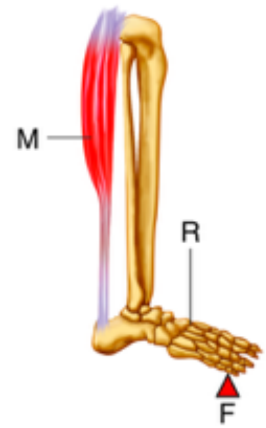
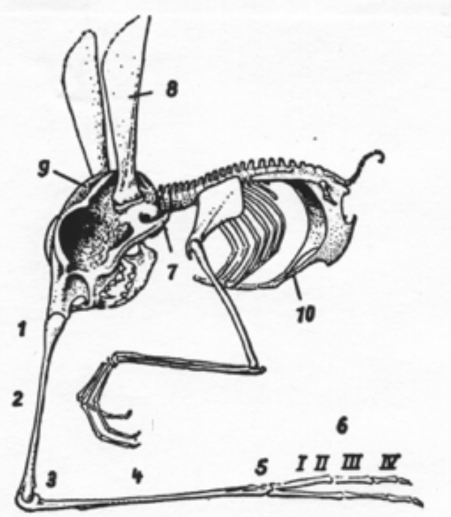
Biology 427 Biomechanics 2016

1. **Tendon stress.** During slow walking, or in standing on the toes of one foot, your mass is supported by a small portion of the foot in contact with the ground. The diagram to the right corresponds to a simplified image of the gastrocnemius muscle (M) and the foot with the tendon of Achilles extending to the heel (3 pt) The distance from the Achilles tendon to F is 15 cm. The distance from the ankle to F is 10 cm.

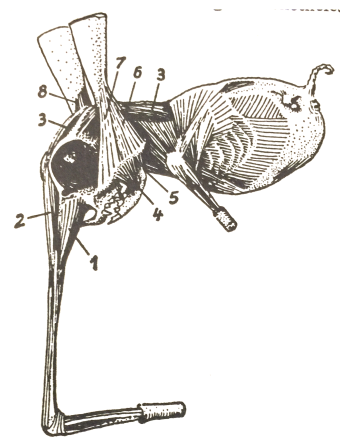


   A. What class of lever best represents this system?
   B. If the mass of the individual is 70 kg and they are standing on one foot with their heel just off the ground, what is the force generated by the gastrocnemius?
   C. If the tendon is 1 cm in diameter and the stress in the tendon is the force divided by its cross-sectional area, what is the stress in the tendon? Be sure to include units
   D.

2. Below are two figures of the now extinct *Otopteryx volitans*, one showing the skeletal reconstruction and the other showing the best estimate of the musculature.



[Fig. 10] *Otopteryx volitans*, skeleton. 1. *Articulatio nasofrontalis;* 2. *Nasur;* 3. *Articulatio deutonasalis;* 4. *Nasibia;* 5. *Articulatio carponasalis;* 6. *Rhinanges* (=*Nasanges*) I–IV; 7. *Processus jugalauris;* 8. *Os alae auris* (=*Cartilago aeroplana*); 9. *Christa temporalis;* 10. *Processus pubici.*

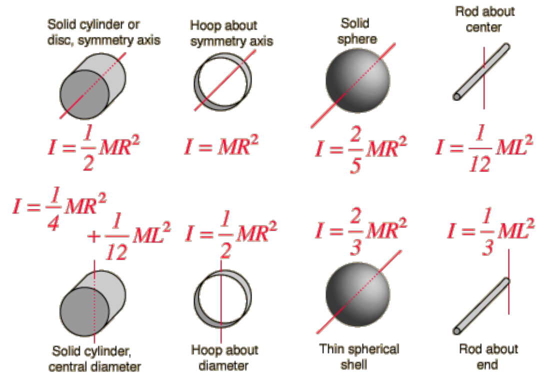


[Fig. 11] *Otopteryx volitans*, musculature. 1. *M. lacrymonasuralis;* 2. *M. extensor nasipodii superf* 3. *M. extensor nasipodii longus;* 4. *M. masseter;* 5. *M. depressor mandibulae;* 6. *M. aeroplano-jugalauri* *posterior;* 7. *M. aeroplano-jugalauris anterior;* 8. *Leva* *aeroplanae*. To the right of 3, *M. extensor nasipodii* bared by partial removal of *M. trapezius cervicalis*.

This creature is known for the wildly unique specializations of the nasal bones (1,2,4,4,5 in left figure above) for what is presumed to be a locomotor function. It is hypothesized that these animals used muscles (numbered 2 on the right figure) to rapidly extend the joint located at "3" on the left figure (3 pts)

   A. What class lever does this muscle and joint represent?
   B. Explain why you don't need to know the scale of the system to calculate speed ratio and mechanical advantage
   C. What is the mechanical advantage and speed ratio of this system? Assume the muscle (2) acts similarly to the gastrocnemius (and estimate appropriate lengths)

3. **3.** The skater in the video shown in Monday's lecture reached a world record rotational speed of 308 rpm (rotations per minute). To accomplish the maneuver, the skater imparts rotational kinetic energy to her body. During that maneuver she kept her arms tightly clenched to her chest and her legs twisted together, approximating a cylinder of radius *R* = 0.5 m, rotating about its vertical axis. The rotational moment of inertia for a cylinder spinning around its axis is $I = \frac{1}{2}\, M\, R^2$ where *M* is the mass (assume 70 kg – see figure to the right). (3 pts)



A. What is her angular kinetic energy?
B. After 10 turns, and assuming no energy loss, the skater spread her arms outward, would her rotational energy increase, decrease or remain the same? Why?
C. Given your answer to part B, would spreading her arms outward increase or decrease her rotational velocity? Why?

4 **Generator packs.** In the paper by Rome et al., the authors describe a backpack capable of converting mechanical energy to electrical energy when attached to a human walker. Design a new device that could be word or carried by a human to harvest mechanical energy of movement (1 pt)