Embryonic growth: Cues and miscues

If this were a monster movie, the opening scene would surely grab the audience. In a quiet laboratory, scientists snip a piece of tissue from a blob of cells destined to develop into a tadpole. Normally, the tissue could only form skin cells, but the scientists have other designs for this embryonic fragment. After soaking in a solution of nutrients and mouse cells, the cultured tissue elongates – the first sign that something out of the ordinary has happened. The next day, an amphibian mouth takes shape at one end, and the other end begins twitching. The outline of a brain appears 24 hours later. And finally, the *pièce de résistance:* Within the mass emerges the unmistakable black eyeball of a tadpole peering out of the petri dish.

The scenario is science, not fiction.

In the Aug. 3 SCIENCE, three researchers report that they have isolated a mouse protein that alters the fate of cultured epidermal tissue from frog embryos. Instead of making skin, the tissue forms an "embryoid" – a miniature embryo including muscle, nerves and even eyes.

"It's quite an amazing transformation to start with just skin cells and then make [organized parts of] an embryo," says Douglas A. Melton of Harvard University, who did the work with graduate student Sergei Sokol and Gordon G. Wong of the Genetics Institute in Cambridge, Mass.

Since 1987, several research groups have identified peptide growth factors, all derived from adult frogs, that trigger development of nerve cells when added to cultured frog embryonic tissue, Melton notes – but none of the compounds induced eye and brain formation. Moreover, he says, the new work marks the first time researchers have isolated from another animal a growth factor that induces changes in frog embryos.

The results suggest that the mouse-derived protein, known as PIF, may occur naturally and play a similar role in several animal species, Melton asserts. He cautions, however, that researchers have not yet tested PIF's ability to alter embryonic tissue from mice.

While scientists have speculated that an assortment of growth factors may occur naturally in embryos to direct cell development, none of these compounds had been detected in untreated, normally developing tissue. But Melton told SCIENCE NEWS that he and other co-workers recently cloned a gene from intact frog embryos and found that this gene induces cells predisposed to forming skin tissue to make nerve tissue and muscles instead.

The protein encoded by this naturally occurring gene, he says, "is virtually identical to" the mouse-derived PIF, clinching the protein's role in guiding embryonic development.

Melton thinks PIF influences one of the earliest and most crucial stages in amphibian embryo development. Newly fertilized frog eggs hold only two kinds of cells – endodermal and ectodermal. Endodermal cells form the gut, while ectodermal cells, if left to their own devices, form skin. But when ectodermal cells receive chemical cues from adjacent endodermal cells, they transform into cells that make nerve and muscle tissue.

PIF appears to resemble the critical chemical signal produced by endodermal cells, Melton says. Alternatively, PIF may act indirectly, triggering endodermal cells to secrete other essential chemical cues. "Without PIF, there would be no further development – only skin and guts, without bone, muscles or nerves," he notes. Melton suggests that several growth factors may work at different stages to ensure proper embryo development.

The team is now examining PIF's similarity to a recently characterized protein that also transforms cultured ectodermal cells into nerve- and muscle-makers. Jack C. Smith and his co-workers at Innogenetics in Ghent, Belgium, and the National Institute for Medical Research in London, England, report in the June 21 NATURE that this compound, known as XTC-MIF, appears structurally similar to activin, a human growth factor. Innogenetics researchers who collaborated with Dutch scientists describe identical results in the same issue. *– R. Cowen*

Heat spikes: Fusers chill, rocketeers cheer

A phenomenon that puzzled and hindered a team of laser-fusion scientists may give a new boost to rocket research. Propellants two to four times as energy-rich as any used today could emerge from the mystery's recent solution, a NASA program manager says, allowing engineers to develop significantly smaller and less expensive rockets to carry hefty payloads.

The discovery that has fired rocketeers' interest comes from Lawrence Livermore (Calif.) National Laboratory, where researchers have been trying to develop new targets for inertial-confinement fusion. In the course of that work, they found surges of heat within frozen hydrogen targets that they had hoped to use as fusion fuel sources.

In inertial-confinement fusion, laser or ion beams bombard a tiny hydrogen pellet from all sides simultaneously to implode it. This can create enough heat and pressure to force the hydrogen nuclei to fuse and form helium nuclei, a process that releases enormous amounts of energy. So far, however, attempts at inertial-confinement fusion have failed to yield more energy than they consume.

Gilbert W. Collins, P. Clark Souers and their colleagues were seeking to improve their mixtures of the frozen hydrogen isotopes deuterium and tritium by aligning the nuclear spins of the molecular hydrogen lattice in a special arrangement. Theoretically, nuclei in a "spin-polarized" lattice would fuse at only half the laser power required for other targets.

The researchers tried harnessing free-roaming hydrogen atoms within the lattice to influence the spins of their paired molecular cousins, but the troublesome heat bursts continually interfered. Sometimes the spikes arose spontaneously; at other times they followed modest heating or a rapid change in the magnetic field used to align spins.

"The heat spikes were driving us up a wall," Collins says.

A NASA scientist had reported similar energy surges 14 years ago, and two theorists had proposed that the heat resulted when free hydrogen atoms suddenly combined *en masse* into hydrogen molecules. That work was largely forgotten, Collins says, but it ultimately provided the explanation for the heat spikes detected at Livermore. Subsequent tests by the Livermore group provided the first verification of the 14-year-old theory, Collins says.

In the July 23 PHYSICAL REVIEW LETTERS, the Livermore team reports successfully suppressing the heat surges by capping hydrogen samples with a layer of liquid helium. But the researchers say the bursts may find a welcome at another stage of the fusion process. Maintaining near-perfect beam uniformity is crucial during target compression, and heat bursts might provide a way to make the targets more uniform. When the spike occurs, the sample explodes and then recondenses evenly on the inner walls of its container, Collins says.

And far bigger heat bursts, if properly controlled, might show promise for propulsion, the researchers suggest. Since the 1950s, NASA and the Air Force have sought ways to store free atoms within hydrogen lattices until their energy is needed. Already, rocket experts have responded to the new report with enthusiasm, says Bryan Palaszewski, a program manager at NASA's Lewis Research Center in Cleveland.

Collins and his colleagues have made the "first real attempt to understand how energy is released [from atomic hydrogen]," Palaszewski says. "If we can understand how it is released, we can understand how to store it."

Even so, he adds, atomic-hydrogen fuels won't see the launch pad for 30 to 50 years. *– P.L. Weiss*