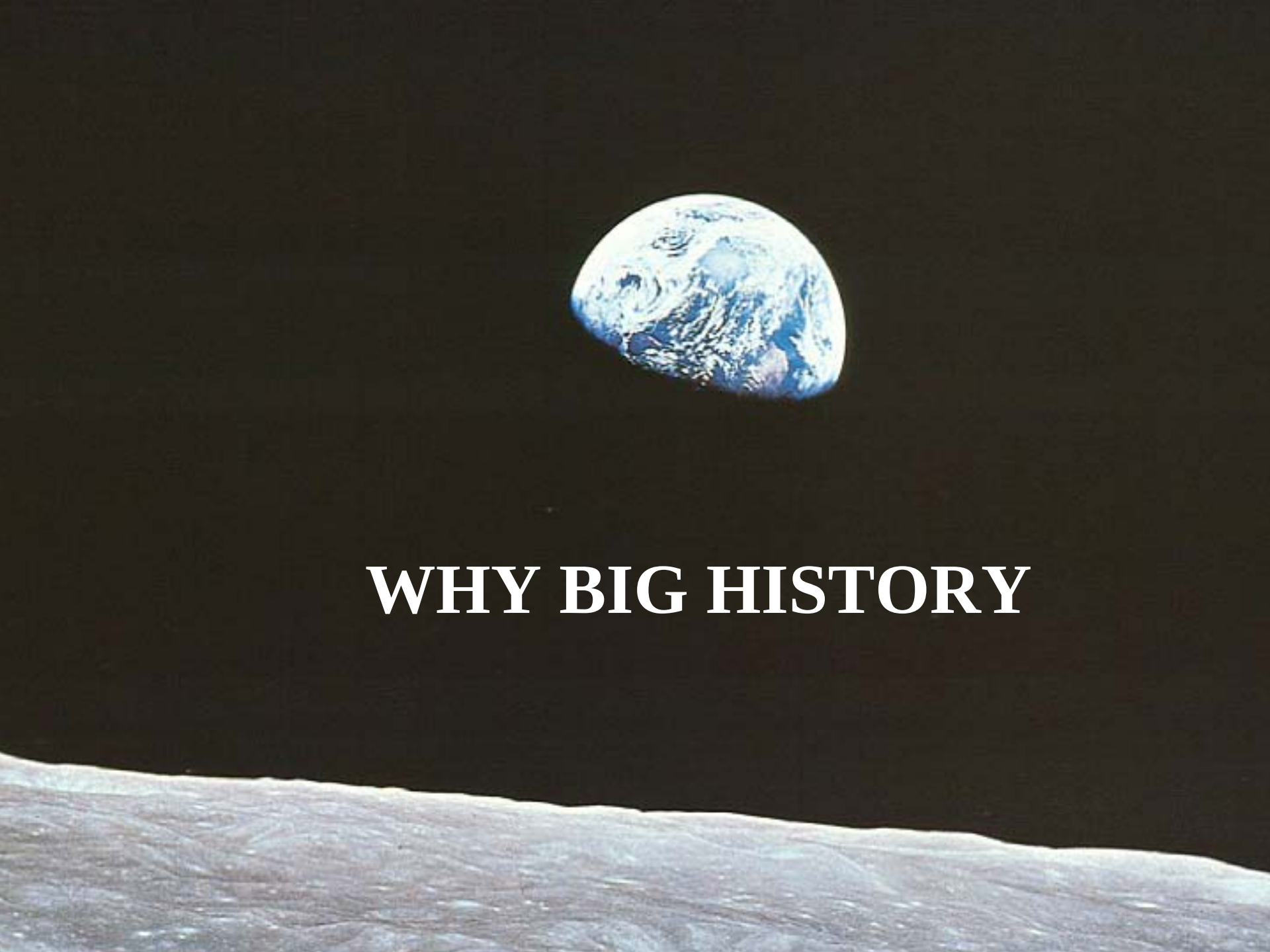

AUSTRALIA Independent state
Bermuda Dependency or area of special sovereignty
Azores Island / Island group
★ Capital
Greenland
CANADA
ROCKY MOUNTAINS
UNITED STATES
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
SIBERIA
RUSSIA
KAZAKHSTAN
MONGOLIA
CHINA
IRAN
ALGERIA
LIBYA
EGYPT
SAUDI ARABIA
SAHARA DESERT
MALI
NIGER
CHAD
SUDAN
ETHIOPIA
SOMALIA
INDIA
BRAZIL
BOLIVIA
PARAGUAY
CHILE
ARGENTINA
SOUTH AFRICA
INDIAN OCEAN
AUSTRALIA
NEW ZEALAND
KIRIBATI
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
SOUTHERN OCEAN
Antarctica
August 1999

Big History, the Universe, and When It All Began

What is Big History ?



WHY BIG HISTORY

I. Big History: What is it and why?

B. Practitioners

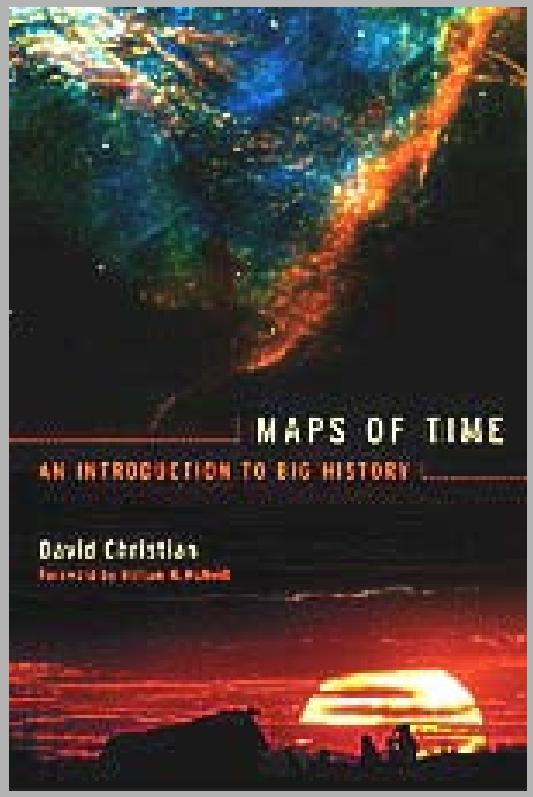
1. David Christian, *Maps of Time: An Introduction to Big History (2004)*

2. Fred Spier, *The Structure of Big History: From the Big Bang until Today (1996)*

   – "How Big History Works: Energy Flows and the Rise and Demise of Complexity," *Social Evolution and History* 4, no. 1 (2005): 87–135.

3. Eric Chaisson, *Cosmic Evolution: The Rise of Complexity in Nature (2001)*

Big History



David Christian, historian
San Diego State University, CA

How Big History Works: Energy Flows and the Rise and Demise of Complexity

Fred Spier
Institute for Interdisciplinary Studies,
University of Amsterdam

ABSTRACT

In this article, I advance an explanatory scheme for all of history from the beginning of the Universe until life on Earth today (big history). My scheme is based on the ways in which energy levels as well as matter and energy flows have made possible both the rise and demise of complexity in all its forms.

INTRODUCTION[1]

Surely, any claim to explain all of history must sound preposterous. So let me be clear about my aims and claims. To begin with, I do not claim to have found exhaustive explanations for every little thing that has ever happened in history. Far from it. Explaining any part of the past always means striking a balance between chance and necessity. My explanatory scheme is about necessity. It consists of general trends that make possible and constrain certain forms of complexity. Yet within these bounds, there is ample room for chance. Although in this essay I do not systematically focus on chance, the reader should keep this in mind[2].

The central concepts of my scheme are matter, energy and entropy (disorder). This will be elaborated below. Seen from the modern scientific point of view, everything that has existed has been composed of matter and energy of some sort. A major advantage of using such general terms is that they are applicable to all aspects of big history. A second major advantage is that no new physics are needed in order to understand the course of big history.

Social Evolution & History, Vol. 4 No. 1, March 2005

I see my explanatory scheme as a further elaboration of concepts explained in my book *The Structure of Big History* (1996). There, I proposed to employ the term *regimes* for all more or less structured processes that make up big history. Now, it seems to me that regimes are not only very useful for describing big history but also for explaining it.

In addition to the general insights into the workings of matter, energy and entropy that I gained during my career in chemistry, my understanding of energy flows has been strongly influenced chronologically by the writings of Marvin Harris (1975, 1980), Jeremy Rifkin (1981), I. G. Simmons (1993, 1994), David Christian (over the period 1991–2004), Ilya Prigogine and Isabelle Stengers (1984), Stuart Kauffman (1993, 1995), Eric Chaisson (over the period 1981–2005), Erich Jantsch (1980), Vaclav Smil (1994) and Leslie White (over the period 1943, 1975)[3]. My argument leans heavily on Eric Chaisson's scholarship, most notably his book *Cosmic Evolution: The Rise of Complexity in Nature* (2001), and also on David Christian's work: his article 'The Case for "Big History"' of 1991 and his book *Maps of Time: An Introduction to 'Big History'* published in 2004. Also the historian John R. McNeill recently wrote an overview pointing in the same direction (2003: 319–323). The synthesis presented here must, therefore, to a considerable extent be considered a communal product.

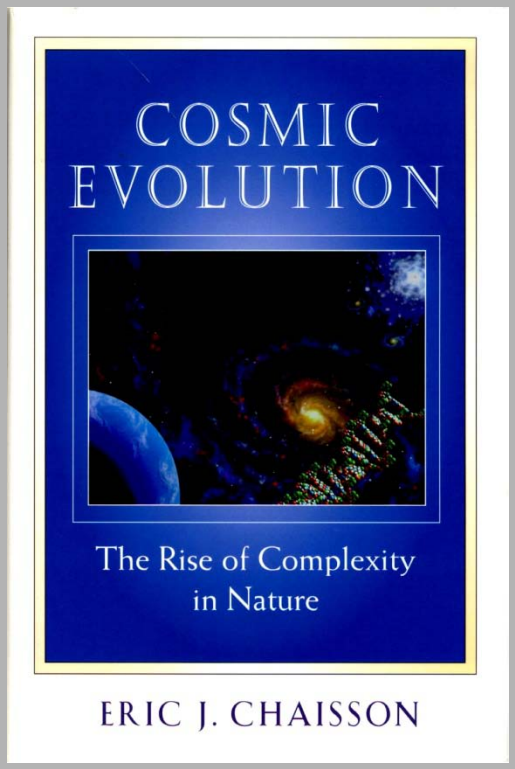
As a result of limited space, in this article I have stripped the argument down to its barest essentials. Many nuances, examples and elaborations needed to be scrapped. Those readers who are not satisfied by this approach will have to wait until my book on the same subject will appear in print, hopefully in a few years' time.

COMPLEXITY AND COSMIC HISTORY

The history of the Universe is the history of emerging complexity. In the beginning there was no complexity at all. The further the Universe evolved the more complex some portions could become. Right now, after about thirteen billion years of cosmic evolution, the human species is arguably the most complex organism in the entire known Universe.

Seen from the most general point of view, complexity is the result of interactions between matter and energy, resulting in more or less complex arrangements of matter (I will call them *matter regimes*). Cosmic history, therefore, primarily deals with the question of how these matter regimes have formed,

Cosmic Evolution



Eric Chaisson, astrophysicist
Tufts University, Harvard University

I. Big History: What is it and why?

B. Practitioners

4. John R. McNeill and William H. McNeill, *The Human Web: A Bird's Eye View of World History* (2003)

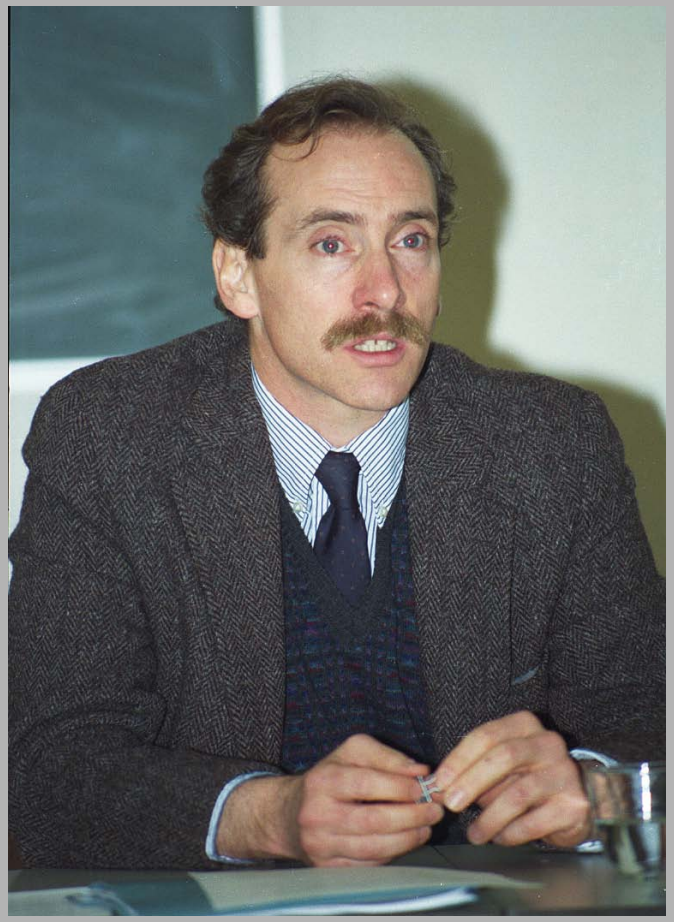
5. N. S. Kardashev (Russian astrophysicist)

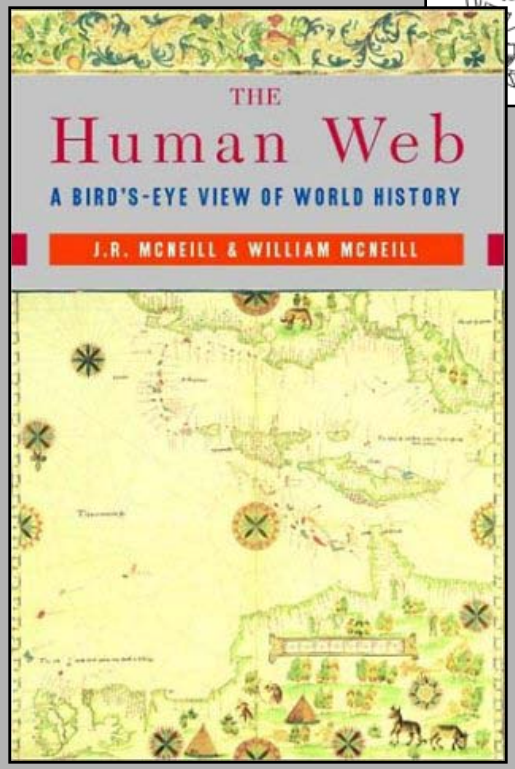
–Levels of technologically developed civilizations

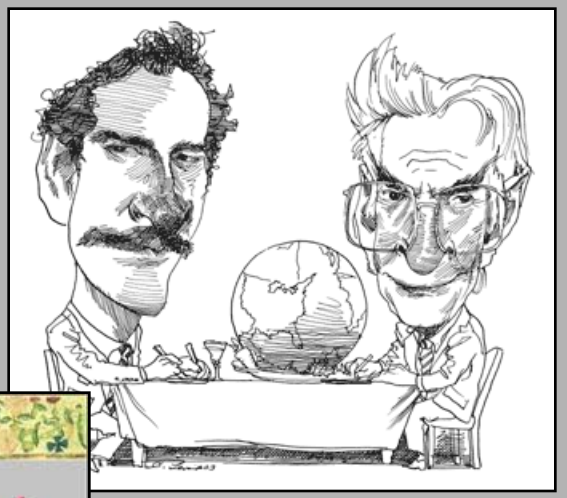
I – energy consumption at the planetary level

II – energy consumption at the solar system level

III – energy consumption at the galactic level





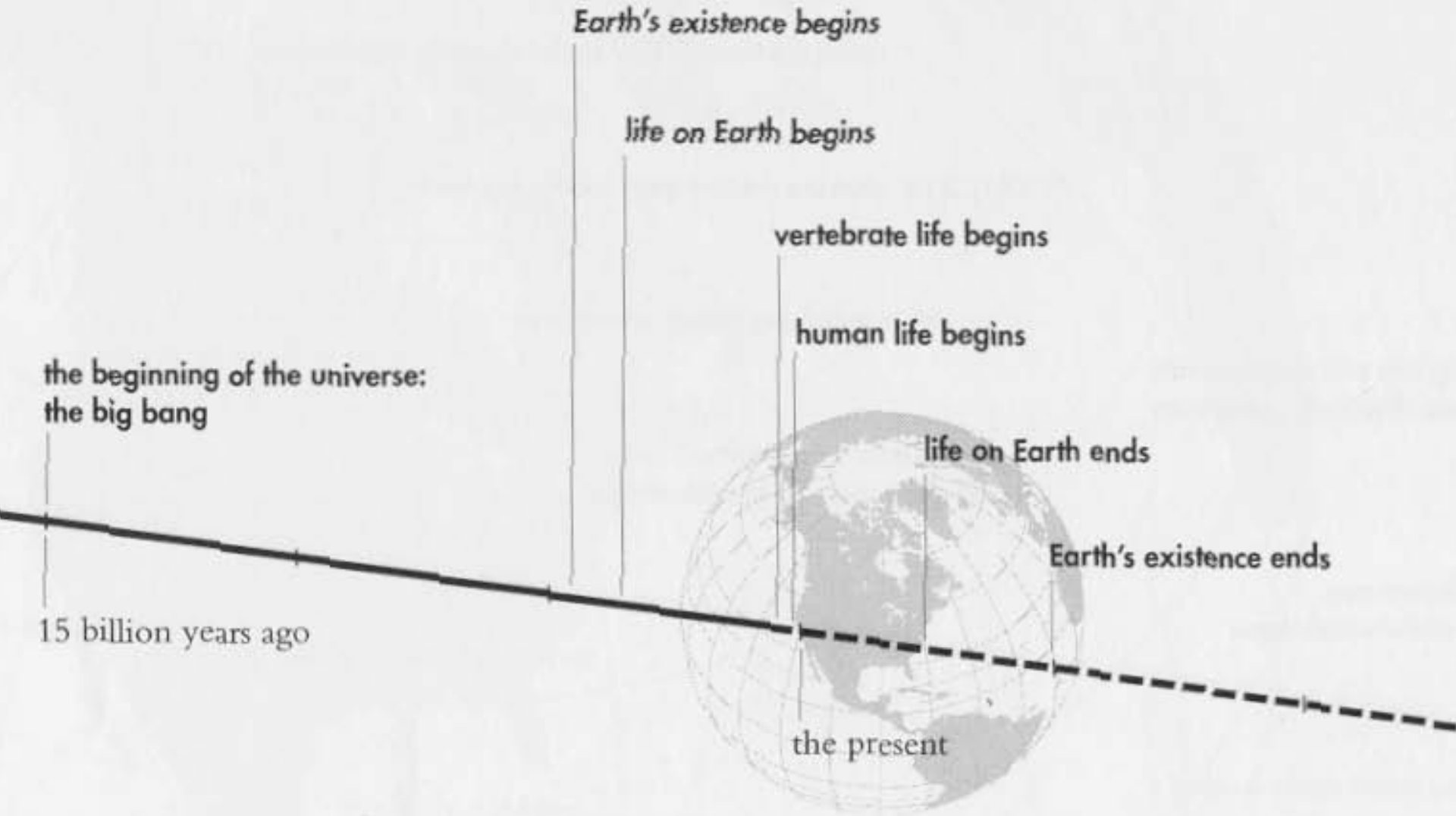


John McNeill, historian

Georgetown University, Washington D.C.

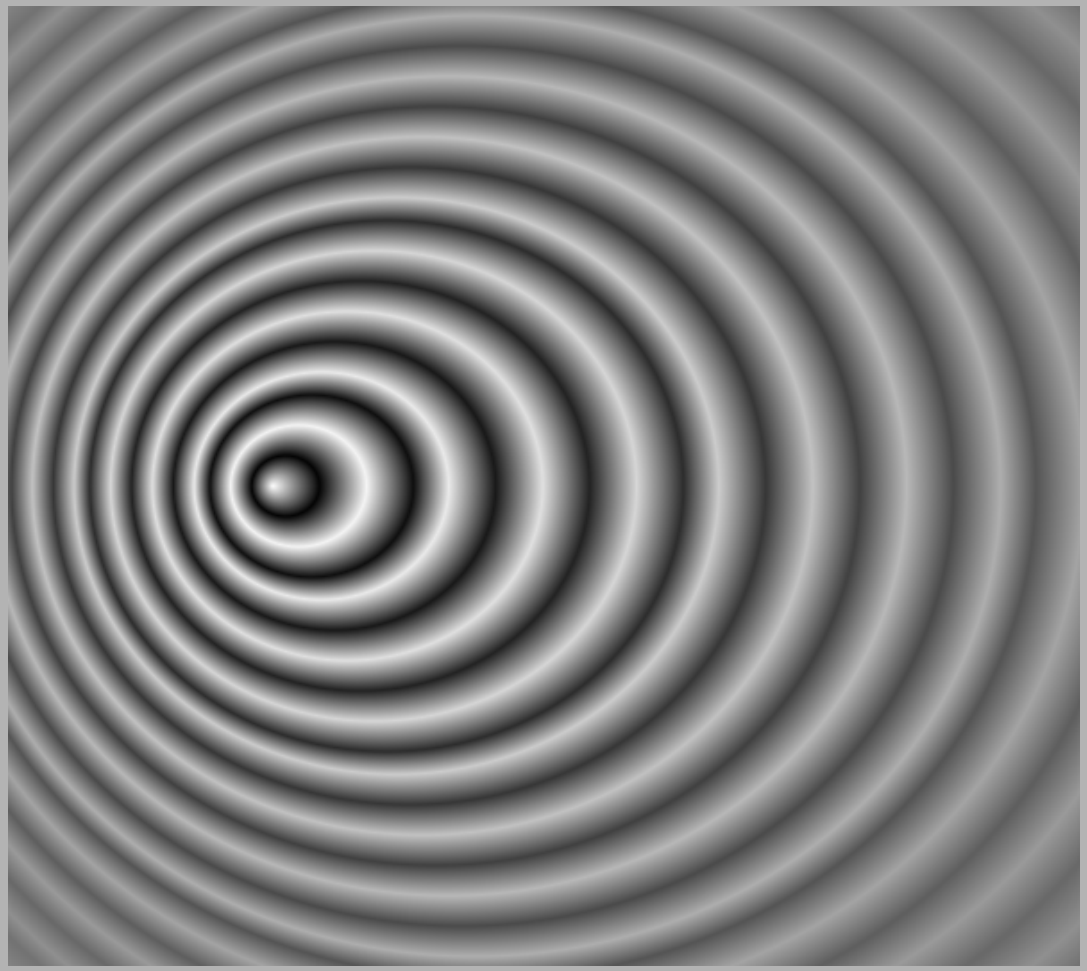
The Place of Human History within Big History

Video: Carl Sagan, *Cosmos*, no. 1: “The Shores of the Cosmic Ocean“ (excerpt)

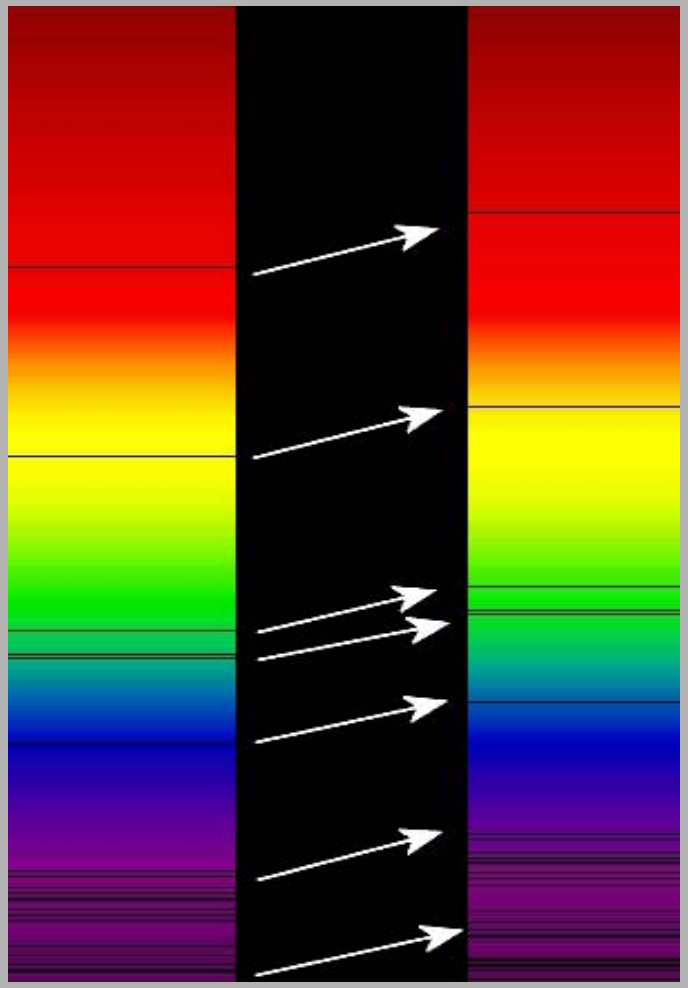


Source: Packard: *Imagining the Universe: A Visual Journey*, p. 146

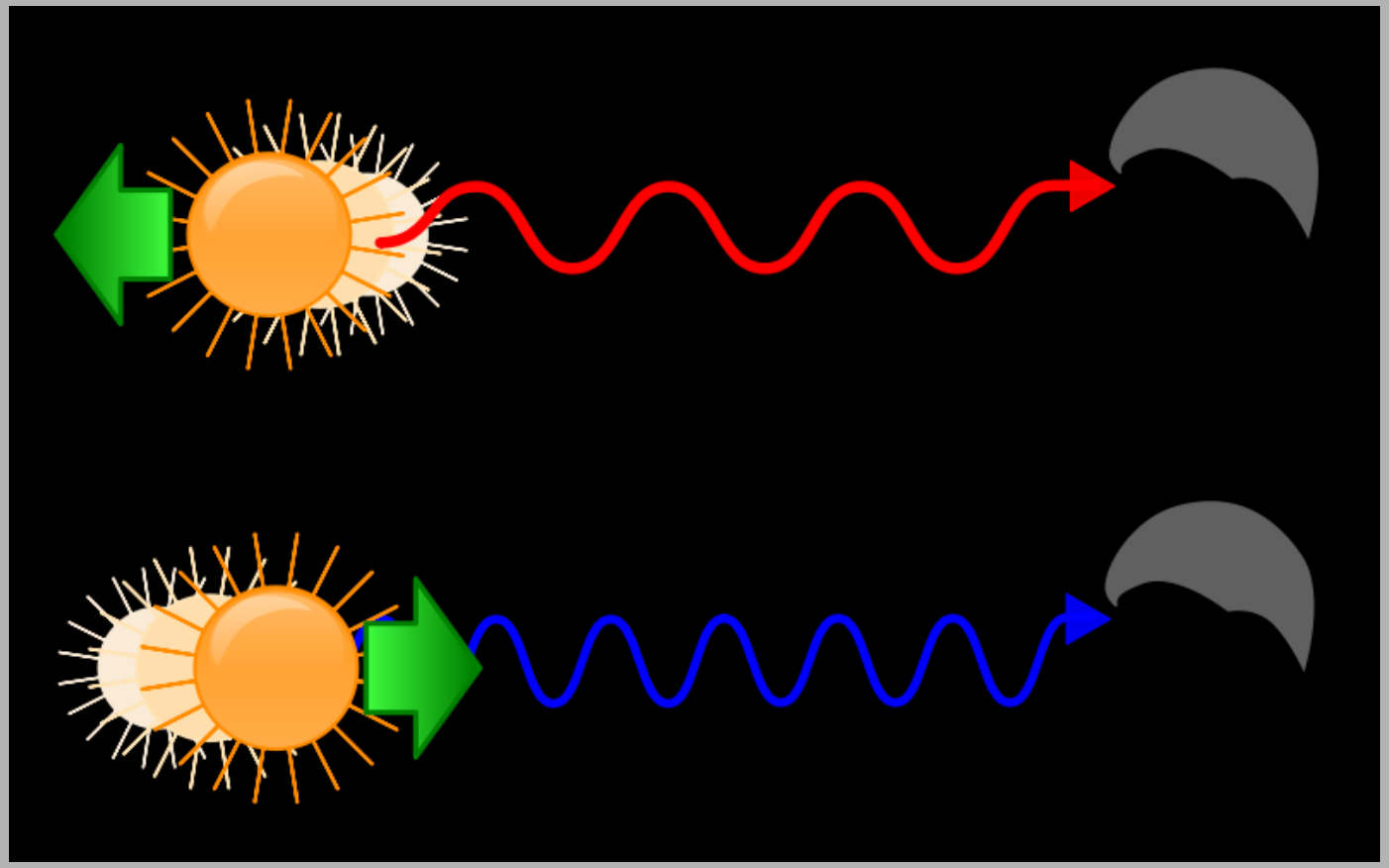
Doppler Effect – Object Moving to the Left



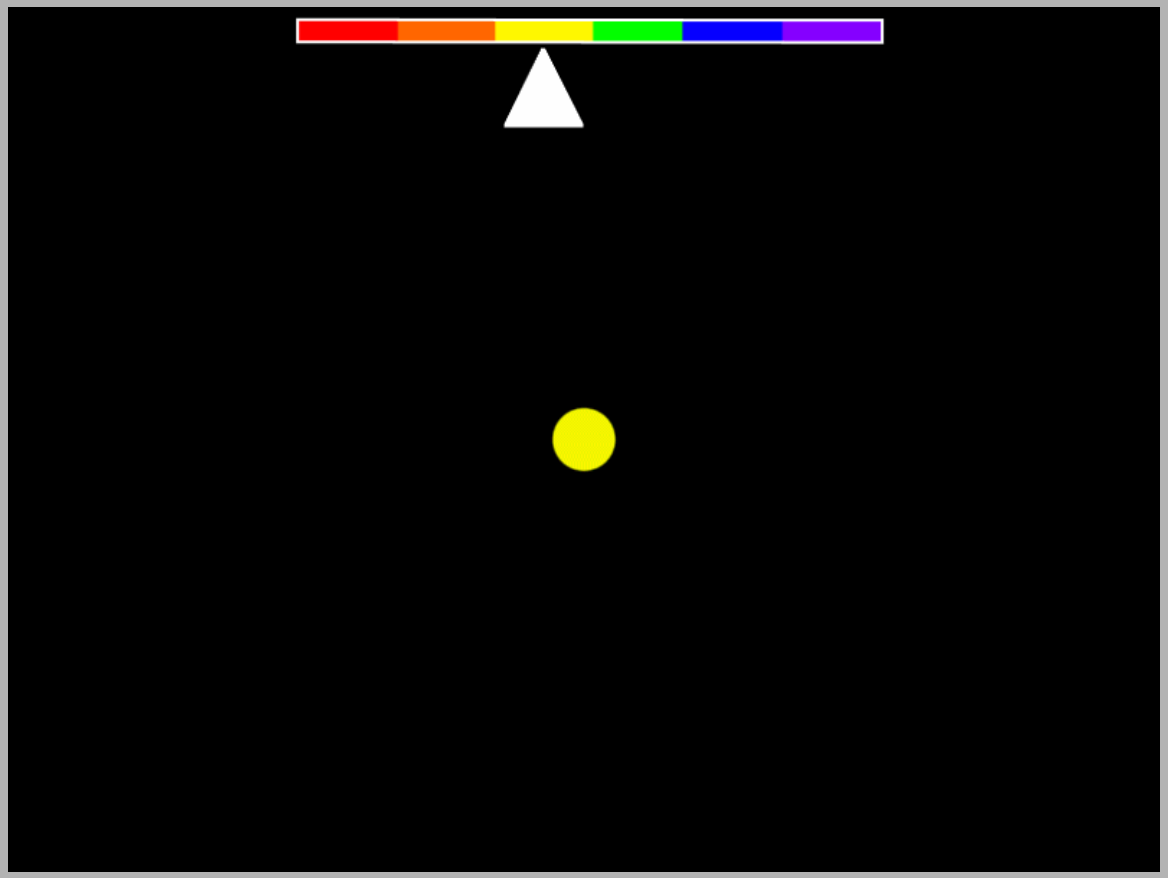
Optical Spectrum of Sun (left) and a Distant Galaxy (right



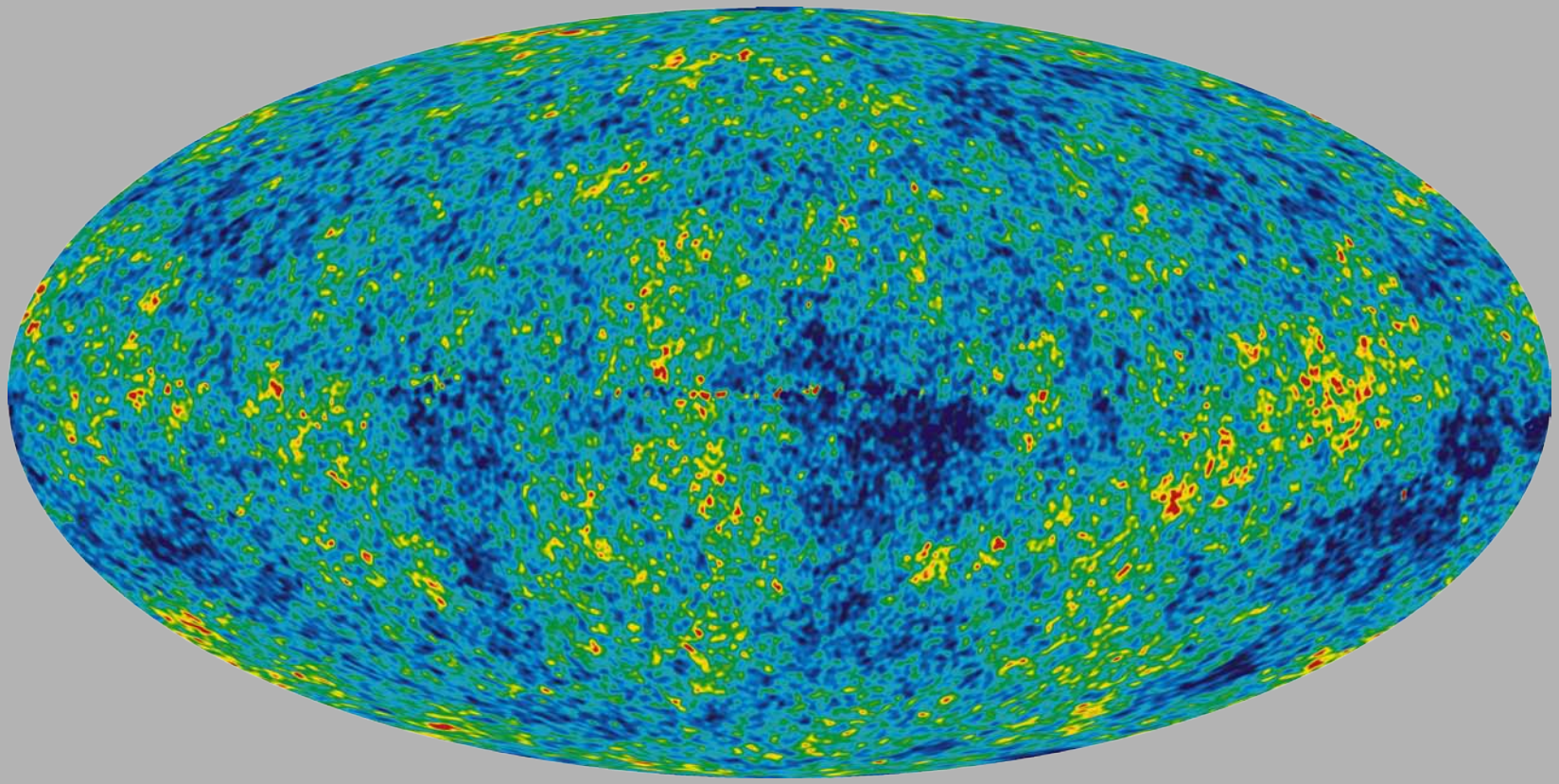
Redshift - Blueshift



Doppler Effect as Red Shift



Cosmic Microwave Background



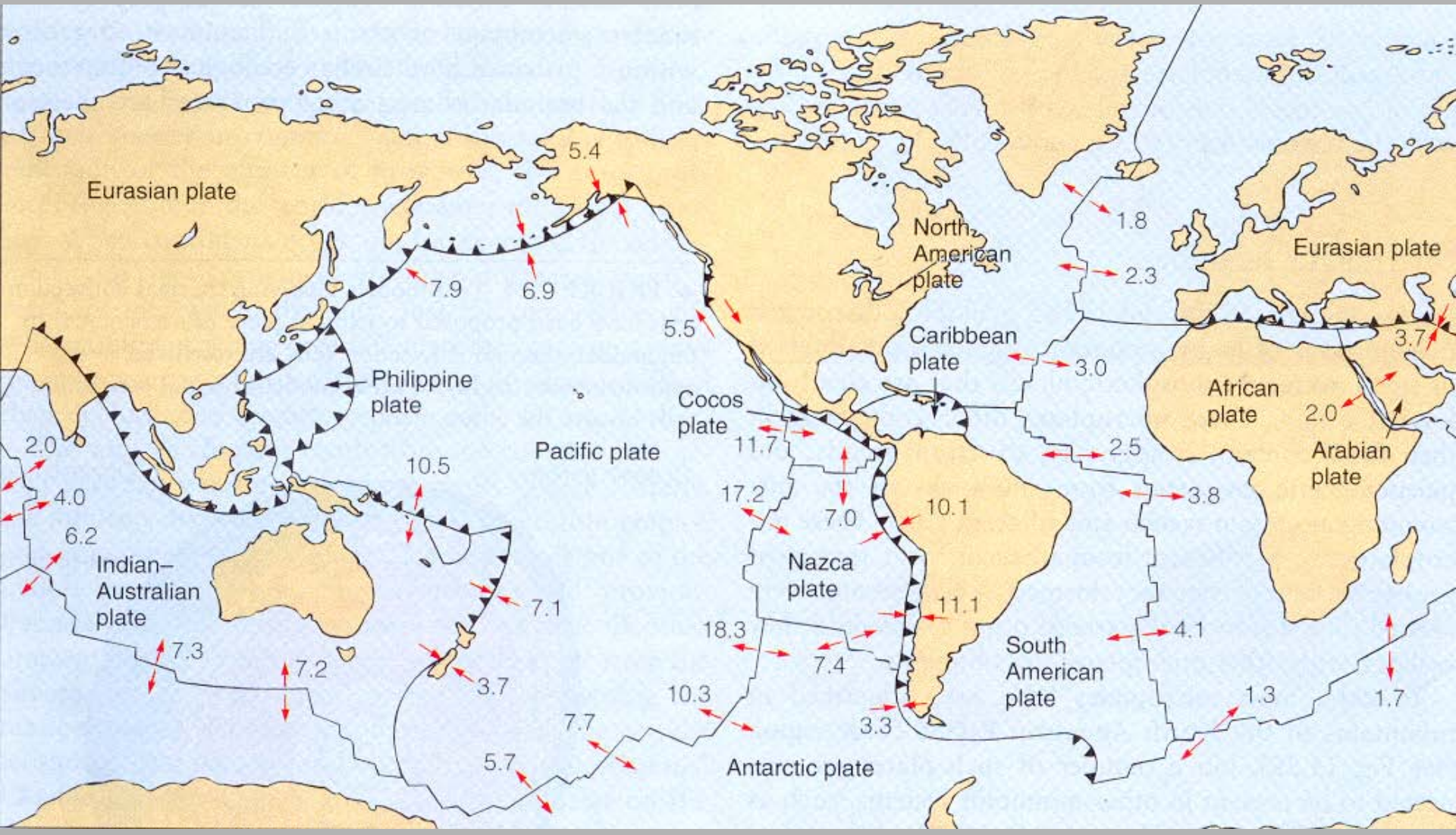


Plate Tectonics: Moving Continents

Source: Wicander & Monroe: *Historical Geology, p.191*

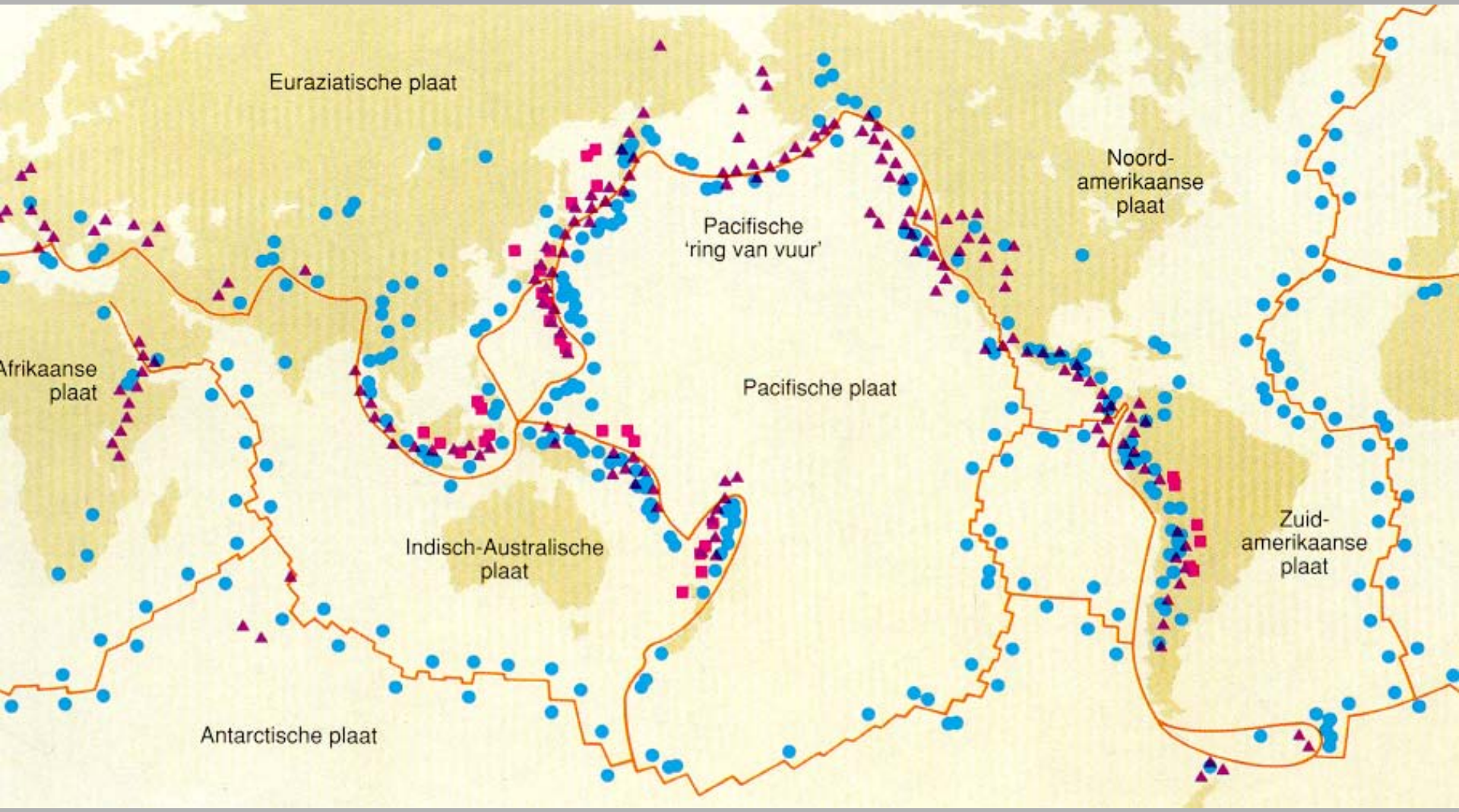
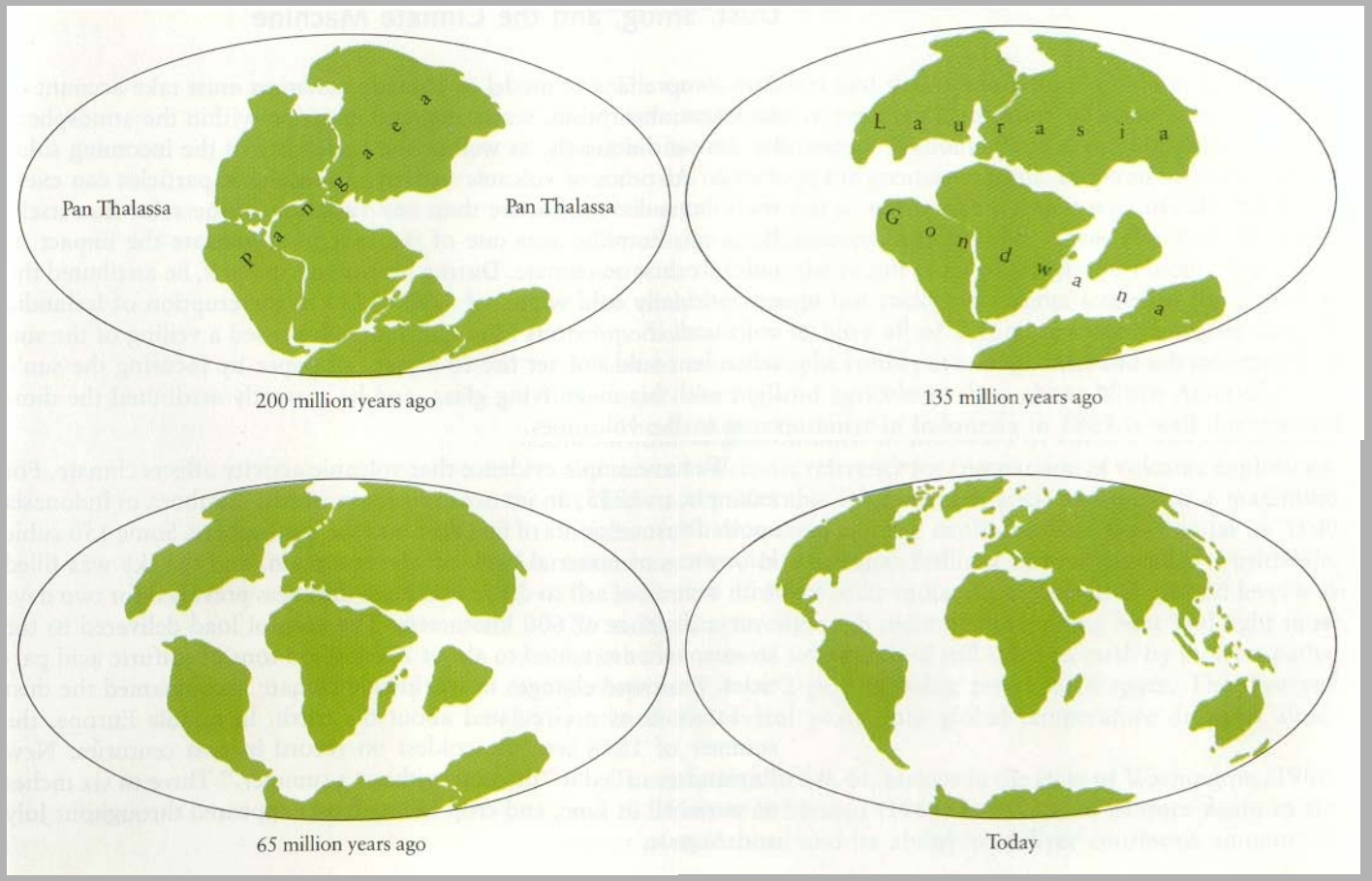


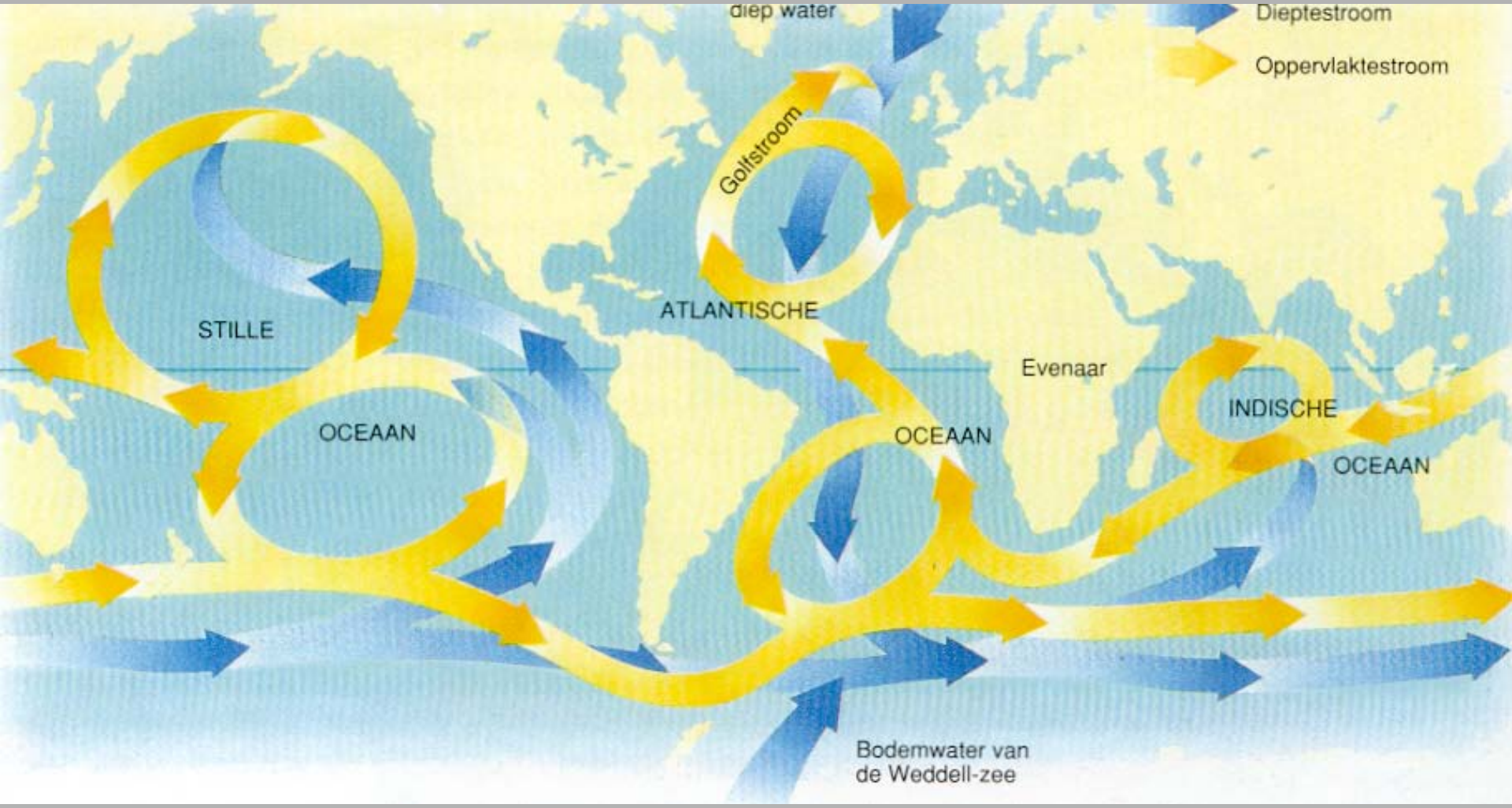
Plate Tectonics: The Ring of Fire

Source: Elsom: *De Evolutie van de Aarde*, p.48



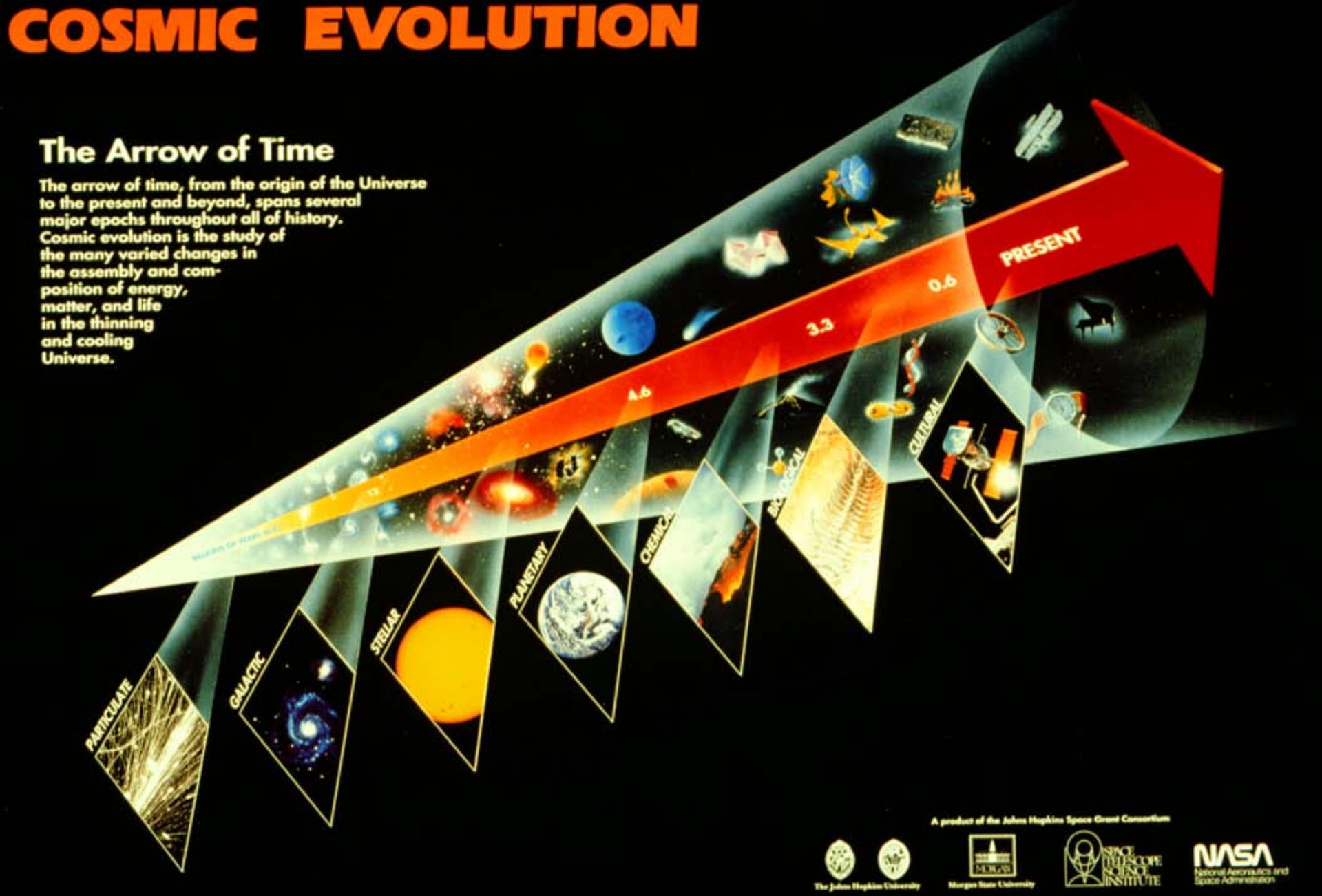
From Pangaea, ca. 200 Million Years B.P., to the Present

Source: Friedman: *Sun and Earth*, p.217



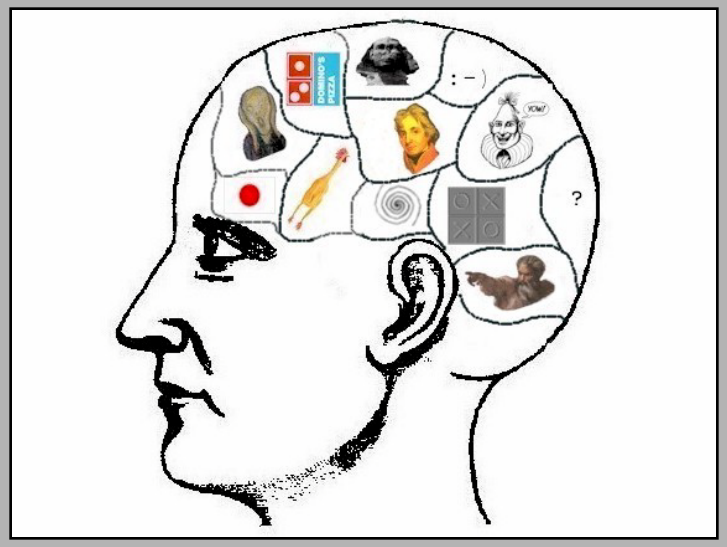
The Most Important Ocean Currents

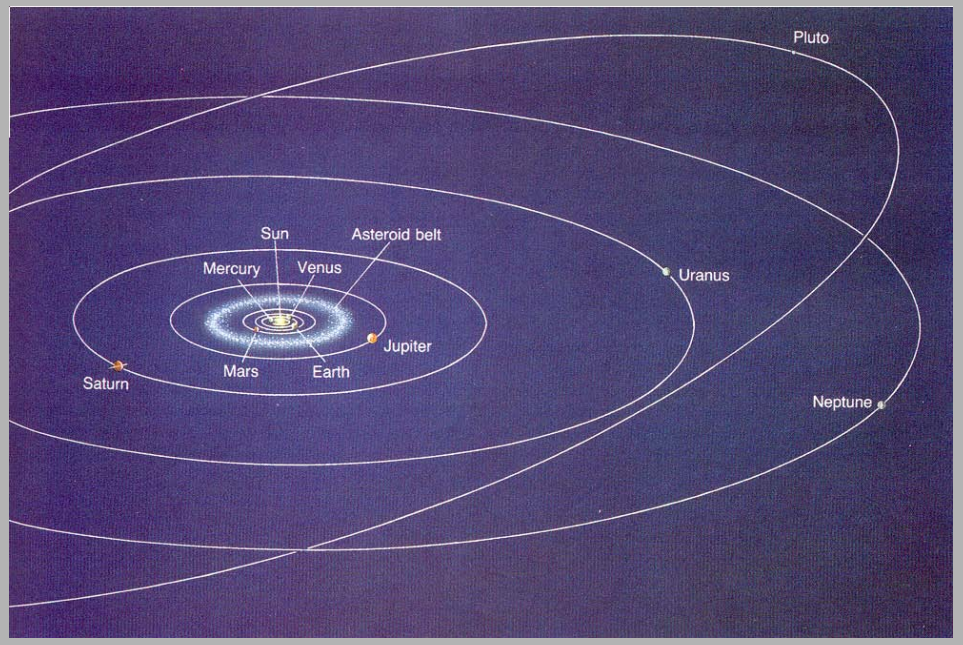
Source: Elsom: *De Evolutie van de Aarde*, p.124

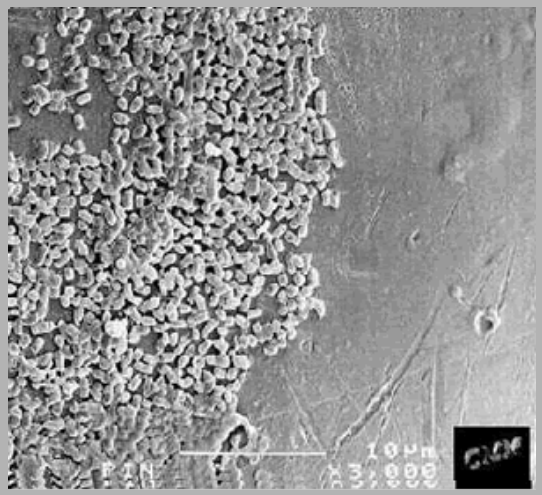


Wright Center for Science Education, Tufts University, Boston, MA, USA

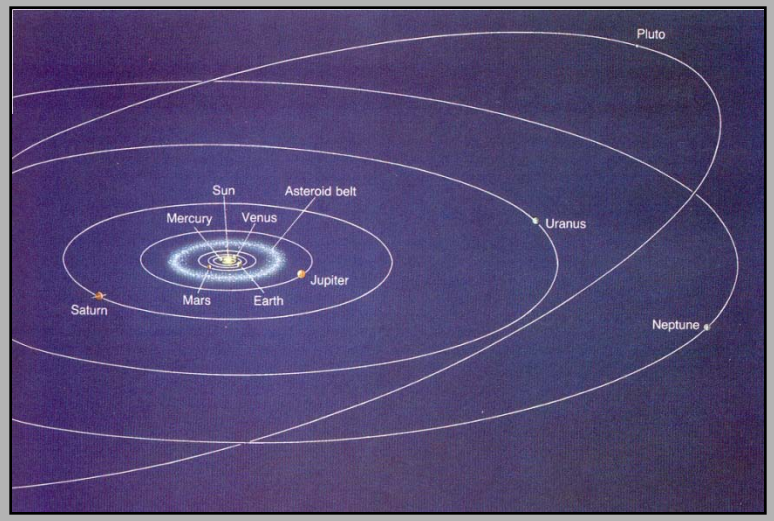
Is There Some Unity in Big History ?

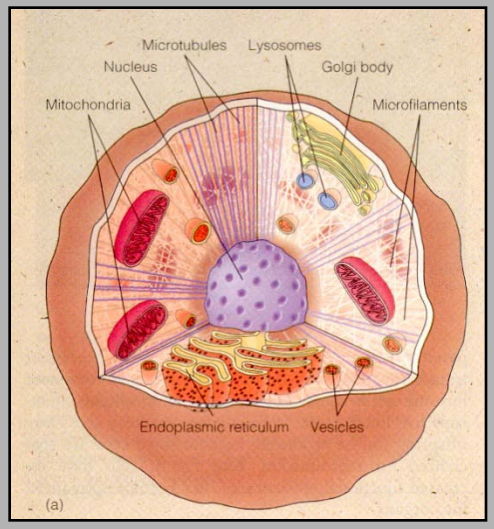


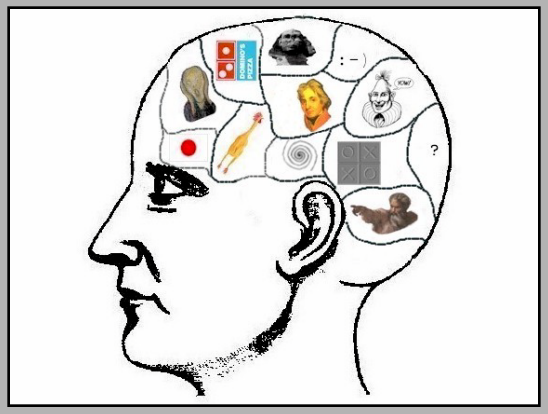




Bacteria on the head of a pin



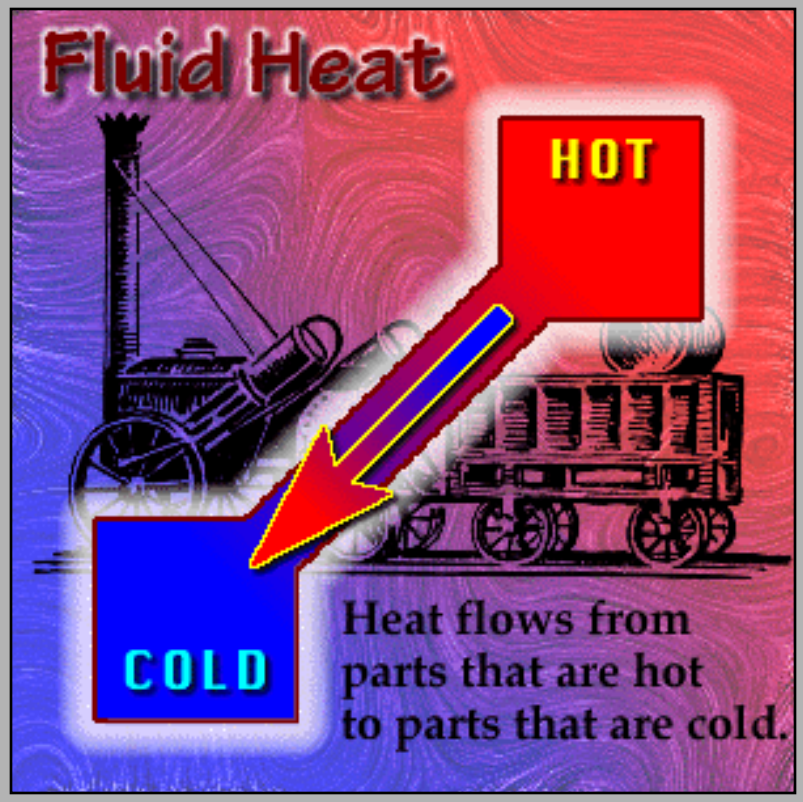


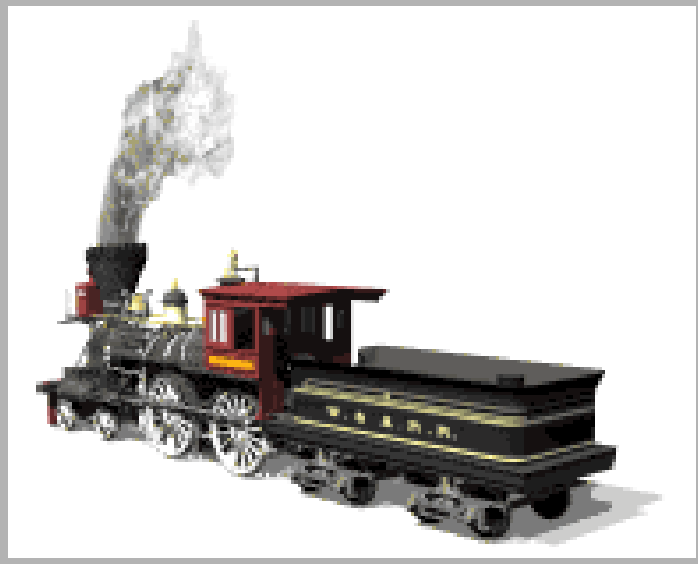


Big History is the history of

LOCALLY INCREASING COMPLEXITY

The Rise of Complexity Requires an Energy Flow through Matter





Free Energy Rate Density:

$$\Phi_m = \frac{\text{Energy (erg)}}{\text{Mass (gram) x Time (seconds)}}$$

Source: Eric Chaisson, *Cosmic Evolution*

Table 2. Some Estimated Free Energy Rate Densities

Generic Structure	*Approximate Age (10^9 y)*	*Average Φ_m (erg $s^{-1}g^{-1}$)*
galaxies (Milky Way)	12	0.5
stars (Sun)	10	2
planets (Earth)	5	75
plants (biosphere)	3	900
animals (human body)	10^{-2}	20,000
brains (human cranium)	10^{-3}	150,000
society (modern culture)	0	500,000

Source: Eric Chaisson: *Cosmic Evolution*, p.139

Locally Emerging Complexity Produces More Disorder (Waste) Elsewhere

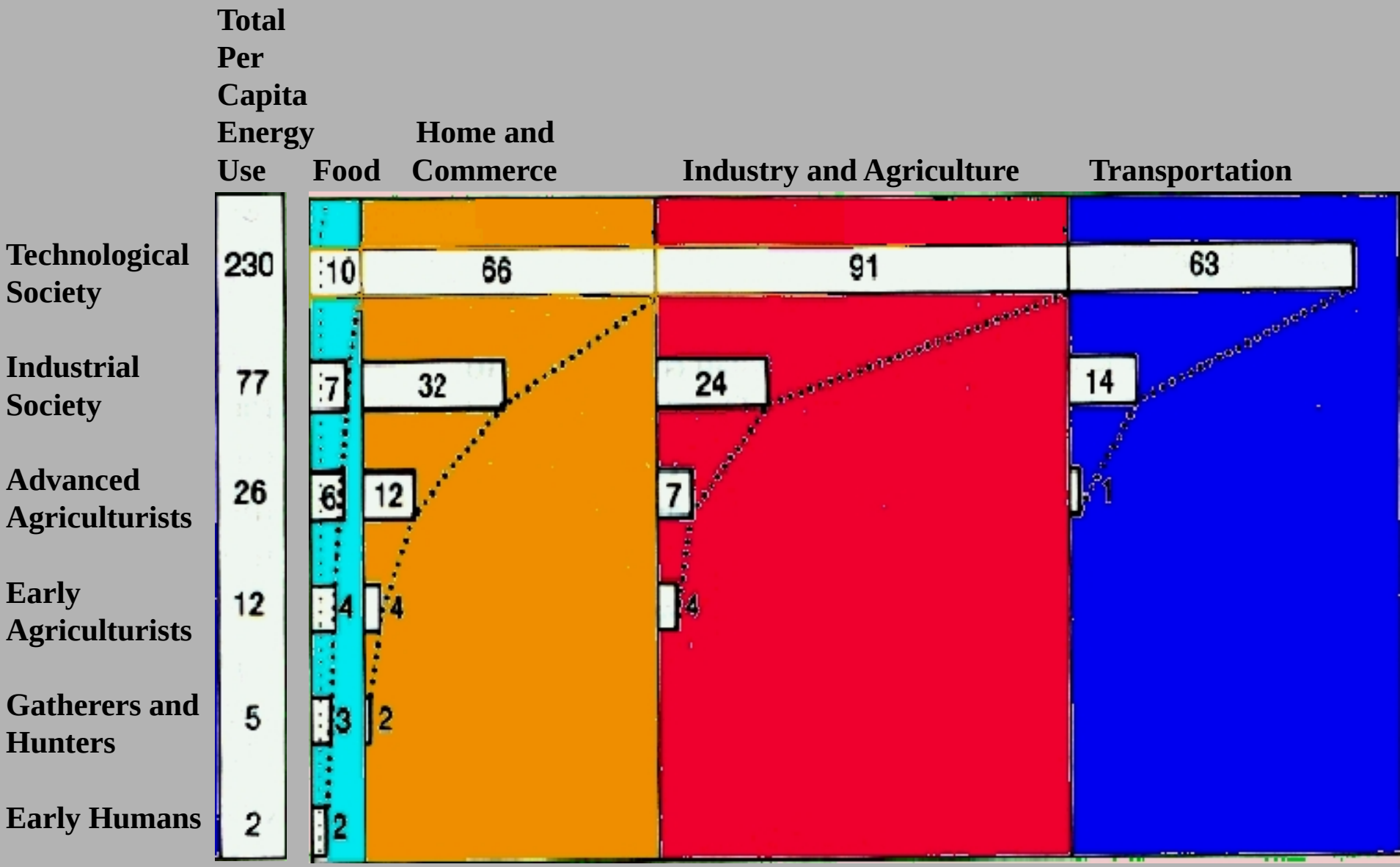
Eric Chaisson:

The increase of local complexity is possible thanks to the expansion of the Universe, which acts as a trash can for disorder (entropy)

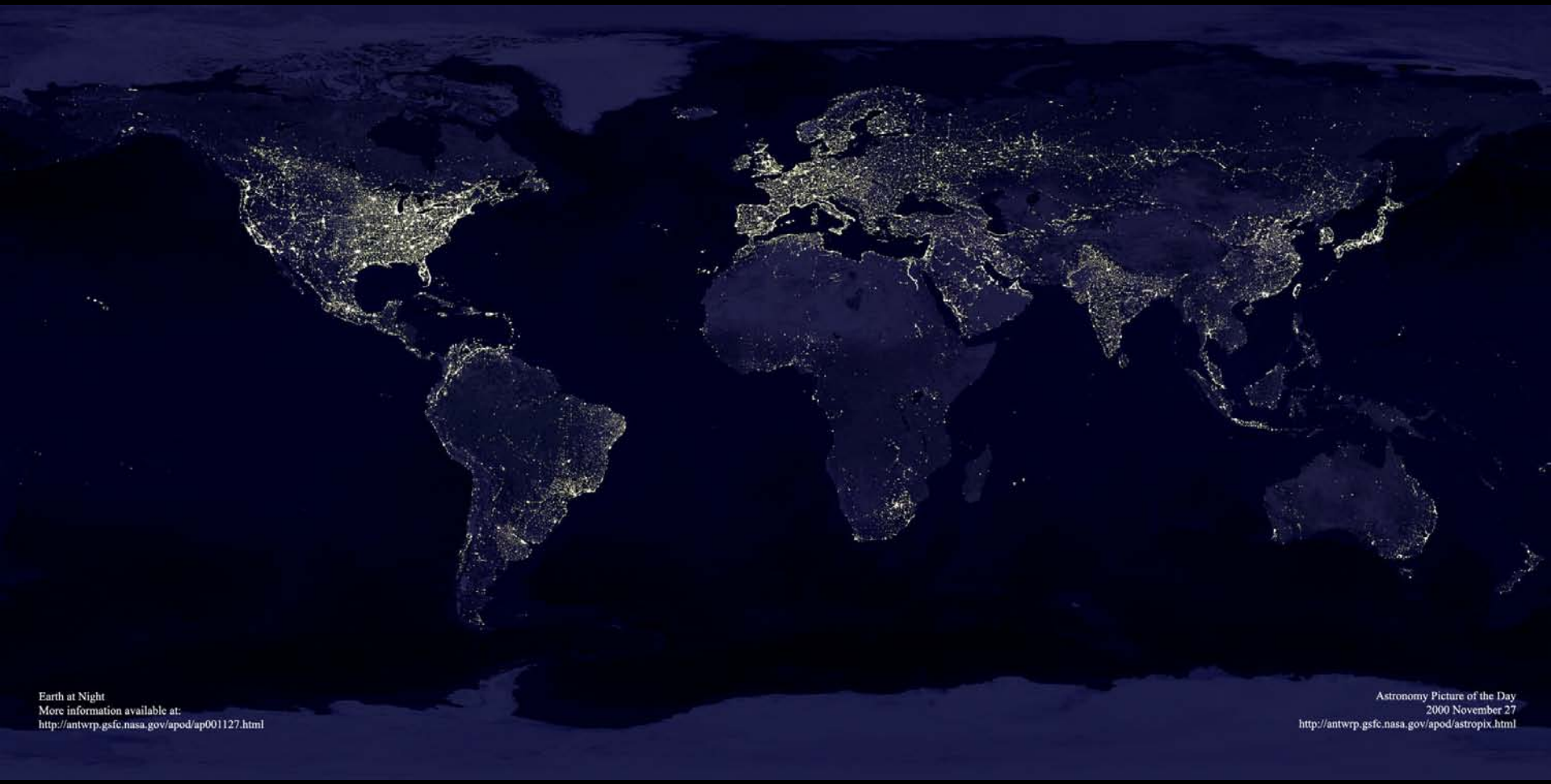
The Most Important Trend in Human History:

- **Humans have increasingly influenced the rest of nature with the aid of culture *(collective learning)***

- **in order to extract matter and energy for their survival and prosperity**



Adapted from: I.G. Simmons: *Changing the Face of the Earth*, p.24


Earth at Night
More information available at:
http://antwrp.gsfc.nasa.gov/apod/ap001127.html
Astronomy Picture of the Day
2000 November 27
http://antwrp.gsfc.nasa.gov/apod/astropix.html

II. Theories of the Age of the Universe

A. Religious Interpretations

1. Cosmologies of various cultures = "Once upon a time...."

2. The Bible = "In the beginning. . . ."

3. Hindu writers (ca. 400 B.C. to ca. 200 A.D.) = interminable cycles of 8.64 billion years each

(*kalpa* = 4.32 billion years)

II. Theories of the Age of the Universe

B. Calculations

1. Theophilus of Antioch, Christian writer (2nd cent. A.D.)
   = 5515 B.C. ± 200

2. Jewish writers—both lunar and solar calculations
   = 5770 years ago

3. Mayan Calendar = 1 million years ago

4. James Ussher, English Archbishop (1581–1656)
   = October 22, 4004 B.C.

II. Theories of the Age of the Universe

C. Estimates Based on Gathered Evidence

1. Georges Buffon, French Naturalist (1707–1788)
   = “at least 70,000 years ago”

2. Abraham Werner, German Geologist (1749–1817)
   = “a million years ago”

3. Charles Darwin, English Naturalist (1809–1882)
   = 300 million years

II. Theories of the Age of the Universe

C. Estimates Based on Gathered Evidence

4. The Scientific View of Mid 20th to Early 21st Century
= 6.4–20 billion years ago

a. Edwin Hubble, American Astronomer (1889–1953)
b. Milton Humason (1891–1957)
c. Red Shift, Doppler Effect,
d. “Big Bang” – term coined by Fred Hoyle in 1949
e. George Gamow, *One, Two, Three ... Infinity* (1947)

II. Theories of the Age of the Universe

C. Estimates Based on Gathered Evidence

4. The Scientific View of Mid 20th to Early 21st Century
   = 6.4–20 billion years ago

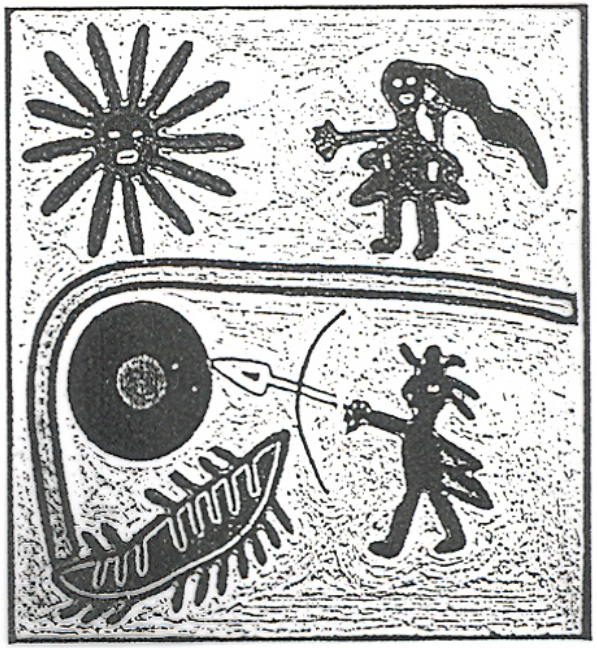
5. Some Dissenting Views
   a. Halton C. Arp—"The Most Feared Astronomer on Earth"
   b. Hannes Alfen—plasma theory

III. Creation Theories

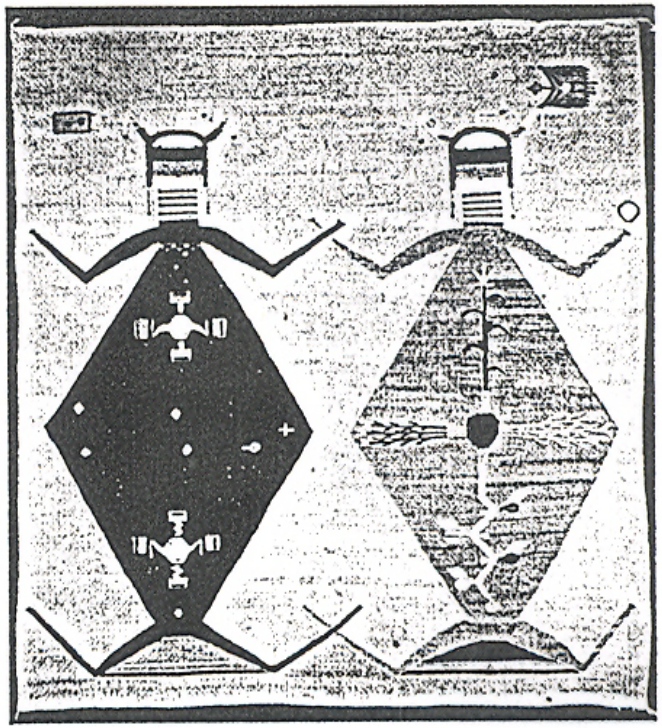
A. Some Non-Scientific Theories

An ancient Chinese creation image showing the intertwined double helix, representing an interaction of opposites, resulting in the Creation. Constellation images are behind the creator gods. Courtesy Museum of Fine Arts, Boston.

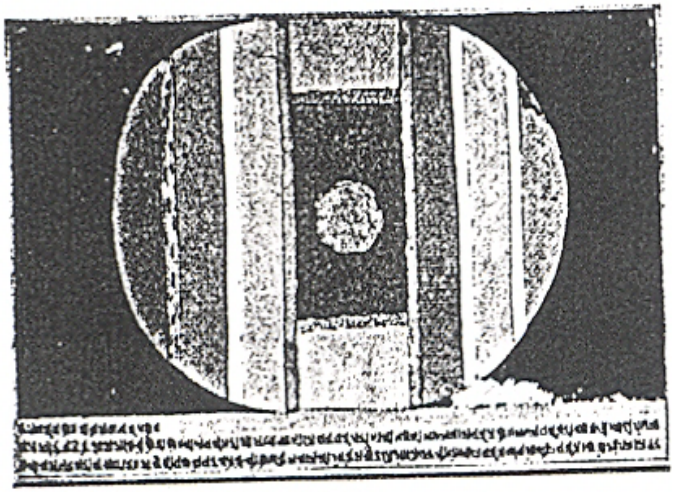
A Huichol beeswax-and-yarn painting from Mexico depicting the Creation. In this image, we see the first beings. The five serpents are the Mothers of Water and represent terrestrial waters. At right the first plant appears, bearing both male and female flowers. At left the Sun Father is flanked by the Morning Star. Courtesy Peter Furst, Delmar, New York.



A Huichol painting showing the origin of the Sun. At upper left the as-yet-unborn Sun is hailed by the Earth Goddess while her son shoots arrows at a solar wheel just before his sacrifice and transmogrification into the solar deity. The rayed shape -lower left is the western lagoon into which the boy descends on his subterranean journey to the east and the first sunrise. Courtesy Peter Furst, Delmar, New York.

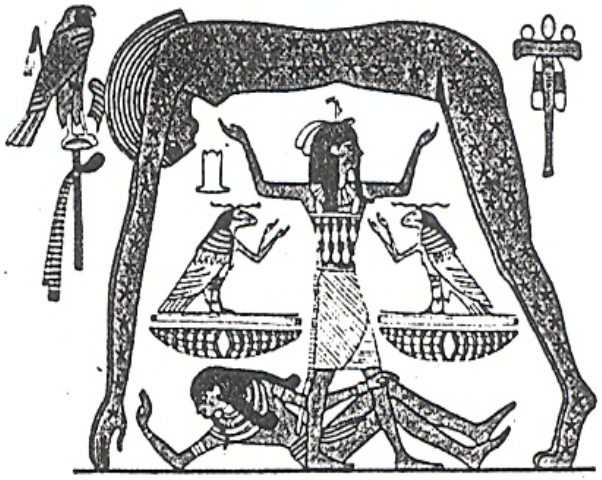


Navajo sand painting, "Father Sky and Mother Earth." Within the black image of Father Sky at left are the various constellations, including, middle, the Big Dipper. Mother Earth, at right, contains within her the Navajos' four sacred plants: beans, corn, tobacco and squash. At upper right is a bat with a medicine pouch (the small yellow diamond) and representing "good." Courtesy Denver Museum of Art, Denver, Colorado.

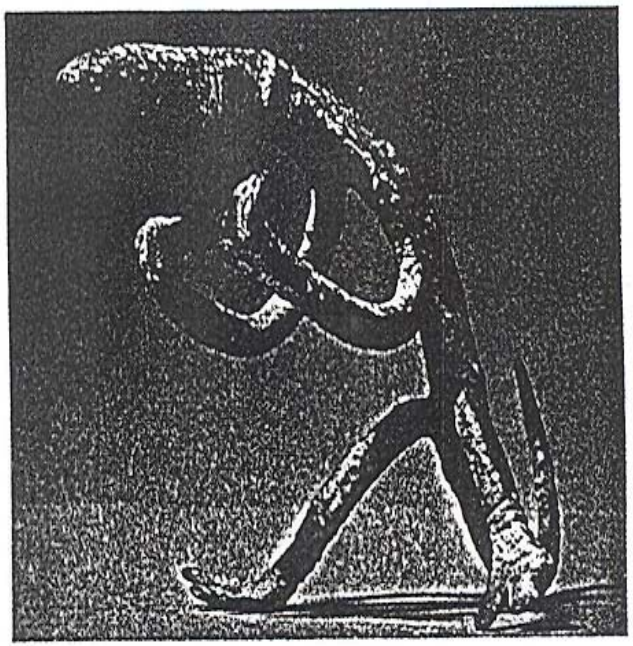


The Tantric Buddhist conception of "pure Being" in the form of a "world egg." At fertilization, the egg differentiates into the female "life force" at center and the male activating energy (the dividing lines). Conscious life emerges. Photograph by Ajit Mookerjee from *Tantra: The Indian Cult of Ecstasy* by Philip Rawson.

The traditional Judeo-Christian view of the Creation of the Cosmos. God (top) makes the Earth and its inhabitants (the first humans, Adam and Eve, at center). Surrounding the Earth are birds, clouds, the Sun, the Moon and the stars, above which are "the waters of the firmament." From Martin Luther's *Biblia*, published by Hans Lufft, Wittenberg, 1534.



A modern rendering of a common ancient Egyptian motif of creation. In this depiction, Shu, god of light and air (arms raised), separates Nut, goddess of the sky, from Geb, god of the Earth, reclining below. Minor deities assist. The falcon figure at left is Horus, god of Lower Egypt and later identified with the reigning pharaoh. Courtesy Brown.



A Dogon creation image from the Republic of Mali, showing Nommo, a phallic creation god, caught at the instant of his metamorphosis into a crocodile. Courtesy Lester Wunderman, New York, New York.

III. Creation Theories

B. Scientific Theories

1. Steady State (Fred Hoyle)
2. Big Bang and the Expanding Universe

IV. Relationship between Religious and Scientific Views

1. Flatland (Edwin Abbott) and The Fourth Dimension

2. Oscillating Universe and Universes within Universes (Hindu cosmology)

Video: Carl Sagan, *Cosmos*, no. 10: “The Edge of Forever “ (excerpt)