

Scientific Change

SC/NATS 1730.06
York University
Faculty of Science and Engineering
Division of Natural Science

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Course website:

- www.yorku.ca/bwall/nats1730
- Consult the website for general information, special announcements, lecture notes, schedule of assignments, supplementary materials, interim marks, etc.

A plea to all students to obtain a York email address

- It is very helpful to have a York email address. It is easy to obtain from the main York website, www.yorku.ca, following the instructions for Current Students
- If you prefer to use another email address, you can forward all mail from your York address to it.

Passport York

- You will need to sign up for *Passport York* if you have not already done so.
- Once you have a *Passport York*, you can select an email address, which you can then forward elsewhere if you like.

Scientific Change

This course is about the development of scientific ideas from the earliest times to the present.

The Main Topics

1. The foundation of civilization and of abstract reasoning.
2. The Middle Ages and the Renaissance, including the Scientific Revolution.
3. The Physical Sciences since Newton.
4. The Life Sciences.

1. The foundation of civilization and of abstract reasoning.

- Prehistoric human life.
- Agriculture and civilization.
- Numbers and writing.
- Ancient philosophy
 - The pre-Socratics, Plato, Aristotle
- The discovery of mathematics: Euclid
- The discovery of astronomy: Ptolemy

2. The Middle Ages and the Renaissance

- Medieval Technology, including printing
- Renaissance astronomy:
 - Copernicus
 - Kepler
 - Galileo
- Classical Physics
 - Galileo
 - Descartes
 - Newton

3. Physical science since Newton

- The founding of chemistry
- Energy and thermodynamics
- Electromagnetism
- Relativity
- The structure of the atom
- Quantum mechanics
- Cosmology

4. The Life Sciences

- Geological theories
- Biological classification
- The discovery of the cell
- The theory of evolution
 - Darwin
- Genetics
 - Inheritance theories, Mendel, the Gene, DNA

What is science?

- Confident knowledge about the world
- Understanding of Nature
- Predictive Power
- Magical power over Nature
- Systematic thinking:
 - Abstract reasoning and logic
- Technological know-how

Science is a human endeavour



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Reasons why science is a human endeavour:

1. Opposable thumbs



SCINATS 1730, 1

Reasons why science is a human endeavour:

2. Stereoscopic vision



SCINATS 1730, 1

Reasons why science is a human endeavour:

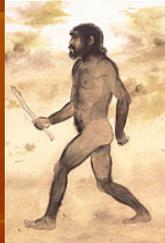
3. Enlarged Brains



SCINATS 1730, I

Reasons why science is a human endeavour:

4. Bipedalism



SCINATS 1730, I

Compared to the history of the universe, the history of science is unimaginably short.

- Age of the universe: Perhaps 15 billion years
- Age of the Earth: About 4 ½ billion years
Extinction of the dinosaurs: About 65 million years ago
- Mammals fully developed and across the Earth: About 45 million years ago

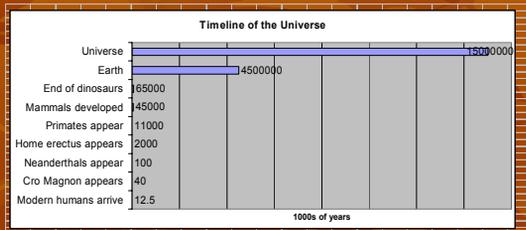
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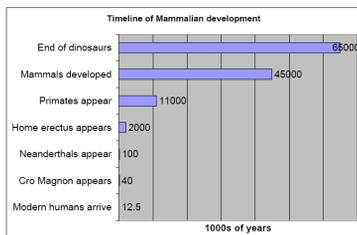
Compared to the history of the universe, the history of science is unimaginably short. (2)

- Earliest primates: 10-12 million years ago
- *Homo erectus*: Between 1-5 million years ago
- *Neanderthals*: About 100,000 years ago
- Cro Magnon: About 40,000 years ago
- Modern humans, anatomically the same as ourselves: 10,000 to 15,000 years ago

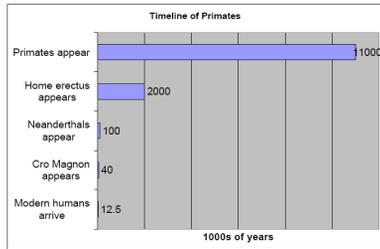
Timeline of the Universe



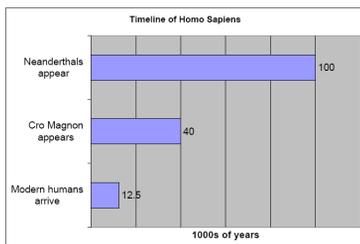
Timeline of Mammals



Timeline of Primates



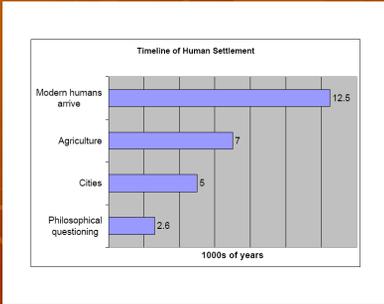
Timeline of Homo Sapiens



From Modern Humans to the earliest beginnings of scientific thinking

- Modern humans emerge: 10-12 thousand years ago
- Agriculture flourishing: 7 thousand years ago
- Cities emerge, writing invented: 5 thousand years ago
- Philosophical speculation about the nature of the world first recorded: About 600 BCE; i.e. 2600 years ago

Timeline of Human Civilization



Back up to the earliest hominids

- “Human” prehistory and early history can be divided into two major periods:
 - Hunting and gathering
 - Paleolithic period – 1 million to 25,000 years ago
 - Neolithic period – about 25,000 years ago till 10,000 years ago
 - The discovery of agriculture, around 14,000 to 10,000 years ago

The Paleolithic Age

- The first part of the Hunting and Gathering Period, lasting about a million years, is called *Paleolithic*, or Old Stone Age.
- It is named after the primitive stone tools that have survived – the first technology.



The Neolithic Age

- The later, much shorter, part of the Hunting and Gathering Period, lasting only 10-15,000 years, is called the *Neolithic* or New Stone Age.
- Also named after the stone tools that survived, these are much more complex and sophisticated tools, specific to particular tasks.



The Discovery of Agriculture

- Agriculture was developed between 14,000 and 10,000 years ago.
- Two stages occurred:
 - No cultivation required, but regularly harvested
 - Cultivation necessary

Stage 1: Emmer

- Emmer is a wild grass with an edible seed.
- It grew widely in the savannahs and elsewhere.
- It could be gathered, hand threshed, and the seeds eaten, or ground into a rough flour and baked into a sort of bread.



Emmer, 2

- Emmer could be simply gathered up where it grew, but if some of the seeds were scattered in a nearby field they would grow there and be found more easily.
- Eventually it was realized that a crop could be grown and harvested regularly.
- The seeds of emmer had 14 chromosomes, and was light enough to be spread by the wind.



Transition

- As often happens in the plant world, emmer underwent a series of spontaneous genetic mutations.
- First to a strain with 28 chromosomes.
- Then to a strain with 42 chromosomes, really a new species.
- This we call *bread wheat*.

Bread Wheat

- Bread wheat, with 42 chromosomes, had much larger seeds.
- Therefore, it made much better food.
- But the seeds were too heavy to spread by wind alone.
- They had to be cultivated.



The Agricultural Revolution

- The transition from hunting and gathering to domesticating animals and planting crops for harvest took about 3,000 years.
- This is lightening speed compared to any of the previous major changes in living conditions.
- Its completion marks the end of the Neolithic Age.

Farming

- The Agricultural Revolution was revolutionary because it completely altered the way people lived.
- They settled in one place and built more substantial homes.
- They had more food to eat than they needed.



Specialization and Leisure

- The development of specialized trades began.
 - Tool makers and smiths
 - Bakers
 - Potters
 - Bureaucrats
 - Priests
- The leisure provided by the food surplus also provided time to think.

An Alternate View

- Hunter-gatherers had plenty to eat, and may have spent less time obtaining food than the early farming communities.
- They had lots of leisure, but, as with existing modern day hunter-gatherer societies, did not choose to spend their leisure in pursuit of better mousetraps and theories of the universe.

Alternate View, continued

- Farming developed all over the world within a few thousand years, and developed differently in different places.
 - Emmer and bread wheat was the sequence in the Near East. Elsewhere it was based on other crops.
- Farming may have arisen because the population had grown such that the land could no longer support it by hunting and gathering.

Relative amount of land to feed an individual



- 1=Land required to feed one person by hunting and gathering, 10 square kilometers.
- 2=Land required to feed one person farming without irrigation.
- 3=Land required to feed one person farming *with* irrigation.
- Irrigated farming can feed 100 people on the land required to feed one hunter-gatherer.

Alternate View, continued

- Farming can provide more food from a fixed area than hunting and gathering.
- Agriculture may have been a response to the problem of starvation.
- However, once farming produced a surplus, then the population rose to meet it, and there was no turning back.
