found that a lack of thyroid hormone causes high LDL levels in the blood and a decrease in LDL receptors whereas too much thyroid hormone has the opposite effect.

But even though the causes of most cases of high cholesterol levels in humans are only dimly understood, Brown and Goldstein argue that the two-drug method of lowering cholesterol concentrations may be worth trying. "We feel that it will work," Brown says. And by using these drugs, it may be possible to answer at last the question of whether lowering cholesterol levels lowers the risk of heart disease. For the first time, a treatment is available that lowers cholesterol enough that a difference in heart disease risk, if it occurs, should be readily apparent in a clinical trial.

The most fundamental question about cholesterol and heart disease is still unanswered, however. How does LDL cause heart disease in the first place? But, once again, the Watanabe rabbit may provide the necessary clues. Several groups of researchers have established that the atherosclerosis that develops in these animals is similar to human atherosclerosis. Thus it is possible to use these animals to study how LDL interact with platelets, endothelial cells, scavenger cells, and the smooth muscle cells that line the artery wall. All of these cells seem to be damaged by high levels of LDL. Carew and Steinberg have recently developed methods to study in whole animals which cells are degrading LDL and how. "We just really have the methodology now in hand—within the last few months," says Carew.

So the unanswered questions in the cholesterol-heart disease story no longer seem so unanswerable as they did in the recent past. The stage is set for dramatic changes in the diagnosis and treatment of heart disease.—GINA KOLATA

Additional Reading

1. J. Goldstein, T. Kita, M. Brown, "Defective lipoprotein receptors and atherosclerosis," *N. Engl. J. Med.* **309**, 288 (1983).

Where Was the Moon Eons Ago?

Where was the moon in the early days of the solar system? Experts will only agree that it was not orbiting at its present distance of 380,000 kilometers; it was much closer to Earth in the past. Today the moon is moving outward at about 4 centimeters per year. A new study of the gravitational interaction of the moon and Earth over geologic time suggests that the moon was never closer than 225,000 kilometers, which would avoid the apparent problem of a close encounter of the two bodies only 2 billion years ago. It also argues against Earth originally calving the moon while still young and hot, or capturing the moon as it made a near miss.

Why the moon is receding has been clear for a long time. It raises tides in Earth's seas that in turn raise the moon to a higher orbit and slow Earth's rotation. The day and the month are becoming longer. The problem is that it is happening so quickly. Tidal currents dragging across the bottom of shallow seas are dissipating tidal energy and lengthening the day so fast that, if the present rate were extrapolated into the past, the moon and Earth would have been so close 1.5 to 2 billion years ago as to melt surface rocks. That did not happen.

To avoid the nonexistent Earth-moon encounter, celestial mechanicians have been looking for a way to calculate a smaller past rate of tidal dissipation. Since the advent of plate tectonics, they have usually done it by moving the continents around or changing sea level, which changes the shape and depth of ocean basins. It appears that the shape, orientation, and depth of today's oceans are particularly well suited to the efficient dissipation of tidal energy. The present 12.5-hour period of tidal forcing produces a resonant response in these particular basins that amplifies the rate of dissipation. Unfortunately, no one knows what the configuration of continents and oceans has been for most of the history of Earth.

Kirk Hansen of the University of Chicago (now at Shell Development Company, Houston) suggested recently* that it is not so much the changing ocean basins but the changing rotation rate of Earth that determines the rate of tidal dissipation over geologic time. To make his point Hansen calculated the dissipation rate in a simplified model of an unchanging ocean and linked the calculations to the changing rotation rate of Earth.

As the model moves back in time, Earth spins faster, as it regains the energy lost to the moon, decreasing the period of tidal forcing and breaking the resonances with the great ocean basins. In the absence of these resonances, the rate of tidal dissipation decreases and the model moon's march inward is slowed. During such a backward extrapolation, the moon does not approach closer than 290,000 kilometers by 4 billion years ago, says Hansen. The closest that the moon can come in the model is 225,000 kilometers. New resonances would form as the day and thus the tidal forcing period shortened, but they would involve smaller basins. These resonances would be less efficient in dissipating tidal energy and could not make up for the loss of the larger scale resonances, Hansen says. The apparent dominance of rotation rate over basin configuration argues against a fission origin for the moon, a recently revived theory, or capture by Earth during a near miss (*Science*, 20 July 1979, p. 292). The alternative is simultaneous accretion of Earth and the moon from the solar nebula as a "double planet."

The coupling of tidal calculations and Earth's rotation has been well received, but it does not settle the question entirely. One concern is the exclusion of any changes in the area of shallow seas that could change the rate of dissipation. Hansen argues that a series of highly unlikely coincidences would be required to preserve the kinds of resonances that produce today's high rate of dissipation. Hansen concedes that tides raised in the hot, more plastic rock of the young Earth might contribute additional dissipation, but the moon's orbital inclination as well as its distance at that time are not consistent with a fission or capture origin, he notes. In addition, other processes not included in his model, such as solar tides, would tend to reinforce the dominance of the rotation rate.

These and other assumptions need to be investigated, but this century-old field looks more interesting than it has in a while—it may not be so intractable as it seemed.

—RICHARD A. KERR

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