Seep and ye shall find: Hidden water flow

Subterranean rivers flowing slowly through the ground carry freshwater into the ocean in quantities far larger than scientists had suspected, according to recent research conducted off the coast of South Carolina. These invisible seeps season the seas with salts, metals, and pollutants.

During July 1994, groundwater oozed out through sediments on the seafloor along the state's coastline at a rate of 30 billion liters per day. This is a little under half the water entering from the region's rivers, says Willard S. Moore of the University of South Carolina in Columbia.

"What we've done is show that the groundwater input to the coastal ocean is extremely important," says Moore, who described his results in the April 18 NATURE.

"This has tremendous implications for understanding everything from pollution to geochemistry," comments ecologist George M. Simmons of the Virginia Polytechnic Institute and State University in Blacksburg.

Although hidden from view, water stored in porous, underground rocks constitutes 97 percent of the world's supply of liquid freshwater. Like surface rivers, which flow downhill toward the sea, some of this groundwater migrates downward through subsurface formations that open beneath the ocean. Scientists have made spot estimates of groundwater entering the sea, but Moore's study is the first to gauge this process on a regional scale.

The South Carolina geochemist happened on a technique for measuring groundwater flow while he was studying naturally occurring radium in a salt marsh. Moore found that the amount of an isotope, ^{226}Ra, in the marsh water exceeded that in ocean water. Because no rivers emptied into the inlet, the radium must have come from groundwater seeping into the marsh, he reasoned.

He then used ^{226}Ra to trace groundwater entering coastal waters and again found excess radium that could not have come from the ocean or rivers. "By process of elimination, the primary source of the ^{226}Ra enrichment must be the discharge of groundwater containing dissolved ^{226}Ra," he concludes.

Moore suspects that when brackish groundwater penetrates fresh aquifers, it causes sediments to release ^{226}Ra, which can then flow into the ocean. People enhance radium movement by pumping drinking water from coastal aquifers; this reduces pressure in the aquifer and allows saltwater to intrude farther inland than it otherwise would.

He expects that other elements and ions behave similarly, making groundwater an important source for many of the ocean's trace constituents, including nutrients that support aquatic life.

In unpublished studies, geochemist William C. Burnett of Florida State University in Tallahassee also has found significant groundwater movement into the northeast Gulf of Mexico. Burnett's group used dissolved radon as a tracer of groundwater flow.

"When you look at the process, it's a lot larger than people might have thought. We were surprised. It's been one of those things in earth science where people know it goes on, but no one to date had really developed a good way of measuring it, so it's generally not talked about," says Burnett.

Before these new measurements, some scientists had suggested that groundwater flow into the ocean might equal only one-thousandth of the river flow. But Burnett estimates that groundwater contributions to the ocean total about one-tenth of the amount supplied by rivers globally. In some locations, the groundwater component may dominate, he says.

Measurements off many coasts indicate that subterranean flow can carry pollutants, as well as naturally occurring elements, into the ocean. In particular, nitrates from septic tanks have seeped into seawater, says Burnett.

— R. Monastersky

Eyes possess their own biological clocks

In the eye, many daily cycles, such as the regeneration of light receptors and increased sensitivity to light, appear timed to the cadence of a unique drummer. Now, two biologists have shown that the retinas of hamsters carry their own circadian timepieces to maintain these rhythms on a roughly 24-hour cycle.

The eye timepieces are distinct from the hub of tissue in the brain's hypothalamus that serves as an orchestral conductor, pacing the symphony of interwoven daily rhythms, from sleep-wake cycles and pain sensitivity to hormone production. Until about 20 years ago, the brain's suprachiasmatic nucleus (SCN) was accepted as the one and only body clock.

Then, biologists found they could throw the eyes' rhythms out of sync with other circadian cycles. Since that time, several researchers have confirmed that eye rhythms persist—and can be reset—even after the SCN, or the eyes' ability to communicate with it, is destroyed.

From such findings, Michael Terman of Columbia University and his colleagues published a hypothesis in 1991 arguing that the eye must possess its own clock, independent of the SCN. However, Terman now notes, because the studies at that time used whole animals, "there was always a nagging suspicion in the field that these results were artifactual"—that they reflected some indirect influence by other systems in the body.

Gianluca Tosini and Michael Menaker of the University of Virginia in Charlottesville have now erased such doubts by finding resettable circadian rhythms in retinas removed from hamsters and maintained in culture in the lab for several days. In the April 19 SCIENCE, they report that these retinas produce the hormone melatonin in quantities that ebb and flow daily. The scientists reset the synthesis cycle of this hormone (SN: 5/13/95, p. 300), normally produced only at night, by illuminating the retinas at different times.

Menaker believes the retinal clock will turn up in other mammals, including humans. "Now, if we can discover what this [clock] is doing for the eye," Menaker says, "we may get a handle on some pathologies that occur there."

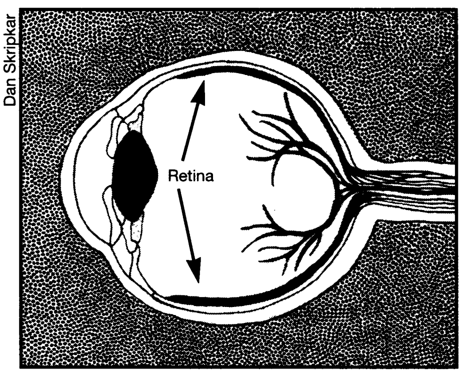
This demonstration of separate clocks in the retina and the brain, adds Terman, means "one has to ask how they talk to each other," because they usually work in synchrony.

Al Lewy of the Oregon Health Sciences University in Portland describes the new study as "just elegant" but expressed deep concern over the implications of its melatonin findings. "If we knew with certainty that melatonin has an important function in the human eye, this hormone [now available as a nonprescription sleep aid] should be taken off the market immediately—no questions asked" until follow-up studies determine whether the supplement harms the eyes.

Ophthalmologist Charlotte Remé of the University of Zurich agrees. Melatonin supplements could change the timing of hormone peaks in the eye. "And when we have a high melatonin level in the retina and are exposed to very bright light," she warns, "we risk light-induced damage."

— J. Raloff

Dan Skripkar



The retina, site of a second biological clock.