be consistently associated with specific DNA sequence motifs (17).

These comparisons suggest a number of potentially useful studies. Although technically challenging, it may prove fruitful to examine regional variation in chromatin accessibility in mammalian meiotic cells. How does this affect the action of recombination-related proteins such as Spo11? In addition to Spo11, at least 11 other proteins are involved in the initiation of double-strand breaks and recombination in yeast (21), and many of the responsible genes have orthologs in humans (such as, RAD50, RAD51, and MRE11). Comparisons of these genes in humans and chimpanzees could reveal differences that affect recombination patterns. In yeast, recombination hotspots can be eliminated by the insertion of the Ty transposable element, which suppresses recombination in nearby sequences (22). Thousands of Alu and LINE1 mobile elements have been differentially inserted in humans and chimpanzees since their divergence 5 million to 6 million years ago (23). Could these elements act in a fashion similar to yeast Ty, contributing to the rapid divergent evolution of recombination hotspots in humans and chimpanzees?

Studies such as that by Winckler et al. demonstrate the value of comparative genomic analysis for understanding basic biological processes such as recombination, and for potentially improving the design of genetic association studies. Their work also demonstrates the utility of analyses of within-species diversity and underscores the need for DNA sequence information from large samples of humans and other species. As this information accumulates, our understanding of biology, as well as our ability to design well-conceived gene-mapping studies, will continue to evolve and improve.

References and Notes
10. S. E. Ptak et al., Nat. Genet., published online 18 February 2005 (10.1038/ng1529).
ful chirping in rats is an important goal of future research. Such knowledge may help to reveal how joking and horsing around emerged in our expansive higher brain regions. Although no one has investigated the possibility of rat humor, if it exists, it is likely to be heavily laced with slapstick. Even if adult rodents have no well-developed cognitive sense of humor, young rats have a marvelous sense of fun. We have already bred rats that exhibit excess playful chirping (12), and thereby hope to track down some of the genes for joy. Perhaps we will even stumble on new molecules to alleviate depression as well as some excessive-exuberance disorders (13, 14).

Research on rough-housing play in mammals, both sapient and otherwise, clearly indicates that the sources of play and laughter in the brain are instinctual and subcortical (1, 3, 8). Although our species-typical capacities for verbal joking surely reflect highly refined cortico-cognitive skills (15), those incoming words must somehow tickle the ancient playful circuits of our minds for joy to occur. As we learn “to rib” each other with words, as opposed to just rough-and-tumble horse-play, we may be developing new synaptic connections to joyous neural zones that reside far below our cerebral crowns. It has long been intimated that laughter has many health benefits as well (16).

Human laughter, however, has a dark and dominant side. According to the philosopher Thomas Hobbes, “Laughter is nothing else but a sudden glory arising from some sudden conception of some eminency in ourselves.” Experts compiling the DSM-V psychiatric guidelines may wish to consider how excessive gloatng laughter contributes to “eminent-domain” disorders worthy of more precise psychiatric diagnosis. New treatments for such disorders might include strengthening the capacity for internal silent laughter (17), one of the few remaining mental capacities that may be uniquely human.

Many still believe that emotional feelings, from joy to grief, are special capacities of the human brain, but as Darwin taught, it just ain’t so (18). The recognition of emotional feelings in our fellow animals should no longer be reflexively deemed an anthropomorphic sin (4, 8). Perhaps it is time for neuroscience to accept that animals are capable of many emotional feelings (8, 19) (despite the consternation that may cause for investigators who treasure the study of fear behaviors more than joy).

We find ourselves at the tall-tale end of an intellectual era when the animal mind was deemed nonexistent or impenetrable. Gentle Darwin was prescient when he coaxed us to see our own emotional nature as continuous with that of our fellow animals (18). By studying the many emotional “instinctual” behaviors and related learning capacities of other animals, we may develop excellent ways to fathom the neuroemotional foundations of human consciousness. Weighty data are tipping the scales of evidence in favor of ever more subtle affective conceptions of animal minds, H. sapiens included (8). Although our emotional systems are neither uniquely nor intelligently designed, it is a blessing that we can finally understand their affective nature (19). As William Blake incompassorly declared in Auguries of Innocence (1863):

It is right it should be so;  
Man was made for joy and woe;  
And, when this we rightly know  
Through the world we safely go.  
Joy and woe are woven fine  
A clothing for the soul divine;  
Under every grief and pine  
Runs a joy with silken twine.

If the mental lives of other animals are also created from the neural threads of joy and woe (not to mention many other feelings), we may need to openly consider the nature of their affective brains in order to understand our own. This brings special responsibilities for the scientifically sapient savants among us (20, 21). Although some still regard laughter as a uniquely human trait, honed in the Pleistocene, the joke’s on them.

References


Playing Nature’s Game with Artificial Muscles

Ray H. Baughman

Feel the pumping of your heart or leap to witness the wonder of some nature’s muscles. Skeletal muscles self-repair, provide billions of work cycles involving contractions of more than 20%, increase strength and change stiffness in response to need, generate stresses of ~0.35 MPa, contract at 50% per second, and can even transform to fuel for the starved body (1). They convert the energy of a safe, energetic fuel (adenosine triphosphate) to mechanical energy with higher maximum efficiency (~40%) than that achieved by a typical car engine (1).

Artificial muscles offering even higher performance are being sought for artificial and damaged hearts, artificial limbs, humanoid robots, and bird- or insect-like air vehicles that fly by flapping wings. How well do such artificial muscles compare with natural muscle, and what are the prospects for future advances? This Perspective focuses on artificial muscles that generate large strains (fractional changes of muscle length) of about 20%, rather than high force, high response rate, and/or high output power at low strain. Instead of mimicking nature by creating large macroscopic strains by the combined effects of trillions of molecular actuators, the artificial muscles use material deformations.

Electronically conducting polymers such as polyaniline and polypyrrole provide one type of high-strain actuator. In what is basically a battery, these muscles actuate by using dimensional changes produced by electrochemically inserting solvated dopant ions into a conducting-polymer electrode. Although first described almost two