Biology 224
Human Anatomy and Physiology II
Week 8; Lecture 1; Monday
Dr. Stuart S. Sumida

Excretory Physiology

The following ELEVEN slides are review. They will not be covered in lecture, but will be useful for studying.

The Nephron and Counter Current Exchange Mechanisms

Counter Current Exchange:

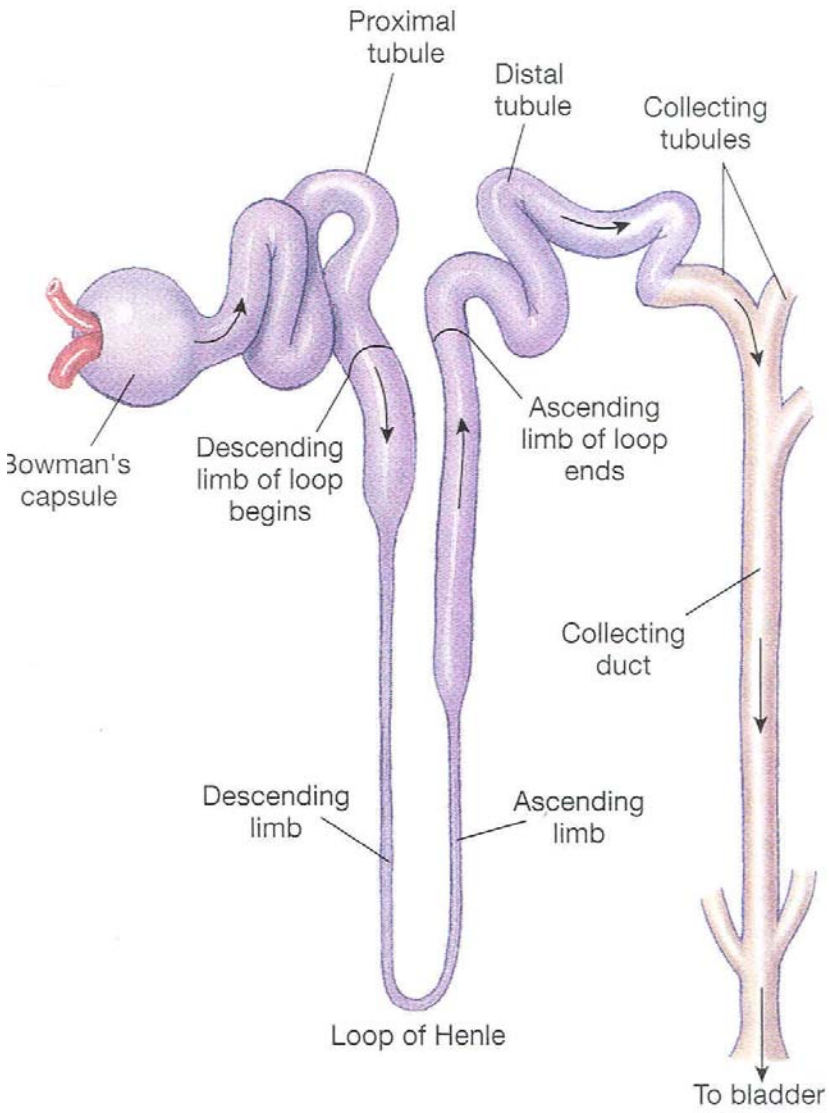
A pair of adjacent channels containing fluid is flowing in opposite directions AND having a gradient directed between the two channels.

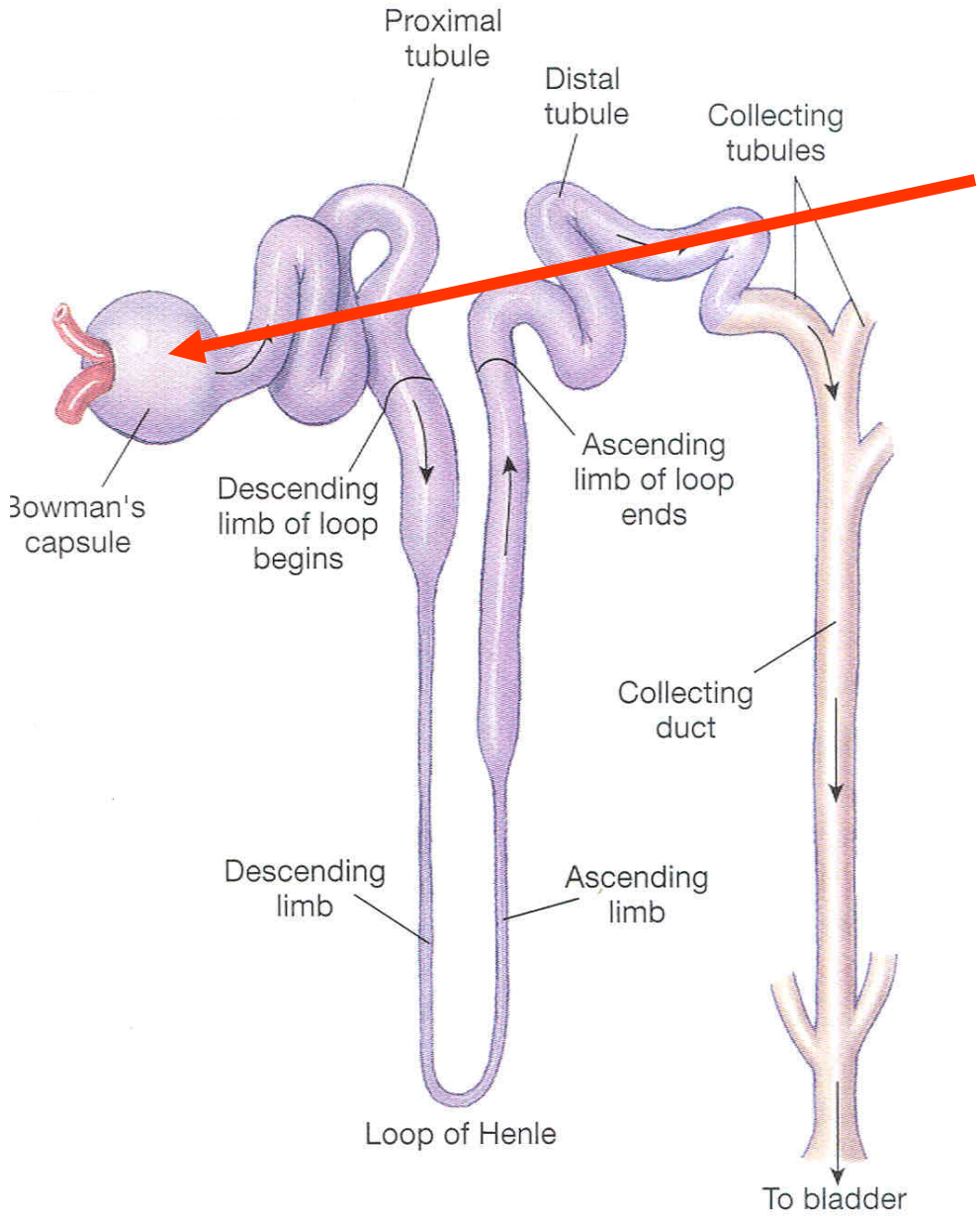
(When fluids in adjacent tubes flow in the same direction, materials in each come to equilibrium at similar concentrations.)

(When fluids in adjacent tubes flow in opposite directions, greater differences between the tubes may be generated.)

When fluids in adjacent tubes flow in opposite directions, greater differences between the tubes may be generated AT OPPOSITE ENDS.

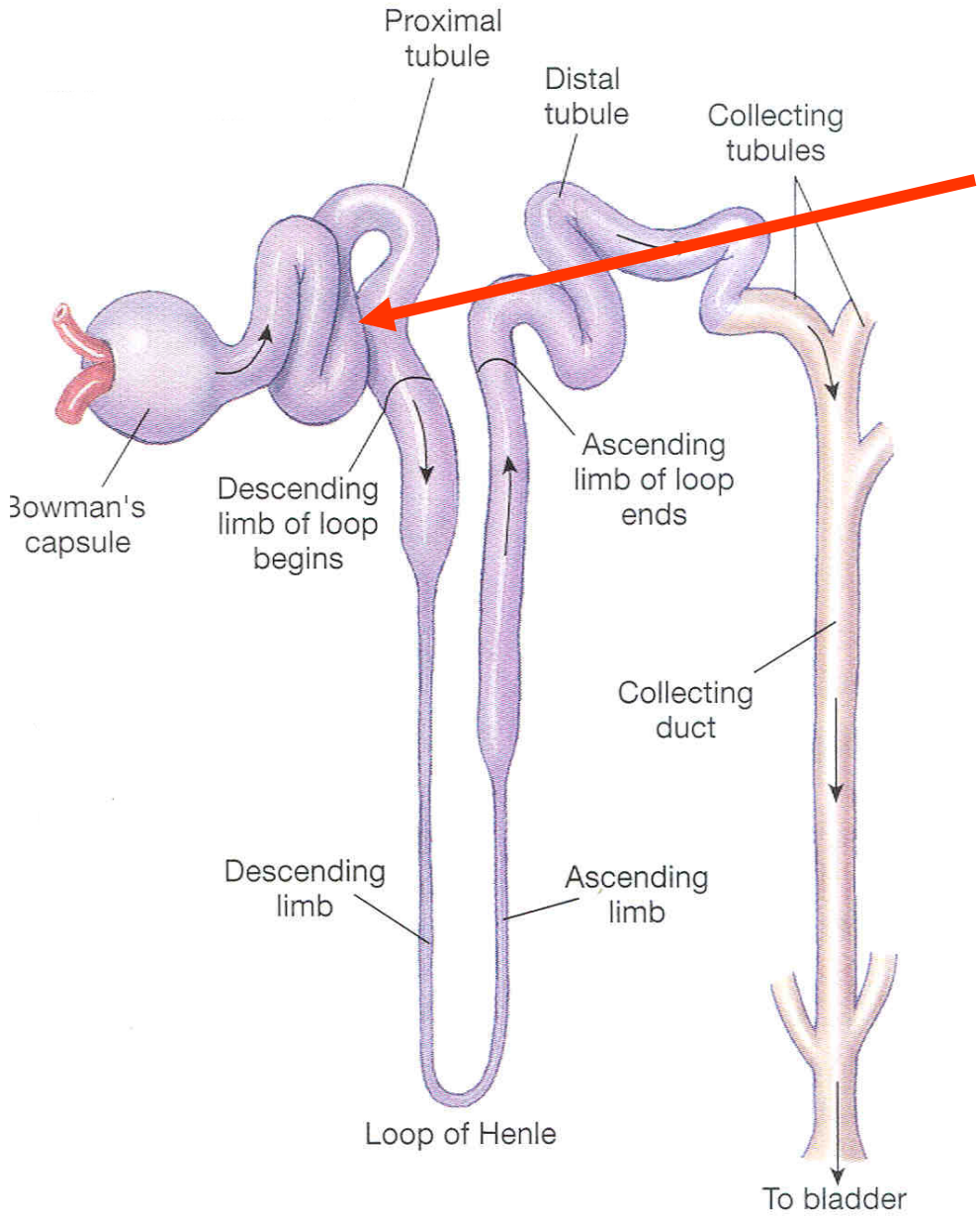
The Nephron


Proximal tubule
Distal tubule
Collecting tubules
Bowman's capsule
Descending limb of loop begins
Ascending limb of loop ends
Collecting duct
Descending limb
Ascending limb
Loop of Henle
To bladder



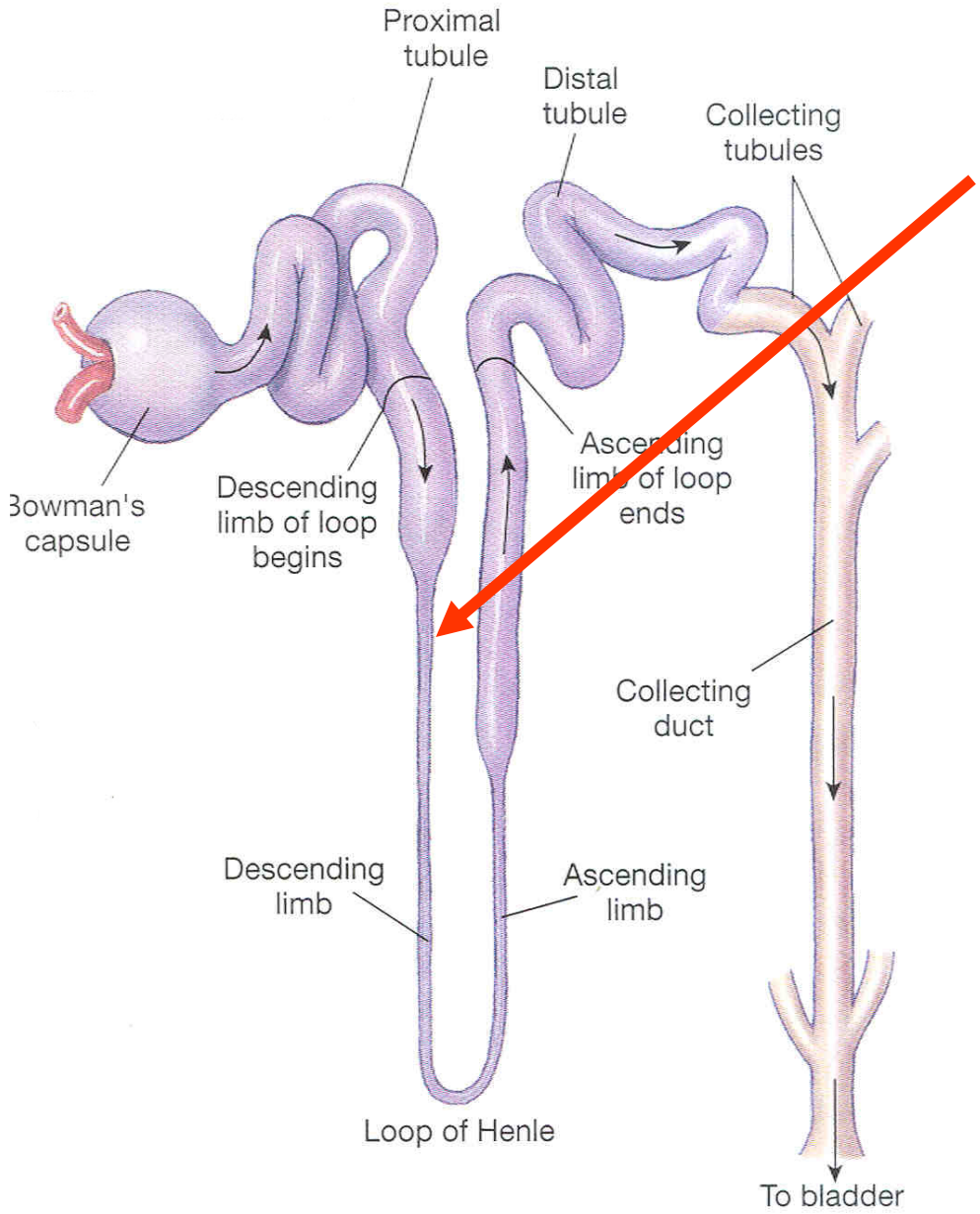
BOWMAN'S CAPSULE:

A spherical capsule around glomerulus (blood vessels).



PROXIMAL CONVOLUTED TUBULE:

About 75% of sodium is removed from fluid here (by active transport, chlorine follows passively.)

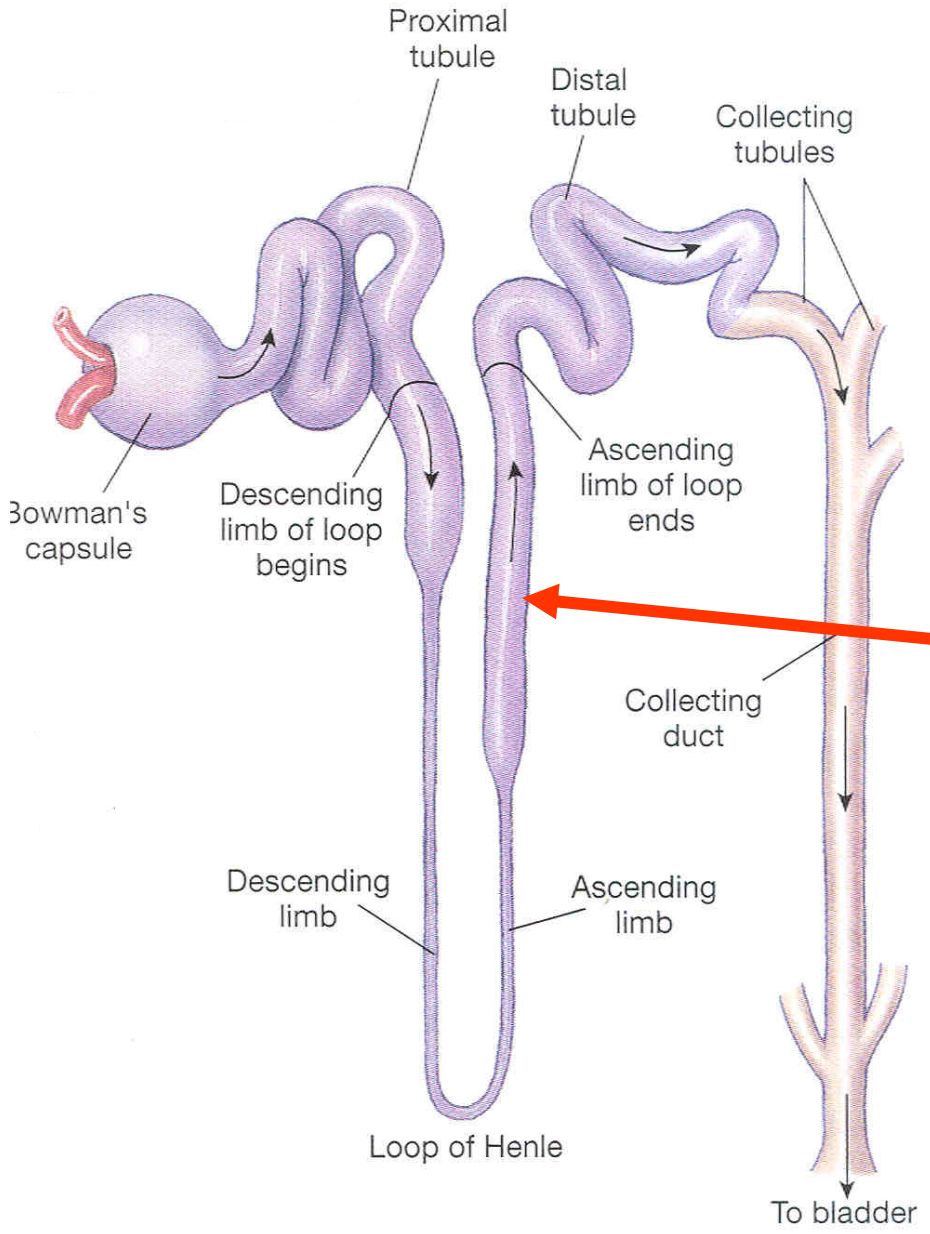


LOOP OF HENLE:

The counter current exchanger:

DESCENDING LOOP OF HENLE:

Permeable to water and other solutes.

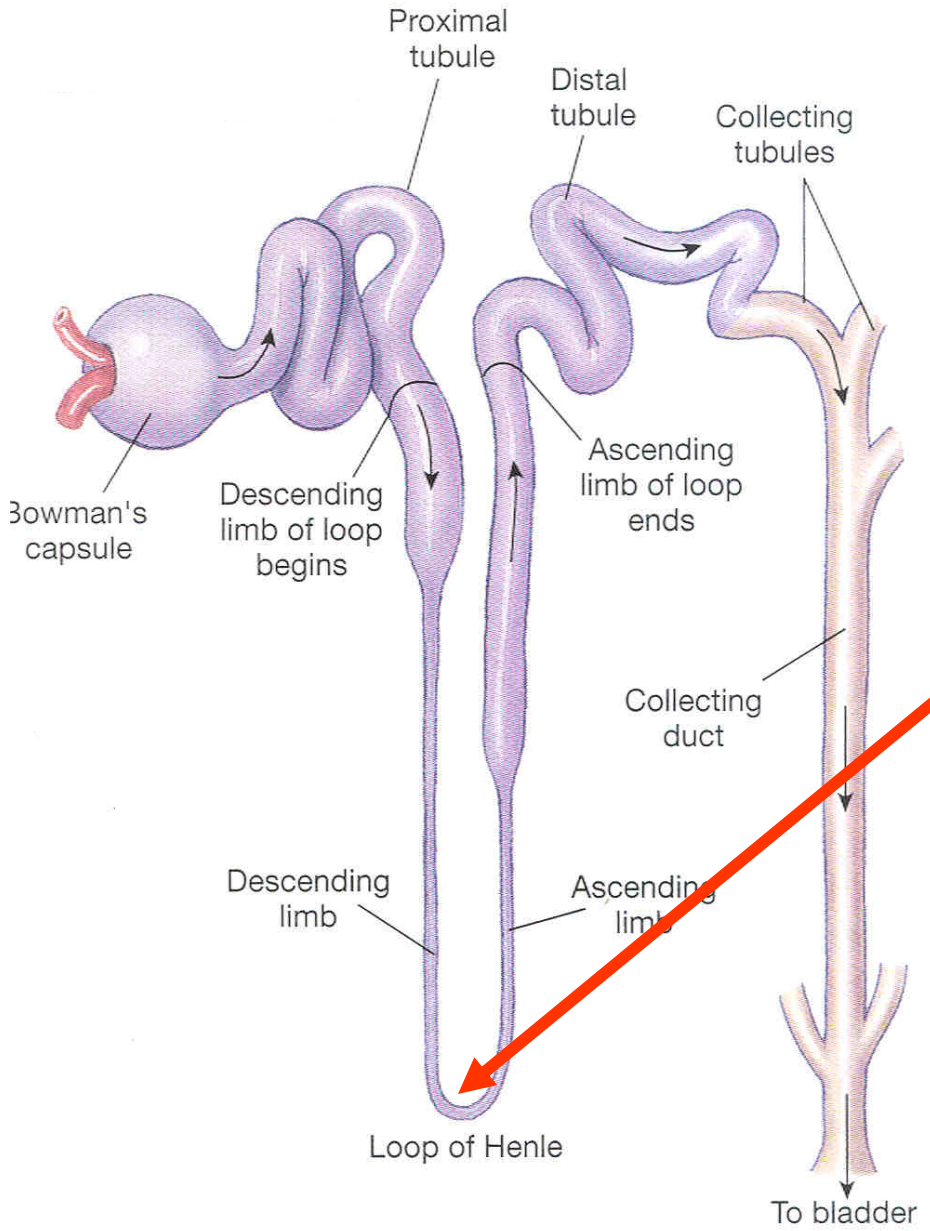


LOOP OF HENLE:

The counter current exchanger:

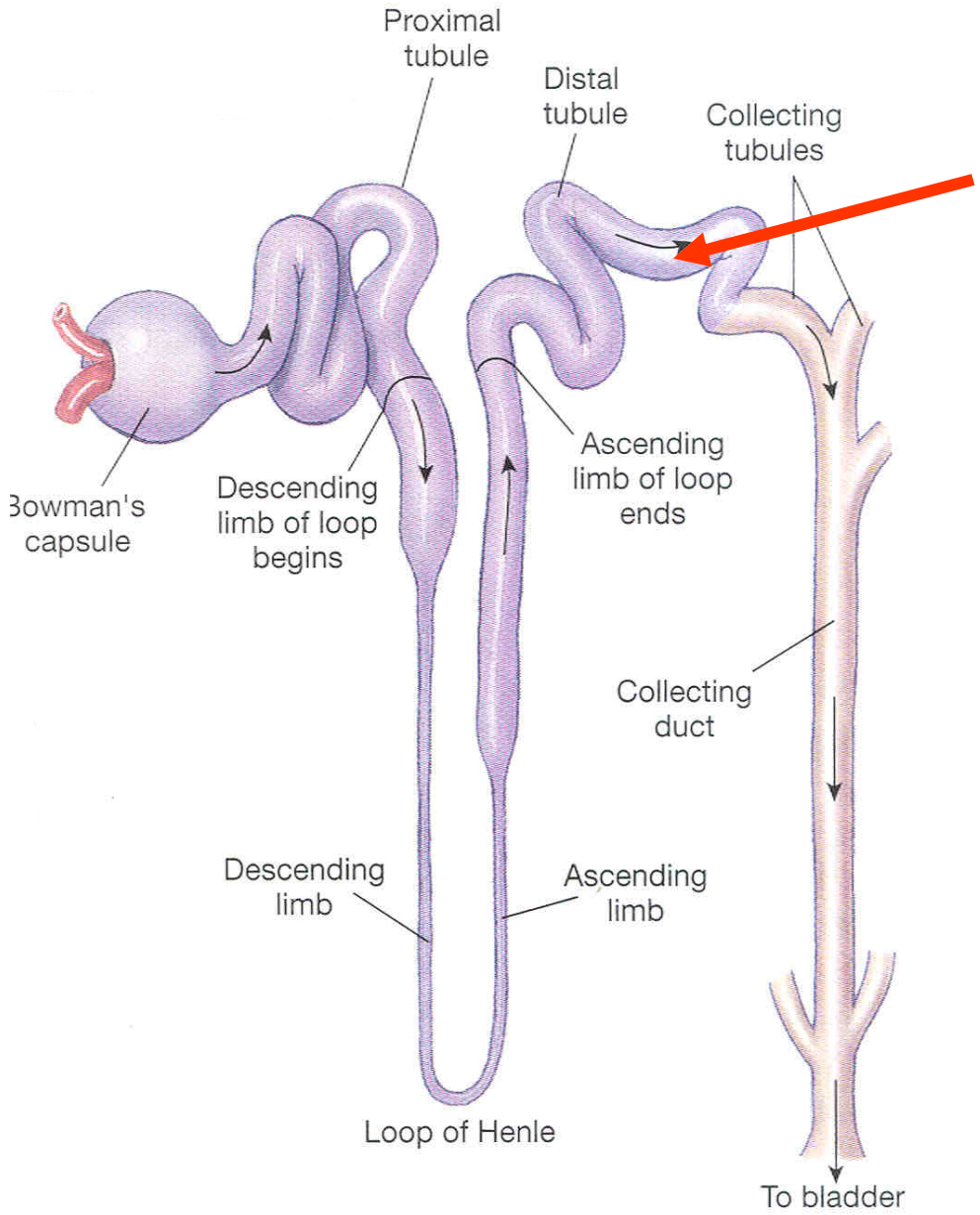
ASCENDING LOOP OF HENLE:

Chlorine ions--active transport out. Sodium follows. Water does NOT.



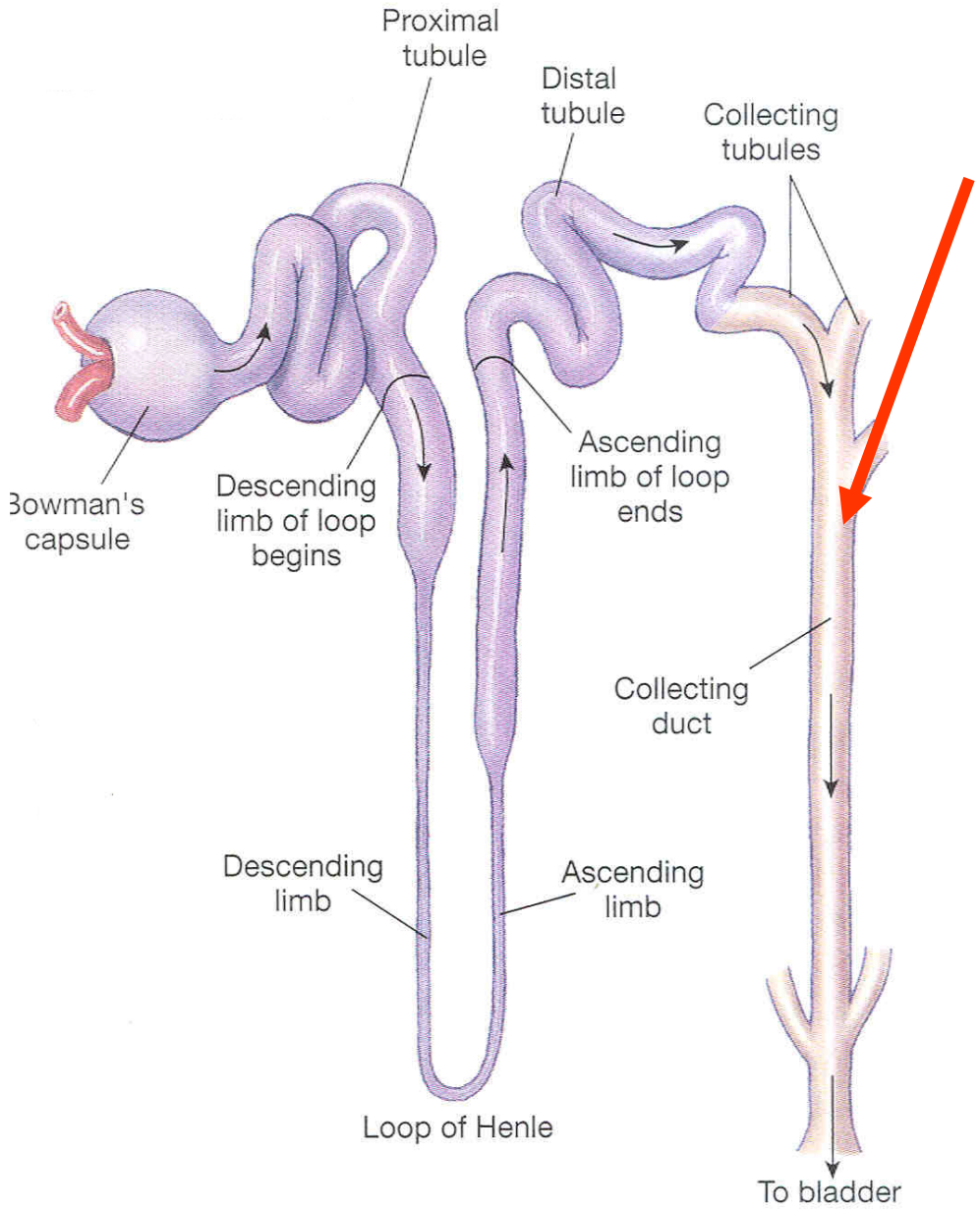
LOOP OF HENLE:

The counter current exchanger sets up a gradient of more salt toward turn in loop, less near convoluted tubules.



DISTAL CONVOLUTED TUBULE:

NaCl, Potassium, ammonia, carbonate removed here.



COLLECTING TUBULE:

Passes parallel to Loop of Henle, THROUGH PROGRESSIVELY MORE CONCENTRATED INTERSTITIAL SPACE.

In Collecting Tubule, water wants to move from region of higher to lower “water concentration” (OSMOSIS). The tendency to do this increases as it passes through more distal regions of collecting tubule.

VASCULARIZATION OF KIDNEYS

Renal Arteries are branches of descending aorta. Ultimately, branches of it give rise to glomeruli.

Kidneys drained by Renal Veins which dump into inferior vena cava. (As body wall structures, they DON NOT dump into hepatic portal system.

INNERVATION OF KIDNEYS

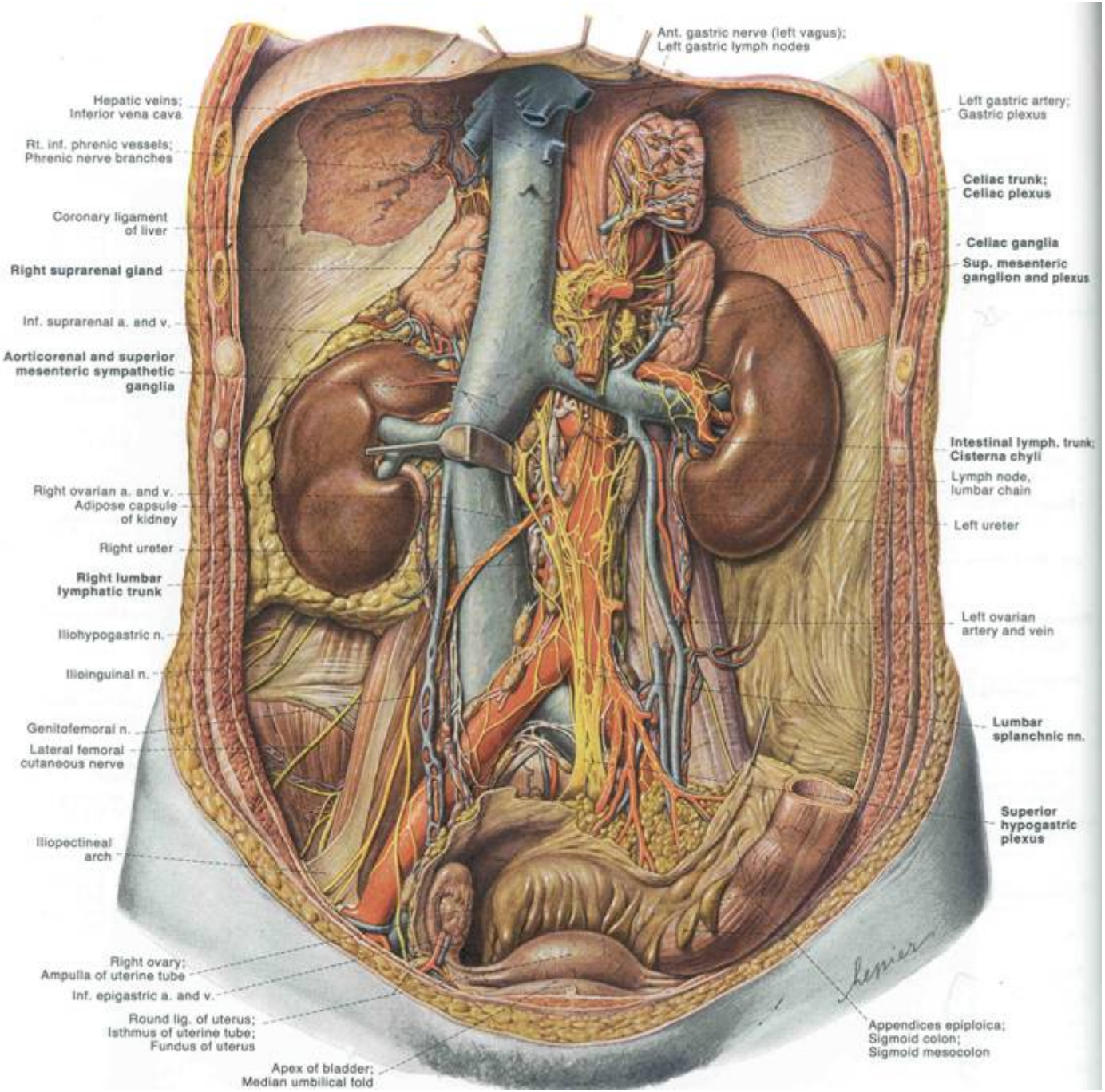
Sympathetic Innervation: Lower thoracic, upper lumbar, T12-L2. Synapse in nearby celiac ganglion.

Sympathetic Function: constricts blood flow to kidneys, decreasing overall kidney output.

INNERVATION OF KIDNEYS

Parasympathetic Innervation: Vagus nerve (of course!) Synapse on target organ.

Parasympathetic Function: increases blood flow to kidneys, increasing kidney filtration function.


Ant. gastric nerve (left vagus); Left gastric lymph nodes
Hepatic veins; Inferior vena cava
Rt. inf. phrenic vessels; Phrenic nerve branches
Coronary ligament of liver
Right suprarenal gland
Inf. suprarenal a. and v.
Aorticorenal and superior mesenteric sympathetic ganglia
Right ovarian a. and v.
Adipose capsule of kidney
Right ureter
Right lumbar lymphatic trunk
Iliohypogastric n.
Ilioinguinal n.
Genitofemoral n.
Lateral femoral cutaneous nerve
Iliopectineal arch
Right ovary; Ampulla of uterine tube
Inf. epigastric a. and v.
Round lig. of uterus; Isthmus of uterine tube; Fundus of uterus
Apex of bladder; Median umbilical fold
Left gastric artery; Gastric plexus
Celiac trunk; Celiac plexus
Celiac ganglia
Sup. mesenteric ganglion and plexus
Intestinal lymph. trunk; Cisterna chyli
Lymph node, lumbar chain
Left ureter
Left ovarian artery and vein
Lumbar splanchnic nn.
Superior hypogastric plexus
Appendices epiploica; Sigmoid colon; Sigmoid mesocolon

VASCULARIZATION OF BLADDER

Superior and Inferior Vesicular Arteries (Right and Left)

Superior and Inferior Vesicular Veins (Right and Left)

INNERVATION OF BLADDER

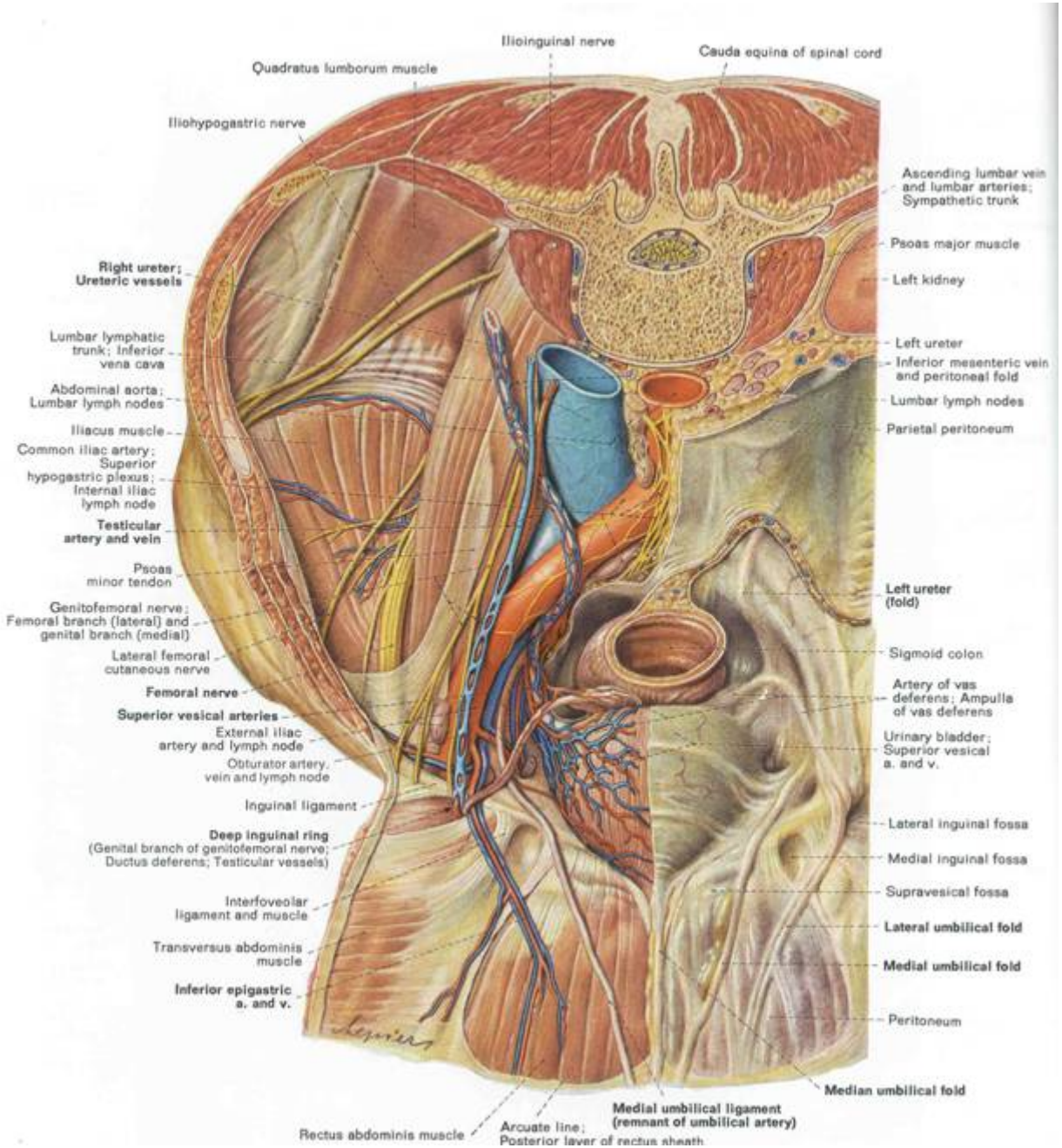
Sympathetic Innervation: L2, L3.

Sympathetic Function: inhibit constriction of muscular wall of bladder, contract sphincters.

INNERVATION OF BLADDER

Parasympathetic Innervation: S2-4. Synapse right on bladder wall.

Parasympathetic Function: stimulate constriction of muscular wall of bladder, relax sphincters.


Ilioinguinal nerve
Cauda equina of spinal cord
Quadratus lumborum muscle
Iliohypogastric nerve
Ascending lumbar vein and lumbar arteries; Sympathetic trunk
Psoas major muscle
Right ureter; Ureteric vessels
Left kidney
Left ureter
Lumbar lymphatic trunk; Inferior vena cava
Inferior mesenteric vein and peritoneal fold
Abdominal aorta; Lumbar lymph nodes
Lumbar lymph nodes
Iliacus muscle
Parietal peritoneum
Common iliac artery; Superior hypogastric plexus; Internal iliac lymph node
Testicular artery and vein
Psoas minor tendon
Left ureter (fold)
Genitofemoral nerve; Femoral branch (lateral) and genital branch (medial)
Sigmoid colon
Lateral femoral cutaneous nerve
Artery of vas deferens; Ampulla of vas deferens
Femoral nerve
Superior vesical arteries
External iliac artery and lymph node
Urinary bladder; Superior vesical a. and v.
Obturator artery, vein and lymph node
Inguinal ligament
Lateral inguinal fossa
Deep inguinal ring (Genital branch of genitofemoral nerve; Ductus deferens; Testicular vessels)
Medial inguinal fossa
Supravesical fossa
Interfoveolar ligament and muscle
Lateral umbilical fold
Transversus abdominis muscle
Medial umbilical fold
Inferior epigastric a. and v.
Peritoneum
Median umbilical fold
Medial umbilical ligament (remnant of umbilical artery)
Rectus abdominis muscle
Arcuate line; Posterior layer of rectus sheath

HORMONAL CONTROL OF EXCRETION

ANTIDIURETIC HORMONE (ADH) -- increases permeability of collecting tubule to water. More water CAN ESCAPE OUT OF IT INTO THE INCREASING CONCENTRATION GRADIENT that was set up by the Loops of Henle.

HORMONAL CONTROL OF EXCRETION

Inhibition of ADH -- decreases permeability of collecting tubule to water. Less water CAN ESCAPE OUT OF IT INTO THE INCREASING CONCENTRATION GRADIENT that was set up by the Loops of Henle. (More water retained in a less concentrated urine.)

EXAMPLES OF DIRUETICS:

- Caffiene
- Hops in beer
- Alcohol
- Pepper or chili (hot spices)
- Mustard
- Large quantities of Vitamin C

KIDNEYS AND BLOOD PRESSURE REGULATION

Because kidneys receive so much vascularization, they are intimately tied to fluid (water balance) regulation, and therefore blood pressure regulation.

WATER BALANCE:

The Amount of water to removed or retained is controlled in part by the kidneys.

Water Gain: Ingested food and fluid; metabolic water

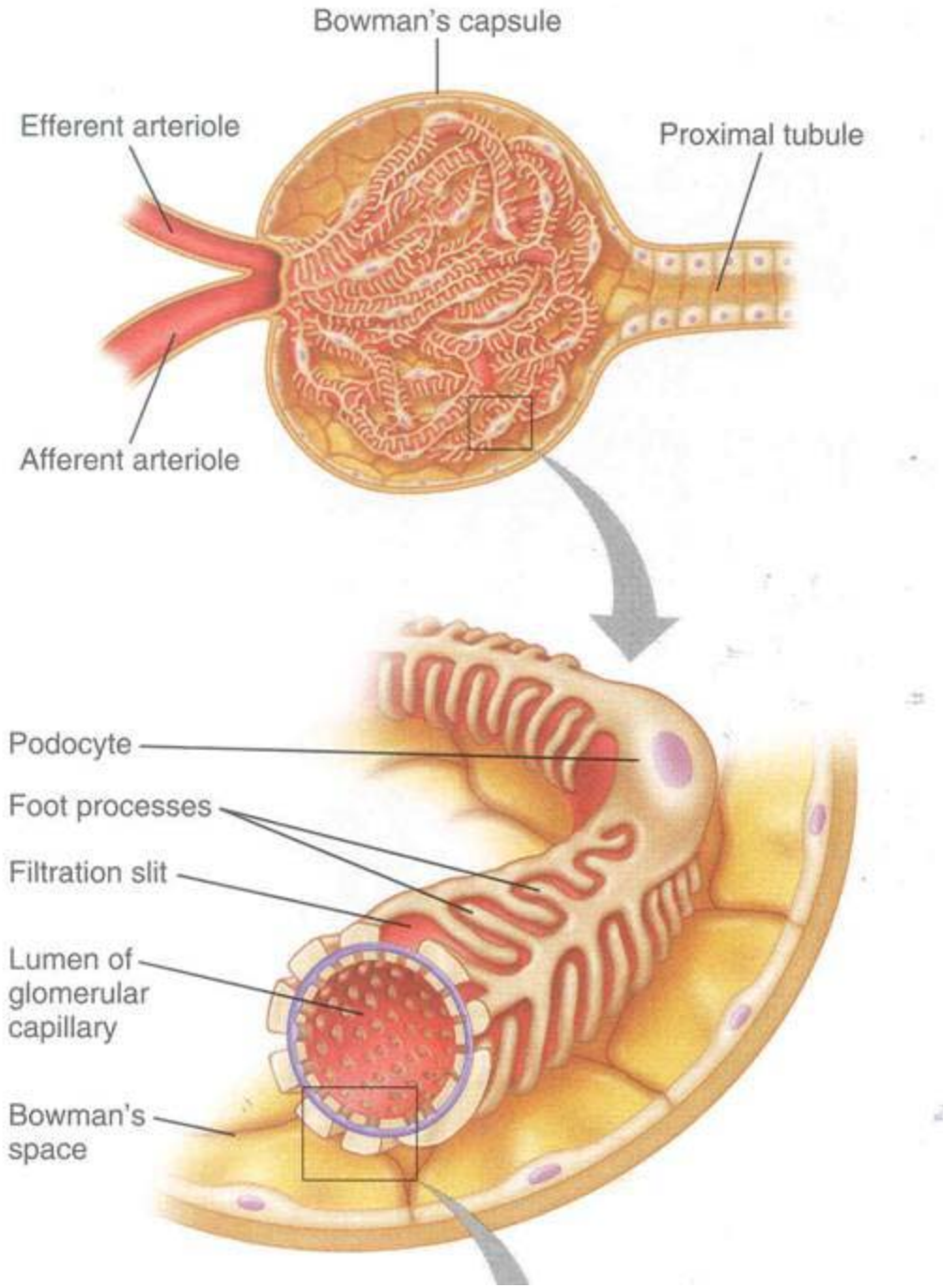
Carbohydrates + Oxygen ➔ Water + CO_2

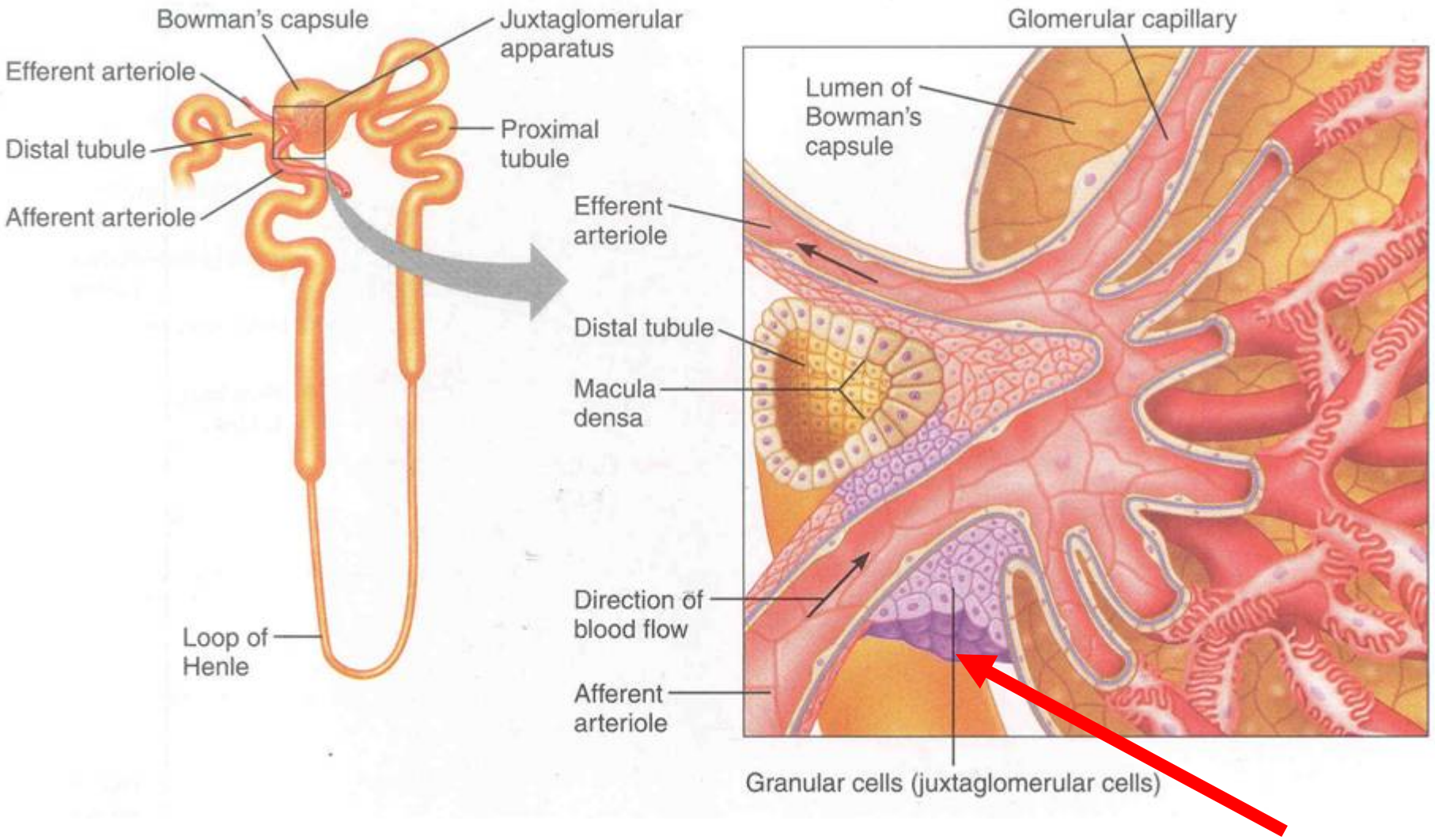
$C_2H_{12}O_6$ + O_2 ➔ H_2O + CO_2

WATER BALANCE:

The Amount of water to removed or retained is controlled in part by the kidneys.

Water Loss: urine, feces, sweat, evaporation at lungs or skin.


Bowman's capsule
Efferent arteriole
Proximal tubule
Afferent arteriole
Podocyte
Foot processes
Filtration slit
Lumen of glomerular capillary
Bowman's space



A change in fluid pressure in the extracellular region is sensed by the JUXTAGLOMERULAR CELLS.

OVERLAP:

INTRODUCING THE ENDOCRINE SYSTEM WITH EXAMPLES FROM THE EXCRETORY SYSTEM.

ENDOCRINE SYSTEM

HORMONAL COMMUNICATION

Note: Nervous system is predominantly electrical in nature, though neurotransmitters are chemicals that diffuse between neurons. The synaptic cleft is very narrow, so nervous transmission remains high.

ENDOCRINE structures communicate by secreting chemicals INTO THE CIRCULATORY SYSTEM.

Because the endocrine system is a system wherein chemical diffuse through the circulatory system, it is slower, but often long-klastnig in effect.

TYPES OF CHEMICAL REGULATGORY AGENTS

•Simple, Widespread, Nonspecific (e.g. carbon dioxide, oxygen, calcium, etc.)

•More Complex and Specifically MESSENGERS.

Animals have specialized tissues that secrete regulatory molecules into the interstitial tissue and blood, and act on remote TARGET CELLS within the same organism (person).

The tissues the produce these molecules are ENDOCRINE GLANDS. The messenger molecules are called HORMONES.

By interaction of a hormone molecule with particular RECEPTOR MOLECULES, there is initiated in the target cell a series of steps that influence one or more aspects of the physiology or metabolism of the target cell.

Although hormones come into contact with all tissues in the body by virtue of their travel through the cardiovascular system, only cells that contain receptors specific for the hormone are affected by the hormone. These types of cells are or organs are called TARGET CELLS or TARGET ORGANS.

PROPERTIES OF HORMONES

1. Hormones are produced and secreted by endocrine cells in TRACE AMOUNTS.
2. Hormones circulate in the blood to reach all tissues.
3. But, hormones react only with specific receptor molecules present in certain target cells/tissues.
4. Hormones act in CATALYTIC QUATIES, frequently activating enzymes.
5. A single hormone may have multiple effects on a single target tissue, or on several different target tissues.

Remember!!!

Just because a structure does one thing, doesn’t meant it can’t do other things.

Many structures are endocrine organs, and have other functions as well.

CLASSIFICATION OF HORMONES
(Hormone Classification by Function)

- Kinetic Effects – generally MOVEMENTS OF SOME KNID. E.g. pigment migration, muscle contraction, glandular secretion.

- Metabolic Effects – consisting mainly of changes in the RATE and balance of chemical reactions and concentrations in the body.

- Morphogenetic Effects – have to do with GROWTH and DIFFERENTIATION.

REGULATION OF HORMONE SECRETION

Generally modulated by NEGATIVE FEEDBACK. That is, the concentration of hormone itself (once it reaches a certain critical level or concentration), or a products of the response to the hormone by a target tissue, willhave an INHIBITORY EFFEECT on the synthetic or secretory processes responsible for the original production of the hormone.

Here, we will use a kidney function to demonstrate an endocrine feedback loop.

KIDNEYS AND BLOOD PRESSURE RUGULATION
THE "RENIN-ANGIOTENSIN SYSTEM"

1. Decrease in blood pressure causes decrease in amount of extracellular fluid.
2. Decrease in extracellular pressure near distal convoluted tubule causes juxtaglomerular cells to release the hormone RENIN.
3. RENIN in blood stream converts the liver enzyme ANGIOTENSINOGEN into ANGIOTENSIN I.
4. ANGIOTENSIN CONVERTING ENZYME (in the lung) converts Angiotensin I into ANGIOTENSIN II.
5. Angiotensin II causes ADRENAL GLAND to secrete/release ALDOSTERONE.
6. Aldosterone is a vasoconstrictor (increasing blood pressure) and INCREASES COLLECTING DUCT PERMIABILITY.
7. Urine volume decreased, fluid retained, blood volume increases, blood pressure up.

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KIDNEYS AND BLOOD PRESSURE RUGULATION
THE "RENIN-ANGIOTENSIN SYSTEM"

7:

- Urine volume decreased
- Fluid retained
- Blood volume increases
- Blood pressure up.