Environmental Ethics and Land Management

ENVR E-120

http://courses.dce.harvard.edu/~envre120

Basic Concepts of Ecology

Timothy C. Weiskel

Class - Session 2 – Part 2
28 September 2006

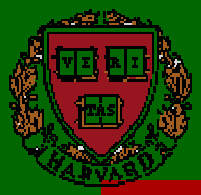
Harvard University Extension School
Fall Semester 2006

Vastly Different Scales of Time & Space

Cosmic time scales - 10^9 - 10^{10} BP

Geologic time scales - present - 10^9 BP

As with “cosmic” time scales and events, so too, we must consider “geological time” scales and events in developing an effective environmental ethic.



What are “geological events?”

Courtesy Isaac Newton Group of Telescopes

Stuff happens

Volcanoes happen…

Volcanoes often happen near inhabited areas, but have wide-spread and sometimes global impacts. *

Thursday, 3 February, 2000, 10:34 GMT

Supervolcanoes could trigger global freeze

Heat rises from under Yellowstone Park

The BBC's Sumit Bose reports
"Annually, there are 50 volcanic eruptions worldwide"
real 28k

Prof Chris Wilson, Geological Society
"Supervolcanoes are a lurking threat"
real 28k

By environment correspondent Alex Kirby

The threat of climate change caused by human activity could turn out to be a minor problem by comparison with a scarcely acknowledged natural hazard.

Geologists say there is a real risk that sooner or later a supervolcano will erupt with devastating force

See also:

- 29 Oct 99 | Sci/Tech
  Scientists improve volcano prediction
- 11 May 99 | Sci/Tech
  Early volcano victims discovered
- 19 Feb 99 | Sci/Tech
  Volcano teaches deadly lessons

Internet links:

- Global Volcanism Program - Smithsonian

Distant and InvisibleVolcanoes...

Tsumanis - giant waves or “walls of water” -- can be triggered by submarine volcanoes or earth slides provoked by volcanoes.

Some of these have received recent publicity.*


Cumbre
Vieja
Volcano
LA PALMA
CANARY ISLANDS
TENERIFE
Atlantic
Ocean


LA PALMA LANDSLIDE TSUNAMI
"Wave train"
track after six hours
CANARY ISLANDS
LA PALMA
Slide

Vastly Different Scales of Time & Space

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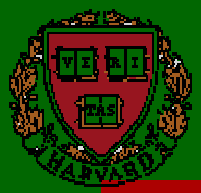
Bioevolutionary time scales - present - 10^9 BP



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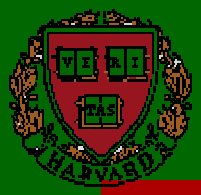

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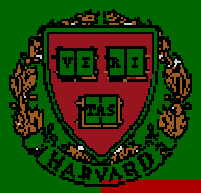

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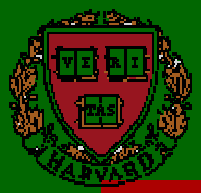
Civilization time scales - 10^4



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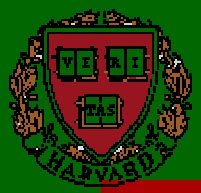
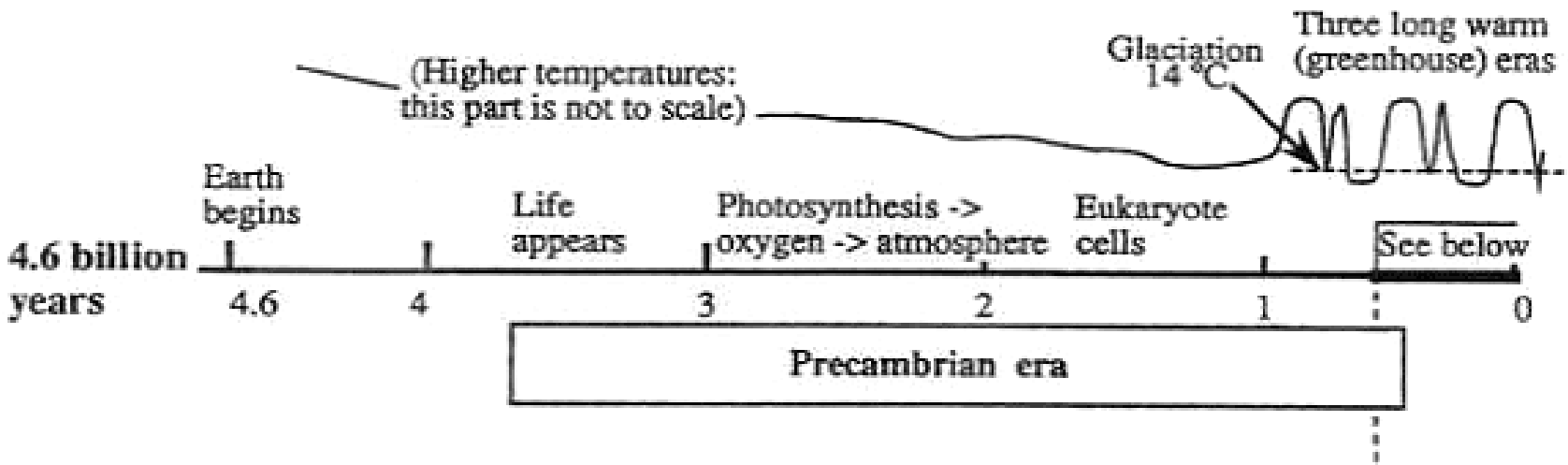
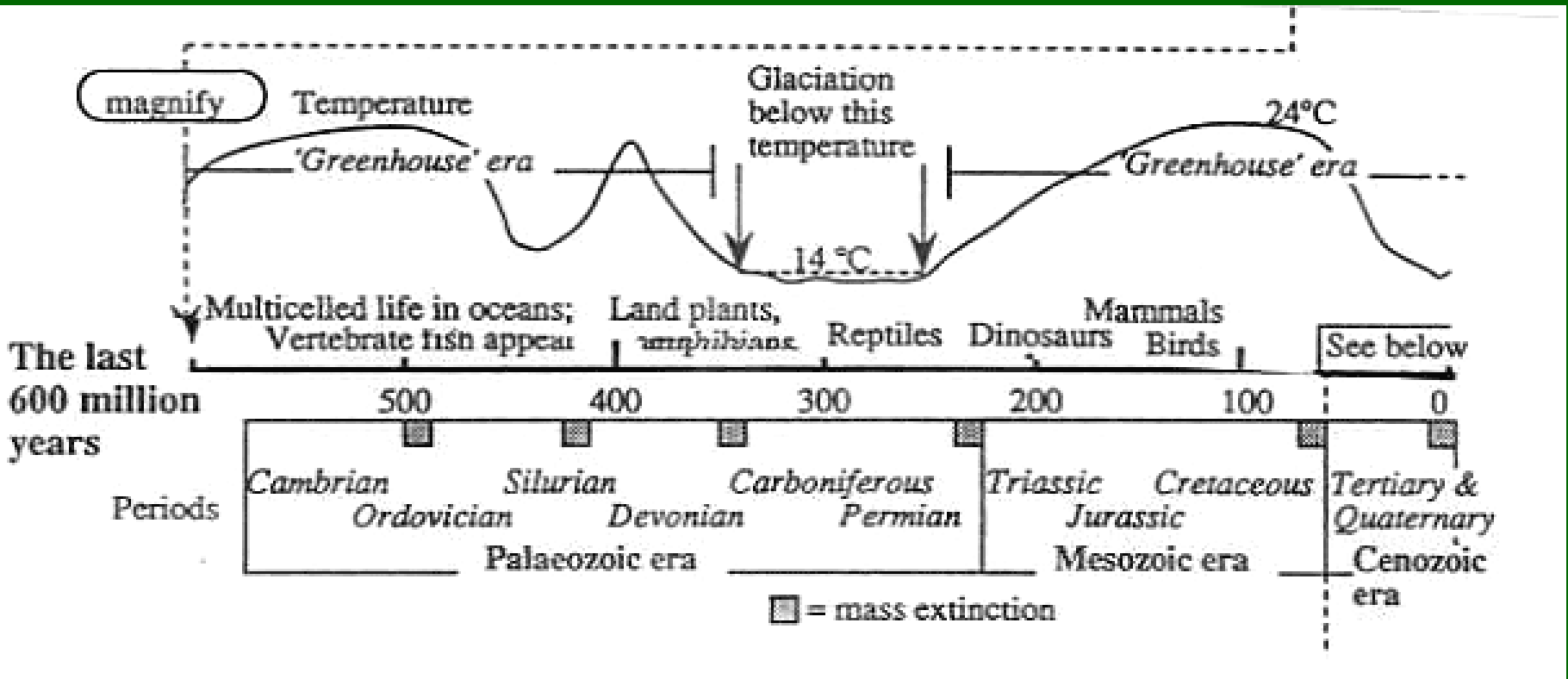
Cultural-Evolutionary time scales - 10^5

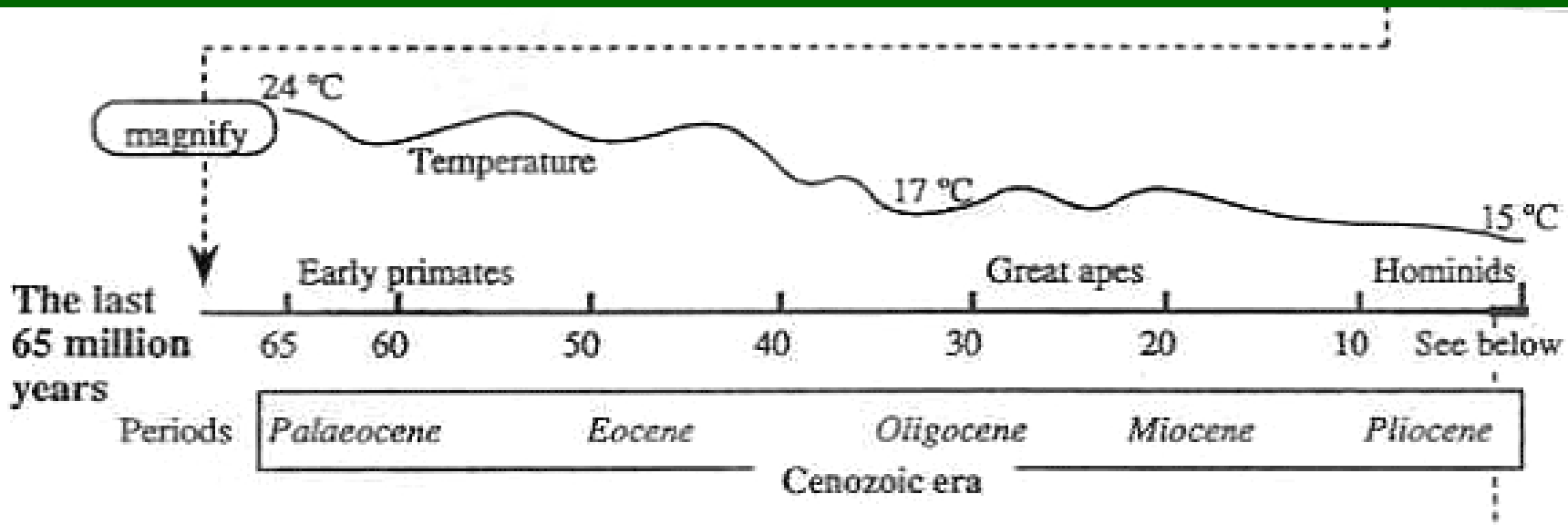
Civilization time scales - 10^4

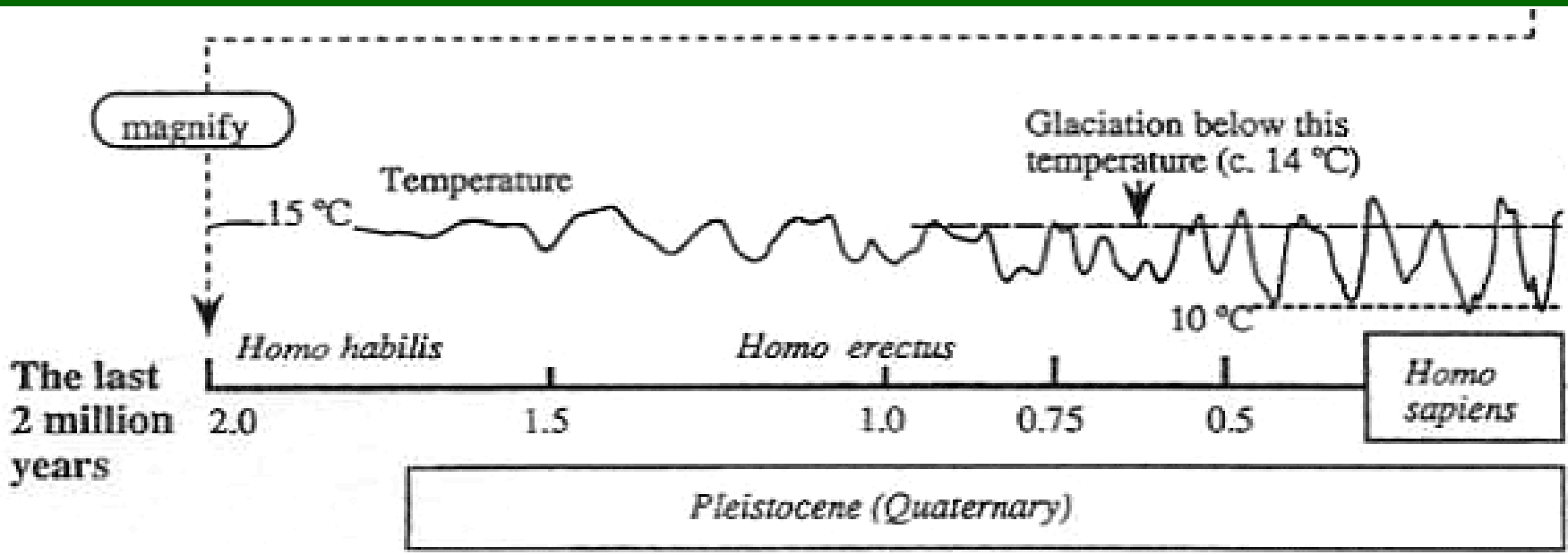
Historical time scales - 10 - 10^3



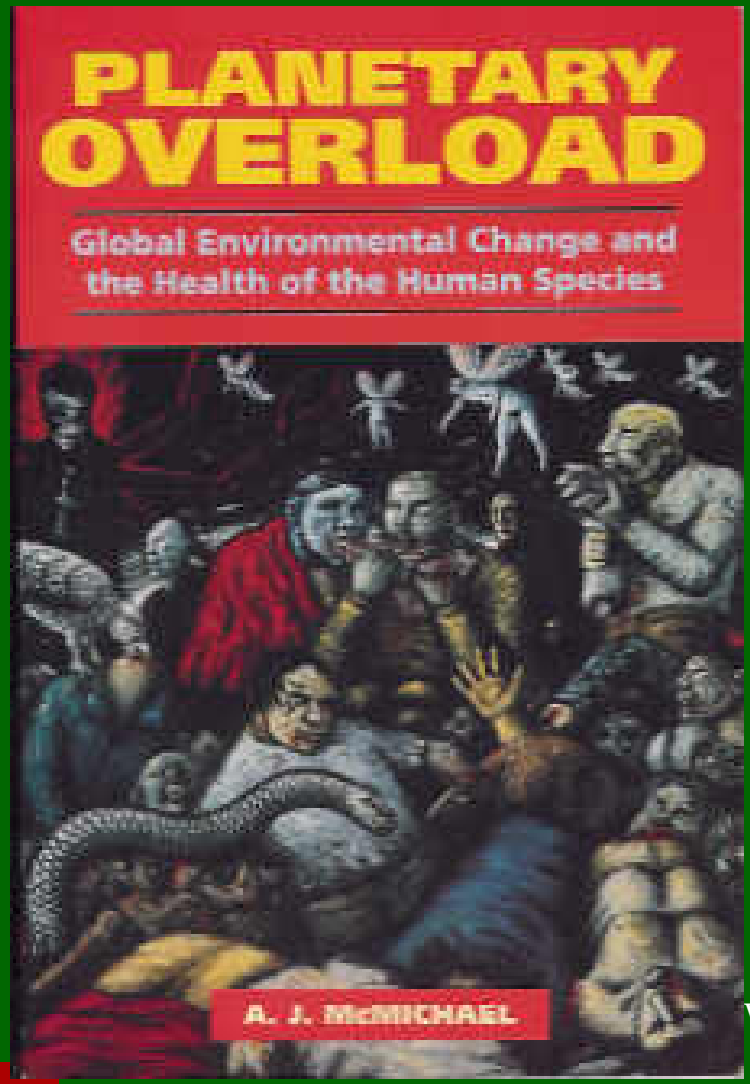

(Higher temperatures:
this part is not to scale)
Glaciation
14 °C
Three long warm
(greenhouse) eras
Earth
begins
Life
appears
Photosynthesis ->
oxygen -> atmosphere
Eukaryote
cells
See below
4.6 billion
years
4.6
4
3
2
1
0
Precambrian era


magnify
Temperature
'Greenhouse' era
Glaciation below this temperature
14 °C
24°C
'Greenhouse' era
Multicelled life in oceans; Vertebrate fish appear
Land plants, amphibians
Reptiles
Dinosaurs
Mammals
Birds
See below
The last 600 million years
500
400
300
200
100
0
Periods
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Tertiary & Quaternary
Palaeozoic era
Mesozoic era
Cenozoic era
= mass extinction


24 °C
magnify
Temperature
17 °C
15 °C
Early primates
Great apes
Hominids
The last 65 million years
65
60
50
40
30
20
10
See below
Periods
Palaeocene
Eocene
Oligocene
Miocene
Pliocene
Cenozoic era

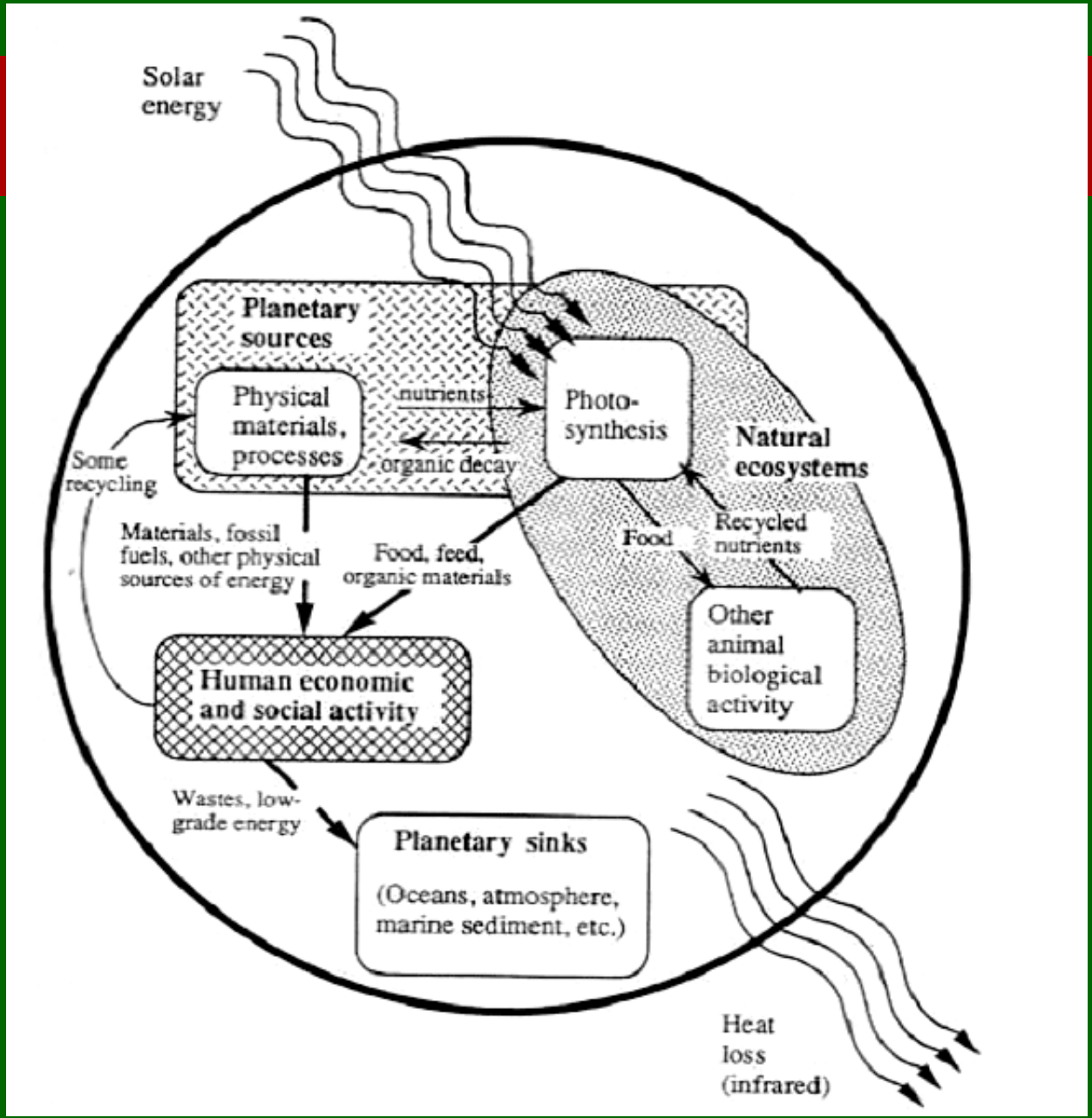

magnify
Temperature
15 °C
Glaciation below this temperature (c. 14 °C)
10 °C
Homo habilis
Homo erectus
Homo sapiens
The last 2 million years
2.0
1.5
1.0
0.75
0.5
Pleistocene (Quaternary)

With all the shocks the earth system has experienced, what could a title like ***"Planetary Overload"*** possibly mean? Is the planet overloaded? In what sense?

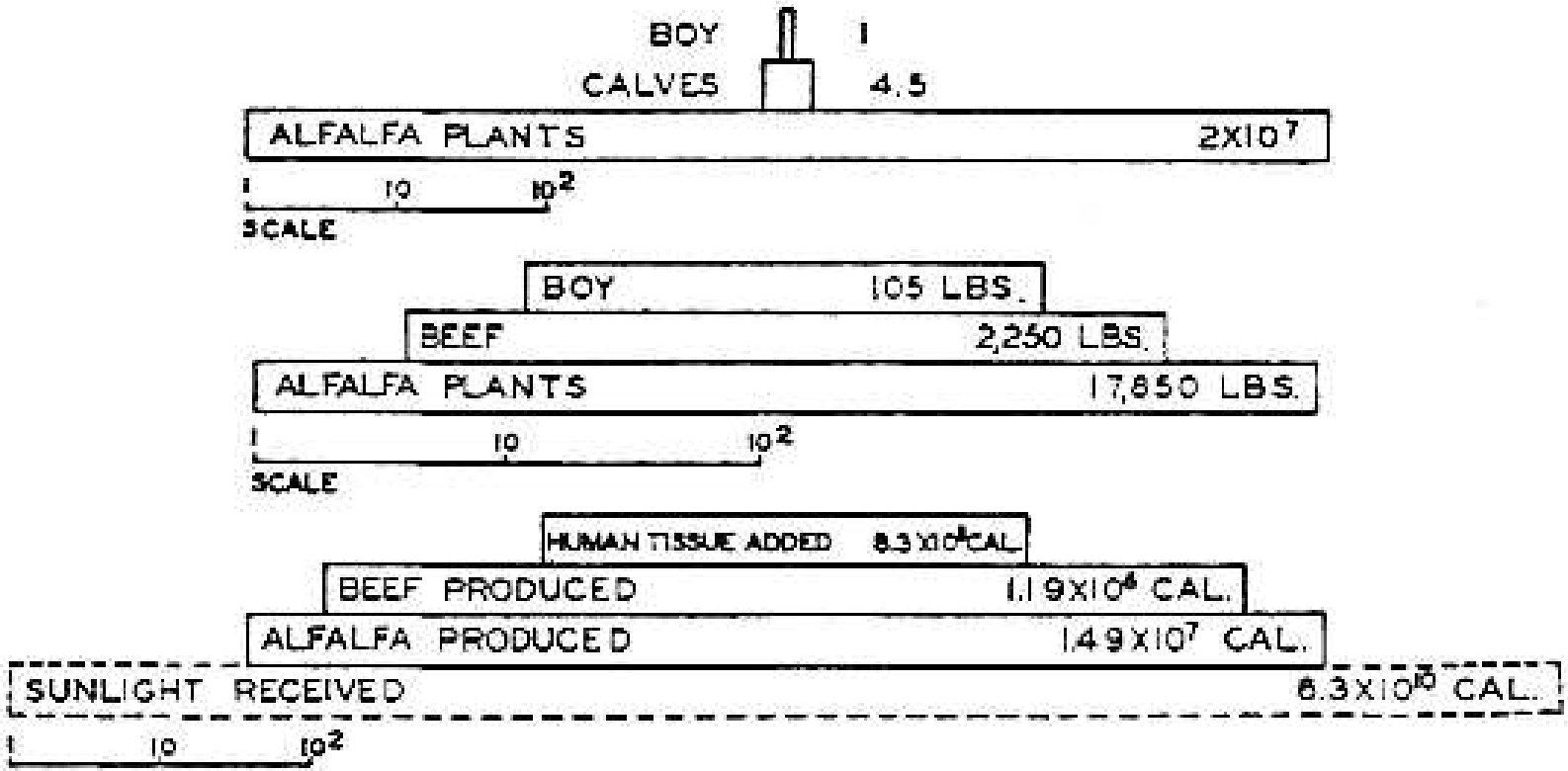


We live in an open energy, closed material system, governed by the second law of thermodynamics.

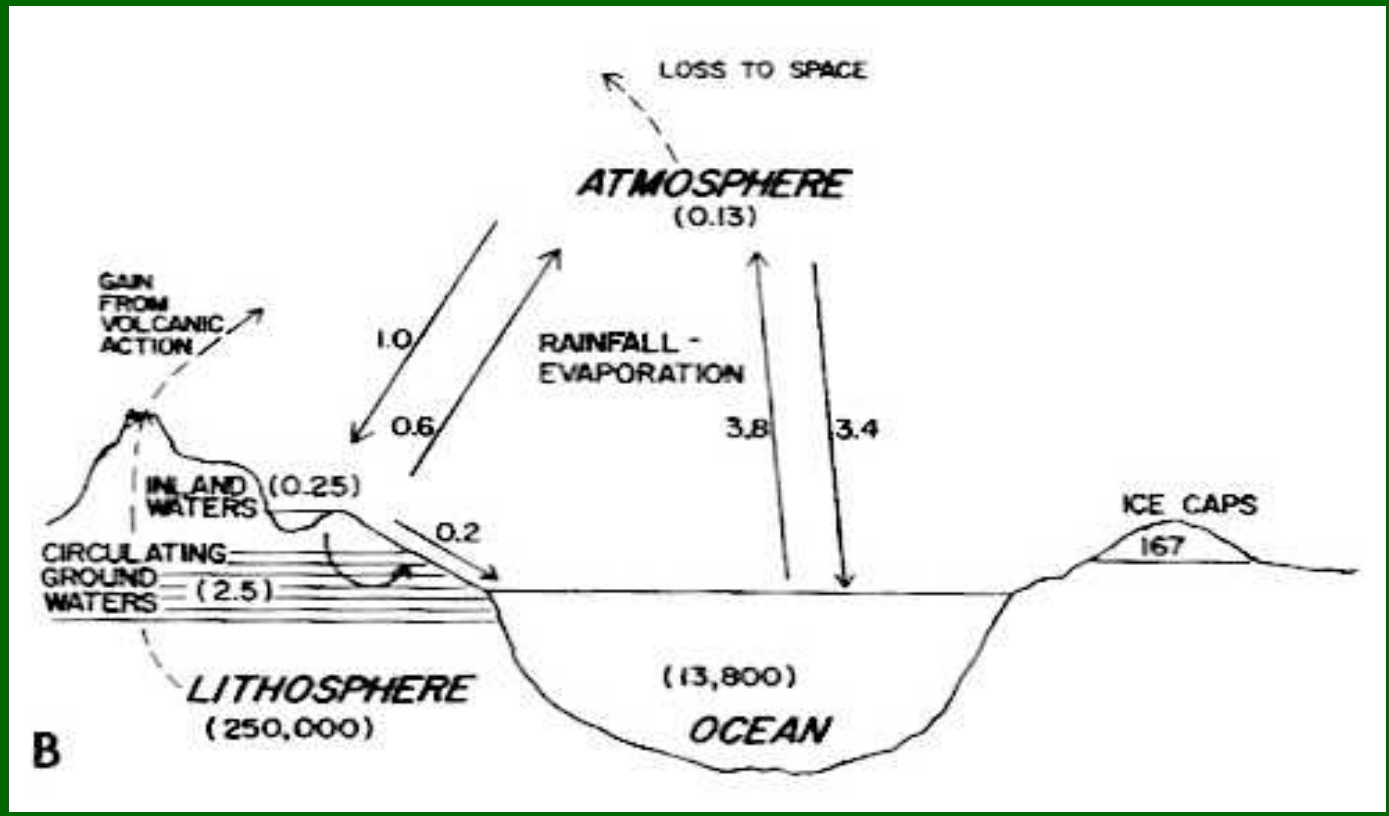
What is our species role in this system?

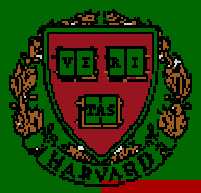


Throughput Energy Flow Can Be Measured



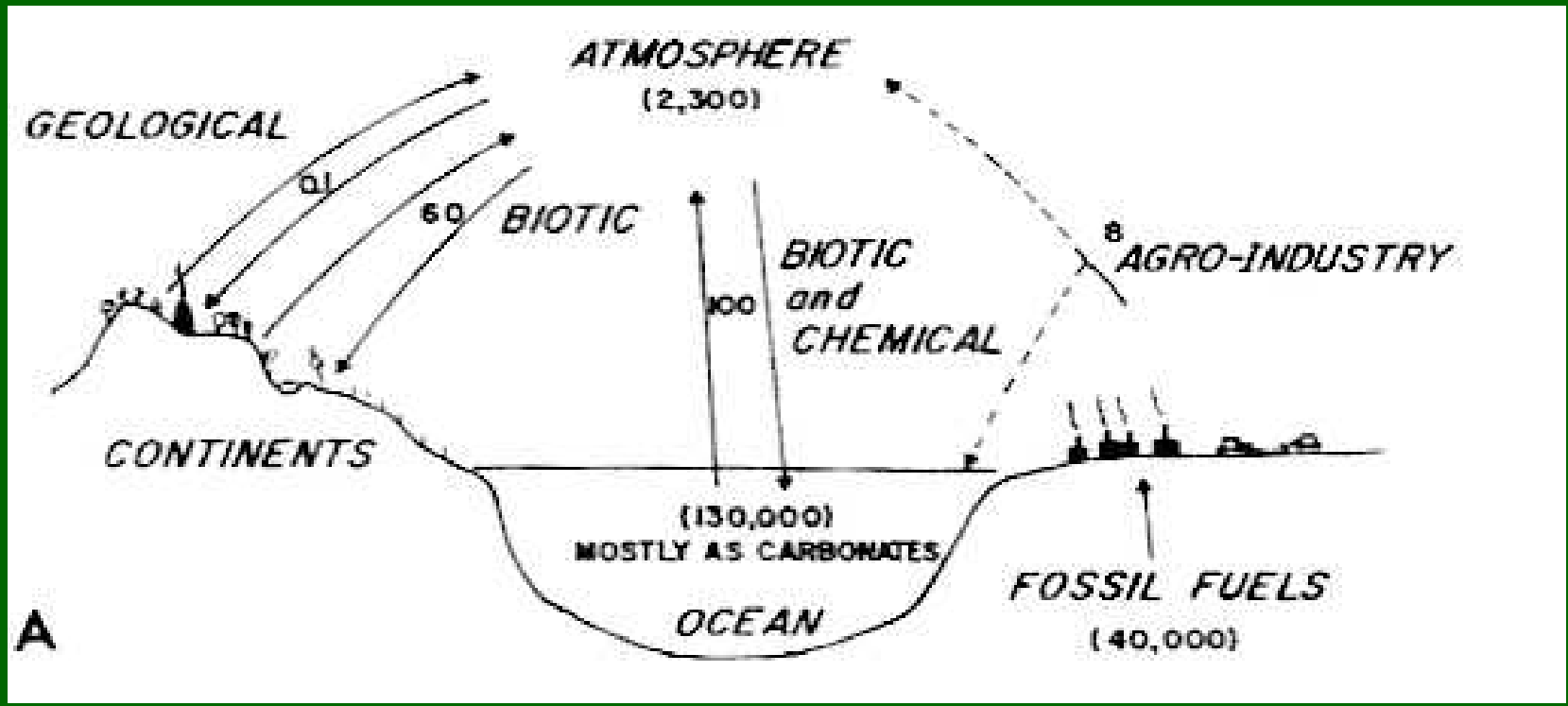
Water Circulation Can be Measured

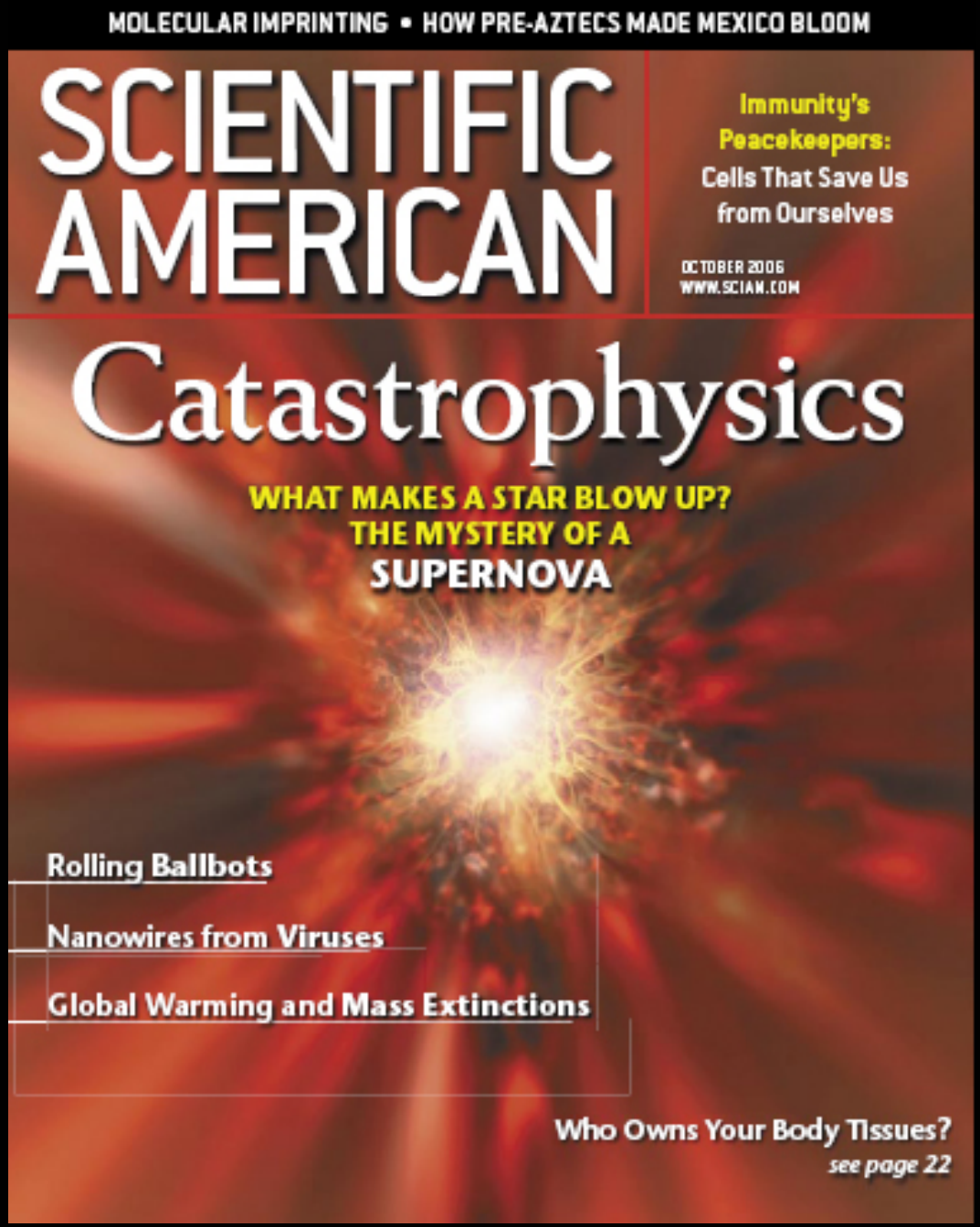




Carbon Circulation (and flow of other elements) Can Be Measured as well…

"stocks" and "flows"

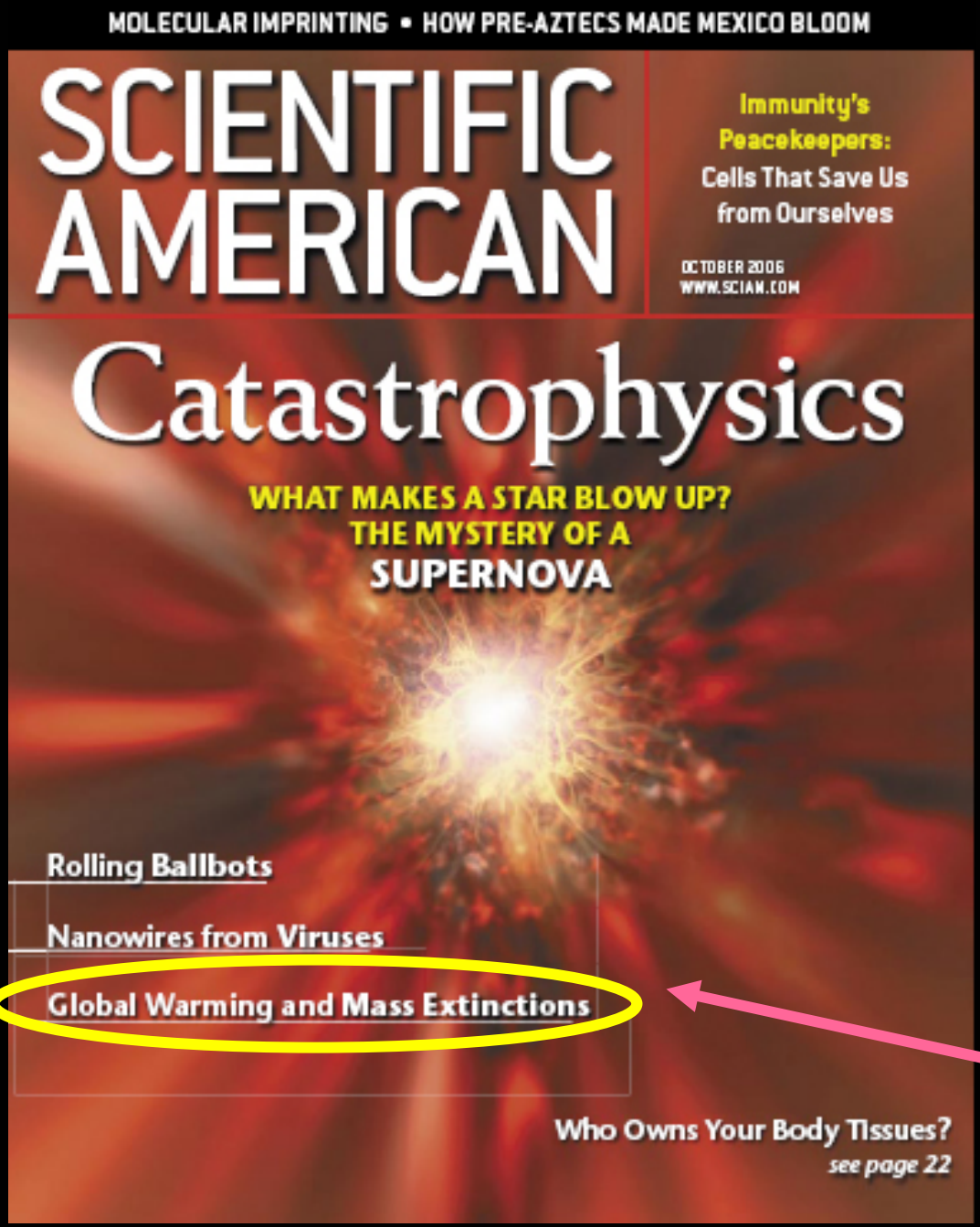




It is now apparent that in the past, large scale and devastating "discontinuities" have occurred in Earth's history.

Many have been associated with celestial events -- meteors, sun changes, etc.

But what about "endogenous" causes?



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GREEN AND PURPLE sulfur bacteria colonizing a hot spring thrive in water depleted of oxygen but rich in hydrogen sulfide. Widespread ocean blooms of these organisms during ancient periods of mass extinction suggest similar conditions prevailed at those times.

IMPACT FROM THE DEEP

Strangling heat and gases emanating from the earth and sea, not asteroids, most likely caused several ancient mass extinctions. Could the same killer-greenhouse conditions build once again? By Peter D. Ward

Philosopher and historian Thomas S. Kuhn has suggested that scientific disciplines act a lot like living organisms: instead of evolving slowly but continuously, they enjoy long stretches of stability punctuated by infrequent revolutions with the appearance of a new species—or in the case of science, a new theory. This description is particularly apt for my own area of study, the causes and consequences of mass extinctions—those periodic biological upheavals when a large proportion of the planet's living creatures died off and afterward nothing was ever the same again.

Since first recognizing these historical mass extinctions more than two centuries ago, paleontologists believed them to have been gradual events, caused by some combination of climate change and biological forces such as predation, competition and disease. But in 1980 the understanding of mass extinctions underwent a Kuhnian revolution when a team at the University of California, Berkeley, led by geologist Walter Alvarez proposed that the famous dinosaur-killing extinction 65 million years ago occurred swiftly, in the ecosystem catastrophe that followed an asteroid collision. Over the ensuing two decades, the idea that a bolide from space could smite a significant segment of life on the earth was widely embraced—and many researchers eventually came to believe that cosmic detritus probably caused at least three more of the five largest mass extinctions. Public acceptance of the notion crystallized with Hollywood blockbusters such as *Deep Impact* and *Armageddon*.

Now still another transformation in our thinking about life's punctuated past is brewing. New geochemical evidence is coming from the beds of stratified rock that delineate mass

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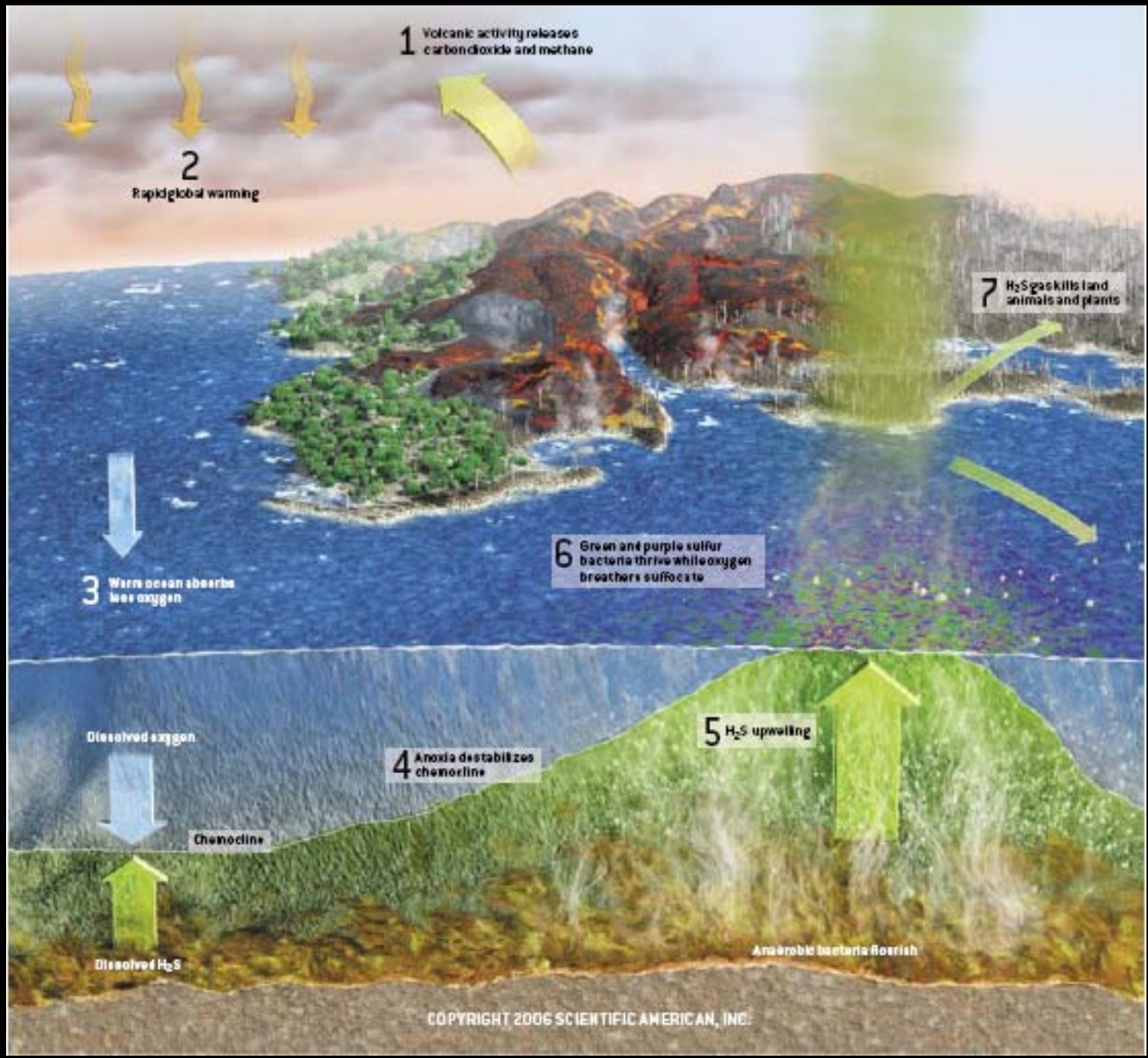
1 Volcanic activity releases carbon dioxide and methane
2 Rapid global warming
3 Warm ocean absorbs less oxygen
4 Anoxia destabilizes chemocline
5 H_2S upwelling
6 Green and purple sulfur bacteria thrive while oxygen breathers suffocate
7 H_2S gas kills land animals and plants
Dissolved oxygen
Chemocline
Dissolved H_2S
Anaerobic bacteria flourish
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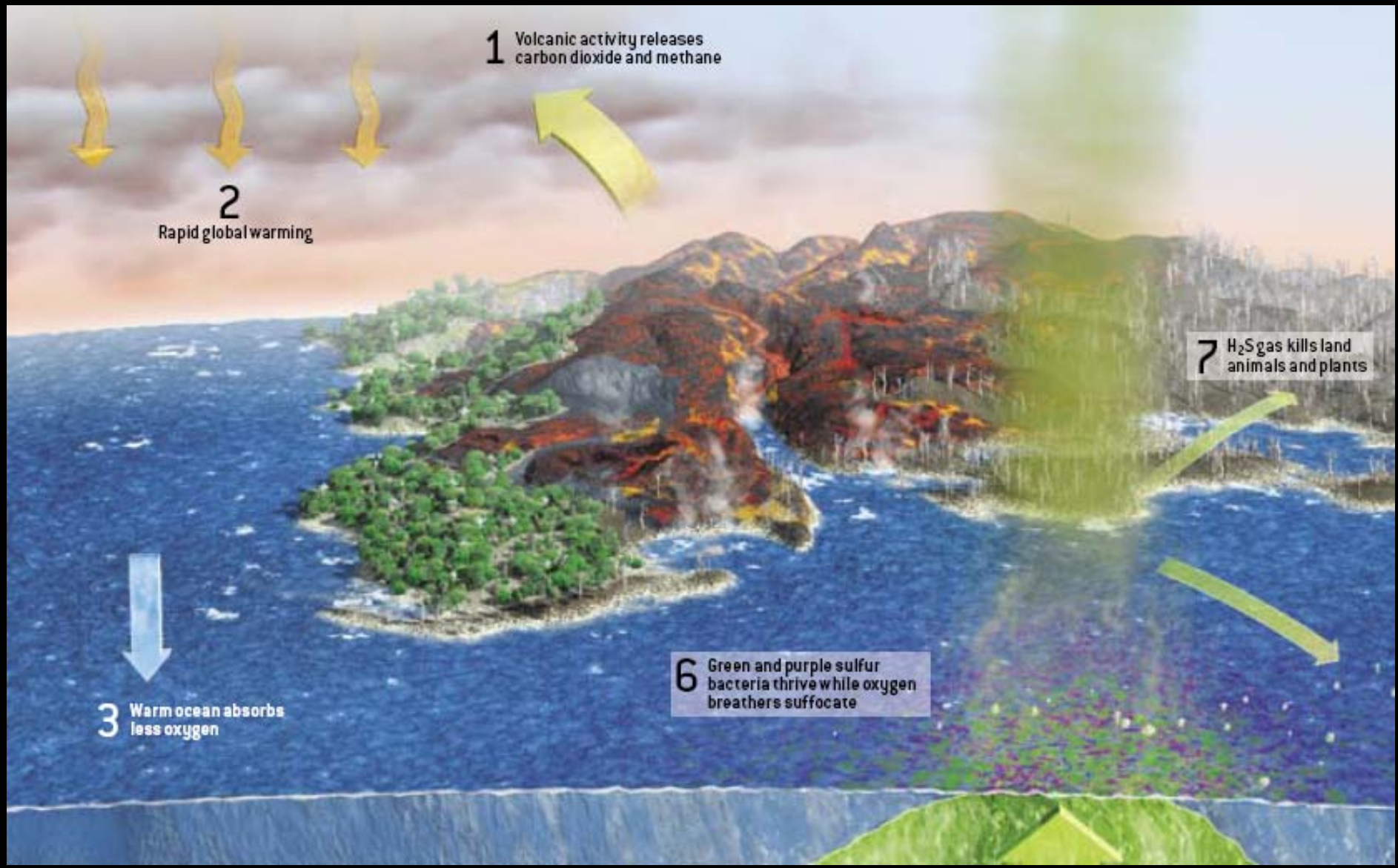
KILLER GREENHOUSE EFFECT

A new model for mass extinctions at the end of the Permian period 251 million years ago and the end Triassic 50 million years later explains how intense global warming could trigger deaths in the sea and on land. Trouble begins with widespread volcanic activity that releases enormous volumes of carbon dioxide and methane (*1*). The gases cause rapid global warming (*2*). A warmer ocean absorbs less oxygen from the atmosphere (*3*). Low oxygen (anoxia) destabilizes the chemocline, where oxygenated water meets water permeated with hydrogen sulfide (H_2S) generated by bottom-dwelling anaerobic bacteria (*4*). As H_2S concentrations build and oxygen falls, the chemocline rises abruptly to the ocean surface (*5*). Green and purple photosynthesizing sulfur bacteria, which consume H_2S and normally live at chemocline depth, now inhabit the H_2S-rich surface waters while oxygen-breathing ocean life suffocates (*6*). H_2S also diffuses into the air, killing animals and plants on land (*7*) and rising to the troposphere to attack the planet's ozone layer (*8*). Without the ozone shield, the sun's ultraviolet (UV) radiation kills remaining life (*9*).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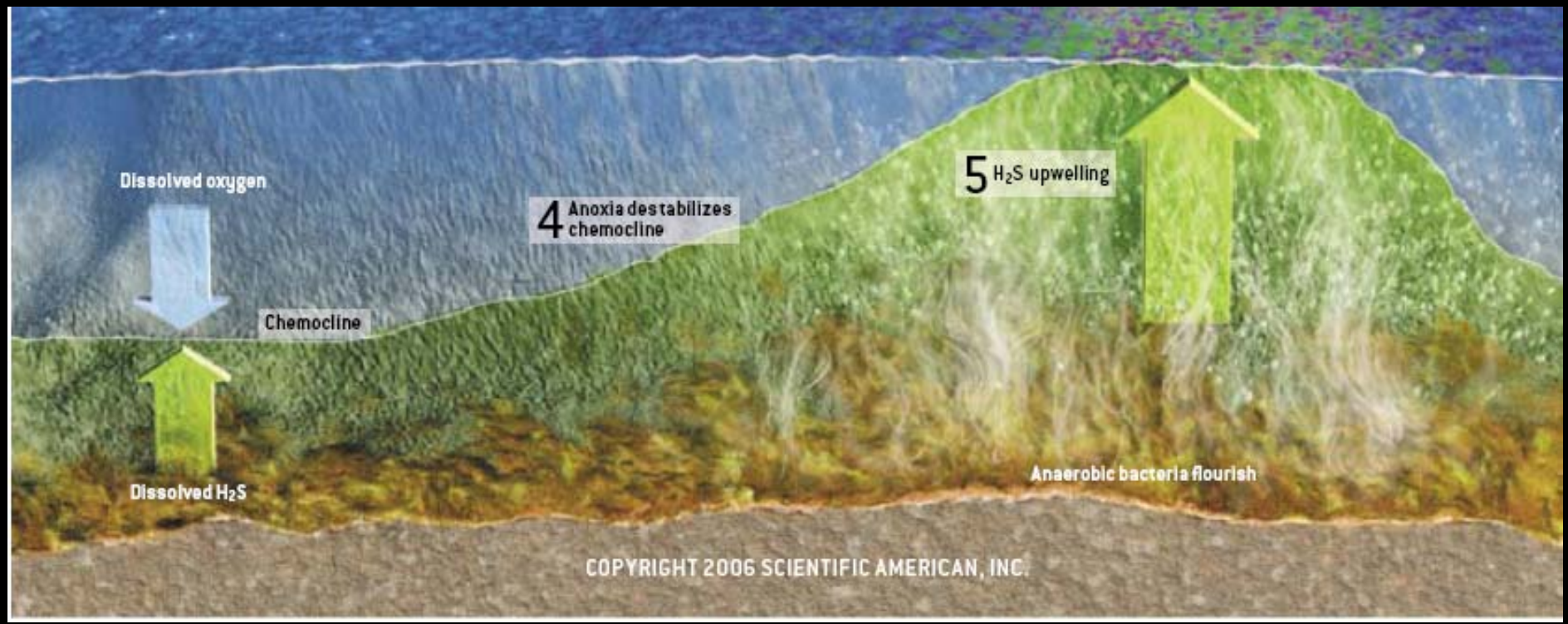
Dissolved oxygen
4 Anoxia destabilizes chemocline
5 H_2S upwelling
Chemocline
Dissolved H_2S
Anaerobic bacteria flourish
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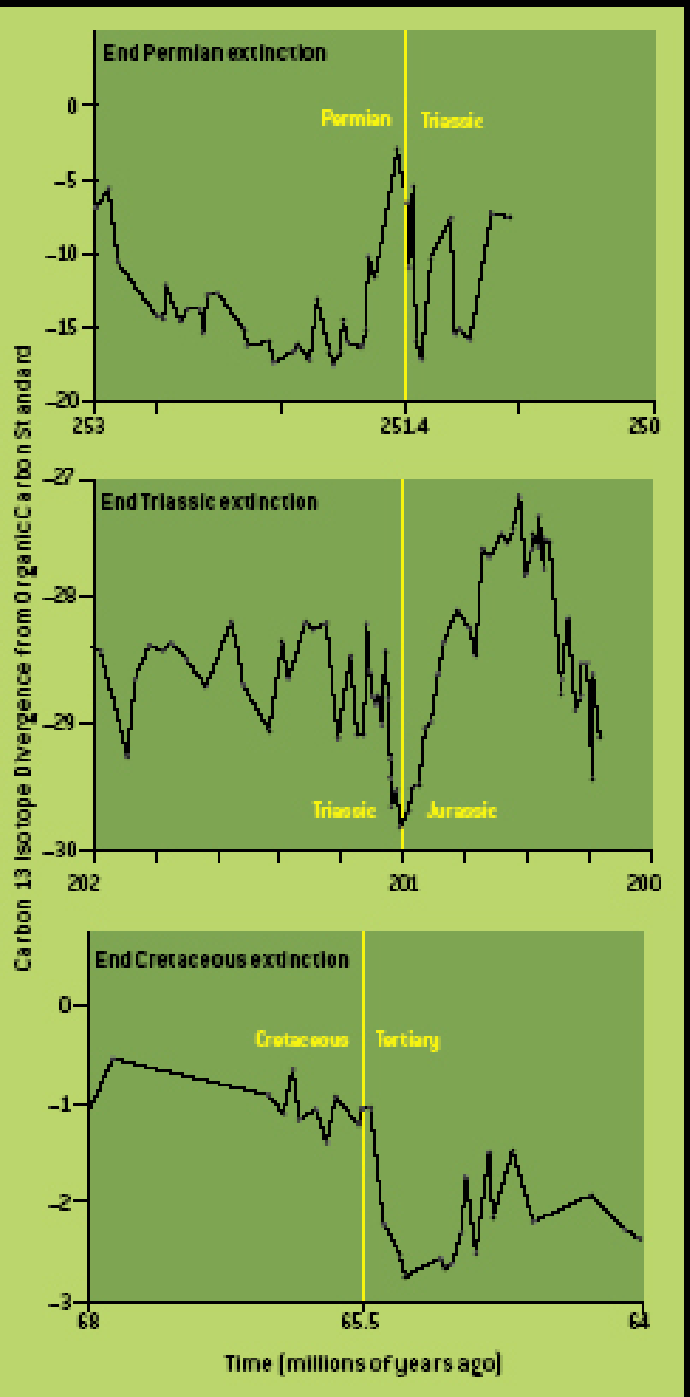
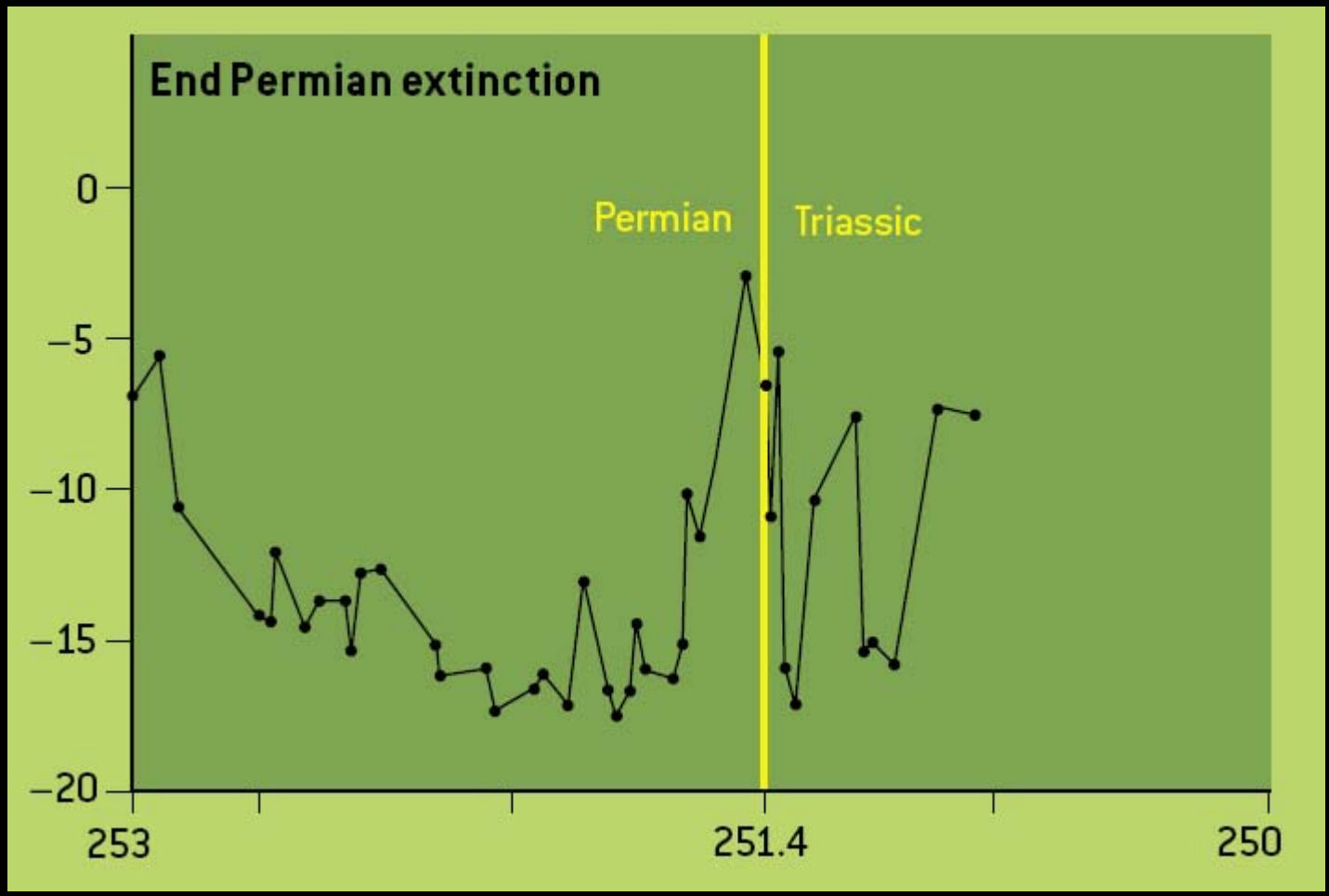
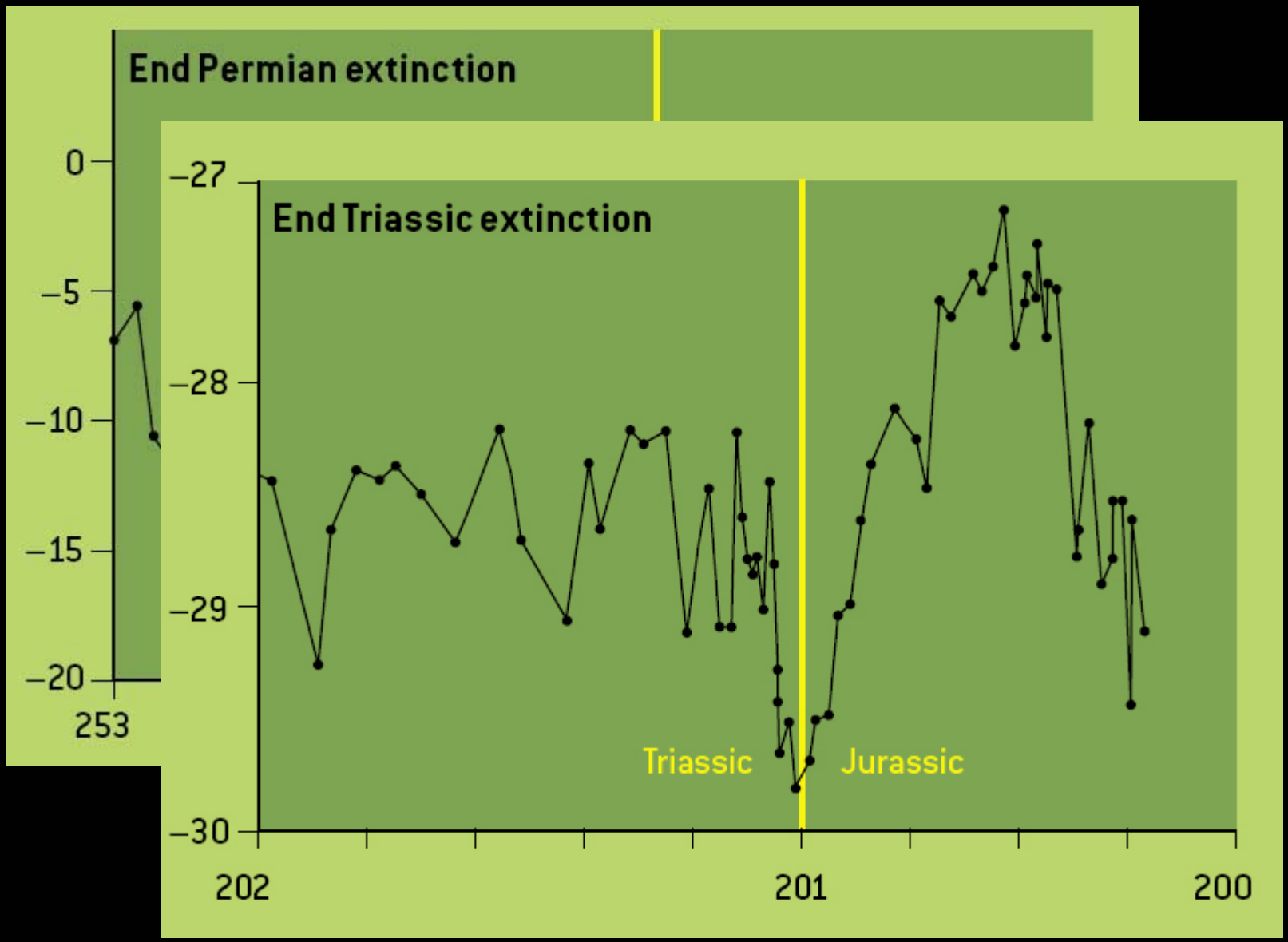
HYDROGEN SULFIDE ERUPTIONS off the coast of Namibia appear in this satellite photograph as pale green swirls on the ocean surface. These regular local events, which result from buildup of hydrogen sulfide in sea-bottom sediments, offer a small modern taste of conditions during the global upwellings proposed for several ancient mass extinction periods: a sulfurous smell fills the air, dead fish litter the water, and oxygen-starved lobsters flee onto beaches trying to escape the poison.

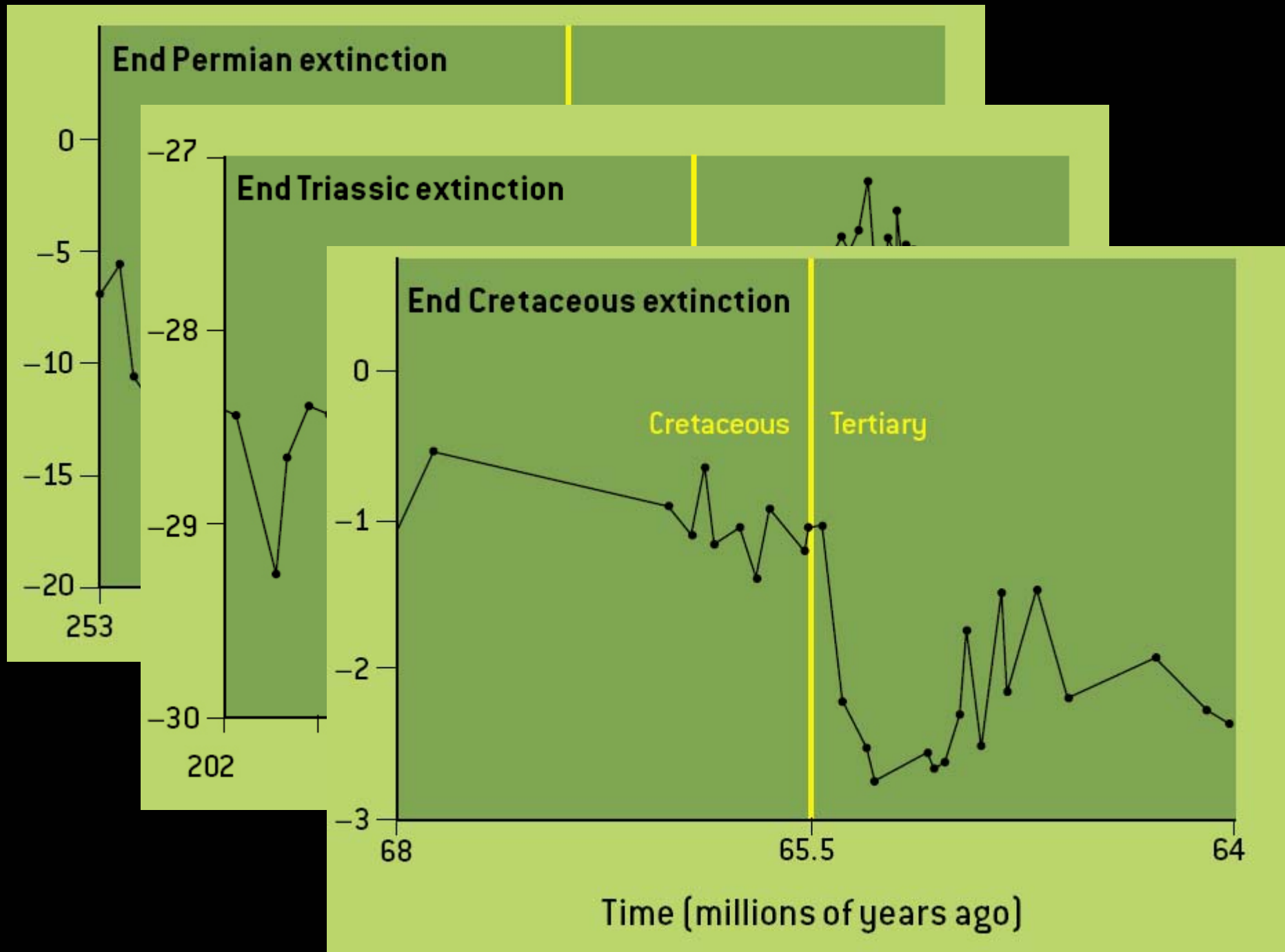
Patterns of Destruction

Carbon 13 (^{13}C) isotopes found in geologic strata suggest longer-acting mechanisms behind two of three ancient extinction events. ^{13}C is more abundant in the atmosphere when land and sea plants are thriving. When plant life dies on a massive scale, ^{13}C drops as a proportion of atmospheric carbon. Comparing ancient samples with a common carbon standard reveals multiple large drops in ^{13}C leading up to the end Permian (*top*) and end Triassic (*middle*) boundaries. The dips imply multiple extinction crises occurring over hundreds of thousands of years. In contrast, a ^{13}C plunge for the period around the Cretaceous-Tertiary boundary (*bottom*) depicts one abrupt ecological cataclysm.

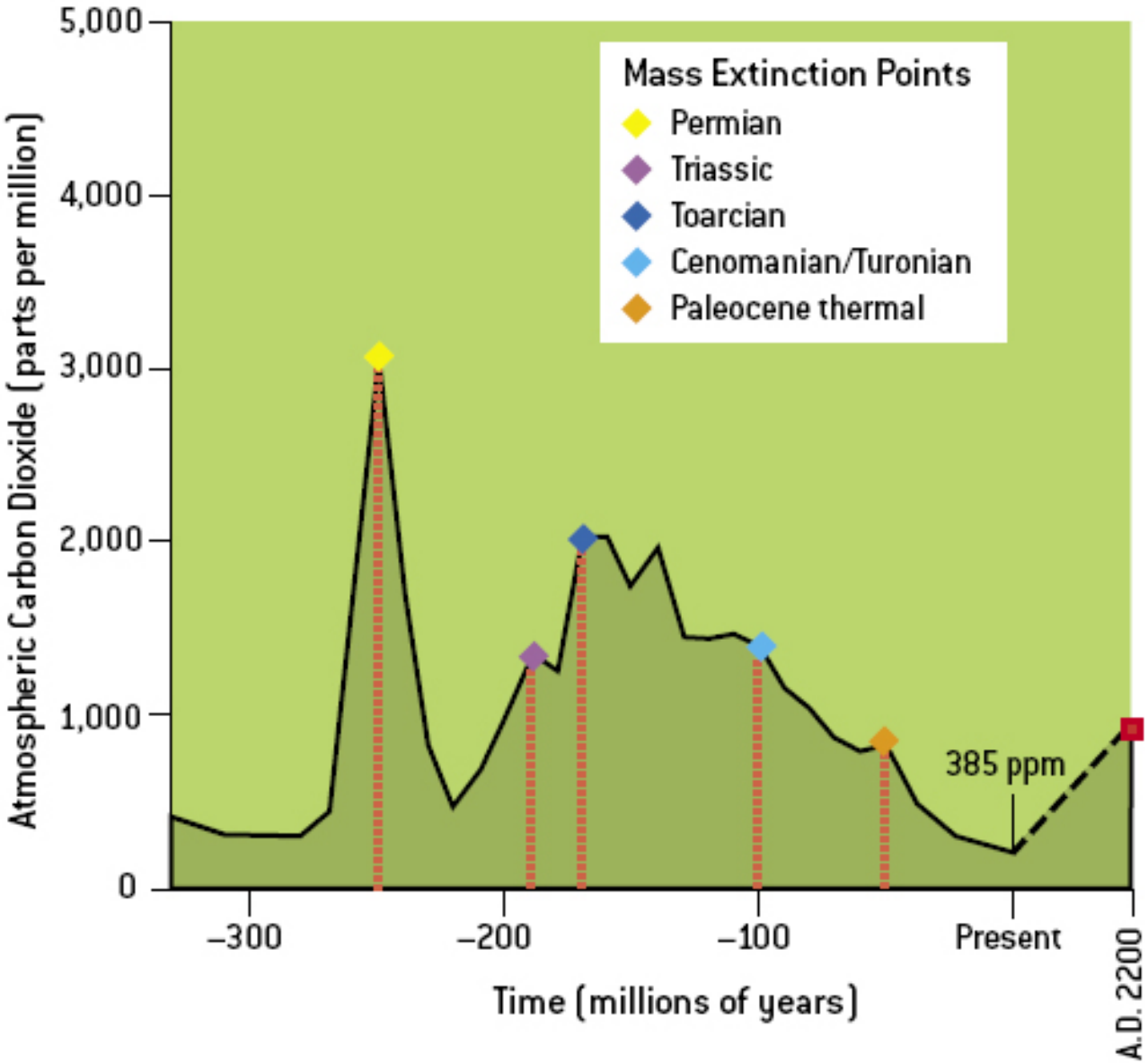

End Permian extinction
Permian
Triassic
0
-5
-10
-15
-20
253
251.4
250
End Triassic extinction
-27
-28
-29
-30
Triassic
Jurassic
202
201
200
End Cretaceous extinction
0
-1
-2
-3
Cretaceous
Tertiary
68
65.5
64
Carbon 13 Isotope Divergence from Organic Carbon Standard
Time (millions of years ago)


End Permian extinction
Permian
Triassic
0
−5
−10
−15
−20
253
251.4
250

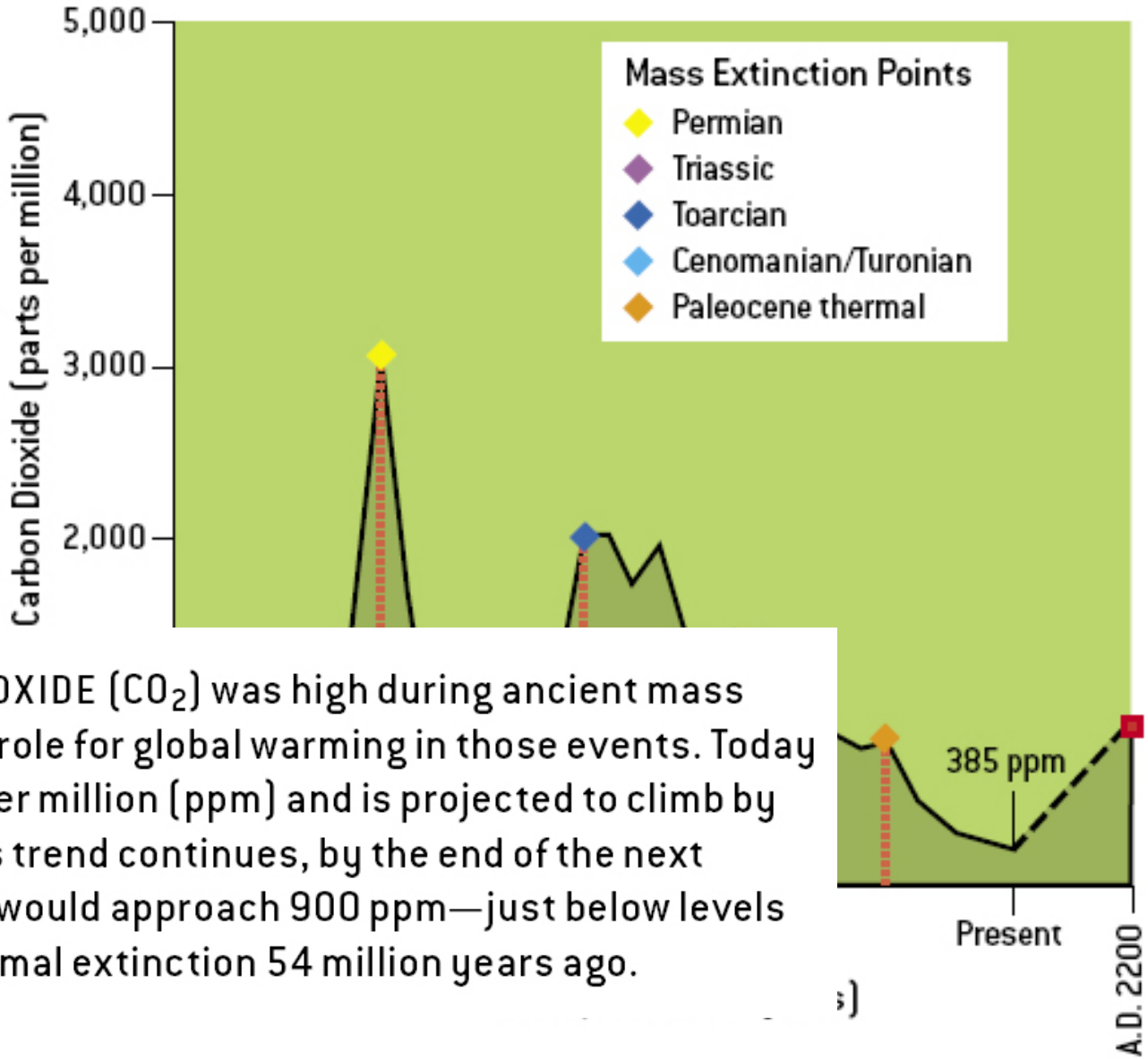

End Permian extinction
0
−5
−10
−15
−20
253
End Triassic extinction
−27
−28
−29
−30
Triassic
Jurassic
202
201
200


End Permian extinction
0
−5
−10
−15
−20
253
End Triassic extinction
−27
−28
−29
−30
202
End Cretaceous extinction
0
−1
−2
−3
Cretaceous
Tertiary
68
65.5
64
Time (millions of years ago)

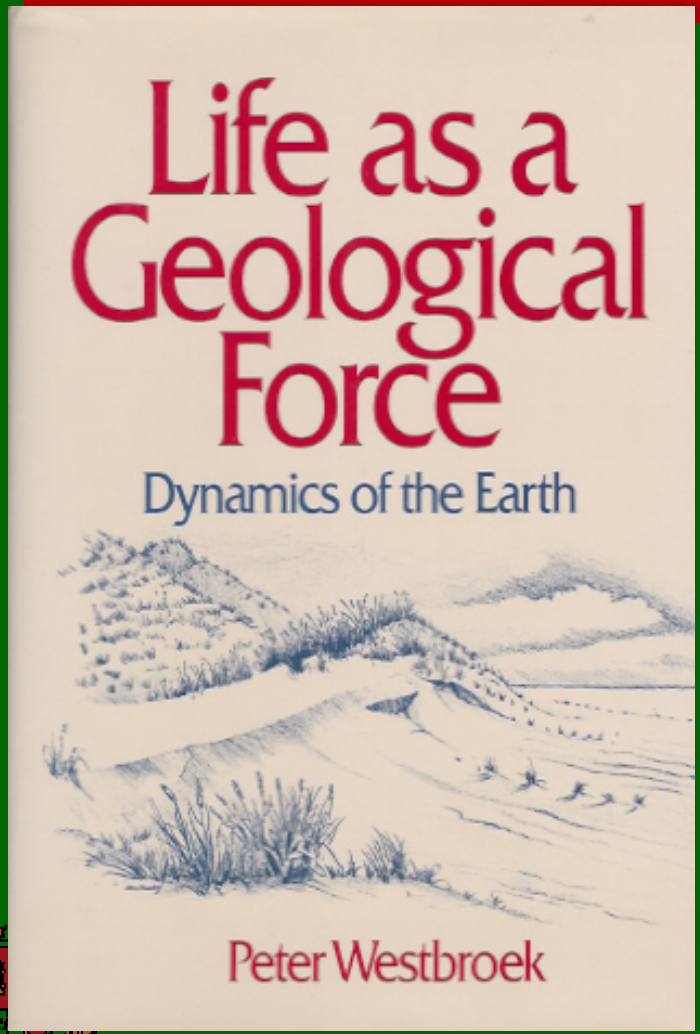
HEADED FOR ANOTHER EXTINCTION?



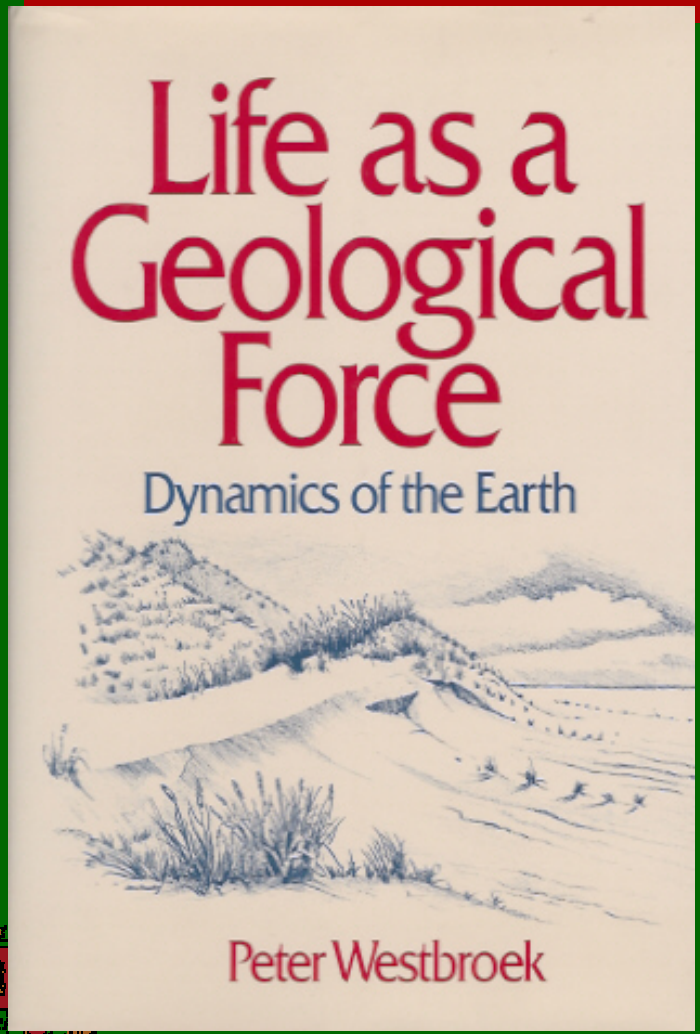
HEADED FOR ANOTHER EXTINCTION?



ATMOSPHERIC CARBON DIOXIDE (CO_2) was high during ancient mass extinctions, supporting a role for global warming in those events. Today CO_2 stands at 385 parts per million (ppm) and is projected to climb by 2 to 3 ppm annually. If this trend continues, by the end of the next century atmospheric CO_2 would approach 900 ppm—just below levels during the Paleocene thermal extinction 54 million years ago.



Life has been a “geological force” on Earth for far longer than humans have been part of the biosphere -- the full “committee of life forms.”



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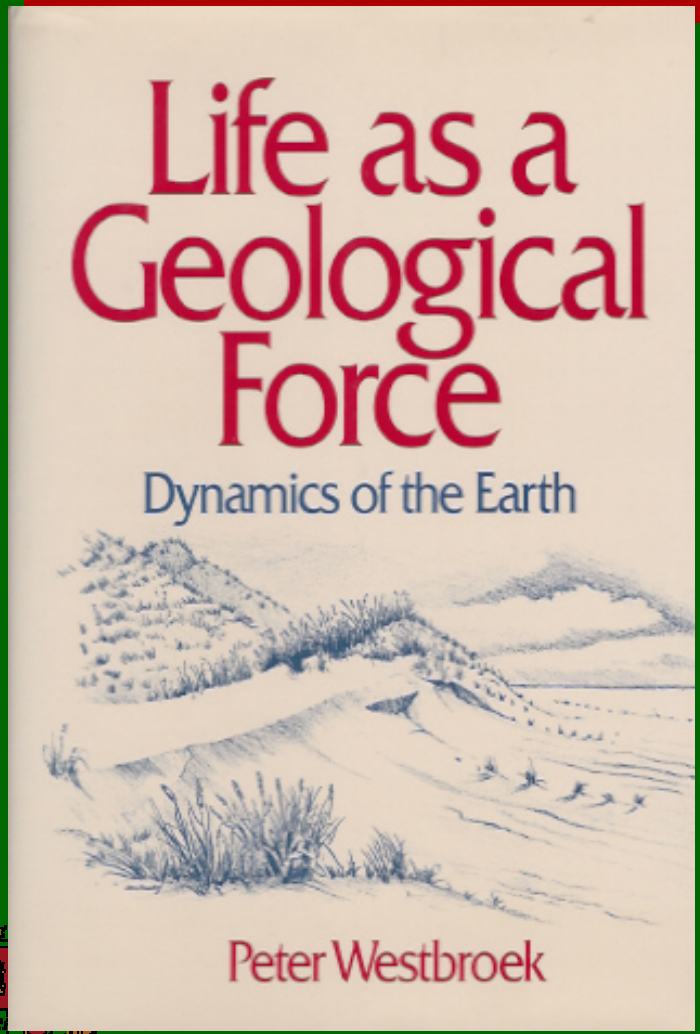
We live in a highly improbable atmosphere made possible by everything from “farting ants” to anaerobic bacteria alive for eons before we emerged as a species



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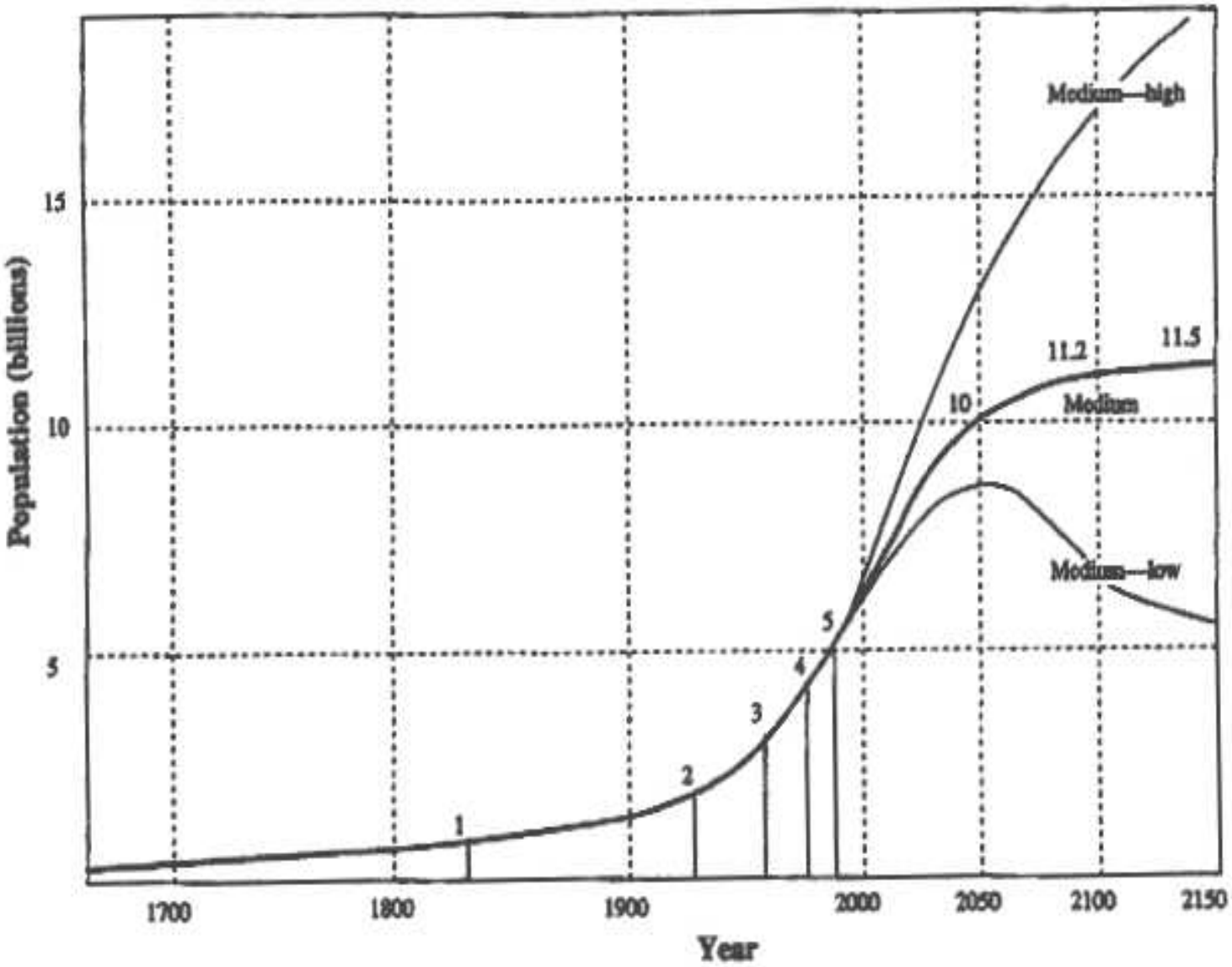
In one respect, however, things are different now that humans have expanded to such massive numbers.

Human population growth is apparent.

Broad range of alternatives in the future. Hard to predict.



Sometimes Humans behave as a “Geological Force”

It is reasonable to talk about not just life, but *human* life as a geological force.

Certainly the impact of humans is visible from space….

And even when our behavior generates emissions that are “invisible” (CO_2) these emissions may yet change Earth’s delicate balances required for life as we know it.

Environmental Ethics = our last, best chance of survival...

We are still assessing the ecological impact of the Viet Nam war and the war in Kuwait a decade ago, and the news is not encouraging.

The question is: Can we survive our own skills of killing and destroying the life support systems we need to survive?

Answer: No, not without a ***new*** environmental ethic.

Environmental Legacy in Kuwait

GREEN CROSS International

An Environmental Assessment Of Kuwait

Seven Years After the Gulf War

Final Report - August 1998

FOREWORD

On August 2, 1990, Kuwait was invaded by Iraqi troops. This sudden attack was followed by a period of intense diplomatic negotiations. The international community was and remains particularly concerned by the situation in the Gulf1, because economic and political stability of the whole region is critical to the world.

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http://courses.dce.harvard.edu/~envre120

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Course Utility Page

Course Announcement
Register for Course

- Course Calendar - Fall 2006
Class Videos

Library Resources:
- Harvard Library (HOLLIS Connection)
- The Environmental Information Center
- Environmental Science and Public Policy Archives

Class Resources

Week 3
Week 2
Week 1

Related Courses

- Certificate in Environmental Management
- Master of Liberal Arts in Environmental Management
- Harvard Extension School-Environmental Studies Courses
- Human Health and Global Environmental Change
- Global Climate Change: The Science, Social Impact and Diplomacy of a World

"Fresh fears on global warming," BBC News Online, (12 September 2006)

Click Controls to Pause, Start, or Stop

What does the methane release in Siberian lakes indicate?

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Environmental Ethics and Land Management

Harvard Extension School

http://courses.dce.harvard.edu/~envse120

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Course Utility Page

Course Announcement
Register for Course

- Course Calendar - Fall 2006
Class Videos

Library Resources:
- Harvard Library (HOLLIS Connection)
- The Environmental Information Center
- Environmental Science and Public Policy Archives

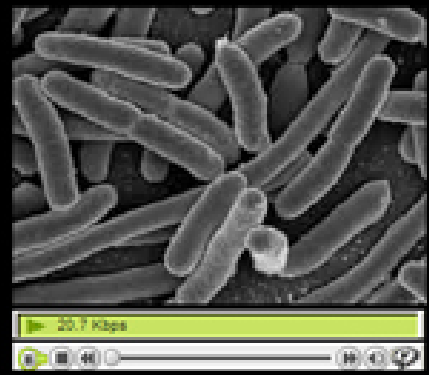
Class Resources

Week 3
Week 2
Week 1

Related Courses
- Certificate in Environmental Management
- Master of Liberal Arts in Environmental Management

"Frozen Micro-Organism Raises Hopes of Martian Life"

WBUR - On Point
24 February 2005



Click to Play, Pause, Stop

What does the reactivation of bacteria frozen 32,000 years ago in Alaska indicate?

Thinking about Environmental Ethics: A Perspective from a Scientist

Understanding the basic concepts of ecology and given our ecological “role” in this complex bio-geo-chemical system we have come to inhabit, how does this man think the human community should be behaving?

James Hansen, NASA Scientist

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ENVR E-120

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Basic Concepts of Ecology

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Class - Session 2 – Part 2
28 September 2006

Harvard University Extension School
Fall Semester 2006