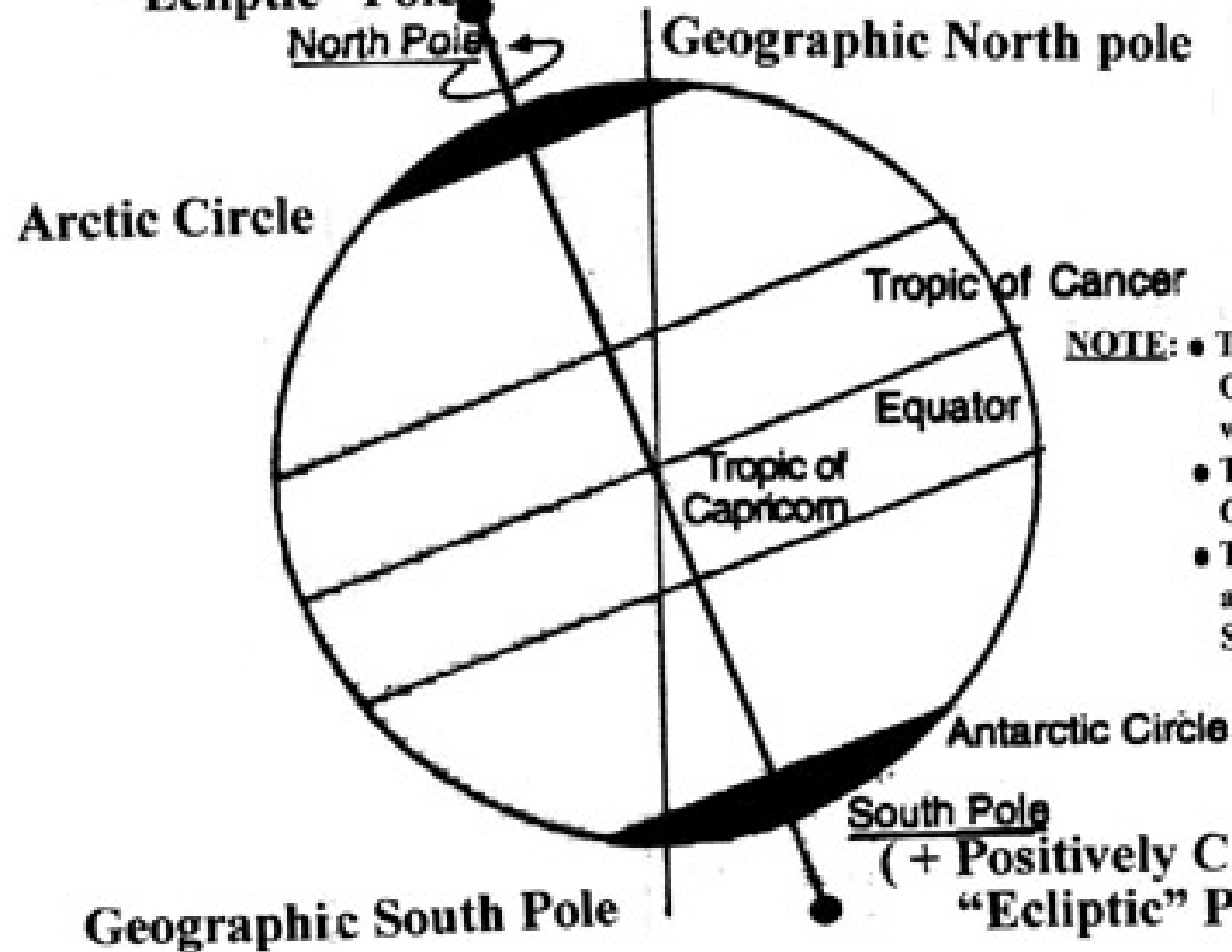


(- Negatively Charged Magnetic

“Ecliptic” Pole)



Geographic North pole

Arctic Circle

Tropic of Cancer

Equator

Tropic of Capricorn

- NOTE:**
- The Magnetic “Ecliptic” and Geographic Poles Do NOT Coincide with 20 Degrees between them.
 - The Earth is Rotating on its Axis Counter Clockwise.
 - The *Tropic of Cancer* is to the North and the *Tropic of Capricorn* is to the South of the *Equator*.

Antarctic Circle

South Pole

(+ Positively Charged Magnetic “Ecliptic” Pole)

Geographic South Pole



The Coming (or Present) Ice Age

*A long-term perspective on the current
global warming fad*

by Laurence Hecht

We are now in an ice age and have been for about the past 2 million years. Over the past 800,000 or so years, the Earth's climate has gone through eight distinct cycles of roughly 100,000-year duration. These cycles are driven by regular periodicities in the eccentricity, tilt, and precession of the Earth's orbit. In each of the past eight cycles, a period of glacial buildup has ended with a melt, followed by a roughly 10,000-year period—known as an interglacial—in which relatively warm climates prevail over previously ice-covered northern latitudes.

The Margerie Glacier in Glacier Bay National Monument, Alaska, is a typical fast-moving mountain glacier.

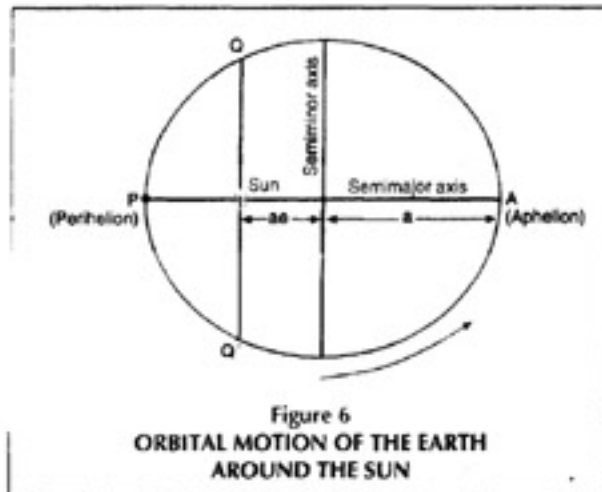


Figure 6
ORBITAL MOTION OF THE EARTH
AROUND THE SUN

Earth's elliptical orbit. Johannes Kepler's discovery in the early 17th century that the planets move in ellipses about the Sun, with the Sun at one focus, and his elaboration of the laws of this motion are the basis of all astronomical hypothesis concerning climate. (Wegener, in fact, had studied classical astronomy and wrote his dissertation at the University of Berlin on the subject "The Alphonsine Tables for the Use of a Modern Calculator," a recalculation of the old tables used to ascertain the positions of the Sun, Moon, and the five then-known planets.)

Geometry of the Solar Cycles

Let $PQ'AQ'$ represent the elliptical orbit of the Earth around the Sun at S (Figure 6). Looking down upon the North Pole of the Earth, the orbital motion is counter-clockwise from P to Q' to A to Q and back to P again. We have exaggerated the ellipse in order to simplify visualization of the processes described. As the Sun sits at one focus of the ellipse, the distance from Earth to Sun is least when the Earth is at P , the position known as *perihelion*, and greatest at A , the *aphelion*.

Let us examine the change in the amount of solar radiation that will be received as the Earth moves from aphelion to perihelion. (The radiation received at the edge of the Earth's atmosphere is known as *insolation*.)

An ellipse is completely described by two parameters, the length of its semimajor axis, a , and the value of the eccentricity, e , which is the factor by which a is multiplied to find the foci. Measuring from the center of the ellipse (where the semimajor and semiminor axes cross), a focus is located at a distance ae along the semimajor axis. The eccentricity e is thus always a number between 0 and 1.

With this in mind, we see that the perihelion point, P , sits at a distance $(a - ae)$ from the Sun while the aphelion, A , is at the distance $(a + ae)$. If, to simplify, we let $a = 1$, then the distances from the Sun are:

$$P = 1 - e, \text{ and} \\ A = 1 + e.$$

Now, since the intensity of light varies as the inverse square of the distance from the source, the insolation at A and P will be:

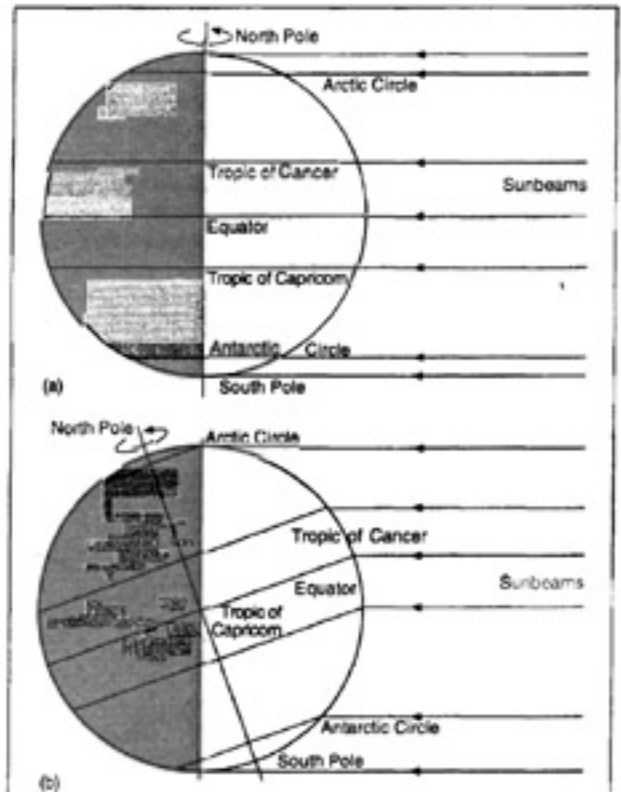


Figure 7
OBLIQUITY AND INTENSITY OF THE SUN'S RAYS
Even without a tilt of the axis, the variation in angle of incidence of the Sun's rays (a) would cause the poles to be cooler. Increasing the angle of obliquity spreads the effect (b).

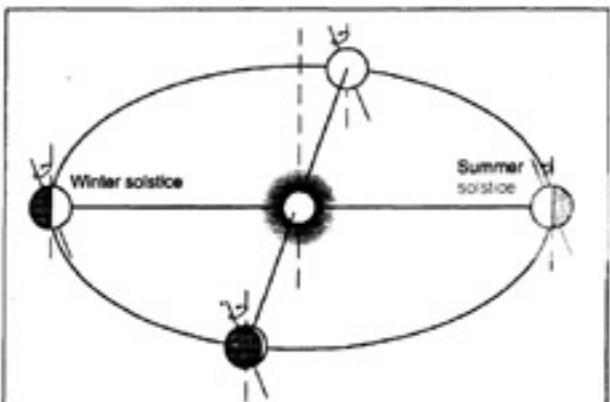


Figure 8
SEASONS AND OBLIQUITY

Seasonal change results from the combined effect of the orbital inclination and the yearly revolution of the Earth around the ellipse. When the Earth's spin axis is pointed away from the pole of the ecliptic, the Northern Hemisphere has its shortest day (winter solstice), while the Southern Hemisphere has its longest day (summer solstice).

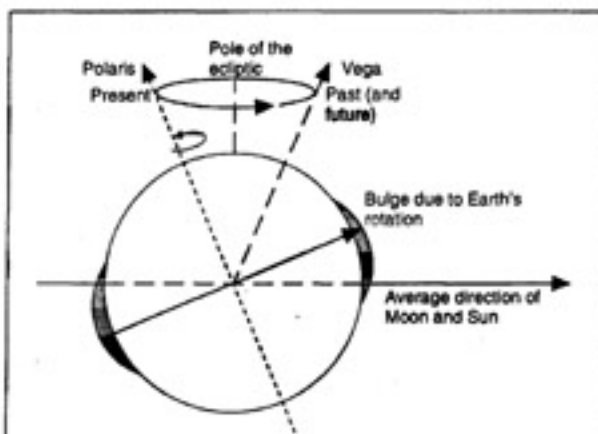


Figure 9
PRECESSION AND CHANGE OF POLE STAR

The Earth's spin axis makes a complete rotation around the pole of the ecliptic in a cycle of approximately 26,000 years. The pole star is now Polaris, but about 13,000 years ago it was Vega.

$$\begin{aligned} P_{\text{insol}} &= \frac{1}{1 - e^2} \\ A_{\text{insol}} &= \frac{1}{1 + e^2} \end{aligned}$$

And the difference of the two is:

$$\frac{1}{1 - e^2} - \frac{1}{1 + e^2} = \frac{4e}{(1 - e^2)^2}$$

This is the maximum variation of insolation between perihelion and aphelion. Since for small values of e the denominator differs insignificantly from 1, the value $4e$ provides a very good approximation for this flux difference.

The present value of eccentricity for the Earth's orbit is 0.017, and the variation in insolation thus comes to 0.068, or approximately 7 percent. But the orbital eccentricity is known to pass through a complete cycle in approximately 94,000 years, varying from near 0 (a circular orbit) to 0.07. At the latter value, the difference in insolation between aphelion and perihelion becomes 28 percent.

Now, the Earth is not simply a moving point, but a solid body of more or less spherical shape. It rotates about an axis that is inclined to the plane of the ellipse by a certain angle known as the *angle of obliquity*. It is this inclination of the Earth's axis, which is now about 23.5 degrees, that causes the main difference in temperature between polar and equatorial regions. The flux of the Sun's rays striking the Earth obliquely is spread over a greater surface area than that of the rays that strike in a more perpendicular direction. Even without that obliquity there would be some variation in temperature between pole and equator, because of the changing angle at which the parallel rays of the Sun will strike the circular arc that represents the Earth's surface (Figure 7). An increase in the angle of obliquity tends to exacerbate this effect.

Seasonal change, that is the yearly passage through spring-summer-fall-winter, is caused by the combined effect of the or-

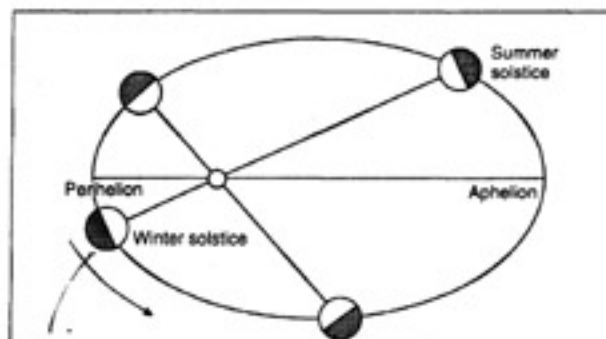


Figure 10
PRECESSION AND LOCATION OF THE SOLSTICE

The precession cycle changes the location on the ellipse where the winter and summer solstices occur. The approximate positions on the ellipse are shown for the solstices today.

bital inclination and the yearly revolution of the Earth around the ellipse. In the course of a year, the Earth's axis of rotation will point to the same approximate direction in the distant sky, no matter where on the ellipse we find ourselves (Figure 8). However, in one annual revolution around the Sun, the axis will take up all orientations with respect to the line perpendicular to the plane of the ellipse and passing through the center of the Sun, which is known as the pole of the ecliptic. When the Earth's spin axis is pointed away from the pole of the ecliptic, the Northern Hemisphere experiences its shortest day, known as the winter solstice. On the same day, the Southern Hemisphere experiences its longest day, the summer solstice. The opposite situation occurs at the position 180 degrees around the ellipse.

If the axis of the Earth had no motion of its own, the seasons would always occur at the same points in the orbit. But the direction in the sky to which the Earth's axis of rotation points varies on a cycle of approximately 26,000 years. In the course of that cycle, the spin axis makes a complete rotation around the pole of the ecliptic, one obvious consequence of which is a change in the pole star (Figure 9). Another consequence, which was noted by the ancient astronomers, was the long-period change of that constellation in which they observed the Sun rising on the day of the vernal (spring) equinox. Later comparison of the physical dynamics of this phenomenon to the precession of a spinning top (the wobbling as it winds down) led to the name *precession of the equinox* for the 26,000-year cycle.

As a result of this phenomenon, we must take into account where on the ellipse the winter and summer solstices occur. When the Earth is at P in Figure 6 and the axis is turned 180 degrees away from the Sun, we will have winter in the Northern Hemisphere. That was the situation in approximately the year 1250. Today we have moved a bit on the precession cycle and find the Northern Hemisphere winter occurring at roughly the position shown in Figure 10.

In addition to the phenomenon known as precession of the equinox, the perturbations in the Earth's orbit caused by the motion of the other planets, most notably Jupiter, cause a

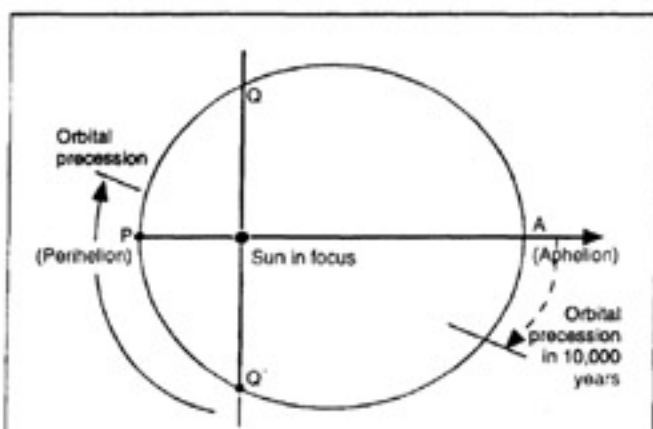


Figure 11
ADVANCE OF THE PERIHELION
OR ORBITAL PRECESSION

Perturbations in the Earth's orbit, the result of the motion of the other planets (in particular, Jupiter) cause a phenomenon known as advance of the perihelion or precession of the orbit, in which the complete cycle of precession takes approximately 21,000 years, not 26,000.

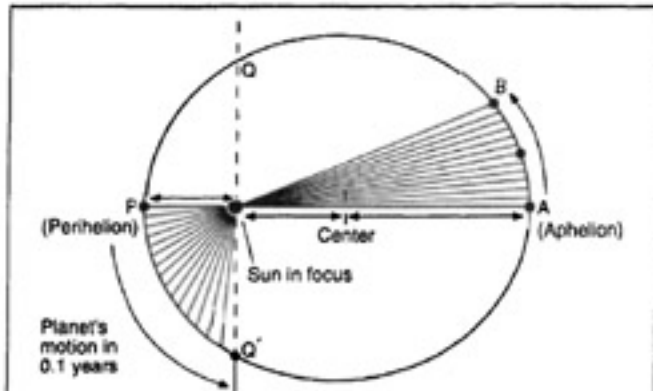


Figure 12
INSOLATION AND THE EQUAL AREA LAW

As Kepler demonstrated, the rate of motion of the Earth in its elliptical orbit is not uniform: Planets move more swiftly when near to the Sun at perihelion than when at aphelion. In this ellipse of high eccentricity, $e = 0.5$, the planet takes the same time to move from aphelion to B as it takes from perihelion to Q'. The rate of change of the angle that the radius vector makes with a fixed direction is inversely proportional to the square of the distance between the Sun and planet. This is the same law that describes the diminution of insolation with distance.

phenomenon known as *precession of the orbit*, or *advance of the perihelion*. The result is that the complete cycle of return to the position where Northern Hemisphere winter occurs at P takes approximately 21,000, not 26,000, years (Figure 11).

Recalling that the most important astronomical requirement for glacial advance is a string of mild summers in which the

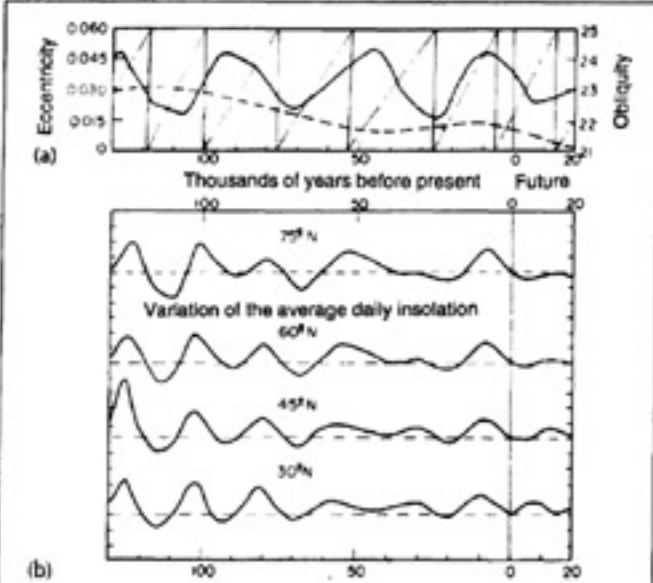


Figure 13
MILANKOVITCH CURVES
AND THE LAST GLACIATION

Milankovitch calculated variations of the orbital and rotational parameters of the Earth, and climate, over the past 130,000 years and the next 20,000.

In (a), the obliquity of the ecliptic (solid line) and the eccentricity of the orbit (dashed line) are shown. The dash-dot line gives the variation of the angle between perihelion and the position at vernal equinox, now about 90°, and going from 0 to 360° in about 20,000 years.

The variation of the average daily insolation from the values of the year 1950 is shown in (b), with 1 unit of the vertical scale corresponding to 25 watts per square meter.

Source: Adapted from A. Berger, 1977, *Celestial Mechanics*, Vol. 15, p. 53, and 1978, *Quaternary Research*, Vol. 9, p. 139. Reprinted with the permission of Macmillan Publishing Company, a Division of Macmillan, Inc., from *Earth and Cosmos* by Robert S. Kandel, Copyright © 1980

winter snow buildup is not completely erased by melt, we are now in a position to examine how the orientations of the orbit might contribute to meeting this need.

Astronomy and Climate

It might at first appear that the occurrence of Northern Hemisphere summer at A, combined with a relatively high eccentricity, would produce the most favorable conditions.

However, we have yet to take one other consideration into account. The rate of motion of the Earth in its elliptical orbit is not uniform. As Kepler was able to demonstrate, the planets move more swiftly when near to the Sun at position P than when at position A. He was able to define the rate of change of velocity as such that the radius vector of the moving planet sweeps out equal areas on the surface of the ellipse in equal times (the Equal Area Law). The case is illustrated for an ellipse of high eccentricity ($e = 0.5$) in which the planet's motion in one-tenth of a year is marked out in portions of the orbit near perihelion and aphelion (Figure 12). When this

variation in time is analyzed more closely, it is found that the rate of change of angle that the radius vector makes with a fixed direction is inversely proportional to the square of the distance between the Sun and planet. Thus, the same mathematical law that describes the diminution of insolation with distance also describes the diminution in rate of change of the angle of the radius vector.

The consequence is that the planet intercepts the same quantity of solar radiation for each degree of angular rotation, although it passes through each degree of rotation at a varying rate. Thus, if the orbit is divided up into four quadrants, such as by the points *P*, *Q*, *A*, *Q* and the lines connecting them to the Sun, the planet will receive exactly the same insolation in all four quadrants. The trick is to recognize that the time spent in the two larger quadrants that surround *A* is longer than that spent in the two smaller quadrants that surround *P*. Thus, the same insolation is received over a longer number of days in the two larger quadrants and its flux density per day is consequently less.

If winter solstice occurs at *P*, climatologists call the two smaller quadrants *caloric winter* and the two larger ones *caloric summer*. One sees then that another way of describing the condition described above is to say that the summer is longer and milder (at least with respect to solar insolation) than winter. The difference in length between caloric summer and winter can be as great as 33 days. At the present time, the difference is 7 days. This will vary with the eccentricity, which, as we have mentioned, has a cycle of about 94,000 years.

As the position of the winter solstice moves around the ellipse, a pair of perpendicular lines drawn through the Sun will always describe the four seasonal positions. Thus it can be seen that a cycle of 21,000 years' duration will be superimposed on the longer cycle of 94,000 years' duration. Let us suppose, for example, that we begin at a point in time when the winter solstice is at *P* and the orbital eccentricity is at a maximum. The greatest excess in the number of days of caloric summer over winter will then be experienced, and consequently the lowest flux density of the summer insolation. Assuming the proper meteorological dynamics, this should be an ideal position for the rapid advance of glaciation.

Let the rotational axis then move through one-half of its 21,000-year cycle of seasonal precession—10,500 years—bringing us to the position where the winter solstice is occurring at *A*. As the eccentricity will have lessened by only about one-fifth of its greatest value in this position (its cycle of change is not perfectly linear), the Earth will now experience a most intense daily flux of solar radiation during the relatively brief caloric summer, creating ideal conditions for glacial melt. The winter, however, will be longer and colder than normal insofar as the solar flux affects it. The outcome is perhaps a toss-up. Half a precessional cycle later, winter solstice occurs again at *P* and the eccentricity is still relatively great. Conditions for glacial advance are again good.

It will only rarely be the case, however, that the ideal situation should occur, in which the maximum of eccentricity and a winter solstice at *P* take place simultaneously. Further, a third cycle, the one that Milankovitch thought primary, must be considered—the variation in the angle of obliquity over a 40,000-year period. When these added considerations are

taken into account, a curve can be derived of the sort illustrated for various latitudes in Figure 13. The close relationship between the variations of average daily insolation and the estimated variation in average temperature during the last 100,000-year-plus ice age cycle is seen.

The relative smoothness of the future 20,000 years of the cycle led Milankovitch at one point to forecast that the onset of the next 100,000-year ice age would not occur for another 20,000 years. The situation is not so simple, however. One sees a similar smoothness in the insolation curve in the period 20,000 to 50,000 years before the present, when the ice age cycle was known to be advancing, in fact, toward the maximum glaciation. Many other things must be taken into account, and one cannot use the mathematically derived curves exactly as a fortune-telling wheel. One of the interesting features of the climate cycle is the fact that an advance of glaciation seems to be self-feeding, because of the increase in the Earth's surface albedo (the reflectance of incident light) caused by a covering of bright white ice or snow. The effect, however, is never direct, but is modulated by weather patterns—the production of winds, clouds, ocean currents, and all the many other interrelated factors that make weather forecasting so difficult and imprecise a science.

Milankovitch's own reflections on the validity of his theory of the astronomical cycles are worth noting: "The fluctuations in the radiation received by the Earth over long periods of time are only one component of the climate of the past, but they are the most important one, and, moreover, one which is amenable to precise investigation."⁷

Laurence Hecht is an associate editor of 21st Century magazine. He began serving a 33-year sentence as a political prisoner in the state of Virginia on Nov. 4, 1993, along with five other associates of Lyndon LaRouche.

Notes

1. See, for example, Hugh W. Elsaesser, 1991. "Setting the 10,000-year Climate Record Straight," *21st Century*, Winter, p. 52; and Dixy Lee Ray, 1990. "Scientific Evidence Vs. Climate Hoaxes: Greenhouse Earth," *21st Century*, Winter, p. 28.
2. H.H. Lamb, 1985. *Climatic History and the Future* (Princeton, N.J.: Princeton Univ. Press), pp. 437-39.
3. Martin Schwarzbach, 1986. *Alfred Wegener: The Father of Continental Drift* (Madison, Wis.: Science Tech, Inc.), p. 76.
4. Schwarzbach, p. 82.
5. Schwarzbach, p. 97.
6. J.D. Hays, J. Imbrie, and N.J. Shackleton, 1976. "Variations in the Earth's Orbit: Pacemaker of the Ice Ages," *Science*, Vol. 194, pp. 1121-32.
7. Schwarzbach, pp. 97-98.

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