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Paleoclimate
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1. Definition: climate is defined by mean and variance of atmospheric condition over "long" periods
2. Typical climate parameters: annual and monthly mean temperatures, diurnal temperature range, precipitation, humidity, winds, cloud cover, ice cover, vegetation cover, CO2…
3. Climate data: direct measurements (present-day); proxy data or climate indicators (past)
4. Climate proxies: geological (landforms, stratigraphy), biological (distribution of species), chemical (isotopes)
5. Element: neutron, proton, electrons. Atomic mass = number of neutrons + protons. Isotopes: elements with same number of protons and electrons, but different number of neutrons. E.g. {Hydrogen, deuterium, tritium}; {^{12}C, ^{13}C, ^{14}C}; {^{18}O, ^{17}O, ^{16}O}. Similar chemical properties. Stable versus radioactive isotopes.
6. Fractionation: separation of isotopes because mass differences. Lighter isotope diffuses faster than heavier isotope. Degree of fractionation is temperature dependent. Hence D/H, $^{18}O/^{16}O$ are useful climate proxies.
7. Biological uptake → lighter C into plant. $^{13}C/^{12}C$ is a useful biological indicator.
8. Sources of paleoclimate data: sediments, ice core, corals, tree rings, …
9. Paleoclimate: Variable. Warmer than present in the Mesozoic. Long-term cooling in the Cenozoic. Clear signatures of glacial-interglacial cycles. Climate has been stable and warm in the past 10 KYBP.

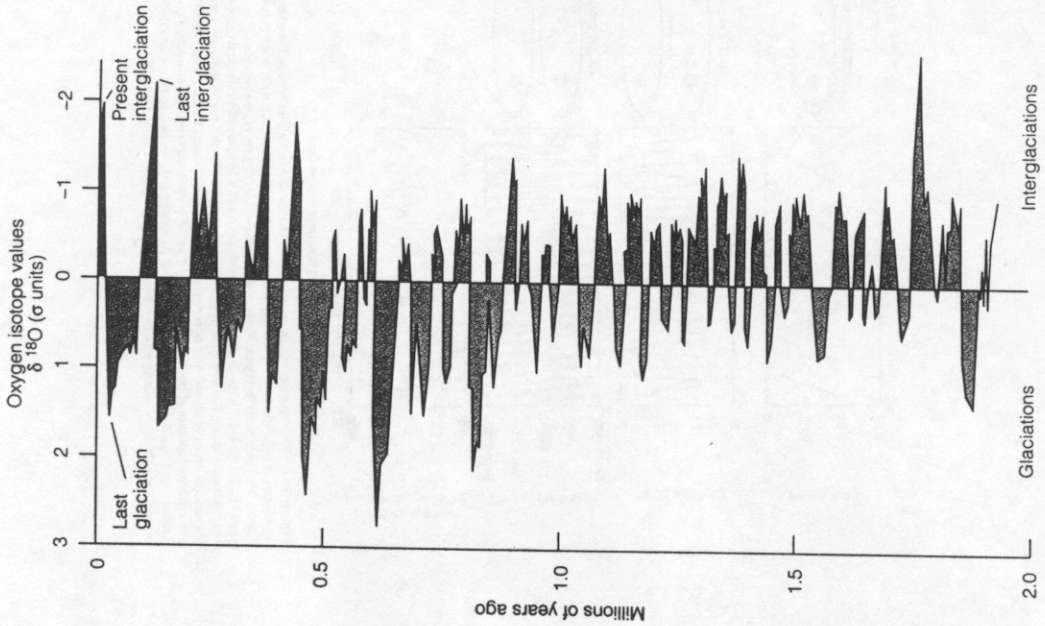

Figure 14.16 Curve of average oxygen-isotope variations during the last 2 million years based on analyses of deep-sea sediment cores. The curve illustrates changing global ice volume during successive glacial-interglacial cycles of the Quaternary Period.

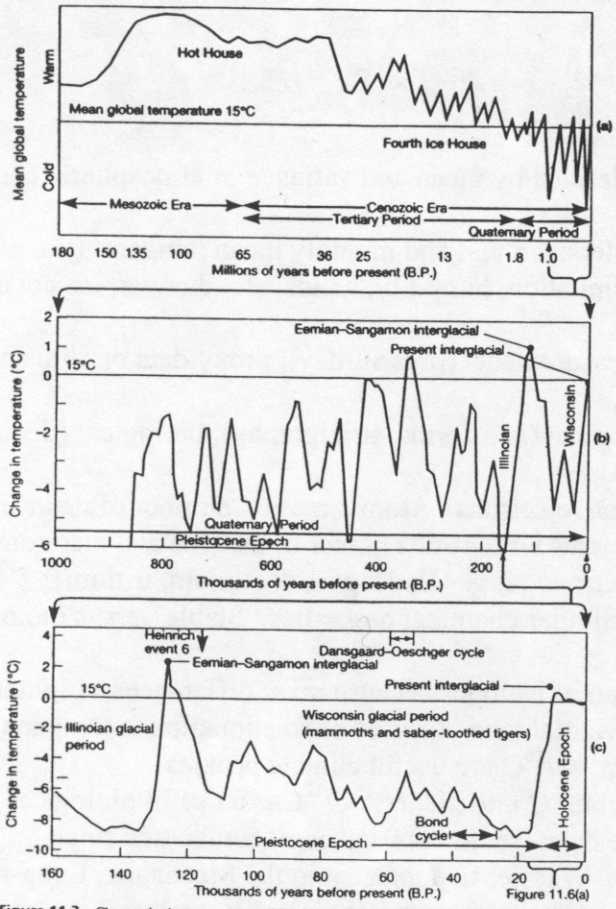

Figure 11.3 Changes in the temperature of Earth over time. (a) The temperature record of Earth during the past 180 million years; (b) an expanded representation of the last one million years; and (c) an expanded view of the last 160,000 years. (After UCAR/OIES, 1991a.)

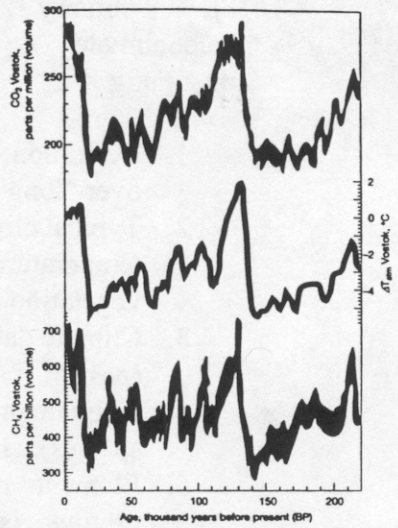

Figure 11.9 The trend of atmospheric CO_2, CH_4, and temperature as recorded in the Vostok, Antarctica, ice core. The atmospheric temperature at Vostok is plotted as a deviation from present-day mean temperature (δTatm). The different line widths represent the ranges in estimates. (After Jouzel et al., 1993).

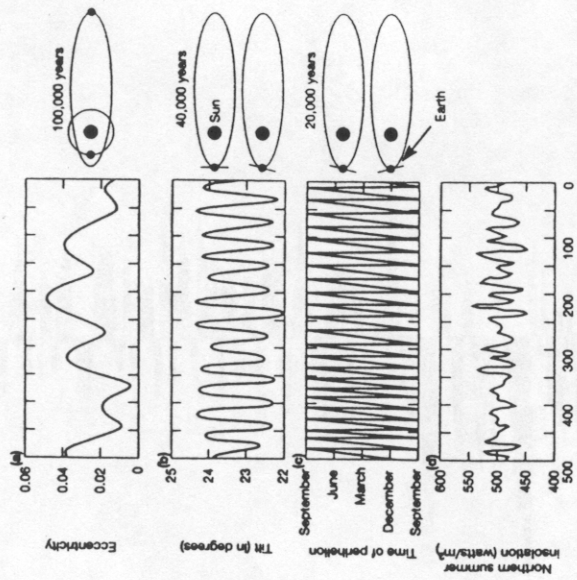

Figure 11.8 The Milankovitch theory of climatic change during the Pleistocene. The onset of ice ages is due to variations in three orbital parameters of Earth. (a) The eccentricity is the degree to which Earth's orbit departs from a circle. Times of maximum eccentricity are separated by roughly 100,000 years. (b) The tilt angle is the angle between Earth's axis and a line perpendicular to the plane of the orbit of the planet. (c) The time of perihelion involves the tilt of Earth's axis at its closest approach to the sun. The cycles of tilt and time of perihelion are roughly 40,000 and 20,000 years, respectively. (d) The calculated amount of sunlight received at 60° to 70° north latitude during the summer (summer insolation, July), based on the cycles of variation of Earth's orbital parameters. One watt = 0.0569 British thermal units (Btu) per minute = 14.28 calories per minute. (After Covey, 1984.)