Evans of the University of Texas Southwestern Medical Center at Dallas. Both had genome center grants before NHGRI's pilot projects began in 1996. And they worked hard last year, with half a dozen others, to meet NHGRI requirements that each center should complete 7.5 megabases of finished sequence data. But last fall, the NHGRI advisory council decided to rank the competitors for new grants in two groups: those that had at least 15 megabases of sequence under their belt, and those that did not. That put some—including Evans and Roe—in the second tier, still awaiting funding. Although Evans applauds NHGRI's fast-paced approach, he also feels a bit left out in the cold. "It's kind of upsetting for all of us," he says.

When the deadline for completing the human genome rolls around next year, some researchers fear that interest in closing gaps in the data and removing errors will fade. Evans, for example, worries that a highly accurate, complete version of the genome may never be done. But Collins thinks these worries are not justified. "We didn't intend to pull the plug on the other centers," he says, although he does not know how much money will be available for them. And he insists that next year's draft genome is on "a direct path" to the goal of producing a polished, error-free version. Morgan agrees: "We are determined to finish," he says. **–ELIZABETH PENNISI**

With reporting by Dennis Normile.

EVOLUTION

From a Flatworm, New Clues on Animal Origins

One of nature's more enduring mysteries has been how millipedes, mollusks, snakes, and butterflies came to be. The fossil record shows an eruption of diversity of such groups—all of which have bilaterally symmetrical bodies—during the Cambrian explosion, some 530 million years ago. But fossils of the very first such creatures have been scarce. Now, a living creature, a humble flatworm, may provide some key clues.

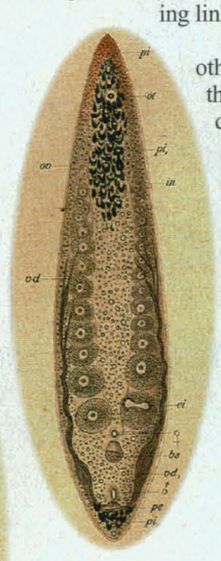
As Jaume Baguñà, a geneticist at the University of Barcelona in Spain, and his colleagues report on page 1919, tiny marine worms called acoels may be one of the closest living representatives of the first bilaterally symmetrical organisms on Earth. Acoels are usually grouped with Platyhelminthes, a group that includes such unpleasant parasites as tapeworms and liver flukes, and whose position in the tree of life has been subject to debate. But using DNA analyses, Baguñà's team concludes not only that the acoels don't belong with other flatworms, but that they alone represent a living relic of the transition between radially symmetrical animals such as jellyfish and more complex bilateral organisms such as vertebrates and arthropods.

Putting acoels in this key position "is going to stimulate a lot of research," predicts Julian Smith III, an invertebrate zoologist at Winthrop University in Rock Hill, South Carolina. The results are "quite exciting," agrees David Jablonski, a paleontologist at the University of Chicago. "We might have one bilateral survivor from before the Cambrian explosion giving us a living window on early metazoan life."

Baguñà and Timothy Littlewood, a molecular biologist at The Natural History Museum in London, decided to use molecular studies to evaluate the acoel's placement on the tree of life because anatomical data—including simpler brains, kinked cilia, and a different pattern of development—suggest that acoels may differ from other flatworms. The pair obtained DNA from 18 acoel species from around the world and sequenced the gene for the 18*S* ribosomal RNA subunit from each. They then compared these data to the same genes from other platyhelminths and from both simpler and more complex organisms.

The team first removed 16 fast-evolving acoel species from the analysis, because their DNA sequences were so different from those of simpler organisms that the phylogenetic analyses would be suspect. When they used only the two slow-evolving species to represent the group, "the acoels dropped out completely from the rest of the platyhelminths," notes Mark Martindale, a developmental biologist from the University of Hawaii, Honolulu. The worms ended up branching off from an ancestral animal after the radial jellyfish and their cousins, but before the three major bilateral groups, today encompassing vertebrates, mollusks, and arthropods, began to diverge. By moving into this prime spot on the animal tree of life—close to the first bilateral animal—the acoels and their idiosyncrasies take on new meaning for evolutionary biologists, offering a living link between primitive and more complex animals, says Martindale.

For example, primitive, radially symmetrical animals have just two types of cells, ectoderm and endoderm, whereas all bilateral animals, including acoels, also have mesoderm. Most of those with three layers have a distinct gut lined with mesoderm, but acoels have mesoderm but no true gut. "They may be some sort of 'missing link,' " says Littlewood.



Living relics. Acoel flatworms, shown in 19th century drawings.

Acoels also differ from other bilateral animals in the way their cells divide during development. During the early cell divisions (called cleavage) of related bilateral animals, the fertilized egg forms two, then four cells. Then each of those cells gives rise to many small cells, explains Martindale. But the acoel egg divides once, and the two resulting cells immediately generate many small cells. "They have a spiral cleavage pattern that's different," and may have evolved separately from the pattern seen in most bilateral organisms, says Martindale. That suggests that acoels branched off from all other bilateral animals very early indeed, and that their cleavage pattern represents an early experiment in the evolution of body form. The acoels would therefore possess many of the same genes as the earliest bilateral animal. "It's beginning to look like we are looking at something close to the fuse for the Cambrian explosion," Jablonski suggests.

If so, then acoel biology may offer clues as to which traits evolved first in evolutionary history. Acoels go directly from egg to the adult form, skipping the larval stage seen in many more complex organisms, including some platyhelminths. That suggests that larvae evolved later in the tree of life.

For all these reasons and more, acoels

CREDIT: L. VON GRAFF, *MONOGRAPHIE DER TURBELLARIEN* (1882)

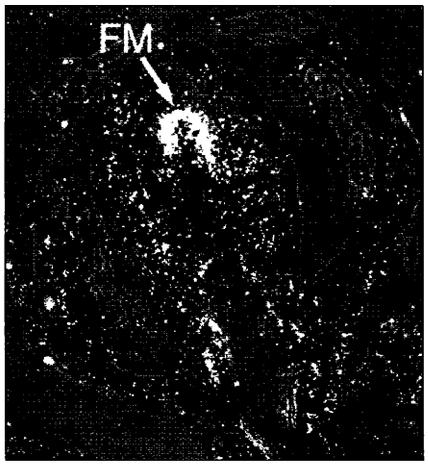
are now quite likely to get more notice. Although the shift out of the Platyhelminthes won't come as a surprise to some, "it will grab the people who teach general biology and shake them up," predicts Smith. Baguñà thinks the group belongs in its own phylum, but Smith notes that a few other so-called platyhelminths may belong with them. And he would like to see more evidence that the acoels, which have a variety of reproductive strategies, are truly simple. "This is a very strange and diverse set of organisms to be finding as a basal group," he says. But he agrees that acoels will have their day in the limelight. Says Jablonski, "Acoels have gone from being an obscure group to one that can provide potentially great insight into the radiation [of multicellular animals]."

–ELIZABETH PENNISI

PLANT BIOLOGY

Key Molecular Signals Identified in Plants

Biologists trying to trace the communication systems that tell plant cells to develop into a leaf or a fruit or a flower, or to fight off deadly pathogens, have found some of the crucial switches and relays but don't know where the wires go. They have identified dozens of proteins called receptor kinases that receive signals from outside the cell, but they've had little luck in finding the signals that trigger specific receptors, or in tracing what happens in the cell once the receptor is activated. Now, two teams report advances toward putting together one such pathway for the plant *Arabidopsis thaliana*.



Partnerless. The bright areas show *CLV1* messenger RNA in a *CLV3* mutant flower meristem (FM)—evidence that CLV1 is present, although it is inactive in the absence of CLV3.

CREDITS: (TOP TO BOTTOM) R. STONE; FLETCHER *ET AL.*

The pathway in question helps control the growth of the specialized region at the tip of the shoot, called the apical meristem, that gives rise to such plant organs as the leaves and flowers. Geneticists have found three genes in that pathway, which were named *CLAVATA* after the Latin "clavatus," for "club," because mutations in the genes cause the meristem to become enlarged and club-shaped. Two years ago, researchers cloned one of the genes, *CLAVATA1 (CLV1)*, and concluded from its sequence that it encodes a receptor kinase. Now, Elliot Meyerowitz of the California Institute of Technology in Pasadena, Rüdiger Simon of the University of Cologne in Germany, and their colleagues report on page 1911 that a protein called CLAVATA3 (CLV3) seems to be the signal, or ligand, that activates the receptor. And in the March issue of *The Plant Cell*, Steven Clark and his colleagues at the University of Michigan, Ann Arbor, announce that they have found two proteins inside the cell that associate with activated CLV1 and presumably help set in motion the intracellular events that keep meristem size in check.

"It is a big advance," says Joanne Chory, who studies plant receptors at the Salk Institute in La Jolla, California. Adds plant biologist John Walker of the University of Missouri, Columbia: "This is giving us direct insight into the mechanism of how [meristem growth control] works." That in turn may pave the way for altering such agriculturally important traits as fruit size and yield. What's more, the new information will also help researchers figure out how similar receptor kinases that control other plant functions work.

Even though many plant receptors resemble those that respond to extracellular signals in animal cells—a similarity researchers used to identify CLV1 and other plant receptor kinases—the match is not perfect. The disparities mean that plant researchers cannot conclude from the comparison alone what signals trigger the receptors, or which molecules relay their downstream effects.

Simon's and Meyerowitz's teams have moved the field beyond that impasse, at least for CLV1, by cloning the *CLV3* gene. Genetic analysis had already hinted that CLV3 interacts directly with CLV1, and the gene's sequence suggests that *CLV3* encodes a small protein ligand, says Meyerowitz postdoc and lead author on the paper, Jennifer Fletcher.

CLV3 has the hallmarks of a protein that is secreted from cells, and it is made in a different region of the meristem than CLV1. Both of these findings, plus others in the paper, suggest that CLV3 is an extracellular signal that travels to exert its effects on CLV1. The researchers have not yet shown that CLV3 binds to CLV1, and until they do, it remains possible that it helps to synthesize or somehow aids the binding of an as-yet-unknown ligand. Nevertheless, "it is very likely" that CLV3 is the ligand, says plant

ScienceScope

Making Science Pay Russia's applied researchers can look forward to government initiatives to make their work pay for itself. Last week, Science Minister Mikhail Kirpichnikov sketched out plans to support applied research by moving into new commercial ventures, and announced that the German government has promised to lend Russia 100 million marks ($56 million) to buy scientific equipment over the next 2 years.

Kirpichnikov has talked much about weaning Russia's dwindling scientific corps off of state support (*Science*, 11 December 1998, p. 1979). Now nearly a half-year into his tenure as minister, he's taking the first steps toward that goal. His ministry, with the Economics Ministry and the Russian Academy of Sciences, has proposed forming a governmental commission to ram through tax incentives to encourage entrepreneurial research—a goal shared by the Duma, which is drafting legislation to that effect.

Eleventh-Hour Reprieve? Taking the smallpox virus off death row could serve science, says a U.S. government advisory panel. The finding, released this week, could aid scientists seeking to delay the planned destruction this June of the last two research stocks of the dreaded virus.

Since it was eradicated 2 decades ago, the variola virus has been bottled up like a genie at two high-security labs in the United States and Russia. In 1993, the World Health Organization ordered the stocks destroyed to prevent future outbreaks from their accidental—or intentional—release. But some researchers say variola should be spared, particularly because it might be useful in preparing defenses against smallpox weapons. This week, the preservationists won a small victory: Although it didn't give a direct opinion on what should happen to the stocks, an Institute of Medicine panel concluded that live variola could play an "essential role" in developing new drugs and vaccines. But destruction proponents, such as D. A. Henderson of Johns Hopkins University, say the report is unconvincing.

Now it's up to President Bill Clinton—who has said White House policy will be guided by the new report—to decide what will happen to the U.S.'s smallpox cache.

Contributors: Andrei Ol'khovatov, Eliot Marshall