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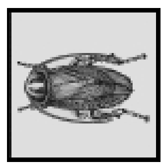
Spotlight on Science at the Smithsonian

Bi-Weekly Newsletter | Vol. 4, No. 9 | 28 April 2006

- Introduction from Dr. David Evans, Smithsonian Under Secretary for Science



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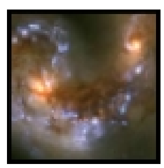

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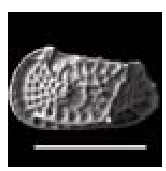

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Spotlight on Science at the Smithsonian

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- Dr. David Evans, Under Secretary for Science
- Theresa Mellendick, Editor, mellendickt@si.edu

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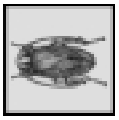 Bugs in the System

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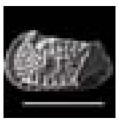 Evolution of Body Size

Introduction from the Under Secretary for Science

Welcome to Spotlight on Science at the Smithsonian, I am David Evans, Under Secretary for Science. This is Volume 4, Issue 9, released on April 28th, 2006. In this installment, we'll look at efforts to control one of the biggest threats to museum collections: bugs. From the dark corners of our collections, we will turn our gaze to the most luminous galaxies in the universe. These galaxies can have thousands of times as much energy as our own Milky Way. Next, we'll hear how our understanding of West Nile Virus outbreaks may help us predict and prevent future diseases that jump from animals to humans. Finally, we'll explore an interesting relationship between body size and climate in organisms.

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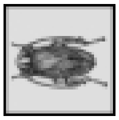
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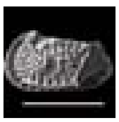
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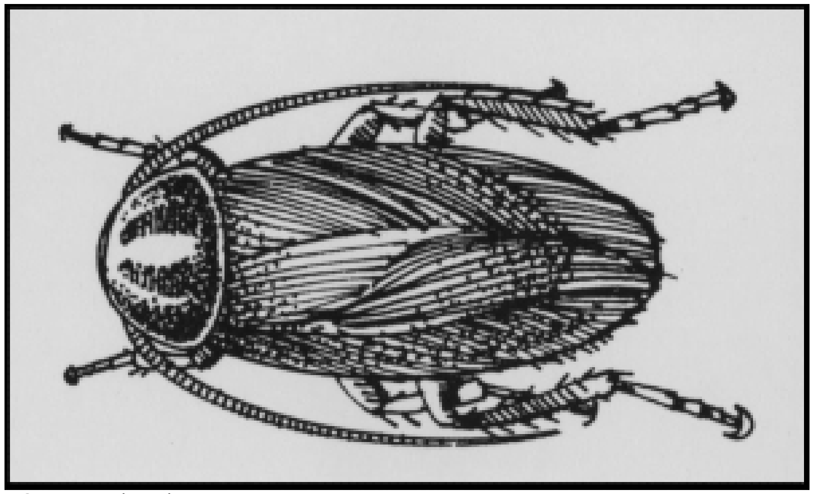


A German cockroach.

Bugs in the System

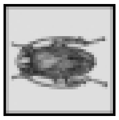
The objects in Smithsonian museums come from all parts of the globe and every imaginable natural habitat. Here they can be studied by our researchers and enjoyed by the public. But nature doesn't stop at the museum door. Museums harbor their own distinctive fauna and flora ready to feast on scientific and cultural treasures. The quiet, climate-controlled environment of a museum collection, stuffed with nutritious plant and animal products, makes a desirable habitat for insects and rodents. One insect species, the museum beetle *Anthrenus museorum*, first became known to science in the 1700's when the zoologist Linnaeus found a population of them happily devouring his precious biological specimens.

At the Smithsonian Museum Conservation Institute (MCI) researchers are constantly looking for ways to ward off the attacks of insects and other pests, without compromising the integrity of the collections or the safety the Smithsonian's staff and visitors. It's a tall order — health and environmental restrictions have gotten tighter in recent decades, but scientific advances have also upped the bar with respect to the integrity of preserved specimens. New genetic and molecular techniques demand that biological tissues be preserved down to the structure of their DNA molecules.

In the early days, museums protected vulnerable collections by coating objects with arsenic or mercury salts. This kept the bugs at bay, but it also posed a health risk for the humans who handled the objects. The advent of agricultural pesticides such as DDT in the mid-twentieth century seemed a boon to museum curators for preserving research and exhibit specimens, but by the sixties these chemicals began to fall out of favor as their harmful environmental impacts became known. Methyl bromide, a widely used fumigant, was among the chemicals phased out by the Montreal Protocol in 1997 for destruction of atmospheric ozone. Even newer generations of more environmentally-friendly pesticides have their downsides. Scientists have found that these agents can inflict their own damage on sensitive objects, degrading dyes, fibers and finishes.

So MCI staff have investigated ways of controlling pests besides poisoning them. Called “integrated pest management”, this strategy relies less on brute chemical force, and more on understanding the ecology of the museum habitat, the biology of the pest organisms, and the nature of the materials to be protected.

One promising approach pioneered by MCI's director, Dr. Robert J. Koestler, is to use non-toxic gasses to suffocate, rather than poison, invading pests. Koestler's method infuses a tightly sealed container with the inert gas argon, which is harmless



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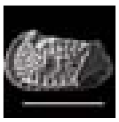

Evolution of Body Size

to objects but effective against insects and some fungi. The gas is heavier than the air it replaces, so it settles to the bottom of the container, forcing oxygen out of an exit hole near the top. It can take weeks before some insect species are killed, but eventually even individuals deeply bored into wood, where liquid poisons can't reach, succumb.

As often happens with research, the spin-offs can be just as valuable as the original purpose. MCI is cooperating with various Smithsonian museums to explore the possibility of using argon not just for de-infestation, but for long-term storage. An argon, oxygen-free atmosphere not only pest-proofs vulnerable materials, but it also protects them against chemical degradation over time, in which oxidation is a prime culprit.

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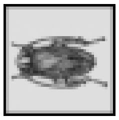

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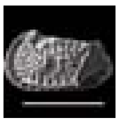

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An infrared image of the sky covering a field about 3 times larger than the full moon, and showing thousands of galaxies, some relatively close and others millions of light-years distant. The corner insert, the Antennae Galaxies, is an image illustrative of galaxy-galaxy collisions taken by the Hubble Space Telescope. Astronomers think collisions may be powering the energy in many of the brightest sources in this field (galaxies which are too far away to image clearly) by activating a black hole and/or triggering bursts of star formation.

The Most Luminous Galaxies in the Universe

The most luminous galaxies in our universe are not all that bright in visible light. Most of the radiant energy from these monsters is emitted at infrared wavelengths, and astronomers have found examples in which this energy amounts to tens, hundreds, or even thousands of times as much energy as that in our Milky Way galaxy. The power source in these so-called "luminous," "ultra-luminous," or even "hyper-luminous infrared galaxies" is not understood, but is thought to be due either to the presence of a massive black hole at each nucleus, or to hyperactive bursts of star formation. Astronomers think each of these processes can heat up the copious dust that surrounds them by producing abundant amounts of ultraviolet light that is absorbed by the dust. No one knows the relative importance of these two different kinds of processes, however, or whether other processes might be responsible. Scientists are trying to understand luminous galaxies both in order to understand why our Sun's own environment is as relatively benign as it is, and what details of the energy sources may hold as clues to the natures of massive black holes and massive young stars.

Smithsonian Astrophysical Observatory astronomers Steve Willner and Howard Smith are part of a team of astronomers who have combined Spitzer Space Telescope, Chandra X-ray Observatory, and ground-based datasets on 25,681 bright galaxies to try to find an answer. The core of the study was a thorough survey of galaxies with Spitzer; that program measured the infrared intensities of these galaxies at two different “color” wavelengths. The team found by comparing datasets that galaxies which were neutral in their infrared color were also galaxies with strong X-ray emission, and hence, they argue, galaxies with massive black holes in their nuclei that were generating X-rays that heated the dust. With similar comparisons, the team discovered sets of bright galaxies whose colors indicated a predominance of normal starlight, and others dominated by bursts of star formation. Analyzing the statistics of all of the objects, they report that nearly three-quarters of the galaxies that are both bright, and far enough away that they date from an era about half the current age of the universe, have active black hole nuclei. They also report less extreme luminous galaxies are powered by bursts of star formation and, there are many more of them. Overall, they conclude that black-hole powered, luminous infrared galaxies contribute only about 3-7% of the total infrared seen from galaxies, but that the most luminous sources were overwhelmingly black-hole dominated. The result indicates that the Milky Way is rather typical in not being extremely luminous, and in not having an active black hole (although it does have a quiescent black hole in its nucleus). They also indicate that black-hole dominated galaxies were more common in an earlier epoch.

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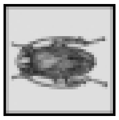

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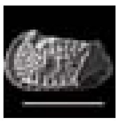

Evolution of Body Size

Mosquitoes are a common vector for West Nile virus.

Shift in Mosquito Feeding Behavior Drives West Nile Outbreaks

West Nile virus (WNV) was first reported in North America in 1999. Since then it has caused several outbreaks and is the main vector-borne disease in that continent. The virus can cause flu-like symptoms in humans and, rarely, fatal encephalitis (inflammation of the brain) or meningitis (inflammation of the lining of the brain and spinal cord).

WNV is maintained in infected bird populations. Transmission occurs when a mosquito bites an infected bird, carries the virus in its salivary glands and then bites another bird, releasing the virus. It can also be transmitted in this way to mammals, including humans.

To determine ways to predict and prevent future epidemics, Smithsonian National Zoological Park scientist, Peter Marra, and colleagues, have analyzed the feeding behavior of mosquitoes with population dynamics of birds and humans. This research tested the hypothesis that WNV outbreaks are the result of a shift in feeding behavior in *Culex pipiens* mosquitoes. They found that in May and June, the primary source of blood meals for the mosquitoes comes from the American robin (*Turdus migratorius)*. Coinciding with the post-breeding dispersal of robins, blood meal sources shifted in *Cx. pipiens* from birds to humans by 7-fold during July, August and September. American robins make up only a small percentage (4%) of the bird population, but provide 51% of early summer *Cx. pipiens* blood meals. This suggests that the shift in mosquito feeding behavior is the result of preference not the decline in the overall bird population.

These results provide an explanation for the increased incidence and intensity of WNV outbreaks in humans in the late summer.

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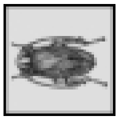

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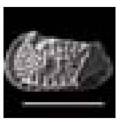

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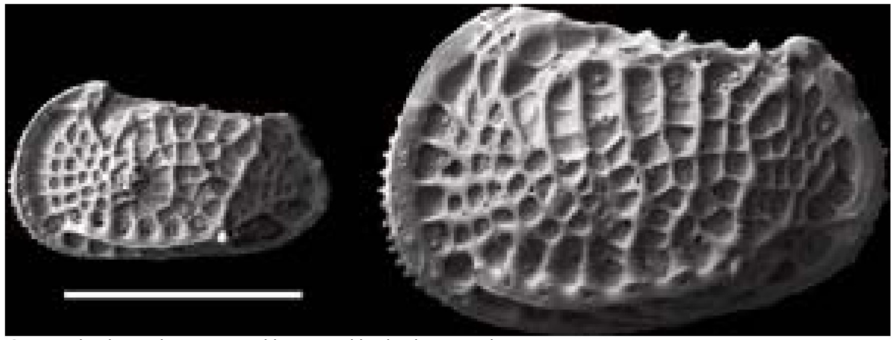

Ostracodes have demonstrated increased body size over time.

Evolution of Body Size

Body size is a trait that influences many aspects of the biology of an organism. Despite its importance, evolutionary patterns that influence body size are poorly understood. A common evolutionary trend is the tendency for body size to increase over geologic time (Cope’s Rule). In addition, body size tends to be larger in populations living in colder climates (Bergmann’s Rule). It has been suggested that Cope’s Rule is the evolutionary result of Bergmann’s Rule. Smithsonian Museum of Natural History paleobiologist, Gene Hunt and his colleague Kaustuv Roy from the University of California, San Diego, tested this hypothesis in the Ostracoda (genus *Poseidonamicus*).

Ostracodes are small marine crustaceans with a bivalve shell that are abundant in the fossil record. By comparing body size over geologic time, Hunt and Roy were able to determine that body size of *Poseidonamicus* has indeed increased by nearly 50% over the past 40 million years. They also found that populations from colder climate intervals tend to be larger than populations from warmer intervals by comparing paleotemperature estimates to body size. These results are consistent with expectations from Cope’s Rule and Bergmann’s Rule, and indicate that temperature is an important factor in macroevolutionary trends in body size of ostracodes.

Reference

Gene Hunt and Kaustuv Roy. Climate change, body size evolution, and Cope's Rule in deep-sea ostracodes. 2006. *Proceedings of the National Academy of Sciences.* Available at: www.pnas.org.

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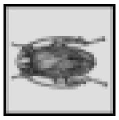

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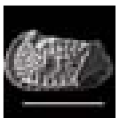

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