Why worry about water?

	Mild	Moderate	Severe
Weight loss	Up to 5%	6-10%	More than 10%
Appearance	Active, alert	Irritable, alert, thirsty	Lethargic, looks sick
Capillary filling (compared to your own)	Normal	Slightly delayed	Delayed
Pulse	Normal	Fast, low volume	Very fast, thready
Respiration	Normal	Fast	Fast and deep
Blood pressure	Normal	Normal or low Orthostatic hypotension	Very low
Mucous memb.	Moist	Dry	Parched
Tears	Present	Less than expected	Absent
Eyes	Normal	Normal	Sunken
Pinched skin	Springs back	Tents briefly	Prolonged tenting
Fontanel (infant sitting)	Normal	Sunken slightly	Sunken significantly
Urine flow	Normal	Reduced	Severely reduced

Dry, sticky mouth
Sleepiness or tiredness
Thirst
Headache
Constipation
Dizziness or lightheadedness

Extreme thirst
Fever
Delirium
Dry skin
Coma

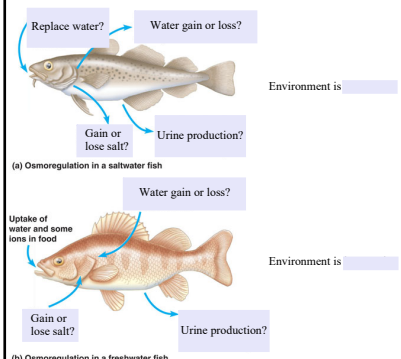
Water loss effects

What water balance problems face organisms?

Animals balance water gain and loss in one of two ways:
1. Osmoconformers
- are isotonic to their surroundings so they do not lose or gain water
- they usually live in stable conditions

2. Osmoregulators
- are not isotonic so they must control their internal osmolarity (total solute concentration)
- they must get rid of excess water if they live in hypotonic conditions
- they must take in water if they live in hypertonic conditions

What's the advantage of being an osmoregulator?
- the animal can live in environments not available to osmoconformers (like on land)



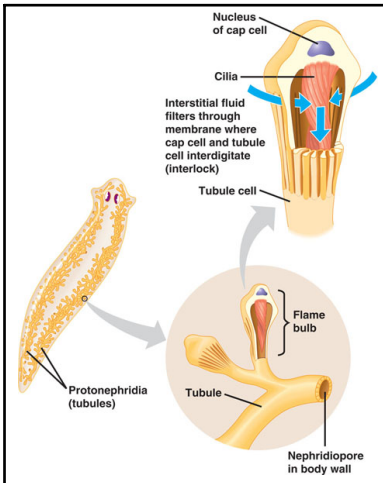
Osmoregulation in fish

1. Being an osmoconformer is much easier than using energy to maintain osmolarity different from the environment. Why aren't all animals simply osmoconformers?

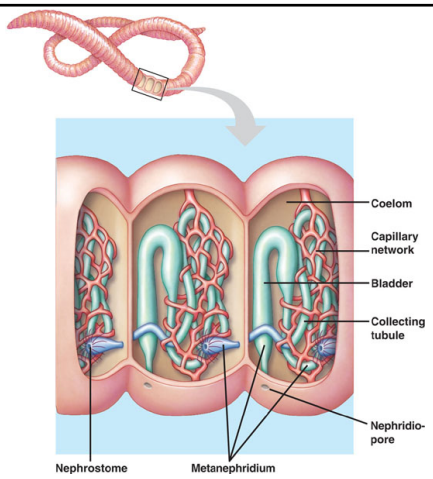
2. Summarize the challenges faced by an osmoregulator in salt water versus one in fresh water.

3. Tardigrades are remarkable animals in that they can survive complete desiccation. Why is drying out fatal to nearly all organisms?

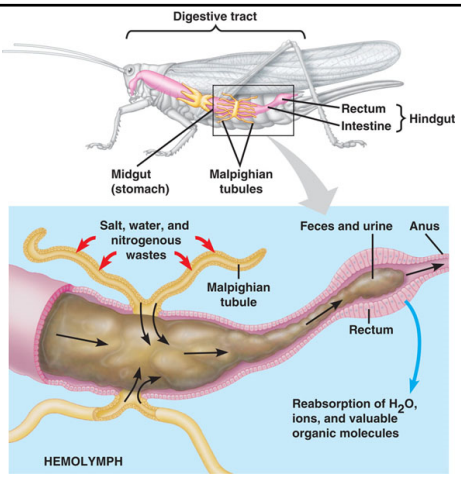
CQ



Flatworm excretion



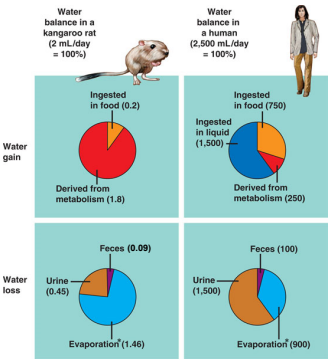
Worm excretion



Insect excretion

How do land animals conserve water?
- waxy layer on the exoskeleton of insects
- shells on land snails
- layer of dead skin cells
- nocturnal lifestyle
- kidneys

- a major problem is the loss of water from the respiratory surface, and in urine and feces



* mostly from respiratory surface

Blood	372 mosm/L	Blood	300 mosm/L
Urine	9,300 mosm/L (25x)	Urine	1,200 mosm/L (4x)

Water balance

4. Not all animals have complex kidneys like yours. How do animals without kidneys manage to excrete metabolic waste?

5. Conserving water is an important role of the kidneys. Name a couple of other important functions of these organs.

6. Your friend says they hardly ever sweat so they don't really need to drink much water. What would you say?

CQ

7. Where does nitrogenous waste come from?

8. You and your friend are watching his goldfish one day and your friend asks "Do goldfish pee?"

a) What would you say?

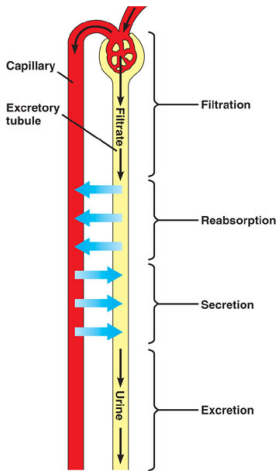
b) Why can't terrestrial animals excrete ammonia like the goldfish?

9. In terms of kidney function, why is a high-protein diet dangerous?

10. In a documentary on the Love Nature channel, you learn about an amphibian, a reptile and a mammal species in the Amazon rainforest. It explains that the amphibian lays eggs without shells in water, the reptile buries its shelled eggs on the sandy shores of the river and the mammal gives birth to live young. Based on this information, predict what kind of nitrogenous waste each one would use and justify your predictions.

11. Dragonfly larvae, which are aquatic, excrete ammonia, whereas adult dragonflies, which are terrestrial, excrete uric acid. Explain.

CQ



selective or not?ot?

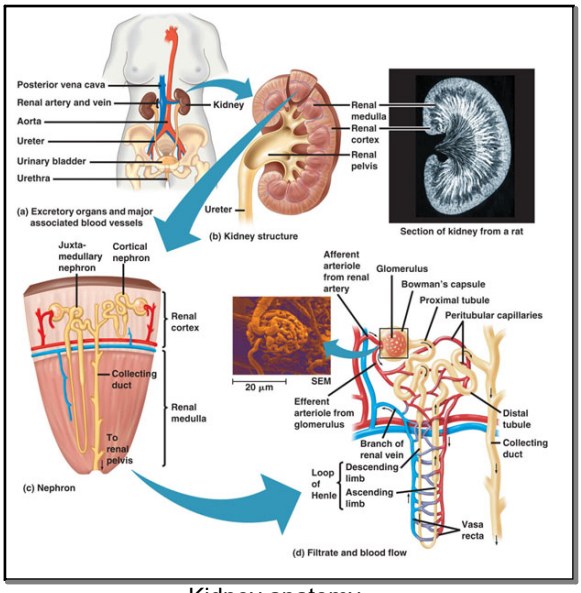
1. Filtration (not selective)
- a filtrate is collected from the blood
- blood pressure forces water and solutes (such as salts, sugars, amino acids, nitrogenous waste) across a selectively permeable membrane

2. Reabsorption selective
- filtration is not selective so valuable solutes are lost along with wastes
- the useful solutes must be reclaimed and put back into the blood

3. Secretion (selective)
- sometimes additional solutes must be ~~actively~~ transported into the filtrate

4. Excretion
- the filtrate (*i.e.*, urine) leaves the body

Excretion steps



Kidney anatomy

12. Filtration removes wastes from the blood. Why, then, are reabsorption and secretion necessary?

13. Imagine a molecule of urea in someone's blood. List the structures in the order the molecule would pass through them during excretion. renal pelvis, urethra, loop of Henle, ureter, bladder, Bowman's capsule, proximal tubule, distal tubule, collecting duct, renal artery.

CQ

How does the kidney produce urine?
- the kidneys get about 20% of total blood flow
- a pair of human kidneys processes between 1,100 and 2,000 L of blood each day
- the nephrons process about 180 L of filtrate
- they produce about 1.5 L of urine

So, how do we get from filtrate to urine?
1. Proximal tubule
- remember that "secreted" means put into the urine and "reabsorbed" means put back into the blood
- toxins are secreted
- nutrients like glucose, amino acids, and K^+ are reabsorbed
- most NaCl is also reabsorbed, which makes water follow by osmosis

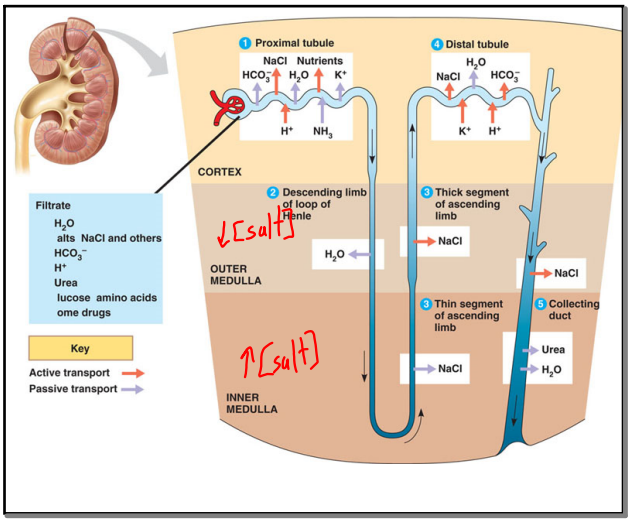
2. Descending limb of the loop of Henle
- water reabsorption continues
- this occurs because the interstitial fluid around the tubule is hypertonic to the filtrate
- moving down the loop, the filtrate gets more concentrated

3. Ascending limb of the loop of Henle
- this limb is permeable to salt but not water (except under hormonal influence)
- the salt that became concentrated in the descending limb diffuses out in the ascending limb
- this maintains the high salt concentration in the interstitial fluid
- a side effect of this is that the filtrate becomes more dilute (although not increasing in volume)

4. Distal tubule
- regulates K^+ and NaCl in the filtrate

5. Collecting duct
- this duct is permeable to water but not salt
- the filtrate becomes more concentrated as it moves through the duct because it encounters more hypertonic interstitial fluid as it moves into the inner medulla
- the duct also is permeable to urea which contributes to the high osmolarity of the inner medulla

Urine production



Urine concetration

14. After water is removed from the blood during filtration, why does it return to the blood during the formation of urine?

15. Why is it important that there are many capillaries inside Bowman's capsule?

16. How would a decrease in blood pressure in the arteriole leading to the glomerulus affect the rate of filtration of blood within Bowman's capsule?

17. As you're telling your friends about all the cool stuff you learned in biology, one of them says "Bah! The kidney is just a filter!" What would say to correct her?

18. When would you expect a person to produce very small quantities of urine?

19. For every 100 mL of seawater consumed, 150 mL of body water is lost. The solute concentration of seawater is greater than that of blood. Provide a physiological explanation for the loss of body water.

CQ

How is the kidney regulated?
- the kidney has to be able to adjust both the volume and concentration of urine

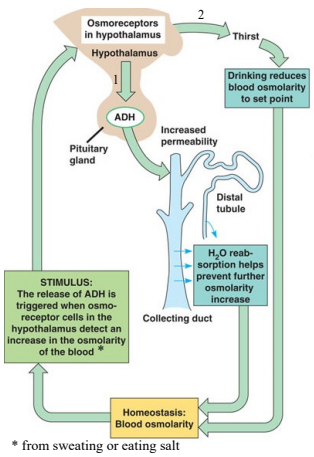
↑ salt intake
↓ low water → ↓ volume of hyperosmotic urine

↓ salt intake
↑ low water → ↑ volume of hypoosmotic urine

- this is accomplished using nervous and hormonal control

Kidney regulation

How does ADH (vasopressin) help regulate water?



* from sweating or eating salt

- high osmolarity causes two responses from the hypothalamus

1. ADH is released
- ADH increases the permeability of the distal tubule and collecting duct to water
- results in more water being reabsorbed
- more concentrated urine

2. Signals thirst
- removing water from urine would not decrease osmolarity
- drinking will add water and reduce osmolarity

- when blood osmolarity decreases the amount of ADH released decreases
- the decreased permeability to water results in more dilute urine

- alcohol inhibits the release of ADH, causing excessive urine production and dehydration

ADH activity

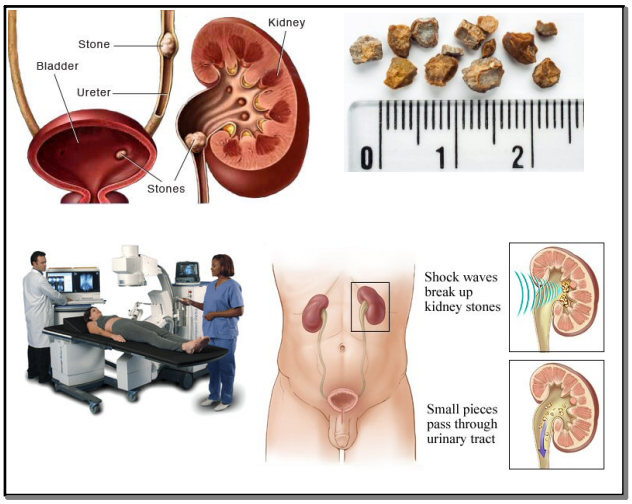
20. Imagine that a blood clot lodges in the renal artery, partially blocking the blood flow to the kidney. Explain why this condition would lead to high blood pressure.

21. Most people know that high blood pressure increases your risk of heart attack and stroke but it can also affect your kidneys. Describe the effect you would expect high blood pressure to have on kidney function.

22. Lots of people know that salty foods can cause high blood pressure but they can also affect kidney function. Explain how your body responds to salty foods.

23. Drinking too much alcohol can cause a hangover, the symptoms of which are believed to be caused by dehydration. Explain this by describing the way alcohol affects water balance in the body.

CQ



Kidney stones

24. A disorder called central diabetes insipidus is caused by a lack of ADH. Predict the symptoms of this disorder and explain why they are caused by a lack of ADH.

25. Your friend's father was recently diagnosed with kidney failure and has to be on dialysis. He wonders what that means and asks you to explain it to him. What do you say?

26. Your friend's father has kidney stones. What are they and what advice would his doctor give him?

CQ