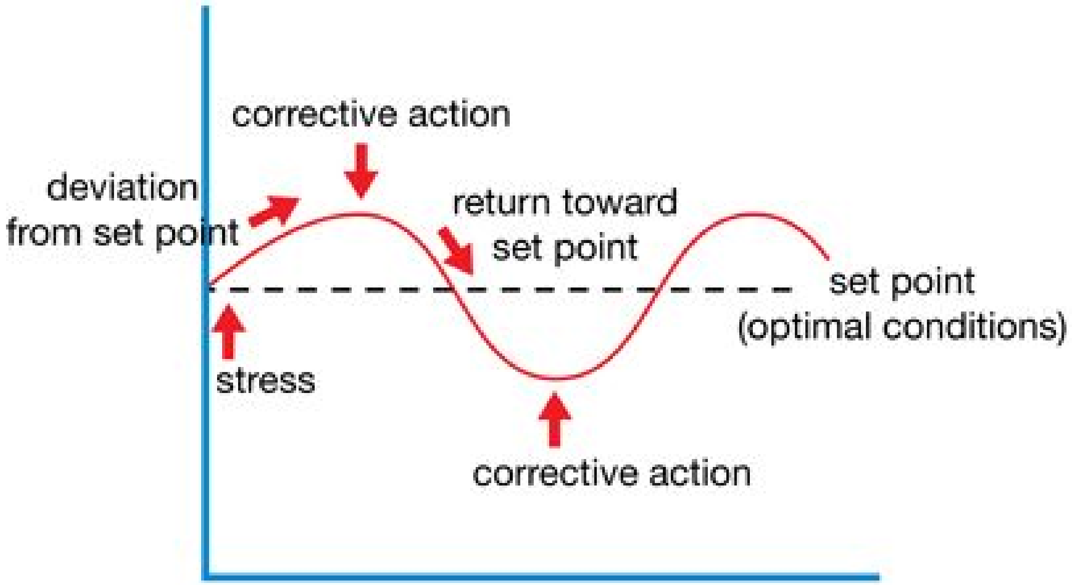
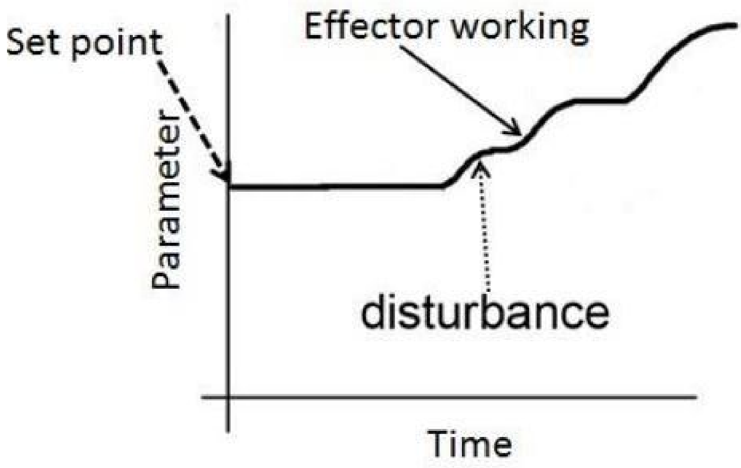
Homeostasis

Maintaining a constant internal environment

Negative Feedback



Positive Feedback:



Ectotherms

- body temperature fluctuates with external temperature
- absorb heat from the surroundings to keep warm
- need less food
- are less active when the external temperature is cold

E.g reptiles and insects

Endotherms

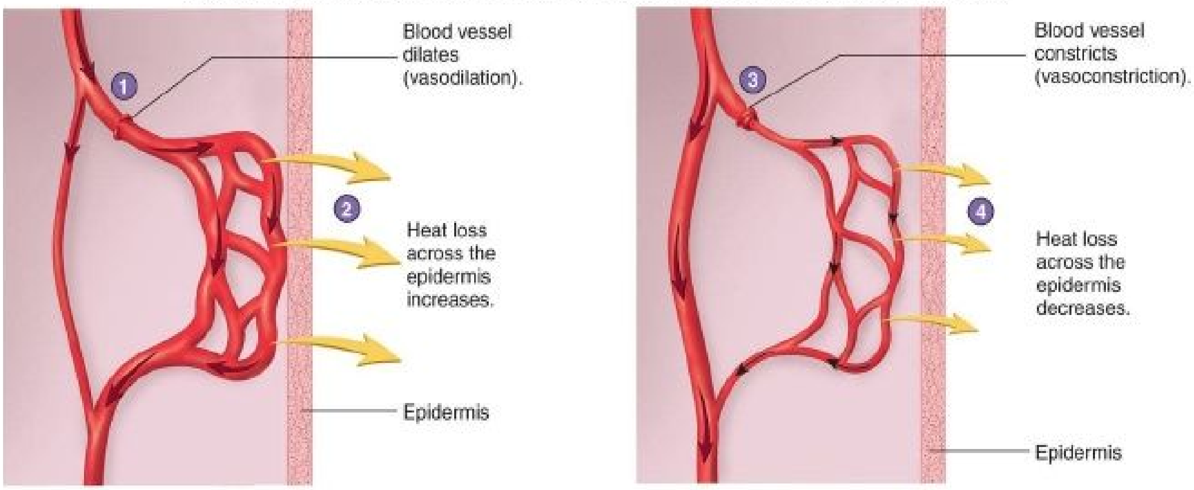
- maintain a constant body temperature
- aerobic respiration provides heat
- need more food
- are active even in extremes of temperature, as enzymes function at their optimal levels at all times

E.g mammals, birds and some fish

Control of Body Temperature in Endotherms (pg 381)

Control Centre: Hypothalamus

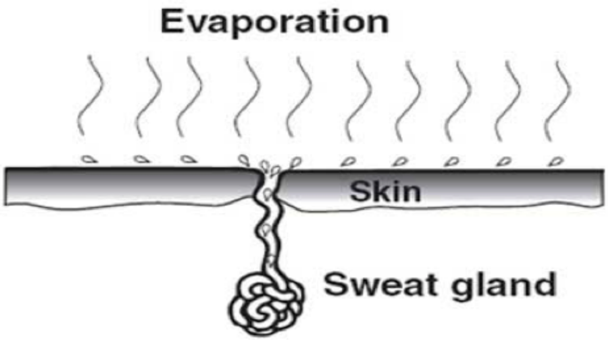
1. Vasoconstriction and Vasodilation



On a hot day, blood is diverted to the capillaries near the surface of the skin = heat loss by radiation

On a cold day, blood is diverted away from the capillaries near the skin surface = heat conserved

2. Sweating



Heat is loss from the skin by evaporation

3. Metabolic reactions

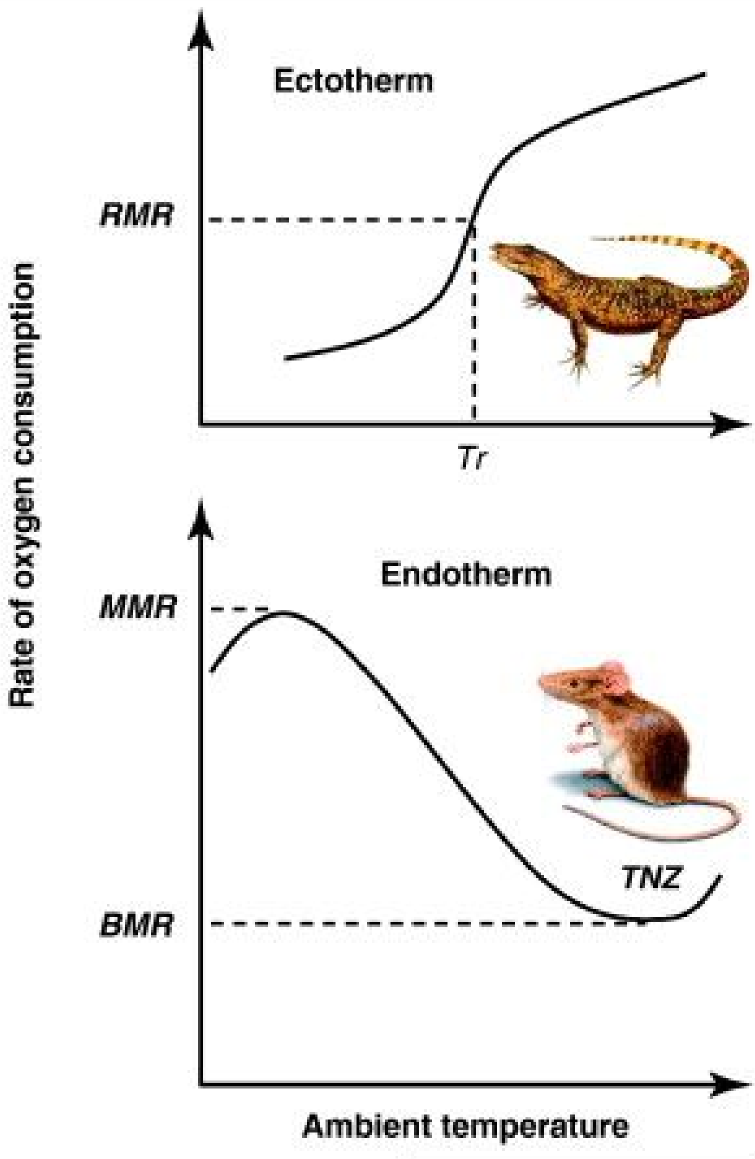
The rate of metabolic reactions (like respiration) can be regulated to control the amount of heat generated in the body

4. Body hair

When the hair erector pili muscles contract, the hairs stand up, trapping a layer of air = insulation
When the muscles relax, the hairs lie flat = easier to lose heat

5. Behavioural mechanisms

Metabolic heat generation in ectotherms vs endotherms (pg 382)



Control of Blood Glucose

Control Centre: Islets of Langerhans in the Pancreas

Two hormones:

Insulin (beta-cells), brings blood glucose levels back to set point

Glucagon (alpha-cells), raises blood glucose levels to set point

Role of insulin

- meal → blood glucose ⇧, detected by beta-cells in IL
- they produce insulin, which diffuses into blood
- binds to (glycoprotein) receptors on all body cells (except RBCs)
- increases the number and type of Glucose Transporter (GLUT) proteins in the cell membrane
- Glucose taken up rapidly

    - Glucose respired → ATP
    - Glucose → Glycogen (Glycogenesis), in liver
    - Glucose → Fat (Adipose Tissue)

Overall effect: blood glucose levels drop to set point

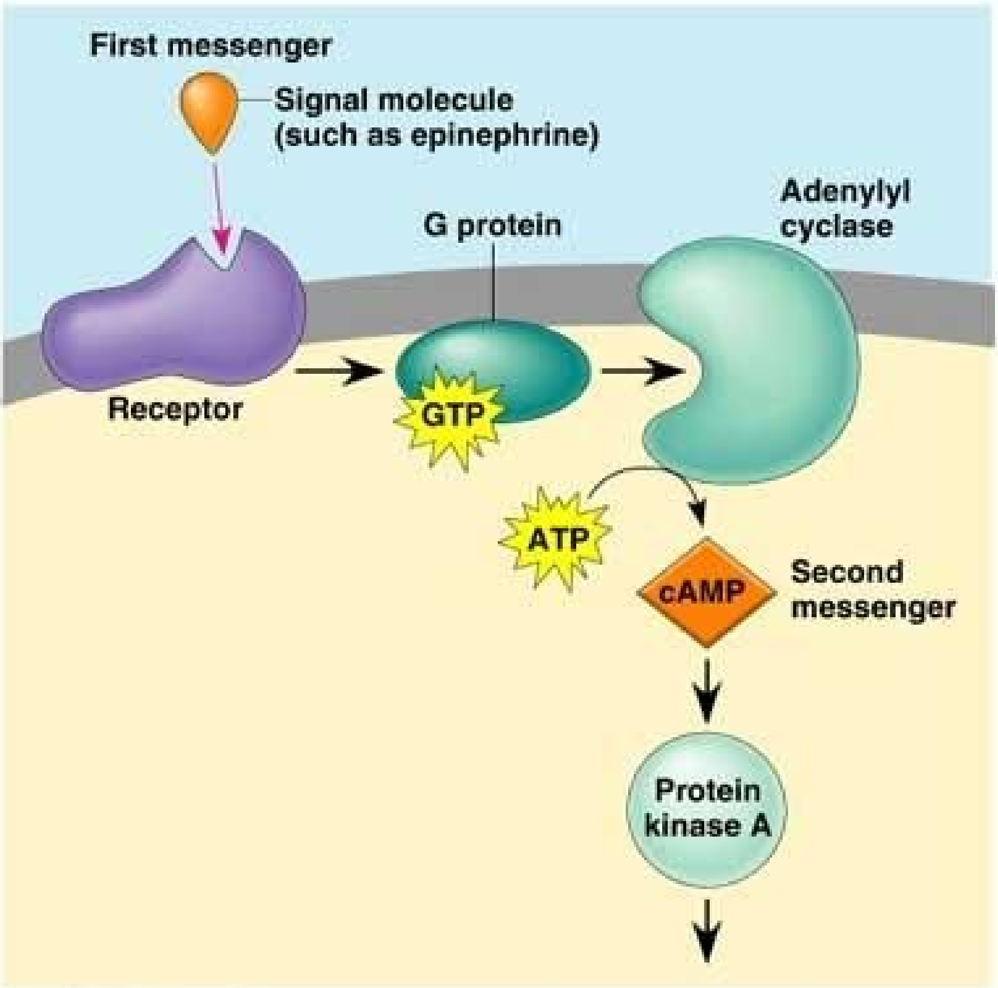
(NB: glycogen also stored in muscle)

Role of glucagon

- ~ 4 hours after meal → blood glucose ⇩, detected by alpha-cells in IL
- they produce glucagon, which diffuses into blood
- binds to (glycoprotein) receptors on liver cells
    - suppresses Glycogenesis
    - increases the rate of Glycogenolysis (glycogen → glucose)
    - increase in rate of Gluconeogenesis (amino acids and glycerol → glucose)

Overall effect: blood glucose levels increase back to set point

Adrenaline, blood glucose and the fight/flight response (pg 386-387) - second messenger model

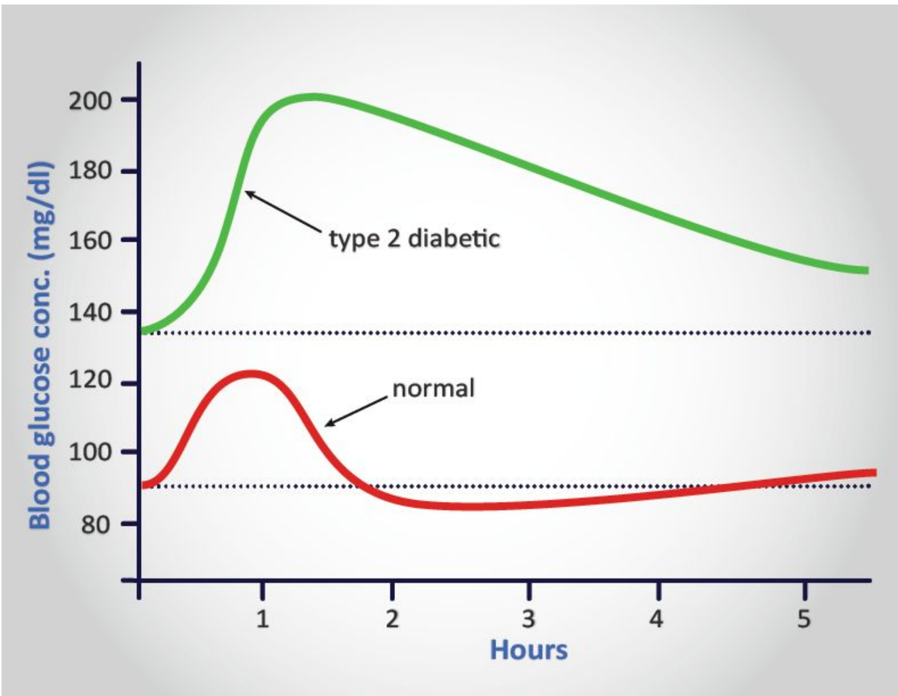


- adrenaline (first messenger) binds to a cell-surface receptor
- binding activates Adenyl cyclase (AC)
- AC converts ATP into cAMP (second messenger)
- cAMP activates Protein Kinase A (PKA)
- PKA catalyses the conversion of glycogen to glucose

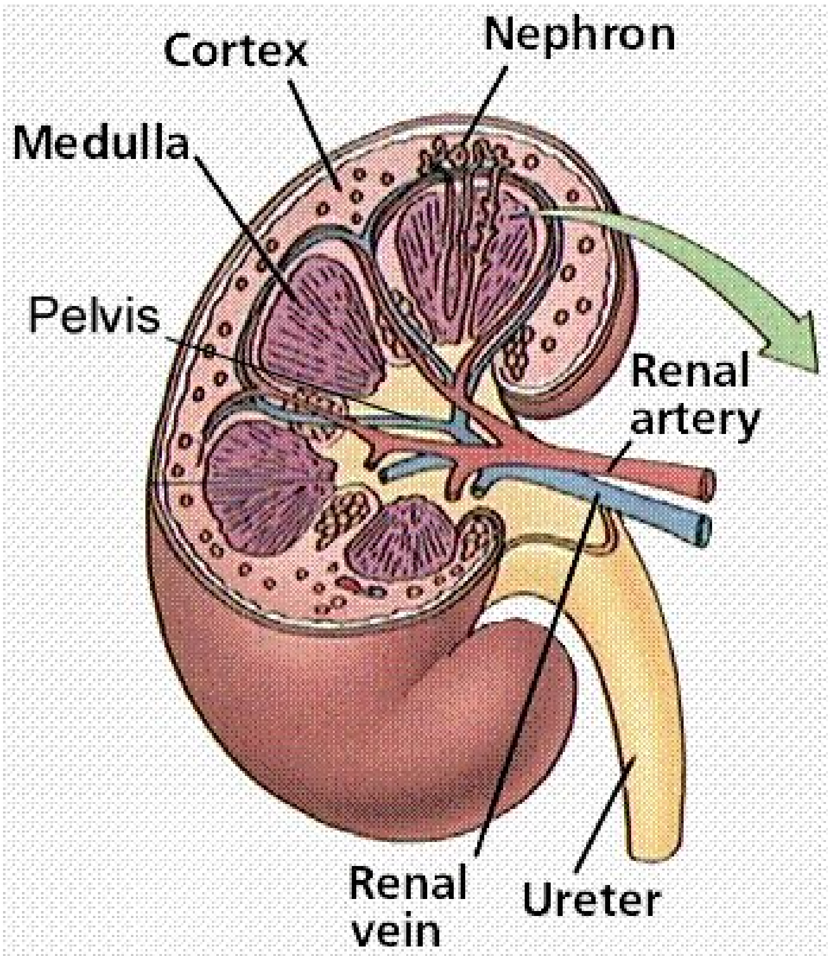
Cascade effect: small amounts of adrenaline lead to large increase in blood sugar levels

Diabetes

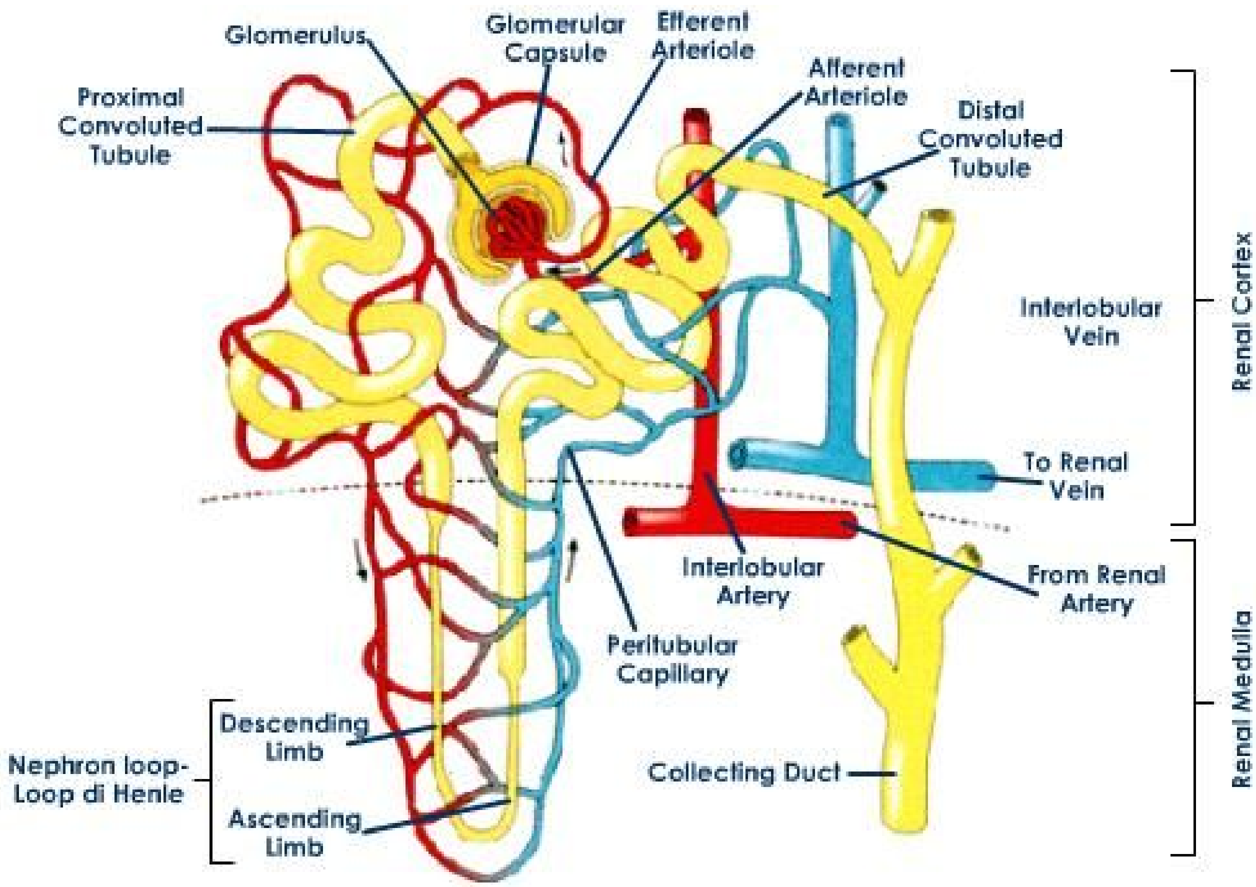
	Type I	Type II
Onset	Juvenile	Adult
Cause	No insulin	Insulin-insensitivity
Effect	Severe	Less severe
Treatment	Daily insulin injections	Diet and exercise



Kidneys (pg 395)



Structure of the nephron (pg 397)



Bowman's Capsule - ultrafiltration

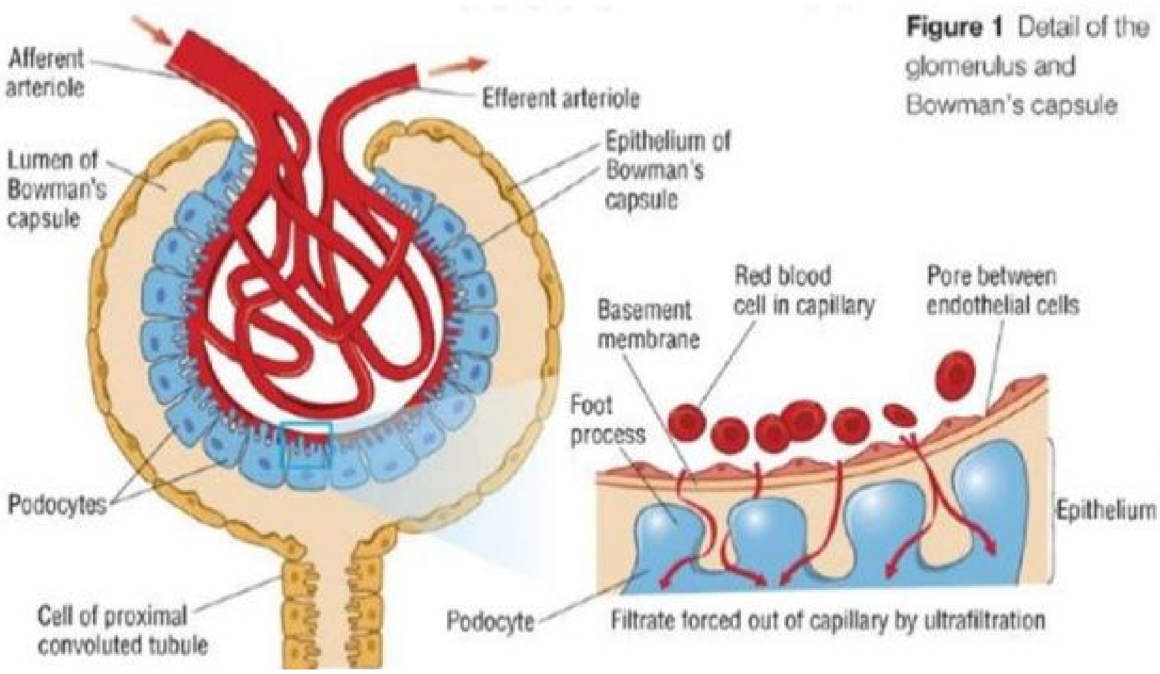


Figure 1 Detail of the glomerulus and Bowman's capsule

- Afferent arteriole is wider than the efferent arteriole = increases hydrostatic pressure within the glomerulus → pushes fluid (filtrate) out

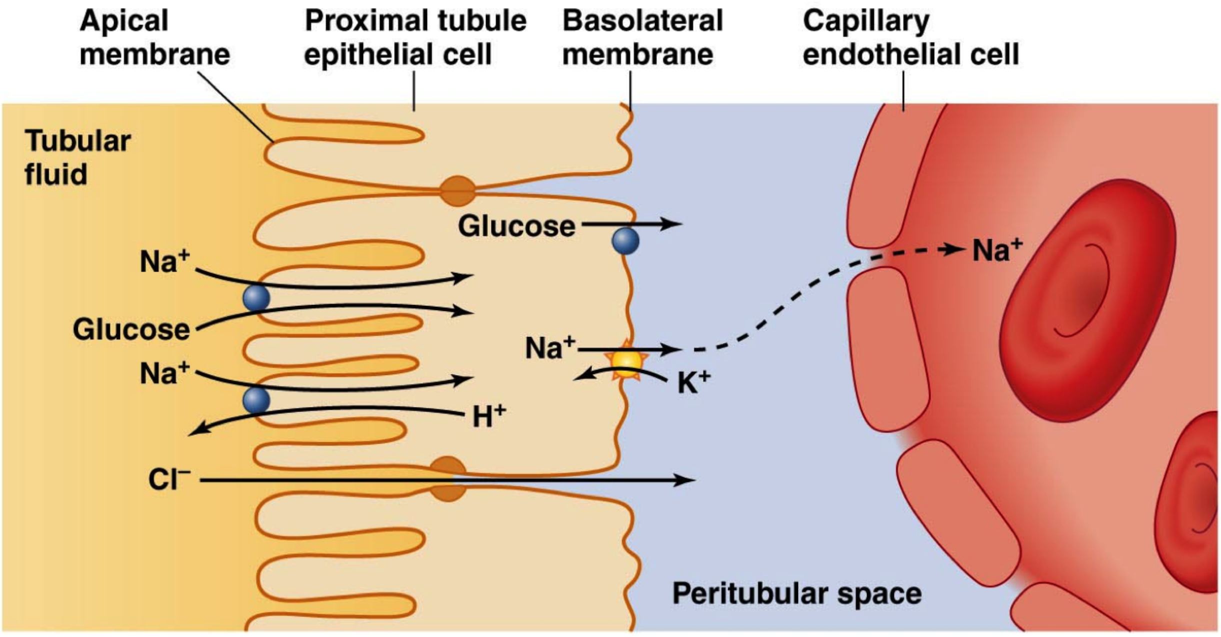
- Basement membrane, which is a mesh of collagen, has a cut-off point of 69,000 daltons (width of 100 nm between cells)

- finger-like projections called podocytes surround the capillaries = allows filtrate to pass through the gaps

OUT = ions, glucose, amino acids, urea, creatinine

IN = RBCs, WBCs, proteins and enzymes > 69,000d, antibodies

Proximal Convoluted Tubule



- Na+/K+ pump actively transports 3 Na+ out of the epithelial cells of the PCT (and into the blood), while transporting 2K+ into the epithelial cells

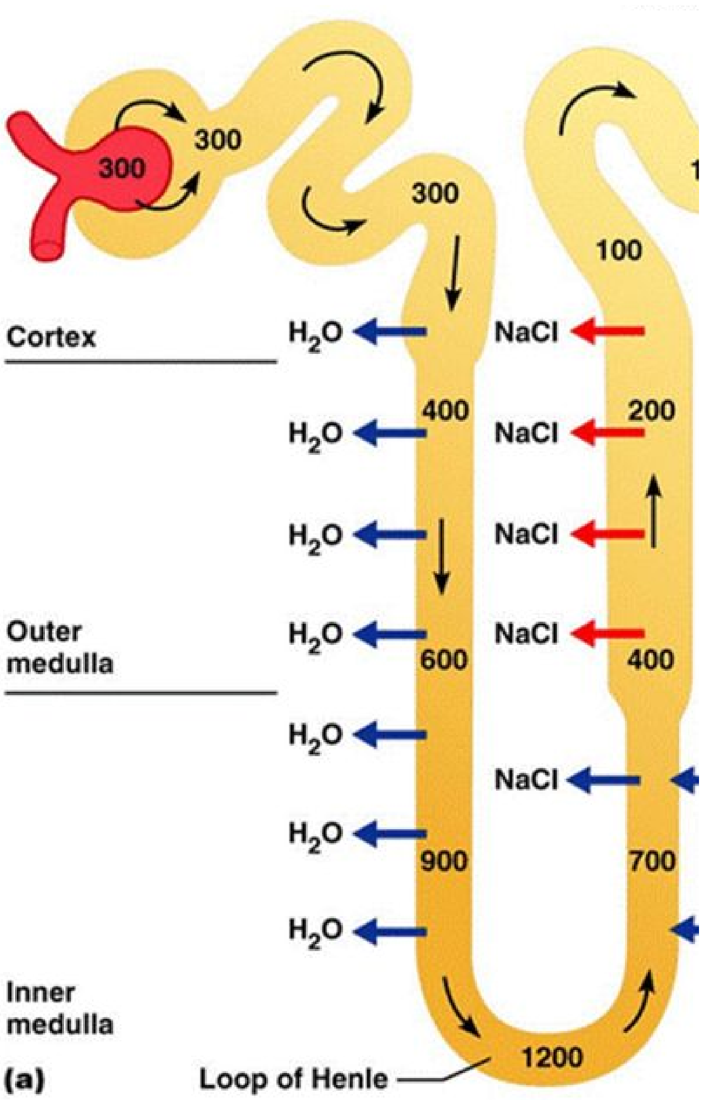
- this creates a concentration gradient for Na+ - concentration of Na+ is higher in the lumen than the epithelial cell

- Na+ diffuses into the epithelial cell using a co-transport protein (facilitated diffusion), which also allows a glucose or amino acid to enter the epithelial cell (against their conc. gradient)

- the glucose/amino acid molecules diffuse into the blood using a complementary carrier protein (facilitated diffusion)

- water enters epithelial cells by osmosis, due to the lower water potential, and is eventually drawn into the bloodstream

Loop of Henle - hairpin countercurrent multiplier



- the ascending limb of the loop of Henle is impermeable to water

- this limb actively transports Na+ and Cl- into the medulla

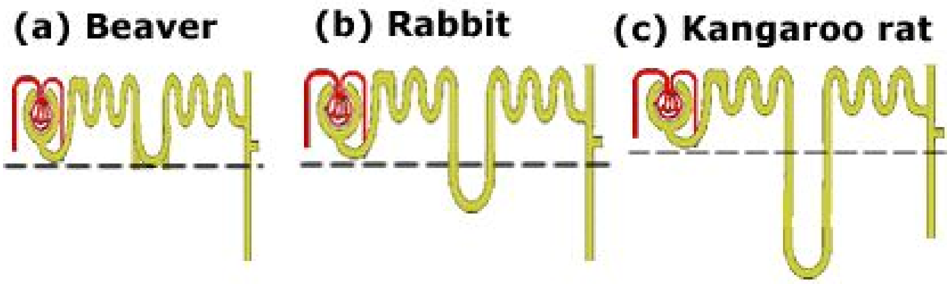
- which reduces the water potential in the medulla, creating a concentration gradient (multiplier)

- water is drawn of the the descending limb by osmosis

- some Na+ and Cl- diffuse into the descending limb

The high concentration of salts in the medulla helps to draw water out from the loop of Henle. This water is transported back into the bloodstream.

Size of the loop of Henle vs Habitat

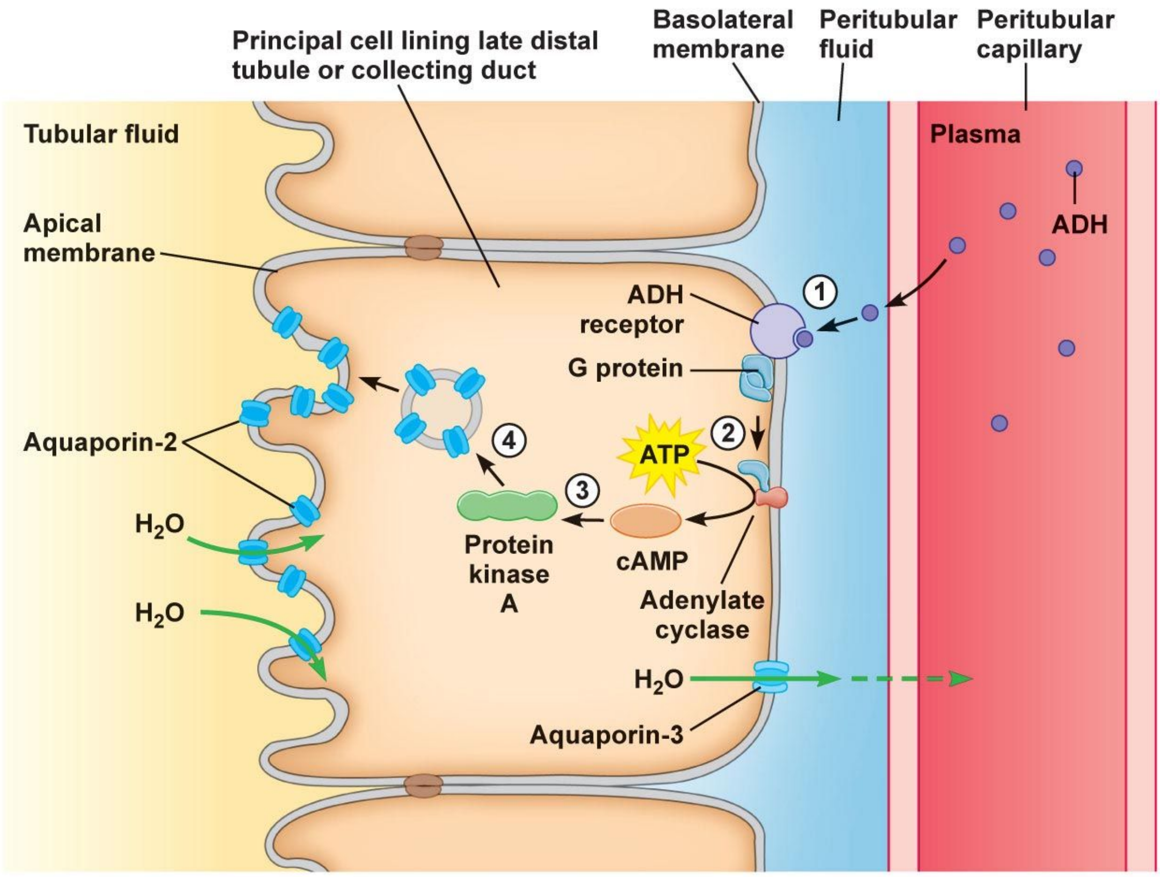


- The deeper the loop, the more the volume of water that is conserved

- Animals living in dry, arid lands (desert) have a longer loop of Henle than animals living in areas where water is abundant

DCT: regulation of pH and concentration of K+

The Collecting Duct - water reabsorption



- water reabsorption in the collecting duct is under the control of the hormone ADH*, secreted by the pituitary

- ADH diffuses into the blood and binds to receptors on the collecting duct

- this activates the enzyme protein kinase A

- Activation of PKA allows vesicles, containing aquaporins⁺, to move towards and fuse with the membrane of the epithelial cells

- the collecting duct becomes more permeable to water, and more water is reabsorbed

*ADH = anti-diuretic hormone
⁺aquaporin = channel proteins that allow water to cross the cell membrane

Homeostasis by ADH - on a hot day

- Water is lost as sweat

- Blood water potential decreases (more negative)

- Osmoreceptors in the hypothalamus shrink

- Hypothalamus produces ADH

- ADH moves to the posterior pituitary gland, from where it is released into blood

- Binding of ADH to the collecting duct increases its permeability to water (via aquaporins)

- Water reabsorbed, blood water potential returns back to set point

Homeostasis by ADH - on a cold day

- decrease in sweating, blood water potential rises

- osmoreceptors swell

- hypothalamus stops producing ADH

- existing ADH in the bloodstream breaks down in 20 minutes

- collecting duct becomes less permeable to water (aquaporins withdrawn)

- less water reabsorbed, blood water potential returns back to set point