BioEd℠

THE SCIENCE OF MUSCLES AND BONES

The Skeleton

by

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RESOURCES

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TEAMING WITH BENEFITS

by Jeffrey P. Sutton, M.D., Ph.D., Director, National Space Biomedical Research Institute (NSBRI)

Dr. Jeffrey P. Sutton

Space is a challenging environment for the human body. With long-duration missions, the physical and psychological stresses and risks to astronauts are significant. Finding answers to these health concerns is at the heart of the National Space Biomedical Research Institute's program. In turn, the Institute's research is helping to enhance medical care on Earth.

The NSBRI, a unique partnership between NASA and the academic and industrial communities, is advancing biomedical research with the goal of ensuring a safe and productive long-term human presence in space. By developing new approaches and countermeasures to prevent, minimize and reverse critical risks to health, the Institute plays an essential, enabling role for NASA. The NSBRI bridges the research, technological and clinical expertise of the biomedical community with the scientific, engineering and operational expertise of NASA.

With nearly 60 science, technology and education projects, the NSBRI engages investigators at leading institutions across the nation to conduct goal-directed, peer-reviewed research in a team approach. Key working relationships have been established with end users, including astronauts and flight surgeons at Johnson Space Center, NASA scientists and engineers, other federal agencies, industry and international partners. The value of these collaborations and revolutionary research advances that result from them is enormous and unprecedented, with substantial benefits for both the space program and the American people.

Through our strategic plan, the NSBRI takes a leadership role in countermeasure development and space life sciences education. The results-oriented research and development program is integrated and implemented using focused teams, with scientific and management directives that are innovative and dynamic. An active Board of Directors, External Advisory Council, Board of Scientific Counselors, User Panel, Industry Forum and academic Consortium help guide the Institute in achieving its goals and objectives.

It will become necessary to perform more investigations in the unique environment of space. The vision of using extended exposure to microgravity as a laboratory for discovery and exploration builds upon the legacy of NASA and our quest to push the frontier of human understanding about nature and ourselves.

The NSBRI is maturing in an era of unparalleled scientific and technological advancement and opportunity. We are excited by the challenges confronting us, and by our collective ability to enhance human health and well-being in space, and on Earth. ◆

NSBRI RESEARCH AREAS

CARDIOVASCULAR PROBLEMS

The amount of blood in the body is reduced when astronauts are in microgravity. The heart grows smaller and weaker, which makes astronauts feel dizzy and weak when they return to Earth. Heart failure and diabetes, experienced by many people on Earth, lead to similar problems.

HUMAN FACTORS AND PERFORMANCE

Many factors can impact an astronaut's ability to work well in space or on the lunar surface. NSBRI is studying ways to improve daily living and keep crewmembers healthy, productive and safe during exploration missions. Efforts focus on reducing performance errors, improving nutrition, examining ways to improve sleep and scheduling of work shifts, and studying how specific types of lighting in the craft and habitat can improve alertness and performance.

MUSCLE AND BONE LOSS

When muscles and bones do not have to work against gravity, they weaken and begin to waste away. Special exercises and other strategies to help astronauts' bones and muscles stay strong in space also may help older and bedridden people, who experience similar problems on Earth, as well as people whose work requires intense physical exertion, like firefighters and construction workers.

NEUROBEHAVIORAL AND STRESS FACTORS

To ensure astronaut readiness for spaceflight, preflight prevention programs are being developed to avoid as many risks as possible to individual and group behavioral health during flight and post flight. People on Earth can benefit from relevant assessment tests, monitoring and intervention.

RADIATION EFFECTS AND CANCER

Exploration missions will expose astronauts to greater levels and more varied types of radiation. Radiation exposure can lead to many health problems, including acute effects such as nausea, vomiting, fatigue, skin injury and changes to white blood cell counts and the immune system. Longer-term effects include damage to the eyes, gastrointestinal system, lungs and central nervous system, and increased cancer risk. Learning how to keep astronauts safe from radiation may improve cancer treatments for people on Earth.

SENSORIMOTOR AND BALANCE ISSUES

During their first days in space, astronauts can become dizzy and nauseous. Eventually they adjust, but once they return to Earth, they have a hard time walking and standing upright. Finding ways to counteract these effects could benefit millions of Americans with balance disorders.

SMART MEDICAL SYSTEMS AND TECHNOLOGY

Since astronauts on long-duration missions will not be able to return quickly to Earth, new methods of remote medical diagnosis and treatment are necessary. These systems must be small, low-power, noninvasive and versatile. Portable medical care systems that monitor, diagnose and treat major illness and trauma during flight will have immediate benefits to medical care on Earth.

For current, in-depth information on NSBRI's cutting-edge research and innovative technologies, visit www.nsbri.org.

OVERVIEW

Students learn about endoskeletons by observing, comparing and contrasting different kinds of chicken bones, and by relating their chicken bone observations to human bones.

ACTIVITY

THE SKELETON

Internal skeletons, or endoskeletons, must be strong enough to support a body against the pull of gravity. They also must be light and flexible enough to allow easy movement. Endoskeletons meet all these requirements by connecting bones of different shapes and sizes (flat, irregular, long, short) that provide support, allow freedom of movement, and protect many of the body's most vital internal organs.

With only a few exceptions, like the tailbone in humans, each bone fulfills a particular need. The skull protects the brain and sense organs (eyes, nose, mouth and ears). A flexible spine encloses and protects the spinal cord—the main highway for messages from the brain to the rest of the body. The rib cage surrounds the lungs, heart and other internal organs. Four limbs (arms and legs in humans) are joined to the spine via broad flat bones (shoulder blades and hip bones). Arms, legs and wings contain some of the longest and strongest bones in vertebrates. More than half of the 206 bones in the adult human body can be found in the limbs.

Vertebrate skeletons are comprised primarily of cartilage and bone. Cartilage is firm, but flexible. The skeletons of most embryos are made of cartilage, which gradually is replaced by a harder material—bone. Bone is living tissue that changes in response to exercise and use.

SCIENCE, HEALTH & MATH SKILLS

GRADES 5–8

- Observing
- Comparing and contrasting
- Inferring

CONCEPTS

- Endoskeletons are made of connected bones inside a body.
- Bones provide support for the body.

TIME

20 minutes, one day ahead of time, for set-up; 45–60 minutes to conduct activity

MATERIALS

Each group will need:

- At least one chicken bone that has been cooked and cleaned (see Setup)
- Magnifiers
- Science journals (or blank paper) to make drawings and record observations
- Copies of both student sheets

SETUP & MANAGEMENT

Before class, cook enough chicken pieces to provide one or more different bones (any sizes or shapes) to each group of students. You also may have students bring leftover cooked chicken bones from home. Remove all meat from the bones (additional boiling may be necessary), and soak the bones in a 1:10 bleach/water solution for five minutes. Allow the bones to dry before using them in class. (Save the bones to use with the activity, "What Are Bones Made Of?" Have students work in groups of 2–4.

Types of Bones

Bones come in many varieties, so they are grouped according to shape: long (arm and leg bones); short (wrist and ankle bones); flat (ribs and bones of the skull); and irregular (vertebrae). The skeletons of many different animals look very similar and contain close to the same number of bones.

What is Cartilage?

Some animals, like sharks, maintain a skeleton made of cartilage throughout their entire lives. Some parts of our bodies also are made of cartilage that never becomes bone. Some examples include the outer ear, the ends of the ribs and the nose. Why might it be important for these structures to stay flexible?

Safety Issues

Please read "Setup & Management," and follow all school district and school laboratory safety procedures. It always is a good idea to have students wash hands before and after any lab activity.

Bone to Stone

Most plant and animal remains rot away over time. Hard parts, such as bones and shells, sometimes become buried in sand and mud. Over millions of years, the shells and bones become transformed into stone. We call them fossils.

Symmetry

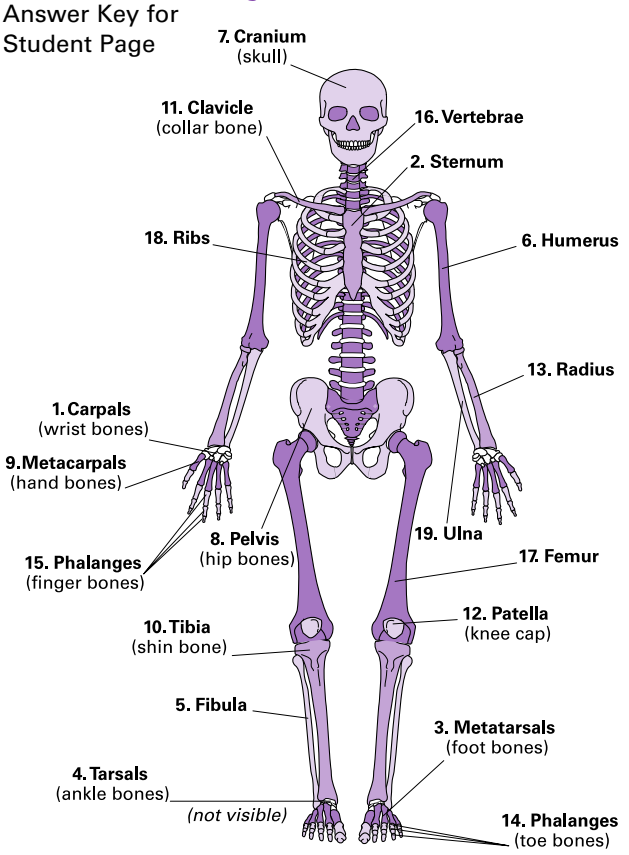
Living things often are symmetrical in one or more ways. Many animal bodies are composed of two halves that are mirror images of each other. This is called bilateral (two-sided) symmetry.

PROCEDURE

1. Remind students of the skeletons they constructed in the activity, "Skeletal Structures." Ask, *What kind of skeleton do vertebrate animals have?* (animals with backbones, or endoskeletons) *What are some examples of vertebrates?* (fish, birds, reptiles, amphibians, mammals)
2. Distribute cleaned chicken bones.
3. Direct the groups to observe the bones carefully with and without their magnifiers. Ask questions to promote careful observations, such as, *What color are the bones? Are the bones as hard as rock? Does the surface texture vary along the length of the bone?* (Students may be able to observe that the ends of some bones are porous, while other parts are smooth.) *Can you see softer parts* (cartilage) *attached to any of the bones?* (Ribs, for example, will have flexible cartilage tips.)
4. Have each student make a detailed drawing or written description of a single bone. Challenge students to think about where the bones they observed would be found in a chicken's body. Discuss their observations.
5. Make a class list of the similarities among the different bones observed. Follow by making a list of the differences.
6. Give each student a copy of the "Chicken Bones" page and have students identify the bones they observed. Ask, *Were you able to predict the location of the bones you observed? What helped you decide where the bones would be found?*
7. Next, ask students to think about the human skeleton. Ask, *Do you think human skeletons are very different from chicken skeletons? Why or why not?* Make an overhead transparency or give each student a copy of the "Head-to-Toes" page. Have students compare the drawing of the human skeleton to the drawing of the chicken skeleton and identify similarities and differences.
8. Using context clues from the poem, help students fill in the appropriate names for the major bones of the body. You may want to have students read the poem aloud or write additional verses.
9. Discuss the human skeleton with students. Have them notice that bones are precisely arranged with bilateral symmetry. Point out that we have pairs of bones. Ask, *Why is this structure a good design for us to maintain balance? Did anyone build an unsymmetrical skeleton* ("Skeletal Structures" activity)? Help students understand that the symmetrical skeleton provides balance and potential for mobility. ◆

Human Skeletal System

Answer Key for Student Page



ACTIVITY

Chicken Bones

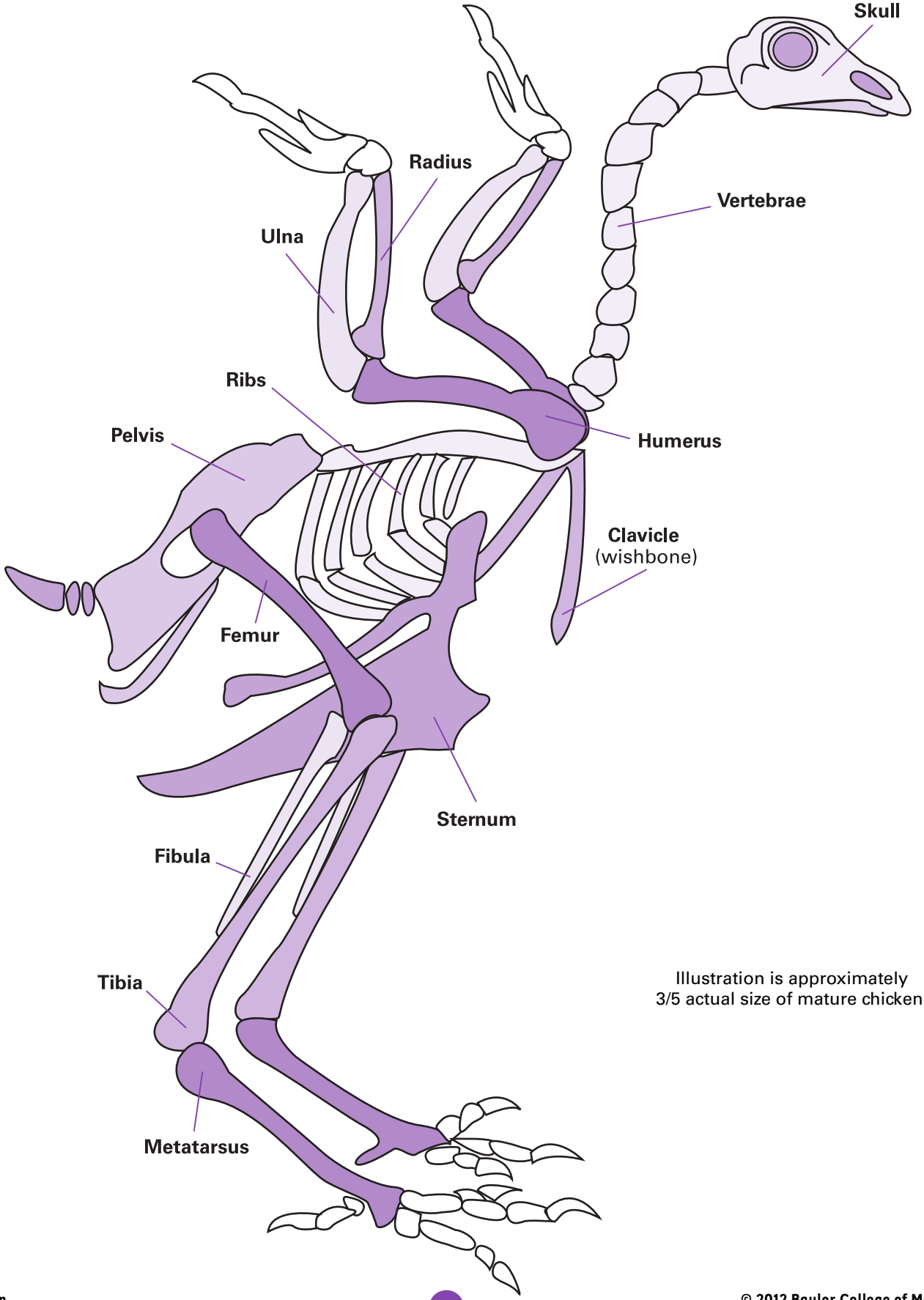


Illustration is approximately 3/5 actual size of mature chicken.

ACTIVITY

HEAD-TO-TOES

by Amanda Byers, Barbara Tharp and Paula Cutler

The bones are very important, you know. They hold up your body from your head to your toe.

The **cranium**, the skull, that's the head of the matter— it's connected to **vertebrae** that down your back scatter.

Your chest is made of arches, 12 sets of **ribs** to be exact—from backbone to the **sternum**, 'round the body they do wrap.

The **clavicle** is your coat hanger, with a **humerus** on each side. The bottom end's an elbow—a "funny bone" that tingles when with objects it collides.

Below the elbow, are the **ulna** and the **radius**, too; a pair that span the forearm on either side of you.

Bones at the wrist are the **carpals**—to the **metacarpals** they connect. They're attached to the **phalanges**— the fingers that get flexed.

Your hip bones are your **pelvis**; your **femur** shapes up your thighs. You need your knobby kneecaps— on your **patella**, you can rely.

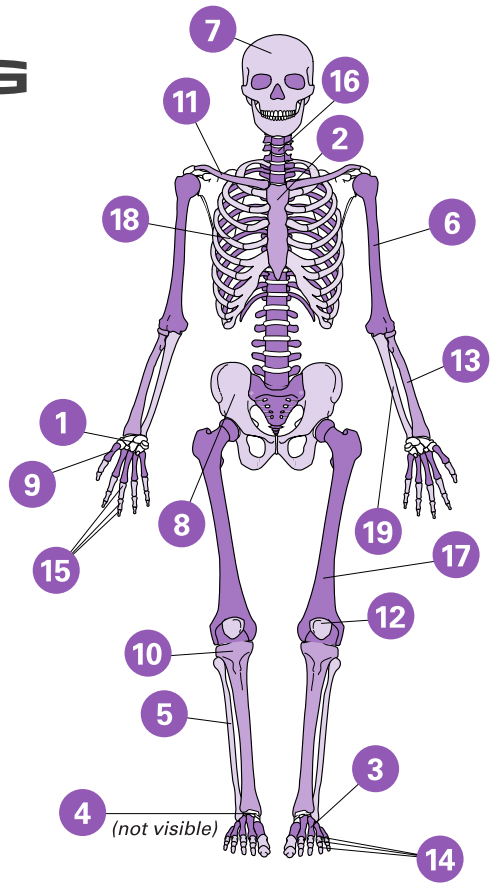
The **tibia** and the **fibula** are the lower legs' two bones. They are side-by-side together 'cause neither stands alone.

The feet, upon which you can stand with ease, have the **tarsals**, **metatarsals** and more **phalanges**.

Where bones do meet is called a joint, and there are many types. Fixed joints hold your skull bones in place so your brain stays nice and tight!

There are hinge and ball and socket joints that let your bones move 'round. Without shoulders, elbows, knees and ankles, you'd flatten on the ground.

The skeletal system is the frame that gives your body shape. It holds you altogether, even better than duct tape!



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