standing of how $PM_{2.5}$ causes harm. Last year, Congress handed EPA $49.6 million for PM research in 1998—nearly twice what the agency had asked for—and, in an unusual move, asked the NRC to help decide how to spend it.

The panel's report, the first of four, says that EPA's Office of Research and Development (ORD) needs to focus its PM research dollars on 10 topics, ranging from exposure studies to toxicology (see table). The NRC's vision of a research program would cost about $440 million and not wind down until 2010, several years after the regulations are first implemented. EPA, says Hopke, has failed to devise "an overall research plan that would, over time, address some of the underlying questions." The agency's research tends to be short-term, because it's "geared to [immediate] regulatory needs," adds panel chair Jonathan Samet, an epidemiologist at Johns Hopkins University. The panel's approach, he says, "would extend beyond the usual horizon."

The report says that EPA "should immediately" funnel more funds to two topics: the relationship between what a fixed outdoor air-pollutant monitor measures and what people who may spend most of the day indoors actually breathe; and pinning down which PM component—such as metals or organic compounds—accounts for their apparent toxicity. The agency's strategy is "crucially inadequate" in these areas, the report says.

Without such basic knowledge, EPA may be casting too wide a net. The agency's plan for an ambitious network of devices to trap fine particles might not measure "the most biologically important aspects" of particles, the report states, and therefore "is moving forward rapidly with too narrow a focus on $PM_{2.5}$." The panel has no qualms over the first step: to install several hundred trapping devices to find out which regions fail to meet the new standard. But it questions, for instance, a $15 million set of "supersites" to measure gases and particle size and chemistry, when it's unclear how useful such data will be for health studies. "It's a cart-before-the-horse kind of thing," Hopke says.

EPA officials say they will address the panel's concerns. "The point is well taken that there has to be an emphasis about what in PM is causing these effects," says John Vandenberg, who manages ORD's PM research program in Research Triangle Park, North Carolina. And EPA will hold a workshop this summer to get outside scientists' input into monitoring. "We will absolutely listen and ... make sure we're optimizing the network for the things they've recommended," says EPA policy official John Bachmann.

Hopke, however, says such a step should have been taken last fall, and now EPA will have no choice but to spend the $66 million it's requested for monitoring in 1999—more than ORD's $44.5 million PM research budget, the report notes. However, he says, "Congress could change the allocation" by, for example, shifting some of the monitoring funds to basic research.

–Jocelyn Kaiser

SCIENCE EDUCATION

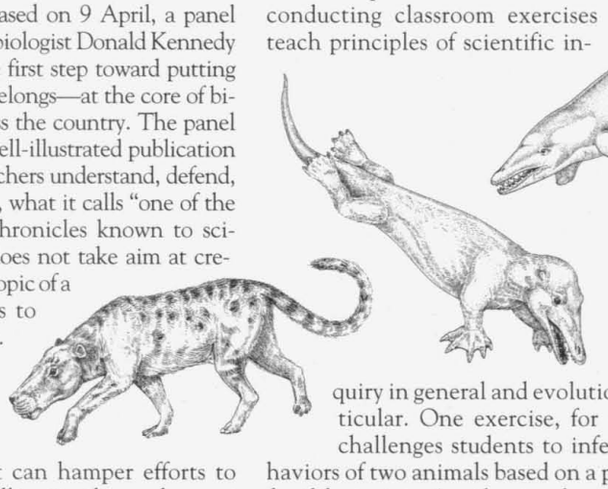
Academy Rallies Teachers on Evolution

Whether it's a symptom of rotten science literacy or a triumph of conservative religious groups, evolution is ignored or downplayed in many classrooms these days. Yet, says a panel of the National Academy of Sciences (NAS), "teaching biology without evolution would be like teaching civics and never mentioning the United States Constitution."

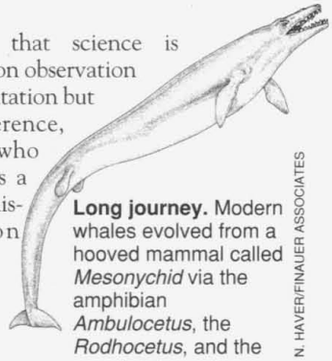
In a report* released on 9 April, a panel headed by Stanford biologist Donald Kennedy attempts to take the first step toward putting evolution where it belongs—at the core of biology curricula across the country. The panel has put together a well-illustrated publication designed to help teachers understand, defend, and teach evolution, what it calls "one of the most magnificent chronicles known to science." This report does not take aim at creationism; that's the topic of a booklet NAS plans to release next summer.

To start with, Kennedy's panel takes pains to correct a major misunderstanding that can hamper efforts to teach evolution: Calling it a theory does not mean it's just a hunch. In science, the report explains, a "theory" is an explanation for a set of known facts and observations—in the case of evolution, facts and observations about the "similarities among organisms" and the "extraordinary variety of life." They include observations that led Charles Darwin to first devise the theory of evolution more than 140 years ago, as well as modern findings such as similarities in the proteins and genes of different species pointing to a common ancestor.

The report also offers instructions for conducting classroom exercises to teach principles of scientific inquiry in general and evolution in particular. One exercise, for example, challenges students to infer the behaviors of two animals based on a pattern of fossil footprints. Another teaches the role of predators in selective survival by having students hunt for "prey" (colored dots of paper) on a busy background.



"In my dealings with K–12 teachers, I find that there's a great hunger for the kind of information in this publication," says panel member Eugenie Scott, who runs the National Center for Science Education Inc. in El Cerrito, California. Teachers must be able to communicate that science is based not just on observation and experimentation but also on inference, says Scott, who claims there is a widespread misapprehension among the general public that if something is not directly observable, it's not science. Indeed, she notes, a group called the American Scientific Affiliation has drafted a model law that would require teachers and textbook publishers to differentiate between "evidence" and "inference" in teaching evolution.



Long journey. Modern whales evolved from a hooved mammal called *Mesonychid* via the amphibian *Ambulocetus*, the *Rodhocetus*, and the completely marine *Basilosaurus*.

N. HAVER/FINAUER ASSOCIATES

Kennedy says he hopes the new report will help dispel suspicions about evolution that are based on this artificial distinction. "That's why I wanted to talk about the very direct evidence for evolutionary change in real time," he says, such as modern-day changes observed in 13 finch species first studied by Darwin on the Galápagos islands.

The academy panelists now hope teachers will heed their message. Says Yale biologist Timothy Goldsmith: "To fail to recognize [evolution] as one of the most important triumphs of human understanding in the history of science is to ignore something just terribly important, exciting, and inspiring."

–Constance Holden

* "Teaching About Evolution and the Nature of Science," NAS, www.nap.edu/readingroom/books/evolution98.