THIS OLD BODY

Evolutionary hand-me-downs inherited from fish and tadpoles have left us with hernias, hiccups and other maladies • • • BY NEIL H. SHUBIN

I started teaching human anatomy at the same time my university renovated my laboratory. As it turns out, this coincidence could not have been more propitious. Teaching anatomy for the first time can be a struggle, and it is not just because there are an enormous number of names to learn. A glimpse inside the body reveals structures left inside of us during the course of evolution, which often seem a confused jumble, with arteries, nerves and other structures taking odd paths to get from one part of the body to another.

While I was struggling to understand the body's internal structures, I was given space in a 100-year-old building that needed to be renovated into a modern laboratory. When we opened the walls to look at the plumbing, wiring and other mechanicals, we saw a tangle that made no apparent sense; cables, wires and pipes took bizarre loops and turns throughout the building. Nobody in their right mind would have designed my building to conform to the snarled mess we saw when the wall was removed. Constructed in 1896, the utilities reflect an old design that has been jury-rigged for each renovation done over previous decades. If you want to understand the twisting pathways for a cable or a pipe, you have to understand their history and how they have been modified over the years. The same is true for structures in the human body.

Take the male spermatic cord. This tube connects the testes, in the scrotum, to the urethra, in the penis. In so doing, it forms a path for sperm to exit the body. The scrotum lies adjacent to the penis, so you would think that the best design would take the shortest course, a straight shot between the two structures. Not so. The spermatic cord ascends from the scrotum, then loops inside the pubic bone, descends through an opening below the hip joints and finally travels to the urethra inside the penis. This path—a historical legacy—is as much a source of vexation for medical students to understand as it is for the human males who suffer certain kinds of hernias because of it.

Piscine Inheritance

To make sense of our own bodies, we need to examine the history we share with everything from microbes and worms to fish and primates. In the case of the spermatic cord, human gonads begin development in a similar way to those of sharks, fish and other bony animals. The gonads—ovaries in females and testes in males—originally form high up in the human body, near the liver, presumably because the interactions between the tissues that develop into the gonads occur there. In adult sharks and fish, the gonads typically remain up near the liver. They probably stay in this ancestral configuration because their sperm can develop within the confines of the body cavity itself.

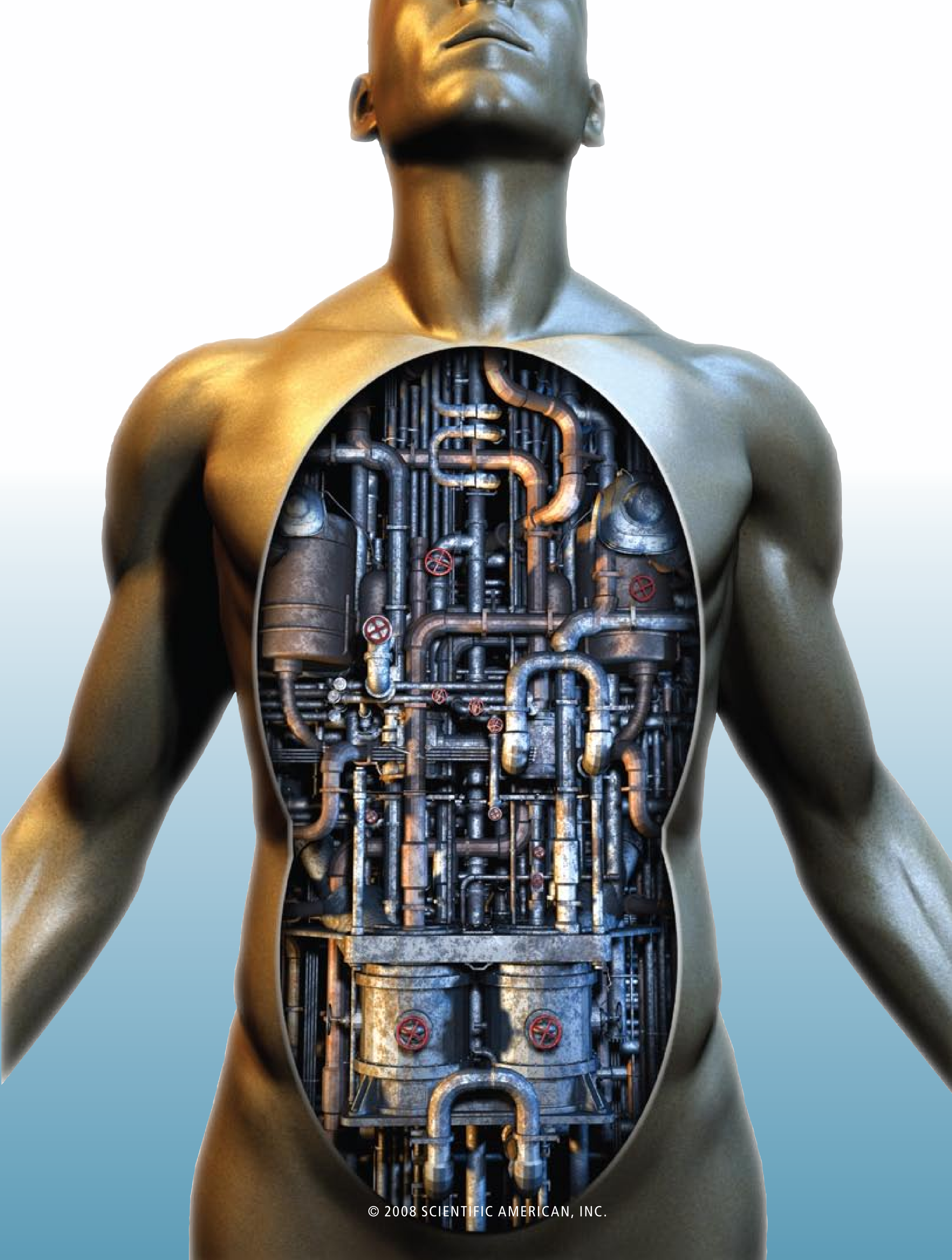
Mammals like us do things differently from our fish ancestors. As a male fetus develops, the gonads descend. In females, the ovaries move down from the midsection to lie near the uterus and fallopian tubes. This movement ensures that the egg does not have far to travel to be fer-

KEY CONCEPTS

- Routing of nerves and fluid pathways in the human body resembles the tangle of wiring and pipes in an aging house, a heritage from fish and amphibian ancestors.
- The tube through which sperm passes forms a roundabout loop that can lead to hernias, a result of major anatomical changes that occurred as we evolved from fish.
- Nerves that are inherited from fish and travel from the brain to the diaphragm can become irritated and trigger hiccups, a closing of the entryway to the windpipe, an action that itself is a hand-me-down from amphibians that breathe with both lungs and gills.

—The Editors

KENN BROWN *Mondolithic Studios*



THE AUTHOR

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tilized. In males, the gonads descend farther, all the way to the scrotal sac, which extends from the body.

This feature is quite important for the production of healthy sperm. One possible reason is that mammals are warm-blooded and that the quantity and quality of sperm are dependent on developing in a cooler temperature than the rest of the body. Indeed, one study even suggests that a shift from tight-fitting jockeys, which can press the scrotum against the body, to boxers, which allow it to dangle, can improve some factors of sperm quality. Accordingly, the mammalian scrotum is a sac separated from the warm body that can rise and fall to control the temperature at which the sperm develops—think "cold-shower effect."

And therein lies the problem. For the testes to sit in this sac, they have to descend a long way, thereby causing the spermatic cord to take a roundabout loop. Unfortunately, for males the loop causes a weakness within the body wall near its apex. Several types of hernias can result when a little bit of gut pokes through this weak spot. These hernias can be congenital: some intestinal pieces travel with the gonads and descend through the body wall. Or they can develop later in life because of this zone of weakness. So the propensity to acquire certain kinds of hernias reflects layers of human history: our fishy past and mammalian present.

Why We Hic

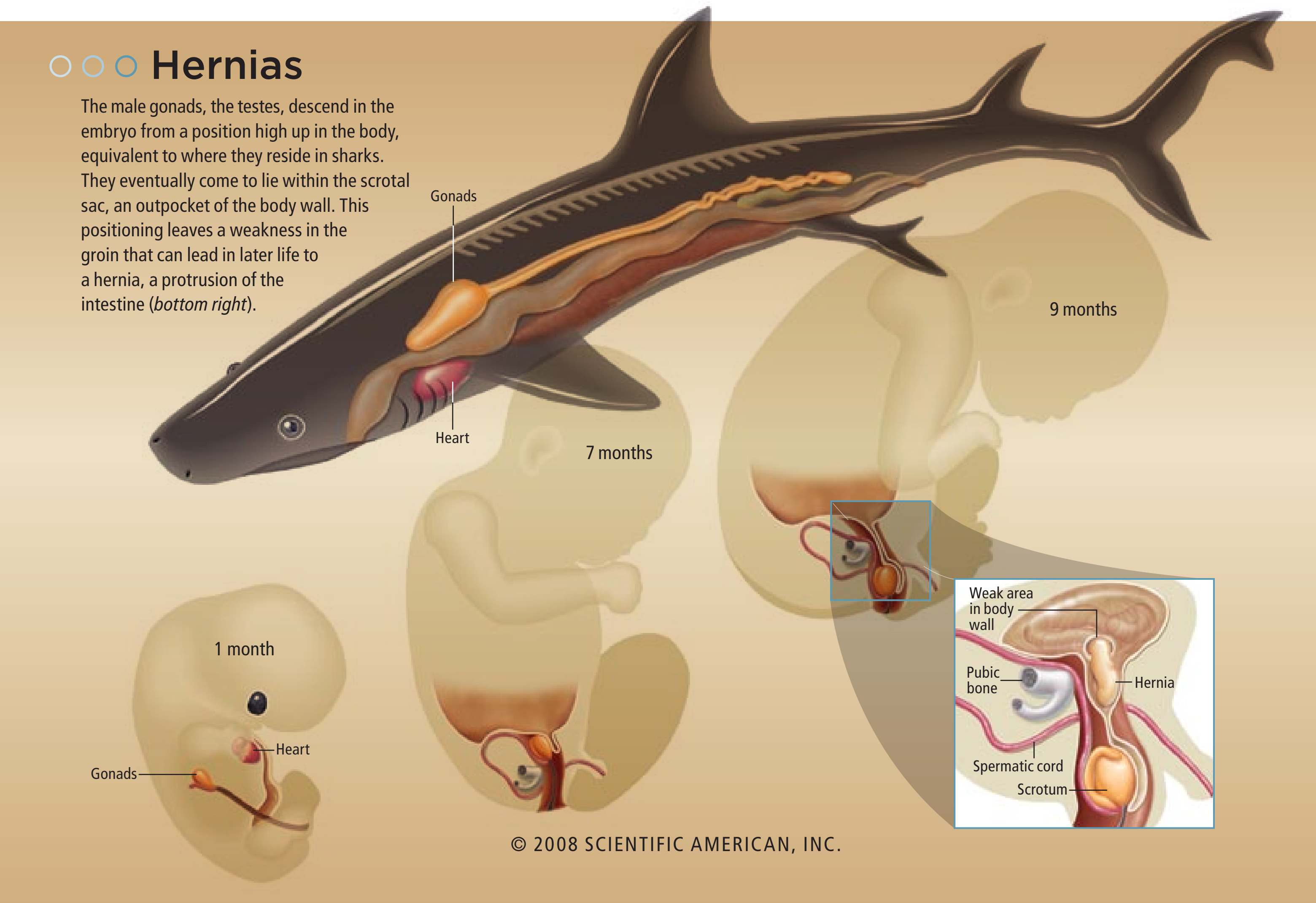
The same kind of evolutionary analysis can be applied to a variety of maladies. Take hiccups, which can range from an annoyance that lasts a few minutes to a major life-altering condition that spans months or, in rare instances, years. A spasm of the muscles in the throat and chest causes a hiccup. The characteristic "hic" sound results when we sharply inspire air while the epiglottis, a flap of soft tissue at the back of the throat, closes. All these movements are completely involuntary; we "hic" without any thought on our part. Hiccups occur for many reasons: we eat too fast or too much; even more severe conditions, such as tumors in the chest area, can bring them on.

Hiccups reveal at least two layers of our history: one shared with fish, another with am-

JOHN WEINSTEIN *The Field Museum* (Shubin); ALICE Y. CHEN (*illustration*)

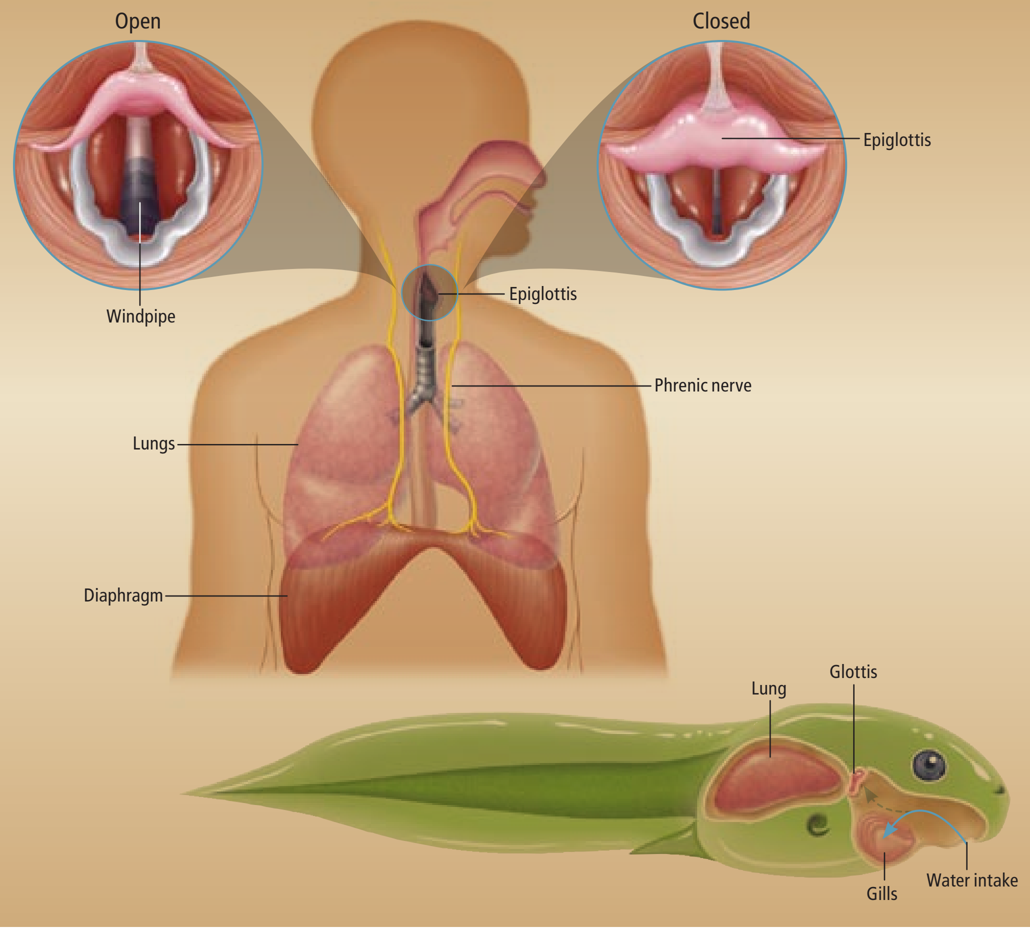
○○○ Hernias

The male gonads, the testes, descend in the embryo from a position high up in the body, equivalent to where they reside in sharks. They eventually come to lie within the scrotal sac, an outpocket of the body wall. This positioning leaves a weakness in the groin that can lead in later life to a hernia, a protrusion of the intestine (*bottom right*).



Hiccups

The hic of hiccups can at times be caused by blockages or lesions that crimp one of the phrenic nerves, which control breathing and are an evolutionary hand-me-down from fish. These nerves relay brain signals that induce a spasm of muscles in the throat and chest, causing the epiglottis to shut the windpipe. The sharp inspiration and blocking of the throat, the hic, are a legacy of a tadpole's pumping of water into its mouth when breathing through its gills. As it ingests water, its glottis closes to prevent fluid from entering its lungs, which are used for breathing on land.



phibians, according to one well-supported hypothesis. We inherited the major nerves we use in breathing from fish. One set of nerves, the phrenic, extends from the base of the skull and travels through the chest cavity and the diaphragm, among other places. This tortuous course creates problems; anything that interrupts the path of these nerves along their length can interfere with our ability to breathe. Irritation of these nerves can even be a cause of hiccups. A more rational design of the human body would have the nerves traveling not from the neck but from a spot nearer to the diaphragm. Unluckily, we became heir to this design from fishy ancestors with gills closer to the neck, not a diaphragm well below it.

If the strange pathway of the nerves is a product of our fish origin, the hiccup itself may have arisen from the past we share with amphibians. It turns out that the characteristic pattern of muscle and nerve activity of hiccups occurs naturally in other creatures. And not just any creatures. More specifically, they turn up in tadpoles that use both lungs and gills to breathe. When tadpoles use their gills, they have a problem—they need to pump water into their mouth and throat and then across the gills, but they need to keep this water from entering their lungs. So what do they do? They shut the glottis to close off the breathing tube, while sharply inspiring. In essence, they breathe with their gills using an extended form of hiccup.

Our deep history was, at different times, spent in ancient oceans, small streams and savanna plains—and not office buildings, ski slopes or football fields. This extraordinary disconnect between our past and present means that our body falls apart in certain predictable ways. The major bones in human knees, backs and wrists arose in aquatic creatures hundreds of millions of years ago. Is it any surprise, then, that we tear cartilage in our knees and suffer back pain as we walk on two legs or develop carpal tunnel syndrome as we type, knit or write? Our fish and amphibian ancestors did not do these things.

Take the body plan of a fish, modify it using genes altered from those that build the body of a worm, dress it up to be a mammal, then tweak and twist that mammal to make a creature that walks upright, talks, thinks and has superfine control of its fingers, and we have a recipe for disaster. We can dress up this fish only so much before paying a price. In a perfectly designed world—one without an extended historic legacy—we would not have to suffer from the infirmities of hemorrhoids or hernias. Nor would our buildings be so expensive to renovate. ■

ALICE Y. CHEN

MORE TO EXPLORE

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