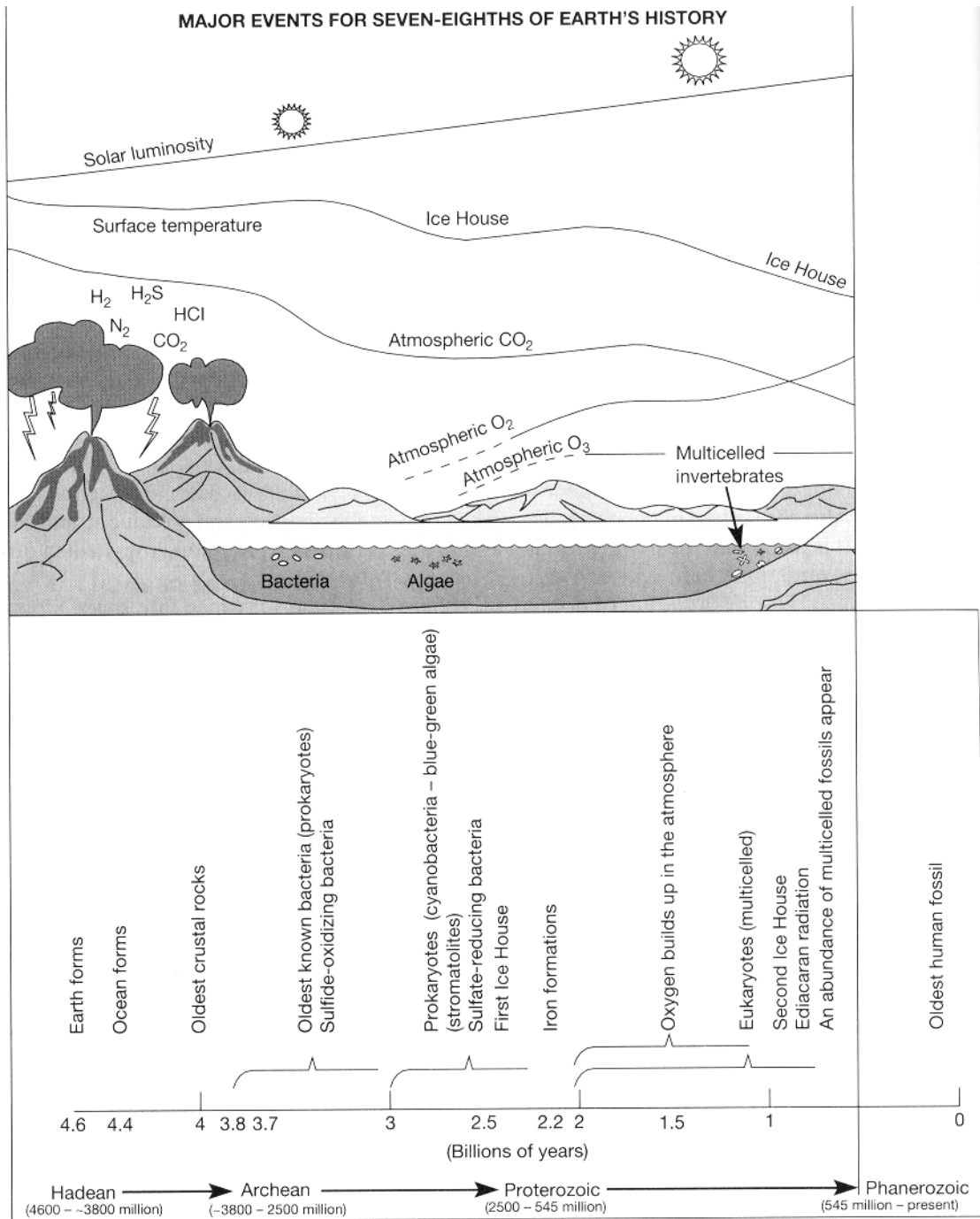


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### Evolution of the Atmosphere and Ocean

1. Inference versus fact. Hypothesis versus theory
2. Hadean: 4.6-3.8BY: long-term cycle of atmospheric CO<sub>2</sub> via dissolution in oceans, weathering of rocks, volcanic outgassing
3. Ocean's composition fairly constant since 3.8BY: weathering → river runoff → evaporites.
4. Archaen: 3.8-2.5BY: faint sun, liquid ocean → enhanced CO<sub>2</sub> concentration (greenhouse) Because of the earth's start: size, mass, rotation rate, distance from sun, as well as plate tectonics – habitable planet.
5. Oxygen: 3.5-2.5BY: evidence: banded iron formation (Fe<sub>2</sub>O<sub>3</sub>). Inference: existence of O<sub>2</sub>.
6. Precambrian: Proterozoic: 2.5BY to 0.545 BY. Documented ice houses (ice age climates) and hot houses. Infer variable tectonic activity → variable atmospheric CO<sub>2</sub> levels.
7. 2.5BY: appearance of bacteria. Ongoing oxidation of reduced atmospheric gases and with exposed crustal minerals. Oxygen levels in atmosphere begin to increase after photosynthetic production exceeds consumption by oxidation reactions.
8. What about oxygen? Original atm had no O<sub>2</sub>. All oxygen tied up. Atmosphere was very reducing. Transition period: 2.2B-1.6B years ago, atmosphere changed from no free oxygen to abundant oxygen. Evidence: iron formation (probably during an extended Hot House) unique for entire 4.6By.
9. 2.0BY: eukaryotes appeared. Eukaryotes more efficient than prokaryotes in generating oxygen. Rapid build-up of O<sub>2</sub> 2.0-1.6 BY. It took 3.0BY to get oxygen in the atmosphere!
  - Figure 6.5 of Mackenzie



**Figure 6.5** Some important biological and physical trends and events in the history of Earth's surface environment during the Hadean and Precambrian.