# Biological stopwatch found in the brain

Musicians have no trouble monitoring a beat. Short-order cooks intuitively flip the burgers before they burn. In a step toward explaining such timing abilities, investigators have found areas in the human brain dedicated to keeping mental track of intervals ranging from seconds to a few hours.

That finding has led another group of scientists to discover that people with Parkinson's disease have difficulty using this so-called interval clock.

Animals possess a number of biological clocks, the most well known being the circadian clock, which establishes day-long patterns of behavior.

The interval clock is less well understood, but researchers contend that the ability to monitor time intervals accurately is vital to learning and memory. For example, the salivating response of a dog to a meal bell depends on its brain's understanding that food will come a short time after a bell is rung.

"Time comes into every aspect of an animal's daily life," says Alex Kacelnik of Oxford University in England, who studies interval timing in birds.

The interval clock, unlike the circadian clock, is something that people can actively control. "It's much like a stopwatch. You can stop it and start it at will," says John Gibbon of Columbia University. Gibbon and other scientists presented the new findings on the interval clock at a session of the American Association for the Advancement of Science's annual meeting in Baltimore this week.

By giving rats drugs that destroy selected areas of the brain, investigators at Duke University in Durham, N.C., recently discovered several brain regions involved in this clock.

The investigators had trained the rats to recognize specific intervals of time by giving them food only when they pressed a lever after a certain period had passed, explains Warren Meck, who headed the research group. After the researchers damaged the substantia nigra, located in an area of the brain known as the basal ganglia, the rats could no longer judge time intervals.

The substantia nigra contains brain cells that make the neurotransmitter dopamine. The researchers found they could largely restore the brain-damaged rats' ability to judge intervals by giving them L-dopa, a dopamine-stimulating drug used by Parkinson's patients.

With functional magnetic resonance imaging (fMRI), a method that reveals the brain regions employed during a task, Meck and his colleagues have also studied college students as they judged time intervals. "The same circuits we measured in rats are selectively activated," Meck says.

The work in both rats and humans suggests that the substantia nigra acts as a metronome, sending a steady stream of dopamine pulses to another brain region called the striatum. A third part of the brain, the frontal cortex, appears to complete the interval clock's neural circuit.

After the Duke group highlighted the importance of dopamine to the interval clock, Gibbon and his colleagues decided to study people with Parkinson's disease, an illness in which dopamine-generating brain cells mysteriously die.

This neurodegeneration causes obvious problems of motor control. Gibbon's group discovered that it also interferes with the ability of Parkinson's patients to store two time intervals in memory at once.

When Parkinson's patients took L-dopa, they could accurately reproduce intervals of 8 and 21 seconds that they had been trained to measure. When they didn't take the drug, they were unable to judge accurately the second interval on which they had been trained.

Researchers are uncertain whether this timing deficit plays any role in the Parkinson's symptoms that patients experience. Gibbon and his colleagues plan to examine people with other neurodegenerative diseases for similar problems. — *J. Travis*

# The first shark: To bite or not to bite?

**Fossil fish scales discovered in Colorado reveal that sharks have been haunting the seas since the middle of the Ordovician period 455 million years ago, a time far more ancient than paleontologists previously thought.**

**Yet these early sharks may not have brandished the fearsome maws of their modern descendants. In fact, the ancient fish may have lacked jaws altogether, says Ivan J. Sansom of the University of Birmingham in England. Sansom and his colleagues describe the new finds in the Feb. 15 NATURE.**

**"We've got enough evidence to say that these are sharks. But we don't have enough evidence to say that they were sharks with jaws," says Sansom.**

**The scales measure about 1 millimeter in length and have multiple, overlapping cusps that look like a miniature mountain range. The distinctive shape matches scales from later sharks, leading Sansom and his colleagues to identify the Colorado species as a shark or shark ancestor. Until now, the oldest shark remains had hailed from the Silurian period, some 25 million years younger.**

**The Colorado fossils fall into a peculiar taxonomic position, comments paleontologist Philippe Janvier of the National Center for Scientific Research** in Paris. Because they resemble later sharks so closely, the Ordovician animals qualify as the closest relatives of the gnathostomes, or jawed vertebrates.

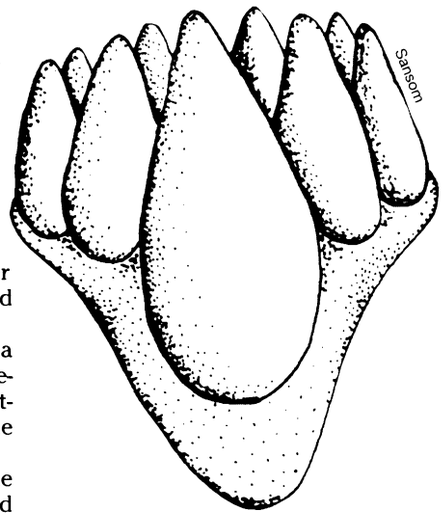
"There is no known jawless vertebrate with similar scales," Janvier says. Yet without more complete fossils, scientists cannot tell whether these early fish actually possessed teeth or jaws.

The appearance of jaws marked a major leap in the evolution of vertebrates, in some ways almost as dramatic as the jump from invertebrates to the first vertebrates (SN: 2/3/96, p. 74).

Whatever their dental details, the Ordovician sharks apparently shared the ancient oceans with true gnathostomes. "Almost certainly, there must have been jawed vertebrates at the time," says Janvier.

He notes that recent fossil finds from China indicate the existence of several different jawed fish early in the Silurian, which began 438 million years ago. This diversity implies that the first jaws must have appeared well before then, presumably by the time of the Colorado shark.

Other paleontologists, however, argue that gnathostomes may not have evolved that early. "It is debatable whether these scales came from animals that we would identify as gnathostomes. I'm not fully convinced," says Mark Wilson of the University of Alberta in Edmonton.




*Sketch of a 1-millimeter-long scale belonging to the oldest known shark.*

Wilson argues that proof would come only when scientists find complete fossils. He asks why, if gnathostomes existed in the Ordovician, scientists haven't found complete fossils of these animals.

— *R. Monastersky*