Chapter 08: Planetary Atmospheres

Follow-up comment on the Geiger counter & granite rock activity

Page 2

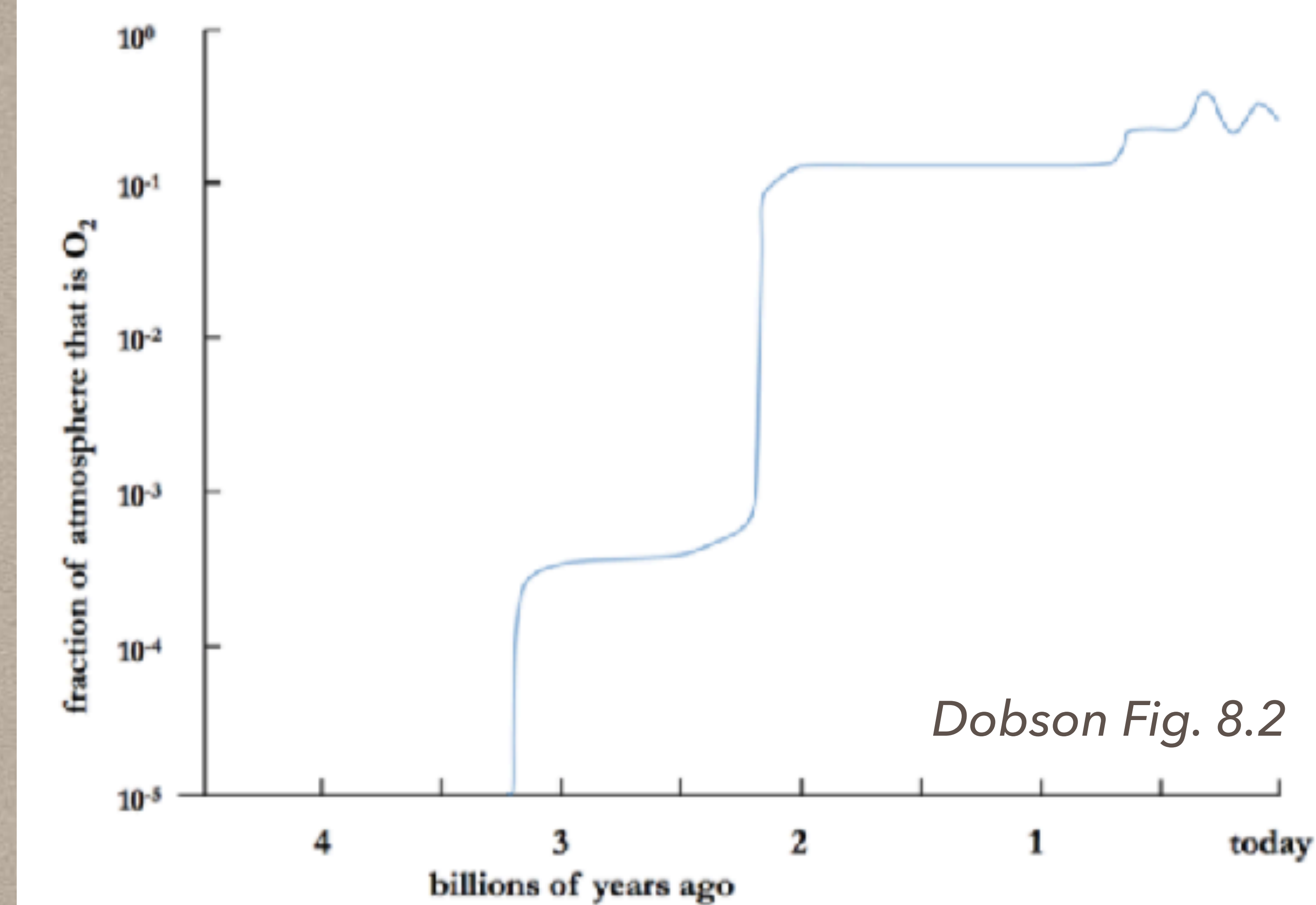
Q: Which description of an equation is incorrect?

A:

Q: Why should we require $v_{esc}/v_{m.p.} > 10$?

A:

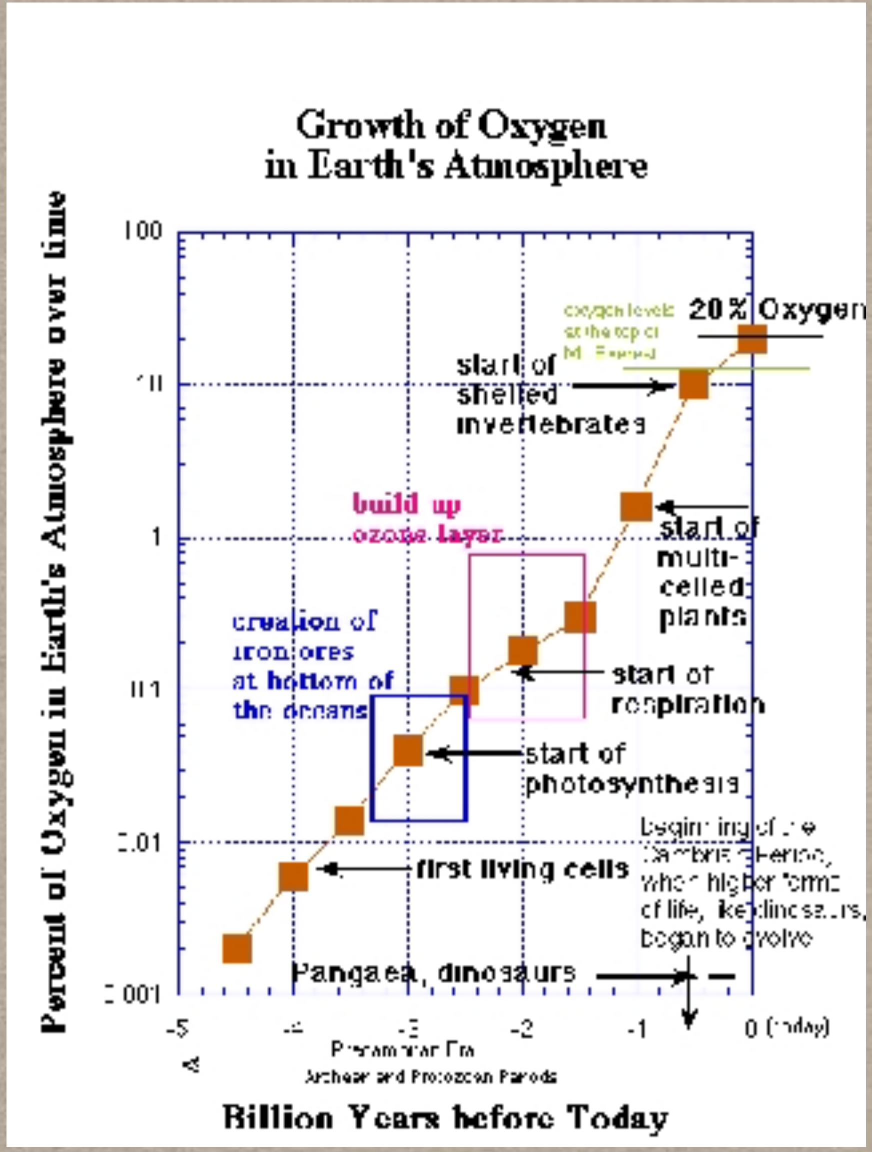
Compute v_{esc} for two Solar System objects: one small & warm and the other large and cool.

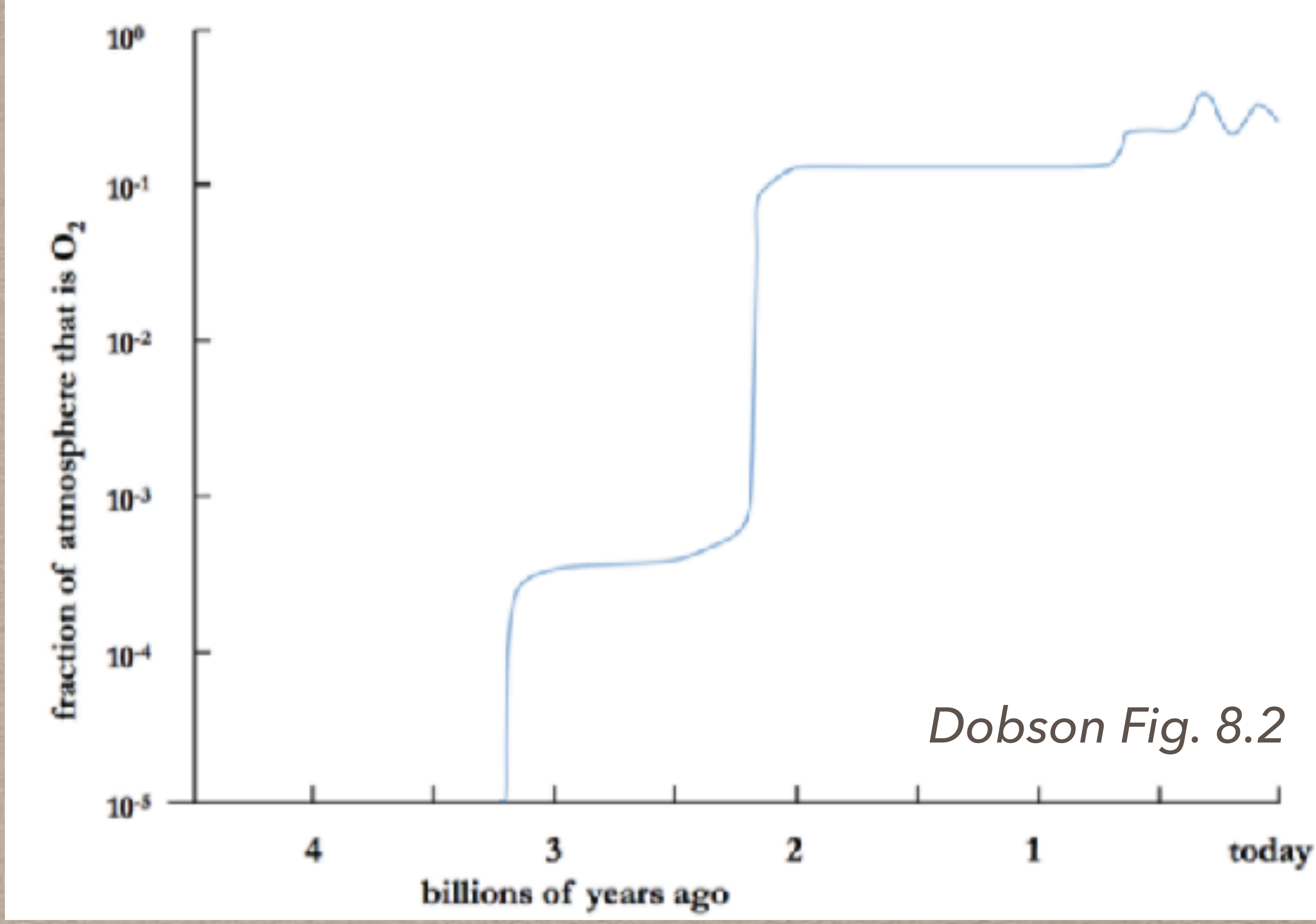


Dobson Fig. 8.2

Page 5

What drove the Earth's oxygen build-up?

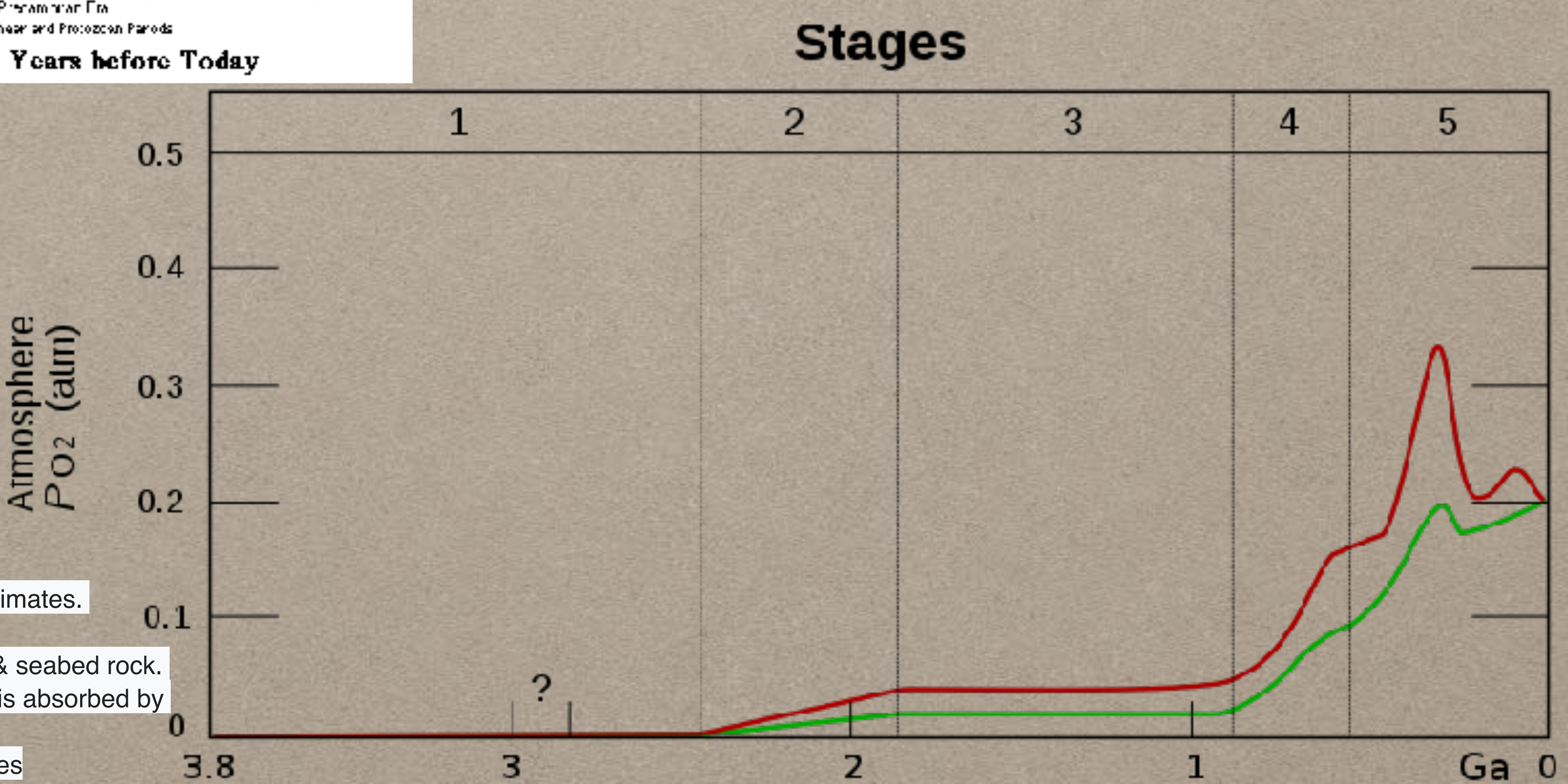




Dobson Fig. 8.2

Page 5

What drove the Earth's oxygen build-up?



Wikipedia
Red & green lines represent the range of the estimates.
Stage 1: Practically no O2 in the atmosphere.
Stage 2: O2 produced, but absorbed in oceans & seabed rock.
Stage 3: O2 starts to gas out of the oceans, but is absorbed by
land surfaces and formation of ozone layer.
Stages 4 & 5: O2 sinks filled, the gas accumulates

The Origin of Oxygen in Earth's Atmosphere by David Biello 08/19/2009

The breathable air we enjoy today originated from tiny organisms, although the details remain lost in geologic time

It's hard to keep oxygen molecules around, despite the fact that it's the third-most abundant element in the universe, forged in the superhot, superdense core of stars. That's because oxygen wants to react; it can form compounds with nearly every other element on the periodic table. So how did Earth end up with an atmosphere made up of roughly 21 percent of the stuff?

The answer is tiny organisms known as cyanobacteria, or blue-green algae. These microbes conduct photosynthesis: using sunshine, water and carbon dioxide to produce carbohydrates and, yes, oxygen. In fact, all the plants on Earth incorporate symbiotic cyanobacteria (known as chloroplasts) to do their photosynthesis for them down to this day.

For some untold eons prior to the evolution of these cyanobacteria, during the Archean eon, more primitive microbes lived the real old-fashioned way: anaerobically. These ancient organisms—and their "extremophile" descendants today—thrived in the absence of oxygen, relying on sulfate for their energy needs.

But roughly 2.45 billion years ago, the isotopic ratio of sulfur transformed, indicating that for the first time oxygen was becoming a significant component of Earth's atmosphere, according to a 2000 paper in Science. At roughly the same time (and for eons thereafter), oxidized iron began to appear in ancient soils and bands of iron were deposited on the seafloor, a product of reactions with oxygen in the seawater.

"What it looks like is that oxygen was first produced somewhere around 2.7 billion to 2.8 billon years ago. It took up residence in atmosphere around 2.45 billion years ago," says geochemist Dick Holland, a visiting scholar at the University of Pennsylvania. "It looks as if there's a significant time interval between the appearance of oxygen-producing organisms and the actual oxygenation of the atmosphere."

So a date and a culprit can be fixed for what scientists refer to as the Great Oxidation Event, but mysteries remain. What occurred 2.45 billion years ago that enabled cyanobacteria to take over? What were oxygen levels at that time? Why did it take another one billion years—dubbed the "boring billion" by scientists—for oxygen levels to rise high enough to enable the evolution of animals?

Most important, how did the amount of atmospheric oxygen reach its present level? "It's not that easy why it should balance at 21 percent rather than 10 or 40 percent," notes geoscientist James Kasting of Pennsylvania State University. "We don't understand the modern oxygen control system that well."

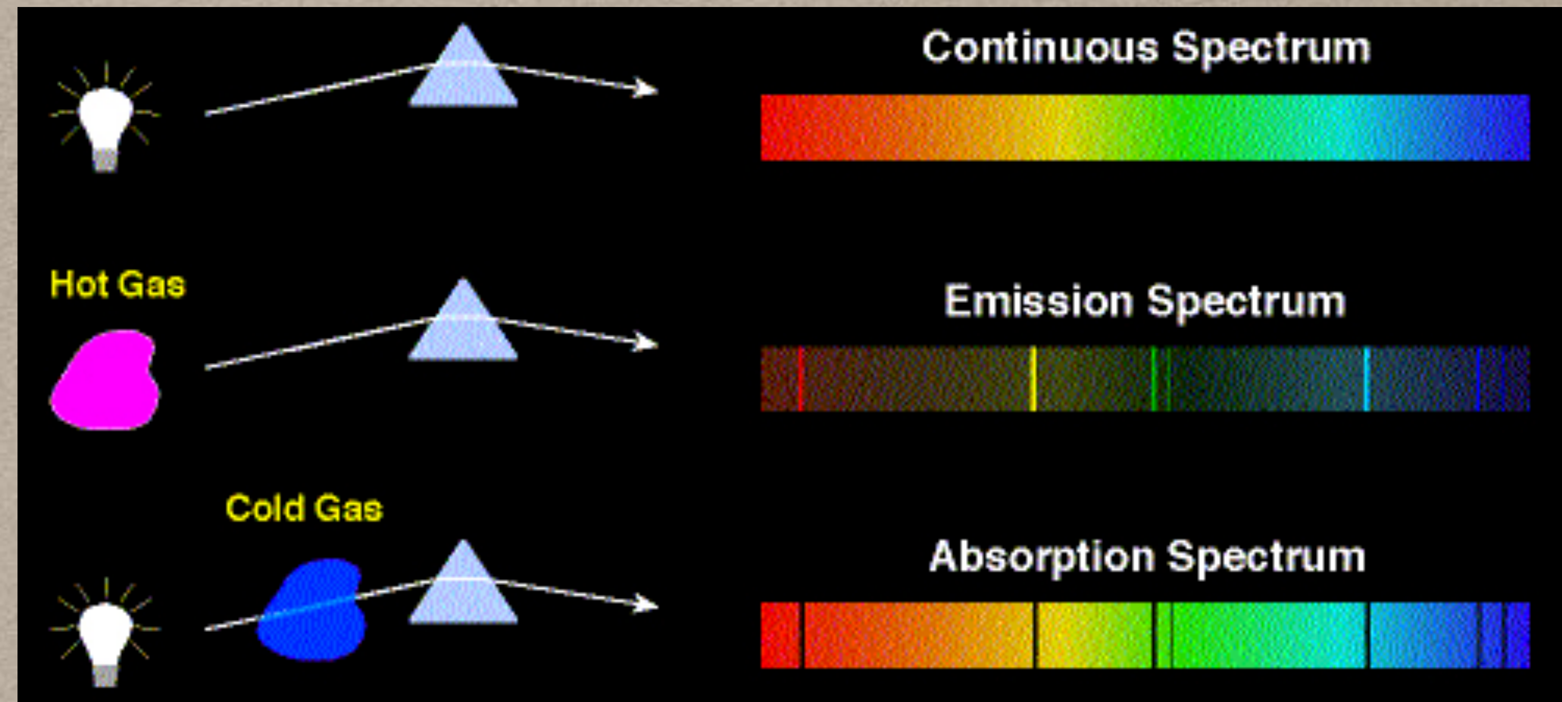
Climate, volcanism, plate tectonics all played a key role in regulating the oxygen level during various time periods. Yet no one has come up with a rock-solid test to determine the precise oxygen content of the atmosphere at any given time from the geologic record. But one thing is clear—the origins of oxygen in Earth's atmosphere derive from one thing: life.

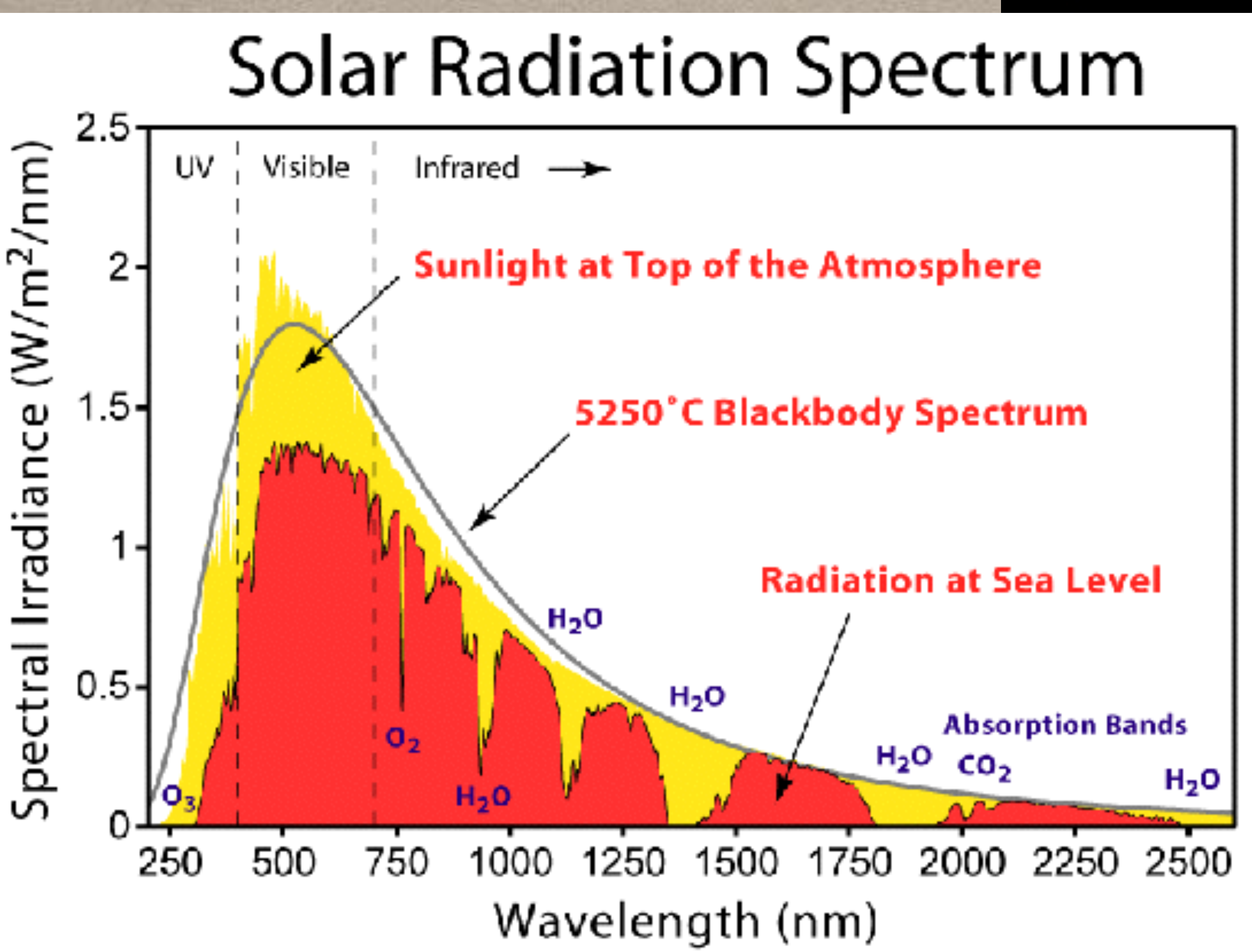
Page 6

Atmospheric compositions are determined through:

- ***absorption spectroscopy***
- ***gas chromatography***
- ***mass spectroscopy***

mv^2/r =

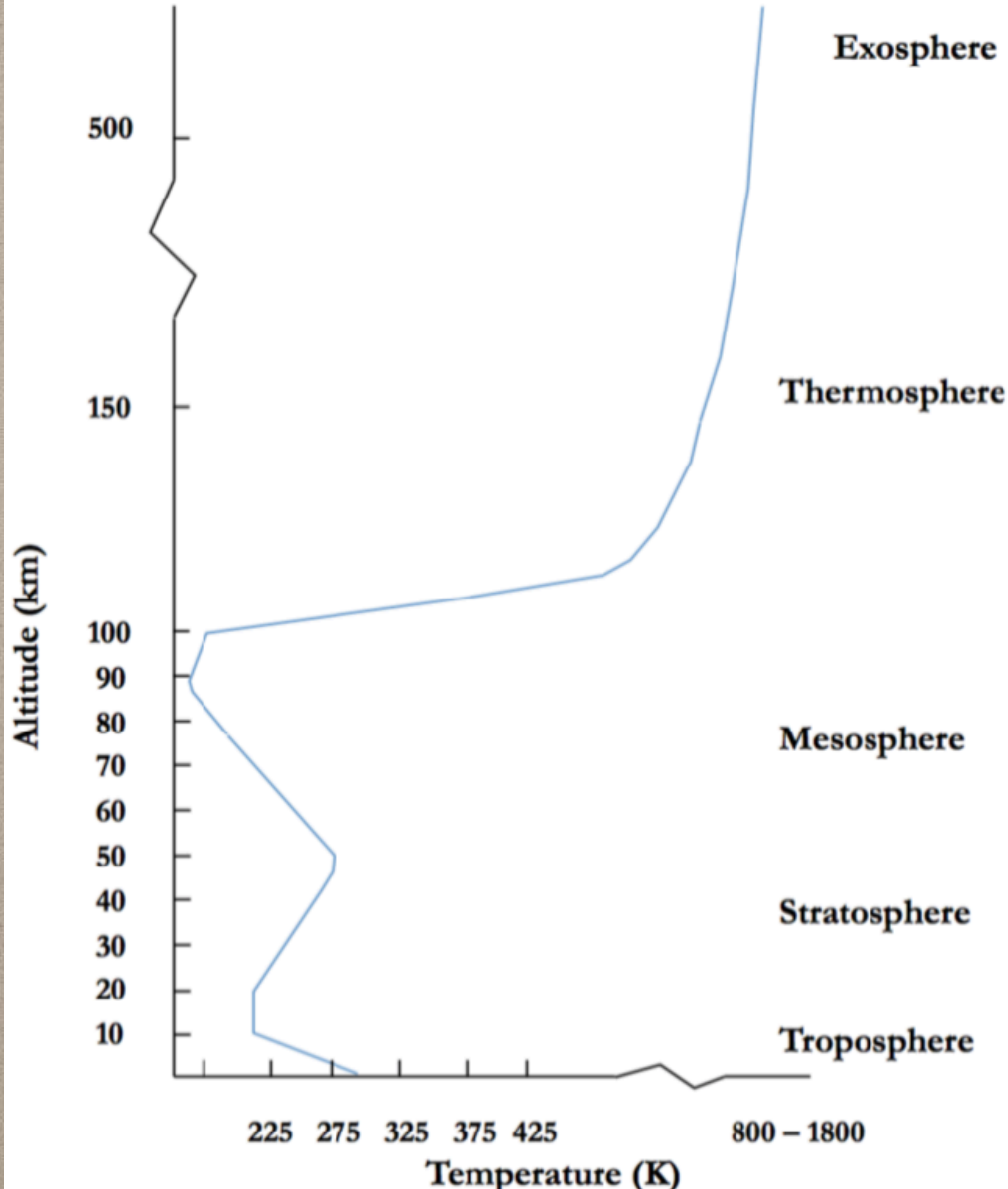




Activity on absorption profiles

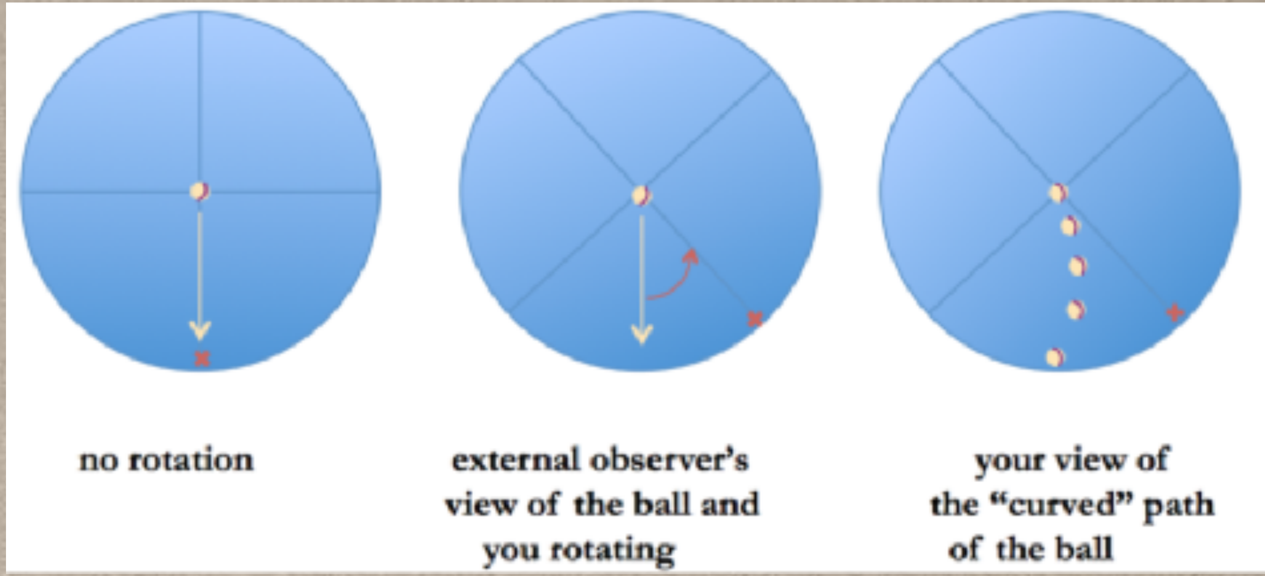
Page 8

Figure 8.4 on Earth's atmospheric temperature profile



Page 9

The rotating Earth influences the direction of winds



Q: From Laramie, you fire a rocket north; the rocket will land

a. east of your longitude

b. west of your longitude

Q: From Laramie, you fire a rocket south; the rocket will land

a. east of your longitude

b. west of your longitude

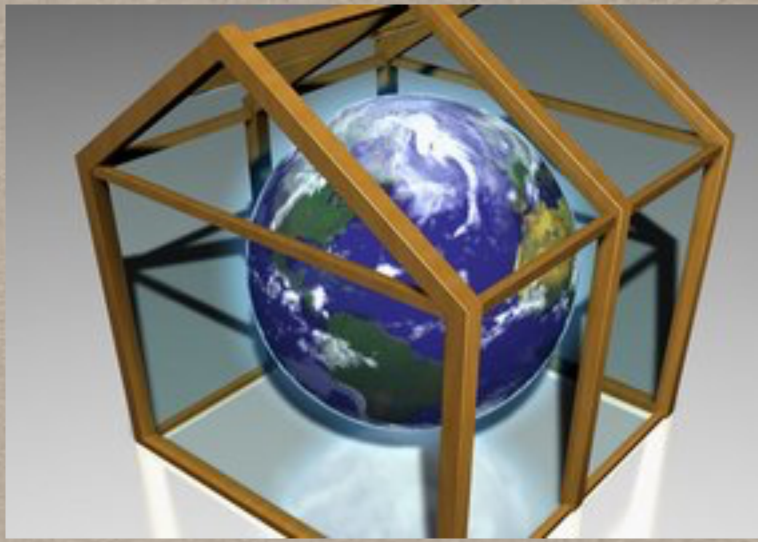
Q: From Buenos Aires, you fire a rocket south; the rocket will land

a. east of your longitude

b. west of your longitude

Page 10

The greenhouse effect



Q: What is the difference between the warming achieved by the greenouse effect in a planet's atmosphere and the warming achieved by an actual greenhouse in a gardener's backyard? In an actual greenhouse, the warming is caused by

a. cuddly rabbits hopping around when nibbling on carrots.

b. vicious Monty Python rabbits exploding holy hand grenades.

c. molecules (CH_4, $H_{2}0$, CO_2) capturing outbound IR radiation.

d. the glass capturing inbound sunlight & re-emitting IR radiation.

e. the glass physically blocking warm air from escaping.