PALEONTOLOGY

Primitive Jawed Fishes Had Teeth of Their Own Design

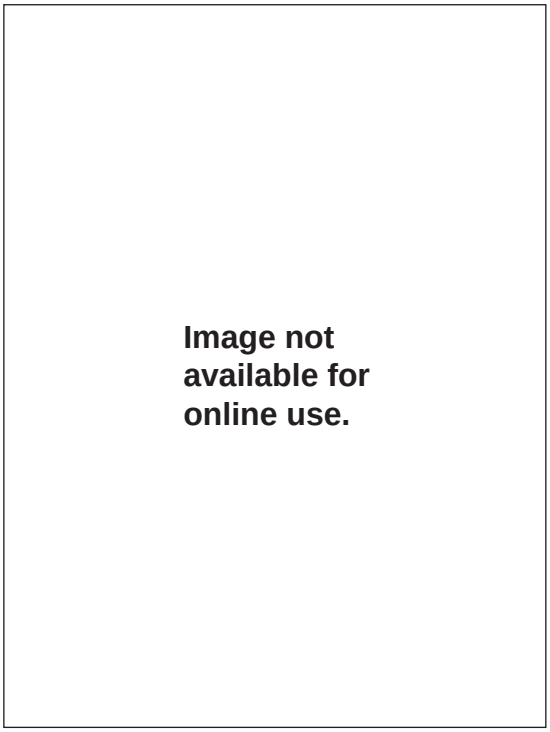
Jagged, straight, artificially whitened—in whatever form they take, teeth are a marvelous invention, enabling us to rip into drumsticks or chew a caramel with abandon. The fact that these complex structures are always organized—into sturdy rows of molars, for instance—has caused researchers to assume that teeth evolved just once, in the common ancestor of jawed vertebrates. But on page 1235, Moya Meredith Smith of King's College London and Zerina Johanson of the Australian Museum in Sydney present evidence that teeth evolved at another time, independently, in a group of extinct jawed fishes called the placoderms.

The finding doesn't reveal how teeth came about, but if they evolved more than once, scientists may need to shake up a significant portion of the vertebrate family tree. "The relationships of the main groups of jawed vertebrates are entering a state of flux," explains Michael Coates of the University of Chicago.

Some 408 million years ago, armored fish known as placoderms ruled the Devonian seas. The first jawed vertebrates, they caught their prey with impressive bumpy gums or bony cutting blades and tusklike structures made of so-called semidentine. Teeth were believed to have evolved—as a better way to capture prey—in a relative of placoderms, one that gave rise to all of the other major groups of jawed vertebrates, such as sharks, bony fishes, and the extinct acanthodians.

Now, Meredith Smith and Johanson have evidence that a group of advanced forms of placoderms, the *Arthrodira*, had true teeth. Instead of a random assortment of small spikes called denticles, they sported conical structures arranged in rows. In studying the tooth wear on well-preserved specimens from western Australia, the scientists realized that two members of this group added new teeth to the end of a row, like a pattern seen today in lungfish. Meredith Smith was able to slice through a few teeth and show that they are made of regular dentine, not semidentine.

Still, placoderms differed from living toothed vertebrates in several ways. New placoderm teeth took root in the back of the mouth, not along the margin of the jaw, says John Maisey of the American Museum of Natural History in New York City. Meredith Smith thinks that new specimens may resolve the difference. In any case, the presence of teeth in advanced placoderms—and their absence in more ancestral forms—indicate that they originated independently of other jawed vertebrates, Meredith Smith and Johanson say.



Pearly gape. Some of the extinct fish called placoderms evolved teeth independently.

Philippe Janvier of the National Museum of Natural History in Paris, as well as Coates, cautions that the independent origin of placoderm teeth depends in part on placoderm phylogeny, which he says has not yet been rigorously established. If the *Arthrodira* are not as advanced as is currently thought, their teeth may have arisen from the same ancestor as all of the other jawed vertebrates, not independently.

Meredith Smith and Johanson are planning to reanalyze the placoderm family tree. Meanwhile, they speculate that teeth might have originated three or more times among jawed vertebrates. For instance, because some acanthodians lacked teeth and early sharks may have too, the researchers believe that these and other groups could have acquired teeth on their own. That wouldn't surprise evolutionary biologist Jukka Jernvall, who studies tooth development at the University of Helsinki, Finland. "Multiple origin of all the things that have something to do with teeth seems to be an emerging theme in evolutionary biology," he says.

Each case may not be entirely de novo, however. Meredith Smith and Johanson speculate that although many of the basic genetic tools needed to make teeth might have evolved just once, the coordination that creates ordered patterns may be unique to each group. "We hope our work will be a spur to considering the development of teeth across a wider range of jawed vertebrates," Johanson says. **–ERIK STOKSTAD**

MICROBIAL FORENSICS

Report Spells Out How to Fight Biocrimes

DENVER, COLORADO—Catching bioterrorists will require changes from the crime scene to the courtroom, according to a new report that concludes that the United States is not sufficiently prepared to combat biocrimes. It may also require scientists to band together in a new discipline.

The report,* presented at the annual meeting of the American Association for the Advancement of Science here on 16 February (see p. 1177), outlines ways to detect outbreaks rapidly, handle evidence correctly, and use it to track down and prosecute the perpetrators. It's intended as a wake-up call in the aftermath of the October 2001 anthrax letters that killed five people and paralyzed the U.S. Senate. The government response to past bioattacks has been "reactive," says committee chair Paul Keim, a microbial geneticist at Northern Arizona University in Flagstaff who helped the FBI analyze samples after the anthrax attacks (*Science*, 30 November 2001, p. 1810). "We'd like a more proactive approach," he says, one that unites federal agencies such as the FBI and the Centers for Disease Control and Prevention with local police, health departments, physicians, and scientists.

The rarity of biocrimes has prevented the buildup of sufficient expertise in microbial forensics, says panel member and FBI researcher Bruce Budowle. Nor are doctors and public health workers equipped to deal with evidence, he says, noting that valuable clues for criminal investigators, such as a bug's precise genomic makeup, may have little medical or epidemiological value.

The American Society for Microbiology ▶

* *Microbial Forensics: A Scientific Assessment.*

CREDIT: J. WINANS

convened the panel in June 2002 to bring together forensics experts and microbiologists. The group advises that first responders must learn how to secure evidence, and that reliable test kits to confirm an outbreak are needed. Because genomic information can help pinpoint the source of an organism, the genomes of at least three different strains of each pathogen and up to 20 for the nastiest ones should be sequenced. And it calls for more basic research into how to exploit genetic variation in forensic work.

Hot pursuit. Microbiological clues, if scrutinized correctly, may help catch bioterrorists.

Before a suspect is brought to trial, the panel says, labs must improve quality-assurance and -control procedures to make sure they have reliable evidence that stands up in court. And new forensic techniques should be scrutinized by independent scientists. The panel's recommendations would apply to a wide range of biocrimes, Keim says, such as using HIV as a murder weapon and tampering with crops and livestock produced for human food.

The report "is an excellent step" because it makes the "specific tactical recommendations [needed] to push this field forward," says forensics expert Randall Murch of the Institute for Defense Analysis in Alexandria, Virginia, a former deputy director of the FBI forensics lab. But more is needed, he adds, including a national summit to establish microbial forensics as a new scientific discipline. The specialty would combine expertise in conventional forensics with knowledge from microbial genomics, phylogenetics, and informatics.

Some of the panel's recommendations are already being implemented, Budowle says. The FBI and the Department of Defense have established a collection of strains, for example, and beefed up biodefense research at the U.S. Army Medical Research Institute of Infectious Diseases in Fort Detrick, Maryland.

–MARTIN ENSERINK AND DAN FERBER

EVOLUTION

How Global Change Shaped the Squirrel Family

Wild yet cosmopolitan, squirrels are a diverse bunch. Ranging in size from just 15 grams to 7.5 kilograms, they and their relatives are adapted to many settings. Some are ground based and some live in trees; a few even soar through the air. Evolutionary biologists now have good evidence that shifting continents and global climate changes have helped create the diversity of the 273 species in this family.

John Mercer and V. Louise Roth of Duke University in Durham, North Carolina, after studying how these species are related, constructed an evolutionary tree or phylogeny and dated major events. They found that key branches of the tree sprouted in parallel with geologic and climate changes, they report online this week in *Science* (www.sciencemag.org/cgi/content/abstract/1079705).

Global influences. Flying squirrels and their relatives trace their heritage to past habitat changes.

In addition to offering a long-awaited phylogeny on squirrels, the results are exciting because they "provide a plausible and provocative scenario for the diversification of squirrels," says Richard Thorington, a mammalogist at the Smithsonian Institution National Museum of Natural History in Washington, D.C. For example, the data show that squirrels became common in South America only after the continent became connected ▶

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ScienceScope

Researchers Want Fishing Curbs to Protect Turtles

More than 400 marine scientists want the United Nations (U.N.) to arrange a moratorium on fishing techniques accused of driving the Pacific leatherback turtle to near-extinction. A petition unveiled at last week's American Association for the Advancement of Science (AAAS, publisher of *Science*) annual meeting in Denver, Colorado, calls on the U.N. to work with its members to impose a temporary Pacific Ocean ban on gillnets and longlines bearing thousands of hooks. Researchers say the two techniques have helped shrink leatherback breeding stocks by 95% since 1980.

Surveys suggest that there are only 5000 nesting female leatherbacks left in the Pacific. "There are just too many hooks adrift to give the leatherback a fighting chance," says Todd Steiner of the nonprofit Turtle Island Restoration Network, noting that longliners set up to 2 billion hooks per year.

The researchers point to U.N. efforts to achieve a global ban on high-seas drift netting in the 1990s as evidence of the organization's clout. A response to the petition could come as early as next week, when delegates to the U.N.'s fisheries body meet in Rome, Italy.

–DAVID MALAKOFF

Congress Clamps Down on Pentagon Computer Research

Congress has placed strict limits on a controversial Pentagon research project to develop database-combing software that could help spot terrorists. Last week's 2003 budget bill (see p. 1160) blocks the Pentagon from continuing its Total Information Awareness project until it files a detailed report with Congress. It's also barred from fielding the tool to investigate U.S. citizens.

A bipartisan group of congressional critics has argued that the project, sponsored by the Defense Advanced Research Projects Agency (DARPA), could infringe on privacy and civil liberties. Adding to concerns was DARPA's choice to lead the project: retired Admiral John Poindexter, who was convicted of lying to Congress during the Reagan Administration.

Poindexter's conviction was later reversed, but he couldn't convince Congress to trust DARPA. Under language championed by Senators Ron Wyden (D–OR) and Charles Grassley (R–IA), the agency has 90 days to deliver a report on the project's goals, price tag, and legal ramifications. Congress, says Grassley, "won't sit on its hands as [this program] moves forward."

–DAVID MALAKOFF