if humans were BUILT TO LAST

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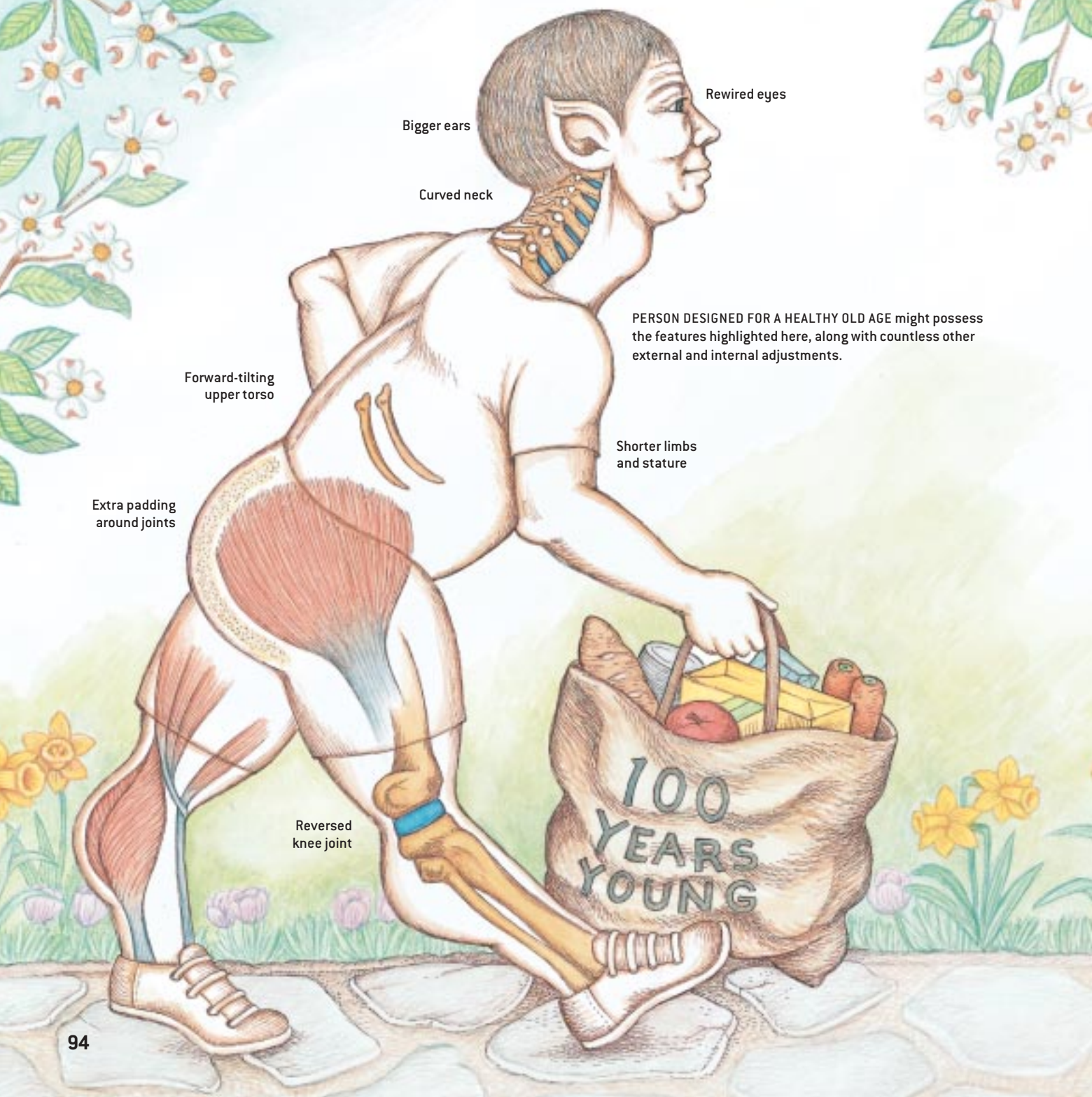
Illustrations by Patricia J. Wynne



PERSON DESIGNED FOR A HEALTHY OLD AGE might possess the features highlighted here, along with countless other external and internal adjustments.

Bulging disks, fragile bones, fractured hips, torn ligaments, varicose veins, cataracts, hearing loss, hernias and hemorrhoids: the list of bodily malfunctions that plague us as we age is long and all too familiar. Why do we fall apart just as we reach what should be the prime of life?

The living machines we call our bodies deteriorate because they were not designed for extended operation and because we now push them to function long past their warranty period. The human body is artistically beautiful and worthy of all the wonder and amazement it evokes. But from an engineer's perspective, it is a complex network of bones, muscles, tendons, valves and joints that are directly analogous to the fallible pulleys, pumps, levers and hinges in machines. As we plunge further into our postreproductive years, our joints and other anatomical features that serve us well or cause no problems at younger ages reveal their imperfections. They wear out or otherwise contribute to the health problems that become common in the later years.

We would look a lot different if evolution had designed the human body to function smoothly for a century or more

In evolutionary terms, we harbor flaws because natural selection, the force that molds our genetically controlled traits, does not aim for perfection or endless good health. If a body plan allows individuals to survive long enough to reproduce (and, in humans and various other organisms, to raise their young), then that plan will be selected. That is, individuals robust enough to reproduce will pass their genes—and therefore their body design—to the next generation. Designs that seriously hamper survival in youth will be weeded out (selected against) because most affected individuals will die before having a chance to produce offspring. More important, anatomical and physiological quirks that become disabling only after someone has reproduced will spread. For example, if a body plan leads to total collapse at age 50 but does not interfere with earlier reproduction, the arrangement will get passed along despite the harmful consequences late in life.

Had we been crafted for extended operation, we would have fewer flaws capable of making us miserable in our later days. Evolution does not work that way, however. Instead it cobbles together new features by tinkering with existing ones in a way that would have made Rube Goldberg proud.

The upright posture of humans is a case in point. It was adapted from a body plan that had mammals walking on all fours. This tinkering undoubtedly aided our early hominid ancestors: standing on our own two feet is thought to have promoted everything from food gathering and tool use to enhanced intelligence. Our backbone has since adapted somewhat to the awkward change: the lower vertebrae have grown bigger to cope with the increased vertical pressure, and our spine has curved a bit to keep us from toppling over. Yet these fixes do not ward off an array of problems that arise from our bipedal stance.

What If?

RECENTLY the three of us began pondering what the human body would look like had it been constructed specifically for a healthy long life. The anatomical revisions depicted on the following pages are fanciful and incomplete. Nevertheless, we present them to draw attention to a serious point. Aging is frequently described as a disease that can be reversed or eliminated. Indeed, many purveyors of youth-in-a-bottle would have us believe that the medical problems associated with aging are our own fault, arising primarily from our decadent lifestyles. Certainly any fool can shorten his or her life. But it is grossly unfair to blame people for the health consequences of inheriting a body that lacks perfect maintenance and repair systems and was not built for extended use or perpetual health. Our bodies would still wear out over time even if some mythical, ideal lifestyle could be identified and adopted.

This reality means that aging and many of its accom-

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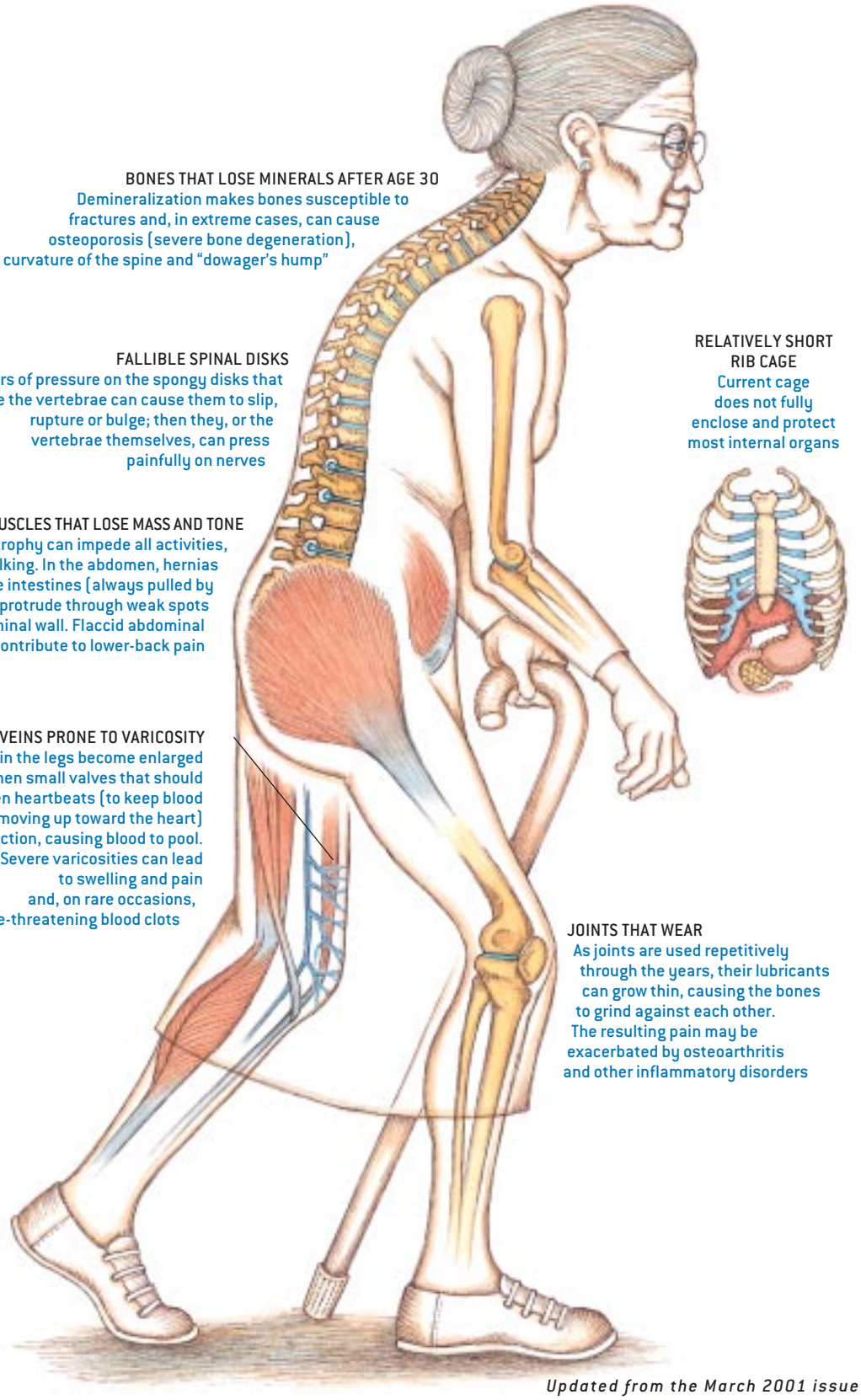
WALK THIS WAY

A NUMBER OF the debilitating and even some of the fatal disorders of aging stem in part from bipedal locomotion and an upright posture—ironically, the same features that have enabled the human species to flourish. Every step we take places extraordinary pressure on our feet, ankles, knees and back—structures that support the weight of the whole body above them. Over the course of just a single day, disks in the lower back are subjected to pressures equivalent to several tons per square inch. Over a lifetime, all this pressure takes its toll, as does repetitive use of our joints and the

FLAWS



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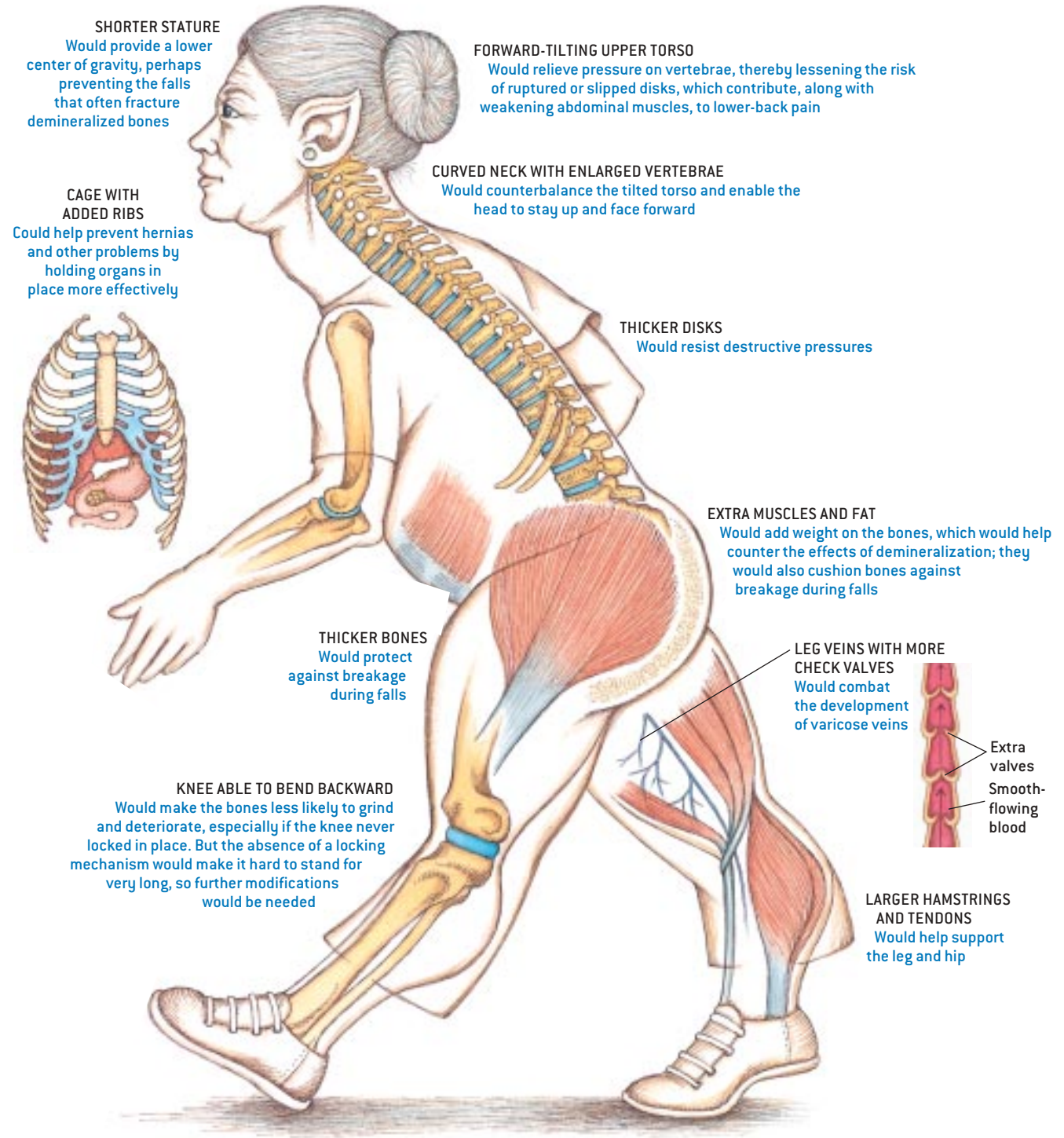
constant tugging of gravity on our tissues.

Although gravity tends to bring us down in the end, we do possess some features that combat its ever present pull. For instance, an intricate network of tendons helps to tether our organs to the spine, keeping them from slumping down and crushing one another.

But these anatomical fixes—like the body in general—were never meant to work forever. Had longevity and persistent good health been the overarching aim of evolution, arrangements such as those depicted below might have become commonplace.

FIXES



PLAN A HEAD

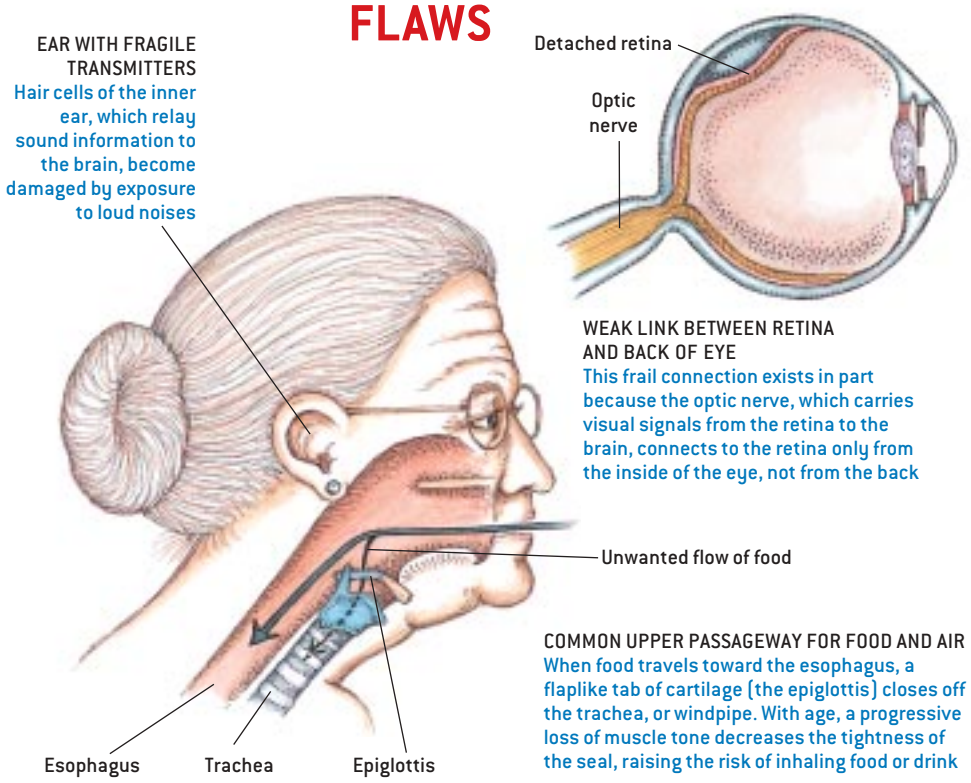
VARIOUS PARTS of the head and neck become problematic with disturbing regularity as people age. Consider the eye: the human version is an evolutionary marvel, but its complexity provides many opportunities for things to go wrong over a long lifetime.

Our vision diminishes as the protective fluid of the cornea becomes less transparent over time. The muscles that control the opening of the iris and the focusing of the lens atrophy and lose responsiveness, and the lens thickens and yellows, impairing visual acuity and color perception. Further, the retina—responsible for transmitting images to the brain—can detach fairly easily from the back of the eye, leading to blindness.

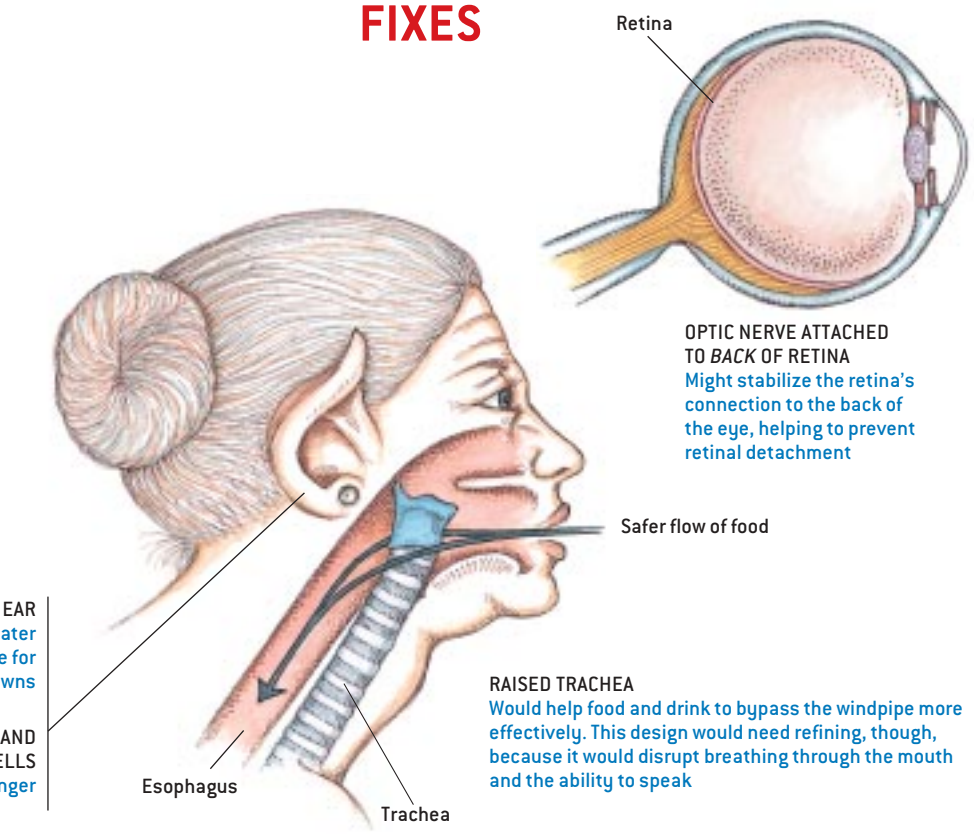
Many of those problems would be difficult to design away, but the squid eye suggests an arrangement that could have reduced the likelihood of retinal detachment. A few anatomical tweaks could also have preserved hearing in the elderly.

Suboptimal design of the upper respiratory and digestive systems makes choking another risk for older people. A simple rearrangement would have fixed that problem, albeit at the cost of severe trade-offs.

FLAWS



FIXES



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panying disorders are neither unnatural nor avoidable. No simple interventions can make up for the countless imperfections that permeate our anatomy and are revealed by the passage of time. We are confident, however, that researchers in the various biomedical sciences will be able to ease certain of the maladies that result from our extended life spans. Investigators are rapidly identifying (and discerning the function of) our myriad genes, developing pharmaceuticals to control them, and learning how to harness and enhance the extraordinary repair capabilities that already exist inside our bodies. These profound advances will eventually help compensate for many of the design flaws contained within us all.

Health, Longevity

OUR RESEARCH interest in redesigning the *Homo sapiens* body is a reaction to the health and mortality consequences of growing old. We focus on anatomical "oddities" and "design flaws" not only because they would be familiar to most readers, but because they represent a small sample of lethal and disabling conditions that threaten the length and quality of life. It is important to recognize that we live in a world in which human ingenuity has made it possible for an unprecedented number of people to grow old. Our redesign goal is thus to draw attention to the health consequences associated with the aging of individuals and populations.

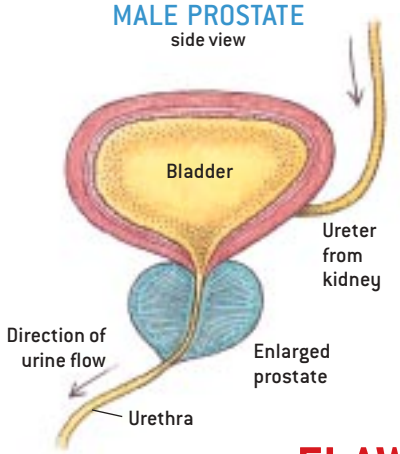
One critical message we wish to convey is that people were

CALL A PLUMBER

AN EXPERIENCED PLUMBER looking at the anatomy of a man's prostate might suspect the work of a young apprentice, because the urethra, the tube leading from the bladder, passes straight through the inside of the gland. This configuration may have as yet unknown benefits, but it eventually causes urinary problems in many men, including weak flow and a frequent need to void.

Women also cope with plumbing problems as they age, particularly incontinence. Both sexes could have been spared much discomfort if evolution had made some simple modifications in anatomical design.

MALE PROSTATE
side view



FLAW

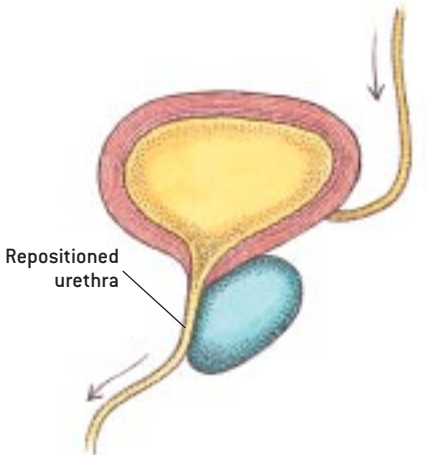
URETHRA PRONE TO CONSTRICTION

The prostate becomes enlarged in one of every two males at some point in life. As it grows, it squeezes the urethra, potentially obstructing the flow of urine. Total obstruction can be fatal

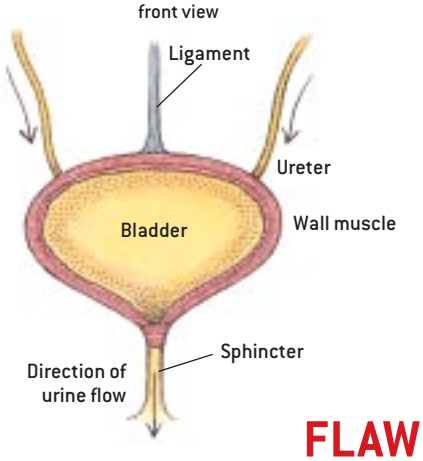
FIX

URETHRA HUGGING OUTSIDE OF PROSTATE

Would not be squeezed if the prostate became enlarged



FEMALE BLADDER
front view



FLAW

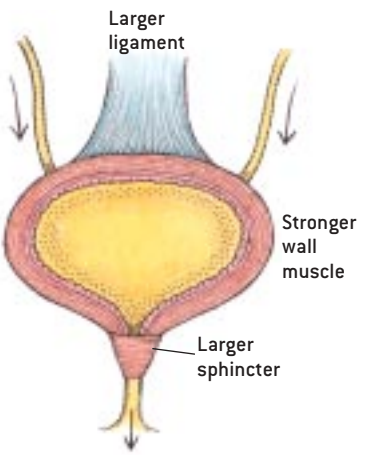
MUSCLES AND LIGAMENTS THAT WEAKEN WITH TIME

Particularly after multiple pregnancies, the muscles of the pelvic floor and the bladder, and the ligaments that support the bladder, can sag, leading to incontinence

FIX

STRONGER SPHINCTER MUSCLES IN BLADDER AND MORE DURABLE LIGAMENTS

Would increase control over bladder function



We need to EXPLOIT OUR KNOWLEDGE of evolution to enhance our quality of life as we grow older.

not designed by evolution for extended survival, so it is not their fault that they ultimately suffer age-related ailments. Most of what goes wrong with us as we grow older is a product of operating our living machines beyond their biological warranty period. Although we have considerable control over the quality of our lives, we still don't have much control over the length of our lives.

Even the term "flaw" requires clarification. Living things, and everything they make, eventually fail. The cause of failure is a flaw only when the failure is premature. A race car that fails beyond the end of the race has no engineering flaws. In the same way, bodies that fail in the postreproductive span of life may contain numerous design oddities, but they have no design flaws as far as evolution goes. Aging, disease and death are natural by-products of bodies that were optimized for reproduction.

There are countless other aspects of human biology that would merit modification if health and longevity were nature's primary objective. For example, gerontologists theorize that aging is caused, in part, by a combination of the molecular damage that inevitably arises from operating the machinery of life within cells and the imperfect mechanisms for molecular surveillance, maintenance, and repair that permit damage to accumulate over time. If this view of the aging process is correct, then modifying these molecular processes to lessen the severity or accumulation of damage, or to enhance the maintenance and repair processes, should have a beneficial impact on health and longevity. These wondrous modifications, however, would have little effect unless the common sense that is needed to avoid destructive lifestyles becomes more widespread among people.

Living things are exceedingly complex, and experience teaches us that undesirable consequences invariably arise whenever humans have taken over the reins of evolution in order to modify organisms (microbes, plants and animals) to suit their purposes. The most worrisome trade-off for genetic manipulation directed toward living longer would be an extension of frailty and disability rather than an extension of youthful health and vitality.

Though cobbled together by the blind eye of evolution, humans have proved to be a remarkably successful species. We have outcompeted almost every organism that we have encountered, with the notable exception of microbes. We have blanketed the earth and even walked on the moon. We are also one of the only species that has figured out how to escape premature death and survive to old age.

At this point in history, we need to exploit our expanding knowledge of evolution to enhance the quality of our lives as we grow older, because the single-minded pursuit of life extension without considering health extension could be disastrous.

Our fanciful designs of anatomically "fixed" humans are not intended as a realistic exercise in biomechanical engineering. Given what is known today about human aging, if the task of designing a healthy long-lived human from scratch were given to a team comprising the father of evolution, Charles Darwin, the great painter Michelangelo, and the master engineer and scientist Leonardo da Vinci, they most certainly would have fashioned a living machine that differs from the one we now occupy. Indeed, anyone who tries his hand at redesign would probably construct a human body that would look unlike the ones we've created on these pages. Yet we invoke this approach as an instructive way of communicating the important message from evolutionary theory that, to a significant degree, the potential length of our lives and, to a lesser degree, the duration of health and vitality are genetic legacies from our ancient ancestors, who needed to mature quickly to produce children before they were killed by the hostile forces of nature. SA

THE AUTHORS

S. JAY OLSHANSKY, BRUCE A. CARNES and *ROBERT N. BUTLER* all have an enduring interest in the processes that underlie human aging. Olshansky is professor in the School of Public Health at the University of Illinois at Chicago. He and Carnes, both senior research scientists at the National Opinion Research Center/Center on Aging at the University of Chicago, collaborate on studies—funded by the National Institute on Aging (NIA) and NASA—of the biodemography of aging (examining the biological reasons for age-related patterns of disease and death in populations). They are co-authors of *The Quest for Immortality: Science at the Frontiers of Aging* (W. W. Norton, 2001). Butler is president of the International Longevity Center in New York City and was founding director of the NIA.

MORE TO EXPLORE

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The Olshansky and Carnes Web site is **www.thequestforimmortality.com**

The International Longevity Center Web site is **www.ilcusa.org**