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4th Stage

Quaternary

Lecture 2: Causes of Quaternary Periods

Causes of Quaternary Periods

There are many factors caused the Quaternary periods , these Theories different by their principles and ideas

The Milankovitch Theory

Put by the Serbian astronomer Milutin Milankovitch

Minor irregularities in Earth's rotation and orbit are sufficient to change the amount of solar radiation that Earth receives at 65° N and then can change the climate .

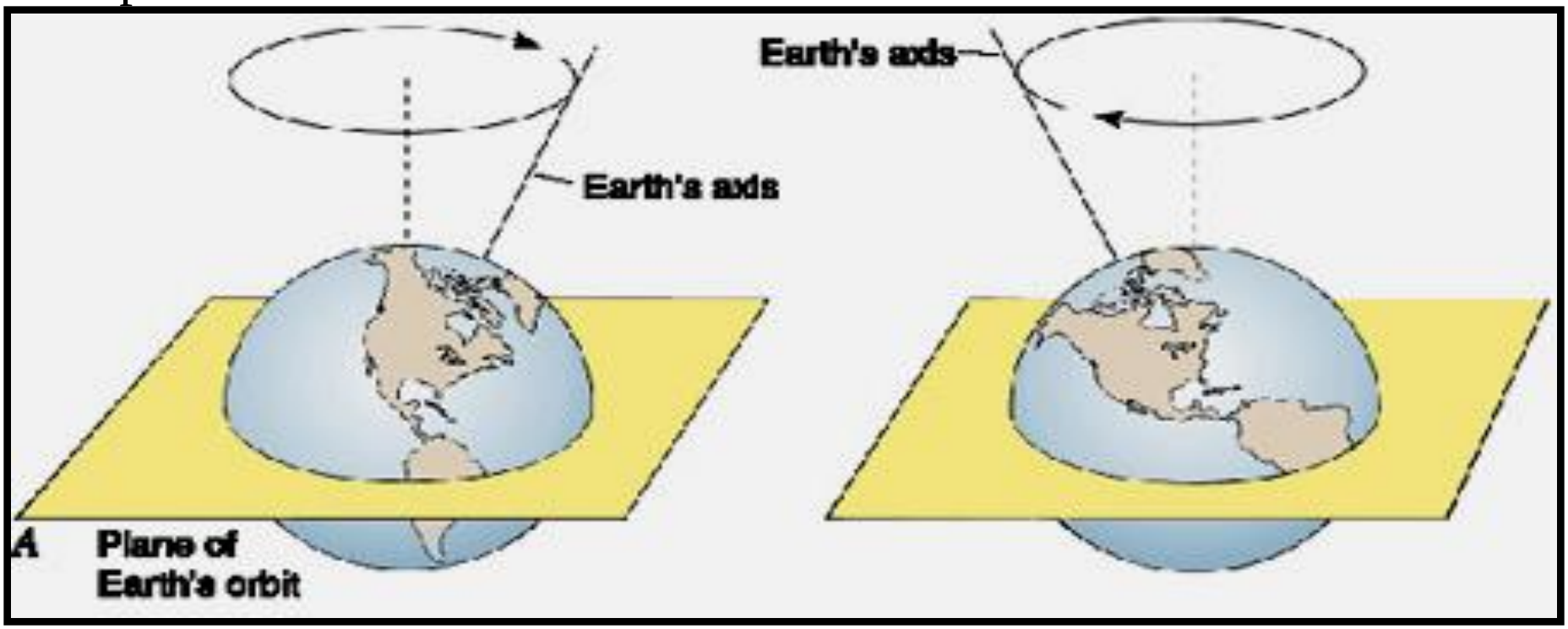
The cyclic climatic changes result from changes in the distance and angular relationships between the Earth and Sun due to periodic fluctuations in Earth's orbit.

There are 3 main variables can cause the Quaternary cycles , combination of these variables periodically results in a change in the amount of solar radiation received by the Earth, which causes cycles of cooling and periodic glaciations

Milankovitch cycles well correspond to glaciations periods , which have occurred every 100,000 years over the past 600,000 years, as indicated by oxygen isotope data.

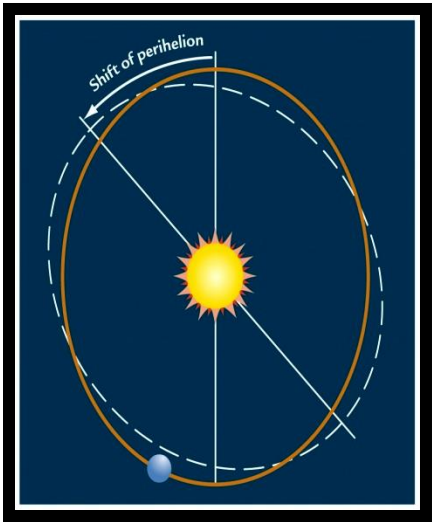
These 3 variables are :

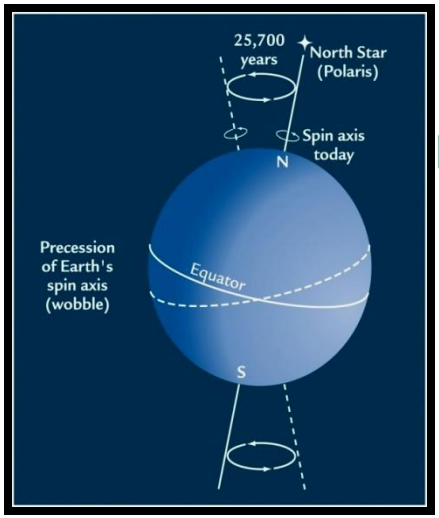
1- Precession - Earth's axis wobbles or moves in a circle like a spinning over 26,000 years, affecting the amount of solar radiation received at the poles. the position of the equinoxes shift slowly around Earth's elliptical orbit

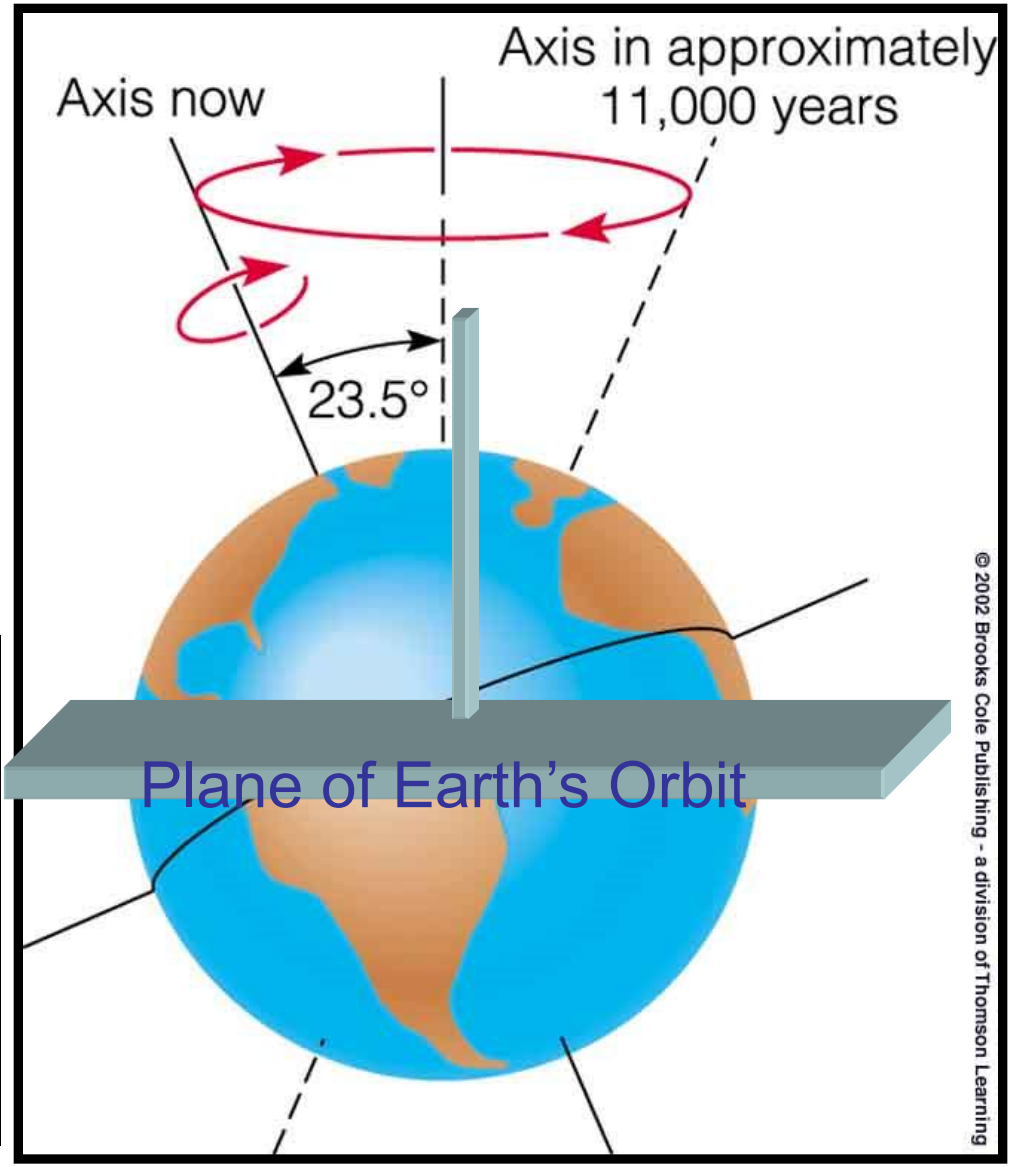


- Earth moves around the Sun
  - spinning on its axis
  - which is tilted at 23.5° to the plane of its orbit
- Earth's axis of rotation
  - slowly moves
  - and make the path shap of a cone in space

Precession of the equinoxes
Ellipse slowly revolves

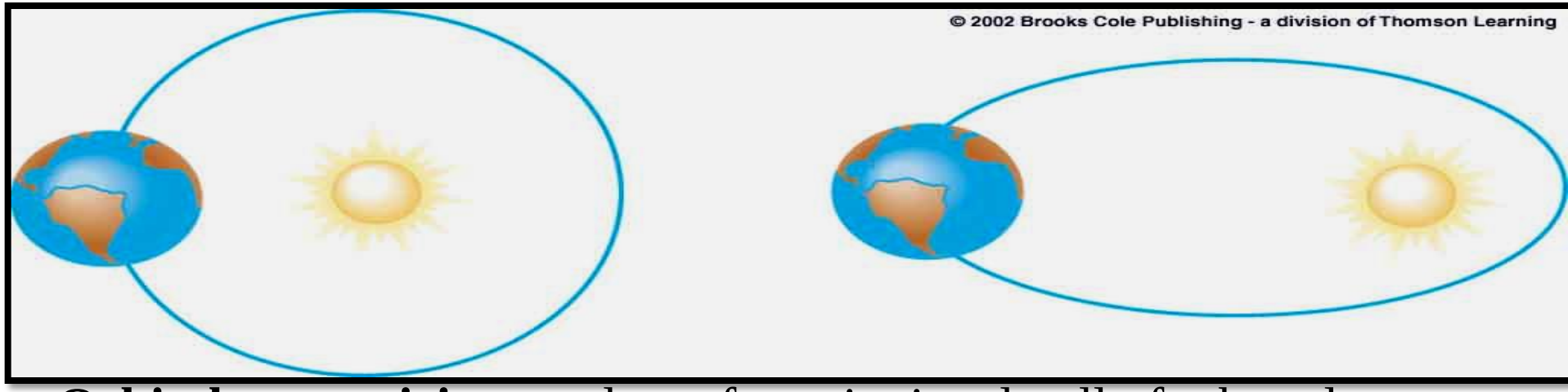




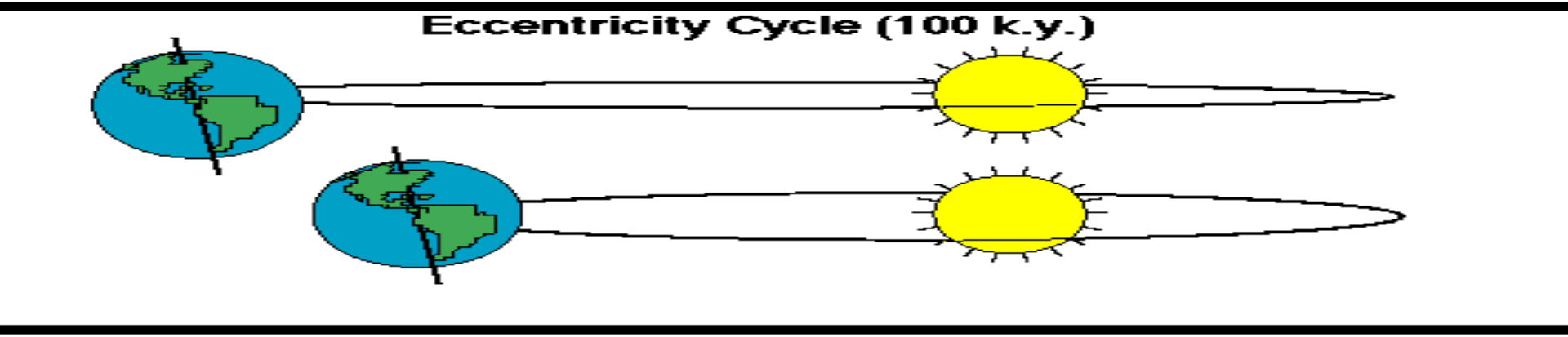


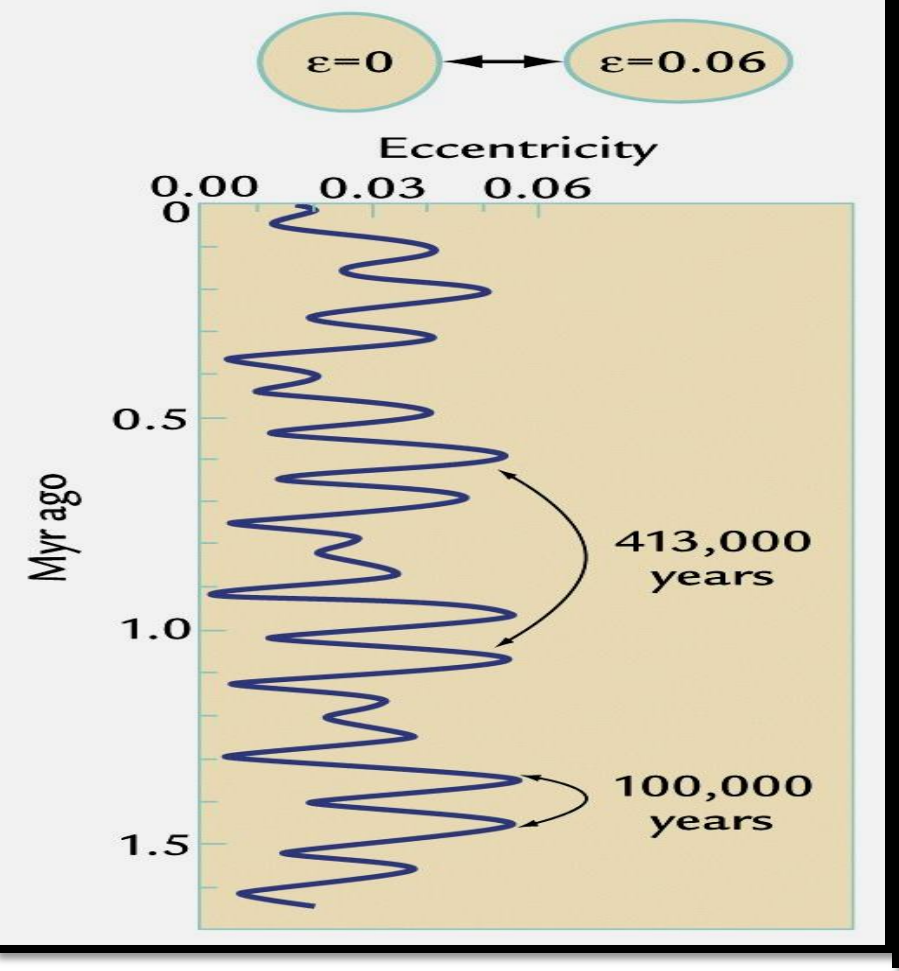
Milankovitch Cycles

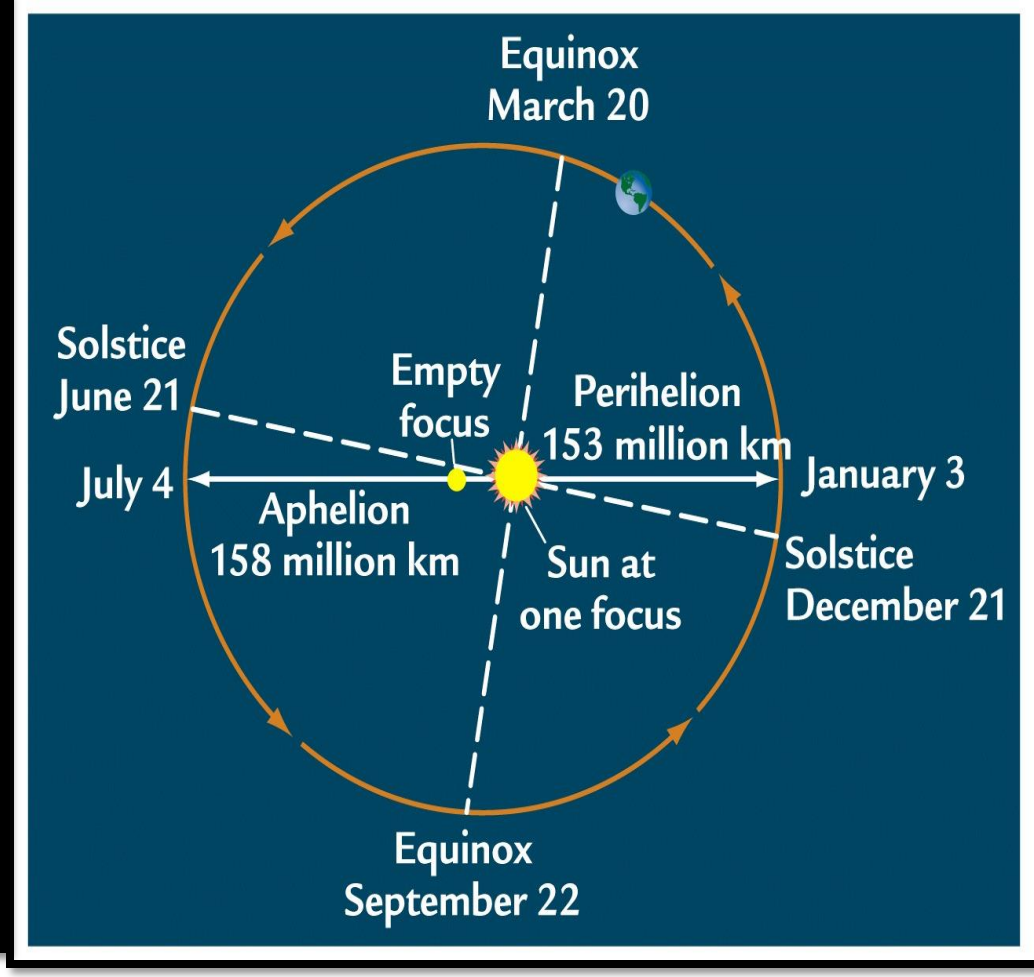
2. Orbital eccentricity - Earth's orbit around the Sun changes from more circular to more elliptical by about 2% over about 100,000 years, moving the Earth closer to or farther from the Sun, and varying the amount of solar radiation received by the Earth.



Orbital eccentricity product of gravitational pull of other planets





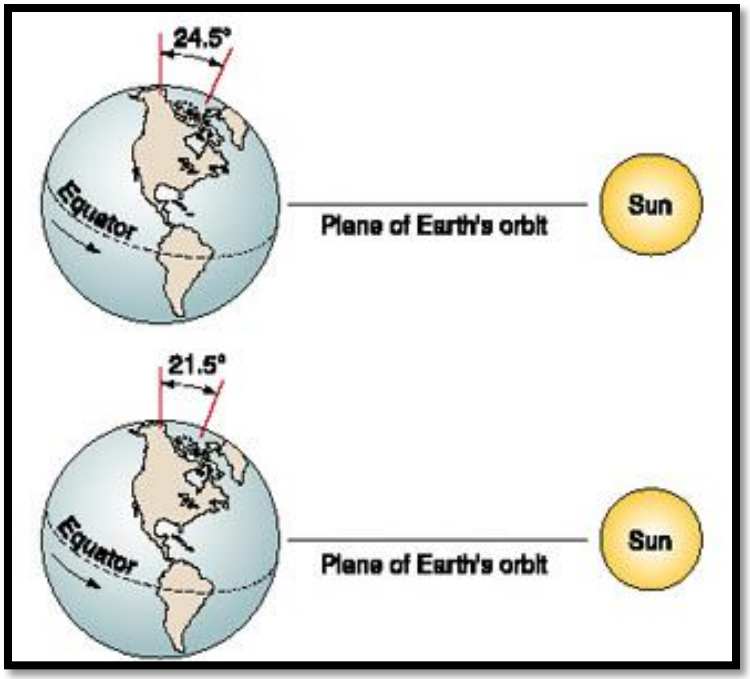


Eccentricity with time

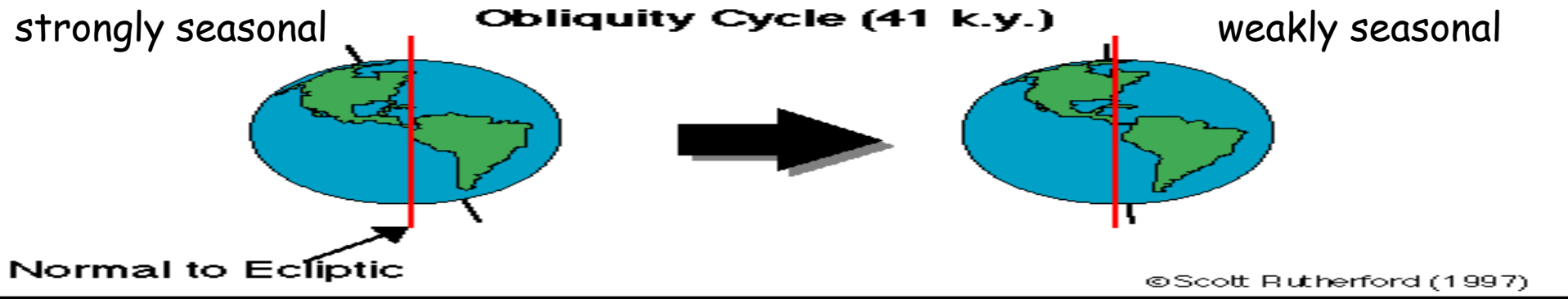
The position change with the time periodically But in random movement And may complete the circle After a fixed period

3. Obliquity: Angle of tilt of Earth's axis currently about 23.5º, this tilt angle causes the seasons.

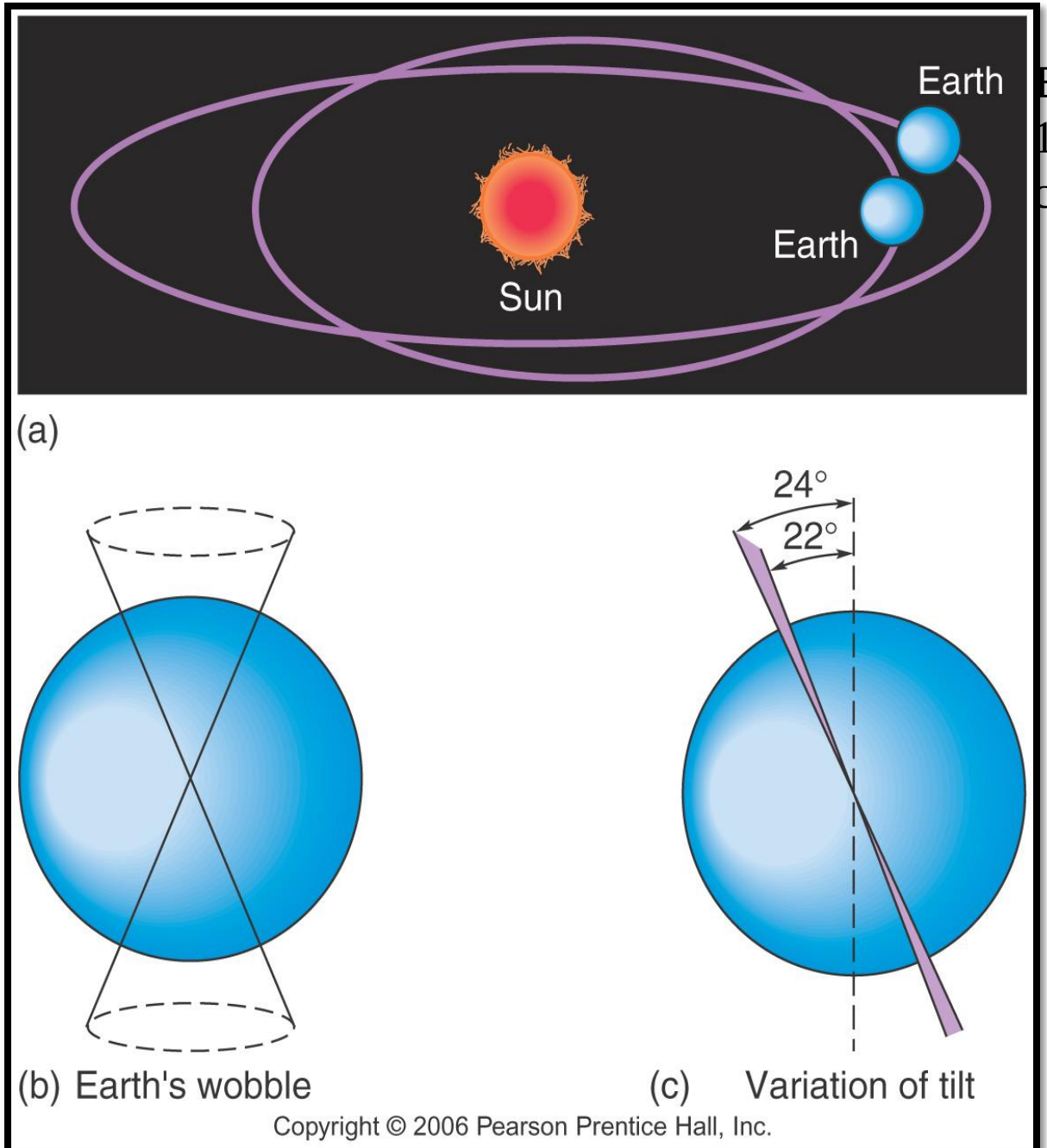
   Tilt angle varies from about 21.5º - 24.5º over about 41,000 years, changing length of days and amount of solar radiation received at the poles. The angle between Earth's axis and a line perpendicular to the plane of its orbit around the Sun



- This angle shifts about 1.5° from its current value of 23.5° during a 41,000-year cycle



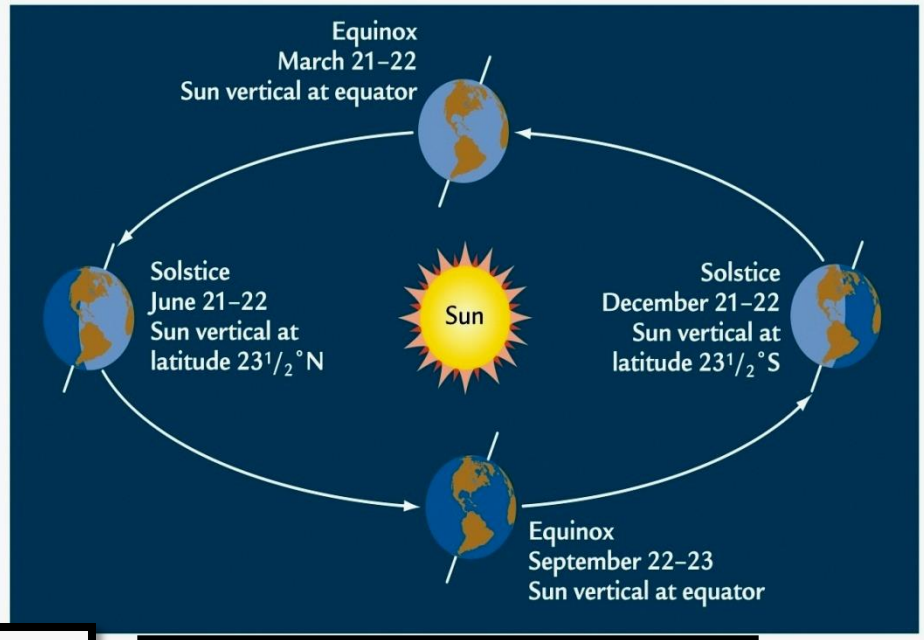
Milankovitch Cycles

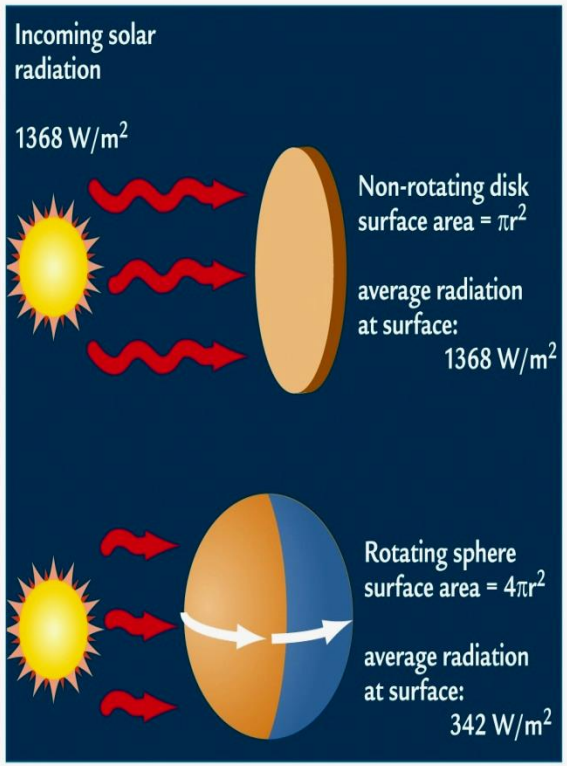


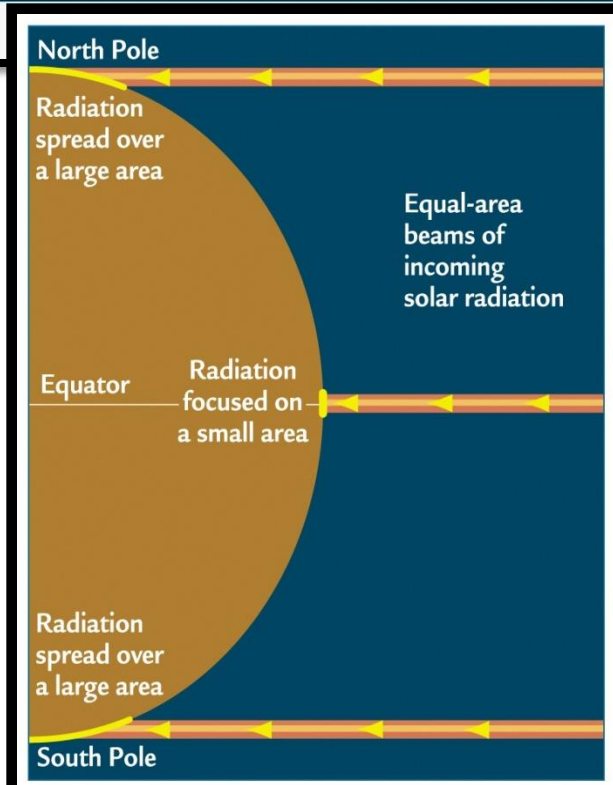
Eccentricity
100,000 year cycle

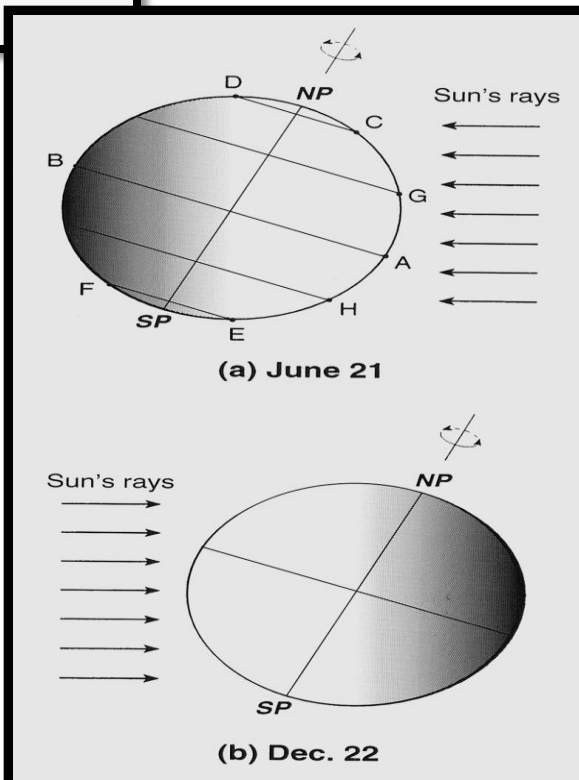
Precession
25,000 year cycle

Obliquity
41,000 year cycle.


Equinox
March 21–22
Sun vertical at equator
Solstice
June 21–22
Sun vertical at
latitude 23½°N
Sun
Solstice
December 21–22
Sun vertical at
latitude 23½°S
Equinox
September 22–23
Sun vertical at equator


Incoming solar
radiation
1368 W/m²
Non-rotating disk
surface area = πr²
average radiation
at surface:
1368 W/m²
Rotating sphere
surface area = 4πr²
average radiation
at surface:
342 W/m²


North Pole
Radiation
spread over
a large area
Equal-area
beams of
incoming
solar radiation
Equator
Radiation
focused on
a small area
Radiation
spread over
a large area
South Pole


D
NP
C
B
G
A
F
SP
H
E
Sun's rays
(a) June 21
Sun's rays
NP
SP
(b) Dec. 22

Short-Term Climatic Events

Climatic events having durations of several centuries, such as the Little Ice Age are too short to be accounted for by plate tectonics or Milankovitch cycles

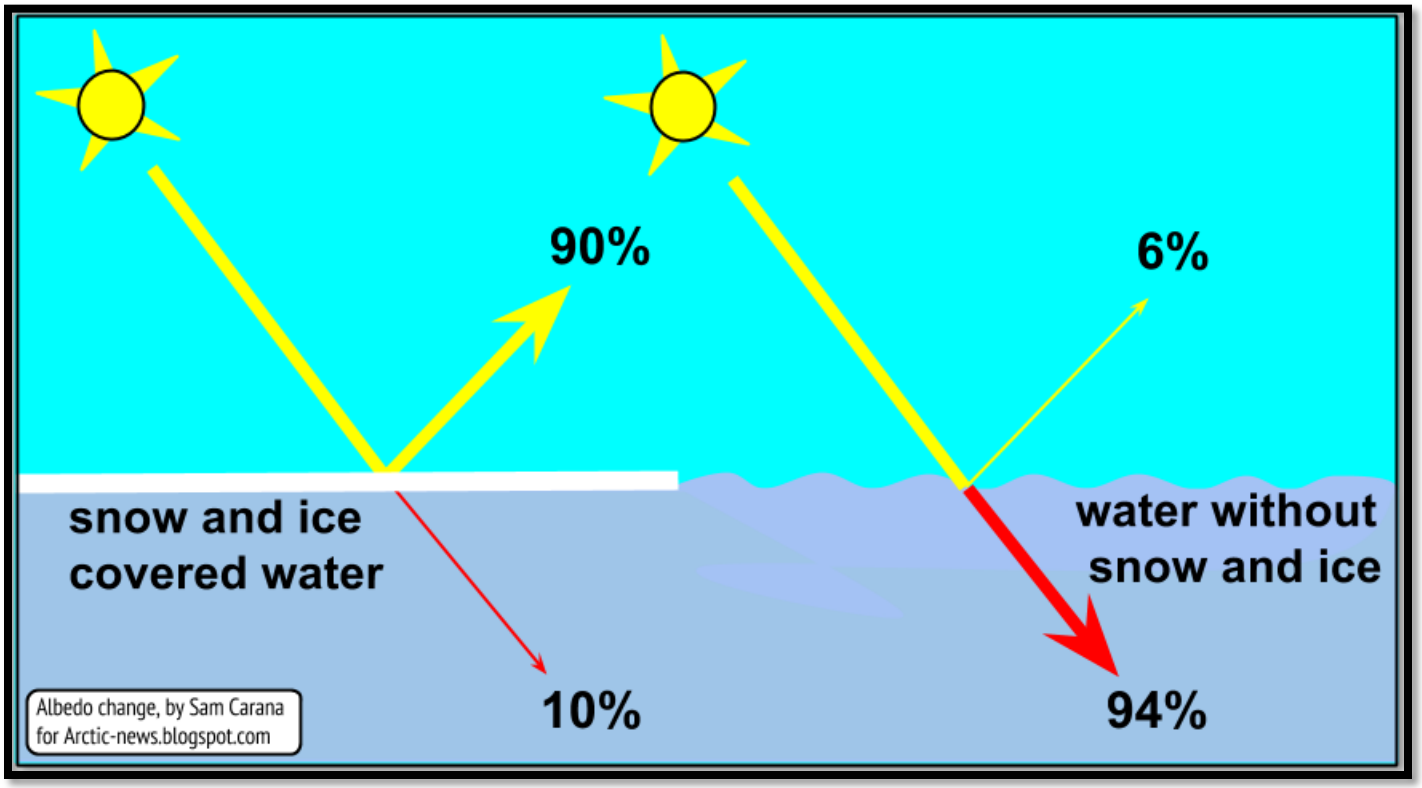
Several hypotheses have been proposed, including variations in solar energy and volcanism

1 #The Variations of Solar Energy

- could result from changes within the Sun or from anything would reduce the amount of the energy that Earth receives from the Sun
- Such a reduction could result from the solar rays passing through clouds of interstellar dust and gas or from in the atmosphere reflecting solar radiation back into space also That may happen by :

1- Albedo or reflectivity of the Earth . If Earth's albedo increased, due to snow cover, cloud cover, or dust in the atmosphere, the atmospheric temperatures would decrease due to reflection of solar radiation into space. As snow cover increased, albedo would increase, producing a

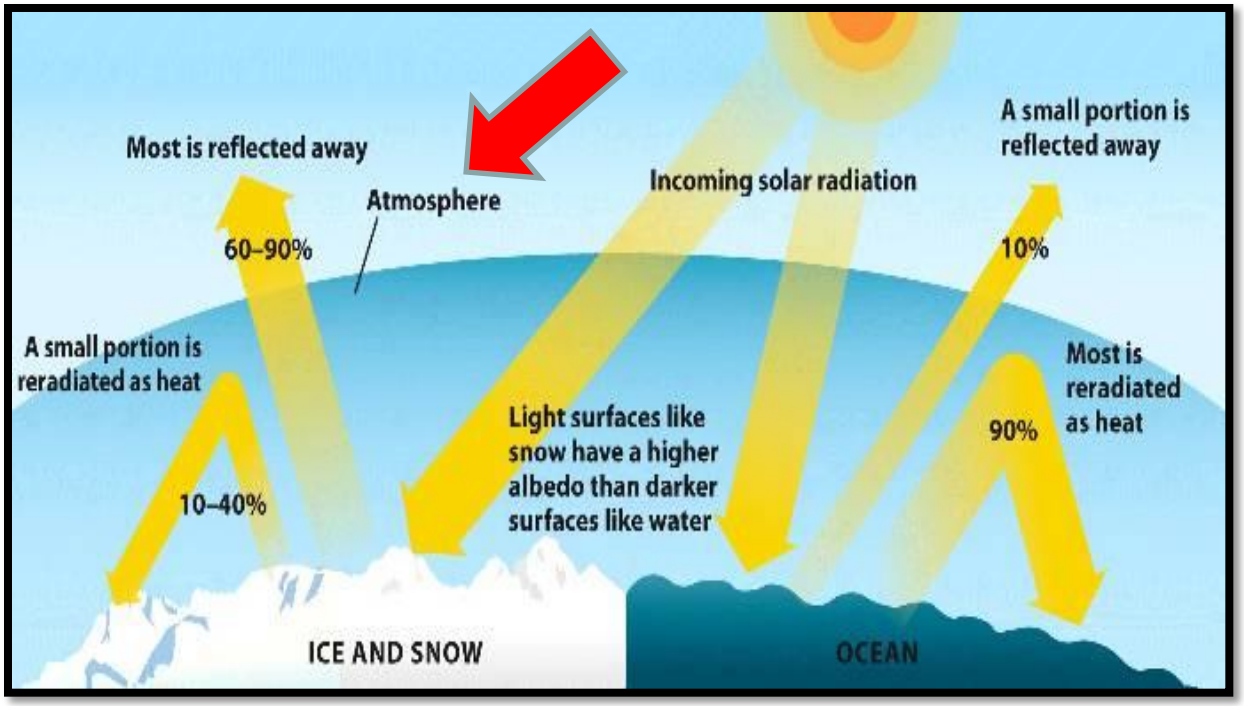
positive feedback relationship, accelerating the rate of glacial growth. A 1% loss of incoming solar energy would result in a temperature drop of about 8^{o} C, which might be sufficient to glacial buildup.



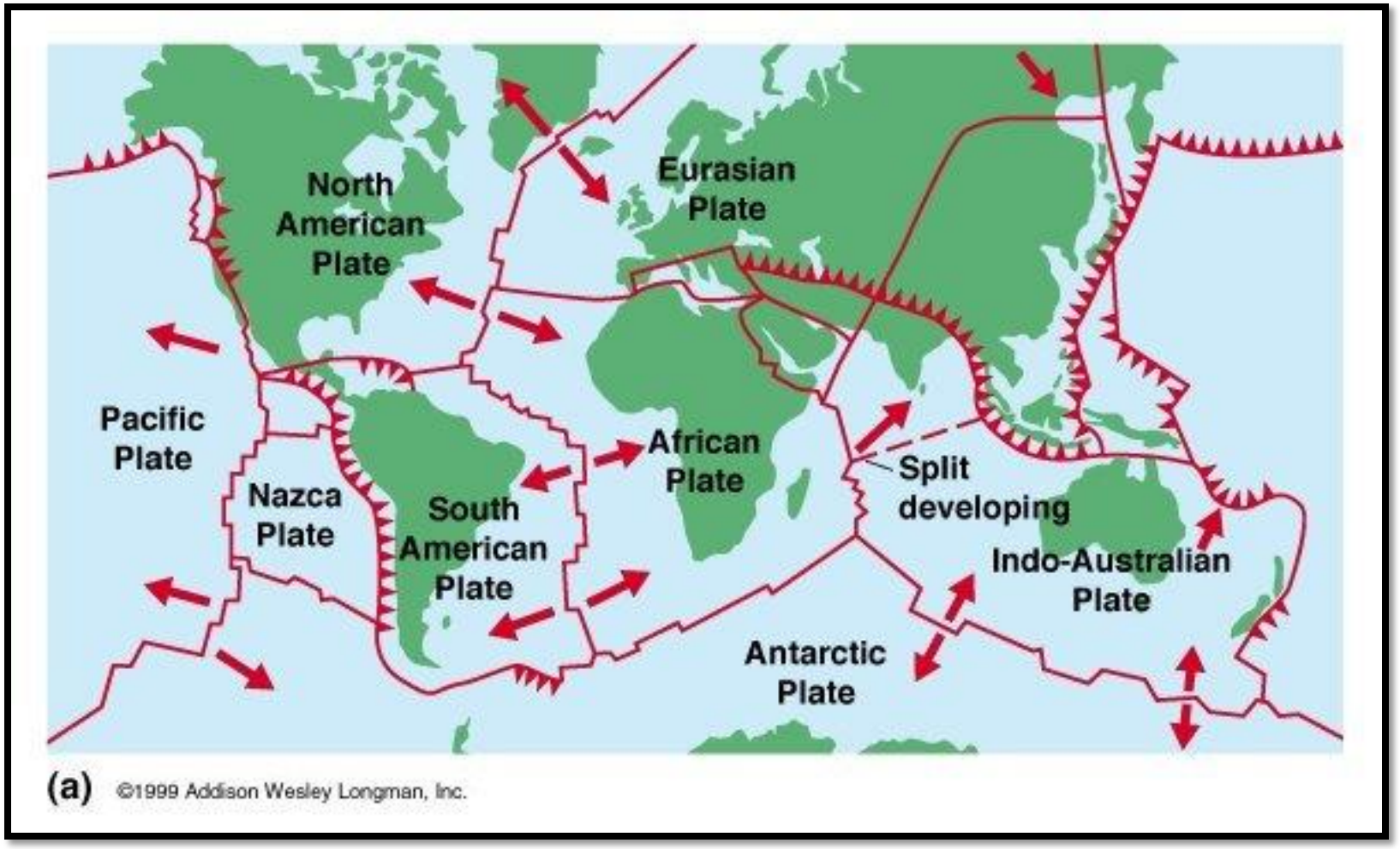
2 - A decrease in atmospheric CO_2 would cause a decrease in the greenhouse effect, and lead to cooling.

3 - increase in atmospheric CO_2 would cause warming, which would result in more rapid evaporation, more cloud cover, and an increase in Albedo, which could cause glaciations.

4 - The warm, moist air associated with this ocean current led to an increase in snowfall in northern areas and the development of continental glaciers.

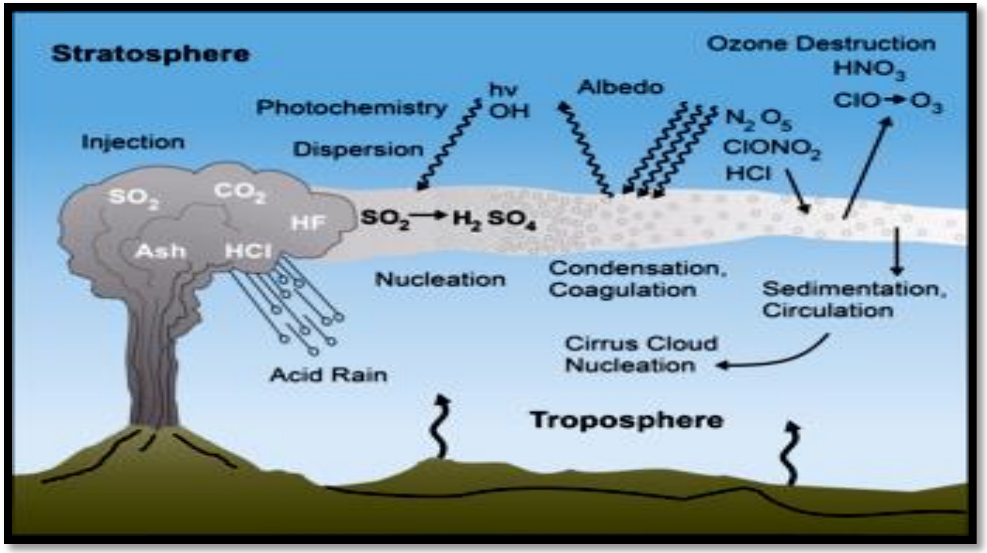


5 - Plate tectonics is important in that a continent must move on or near a pole for snow to build up to form a glacier.



2 # Climatic Effects of Volcanic Events

- Several such large-scale volcanic events have been recorded, such as the 1815 eruption of Tambora and in the 1991 eruption of Mount Pinatubo, and are known to have had climatic effects
- However, no relationship between periods of volcanic activity and periods of glaciations has yet been established
- During large volcanic eruptions, Huge amounts of ash and gases are spewed into the atmosphere where they reflect incoming solar radiation and thus reduce atmospheric temperatures
- Small droplets of sulfur gases remain in the atmosphere for years and can have a significant cooling effect on the climate



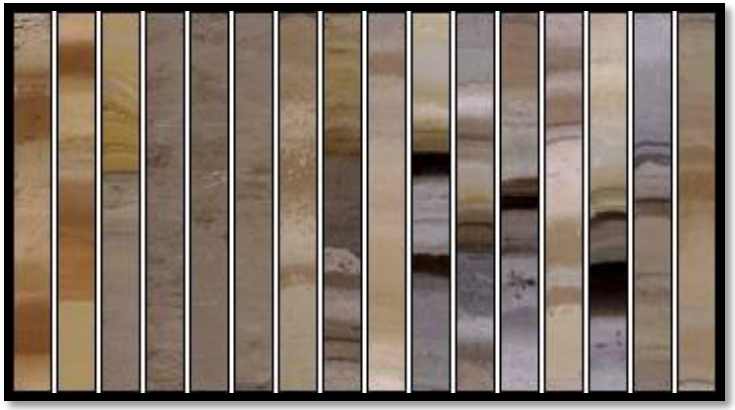
Hypothesis of Interglacial periods

The traditional, accepted theory holds that the interglacial always occurred when the ice sheets of the northern hemisphere melted as the result of an increase in summer radiation in those latitudes.

The solar radiation received during the summer months in the northern hemisphere reached a maximum 127,000 years ago. This would then have been the cause for the melting of the northern ice sheets

analyses of oceanic sediments estimate that the interglacial began as early as 135,000 years ago, or even earlier Radiometric dating of coralline terraces The oxygen isotopes of the limestone in the Caribbean shores indicates that the sea level rose earlier than 130,000 years ago, since by around 135,000 years ago it was only about 20 meters beneath modern-day levels .

certain core samples from the Tropical Pacific Ocean indicate that, based on the evolution of the Ca/Mg ratio in foraminifera, the temperature changes on the surface coincide more with the traditional dating based on Milankovitch's work



If climatic cyclist is related to Earth's orbit, it is possible to speculate on future climatic trends.

Calculations for the next 20,000 years suggest a trend toward extensive glaciations in the Northern Hemisphere.

References

Glacial and Quaternary Geology
http://www.colby.edu/geology/GE354/Index_GE354.html

Internet Remote Sensing Lectures sites