# New Look at Turtle Migration Mystery

Each year around Christmas time, green turtles (*Chelonia mydas*) leave their shallow feeding grounds along the coast of Brazil and embark upon a 2000 km journey to their nesting grounds, the beaches of Ascension Island, in the mid-Atlantic. The journey takes a little more than 2 months in both directions, and is a miracle of navigation. Biologists have long wondered how the turtles manage the feat, and also why they bother to do it at all.

Fifteen years ago two researchers, Archie Carr and Patrick J. Coleman, advanced an ingenious hypothesis that appeared to take the mystery out of the migration. The answer, they said, was continental drift. The turtles were assumed always to return to the beach at which they were born: a behavior that biologists call natal homing. For the ancestors of the modern turtle species, this was not a major problem 40 million years ago because the mid-Atlantic was then on Brazil's geological doorstep.

However, with the distance between Brazil and the volcanic islands of the mid-Atlantic ridge widening by some 2 cm a year through sea floor spreading, the passage of 40 million years transformed a short journey into an heroic odyssey. Locked into the need to nest on the beaches of Ascension Island (and its forerunners) by the biological imperatives of natal homing, the green turtle gradually adapted to an ever longer migration. Carr and Coleman acknowledged that theirs was an audacious hypothesis, but it also seemed persuasive.

About a decade ago Harvard biologist Stephen Jay Gould challenged the hypothesis, partly on the grounds that with the ebb and flow of climatic and environmental change over a span of 40 million years, there surely would have been periods when no suitable nesting beaches existed on the islands of the mid-Atlantic ridge. A hiatus of one generation would have been sufficient to have extirpated the biological link between the beaches of Brazil and Ascension Island. Until now, however, the Carr-Coleman proposition has not been properly tested with empirical data.

The required test has been made possible by restriction mapping of mitochondrial DNA (mtDNA), and applied by Brian W. Bowen and John C. Avise of the University of Georgia and Anne B. Meylan of the Florida Institute of Marine Research. The technique effectively tracks the genetic history of the female lineage, because offspring receive mitochondria only from the mother, not the father. And since natal homing focuses particularly on females, the mapping of mtDNA is an excellent tool for the task.

Bowen and his colleagues compared the mtDNA of green turtles from the Ascension Island beaches with individuals from two rookeries elsewhere in the Atlantic, one off Florida, the other off Venezuela. "If females have homed faithfully to their natal beach on Ascension Island over the evolutionary time-spans proposed under the Carr-Coleman scenario, the consequences should be reflected in extensive mtDNA sequence divergence," note the researchers. "The genetic results are straightforward."

The data show that, yes, there are identifiable differences between the three rookeries of the Atlantic, indicating that natal homing probably does occur. But the degree of difference is so small that a history of population separation of 40 million years is out of the question. Making a calculation based on the rate of mtDNA mutation, Bowen and his colleagues suggest that separation occurred a few 10s of 1000s of years ago at most.

The researchers offer two classes of (non-exclusive) hypothesis to account for the apparent close genetic relatedness of the modern Atlantic populations. The first invokes imperfect natal homing, in which every now and then a female makes a navigational error, and goes to the wrong nesting site. Even a low rate of genetic "leakage" of this sort is sufficient to homogenize otherwise genetically separated populations.

The second hypothesis concerns the probable long-term fragility of green turtle nesting grounds. Given the stringent conditions necessary for successful nesting, even modest shifts in environmental conditions can be catastrophic, thus causing the population to seek new nesting sites and probably throwing together previously separated populations. "These environmental perturbations could cause a periodic restructuring of green turtle populations through rookery extinctions and colonizations" suggest Bowen and his colleagues. In any case, they say, "The genetic data . . . are consistent with a recent origin [of the Ascension Island colony], perhaps the result of a rare colonization."

■ ROGER LEWIN

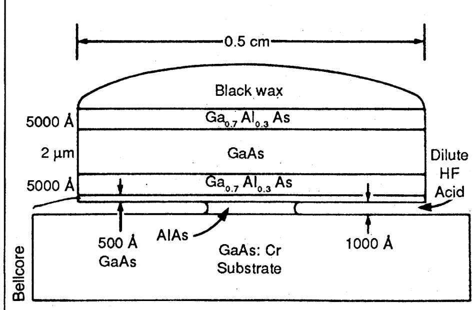
ADDITIONAL READING

B. W. Bowen *et al.* "An odyssey of the green sea turtle: Ascension Island revisited," *Proc. Natl. Acad. Sci. U.S.A* **86**, 573 (1989).

# Lift-Off Laser: GaAs on Glass

Researchers at three laboratories have successfully made "lift-off" semiconductor devices that are fabricated on one surface, then lifted off and affixed to a second surface. The technique will allow semiconductor manufacturers to put devices such as transistors or solid-state lasers on base layers of an entirely different composition than the devices themselves. Potential applications include cheaper solar cells, faster computer circuits, and military hardware that will not be shorted out by nuclear radiation.

A group of researchers at Bell Communications Research headed by Eli Yablonovitch announced they have placed a gallium arsenide (GaAs) laser directly on glass, the first time such a laser has been combined with a glass substrate. "What is most remarkable here," Yablonovitch said, "is that we can take gallium arsenide devices—lasers and high-speed electronics, for instance—produced by traditional laboratory methods and lift them off their base. Then we can put these high-quality films of gallium arsenide—the only functional part of the device and a mere ten millionths of an inch thick—on a wide range of new materials."




**Lift-off laser:** *After the AlAs layer is etched away, the wax pulls off the laser.*

The laser-on-glass success comes a year after the Bellcore team first described a technique for transferring GaAs thin film devices to other substrates from the GaAs substrates on which they are formed. Using this technique, scientists from two other institutions also have put GaAs devices on new substrates. Researchers in Belgium have put MESFETs (metal-semiconductor field effect transistors) onto glass. And a Sandia National Laboratory team led by John Klem has placed "strained quantum well" transistors on glass and silicon substrates. (Strained quantum well transistors consist of thin layers of indium gallium arsenide (InGaAs) between sheets of GaAs; the strain arises because the crystalline lattices of InGaAs and GaAs have slightly different structures, and the InGaAs layers deform in order