Solid or Spongy? Bone Tissue Lab: Teacher Guide

mrsajdak.com/bonetissue · Anatomy & Physiology, Hole's Essentials of Human Anatomy & Physiology 3e, Section 7.2 Bone Structure (pp. 228–232) · one period, about 35 to 40 minutes · © Ryan Sajdak, CC BY-NC-SA 4.0

What students do

The virtual version of the split-bone hands-on lab. Students measure the solid wall of a real human femur at its shaft and at the thin rim of its neck, run a drop test on each, count points on real micrographs of compact and spongy bone, measure an osteon and its central canal, and then use real bone-loss data in a simple model to see why osteoporosis breaks the hip, spine and wrist first.

Tab	Students	Learn It teaches	Sheet
Do Now	Why might a bone be hollow? Are the holey ends weak?		A, B
1. Cut the bone open	Click two edges of the wall at four marked spots in a zoomed view (the lab accepts within 20% and gives its own value). Drop test, two tries per spot, timer at 6x speed.	diaphysis, epiphysis, medullary cavity, compact bone, spongy bone, red marrow	1–7
2. Under the microscope	Point-count 25 rings on compact and spongy bone (two tries, then the lab circles the fixes); measure osteon A and canal A.	osteon, central canal, osteocyte, trabeculae, porosity numbers, spongy is not soft	8–13
3. Bone loss over a lifetime	Set sex and age; record a woman at 50 and 90 and a man at 90; read bone left at the forearm shaft, hip and spine.	osteoporosis, spongy bone lost first, hip/spine/wrist, women and men	14–17

Each Learn It box opens only when the student has the data for that part, so no question asks about an idea before it is taught. Questions before each READ FIRST line are data only.

Opening: pick a phenomenon

Option	What it is	Notes
A. Video: Cut Through a Bone	Clip 1 is a butcher cutting a beef marrow bone on a band saw. Clip 2 is a micro-CT scan, a 3D X-ray, of the inside of a bone. Clip 3 is a short news story about a new way to see bone loss. • Clip 1: "Cutting marrow bone with bandsaw machine.", ASM butchers (youtube.com/watch?v=0e5rVKxn1Hc), 0:00 to 1:05. • Clip 2: "Growing Bone in Space: Studying Spaceflight-induced Osteoporosis with Micro-CT", Micro Photonics (youtube.com/watch?v=PIgU95fL0qg), 0:00 to 1:08. • Clip 3: "New bone imaging technique could lead to improved osteoporosis treatment", Canadian Light Source (youtube.com/watch?v=6ST2dJ9D53w), 0:00 to 1:36.	Preview every clip on the school network first (they were checked to embed, not watched end to end). Mute Clip 1 (saw noise). Do not name compact or spongy bone yet. Clip 2 is a lab company video about mouse bone in space; stop it when the talk turns to the company. Clip 3 is the Canadian Light Source (a research lab) on osteoporosis imaging: save it for the revisit if time allows.
B. Try it: Sponge or Bone? (4 min)	Put on gloves. Look at the cut end of the class bone. It is full of holes, like a sponge. Press a kitchen sponge with a pencil eraser. Watch it squash. Press the spongy end of the bone the same way. Tap it with the pencil. Put one drop of water on the sponge and one on the bone end. Where does it go? **Need:** A clean, dry kitchen sponge; The class bone, split, with a spongy end (cooked and cleaned); A pencil; A dropper and a cup of water; Gloves.	This is the misconception the lesson names: spongy bone is soft like a kitchen sponge. Let students feel that it is hard. Do not explain the holes yet; the lab measures how much of each tissue is open space in Part 2.
C. Photos: One Bone, Two Cuts	The two Tab 1 photos side by side: a femur sawn across its shaft, and the neck of a femur cut across after a hip replacement.	Names only on the "Where Were These Cuts?" slide; it does not teach the tissues.

All three lead to the same Observe, Wonder, Predict slide and driving question: *Why is one bone built two ways: solid in the middle, full of holes at the ends?* The deck comes back to it at the end.

Standards

NYSSLS	**HS-LS1-2** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms: tissue (compact, spongy) to organ (a long bone) to system (where spongy bone sits in the skeleton). Touches **HS-LS1-1** through osteocytes and the blood-forming cells of red marrow.
SEP 2 Developing and Using Models	The bone-loss model: what each number stands for and what it leaves out (Q16).
SEP 3 Planning and Carrying Out Investigations	The drop test plan check (Q4).
SEP 4 Analyzing and Interpreting Data	Point counts to percent bone and open space (Q8, Q10); records by site (Q14–15).
SEP 5 Using Mathematics	Averages and the wall ratio (Q2–3).
SEP 6 Constructing Explanations	Explain it: why osteoporosis breaks the hip, spine and wrist (Q17).
CCC 6 Structure and Function	Solid tube resists bending; lattice is light and holds marrow (Q13, Q17).
CCC 4 Systems and System Models	Which sites of the skeleton are spongy-rich, and what that means for the whole body (Q14–16).
CCC 3 Scale, Proportion, and Quantity	Micrometers, millimeters and "15 times as much open space" (Q9–10).

District curriculum

BPS A&P Unit 2, Section 7.2 Bone Structure: describe the macroscopic and microscopic structure of a long bone and the functions of its parts. The lab serves the district's APR histology pieces (Compact Bone LM, Spongy Bone SEM) and the Major Parts of a Compact Bone labeling activity with real micrographs. **Additions beyond the district list:** the wall measurement and drop test (mirroring the class's split-bone hands-on lab), point counting, and the osteoporosis bone-loss model.

Misconceptions to plan for

- **"Spongy bone is soft, like a kitchen sponge."** Same hard material, built as a lattice (Learn It 2, Q12, Option B).
- **"Big bones are compact, small bones are spongy."** The tissue depends on the place in the bone (shaft or end), not the bone's size (Tab 3, Q15).
- **Counting dark specks as holes** in compact bone. They are osteocyte spaces inside the matrix; the lab's check says so.

Running it

- Pairs: one clicks, one writes. Tab 1 about 10 minutes, Tab 2 about 12, Tab 3 about 8.
- Students write the lab's value for each measurement, so every class gets the same key; their own clicks only have to be close.
- Pairs with the hands-on split-bone lab (Worksheet/AP_HandsOnLab.pdf in the lesson folder): same measurements and drop test on a real beef bone, where the ratio is usually 3 to 6.
- The answer key is a separate file, kept off the public site.

Sources

Clarke B (2008) Normal bone anatomy and physiology. Clin J Am Soc Nephrol 3: S131–S139: skeleton 80% compact, 20% spongy; compact-to-spongy ratio 25:75 in a vertebra, 50:50 in the femoral head, 95:5 in the radius shaft; compact bone porosity under 5%; osteons about 200 µm wide. Ott SM (2018) Cortical or trabecular bone: what's the difference? Am J Nephrol 47: 373–375: in spongy

bone about 20% of the volume is bone. Riggs BL and others (2004) J Bone Miner Res 19: 1945–1954: over life, spongy (trabecular) density at the spine and hip fell about 55% in women and 46% in men; compact density about 25% and 18%. Riggs BL and others (2008) J Bone Miner Res 23: 205–214: trabecular loss begins in young adulthood, cortical loss in midlife. The lab spreads each loss evenly (spongy 20 to 90, compact 50 to 90) and weights it by each site's ratio: a simplified model. NIH (2006): about 1 in 2 women and 1 in 4 men over 50 will have an osteoporosis-related fracture, most often hip, spine or wrist. Photos: femur shaft, MAKY.OREL, CC0; femoral neck section, Steven Fruitsmaak, public domain; compact bone ground section, Lord of Konrad, CC0 (scale from the 40 µm bar on Katsamenis's copy, public domain); spongy bone, Nataliia Maryenko, CC BY-SA 4.0; vertebrae, Turner Biomechanics Laboratory, CC0; humerus head, OpenStax, CC BY 4.0. Estimates: the shaft photo's scale (set from a typical adult femur, about 30 mm across) and the drop times.