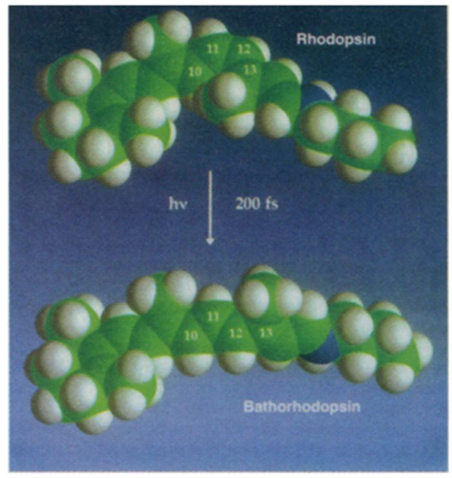
The eye's photochemistry: A quick snap



In 200 femtoseconds, photons prompt rhodopsin to twist into a new shape.

One of nature's most sensitive photodetectors, the human eye has puzzled scientists seeking to figure out how it converts light falling onto the retina into the images we call vision.

Photons whisking through the eye's lens plunge into a forest of vision cells embedded in the retina. There the photons set off stepwise chemical reactions that result in energetic signals flashing to the brain.

Yet until recently, scientists have known little about the earliest moments of this photochemical process. Qing Wang and Charles V. Shank, both chemists at the Lawrence Berkeley Laboratory and the University of California, Berkeley, and their colleagues have now observed and measured chemical reactions during vision's initial split seconds.

Using a femtosecond pump-probe laser, the team took strobelike snapshots of events occurring in the retinal chromophore of rhodopsin, the molecule chiefly responsible for capturing light and transforming it into chemical signals.

Indeed, they find that the entire reaction takes place in a mere 200 femtoseconds, making it "one of the fastest photochemical reactions ever measured in a biological system," says Wang. Among other things, the chemists report finding "coherent vibrational motion" in the reaction. This observation, they state, suggests what may become "a new paradigm for the photochemistry of vision." Their report appears in the Oct. 21 SCIENCE.

"Since we are so visual, understanding the earliest photochemistry of vision is extremely important," says Shank. "The reactions have not been accessible to analysis before because they happen so quickly."

The chemists observed that when photons strike a rhodopsin molecule, it moves into an energized state that results in a quick twisting of its physical structure. "The reaction is almost like triggering a cocked spring," says Shank. "Once it is set off, the motion of the molecule, its kinetic energy, drives the reaction forward to completion. . . . The molecule sort of snaps into a new configuration and then sits there quivering in an excited state."

According to Richard A. Mathies, a chemist at UC Berkeley, showing how rhodopsin moves through its transition state offers a new interpretation of how the eye manages to capture and convert light energy into signals. "In a sense, it's like watching a marble roll downhill," he says of the reaction. "After injecting a photon into the molecule, we can see that it starts to twist. The twisting picks up speed until it gets over a transition bump; then it settles there."

"This observation is relevant to everyday life," he adds. "It tells us that the very basic biological process of sensing light depends on femtosecond changes in a molecule's excited state."

Mathies envisions the possibility of putting this process to technological use. "If we can understand how light energy gets converted into chemical signals, then perhaps we can ask, How might we design a protein to absorb light and convert it into information?"

"That's a very difficult problem to solve," he says. "But that's what many people are working toward." — *R. Lipkin*

Yet another blow to climate stability

Fossilized pollen from two sites in Europe now provide additional evidence that temperatures shifted dramatically during the last interglacial stage, 120,000 to 130,000 years ago, report Michael H. Field of the University of Cambridge in England and his colleagues.

Conditions during that period, the Eemian, interest scientists in part because they may shed light on how easily today's climate might shift. Earth, now in another interglacial stage, has enjoyed remarkably stable temperatures for the past 10,000 years. But some investigators worry that modern pollutants threaten that long record and will cause global changes in climate.

For years, researchers thought that stable, mild temperatures characterized the Eemian. Then in 1993, two teams studying ice cored from the Greenland ice cap reported conflicting findings on the Eemian (SN: 12/11/93, p.390). A European group contended that fluctuating temperatures marked that period. But U.S. researchers said they could draw no conclusions about the Eemian from their ice, drilled nearby.

Now, pollen records appear to support the Europeans' conclusions, Field's group reports in the Oct. 27 NATURE.

However, "it's too early to say whether there is or isn't a match between specific wiggles in our curve and specific wiggles in their curve," concerning the timing and degree of climate change, warns coauthor Brian Huntley of the University of Durham in England.

"The ice core records tell principally about the mean annual temperature. [Pollen] can tell more about seasonal fluctuations," he adds.

The study "is really exciting," says Kendrick C. Taylor of the Desert Research Institute in Reno, Nev., one of the U.S. ice core investigators. But he remains unconvinced that the Eemian had unstable weather. They need more evidence to back up their argument, he says.

Field and his colleagues analyzed data describing the abundance of different types of ancient bush and tree pollen in the sediment below Bispingen in northern Germany and La Grande Pile in eastern France.

Using information on what trees and shrubs grow in different conditions, they found that the climate warmed rapidly at the beginning of the Eemian and remained temperate for about 3,000 years. During that time, the mean temperature of the coldest month was about 5°C warmer than it is today.

Then the weather, particularly the winters, became cooler, and readings dropped almost to ice age lows, Huntley says. Temperatures also fluctuated more widely, especially in winter. As the weather cooled, conifers became more abundant, the researchers report. The French site experienced less erratic conditions than the German site, however.

Since submitting their article to NATURE, Field's team has analyzed data from 10 additional areas in Europe and England. The results "give some overall support to the pattern we've reported," says Huntley. The group detected "violent fluctuations" in the climate, but more so at the northern and eastern locations than the southern and western ones, he says.

Shifts in the location of the polar front in the north Atlantic, where surface temperatures drop most dramatically, may have caused Eemian fluctuations, says Huntley.

The new work supports the conclusions of other scientists that "the whole [climate] system can readily become rather unstable," says Huntley. Global warming due to pollutants could trigger "some of these inherent unstable mechanisms in the system... but we don't know," he adds. — *T. Adler*