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'Bones' Review: Getting Down to the Marrow

Sticks and stones may break them, but your bones don't take a fracture lying down.

The ossuary of St. Catherine's monastery in Sinai, Egypt.

PHOTO: JEAN-LUC MANAUD/GAMMA-RAPHO/GETTY IMAGES

By John J. Ross

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Roy A. Meals is in love with bone, insofar as a man can be infatuated with calcified connective tissue. His new book, "Bones: Inside and Out," is a valentine to what Dr. Meals calls "the world's best building material," taking us on a lively, lucid and entertaining tour of bone in health and disease, and its strange afterlife in human culture.

Bone is a dynamic, living organ, composed of long coils of a protein called collagen, stiffened by crystals of calcium hydroxide and phosphate—hydroxyapatite—to give the vertebrate body its framework. (Bathe the thigh bone of a chicken in vinegar for weeks to dissolve the calcium, and you are left with a strong but rubbery bonelet.) These crystals also have an unusual property: When compressed, they give off tiny electrical charges. These sparks are a sign of bone under stress, and they attract "cutting cones" of cells that break bone down and rebuild it, like "a giant boring machine that digs subway tunnels under cities and is followed by materials and equipment that line the new tunnel with concrete."

Other materials are necessary, too: Bones need vitamin C to strengthen the collagen. Without it, scurvy develops, and hair, gums, skin, muscles and bones all start to unravel. Vitamin D, from sunshine or food, contributes to bone strength; in its absence bones remain soft in the condition called rickets.

But while we tend to think of our skeletons in terms of construction and architecture, bone is also our "loyal calcium banker." The heart muscle needs calcium to contract, and works poorly if levels of calcium are too high or too low. Fortunately, bone serves as a mineral reservoir, keeping calcium levels steady so that the cardiac muscles can pump merrily away. Unlike a Halloween skeleton, your bones have a blood supply, but the arteries in many bones are small. If they were larger, the holes by which they get into bones would be weak spots that could

A nuclear medicine bone scan.

PHOTO: MEDICAL BODY SCANS/SCIENCE SOURCE

BONES: INSIDE AND OUT

By Roy A. Meals

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lead to fractures. The tenuous blood supply some bones get as a result can lead to poor healing if a fracture does occur.

And occur they do: Setting fractures is among the earliest recorded medical arts, and "Bones: Inside and Out" is in part the story of bonesetting evolution. Fractures have been splinted with strips of wood or lead, or wrapped in bandages suffused with lard or blood, for at least 5,000 years. Casting was invented in the mid-19th century, when Dutch army surgeon Antonius Mathijsen impregnated rolls of gauze with plaster of paris, dunked them in water, wrapped up broken limbs, and let the wet gauze dry into a hard, protective shell. While water is preferred, other liquids have been successfully used. According to legend, when Crimean War surgeons ran out of water, they soaked their plaster strips in urine.

The use of casts to mend fractures has its own problems, including long periods of immobility, and the worst fractures may fail to mend. Anesthesia and X-rays

emboldened surgeons to try using hardware to hold severed bones together, but early efforts went badly. Ivory was too brittle, and iron and aluminum fared poorly in the "gallons of salt water contained inside our waterproof skin." Metallurgists solved this problem with stainless steel and titanium alloys that resisted corrosion. These allowed fractures to be held in place with plates and screws, or rods jammed into bones' marrow cavities.

Dr. Meals, a clinical professor of orthopedic surgery at UCLA, singles out several surgeons for their revolutionary contributions to the field. John Charnley (1911-82) invented both the modern hip implant and the means (surgical "space suits" and advanced air-filtration during the procedure) to keep infection of the implants at bay. Charnley also carried on the long, heroic and often sketchy tradition of medical self-experimentation. He injected Teflon debris from failed hip implants into his thigh to see how bad the inflammatory response was, and even had a colleague put a bone graft in his leg to see if it survived (spoiler alert: it did not).

Meanwhile, Gavriil Ilizarov (1921-92), working in primitive conditions in Siberia, stumbled on a way to make bones longer. After World War II, he used external fixators to stabilize the mangled legs of Soviet soldiers. His apparatus—two metal rings around the leg, attached to pins driven into the bone and connected by threaded rods—looked somewhat like a torture device made from bicycle wheels.

Minute daily adjustments of the rods with a wrench allowed the ends of the bone to be slowly brought into closer contact, promoting healing over several weeks. When one patient misunderstood the instructions, and turned the wrench the wrong way, Ilizarov found the bone had healed anyway, and the result suggested a way of lengthening a limb that was too short. He became adept at treating patients with unequal leg length, but the Russian medical establishment regarded Ilizarov as a quack, only changing their minds only after he fixed the leg of an Olympic high jumper who had lost a chunk of shin bone after a motorcycle accident.

> **Orthopedic surgeons once needed to be handy with a saw. Now, a 3-D printer may be the best tool for the job.**

Some of the surgeries that Dr. Meals describes are ingenious to the point of sounding bizarre. Bone cancers involving the knee are sometimes treated with a Van Nes rotationplasty, in which the knee joint is removed, the leg is spun around, the ankle becomes the new knee, and the now-backwards foot can be inserted into a prosthetic lower leg. Lost thumbs can be restored with three techniques, which Dr. Meals calls "beg, borrow, and steal." One can use Ilizarov's technique to lengthen the stump (beg), rotate over an index finger (borrow) or transplant a big toe (steal).

An old stereotype cast orthopedic surgeons as brawny, macho ex-jocks, fond of hammers and saws, "strong as oxen and twice as smart." Power tools in the operating room have put an end to "orthopedists being characterized as Attila the

Hun's offspring," and the world of orthopedic surgery now includes more women than ever. Dr. Meals offers his impression that orthopedists still differ from other doctors in one respect: they are more likely to be left-handed. Some studies have shown lefties have better spatial skills than righties, which helps immensely in the difficult task of correctly placing hardware in bone based on two-dimensional images. Now 3-D printers can make models of broken bones before surgery, allowing orthopedists new precision in planning.

Humans have been burying their dead for at least 100,000 years, and the bones left behind offer clues about the lives of the people they once were. Paleolithic skeletons have been found in a cave in Israel, carefully arranged with deer antlers in their hands; ocher pigment in the cave suggests the bodies were painted. Since then, human bodies have been buried in the ground, tucked into crannies in cliffs, suspended in trees or mummified. Because they are so well preserved, mummies are an especially rich source of data about ancient lifestyles. For example, Nubian mummies from 2,000 years ago are "laced" with the antibiotic tetracycline. (Presumably, this came from bacterial contamination of early beer rather than the drug pipeline of Big Nubian Pharma.)

Some Buddhists in Tibet still practice sky burial, carrying bodies to mountain peaks to be devoured by vultures. The cleansed bones can be upcycled into musical instruments with ceremonial and spiritual uses. Retrieved skulls can be used to make drums, and thighbones became elaborate trumpets called kanglings ("leg-flutes"). Just as Stradivari fashioned his violins from perfect spruces, "bones from individuals who were free from worldly faults are favored" for the higher quality of their psychic energy.

Cremation was common in pagan Europe, but it was forbidden by the early Christian church because of the logistical challenges it posed for the resurrection of the dead. As a result, archeologists use the spread of cemeteries to track the growth of Christianity in Europe. The early Christians of Rome could not afford elaborate tombs, instead burying their dead outside the city walls in tunnels hewn into porous volcanic stone; as many as 750,000 of the faithful were interred there. The catacombs were eventually forgotten, and then rediscovered by accident in 1578. It was assumed that those within must have been holy martyrs, leading to a lucrative trade—ultimately embarrassing to the church—in the skeletons of "catacomb saints," some given names like St. Incognito and St. Anonymous.

Animal bones, like human bones, have been prized for their resilience. In the treeless high Arctic, the Inuit made bone serve all the uses to which Europeans put wood and steel. Bone provided knives and fish spears, buckles and toggles for sleds, and goggles to prevent snow blindness. On the hunt, the Inuit probed slushy ice with whale ribs to find the breathing holes of seals. They scratched ice nearby with a bony rake to trick the seal into thinking a competitor was infringing on his turf, and impaled him with a bone harpoon when he came up to investigate. Bone also provided shelter. Whale jaws made frames for their sealskin tents, and penis bones from walruses acted as tent stakes.

Of these last: many mammals have penis bones, including dogs, cats, raccoons and sea lions. In shape, the penis bone varies "from rodlike to fantastic" (or downright alarming, as in the case of the ground squirrel). It seems to allow for prolonged intercourse, thus limiting the reproductive opportunities of other suitors. While our gorilla and chimp cousins still have penis bones, ours vanished in the course of evolution. Whether this was a net gain or loss for humanity, Dr. Meals declines to say.

—Dr. Ross is the author of "Shakespeare's Tremor and Orwell's Cough."