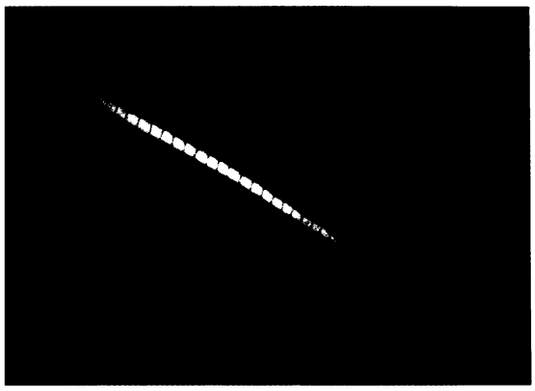
Vertebrates' Cousin Shares Key Genes



M. Dale Stokes/Scripps

Male adult amphioxus (1.5 inches long) from the sands of Tampa Bay, Fla.

Whether a scientist or a romantic, one cannot help but marvel at the incredible diversity of Earth's organisms. Worms seem nothing like elephants; eagles bear little resemblance to octopuses. Yet research reported this week reveals how nature improvises with certain genetic material, called homeobox (hox) genes, to create this variety.

The number and locations of hox genes and their DNA sequences in a wormlike, seemingly headless creature called amphioxus place this animal as a missing link — genetically speaking — between animals with backbones and animals without. Furthermore, the genetic makeup of amphioxus indicates that multiple copies of hox genes and of sets of these genes may drive the evolution of ever more complex animals, says Peter W.H. Holland of the University of Reading in England.

For more than a century, biologists have debated the status of amphioxus as a close relative of vertebrates, basing their arguments on morphological and biochemical studies. While at the University of Oxford in England, Jordi Garcia-Fernández and Peter Holland joined in by tracking down this animal's hox genes. They first found nine hoxlike DNA fragments by using a technique called polymerase chain reaction. Further screening revealed one more, for 10 in all, they report in the Aug. 18 NATURE.

The protein products of hox genes control the activation of other genes, ensuring that various body parts develop in the appropriate places. "These are the blueprint genes," explains Nicholas D. Holland, a zoologist at the Scripps Institution of Oceanography in La Jolla, Calif.

In cells, genes belonging to one chromosome are strung like beads on a necklace, often with other bits of DNA interspersed. In nematodes, a single chromosomal necklace contains all the hox genes. In all the animals now studied, the order of the beads reflects the order in which each gene is expressed along the developing embryo's head-to-tail axis; however, mammals and other vertebrates possess four such chromosomes, each with its own set of hox genes.

To determine whether the amphioxus hox genes lay on one chromosome, Garcia-Fernández carried out a "chromosome walk," a tedious analytical technique for determining the order and position of genes. He and Peter Holland found that, indeed, these genes do cluster. Also, surprisingly, the DNA sequences of these 10 matched closely the sequences of mammalian hox genes, even though the lineages of vertebrates and amphioxus separated 520 million years ago, says Garcia-Fernández, now at the University of Barcelona in Spain. Because mammalian clusters can contain 13 hox genes, the two scientists hope to find three more in amphioxus.

Like nematodes, amphioxus uses a single set of hox genes. But unlike fellow invertebrates' genes, amphioxus' set closely resembles those of vertebrates, says Peter Holland.

The DNA of the modern-day amphioxus does in fact reflect the makeup of the invertebrate ancestor of all vertebrates, comments John W. Pendleton, a molecular biologist at the Oregon Regional Primate Research Center in Beaverton. As a result, "I think the status of amphioxus as an archetypal primitive chordate [an animal possessing a primitive spinal cord and neural tube at some point during its development] will be more accepted," he adds.

In mammals, the hox genes at each position in each of the four sets resemble those at comparable positions in the other sets, suggesting that the multiple sets arose as duplicates of the original, Peter Holland explains. Fish, birds, amphibians, and other vertebrates also have multiple sets. He wonders whether other groups of genes have expanded similarly in vertebrates. Moreover, some hox genes seen in amphioxus look as if they arose first as duplicates of other hox genes.

Thus this discovery in amphioxus indicates that the evolution of more complex organisms proceeded in parallel with the increasing complexity of hox genes. "The idea is that by gene duplication, you could suddenly make really major steps in evolution," Nicholas Holland explains.

Hox genes in particular increase the flexibility of the developmental process. "And development is the currency of evolution," says Pendleton.

"If you fiddle around with genes at [the hox] level, there are all sorts of opportunities for massive and very rapid advances," Nicholas Holland adds.

— E. Pennisi

Large meteorite scar identified in Virginia

If geologist C. Wylie Poag is correct, the Chesapeake Bay owes its existence to an ancient splash.

The U.S. Geological Survey (USGS) researcher from Woods Hole, Mass., and his colleagues have uncovered evidence that a large buried crater underlies the southern section of the bay. According to their theory, a meteorite impact in this spot 35 million years ago determined subsequent river flow in the mid-Atlantic region, causing them to drain toward the present position of the bay.

Poag first uncovered signs of the crash several years ago while studying rock samples pulled up from drilling operations in southern Virginia. The drill cores revealed an unusual layer of jumbled sediments and boulders, called breccias, from the late Eocene period.

Because he was studying a meteorite crater of the same age located off the coast of New Jersey (SN: 11/14/92, p.334), Poag reasoned that the Virginia breccias formed during a tsunami triggered by the same offshore impact. In the late Eocene, eastern Virginia would have been underwater, with the coastline sitting more than 100 kilometers to the west.

Poag changed his mind after examining the results of seismic studies that imaged the rocks beneath the Chesapeake Bay. Oil companies had collected such information by sending seismic waves down into Earth and measuring the vibrations that reflect off buried structures.

These seismic reflection studies revealed a pattern of faults that form concentric circles, similar to a well-known impact crater in Germany, report Poag and his colleagues in the August GEOLOGY. "This shows clearly that there is a large impact crater in the southern part of the Chesapeake Bay," says Poag, who titled his paper "Meteoroid mayhem in Ole Virginny."

Judging from the span of the rings, the USGS geologists calculate that the crater measures 85 kilometers across, filling an area larger than Rhode Island. A structure this size would rank as the largest crater in the United States and among the top 10 known on Earth.

It might also explain a puzzling triangle of impact debris stretching from New Jersey to Texas to Barbados. Within this

large region, geologists have discovered a layer of tektites — distinctive rocks thrown into the air by an impact — dating to the late Eocene period. Poag and his colleagues propose that the crash at the southern end of the Chesapeake Bay created this vast field of tektites.

Poag's report has made a splash among other geologists, who would welcome the opportunity to study a large, relatively young crater. But the limited evidence has yet to bowl over most scientists. "It's not obvious that we're dealing with an impact deposit," comments Richard A.F. Grieve, who studies craters for the Geological Survey of Canada in Ottawa.

Grieve and his coworkers are currently studying rock samples from the Virginia breccias. They are looking for "shocked" mineral grains, which bear distinctive fracture patterns formed by the high-pressure shock waves generated during impacts. A preliminary search has not turned up clear examples of any shocked grains, but his group will continue this work for the next several weeks.

Lacking any shocked minerals, Poag may have a difficult time making his case. Grieve remains skeptical about the seismic reflection data because such images are equivocal. "Seismics are a matter of interpretation. People see what they want to see," he says. — *R. Monastersky*

Dante rescued from volcano

After all the high-tech, attention-grabbing wizardry, the saga of the robot Dante 2 ultimately ended with two humans climbing into a volcano on foot last week to retrieve the disabled machine.

Built by researchers at Carnegie Mellon University in Pittsburgh, Dante had crawled into the crater of Alaska's Mt. Spurr in late July. The eight-legged, spiderlike walker spent 8 days navigating 660 feet down the steep slopes and analyzing gases escaping from the floor of the crater. After completing its mission, Dante started its ascent. It had scaled 250 feet of the return route before rolling over on Aug. 5 (SN: 8/13/94, p.101).

The Dante crew first tried airlifting the robot using its tether, a power and communications umbilical cord designed to hold the 1,700-pound machine. But the tether inexplicably snapped during the attempted rescue. After waiting for the weather to clear, project manager John E. Bares and an Alaska National Guardsman hiked into the crater on Aug. 13. They rigged the robot to a line from a helicopter, which then flew Dante 2 to Anchorage. — *R. Monastersky*

Polymers grafted by interlocking strands

They run along the edges of outdoor gear, the tops of sneakers, the borders of bags. These fasteners — Velcro being the best-known brand — have two strips: one bristly and one fuzzy. Pressed together, they stick, as tiny hooks on the rough side grasp the soft side's looping threads.

Designed properly, polymers can join in the same way: Their surfaces can bear the molecular equivalents of hooks and threads.

Dilip Gersappe, a materials scientist at the University of Pittsburgh, and his colleagues describe a new method for grafting polymers with interlaced strands. A report on what they call "molecular Velcro" appears in the Aug. 19 SCIENCE.

"At the molecular level, it's like joining your hands together by interlocking your fingers," says coauthor Anna C. Balazs, also a Pittsburgh materials scientist. "Think of each hand as a different polymer, and think of your fingers as the strands that hook them together."

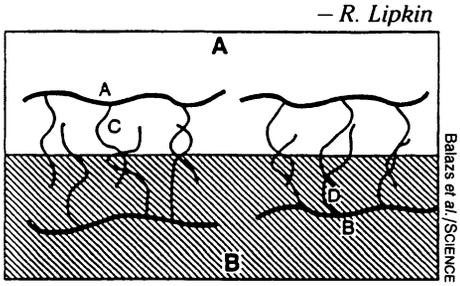
To create such a polymer concoction, the researchers used three compounds that otherwise do not mix: two "homopolymers," A and B, and a third "copolymer," C. When blended together, polymers A and B each form tiny globules surrounded by polymer C. The grafts occur when polymer C binds the surfaces of A and B.

The researchers first modeled the hook and loop interaction on a computer. Then they mixed up suitable polymers, Balazs says. For homopolymers A and B, they used deuterated poly(ethyl acrylate)(d-PEA) and poly(methyl methacrylate)(d-PMMA), respectively. For copolymer C they combined PEA-polystyrene(PS) and PMMA-PS. They subsequently blended, cooked, and cooled various combinations of the polymers and then tested them for their physical properties.

Interestingly, the scientists found that these bonds "significantly improved the structural integrity and mechanical properties" of the materials. The new polymer blend proved stronger, more pliant, and less likely to snap than either of the homopolymers.

"What's nice about this technique is that it's very general," Balazs says. "It will work for a whole class of materials."

— *R. Lipkin*



Balazs et al./SCIENCE

Polymer A grafts to polymer B via strands of polymer C.

Chronic depression: Drugs show promise

A majority of people who struggle through recurring periods of major depression for years, often returning to a low-grade sadness between episodes, improve markedly during 12 weeks of antidepressant drug treatment, according to early results from the largest-ever clinical trial aimed at relieving this debilitating condition.

"To get such a high response to weekly antidepressant administration with no psychotherapy was absolutely striking," asserts Martin Keller, a psychiatrist at Brown University in Providence, R.I., and director of the ongoing multicenter study. "These people had been depressed for an average of 17 years."

Keller and his colleagues described their preliminary findings at the annual meeting of the American Psychological Association in Los Angeles last week.

About one in three cases of depression lasts more than 2 years and is classed as "chronic," Keller says. Some individuals suffer bouts of major depression that last for months or years at a time; some experience a persistent, moderate sadness known as dysthymia; and others encounter "double depression," in which at least 2 years of dysthymia lead to recurring major depression.

Chronic depression afflicts an estimated 3 percent to 5 percent of people in the United States at some time in their lives. However, scant research has examined either drug or psychotherapeutic treatments for this condition.

The new project, which began in April 1993, consists of 300 people with double depression and 240 with chronic major depression who sought help at one of 12 medical centers throughout the country. Two-thirds of each group took sertraline, a chemical cousin of Prozac (fluoxetine), for 12 weeks; the rest received imipramine, from another class of antidepressants, also for 12 weeks. Physicians adjusted the dose, if needed, on a weekly basis.

Another 16 weekly drug doses follow, after which clinicians administer antidepressants as needed for 76 weeks.

Volunteers who discontinue one antidepressant can switch to the other.

The data reported by Keller cover treatment for 89 individuals with chronic major depression and 123 with double depression. Most had attended college, yet about 30 percent had no job. A large majority were unmarried.

Approximately two-thirds of both depressed groups showed a significant lessening of their symptoms by the end of 12 weeks, Keller notes. The rest decided to stop receiving their assigned antidepressant, although most of these volunteers agreed to give the alternative drug a try.