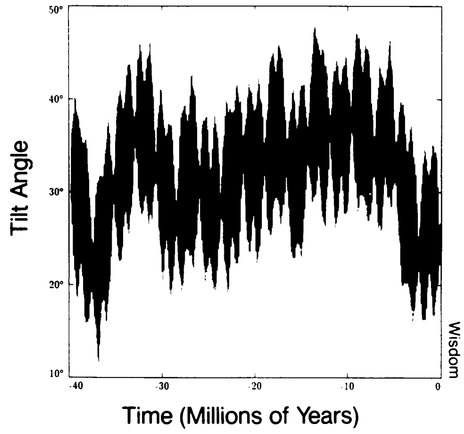
# Tilted: Stable Earth, Chaotic Mars

Without the moon, life on Earth would likely face the same kinds of wild fluctuations in climate that Mars has apparently experienced through the eons. Its spin axis no longer maintained by the moon at an angle of 23.5 degrees, Earth could drastically change its tilt in just a few million years, sometimes dipping enough to bring more sunlight to polar regions than to equatorial zones.

These startling conclusions arise out of new calculations revealing that the chaotic wobbles of a planet's orbit around the sun can have a strong influence on the angle at which the planet's spin axis is tilted with respect to the plane of its orbit. In Earth's case, the moon has a stabilizing influence. In contrast, the tiny satellites of Mars are too small to keep the tilt, or obliquity, of the planet's spin axis from varying erratically over a wide range of angles.

These results follow from the recent discovery that the evolution of the solar system appears chaotic (SN: 2/22/92, p.120). Because the details of its evolution over millions of years are sensitive to precisely where the planets are at any given moment, researchers cannot accurately calculate and predict the erratic variations possible in the past or future shapes and inclinations of planetary orbits.

"One of the most dramatic consequences of this chaotic evolution of the planets turns out to be that the [tilt of the spin axis] of Mars is wildly irregular over multimillion-year time scales," says Jack Wisdom of the Massachusetts Institute of Technology. The new results may alter considerably the kind of information that planetary scientists must put into computer models used for tracing and predicting the evolution of the climate and surface features of Mars.




*The obliquity of Mars over the last 40 million years shows large, irregular shifts.*

Wisdom and Jihad Touma of the Massachusetts Institute of Technology report their findings on the chaotic obliquity of Mars in the Feb. 26 SCIENCE. Jacques Laskar and his colleagues at the Bureau des Longitudes in Paris describe in the Feb. 18 NATURE how the moon may act as Earth's climate regulator.

Astronomers have long known that the spin of Mars is strongly affected by variations in its orbit. However, previous calculations disagreed on how large this effect has been in the past and when changes in tilt might have occurred. Some researchers had also suggested that intense volcanic activity and other geologic processes could play an important role in these tilt fluctuations by altering the planet's mass distribution sufficiently to change its spin and cause large shifts in its tilt angle.

"All sorts of things happen when you change the obliquity of Mars," Wisdom says. "At high obliquity, the ice at the poles is probably no longer stable. At low obliquity, the atmosphere freezes out."

Wisdom and Touma's calculations show that orbital variations alone can cause such drastic changes. Their model suggests that the resulting tilt angles can range from about 11 degrees to 49 degrees (see diagram). Moreover, these irregular variations in the tilt of Mars over intervals longer than 10 million years appear inherently unpredictable.

However, despite this long-term uncertainty, orbital models can provide a glimpse of what has happened to Mars in the last 10 million years. Indeed, different orbital models now qualitatively agree that the average obliquity of Mars

## Antibody mimics rival the real thing

Custom-tailored by the immune system to identify and nab specific chemical invaders, antibodies are masters of molecular recognition. Scientists often use them to target a substance within a mixture and measure the amount present. Now, a group of European researchers report they can make artificial antibodies that match the real thing when it comes to detecting minute quantities of two drugs in blood serum.

The researchers built their synthetic antibodies out of polymers, using a technique called molecular imprinting to construct a cast around a target molecule. Because these mimics are robust, reusable, and inexpensive to produce, they may one day replace antibodies harvested from laboratory animals for use in diagnostic tests. "Molecular imprints may be made against a great number of organic molecules, for example, drugs, hormones, and toxins," Klaus Mosbach of the University of Lund in Sweden and his colleagues write in the Feb. 18 NATURE. "This technique may have many applications."

The team made antibody mimics against two chemically unrelated drugs, the asthma medication theophylline and a tranquilizer called diazepam. They used a "cocktail" approach, Mosbach says, adding simple organic chemicals called monomers that interact with the "print" molecule in a variety of ways. For instance, methacrylic acid linked up in repeating units to form a polymer cage around the drug molecule, while a chemical cross-linker called ethylene glycol dimethacrylate strengthened the cage. After removing the drug molecule, the researchers had a rigid, insoluble polymer imprinted with the exact shape of the drug, like a handprint set in concrete.

The group found that the mimics showed the same specificity as their antibody counterparts. The synthetic antibody for theophylline invited into its folds only one of the eight structurally related drugs and metabolites tested. The synthetic antibody for diazepam was tricked by several compounds, just as real antibodies are.

The proof came, however, when the researchers used the antibody mimics to determine the amount of drug in serum samples from 32 patients. The team compared the results with those obtained through a technique using real antibodies, called enzyme-multiplied immunoassay technique (EMIT). The two methods showed complete agreement, Mosbach's group reports.

This is the first demonstration that such antibody mimics can perform as well as real antibodies in a practical application, says Frances H. Arnold of the California Institute of Technology in Pasadena. "This is quite an exciting paper that clearly shows the potential for these imprinted molecules."

At present, imprinted polymers need organic solvents around them in order to work, which makes them more cumbersome to use in biomedical assays than water-loving antibodies. However, Mosbach says, "It's only a matter of a year or so before the molecular imprint methods will be as good as, if not better than, current immunoassay techniques." —*K.F. Schmidt*