



Animate Earth

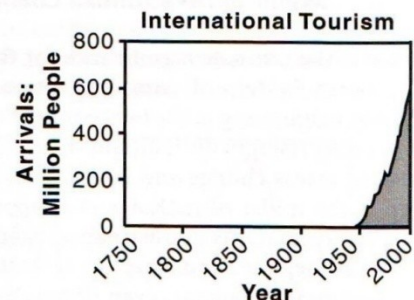
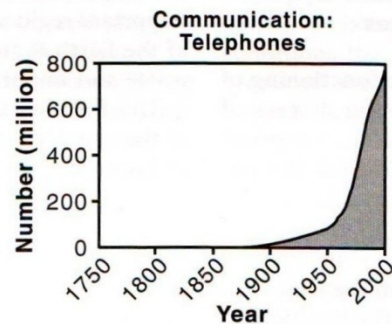
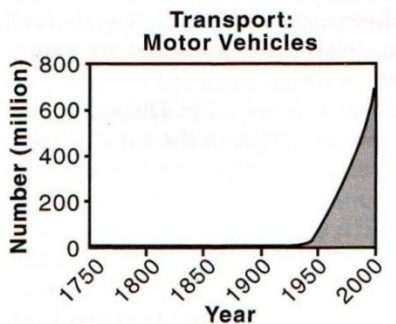
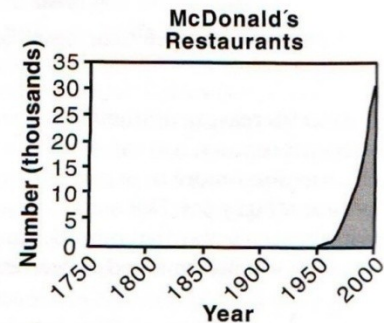
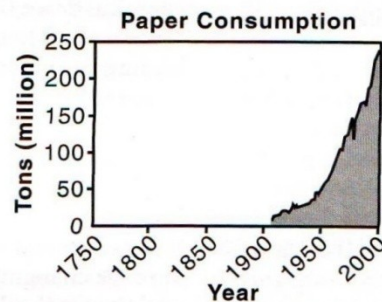
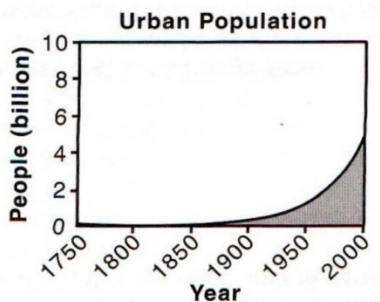
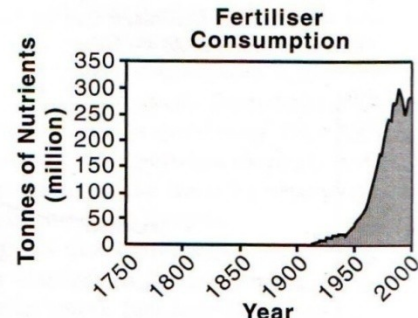
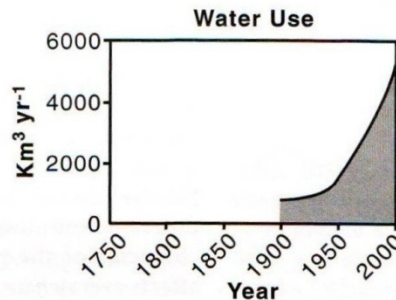
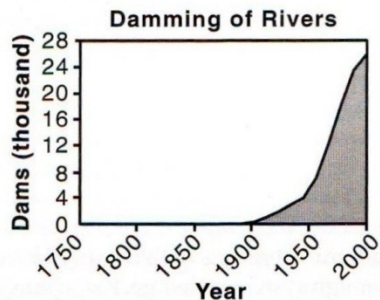
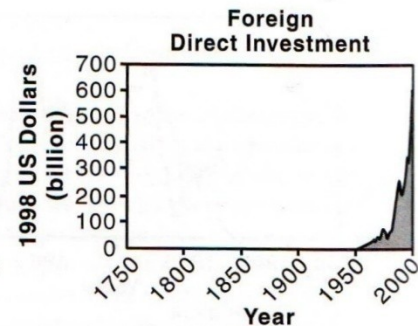
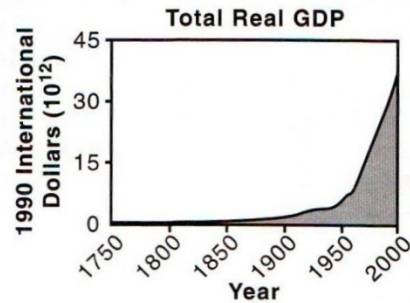
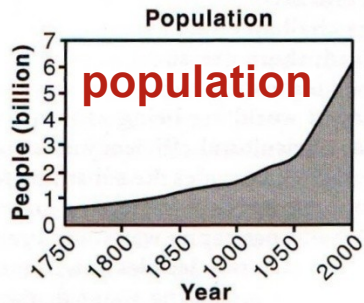
Dr Stephan Harding, Schumacher College.



Schumacher College,
Dartington, UK.

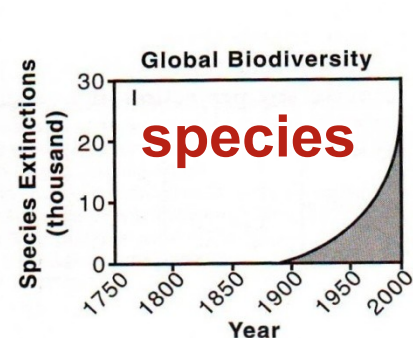
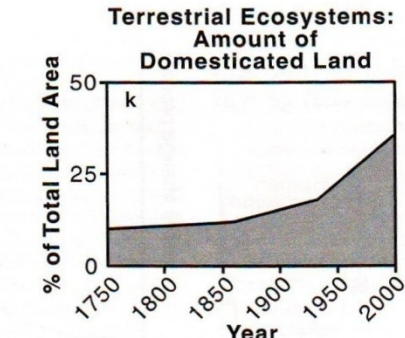
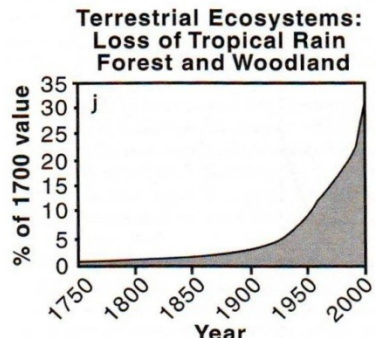
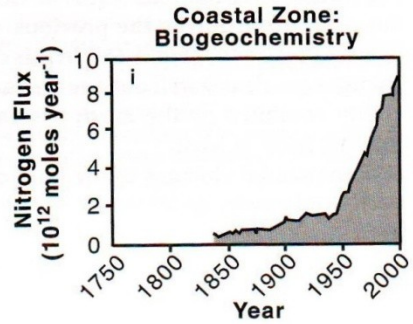
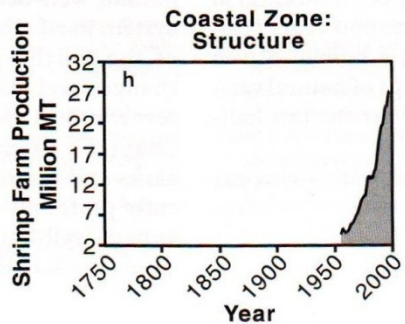
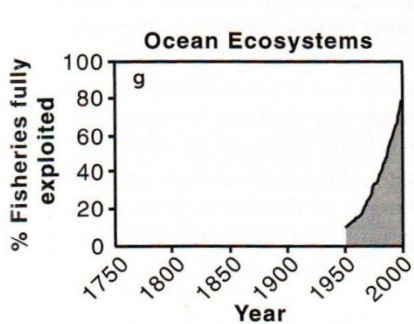
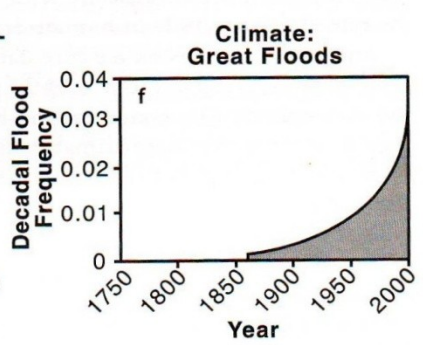
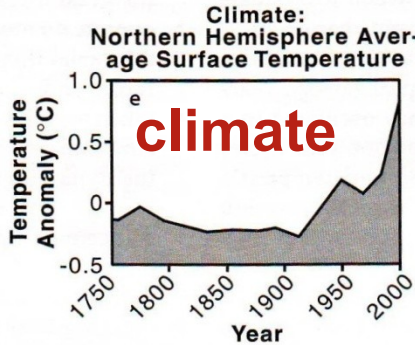
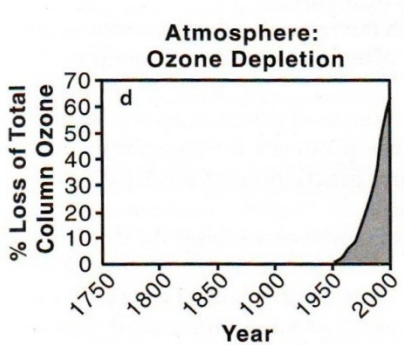
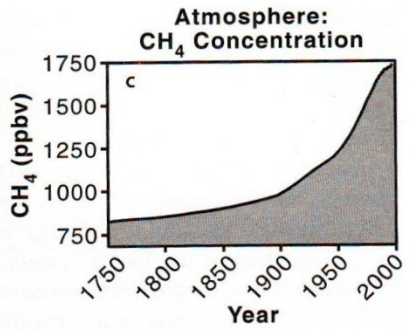
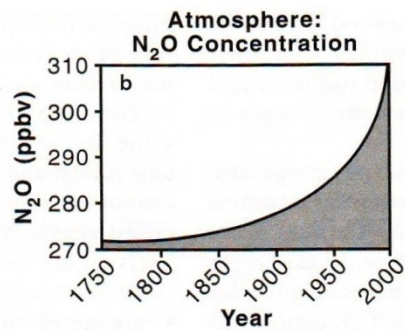
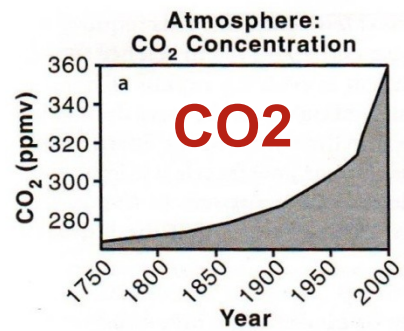
The state of the Earth

Drivers of Global Change



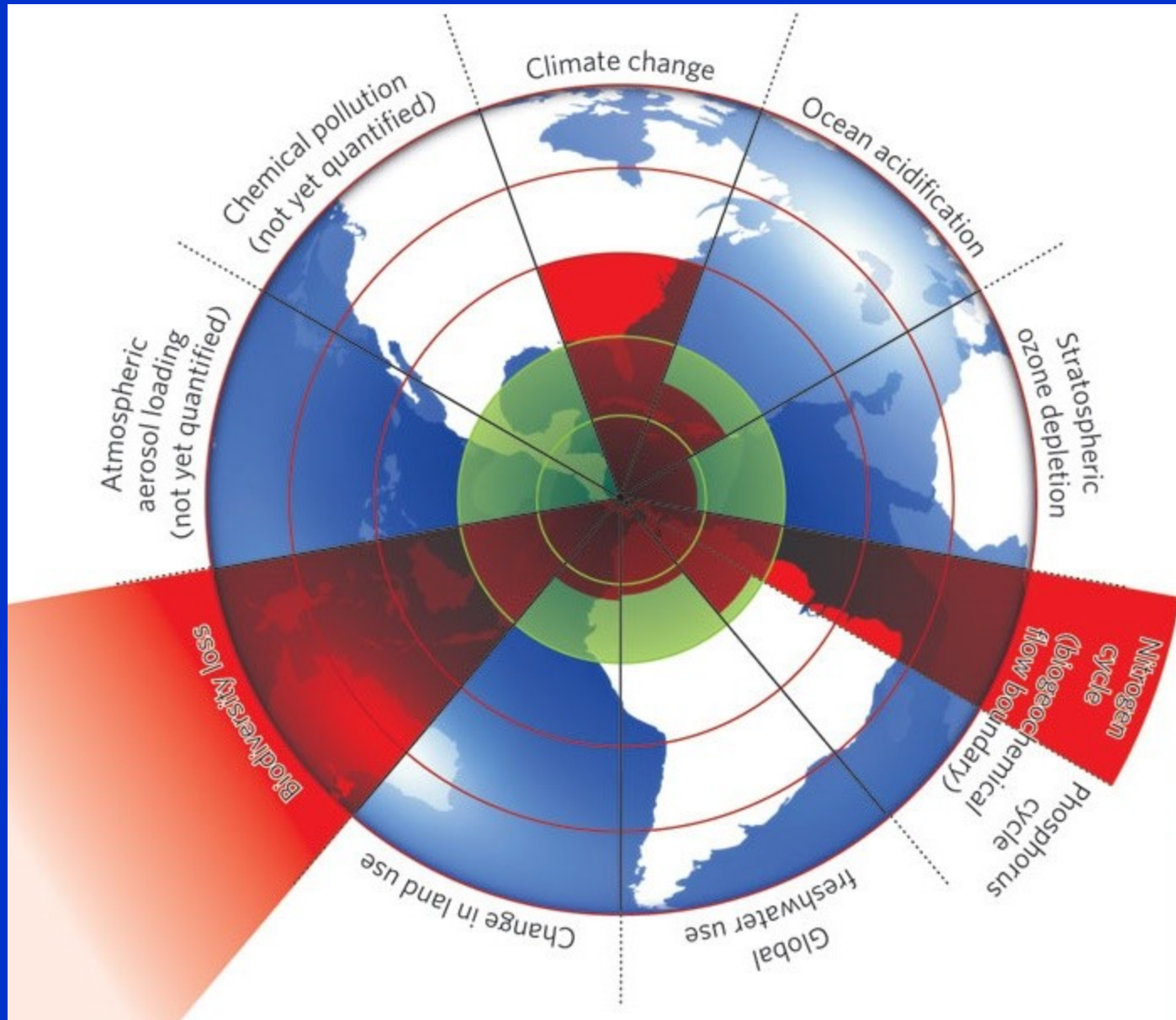
From: Steffen et. al
2004

Metrics of Global Change

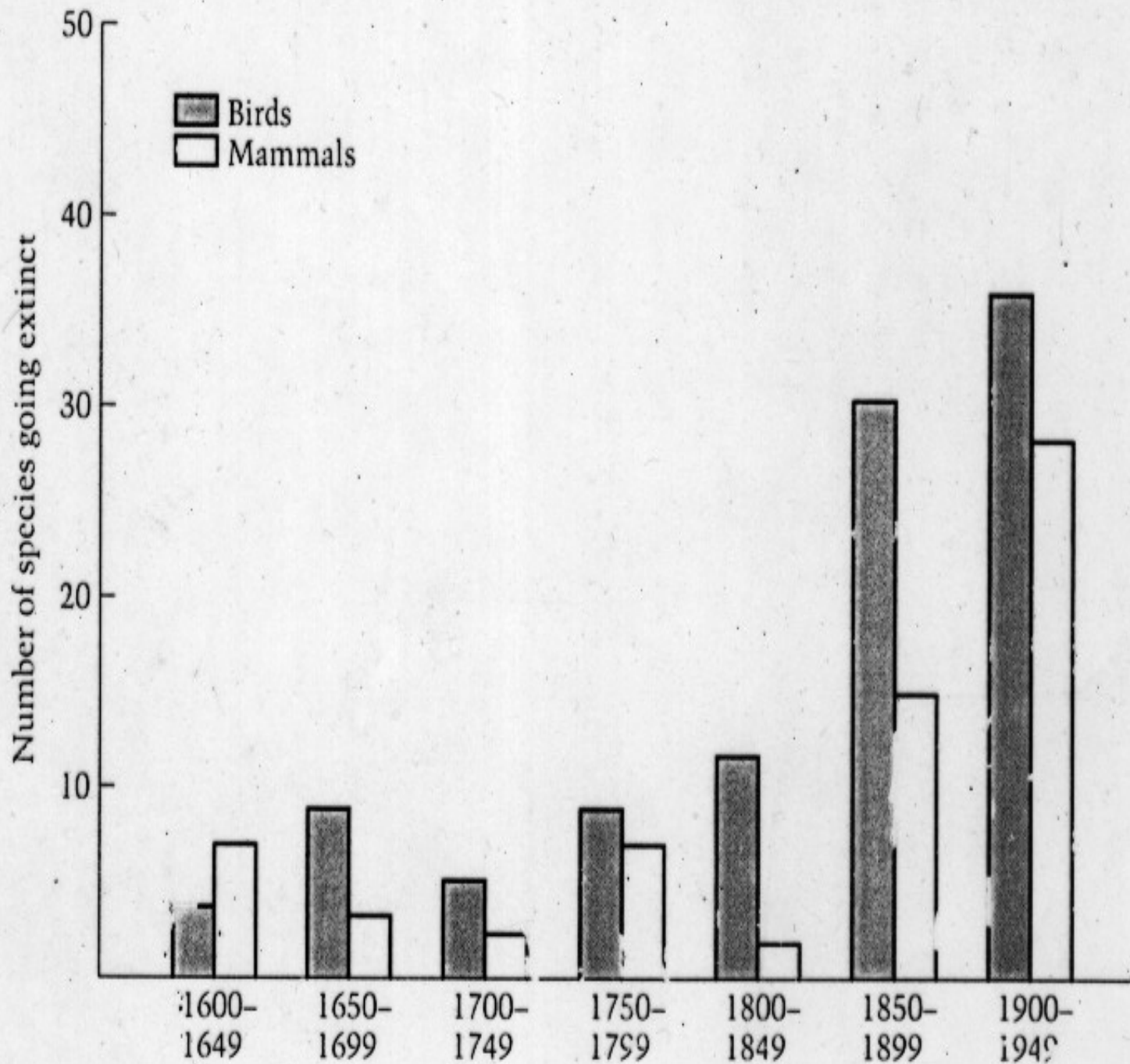


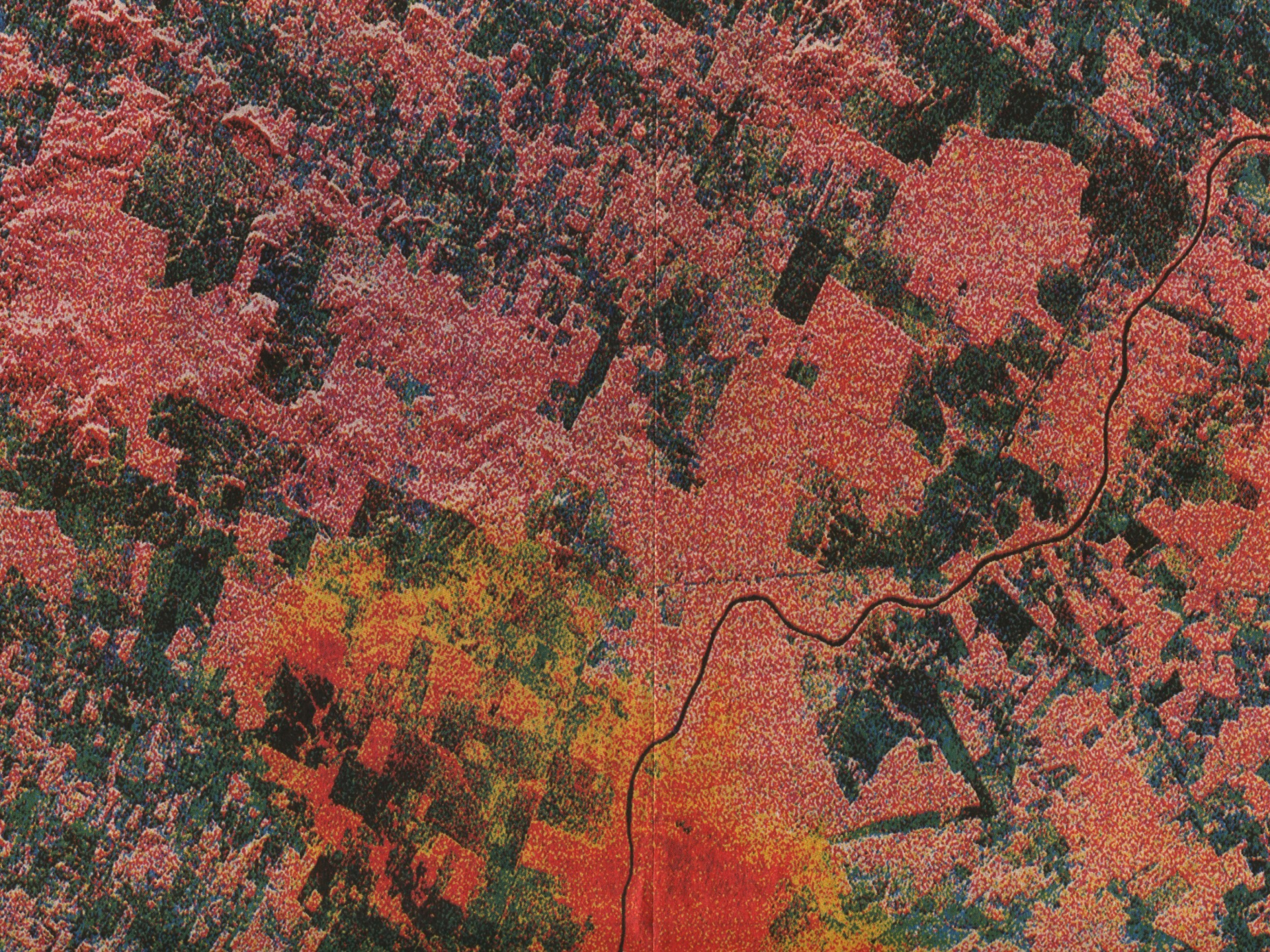
From: Steffen et. al 2004

Planetary Boundaries



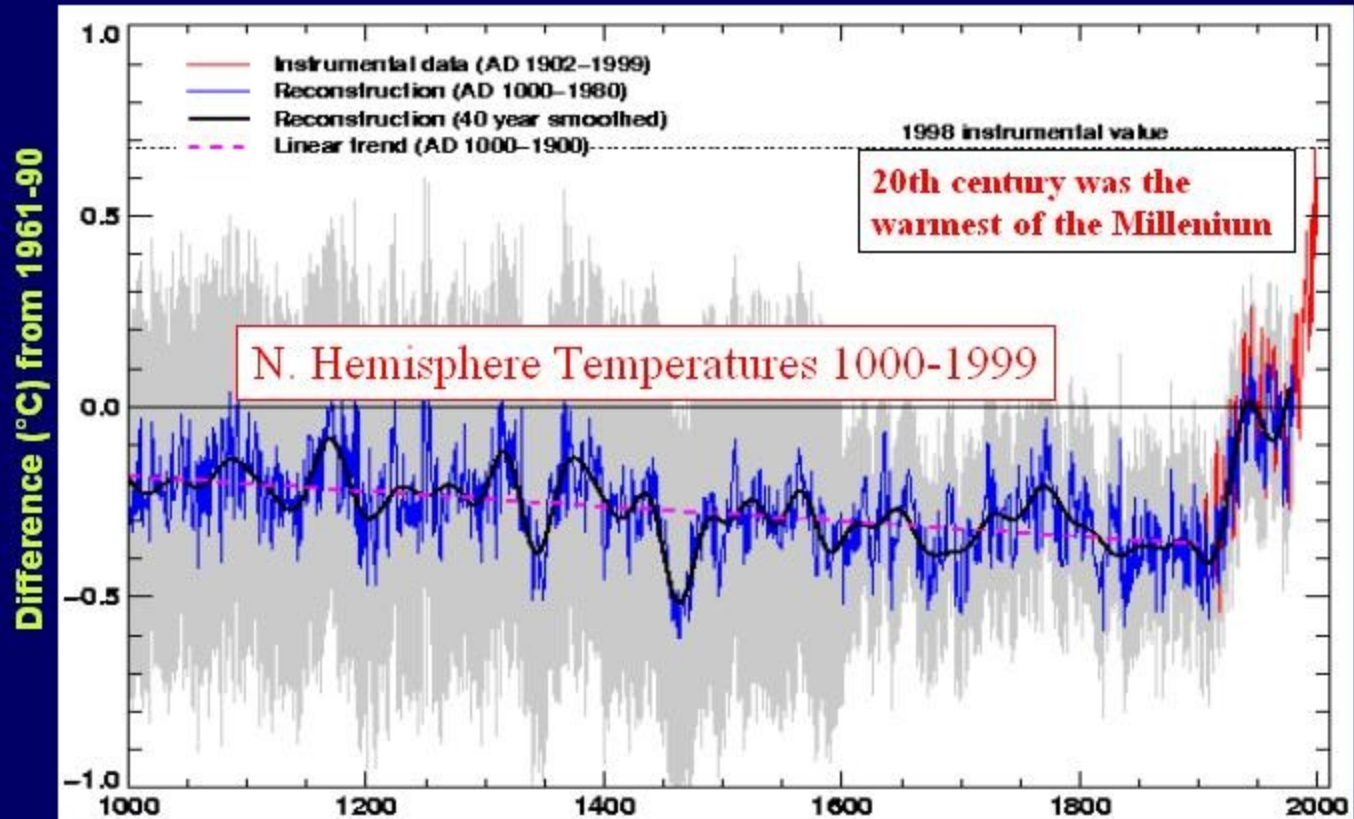
4.5 Extinction rates for birds and mammals have been steadily increasing, with the most dramatic increase occurring within the last 150 years. (Data from Nilsson 1983; IUCN 1988.)







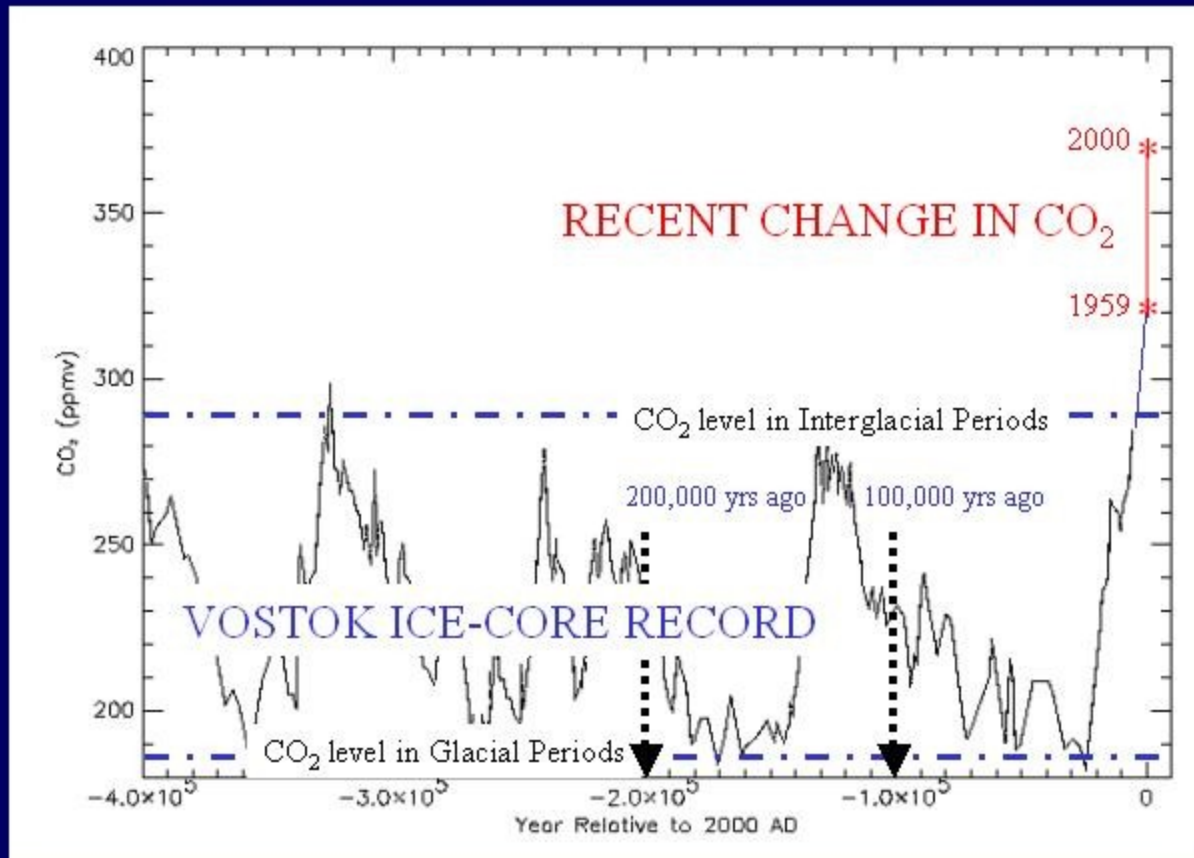
Recent Warming is very rapid prepared to past changes

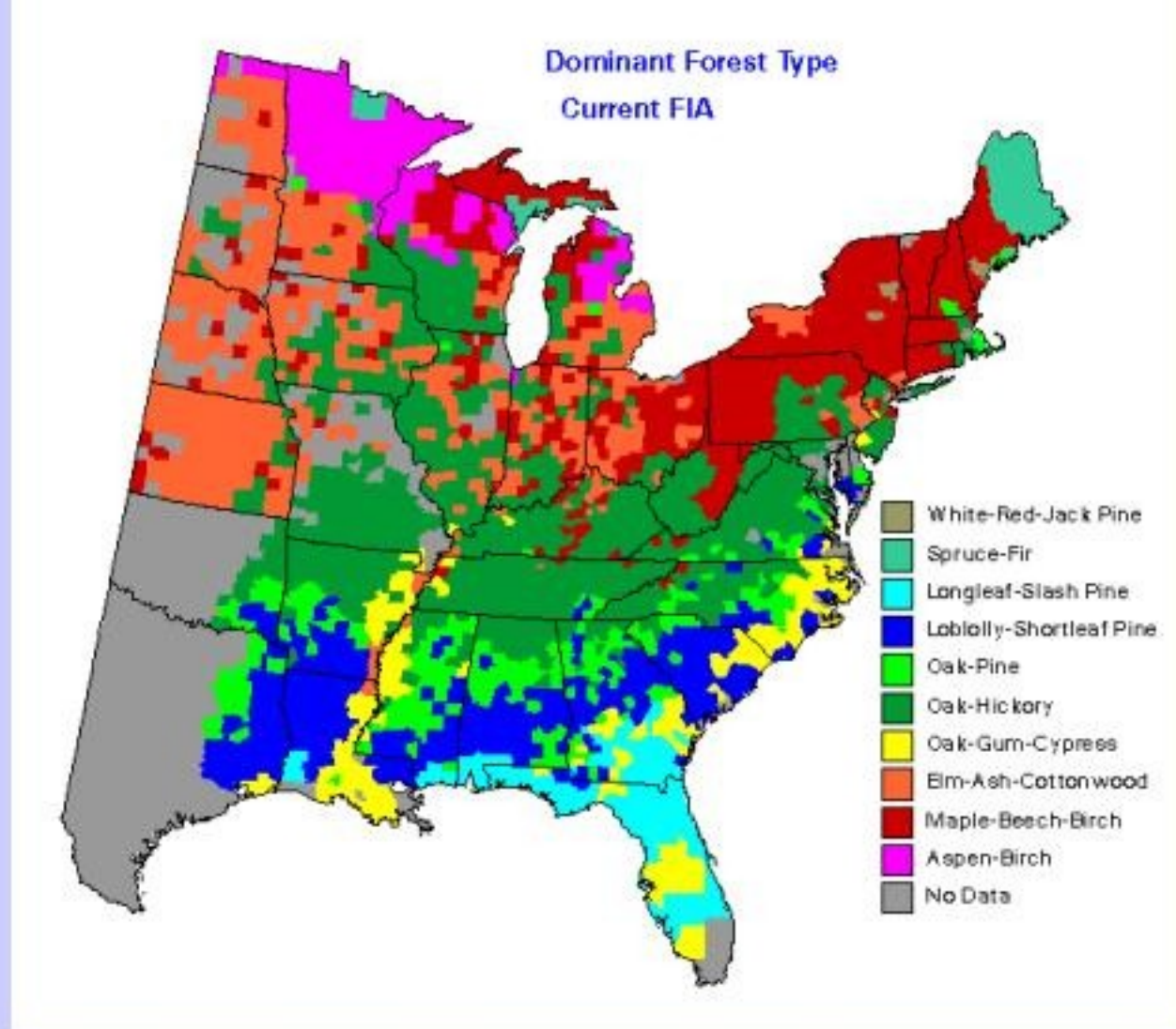


Source: IPCC TAR



The planet is now outside of its normal "Operating Regime", making prediction difficult.....

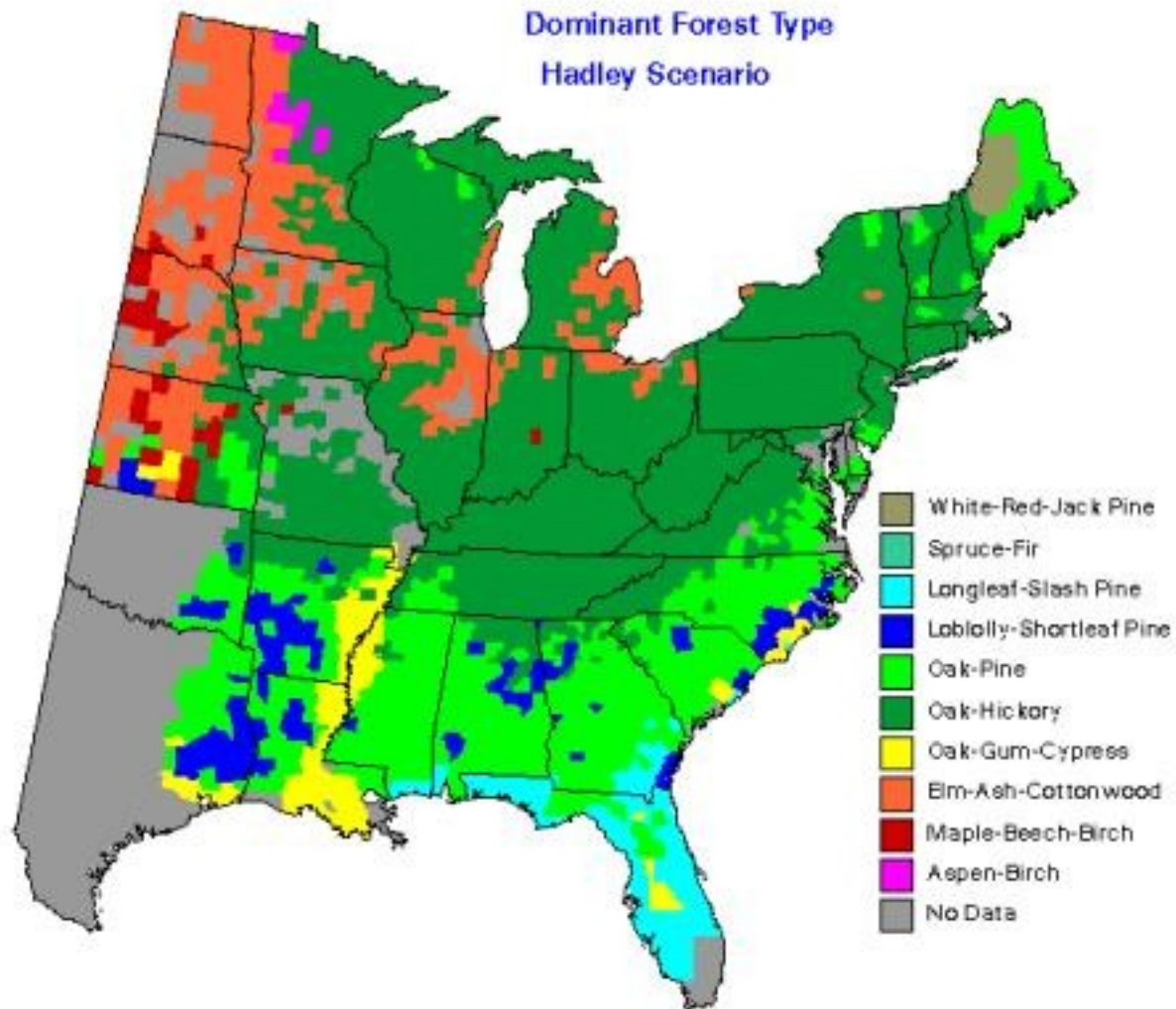




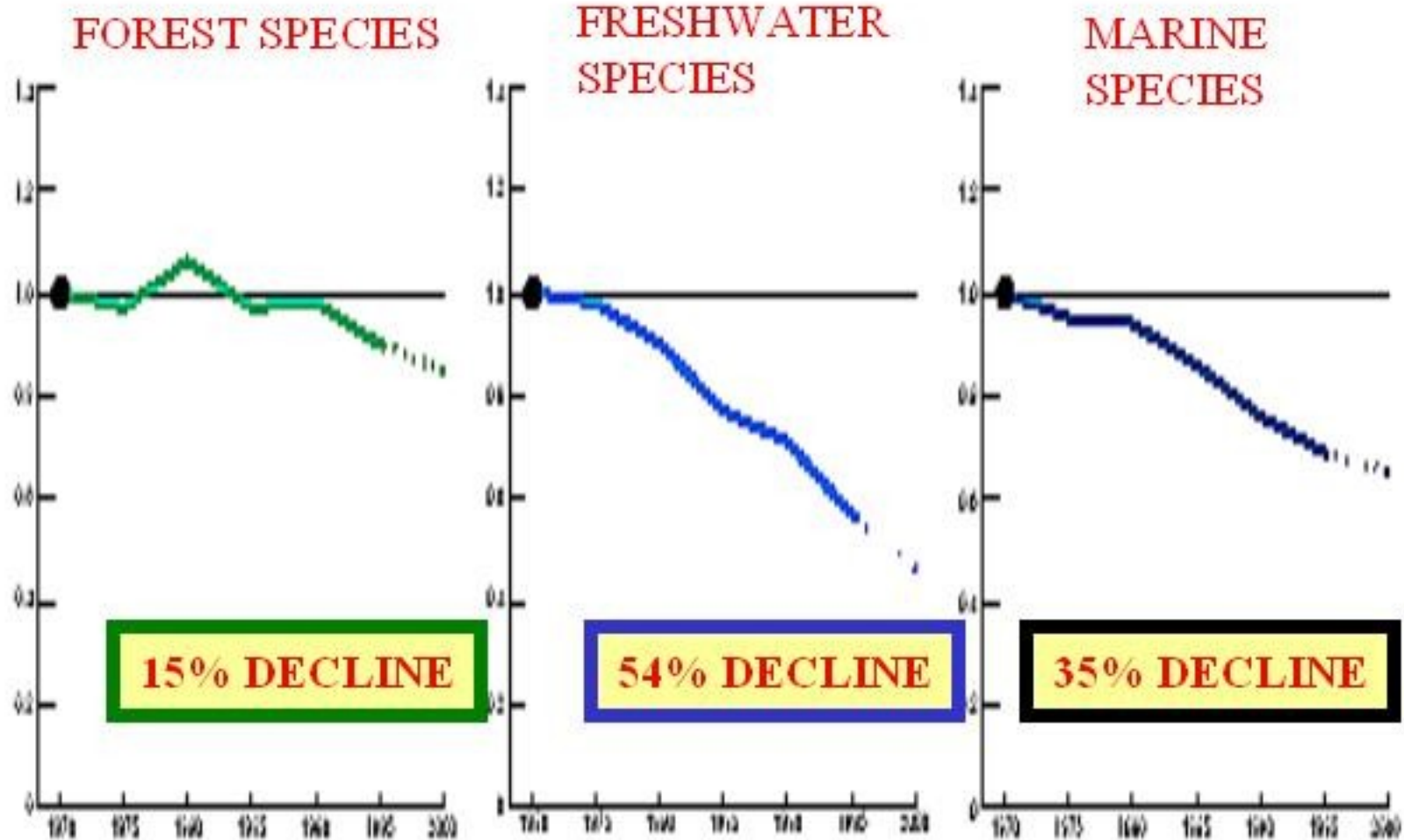
Prasad, A. M. and L. R. Iverson. 1999-ongoing. A Climate Change Atlas for 80 Forest Tree Species of the Eastern United States [database].

<http://www.fs.fed.us/ne/delaware/atlas/index.html>, Northeastern Research Station, USDA Forest Service, Delaware, Ohio.

Dominant Forest Type
Hadley Scenario

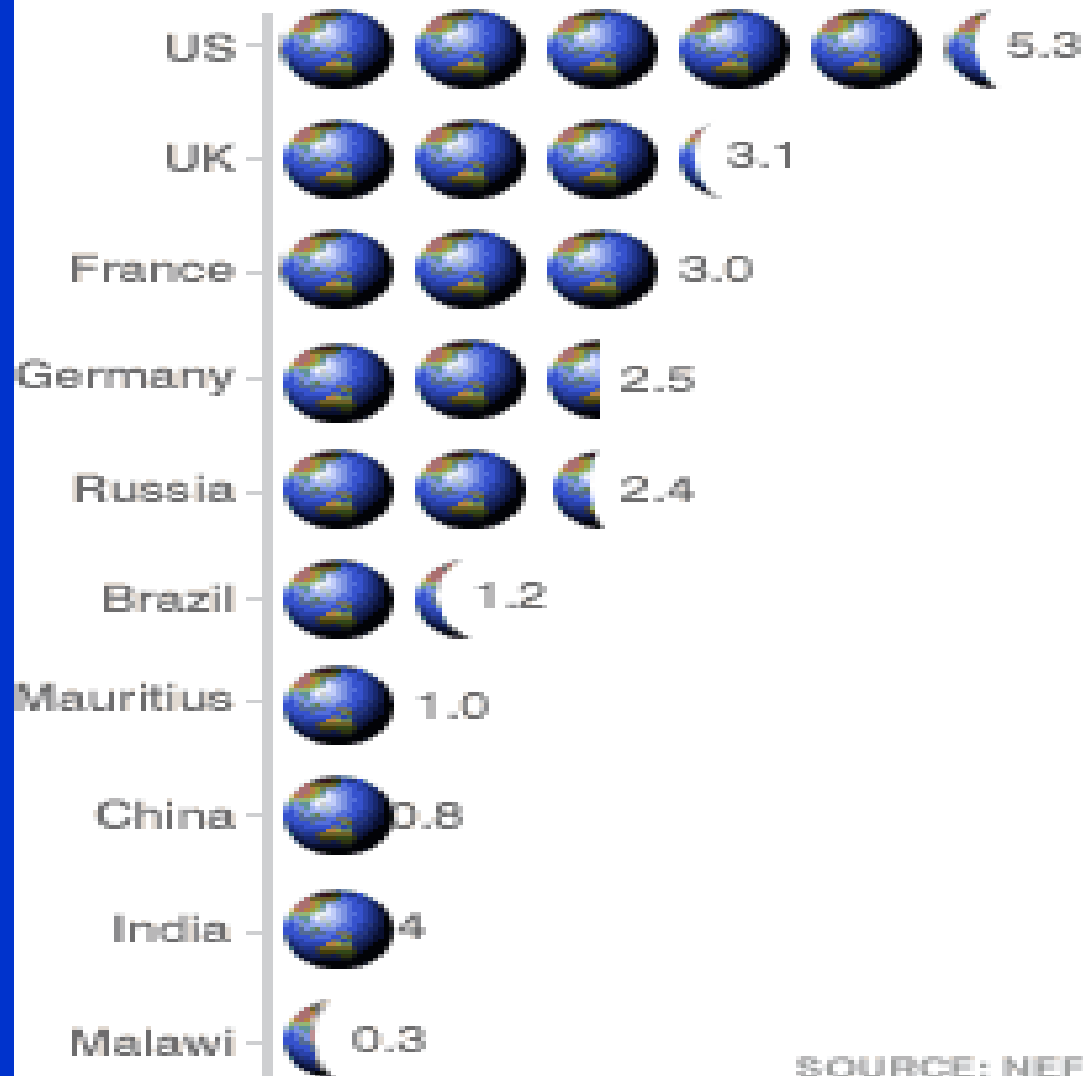


Living Planet Index, 1970-2000



Source: WWF, 2002

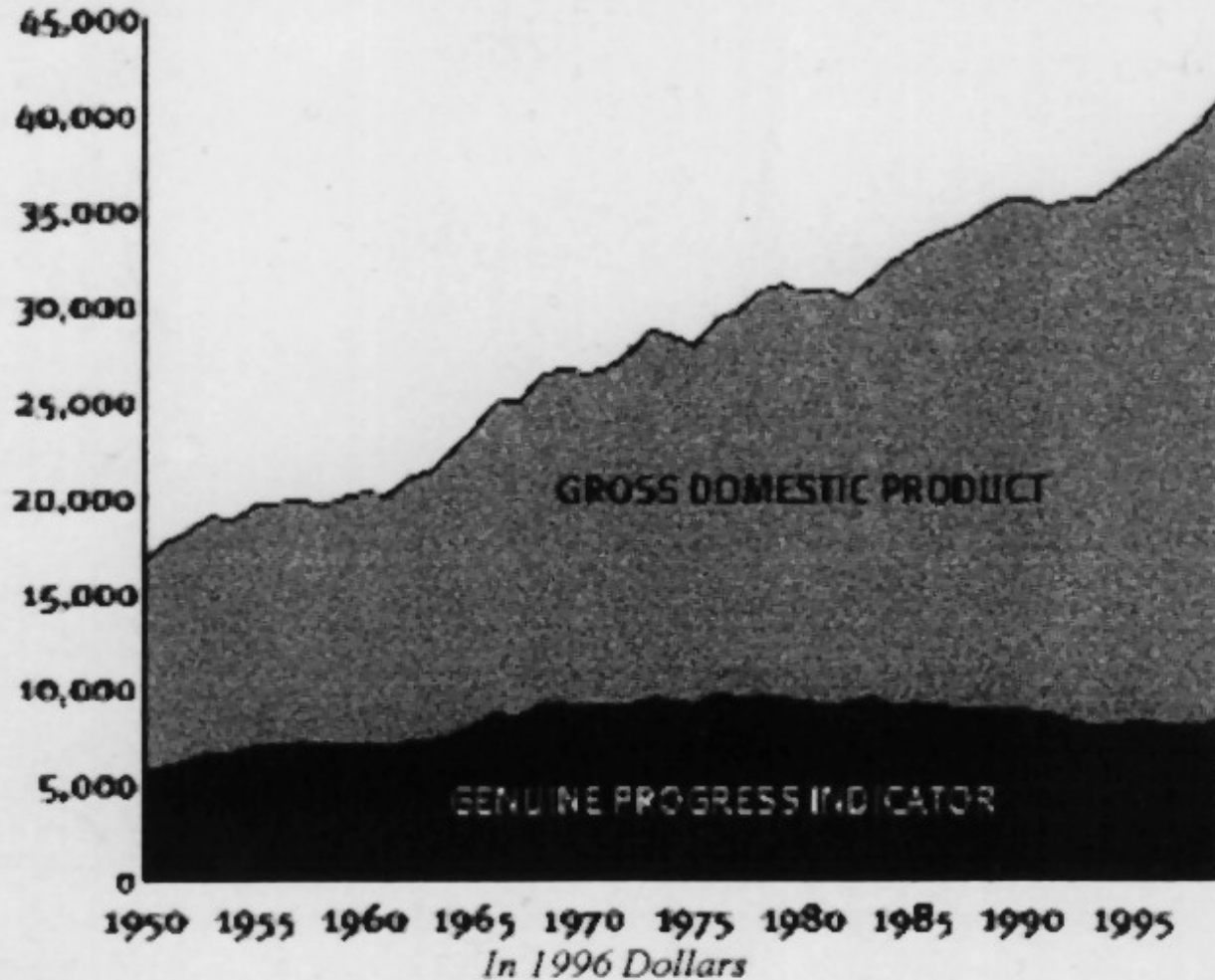
NATIONS' ECO FOOTPRINTS



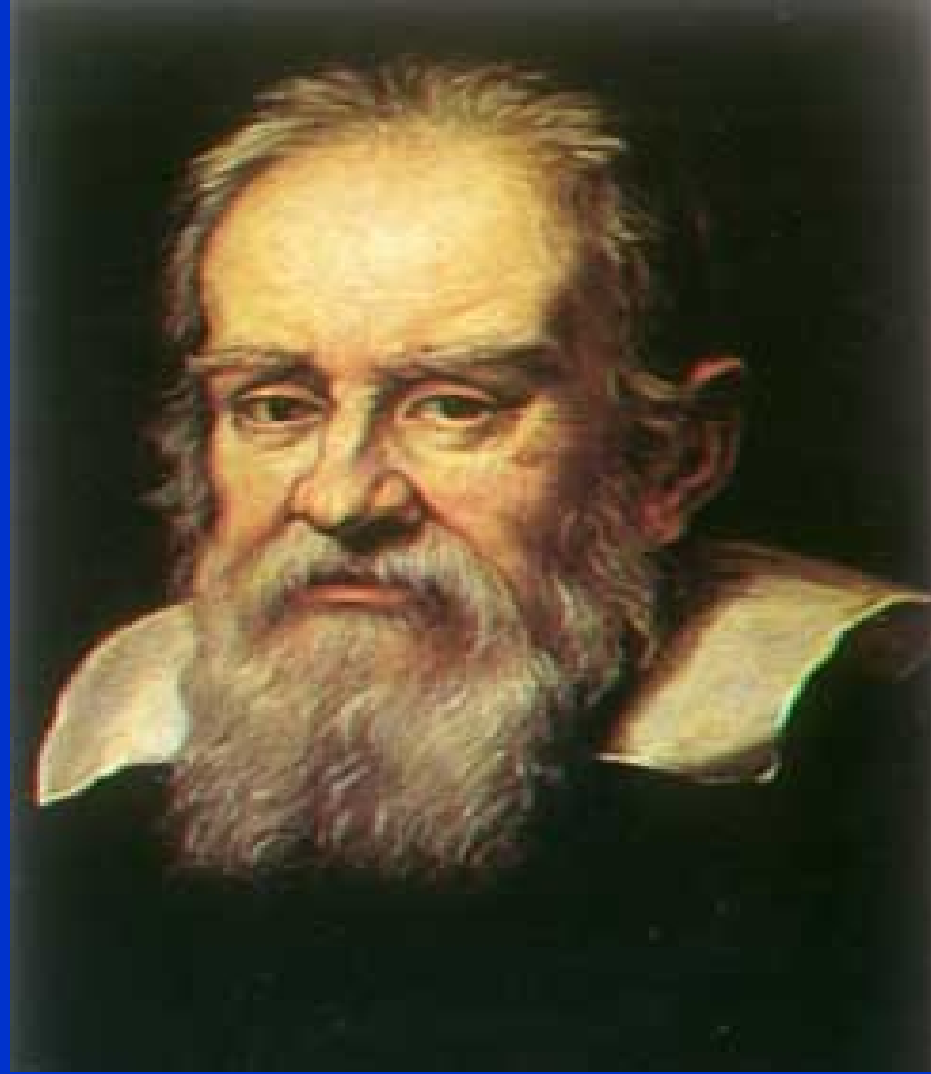
SOURCE: NEF

GENUINE PROGRESS INDICATOR

GROSS PRODUCTION VS. GENUINE PROGRESS, 1950



The scientific revolution



“The book of the Universe...is written in the
Language of mathematics.” *Galileo. 1564 - 1642*

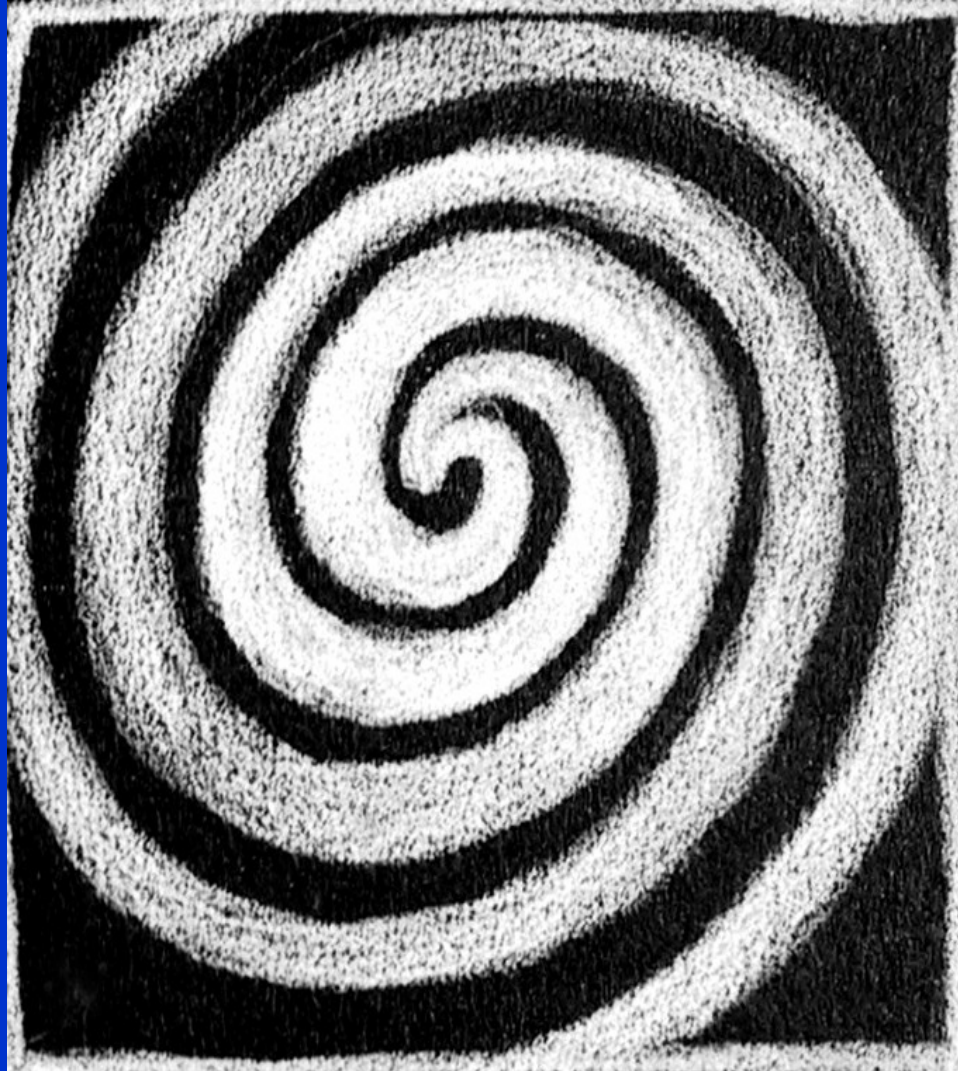


“I have described the Earth and the whole visible Universe in the manner of a machine.”

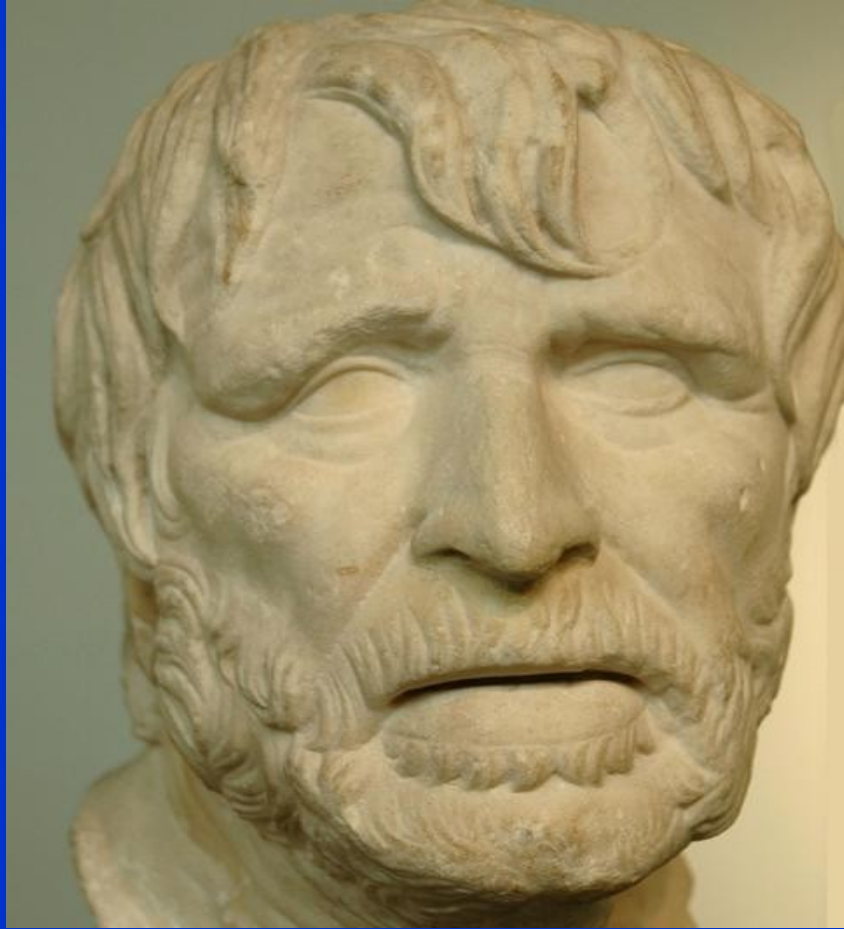
Descartes. 1596 -1650



“We should endeavor to establish and extend the power and dominion of the human race itself over the Universe.” *Francis Bacon. 1561- 1626*

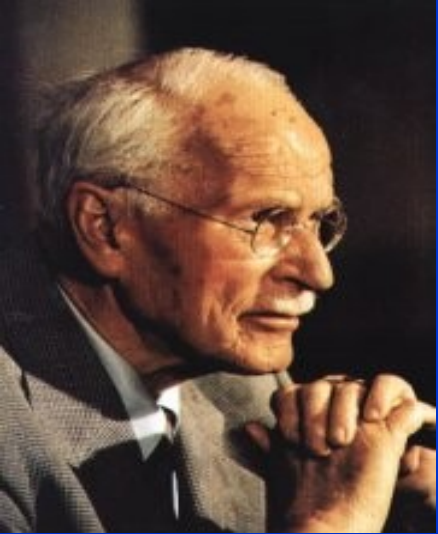


Anima Mundi



“Gaia, the beautiful, rose up, broad blossomed, she that is the steadfast base of all things. And fair Gaia first bore the starry Heaven, equal to herself, to cover her on all sides and to be a home forever for the blessed Gods.”

Hesiod. 700 BC



C.G. Jung

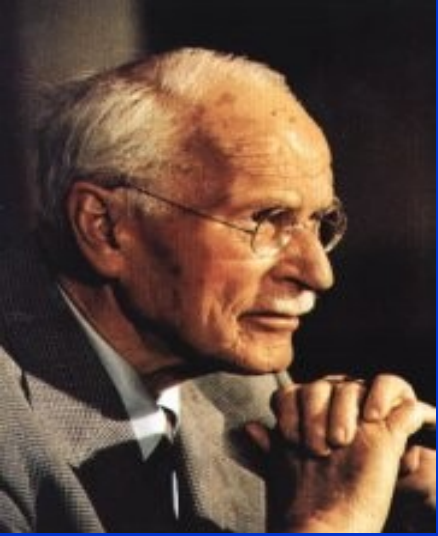
The 'Jungian Mandala'

Intuition

Feeling

Thinking

Sensing



C.G. Jung

The 'Jungian Mandala'

Intuition

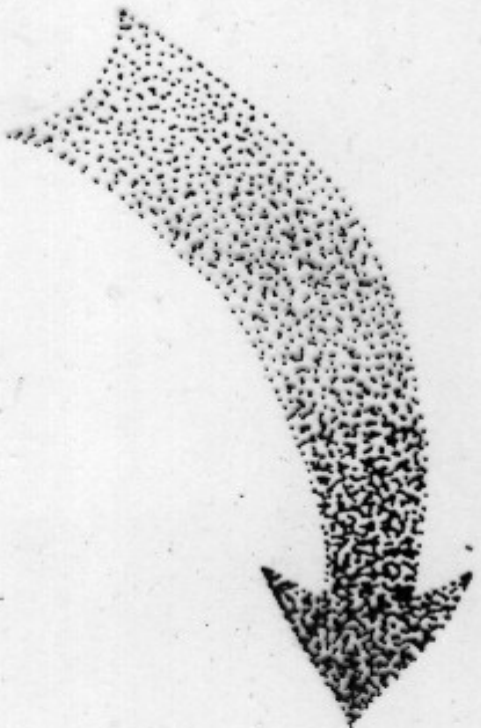
Feeling
(ethics)

Thinking

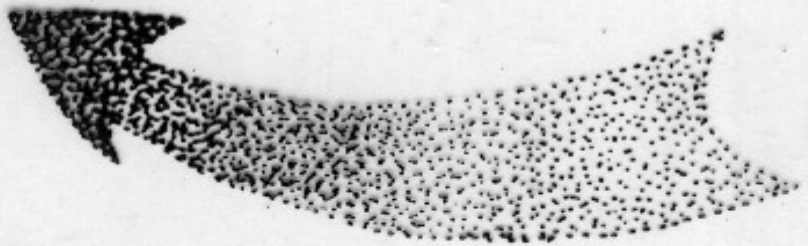
Sensing

Deep Ecology

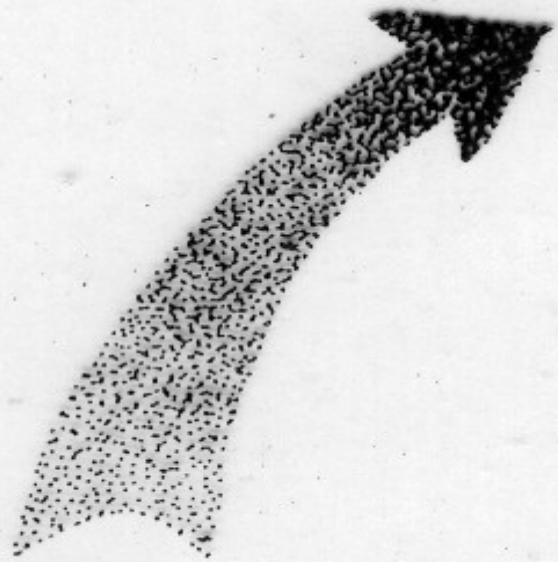
deep
experience



deep
questioning



deep
commitment





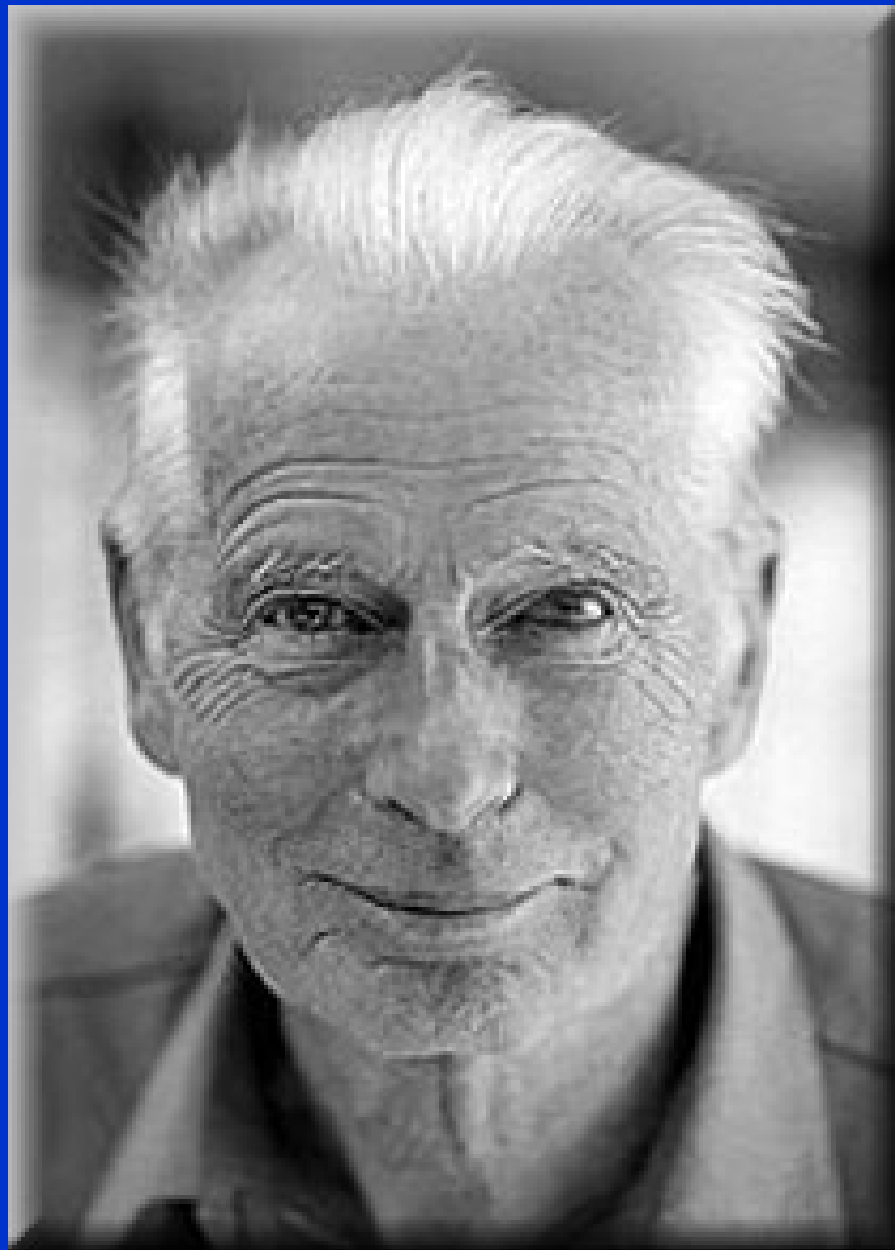






Aldo Leopold, 1887-1948

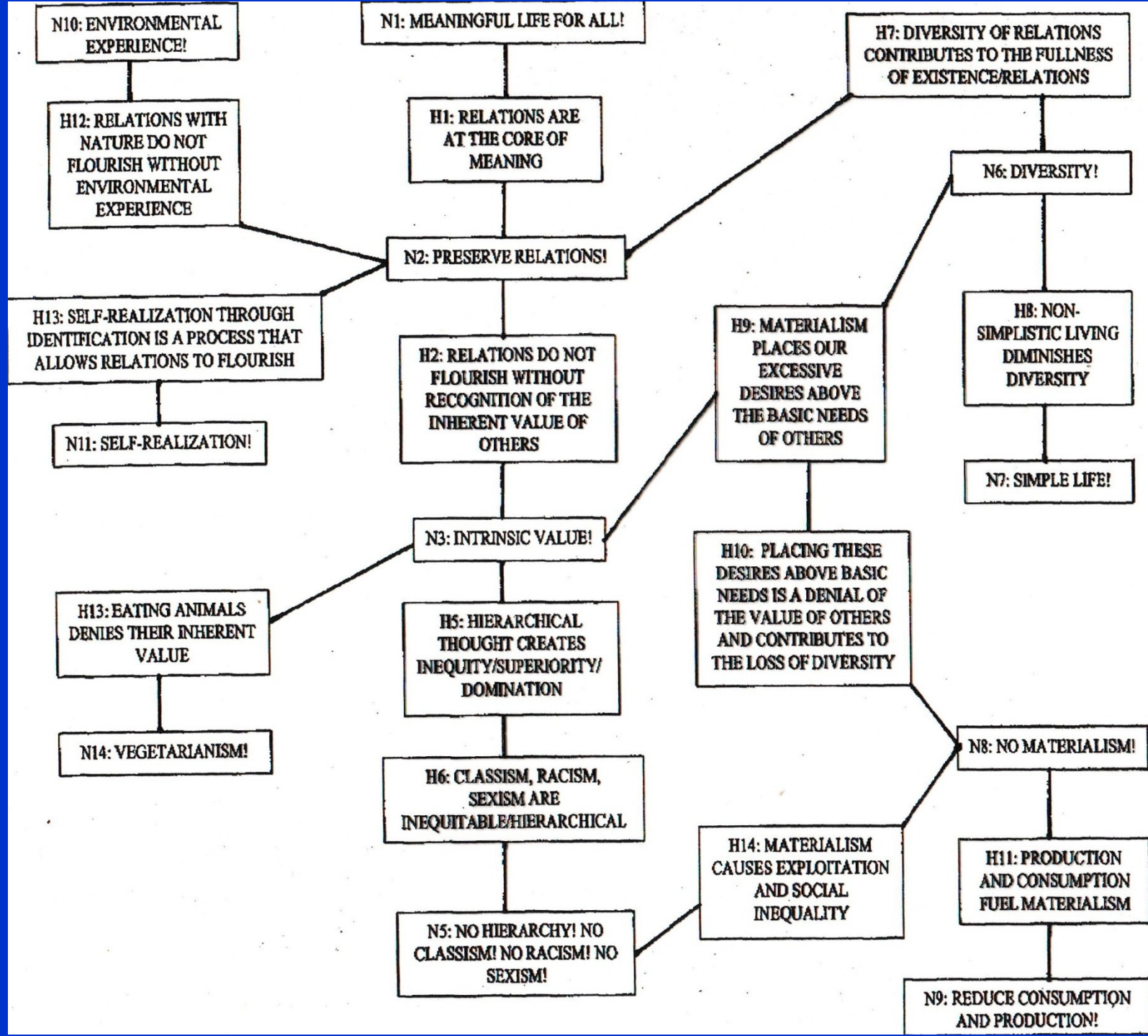
“A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community, it is wrong when it tends otherwise”



Arne Naess

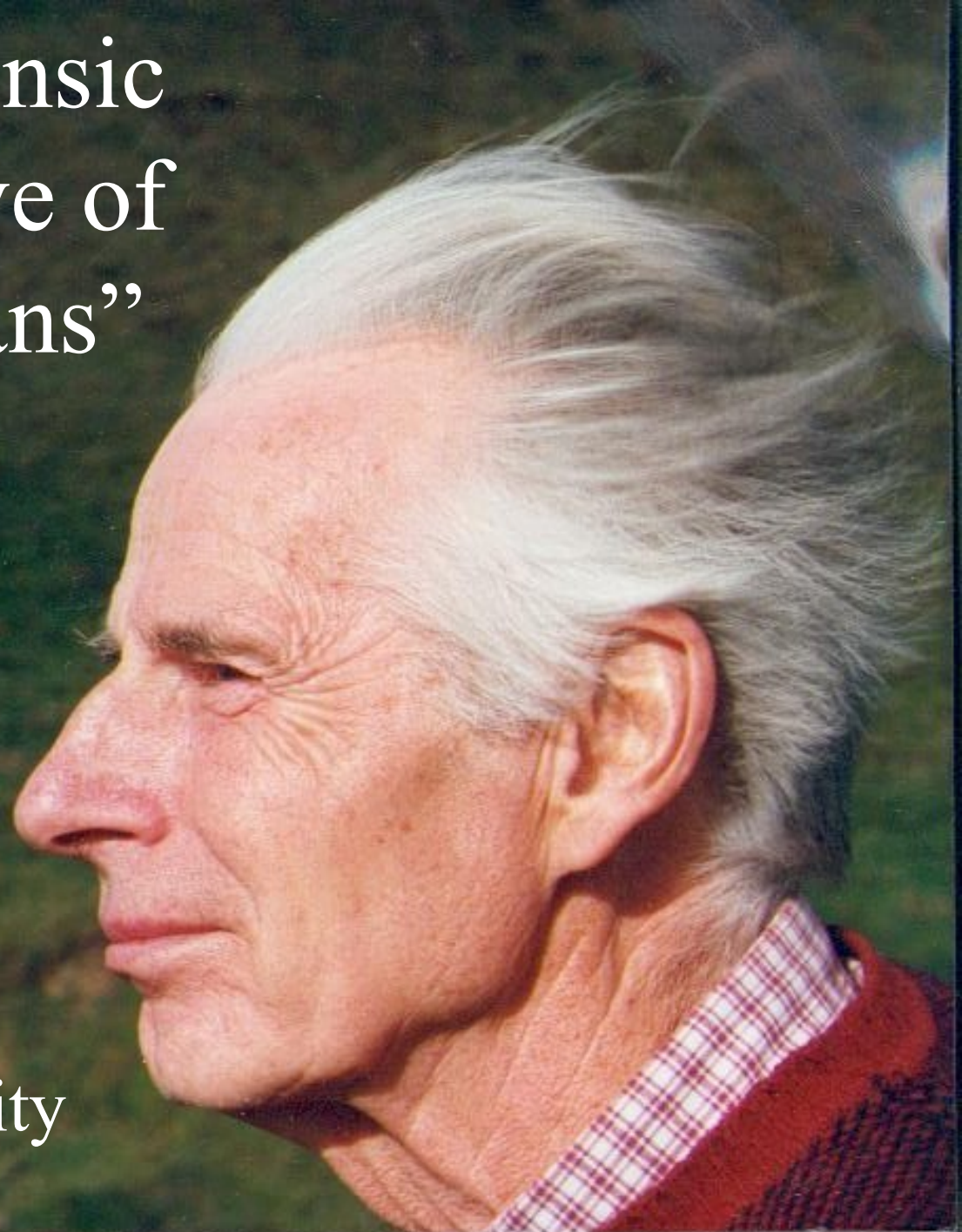


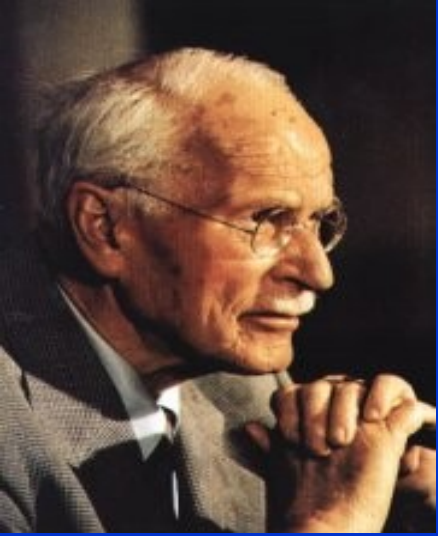




“All life has intrinsic value, irrespective of its value to humans”

Arne Naess, Professor
Emeritus, Oslo University





C.G. Jung

The 'Jungian Mandala'

Intuition

Feeling

Thinking

Sensing

Holistic Science

involves a shift in emphasis from:

Parts to Wholes

Objects to relationships

Hierarchies to networks

Truth to approximate descriptions

Objective knowledge to contextual knowledge

Utilitarian values to Intrinsic values

Gaia Theory



James Lovelock



Lynn Margulis

The mainstream view in the 1960's:

The biota

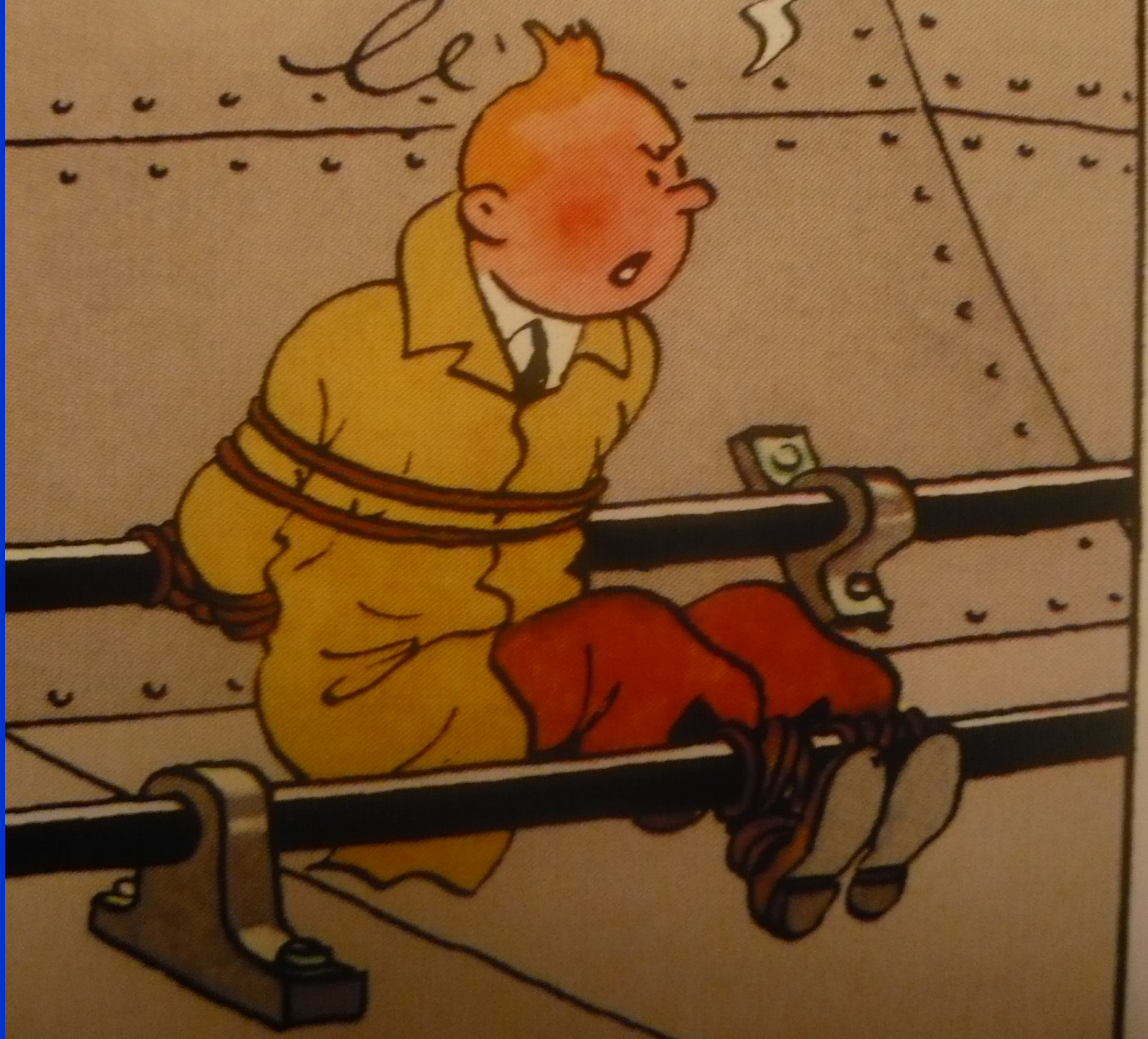


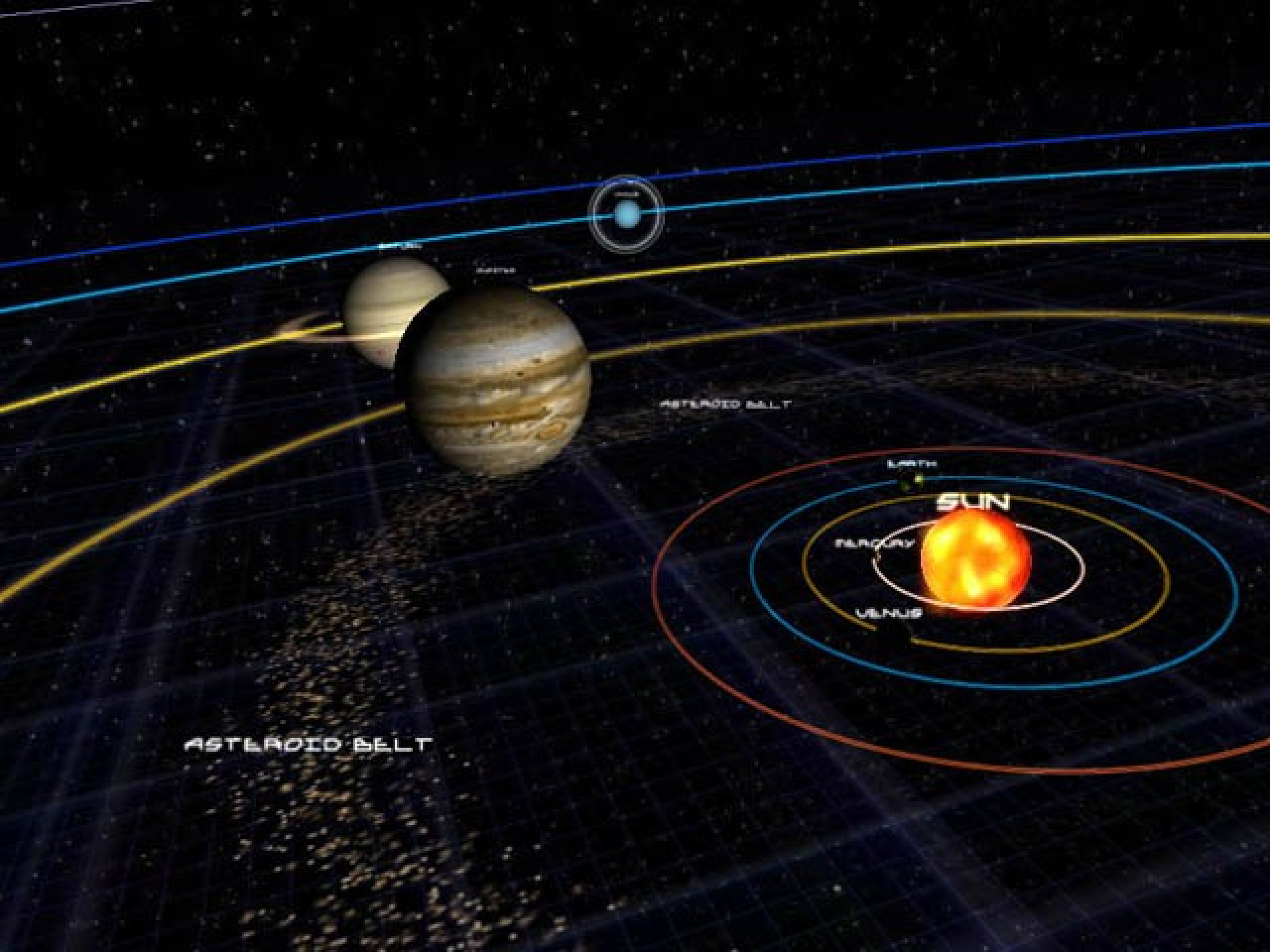
The abiotic environment



- Rocks
- Atmosphere
- Water







ASTEROID BELT

ASTEROID BELT

SUN

MERCURY

VENUS

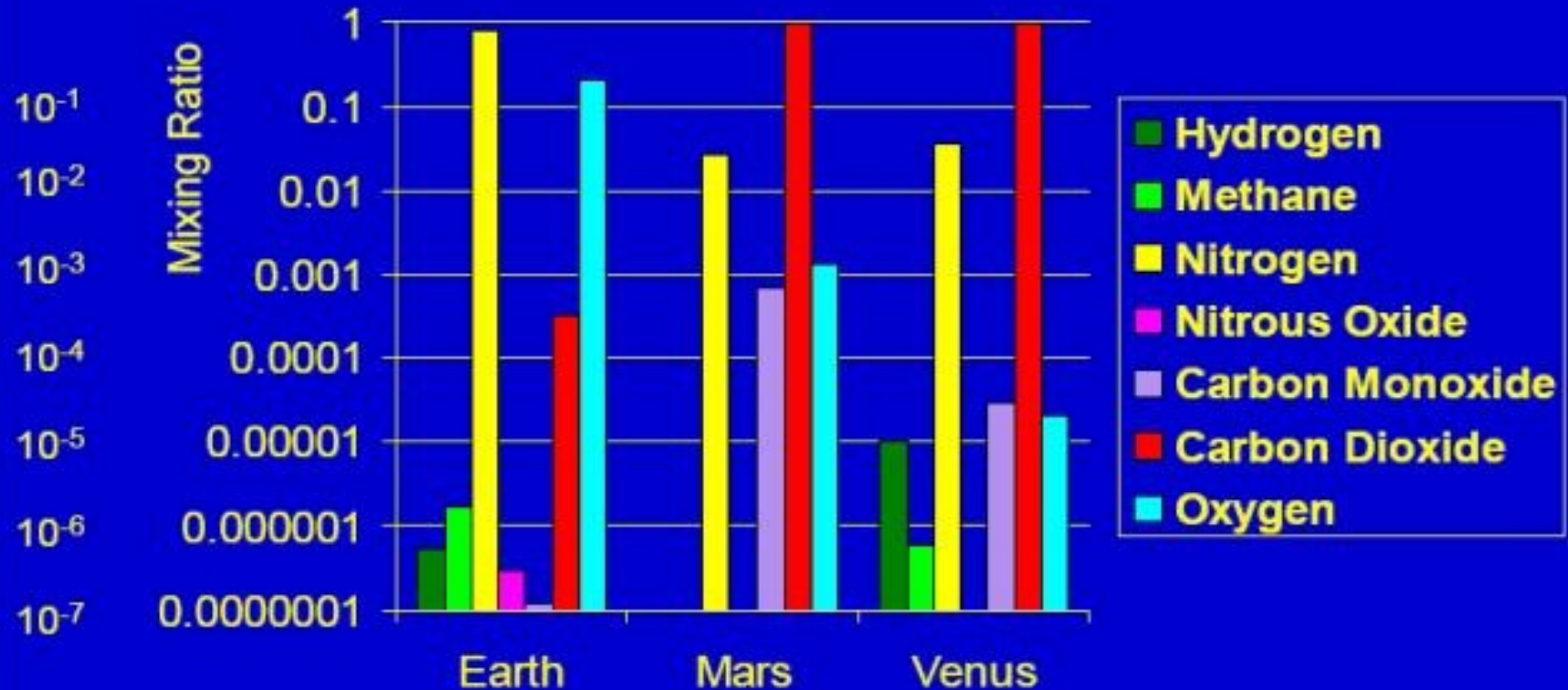
EARTH

MARS

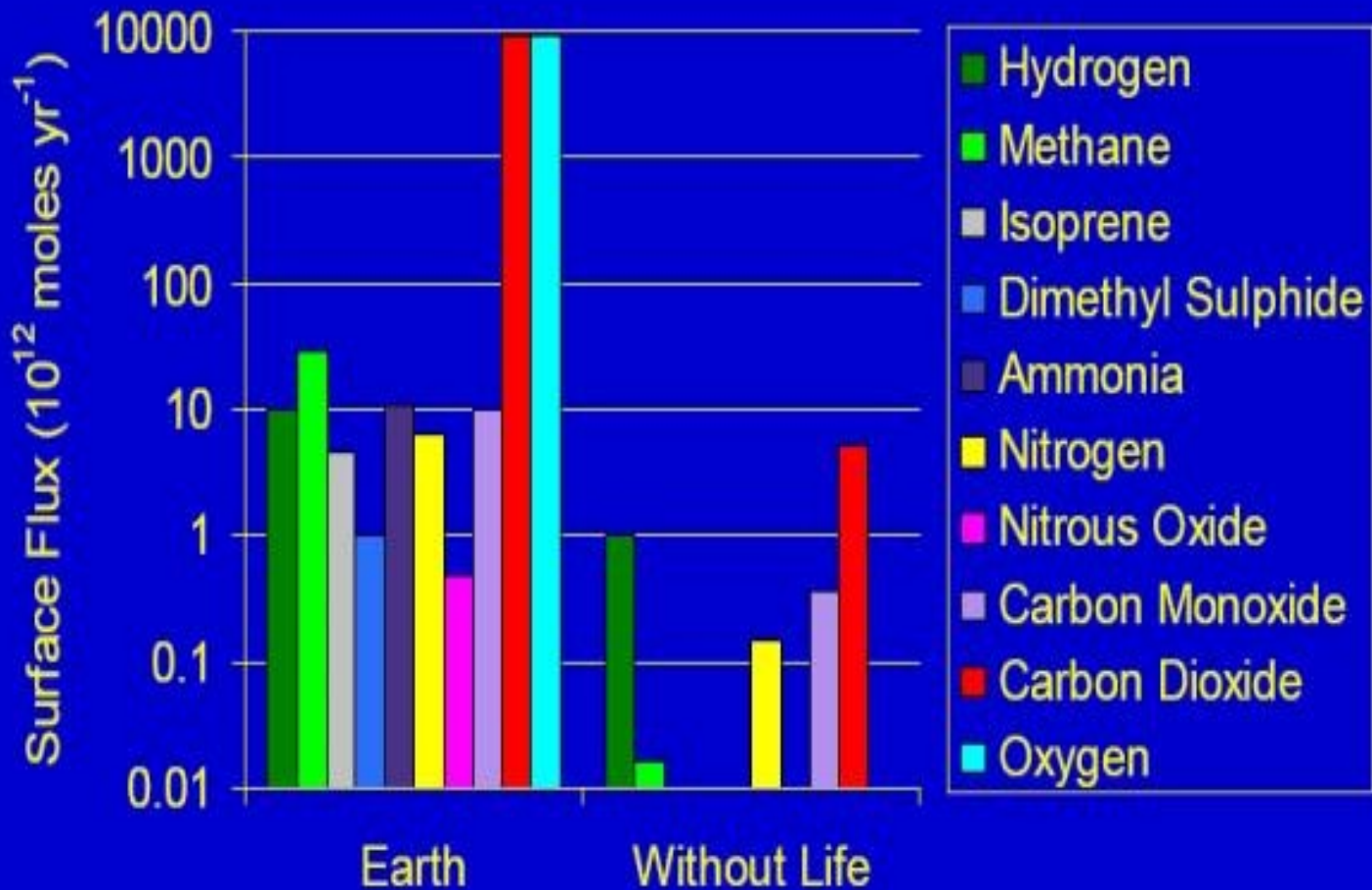
JUPITER

SATURN

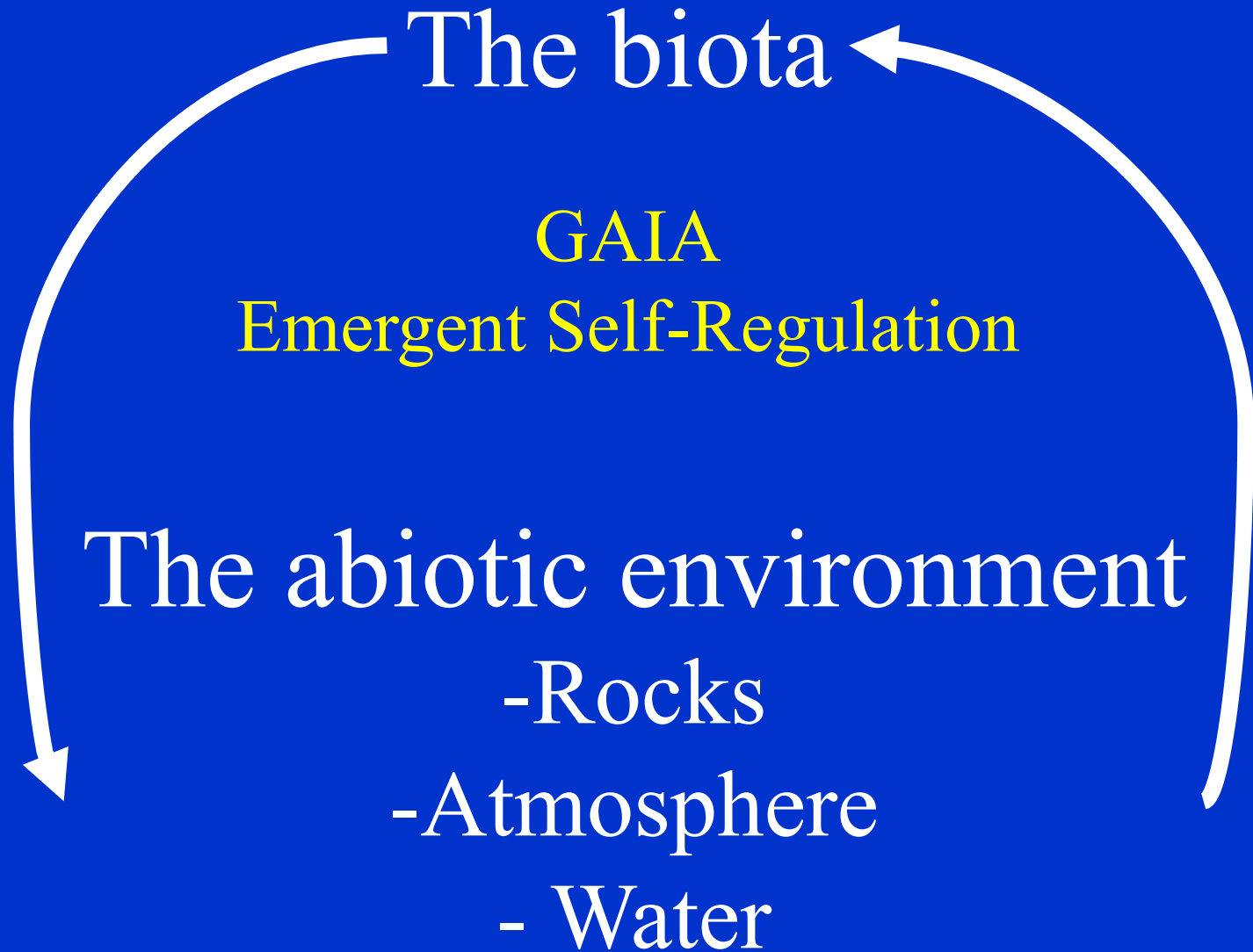
Atmospheric compositions

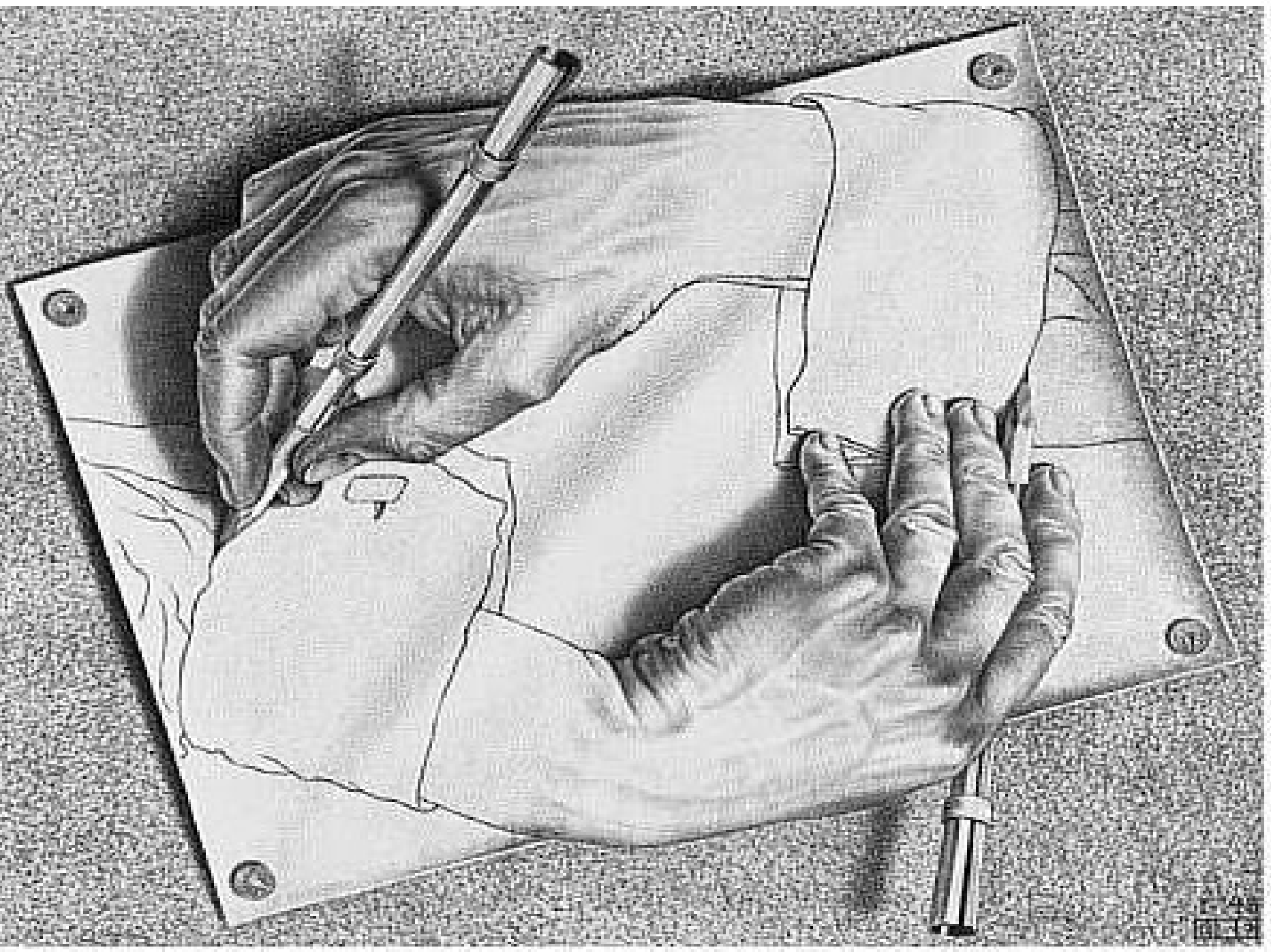


Fluxes of gases



According to Gaia Theory:





Hermeneutics:

The art, theory and practice of interpretation of texts and other 'signs'

“.. the expression of life shapes the context within which life understands itself (e.g. the atmosphere), thus leading to new interpretations and to new meaningful expressions (metabolic novelty) – the hermeneutic circle lives as Gaia.”

Paraphrased from Adam Croft.
MSc Holistic Science dissertation, 2007.

The evidence for Gaia

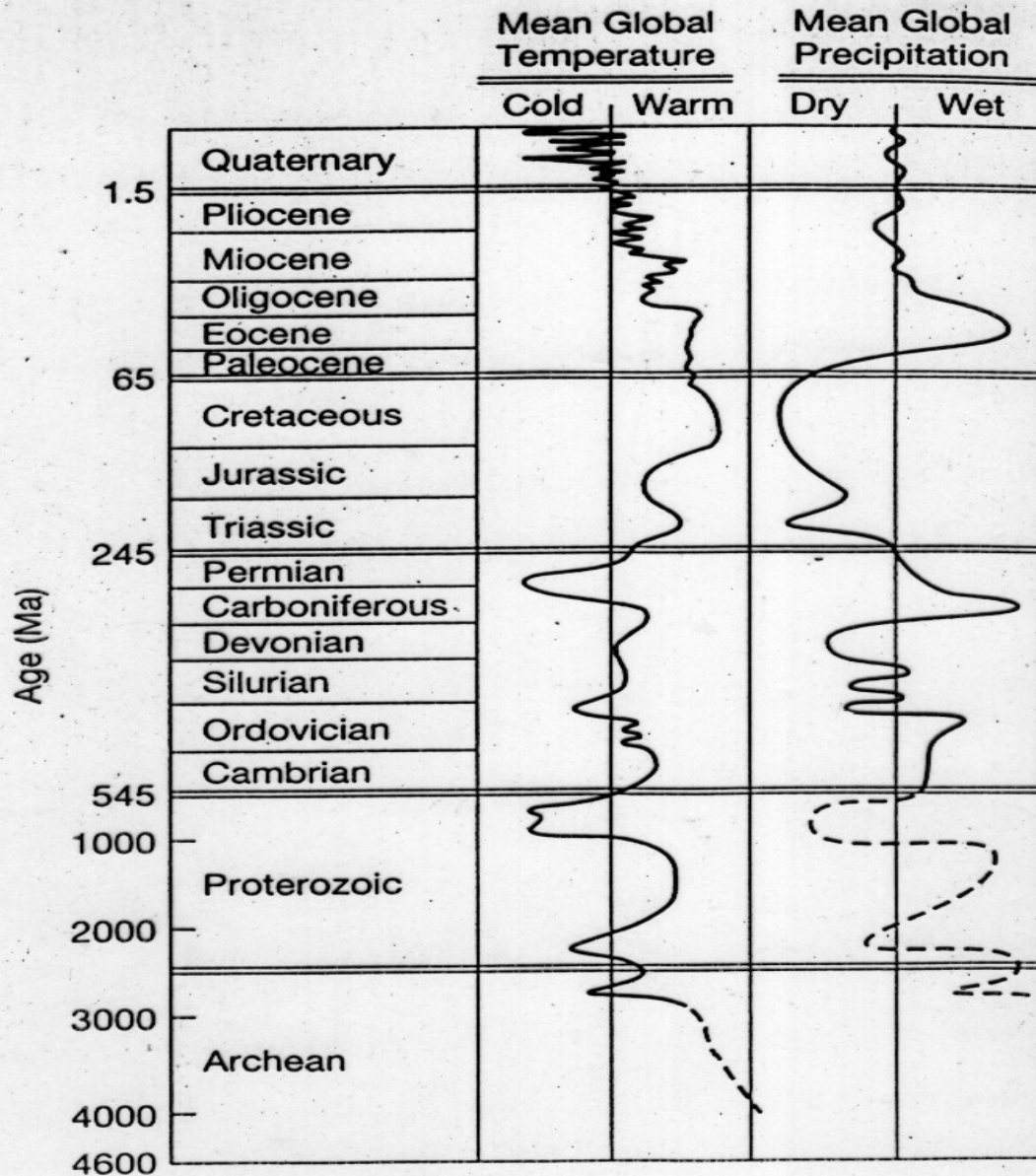
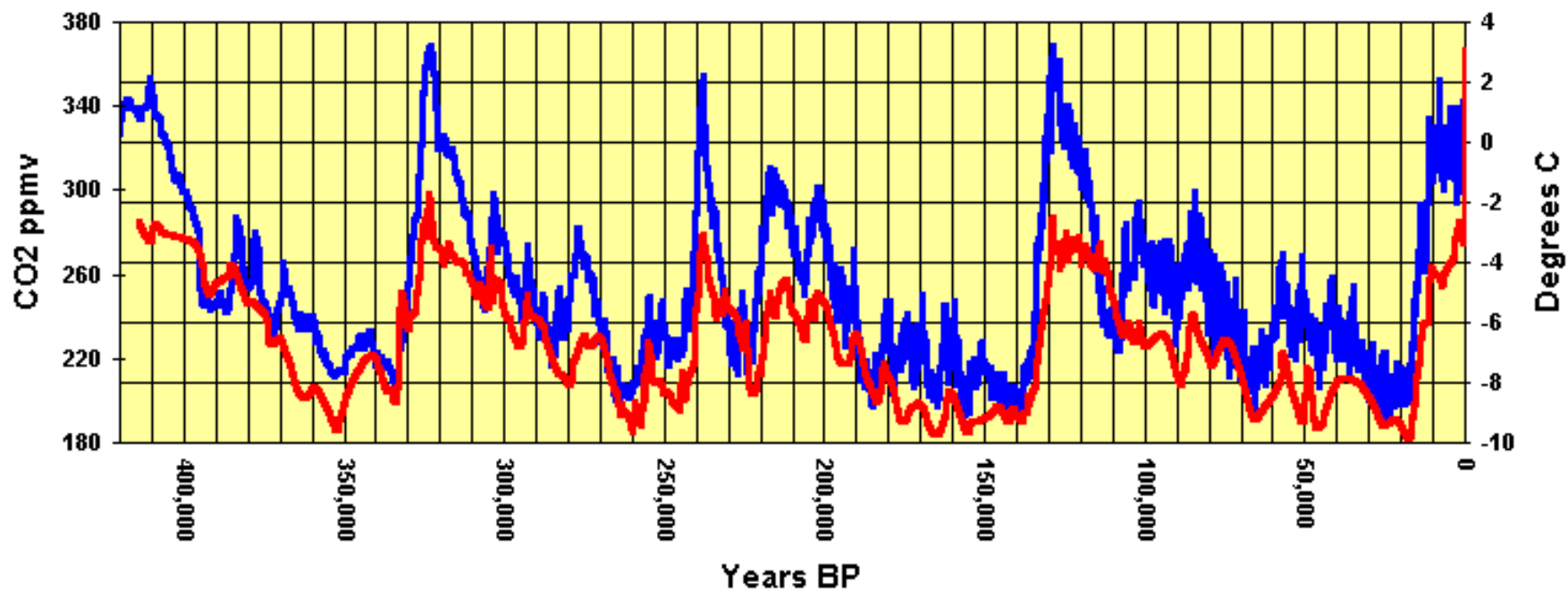


FIGURE 8-14

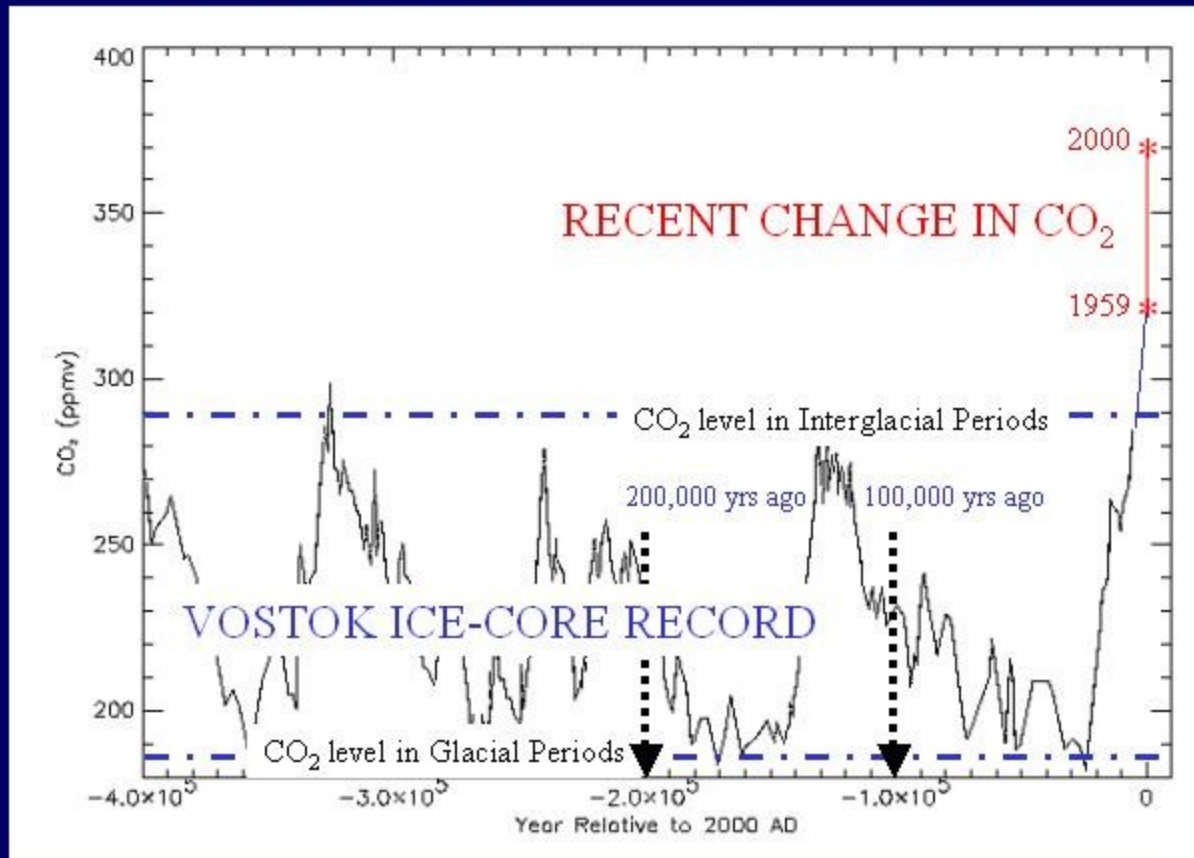
Estimated change in surface temperature during the Phanerozoic eon. (From K.C. Condie and R.E. Sloan: *Origin and Evolution of Earth: Principles of Historical Geology*, 1998. Reprinted by permission of Prentice Hall, Upper Saddle River, N.J.)

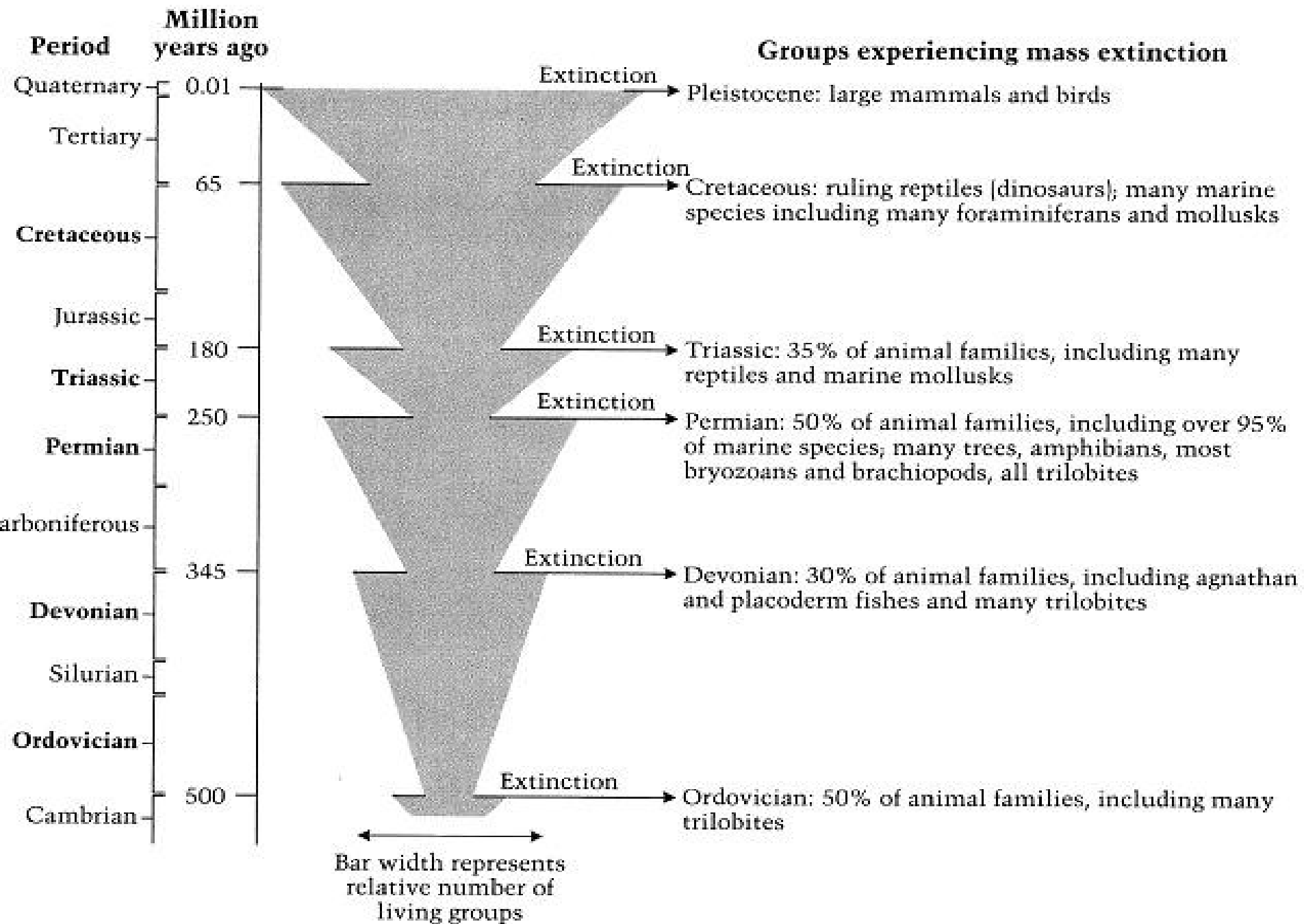
Antarctic Ice Core Data 1

— Temperature Variation — CO2 Concentration



The planet is now outside of its normal "Operating Regime", making prediction difficult.....



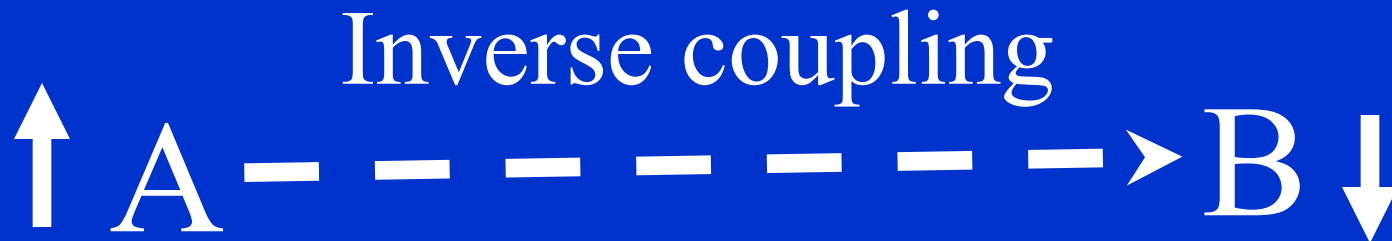
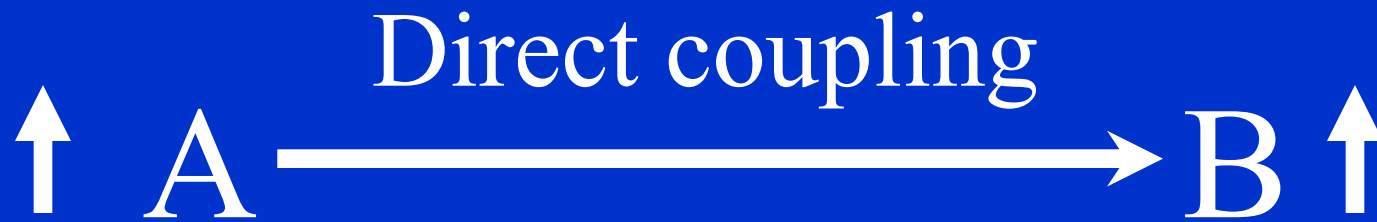


Gaia in action

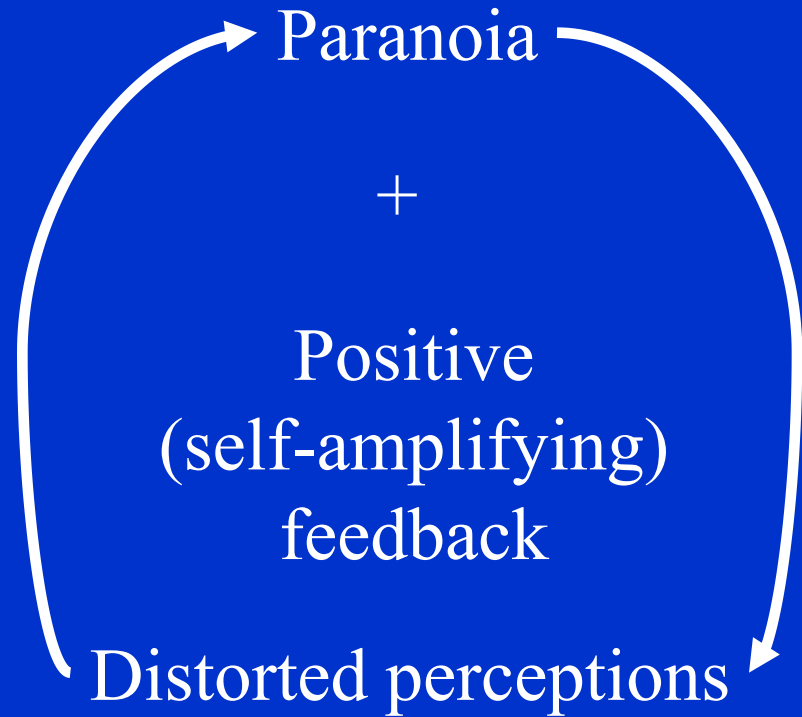
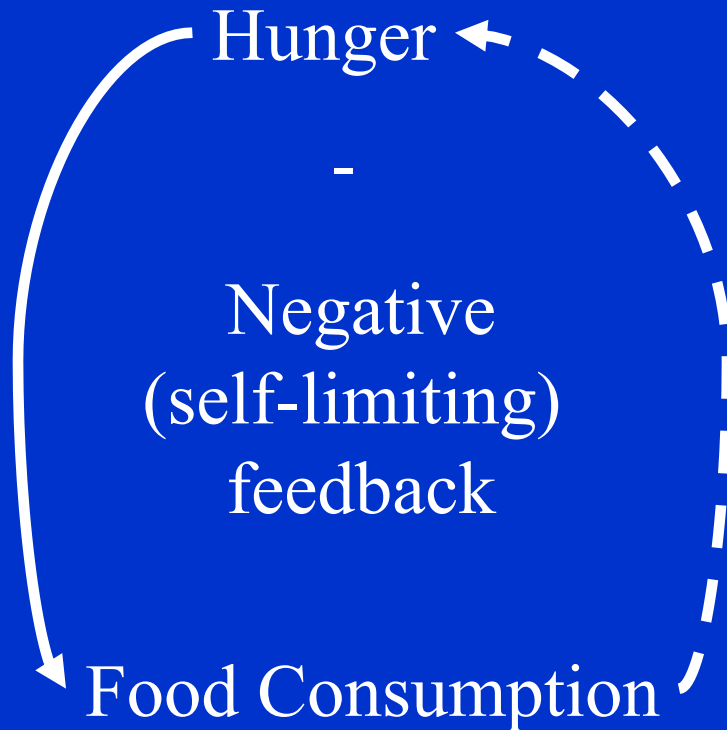
Cybernetics

Cybernetics was defined by Norbert Wiener, in his book of that title (1948), as *the study of control and communication in the animal and the machine.*

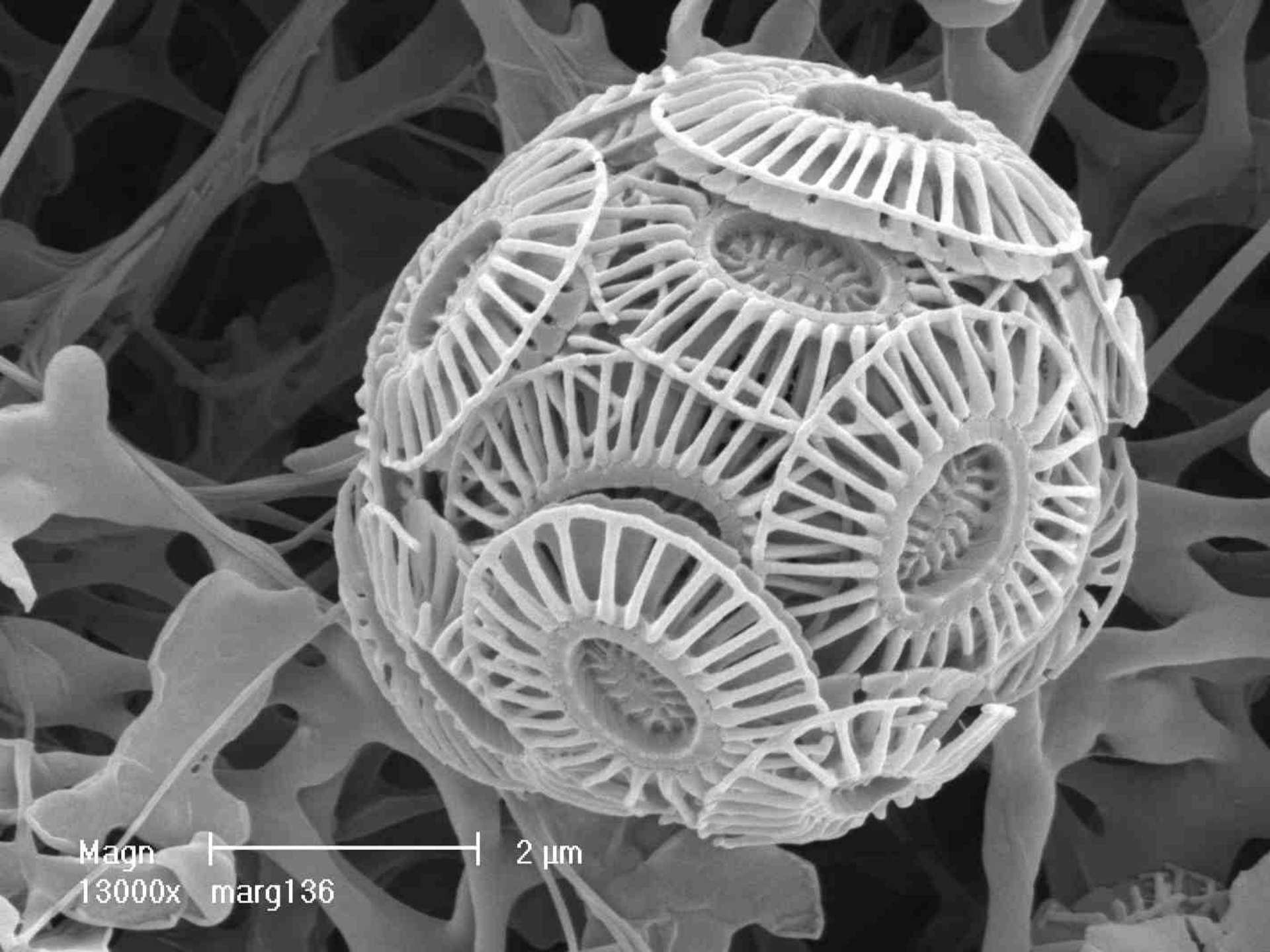
Basic Cybernetics



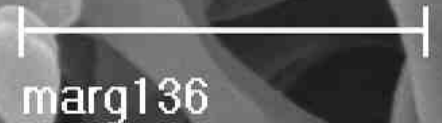
Negative and Positive Feedback







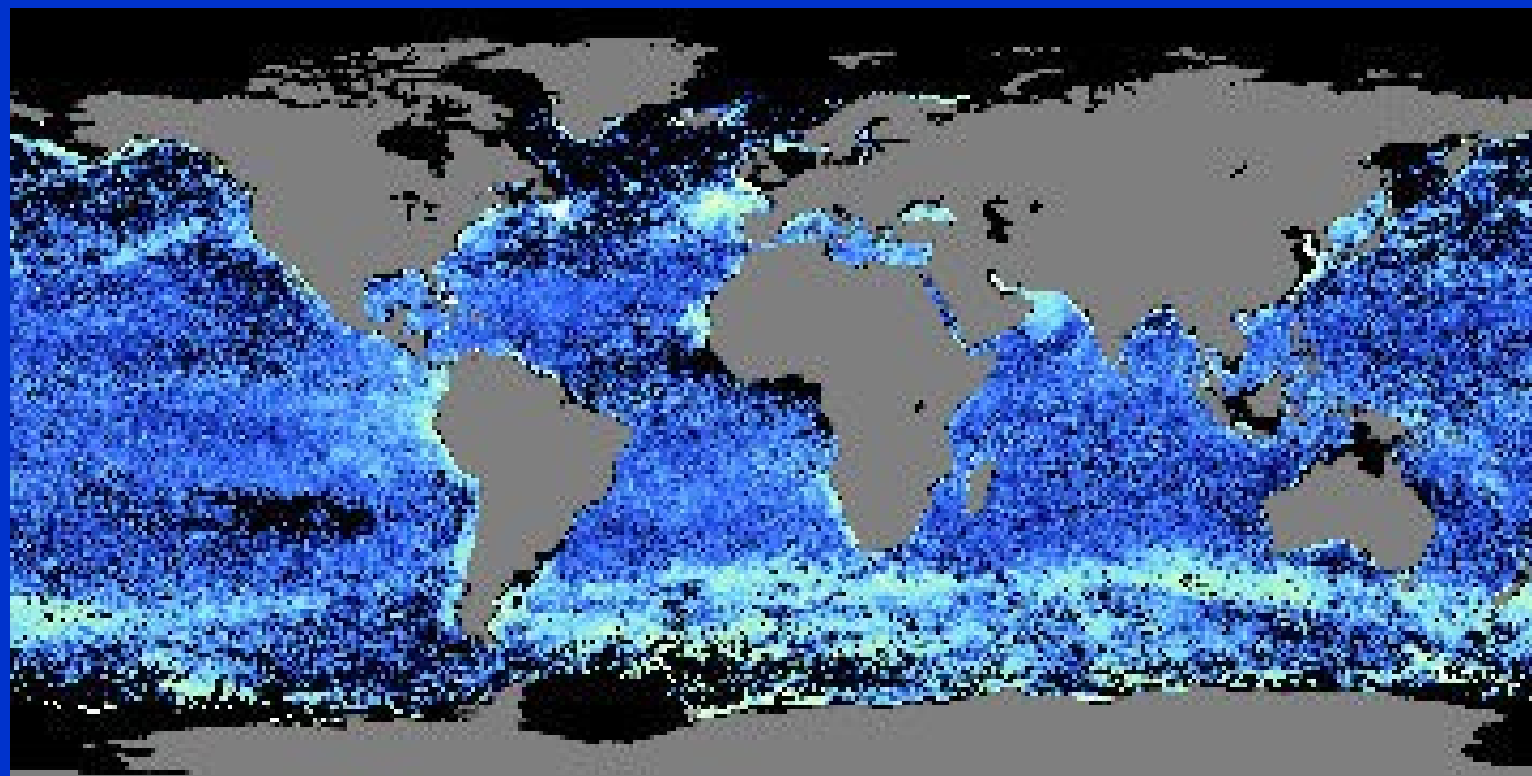
Magn
13000x



2 μ m

marg136

Coccolithophore calcite production, March 2003



Calcite Concentration (mgC/m³)

0.1

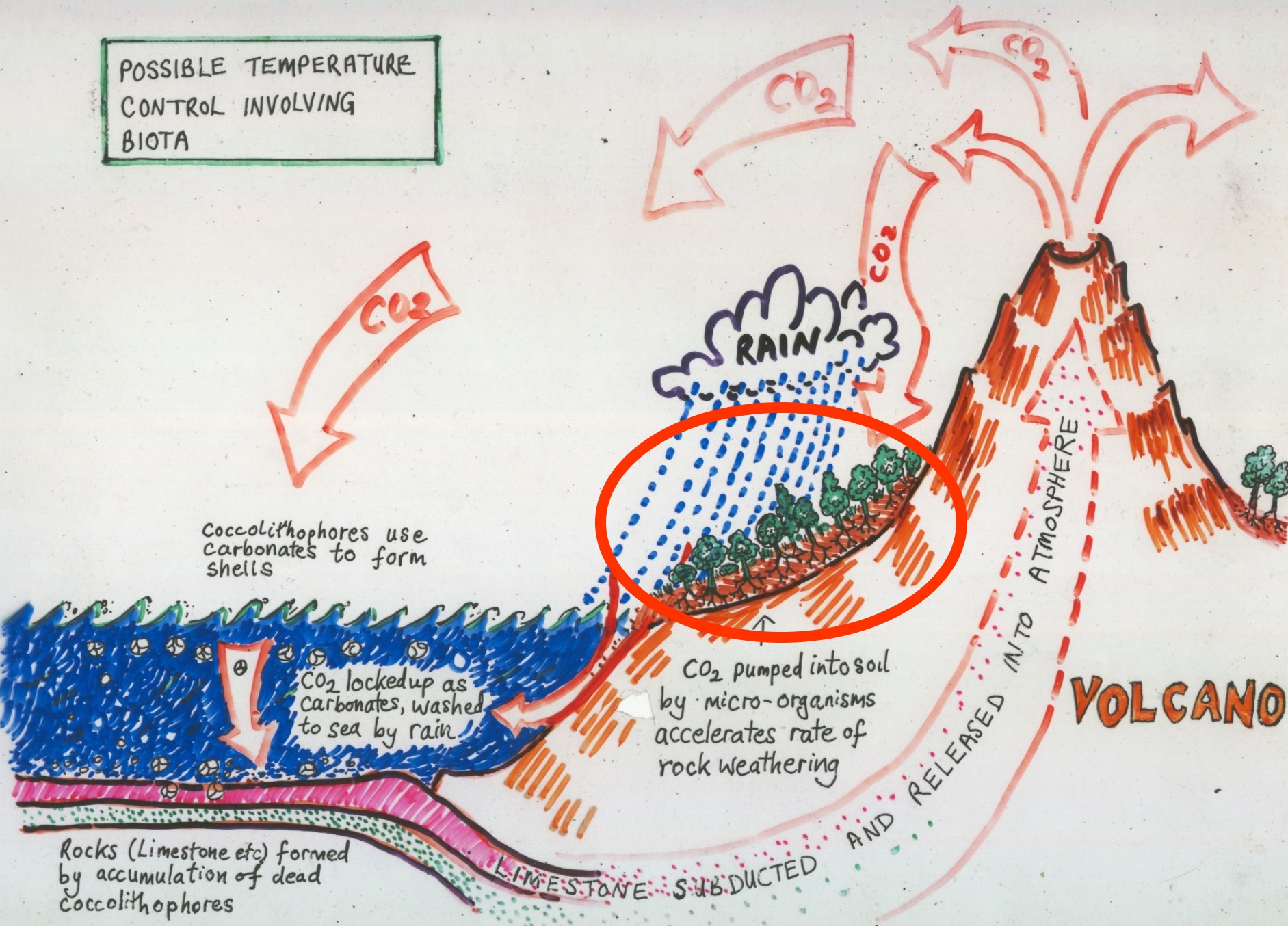
1

1.0

10

20

POSSIBLE TEMPERATURE CONTROL INVOLVING BIOTA



Coccolithophores use carbonates to form shells

CO₂ locked up as carbonates, washed to sea by rain

CO₂ pumped into soil by micro-organisms accelerates rate of rock weathering

Rocks (Limestone etc) formed by accumulation of dead Coccolithophores

LIMESTONE SUBDUCTED

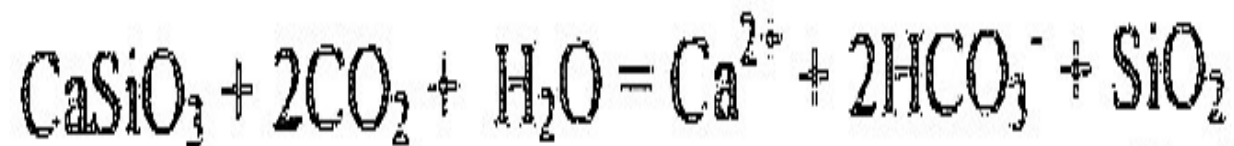
VOLCANO

AND RELEASED INTO ATMOSPHERE



LAND

Silicate rock weathering

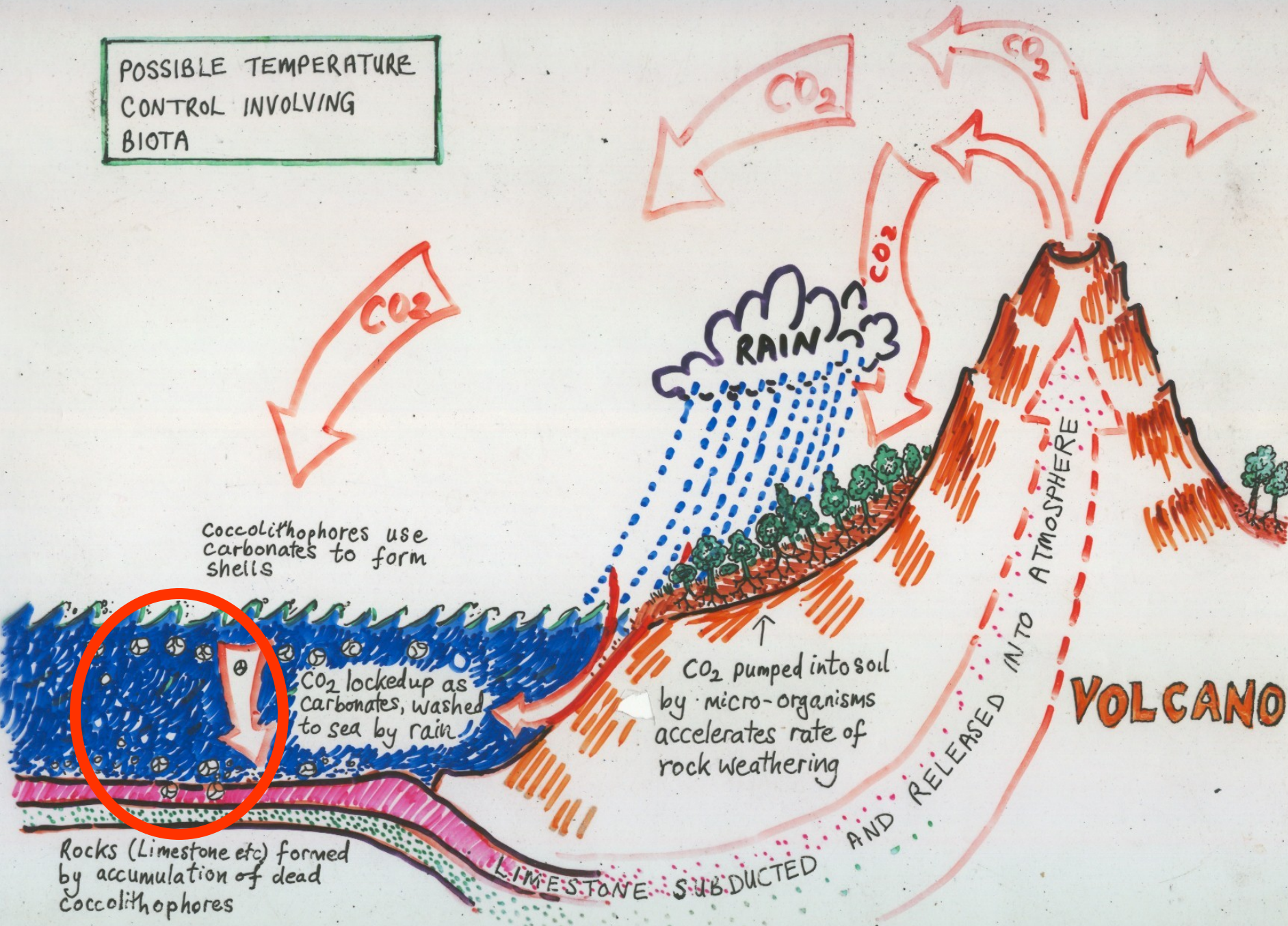


from atmosphere

used by diatoms



POSSIBLE TEMPERATURE CONTROL INVOLVING BIOTA



Coccolithophores use carbonates to form shells

CO₂ locked up as carbonates, washed to sea by rain

CO₂ pumped into soil by micro-organisms accelerates rate of rock weathering

Rocks (Limestone etc) formed by accumulation of dead Coccolithophores

LIMESTONE SUBDUCTED AND RELEASED INTO ATMOSPHERE

VOLCANO

Coccolithophorids

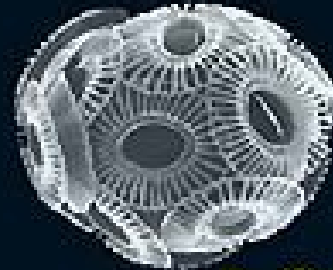
円石藻のいろいろ



Helicosphaera



Oolithus



Emiliana



Algirosphaera



Calcidiscus



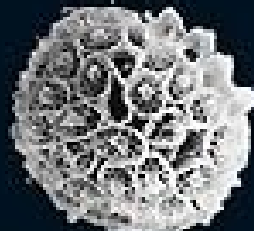
Rhabdosphaera



Umbellosphaera



Braardosphaera



Cayptrolithina



Coronosphaera



Gephyrocapsa

Diatoms

珪藻のいろいろ





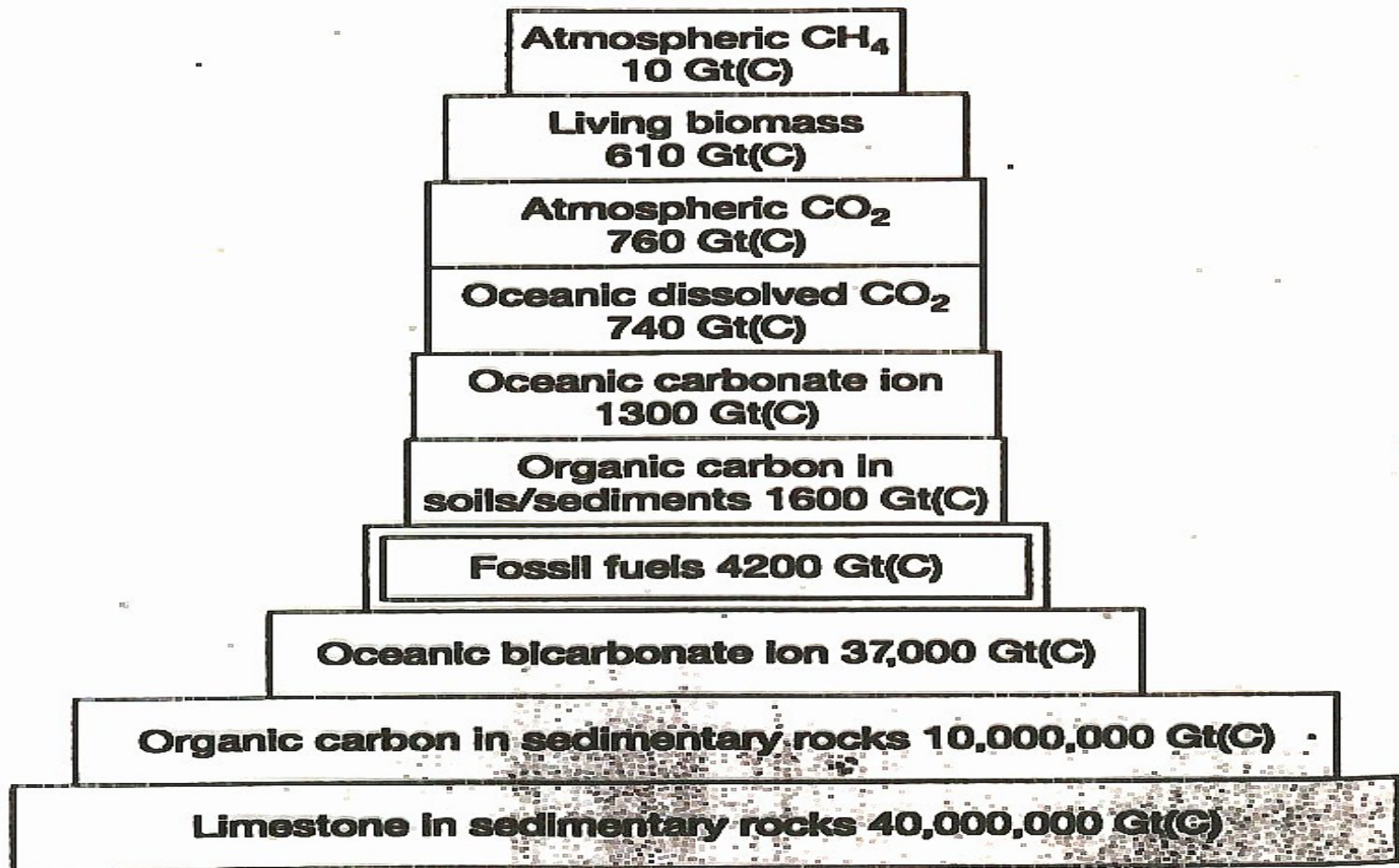
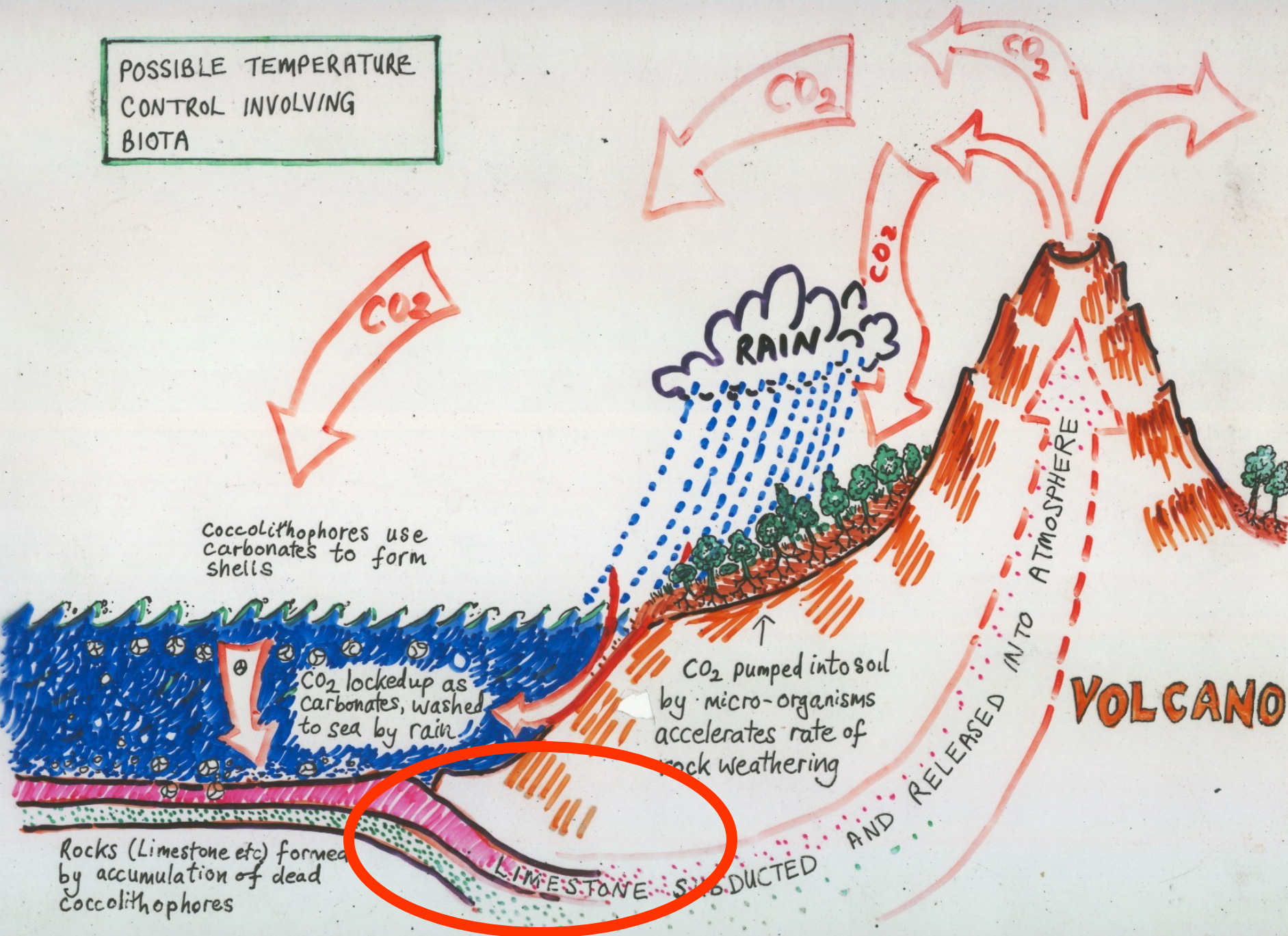


FIGURE 7-3

Reservoirs of carbon at or near Earth's surface (circa 1997).

POSSIBLE TEMPERATURE CONTROL INVOLVING BIOTA



Coccolithophores use carbonates to form shells

CO₂ locked up as carbonates, washed to sea by rain

CO₂ pumped into soil by micro-organisms accelerates rate of rock weathering

Rocks (Limestone etc) formed by accumulation of dead Coccolithophores

LIMESTONE SUBDUCTED AND RELEASED INTO ATMOSPHERE

VOLCANO

RAIN

CO₂

CO₂

CO₂

CO₂

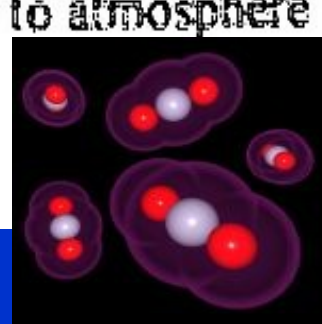
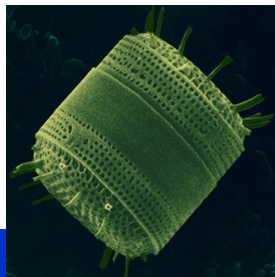
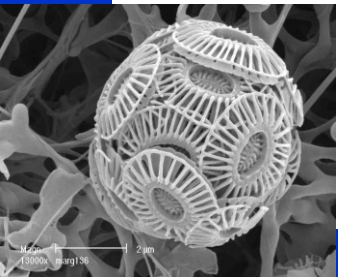
RELEASED INTO ATMOSPHERE

SUBDUCTION ZONES

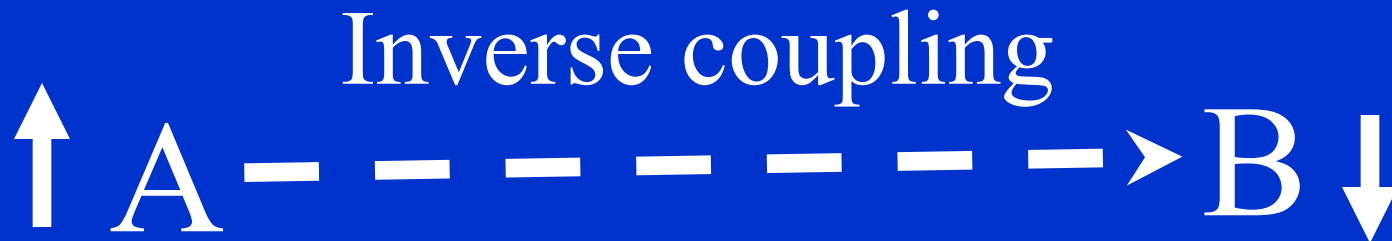
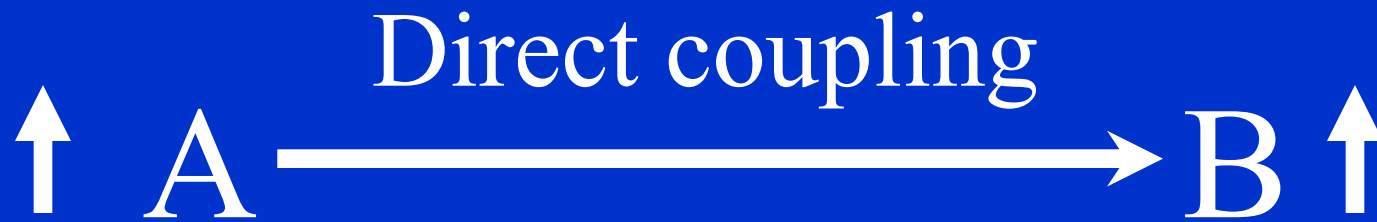
Carbonate metamorphism



to atmosphere



Basic Cybernetics



Volcanic eruptions



Carbon dioxide in
the atmosphere



Gaia's
Temperature



Rainfall



Biologically assisted
silicate rock weathering



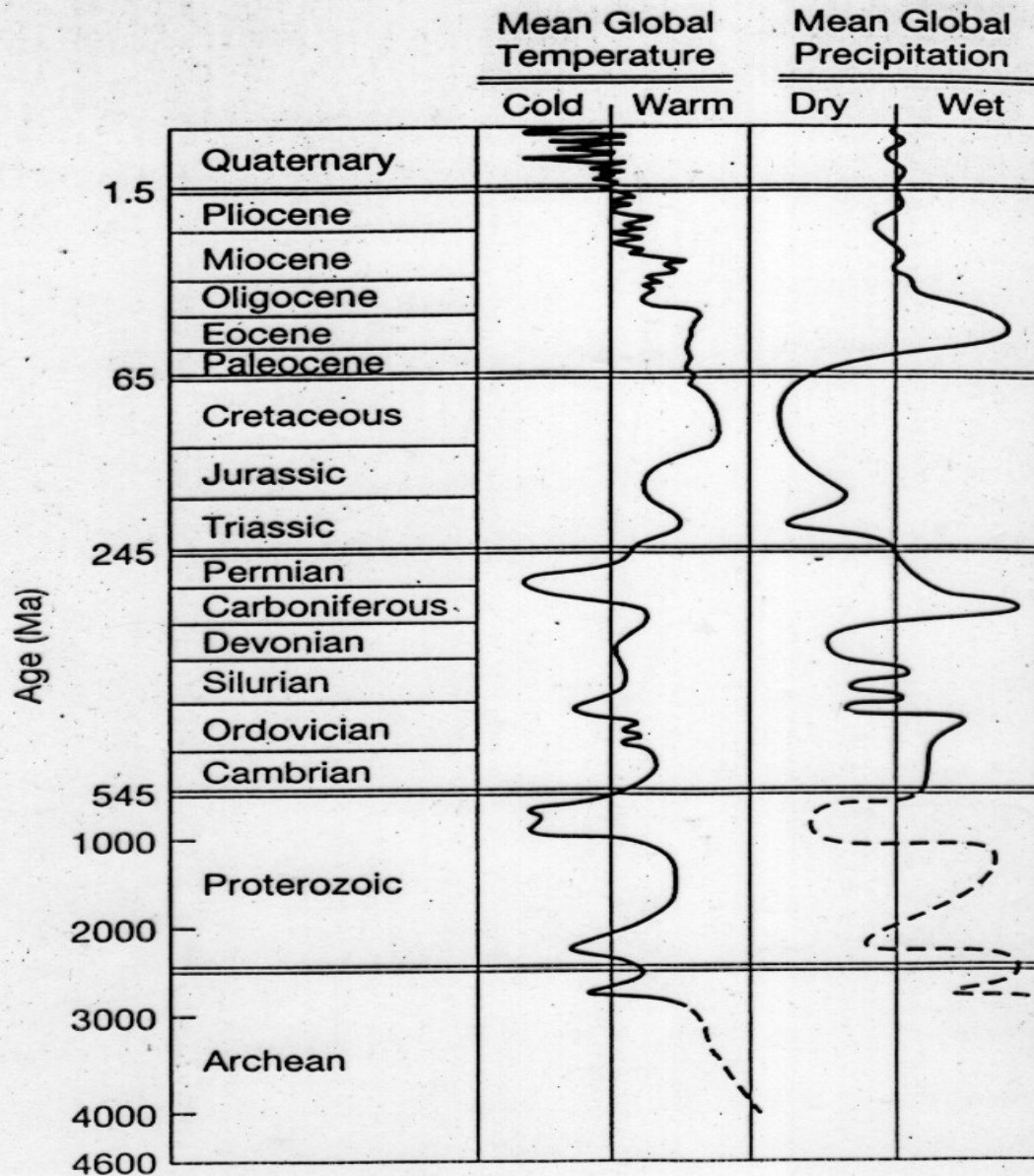
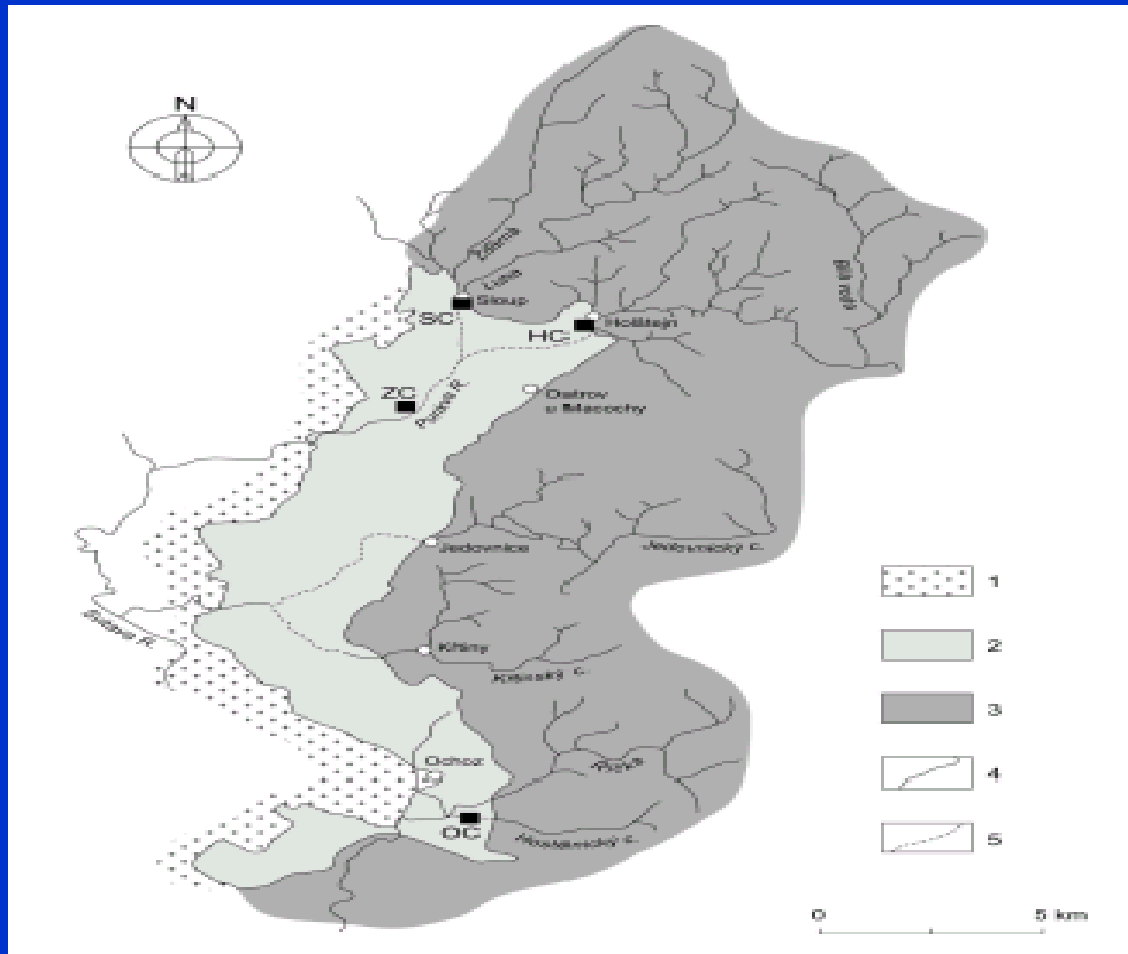


FIGURE 8-14

Estimated change in surface temperature during the Phanerozoic eon. (From K.C. Condie and R.E. Sloan: *Origin and Evolution of Earth: Principles of Historical Geology*, 1998. Reprinted by permission of Prentice Hall, Upper Saddle River, N.J.)

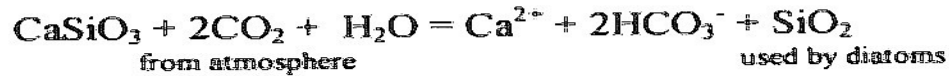


1 – Proterozoic granitoids; 2 – Devonian to Lower Carboniferous limestones; 3 – Lower Carboniferous shales, greywackes and conglomerates; 4 – surface reaches of streams; 5 – subsurface reaches of streams; caves with key sedimentary sections: SC – Sloupsko-sosuvská Cave; HC – Holštejnská Cave; ZC – Zazdená Cave; OC – Ochozská Cave

The Carbonate-Silicate (Bio)Geochemical Cycle

LAND

Silicate rock weathering



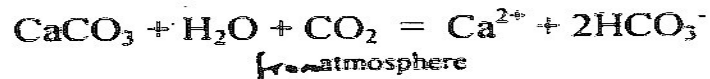
OCEAN

Carbonate deposition by marine algae and corals



LAND

Carbonate weathering



SUBDUCTION ZONES

Carbonate metamorphism

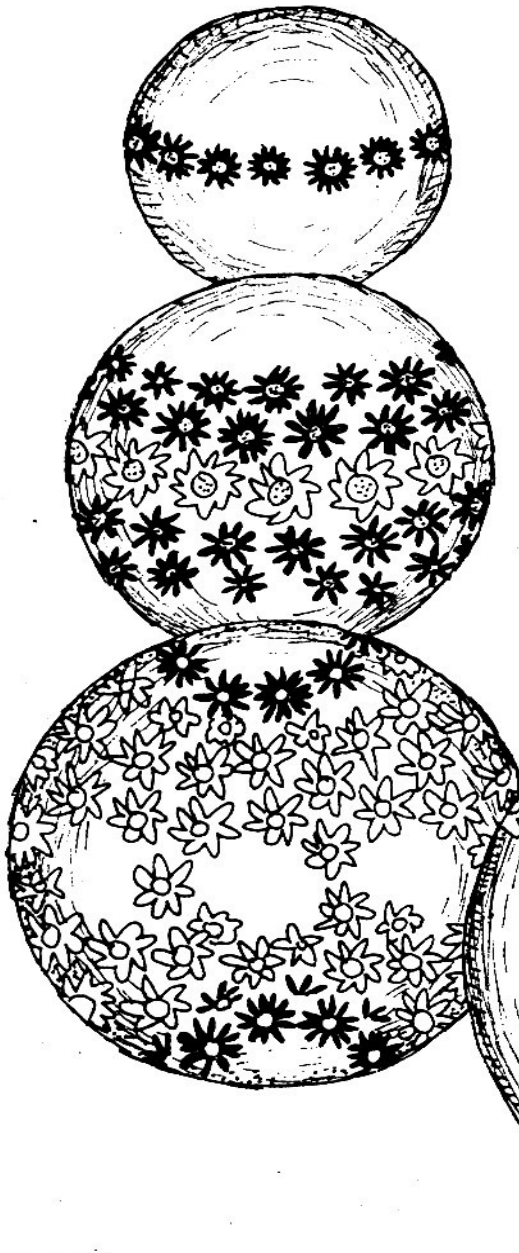




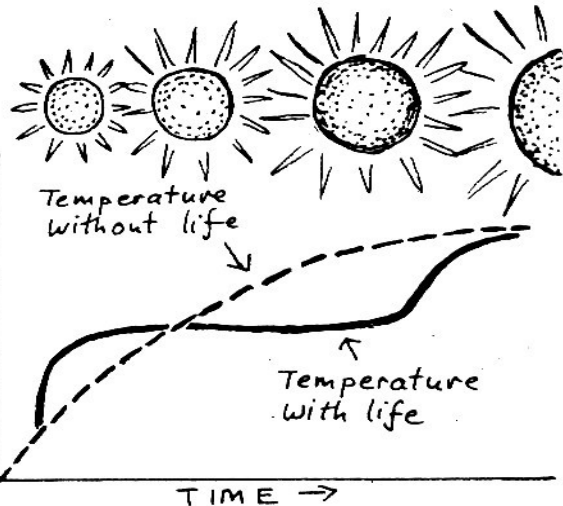
Daisyworld

Albedos of Some Common Surfaces

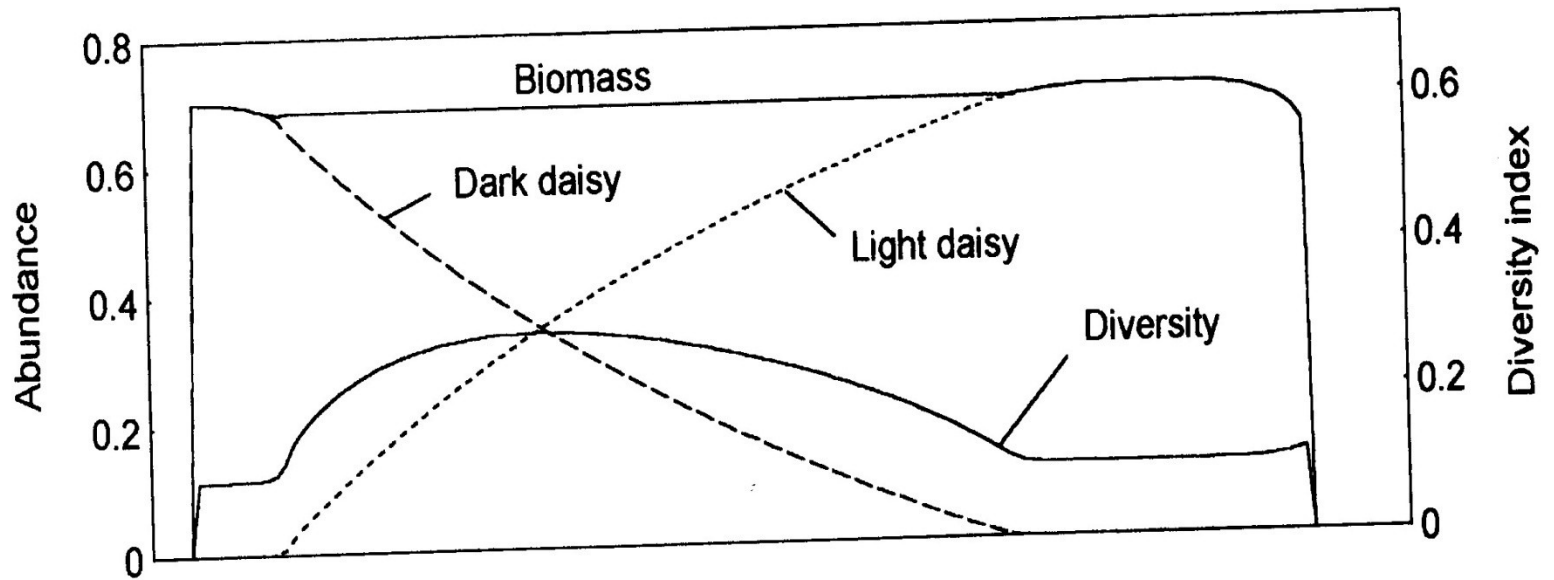
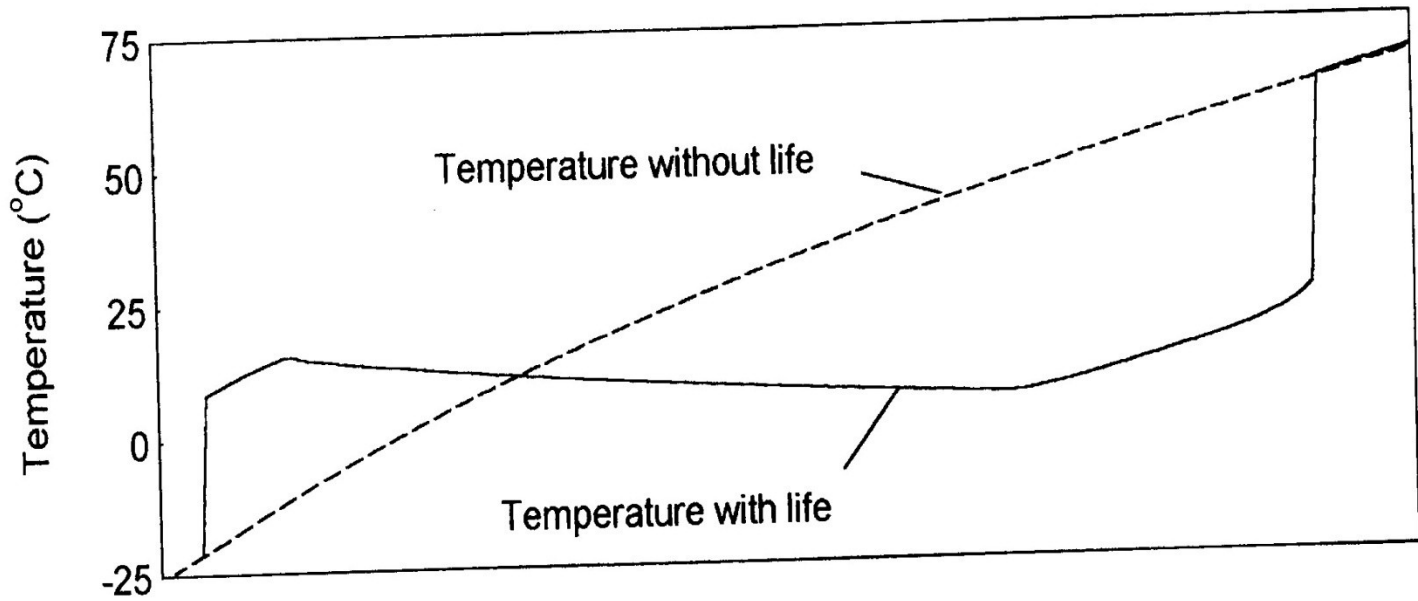
<i>Type of Surface</i>	<i>Albedo</i>
Sand	0.20–0.30
Grass	0.20–0.25
Forest	0.05–0.10
Water (overhead Sun)	0.03–0.05
Water (Sun near horizon)	0.50–0.80
Fresh snow	0.80–0.85
Thick cloud	0.70–0.80



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THE EVOLUTION OF
CLIMATE ON
DAISYWORLD

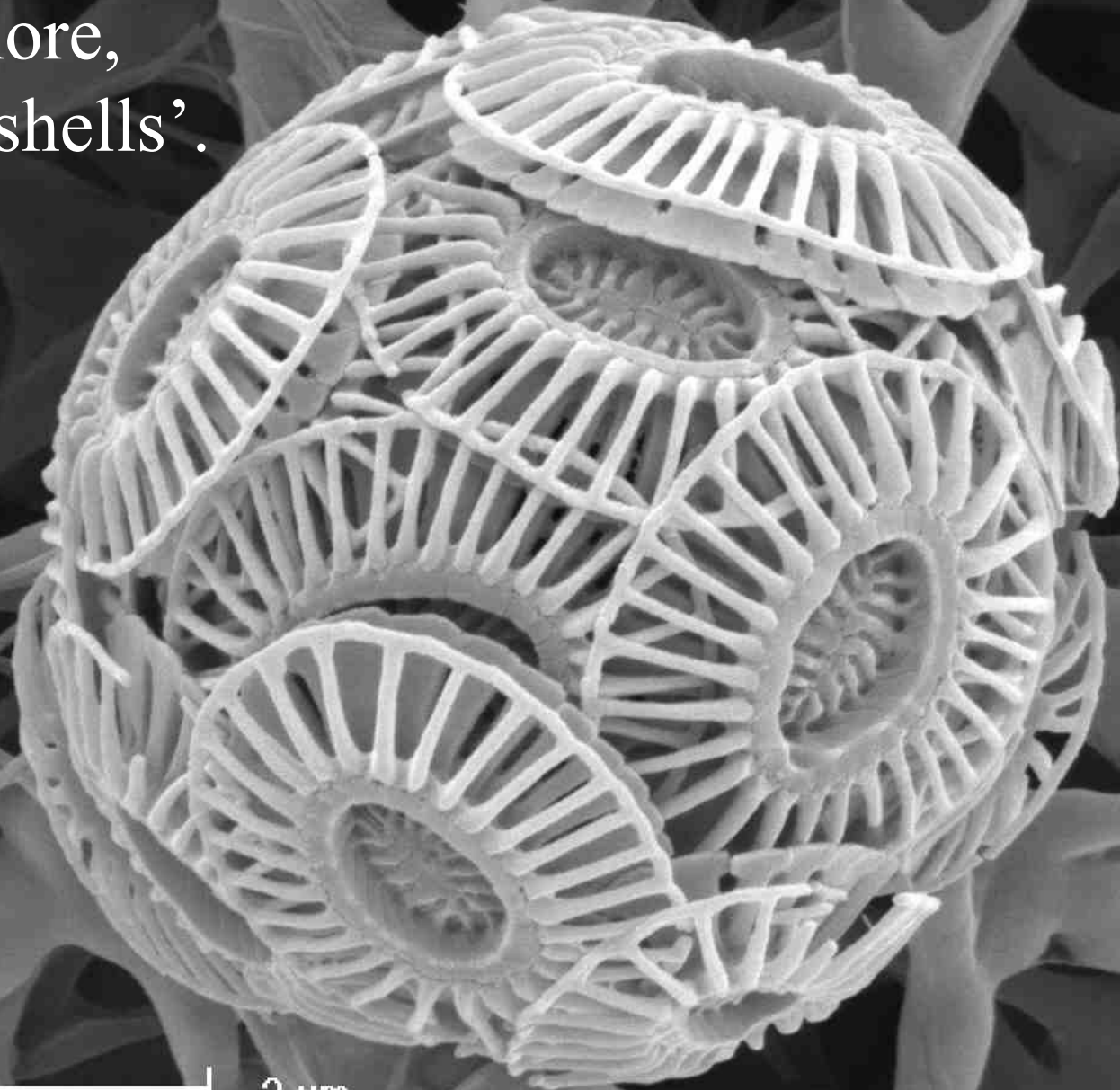


Recipe for a Gaian system.

1. Living organisms which grow exponentially.
2. Natural Selection.
3. Organisms which affect their physical and chemical environment.
4. Constraints or bounds to organisms' growth set by the environment.

Gaia theory is about the evolution of a tightly coupled system whose constituents are the biota and their material environment, which comprises the atmosphere, the oceans, and the surface rocks. Self-regulation of important properties, such as climate and chemical composition, is seen as a consequence of this evolutionary process.

Coccolithophore,
with calcite 'shells'.

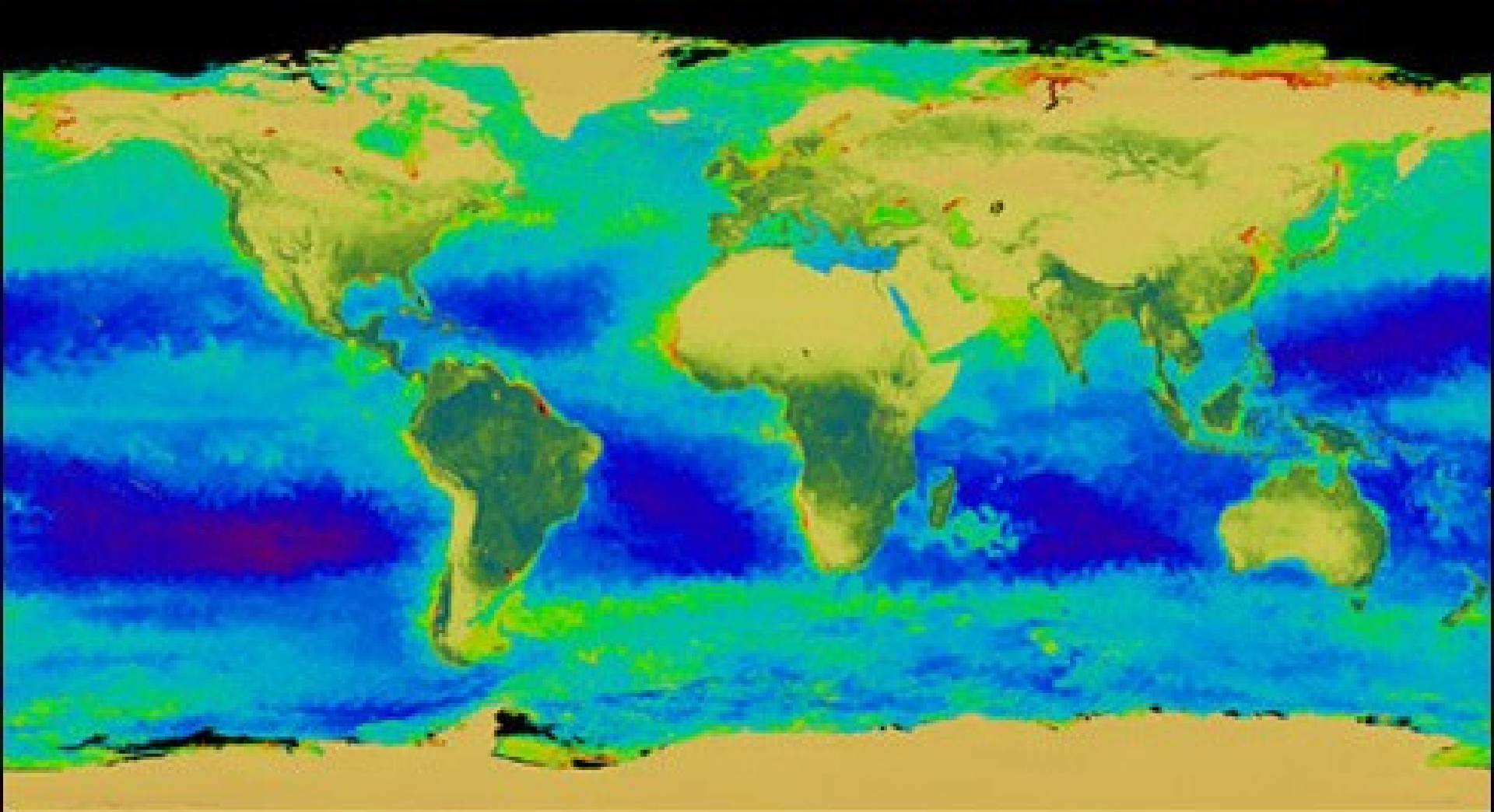


Magn

13000x

marg136

2 μ m



Chlorophyll *a* Concentration (mg/m³)



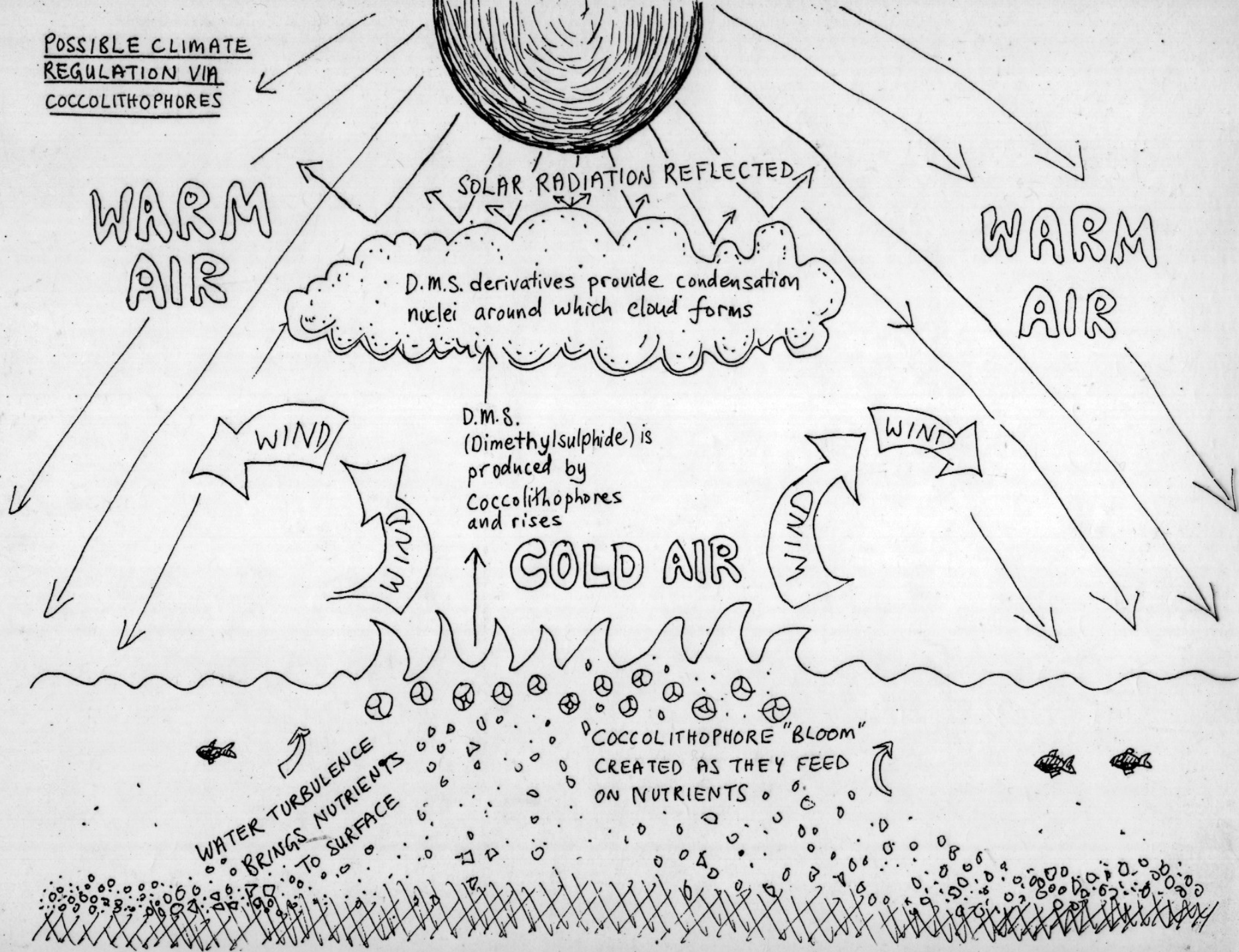
Normalized Difference Vegetation Index







POSSIBLE CLIMATE
REGULATION VIA
COCCOLITHOPHORES



SOLAR RADIATION REFLECTED

WARM AIR

WARM AIR

D.M.S. derivatives provide condensation nuclei around which cloud forms

D.M.S. (Dimethylsulphide) is produced by Coccolithophores and rises

WIND

WIND

COLD AIR

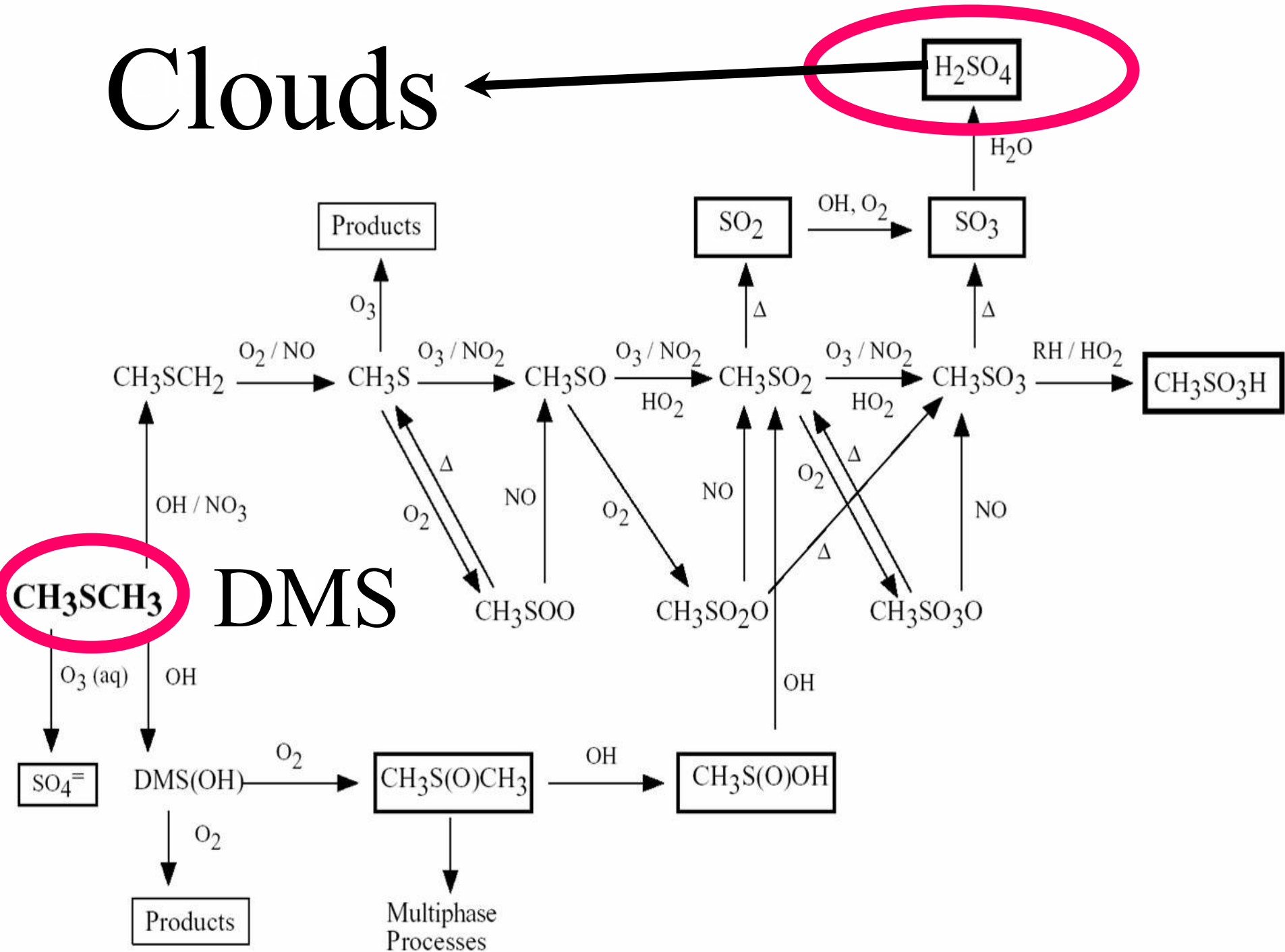
WIND

WIND

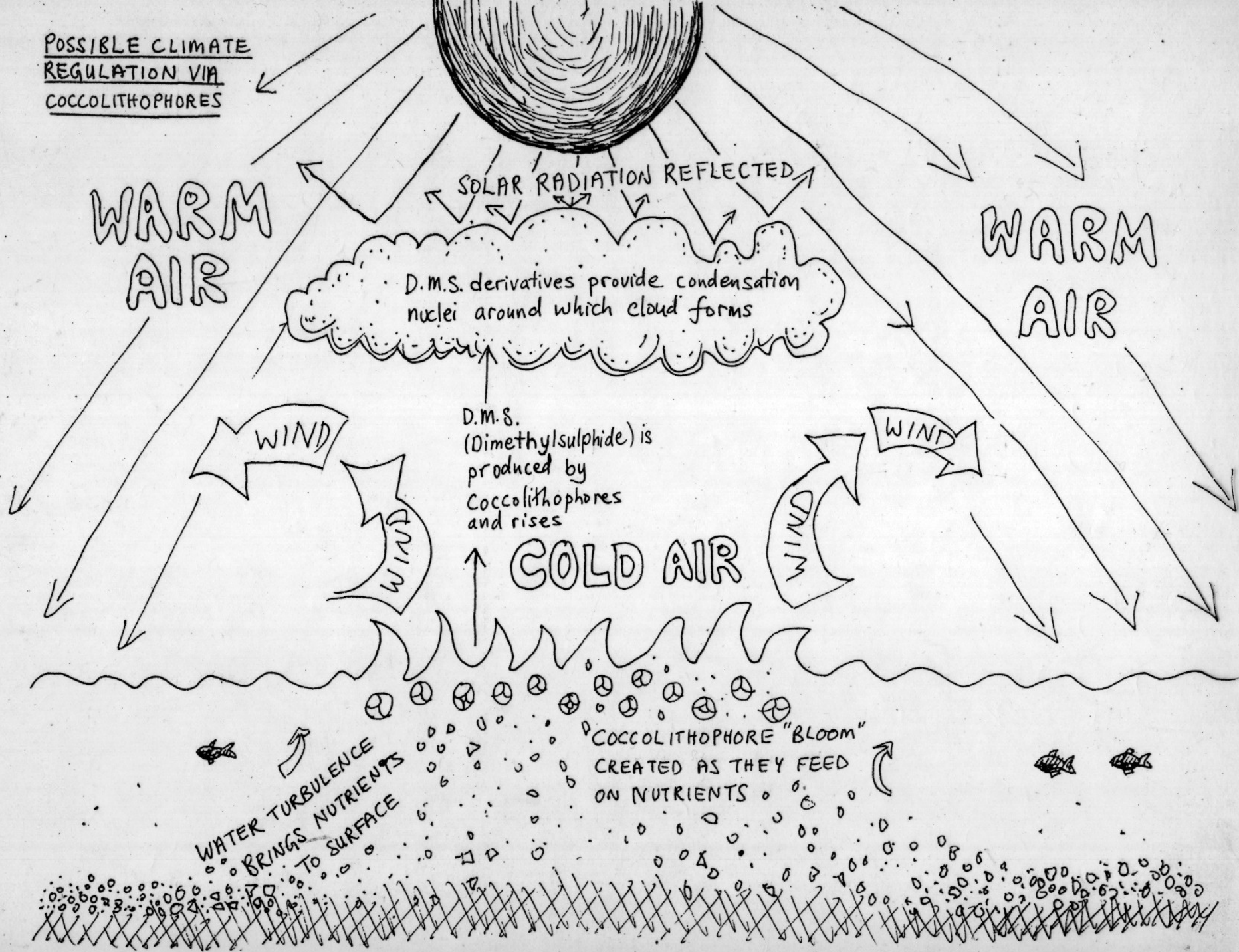
WATER TURBULENCE BRINGS NUTRIENTS TO SURFACE

COCCOLITHOPHORE "BLOOM" CREATED AS THEY FEED ON NUTRIENTS

Clouds



POSSIBLE CLIMATE
REGULATION VIA
COCCOLITHOPHORES



SOLAR RADIATION REFLECTED

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WIND

WIND

COLD AIR

WIND

WIND

WATER TURBULENCE BRINGS NUTRIENTS TO SURFACE

COCCOLITHOPHORE "BLOOM" CREATED AS THEY FEED ON NUTRIENTS







Atmosphere

clouds

- ?

Sea surface
temperature

DMS production

Coccolithophore blooms

Ocean

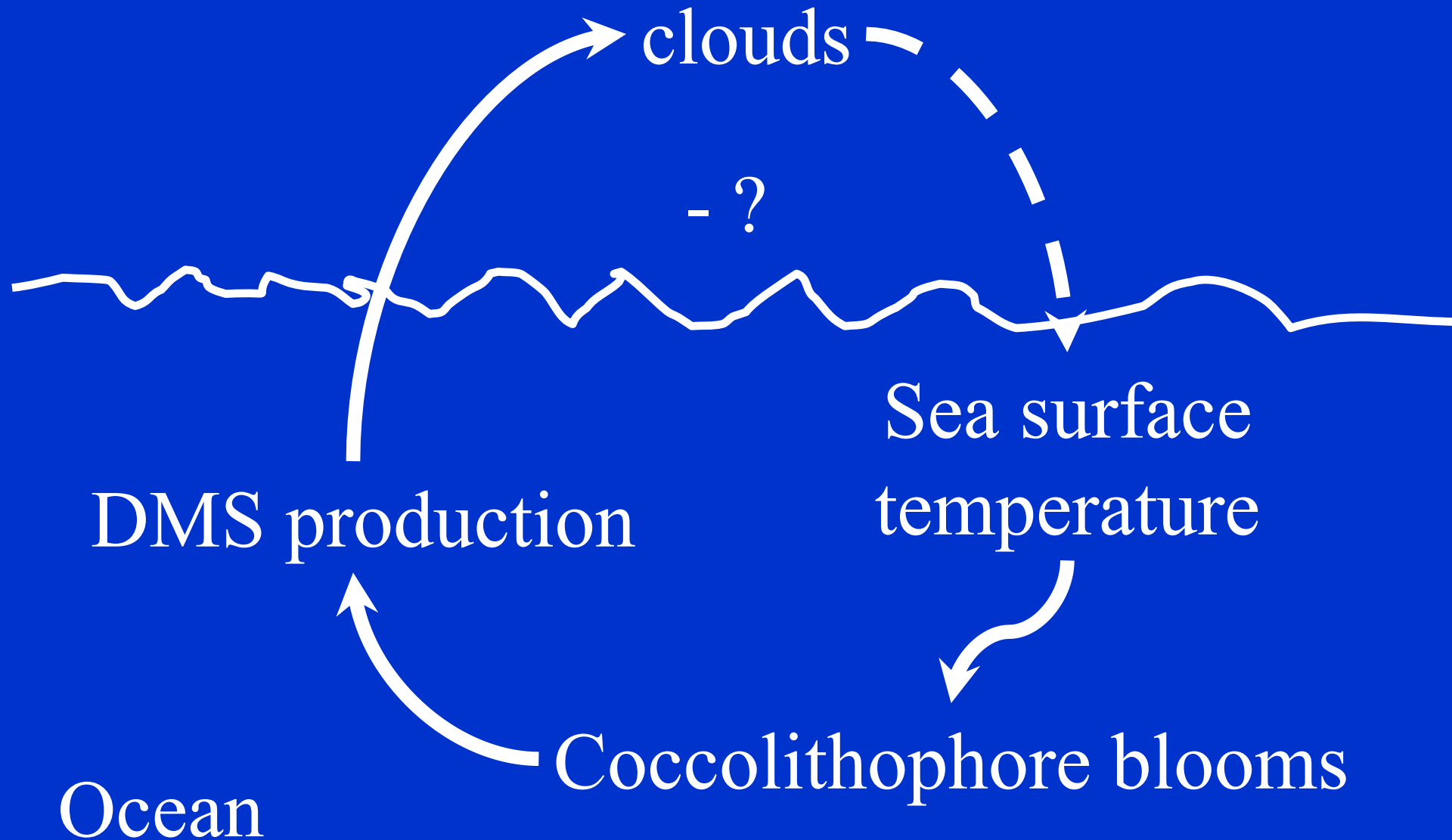
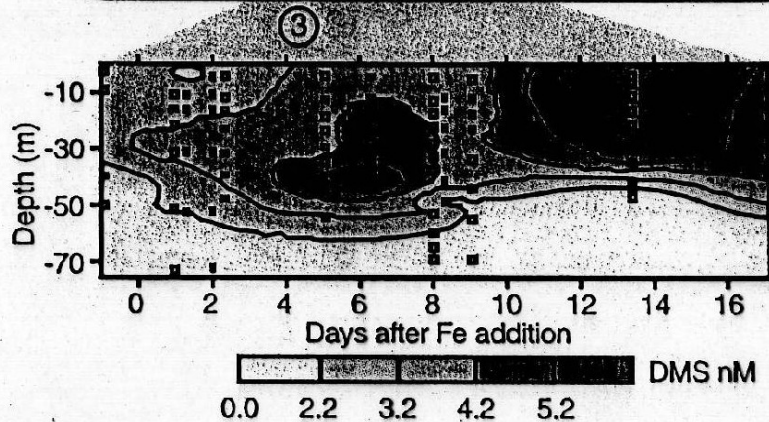
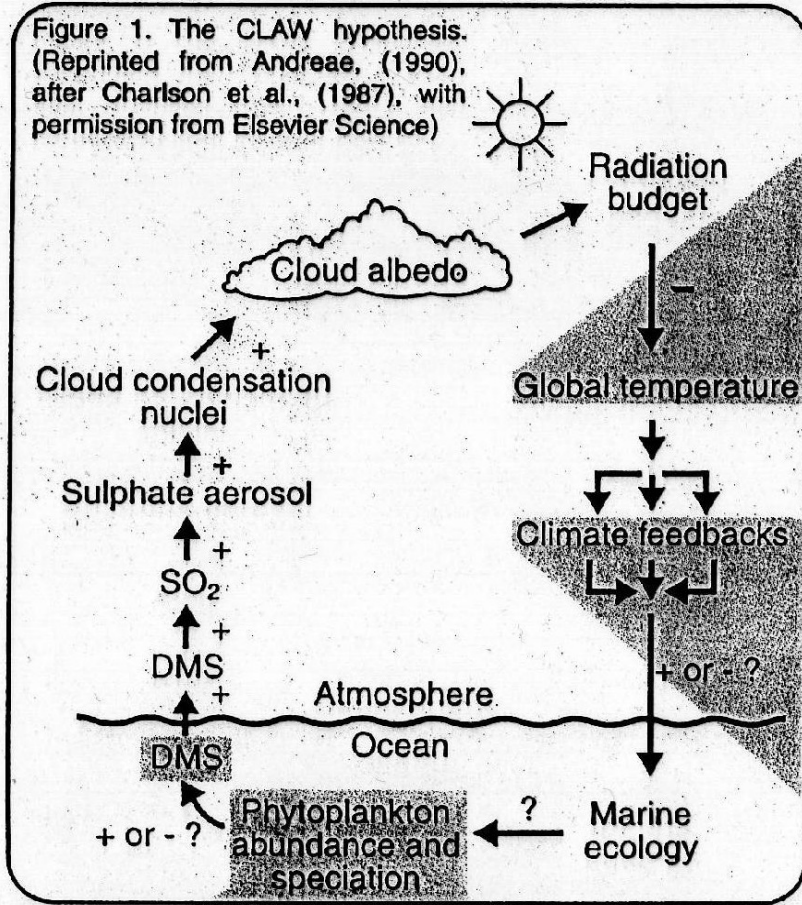
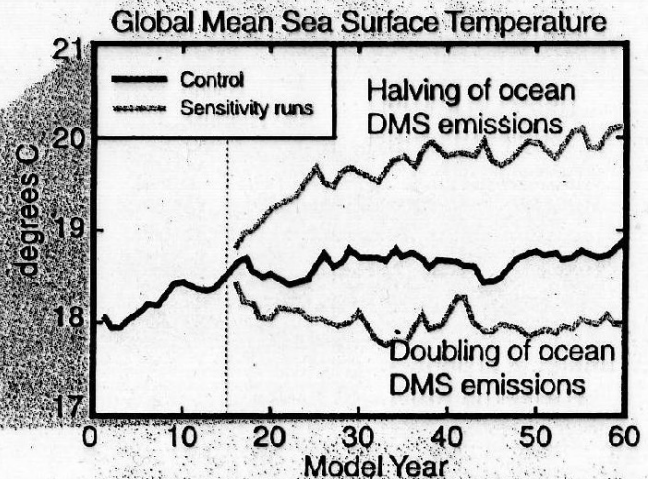


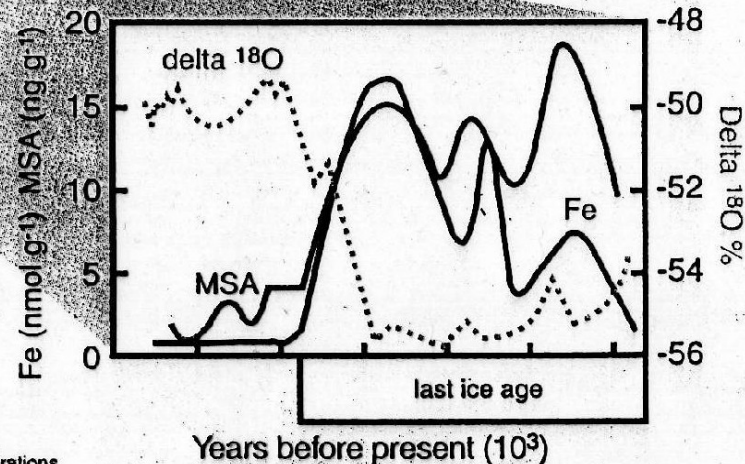
Figure 1. The CLAW hypothesis. (Reprinted from Andreae, (1990), after Charlson et al., (1987), with permission from Elsevier Science)



DMS concentrations during an Fe addition experiment in the tropical Pacific (Iron Ex II). DMS concentrations increased by a factor of 3.5 during the experiment. (Image: S. Turner, data from Turner et al. (1996) Nature 383: 513.

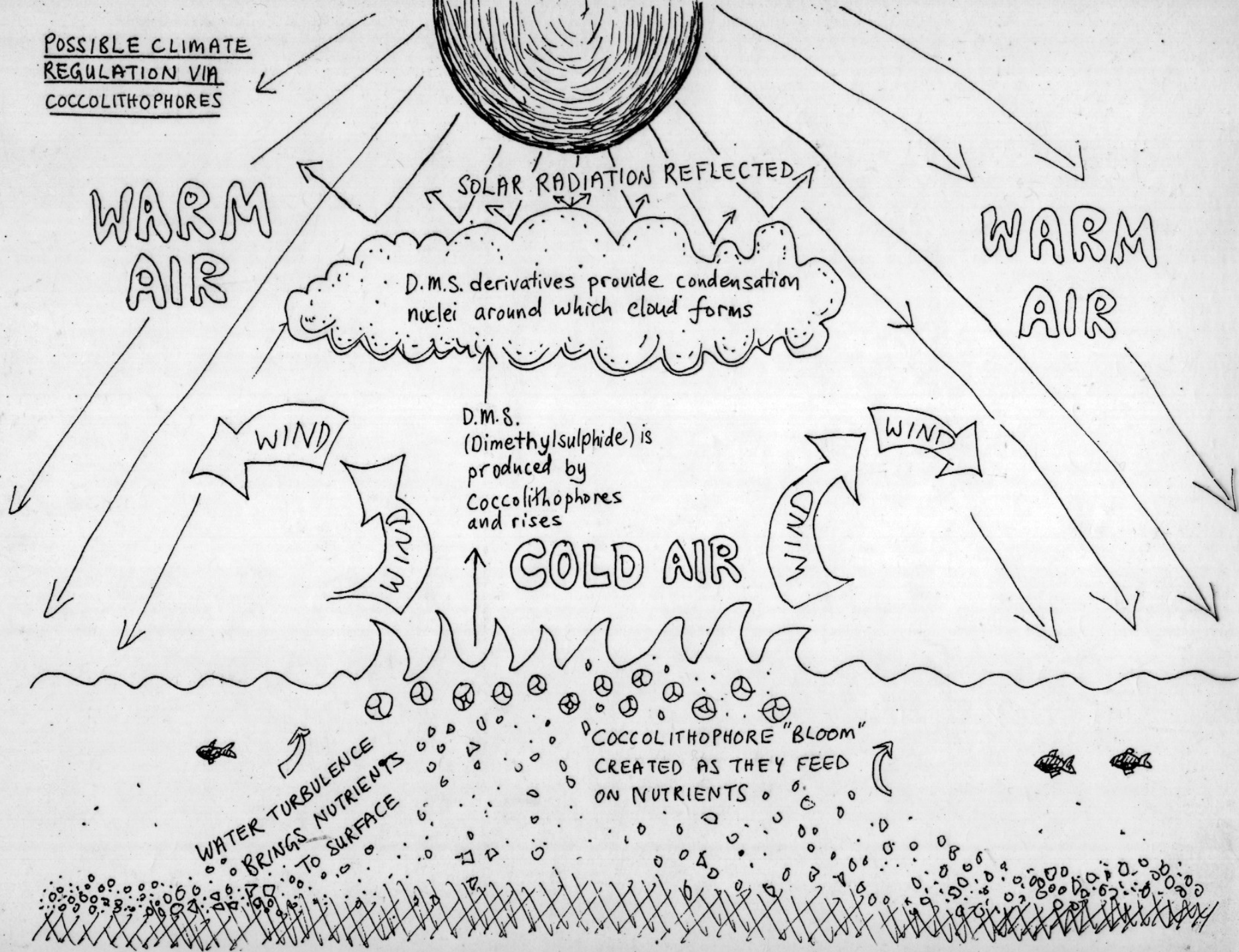


Global mean sea surface temperature simulated in the Hadley Centre atmosphere/ocean coupled model (HadCM3). The simulation includes a representation of the effect of ocean DMS emissions on cloud properties. Sensitivity experiments show a strong climate response to changes in ocean DMS emissions. From Met Office (2001). Science and Technical Review 2000/1.



Ice core data for the Holocene and the end of the last ice age. MSA (green) is a proxy for atmospheric DMS concentrations and $\delta^{18}O$ (blue) is a proxy for temperature (data from an ice core at Dome C, east Antarctica). Estimated Fe concentrations are shown in red (data from Vostok, Antarctica). After: Turner et al. (1996) Nature 383:513, reprinted with permission from Macmillan magazines.

POSSIBLE CLIMATE
REGULATION VIA
COCCOLITHOPHORES



SOLAR RADIATION REFLECTED

WARM AIR

WARM AIR

D.M.S. derivatives provide condensation nuclei around which cloud forms

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WIND

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COLD AIR

WATER TURBULENCE BRINGS NUTRIENTS TO SURFACE

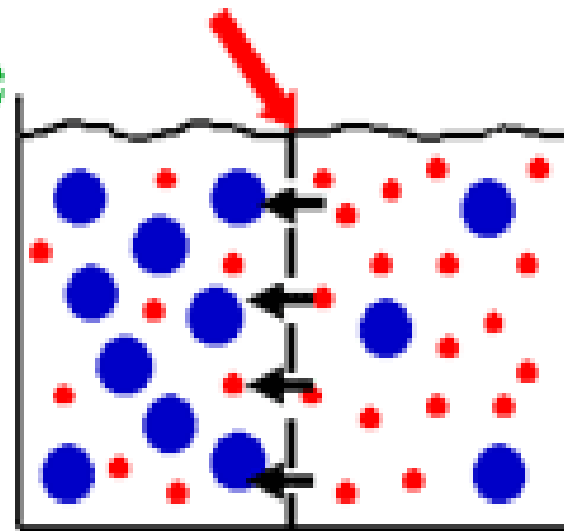
COCCOLITHOPHORE "BLOOM" CREATED AS THEY FEED ON NUTRIENTS

Why emit DMS?

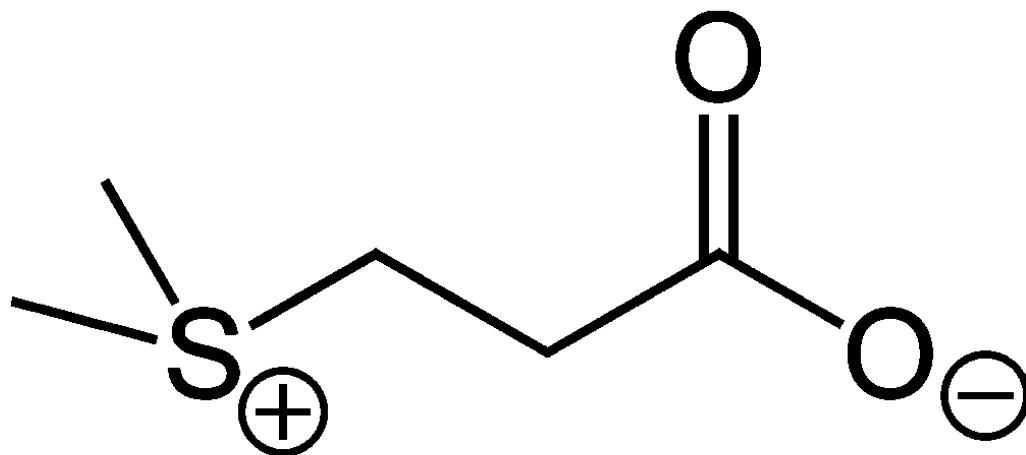
1. For the good of Gaia
2. To combat drying out
3. Dispersal

Osmosis

- Semipermeable membrane

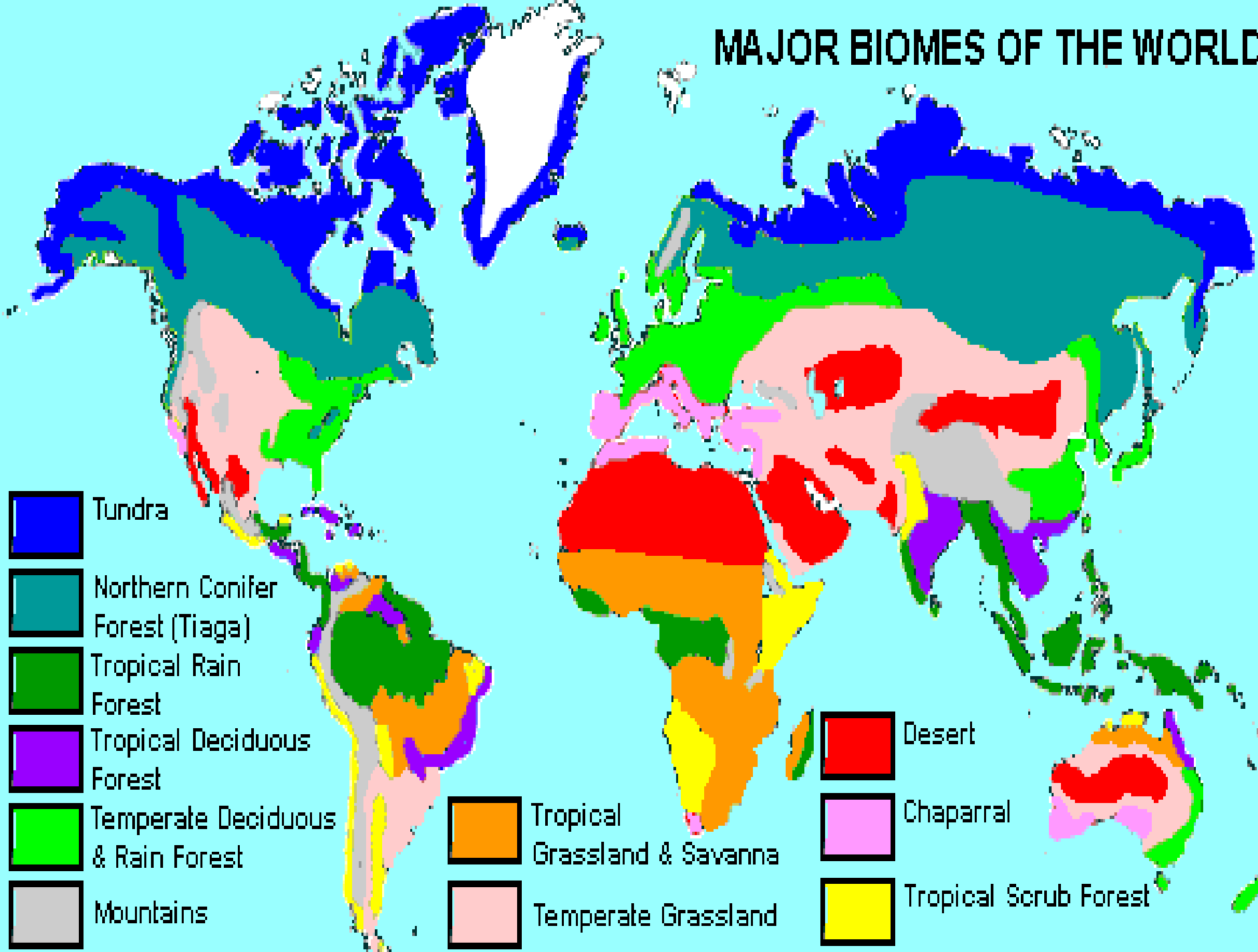


High Solute Low Solute



DMSP

MAJOR BIOMES OF THE WORLD





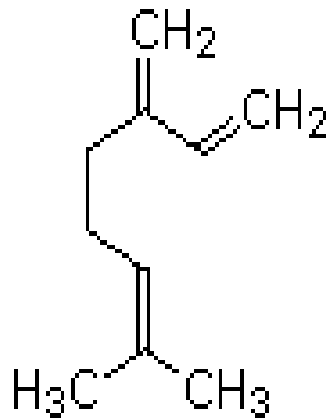


Cecropia spp.

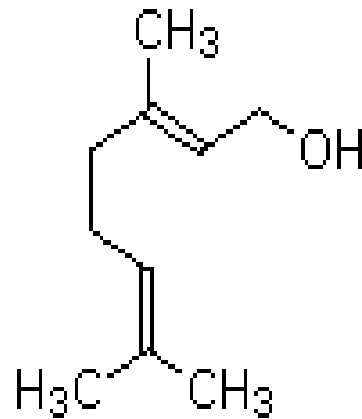


0.094 mm

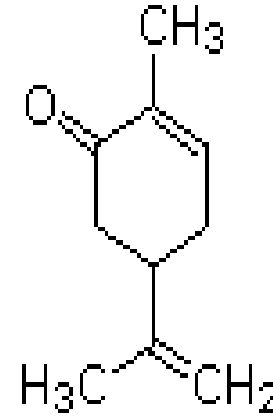
Monoterpenes



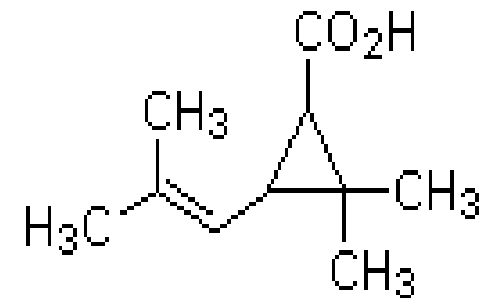
myrcene



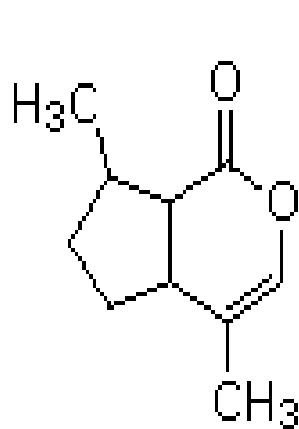
geraniol



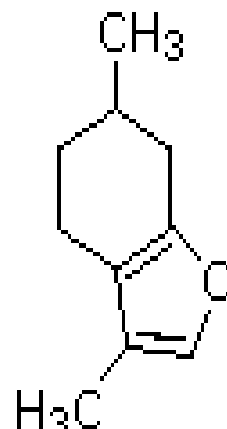
carvone



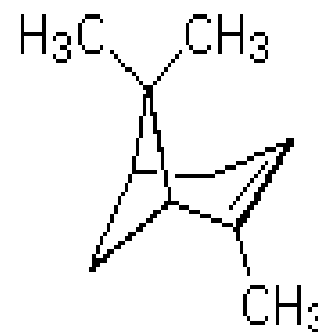
chrysantheric acid



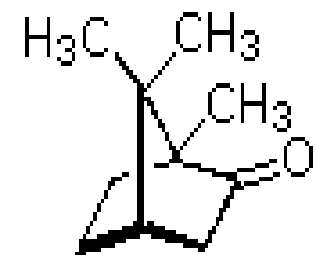
nepetalactone



menthofuran



α-pinene



camphor

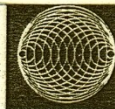




Sperm Whale



12,000 Sperm Whales in the Southern Ocean fix 240,000 tonnes of C/yr by transferring Fe from the ocean depths to the photic zone via their (liquid) faeces



Rare Earth Factors

Right distance from star
Habitat for complex life.
Liquid water near surface.
Far enough to avoid tidal lock.

Right planetary mass
Retain atmosphere and ocean. Enough heat for plate tectonics.
Solid/molten core.

Plate tectonics
CO₂-silicate thermostat.
Build up land mass.
Enhance biotic diversity.
Enable magnetic field.

Right mass of star
Long enough lifetime.
Not too much ultraviolet.

Jupiter-like neighbor
Clear out comets and asteroids. Not too close, not too far.

Ocean
Not too much.
Not too little.

Stable planetary orbits
Giant planets do not create orbital chaos.

A Mars
Small neighbor as possible life source to seed Earth-like planet, if needed.

Large Moon
Right distance.
Stabilizes tilt.

The right tilt
Seasons not too severe.

Atmospheric properties
Maintenance of adequate temperature, composition and pressure for plants and animals.

Right kind of galaxy
Enough heavy elements.
Not small, elliptical, or irregular.

Giant impacts
Few giant impacts.
No global sterilizing impacts after an initial period.

Biological evolution
Successful evolutionary pathway to complex plants and animals.

Right position in galaxy
Not in center, edge or halo.

The right amount of carbon
Enough for life.
Not enough for Runaway Greenhouse.

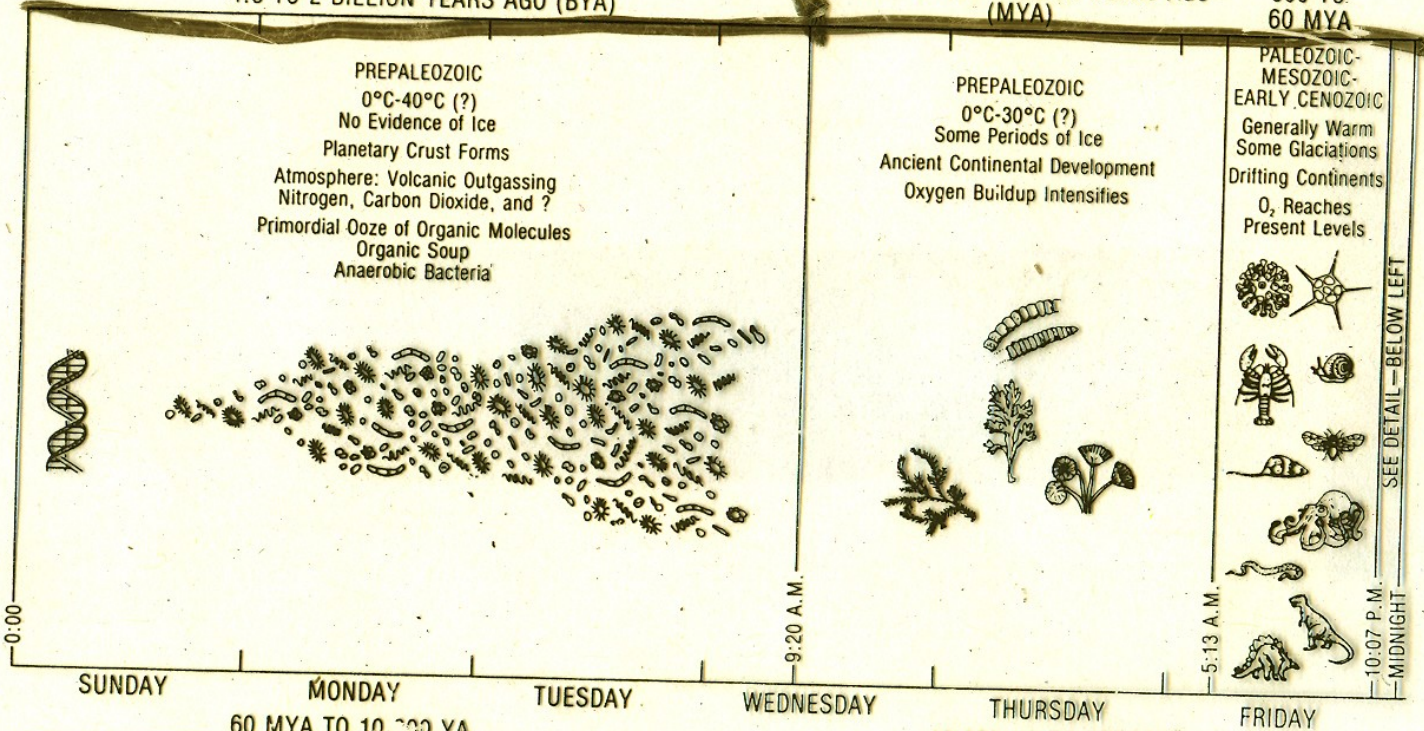
Evolution of oxygen
Invention of photosynthesis. Not too much or too little. Evolves at the right time.

Wild Cards
Snowball Earth. Cambrian explosion. Inertial interchange event.

4.6 TO 2 BILLION YEARS AGO (BYA)

2 BYA TO 600 MILLION YEARS AGO (MYA)

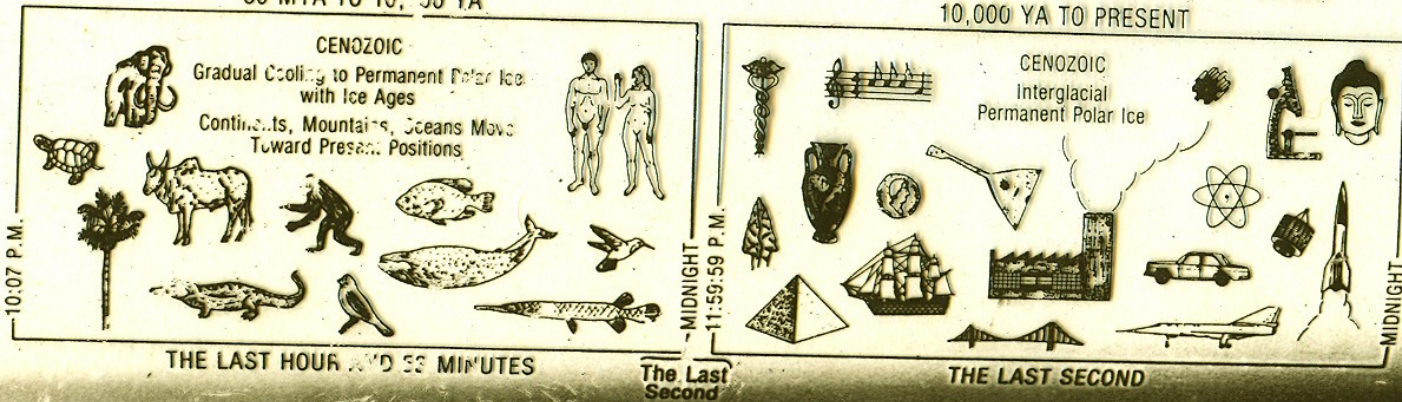
600 TO 60 MYA



SEE DETAIL — BELOW LEFT

60 MYA TO 10,000 YA

10,000 YA TO PRESENT

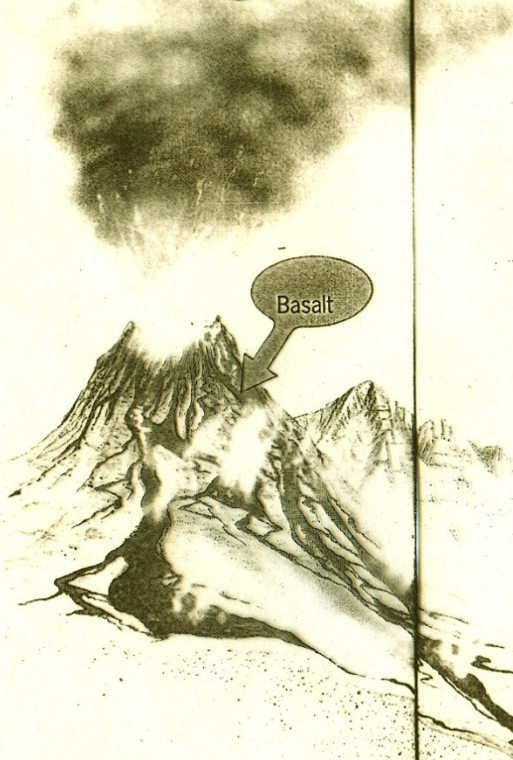




4.1 Photomicrographs of cyanobacteria. These are the organisms that first used the energy of sunlight to produce organic materials and oxygen. They have been, both in the free state, and as endosymbionts, the primary producers from the beginning of the Archean until now. (Photographs courtesy of Michael Enzien.)



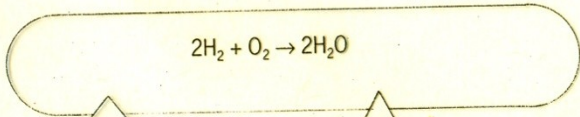
CO₂



Basalt

Hydrogen loss

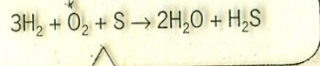
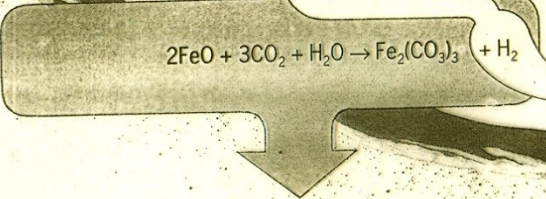
During the Archean, there would have been a continuous production of hydrogen gas from the reaction of oxides in basalt rock with carbon dioxide and water. Water would have been split (see diagram) releasing hydrogen to the atmosphere, and locking the oxygen into the various carbonates of sodium, potassium, calcium, magnesium, and iron. Two important consequences would have arisen from this reaction. Firstly, the maintenance of an oxygen-free atmosphere and surface, providing a favourable environment for the accumulation of life chemicals. And secondly, the loss of hydrogen to space.



H₂

O₂

Photosynthesizers



Bacteria

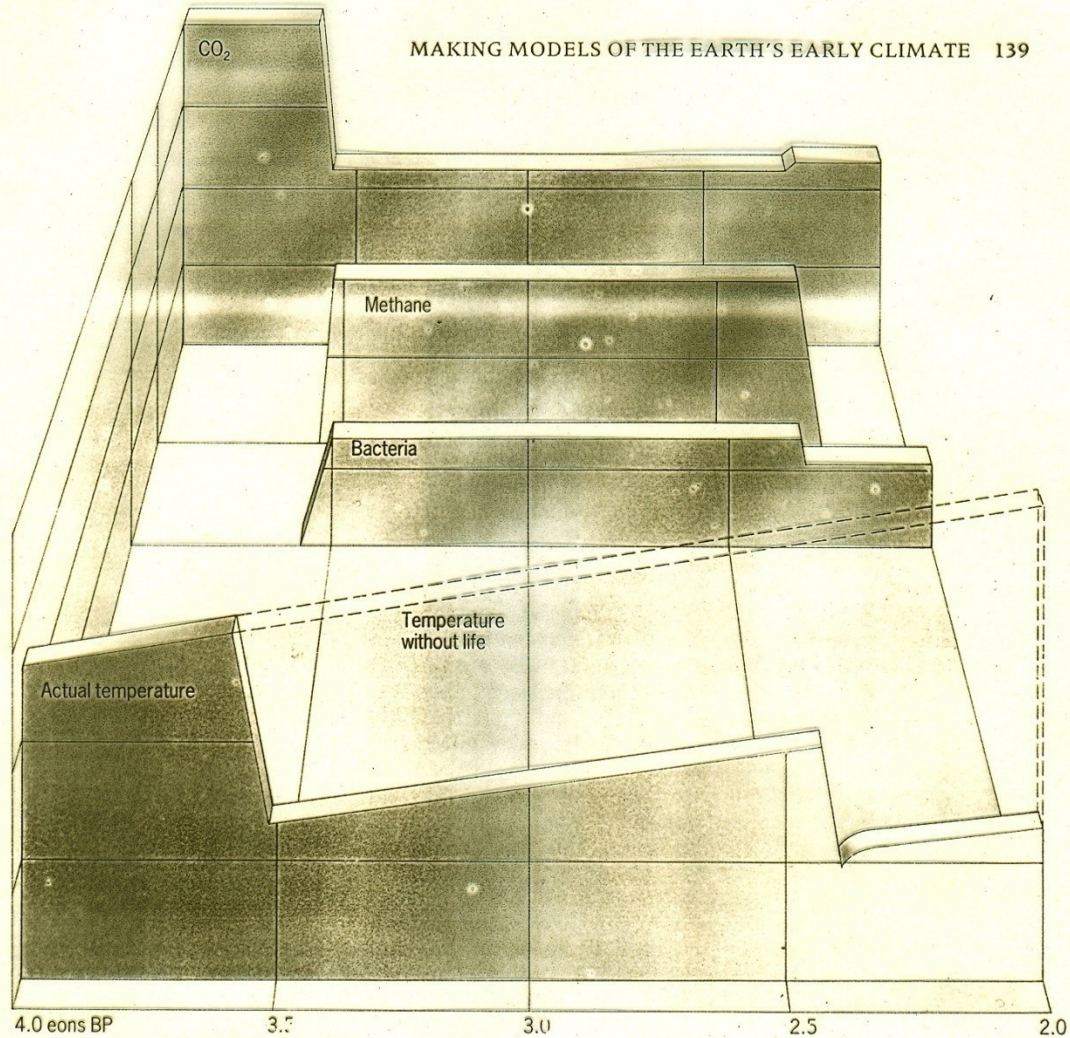
Basalt from sea-floor spreading

How life has kept the planet moist

If hydrogen had continued to escape to space, then within a couple of billion years, Earth might well have lost all its water and become an arid, lifeless planet like Mars or Venus.

of photosynthesis (and of carbon burial). Some of this oxygen would undoubtedly have combined with free hydrogen in the reducing atmosphere of the Archean to form water, preventing its loss to space.

diagram) would have been used by certain bacteria to gain energy by making hydrogen sulphide, and the hydrogen thus would have been retained. The presence of life in the Archean saved our planet from a dry



The results of the Archean model

The model results match what is known of the Earth's early history. The climate graph (lower) shows how, without life, the warming Sun would have led to a steadily warming Earth (dotted line). The solid line on the same graph shows how life changed all this. There is an abrupt fall of temperature after life starts, due to a rapid decline of carbon dioxide as it was used up by the photosynthesizers. The temperature then stabilizes, rising slowly throughout the Archean. The upper

graphs of the gases and the bacterial populations show why — methane from the fermenters was accumulating in the atmosphere and its greenhouse effect replacing that of carbon dioxide. The temperature suddenly falls once more at the end of the Archean, when the sudden appearance of free oxygen marks the decline of methane.

A rapid reduction of carbon dioxide abundance after life began is consistent with the Earth's rock weathering record. The Earth's

temperature was fairly stable in the Archean but a cold glacial interlude about 2.3 eons ago may have marked its end. The model matches this pattern.

Like Daisyworld, this model shows an abrupt change of conditions as soon as life starts. The organisms grow and change their environment and the atmosphere rapidly, until a steady state is reached and Gaia runs on in comfortable homeostasis.

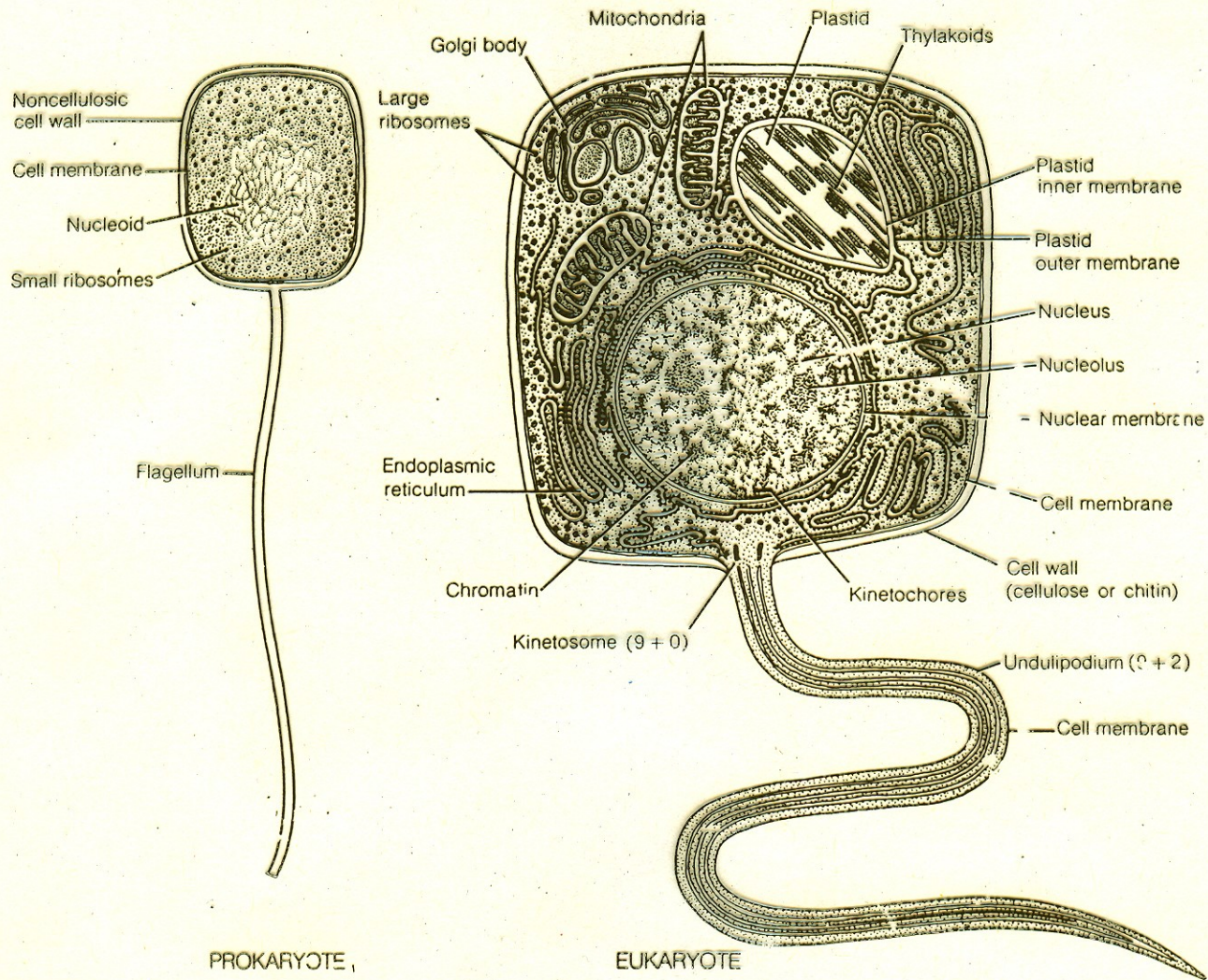
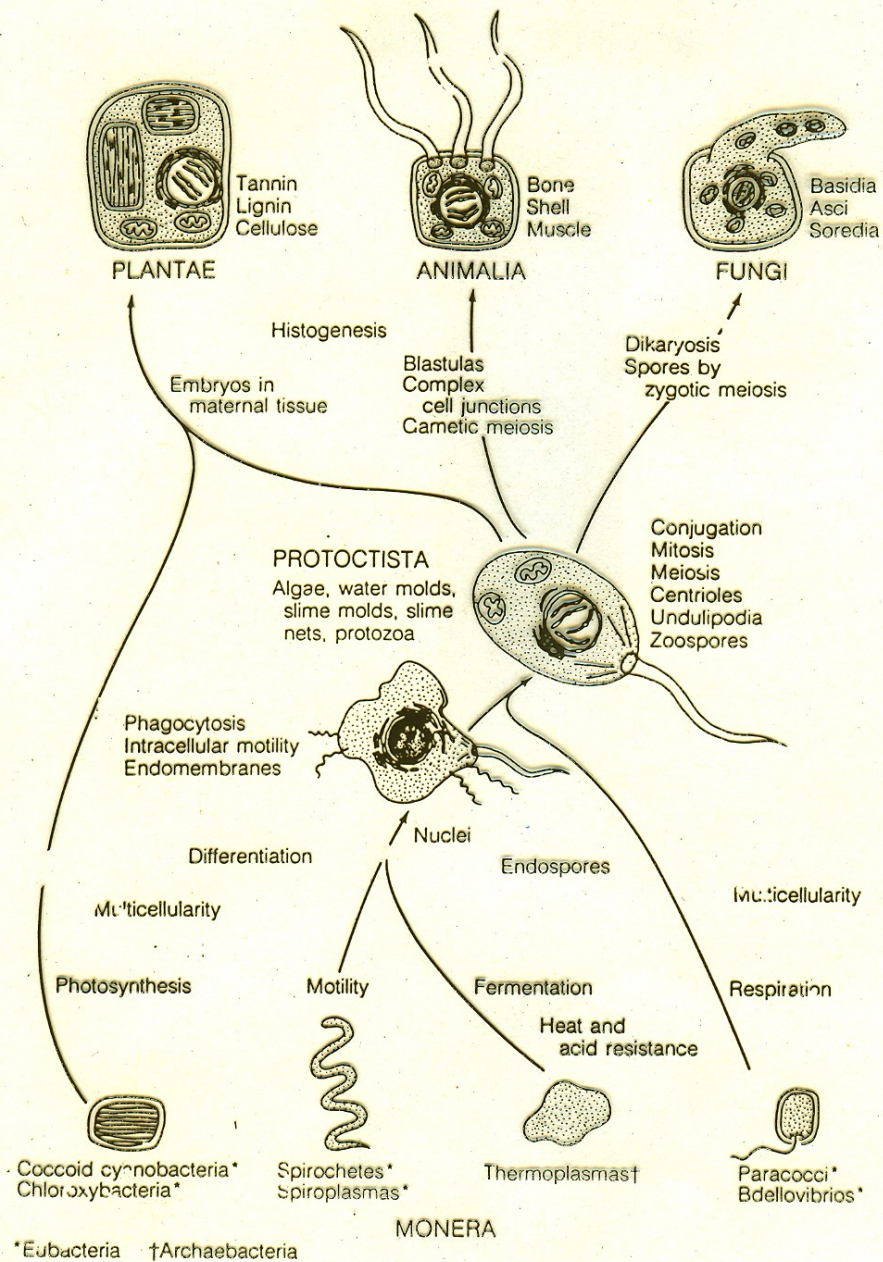


Figure 1-1

Typical prokaryotic and eukaryotic cells, based on electron microscopy. Not every prokaryote or eukaryote has every feature shown here. "9 + 0" and "9 + 2" refer to the cross sections of kinetosomes and undulipodia, shown in Figure 1-2.

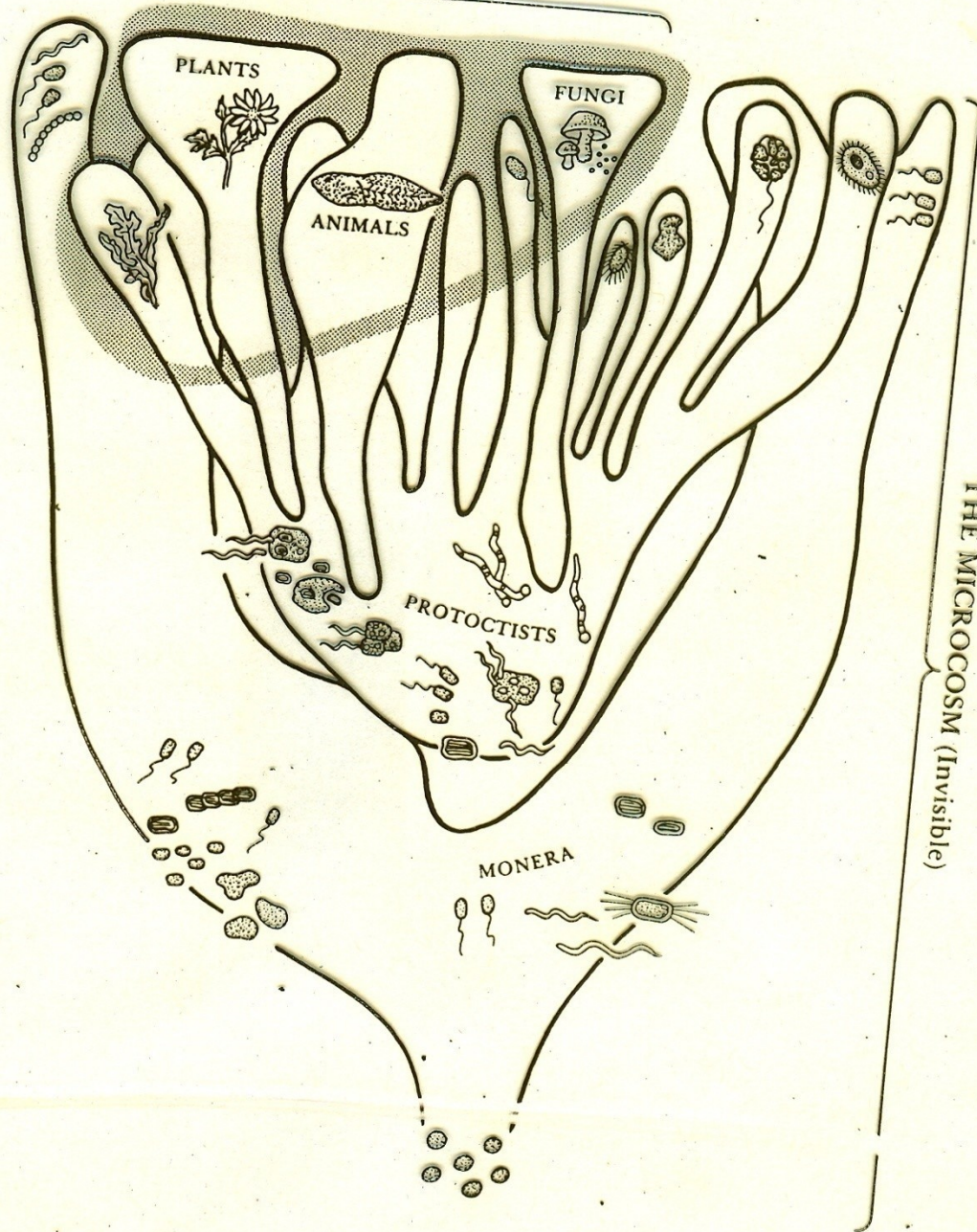


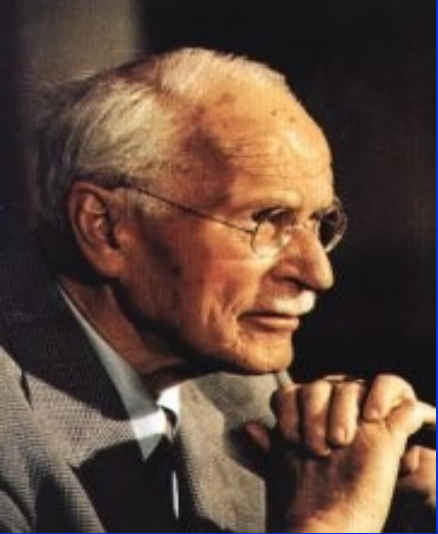
*Eubacteria †Archaeobacteria

FIGURE 1-1

Model for the origin of eukaryotic cells by symbiosis.

THE MACROCOSM (Visible Organisms)





C.G. Jung

The 'Jungian Mandala'

Intuition

Feeling

Thinking

Sensing

How do we value
nature?



What's it worth?

Global value of annual
'ecosystem services' (\$ trillion)

Marine	20.949
Coastal	12.568
Open ocean	8.381
Terrestrial	12.319
Wetlands	4.879
Forest	4.706
Lakes/rivers	1.700
Grasslands	0.906
Crops	0.128
Total	33.268

TABLE 2

Shallow (Reform) Ecology

Natural diversity is a valuable resource for us.

It is nonsense to talk about value except as value for mankind.

Plant species should be saved because of their value as genetic reserves for human agriculture and medicine.

Pollution should be decreased if it threatens economic growth.

Developing nations' population growth threatens ecological equilibrium.

"Resource" means resource for humans.

People will not tolerate a broad decrease in their standard of living.

Nature is cruel and necessarily so.

Deep Ecology

Natural diversity has its own (intrinsic) value.

Equating value with value for humans reveals a racial prejudice.

Plant species should be saved because of their intrinsic value.

Decrease of pollution has priority over economic growth.

World population at the present level threatens ecosystems but the population and behavior of industrial states more than any others. Human population is today excessive.

"Resource" means resource for living beings.

People should not tolerate a broad decrease in the quality of life but in the standard of living of overdeveloped nations.

Man is cruel but not necessarily so.

The new Ecuadorian Constitution

- "Nature or Pachamama, where life is reproduced and exists, has the right to exist, persist, maintain and regenerate its vital cycles, structure, functions and its processes in evolution. Every person, people, community or nationality, will be able to demand the recognitions of rights for nature before the public bodies."

The Deep Ecology Platform

1. The well-being and flourishing of human and nonhuman life on Earth have value in themselves (synonyms: inherent worth, intrinsic value, inherent value).

These values are independent of the usefulness of the nonhuman world for human purposes.

2. Richness and diversity of life-forms contribute to the realization of these values and are also values in themselves.

3. Humans have no right to reduce this richness and diversity except to satisfy vital needs.

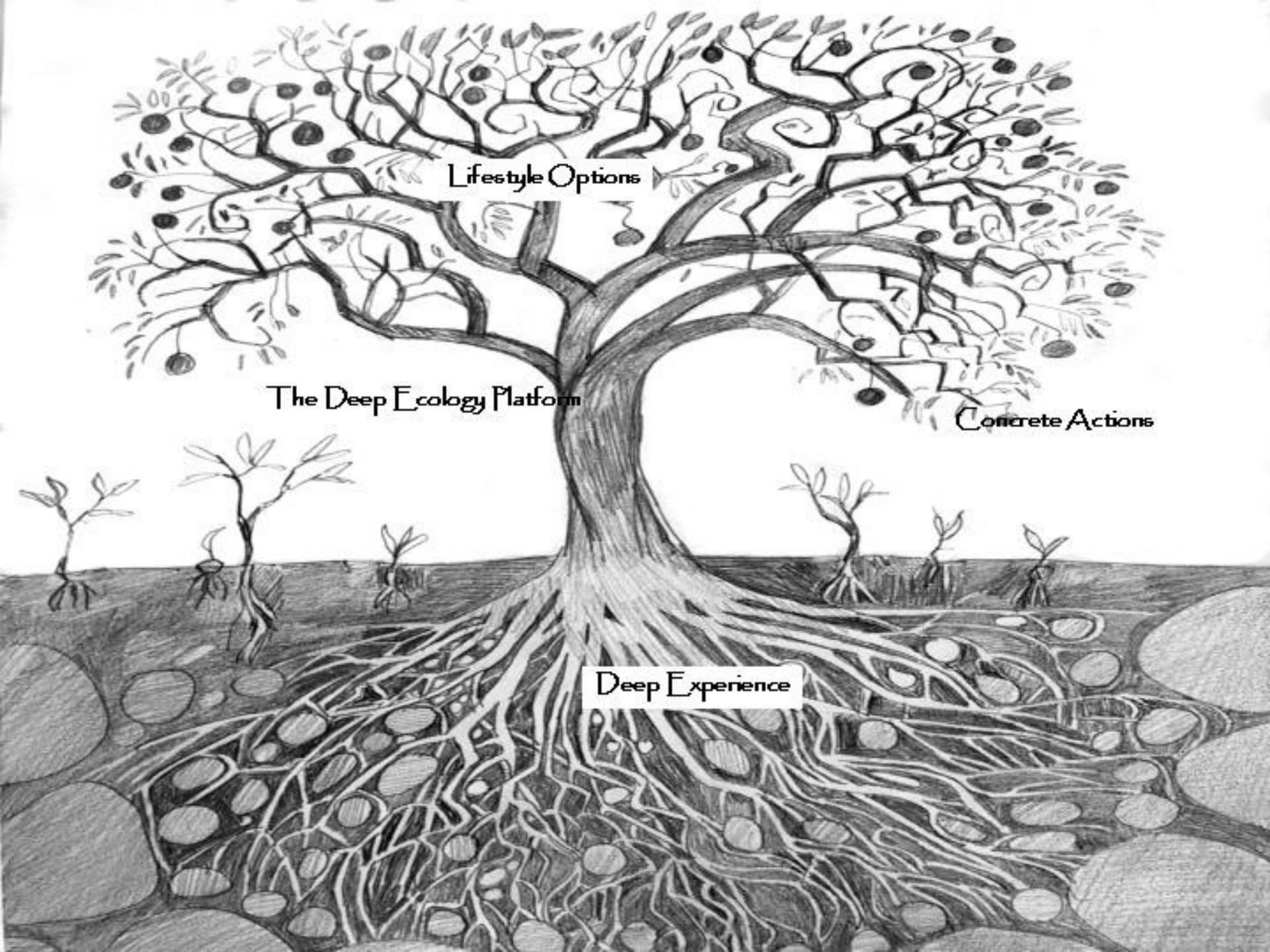
4. Present human interference with the nonhuman world is excessive, and the situation is rapidly worsening.

5. The flourishing of human life and cultures is compatible with a substantial decrease of the human population. The flourishing of nonhuman life requires such a decrease.

6. Policies must therefore be changed. The changes in policies affect basic economic, technological, and ideological structures. The resulting state of affairs will be deeply different from the present.

7. The ideological change is mainly that of appreciating life quality (dwelling in situations of inherent worth) rather than adhering to an increasingly higher standard of living. There will be a profound awareness of the difference between big and great.

8. Those who subscribe to the foregoing points have an obligation directly or indirectly to participate in the attempt to implement the necessary changes.

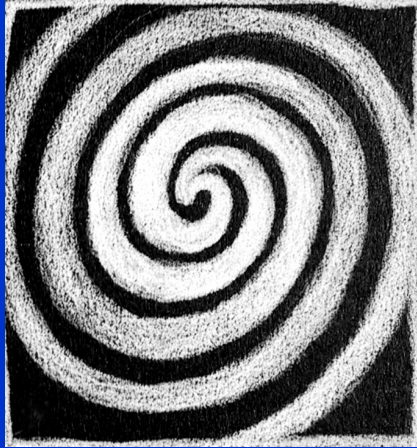


Lifestyle Options

The Deep Ecology Platform

Concrete Actions

Deep Experience



Tab. 1 – Some differences in emphasis between two modes of holistic science.

<i>Detached Holistic Science</i>	<i>Participatory Holistic Science</i>
Detached observers of systems	Participatory experiencers embedded in the world.
Implicit instrumental values	Explicit intrinsic values
Knowledge for control	Knowledge as belonging
Intuition hardly acknowledged	Intuition as method



"*Animate Earth* represents systems science at its best . . . gives a whole new dimension to what 'environment-friendly' really means."

Jonathon Porritt

"For depth of understanding of Earth functioning and our human role in the process, Stephan Harding's *Animate Earth* is the finest of recent studies."

Thomas Berry, author of *The Great Work*

In *Animate Earth* Stephan Harding explores how Gaian science can help us to develop a sense of connectedness with the 'more-than-human' world. His work is based on a careful integration of rational scientific analysis with our intuition, sensing and feeling—a vitally important task at this time of severe ecological and climate crisis.

Stephan Harding replaces the cold, objectifying language of science with a way of speaking of our planet as a sentient, living being rather than as a dead, inert mechanism. For example, chemical reactions are described using metaphors from human life, such as marriage, attraction, repulsion etc, so as to bring personality back into the world of rocks, atmosphere, water and living things. In this sense, the book is a contemporary attempt to rediscover *anima mundi* (the soul of the world) through Gaian science, whilst assuming no prior knowledge of science.

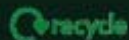
Animate Earth argues that we need to establish a right relationship with the planet as a living entity in which we are indissolubly embedded—and to which, in the final analysis, we are all accountable. The book inspires the reader to connect with a profound sense of the intrinsic value of the Earth, and to discover what it means to live as harmoniously as possible within a sentient creature of planetary proportions.

The Author: Dr Stephan Harding holds a doctorate in ecology from the University of Oxford. He is the Co-ordinator of the MSc in Holistic Science at Schumacher College, where he is also Resident Ecologist and a teacher on the short course programme. He lives in Dartington, Devon, where the college is based.

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ANIMATE EARTH



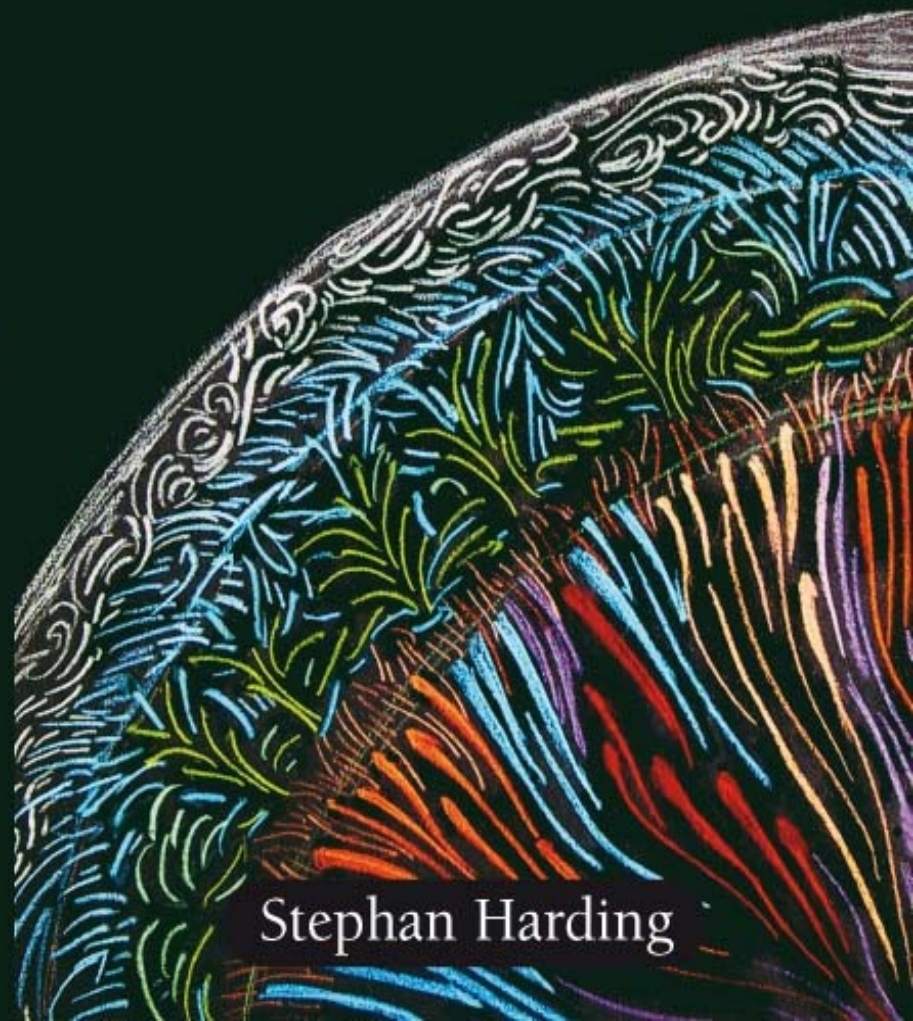
Stephan Harding



"A wonderful and beautiful book" James Lovelock

ANIMATE EARTH

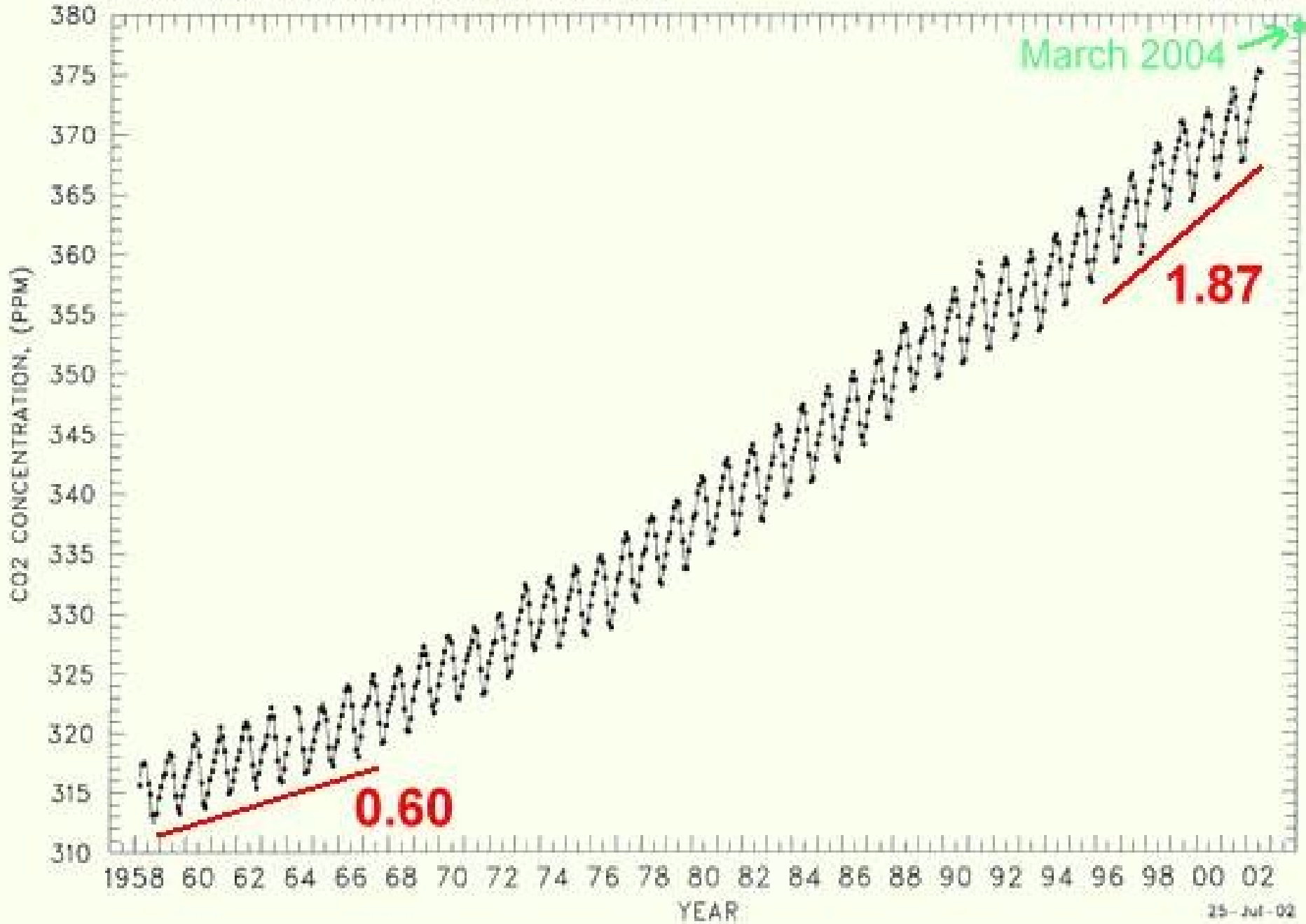
Science, Intuition and Gaia

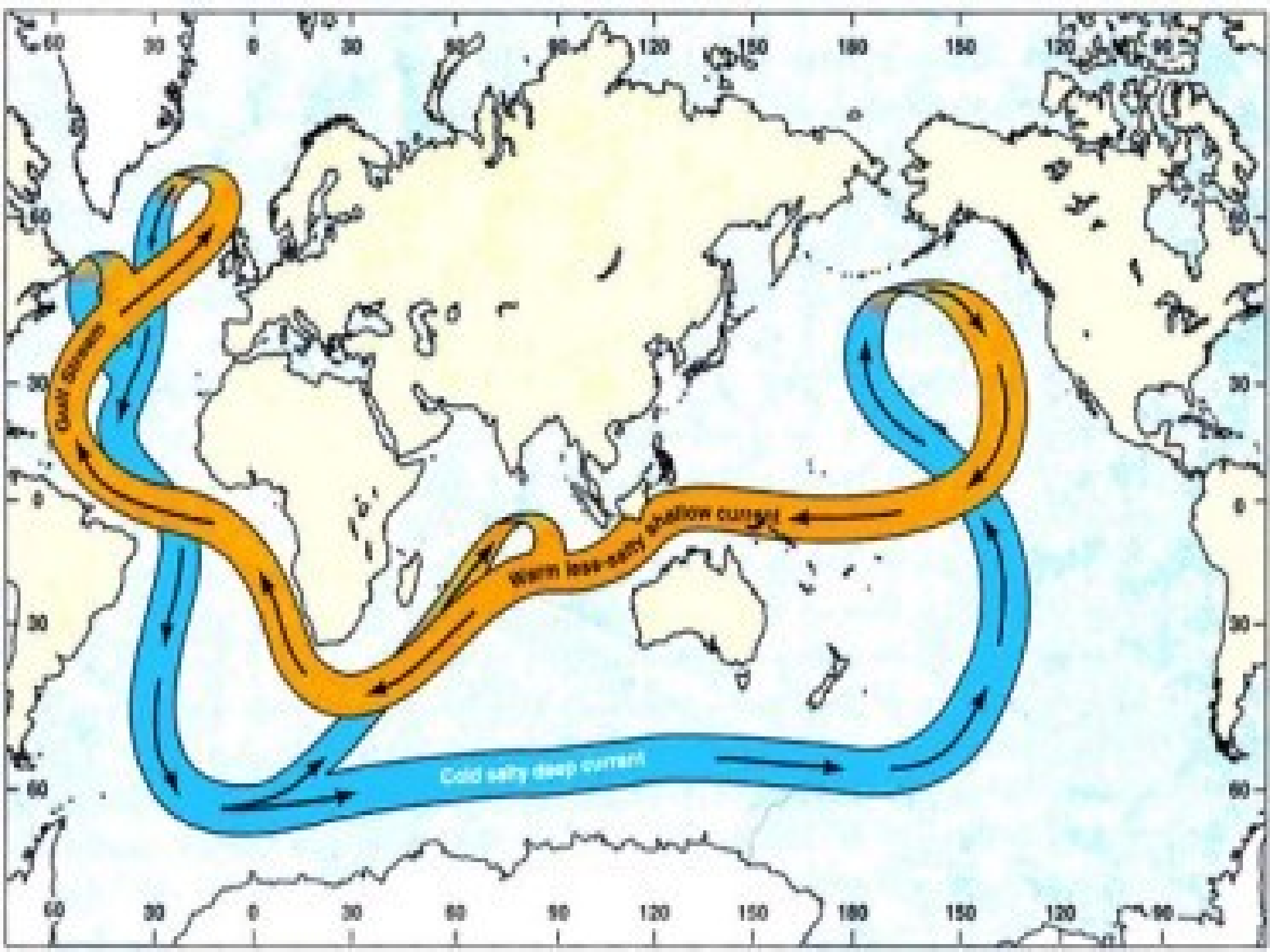


Stephan Harding

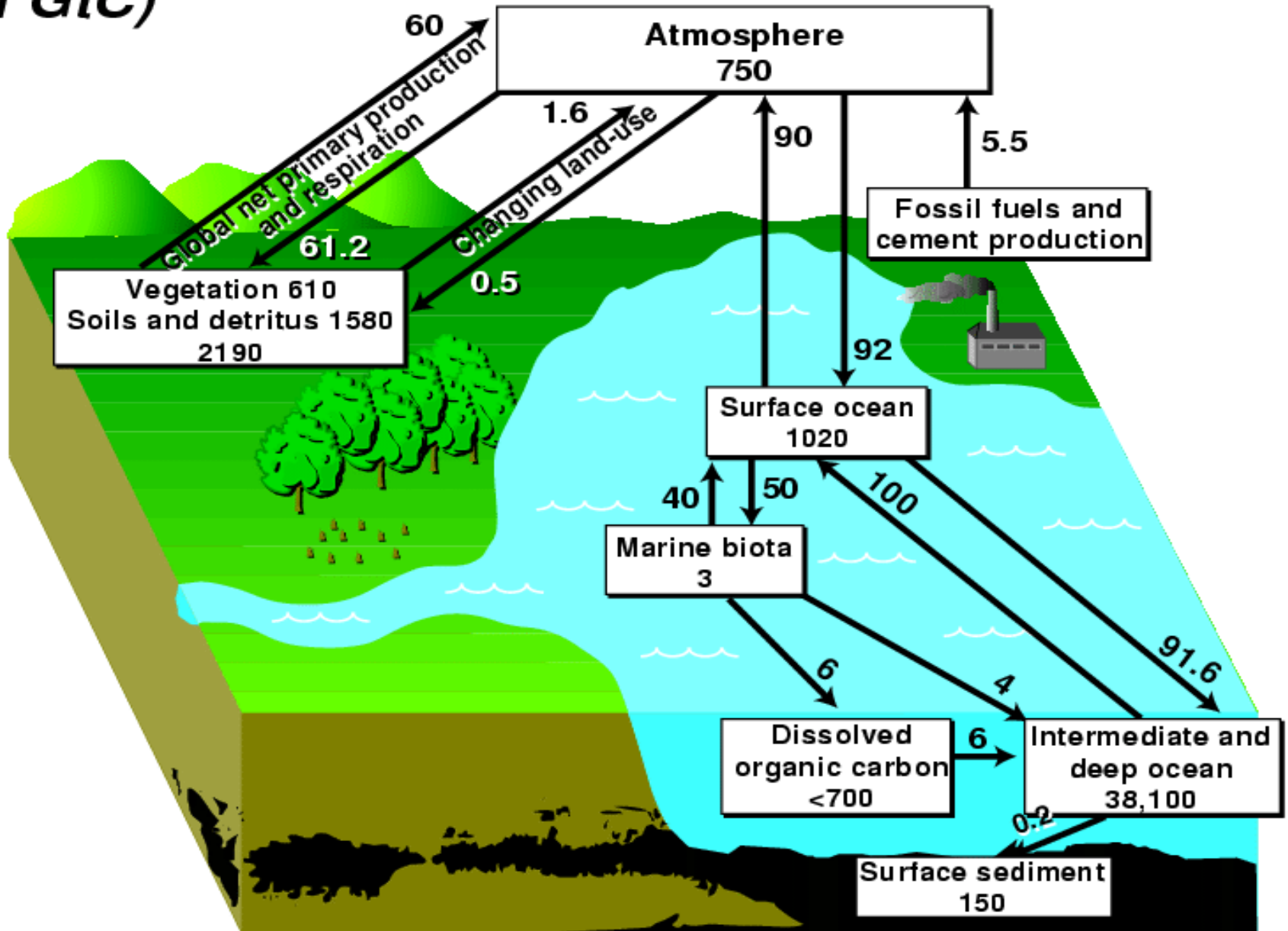
MAUNA LOA OBSERVATORY, HAWAII
MONTHLY AVERAGE CARBON DIOXIDE CONCENTRATION

MLO-143





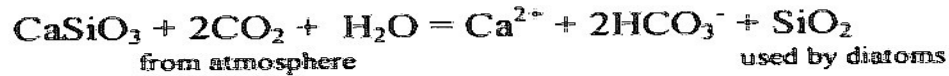
Global Carbon Cycle (in GtC)



The Carbonate-Silicate (Bio)Geochemical Cycle

LAND

Silicate rock weathering



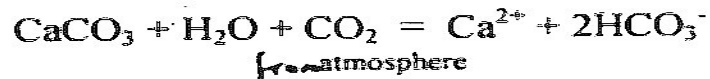
OCEAN

Carbonate deposition by marine algae and corals



LAND

Carbonate weathering



SUBDUCTION ZONES

Carbonate metamorphism



Major proponents of the Scientific Revolution

Bacon 1561-1626

“We should endeavour to establish and extend the power and dominion of the human race itself over the universe.”

“I am leading you to nature to bring her into your service and make her your slave.”

Galileo 1564-1642

The book of the universe “ .. is written in the language of mathematics, and its characters are triangles, circles and other geometric figures.”

“Hence I think that tastes, colours, and so on are no more than mere names.”

Descartes 1596-1

“I have described the Earth and the whole visible universe in the manner of a machine.”

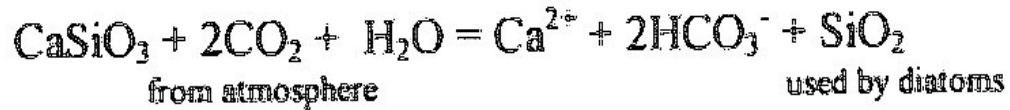
“... and therefore to become like Lords and possessors of nature.”

Newton 1642-1727

“For the rays (of light) to speak properly are not coloured. In them there is nothing else than a certain power and disposition to stir up a sensation of this or that colour.”

LAND

Silicate rock weathering

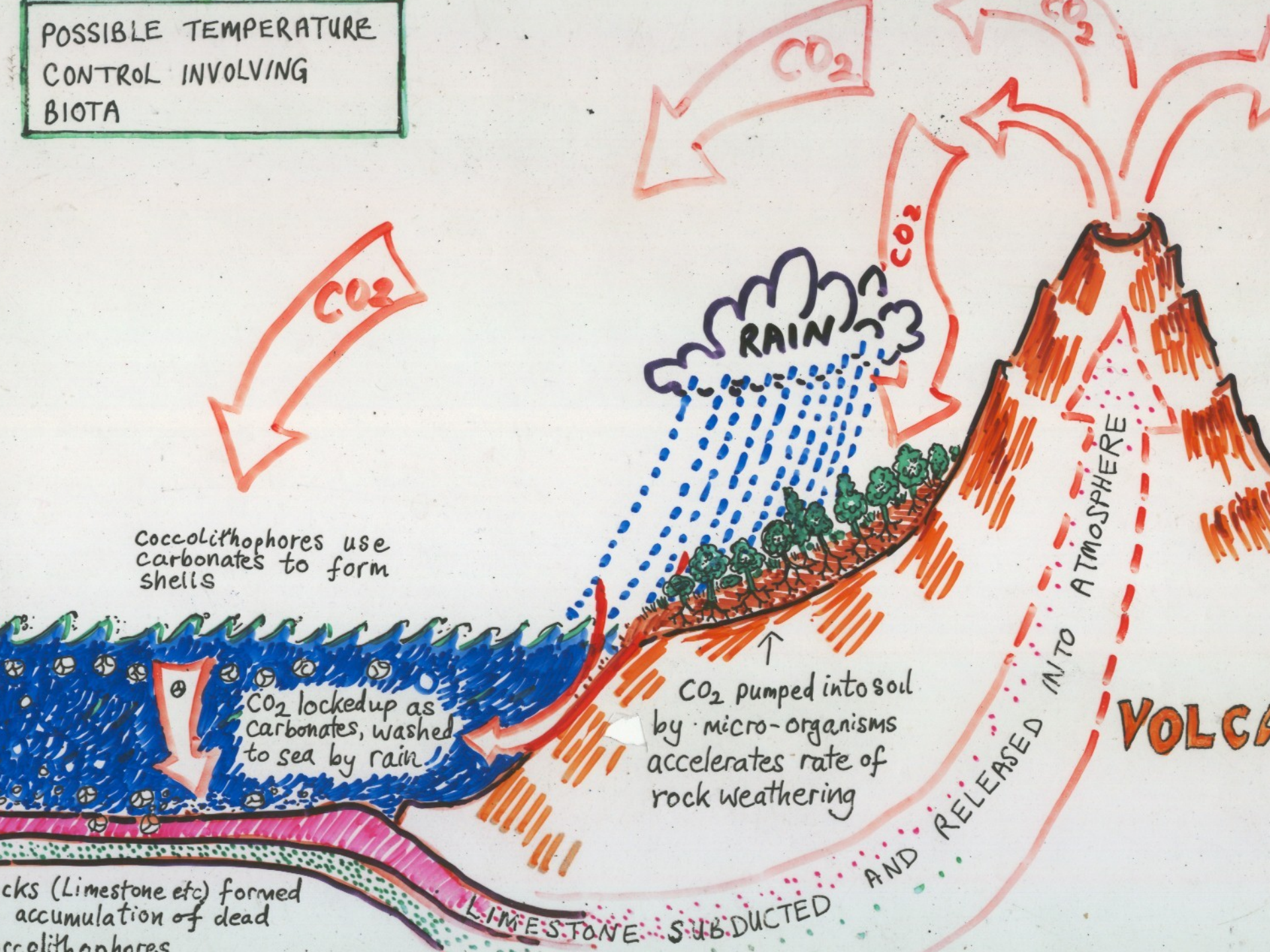


SUBDUCTION ZONES

Carbonate metamorphism



POSSIBLE TEMPERATURE CONTROL INVOLVING BIOTA



Coccolithophores use carbonates to form shells

CO₂ locked up as carbonates, washed to sea by rain

CO₂ pumped into soil by micro-organisms accelerates rate of rock weathering

rocks (Limestone etc) formed accumulation of dead coccolithophores

LIMESTONE SUBDUCTED AND RELEASED INTO ATMOSPHERE

VOLCANO

RAIN

CO₂

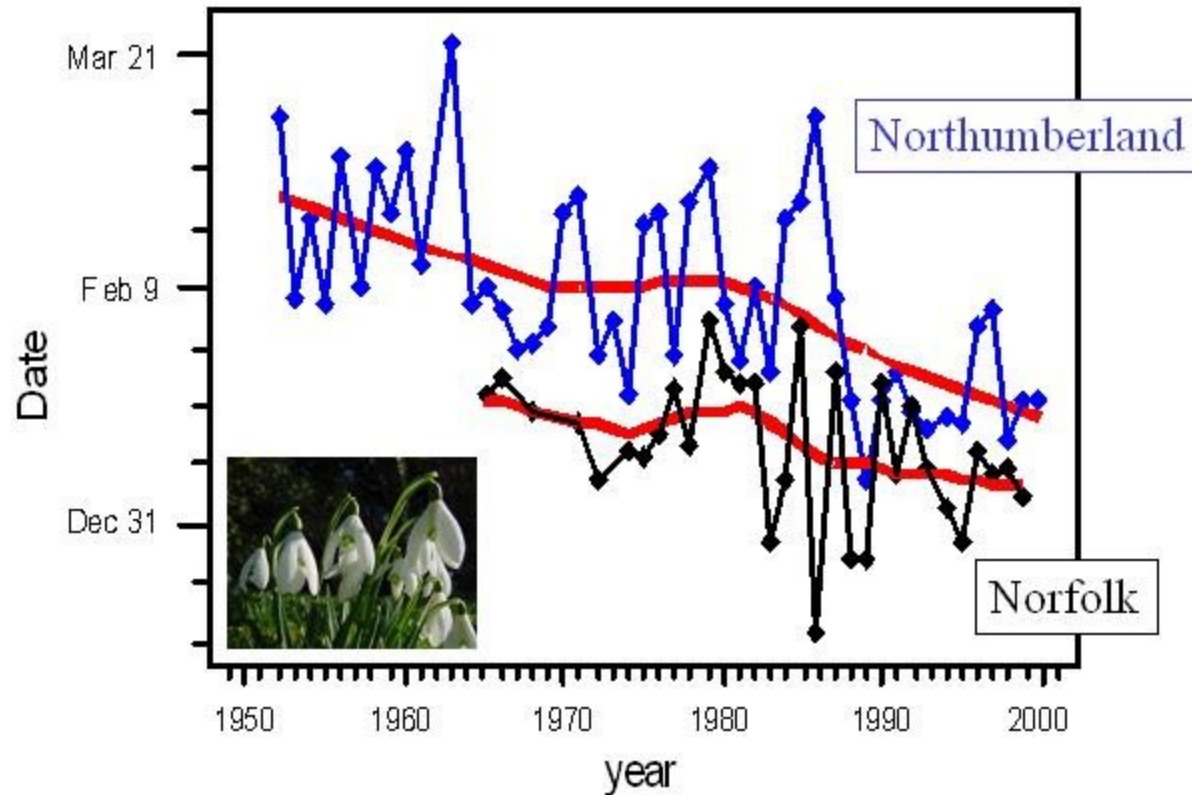
CO₂

ATMOSPHERE

CO₂

CO₂

Earlier Flowering of Snowdrops across England



Source: UK Phenology Network (www.phenology.org.uk)

“We humans are plain members of the biotic community”

“A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community, it is wrong when it tends otherwise”

- Aldo Leopold

Holistic Science

involves a shift in emphasis from:

Parts to Wholes

Objects to relationships

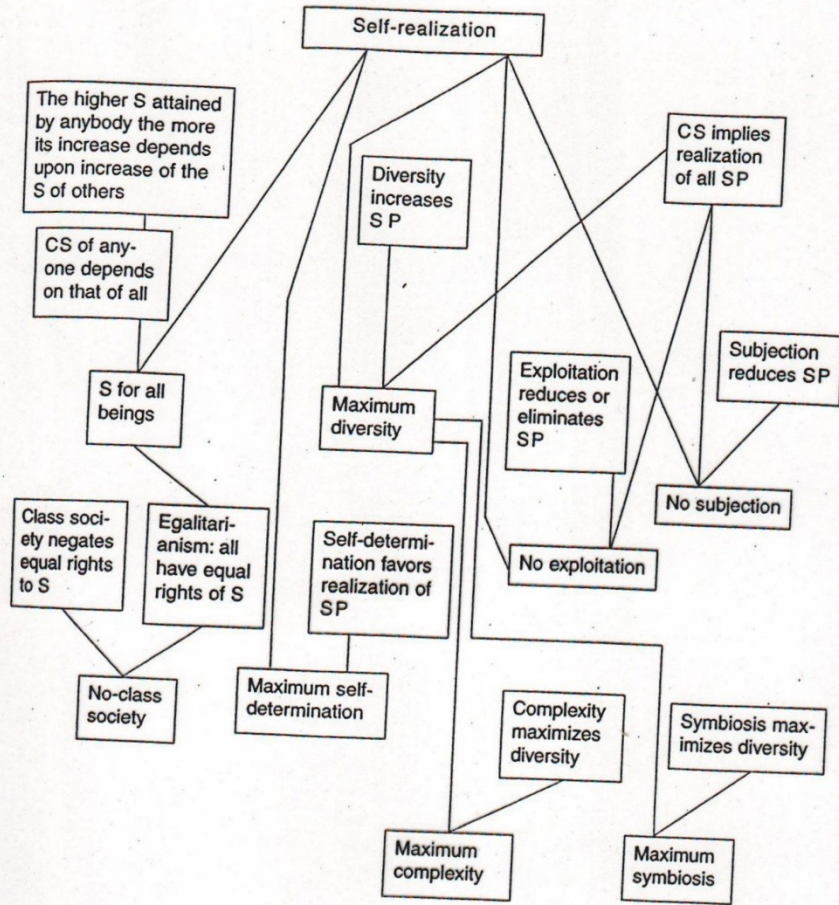
Hierarchies to networks

Truth to approximate descriptions

Objective knowledge to contextual knowledge

Utilitarian values to Intrinsic values

Ecosophy T



S = Self-realization

C = Complete

P = Potential

SP = Self-realization potentials

Tab. 2 – Some possible distinctions between Earth System Science and my own proposal for a Gaian Science.

<i>Earth System Science</i>	<i>Gaian Science</i>
Humans as observers of the Earth	Humans as 'plain members' of the Gaian community
Earth as a machine	Gaia as an organism
Earth system has instrumental value	Gaia has intrinsic value
Earth system services sustain the human economy	Gaian system services sustain the web of life
Prioritises global scale technical fixes for global environmental problems	Prioritises local scale appropriate technology
Seeks not to become involved in the political implications of its findings	Seeks to use its findings to foster ecologically sound life-styles and societies

Example:

Tumour Growth

