Internal fight settles size of body parts

Most animals compete fiercely for limited resources, as the phrase "survival of the fittest" suggests. An unusual new study showing that the absence of one growing organ or tissue allows another to become larger now hints that a similar competition exists internally as animals develop.

The experiments—in which butterflies grew large front wings in response to missing hind wings and male beetles deprived of their characteristic horns developed big eyes—address the intriguing biological question of what determines how large various body parts become.

While much of the information seems hardwired into an animal's genes, the new results indicate that to some extent, growing body parts directly influence each other's ultimate size. "Each tissue or organ isn't just running on its own genetic program and knows how big it's supposed to get," says H. Fred Nijhout of Duke University in Durham, N.C.

Nijhout and his colleague Douglas J. Emlen, now at the University of Montana in Missoula, describe their manipulation of insect development in the March 31 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

"This is an absolutely delightful paper and really original. My bet is it's going to be a landmark," says Sean Carroll of the University of Wisconsin-Madison.

"It's pretty amazing work," agrees Rudolf A. Raff of Indiana University in Bloomington. "Here's a situation in animals where you can see competition, developmentally, between parts of the body."

More than a century ago, in his book *The Origin of Species*, Charles Darwin pondered whether developing body parts clash with each other for nutrients. Until now, investigators had never found a way to view such conflict.

Nijhout and Emlen approached the issue by working with holometabolous insects. In their larval stage, these insects stop feeding just before most adult structures form, providing a closed system in which the developing organisms have a finite supply of nutrients and other resources.

In the case of the butterfly *Precis coenia*, the scientists removed from caterpillars the tissues that give rise to the adult's hind wings. After the caterpillars metamorphosed, the butterflies had larger front wings than butterflies from untreated caterpillars. The size increase was greater if larval tissue for both hind wings, rather than just one, had been removed.

As for the beetle *Onthophagus taurus*, whose males sport horns that they use to fight for females, the investigators treated larvae with a hormone known to stunt the horns' growth. The beetles that emerged from this treatment had short horns, or none at all, and had larger eyes than untreated beetles of the same size.

Nijhout and Emlen/PNAS

The beetle Onthophagus taurus.

To examine whether the hormone was causing the larger eyes, the scientists gave it to female beetles, who have no horns. Their eyes remained the normal size.

In neither species did shrinking or removing a body part spur widespread changes in the developing insect, notes Nijhout; rather, it increased the size only of body parts growing near the treated area. He plans to study why the response is localized and whether it stems from reallocating scarce resources, such as nutrients, or from the removal of growth inhibitors that one developing body part directs at others. —*J. Travis*

Evading quantum barrier to time travel

Ruling out the possibility of traveling back in time has turned out to be trickier than many physicists had supposed.

Two researchers have now shown that quantum effects do not necessarily prevent the occurrence of loops in time. Li-Xin Li and J. Richard Gott III of Princeton University present their case in the April 6 PHYSICAL REVIEW LETTERS.

Einstein's special theory of relativity unifies space and time as aspects of a single, four-dimensional entity known as space-time. His general theory of relativity describes how the presence of matter warps the fabric of space-time.

Physicists have found that general relativity equations yield many solutions representing different space-times. Sometimes, sufficient warping of a particular space-time makes possible the existence of paths known as closed timelike curves (SN: 3/28/92, p. 202; 11/5/88, p. 302). A traveler moving along such a path would find that his or her watch always runs forward, even though the traveler eventually ends up where—and when—he or she started.

In 1982, William A. Hiscock of Montana State University in Bozeman and Deborah A. Konkowski of the U.S. Naval Academy in Annapolis, Md., calculated the quantum state of the space, or vacuum, pervading a simple type of space-time called Misner space, which includes closed timelike curves. Their result indicated that such a combination of gravitational space-time and vacuum quantum state could not exist.

Noting that result, Stephen W. Hawking of the University of Cambridge in England proposed the chronology protection conjecture, stating that physical laws do not permit the appearance of closed timelike curves. For example, quantum theory could conspire to prevent time travel by ruling out the existence of space-times with such paths.

Misner space can exhibit more than one type of vacuum state, however. Li and Gott demonstrate that one of these states permits the occurrence of time loops. That state is self-consistent, meaning that going back in time doesn't alter what happens later in the system.

"We have found a counterexample to Hawking's conjecture," Gott says. "Quantum effects do not automatically enforce chronology protection in every case."

That doesn't mean a person could build a machine to travel back in time. The amount of space-time warping required for such a feat would lead to all sorts of practical problems.

The calculations also involve crucial approximations and may not apply to the "real" cosmos, Konkowski says.

However, the possible existence of closed timelike curves under certain extreme conditions may offer a solution to the problem of what came before the Big Bang, which most cosmologists believe started our universe.

In a paper submitted for publication, Li and Gott explore the question of whether anything in the laws of physics would prevent the universe from creating itself. "The universe wasn't made out of nothing," Gott suggests. "It arose out of something, and that something was itself. To do that, the trick you need is time travel."

Li and Gott speculate that a universe undergoing the rapid early expansion known as inflation could give rise to baby universes, one of which (by means of a closed timelike curve) would turn out to be the original universe.

As they did for Misner space, the two physicists found a self-consistent vacuum state, demonstrating that closed time loops can occur under inflationary conditions in certain space-times. Hence, the researchers say, "the laws of physics may allow the universe to be its own mother." —*I. Peterson*