Do sea turtles smell the way home?

Ridleys released at Padre Island this year will wear a "living tag." In the experimental procedure, a plug of light under-shell (see inset) is grafted to darker upper shell. Shown are similarly tagged green sea turtles.

Ed Powers, Cayman Islands News Bureau

A few short minutes out of their eggs, sea turtle hatchlings will have already taken their bearings and begun racing down the beach of their birth and into the sea. That brief encounter with home will likely be their last—until females return to nest some 15 to 30 years later. Do clues imprinted on the hatchlings guide adults back? New research lends stronger support to the idea that olfactory imprinting does permit turtles to at least recognize their home waters.

For six years, the U.S. Fish and Wildlife Service has collected about 2,000 sea turtle eggs annually at Rancho Nuevo, Mexico, the sole nesting site of the endangered Kemp's ridley. Caught in plastic bags as they leave the mother's body, the eggs never touch the beach. Carried from Mexico in boxes lined with sand from Padre Island, Texas, these eggs hatch and are then set on the beach at Padre Island and allowed to run down to the sea. Fifty yards or so offshore, they are collected again and taken to be raised for a year in Galveston, Texas. Then it's back to Padre Island for a final send-off. The goal is to establish a new, backup nesting beach. But will the turtles have been imprinted with Texas-homing cues?

An experiment with four-month-old ridleys imprinted at Padre Island has shown evidence suggestive that the young animals can not only distinguish a difference between seawater from Galveston and Padre Island, but also that they show a preference for Padre Island water.

In the test reported in the April 6 Science, each of 12 turtles was given a separate two-hour swim inside a tank containing four compartments. Water flowed from each compartment into a central area fitted with a drain. "Instant Ocean," a generic, commercially marketed brand of seawater, flowed from two compartments. From a third came a dilution (1 to 45) of water drained from an initial mix of Padre Island sand and water. A similarly dilute concentration of an initial Galveston sand-and-water mix flowed from the fourth.

The turtles made about 75 to 85 compartment entries per test, most of them into the Galveston water. Explains David Owens, one of four researchers who conducted the tests at Texas A&M University in College Station, "It was as if there was something about this Galveston water that was interesting, but not right." But he notes that once the animals entered the Padre Island water, "they stayed there much longer," — always more than twice the 45 seconds typical of Galveston water. Turtles entered Instant Ocean less than Galveston water, and for briefer stays.

Because the turtles were not fed the day of the test, Owens believes the animals initially sought food. But once a turtle "found Padre Island, the initial feeding attraction was temporarily transformed by another cue — something remembered from the past," he believes. Tested separately, all turtles reacted the same.

The researchers conclude that these animals have been "behaviorally imprinted to the chemosensory environment of Padre Island." —*J. Raloff*

Biological information storage: How to fold proteins

The structure of a protein is basically a long string that is folded and convoluted in a complicated shape and connected to itself laterally here and there. How nature codes in the genes of organisms the information to produce such three-dimensional structures is the concern of a group working at Harvard University under the direction of Steven A. Benner. Most recently they have succeeded in chemically synthesizing a gene that produces a ribonuclease, an enzyme chain of 124 amino acids with four cross-links that breaks down RNA, which plays a key role in protein production. "This altered gene has been engineered to permit rapid mutation by design, and appears to be the first synthetic gene for any enzyme," they reported in the March 23 Science. Benner spoke also at the recent meeting in Detroit of the American Physical Society.

Gene synthesis experiments usually aim at specific biological results. Benner stresses that his group's main interest is in the informational and mathematical question: how nature codes within the one dimensional sequence of the DNA molecule the information needed to produce the complicated three-dimensional structure of the proteins the organism makes.

Nature is a very efficient storer of information, Benner points out. An *Escherichia coli* bacterium can store the equivalent of 200 billion bits of information, a density of about 10^{19} bits per square centimeter. However, the information is not stored in the binary form used by computers, but in some quaternary scheme based on the order of the amino acids coded for by three-digit sets composed of adenine, thymine, cytosine and guanine in the DNA structure. "This business of Boolean algebra with its yesses and noes is very artificial," Benner says. "Nature wouldn't use for protein purposes a machine that only thinks in ones and zeroes."

The group studies natural information coding by making synthetic DNA, altering it in specific places and then finding out how those alterations change the resulting proteins. The usual way to make DNA has been to start with a solid support, usually silica particles, and attach the first base pair of the DNA to them, and then add the other base pairs in turn. The particles are large enough to be strained out by filter paper. But these particles are porous and the DNA often grows inside them, and so reagents have to be able to penetrate them. Benner and co-workers have developed a method that uses much smaller particles of magnetite in a colloidal suspension. This grows the DNA more efficiently, more accurately and all on the outside of the particles. The results are collected by magnetic fields.

Ribonuclease — and its synthesis — is important for the evolutionary question of how nature found the best way of coding information for particular purposes. It differs from organism to organism. About 40 varieties are known, mostly from herbivores. Linguists can reconstruct the vocabulary of the long-vanished Indo-European language by comparing its descendants in Europe and northern India. Likewise Benner hopes to be able to deduce the structure of ancient DNA by comparing the modern examples. "It's as if nature had done the experiment for us," he says.

Benner stresses that he is not interested in "biochips," artificial information storage in biological systems. However, it may be possible to alter the natural information storage to produce, for example, enzymes tailored to specific purposes. Enzymes have the information to recognize substance A and convert it to B while ignoring anything else present. An enzyme might be tailored to recognize minute quantities of herpes DNA molecules in the blood of persons suspected of having the disease, Benner says. Many other examples can be imagined. —*D. E. Thomsen*