# How fowl: Chickens that behave like quail

Evan Balaban has something to crow about: The scientist has successfully transplanted developing brain cells from quail embryos to chicken embryos and created chickens whose crowing resembles that of quail.

Balaban's unusual research effort has prompted many jokes, but it has also earned plaudits from neuroscientists.

"The questions Evan asks with [these transplants] are extremely profound and subtle," says Ralph J. Greenspan of New York University, who studies brain regions involved in fruit fly mating. "They get at the neurobiological basis of what makes a behavior species-specific."

Balaban's interest in avian brain cell transplants emerged in the last decade while working with Nicole Le Douarin of the College of France in Nogent-sur-Marne. Le Douarin pioneered the transplanting of embryonic quail cells into chicken embryos as a method of studying how embryos develop. Balaban began to wonder if the cell transplants could also help probe avian behavior.

To address that question, he focused on crowing, an easily studied activity that clearly differs in quail and chickens. Young chickens emit quick squeaks, while quail crows have three parts, the final one fluctuating in frequency and amplitude. Quail "warble," says Balaban.

In the late 1980s, Balaban and his French colleagues discovered that quail cell transplants could transform a chicken's uninterrupted crow into the multiple-part vocalization of a quail.

The researchers took newly laid quail and chick eggs and cut windows into their shells. With handmade surgical instruments, they removed bits of the neural tube—the embryonic region that gives rise to the brain and spinal cord—from the chicken embryos and filled in the gaps with cells taken from the same areas of the quail neural tube. They then resealed the eggs with tape and waited for the chicks to emerge and crow.

The scientists eventually discovered the specific neural tube region—an area that develops into part of the avian midbrain—needed to make a chicken's crow like a quail's. The metamorphosis was incomplete, however: The chickens didn't warble.

Balaban speculated that warbling stems from the way that quail, but not chickens, bob their heads rapidly when they crow. "A chicken doesn't shake its head at all," says the researcher, now at the Neurosciences Institute in San Diego.

Balaban recently identified the bit of neural tube that governs head bobbing. The region develops into a part of the brain near the tip of the spinal cord. When he replaces chick cells from this neural tube region with their quail counterparts, the resulting birds produce uninterrupted squeaks, like chickens, but bob their heads as they do so, Balaban reports in the Mar. 4 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

Yet even these birds don't warble, notes Balaban. So he is now studying chicks that received quail cells from both of the known crow-governing brain regions.

The just-published results, together with the earlier work in France, establish that species differences in crowing behavior don't stem from a single brain area, a finding that surprised Balaban. "There's not one master brain region that evolution has changed," he says.

Balaban plans to investigate what makes the crow-governing brain cells of the two birds different and whether the transplanted quail cells induce changes in neighboring brain cells of the chick.

Balaban is also exploring another avian behavior, the response to the species-specific maternal warning cry.

"Mothers typically give [this cry] when there's danger. It's a very potent stimulus for young birds. They react to it immediately and run towards the source of the sound," he notes. Balaban already is trying to create chicks that respond to a quail's maternal cry but not to a chicken's. —*J. Travis*

# Mapping helium atoms' quantum states

Imagine, as Plato once did, prisoners chained in a cave so they can see only the shadows of things outside their prison, not the things themselves. Physicists face a similar situation in the quantum realm when they try to observe atoms and electrons in motion. They cannot see such physical objects as they are; they can only detect aspects of those objects, which appear particlelike or wavelike, depending on the type of observation.

To build up a picture of a hidden object from the different shadows it casts, one can use a method called tomography. For example, one can generate an image of a person's internal organs from measurements of the intensities of X rays that have passed through in different directions.

A special sort of tomography can be used to measure the quantum state of atoms or photons. With this technique, Jürgen Mlynek and his colleagues at the University of Konstanz in Germany determined the quantum state of moving helium atoms and have shown experimentally, for the first time, that the atoms' motion has wavelike characteristics.

The researchers report their findings in the March 13 NATURE.

According to quantum theory, an atom can behave like a wave. Thus, atoms traversing a pair of slits should produce an interference pattern. Atoms reach a detector only at positions where the waves reinforce each other, producing a pattern of evenly spaced bars.

Mlynek and his colleagues set up an experiment in which a beam of helium atoms passes through a pair of slits in a screen. If an atom moved like a tiny pellet, it would either pass through a slit or strike the barrier. All the information about an atom's state of motion at any moment would be given by its position and its momentum, the product of its mass and velocity.

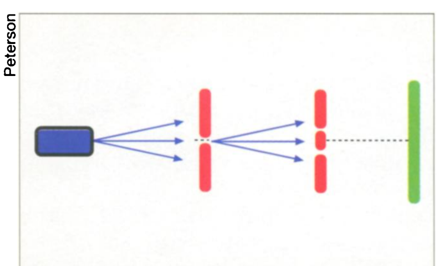
The Heisenberg uncertainty principle, however, asserts that the position and momentum of a quantum particle can't be determined simultaneously to a high precision. If one quantity is known very precisely, the other has a corresponding uncertainty.

"You can never determine the complete quantum state in one measurement," says Christopher Monroe of the National Institute of Standards and Technology in Boulder, Colo. "The idea [of quantum tomography] is to take many measurements to piece together the state, just like a CAT scan."

The relationship between a quantum particle's position and its momentum forms a mathematical entity called the Wigner function. By applying quantum tomography to helium atoms passing through a pair of slits, Mlynek and his team obtained data to calculate the Wigner function and, in effect, map the quantum state of the moving helium atoms.

Researchers have already measured the states of various quantum systems, including arrays of photons, a vibrating molecule, and a single ion trapped in a magnetic field (SN: 5/25/96, p. 325). The work of Mlynek and his team represents an important extension of these efforts, says Monroe. —*I. Peterson*

Peterson



*A single slit narrows a beam of helium atoms emitted by a source. The atoms then traverse a double slit to arrive at a detector, which measures their arrival times and positions.*