


# History of Biology: Before Darwin

Sept. 5th, 2014

**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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# History of Biology: Before Darwin

## 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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-influences from physical sciences

-vague: "stem-pickers"

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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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-underlying key of genetics

-rely on heritability

-relatively new

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# History of Biology: Before Darwin

**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 – 16<sup>th</sup> century: Medieval ages
  - 16<sup>th</sup>-18<sup>th</sup> century: Renaissance and SR
- **Darwin and evolutionary thought**  
(late 1800's – mid 1900's)
- **Modern theory of evolution and more**  
(mid 1900's – present)

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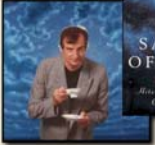
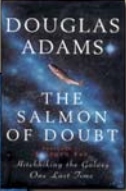
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**Important stages in the history of Biology**  
**16<sup>th</sup>-18<sup>th</sup> century: The scientific revolution and the start of modern sciences**

**Douglas Adams 1952-2001**

**Four ages of sand**

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



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-1608 included mathematics and testability (external)

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- 2nd age (1678) (internal)

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- 3rd- refers to silicon chip: revolutionized engineering

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- 4th- mouvement of info

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(permits collaborations) ie. before, Mendel and Darwin, no contact

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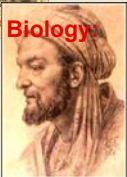


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**Major events in the history of Biology: Predarwinian**



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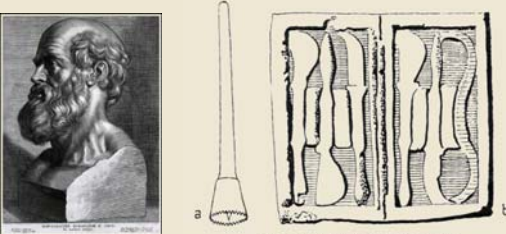
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# History of Biology: Before Darwin

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) Seventeenth-century instrument of ancient type. (d) Relief in the Asclepeion, Aegina.

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-collected medical writings = Hippocratic Corpus

-human biology is separate

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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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-organized mass collections on organisms

-prioritized living world

-first classification

-scala natura

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**Some initial definitions about naming**

- Classification
- Taxonomy
- Hierarchical
- Systematics



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-taxonomy= regulated collection

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# History of Biology: Before Darwin

**Types of taxonomies**

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



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-Folk transmitted verbally

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-Aristotle creates artificial: written

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-ancient father of taxonomy

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




Theophrastus (371-287 BCE)

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-organized plants (herbal medicine)

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-classified based on reproduction

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-quite accurate

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-books reprinted for centuries

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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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-animate v. inanimate: essence

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# History of Biology: Before Darwin

**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 – 16<sup>th</sup> century: \_\_\_\_\_
  - 16<sup>th</sup>-18<sup>th</sup> century: \_\_\_\_\_
- **Darwin and evolutionary thought**  
(late 1800's – mid 1900's)
- **Modern theory of evolution**  
(mid 1900's – present)

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400 BCE-16th: Medieval Ages

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16th-18th: Renaissance and the scientific revolution

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**Important stages in the history of Biology**  
**450-16<sup>th</sup> century: Medieval ages**

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



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- difference (v. Greeks and Romans) : one entity

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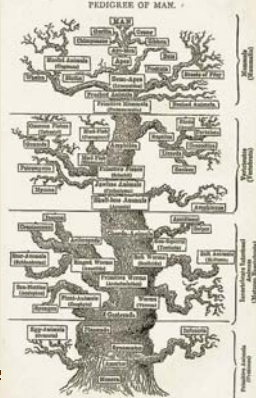
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**Special creation**

- **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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-1650

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- everything appeared at once

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-random statement

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- revolutionary: set earth's age

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# History of Biology: Before Darwin

Important stages in the history of Biology  
**450-16<sup>th</sup> century: Medieval ages**

- **Europe**
  - 400-700 Early middle ages (Dark Ages)
  - 1000-1300 High middle Ages
  - 1300-1500 \_\_\_\_\_



**Black plague (1347-1351)**

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- blank: late middle ages
- high middle ages: churches conquer
- society advances, then crashes due to plague
- only affected Europe

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Important stages in the history of Biology  
**450-16<sup>th</sup> 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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- roman works translated

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Important stages in the history of Biology  
**450-16<sup>th</sup> 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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# History of Biology: Before Darwin

Important stages in the history of Biology  
**450-16<sup>th</sup> 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 conclusion
7. Publication of findings



Alhazen

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-relevant until 17th century

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Important stages in the history of Biology  
**450-16<sup>th</sup> century: Medieval ages**

- **Byzantium and Islamic world**
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  - Alhazen (965-1040)
  - Ibn al-Baitar (1197-1248)



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-Ibn al-Baitar: pharmaceuticals (doses)

- used until the 1800's

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**Major events in the history of biology:**

- **Predarwinian and the natural sciences**  
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- **Darwin and evolutionary thought**  
(late 1800's – mid 1900's)
- **Modern theory of evolution**  
(mid 1900's – present)

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-blank 1: Greek and Roman ages

-blank 2: Medieval Ages

-Renaissance and SR

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# History of Biology: Before Darwin

Important stages in the history of Biology  
**16<sup>th</sup>-18<sup>th</sup> 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
- Pascal (1623-1662) – \_\_\_\_\_
- Descartes (1596-1650) – geometry

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

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-Pascal: Origins of Calculus

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-Harvey: Anatomy and physiology

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-Copernicus keeps quiet

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-published his book the day he died

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-Galileo executed for his work

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-natural sciences: no advancement

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



Van Leeuwenhoek  
(1632-1723)

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-glass bead reflects specimen

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-bought a patent

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



Andrea Vesalius  
(1514-1564)

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-1543: Illustrations of Human Anatomy

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-first of its kind


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-father of anatomy

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# History of Biology: Before Darwin

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



Harvey  
(1578-1657)

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-physiology

-depicted blood flow

-father of physiology

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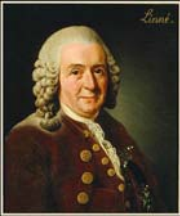
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Important stages in the history of Biology  
**16th-18th century: The scientific revolution**



Linnaeus  
(1707-1778)

First published 1735

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-created mechanical taxonomy

-groups organisms based off of collected descriptions

-nested hierarchy

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**Types of taxonomies**

- \_\_\_\_\_
- Artificial
- Mechanical
- Natural (Evolutionary)
- Cladistic (Phylogenetic)



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-Blank: Folk

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# History of Biology: Before Darwin

Some initial definitions about naming

- Classification
- Taxonomy
- Hierarchical
- Systematics



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The "scientific revolution" 16<sup>th</sup> – 18<sup>th</sup> century  
Linnaeus – Taxonomic hierarchy




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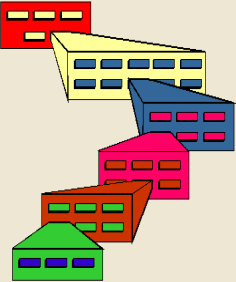
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The "scientific revolution" 16<sup>th</sup> – 18<sup>th</sup> century  
Linnaeus – Taxonomic hierarchy



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

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-red: more recent additions

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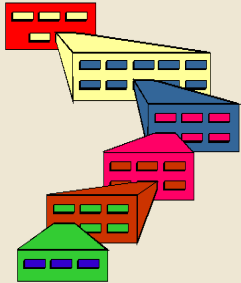
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# History of Biology: Before Darwin

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



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



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-autapomorphy: unique characteristic attributed to one group

-animal: must consume food

-chordata: have a notocord


-mammalia: secretion of milk

- rodentia: growing front teeth

-castoridae: protective fur

- Canadian beaver

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



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

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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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# History of Biology: Before Darwin

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



*Apis mellifera*  
(Honey bee)

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-Latin different from body of text

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Changing thoughts on what living things are

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

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-after scientific revolution

-physicalists: technicality of living world

-vitalists: more than just processes

-essence still in play since Aristotle

-vitalists agree with physicalists but believe there's more

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

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-essence today=energy

-physical: also external to earth

-natural science: no access to the external

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# History of Biology: Before Darwin

**Physical science**

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

**Natural science**

- Animate objects
- More than physical and chemical laws (Genetics)
- Not Universal
- Based on historical narratives
- Induction most used method

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-physical:numeric (empirical)

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-natural:observe then explain

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-opposing methods

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-replace experimentation with deductive

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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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-induction due to variation

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-natural science with use of induction:  
no need to discard explanation

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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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- natural and physical:similar in their ways

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-narrative vs. equation

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-questions differ

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# History of Biology: Before Darwin

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

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-narrative accepted through Darwin:  
well-supported

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Physical science	Natural science
<ul style="list-style-type: none"><li>• Inanimate objects</li><li>• Physical and chemical laws</li><li>• Universal</li><li>• Based on empirical observations</li><li>• Experimentation preferred method</li><li>• Single theory</li><li>• Single falsification enough to abandon a theory</li></ul>	<ul style="list-style-type: none"><li>• Animate objects</li><li>• More than physical and chemical laws (Genetics)</li><li>• Not Universal</li><li>• Based on historical narratives</li><li>• Induction most used method</li><li>• Multiple theories</li><li>• Single falsification not necessary to abandon a theory</li></ul>

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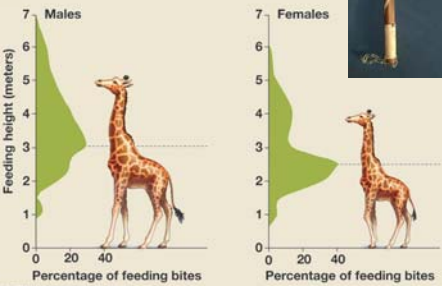
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**Multiple theories**

- Food competition
- Sexual competition

Video 



Feeding height (meters)

Percentage of feeding bites

Males

Females

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-sexual competition: males use neck as weapons  
-longer neck=more momentum  
-food: in periods of drought, they stretch necks

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# History of Biology: Before Darwin

**Changing thoughts on what living things are**

- **Physicalists** – with the exception of humans all living things are machines (Descartes, 17<sup>th</sup> 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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-essence: genetic program

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-more than sum of parts (ie.salt)

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-protein folding dependent on environment

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**Scientific method**  
**Some terms used in doing science**

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

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-theory > fact

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-fact=unchangeable

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-theory: observation and manipulated  
in experiment (scientific)

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-for general public: theory is unstable

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-a working hypothesis=theory

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-law is universal (Mendel's Law)

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-never a fact

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-prediction: baby hypothesis

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**Scientific method**  
**Steps or stages**

- **A question that needs to be answered**
- **Gather information already known**
- \_\_\_\_\_
- **Interpret the results of the test**
- **Retest**
- **Publish results**

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-blank: Develop a hypothesis and test it

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-hasn't changed in 2000 years (Islamic world)

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# History of Biology: Before Darwin

**Additional experimental components**

- Controls
- Control of variables
- \_\_\_\_\_
- Repeat the test



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-blank:sampling error

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**Distribution of scientific facts**

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

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-\*Nature and Science

-impact factor: # of citations in other works

-review: anonymous

-can argue revision

-pay to publish (partially due to expert review)

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**Types of literature – what's the difference**

- Primary
- Secondary
- Tertiary

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-primary: author that publishes to journal

-secondary: expert summary

-tertiary: seldom used (Google, textbook,etc.)  
author isn't an expert, no accredited source

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# History of Biology: Before Darwin

**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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<--- Death of Darwin

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



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- changes within the gene frequency
- genetic adaptation to external factors
- first demonstration of this
- inheritance +natural selection

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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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# History of Biology: Before Darwin

**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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-fitness=offspring

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-null: back-up hypothesis

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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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-also light and dark moths on top of light trees

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-question if industrial activity correlates to shading of bark

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-placed moths on trunk rather than branches (doesn't matter)

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~~-thought to be a flawed experiment~~

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-different species on different continents solidify the legitimacy of the experiment

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- + genetic inheritance has been proven

**Peppered moth**

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



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# History of Biology: Before Darwin

## 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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