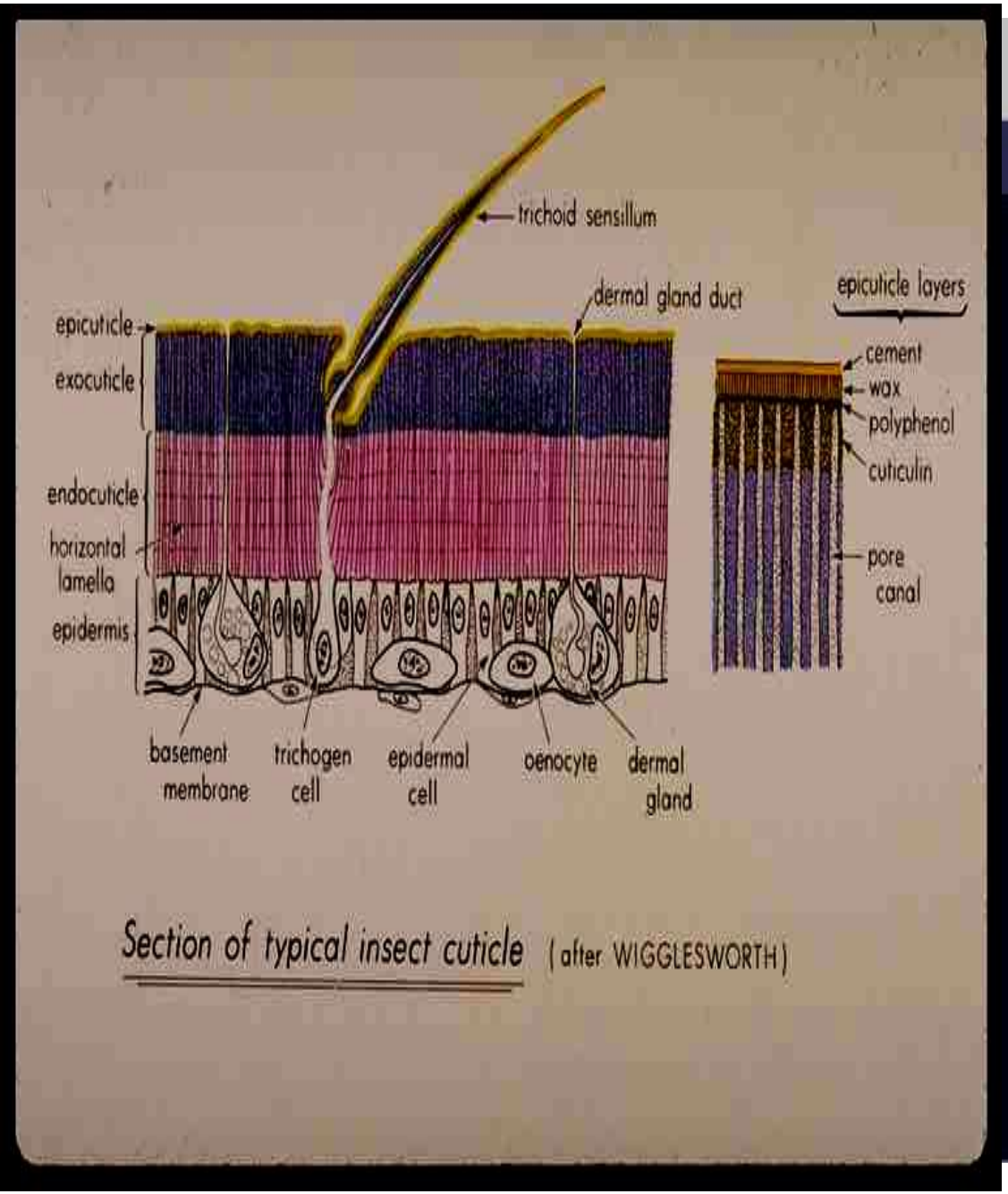
Problems of terrestrial living

→ **Water loss is main problem.**

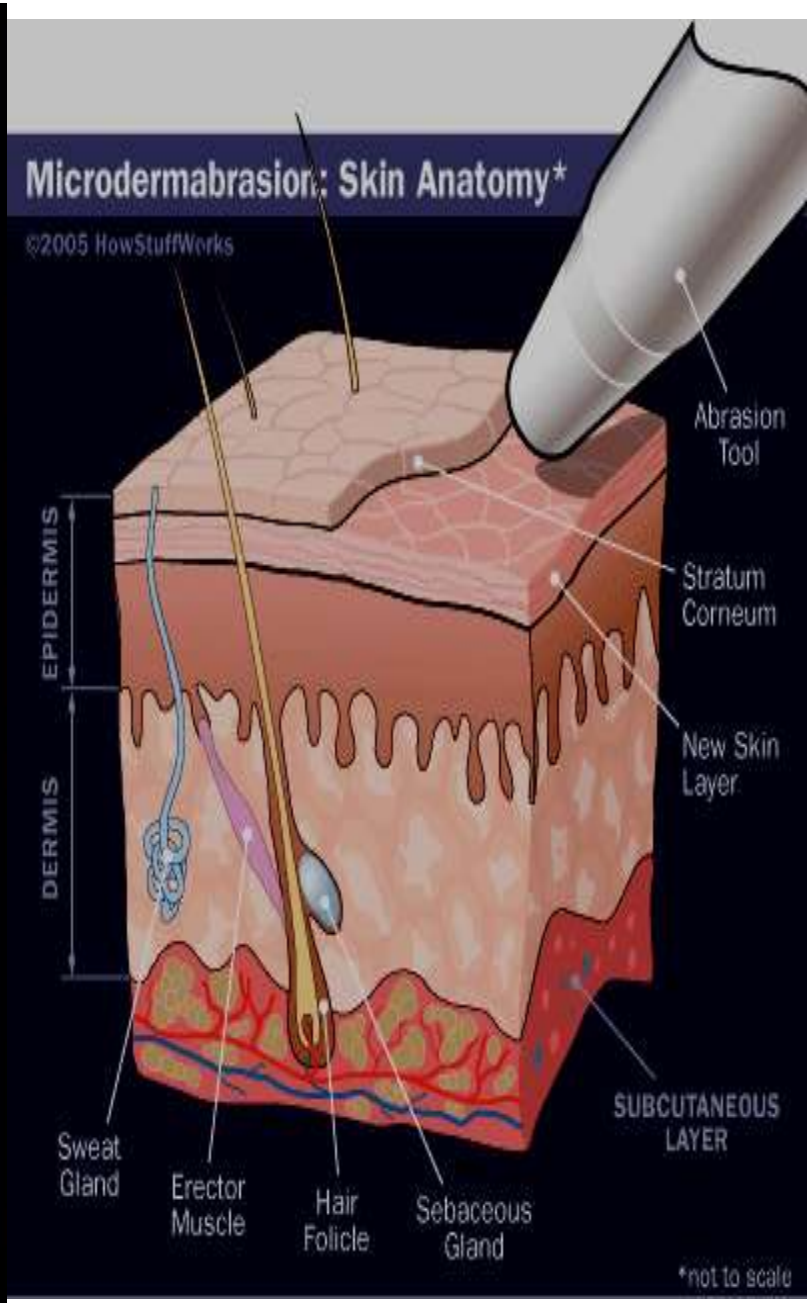
→ **Along with water loss salt (ionic) loss is also seen.**

- **Water loss is in form of**
  - **i) Integumentary water loss**
  - **ii) Respiratory surface water loss**
  - **iii) Urinary water loss**

- **Prevention of integumentary water loss**
- **→ Animals make their integument impermeable to water**
- **Arthropods use chitin & calcium**
- **Insects have chitinous integument + Waxy layer on body due to this evaporation is prevented.to a great extent.**
- **In vertebrates there is a layer stratum cornium which is keratinized epithelium to prevent water loss. (In Amphibian the stratum corneum is absent. So they depend much on water.**



Section of typical insect cuticle (after WIGGLESWORTH)



- **<u>Prevention of Respiratory surface water loss</u>**
- **→ Insects have cyclical respiration. In cockroaches the spiracles remain closed for a**
- **long time & remain open for a short time. During open phase large amount of CO2 is given out.**
- **→ In birds, mammals & reptiles the nasal mucosa is moist due to which vapour is condensed & water going out is minimized.**
- **→ In some desert animals like Kangaroo rats the nasal passage is longer and moist to prevent water loss.**
- **Thus the animals try to prevent respiratory surface water loss.**

- **Prevention of Urinary water loss**
- **→ For this mainly kidneys have to be modified**
- **→ Kidneys in amphibians, mammals & reptiles have less no. of glomeruli. This causes low filtration & less urine formation.**
- **→ Mammals have loop of Henle in which ions & water is reabsorbed. It facilitates more absorption of water whenever needed.**
- **→ In amphibians & turtles water from urine is absorbed in urinary bladder.**
- **→ Birds, crocodiles, lizards urine is given out in cloaca. It is passed in the rectum where water is reabsorbed.**

- **For further prevention all these organisms are equipped with hormones hormones like antidiuretic hormone (ADH) and diuretic hormones (DH).**
- **They are secreted in earthworm by brain cells.**
- **In snails secreted by green cells of pleural ganglion or yellow cells.**
- **In insects secreted by Thoracic ganglion.**
- **In Rhodnius bug, when fully fed, crop is full of blood. Due to this pressure is developed on thoracic ganglion, it secretes diuretic hormones & excess of water is removed.**
- **Desert mammals need more hormone for regulation & pituitory is larger in size,**


Photo Larry Simpson

- **Apart from this the animals are equipped with some additional phenomena. -**
- **like absorption of water from surrounding e.g.**
- **Insects have vesicles associated with rectum which absorbs water vapour or moisture from air. These vesicles are pencil like.**
- **Amphibians absorb water from surrounding through their skin.**
- **Some animals have ability to efficiently use metabolic water**
- **Especially in desert mammal the metabolic water generated**
- **Ex. Kangaroo rat don’t consume water at all. Fat rich food products are consumed more to regulate metabolic rate.**

Ionic Regulation

- **Normally ions are lost through urine. The terrestrial animals try to minimize ion loss through different ways. The ions are also restored through the salts in the food.**
- **For this the animals show different behaviors.**
- **Ex. Herbivores animals consume grass which is raw and does not contain much salts. Therefore animals like deer show salt licking phenomenon to regulate ions. The salt levels in the body affect preferences of the animals. e.g. Rats that are given salt free diet prefer to drink salty water rather than normal water.**

- **Hormonal regulation of salts :**
- **Different hormones in different organisms play important role in regulation of salts.**
- **In Pulmonate snails green cells of pleural ganglion & Yellow cells of parietal ganglion secrete hormones for ionic balance.**
- **In corpora cardiaca in insects secretes chloride Transport stimulating hormone (TSH) that stimulates cyclic AMP production in rectal cells & activates the chloride pump for regulation. This hormone also has effect on cells of Malpighian tubules.**

- **Hormones of higher organism**
- **In vertebrates pituitary & adrenal gland hormones are important in ionic regulation.**
- **These hormones in birds affect salt glands & cause ionic regulation**
- **In mammals they affect the kidney, intestine, skin, mammary glands & amniotic membrane.**

- **Adreno cortico steroid (Aldosteron) secreted by adrenal cortex is responsible for ionic regulation**
- **If adrenal cortex is removed it causes loss of Na, Cl & water & retention of potassium. Thus aldosteron governs absorption of Na, Cl & water & excretion of 'K'.**
- **It not only affects kidney but also sweat glands, salivary glands & intestine. It is present in amphibian, reptiles, birds & mammals.**
- **Apart from this adrenaline, thyroid hormones & also insulin have effect on ionic or electrolyte regulation.**

- **Renin – Angiotensin system is highly evolved in mammalian kidney & it regulates Na, Cl & blood pressure etc.**
- **In mammals kidney there is Juxta glomerular apparatus (JG apparatus) which is made up of two components**
- **i) Juxta glomerular cells present in afferent glomerular artery.**
- **ii) Macula Densa cells in distal convoluted tubules. These together form JG apparatus.**

- **This apparatus is sensitive to low B.P., low Na & Cl in blood, low extra cellular fluid or non-epinephrine/ nor-adrenaline & whenever influenced by these it is stimulated & produces an enzyme Renin.**
- **This enzyme acts on Angiotensinogen in plasma and converts it to <u>Angiotensin I</u>**
- **which is then converted to Angiotensin II which causes vasoconstriction to rise B.P**

- Angiotensin II also secrets nor-epinephrine

↓

stimulates adrenal cortex

↓

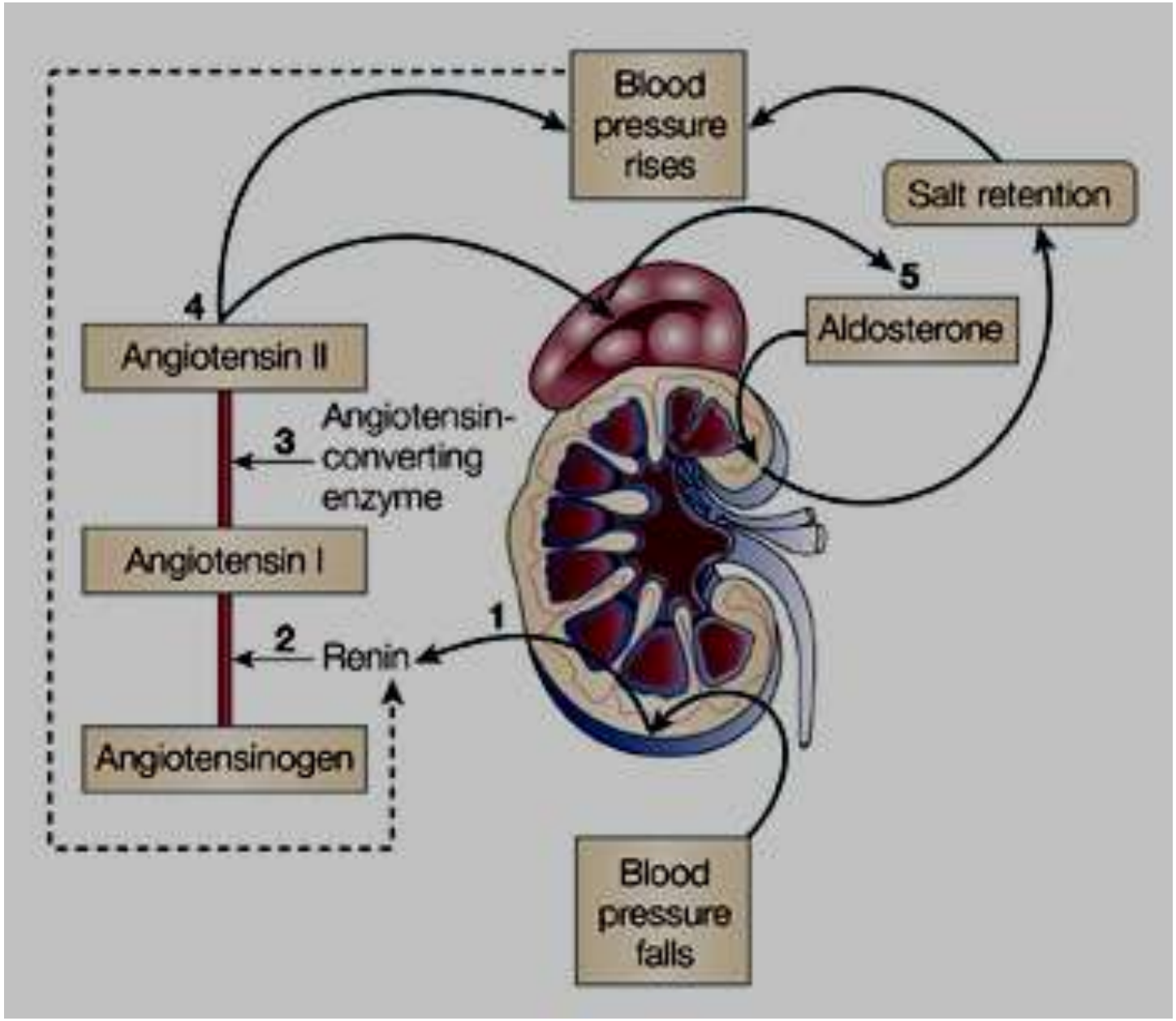
leading to secretion of Aldosteron

↓

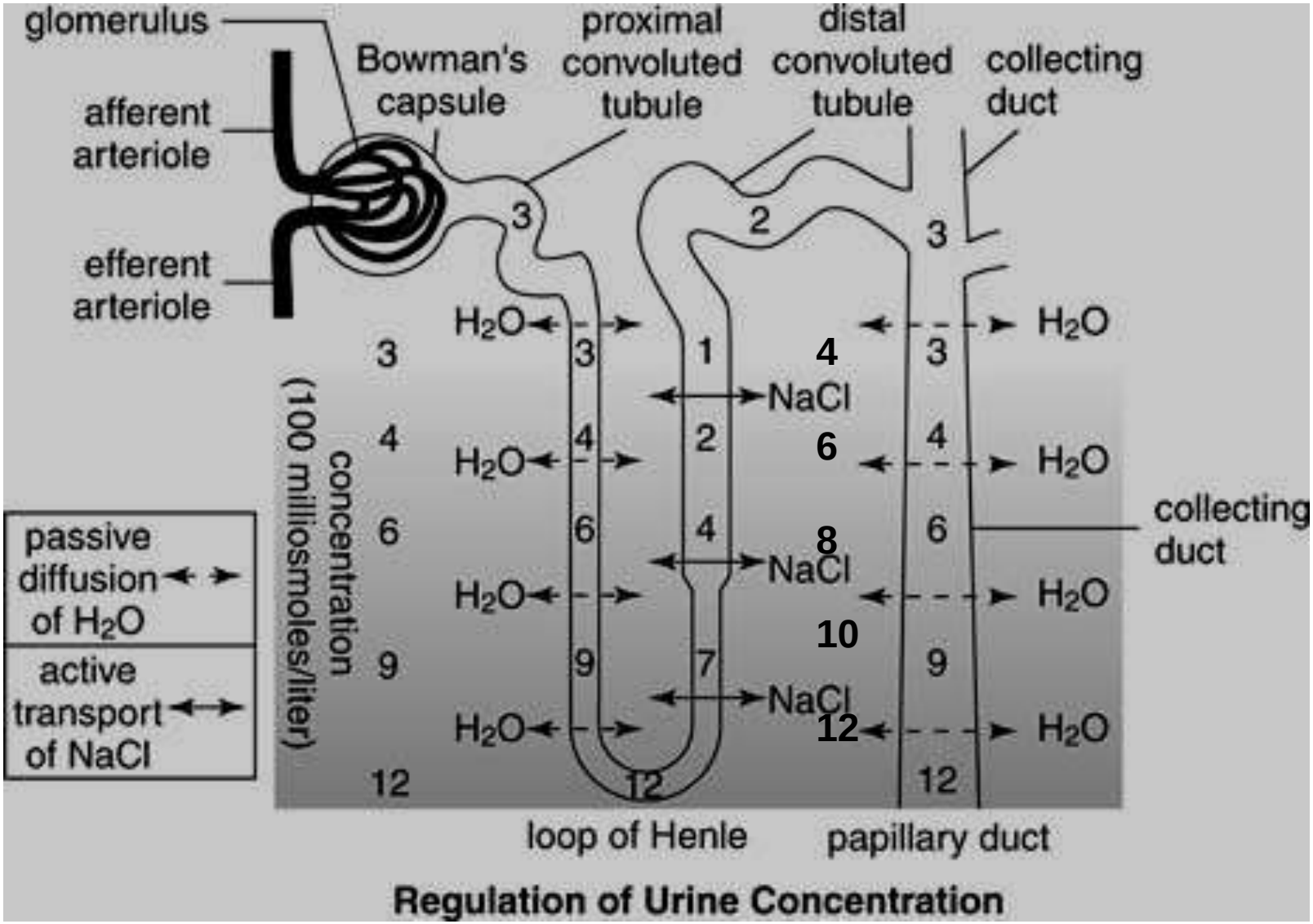
Aldosteron affects kidney to retain Na & water

↓

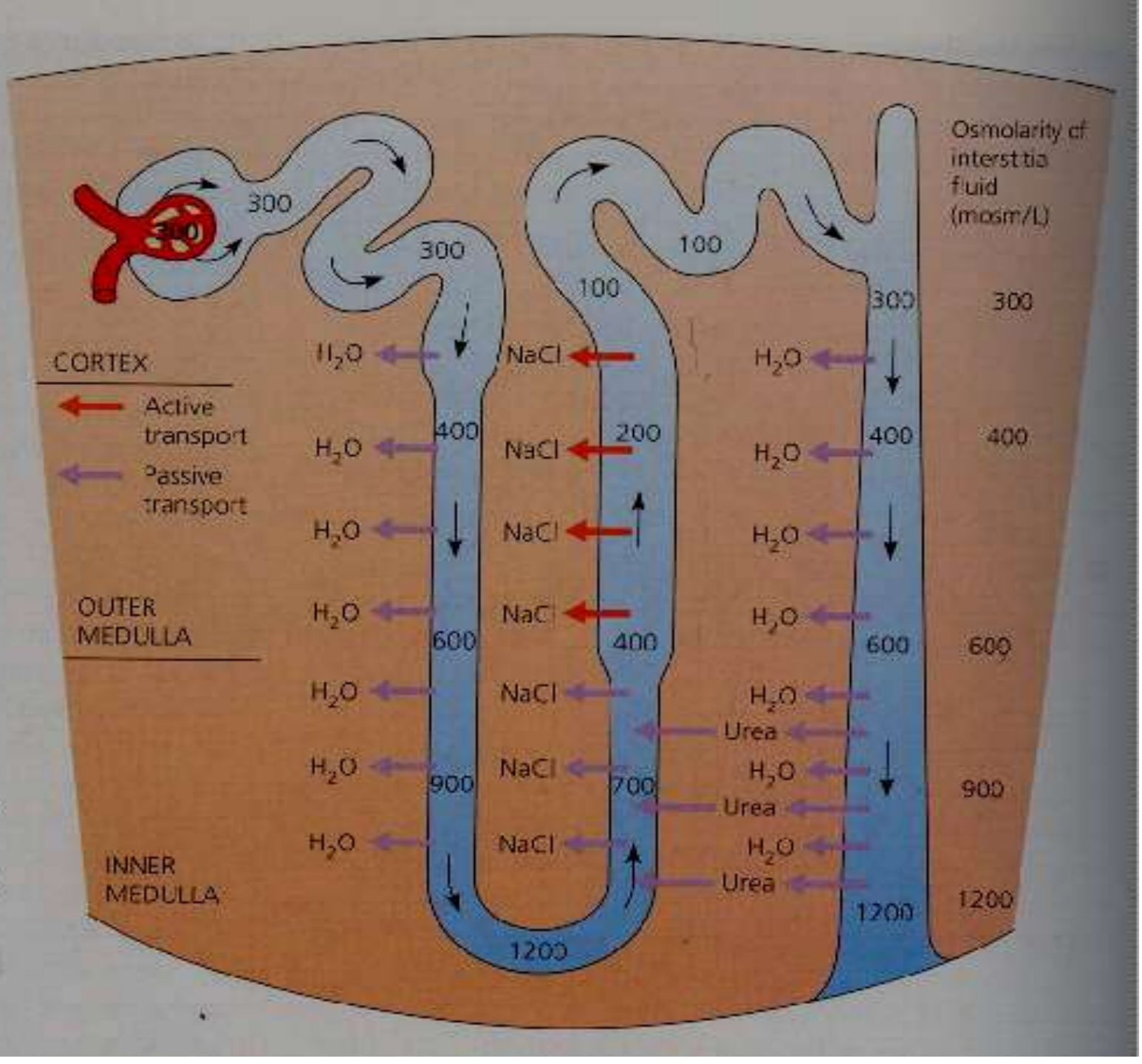
The net result is rise in B.P., rise in Na & water. This change leads to feed back inhibition of the JG apparatus to stop the reaction chain .


Blood pressure rises
Salt retention
5
Aldosterone
4
Angiotensin II
3
Angiotensin-converting enzyme
Angiotensin I
1
2
Renin
Angiotensinogen
Blood pressure falls

- **Counter current multiplier system**
- We know very well that in mammals there is hair pin loop i.e. loop of Henley which is used re absorption of urine & water. 180 l urine is formed by ultra filtration in a day but actually only 1.5 l urine is finally excreted. This is due to re absorption in the loop of Henley
- In loop of Henley there is counter current multiplier system due to which Na, Ca, K & Mg and water are reabsorbed.



Regulation of Urine Concentration


300
300
100
100
300
Osmolarity of interstitial fluid (mosm/L)
300
CORTEX
Active transport
Passive transport
H_2O
NaCl
400
200
400
400
OUTER MEDULLA
600
400
600
600
Urea
900
700
900
INNER MEDULLA
1200
1200
1200

- **As shown in the diagram in the descending limb water goes out passively and Na enters in causing built up of salt concentration. The ascending limb is impermeable to water & pump out Na to build a concentration gradient of salt on both sides(In interstial fluid). Due to this gradient when urine comes down in collecting tubule it meets with a salt gradient of higher concentration. Walls of collecting duct are permeable to water. So water gets reabsorbed thus minimizing water loss.**

- **In this system urine follows in counter current manner i.e. downward → upward → downward & higher concentration gradient is formed or multiple concentration gradient is formed. Hence the system is known as counter current multiplier system.**