OSMOREGULATION

PROBLEM SET 7

1. A largemouth bass is a stenohaline (narrow range of salinity tolerance) fish living in fresh water. How does it regulate ions? How does it regulate water? During an extremely high tide the pond, which is near the ocean, becomes flooded by seawater. The largemouth bass dies. Why? What did it actually die of (hint: ions/water)? A stickleback (a euryhaline fish) in the same pond did not die. Euryhaline fish have the same osmo/ionoregulatory pattern as freshwater fish in freshwater and of seawater fish in seawater, i.e., they ionoregulate by ion pumping in opposite directions in freshwater and seawater. Therefore, how does it differ from the stenohaline fish in how it regulates ions? Water? 3pts

2. The salt gland of penguins secretes a salty fluid that has an osmotic concentration of 1660 mOsm (800 mOsm Na^+, 30 mOsm K^+, and 830 mOsm Cl^-). If a penguin drinks 100 ml of sea water (1000 mOsm concentration) how many mls of salty fluid will be produced by the nasal gland to rid its body of this salt? How much "pure" water will the penguin gain from this activity? How much water would be gained by a human drinking the same 100ml of sea water? 3Pts

3. Draw the mammalian nephron (including loop of henle and collecting duct). Describe the mechanism for the osmostic concentration of urine by countercurrent multiplication in relation. What are the steps involved and where does it occur (indicate on your drawing)? How are the nephrons arranged in the kidney, and how does this arrangement help with urine concentration? Why is it that mammals can concentrate urine but fish cannot? 5pts

4. A 2 kg duck lives in a freshwater pond. Its metabolic rate is 576 kJ/day. The food it eats is 80% water, 5% protein, 8% carbohydrate, 2% fat and 5% indigestible material. It eats a total of 240 grams of food per day and has an assimilation efficiency of 95%.

a. How much water does it get just by eating its food? 1pt

b Assuming that the metabolism is maintained entirely by carbohydrate, how much metabolic water is produced? 2pt

c. How much water does the duck lose through its feet (the oily feathers keep water away from its body)? Use the value of P_{Osm} for lizard skin (Uromastix) from Table 16-2. Develop your own estimate of surface area (hint: the legs are about 10 cm long and 1.5 cm in diameter with the webbed feet being 6 cm in diameter.

Water Flux = $P_{Osm}*SA*(n_{s,i}/n_{w,i} - n_{s,o}/n_{w,o})$
where P_{Osm} is osmotic permeability in microns/sec pg. 785. You may need the MW of water, which is 18, in order to calculate the moles of H_20/L. 4pts

d. How much water does the duck lose in the feces each day (Use the fiber value above and values of 10% for bacterial weight in the feces and 60% for the weight of water). 3pts

e. How much water does the duck lose in the urine per day assuming that the maximum uric acid concentration it can achieve is 100 mOsm? 3pts

f. How much water does the duck lose due to respiratory water loss? Assume 45% oxygen extraction (bird lungs are better than mammalian lungs at extraction). Also assume a body temperature of 40^o C and an air temperature of 20^o C with a 70% relative humidity (a nice, humid, summer day). 4pts

g. Assuming that the evaporative water loss from the skin of the duck is minimal, is the duck in water balance? If not, either reduce the urine concentration or increase water intake by drinking. Which is needed, and by how much? 2pts