Pushpangadan, now head of the National Botanical Research Institute in Lucknow, disagrees, saying that he would not have fought against the odds for 12 years unless he was sure that the arrangement would benefit the Kani. And botanist Peter Raven, director of the Missouri Botanical Gardens, considers this agreement a "very good model for future" partnerships throughout the developing world. The current agreement must be renegotiated in 7 years, and the tribal community is expected to use the money for health care facilities and schools.

–PALLAVA BAGLA

DEVELOPMENTAL BIOLOGY

New Findings Reveal How Legs Take Wing

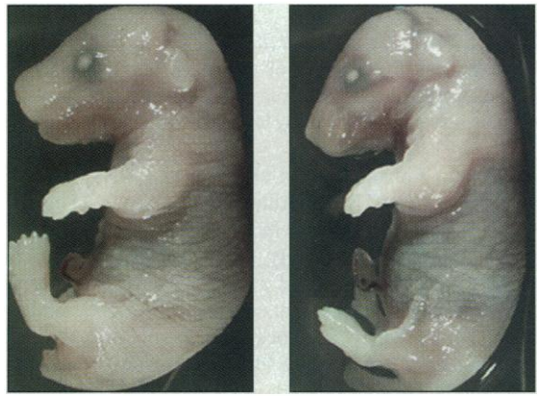
It doesn't take training at Kentucky Fried Chicken to know the difference between a chicken wing and a leg. But it's taken researchers a long time to figure out the molecular signals that tell the developing embryo which kind of limb to make. Now, work from at least four labs points to a set of proteins that appear to play a leading role in separating legs from wings.

In the past decade, developmental biologists have made impressive progress in identifying the genes that control a limb's growth from trunk to tip and from front to back. But almost all of those genes turned out to be the same in both arms and legs. That left researchers wondering just what genes control the many shape differences between the limbs. "To identify the genes that convey 'legness' is amazing," says developmental biologist Cheryll Tickle of the University of Dundee in the U.K., who has helped uncover many of the embryonic genes that structure the limbs.

The first clues came last year, when several groups reported that in a number of vertebrates, at least three genes are expressed only in either forelimbs or hindlimbs. *Pitx1* and *Tbx4* are found in the legs, while *Tbx5* is expressed in wings and arms.

Suspecting that these genes might help differentiate the limbs, several groups began to examine their effects in embryos, and results are now rolling in. Last month, developmental biologists Juan Carlos Izpisúa Belmonte of the Salk Institute for Biological Studies in La Jolla, California, and Michael Rosenfeld of the University of California, San Diego, and their colleagues reported in *Genes and Development* that in genetically engineered mice lacking the leg-specific *Pitx1*, the hindlegs have short, thin bones that resemble forelimbs. Although the animals' fore- and hindlimbs are not identical, there is "an element of armness that's come to the leg," says Rosenfeld.

The opposite experiment—expressing *Pitx1* in the wings of developing chicks—seems to bring a bit of leg to the wing, as Izpisúa Belmonte and Rosenfeld reported, and as Clifford Tabin and Malcolm Logan of Harvard Medical School in Boston now report on page 1736 of this issue. To express *Pitx1* in the forelimb, Tabin and Logan inserted the gene into a virus and then infected the chick embryonic region destined to become the wing bud. Although the wing was not completely transformed, the results were striking. Chicken wings normally bend downward at the equivalent of the wrist, but in the infected wing the bones grew straight, similar to the junction between a chicken's ankle and foot. The affected wings did not grow feathers and often sprouted claws. (Izpisúa Belmonte and Rosenfeld's experiments yielded similar results.) Logan and Tabin also found changes in the chick's muscle structure: Infected wings developed the four muscles characteristic of the chicken drumstick, but lacked the usual seven wing muscles.



On the other hand. A mouse embryo lacking the *Pitx1* gene (*right*) forms short, slender, armlike hindlimbs.

Pitx1 apparently doesn't produce these changes alone; it seems to exert its influence by turning on another leg-specific gene, *Tbx4*. In infected wings, Logan and Tabin found the *Tbx4* gene turned on wherever the *Pitx1* gene was active. *Tbx5*, the forelimb gene, was also active, however, which may explain why neither group found complete transformations from wings to legs.

At the Nara Institute of Science and Technology in Japan, developmental biologist Toshihiko Ogura and his colleagues have found even more dramatic transformations by working with *Tbx4* and *Tbx5*. Ogura declined to discuss the as-yet-unpublished work, but those familiar with the study, such as Sumihare Noji of the University of Tokushima, who heard Ogura pre-

CREDITS: (TOP) NANCY ALEXANDER/VISUALS UNLIMITED; (BOTTOM) M. LOGAN AND C. J. TABIN

ScienceScope

Road Kill When students change schools often, math and science can get lost in the shuffle. That's the message from the National Science Board (NSB), which has just issued a report on improving the poor performance of U.S. students (see p. 1616). "The importance of [student] mobility hasn't been recognized" in the current push for national standards on curricula, says NSB chair Eamon Kelly, citing studies that show nearly one-third of U.S. eighth graders have changed schools two or more times. Low-income students are more likely to move frequently, he adds, a factor that could exacerbate the achievement gap between minorities and whites.

In other recommendations, the report, "Preparing Our Children" (www.nsf.gov/nsb), proposes a national campaign to improve instructional materials and teacher preparation as well as strengthen links between academic researchers, K-12 teachers, and school districts. Kelly admits that the suggestions aren't new, but says the board hopes to "raise the consciousness" of policy-makers and the public on the subject.

Trouble for IT²? Representative James Walsh (R–NY) is making it clear that he doesn't like the politics behind IT², the $366 million information technology initiative trumpeted by the Clinton Administration (*Science*, 29 January, p. 613).

At a hearing last week, Walsh gave the National Science Foundation–led effort credit for being "much more focused" than NSF's previous program to make computer networks faster and more user-friendly, dubbed Knowledge and Distributed Intelligence. But he is concerned about "NSF's ability to act independently and not just follow orders from the White House" when it comes to spending its $144 million share of the six-agency initiative. The words from Walsh, who chairs the House panel that oversees NSF's budget, suggest that IT² could face problems if money is tight.

Contributors: Michael Balter, Constance Holden, Jeffrey Mervis

sent it at a meeting, say that Ogura's team used electroporation to misexpress the *Tbx4* and *Tbx5* genes in the developing wings and legs. And they got almost complete transformation from both hindlimb to wing and wing to hindlimb. These more dramatic results may be due to interactions between the proteins that are not yet understood, or to the electroporation method Ogura used to insert the new gene, which triggers gene expression in 2 to 3 hours instead of 12.

These genes may shape arms and legs in all vertebrates; scientists have already identified human equivalents of both *Tbx4* and *Tbx5*. A rare disorder called Holt-Oram syndrome, which causes severely shortened arms and heart defects, has been traced to defects in the human *TBX5* gene. Versions of the genes are also present in the newt, and scientists are searching for the zebrafish versions, hoping for clues to the genes' evolutionary history.

Based on other work on developmental signals, the researchers suspect that *Pitx1*, *Tbx4*, and *Tbx5* influence "wingness" or "legness" by altering a cell's response to similar growth factors. The difference between legs and wings could be due to subtle variations in when and where the common growth factors are active, leading to minor changes in the growth of analogous sets of bones in the two limbs, researchers say. "You have all the same cell types, but a slightly different pattern" in the different limbs, says Tabin. "And these genes turn out to be the heart of that difference."

The next step, says Logan, is to figure out how the limb-specifying genes fit into the hierarchy of signals that build arms and legs. For example, although *Pitx1* seems to turn on *Tbx4*, no equivalent gene has been found to direct *Tbx5* expression. And scientists are eager to discover exactly which growth factors and other genes *Tbx4* and *Tbx5* help to control. "It's a very complicated story," says Rosenfeld, "one that's not solved at all." ?

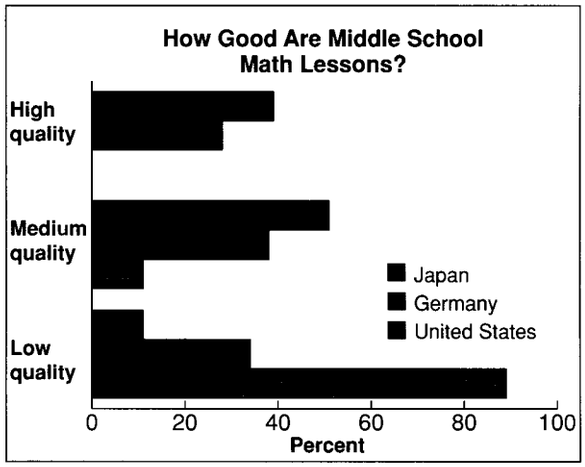
–GRETCHEN VOGEL

MATH EDUCATION

Videotapes Expose Classroom Faults

Test scores have documented how poorly many U.S. students do in math compared to their counterparts around the world. But why are their scores so low? A new analysis* just released by the U.S. Department of Education suggests that what happens in the classroom—what students are asked to do and how the material is taught—could provide at least part of the answer. And the data are in living color rather than being buried in answer sheets or questionnaires.

In 1994–95 researchers videotaped 231 eighth-grade mathematics classes in the United States, Japan, and Germany as part of the Third International Mathematics and Science Study (TIMSS). Conceived as an interesting sidelight to the main event—international tests of student achievement among fourth graders, eighth graders, and students in the last year of secondary school—the tapes have become one of the most informative and influential parts of TIMSS. Although confidentiality agreements prevent most of the tapes from being shown publicly, educators who have watched excerpts of a few that have been released and shown at conferences and workshops say they are shocked at the shortcomings of U.S. pedagogy. "I've seen teachers with tears of admiration in their eyes after watching some of the lessons from other countries," says one researcher who has analyzed them. "It's amazing to see a lesson play out so well."



Poor grades. The quality of the math taught in U.S. middle schools, judged by such measures as complexity and the use of deductive reasoning, is markedly lower than in Japan and Germany.

The tapes highlight teaching methods long suspected of pulling down U.S. achievement levels. "What the videotapes show—for example, that U.S. teachers cover more topics in a class than do teachers in other countries—is very consistent with earlier findings about the U.S. curriculum," says William Schmidt of Michigan State University in East Lansing, the national coordinator for U.S. TIMSS research. "And common sense says that the characteristics of the curriculum are going to have an effect on student achievement."

The classrooms videotaped were chosen at random from the pool of those that participated in TIMSS. A single lesson in each classroom was videotaped, and the video was then digitized, translated, transcribed, and put on a CD. Six coders, two from each country, watched the lessons and quantitatively analyzed the mathematics presented and the actions of students and teacher. In addition, a group of experienced college mathematics teachers read transcripts and judged the quality of each lesson after the source was disguised.

Perhaps the most distressing finding from the educators was the subpar mathematical content of the U.S. classes (see graphic). "Any particular indicator of quality might be questioned," says James Hiebert of the University of Delaware, Newark, a contributor to the study. "But no matter what indicator was used, most people agreed that the quality of the lessons was lower." Also, U.S. students typically were taught subjects one to two grades below those taught to their peers in Germany and Japan.

Teaching practices were remarkably uniform within each country, but they differed sharply from nation to nation. In Japan, teachers usually present their students with a problem and then let them work on it individually and in small groups so that students have to struggle with the relevant mathematical concepts. In the United States and Germany, teachers tend to drill students on concepts they have just described. The result, says the principal investigator for the study, James Stigler of the University of California, Los Angeles, is that "American and German students tend to practice routine procedures, while Japanese students are doing proofs."

Most of the teachers videotaped said that they had implemented practices from the standards issued by the National Council of Teachers of Mathematics (NCTM), which break the mold of traditional U.S. math classes by emphasizing high-level problem solving and greater flexibility in attacking a problem. But the tapes show little evidence of such innovations. "At the policy-making level, states and districts have been very influenced by the standards," says Glenda Lappan of Michigan State, the current NCTM president. "But there aren't many places where teachers [are encouraged] to move forcefully toward the standards."

However, Stigler and Hiebert say that teachers should not shoulder all the blame for the poor performance of U.S. students. "Teachers have been encouraged to teach the way they do," they write in a forthcoming book.† "They have been provided no

SOURCE: TIMSS VIDEOTAPE CLASSROOM STUDY

* The TIMSS Videotape Classroom Study, available at nces.ed.gov/timss

† *The Teaching Gap*, by James Stigler and James Hiebert, to be published in August by Free Press.