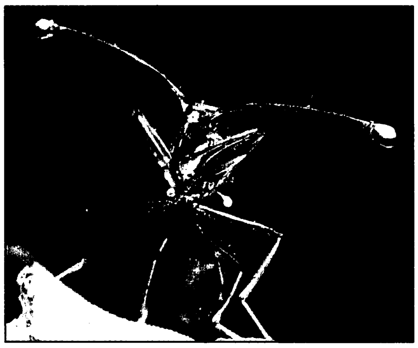
manipulated frog reproduction. For 2 years she removed the eggs from about 10 female tree frogs, then fertilized half the eggs with sperm from a short-calling male and half with sperm from a long caller. Next, working with Missouri ecologist Raymond Semlitsch, she compared how the offspring fared as tadpoles and after they metamorphosed into frogs, measuring their growth rates under regimes of scarce and plentiful food. Descendants of long callers won out. "Every single significant effect was in favor of the long callers," says Gerhardt.



P. SAVOIE

Stalk envy. Although seemingly useless, long stalks in male stalk-eyed flies appeal to potential mates.

Other researchers praise the study because it neatly circumvents problems plaguing other "good genes" experiments, such as biased provisioning of eggs by the mother, which alters the offspring's chances. And unlike many studies, Welch's work can rule out the possibility that flamboyant males offer some benefit to their offspring other than good genes, such as food or rich territories, says population geneticist Mark Kirkpatrick of the University of Texas, Austin. Male tree frogs have no contact with their offspring except for fertilization, so their only contribution is genetic. "It's one of the most convincing documentations [of the "good genes" theory] that I've seen," says Brian Charlesworth, a population geneticist at the University of Edinburgh in Scotland.

Kirkpatrick adds that Welch's large sample sizes will help the researchers quantify the extra fitness that long callers confer on their offspring: The study "gives us some numbers that will give us an estimate of how strong the 'good gene' influence is [in these organisms]." But Welch's team says it may be a while before they can answer the biggest question of all—what makes the long callers and their descendants more fit.

Another recent experiment, however, may have identified an actual genetic advantage that accompanies the females' seemingly arbitrary tastes. Gerald Wilkinson, a behavioral ecologist at the University of Maryland, College Park, and his colleagues studied species of stalk-eyed flies in which females generally outnumber males. The team determined that the biased sex ratio was caused by certain "selfish" genes on the X chromosome, which somehow attack Y-bearing sperm. As a result, during mating, the male contributes many X-bearing sperm but few Y's, and the next generation has more females than males. (In flies, as in humans, males have one X and one Y chromosome, while females have two X's.) These selfish genes are overly represented in each successive generation.

But some males have a gene on their Y chromosome that protects against the "selfish" X. And in the 15 January issue of *Nature*, the team showed in selective breeding experiments that this protective gene is linked to longer eyestalks. Populations descended from long-stalked males had an even sex ratio, and sometimes more males than females, showing that they had overcome the effects of the selfish X chromosome.

The researchers surmise—although they did not prove—that female flies prefer long stalks because they are genetically linked to a gene that blocks the selfish X chromosome, allowing the birth of males. That helps propagate the female's genes because their sons, as scarce males among females, will likely have many offspring. The work "provides a powerful but unusual example of how the 'good genes' mechanism can operate," says Kirkpatrick, who was once something of a "good genes" skeptic. The Welch experiment, in contrast, shows the expected and perhaps more general outcome of good genes—enhanced fitness in the offspring.

For frogs, longer calls are costly to sustain, suggesting that the same genes—perhaps for stamina or more efficient metabolism—may underlie both calling and the enhanced survival of the young. But in the flies, the only link between long stalks and the restored sex ratio may be that the genes for both traits lie near each other on the Y chromosome. In either case, the female's choice is far from capricious, says Gerhardt. Instead, "they are making [life] better for their offspring"—and that's what good genes are all about.

–Elizabeth Pennisi

DEVELOPMENTAL BIOLOGY

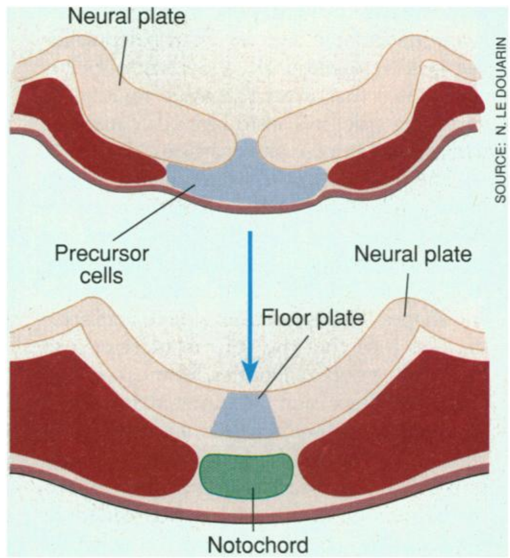
Embryo's Organizational Chart Redrawn

Organizing the developing nervous system requires a formidable bureaucracy. In the classic organizational chart, the notochord, a rodlike group of cells running from the embryonic head to the tail, is the CEO of neural cell fate. Early in development, it sends out a command to tissue destined to be part of the spinal cord, ordering it to differentiate into a specialized sheet of cells called the floor plate. In turn, the floor plate—the middle manager in this hierarchy—sends out signals that trigger the formation of motor neurons, which transmit signals between the spinal cord and muscles.

But now both developmental and genetic evidence suggests that this textbook version of the organizational chart is wrong. Work presented last month at a meeting of developmental scientists* by Nicole Le Douarin of the College de France in Nogent-sur-Marne and her colleagues suggests that the floor plate is not ordered into existence by the notochord. Rather, it is another member of the executive committee, forming at the same time and from the same group of precursor cells as the notochord itself.

This and genetic studies in the zebrafish are forcing embryologists to reconsider some of their basic assumptions. "It really does change the view of how the patterning of the nervous system happens," says developmental biologist Igor Dawid of the National Institute of Child Health and Human Development.

The view that the floor plate is created in response to orders from the notochord grew out of a set of elegant experiments begun in the 1980s. Biologists had already shown that early in development, a sheet of cells called the neural plate curls into a tube that eventually develops into the spinal cord. In the middle of the ventral side of the tube is a layer of cells called the floor plate. If the floor plate fails to form correctly, an embryo's ner-



Co-directors. In a new view, the floor plate and notochord develop from precursors at the same time.

* Molecular Genetics of Development, 6–9 May, Airlie, Virginia. Sponsored by the National Institute of Child Health and Human Development.

vous system goes haywire, with some neurons failing to develop and others becoming misdirected. Because the floor plate sits next to the notochord, known to influence various events in development, researchers tested its effects on floor-plate formation.

By either removing bits of notochord from chick embryos or grafting in extra pieces, researchers found that with extra notochord tissue, a second floor plate appears; without part of the notochord, part of the floor plate was missing (*Science*, 16 November 1990, p. 985, and 15 November 1996, p. 1115). Scientists were even able to identify the notochord's molecular messenger: a powerful protein called Sonic hedgehog, which in culture can cause certain cells to develop characteristics of the floor plate.

But Le Douarin's work indicates that this classic hierarchy is too simple. In very early chick embryos, her team replaced a group of notochord precursor cells with the corresponding cells from a quail embryo. Chick and quail cells are readily distinguishable, making it easy to track the fate of the transplanted cells. A few days later, the team found that the resulting chimera had formed a notochord and a floor plate—both made of quail cells. If the notochord were directing the floor plate to form, says Le Douarin, the floor plate would have been of chick cells.

Genetic data also support the floor plate's independence from the notochord's signal. Zebrafish mutants missing a notochord can develop floor plates, and distinct notochord and floor plate cells can be detected in very early zebrafish embryos, says developmental geneticist Marnie Halpern of the Carnegie Institution of Washington.

To Le Douarin, these results mean that the precursors of both the notochord and the floor plate are present in the very early embryo and move together through the developing neural tube. She suggests that previous experiments may have been misinterpreted, and that when the notochord was removed, the floor plate predecessors came along.

But Columbia University developmental biologist Tom Jessell, who did some of the earlier experiments, disagrees. He says previous work shows that the floor plate may be a team project, of notochord precursor and other cells, but the commands still originate from the notochord. The chimera experiments don't indicate when the floor-plate cells begin to differentiate, he says. He argues that the notochord's production of Sonic hedgehog is crucial, noting that in Sonic hedgehog knockout experiments, the notochord degenerates and a floor plate does not form.

Le Douarin is not surprised by the reluctance to revise what seemed an orderly chain of command. "Everybody assumed that they knew what was right," she says, "but all assumptions are subject to revision."

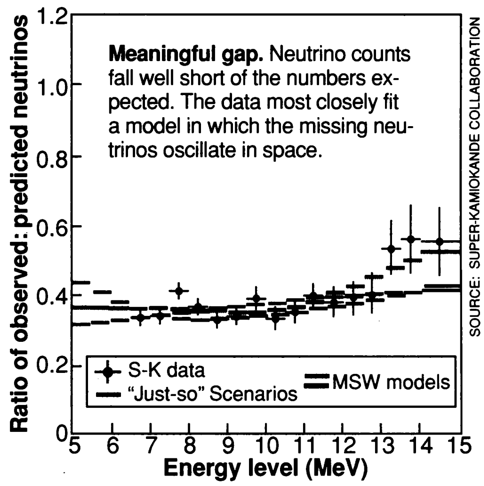
–**Gretchen Vogel**

PARTICLE PHYSICS

Heavy News on Solar Neutrinos

TAKAYAMA, JAPAN—The recent announcement by a team of Japanese and American physicists that they have found evidence of mass in neutrinos from the atmosphere stole the show at an international conference here (*Science*, 12 June, p. 1689). Almost lost in the excitement was a hint that the same may be true for another kind of neutrino also being captured by the thousands at the Super-Kamiokande collaboration's 50,000-ton water-filled detector, which is located in a mine 1 kilometer underground. A report of a deviation in the expected number of neutrinos generated by the sun at certain energy levels suggests that, like the atmospheric neutrinos, solar neutrinos can change their identity while in flight. That feat would require these ephemeral subatomic particles to have at least a smidgen of mass.

"We don't want to say anything too strongly about [the evidence] yet," says Yoichiro Suzuki of the University of Tokyo, who heads the collaboration's solar neutrino analysis team. "We need more data." But to some onlookers, the small variations in solar neutrino counts by energy reported by the team look like the signature of neutrino oscillations, or identity shifting. "It is the first time the effect has been observed within one experiment," says John Bahcall, a neutrino expert at the Institute for Advanced Study in Princeton, New Jersey. Previous attempts have cobbled together results from different experiments, he explains.



Meaningful gap. Neutrino counts fall well short of the numbers expected. The data most closely fit a model in which the missing neutrinos oscillate in space.

The first clues that neutrinos might have mass came from experiments in the 1960s that picked up only between one-third and one-half the expected number of neutrinos streaming from the sun. Because neutrinos come in three types, or flavors, and the detectors were sensitive only to a subset of flavors and energy ranges, some researchers speculated that the missing neutrinos had converted, or oscillated, to a type that could not be detected. But the laws of quantum mechanics state that a particle must have mass to oscillate. That suggested a flaw in the Standard Model, the established theory of particles and forces that has served as the basis of modern physics, which posits zero mass for neutrinos.

There are at least two theories to explain where the oscillations are taking place. In one, dubbed the "just-so" scenario, solar neutrinos oscillate in a vacuum. In that picture, the number that change into an undetectable form should depend on the neutrinos' energy and the distance they travel from the sun to the detector on Earth. The theory gets its name from the fact that calculations of where particle oscillation is likely to peak required that the oscillation length be nearly equal to Earth's orbital radius. In the other, called MSW for the initials of its three inventors, the oscillations get a kick whenever the neutrinos interact with matter, whether in the sun or on Earth.

In the MSW scenario, the number of neutrinos detected should fluctuate from day to night, when Earth's rotation places the planet's entire mass between the sun and the detector. The effect should be largest for neutrinos that travel straight through Earth's dense core. The just-so picture predicts no day-night effect, but it does predict a slight variation in neutrino counts by energy and by season, as Earth's distance from the sun varies.

Earlier neutrino detectors couldn't gather enough data to test these predictions. But since it started operating in April 1996, Super-Kamiokande has recorded evidence of some 7000 electron neutrinos, more than three times the number spotted by every other neutrino detector combined.

So far, researchers have not found any day-night effect, and there appears to be no enhancement of the oscillation effect for neutrinos coming through Earth's core. The new results don't doom the MSW theory, however: Under certain parameters, the effect might not be seen for neutrinos flowing through Earth. On the other hand, Super-Kamiokande did see a small deviation from the expected spectrum curve at particularly high energies and a very slight seasonal variation in the number of high-energy neutrinos, support for the idea that oscillations can take place in empty space.

Neutrino researchers agree that more evidence is needed to make a definitive case for solar oscillations. But Bahcall and others say that the new data from Super-Kamiokande represent "real progress" in solving a decades-old puzzle.

–**Dennis Normile**