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Keeping Things in Proportion

Evolutionary biologists take some things for granted: for instance, that the length of a creature's arms or wings will be proportional to its body size. But a new study shows this isn't always the case. Researchers have bred butterflies to have disproportionate wing-to-body ratios, suggesting that natural selection plays a larger than expected role in determining animal form.

Proportion matters. The size of a butterfly's wings compared to its body may be determined more by natural selection than by genetics.
CREDIT: Anthony Frankino

The proportionality of animal shapes has long fascinated and divided evolutionary scientists. Some argue that these relationships are the result of genetic constraints that limit variation in shape and size. Others prefer the idea that natural selection is the true driver of body form.

Evolutionary biologists Paul Brakefield of Leiden University in the Netherlands and Anthony Frankino of Princeton University in New Jersey, set out to settle the debate by breeding the *Bicyclus anynana* butterfly. The team culled each generation, selecting only butterflies at the extremes of wing and body size ratio. To their surprise, canceling out the natural wing-to-body size rule of thumb was easy. After only 13 generations of artificial selection, the team had two distinctly

different groups of butterflies: ones with small wings and a beefy body; and ones with large wings and petite body.

Frankino and Brakefield then set up a mating contest between the modified males and normal males to see what would happen when natural selection was allowed to govern reproduction. In two breeding trials, normal males were 3 times more successful than the modified males in mating, the team writes in the 4 February issue of *Science*. "At least in the short term, there seemed to be no limit to how much we could change the body-to-wing ratio through artificial selection, but natural selection immediately selected for the proportional form," said Frankino.

"This research unambiguously resolves the controversy" of whether genetic controls constrain proportionality, said evolutionary biologist Doug Emlen of the University of Montana, Missoula. Developmental biologist Joseph Kunkel of the University of Massachusetts in Amherst says the study does not address the real issue. Researchers should stop searching for genetic limits on variation and instead "focus on discovering the mechanisms that allow species to stabilize a 'normal' body style," he said.

--DEBORAH HILL

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Brakefield's Web site
Frankino's Web site
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PAGE TOP Previous Story Next Story *Science*NOW Home

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Saturnian Hot Spot

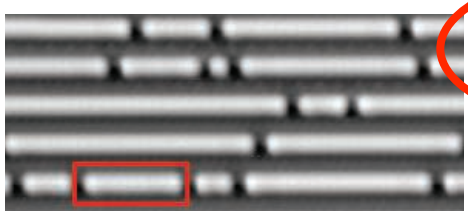
Ground-based infrared observations of Saturn with the Long Wavelength Spectrometer on the Keck I Telescope on Mauna Kea reveal a hot spot in the atmosphere within 3□of the south pole, a warm polar cap, anomalous temperature bands, and oscillations in temperatures in the southern hemisphere that are not correlated with cloud patterns. **Orton and Yanamandra-Fisher** (p. 696) suggest these features are related to radiative forcing and dynamical forcing that are consistent with 15 years of constant solar illumination of the southern hemisphere as Saturn goes through its southern summer solstice.

Two's Company, Three's a Cloud?

It has long been thought that the in situ creation of new (secondary) cloud condensation nuclei arises mainly from the reaction of gas phase sulfuric acid and water, but the rate of particle formation observed in laboratory studies has been too slow (by many orders of magnitude) to account for the number concentrations found in nature. A faster, ternary mechanism that includes ammonia has been postulated on the basis of theoretical factors. **Berndt *et al.*** (p. 698) now report experimental production of particles from a mixture of sulfuric acid and water at concentrations like those naturally found in the atmosphere, with ammonia at concentrations lower than those normally observed. The measured rate is consistent with that required to explain atmosphere number concentrations.

The End of the Line

The breaking of the translation symmetry of crystals at their surfaces gives rise to localized surface electronic states, and, in principle, similar effects should be seen at the ends of one-dimensional wires. **Crain and Pierce** (p. 703) present experimental evidence for such electronic states at the ends of one-dimensional gold chains of gold grown on the stepped Si(553) surface. Scanning tunneling microscopy images show markedly different contrast for the end atoms of chains when the bias voltage is reversed, and differential conductance measurements reveal the details of the electronic states of the end atoms that agree well with the results of tight-binding calculations. The formation of end states helps lower the energy of filled states for atoms within the chain.



CREDITS: (TOP TO BOTTOM) POULSEN AND BOOMSMA; CRAIN AND PIERCE

Fungus Monoculture on the Ant Farm

Leaf-cutting ants live in obligate ectosymbiosis with clonal fungi that they rear for food. These symbionts are vertically transferred during colony foundation, but fungus gardens are, in principle, open for horizontal symbiont transmission later on. **Poulsen and Boomsma** (p. 741) show that fungal ectosymbionts prevent competing fungal strains from becoming established by ancient incompatibility mechanisms that have not been lost despite millions of years of domestication and single-strain rearing by ants. These fungal incompatibility compounds travel through the ant gut to make the ant feces incompatible with unrelated strains of symbiont. Thus, the fungi manipulate the symbiosis to their own advantage at the expense of the ants' potential interest in a genetically more diverse agriculture.

Glimpses into the P/T Boundary

The Permian-Triassic extinction was the most extreme in Earth's history. It has been difficult in part to determine the environmental conditions that may have led to the extinction. **Grice *et al.*** (p. 706, published online 20 January 2005) present a detailed chemical analysis of marine sections obtained by drilling off western Australia and South China. The data suggest that the upper part of the oceans at the time of the extinction were extremely oxygen poor and sulfide rich. **Ward *et al.*** (p. 709, published online 20 January 2005), in contrast, reconstruct a record of the terrestrial vertebrate extinctions in the Karoo Basin, Africa. This area preserves the most detailed vertebrate fossil record from this time, but correlating rocks in different parts of the Basin has been problematic. Using paleomagnetism and carbon isotopes, they show that extinctions were accelerated up to a pulse at the boundary, and that the pattern of appearance of Triassic fauna may imply that some originated even before the final pulse.

Protein Kinase Inhibition Revealed

An important target of the second-messenger cyclic adenosine monophosphate (cAMP) is protein kinase A (PKA). PKA, which regulates processes as diverse as growth, memory, and metabolism, exists as an inactive complex of two catalytic subunits and a regulatory subunit dimer. cAMP binds to the regulatory subunits and facilitates dissociation and activation of the catalytic subunits. **Kim *et al.*** (p. 690) have determined the 2.0 angstrom resolution structure of the PKA catalytic subunit bound to a deletion mutant of the regulatory subunit (RIα). The complex provides a molecular mechanism for inhibition of PKA and suggests how cAMP binding leads to activation.

A Matter of Scale

A striking feature of morphological diversity across animal species is the variability in the relative size, or allometry, of different appendages. Virtually nothing is known of the forces that underlie the evolution of scaling relationships. Using the butterfly species *Bicyclus anynana*, **Frankino *et al.*** (p. 718) tested the roles of developmental constraints and natural selection in determining the size of the wings relative to the body, which as a measure of wing loading has clear functional and ecological importance. Artificial selection experiments on the size of the forewing relative to overall body size resulted in a rapid evolutionary response. In this case, developmental constraints did not limit the evolution of the scaling

CONTINUED ON PAGE 643

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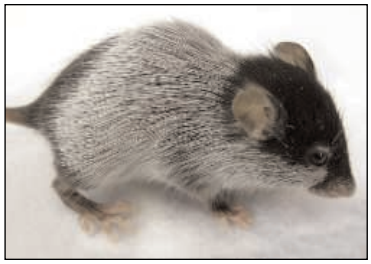
relationship. Instead, it is the pattern of natural selection imposed by the external environment that determine the wing-body size allometry.

Packaging and Power Combining

Mitochondrial DNA (mtDNA) is packaged with proteins into a nucleoid. **Chen *et al.*** (p. 714) show that one of the mtDNA packaging proteins is the Krebs cycle enzyme, aconitase, that the mitochondrion uses to generate metabolic energy. In this second role, aconitase is required for mtDNA maintenance under particular metabolic conditions. This finding provides a direct link between energy generation and mtDNA stability, mitochondrial disease, and aging.

Fade to Gray



Aging brings on many changes in the human body, among them the graying of hair. **Nishimura *et al.*** (p. 720; published online 23 December 2004) found in a mouse model of hair graying that a deficiency of the gene *Bcl-2* caused progressive loss of pigment cells in the bulge of the hair follicle—the hair stem-cell niche. Thus, the physiology of hair graying involves defective self-maintenance of melanocyte stem cells with aging, and may serve as a paradigm for understanding aging mechanisms in other tissues.

Autophagic Arms Race

One defense against intracellular invaders is to enclose them within autophagic vacuoles that then fuse with degradative lysosomes to destroy the pathogen. **Ogawa *et al.*** (p. 727, published online 2 December 2004) show that the invading bacterial pathogen *Shigella* can be recognized and trapped by autophagy. Generally, the pathogen circumvents the autophagic event by secreting an effector protein called IcsB during multiplication within the host cytoplasm; mutant bacteria lacking IcsB are particularly susceptible to autophagic killing. The *Shigella* VirG protein acts as the target that stimulates autophagy, but the IscB protein can camouflage it.

Giving Mice the Nod

The detection of bacteria in the gut by the immune system is regulated, in part, by the Nod proteins, which recognize peptidoglycan motifs from bacteria, and there is a strong association of the inflammatory bowel disorder Crohn's disease with mutations in the *Nod2* gene. Nevertheless, questions remain about the normal physiological role of the Nod proteins in maintaining homeostasis in the gut and how impaired Nod function leads to inflammation. **Maeda *et al.*** (p. 734) observed that Nod mutations in mice, corresponding with those carried by Crohn's disease patients, increased susceptibility to intestinal inflammation caused by the bacterial cell wall precursor muramyl dipeptide. **Kobayashi *et al.*** (p. 731) generated Nod2-deficient mice. Although these animals did not spontaneously develop intestinal inflammation, they were more susceptible to oral infection with the bacterial pathogen *Listeria monocytogenes*. Production of a group of mucosal antimicrobial peptides was particularly diminished in Nod2-deficient animals, which suggests that a similar defect may contribute to inflammatory bowel disease in humans.

Cytokine Production and Kaposi's

When tissues are infected with Kaposi's sarcoma–associated herpesvirus (KSHV), they produce large amounts of proinflammatory cytokines that are linked to disease progression. **McCormick and Ganem** (p. 739) show that a viral protein, kaposin B interacts with mitogen-activated protein kinase–associated protein kinase 2 and enhances the activity of this host cell protein, serving to block the decay of AU-rich messenger RNAs and increase the level of secreted cytokines. This result explains the association of KSHV-related disease and enhanced cytokine production.

CREDIT: NISHIMURA *ET AL.*

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