Evolution of Animal Form & Function
ECOL 330 | Spring 2019

Ideas for topics:
(expand on any of these or select your own)

1) How does drug addiction work? Why do drugs differ in how addictive they are and what is the mechanism behind addiction from the first use? Can mechanism of addiction be used for something useful – like good habits, supereffective learning, exceptional work productivity, performance etc? Is there shared mechanisms behind addictions?

2) How does sport doping work? What are the mechanisms behind its performance-enhancing effects? Are these unique to substances or do they capitalize on some existing organismal function? If they are physiological limits of performance of human athletes in some sports – how do doping overcome these?

3) Are snakes immune to their own venom? Do they die if they swallow it accidentally when eating their poisoned prey or “bite their lips”? How is venom produced and kept to prevent self-poisoning? In general, how does one become immune to a specific venom (e.g., some rodent species)? How do antivenom injections work in humans?

4) Our skeleton constantly remodels itself in response to current mechanical conditions. Both muscle load and muscle activity are crucial in this process. Under weightless conditions astronauts lose bone mass even when they exercise vigorously. Paralyzed embryos in birds and mammals fail to develop normal skeletons. We lose substantial amount of bone density simply by staying in bed with flu for a few days or staying motionless during prolonged exam studies. Then we get our skeleton mass back in days. Review the fascinating interface of physical activity and bone growth in humans.

5) Cartilage as a tissue flourishes in a pressurized environments. Thus reconstructive orthodontics use special devices to compress and extend some facial bones during reconstructive surgeries. Review such appliances and their efficiency and suggest other methods of reconstruction of bones in fully grown adults. Review “distraction osteogenesis” procedure where the bone is strengthened mechanically. Review recent military applications/patents that enable soldiers to fuse bone breaks in the field.

6) In mammalian embryos, in the absence of breathing-like movements, the developing lungs fail to grow; in the absence of skeletal muscles, (and thus, lack of the ability to move the chain of three middle ear ossicles), the hearing and inner ear fails to develop. In birds, the lack of muscle movements prevents formation many of skeletal features, including opposable “perching digit”. Review the mechanisms behind inductive influence of function on form during development.

7) It is commonly observed that people with one sensory modality impairment – such as early blindness – develop amazing compensatory abilities in other sensory modalities (such as in hearing, echolocation, tactile communication, etc). What is the basis of such compensation? Can this mechanism be coopted in healthy humans? Can we train and reprogram neurons and associated networks for our current needs?

8) During childhood learning, we prune an overwhelming amount of neural connections in our brain. This is associated with reduction to phonetic sensitivity outside of our normal environments, critical periods in language learning and motor skill development. How does adult learning work? Do we during ECOL330 prune even more of our neurons? Rewire previous connections? Form completely new ones?

9) There is a strong association between learning and morphology. It is particularly evident in asymmetrical traits – such as feeding with crossed bills in crossbills, habitat selection in flatfishes, some mating in polychaetas, and, of course, habits of right- vs left-handed humans. For example arm bones in right-handed humans are heavier on the right side while leg bones are heavier on the left. The cross-section of upper arm bone (humerus) in the racket arm in professional tennis players is 40% greater than the same cross-section in a non-racket arm. In general human population the difference is less than 2%. Discuss the evolutionary significance of within-generation association between learning (or behavior in general) and morphology.

10) Grizzly bears going into hibernation accumulate so much fat in their organisms that their plasma circulating cholesterol level is thousands of times of what would instantly cause the atherosclerosis (the build up that narrows the arteries) in any human. Yet, bears can fluctuate their cholesterol without any evidence of atherosclerosis. Why? How? What are the implications for atherosclerosis treatment in humans?

11) We have enlarged brains and susceptible to brain cancer. Yet bone cancer is unknown in elk and deer even though they re-grow their massive antlers every year, essentially releasing huge and variable accumulation of bone tissue locally and repeatedly. What prevents this tissue from going out of control in these animals? What are the implications for bone cancer treatment in humans?

12) Pronghorn antelope – the fastest North American mammal - can run with speeds up to 70mph for many hours, but none of their contemporary predators can reach such speeds even in sprints. Even five week old pronghorns can outrun any extant predator both in speed and duration of running. What maintains this evidently excessive running performance in this species?
13) Folk tales tell of several methods to determine the gender of unborn baby during pregnancy (cravings for certain foods, movement patterns of the baby). Do you think there is a scientific basis for these folk tales? If so, why?

14) How can giraffe lower and lift its head from the ground level to 6 meter height in 0.1 sec and avoid passing out or hemorrhaging its brain (which would be an instant human reaction to such exercise)?

15) How do normally marine sharks, rays and fish adjust urea metabolism when they seasonally move far up the freshwater rivers?

16) How do pigs, hippos, horses and other mammals deal with UV in sunlight? Do they have their own sunscreen-like substance? What is the basis of that substance? How do human sunscreen lotions work?

17) How pocket gophers and banks swallows cope with the low oxygen and high carbon dioxide concentrations in their burrows?

18) Birds have extremely high metabolism. How can they migrate over Himalayas in the conditions of low oxygen and very low temperatures that would put any mammal into torpor or coma?

19) Some Artic seals manage to transfer nearly all of the energy stores from mother to pup in just 4 days of lactation. Investigate this amazing adaptation and ways to store and use such short-term resource with life-long consequences.

20) How do we know what the dinosaurs ate, how they mated, slept, walked? How can you infer function from the form of extinct animals?

21) Your cat can see clearly under conditions that you would consider absolute darkness. How? What is the basis of seeing in the dark? Do people vary in this ability?

22) Can humans bias the gender of their babies during or before conception? What is the evidence for and against such ability?

23) Because of their large mass, beached whales die of overheating within hours of exposure to the air. What prevented huge terrestrial dinosaurs from overheating?

24) Our brains, and nervous system activity in general, generate a substantial amount of electricity. Can humans transmit electromagnetic fields? Receive them? Communicate with them? Or at least “feel” them. How about other terrestrial forms?

25) It is often observed that free mate choice in animals results in the production of healthier and more numerous offspring. Yet in endangered species, in some domestic breeds, and in arranged marriages, partners are often provided with limited choice of preselected mates. Review possible consequences of such choice. What is the basis of great offspring quality based on “free mate choice”.

26) How can a baby whale feed under water on his mother’s milk without breathing?

27) Select an organ or a system in the organism and write about its development and evolution. Don’t limit yourself to regular organs - select something strange – elephant tusks, rhino horns, porcupine needles, os penis of walrus, elephant trunk, whale leg appendages, bat wings or noses, etc

28) Why don’t birds fall off their perches while asleep?

29) You roll up your car windows when driving on a very dusty road. How do various antelope species – that run up to 70 mph in huge herds in steppes and deserts – deal with the dust?