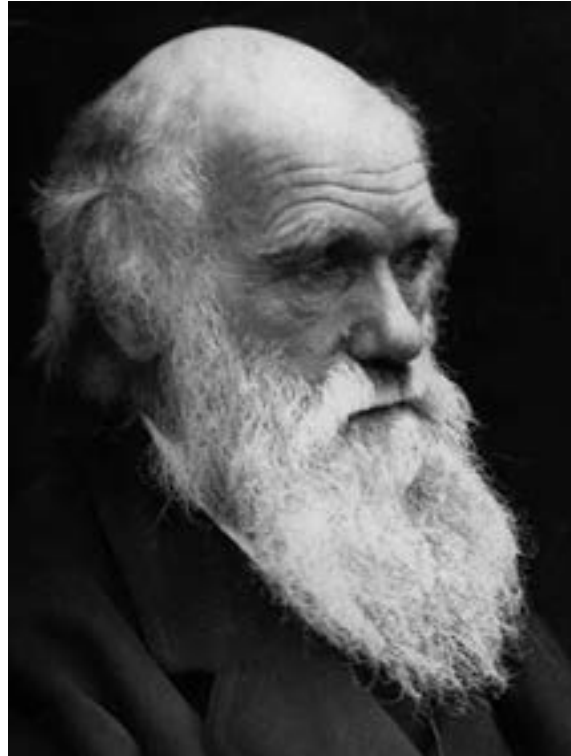


Evolution of Complexity

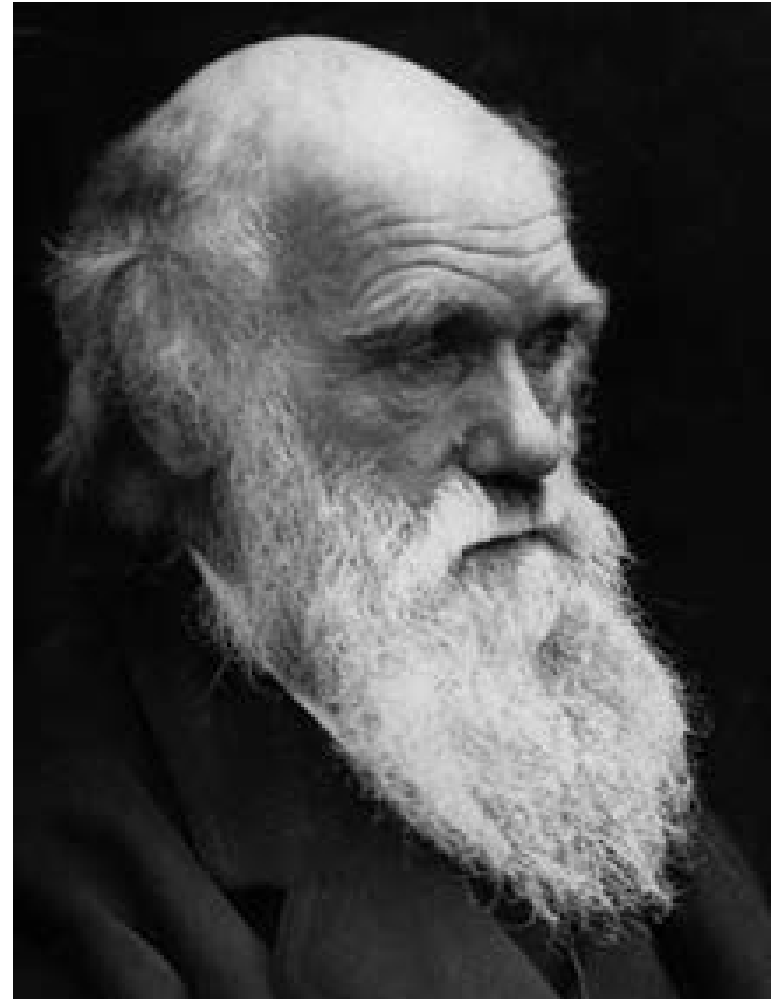
A Brief History of Evolution



Natural selection, adaptation, complexity

Outline

1. **Course Themes**
2. Historical Developments
 - Pre-Darwinian evolution
 - Natural selection
 - The modern synthesis



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Expert in the *evolution of simple systems*

Why Evolution?

- The exemplar of a complex systems is life
- We believe life evolved
- Other complex systems (e.g. the economy) have much in common with life
- It is a fair to postulate that the only way for a complex system to develop is through evolution and “natural selection”
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- Complex systems are too too complex to design—“The law of unintended consequences” makes design almost impossible

Why Complexity?

- The much more challenging question is

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why does evolution lead to complexity?
- The modern argument of “intelligent design” and its pre-Darwinian predecessor “natural theology” questions the plausibility of complexity arising spontaneously
- One theme of this course is to explore the rise of complexity through **unintelligent design**

What is Complexity?

- No established definition
- One fruitful characterisation is that it is a system with many levels of organisation
- Properties at high levels are often ‘emergent’—i.e. they are not directly predictable from lower levels

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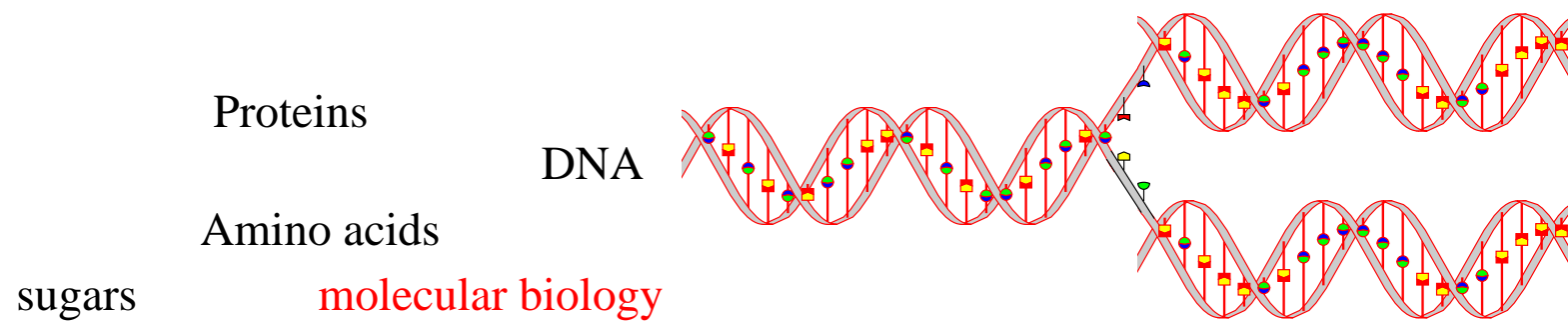
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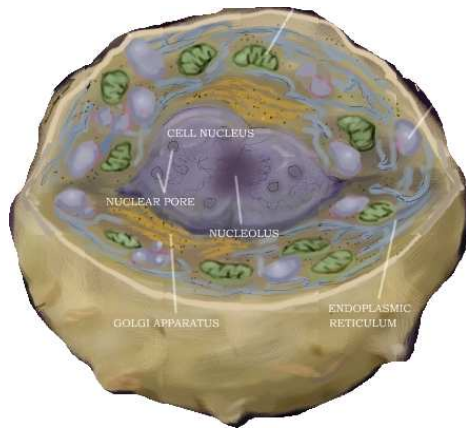
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Levels of Life



Levels of Life



cell biology

cell nucleus

mitochondria

membranes

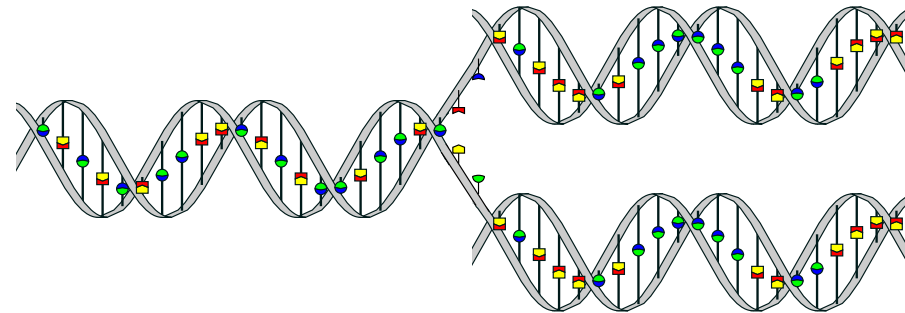
Proteins

DNA

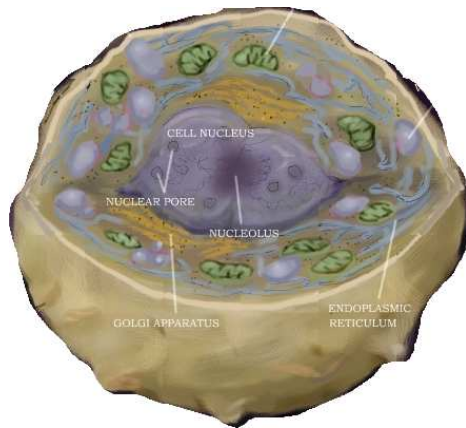
Amino acids

sugars

molecular biology



Levels of Life



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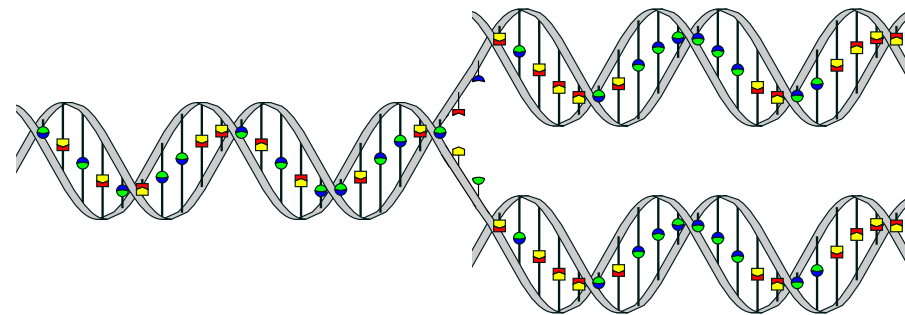
organisms

specialisation

cell differentiation

communication

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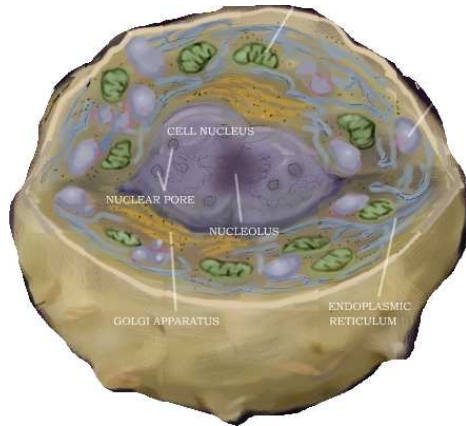


molecular biology

Levels of Life



populations



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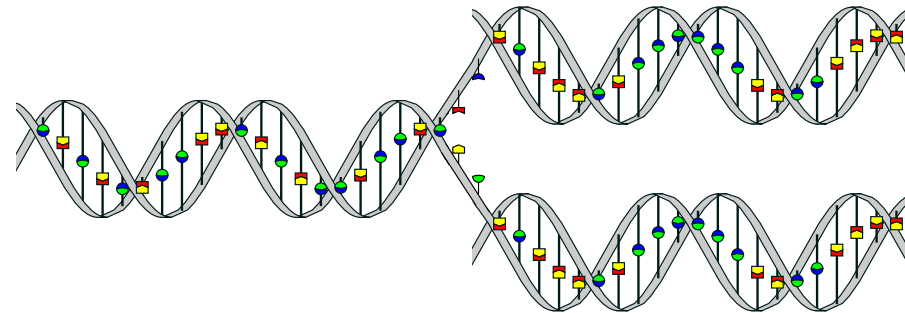
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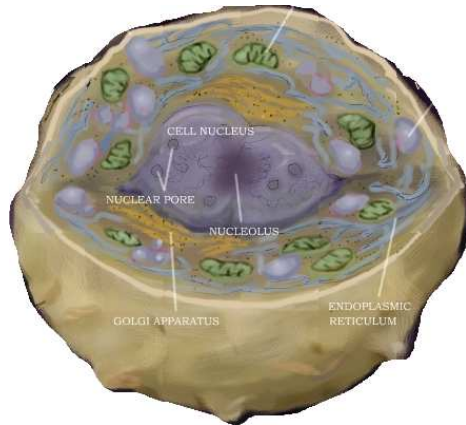


Levels of Life



populations

eco-systems



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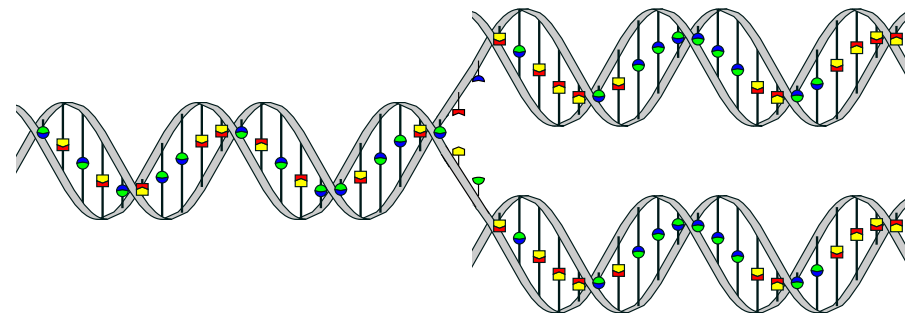
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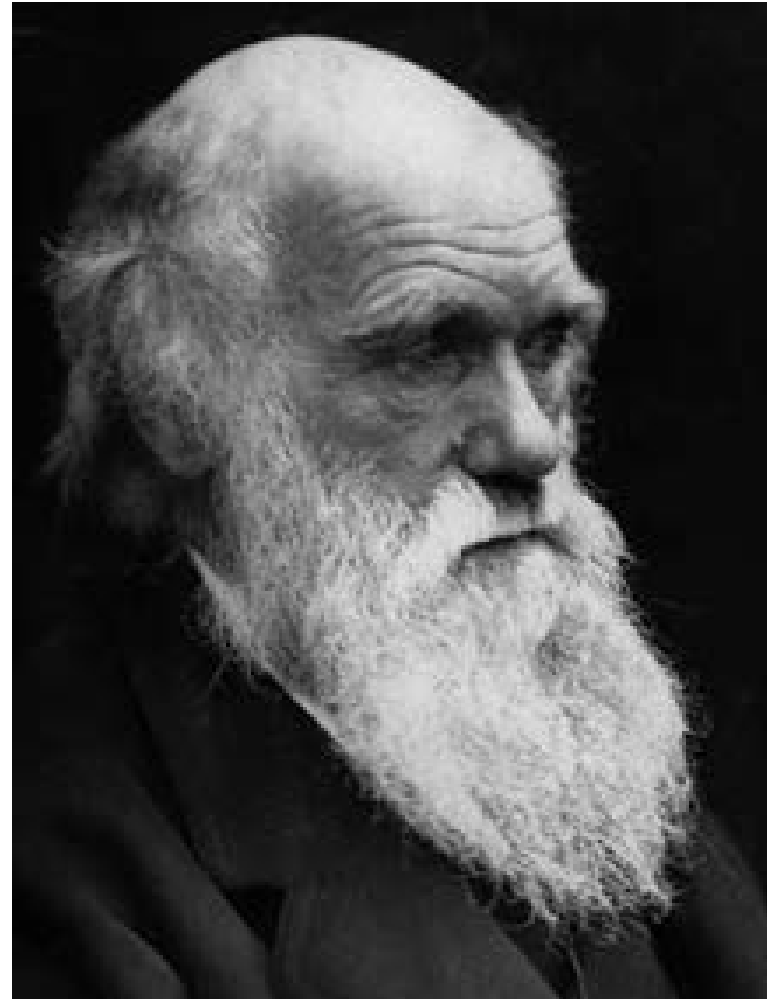
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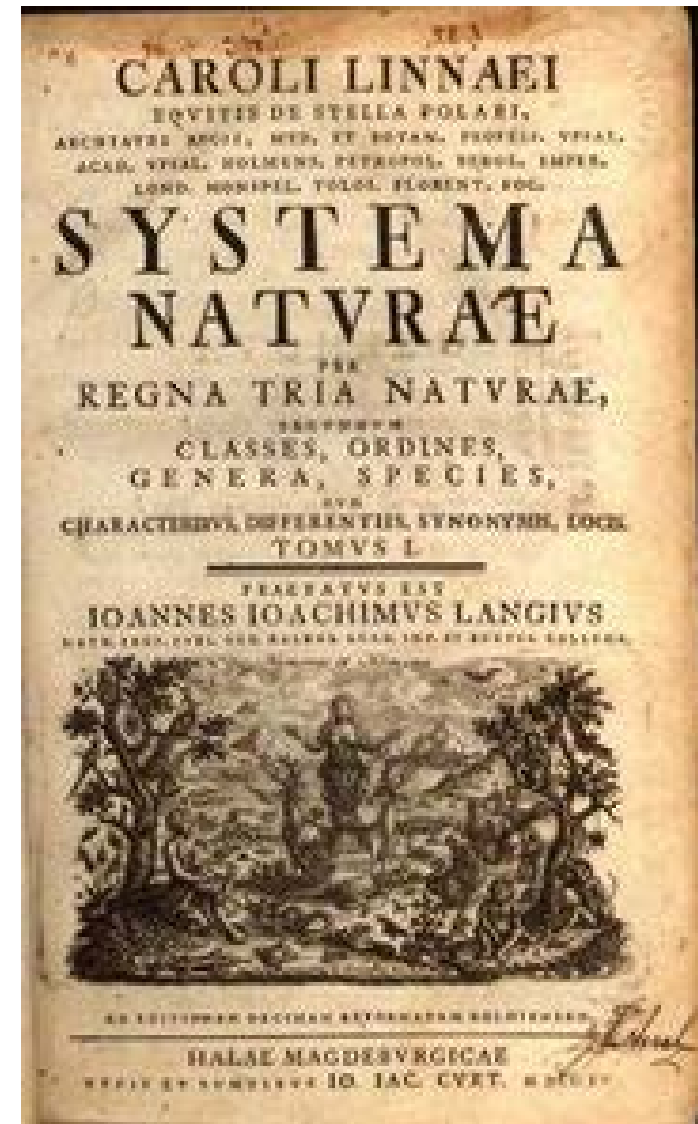
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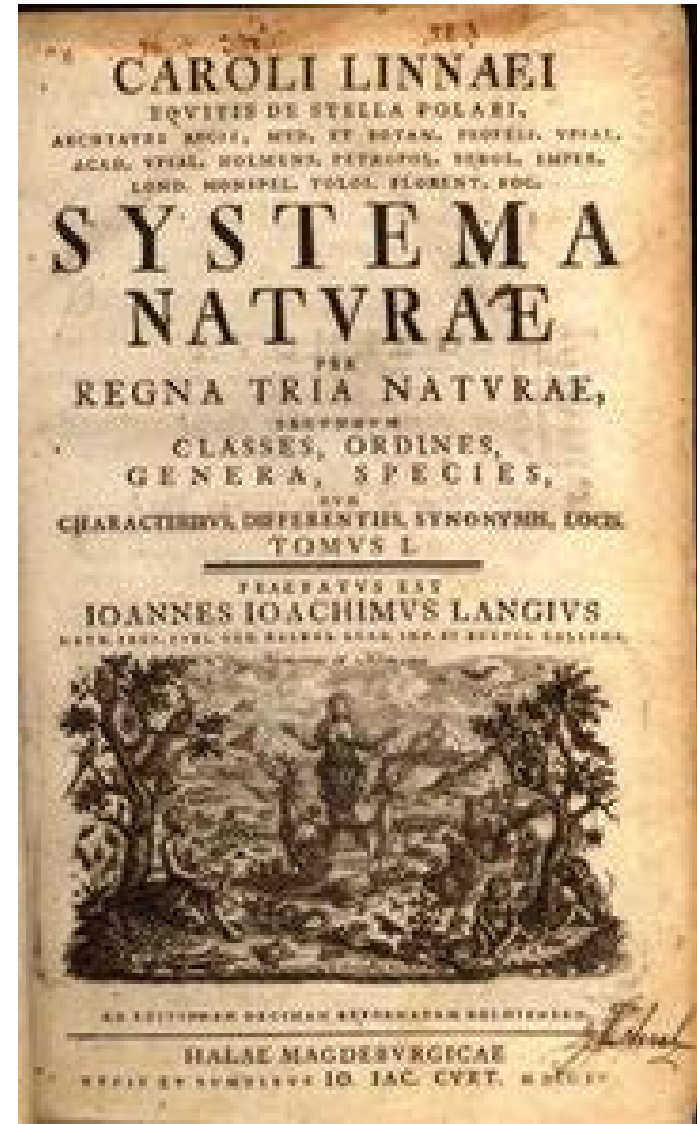
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- The 10th edition published in 1758 set up the formal classification that is used with few changes today
- Systematic biology took off



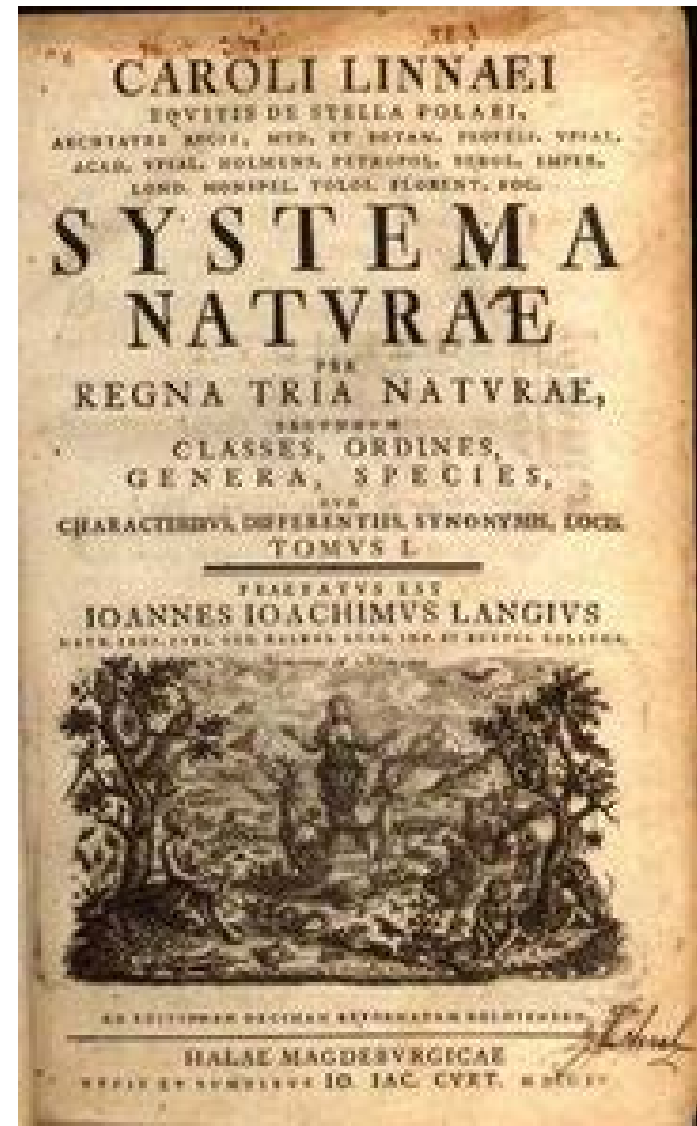
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- A famous early proponent was Charles Darwin's grandfather Erasmus Darwin
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- In contrast “natural theology” advocated by the likes of William Paley used the complexity of life as evidence for God.

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- Although he advocated that species could change he did not see all of life as sharing a common ancestral tree
- He is remembered mostly for his theory of “acquired characteristics” which provide a mechanism for explaining adaptation
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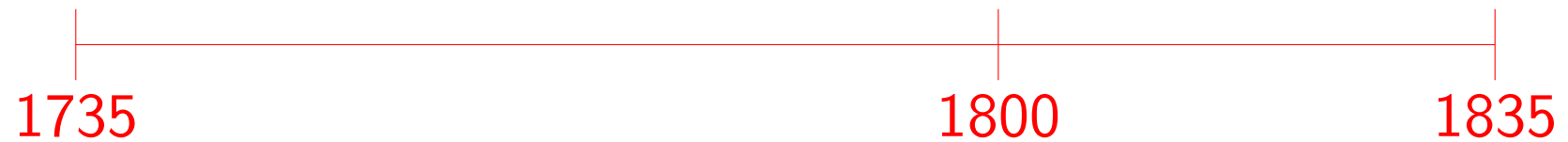


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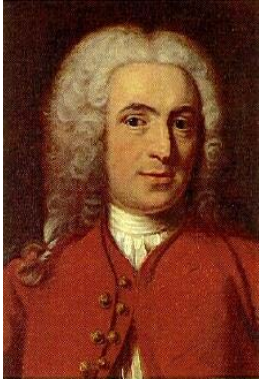
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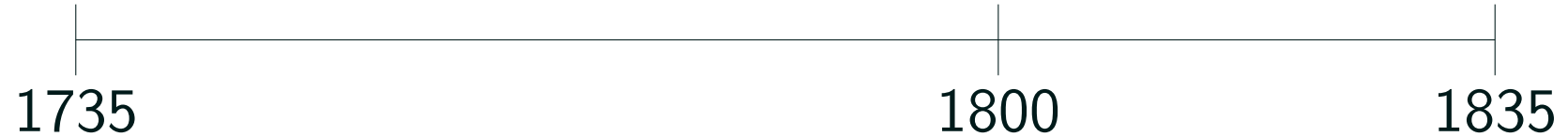
Pre-Darwinian Views



Pre-Darwinian Views



Systema Naturae



Pre-Darwinian Views



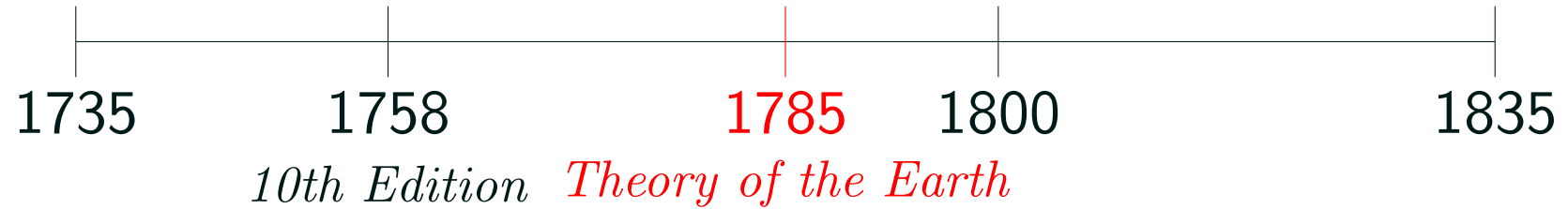
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Pre-Darwinian Views



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Zoonomia

10th Edition Theory of the Earth



Pre-Darwinian Views

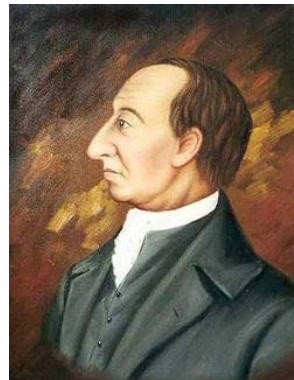


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10th Edition Theory of the Earth



Philosophie zoologique

Pre-Darwinian Views



Systema Naturae

1735

1758

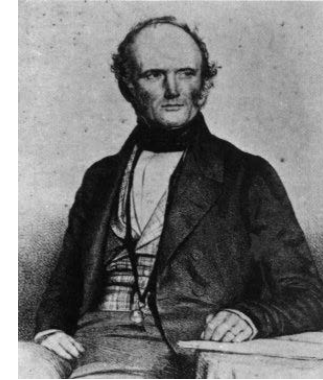
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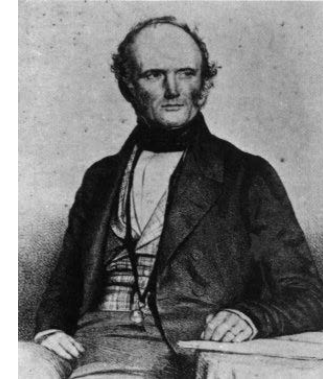


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Principles of Geology

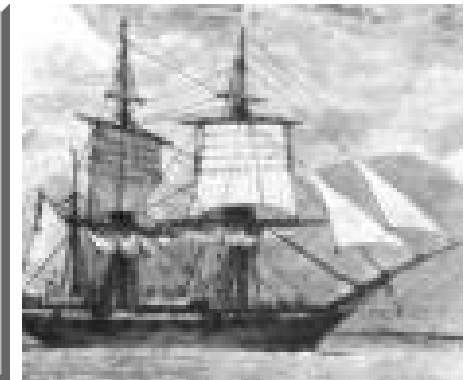
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10th Edition Theory of the Earth

Beagle sets out

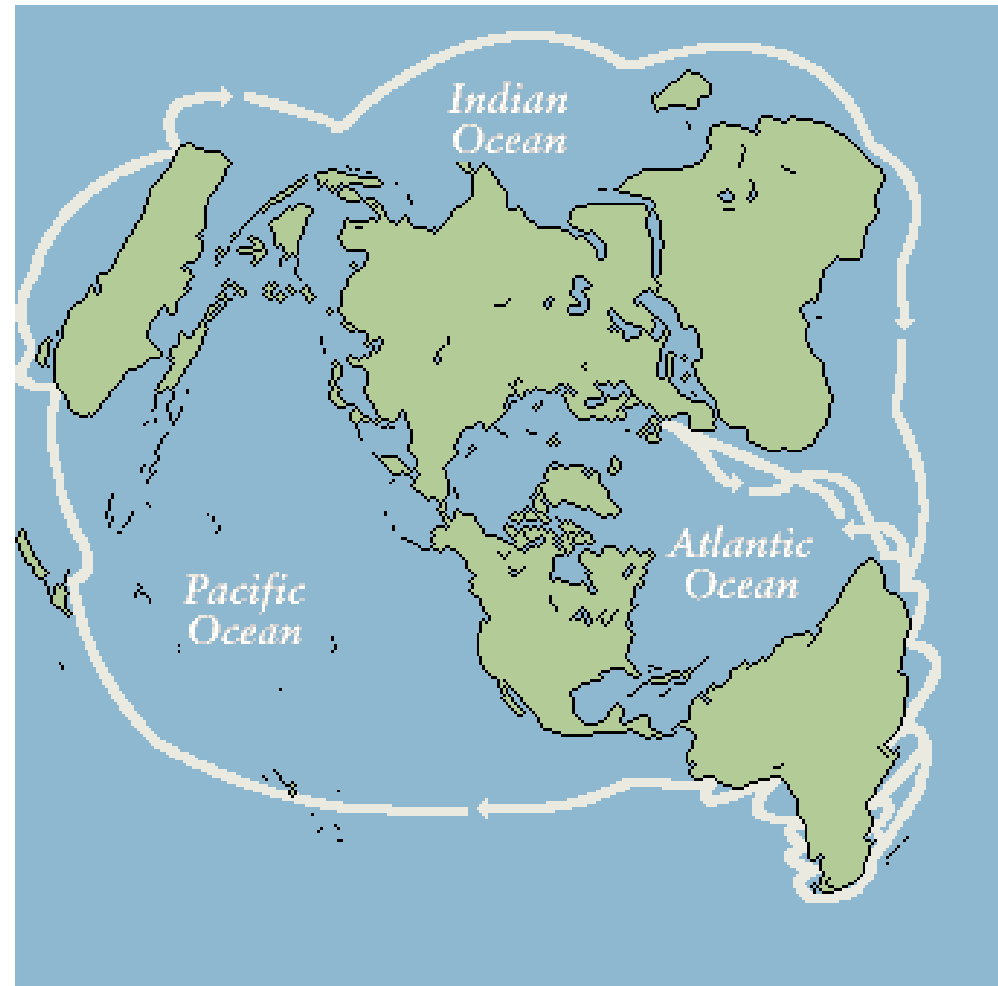


Philosophie zoologique



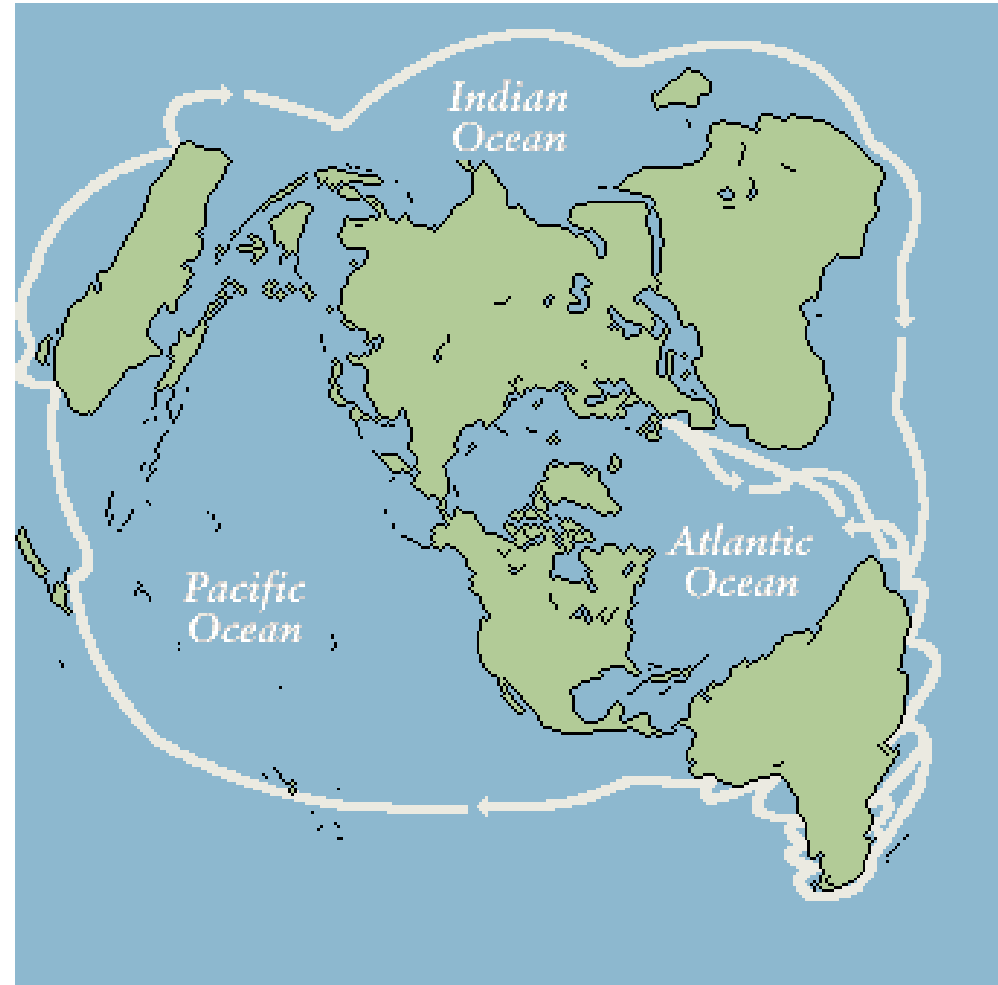
Voyage of the Beagle

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- It also raised the questions which lead to the theory of natural selection



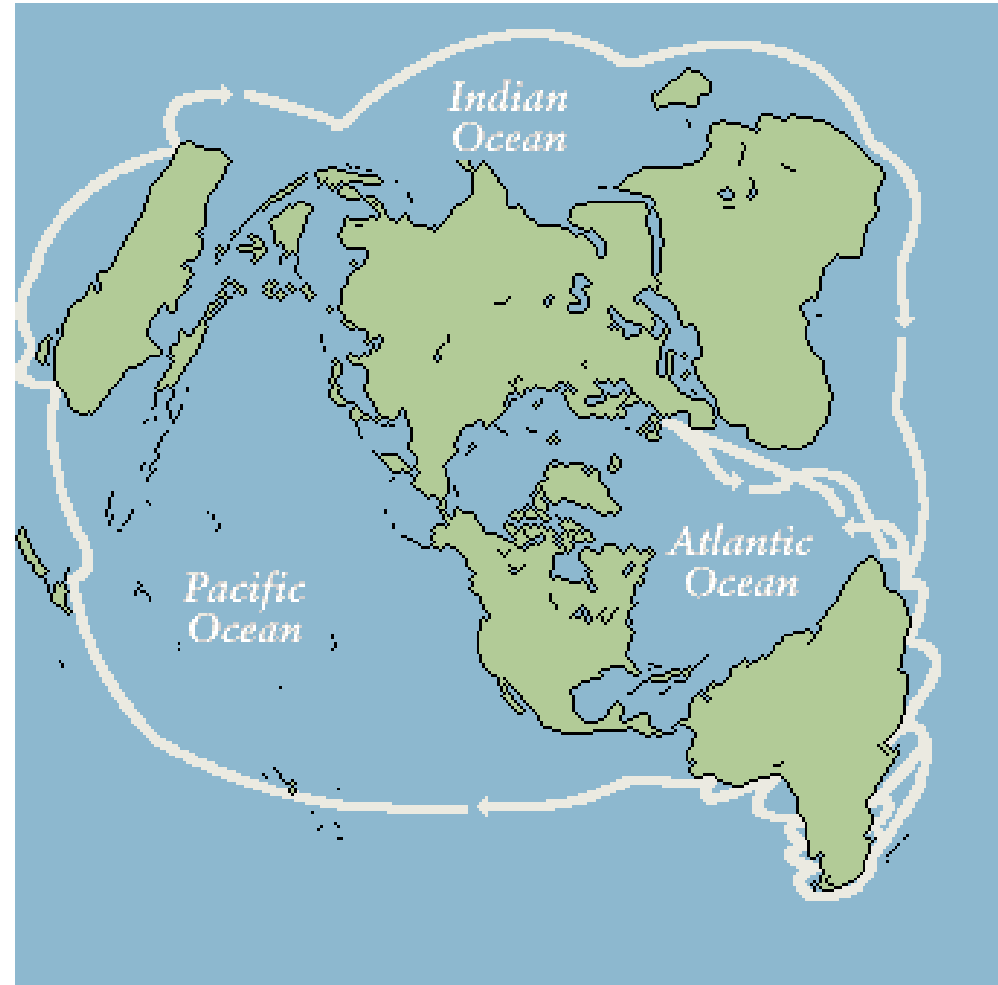
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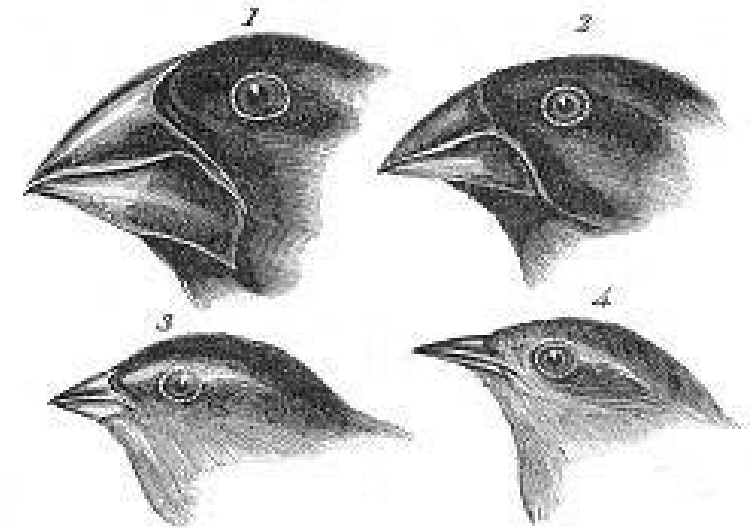
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Galapagos Finches

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- However, on close examination they proved to be many species
- The simplest explanation was that a single migrant had adapted to the habitat on different islands



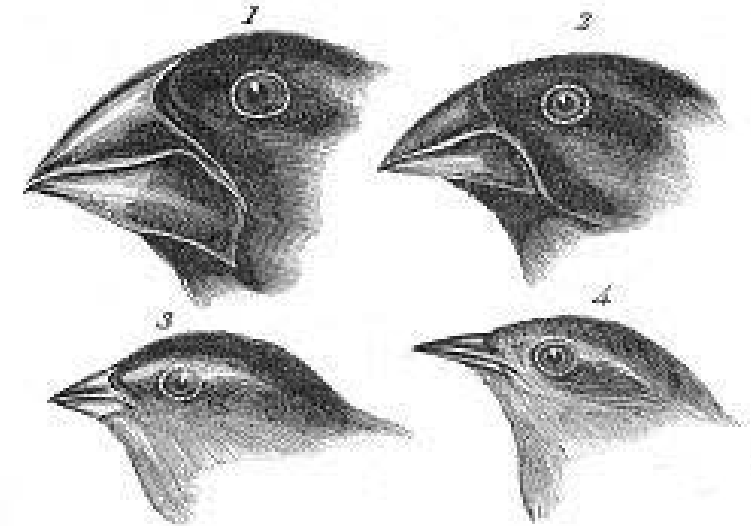
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Finches from Galapagos Archipelago

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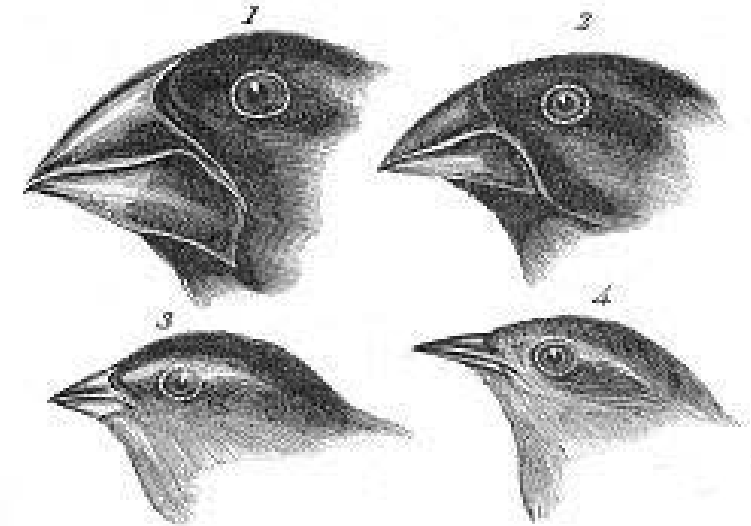
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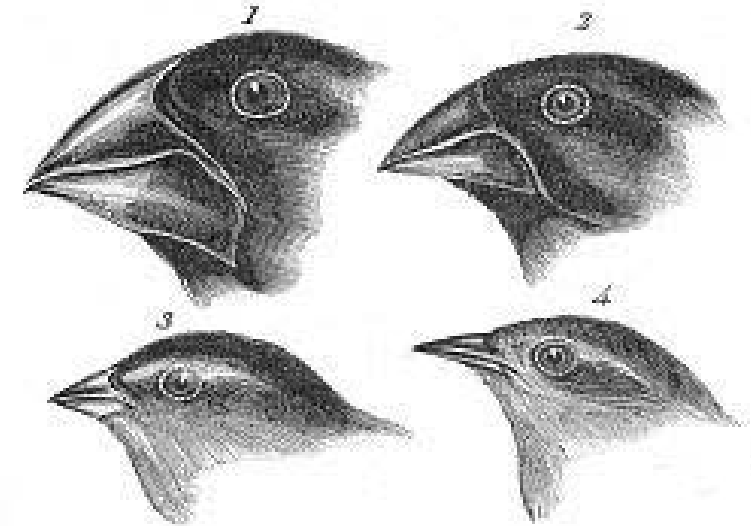
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- Strongly influenced by Thomas Malthus's *Essay on the Principle of Population* (1798) Darwin developed the theory of **natural selection**

Natural variations in populations that provide small selective advantages will take over the population

- This relies on the potential geometric growth of a trait in a population

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- He did what any reasonable person would do
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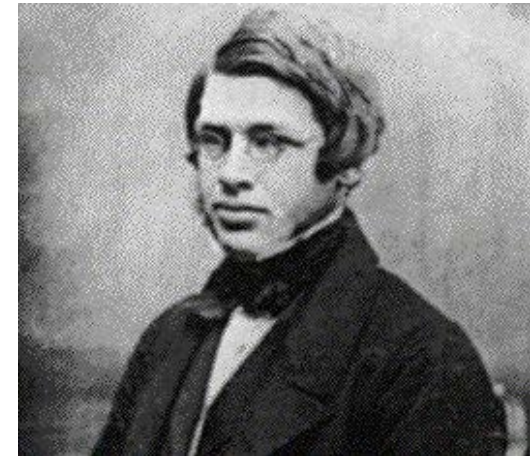
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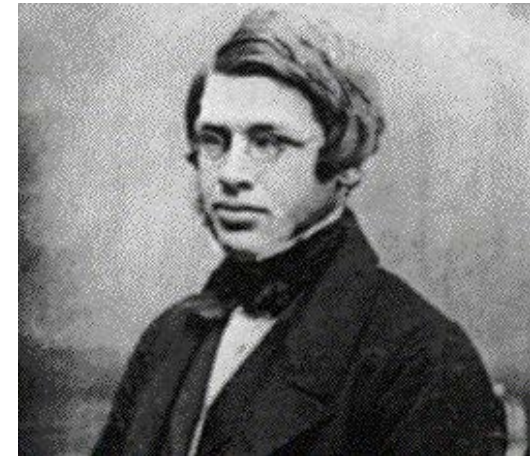
Alfred Russel Wallace

- While Darwin waited another naturalist, Alfred Wallace, again influenced by Malthus, arrived at the same theory of natural selection
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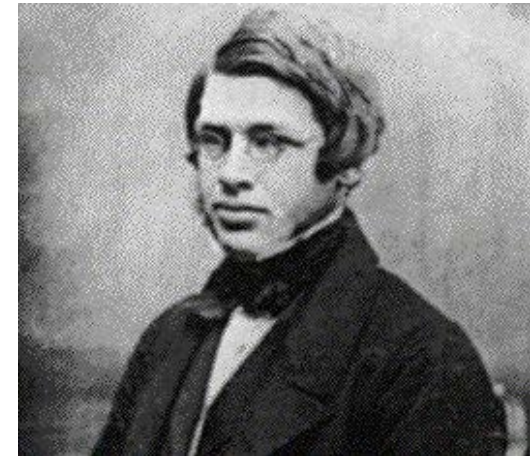
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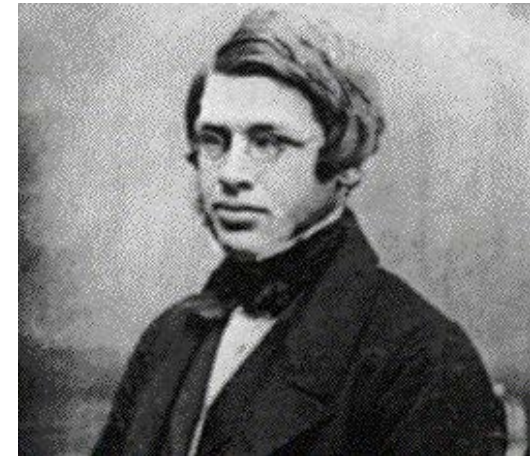
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 - ★ the population of isolated islands by chance migrations
 - ★ the relatedness of species in a tree like structure
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