ALUMNI

Fishing for Answers

A paleontologist looks at the origins of the human body.

N 2005, parents and school officials in Dover, Pennsylvania, were locked in a courtroom debate over a schoolboard mandate that intelligent design be presented as an alternative to evolution in ninth-grade science classes. The judge in the case ultimately ruled in the

parents' favor, deciding that the requirement was unconstitutional. Throughout the trial, paleontologist Neil Shubin, Ph.D. '87, Bensley professor in the department of organismal biology and anatomy at the University of Chicago, struggled to remain quiet in his office: on his desk lay



the bones of a strange flat-headed, fishcum-crocodile-like creature-with-a-neck that he and colleagues had found the year before while scraping away at ancient rocks in the Canadian Arctic.

Roughly 375 million years old, from the Late Devonian period, the fossilized creature was a genus of the extinct sarcopterygian (lobe-finned) fish that shares several key features with tetrapods (early four-legged animals). In addition to the neck and non-conical head, Tiktaalik roseae, as it was named, boasted expanded ribs and parts of a shoulder, along with webbed fins-inside which were also primitive bones corresponding to an upper arm, forearm, and pieces of a wrist. All are explicitly non-fish features. Shubin and other scientists say Tiktaalik helps bridge the gap in our understanding of what changes occurred as sea animals crept ashore, and plays a critical role in understanding-and proving-human origins.

"During the Dover trial, I couldn't tell anyone apart from colleagues about our find," Shubin says now, with a smile: the news was an exclusive, scheduled to be announced in *Nature*'s April 2006 cover story. Most of the nation's news media, major publications, and science magazines followed up with articles about *Tiktaalik* (the word means "large, freshwater fish" in the Inuktitut dialect of Inuit).

Hailed as "the fish that crawled out of the water" and "the missing link," *Tiktaalik* is by far the most important discovery of Shubin's career, which has centered on the evolution of limbed beings. "I've devoted my life to this evolutionary biology stuff—I love it," he exclaims. "I enjoy going to work because it's fun working with worms, fish, and salamanders. I think it's beautiful that remedies for the problems we suffer from will be found by seeing pieces of us nestled in the most primitive and humble creatures that live on the earth."

His new book, *Your Inner Fish*, is an infectious exploration of the 3.5-billion-year history of the human body. It traces our organs back to fossils and prehistoric DNA—how our arm and hand bones came from fins; how our teeth first formed as spiky structures in the mouths of tiny, ancient, jawless lamprey-like fish known as conodonts; and how major aspects of our genome are similar to those of worms. Our ability to talk, for example, depends on the larynx, which is composed primarily of cartilage akin to the gill bars in a fish or shark. Even hiccups—a nerve spasm and inhalation, followed almost immediately (35 milliseconds, Shubin writes) by the "hic" sound—are the product of our shared history with fish and tadpoles, respectively. And the process through which teeth first formed in fish—at base, from the interaction between two layers of tissue—is the same process involved in the subsequent development of scales, hairs, feathers, and sweat glands.

Shubin says he wrote the book to explain his work to his father, Seymour Shubin, who still writes crime novels and thrillers for a living at 87. "I gave him the first draft and he said, 'I don't understand it," Shubin said at a winter reading at Harvard Book Store in Cambridge. "He told me, 'Neil, nobody ever lost money writing a page turner.' I said, 'Dad, I'm a scientist. We don't write page turners.' But I wrote it over again. And this time he liked it."

Your Inner Fish, in fact, is something of an adventure tale. It pulls in the reader even though the Tiktaalik discovery took six years and four often frustrating, errorfilled trips into deep wilderness to complete. "For starters, there were polar bears," says Shubin, a city boy from Philadelphia. "And polar bears eat people." On the group's first expedition to the Canadian Arctic, in 1999—which Shubin calls a "colossal bad choice" all around-they took rifles and motion detectors, which they set up in their tents before going to sleep. Not long after, the detectors went off and everyone jumped up, cocked their guns, and raced outside. Nothing was there. This scenario played out at least four times before someone realized that it was not lurking man-eaters setting the detectors off, but ferocious winds. "These detectors were made for suburban New Jersey, not the Arctic," Shubin jokes. "You've just got to learn in fieldwork that you never get it just right."

THAT WASN'T the first field trip to leave a strong impression on him. As a child, he loved going to museums, especially the Academy of Natural Sciences in Philadelphia and the Natural History Museum in New York City. In high school, he worked on an urban archaeological site and "loved ancient Egypt and Tutankhamen and seeing the past inside the dirt," he explains. "Paleontology pulled me into the immediacy of discoveries. If you know where to look, and crack inside the rocks, and find a physical piece of evidence that can change the way we look at our pastthis struck me as very powerful." At

Columbia, he majored in biology and anthropology, which led to paleontology and then doctoral work at Harvard.

In the 1980s, academic research in anatomy and development focused on the relationships between living creatures and fossils on the cellular level, using embryos. "Only a handful of people were doing it, and few as well as those at Harvard," Shubin points out. (This was before new technological tools enabled scientists to work on the molecular level.) His first Harvard-affiliated expedition came in 1983, on the field team of professor of biology and curator of vertebrate paleontology Farish A. Jenkins Jr., who was working in the American West, looking for new sites and early mammals that could help explain how humans developed the ability to chew. Shubin writes that the mammalian method for chewing first emerged in fossil records dating from 225 million to 195 million years ago, in big-headed reptiles that walked on all fours and had bony jaws with teeth that fell out and re-grew throughout their lives.

Having finally learned how to spot bones in the dust, mud, and dirt, Shubin grew eager to lead his own trip. He explored 200-million-year-old Connecticut rocks a half-day's trip away from Cambridge before expanding to Nova Scotia; ultimately, he found enough bones to fill a few shoeboxes among the sandstone cliffs in the Bay of Fundy. Among them was a significant find: a piece of an early mouse-like mammal with a tiny jaw and Remains, and a reconstruction of what researchers believe *Tiktaalik rosea*e looked like as it roamed its corner of the earth millions of years ago

a few teeth best seen under a microscope. The remains of this tritheledont, previously linked only to South Africa, showed it had a human way of chewing food. "I had an idea for field research and Harvard had the resources to support this independent research," he says. "If that hadn't existed, I wouldn't be here talking about all of this today."

By now, his main academic interest was the morphology of the tetrapod limb. Working with the embryos of salamanders, frogs, and fish, Shubin wrote his dissertation on developmental biology and the similarities between fins and limbs. He spent the next two years doing postdoctoral work at the University of California, Berkeley, where he also met and married geologist Michele Seidl '85 (now director of planning for biological sciences at the University of Chicago). An 11-year stint at the University of Pennsylvania followed.

AT PENN, and still searching for the origins of limbed creatures, Shubin focused his sights on the already well-studied Catskill Formation of Pennsylvania. In the Late Devonian age, when Shubin and others say some animals were making the switch from sea to land, this region was akin to today's Amazon River delta, he notes, with many streams draining into a large sea where Pittsburgh now stands. In 1993, he and one of his graduate students, Ted Daeschler, began visiting rock zones recently blasted out by the state transportation department to prepare for more roadways. To their surprise, Shubin relates in *Your Inner Fish*, Daeschler one day found "a marvelous shoulder bone" that they named *Hynerpeton*, Greek for "little creeping animal from Hyner," Pennsylvania.

The two men formed a dynamic partnership—Shubin always pushing on to the next target; Daeschler patiently working to examine a given spot thoroughly. In 1998 they were in Shubin's office, having an academic argument about the next most plausible search sites, when one of them pulled out a geology textbook to prove a point and found a diagram that stopped them short. It showed three places on earth with known Late Devonian freshwater rocks: eastern North America—home of Hynerpeton; the east coast of Greenland (where the earliest known tetrapods had already been found); and well-exposed rocks in the Canadian Arctic that, the duo realized, were unexplored. No paleontological field guides existed for that area, but Shubin knew one man who had led previous trips to Greenland and was experienced enough to help them: Farish Jenkins. (Later that day, Shubin adds, he and Daeschler went to a Chinese restaurant where Shubin's fortune cookie held this gem: "Soon you will be at the top of the world." This slip of paper was taped to his office door for years.)

That first outing, in 1999—the time of the motion-detector debacle, when terrible weather kept the researchers inside tents for three weeks rereading every book they'd brought—was on Melville Island in the western part of the Canadian Arctic. They found plenty of fish fossils, but all appeared to be deep-water dwellers, not the shallows skimmers that ultimately crept on shore.

The following year, better prepared for five weeks in the wild, Shubin, Daeschler, and their team set up camp on Ellesmere Island, with permission from the Inuit people of the Nunavut Territory. One evening, an undergraduate in the party, Jason Downs, failed to return to the base camp on time. "We were very worried, but then he came limping into the cook tent with a wild-eyed stare, like he'd been chased by polar bears," Shubin recalls. "But we knew he hadn't been, because his pockets were full of bones." That same night, the team spent hours (in the Arctic summer, the sun never sets) documenting the site and gathering fragments.

Fast-forward to July 2004. With grant money running out, and the prognosis looking poor, Shubin and Daeschler opted for a fourth and final trip (their third to Ellesmere). Shubin describes cracking ice and rock in the bottom of a quarry one day when he saw a patch of fossilized scales and a jaw-like "blob" in ice unlike any fish mouth he'd ever seen. The next day, while foraging at the top of the same quarry, Shubin's colleague and former fellow graduate student Stephen Gatesy, Ph.D. '89 (now a biology professor at Brown), dug out a piece of rock and "we realized we saw a flat-headed something, something unknown," Shu-

Centennial Salute

One hundred years ago, Henry Lee Higginson, class of 1855, founder of the Boston Symphony Orchestra and donor of Soldiers Field and other gifts to Harvard, became the first president of the Harvard Club of Boston. He and other early club leaders set the tone of solid relations with the University, philanthropicminded ventures, and the promotion of "social intercourse" among Harvard men and, in time, women (at first admitted only to an "annex," in 1940) that remain hallmarks of the club today.

About 400 alumni and guests gathered on March 12 to celebrate the club's centennial with a lavish dinner and listen to remarks by President Drew Faust. When the club founders agreed to "disseminate the standards of education and right living of Harvard University," she told the crowd, they did so at a time when their annual expenses were just over \$1,700---"which would not even pay for our parking bills tonight." But in essence, they "were part of a world of aspirations and initiatives really no different from our own." Among the early recipients of a Harvard Club scholarship for Boston boys, she noted, was James B. Conant, "the Harvard president perhaps best known for opening the University to what he called 'gifted youth of limited means.'" Continuing in that tradition, the club last spring awarded 36 scholarships worth \$4,500 each to incoming freshmen of the class of 2011. The club also recognizes nearly 300 high-school students each year for academic excellence, sponsors 13 summer interns at nonprofit agencies in Greater Boston, and this year plans to launch and fund a Harvard Club of Boston community-service fellowship under the auspices of the Phillips Brooks House Association, says Philip C. Haughey '57, president of the club's board of governors (and a member of this magazine's Board of Incorporators).

The club works actively to retain its 5,272 members and recruit more, especially younger ones. "It is not an easy time for clubs in general, because people have moved to the 'burbs, families are buried in regulated activities with their kids, and it's a challenge to know how best to appeal to young members and their families," Haughey says. The main club on Commonwealth Avenue (built in 1913) offers fitness centers, squash courts, dining, and something to see or do almost every night of the week: from concerts, films, and lectures to sports-oriented events, holiday dinners, and the annual children's Christmas party and father-daughter tea dance. The downtown affiliate on Federal Street also offers dining and events.

A mix of members came to celebrate the centennial. Friends Bruno Marino, Ph.D. '91, and Lewis Lutin, A.L.M. '88, were chatting in the oak-paneled bar. "This place is my home away from home," reported Marino, a scientific entrepreneur who lives in Maine and spends at least one night a week at the club for business reasons. "It's a great place to meet all kinds of people for all kinds of reasons." Lutin, of Falmouth, Massachusetts, added, "I've been coming here every week for 20 years. This place is about friendship." Boston attorney Maura Pelham '00 said she found the majestic rooms, glittering chandeliers, and Old World ambience so beautiful, she joined the club last year mostly so she and her fiancé could bin reports. "It was a snout sticking straight out from the rock."

The team spent the rest of the summer painstakingly chipping away at the rock around the creature so they could wrap up the boulder-cum-fossil and transport it thousands of miles to the lab where, for two months, preparers used dental tools to pick apart the specimen. What was revealed was a creature with eyes on top of its flat head, a neck, upper arm bones, a wrist, parts of a palm, and "an elbow joint that Tiktaalik would've used to push itself up off the substrate, as if it were doing push-ups," Shubin explains. "And it had ribs—larger and more expandable ribs than you'd ever see on a fish." In short, "Tiktaalik is not a random find," he says. "It is a piece of the human story."

To date, the core research team has found about 20 individuals—based on isolated fins, jaws, and other pieces-but only about four really good specimens. "We're the only people working up there and we're going back this summer, in July, in hopes of finding more bones," Shubin says. "You never know what's going to happen when you get there, because of the weather, but the goal is to go to the original site and work on new areas around it" to find slightly younger or slightly older rocks and see if any bones they contain shed light on further developmental changes. The group has found other water-based creaturessome "really bizarre-looking" armored fish, some eight- or nine-foot-long predatory fish, and some fish as tiny as a fingernail.

Shubin is excited that the Tiktaalik find has also inspired other scientists, who are looking at new, undisclosed geological locations for more Late Devonian specimens. "We are beginning to unlock the mechanisms that underlie evolutionary change, so we can ask what is the genetic and developmental recipe that built the human, and how is it different from fish?" he says. "We're at a moment in scientific discovery where we can begin to see that that kind of understanding is possible within our lifetimes, that the basic tool kit and developmental processes are very ancient-that a version of same tool kit that builds a worm builds a human. It's been a remarkable time for paleontology, a very powerful revolution on a lot of scientific fronts."

After his talk at Harvard Book Store. the audience asked Shubin questions that ranged from specifics about Tiktaa*lik's* anatomy to his arctic experiences and plans for the future, to his views on intelligent design and creationism. Did he think his discovery would sway religious beliefs? What should teachers say about Tiktaalik—how is it a scientific tool for students? "No degree of evidence will shift the views of a creationist, " Shubin responded, then added with a laugh, "but if, next to my Tiktaalik, I'd

President Drew Faust addressing a soldout crowd at the Harvard Club of Boston's centennial celebration; the club rolls out the crimson carpet; a delectable Veritas dessert

hold their wedding reception there. "None of my friends are members," she noted, "but I am going to make an effort to get them here." Norton Reamer, M.B.A. '60, a former Radcliffe College trustee who finds the downtown club more convenient for lunch and business meetings, had come to

the main clubhouse primarily to hear Faust in her new role.

The president spoke of making Harvard more affordable, of addressing changes in undergraduate teaching and advising, and of developing the new Allston campus. She discussed the new task force she has charged with defining the role of the arts at a research university and in a liberal-arts education, and laid out the increasingly international nature of

the University on the eve of departing for the Harvard Alumni Association's global series event in China (see page 67).

In closing, she talked about Harvard president Charles William Eliot, the guest speaker at the first annual Harvard Club of Boston dinner, in 1909, not long before he stepped down after 40 years in office."'The University has before it an opportunity to make sure







of continuous growth and continuous

improvement," Faust quoted from his speech."I hope we have accepted his challenge," she declared. "I hope we continue to carry it forward. And I acknowledge the partnership with the Harvard Club of Boston that has made possible the advancement of the University and the continuing of the University....I will look forward to spending more birthdays with you."

found a human skull, then that would be truly devastating" to evolutionists. What about intelligent design? "I don't have time for it because it's not testable, it's not science," Shubin explained. "I have a job to do and that's making hypotheses and going out in the field and finding out if they are true. I became a scientist because I like looking at creatures and discovering new things that tell us about the history of life."

~NELL PORTER BROWN

For Overseer



Lynn Chang

Anne Fadiman **Paul Finnegan**



Robert Freedman

Eve Higginbotham Michael Holland



Anand Mahindra David Oxtoby Regina Montoya

Vote Now

THIS SPRING, alumni will choose five new Harvard Overseers and six new elected directors for the Harvard Alumni Association (HAA) board. The candidates' names appear in ballot order below, as determined by lot.

Ballots, mailed to reach alumni by April 15, must be received back in Cambridge by noon on May 30 to be counted. The results will be announced at the HAA's annual meeting on June 5, on the afternoon of Commencement day. All Harvard degree holders, except Corporation members and officers of instruction and governance, are entitled to vote for Overseer candidates. The election for HAA directors is open to all alumni.

For Overseer (six-year term, five to be elected):

Lynn Chang '75, Newton, Massachusetts. Concert violinist; violin professor.

Paul Finnegan '75, M.B.A. '82, Chicago. Co-CEO, Madison Dearborn Partners, Inc.

Michael Holland '66, New York City. Chairman, Holland and Company LLC.

Anne Fadiman '74, Whately, Massachusetts. Author; Francis writer-in-residence, Yale.

Eve Higginbotham, M.D. '79, Atlanta. Dean and senior vice president for academic affairs, Morehouse School of Medicine; surgery professor.

Regina Montoya, J.D. '79, Dallas. CEO, New America Alliance.

David Oxtoby '72, Claremont, California. President and professor of chemistry, Pomona College.

Anand Mahindra '77, M.B.A. '81. Mumbai, India.

Vice chairman and managing director, Mahindra and Mahindra Limited.

Robert Freedman '62, Philadelphia. Partner, Dechert LLP. (Nominated by petition.)

For Elected Director (three-year term, six to be elected):

Robert Kraft '76, Los Angeles. President, Fox Music.

Kevin Jennings '85, New York City. Founder and executive director, Gay, Lesbian and Straight Education Network (GLSEN).

Alejandro Santo Domingo '99, New York City. Managing director, Quadrant Capital Advisors Inc.

Carolyn Hughes '54, Oceanside, New York. Retired; former project manager, Empire Blue Cross Blue Shield.

Elizabeth Reilly '91, Boston. Attorney, WilmerHale.

Joseph Bae '94, Hong Kong. Member and managing partner, KKR Asia.

Rosa Wu '03, San Francisco. Associate product manager, Google.

Rodney Hardy '60, Minneapolis. Vice president/owner, Sienna Corporation.

Andrea Zopp '78, J.D. '81, Chicago. Senior vice president and chief human resources officer, Exelon Corporation.

For Director



Joseph Bae

Rodney Hardy Carolyn Hughes





Kevin Jennings

Robert Kraft Elizabeth Reilly



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Andrea Zopp