

Natural Disasters

Lecture 26

Ch #17 – The Great Dying (Mass Extinctions)

Text Source Today:

Chapter 12 (p. 313-314)

Chapter #17 (p. 2-9)

#17.1: Ch. #17 – The Great Dyings (Mass Extinctions)

♦ **Early Earth Climate – An Intense Greenhouse:** billions of years ago, the early Earth atmosphere was rich in CO_2 (98%) and deficient in N_2 (2%) and O_2 (trace). It was also a **hot** (290°C ; $> 550^\circ\text{F}$) and high pressure (60 atmospheres) planet! The presence of **free hydrogen** and a lack of oxygen made this a “**reducing atmosphere**”.

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	Venus	Early Earth	Mars	Earth Today
CO_2	96.5%	98%	95.3%	0.038%
N_2	3.4%	1.9%	2.7%	78%
O_2	trace	trace	0.13%	21%
Ar	0.01%	0.1%	1.6%	0.93%
Temperature $^\circ\text{C}$	477	290	-53	16
Pressure (bars)	92	60	0.006	1

♦ **Earth Today- A Lesser Greenhouse:** our atmosphere is rich in N_2 (78%) and O_2 (21%) and deficient in CO_2 ($< 0.04\%$); an “**oxidizing atmosphere**.” It is a much more temperate (16°C ; 61°F) planet. Without a “greenhouse effect”, the average surface temperature would be 34°C colder (-18°C ; 0°F)!

- Where did all that early Earth CO_2 go?

♦ Over geologic time, CO_2 was dissolved into the oceans and CaCO_3 sediments formed. Oceanic life used the CaCO_3 to build their skeletons, shells and reefs. Today, about **80%** of that CO_2 is locked up in **limestone rock**.

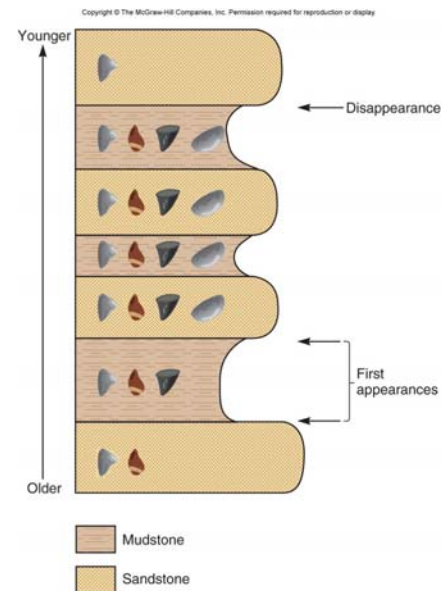
♦ Early **photosynthetic life** pulled more CO_2 out of the atmosphere and replaced it with O_2 . This **biologic** use of CO_2 lessened its concentrations in the atmosphere to today’s trace gas levels.

♦ **Fossils:** are evidence of **former life**. To become **fossilized**, an organism must: (1) be in **possession of hard parts**, such as teeth (sharks), shells (oysters, snails, clams) or bones (dinosaurs); and, (2) have **rapid burial** (tar pits, amber), which protects organisms from being scavenged and disintegrated.

(Fig. #17.10)

- In 1786, Georges Cuvier proved that **extinction of species** had occurred (e.g., **mammoths** are distinctly different than today's **elephants** and are thus, extinct).

- Cuvier also noted that in a nonoverturned sequence of sedimentary rocks (oldest on bottom; youngest on top), that entire communities of plants and animals make **abrupt appearances** in rock layers and others **abrupt disappearances (extinctions)** in geologically short lengths of time.



♦♦ **Species and the Fossil Record:** over **99.9%** of all plant and animal species that have ever lived are **extinct**!

♦ **Species:** is the **smallest** biologically real and distinct unit of individuals that share a **common ancestor** not shared with other organisms; each species is **unique**; each new species is **never** entirely the same as any previous one.

- **Extinctions** clear out living space (habitats) and provide new opportunities for different organisms to evolve new ways of life, to occupy vacated **niches** in the environment, and in so doing, create even more new **niches**.

- **Background extinctions** occur at a moderate rate and continuously open up a limited number of opportunities for the origin of new **species** and new **niches**.

- ◆ **Mass extinctions** cause **worldwide** elimination of numerous **species** (**40% or greater**), opening up a wealth of **niches** for new organisms to fill the evolutionary process.

- **Example:** each time a mass extinction eliminated the **tropical reef-builders** of its day, there followed a long interval of time before other creatures were able to fill the environmental void; each time **reefs** disappeared from the planet, they were re-built by **a different group** of organisms!

- ◆ **“Brief” History of Life:**

- ▶ **3.8 billion years ago:** **archaea (extremophiles)** were alive; an ancient branch of life that thrived under high pressures and high temperatures; they derived their energy by breaking chemical bonds of inorganic molecules (CO_2 , H_2O , N_2). Today, **archaea** are found over 2 miles below ground (at pressures over 200 atmospheres) and at hot springs and deep ocean spreading centers with temperatures up to 113°C (232°F), but they are killed by **oxygen (O_2)**!

- ▶ **3.5 to 2.5 billion years ago:** **cyanobacteria (photosynthetic bacteria)** were forming **stromatolites** and removing some of the abundant CO_2 and combining it with water and sunshine, to create O_2 .



Organisms of these early times reproduced by **simple division of their cells**, and lived primarily below the surface, **in the oceans** and within sediments and rocks. (Earthlings back

then were basically **slime and made of goo!**)

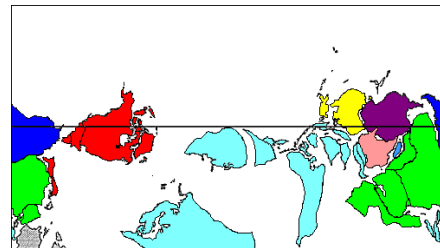
► **2.4 billion years ago:** the increased O_2 and decreased CO_2 likely led to the first **global glaciation**, known as **“Snowball Earth”**, likely causing the first “mass extinction” (of slime)!



◆► **2.1 billion years ago:** the first **single-cell eukaryotes** fossils (our direct and distant ancestors) are found.

► **1 billion years ago:** life rebounded and **sexual reproduction** had appeared, and cells could share and mix genetic material, thus speeding up evolutionary changes by **thousands** of times. The super-continent of **Rodinia** had formed and covered most of the **equator**, but was **devoid of life and highly reflective**, causing significant global **cooling**.

► **750 to 620 million years ago - The Cryogenian Period:** there were perhaps as many as **four** **“Snowball Earth”** episodes, that likely again caused mass extinctions of life in the

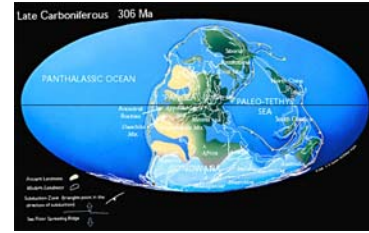


oceans. With the **Rodinia** super-continent broken into pieces and large amounts of land in a band **around the equator**, the colder ocean waters were confined to the poles. The land, still **devoid of life**, had a **higher albedo** than the oceans, creating a significant cooling. The plethora of **cyanobacteria** in the



oceans caused a **significant decrease** in concentration of the greenhouse gas CO_2 , and led to an **extreme** global glaciation. It may have taken just **3 million** years to ice up the **entire planet!** Once the ice cover reached 30° latitude, the **very**

► **360 to 260 million years ago:** this 100-million-year-long **“Ice Age”** appears to be due to the formation of **Pangaea**. The supercontinent covered much of the **south pole** and was blanketed by massive glaciers. It also stretched north past the equator, thus deflecting ocean-water circulation more **longitudinally (north-south)**, bringing tropical moisture in the form of snowfall to the higher latitude landmasses.



● This lengthy **“Ice Age”** likely ended when **Gondwanaland** began to **break up and disperse**, thus allowing ocean-water circulation patterns to change globally.

► **300 million years ago – The Carboniferous Period:** **O₂** levels during the lengthy **“Ice Age”** may have risen as high as **35%**. On land, there were Amphibians (as big as pigs), early reptilians (bigger than sheep) and **huge**



insects (millipedes as big as dogs, 50-pound **scorpions**, and **dragonflies** with 2-foot wingspans). It was also a time of massive **wildfires**. This period led to much of the **coal, oil and gas** we are mining and using for energy today!

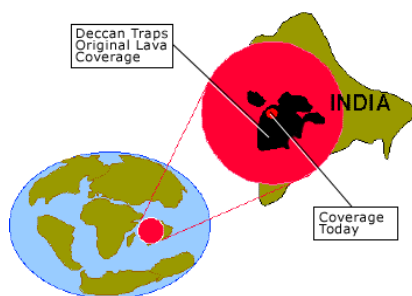
► **250 million years ago:** the **Siberian Traps Flood Basalt** may have been the primary cause of the **End Permian Extinction**, in which **95%** of all living



marine species and **70%** of all terrestrial vertebrate species **died**. In the following **100** millions of years, in the **Triassic** and **Jurassic**, new species originated and the diversity and volume of life increased significantly, including the most famous of all, the **dinosaurs**.

- ▶ **180 million years ago: Pangaea** began to break apart.
- ▶ **100 million years ago: Dinosaurs** dominated a world largely covered by **lush, tropical** landscapes. There were little, if any, **ice caps or glaciers** on the planet. The resulting higher sea levels led to lots of warm, **shallow inland seas** on the continents. **Palm trees** were growing north of the Arctic Circle and in Antarctica.

- ▶ **65 million years ago:** A large (10km; 6 mile wide) asteroid crashed into **Mexico's (submerged) Yucatan Peninsula**. This cataclysmic event was coupled with the **Deccan Traps Flood Basalt in India** (which



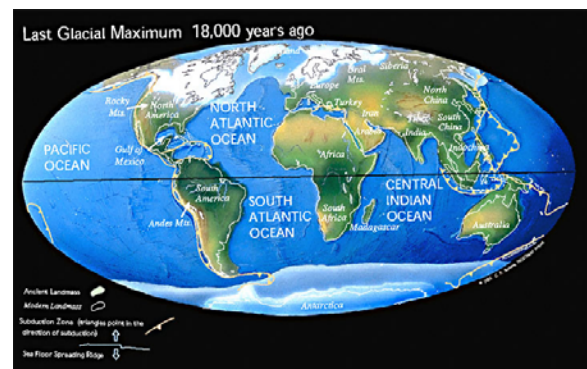
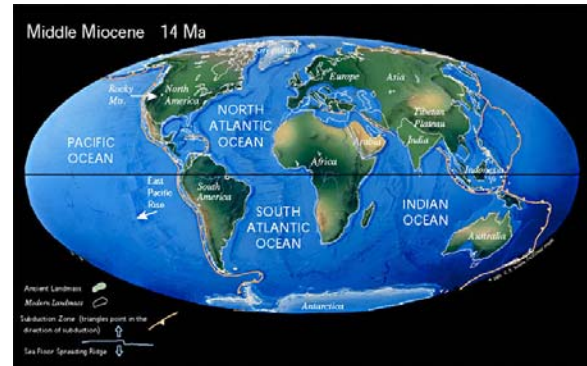
was just approaching the equator on its way to a collision in Asia). These two major events likely killed off 70% of all species on Earth, including the **dinosaurs (except birds)**, who had ruled the planet for about **165 million** years!

- ▶ **55 million years ago – The “Torrid Age”:** There was **more heat** in the oceans and atmosphere than at any time since! Once again, life took advantage of an opportunity. **Flowering plants** expanded rapidly and **mammals** took over from the land vacated by the **dinosaurs**. Continental drift began to place the

continents in familiar alignment. Due to extreme **global warming, palm trees** again reached above the Arctic circle.

► **2 million years ago:**

Ancestors of **modern humans** are first seen. Volcanism had created the **Isthmus of Panama**, which connected North and South America, thereby separating the Pacific and Atlantic Oceans and re-routing the ocean currents. The **Drake Passage** had opened up, isolating Antarctica, allowing a huge ice cap to form. The Atlantic grew **saltier** than the Pacific, due to more continental run-off. This established the global ocean circulation pattern in place today. The **“Ice Ages”** return.



► **12,900 years ago:** near the end of the last **“Ice Age”**, the **“Last Extinction”**, an ongoing *mystery*, occurred when mainly large-bodied animals in North America suffered an abrupt demise.



► **10,000 years ago:** the last ice sheets retreat to the poles. **Human life** flourishes to this day.

