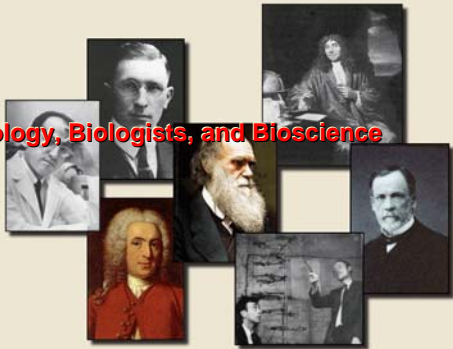


Biology, biologists and Bioscience

Biology, Biologists, and Bioscience



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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 – 450: 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)

(384-322 BCE)

Theophrastus
(371-287 BCE)


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

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



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Page 2

Biology, biologists and Bioscience

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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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)



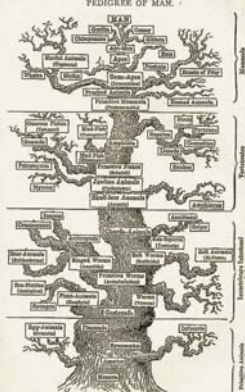
Avicenna

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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) – _____
- Boyle (1627-1691) – behaviour of gases
- Pascal (1623-1662) – origins of calculus
- Descartes (1596-1650) – _____
- Van Leeuwenhoek (1673) – first microscope,
- 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)



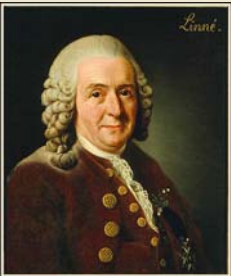
Harvey
(1578-1657)

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The “scientific revolution” 16th – 18th century
Linnaeus – *Systema naturae*, 1735



Linnaeus

- Taxonomic hierarchy
- _____ and binomial nomenclature

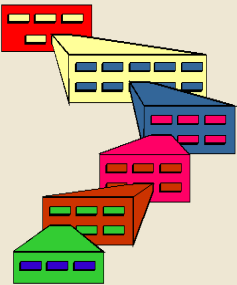
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The “scientific revolution” 16th – 18th century
Linnaeus – Taxonomic hierarchy



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





Figure 19.8

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




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




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Binomial nomenclature



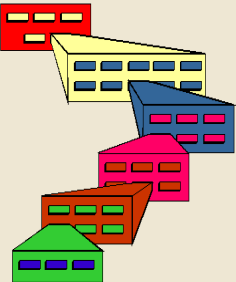
Apis mellifera
(Honey bee)

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



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



Kingdom Monera
(includes all prokaryotes)



Kingdom Protista
(includes several groups of unicellular eukaryotes)


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Figure 1-7a,b

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Kingdom Plantae

Kingdom Fungii

Kingdom Animalia

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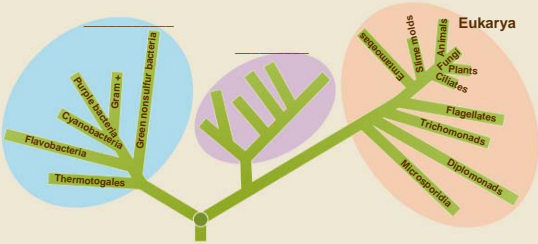
Figure 1-7c

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Domains of life



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Figure 19.16

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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
- Extinction

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Charles Lyell
(1797- 1875)



- Uniformitarian theory of geological change
- Stratigraphy and the


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Jean-Baptiste Lamarck
(1744-1829)



- Transmutation of species

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Essentialist explanation of change


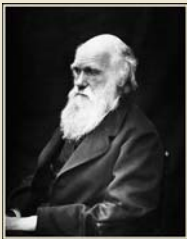
- Transmutation (not Lamarck)
- Transformation
 - Finalism
 - Environmental (this is Lamarck)

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



Darwin
(1809-1882)

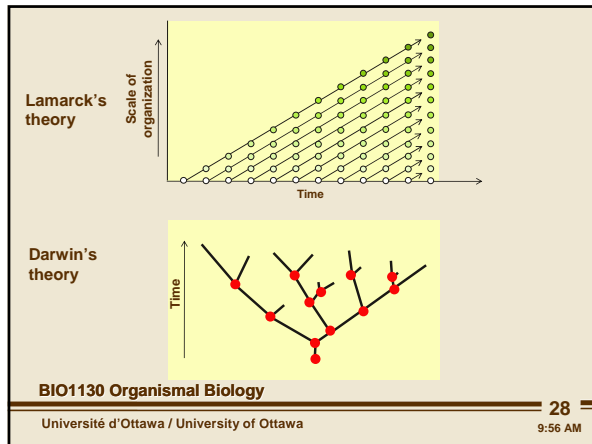
Wallace
(1823-1913)

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Darwin's five theories

- No constancy of species
- Common ancestry
- _____
- Population change (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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Biology, biologists and Bioscience

Darwin's five theories – No constancy of species

Fossils


Petrified wood


Invertebrate


Insects in amber



Mammoth in permafrost

Figure 20.5

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

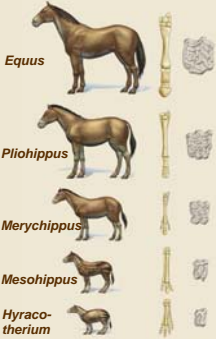
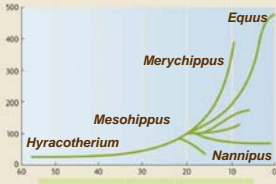



Figure 20.13

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Darwin's five theories – No constancy of species

Transitional forms

Archaeopteryx lithographica



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Figure 20-17a

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Darwin's five theories – No constancy of species

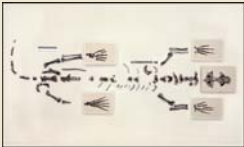
Transitional forms

Puijila darwini



Meet the discoverer





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Darwin's five theories

Common ancestry - evidence

- Comparative anatomy
- Comparative embryology
- Vestigial structures
- Biogeography
- Molecules

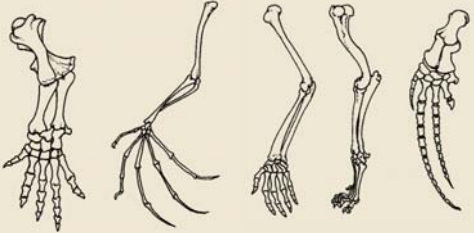
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Darwin's five theories - Common ancestry
Comparative anatomy
Homology – Divergent evolution

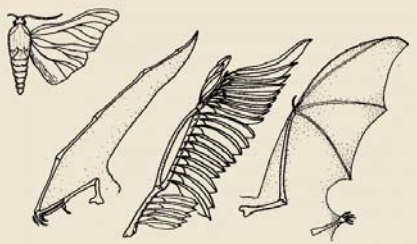


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Darwin's five theories - Common ancestry
Comparative anatomy
Homoplasy (analogous) – Convergent evolution



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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"

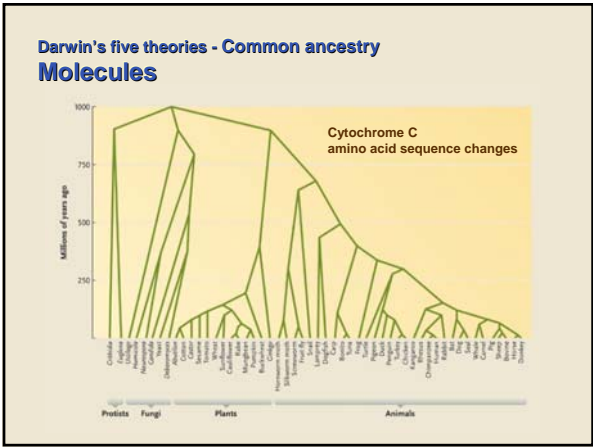
Nictitating membrane

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Darwin's five theories

- No constancy of species
- Common ancestry
- _____
- Population change (multiplication of species)
- Natural selection

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(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 _____
 - 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 _____


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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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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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Biology, biologists and Bioscience

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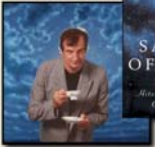
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Important stages in the history of Biology
16th-18th century: The scientific revolution and the start of modern sciences

Douglas Adams 1952-2001
Four ages of sand

- First - Telescope 1608
- Second - _____
- Third - Computer chip 1961
- Fourth - Fiber optics 1980s



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Some terms used in doing science

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

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Biology, biologists and Bioscience

Physical science

- Inanimate objects
- Physical and chemical laws
- Universal

Natural science

- Animate objects
- More than physical and chemical laws (Genetics)
- Not Universal

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Changing thoughts on what living things are

- **Physicalists** – 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

- Inanimate objects
- Physical and chemical laws
- _____
- Based on empirical observations
- Experimentation preferred method

Natural science

- Animate objects
- More than physical and chemical laws (Genetics)
- _____
- 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](#)

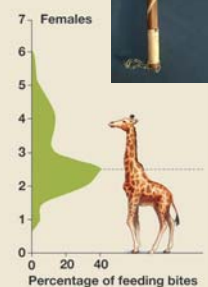
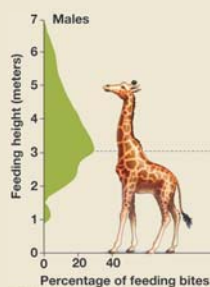


Figure 1-10a

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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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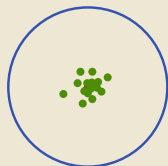
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Additional experimental components

- 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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Fish capture sizes



- **Observation:** Over fishing is decreasing size and abundance of fish. Size quota had been implemented along with fishing bans.
- **Question:** Will size in fish populations change due to fish management strategies?

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Fish capture size

- **Hypothesis** - If fishing induced evolution is irreversible, or slow to change than the populations should retain their character states after fishing ceases.
- **_____ hypothesis** - If fishing induced evolution is reversible, than the populations should return to their original character states after fishing ceases.

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Experiment

- Constant conditions, duplicate populations
- 2 sets of fish – remove 90% largest
- 2 sets of fish – remove 90% smallest
- 2 sets of fish – randomly remove 90% regardless of size

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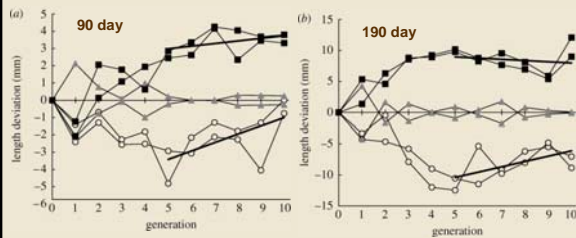
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Fish capture size

Results



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Fish capture size

Conclusion?

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Biology, biologists and Bioscience

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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Biology, biologists and Bioscience

Distribution of scientific facts

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

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