BIO1130 Organismal Biology
Jon G. Houseman

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Organismal Biology – Main themes.

- Major events in the history of Biology
- Earth's changing biodiversity

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Major events in the history of Biology

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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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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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manifestations of life

laws & conditions that control their existence

How are those living things effected by the environment

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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Major events in the history of biology:

- **Predarwinian and the natural sciences**
  (400 BCE – late 1800's)
  - 400 BCE – 450CE: Greek and Roman ages
  - 450 – 16th century: _____
  - 16th-18th century: _____
- **Darwin and evolutionary thought**
  (late 1800's – mid 1900's)
- **Modern theory of evolution and more**
  (mid 1900's – present)

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Validates non-mathematic science.
- communications of education were destroyed as the Roman Empire ends.

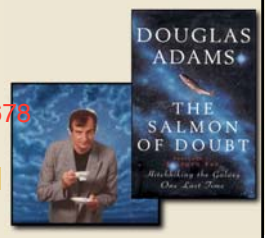
Important stages in the history of Biology

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 - Computer chip 1961
- –Fourth - Fiber optics 1980s



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heat silica with high temp. = glass
silica charged-stage 1
non-charged stage 0
4th = connectivity

Major events in the history of Biology: Predarwinian

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History of Biology: Before Darwin

Important stages in the history of Biology

400 BCE – 450: Greek and Roman ages

Hippocrates
(460-370 BCE)

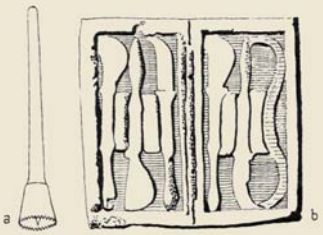

Fig. 15. Types of instruments used by Greek surgeons
(a) Simple trephine with centre pin. (b) Case of scalpels.
(c) Sixteenth-century instrument of ancient type. (d) Relief in the Asclepieion, Athens.

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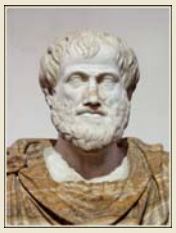
He created modern medicine by collecting

hippocratic corpse

Important stages in the history of Biology

400 BCE – 450: Greek and Roman ages



Aristotle
(384-322 BCE)

Fig. 18. The *Scala Naturae* or 'Ladder of Life' according to the descriptions of Aristotle.

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creating inventory about studies of living and non-living things.

Some initial definitions about naming

- Classification
- Taxonomy
- Hierarchical
- Systematics

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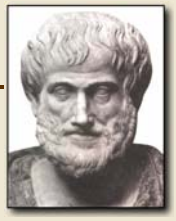
taxonomy - applying rules to classification

rg

Types of taxonomies

- folk
- Artificial
- Mechanical
- Natural (Evolutionary)
- Cladistic (Phylogenetic)



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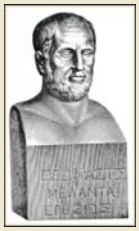
major difference between folk and artificial - no longer rely on human memory, written work which allows edition.

artificial: based on physical appearances

Important stages in the history of Biology

400 BCE – 450: Greek and Roman ages



Theophrastus
(371-287 BCE)

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Important stages in the history of Biology

400 BCE – 450: Greek and Roman ages

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

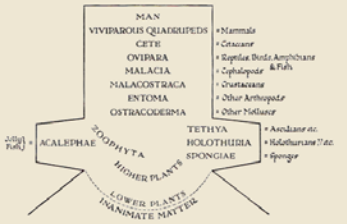

FIG. 18. The *Scala Naturae* or 'Ladder of Life' according to the descriptions of Aristotle.

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Major events in the history of biology:

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  (mid 1900's – present)

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Important stages in the history of Biology

450-16th century: Medieval ages

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

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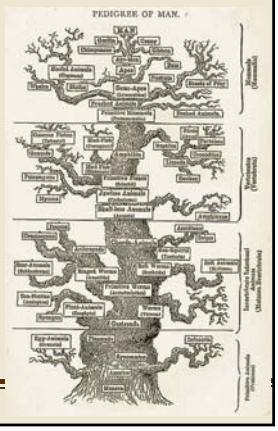
No change at all since essentialism

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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Saturday Oct. 23 4004 BCE

Important stages in the history of Biology

450-16th century: Medieval ages

- Europe
  - 400-700 Early middle ages (Dark Ages)
  - 1000-1300 High middle Ages
  - 1300-1500 late middle Ages

Black plague (1347-1351)

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plague wiped out half of the population of Europe

Important stages in the history of Biology

450-16th century: Medieval ages

- Byzantium and Islamic world
  - Al-Jahiz (781-869)

Animals engage in a struggle for existence; for resources, to avoid being eaten and to breed. Environmental factors influence organisms to develop new characteristics to ensure survival, thus transforming into new species. Animals that survive to breed can pass on their successful characteristics to offspring.

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The idea of Natural Selection begins to form

Important stages in the history of Biology

450-16th century: Medieval ages

- Byzantium and Islamic world
  - al-Jahiz (781-869)
  - al-Dinawari (826-896)
  - Avicenna (980-1037)
  - Alhazen (965-1040)
  - Ibn al-Baitar (1197-1248)

Avicenna

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Avicenna - Hypocrites corpus and added medical advances of Islamic World

Important stages in the history of Biology

450-16th century: Medieval ages

- **Byzantium and Islamic world**
  - **Alhazen (965-1040)**

Scientific Method
1. Observation
2. Statement of problem
3. Formulation of hypothesis
4. Testing of hypothesis using experimentation
5. Analysis of experimental results
6. Interpretation of data and formulation of conclusio
7. Publication of findings

Alhazen

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Ibn Al-Baitar - puts together the most complete pharmaceutical writing of medicinal plants of the time

Dosage, instructions etc.

Important stages in the history of Biology

450-16th century: Medieval ages

- **Byzantium and Islamic world**
  - **al-Jahiz (781-869)**
  - **al-Dinawari (826-896)**
  - **Avicenna (980-1037)**
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  - **Ibn al-Baitar (1197-1248)**

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Major events in the history of biology:

- **Predarwinian and the natural sciences**
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  - **16th-18th century:** _____
- **Darwin and evolutionary thought**
  (late 1800's – mid 1900's)
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  (mid 1900's – present)

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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 sub
- Boyle (1627-1691) – behaviour of gases
- Pascal (1623-1662) – Origins of Calculus
- Descartes (1596-1650) – geometry

- Van Leeuwenhoek (1673) – first microscope,
- Andrea Vesalius (1542) - Anatomy
- Harvey (1650's) Anatomy and physiology
- Linnaeus (1735) – Systema naturae.

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Important stages in the history of Biology

16th-18th century: The scientific revolution

Van Leeuwenhoek
(1632-1723)

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biodiversity - introduced by microscopes

Important stages in the history of Biology

16th-18th century: The scientific revolution

Andrea Vesalius
(1514-1564)

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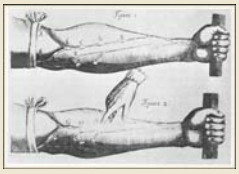
Human dissection

Important stages in the history of Biology

16th-18th century: The scientific revolution

Harvey
(1578-1657)



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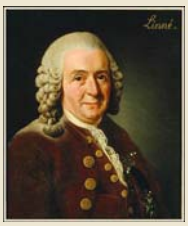
Important stages in the history of Biology

16th-18th century: The scientific revolution



Linnaeus
(1707-1778)

First published 1735

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- Short descriptions to two words genus species
- Organized organisms in a hierachy
- Father of the modern taxonomy
- Mechanical taxonomy

Types of taxonomies

- folk
- **Artificial**
- **Mechanical**
- **Natural (Evolutionary)**
- **Cladistic (Phylogenetic)**

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Some initial definitions about naming

- Classification
- Taxonomy
- Hierarchical
- Systematics

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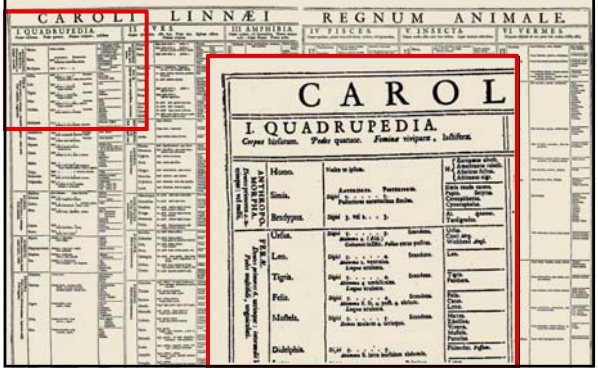
universal definition of hierarchical system

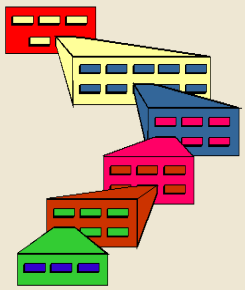
The "scientific revolution" 16th – 18th century
Linnaeus – Taxonomic hierarchy



Linnaeus takes Aristotle's Scala Naturae and refined it with more complexity. Aristotle's Scala Naturae is a linear system

(also the difference between artificial and mechanical)

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



Kingdom:
Phylum:
Class:
Order:
Family:
Genus:
Species:

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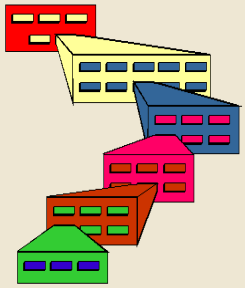
The "scientific revolution" 16th – 18th century
Linnaeus – Taxanomic hierarchy



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

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define animal - multicellular ingestive heterotrophic eukaryotes

define plants - multicellular ingestive autotroph eukaryotes

define fungis - multicellular absorptive heterotrophic eukaryotes

mammal - hair, memory glands, glands within skin

Rodentia - sharp teeth which allow them to break shells

Chordata - Having a nerve cord

The "scientific revolution" 16th – 18th century
Linnaeus – Binomen

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

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Binomen - Two words descriptions of organisms

The "scientific revolution" 16th – 18th century
Linnaeus – Binomen

The fuzzy bee with the greyish thorax, hairless hind legs that are bordered with hairs on both sides

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The "scientific revolution" 16th – 18th century
Linnaeus – Binomen

Apis mellifera
(Honey bee)

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Italic - different language from the language that the text is written.

Changing thoughts on what living things are

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

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Vitalists: properties that are difference than just having the physical and chemical properties. Behave differently (essence)

Physical science	Natural science
• Inanimate objects	• Animate objects
• Physical and chemical laws	• More than physical and chemical laws (Genetics)
• Universal	• Not Universal

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Physical science	Natural science
• Inanimate objects	• Animate objects
• Physical and chemical laws	• More than physical and chemical laws (Genetics)
• Universal	• Not Universal
• Based on empirical observations	• Based on historical narratives
• Experimentation preferred method	• Induction most used method

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biology back then was a narrative science.

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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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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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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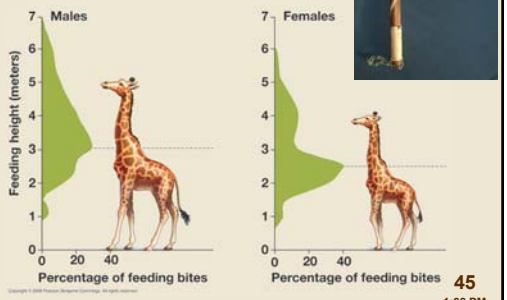
Multiple theories

- Food competition
- Sexual competition

Video



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Sexual competition and Food competition

Changing thoughts on what living things are

- **Physicalists** – with the exception of humans all living things are machines (Descartes, 17th century)
- **Vitalists** – 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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Emergence: whole is great than sum of the parts

Scientific method
Some terms used in doing science

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

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Theory: An explanation of something that has happened multiple times.

Most supported scientific explanation.

There are no facts in science. Law is more enhanced than a theory. Difference: Physical scientists have laws and Natural scientists have theories. Laws are universal.

Biology is restricted on planet Earth.

Hypothesis: Scientists try to test the hypothesis. Predictions are supported by arguments

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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null hypothesis: Opposite of the hypothesis you generate

Additional experimental components

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

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Sampling Error: Several measurements are produced
10% of the population are usually measured, but it varies based on the population

7.0 +/- 1.0 (n=6)
by increasing the number of n, you will decrease the error associated

Distribution of scientific facts

- Journal selection
- Manuscript preparation
- Peer review
- Revision
- Publication

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2 Ultimate Journals - Nature and Science

manuscript - read from colleagues and sent to supervisor
Editors will send them to experts, and papers will come back with corrections

Types of literature – what's the diffence

- Primary
- Secondary
- Tertiary

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Primary - the person who came up with the science is the author of the article

Secondary - The person who is writing the article is not the person who came up with the report (Peer Review is part of secondary)

The author has a general background of the field. Also reviewed by experts

Stages in an investigation.

- The question
- Gather information
- Develop a hypothesis and test it
- Interpret the results of the test
- Retest

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

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Story of natural selection - industrial revolution

follows classic steps of scientific method (theory and proof)

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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Evolution is defined as frequency of genes

Peppered moth

- **Hypothesis 1:** Fitness decreased when the moths that were more visible against the background colour of the trees.
- **Null hypothesis1:** 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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Dark trees are in industrial areas,

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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Alleles are no longer in the population, changes gene frequency, which means we have a natural selection.

The criticism of not knowing if birds ate them or not, therefore the experiment isn't accurate is applying physical science to natural science

Peppered moth

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

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black moths tend to rest on dark trees, white moths tend to rest on white trees

Pollution control: if turning all the trees white, what would happen to the population?

white alleles then become dominant

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