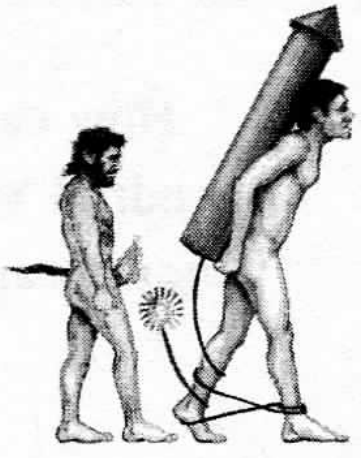
SCIENCE INTERLUDE
RAPID EVOLUTION

By Jane Palmer

If the human race is suffering from terminal information overload, there is worse to come: We're going to have to do more with less. Our brains are shrinking.

It's true. Or at least our skulls are shrinking. Take the mammoth skull of Robert the Bruce, the fourteenth-century king who freed Scotland from the grip of the English. Nearly twenty centimeters long, sixteen centimeters wide across the forehead, Bruce's sturdy skull was designed to take a bash or two—which it most likely got from the vengeful English.

Robert the Bruce is not alone in his massive brain box.* Our predecessors have us beaten when it comes to skull size. Five thousand years ago our skulls were approximately 150 cubic centimeters larger than they are now—the size of a large bag of M&M's—able to house 10 percent more brains!



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* Who else is in there?

Heads Are Not All That Are A-Changing

A dwindling brain is just one of a plethora of changes taking place in our species in recent history. Humans are evolving faster than ever before, picking up new traits and talents to deal with an equally fast-changing environment. This gives birth to the concept of rapid evolution—*rapid* and *evolution* being two words you never expected to see in the same sentence.

Human evolution, anthropologists say, accelerated a hundred-fold in the past ten thousand years. Ironically even evolution has to keep up with the pace of life.

Lobe finned fish, the famous fish that first crawled onto land, lived in ponds subject to seasonal drought. Fleshy fins allowed them to "walk" from drying pools to deeper water, and the swim bladder evolved into a sac able to breathe air. Lobe finned fish are the ancestors of amphibians and all higher types of vertebrates, including man.

Shrinking brains were a big surprise. But a hundred-fold increase in the speed of evolution is almost inconceivable! To come to this startling conclusion, anthropologists themselves had to evolve from a group obsessed with skeletons, to one that also fully embraces molecular technology. Today the skeleton geeks are sifting through not only dirt, but also DNA sequences to find point mutations (affecting a single nucleotide) that show just when various evolutionary changes took place.

How can scientists tell how old a particular mutation is? One hundred years old—or older than before our genome diverged from the ape or the lobe-finned-fish? Luckily there's a giveaway.

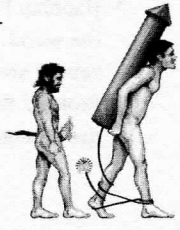
The Molecular Clock

Each mutation has "hitchhiking neighbors" nearby—in science jargon, juxtaposed genes—that, like our own neighbors, simply happen to live close to one another. When our diploid chromosomes recombine into haploid eggs or sperm, any given piece of DNA usually sorts out with its nearby neighbors. In each generation, the probability of two neighbors being shuffled apart is low. Only over time do the neighboring DNA sequences separate.

Scientists observe how many hitchhiking neighbors are associated with a mutation, and compare results from different samples. If many common neighbors are founds, the mutation is recent. If not, then the mutation is older and its neighborhood has changed over a period of time. This is the so-called **molecular clock.** We share *most* of our juxtaposed genes with other humans, *many* of our juxtaposed genes with apes, and *some* of our juxtaposed genes with the lobe-finned fish that lived 400 million years ago, By cross-referencing this information with data obtained from the fossil record, we can date when each mutation, point by point, changed us from fish to amphibian, monkey to man.

Molecular Clock: the DNA surrounding a point mutation that reveals whether the mutation is recent, ancient, or somewhere in between

Now let's turn the molecular clock forward, and shed some light on the modern day. When this phenomenally informative tool was applied to a large collection of human



DNA, the HapMap Database*, we discovered that hundreds of genes have changed in the last ten thousand years. In fact, small or large changes occurred in approximately 7 percent of all human genes. That's a lot!

If evolution had been ticking steadily at the current rate for the last six million years—since humans and chimpanzees separated—there would be 160 times more differences between us and the chimps than we actually observe. Pretty weird, huh? Evolution used to be slower, and it's speeding up!

What is driving this whirlwind of genetic activity?

It turns out that behind the accelerated rate of evolution are two familiar forces: civilization and a population explosion.

Nobody farmed, milked animals, or lived in cities thirteen thousand years ago. Vast changes in cultures and ecological niches have resulted in new opportunities for adaptation. Our genes had to hustle to enable us to survive and thrive in all that chaos called "civilization."

Add to that an unrelenting drive to reproduce that has increased our population from millions to billions in the last ten thousand years. More people means more mutation opportunities.

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* HapMap Project: A catalog of genetic differences among populations around the world. Three million point mutations have been identified; medical advances are one of the many benefits expected to emerge from the HapMap Project. ScienceDaily has a fascinating article about the project: http://tinyurl.com/23qpymp

Malaria, Milk, and Earwax

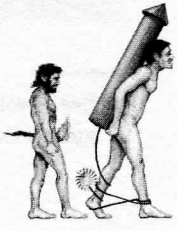
Peek inside the human body and check out some recent mutations. Some we can explain, others are still mysteries.

In Africa, India, and Pakistan, where inhabitants face the long-standing and pervasive threat of malaria, 10–15 percent of the population has evolved resistance to the disease. This resistance developed within the last four thousand years, in the unlikely form of the gene for sickle cell anemia. The same gene that damages red blood cells, resulting in life-threatening tissue damage, also prevents the malaria parasite from turning innocent blood cells into malaria factories. Our new genetic defense is a double-edged sword.

Earwax is on the wane.

Eight thousand years ago, the gene that enabled adults to digest milk first made its appearance in Europe. This mutation is a simple regulatory change that allows lifelong production of the infant enzyme lactase. The ability to digest milk from cradle to grave suddenly made dairy a rich source of food for adults. Dairy farming became such a wildly successful means of feeding your family that the "dairy gene" quickly spread. How quick is quick? After eight thousand years, approximately 95 percent of the German population has the gene, as well as the Masai in Africa and the Lapps in Finland.

Endemic malaria and the advent of dairy farming have associated mutations that show how environments mold our genes, but the rationale for some mutations is still baffling. Hop over to Asia where we find rapidly spreading genes that suppress body odor and earwax! Less sweat could conceivably offer a slight benefit in cold cli-



mates, but no scientist yet has claimed to understand what survival advantage *less earwax* might confer.

Our scientists are searching for human mutations big and small, from those involving the onset of speech to those that might impact Q-tip sales. From a genetic vantage point, we are finding that the human race resembles a diverse cluster of weird mutants. But one new evolutionary trend is shared between populations in Asia, Europe, Africa, Australia, Anerica, and every country where anthropologists have been able to take calipers: The human skull is shrinking, even as our bodies grow.

WENDY'S SEXY NEIGHBOR NOTION

If an advantageous mutation occurs, the neighborhood around that mutation is selected for too. So something really great like **X-Ray vision** or the ability to **smell flowers** can be linked to something meaningless, like green eyes. *We can track some beneficial mutations just by looking at associated visible traits.* Imagine that green eyes were linked to a wildly successful mutation allowing the immune system to defeat cancer*. How many generations would it take before we notice that the healthiest people are green-eyed? How long before they are sought as wives and husbands for their longer life spans? If eye color becomes a *marker* for improved health, how long before the marker itself is considered sexy?

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* See "Evolving Cancer" (p. 171) for more about the battles our bodies wage against cancer.

Whether our intelligence is also shrinking is a question for debate. When it comes to our cerebral cortex, size isn't everything—Albert Einstein and Anatole France, the infamous French novelist, were both pea-brained geniuses. But even if our wits are waning, in a world where you can outsource many of your mental tasks to a computer, and where the onslaught of modern media rewards those with the attention span of a gnat, the downsizing of our intellect could be a huge plus. Big brains are expensive to make and maintain, and if Mother Nature can get by with less—she will.

We could be evolving rapidly toward idiocracy.

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