EVOLUTION'S CHILD:
LOOK FOR THE DESCENDANTS OF *HOMO SAPIENS*
IN THIS GALLERY OF FUTURE FORMS

THE WHOLE EVOLUTION ALMANAC

When the book of evolution is written, what will it say about the descendants of man? Will the heirs to the human throne be tiny green creatures that feed off the sun, expansive clouds of cosmic dust, or robots with virtually no organic components at all? When challenged by the creative force of evolution, our far-flung progeny might take some innovative forms.

Whatever the outcome, several of the scientists we con-

These highly intelligent robots, capable of thinking much like us, will begin a trek across the cosmos, leaving the Earth as a human preserve.

At this juncture, says Moravec, organic, mortal humans will want to transfer their thoughts and feelings—indeed, their very essence—into the vessel of the immortal machine. As time goes on, Moravec adds, humans will meld with their lab creations

WHOLE EVOLUTION ALMANAC

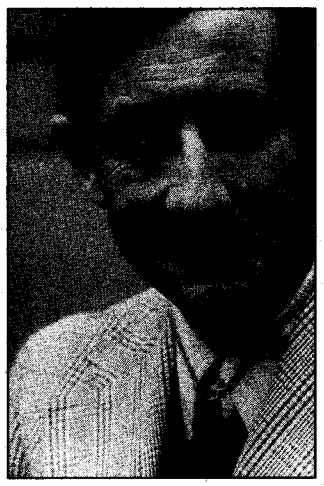
HEIRS TO THE HUMAN THRONE MAY ASSUME A VARIETY OF INNOVATIVE FORMS

COSMIC CLOUD

He will be the size of a planet, though the human of today could walk right through the grain-sized iron particles that make up his Brobdingnagian frame. This giant creature, inhabiting the empty reaches of space, would greet friends with a blast of solar energy and blow hydrogen gas to whisk cosmic debris away.

More than a decade ago, physicist Freeman Dyson, building on an idea from astronomer Fred Hoyle, suggested that the evolutionary last stand of the human might be in the form of a giant, intelligent black cloud. "What I envisage as the structural unit of such a creature is simply dust grains," Dyson said, "probably made of iron or some convenient stuff, charged and working on each other with electric and magnetic forces. Such creatures could be just as complex, if not more complex, than the creatures we see around us now."

In a recent interview, the physicist at the Institute for Advanced Study in Princeton said that the creature's sensory organs would be collections of solid particles tuned to respond to radio waves, visible light, and X rays—a fuller spectrum than humans can perceive. It would live on sunlight or perhaps interstellar gas and radiate long-wave energy—infrared or radio waves—to aid in the excretion of wastes. "It might get rid of things it considers junk," Dyson says, like hydrogen by-products, for instance, in an occasional volcanic belch.



Freeman Dyson suggests humans may evolve into giant clouds.

Will the cosmic cloud have feelings? Will it suffer pain, laugh and love, or pray? "There's no reason why it shouldn't do all of the above, or none," Dyson says. "They may not share any of our concepts, or on the contrary, they may share a great deal."

The cloud could evolve much more rapidly than we did, Dyson speculates, and might prove even more damaging to the earth's environment than we are. In its wanton wanderings, the dust cloud might sometimes park between the earth and the sun, casting a cold shadow over the remnants of anachronistic humans, still in solid organic form.

ANTIGRAVITY GRUNT

She will have to be thick-skinned about wisecracks concerning her weight: almost nothing, because she'll live in a zero-g environment. She'll be thick-skinned about everything else as well, because genetic engineers will build her that way, with several inches of tough hide surrounding her human bones, an organic space suit that will enable her to live forever in orbit.

British science writer Dougal Dixon, author of *Man After Man* (St. Martin's Press), imagines that the antigravity grunt will be launched with genes from human parents on pollution-plagued Earth in 200 years. Then she'll enter permanent service to work on a starship under construction in orbit. There will be no smog in her workplace. But Dixon says she will worry about solar wind—streams of ionized particles hurled past the earth from the sun. When the solar wind is high, her alligatorlike skin will close over two sealed lenses covering her eyes, the most vulnerable part of her anatomy. Her gray, ovoid body, about four feet long, will include a balloonlike base, two arms and two legs, and long fingers and toes. Her tough skin will house a compressed human skeleton and organs, including a few spare lungs, one containing high-pressure breathing gases and another for use in venting carbon dioxide. The fourth lung will come in handy if she loses her grip on the starship's struts and floats free in space. Then she'll be able to blow off some waste gas to push herself back to the safety of the spaceship.

Far above the earth, the weightless creature will also find time for play. "She'll shoot pool in three dimensions," Dixon suggests, the balls ricocheting off the inside walls of a sphere. With rudimentary understanding of human society, she'll be able to laugh at visitors' jokes about how lighthearted she is. But sealed inside her skin, she'll never hear the jokes well or speak with a human voice. Instead she'll communicate through a set of quivering antennas, like a bee. Starship workers will carry electronic translators to convert their speech into vibrations transmitted by direct touch from plastic antennas to her artificial sensory organs.

She will learn through this touch-talk how "unique" she is, says Dixon, a euphemistic way of telling her that she wasn't built to breed. She'll never reproduce. If there is a need for more vacuumorphs, as Dixon calls them, engineers will pull out the blueprints and build more.

HER GRAY, OVOID BODY WILL BE ABOUT FOUR FEET LONG. HER THICK OUTER HIDE WILL PROTECT HER FROM THE ONSLAUGHT OF LIFE IN ZERO G. THOUGH SHE CARRIES HUMAN GENES, SHE WILL NEVER REPRODUCE.

HO-HUM HOMINID

We have seen the future, and it is us. According to many evolutionary biologists, it seems humans are no longer evolving at all. "Indeed, when one looks at the evolution of brain size and longevity," says gerontologist Richard Cutler of the National Institute on Aging, "it appears that evolution for humans stopped fifty to a hundred thousand years ago." In fact, Cutler says, technology has rewritten survival-of-the-fittest laws. Men with defective eyesight, who would have been devoured by tigers in the primeval jungle, wear contact lenses today and pass on their biological blueprints for myopic men of the future. "Not only are we not improving," says Cutler, "we're getting worse."

One evolutionary biologist who believes that human evolution has slowed to a halt is Harvard's Stephen Jay Gould. "Review the incredible things we've done, how all of civilization has been built in twenty-five thousand years from Cro-Magnon to this, with no change in morphology," he says, "so why should we predict anything else?"

Gould made his case to *Omni* writer Delta Willis, who interviewed paleontologist Richard Leakey as well. Further evolution, notes Leakey, would require major life-style changes—living in a space colony, for example. But Leakey says that

PLANT PEOPLE

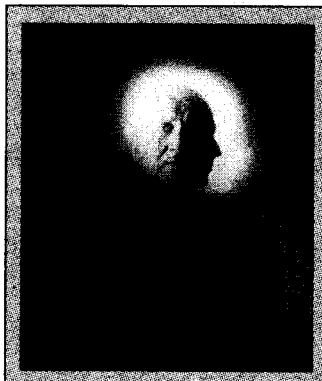
In the future, those who eat spinach may not have to eat much else. Tomorrow's vegetarian will learn to incorporate plant cells into the human body without digesting them. So, like the plants they eat, humans will draw their energy from the sun through photosynthesis—the process by which plants combine sunlight, water, and oxygen into carbohydrates, the basic foodstuffs of life. For these photosynthetic people of tomorrow, the alteration will bring a side benefit: They won't have to worry about suntanning because they'll be green.

Fatima Linda Jackson, an anthropologist at the University of Maryland, is already at work researching how we might make better use of the components of plants for good health. The ultimate goal: protecting the plants we eat from digestion so they can continue to live inside our bodies.

One animal has already solved the problem—the lowly sea slug, a green blob less than an inch long that lives at the base of grass in saltwater marshes. Sidney K. Pierce, Ph.D., professor and associate chair in the department of zoology at the University of Maryland, has discovered that the slug sucks nutrients out of certain hairlike kinds of algae and supports the plant material inside its body. Under light, the material produces oxygen and fats that feed the slug. Pierce says he's kept a colony of slugs alive with nothing more than ordinary fluorescent light for months.

Even before we learn the slug's secret, we could load the cargo bays of spacecraft with batches of the animals to supply oxygen. But Pierce says there's a limit to the blob's beneficence. Colonies die out after about a year. Keeping them cool—close to freezing—adds about six weeks to their lives, roughly 12 percent, suggesting that future green men might want to take a cue from today's florist-shop roses and remain refrigerated when they're not out feeding in the sun.

—Gurney Williams III



Homo sapiens futurus. *Big head and Mickey Mouse eyes.*

THE CHILD IS FATHER TO THE MAN

Scientists call it neoteny, but you could think of it as the Hollywood hypothesis. The future human will have a larger head at birth than our size of ours. Like Mickey Mouse, he'll also have comparatively large eyes, suggests gerontologist Richard Cutler. If Cutler and other researchers are successful, *Homo sapiens futurus* will be smarter than we are and won't reach middle age until sixty. And like the lead in a fairy-tale movie, the creature will live happily almost ever after—perhaps 200 years.

The neoteny hypothesis holds that the more advanced the species, the more juvenile its features. With evolution comes larger cranial domes and smaller facial masks below—that is, increasing "babyishness"—according to cognitive psychologist Robert Shaw at the University of

computer simulations of how human heads grow. Running his simulation backward, Shaw regressed the face to a hypothetical time before birth, generating a picture of the large-headed individual into which the neoteny hypothesis suggests we will evolve. The bigger brain, Shaw points out, would require a bigger body to supply it with nutrients and to diffuse the increased production of heat.

Cutler adds that the genetic engineering to spawn this creature might be simple, involving the fine-tuning of a few hundred genes. But politics might prevent it. "We don't want a lot of smart guys around," says Cutler. "We're afraid of

WHOLE EVOLUTION ALMANAC

THE DEVOLUTION PROGRAM: A FIVE-DAY PLAN FOR ACHIEVING LOWER CONSCIOUSNESS

BY KEITH HARARY

Becoming a fully evolved [redacted] apelike features of your

bucket of fried chicken from a local stand or one of the fast-food chains. Spread all the chicken parts out on a table and try to reassemble the pieces into a complete chicken. Use a needle and thread, a staple gun, or masking tape to hold everything together. If you are a vegetarian, you may carry out this exercise with a large order of French fries, which you can reassemble into potatoes. (You might also take a cue from the writers of *Late Night With David Letterman,* as recently reported in *The New York Times.* The team suggested rummaging through meat plant Dumpsters and pulling out enough different parts to assemble your own cow.)

ORDER A BUCKET OF FRIED CHICKEN FROM A LOCAL FAST-FOOD PLACE AND TRY TO REASSEMBLE THE PIECES INTO A COMPLETE ANIMAL. VEGETARIANS MAY ORDER FRENCH FRIES AND REASSEMBLE THEM BACK INTO POTATOES.

By the way, for the ultimate in primitive eating, you might try dining out at some of the finer vending machines in your area. Suggested fare includes canned sodas, candy bars, and onion and sour cream chips. Some of the more elaborate, Automat-type machines also offer petrified hamburgers, prehistoric egg salad, and Precambrian tuna on white bread.

DAY THREE: THE HUNTER-GATHERER

Early man depended on nature to provide the basic necessities. On day three of the devolution program, pay homage to this tradition for an afternoon. Your goal: to gather and enjoy as much free stuff as possible.

Begin by dousing yourself with five or six different fragrance samples from the nearest perfume or cologne counter. Ask the salespeople to give you a pocketful of additional samples. Next, stop by your doctor's office and try to get some free samples of any prescription drugs you may be using. Then seek out a crowded hot dog stand where you can graze unnoticed from the open sauerkraut, relish, and pickle bins for a tasty lunch. Use plenty of ketchup and mustard and take some extra packets of these condiments with you. If you can't find a convenient hot dog stand, seek out a bar that serves free hors d'oeuvres and eat your fill. Stuff your remaining pockets with as much free food as possible, along with any loose bags of sugar or low-calorie sweetener that you can easily lay hands on. Keep alert for any free books of matches.

Finally, head to the nearest bakery and make a dessert out of any pastry samples that may have been placed in little dishes on the counter. On the way home, pick through other people's garbage for anything you can use.

DAY FOUR: PRIMITIVE CONSCIOUSNESS

In an effort to be more evolved, many people try to relate to others in a purely rational way. Yet there is still something of the primitive in all of us, an inner sense that responds to people and events on an emotional, instinctive level.

On day four of our devolution program, allow yourself to get more consciously in touch with this aspect of your awareness. Whenever any stressful circumstances arise during the course of your day, ask yourself, "What would *Australopithecus afarensis* do in this situation?" Allow your responses to emerge from a deep gut level to whatever extent possible. If you pass a pretty flower on the street, for example, take time to savor its organic aroma. If you get in an argument with your mate, don't just deal with the situation from an intellectual distance. Stay in touch with your deepest feelings throughout the discussion. If you feel stressed out in the course of your day, go off to a place where you can be alone and wildly pound your fists into pillows or sofa cushions while allowing yourself the luxury of a primal scream. Finally, at some point today, spend time in a natural setting like a woodland or park and let go of the intellectual priorities of the civilized world.

DAY FIVE: THE COMPETITIVE SELF

The more we evolve, the more we must learn to live in harmony with each other. On the final day of our devolution program, however, you will loosen some of the shackles of socially evolved behavior and allow your innermost competitive self to come to the fore. Your focus should be on allowing yourself to be as competitive as possible, without becoming really obnoxious or mean.

If you work as a secretary, for example, you might organize a speed-typing competition in your office, along with events in pencil sharpening, envelope stuffing, and stamp licking. Try to shoot a rubber band across the office farther than anyone else. Or create miniature Olympic events less specific to your occupation, including such feats as watermelon eating, necktie knotting, and speed shaving. If you can't find people to compete with, compete with yourself: Get a book of brainteasers and see how many you can answer correctly. See how many Barry Manilow tunes you can listen to, or how many times you can play Paul Anka singing "Havin' My Baby" without throwing up. If you normally tell yourself not to be rankled by the political machinations of that manipulative colleague of yours, now is the time to let feelings of intense annoyance to creep in—and to act on them. Complete the exercise by playing Risk or Monopoly—and playing to win. ∞

WHOLE EVOLUTION ALMANAC

DO-IT-YOURSELF MUTATION KIT: ORCHESTRATING EVOLUTION AT YOUR KITCHEN TABLE

BY HEMANT CHIKARMANE

YOU DON'T NEED TO BE A MOLECULAR BIOLOGIST TO SEE EVOLUTION IN ACTION. EXPLORE THE MUTATIONS THAT DRIVE NATURE'S DIVERSITY WITH A HOME LAB, AND LET *SACCHAROMYCES CEREVISIAE*, A COMMON YEAST, BE YOUR GUIDE.

The idea of orchestrating evolution yourself seems like heady stuff indeed. But with our Do-It-Yourself Mutation Kit, described in the pages that follow, you should be able to observe the process at your kitchen table. We'd like to start you off with some basic biology: Individual organisms and entire species change as a result of mutations in genes. You might think of a genetic mutation as a spelling mistake within the subunits that compose the gene. Since most mutant organisms have trouble adjusting to the environment, it's a good thing that mutations are rare. Of course, every so often a mutant is better suited to a given habitat than its ancestors. When that happens, the mutant organism will have more offspring than its nonmutant siblings. As evolution takes its course, the mutants will thrive.

To see the process in action, all you've got to do is follow the instructions below. Your guide for this journey of exploration will be *Saccharomyces cerevisiae*, a common yeast. Since the yeast grows rapidly, you will be able to observe the results of each experiment in two to three days.

To order the kit, send a $20 check or money order to molecular biologist Hemant Chikarmane at the Marine Biological Laboratory, Woods Hole, MA 02543.

INSTRUCTIONS

After you have received your kit, open it up and make sure all the materials are there. You should find five petri dishes labeled as follows: ADENINE NEGATIVE A and ADENINE NEGATIVE B (these two plates lack adenine, an essential nutrient); COPPER A and COPPER B (these two plates contain copper salt, which can kill the yeast); and MASTER, a master plate that contains a cocktail of nutrients on which all forms of yeast can grow. You should also find a tube of yeast culture, four sterile spreaders, four sterile pipettes, and 40 sterile toothpicks. Keep the kit in the refrigerator until you decide to use it. For each experiment, take out only those items that you actually need.

To help you with your experiments, get hold of a marker, as well as paper and pencil to keep track of your results. We also suggest that you go to the drugstore and buy some antibacterial soap, antiseptic, and ordinary bleach (ask the pharmacist to suggest appropriate brands). A small container for waste would help, too.

Before you begin, read the instructions once through and keep these basic laboratory principles in mind:

Cleanliness and sterility. Make sure you work at a clean table with as little draft as possible. Wipe the table clean with an antiseptic such as Lysol before and after you work. Since the air contains bacteria and fungi that can contaminate your experiment, be careful not to open your petri dishes unless you are working with them. Since your fingers also have all sorts of bacteria on them, do not touch the sterile surface of the plate with your fingers. Transfer of organisms should be done only with the sterile pipettes or sterile toothpicks. After each experiment, wash up with antibacterial soap.

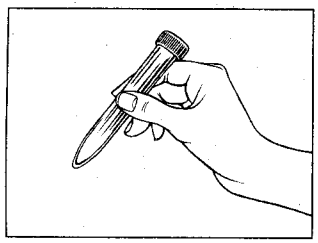
Spreading culture on the plate. To isolate mutants that have evolved, you must spread yeast from the culture uniformly on the petri dish. To do so, place the petri dish on the table and lift the cover with your left hand, placing it beside the dish. Pick up the culture tube of yeast with your left hand and shake it (figure 1). Then unscrew the top and place that on the table, too. Pick up a sterile pipette, squeeze the top, and dip the tip into the yeast culture tube (figure 2). Slowly release the bulb to draw yeast culture into the pipette. Hold the tip of the pipette about a quarter inch above the center of the open plate. Gently squeeze the pipette bulb so that two to three drops fall on the surface (figure 3). Discard the pipette into a waste container filled with bleach. Cap the tube. Now pick up the spreader and hold it so that the short arm gently touches the surface of the petri dish. Spread the liquid evenly over the surface (as shown in figure 4) and carefully rotate the plate.

Growing yeast. After you have spread the culture on your plate, leave it alone at room temperature (70–75° F or 22–25° C) for one to three days. (Keeping the petri plate at 85° F or 30° C will promote faster growth.) Through the course of these instructions, this will be referred to as incubation. Yeast will first appear as pinhead-sized dots and may ultimately assume a diameter of an eighth of an inch.

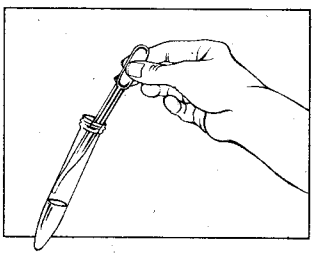
Transferring yeast from plate to plate. Open a petri dish and, using a sterile toothpick, remove a yeast sample about the size of a pinhead (figure 5). Open the second petri dish and touch the tip of the toothpick to the surface. Slide the toothpick gently, making a streak about half an inch in length. Discard the toothpick and do not reuse.

THE EXPERIMENTS

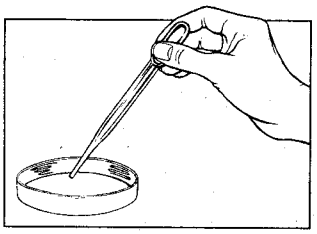
1. Selecting for mutants that regain a lost function. Normal yeast cells have the ability to make their own adenine, an essential component of DNA. The yeast strain in *your* tube, however, has a mutation in the gene called *ade1* (for adenine). As a result of the mutation, an important enzyme is no longer active and the yeast cannot make adenine. Without adenine, yeast cannot replicate (unless you supply the adenine yourself).



However, if you place these mutants on your petri dish, they will still produce the cascade of chemicals leading up to (but not including) the crucial enzyme. The chemical that accumulates when the enzyme cannot be produced is red; therefore, the colony that you will plate out and incubate in your petri dish will appear red. In this experiment, you will start with red yeast and mutate some organisms back to the original form—white yeast with the ability to produce adenine. Experimental procedure: Shake up your tube of yeast and put three drops of yeast culture on the petri dish marked ADENINE NEGATIVE A. Spread the drops carefully and uniformly with the spreader. Then incubate the plate for two to four days, until white colonies—the new mutants—start to grow. The mutants arose spontaneously and, according to current evolutionary thought, have been "selected" by the environment to survive. Refrigerate this plate and save it for experiment 3.

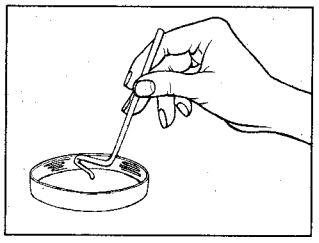


2. Selecting for mutants that develop resistance to a poison. In this experiment you will isolate mutants that can resist the lethal power of copper salt. Compounds of metals like copper, lead, and mercury are toxic to cells because they block the action of proteins and enzymes. Some cells randomly develop mutations that lead to resistance to metal salts. In the case of yeast, these mutations work by overproducing a protein that binds tightly to the metal, preventing damage to the cell. Experimental procedure: Spread three

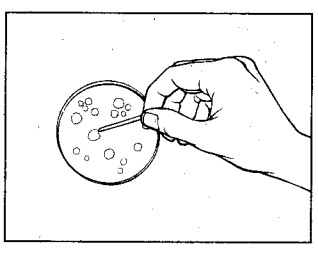


drops of yeast from your culture tube onto the plate marked COPPER A and incubate for two to five days. You should see small colonies of copper-resistant yeast forming. Wait until the colonies grow to about an eighth of an inch in diameter. Then refrigerate the plate and save it for experiment 3.

3. Proving that all the mutations are transmitted to offspring whether or not they are advantageous to the organism. In this experiment you will grow your mutant yeast cells on the MASTER dish, which will enable all your cells to grow equally well. Experimental procedure: Gather the two petri



dishes you used in experiments 1 and 2 and place them beside you on the table. Take your marker and, turning over the MASTER dish, draw a line down its center so that you divide it in half. Mark one area ADENINE and mark the other area COPPER. Now take the plate labeled ADENINE NEGATIVE A and choose a colony at random. Pick up that colony on the tip of a sterilized toothpick and transfer it, in the form of an individual streak, to the area marked ADENINE on the MASTER dish. Create four more adenine streaks on this area, then store the ADENINE NEGATIVE A plate in the refrigerator. Now streak the copper-resistant mutants from the COPPER plate onto the area marked COPPER in a similar fashion. Incubate the plate for one to two days, and note that the streaks will grow up into elongated colonies. These colonies grow even though the mutants no longer have any particular survival advantage.



4. Showing that mutations affecting one trait arise independently of mutations affecting another. Experimental procedure: Remove from the refrigerator the plates labeled ADENINE NEGATIVE B (this plate contains no adenine) and COPPER B (this plate contains copper salt). Take your marker, turn the plates over, and draw a line down the center of each dish, as you did with the MASTER plate in experiment 3. As you did in experiment 3, label one half of each plate ADENINE and label the other half COPPER. Now place the MASTER dish in front of you. Using sterile toothpicks, transfer material from the COPPER section of the MASTER dish to each of the two areas labeled COPPER on the two new plates. Transfer material from the ADENINE section of the MASTER dish to each of the two areas labeled ADENINE. Incubate these two dishes. Note that the mutant colonies isolated from the ADENINE segment of the MASTER dish will grow on the second ADENINE NEGATIVE plate but not on the COPPER plate. The mutant colonies isolated from the COPPER segment of the MASTER dish will grow on the second COPPER plate but not on the ADENINE NEGATIVE plate. Consider the history of these yeast colonies and you will reach one conclusion: The yeast cells have retained their mutant traits throughout each and every transfer. These colonies should grow quickly, since the mutants adapted to these two plates have already evolved during experiments 1 and 2.

A BRIEF HISTORY OF HUMAN TIME

SCIENTISTS EXPLORING HUMAN ORIGINS PICK A FEW BONES

BY DELTA WILLIS

The study of human evolution has been plagued by personal conflicts and idiosyncrasies ever since Charles Darwin began his study of life aboard the HMS *Beagle.* Discussing the search for human origins, Mark Twain noted that "scientists have already cast much darkness on this subject, and if their investigations continue, we shall soon know nothing at all." Of course, researchers now know a great deal about human ancestors. But the arguments and counterarguments between them go on. In fact, judging from newspaper reports, it

seems that the fields of evolutionary biology and paleoanthropology have been host to professional battles and personal wrangles in spades.

To illustrate the monkey business that has often accompanied the search for missing links, we have created a couple of time lines: a Discovery Line, to depict important scientific discoveries about human origins, and an Inside Line, to illustrate the behind-the-scenes footnotes to those discoveries. To help you put it all in context, we also present a life line that illustrates a reasonable timetable for how hominid species actually evolved. (When reading the life line, you'll note some incongruities, but our numbers merely reflect the data of a science still in the process of being unearthed.)

As you read through our charts, you'll probably realize that bigheadedness afflicts the human species in more ways than one. After all, scientists don't deserve all the heat. They belong to the same species as the rest of us, and their behavior tends to reflect the apish and territorial—though thoroughly conventional—view that success lies in displacing the competition.

Australopithecus boisei. Found in East Africa,

Homo habilis. The first species in the genus

Homo erectus. A more evolved, bigger-brained

Homo sapiens (archaic). These ancient human forms, which seem to have

A BRIEF HISTORY OF HUMAN TIME

PALEOANTHROPOLOGISTS CAN BE APISH AND TERRITORIAL, JUST LIKE THE REST OF US


Homo sapiens


Homo sapiens