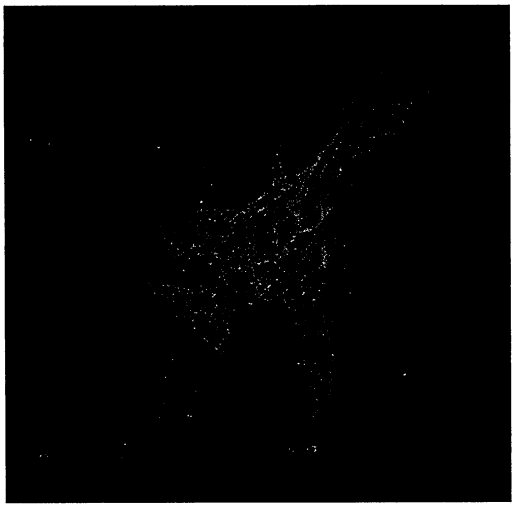

Making contact. As indicated by the red-staining synaptic vesicles, axons from brain neurons begin forming synapses when they contact kidney cells making neuroligin 1 (green stain).

CREDIT: (TOP) P. SCHEIFFELE AND T. SERAFINI

tually initiate synapse formation.

Now, Serafini and his colleagues have done just that. The group, led by postdoc Daniel Emerling, first took mice and dissected out a set of brain neurons called pontine cells. The investigators then teased out a second group of neurons, granule cells, that connect with the pontine neurons in the brain. The researchers found that the two types of neurons form synapses in the petri dish, as they do in the intact brain. They could tell that the neurons were connecting, because they could see clusters of neurotransmitter-containing vesicles forming at the synapse. "We have this [granule] cell type that we know forms synapses very well with the pontine neurons," Serafini says. "The beauty of our system is that we can mine it for the molecules involved in synaptogenesis."

Already the mine is yielding gold. Serafini, postdoc Peter Scheiffele, and their colleagues began by looking at a cadre of candidate genes for synapse formation that are active in granule cells. The researchers genetically engineered those genes, one at a time, into cells that would normally never steer synapse formation, such as human kidney cells or fibroblasts, and then they mixed the modified cells with pontine neurons in their culture system. After a series of genetic duds, the team hit pay dirt with the genes for neuroligin 1 and -2. Kidney cells that expressed either gene could trigger early synapse formation in the pontine neurons just as readily as their normal granule cell partners.

At the outset, says Serafini, his team had hoped for nothing more than some slight changes in the pontine cells that would indicate they were beginning to form connections. "We never expected that a single protein, when expressed in multiple cell types, would drive the entire program of presynaptic development," he says.

Initially, many critics didn't believe the results either. Citing studies showing that plastic beads coated with a substance called polylysine also cause signs of early synapse formation, they argued that the neuroligins' effects might be nonspecific. But Serafini's group went on to address those concerns. For example, in what Serafini calls the "clinching experiment," his team added a neurexin known to bind to neuroligin 1 to the cultured brain neurons.

As hoped, they found a major drop in vesicle clustering—presumably because the neurexin bound to neuroligin 1 and hindered it from acting on the pontine cells. Synapse formation did occur, however, when they used a related neurexin that doesn't bind neuroligin 1. "These are very good controls for specificity," says Scheller, who says he is convinced. "Now this molecule needs to be studied in more detail."

One way of doing that is to knock out the neuroligin genes in mice and see how that affects brain formation and function. Südhof's team already has a neuroligin 1 knockout. Although the rodents appear normal, Serafini notes that another neuroligin could easily pick up the slack for neuroligin 1. So the next step, he says, is to knock out all three neuroligin genes.

Now that the Serafini team's assay has proved its mettle, the researchers plan to use it to look for more genes involved in synapse formation by brain neurons. "We are asking a big question, 'What are the molecules that drive synapse formation in the central nervous system?' " says Serafini. As his team and others continue to "mine" nerve cells for their molecular precious metals, investigators are likely to gain a treasure chest of insights into how the brain develops and functions. **–TRISHA GURA**

Trisha Gura is a science writer in Cleveland, Ohio.

GERMAN SCIENCE

Max Planck Charts New Path

Germany's premier basic research organization, the Max Planck Society, released a long-awaited blueprint for change during its annual meeting this week, recommending that the society's nearly 3000 scientists embrace more interdisciplinary and international projects in a range of new research priorities.

In the half-century since Max Planck rose, reconstituted from the ashes of World War II, it has created a loosely knit empire of 78 institutes. Each institute is built around a handful of top researchers who have been given ample resources and considerable independence. Although that formula has produced excellent science—Max Planck scientists have won 10 Nobel Prizes since 1984—some critics contend that it has prevented the society from reacting quickly enough to sudden changes in the scientific landscape and has isolated its researchers from Germany's university system and from colleagues at other institutes (*Science*, 4 June 1999, p. 1595).

Since becoming president of the Munich-based Society 4 years ago, biologist Hubert Markl has sought to address such concerns. He has, for instance, required more frequent outside evaluations of institutes, hired more researchers on short-term contracts, and developed "International Max Planck Research Schools," which starting this fall will offer Ph.D. degrees in cooperation with German universities. The new blueprint, says Markl, will make the institutes "perhaps a little less independent, but much better interconnected with other research groups." According to U.K. Engineering and Physical Sciences Research Chief Richard Brook, who led an international evaluation of Max Planck last year, the recent moves and the new report "indicate that Max Planck is moving in the right direction."

The report, called Max Planck 2000-

A SAMPLING OF MAX PLANCK'S NEW PRIORITIES

"The Molecules of Life"

Structural biology and macromolecules

"From Genes to Organisms"

The Human Genome Project, embryonic development, and cellular regulation

"The Brain"

Information processes, signal transmission, and the molecular basis for cognition, memory, and language

"The Individual and the Environment"

Viruses, gene therapy, and interactions between organisms

"Structure of the World and the Universe"

Astrophysics, plasma physics, and traditional particle physics

"Atoms, Molecules, Materials, and New Technologies"

Smart materials and fast lasers

"Complex Processes and Systems"

Advanced math and applied computer science

Plus, is the product of an 18-month-long internal review. Its recommendations were formulated by some two dozen Max Planck researchers and administrators, who sought input from every institute. "We found a real spirit of innovation," says Eduard Arzt, a director of the Max Planck Metal Research Institute who compiled the report's materials science section.

Noting that "competitive, high-tech research is, in many cases, beyond the scope of one or several institutes," the 2000-Plus report seeks to remedy that flaw by having scientists develop "an even more intensive collaboration" with universities and other research outfits. Toward that end, Markl says, Max Planck will soon launch the first nine International Research Schools for Ph.D. students, many from outside Germany.

To cope with the data flood from "big science" efforts such as the international Human Genome Project, the report urges the rapid development of bioinformatics research at various institutes and multidisciplinary teams spanning several institutes and including other organizations. Some of this is happening already: Max Planck's astronomy researchers, for example, work closely with counterparts in Europe and North America to avoid costly redundant research.

These changes, once implemented, could whittle away a researcher's ivory tower independence. But Markl thinks the trade-off—more collaborations and an influx of young minds—will spur a new era of creativity. "The most important driving force," he says, "will be the increasing mobility of scientists, especially young researchers, across borders and among institutions." **–ROBERT KOENIG**

PALEONTOLOGY

New Feathered Dino Firms Up Bird Links

BEIJING—Volcanic eruptions some 125 million years ago entombed a menagerie of ancient animals at a site in northeastern China that is proving to be a treasure trove for paleontologists. It has also become ground zero for the continuing debate on the origins of birds. Last week, Chinese scientists presented evidence from a new specimen dug up in Liaoning Province (*Science*, 13 March 1998, p. 1626) that they say strengthens the case for a link to dinosaurs—and for the value of further work at the site.

The finding, one of several fossils displayed at a meeting here,* is the third known specimen of a strange creature known as *Caudipteryx*. When the first *Caudipteryx* was discovered in Liaoning in 1998, most paleontologists classified it as a member of a group of two-legged, carnivorous dinosaurs known as theropods (*Science*, 25 June 1999, p. 2137). Unlike any other known dinosaur fossil, though, the tail and stubby forelimbs of *Caudipteryx* showed the unmistakable imprints of feathers—features most paleontologists believed it had inherited from a dinosaurian common ancestor it shared with birds. However, *Caudipteryx* appears to have been earthbound, lacking a full set of wing feathers and other features of wings.

The new specimen was described by Zhou Zonghe, a paleontologist at the Chinese Academy of Sciences' Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) in Beijing. Although the fossils reveal some beautifully preserved feather impressions, "it's the bones that are important," says Zhou. The fossil lacks a head, but the rest of its skeleton (see picture) is better preserved and better articulated than those of its two predecessors. Zhou admits that the bones show a number of birdlike characteristics usually absent in dinosaurs, including a thumblike appendage for perching. But he has identified 16 characteristics more similar to dinosaurs than to early birds, including the proportions of the bones in the foot and the shape and orientation of the pelvis and bones in the pelvic region. He has labeled the new species *Caudipteryx dongi*, after prominent Chinese dinosaur expert Dong Zhiming.

Nom de plume. China's latest *Caudipteryx* fossil has a pelvis (above bent leg) similar to that of other theropods.

Zhou's work reinforces the views of most Western scientists. "The Chinese finds are [illustrating] very nicely the transition between things that are true dinosaurs to fully avianlike creatures," says Luis Chiappe, a paleontologist at the Natural History Museum of Los Angeles County. University of Chicago paleontologist Paul Sereno agrees that identifying more dinosaurlike features "is big news" that lends support for the idea that there is no sharp evolutionary dividing line between dinosaurs and birds.

A minority remain unconvinced, however. The feathers on *Caudipteryx* are considered less evolved than those on *Archaeopteryx*, the oldest commonly acknowledged bird, notes Storrs Olson, an avian paleontologist at the Smithsonian Institute in Washington, D.C., yet the Liaoning fossils are 25 million years younger than *Archaeopteryx*. And although *Caudipteryx* may have had true birdlike feathers, he says, that doesn't make the case for other recent Liaoning finds such as *Sinosauropteryx*, whose hairline "protofeathers" he dismisses as "fuzz." The Liaoning sites, he adds, "are showing us kinds of birds we didn't know a whole lot about. But there is no information about the origin of birds."

Zhou disagrees, saying that placing *Caudipteryx* with the birds would require its bird ancestors to have evolved an implausible number of dinosaurlike characteristics. It is more likely, he says, that the creature's handful of bird characteristics are either due to parallel evolution or appeared on the way to the origin of birds.

The dinosaur-to-bird believers think it can only be a matter of time before more of the missing links are uncovered. "We are convinced that birds evolved from theropod dinosaurs," says Ji Qiang, director of China's National Geological Museum in Beijing. "But we don't know yet from just which group [of theropods]." He and others hope that the ground will yield more definitive answers. And they agree that the most logical place to dig is in Liaoning Province.

–DENNIS NORMILE

CREDIT: IVPP/CHINESE ACADEMY OF SCIENCES

* 5th International Meeting of the Society of Avian Paleontology and Evolution and the Symposium on Jehol Biota, IVPP, Beijing, China, 1 to 4 June.