FUNCTIONS OF KIDNEY

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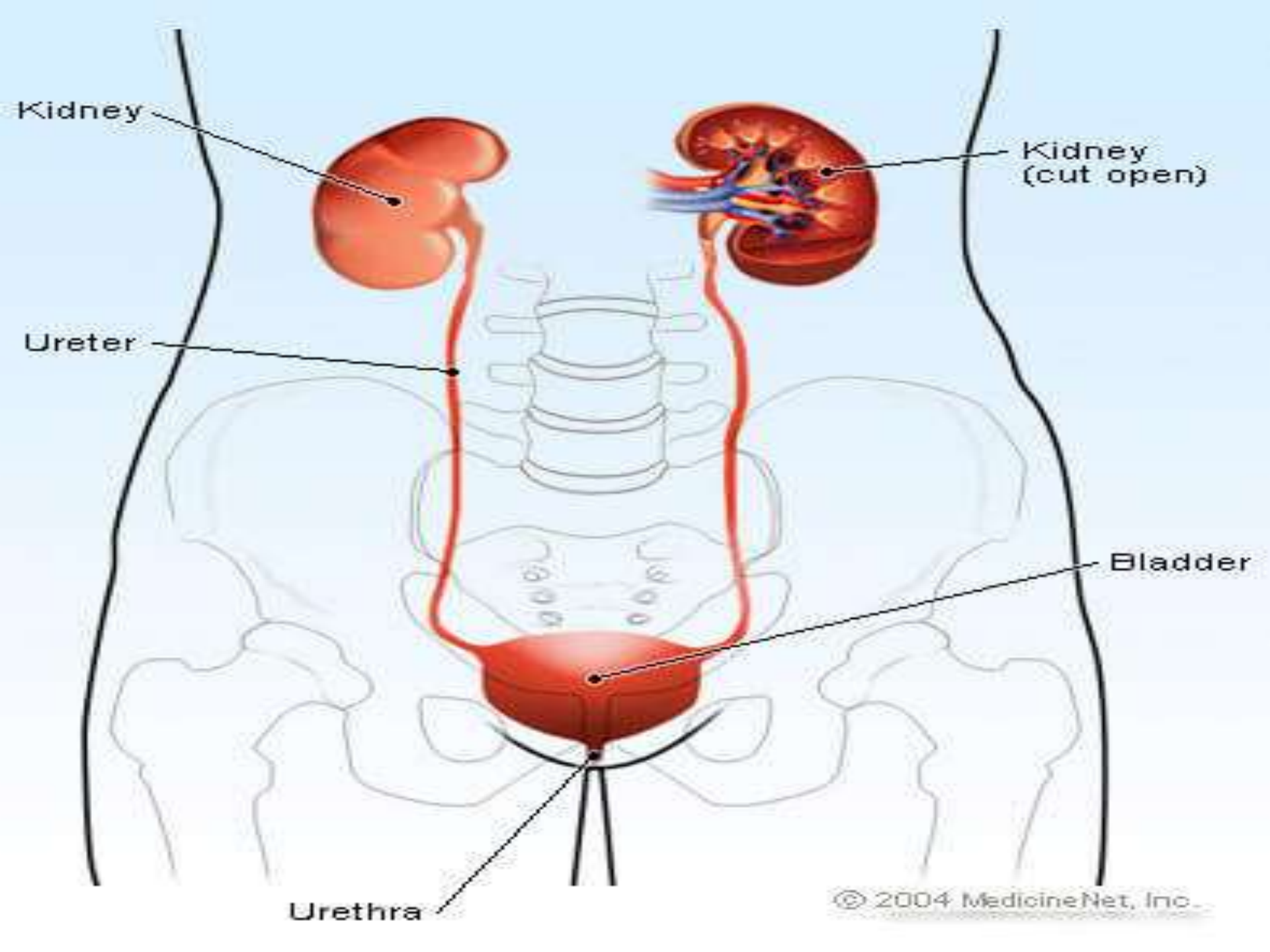
Kidney
Kidney (cut open)
Ureter
Bladder
Urethra
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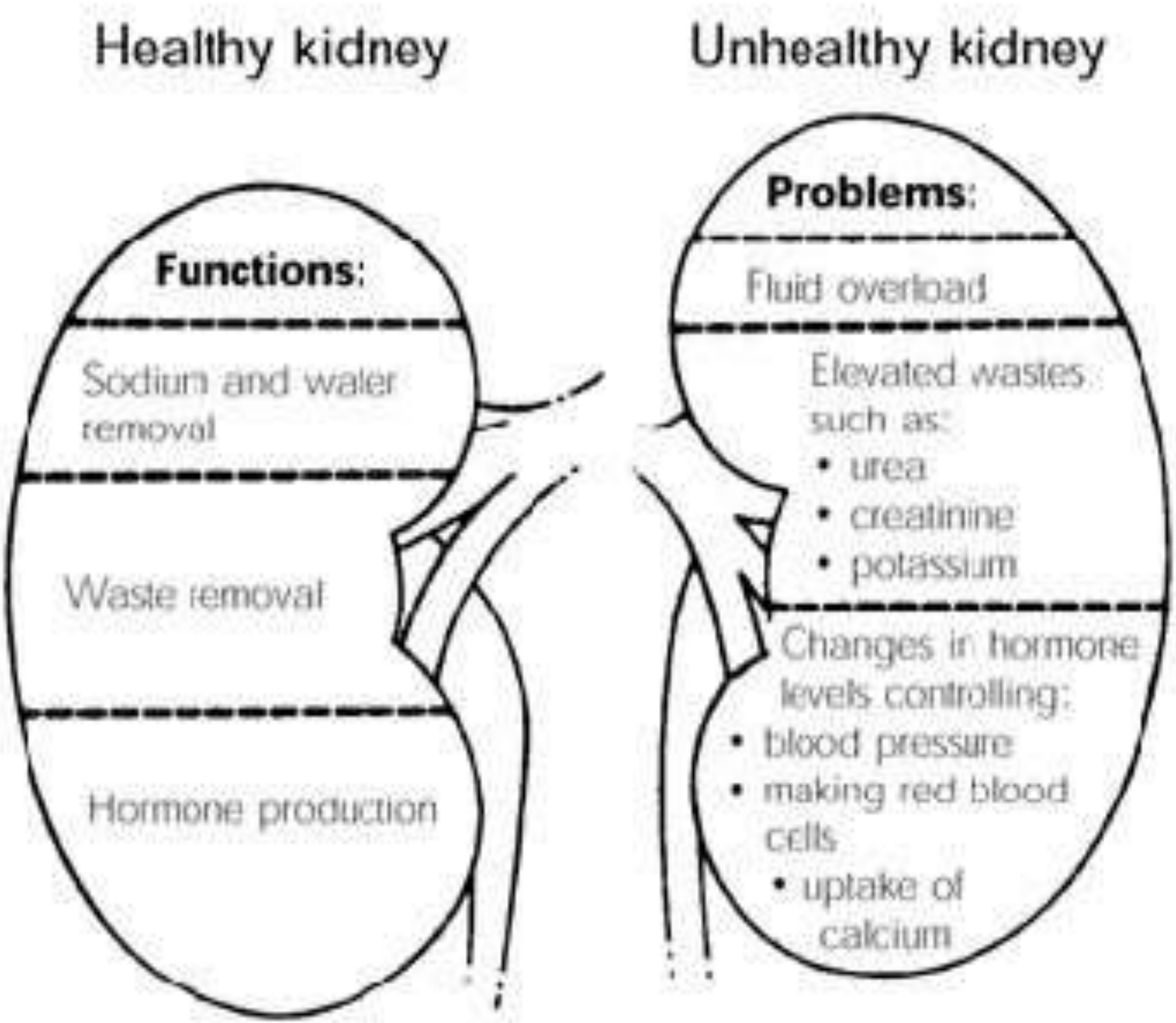
OVERVIEW OF KIDNEY FUNCTIONS

- Excretion of wastes and other foreign substances.
- Regulation of blood ionic composition.
- Regulation of blood pH.
- Production of hormones.
- Regulation of blood pressure.
- Regulation of blood volume.
- Maintenance of blood osmolarity.
- Regulation of blood glucose level.


Healthy kidney
Unhealthy kidney
Functions:
Sodium and water removal
Waste removal
Hormone production
Problems:
Fluid overload
Elevated wastes such as:
• urea
• creatinine
• potassium
Changes in hormone levels controlling:
• blood pressure
• making red blood cells
• uptake of calcium

EXCRETION OF WASTES AND OTHER FOREIGN SUBSTANCES

- By forming urine, the kidneys help excrete wastes- substances that have no useful function in the body.

- Some wastes excreted in urine result from metabolic reactions in the body. These include:
  - Ammonia and urea from deamination of amino acids.
  - Bilirubin from the catabolism of haemoglobin.
  - Creatinine from the breakdown of creatinine phosphate in muscle fibres.
  - Uric acid from the catabolism of nucleic acids.

- Other wastes include foreign substances from the diet, such as drugs and environmental toxins.

Excess minerals and other wastes are eliminated in urine

Urine

Proteins are the major contributor to waste production. Our kidneys can balance minerals when in excess

Excess minerals

Urea

Uric acid

Oxalate

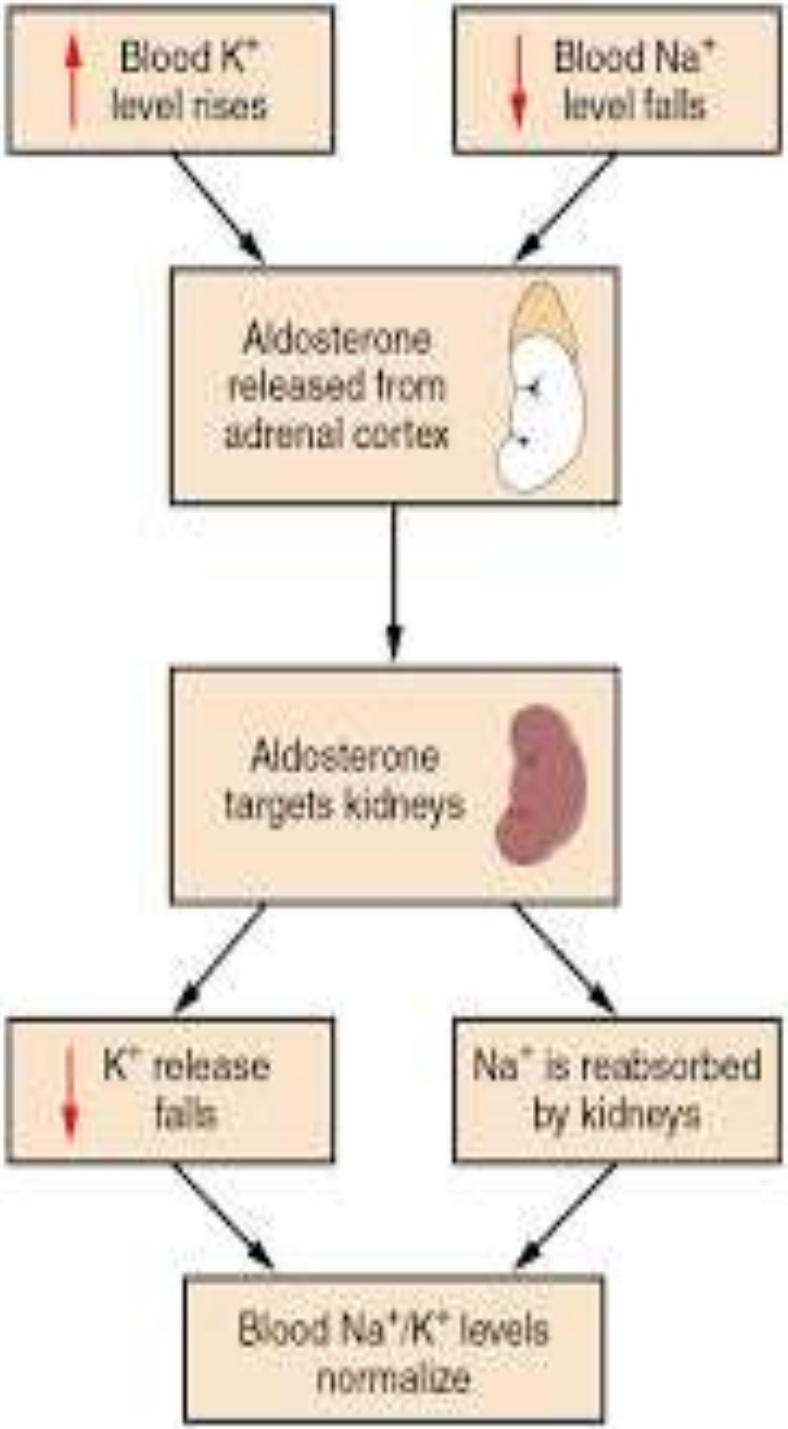
REGULATION OF BLOOD IONIC COMPOSITION AND pH

- The kidney can correct any imbalances by:
  - Removing excess acid (hydrogen ion) or bases (bicarbonate) in the urine and
  - Restoring the bicarbonate concentration in the blood to normal.
- The kidney cells produce a constant amount of hydrogen ion and bicarbonate because of their own cellular metabolism (production of carbon dioxide).

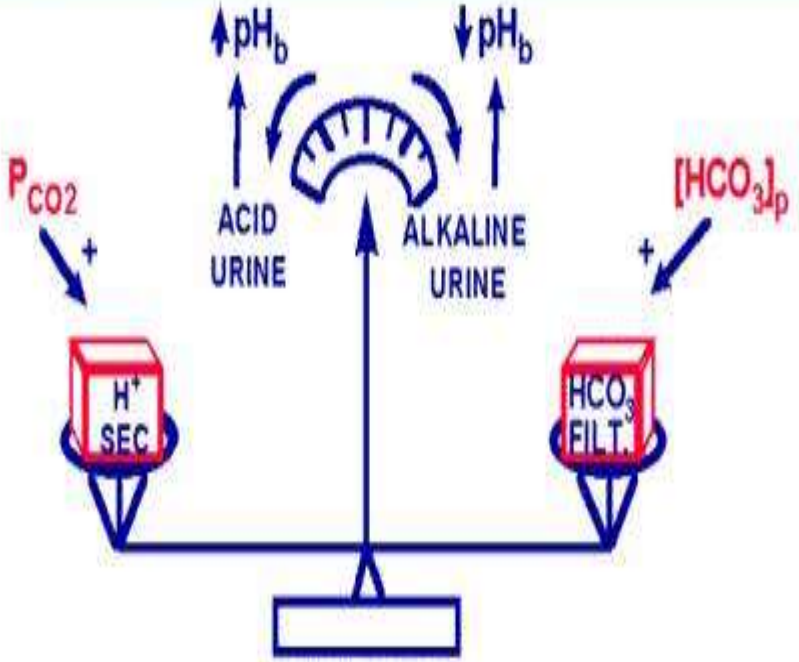
- Whether the kidney removes hydrogen ions or bicarbonate ions in the urine depends upon the amount of bicarbonate filtered in the glomerulus from the blood relative to the amount of hydrogen ions secreted by the kidney cells.

- If the amount of filtered bicarbonate is greater than the amount of secreted hydrogen ions, then bicarbonate will be lost in the urine.

- Likewise, If the amount of secreted hydrogen ion is greater than the amount of filtered bicarbonate, then hydrogen ions will be lost in the urine (i.e. acidic urine).



ACID-BASE BALANCING BY THE KIDNEY



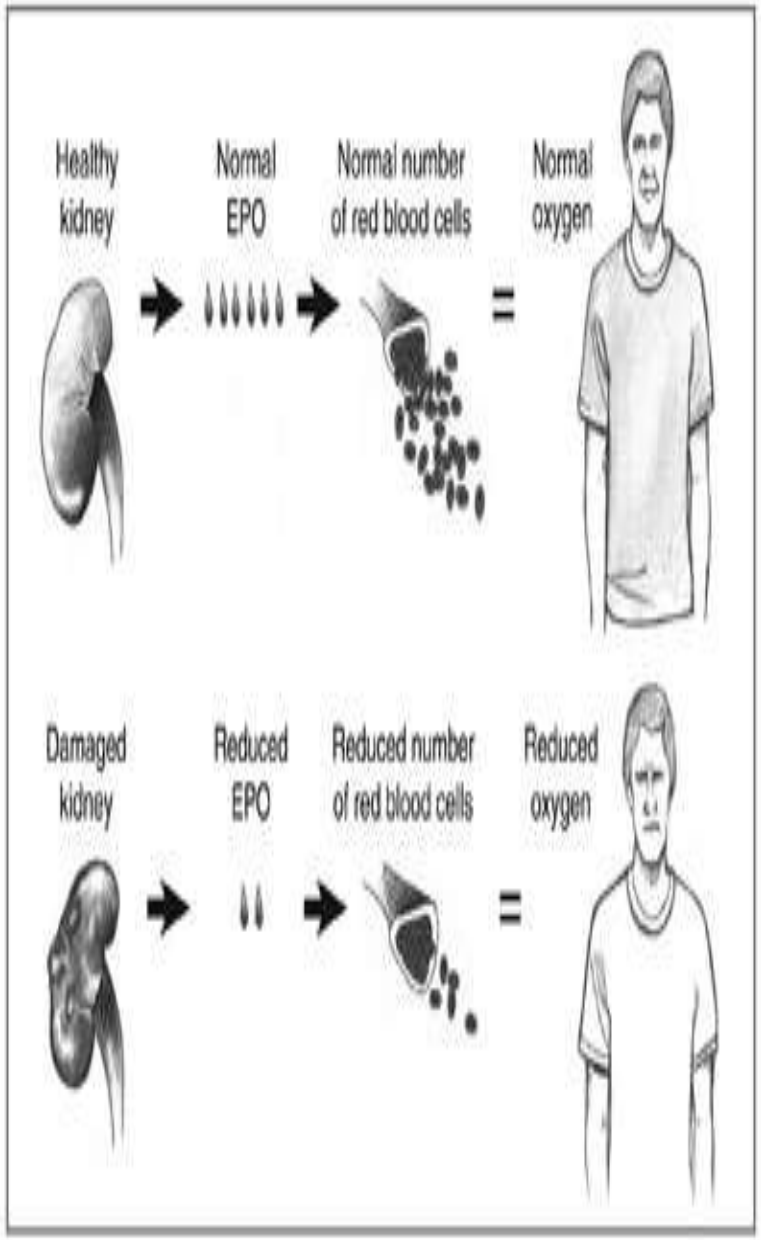
- The response of the kidney to acid-base imbalances is governed by the relative magnitudes of proton secretion and HCO_3 filtration because these two factors affect the rates of acid and alkali excretion.
- If P_{CO2} rises, proton secretion becomes dominant and the kidney excretes acid, raising blood pH.
- If $[HCO_3]_p$ rises, HCO_3 filtration increases and the kidney excretes alkali, reducing blood pH.

PRODUCTION OF HORMONES

- The human kidney secretes two hormones:
  - Erythropoietin (EPO)
  - Clacitriol (1,25[OH]$_2$ Vitamin D$_3$

Erythropoietin

- Glycoprotein.
- It acts on the bone marrow to increase the production of red blood cells.
- Stimuli such as bleeding or moving to high altitudes (where oxygen is scarcer) trigger the release of EPO.
- People with failing kidneys; dialysis. Without a source of EPO, these patients suffer from anaemia.
- Recombinant EPO.
- Athletes urine.



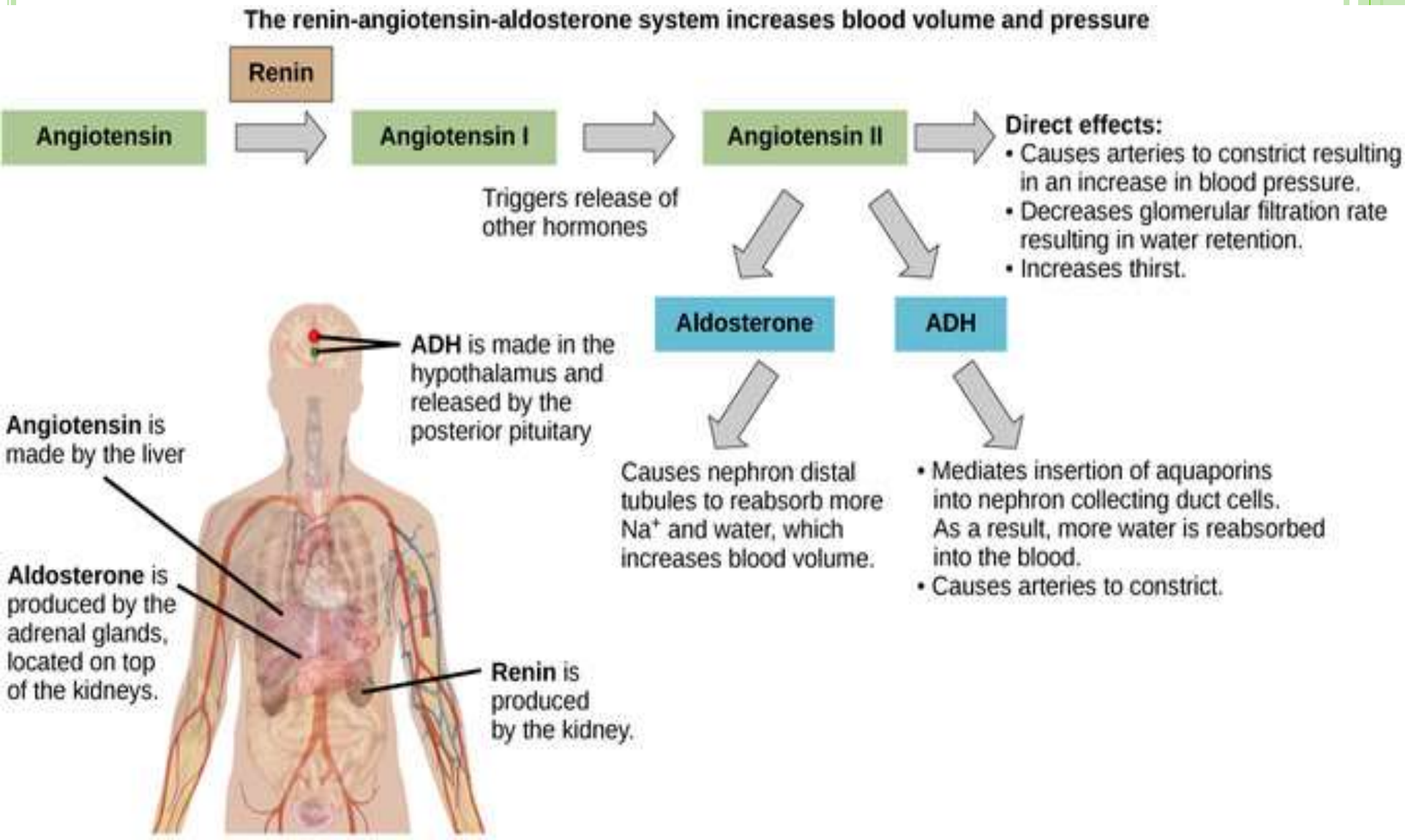
CALCITRIOL

- Calcitriol is 1,25[OH]$_2$ Vitamin D$_3$, the active form of vitamin D. It is derived from
  - **calciferol** (vitamin D$_3$) which is synthesized in skin exposed to the ultraviolet rays of the sun
  - precursors ("vitamin D") ingested in the diet.

- Calciferol in the blood is converted into the active vitamin in two steps:
  - calciferol is converted in the **liver** into 25[OH] vitamin D$_3$
  - this is carried to the **kidneys** where it is converted into calcitriol. This final step is promoted by the **parathyroid hormone** (**PTH**).

- Calcitriol acts on
  - the cells of the intestine to promote the absorption of calcium and phosphate from food
  - bone to mobilize calcium from the bone to the blood

REGULATION OF BLOOD PRESSURE



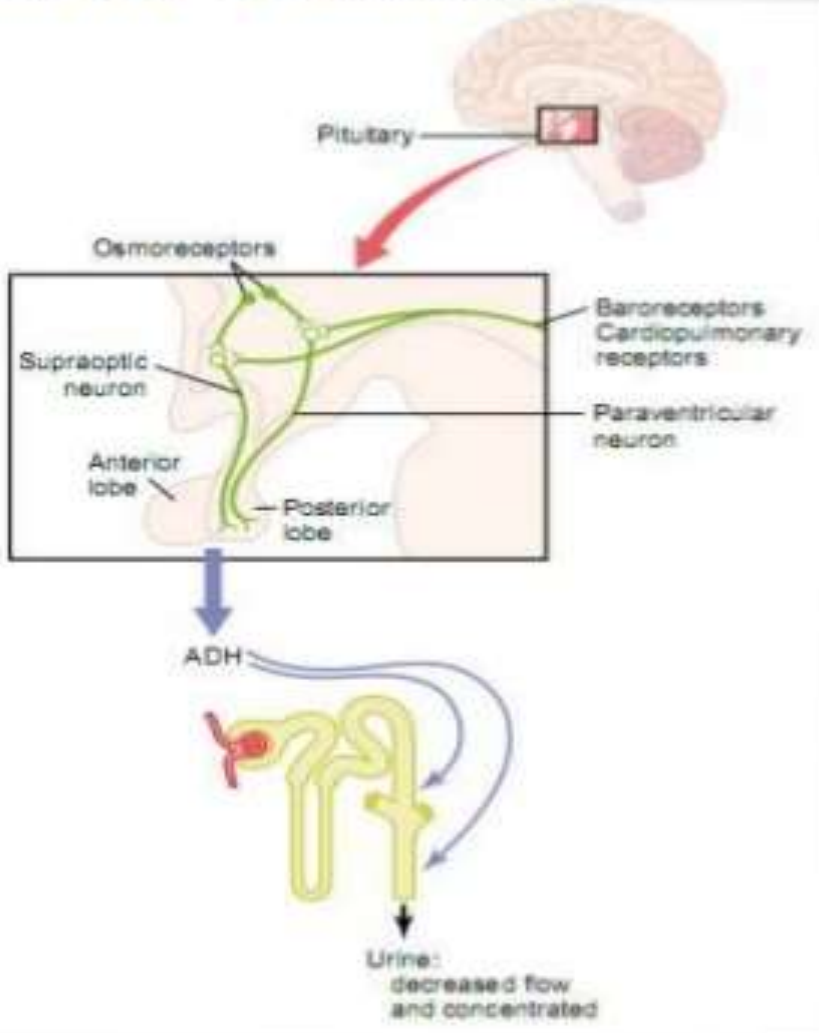
RENIN

- One of the functions of the kidney is to monitor blood pressure and take corrective action if it should drop. The kidney does this by secreting the proteolytic enzyme renin.
- Renin acts on **angiotensinogen**, a plasma peptide, splitting off a fragment containing 10 amino acids called **angiotensin I**.
- angiotensin I is cleaved by a peptidase secreted by blood vessels called angiotensin converting enzyme (**ACE**) — producing **angiotensin II**, which contains 8 amino acids.
- Angiotensin II
  - constricts the walls of arterioles closing down capillary beds;
  - stimulates the proximal tubules in the kidney to reabsorb sodium ions;
  - stimulates the adrenal cortex to release **aldosterone**. Aldosterone causes the kidneys to reclaim still more sodium and thus water.
  - increases the strength of the heartbeat;
  - stimulates the pituitary to release the **vasopressin** .
- All of these actions lead to an **increase in blood pressure**.

REGUATION OF BLOOD VOLUME

Role of the Kidneys in Regulation of Osmolarity and Volume

- Kidney excretes excess water in hyperhydrationin the form of dilute urine or save water in dehydration by excreting concentrated urine.
- Central osmoreceptors (hypothalamus) and peripheral osmoreceptors (kidneys, liver, spleen and blood vessels) sense changes in blood osmolarity and send information to the hypothalamus, which regulates the concentration of ADH in the blood.



MAINTENANCE OF BLOOD OSMOLARITY

- By separately regulating loss of water and loss of solutes in the urine, the kidneys maintain a relatively constant blood osmolarity close to 300 milliosmoles per litre.

REGULATION OF BLOOD GLUCOSE LEVEL

- Like the liver, the kidneys can use the amino acid glutamine in gluconeogenesis, the synthesis of new glucose molecules.

- They can then release glucose into the blood to help maintain a normal blood glucose level.

RENAL GLUCONEOGENESIS

- Gluconeogenesis, the synthesis of glucose from amino acids and other precursors, occurs in the kidney.
- Under normal conditions this is a minor function but during prolonged fasting the kidney can become a major source of blood glucose producing about one fifth as much glucose as the liver.
- Organic nutrients such as glucose and amino acids are normally maximally conserved by the kidney. They are actively reabsorbed against steep concentration gradients and normally their urinary excretion is essentially zero.