Week 1

Big History

Global history – study of globalisation over the last 500 years. Reads backwards, looks at the globalised world of today and asks how and why we got here.

World history – comparative history of humanity over past 5000 years. Reads forwards, starts with earliest historical evidence to understand the phenomena historians see repeatedly by comparing them.

Deep history – the study of humankind from the advent of our species (3000 years) or the beginning of tool making (3 million years ago). Scope - world, timeframe – 3,000-3,000,000 years, multi-disciplinary.

Big history – integrated history of the cosmos, earth, life, and humanity. Scope – universe, timeframe – 4.6 billion years, multi-disciplinary.

Big Bang Timeline

Big Bang

- 13.8 billion years ago
- Start of all space and time

The Primordial Date

- 10^-43 seconds after the Big Bang
- Universe smaller than an atom

Guthian Cosmic Inflation

- Universe expanded faster than it does today
- Beginning of all stars, organisms and complexities

The Annihilation of Matter and Anti-Matter

- 10 seconds after Big Bang

First Hydrogen & Helium Nuclei

- 3 minutes after Big Bang
- Hydrogen and helium later formed stars

Cosmic Background Radiation

- 380,000 years after Big Bang
- Slowly cooling down over this period
- Until cool enough for nuclei hydrogen and helium to capture electrons and create atomic matter.

Concepts

- There is nothing in the universe older than 13.8 billion years
- The universe is expanding
- There are other galaxies outside of our own, The Milky Way, which is 100,000 light years across, just one small island in a sea of at least 2 billion other galaxies
- Most of these galaxies are moving away from ours, **Doppler Effect**
    - If a galaxy is moving toward us, its light waves get bunched up, and so the light appears blue shifted on the electromagnetic spectrum.

    - Most galaxies, the overwhelming majority, are moving far, far away from us. And so their light waves are getting stretched out, appearing redshifted on the spectrum.
- All galaxies were once much closer
- The Primordial Atom – contained all the galaxies in our universe
- 1 second after the Big Bang, the universe was big enough for gravity, electromagnetism, and the strong and weak nuclear forces to come into being. The fundamental four of all physics
- 75% of universe is Hydrogen, 23% is Helium and the remaining includes the rest of the elements on the periodic table.
- 380,000 years after the Big Bang, Hydrogen and helium nuclei were cool enough to capture – electrons
- 13.82 billion years old, updated in 2013.

Controversies

- Time did not exist before the Big Bang
- There was no space before the Big Bang, without space there could be no concept of time
- The Big Bang began at a point of such intense pressure and heat that the very laws of physics themselves would have broken down.
- There is energy everywhere in the universe
- There is nowhere in the universe that contains "nothing"
- We are talking about a concept that has no reason to exist within the laws of the Universe. Why would we assume this human concept would exist anywhere else?
- The Universe is most likely a beige colour if viewed from outside, which is impossible as there is no space outside the Universe
- The universe is 93 billion light years across
    - Imagine the Universe is a cosmic bubble
    - The Universe is expanding faster than the speed of light and always accelerating
    - If we could travel faster than the rate the Universe is expanding, we still would not reach the "edge", we would eventually end up where we started.
    - There is no edge, because that would imply there is something beyond the edge. But there's no space. As far as we know, there is no outside (of our Universe).
    - Everything is expanding at once, so technically everything is the centre.
- A tiny spec to 93 billion light years across in 13.8 billion years
- What is the shape of the Universe?
    - Depends on the perspective
        - Expanding cosmos – a bubble
        - Total curvature of space time – flat like a tabletop with no edge and constantly expanding
        - 3 dimensions - Height, width, length plus the 4th coordinate of time, then you'd argue the Universe is shaped like a 4-dimensional donut
- Dark matter and dark energy are a big mystery to present day cosmology
    - Don't know what they are
    - They don't seem to change much

13.8-Billion-year Timeline

Simplest way to subdivide and conceive the 13.8 billion year narrative

Inanimate Phase

- 13.8 billion – 3.8 billion years ago
- Diverse chemicals, minerals and geological structures formed
- Evolves by accident of physics

Biological Phase

- 3.8 billion – 300,000 thousand years ago
- Inanimate and biological phase continue today
- Typified by living things that harness more energy flows and actively seek out energy
- Forms of complexity with much more structural intricacy

Cultural Phase

- 300,000 thousand years ago – present day
- Collective learning afforded much faster innovation and adaptation compared to natural evolution
- Rather than genes being passed from one generation to the next, ideas are passed on many times within a generation and then kept in the many generations to follow
- Innovations stack up and complexity goes into overdrive

Thresholds

Another way to track the major changes in complexity is to view Big History as a series of Thresholds:

1. The Big Bang
2. The Emergence of the First Stars
3. New Chemical Elements on the Periodic Table
4. The Solar System
5. Life on Earth
6. Evolution of a Species Capable of Collective Learning (Humans)
7. Invention of Agriculture
8. Modernity
9. The Future (conceptual)

Connections – Complexity and Energy Flow

Complexity

- Complexity is the unifying theme of big history.
- Complexity serves as a milestone, or yardstick, that helps us keep track of the vast chronology of this course.
- Big History can be split into 8 levels of complexity, the 8 thresholds
- No one precise definition can be agreed upon
- "we have a general notion that complexity represents all the stuff in the universe…"
- The sun is something of a very simple form of complexity

Energy Flows

- "the movement of a big clump of energy from one location with a lot of energy to another location with less energy"
- For the sun to burn, energy must flow from explosions in its cores to its surface
- Complexity depends on energy flows to be created in the first place
- Complexity depends on energy flows to sustain itself
- Complexity depends on energy flows to increase itself

System Complexity (ranked from lowest to highest)	Free Energy Rate Density (Averages of erg/g/s)
The Milky Way	0.1
The Sun	2
A Red Giant Star near to supernova	120
Algae (photosynthesizing)	900
Multi-celled plants (e.g. trees)	5000-10,000
Warm-Blooded Mammals (average)	20,000
Australopithecines	22,000
Human Foragers (Africa)	40,000
Birds in flight	90,000
Agricultural Society (average consumption)	100,000
19th century textile machine	100,000
A Human Brain	150,000
Industrial Society (average)	500,000
A Model-T Automobile (c.1900)	1,000,000
Modern Society (average consumption)	2,000,000
Average Airplane	10,000,000
A Jet Engine (F-117 Nighthawk)	50,000,000

- Complexity harnesses more and more energy flows, this is how it increases.
- **<u>Energy flows are required to create, sustain, and increase complexity</u>**

The First and Second Laws of Thermodynamics

First Law: "matter and energy are neither created nor destroyed"

- Now of the Big Bang, everything in the Universe today, already existed and has merely changed form in the last 13.8 billion years.
- Big History is a story of the same stuff in the Universe changing form, a cosmic evolution

Second Law: "energy will always flow toward equilibrium"

- Energy will always want to move from where there is more energy to where there is less energy
- Without energy flowing from one location to another, there would be no complexity nor increases in complexity

Unifying theme of big history

- Energy flows create, sustain and increase complexity