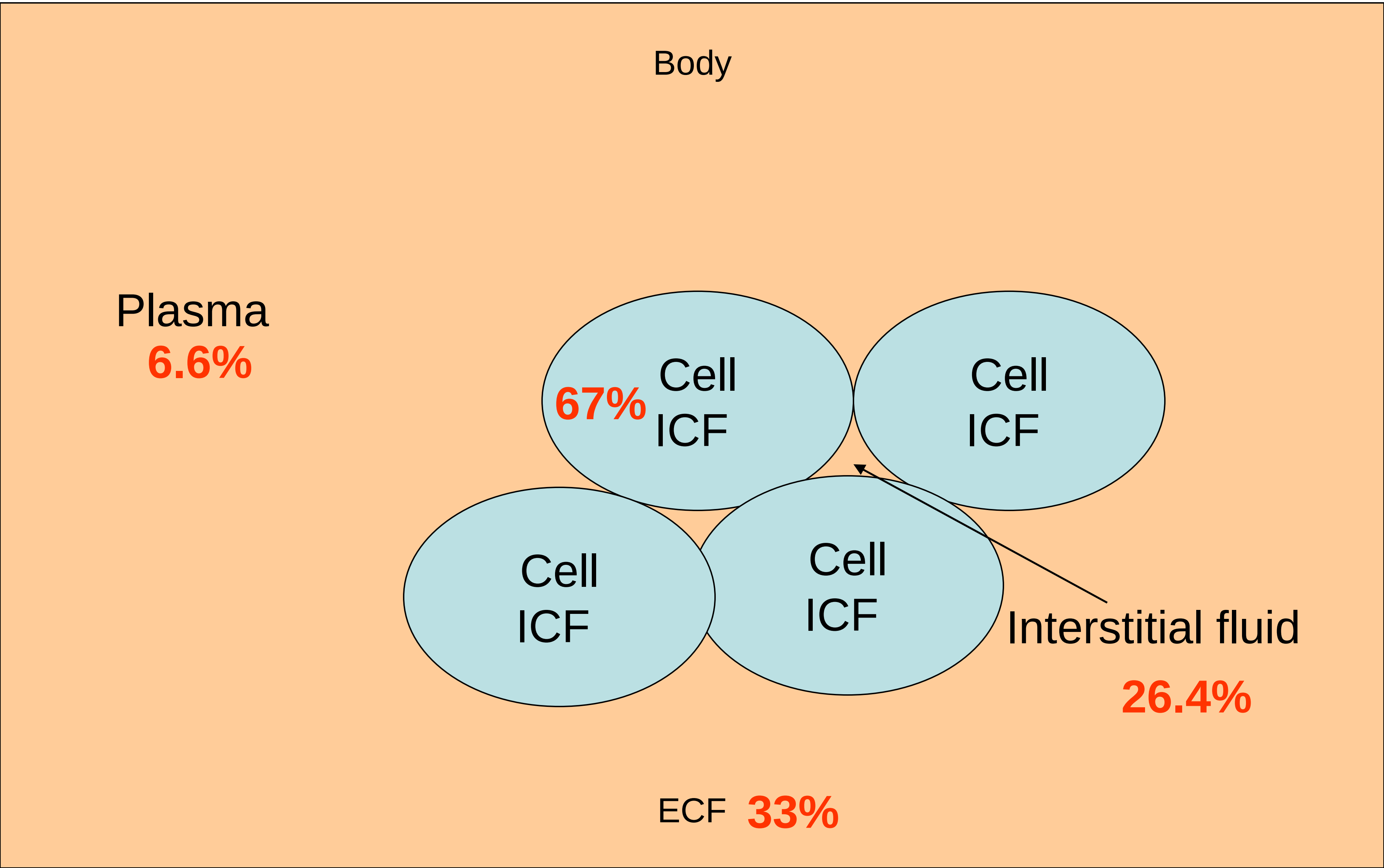
5. Osmoregulation in vertebrates

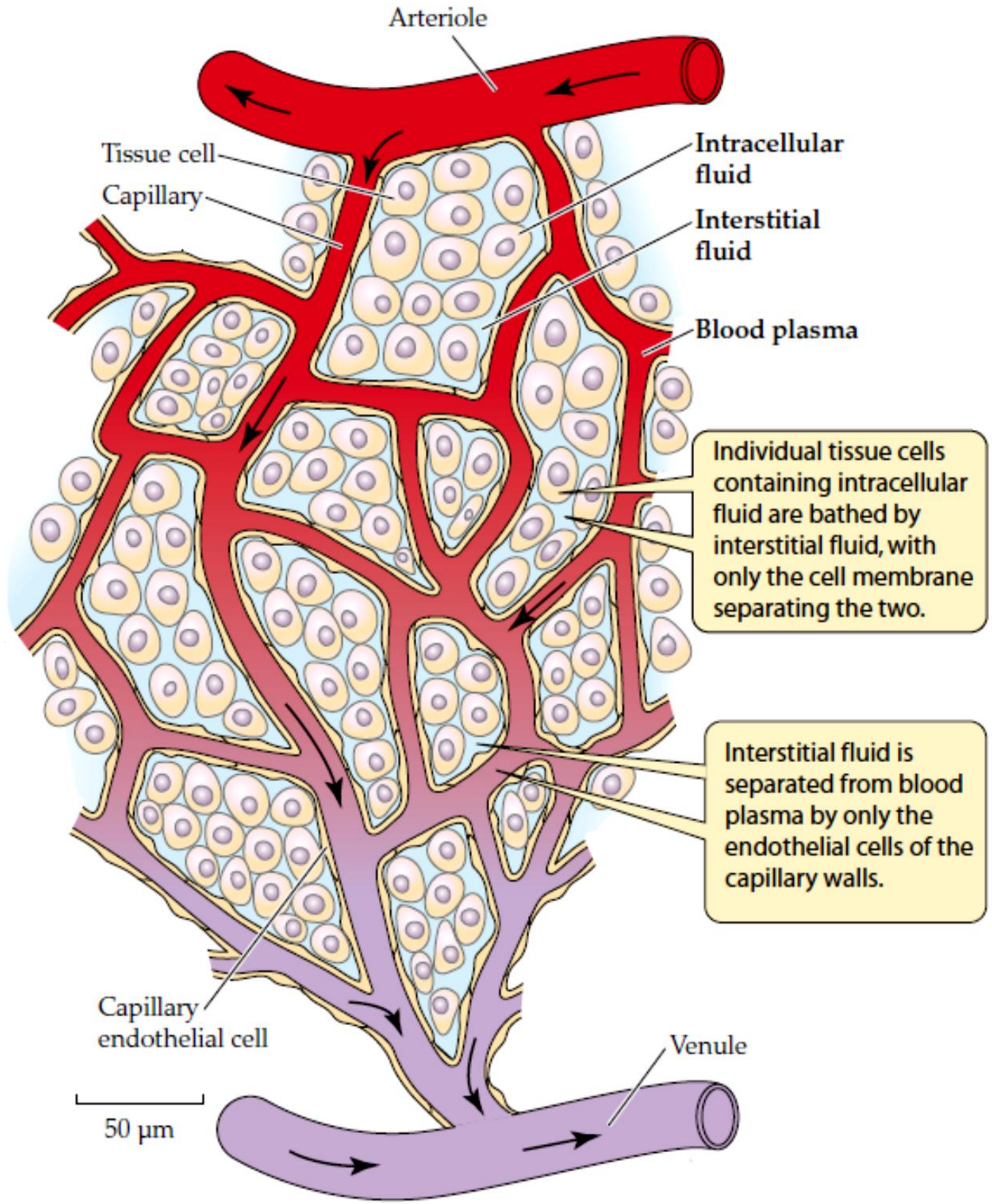
BIOS 0501B (Group A)

DBS, PU, Sem 5; 2016

Distribution of body fluid

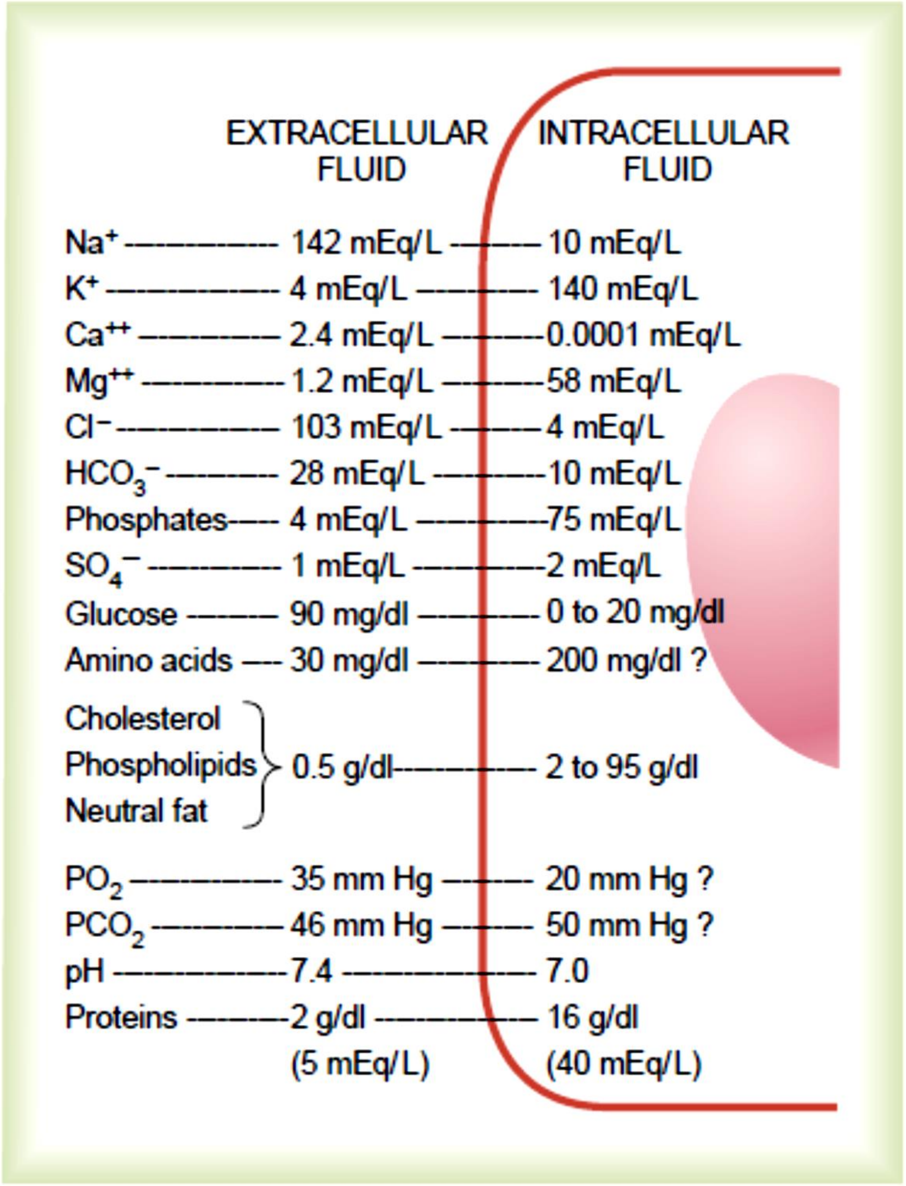


Or


Arteriole
Tissue cell
Capillary
Intracellular fluid
Interstitial fluid
Blood plasma
Individual tissue cells containing intracellular fluid are bathed by interstitial fluid, with only the cell membrane separating the two.
Interstitial fluid is separated from blood plasma by only the endothelial cells of the capillary walls.
Capillary endothelial cell
Venule
50 μm

Remember this?

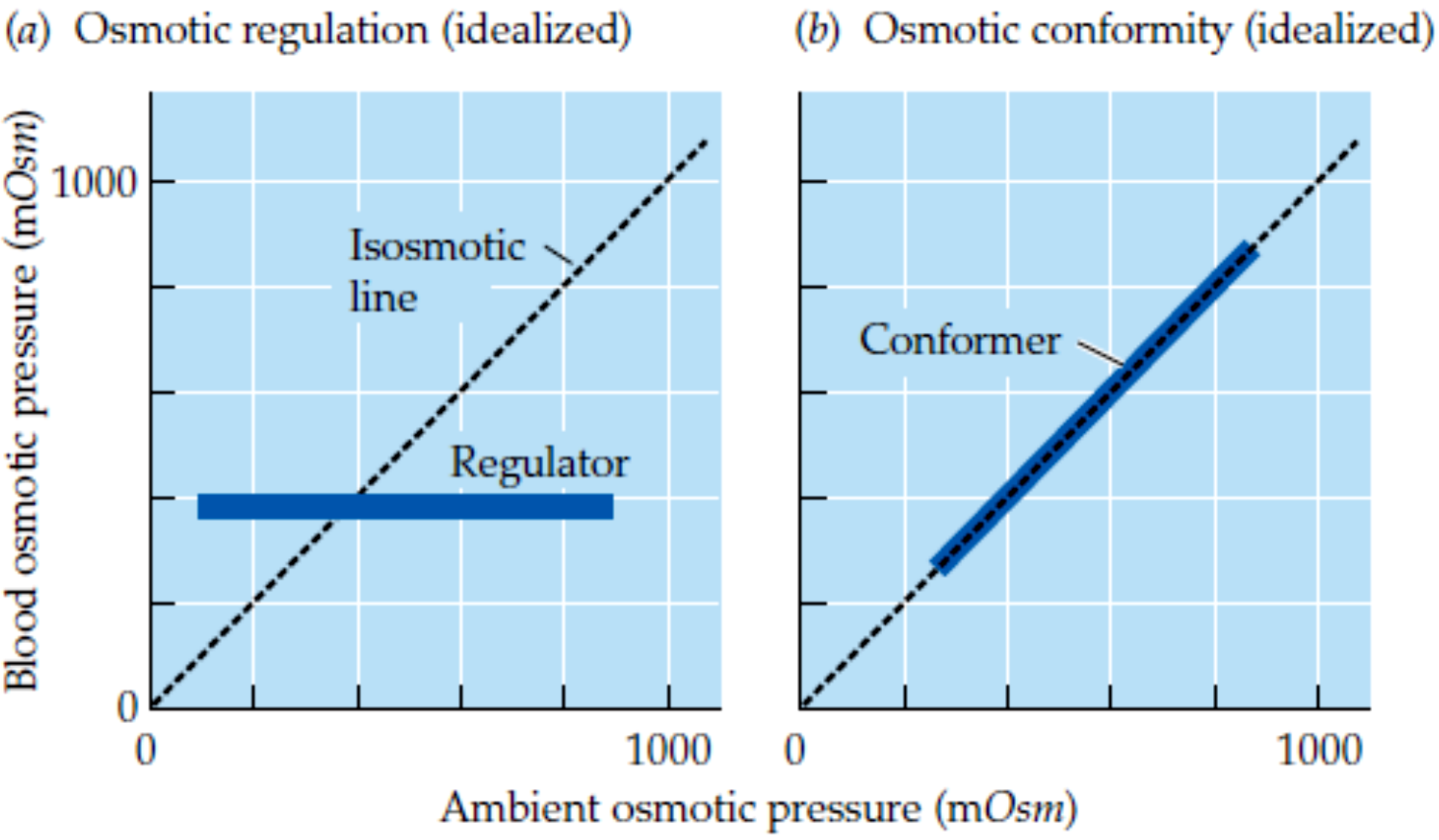
- Intra and extra cellular fluids are not equal
  - Unequal distribution of ions
  - ICF have proteins
  - ICF also have organic osmolytes
- This creates an ionic imbalance
- And a cell works very hard to maintain the osmotic balance



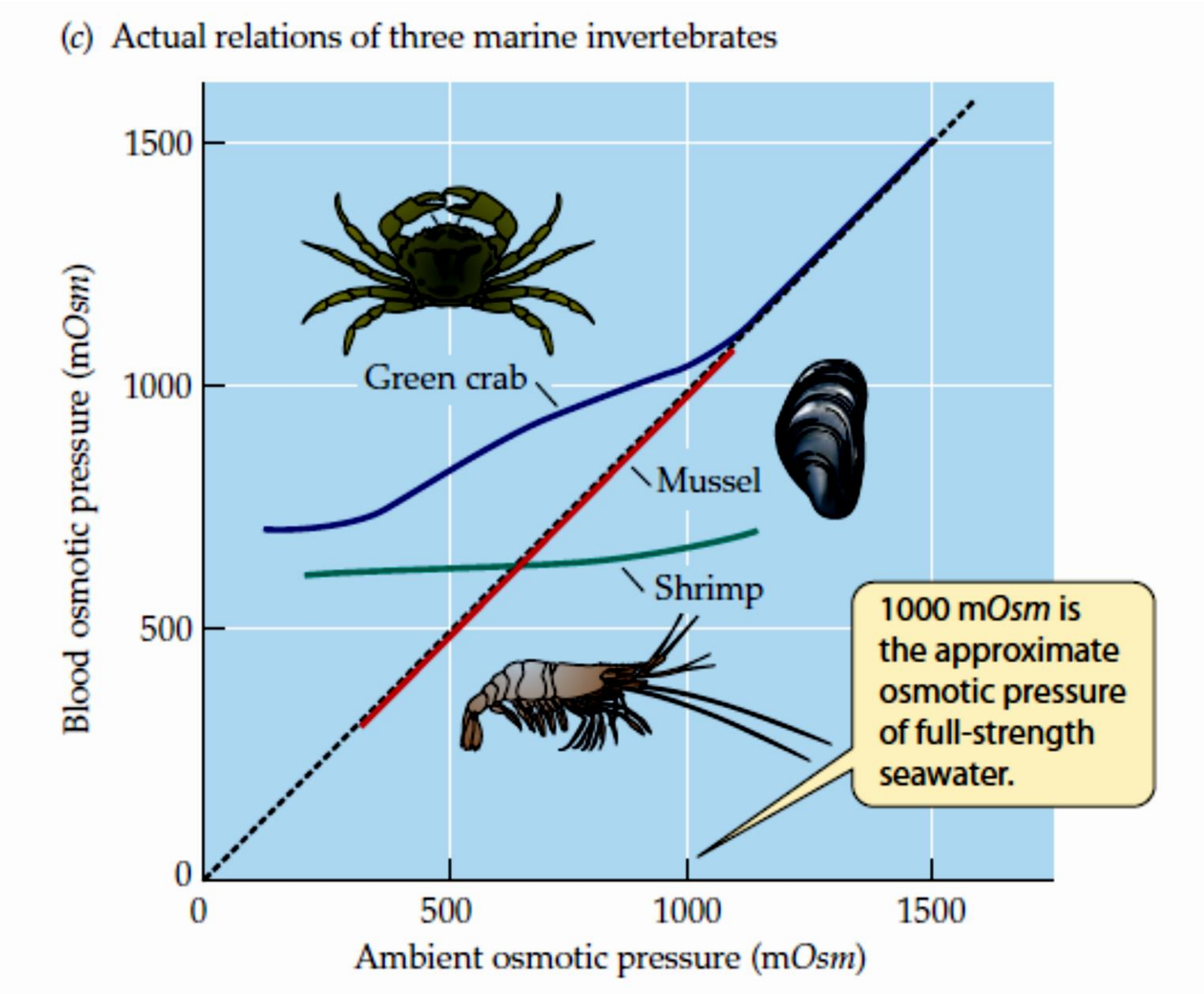
Osmotic challenge

- A cell either have a hypo or hyper osmotic environment
- So every cell have a tendency to either swell or shrink
- Examples
  - Evaporation
  - Osmosis
  - Freezing
  - Excretion
  - Diseases, like diabetes

Two strategies



Examples


(c) Actual relations of three marine invertebrates
Blood osmotic pressure (mOsm)
1500
1000
500
0
Green crab
Mussel
Shrimp
1000 mOsm is the approximate osmotic pressure of full-strength seawater.
0
500
1000
1500
Ambient osmotic pressure (mOsm)

Two examples

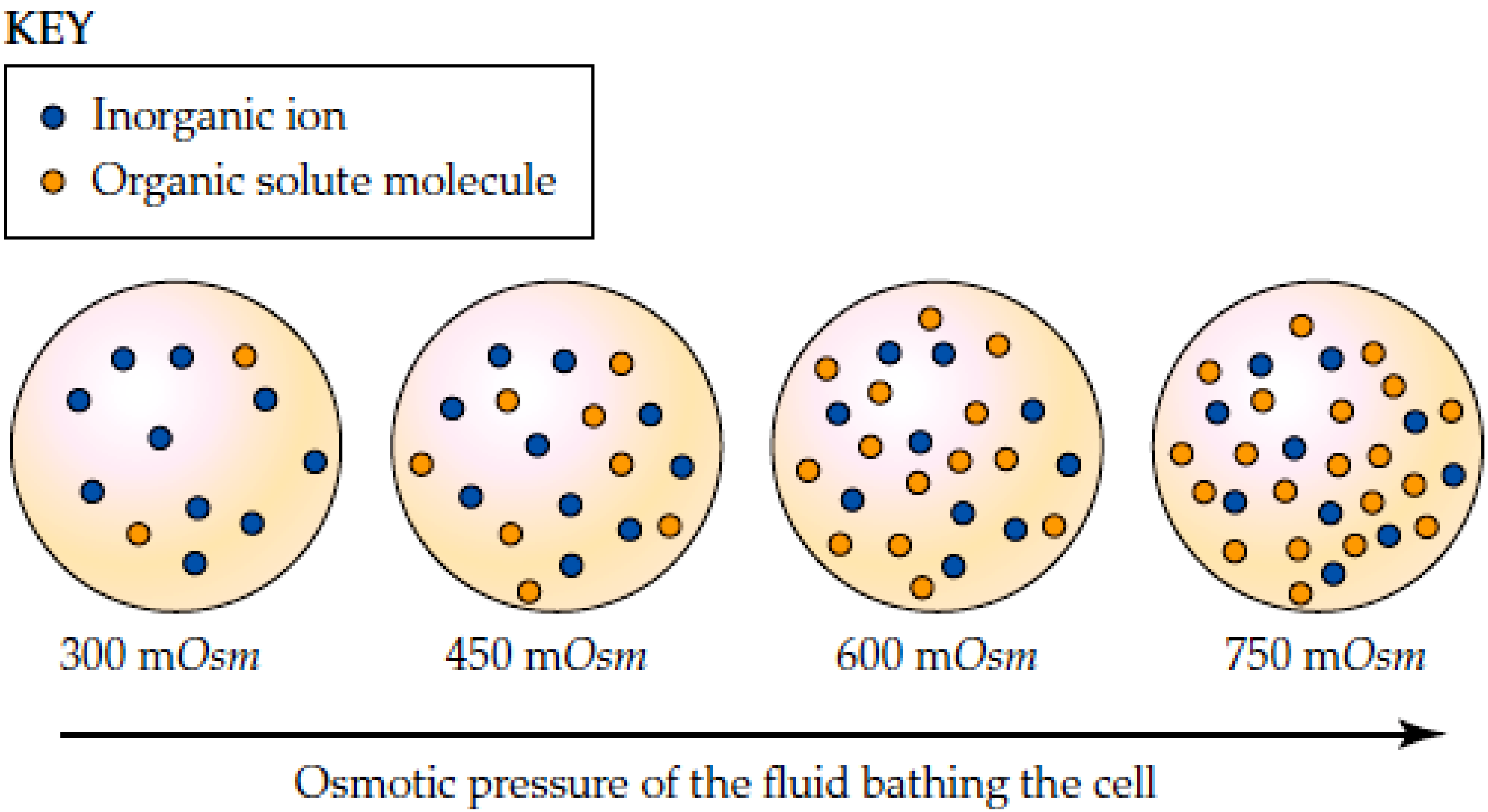
Osmoconformers

TABLE 28.3 **The composition of the blood plasma or other extracellular body fluids in some marine invertebrates and hagfish**

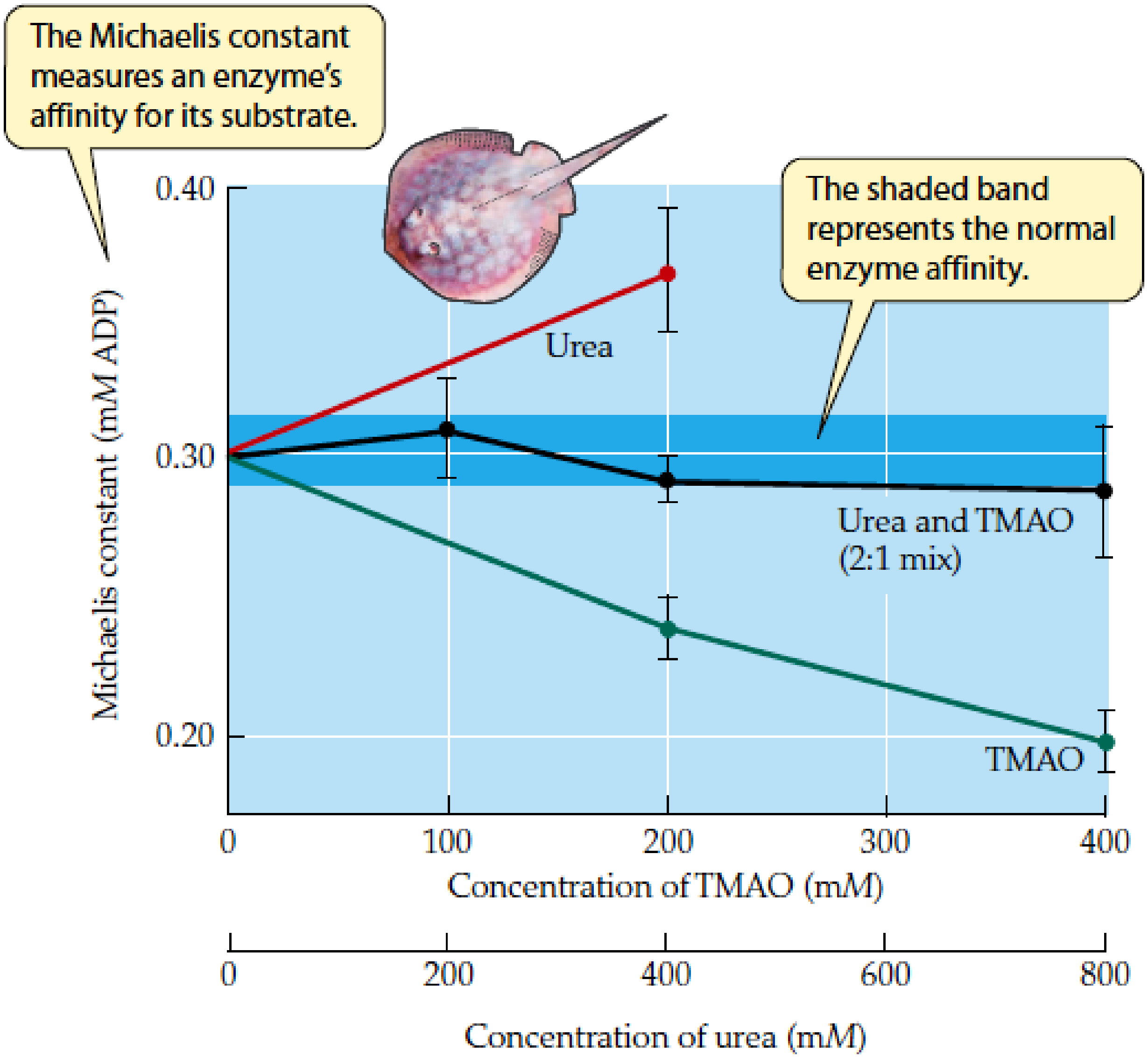
All these animals are isosmotic to seawater. The ion concentrations listed are for animals living in seawater of the composition specified in the last row of the table.

	Ion concentration (mmol/kg H_2O)					
Animal and body fluid	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}
Mussel (*Mytilus*), blood plasma	474	12.0	11.9	52.6	553	28.9
Squid (*Loligo*), blood plasma	456	22.2	10.6	55.4	578	8.1
Crab (*Carcinus*), blood plasma	531	12.3	13.3	19.5	557	16.5
Sea urchin (*Echinus*), coelomic fluid	474	10.1	10.6	53.5	557	28.7
Jellyfish (*Aurelia*), mesogleal fluid	474	10.7	10.0	53.0	580	15.8
Hagfish (*Myxine*), blood plasma	537	9.1	5.9	18.0	542	6.3
Seawater	478	10.1	10.5	54.5	558	28.8

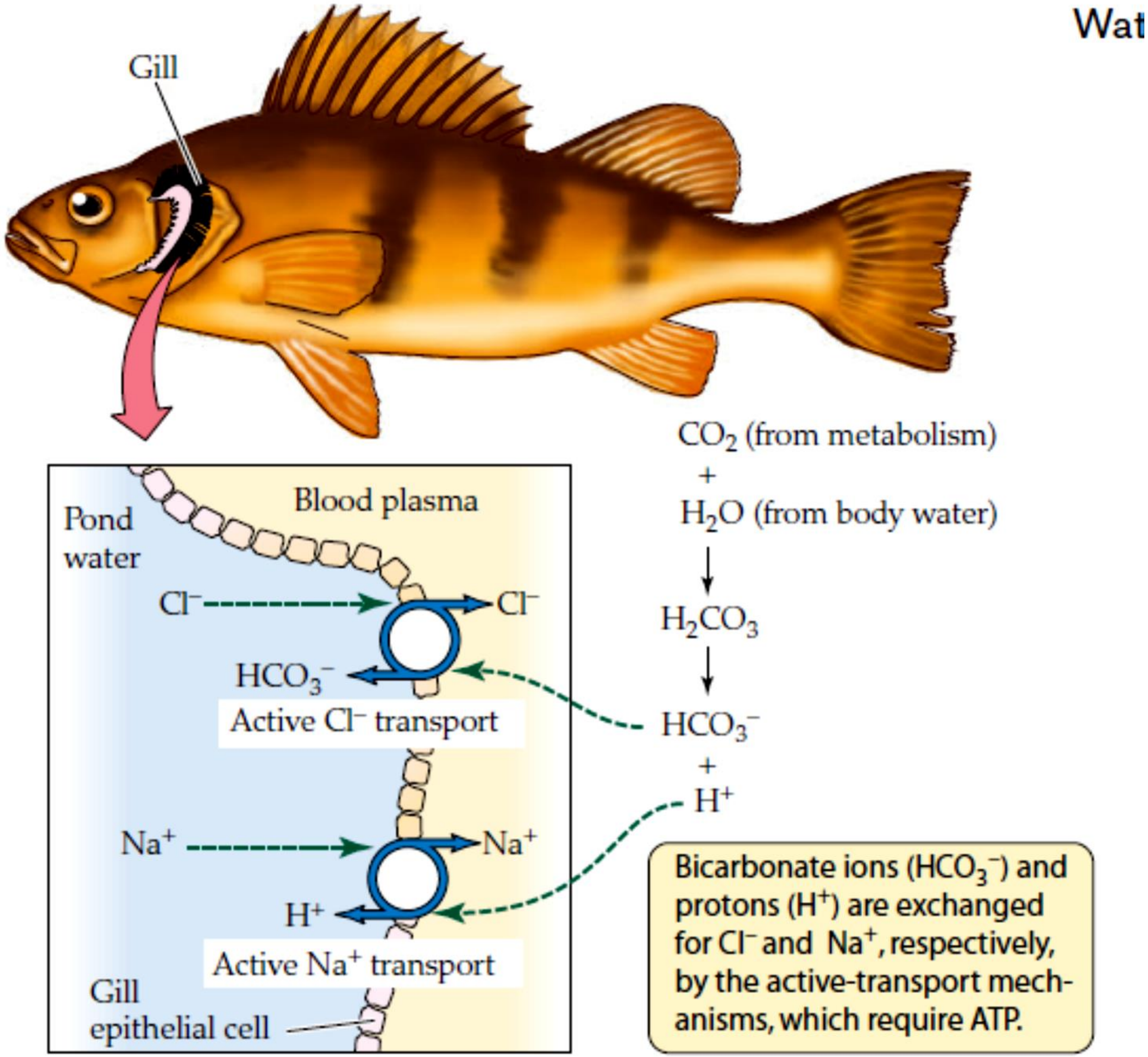
Mechanism of volume control



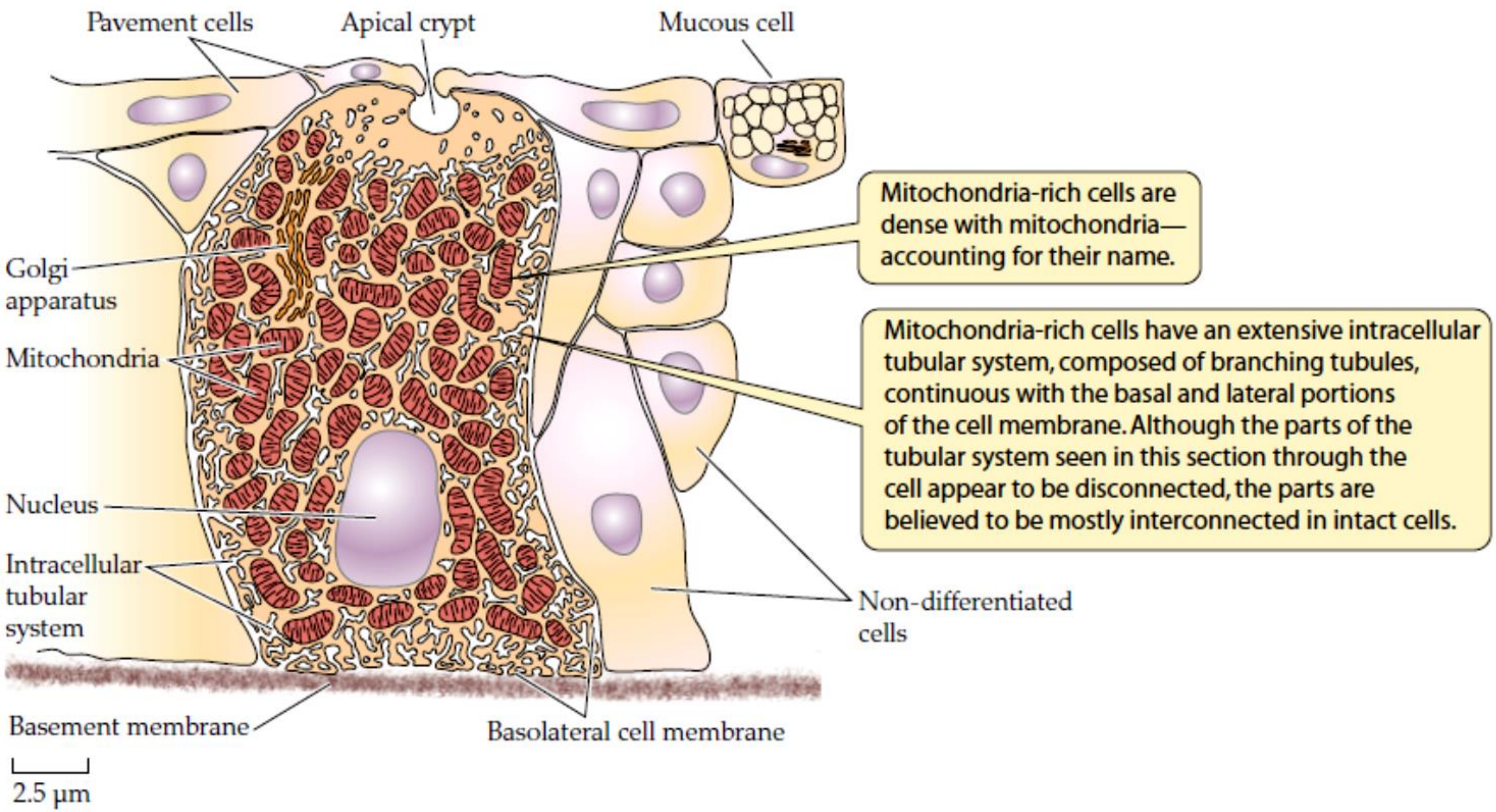
Osmoregulation in chondrichthyes



The other side

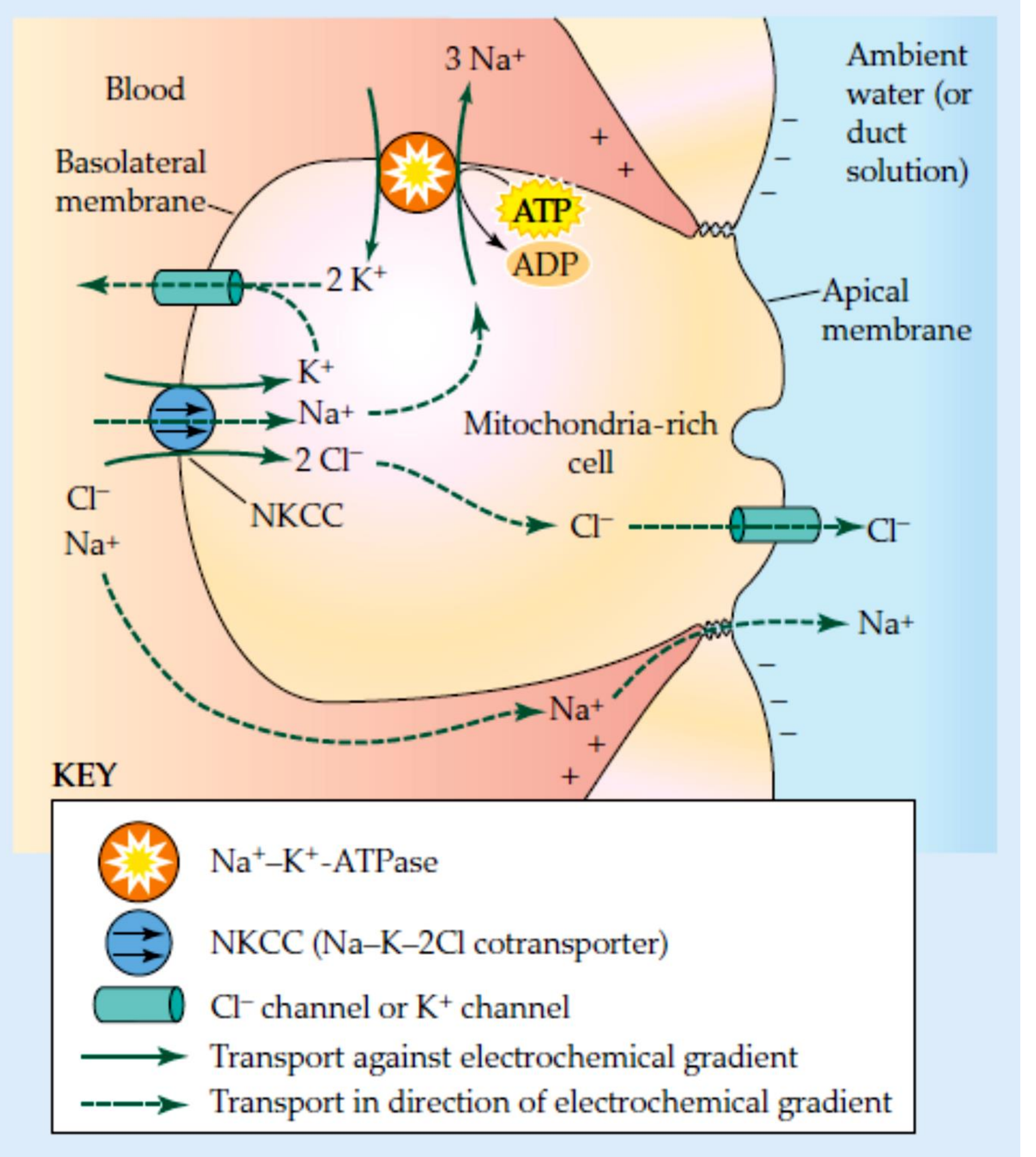


Energy is the key



You've seen this before

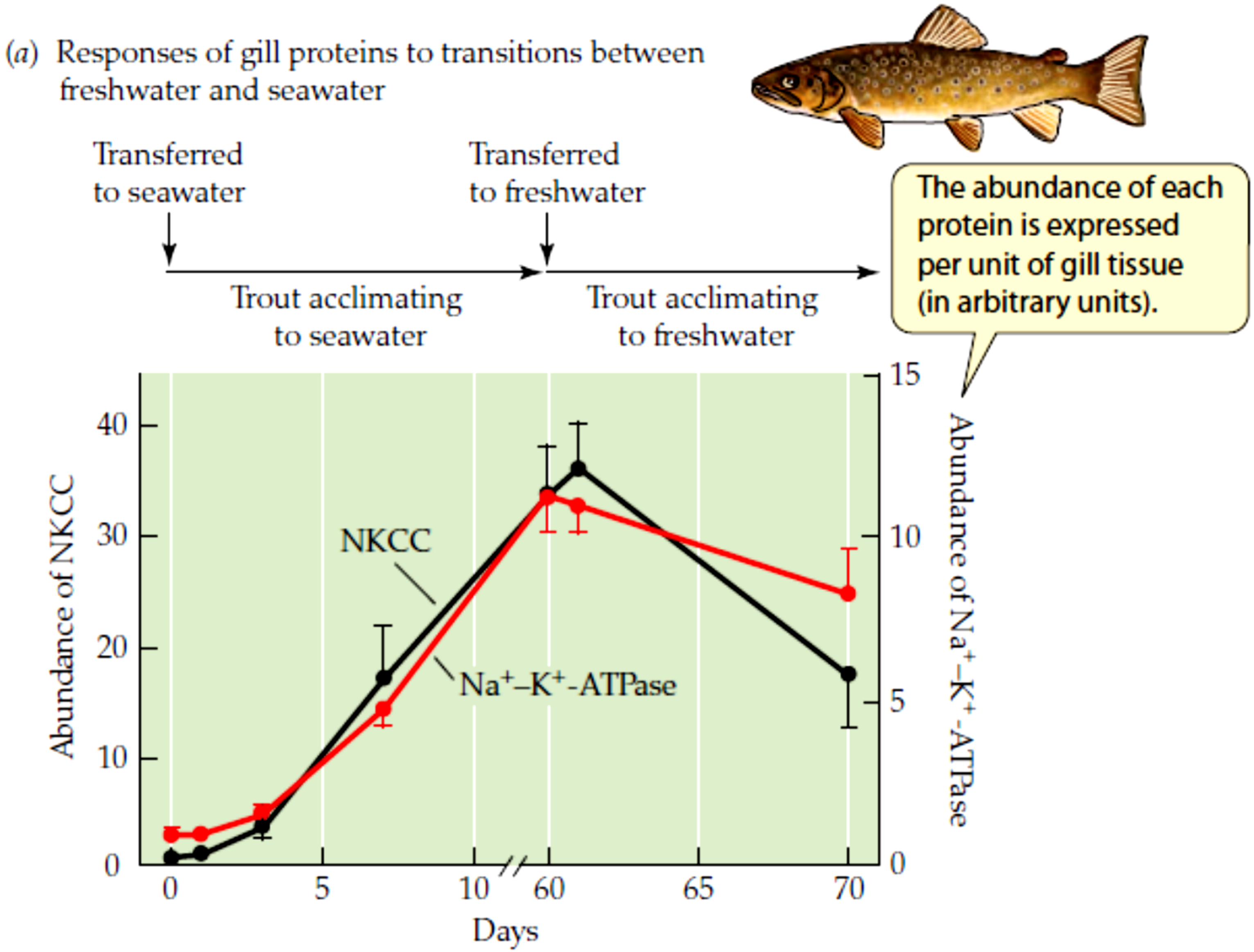
Teleost chloride cell



What if you can change

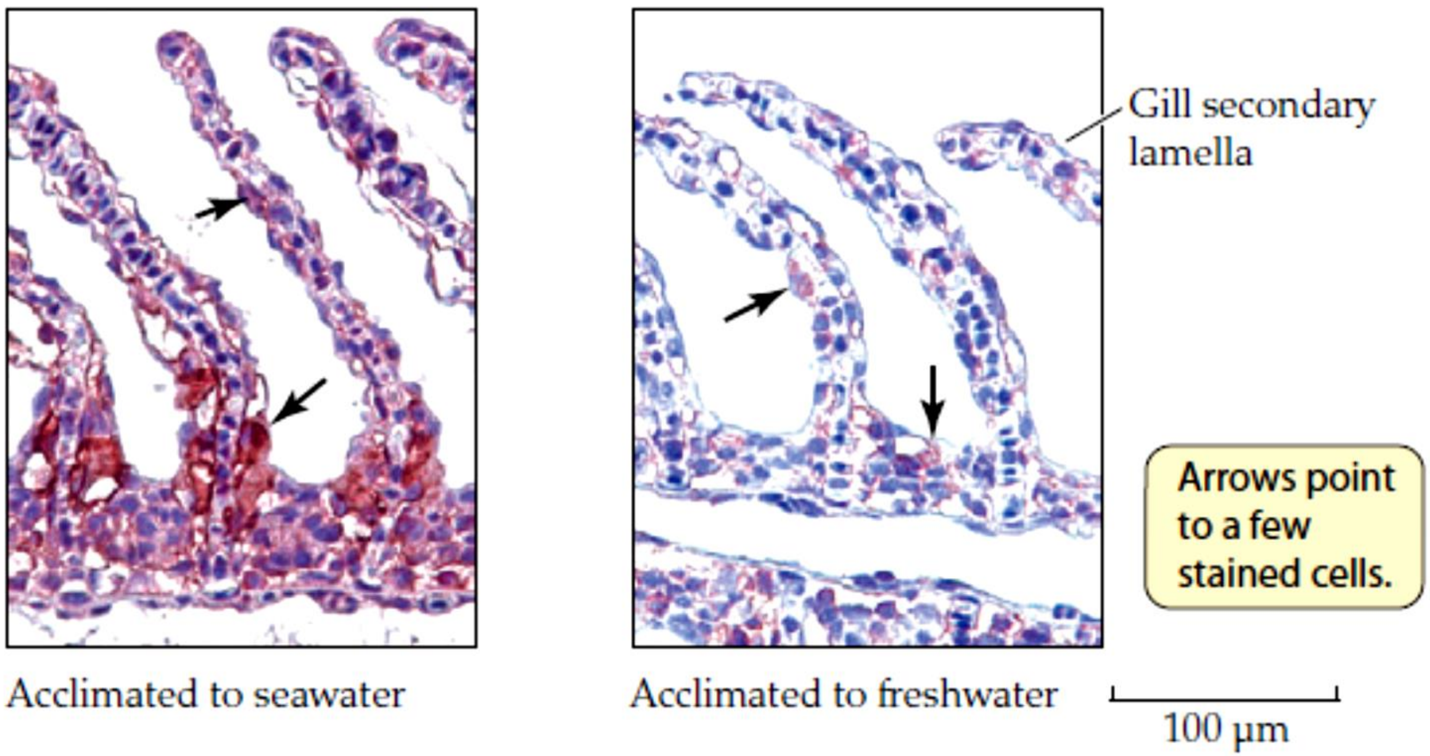
- Euryhaline
  - Salmons: hypo osmotic in in the oceans but hyper-osmotic in fresh water
  - They hatch in fresh water
  - When they start migrating to the ocean (growth hormone and cortisol) they make changes to the gill structure function: an anticipation mechanism
  - In the estuaries: more sodium = more cortisol = branchial chloride cells
  - Prolactin helps in reversion during spawning behaviour

NKCC (Na–K–2Cl cotransporter)



NKCC

(*b*) Gill tissue in which NKCC is stained for identification



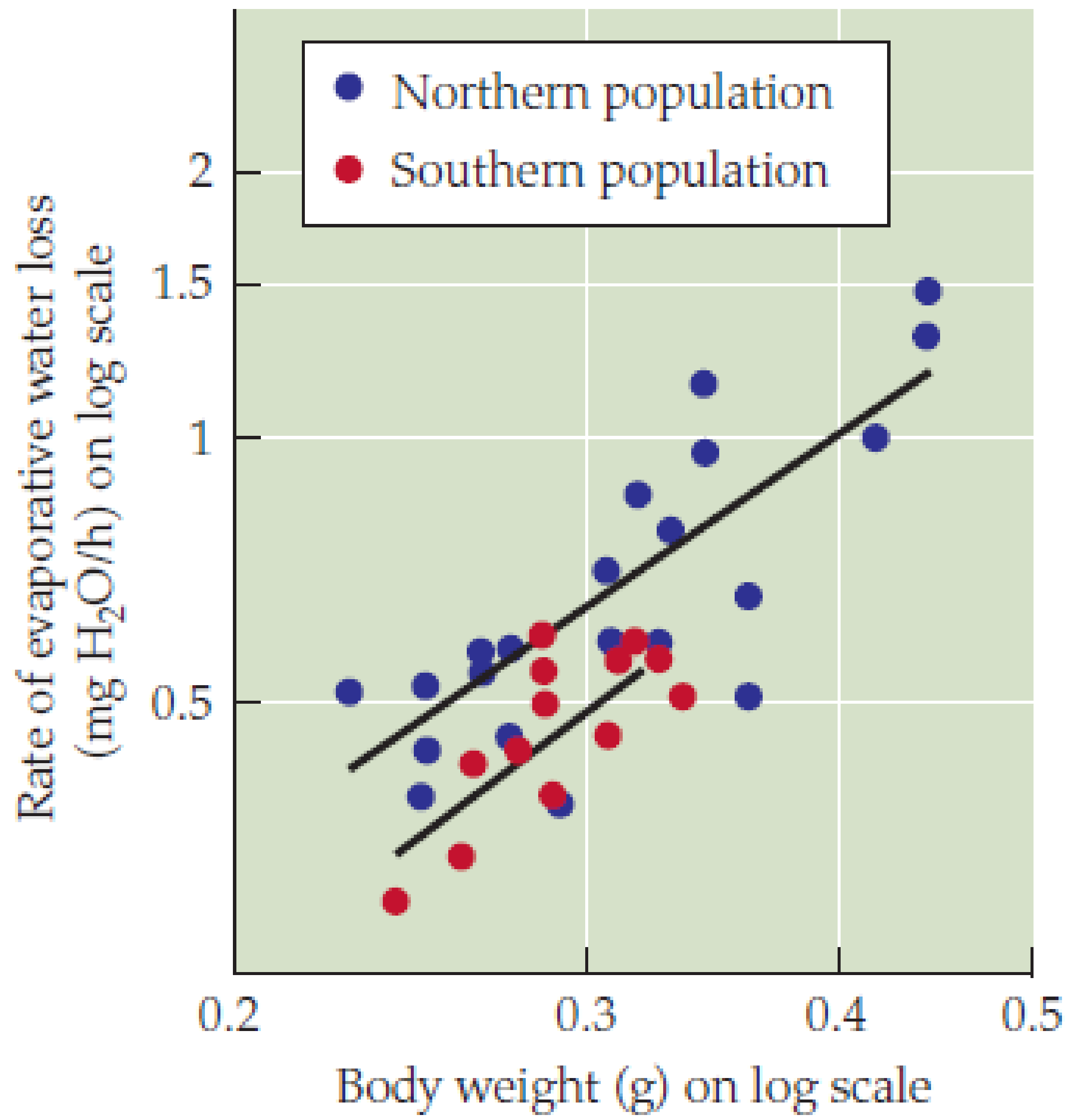
In land

TABLE 28.6 Resistance of the skin to evaporative water loss in vertebrates

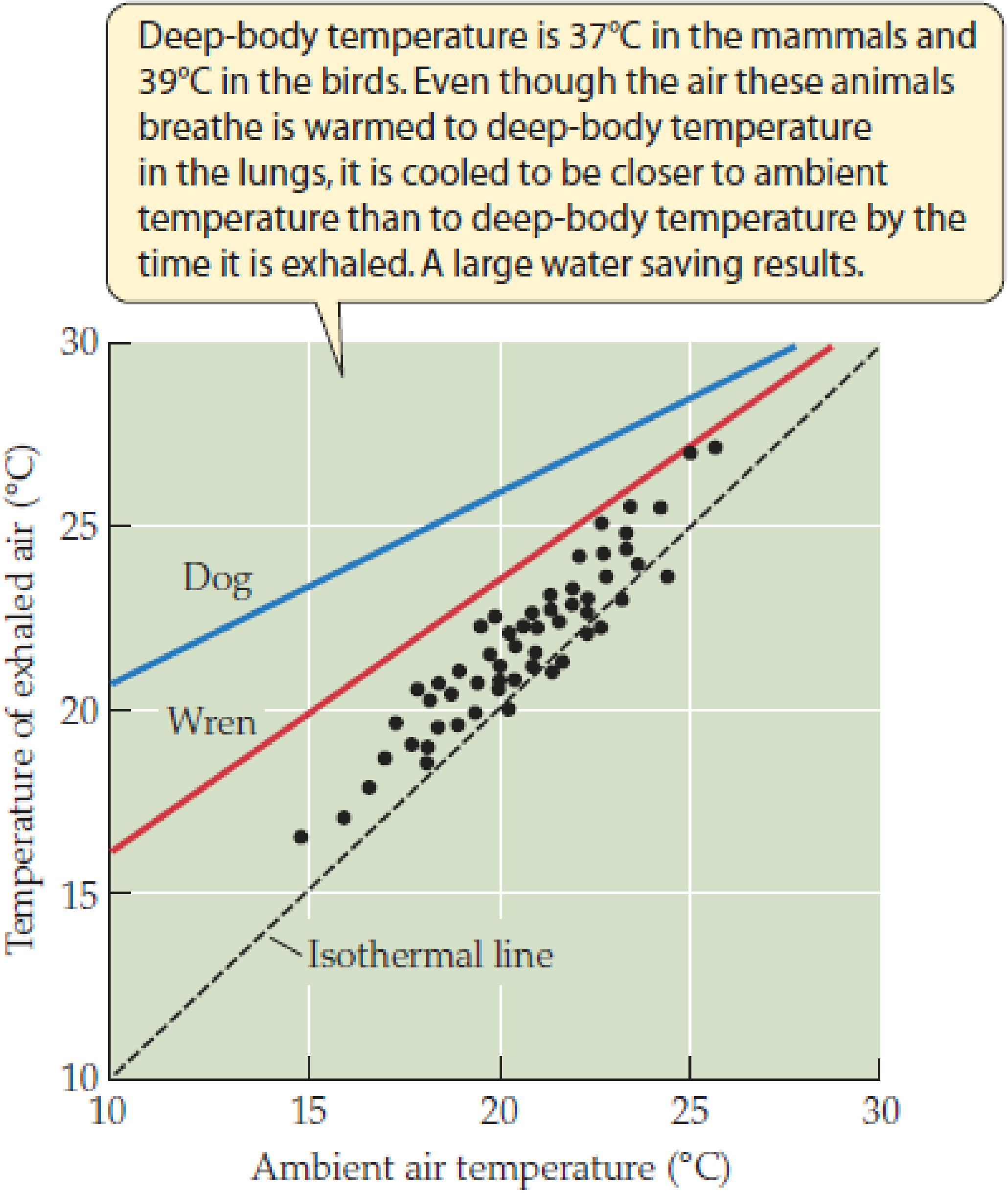
Values are for a standardized area of skin. Where a range is listed, the values are averages for different species within the group of animals.

Group of animals	Resistance (s/cm)[a]
Ranid frogs and bufonid toads	0–3
Colubrid snakes (e.g., racers)	150–890
Viperid snakes (e.g., vipers)	790–1690
Iguanid lizards	110–1360
Birds	30–200
Human	380
House mouse	160

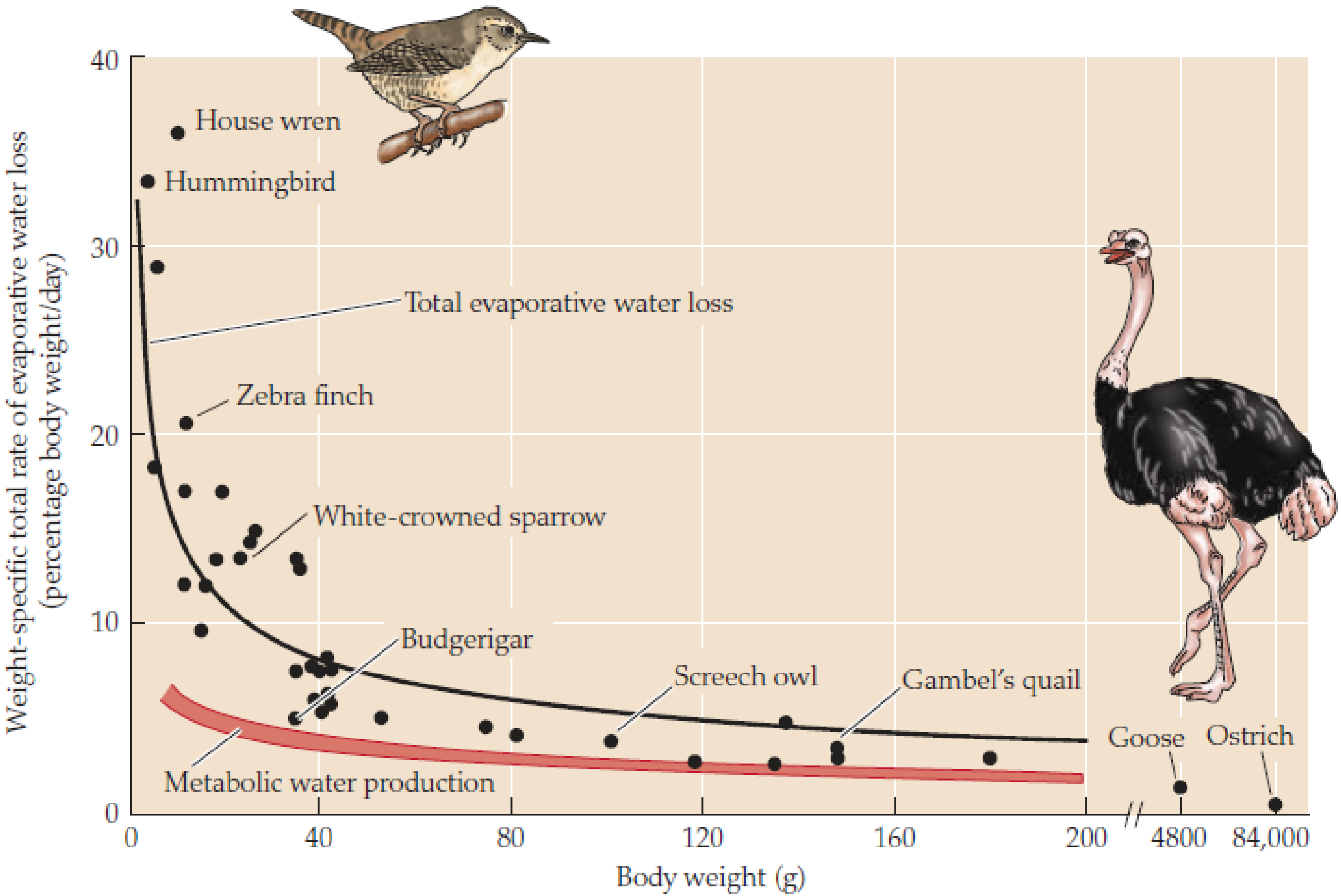
Strategy 1 – Skin



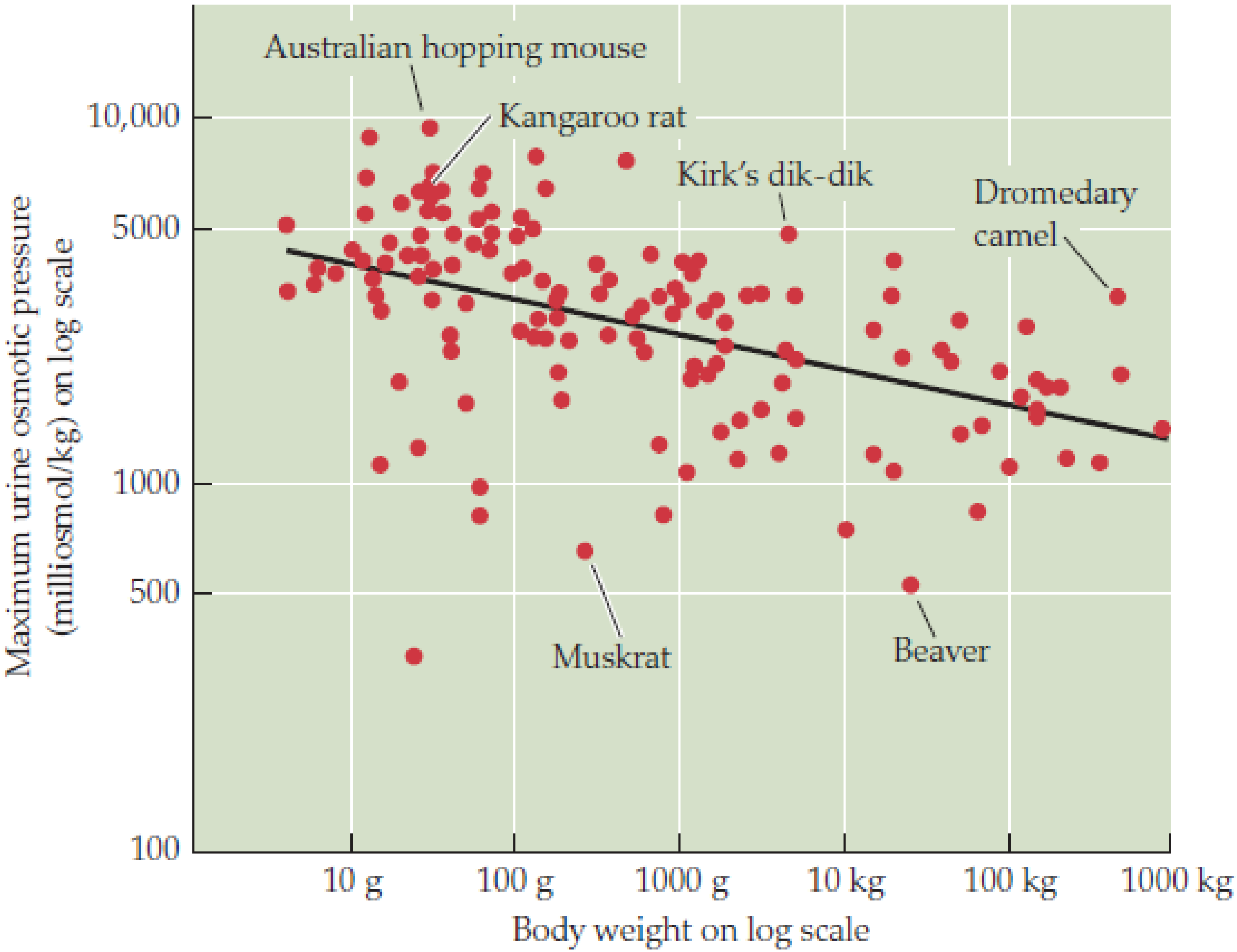
Strategy 2 - Lung



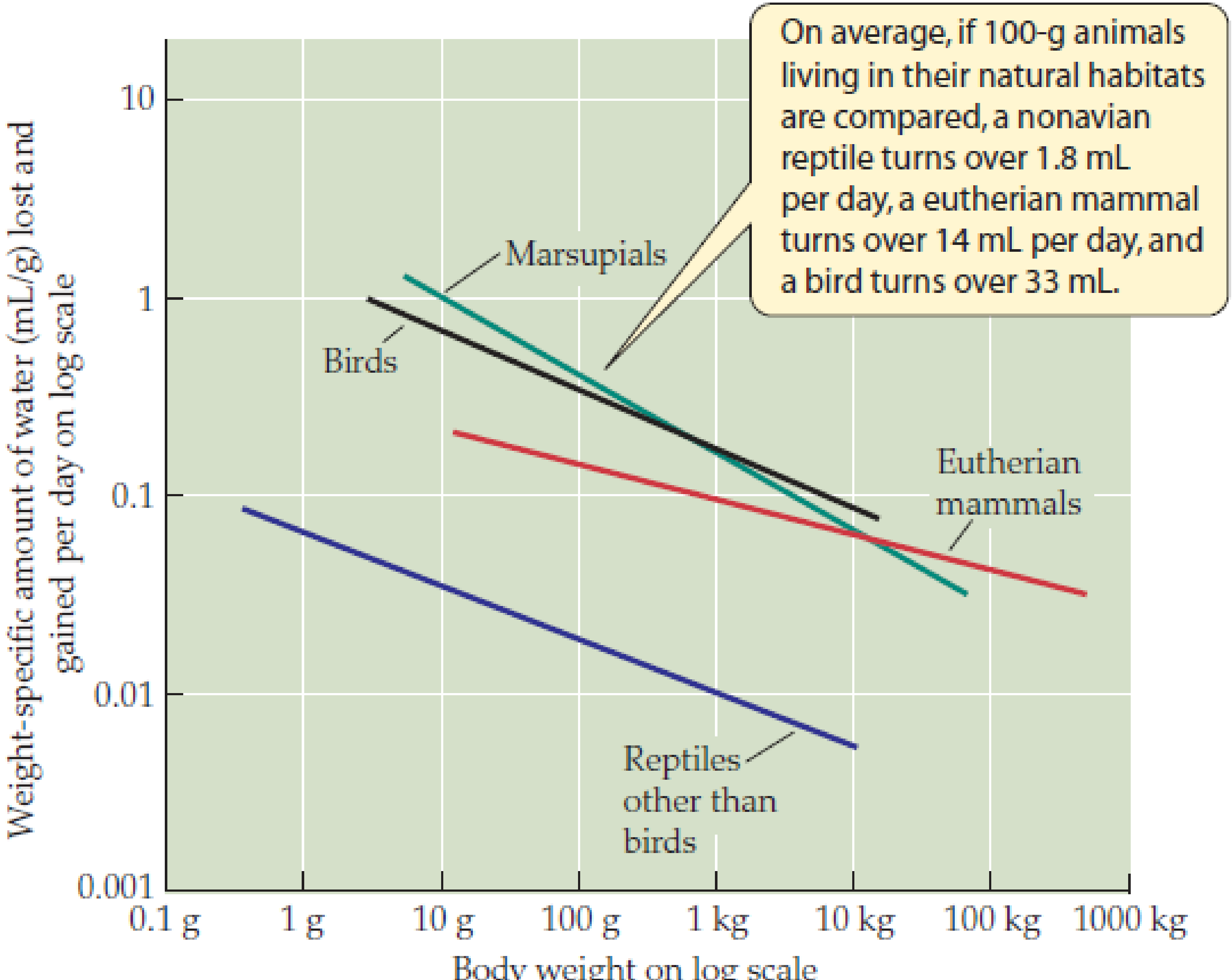
Size matters



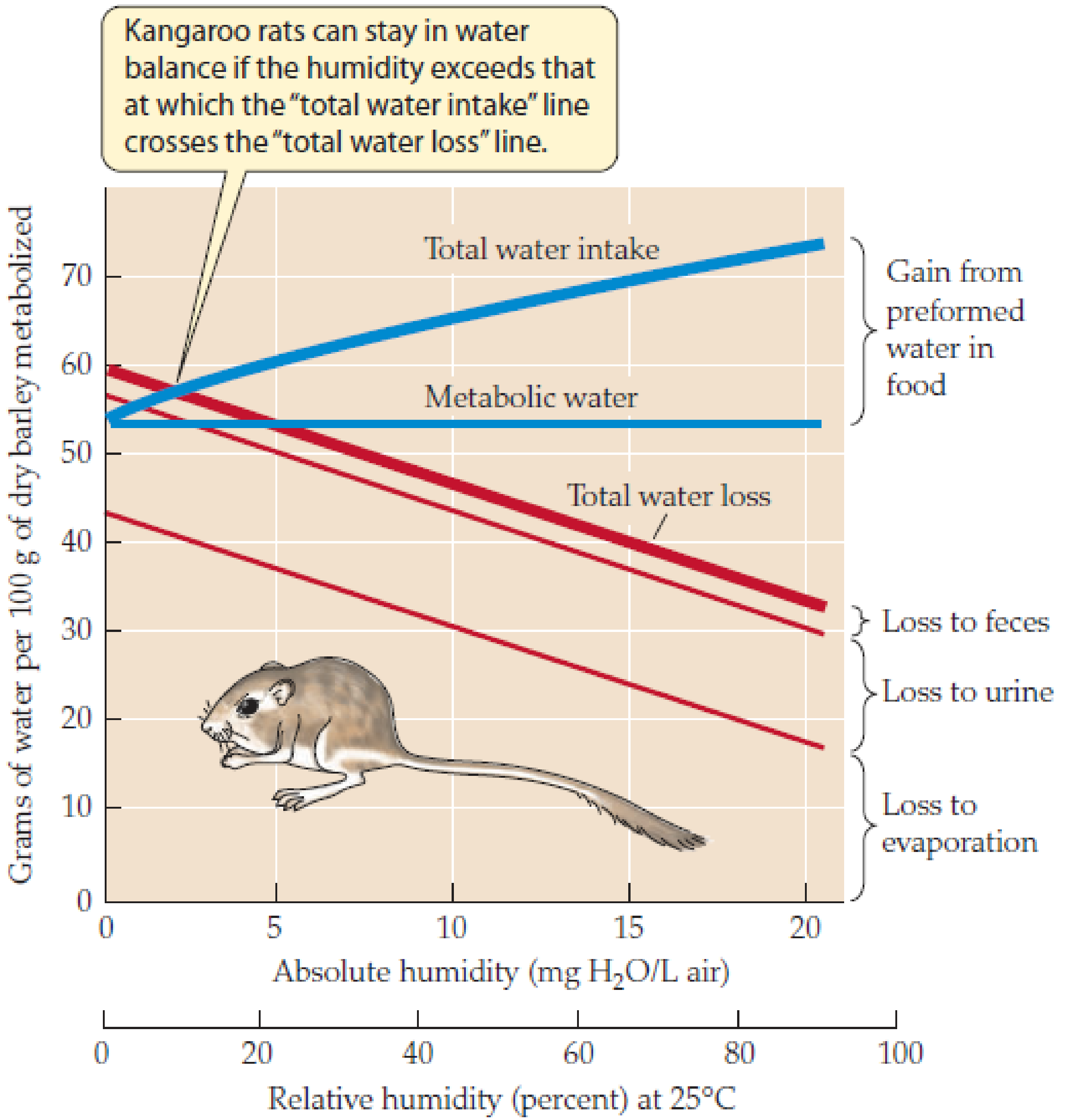
Strategy 3 – Excretion



Over view


On average, if 100-g animals living in their natural habitats are compared, a nonavian reptile turns over 1.8 mL per day, a eutherian mammal turns over 14 mL per day, and a bird turns over 33 mL.
Marsupials
Birds
Eutherian mammals
Reptiles other than birds
Weight-specific amount of water (mL/g) lost and gained per day on log scale
10
1
0.1
0.01
0.001
0.1 g
1 g
10 g
100 g
1 kg
10 kg
100 kg
1000 kg
Body weight on log scale

An extreme example



Read: Hill & Sherwood

Images: Hill, Guyton & www