Discussion Week 9

Animal Physiology
Discussion Questions and Reading Assignments

Reading assignment: Withers Ch. 10 (biomechanics pp. 449- 460, Supplement 10-1, 10-2)

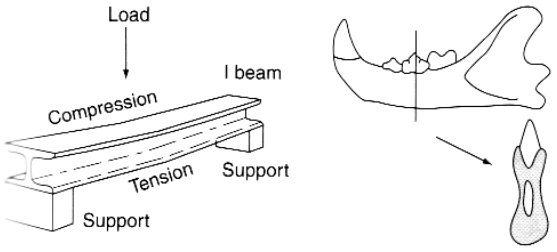
Biomechanics

Know:

- ☐ The meaning of stress, strain, elastic region, plastic region, strength
- ☐ Types of stresses: tension, compression, torsion, bending
- ☐ Hydrostatic skeletons, exoskeletons, and endoskeletons
- ☐ Properties of bone, how they perform under stress, and adaptations of bone form.
- ☐ Joints: elastic and sliding
- ☐ Lever mechanics: the torque equation, mechanical advantage

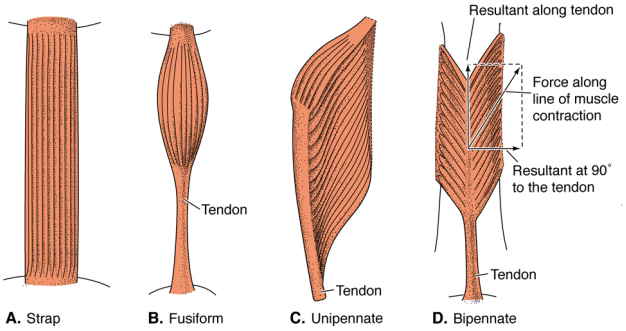
Discuss:

1. An I-beam can support a load as in the figure almost as well as a solid beam of metal, but they use much less material. Do bones exemplify material economy? Consider how changing shape or other properties can maximize support and stress under locomotion. In which taxa are these most evident? Which bones? What costs might be minimized ? How do biomaterials compare to engineered materials in their material properties?



A. An I beam with a load **B.** Mandible as an I-beam

FIGURE 5-20
A An I-beam supported at each end and loaded in the center tends to bend in the middle, so the top surface is under compression and the bottom surface is under tension. B A biological example of an I-beam–like structure is the mandible of a mammal.



A. Strap **B.** Fusiform **C.** Unipennate **D.** Bipennate

2. How should the different muscle architectures vary in performance? Consider force, speed, amount of shortening, and direction of fiber shortening vs. muscle shortening. What are the mechanistic explanations?

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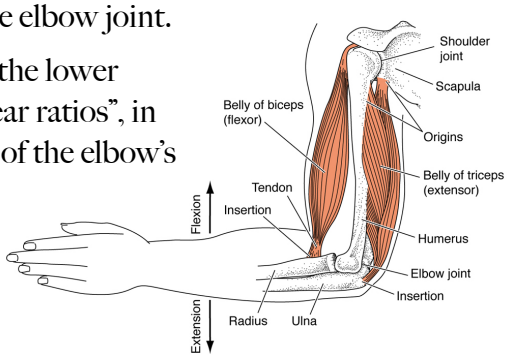
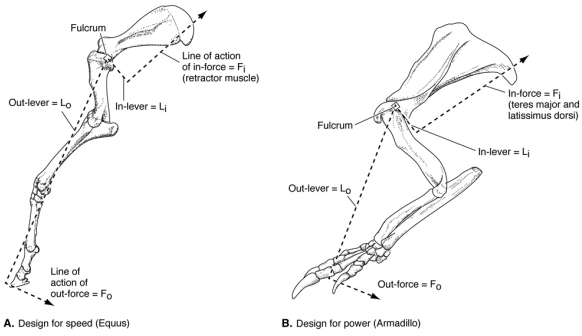
3. The biceps and triceps are antagonistic muscles which stabilize the elbow joint.

The triceps has three origins at the scapula, the upper humerus and the lower humerus. The three heads of the triceps are said to have different "gear ratios", in other words, be optimized for force production at different portions of the elbow's range of motion. Can you explain this?



What types of muscle architecture do they have? Can you explain why the biceps is the powerful muscle producing most of the motion in flexion whereas the triceps primarily stabilizes? What aspects of their morphology supports this statement?



4. Compare the limbs of the horse (a runner) and the armadillo (a digger). Which is optimized for speed and which is for power? Explain. On each, identify the in-lever and out-lever. Make up some numbers to illustrate differences in mechanical advantage.

Discussion Week 9

Reading assignment: Withers Ch. 10 (locomotion pp. 460-487)

Locomotion

Know:

- ☐ The forms of terrestrial locomotion, the gaits of walking/running
- ☐ friction drag, pressure drag, lift, thrust, and the pull of gravity.

Discuss:

1. Which gaits are used for fast vs. slow locomotion? What are their pros/cons?

2. Elastic storage and recovery occurs in walking and running locomotion, so that animals don't have to produce all of the force for each step of a walk or a run. How could energy be stored in the series elastic elements of the leg? How is it released? How would kinetic and potential energy be exchanged (conservation of energy)? How do these relate to the inverted pendulum and mass-spring models of locomotion?

3. Which requires more power? Running or jumping? Why?

4. Compare and contrast gliding vs. flapping flight.

5. What is rowing versus undulating locomotion in aquatic animals? How is thrust produced by each?

6. Look at figure 10-22. What are the dominant forces as we move from the smallest to the largest organisms? What significance does size and Reynolds number have for their locomotion and their locomotor morphology?

7. What is the relationship between cost of transport and velocity? and distance? mass? Which forms are more expensive than others: burrowing, running, flying, gliding, and swimming?