


Biology, biologists and Bioscience

Biology, Biologists, and Bioscience

The dead dudes lecture



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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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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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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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Important stages in the history of Biology

400 BCE – 450: Greek and Roman ages



Hippocrates
(460-370 BCE)

Aristotle
(384-322 BCE)

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



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

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



Black plague (1347-1351)


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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

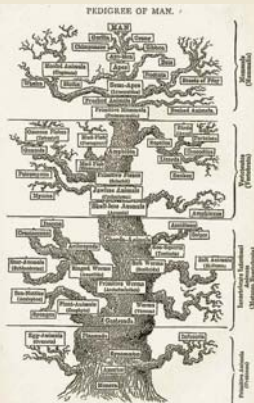
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Special creation

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



Van Leeuwenhoek (1632-1723)



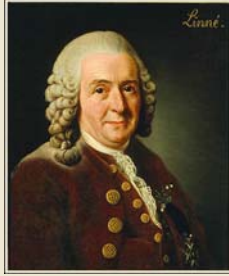
Harvey (1578-1657)

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



Linnaeus

- **Taxonomic hierarchy**
- **Binomen and binomial nomenclature**

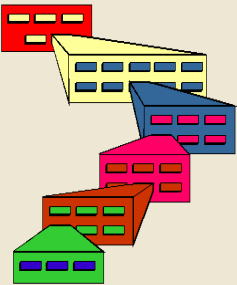
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The "scientific revolution" 16th – 18th century
Linnaeus – Taxonomic hierarchy



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



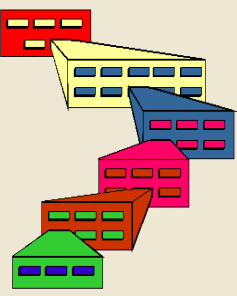
Apis mellifera
(Honey bee)

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




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

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Kingdom Monera
(includes all prokaryotes)




Kingdom _____
(includes several groups of unicellular eukaryotes)


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Kingdom Plantae



Kingdom Fungi



Kingdom Animalia

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Domains of life

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Figure 3.20 and 18.16

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

- Common ancestor
- Biogeography

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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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Georges Cuvier (1769-1832)

- Catastrophic theory
- _____

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Charles Lyell (1797- 1875)

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

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Jean-Baptiste Lamarck (1744-1829)

- Transmutation of species

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Essentialist explanation of change

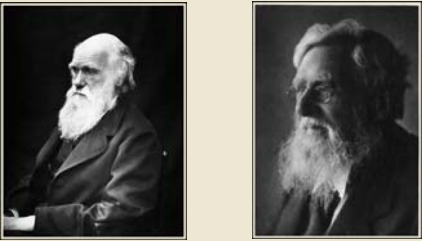
- **Transmutation** (not Lamarck)
- **Transformation**
 - _____
 - **Environmental** (this is Lamarck)

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



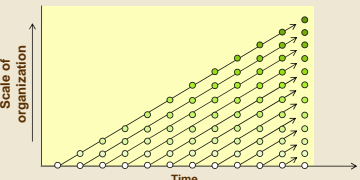
Darwin (1809-1882) Wallace (1823-1913)

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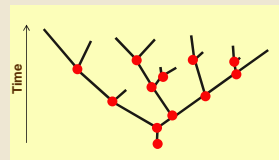
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Lamarck's theory



Darwin's theory



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Darwin's five theories

- **No constancy of species**
- **Common ancestry**
- _____
- **Multiplication of species**
- **Natural selection**

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Darwin's five theories
No constancy of species

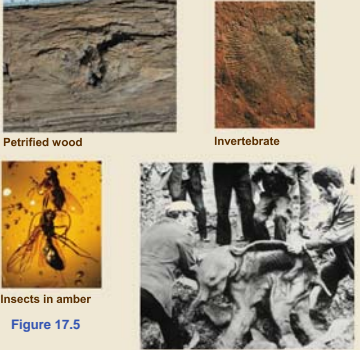
- **Fossils**
- **Extinction**
- **Transitional forms**
- **(Vestigial structures)**

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Darwin's five theories – No constancy of species
Fossils



Petrified wood Invertebrate

Insects in amber

Mammoth in permafrost

Figure 17.5


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Darwin's five theories – No constancy of species
Extinction

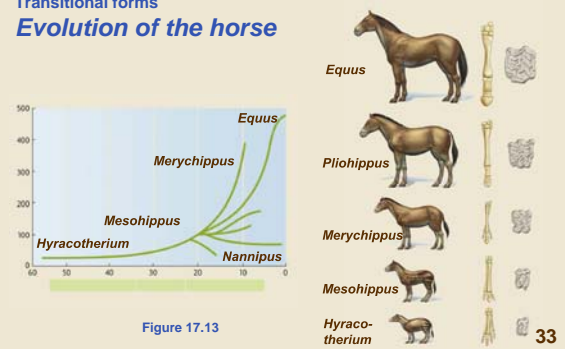


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Darwin's five theories – No constancy of species
Transitional forms
Evolution of the horse



Equus

Pliohippus

Merychippus

Mesohippus

Hyracotherium

Figure 17.13

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




Figure 17-21a



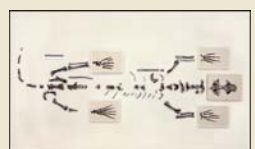
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Darwin's five theories – No constancy of species
Transitional forms
Puijila darwini

Meet the discoverer

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Darwin's five theories
Common ancestry - evidence

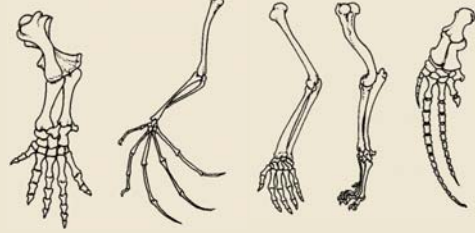
- Comparative anatomy
- Comparative embryology
- _____
- Biogeography
- Molecules

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



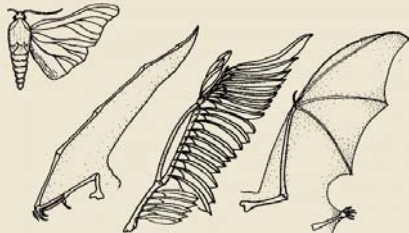
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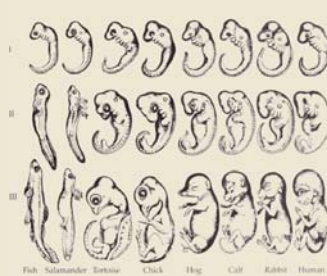
Darwin's five theories - Common ancestry
Comparative anatomy
Homoplasy (analogous) – Convergent evolution



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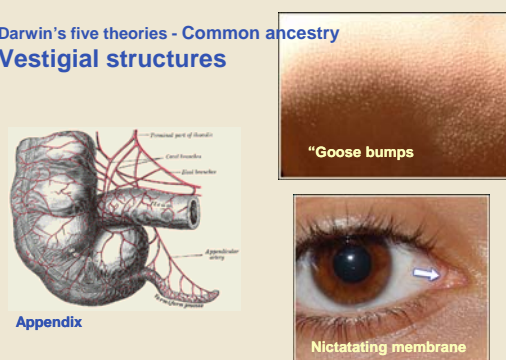
Darwin's five theories - Common ancestry
Comparative embryology



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Darwin's five theories - Common ancestry
Vestigial structures



Appendix

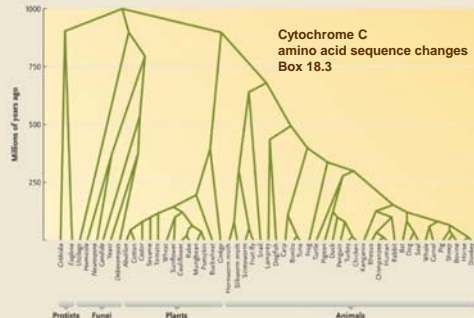
"Goose bumps"

Nictitating membrane

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Darwin's five theories - Common ancestry
Molecules



Cytochrome C amino acid sequence changes
Box 18.3

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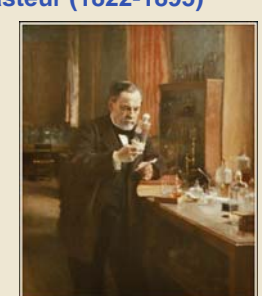
Darwin's five theories

- 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 cell come from the division of other cells



Schleiden (1804-1881)

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Mendel (1822-1884)




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

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Important stages in the history of Biology
20th century

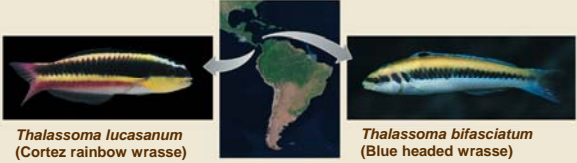
- _____ theory of evolution
 - Population genetics and natural selection based on Mendelian genetics



Huxley (1887-1975)

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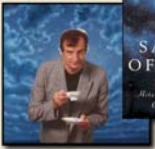
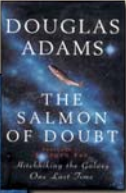
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Important stages in the history of Biology
16th-18th century: The scientific revolution and the start of modern sciences

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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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

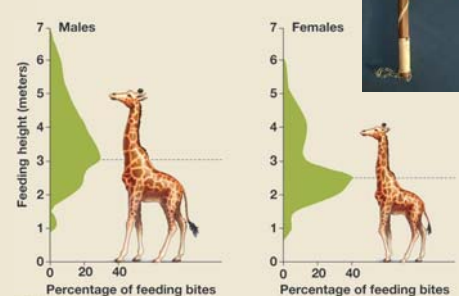
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Multiple theories

- Food competition
- Sexual competition

Video 1, 2



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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)

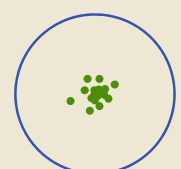
- Genotype - Genes and history
- Variable (probabilistic)
- Evolutionary past
- Changes in genetic programs
- Historical narratives

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Additional experimental components

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

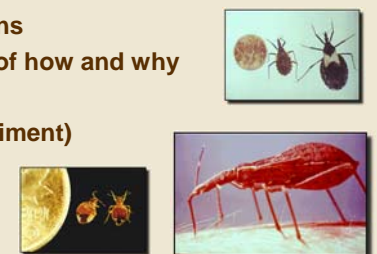


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Stages in an investigation.

- 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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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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