

Important stages in the history of Biology
19th century: Modern biology



Darwin
(1809-1882)

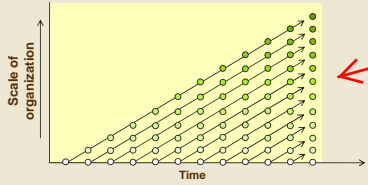


Wallace
(1823-1913)

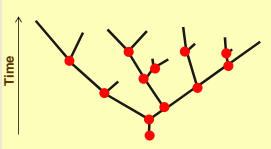
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- big beaks, little beaks of birds on an island
- survival of the fittest
- indigenous to area or not
- artificial selection- take traits, breed them
- natural selection - mother nature determines traits
- both present their findings, backup each others with papers
- Darwin had more data than Wallace, more associated

Lamarck's theory



Darwin's theory



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- individual change, spontaneous organism to final human form "scala naturae" - finalism

Cladogram

- variation in population not individual
- Ex: Big beaks get big seeds, little beaks can't crack them open
- traits suited for environment, branched off to different species
- Ex: dogs and wolves can interbreed - artificial selection
- different species mix, house pets.

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Darwin's five theories

- No constancy of species
- Common ancestry
- *Evolution/Change*
- Multiplication of species
- Natural selection

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accepted by people, this research had been done before
- didn't know about genetics and inheritance

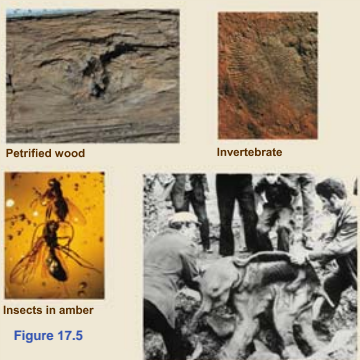
Darwin's five theories
No constancy of species

- Fossils
- Extinction
- Transitional forms
- (Vestigial structures)

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missing links could be some transitional forms
- vestigial structures may be related to transitional structures

Darwin's five theories – No constancy of species
Fossils




Petrified wood Invertebrate
Insects in amber Mammoth in permafrost

Figure 17.5 31
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- dead preserved species
- animals mostly decompose; absorbed by fungi
- fossils only happen when no recycling system exists; fungi can't break down cellulose in this time

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Darwin's five theories – No constancy of species
Extinction



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soft body fossils
are possible

- 5 global mass extinction

Darwin's five theories – No constancy of species
Transitional forms
Evolution of the horse

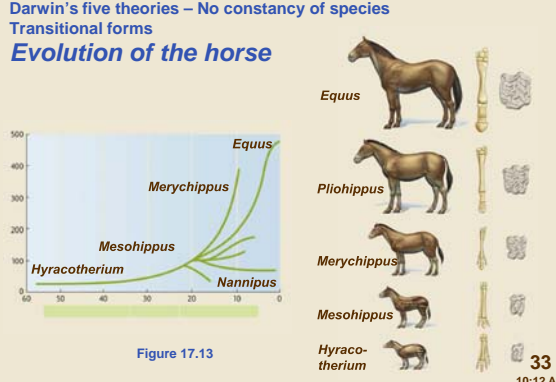


Figure 17.13

Equus

Merychippus

Pliohippus

Merychippus

Mesohippus

Hyracotherium

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- cell wall of cellulose protects cytoplasm where nutrients are.
- can't break open cell walls no nutrients
- increase teeth that can break cell walls evolution
- to get speed digits become hoof for less contact, longer strides

Darwin's five theories – No constancy of species
Transitional forms
Archaeopteryx lithographica

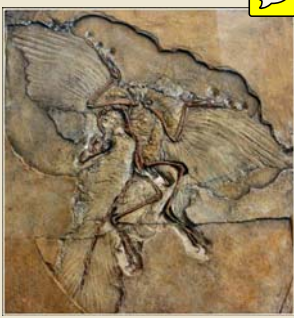


Figure 17-21a

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- birds and reptiles with wings
- origins of feathers solved last year
- found one ton dinosaur with feathers to keep warm

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Darwin's five theories – No constancy of species
Transitional forms
Puijila darwini

[Meet the discoverer](#)



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Darwin's five theories
Common ancestry - evidence

- Comparative anatomy
- Comparative embryology
- _____
- Biogeography
- Molecules

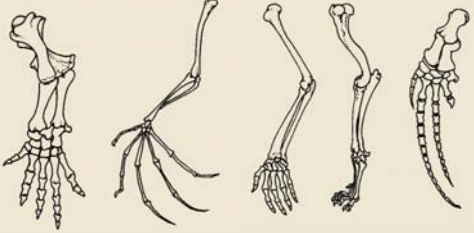
Vestigial structures

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Darwin's five theories - Common ancestry
Comparative anatomy
Homology – Divergent evolution



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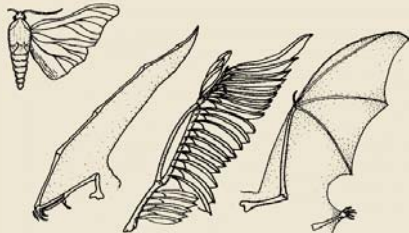
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- same identical embryology, traits inherited, developed into branches for different things

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Darwin's five theories - Common ancestry
Comparative anatomy
Homoplasy (analogous) – Convergent evolution



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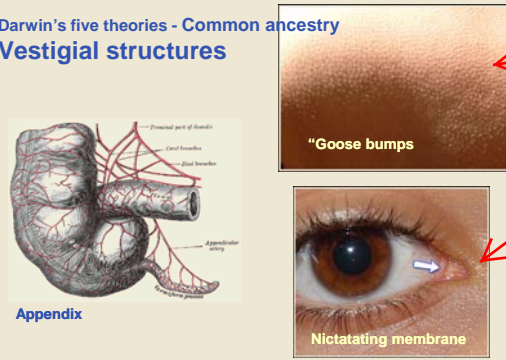
Analogy - same function, different ancestry

Darwin's five theories - Common ancestry
Comparative embryology



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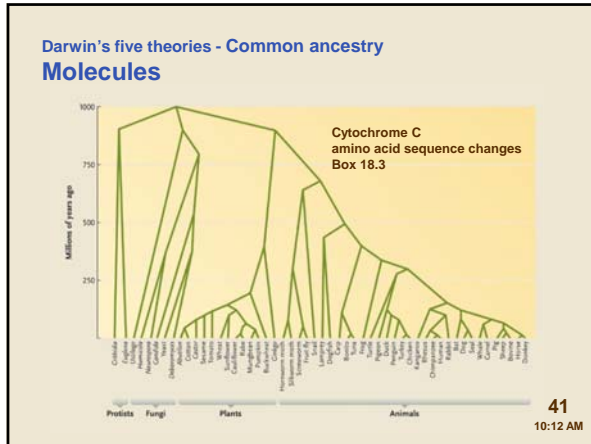
Darwin's five theories - Common ancestry
Vestigial structures



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Goosebumps - descend from animals used for warmth, look bigger when hairs stand - used to cover over under water to see submerged.

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- Darwin's five theories**
- No constancy of species
 - Common ancestry
 - Gradual changes
 - Multiplication of species
 - Natural selection
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Pasteur (1822-1895)

- Life from life not spontaneous generation
- Germ theory


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Important stages in the history of Biology
19th century: Modern biology

- **Cell theory**
(Schleiden and Schwann – 1860)
 - The basic unit of all organisms is the cell
 - Individual cells have all the characteristics of life and
 - All cells come from the division of other cells




Schleiden
(1804-1881)

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Cell is basic indivisible unit of life

Mendel
(1822-1884)



- Rediscovered 1900.
- Law of segregation of characters
- Law of independent assortment

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alleles separate to 1 or 2 come back together

- worked with pea plants
- dominance and recessive traits
- inheritance of traits in discrete packages
- 2 traits - diploid, 1 trait: haploid

Important stages in the history of Biology
20th century

Synthetic theory of evolution

- Population genetics and natural selection based on Mendelian genetics




Huxley
(1887-1975)

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links variation to inheritance (genetics)
- frequency of gene

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Darwin's five theories – Gradual change
Biogeography – gradual population changes



Thalassoma lucasanum
(Cortez rainbow wrasse)

Thalassoma bifasciatum
(Blue headed wrasse)

[Continental drift 1](#)
[Continental drift 2](#)

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Important stages in the history of Biology
20th century: Modern biology

- Cellular respiration, ATP and mitochondria (1930-1950)
- Ecology (1940's)
- DNA is the genetic materials (1943)
- DNA structure (1953)
- Gene regulation (1961)
- Genetic code (1960's)
- Recombinant DNA experiments (1970's)
- Cloning of a mammal (1997)
- Human genome sequence (2000)

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Types of Biology

- Molecular biology and biochemistry
- Genetics
- Cell biology
- Physiology
- Developmental biology
- Morphology
- Evolution and systemic biology
- Ecology
- Behavioural biology
- Nutrition
- Disease mechanisms
- Pharmacology
- Genomics
- Proteomics

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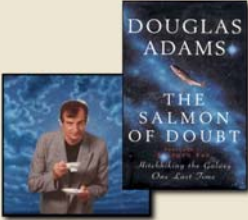
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Important stages in the history of Biology
16th-18th century: The scientific revolution and the start of modern sciences

Douglas Adams 1952-2001

Four ages of sand

- First - Telescope 1608
- Second - Microscope 1678
- Third - _____ 1961
- Fourth - Fiber optics 1980s



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Some terms used in doing science

- Theory and Fact
- Hypothesis
- Law
- Prediction (logical vs chronological)

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- does not always become a fact
- theories are hypotheses that have been mastered - close to - facts not the same
- best possible explanation for a phenomena

see a pattern --> predict outcome
- test observation, make prediction

Physical science	Natural science
<ul style="list-style-type: none">• Inanimate objects• Physical and chemical laws• Universal	<ul style="list-style-type: none">• Animate objects• More than physical and chemical laws (Genetics)• Not Universal

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Changing thoughts on what living things are

- _____ – with the exception of humans all living things are machines (Descartes, 17th century)
- _____ – physical and chemical laws apply but living things have a vital force (essence)

↓ ↓

- **Organicists (1930)** – vital force replaced by genetic program and the importance of emergence (**swarm behaviour**)



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Physical science	Natural science
<ul style="list-style-type: none">• Inanimate objects• Physical and chemical laws• Universal• Based on empirical observations• Experimentation preferred method	<ul style="list-style-type: none">• Animate objects• More than physical and chemical laws (Genetics)• Not Universal• Based on historical narratives• Induction most used method

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Induction vs. Deduction

- **Deduction** (from the general to the specific): All insects have wings and this animal is an insect. This animal has wings.
- **Induction**: (from the specific to the general) This animal is an insect and it has wings therefore all insects have wings. (many multiple observations!)



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Physical science

- Inanimate objects
- Physical and chemical laws
- Universal
- Based on empirical observations
- Experimentation preferred method
- Single theory
- Single falsification enough to abandon a theory

Natural science

- Animate objects
- More than physical and chemical laws (Genetics)
- Not Universal
- Based on historical narratives
- Induction most used method
- Multiple theories
- Single falsification not necessary to abandon a theory

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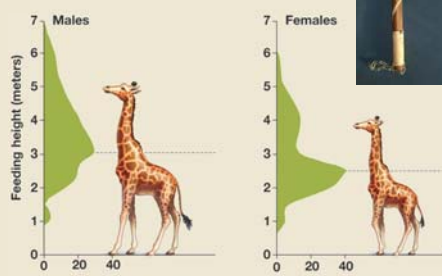
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Multiple theories

- Food competition
- Sexual competition

[Video 1, 2](#)



7 Males

Feeding height (meters)

Percentage of feeding bites

7 Females

Percentage of feeding bites

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Anatomy of a scientific explanation (theory)

- Two parts
 - Pattern
 - Mechanism or process
- Questions to be asked
 - What?
 - How (proximate cause)? or Why (ultimate causes)?

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Proximate causes
(Physical science-like biology)

- Phenotype – morphology and behaviour
- Mechanical (predictable)
- Here and now
- Genes in action
- Experiments

Ultimate causes
(Natural science-like biology)

- Genotype - Genes and history
- Variable (probabilistic)
- Evolutionary past
- Changes in genetic programs
- Historical narratives


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Additional experimental components

- Controls
- Control of variables
- Sampling error
- Repeat the test






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Stages in an investigation.

- Observations
- Questions of how and why
- Hypothesis
- Test (experiment)
- Conclusion




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Darwin's five theories – Natural selection
Natural selection – Industrial melanism



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Peppered moth

- **Observation 1:** Original museum collections had all white peppered moths and by 1900 traps collected 90% black.
- **Question 1:** Why did the moths shift from light to dark morphs?

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Peppered moth

- **Hypothesis 1:** Fitness decreased when the moths that were more visible against the background colour of the trees.
- **Null hypothesis 1:** Fitness remains the same and is not affected by the background.
- **Hypothesis 2:** The bark colour of the trees has changed.
- **Null hypothesis 2:** The bark colour of the trees has not changed.

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Biology, biologists and Bioscience

Peppered moth

- **Experiment 1:** Artificially rear light and dark morphs and place on tree and observe survival (fitness)
- **Experiment 2:** Locate light and dark coloured trees.



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Peppered moth

- **Result 1:** Birds selected most visible moths
- **Result 2:** Dark trees showed same distribution as coal based industry



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Peppered moth

- **Question:** Do moths “rest” on backgrounds that match their colouration?
- **Question:** What impact would the clean air act, that reduced pollutant immisions have on the moth population morphs?
- **Question:** What happens to other moths with light and dark colour morphs

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Distribution of scientific facts

- Journal selection
- Manuscript preparation
- _____
- Revision
- Publication

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Types of literature – what's the difference

- Primary
- Secondary
- Tertiary

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