Balans Air Dan Ekskresi

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- Air berperanan sangat penting dalam kehidupan, dan tidak ada kehidupan yang terlepas dengan air
- Fungsi jaringan yang normal dan perkembangannya dalam kehidupan hewan tergantung, terpelihara dan terkontrolnya komposisi cairan tubuh
- Kebanyakan ion-ion dan molekul-molekul penyusun bagian kehidupan mempunyai hubungan kimiawi dan fisik dengan air. Jumlah bahan kimia yang termasuk cairan sangat besar
- air mempunyai sifat fisik yang khas: air mempunyai panas spesifik yang sangat tinggi, sehingga air dapat menyimpan sejumlah panas yang besar tanpa adanya kenaikan temperature yang besar. Sehingga air tidak hanya memberikan bahan pada proses terjadinya kehidupan, tetapi juga ikut berperan aktif dalam proses tersebut.

Distribusi Air Dalam tubuh

- Total air dalam tubuh bervariasi diantara species, umur, jenis kelamin, pakan dan kondisi-kondisi lainnya
- Kandungan air tertingi ditemukan pada hewan yang baru lahir, dengan meningkatnya umur maka kandungan air menurun secara cepat kemudian sangat perlahan
- Pada umumnya, hewan dewasa yang kurus (nonherbivora) mempunyai kandungan total air tubuh sekitar 70% dari berat badannya. Jaringan lemak akan menurunkan kandungan air sebesar 10%, sehingga total air tubuh pada seekor hewan yang gemuk akan lebih rendah dibandingkan hewan yang kurus. Suatu hasil penelitian menunjukkan bahwa ternak sapi yang sangat kurus sekitar 70% dari berat badannya adalah air, sedangkan pada sapi yang sangat gemuk sekitar 40%.

- Intracellular Fluid (ICF) comprises 2/3 of the body's water. If body has 60% water, ICF is about 40% weight. The ICF is primarily a solution of potassium and organic anions, proteins etc. The cell membranes and cellular metabolism control the constituents of this ICF.
- Extracellular Fluid (ECF) is the remaining 1/3 of body's water. ECF is about 20% of weight. The ECF is primarily a NaCl and $NaHCO_3$ solution. The ECF is further subdivided into three sub compartments:
  - Interstitial Fluid (ISF) surrounds the cells, but does not circulate. It comprises about 3/4 of the ECF.
  - Plasma circulates as the extracellular component of blood. It makes up about 1/4 of the ECF.
  - Transcellular fluid is a set of fluids that are outside of the normal compartments. These 1-2 liters of fluid make up the ECF, Digestive Juices, Mucus, etc.

Movement of Fluid between Compartments

- Hydrostatic pressure and osmotic pressure regulate the movement of water and electrolytes from one compartment to another
- Although the composition of body fluids varies from one compartment to another, the total solute concentrations and water amounts are normally equal
- A net gain or loss of water will cause shifts affecting both the intracellular and extracellular fluids due to osmosis

Water Balance

- Water balance exists when water intake equals water output
- Water Intake:
  1. The volume of water gained each day varies from one individual to the next
  2. About 60% of daily water is gained from drinking, another 30% comes from moist foods, and 10% from the water of metabolism.
- Regulation of Water Intake
  1. The thirst mechanism is the primary regulator of water intake
  2. The thirst mechanism derives from the osmotic pressure of extracellular fluids and a thirst center in the hypothalamus
  3. Once water is taken in, the resulting distention of the stomach will inhibit the thirst mechanism

Water Output

- Water is lost in urine, feces, perspiration, evaporation from skin (insensible perspiration), and from the lungs during breathing
- The route of water loss depends on temperature, relative humidity, and physical exercise

Regulation of Water Output

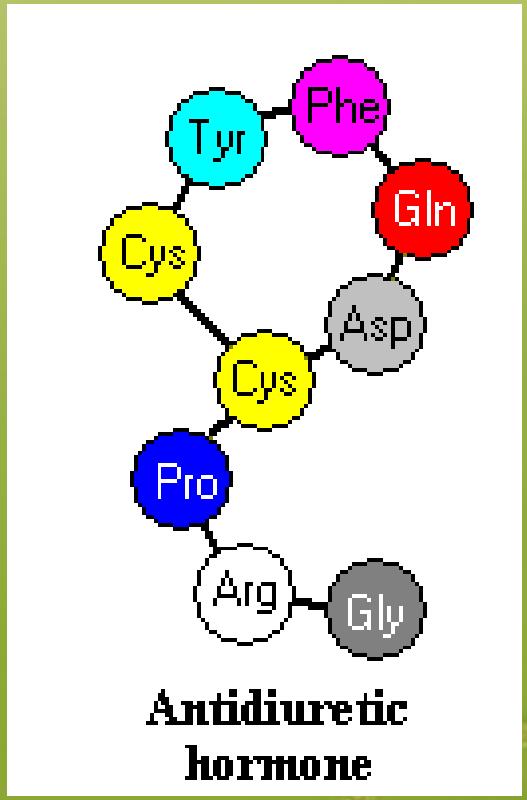
- The distal convoluted tubules and collecting ducts of the nephrons regulate water output
- Antidiurectic hormone from the posterior pituitary causes a reduction in the amount of water lost in the urine. When drinking adequate water, the ADH mechanism is inhibited, and more water is expelled in urine

Ekskresi urin

- Bila seekor hewan dikurangi pemberian air minumnya maka jumlah air yang diekskresikan lewat urin menurun, dan sebaliknya (dlm batas tertentu)
- Volume minimum urin ditentukan oleh jumlah cairan yang diekskresikan dan oleh kemampuan ginjal mengkonsentrasi urin
- Maksimum konsentrasi urin sangat bervariasi diantara hewan
- Ekskresi air lewat ginjal terutama dikontrol oleh ADH (vasopressin). ADH berpengaruh terhadap nephron untuk menaikkan reabsorpsi air dan ekskresi urin turun. Selama pengurangan pemberian air maka konsentrasi ADH dalam darah naik dan volume urin menjadi turun

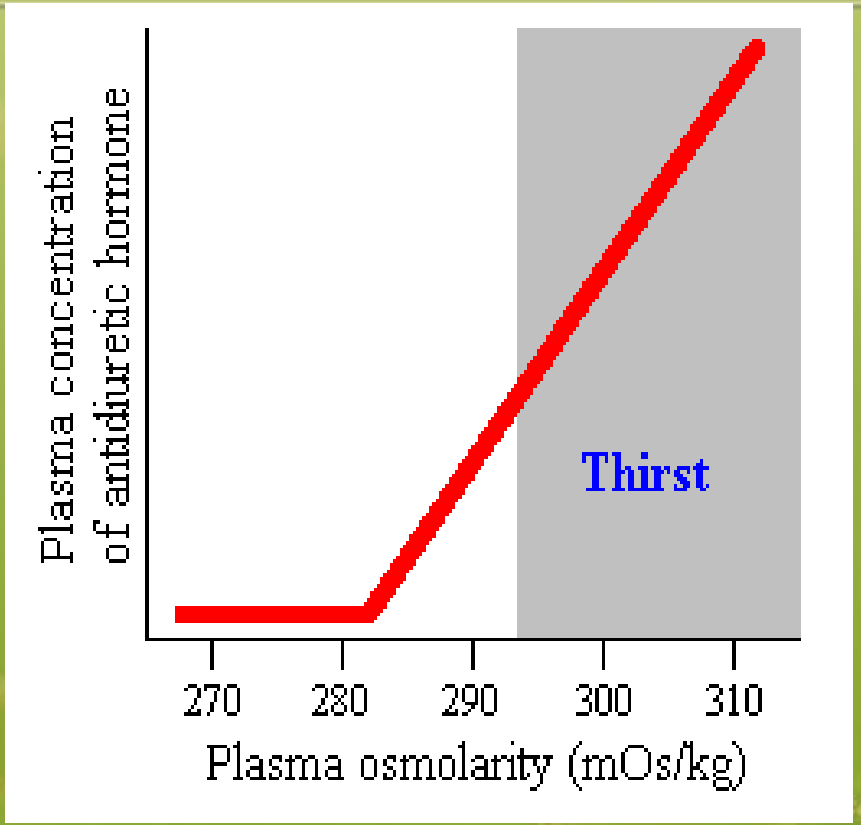
Physiologic Effects of Antidiuretic Hormone (Effects on the Kidney)

The single most important effect of *antidiuretic hormone* is to conserve body water by reducing the output of urine. A diuretic is an agent that increases the rate of urine formation. Injection of small amounts of antidiuretic hormone into a person or animal results in antidiuresis or decreased formation of urine



Control of Antidiuretic Hormone Secretion

- The most important variable regulating antidiuretic hormone secretion is plasma osmolarity, or the concentration of solutes in blood. Osmolarity is sensed in the hypothalamus by neurons known as an osmoreceptors, and those neurons, in turn, simulate secretion from the neurons that produce antidiuretic hormone



Disease States

- The most common disease of man and animals related to antidiuretic hormone is diabetes insipidus. This condition can arise from either of two situations:
  - Hypothalamic ("central") diabetes insipidus results from a deficiency in secretion of antidiuretic hormone from the posterior pituitary. Causes of this disease include head trauma, and infections or tumors involving the hypothalamus
  - Nephrogenic diabetes insipidus occurs when the kidney is unable to respond to antidiuretic hormone. Most commonly, this results from some type of renal disease, but mutations in the ADH receptor gene or in the gene encoding aquaporin-2 have also been demonstrated in affected humans.
- The major sign of either type of diabetes insipidus is excessive urine production. Some human patients produce as much as 16 liters of urine per day. Hypothalamic diabetes insipidus can be treated with exogenous antidiuretic hormone.

Dehydration

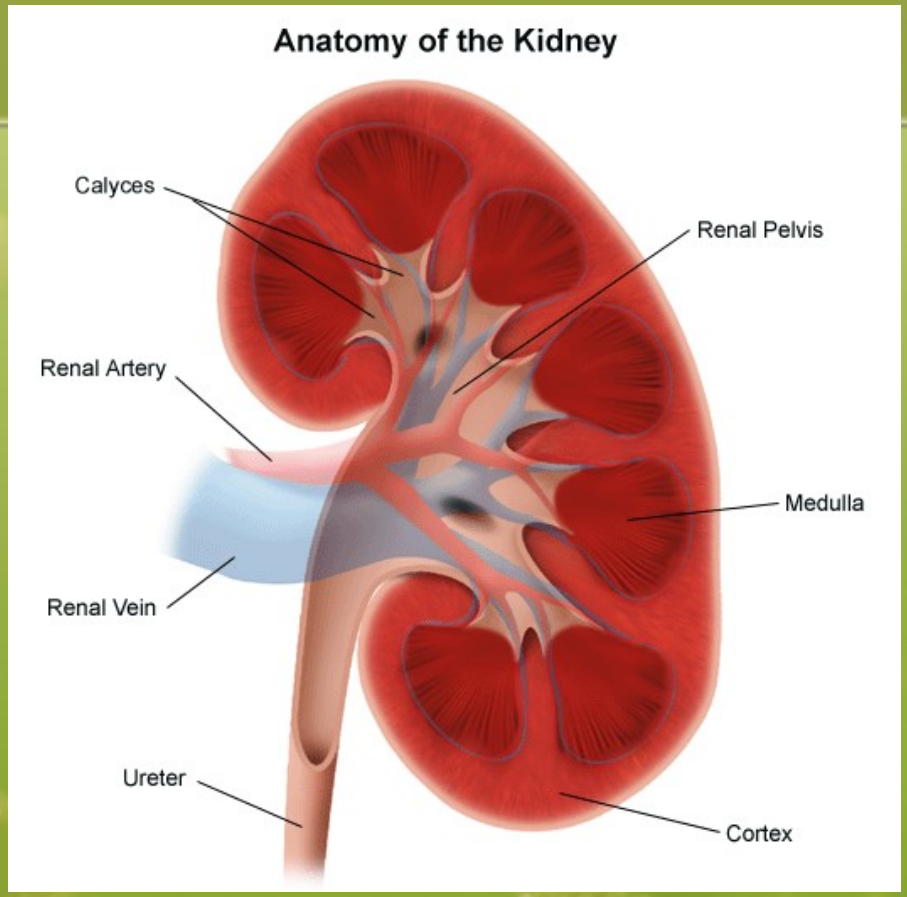
- Dehydration means your body does not have as much water and fluids as it should. Dehydration can be caused by losing too much fluid, not drinking enough water or fluids, or both. Vomiting and diarrhea are common causes
- youngs are more susceptible to dehydration than adults because of their smaller body weights and higher turnover of water and electrolytes. The elderly and those with illnesses are also at higher risk
- Dehydration is classified as mild, moderate, or severe based on how much of the body's fluid is lost or not replenished. When severe, dehydration is a life-threatening emergency(***)

- body may lose too much fluids from:
  - ✓ Vomiting or diarrhea
  - ✓ Excessive urine output, such as with uncontrolled diabetes or diuretic use
  - ✓ Excessive sweating (for example, from exercise)
  - ✓ Fever
- not drink enough fluids because of:
  - ✓ Nausea
  - ✓ Loss of appetite due to illness
  - ✓ Sore throat or mouth sores

Ginjal

- Fungsi utama ginjal adalah sebagai tempat pembentukan urin. mempunyai fungsi yang menjaga integritas fisiologis terhadap volume ECF, proses-prosesnya:
  - Penyimpanan air, kation tertentu, glukosa dan asam amino. Penyimpanan bahan tersebut digunakan secara luar, dan secara langsung kembali ke cairan tubuh sesuai dengan kebutuhan tubuh, dan kelebihannya diekskresikan lewat urin.
  - Menyingkirkan/membuang:
    - Nitrogenous (produk akhir hasil metabolisme protein), terutama urea (pada bangsa burung asam ureat), kreatinin dan ammonia
    - Kelebihan ion H dan memelihara pH fisiologis cairan tubuh
    - Senyawa organic komplek baik yang endogenous maupun yang eksogenous

- Dua substrat endokrin penting yang disekresikan ginjal, yaitu *erythropoietin* dan *rennin*. Erythropoietin berperanan dalam hematopoiesis. Renin ikut berperan dalam pengaturan sekresi aldosteron oleh kortek adrenal
- Secara anatomis ginjal pada mamalia terdiri dari dua tipe nephron yang dapat dibedakan, yaitu pada daerah cortex yang disebut glomerulus dan perluasan dari lengkung Henle yang menembus medulla



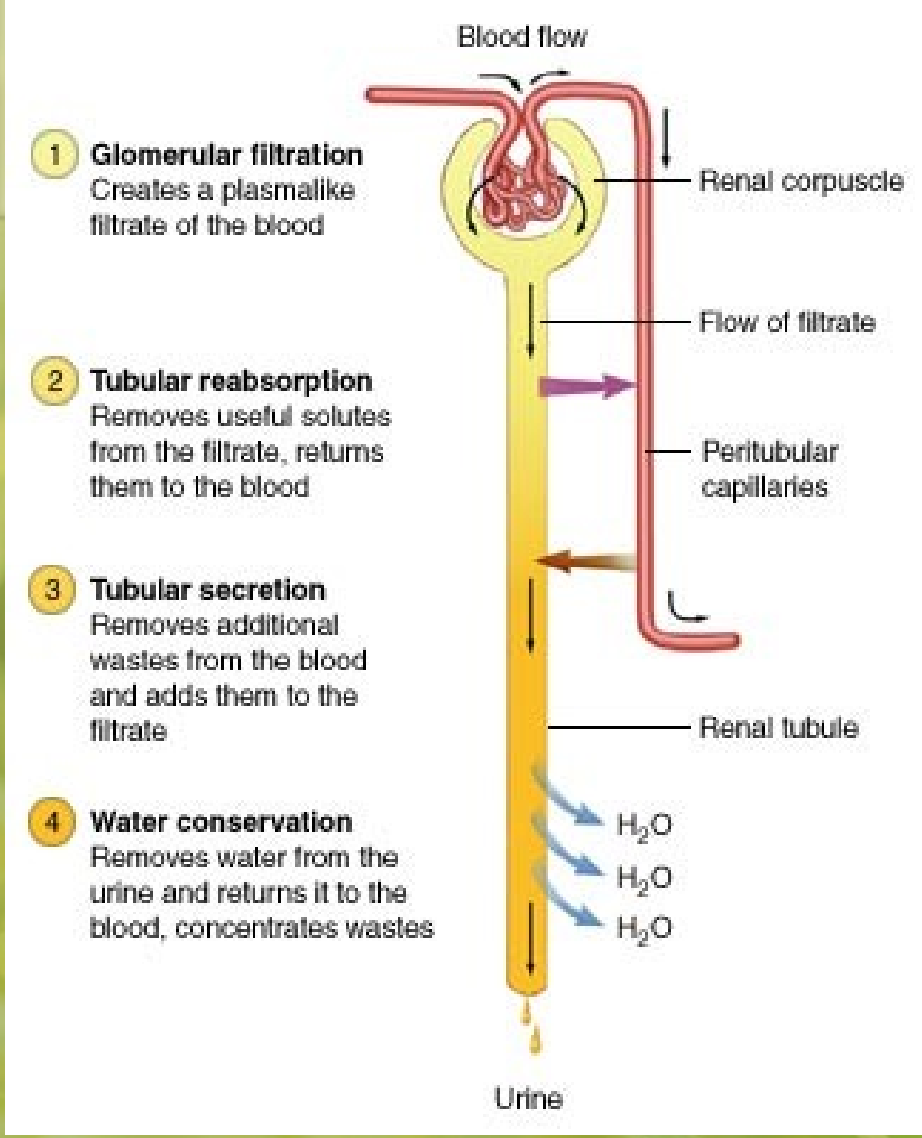
The nephron is a tube; closed at one end, open at the other. It consists of a:

- **Bowman's capsule**. Located at the closed end, the wall of the nephron is pushed in forming a double-walled chamber
- **Glomerulus**. A capillary network within the Bowman's capsule. Blood leaving the glomerulus passes into a second capillary network
- **Proximal convoluted tubule**. Coiled and lined with cells carpeted with microvilli and stuffed with mitochondria.
- **Loop of Henle**. It makes a hairpin turn and returns to the
- **Distal convoluted tubule**, which is also highly coiled and surrounded by capillaries.
- **Collecting tubule**. It leads to the pelvis of the kidney from where **urine** flows to the bladder and, periodically, on to the outside world.

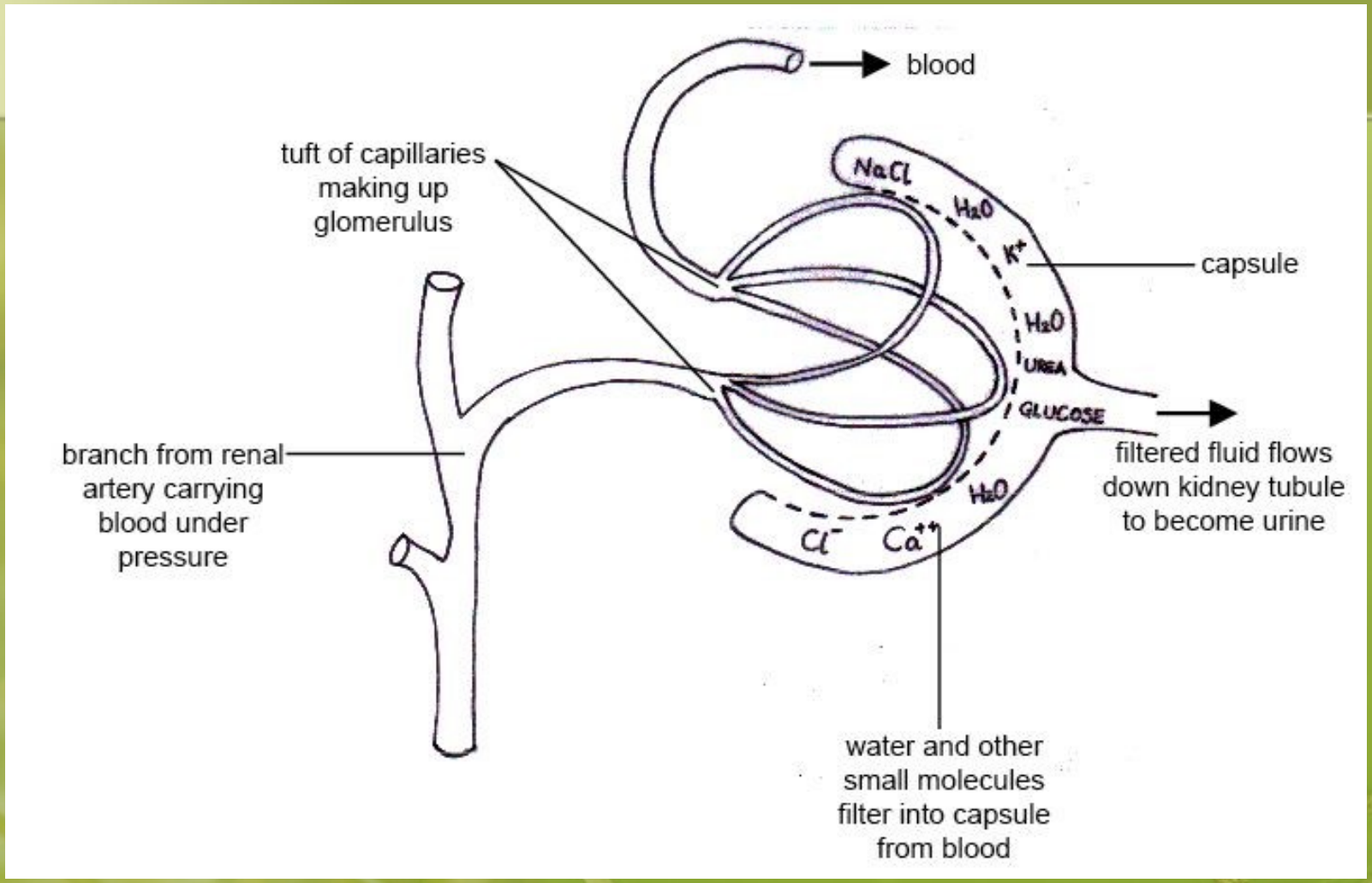
Formation of urine

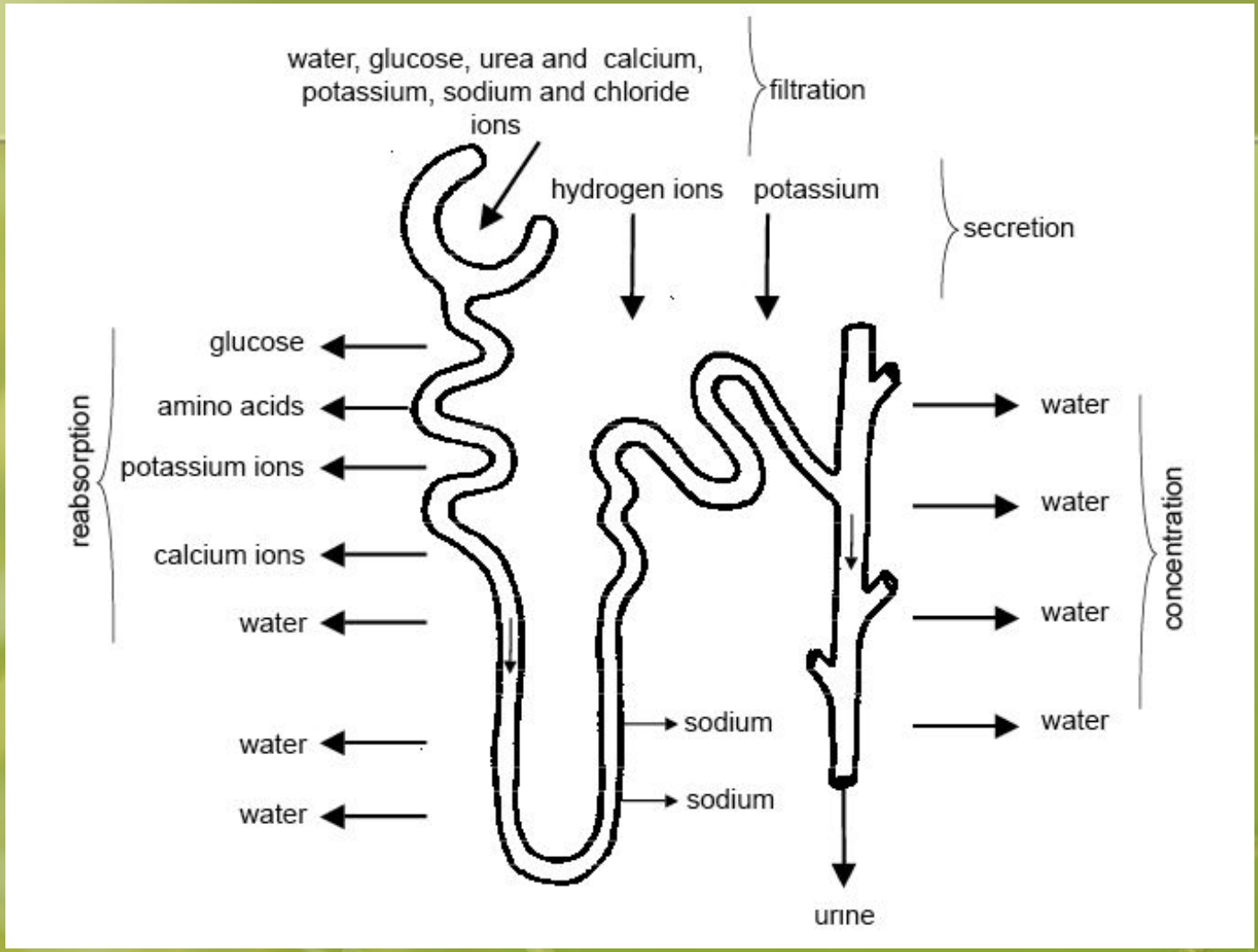
- The nephron makes urine by filtering the blood of its small molecules and ions and then reclaiming the needed amounts of useful materials. Surplus or waste molecules and ions are left to flow out as urine
- Blood enters the glomerulus under pressure.
- This causes water, small molecules (but not macromolecules like proteins) and ions to filter through the capillary walls into the Bowman's capsule. This fluid is called nephric filtrate.
- Nephric filtrate collects within the Bowman's capsule and then flows into the proximal tubule.

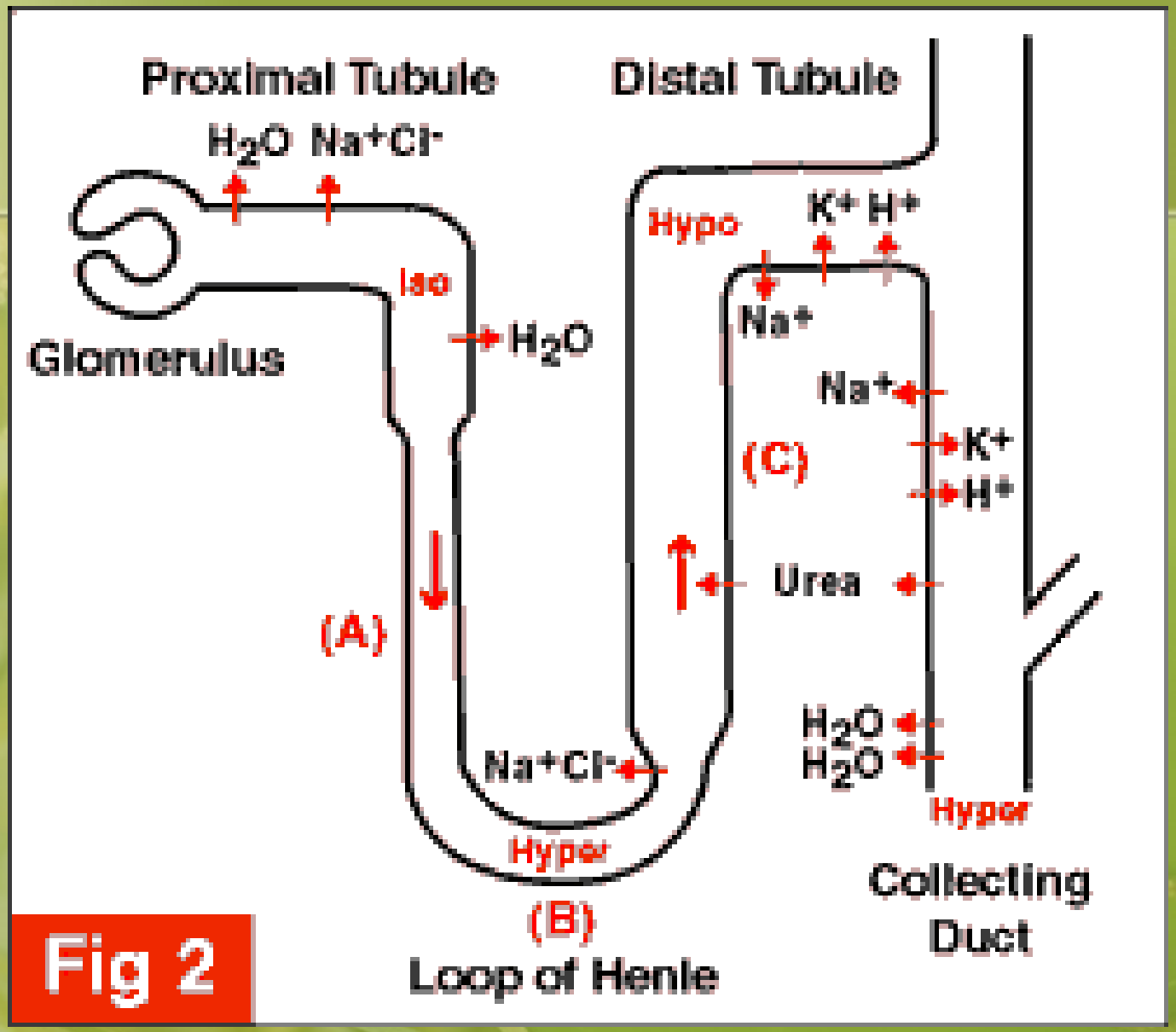
- Here all of the glucose, and amino acids, >90% of the uric acid, and ~60% of inorganic salts are reabsorbed by active transport
  - The active transport of Na+ out of the proximal tubule is controlled by angiotensin II
  - The active transport of phosphate is regulated (suppressed by) the parathyroid hormone
  - As these solutes are removed from the nephric filtrate, a large volume of the water follows them by osmosis (80–85% of the 180 liters deposited in the Bowman's capsules in 24 hours)
- As the fluid flows into the descending segment of the loop of Henle, water continues to leave by osmosis because the interstitial fluid is very hypertonic. This is caused by the active transport of Na+ out of the tubular fluid as it moves up the ascending segment of the loop of Henle
- In the distal tubules, more sodium is reclaimed by active transport, and still more water follows by osmosis
- Final adjustment of the sodium and water content of the body occurs in the collecting tubules



Urine is formed through a combination of four basic processes: 1) glomerular filtration, 2) tubular reabsorption, 3) tubular secretion, and 4) water conservation. Blood is under high pressure in the glomerulus; thus, plasma (except for plasma proteins) moves into the glomerular capsule. This fluid is called filtrate. As the filtrate moves along the tubules, it is referred to as tubular fluid. Most of the water and many other molecules are reabsorbed into the blood, while some substances are secreted into the tubular fluid. Once the fluid moves into the collecting duct it is called urine. While in the collecting duct, additional water is removed from the urine, concentrating the wastes.


blood
tuft of capillaries making up glomerulus
NaCl
H₂O
K⁺
capsule
H₂O
UREA
GLUCOSE
branch from renal artery carrying blood under pressure
filtered fluid flows down kidney tubule to become urine
H₂O
Cl⁻
Ca⁺⁺
water and other small molecules filter into capsule from blood


water, glucose, urea and calcium, potassium, sodium and chloride ions
filtration
hydrogen ions
potassium
secretion
glucose
amino acids
potassium ions
calcium ions
water
water
water
reabsorption
sodium
sodium
water
water
water
water
concentration
urine


Proximal Tubule
Distal Tubule
H_2O Na^+Cl^-
Hypo
K^+ H^+
Iso
H_2O
Glomerulus
Na^+
Na^+
K^+
H^+
(C)
(A)
Urea
H_2O
H_2O
Na^+Cl^-
Hypo
Hypo
Collecting Duct
(B)
Loop of Henle
Fig 2