

National Educators Workshop 2010

Bone Strength Competition

for K-12 Engineering Education

Mr. Jason Bartlett, Dr. Cynthia Waters
Education & Outreach Coordinators within the
NSF ERC for Revolutionizing Metallic Biomaterials at
North Carolina Agricultural & Technical State University



♪♪ Your Smart Bone's Connected to...? ♪♪

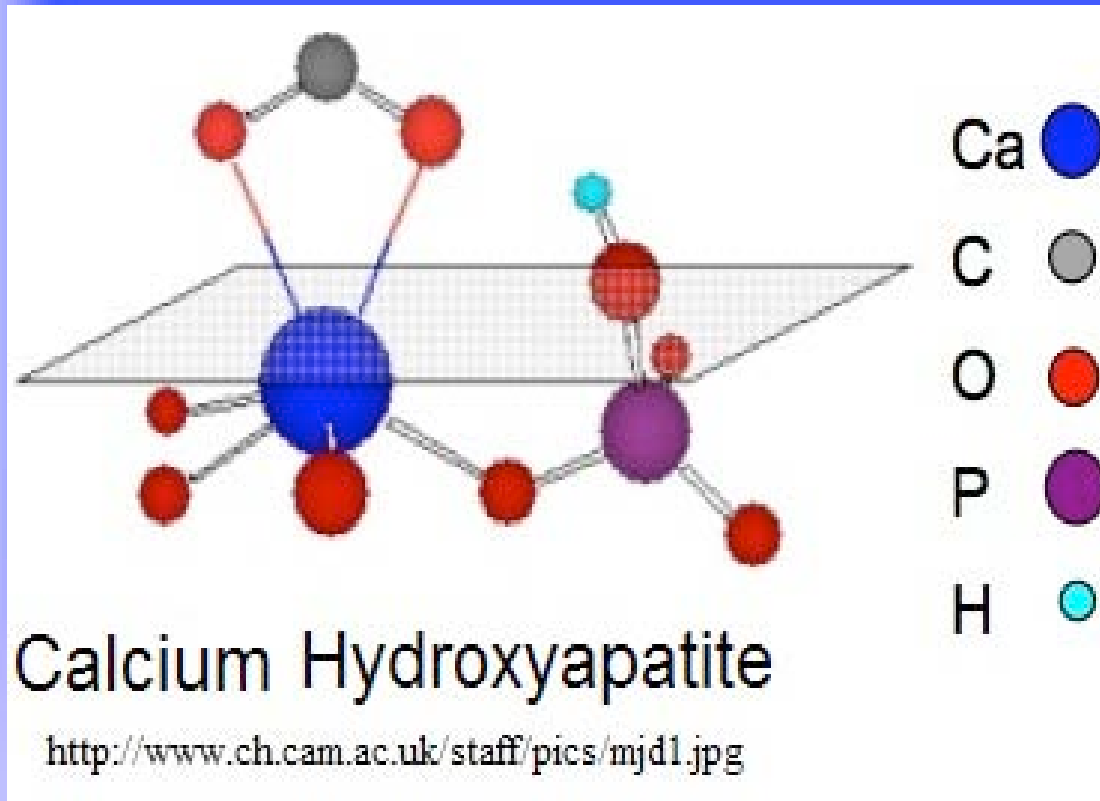
Bones serve several roles:

- Bones support the body & protect vulnerable organs
- Bones generate new blood cells
- Bones store minerals for future release
- Bones can be harvested for Stem Cells



<http://depts.washington.edu/bonebio/ASBMR/structure.html> © 2010 ASBMR

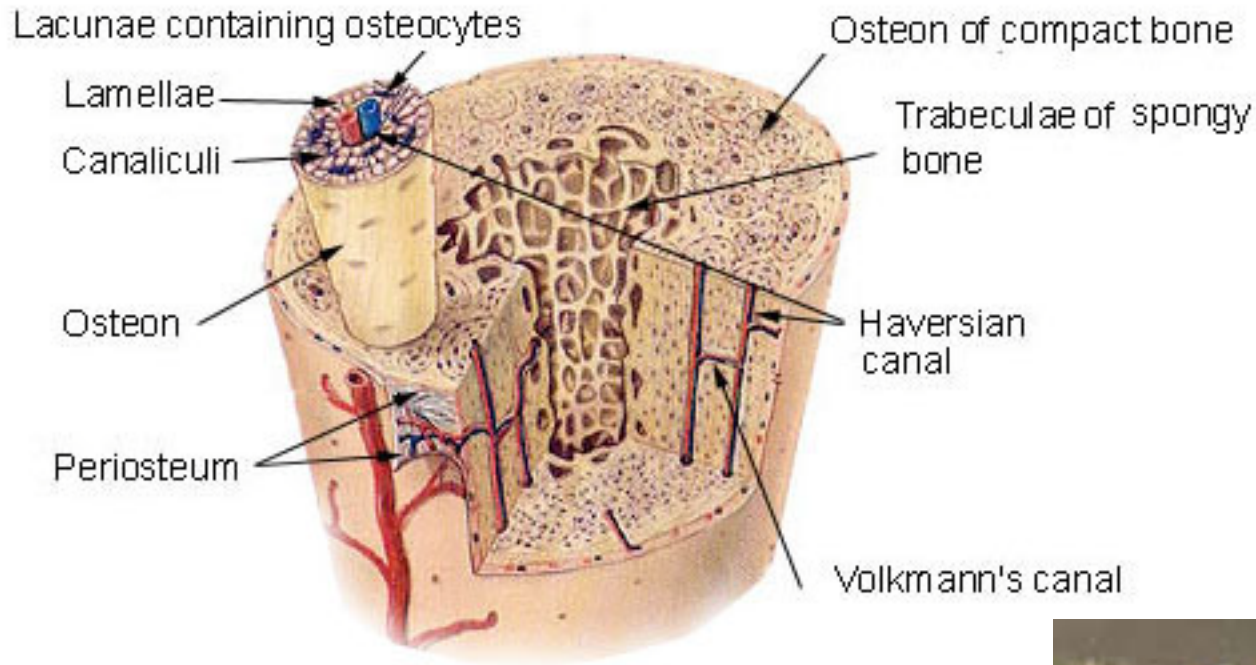
What are Bones made of?



- Bones consist of primarily a mineral called Calcium
- Bones also contain phosphorus
- Bones contain a polymer known as Collagen.
- Bones are a natural Composite material

Parts of a “Long” Bone

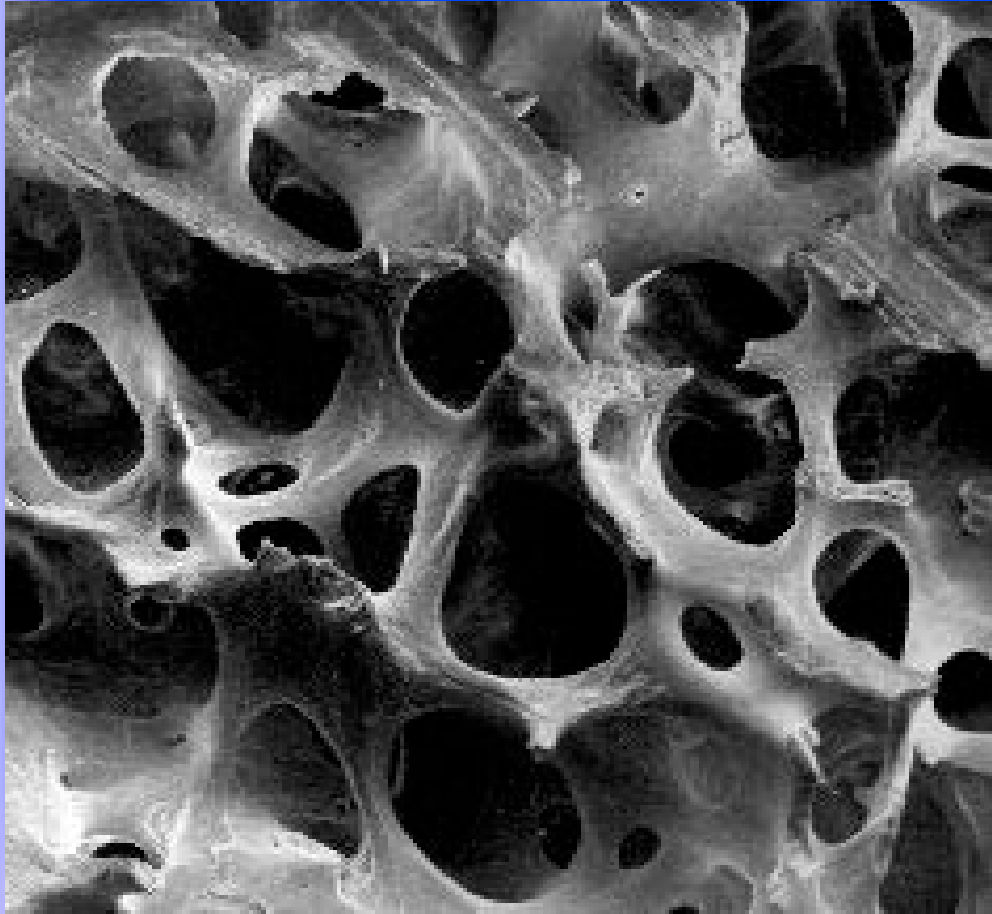
Compact Bone & Spongy (Cancellous Bone)



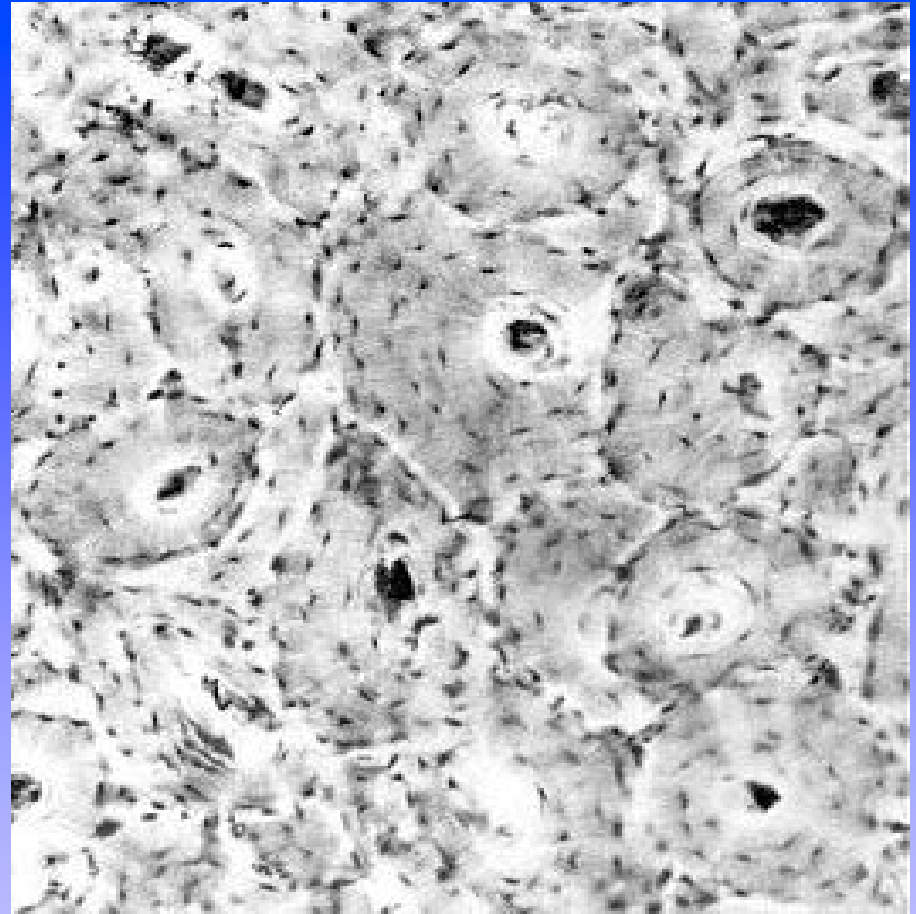
- Compact Bone
- Cancellous (Spongy) Bone
- Periosteum



Let's Investigate Smaller



- Spongy Bone under an SEM



- Compact Bone under an SEM

Why Must Our Bones Be Strong?

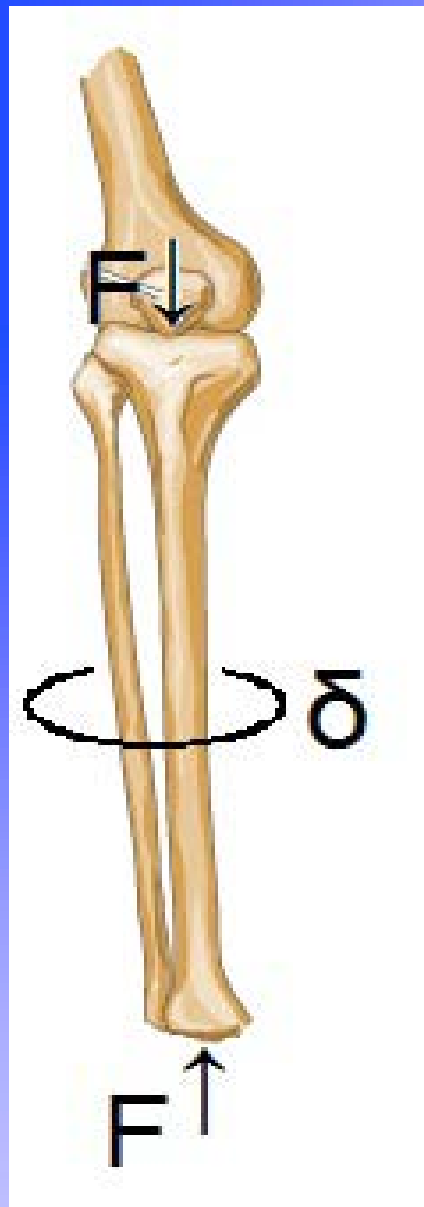


- Bones can support lots of weight, and experience large amounts of stress.
- Bones may experience different types of loads.
- Bone consistency is always changing, growing new cells.

Changing Loads!

Standing

- The load acting on the legs is about half the body weight.
- Gradual, static loading that eventually becomes steady.
- The load does not change with time.



Running

- If running, or jumping, and landing on one leg, that leg takes all the weight.
- The load of the body weight is given all at once when the runner's foot strikes the ground.
- The loading on the legs alternates with time.

The stress acting on the smallest cross-section of the leg is highest when the force is high, and the cross section's area is small. With enough force, the leg could easily break!

Bone Strength in Summary

- If the bones in our bodies were not living and constantly replacing cells, then they would surely not be able to withstand the stresses we place on them. Most likely, they would fail in fatigue because even light walking produces much heavier stresses on them than just standing!
- Thought: Imagine having to develop a prosthetic limb for an athlete like LeBron James. The design would need to allow him the ability to still play basketball despite the prosthesis.
 - How would you design it?
 - What materials would you use?
 - Could it be as strong as a real one?
 - What are potential problems?

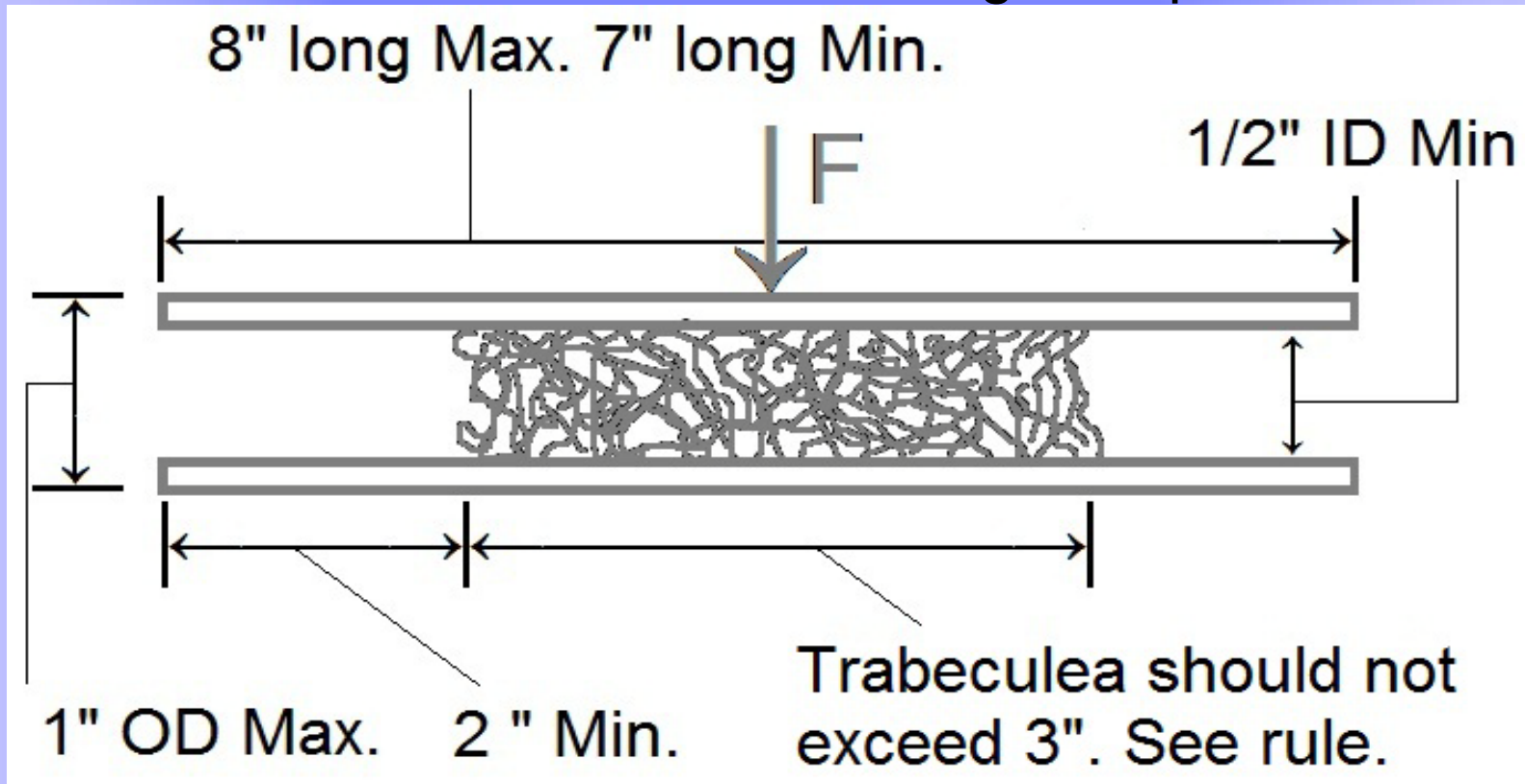
Time to Build a Bone!

Contest Rules

- The contestants must use the materials provided to create a model bone for LeBron James, particularly, a new tibia.
 - 18” of clear plastic tape
 - 2 - 8 1/2” X 11” sheet of white card stock paper
 - 1 - pair of scissors & ruler
- The bone must be manufactured according to design constraints
- The bone will be tested by the contestants under judge's supervision in the flexure-test until failure using incremental weights.
- The design with the highest flexure strength wins!

Design Requirements

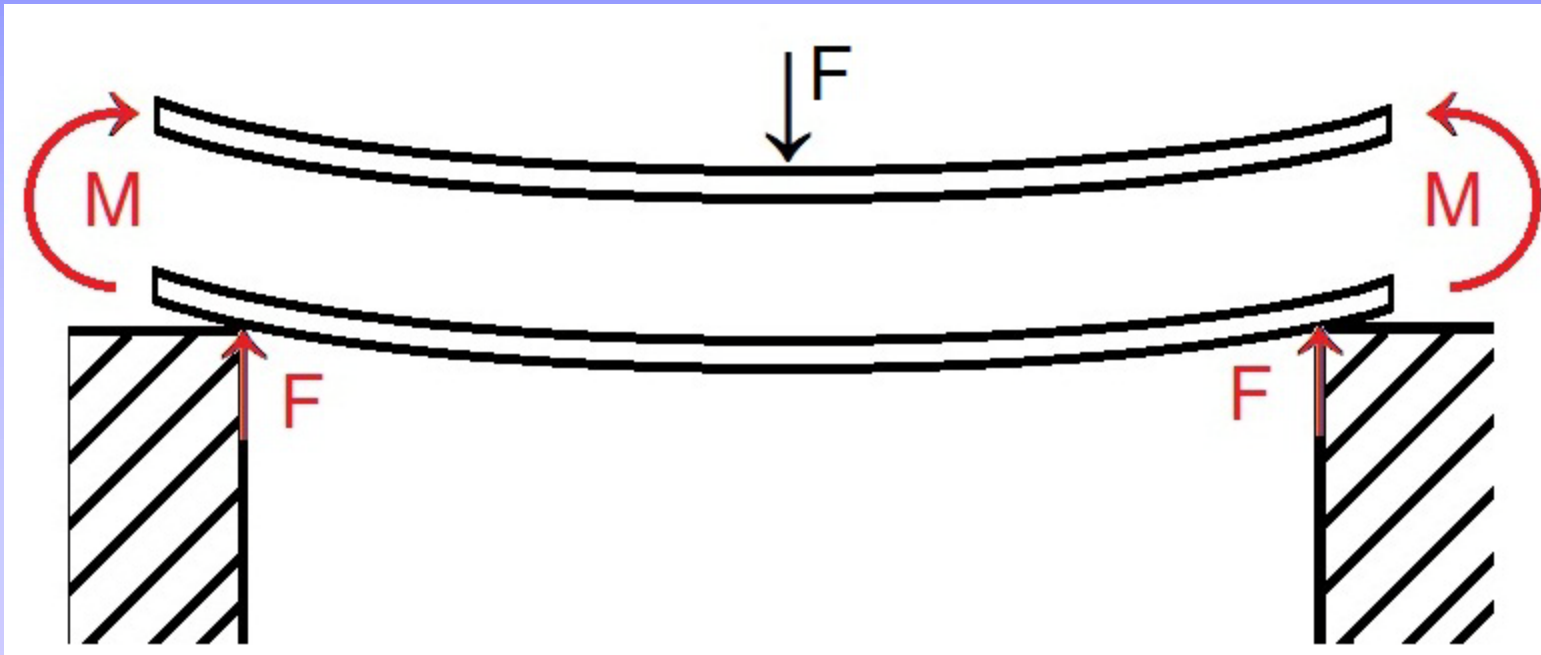
Using the card stock paper, each contestant must build a model bone to be tested in the flexure apparatus shown. The bone must be designed according to the following constraints. The bone does not have to be round! The bone must fit the design template.



The general rule for the trabeculae is that you may compact paper inside the bone, however, the judge must be able to insert a pencil to a minimum depth of 2". Be creative!

Testing the Model Bone

- Contestants will secure the bone in the apparatus using tape (supplied for test, not for bone design). The bone must have no more than 1/2" in contact with the support.
- Contestants will hang a bucket from the approximate center of the model bone.
- Contestants will load the bone with incremental weights until failure. The bone must support the static, hanging load for 5 seconds for strength to be recorded.



This concludes the Bone Strength Competition!

Questions?

Artwork from:



Special Thanks to:

Dr. Jag Sankar – NSF ERC Director, NC A&T

Dr. Devdas Pai – Sr. Education & Outreach Coordinator

Mr. Oliver Lewis – Mechanical Engineering Lab Manager

PTIE – Pittsburgh Tissue Engineering Institute

