GENITOURINARY SYSTEM

Subsystem : Physiology
Lecture Title : Kidney overview
Lecture Date : 07.04.2020
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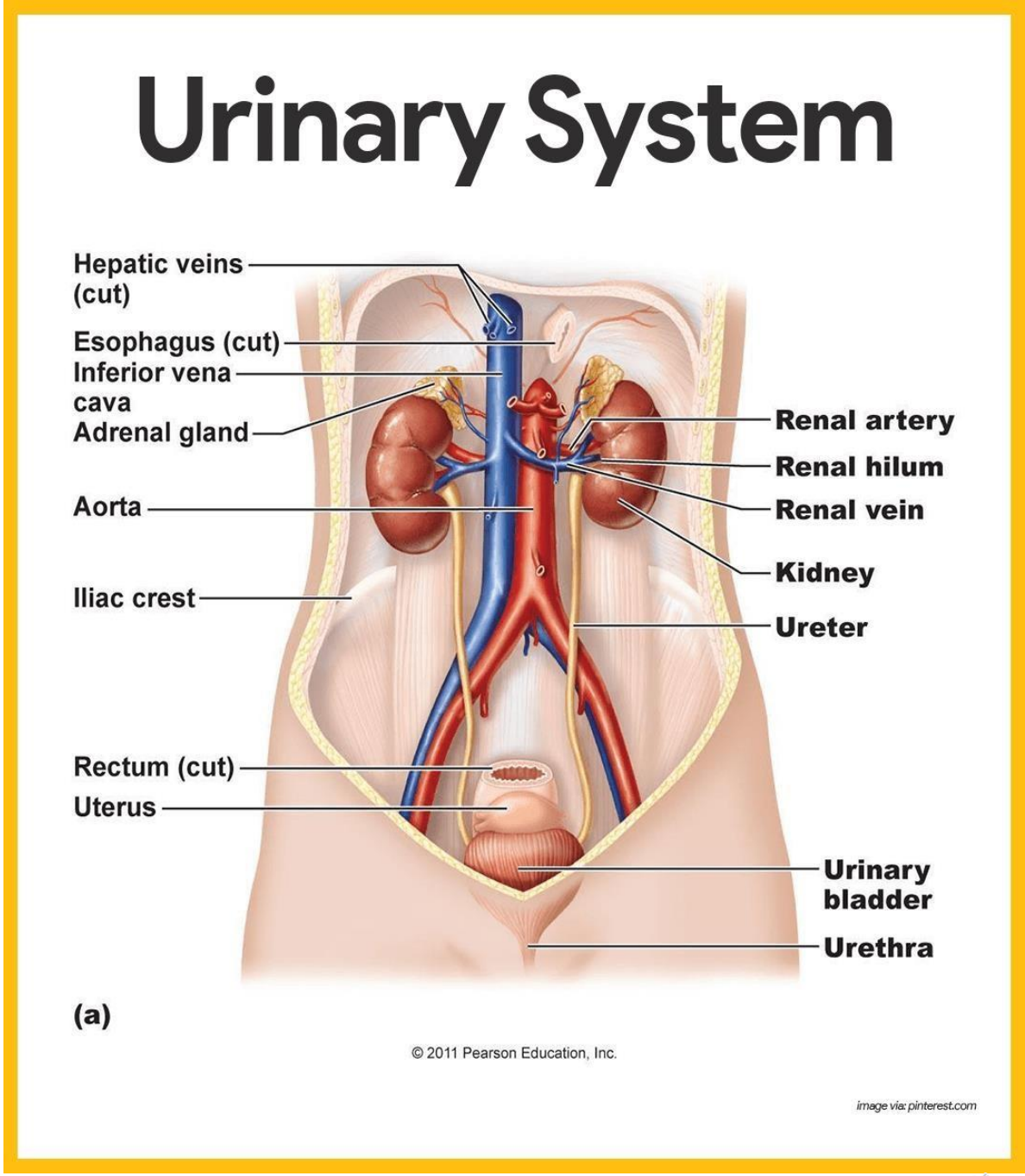
RENAL SYSTEM
lecture 1

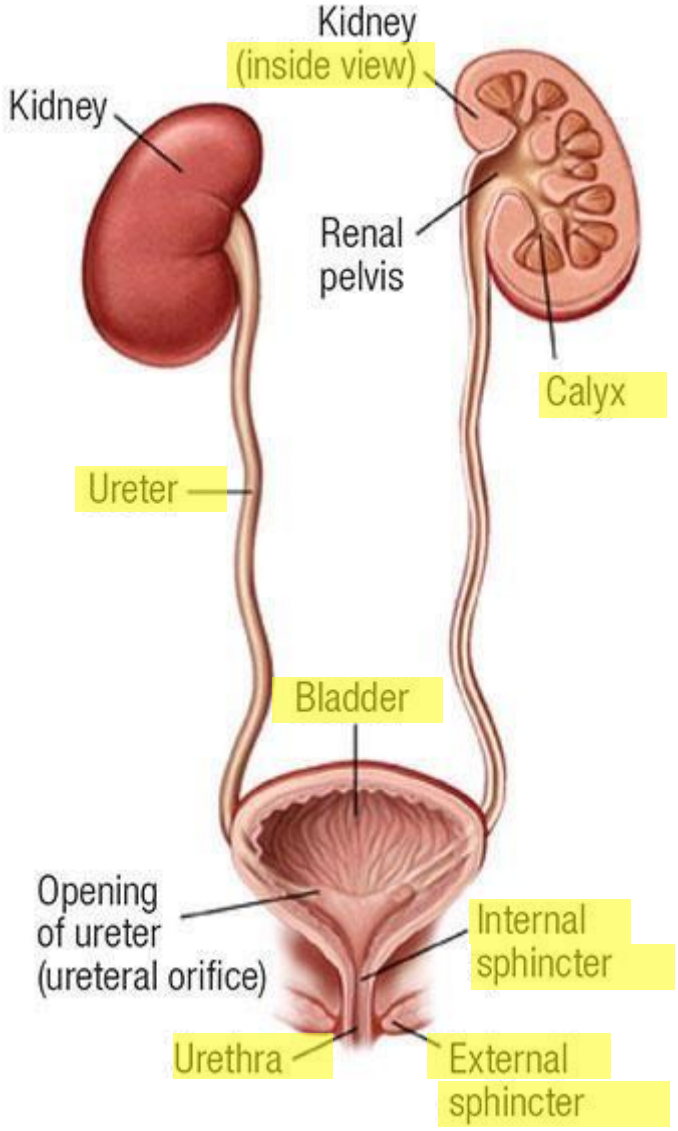
Kidney function, Nephron and Renal blood flow

^Brief anatomy of the renal system : we have 2 kidneys, 2 renal arteries, aorta, inferior vena cava, common iliac

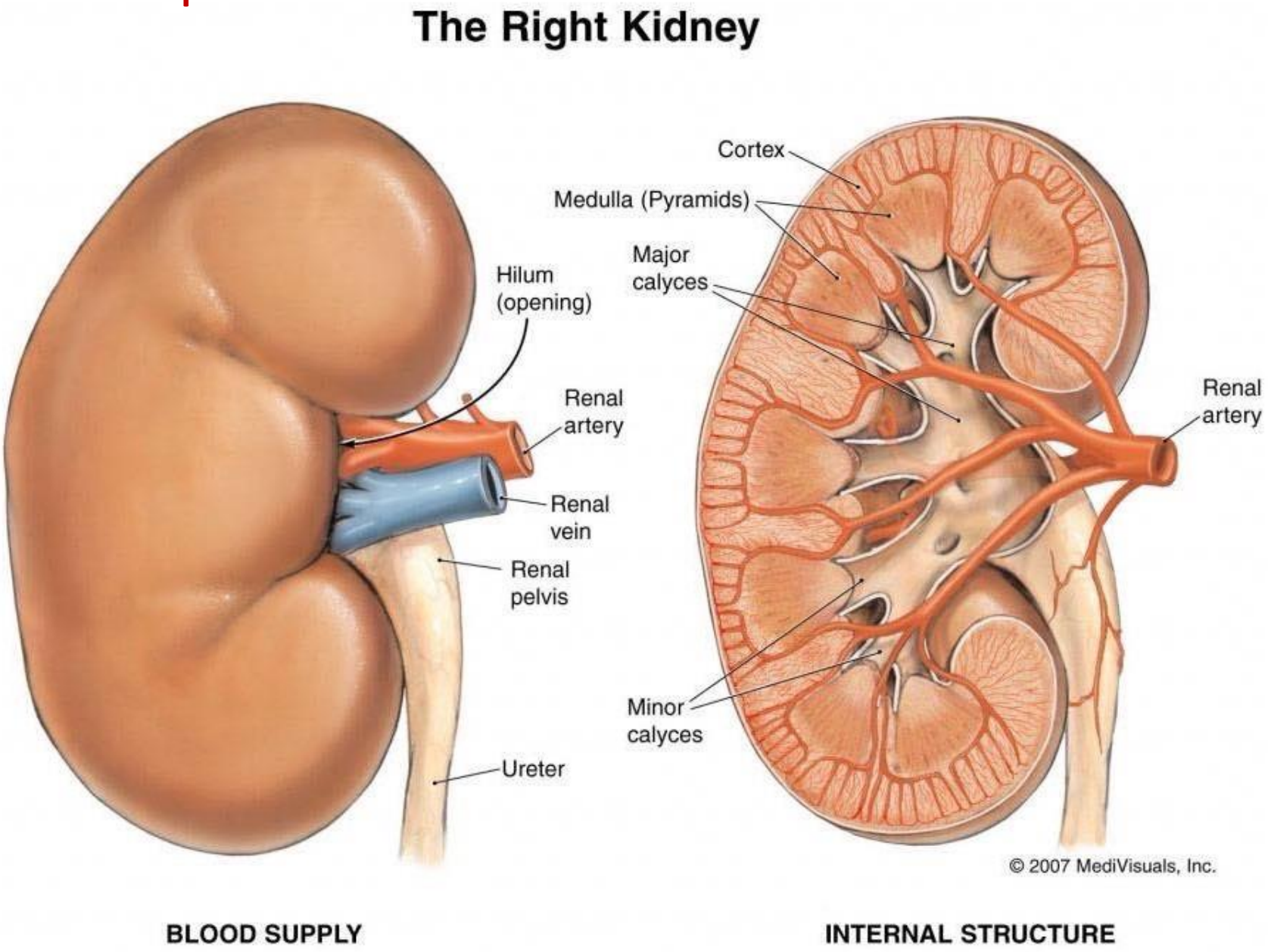
^One of the major roles of the kidneys is urine formation, it will pass urine to the ureter – then to the bladder – and finally to the urethra to be excreted out of the body

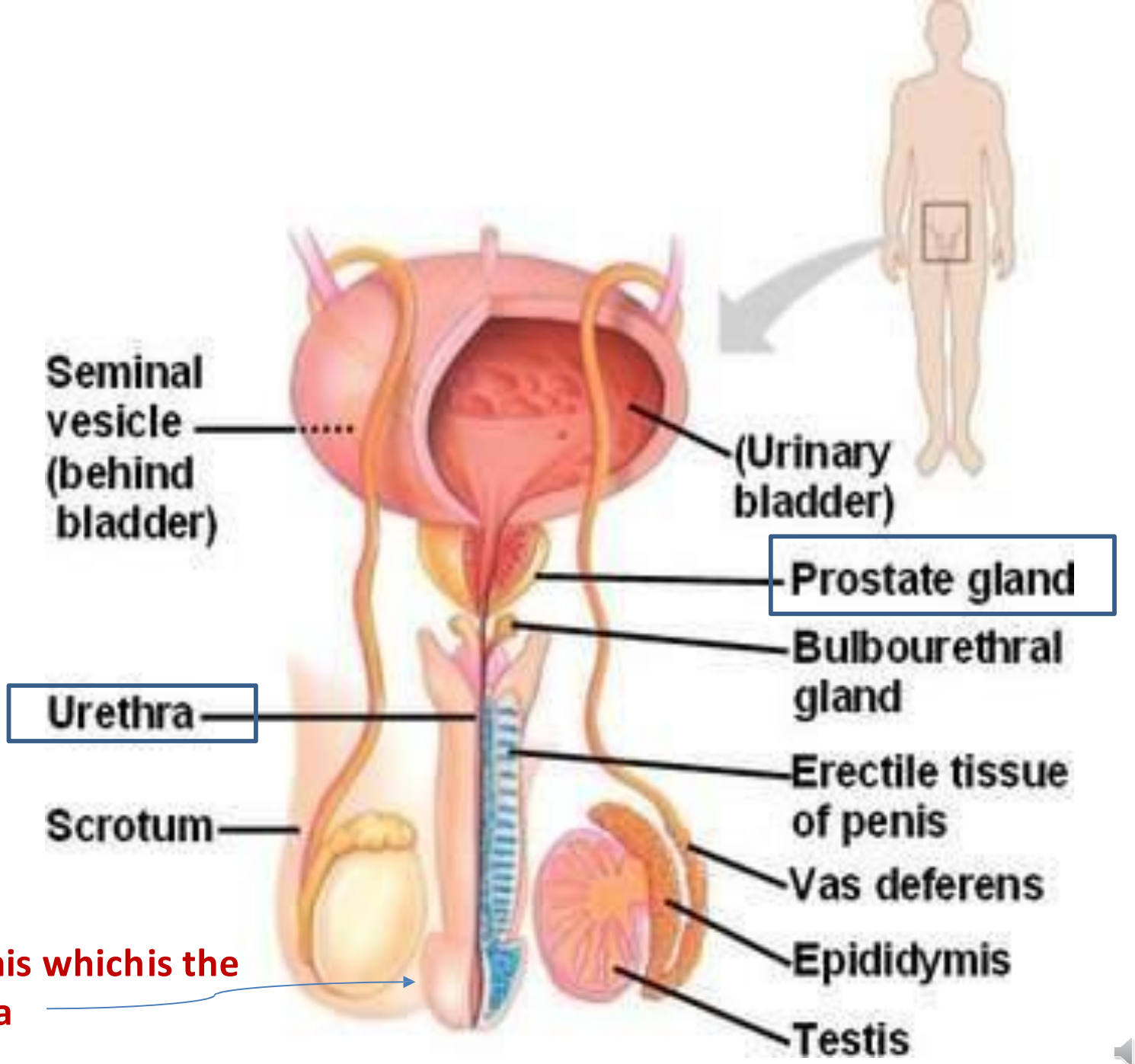


^The doctor mentioned all of these structures



^More detailed picture





^This is the penis whichis the external urethra

Functions:

1. Get rid of waste (ingested or metabolized)
2. Control the volume and composition of Body fluids
3. Regulation of water and electrolytes balances
4. Regulation of fluid osmolality
5. Regulation of Acid - Base balance **((bcz it's involved mainly in the excretion of the hydrogen ion according to the ph of the blood))**
6. Regulation of Arterial pressure
7. Secretion of hormones
8. Gluconeogenesis
9. Producing erythropoietin & renin. Converting vit. D

Water and electrolyte balance:

- Eating and drinking habits salts and other electrolytes might increase 10 folds daily or decrease 1/10 fold daily, with a slight or modest changes in ECF volume or (Plasma Na)
- **((Sometimes we eat/drink more than what we need, and sometimes we eat less than what we need … as far as the kidney function is normal everything will remain constant: ECV, ICV and osmolarity)).**

Excretion of metabolic waste and foreign chemicals :

1. Urea from amino acid
2. Creatinine from muscles
3. Uric acid from nucleic acid
4. Bilirubin from Hb breakdown
5. Pesticides, drugs, food additives.

Kidney Function

- **Regulation of arterial pressure: -**
  - Long-term: excreting Na and water
  - Short-term: renin secretion.
- **((long term regulation is concerned with regulation of blood pressure when we have an acute/sudden change which involve the baroreceptors (happen in changing position from supine to standing & vice versa) it takes about 30min for the renin/angiotensin to be secreted and then the excretion of NA/water will start (longer time))**
- **((Short term: it is not an acute regulation))**
- **Regulation of acid-base balance:** excreting acid or base urine (sulfuric & phosphoric acids) **((involves renal & respiratory systems))**
- **Regulation of erythrocyte production:** Secrete erythropoietin **((Increase erythropoietin to increase RBCs formation, decrease erythropoietin will decrease RBCs formation and this will occur in kidney disease))**

Kidney Function

- **Regulation of 1,25 dihydroxy vitamin D3 production:**

Kidneys produce active form of vit. D, by hydroxylating this vitamin .

- **Glucose synthesis:**

From a.a's and other precursors during prolonged fasting/ starvation.

Physiological anatomy:

1. General organization :
   - 2 kidneys posterior, outside peritoneal cavity. 150 gm, size of a clenched fist.
   - Outer :cortex
   - Inner :medulla: renal pyramids___papilla . renal pelvis major and minor calyces ___ureter .

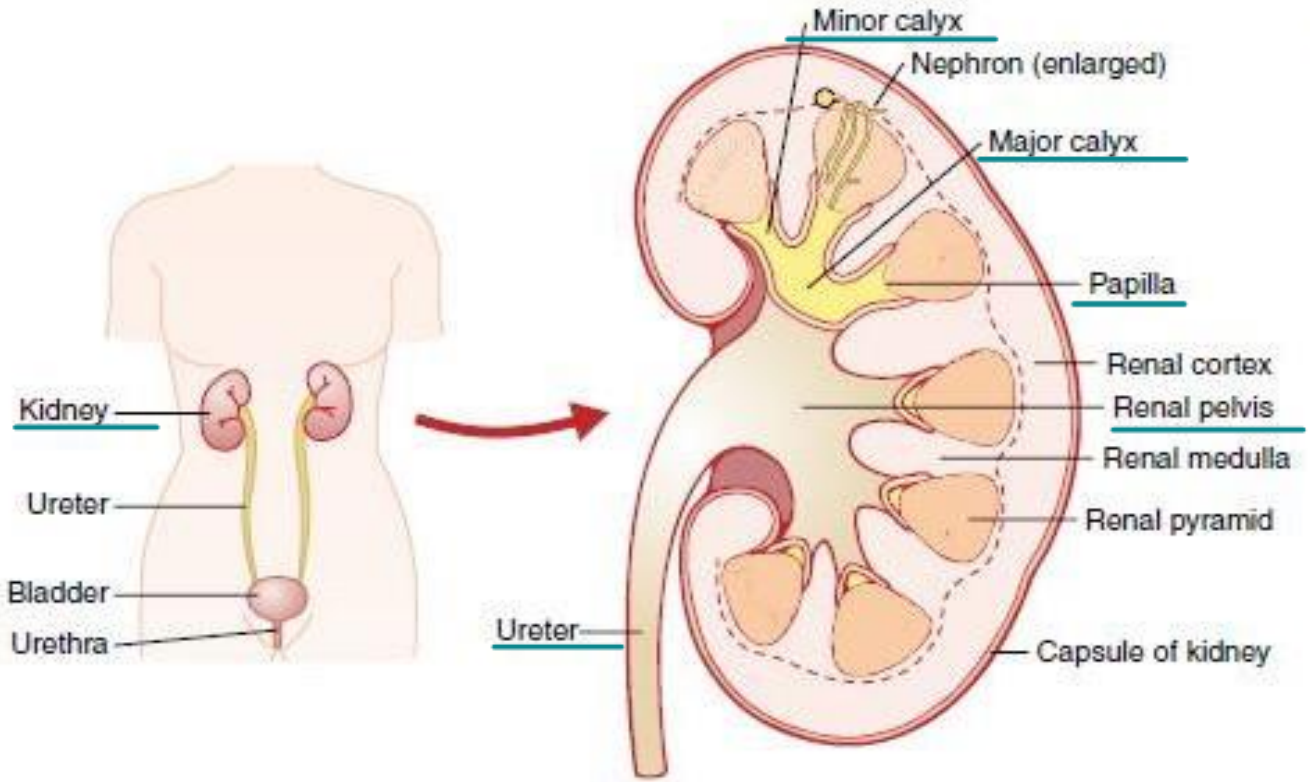


Figure 26-2 General organization
the kidneys and the urinary system.

Branches of Renal artery 1-5

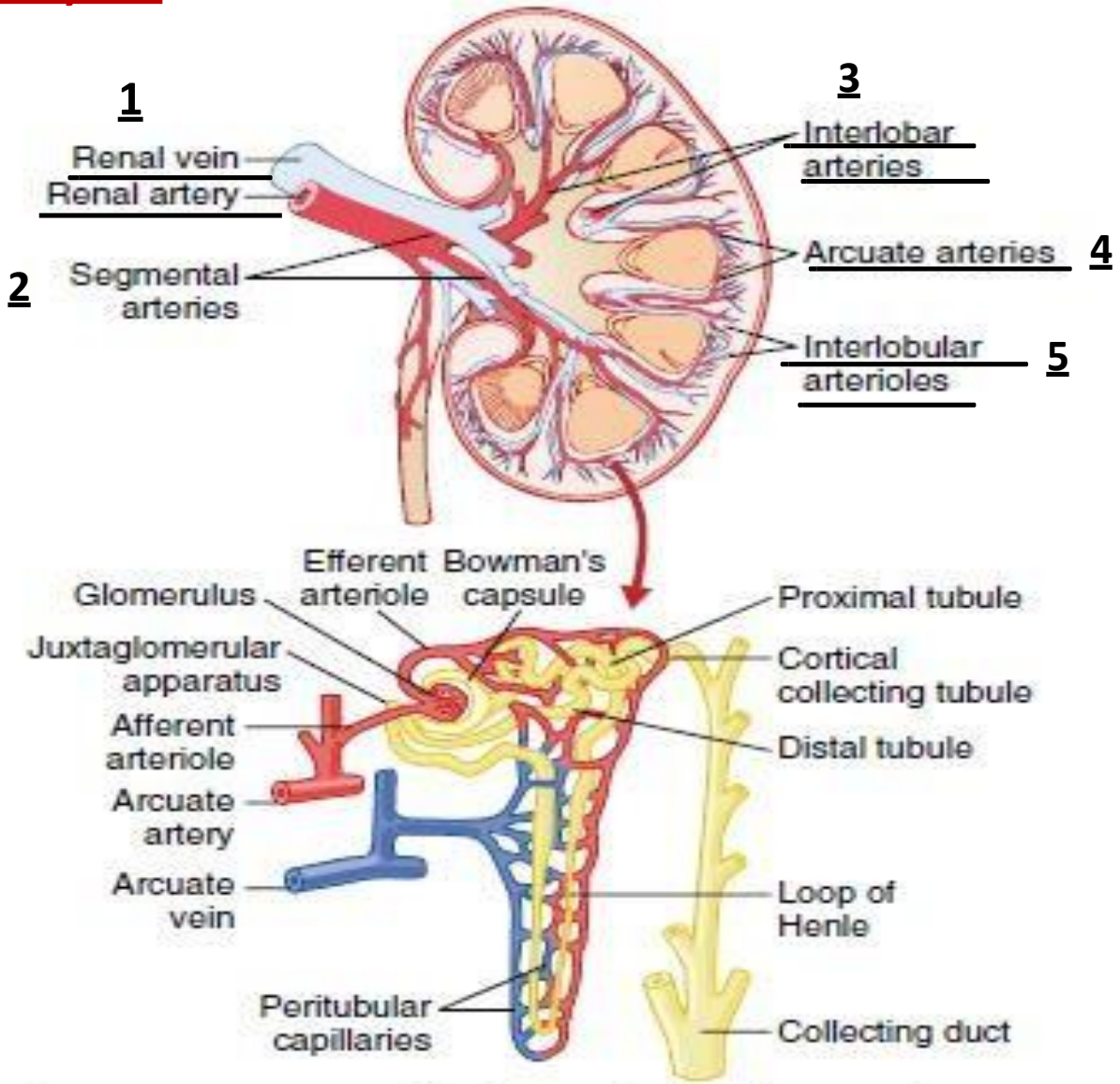
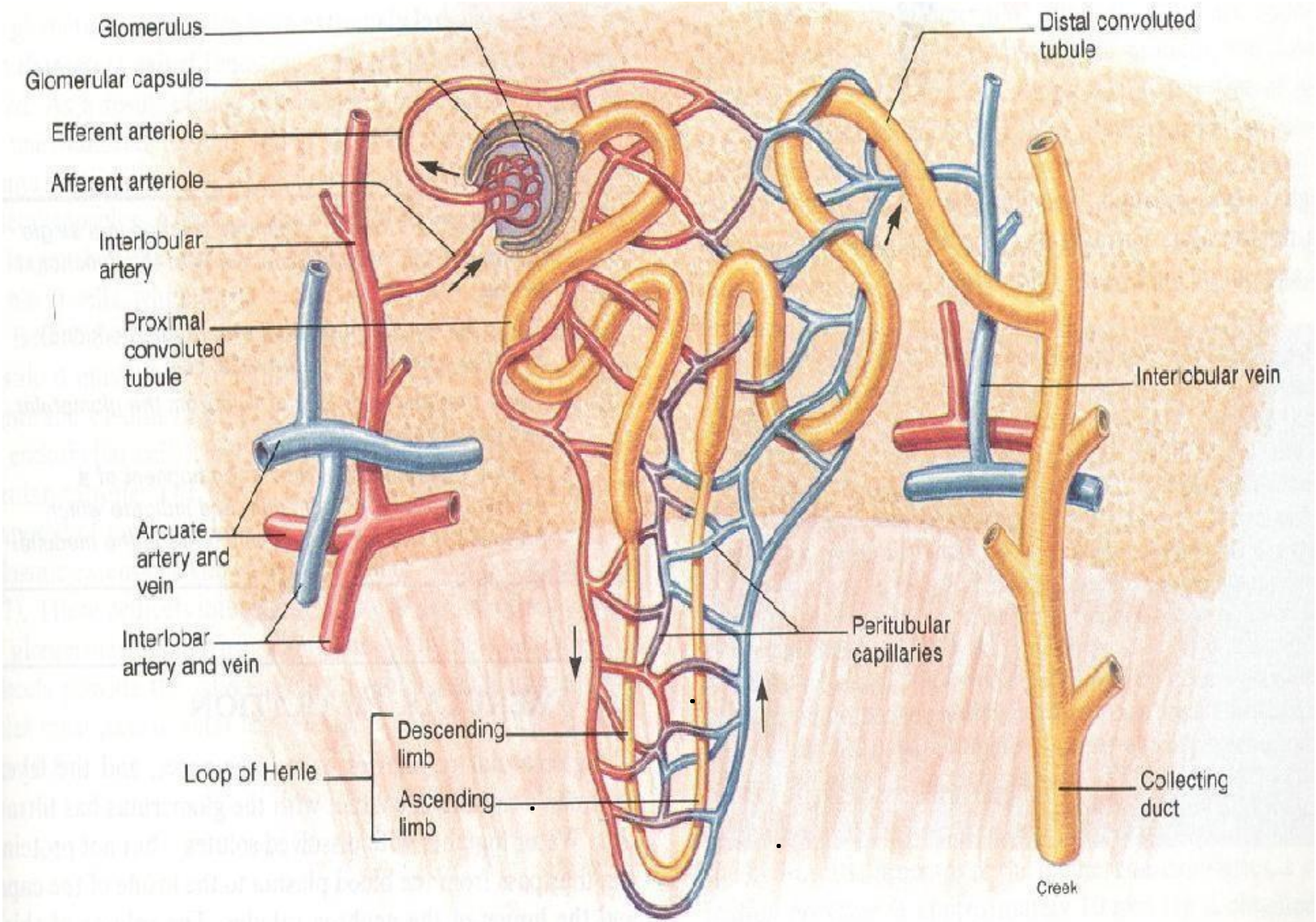
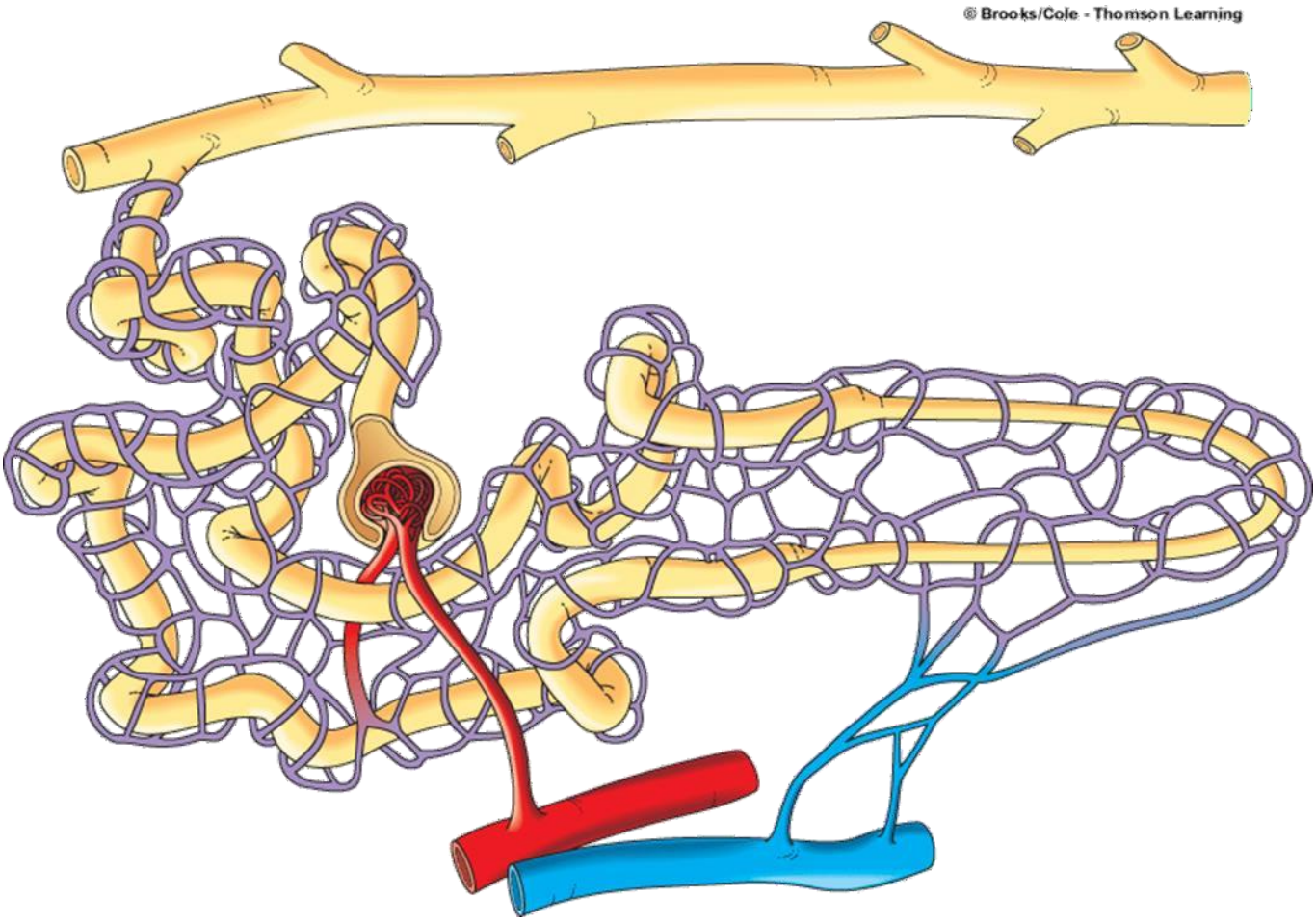


Figure 26-3 Section of the human kidney showing the major vessels that supply the blood flow to the kidney and schematic of the microcirculation of each nephron.

Structure of a nephron :



Nephron is the functional unit of a kidney : It is composed of
1- Glomerulus(juxtaglumerulus apparatus) 2-Proximal Renal tubules 3- loop on henle(ascending and descending) 4- distal tubule(have proximal part and late part) 5- collecting ducts 6- pelvis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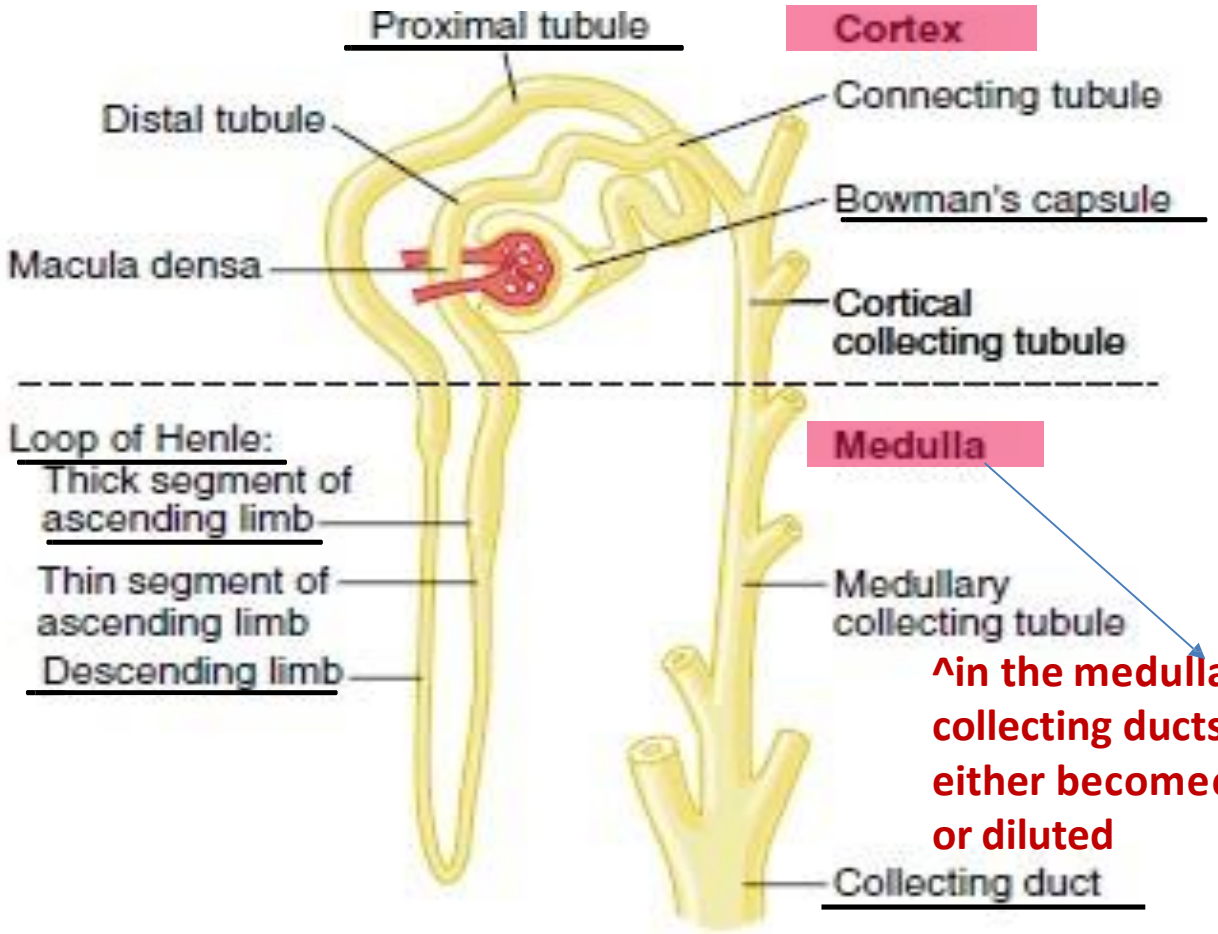
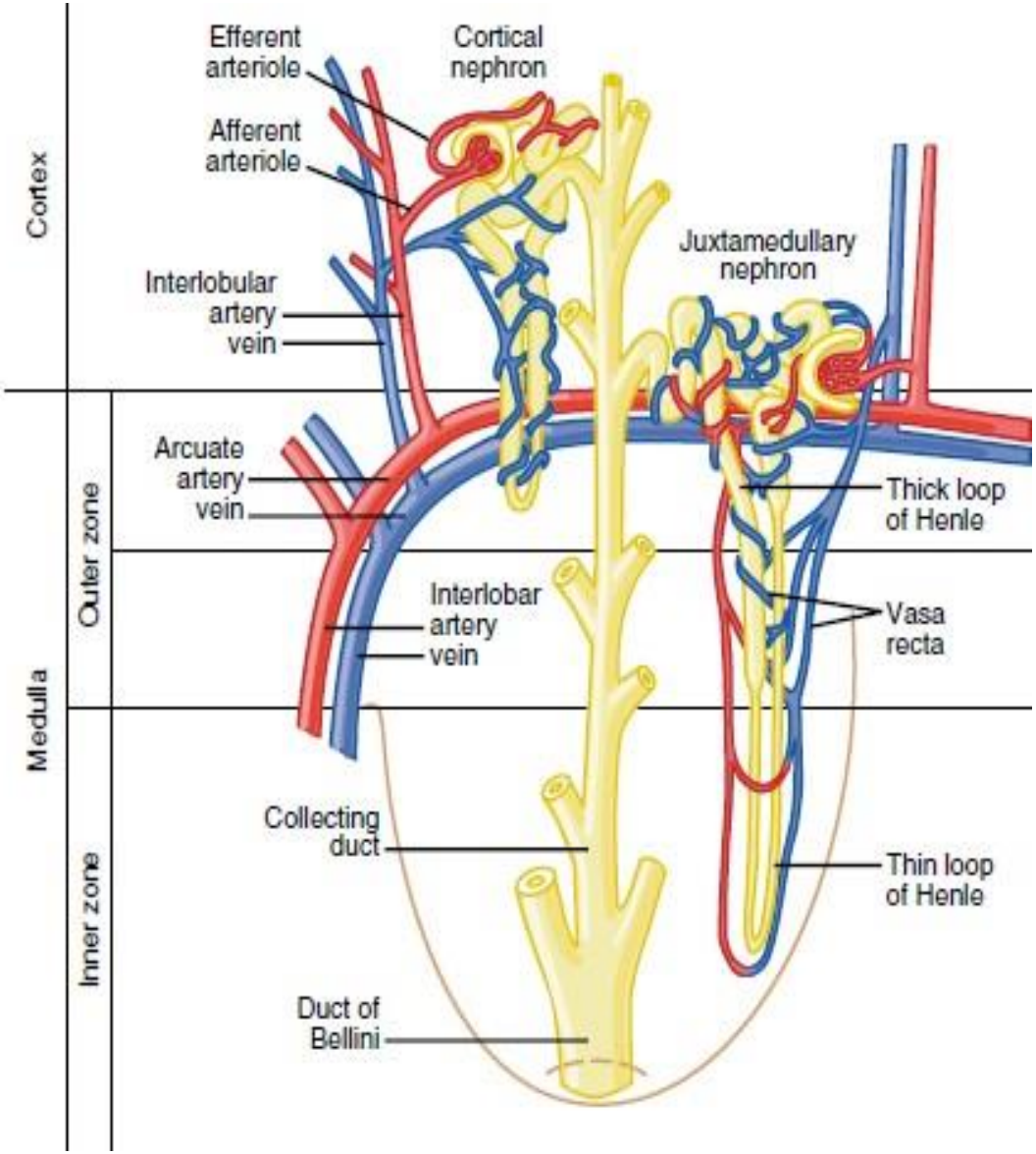


Figure 26-4 Basic tubular segments of the nephron. The relative lengths of the different tubular segments are not drawn to scale.

Figure 26-5 Schematic of relations between blood vessels and tubular structures and differences between cortical and juxtamedullary nephrons.

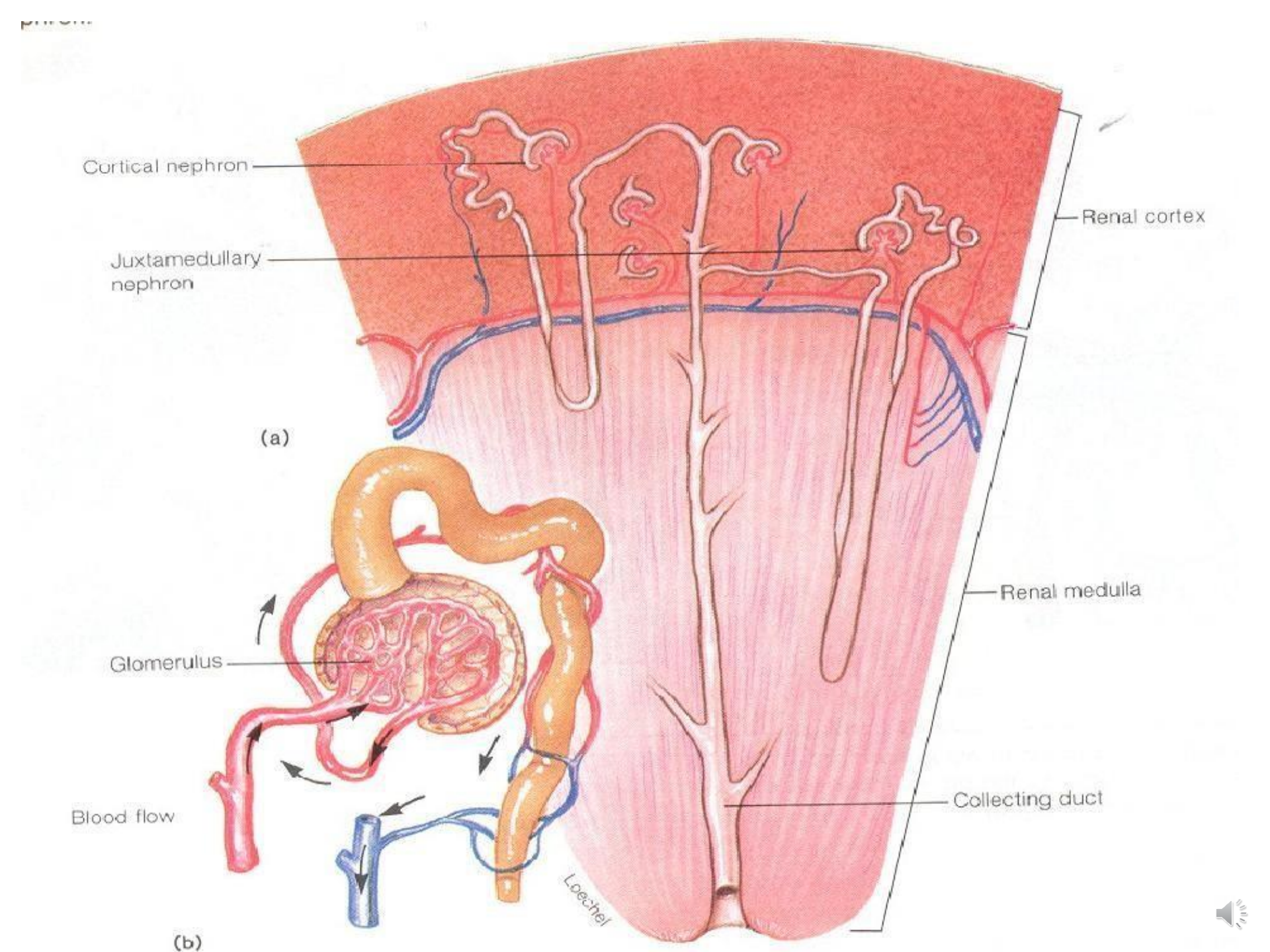


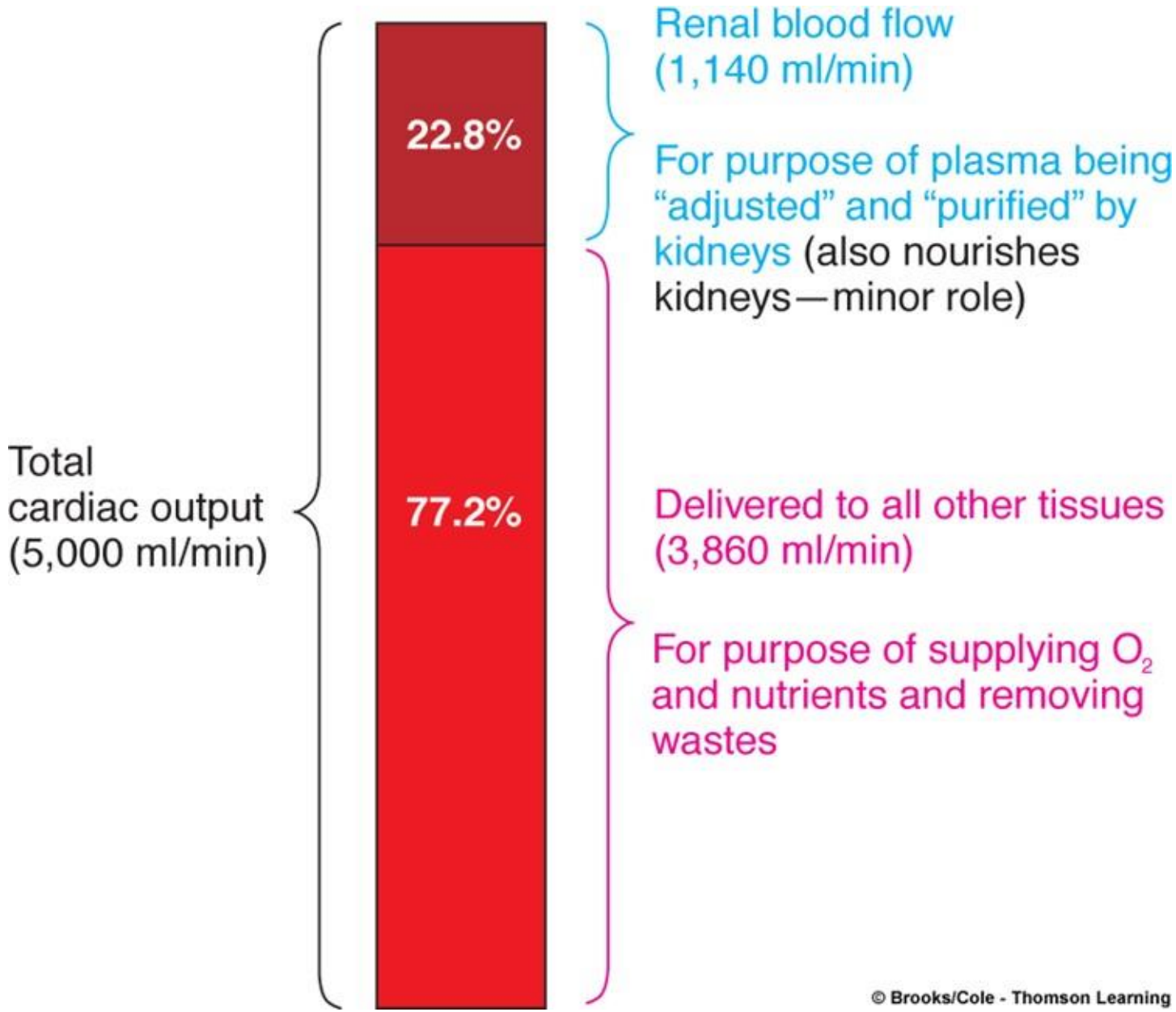
((We have two types of nephrons))
1- cortical : starts in cortex but only until the upper part of medulla(does not go deep)

2- juxtamedullary : which starts in the cortex and goes deep in the medulla (where the concentrated urine will be)

Physiological Anatomy Cont

2. Renal blood supply :
   - 22% of Cardiac Output, about 1200 ml/min
   - Renal artery____interlobar arteries___arcuate arteries___interlobular arteries___afferent arterioles ____glomerular capillaries ___efferent arterioles____peritubular capillaries_Venous system___Interlobular __arcuate__Interlobar__Renal vein.


Cortical nephron
Juxtamedullary nephron
Renal cortex
(a)
Renal medulla
Glomerulus
Collecting duct
Blood flow
Loechel
(b)


Total
cardiac output
(5,000 ml/min)
22.8%
77.2%
Renal blood flow
(1,140 ml/min)
For purpose of plasma being "adjusted" and "purified" by kidneys (also nourishes kidneys—minor role)
Delivered to all other tissues
(3,860 ml/min)
For purpose of supplying O_2 and nutrients and removing wastes
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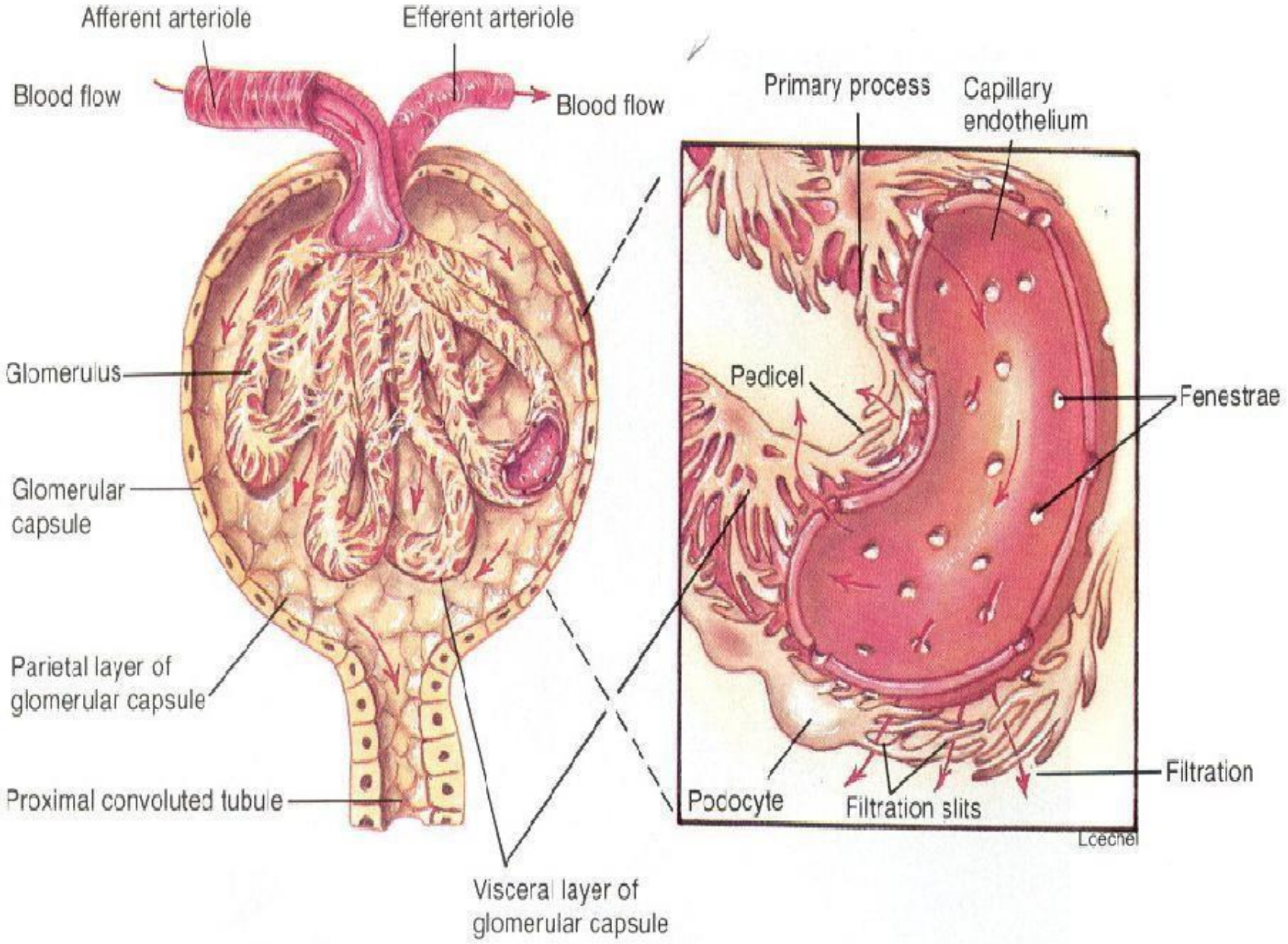
NEPHRON

1 million/kidney after 40year old.

((Gradually Decrease with age)) 1% each/year decrease , and can not be regenerated.

1. **Glomerulus :** capillaries network (60 mmHg) covered by epithelial cells and all are encased in Bowman's capsule .



((Glomerular capillaries: they are involved mainly in the filtration of blood coming to the kidney according to the needs of our body))

2. Tubular system

- 1.Proximal
- 2.loop of Henle:
- a. Descending
- b. Ascending (last part thick segment)
- 3.Distal tubule**((have proximal part and late part))** collecting tubule___cortical collecting tubule
- 4.cortical collecting duct___(8 to 10) ducts join to form single large collecting duct__Medullary collecting duct___Renal papillae__Renal pelvis__Ureter__Bladder (250 large coll. Ducts/kidney)

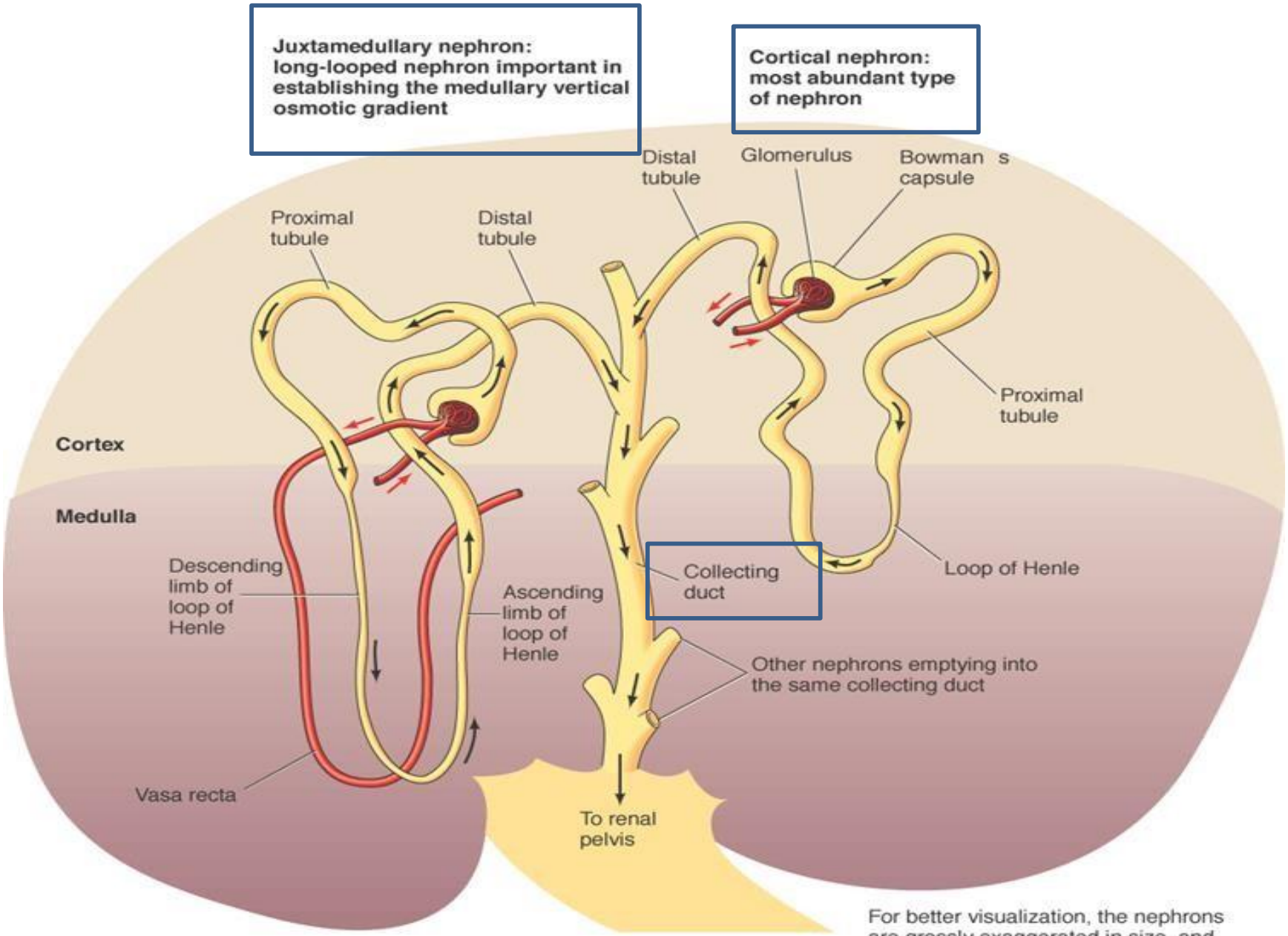
RENAL NEPHRON

Cortical Nephrons: (70-80% **of the total number of nephrons *1million***)

- Glomerulus in outer cortex, short

Juxtamedullary Nephrons :

- Glomerulus in deep cortex
- Long Loop of Henle
- 20 - 30% total
- Vasa recta


Juxtamedullary nephron: long-looped nephron important in establishing the medullary vertical osmotic gradient
Cortical nephron: most abundant type of nephron
Distal tubule
Glomerulus
Bowman s capsule
Proximal tubule
Distal tubule
Proximal tubule
Cortex
Medulla
Descending limb of loop of Henle
Ascending limb of loop of Henle
Collecting duct
Loop of Henle
Other nephrons emptying into the same collecting duct
Vasa recta
To renal pelvis
For better visualization, the nephrons are grossly exaggerated in size, and the peritubular capillaries have been omitted, except for the vasa recta.
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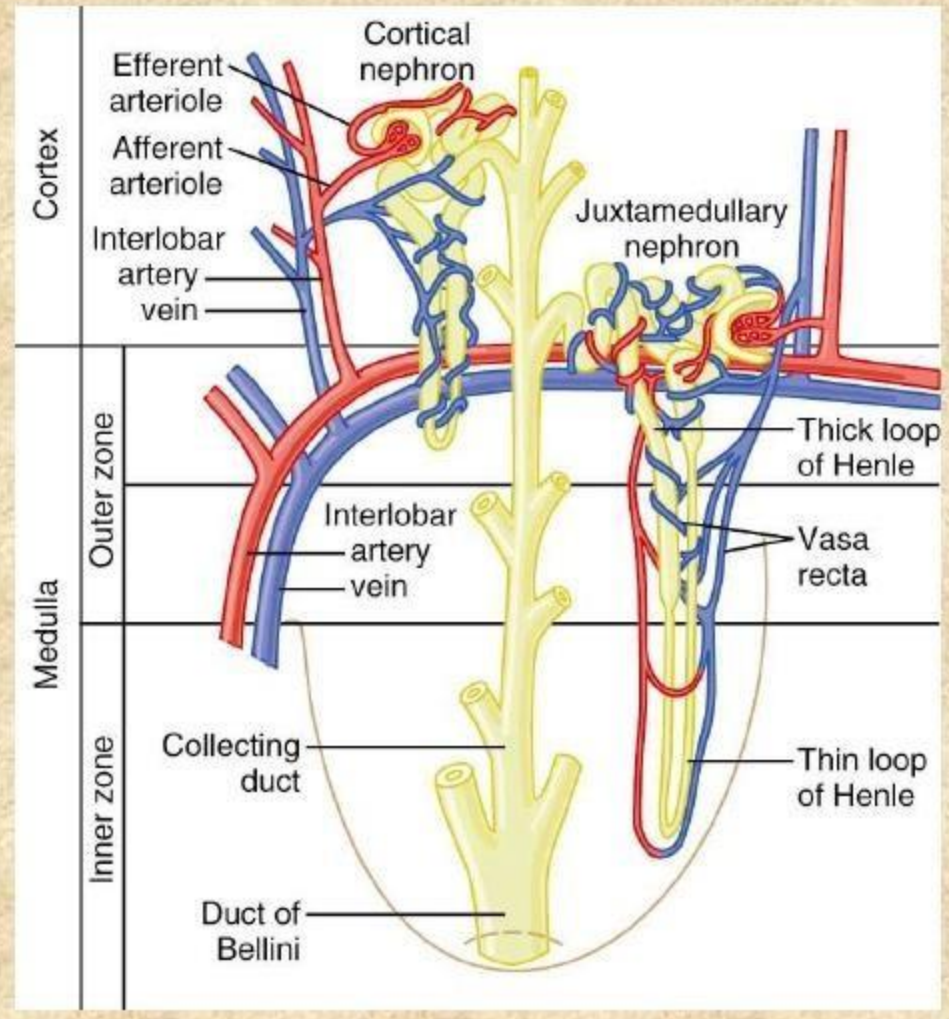
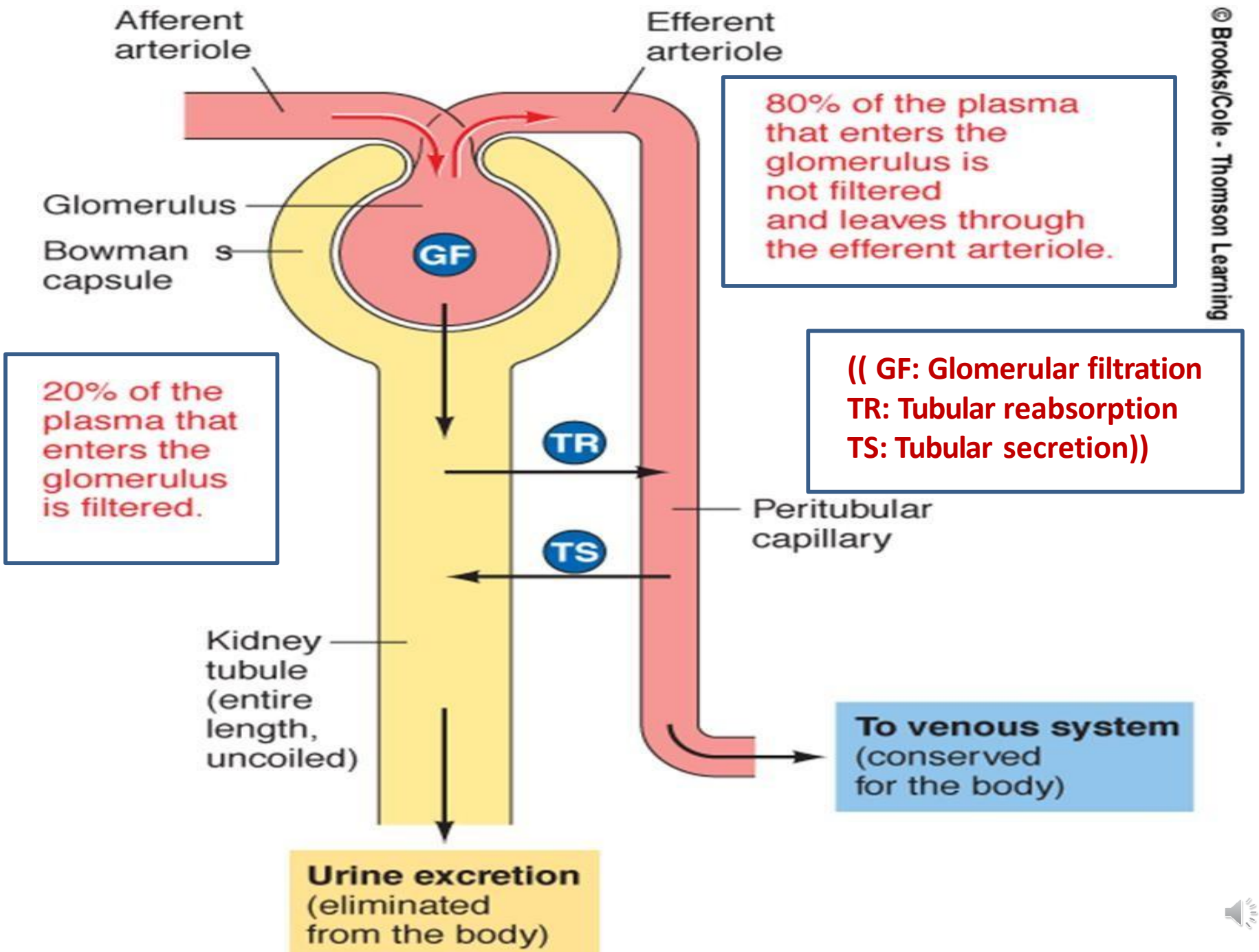

Cortical nephron
Efferent arteriole
Afferent arteriole
Interlobar artery
vein
Cortex
Juxtamedullary nephron
Thick loop of Henle
Medulla
Outer zone
Interlobar artery
vein
Vasa recta
Inner zone
Collecting duct
Thin loop of Henle
Duct of Bellini

URINE FORMATION

- ***Urinary excretion rate = filtration Rate - reabsorption Rate + secretion Rate***

- *((blood comes to kidney- pass into nephron – in the apparatus of glomeruli plasma will be filtrated to the renal tubule , the a part of filtrated plasma will be reabsorbed + there may be secretion from blood to renal tubules*
- *((The part which pass from the glomerular capillaries to the renal tubules is called filtration rate))*
- *So in renal tubules we have :*
- *1- filtration rate which is coming from glomerular capillaries*
- *2-reabsorption rate (part which will be reabsorbed from renal tubules to peritubular capillaries)*
- *3- secretion from blood(peritubular caillaries) to renal tubules.*


Afferent arteriole
Efferent arteriole
80% of the plasma that enters the glomerulus is not filtered and leaves through the efferent arteriole.
Glomerulus
Bowman s capsule
GF
20% of the plasma that enters the glomerulus is filtered.
((GF: Glomerular filtration
TR: Tubular reabsorption
TS: Tubular secretion))
TR
Peritubular capillary
TS
Kidney tubule (entire length, uncoiled)
To venous system (conserved for the body)
Urine excretion (eliminated from the body)
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Determinants of the GFR

- **GFR is determined by (1) sum of the hydrostatic and colloid forces across the glomerular membrane (net filtration pressure), and (2) the glomerular capillary filtration coefficient.**

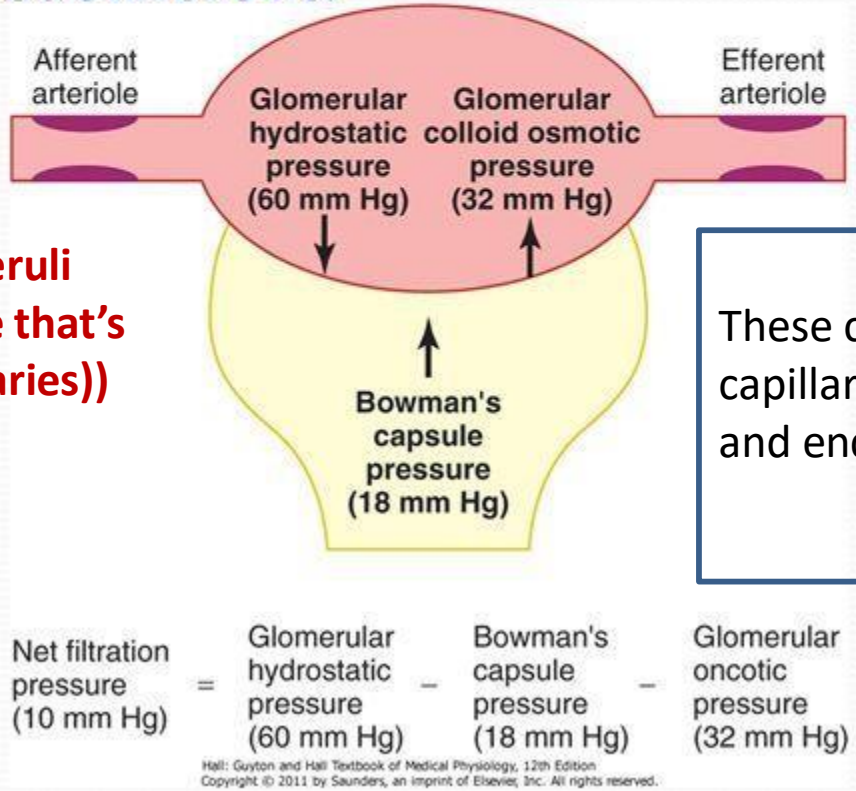


Fig. 26.13

((Fluid filtration in glomeruli depends on the pressure that's present in tubular capillaries))

These capillaries are special capillaries (begin with arteriole and end with arteriole

RENAL HANDLING :

A. Freely filtered, not reabsorbed. , not secretion
   excretion rate = filtration rate

   creatinine , inulin

B. Freely filtered, partially reabsorption, most electrolytes

C. Freely filtered, not excreted completely reabsorption, amino acid , glucose

D. Freely filtered, not reabsorbed , but secreted, H .

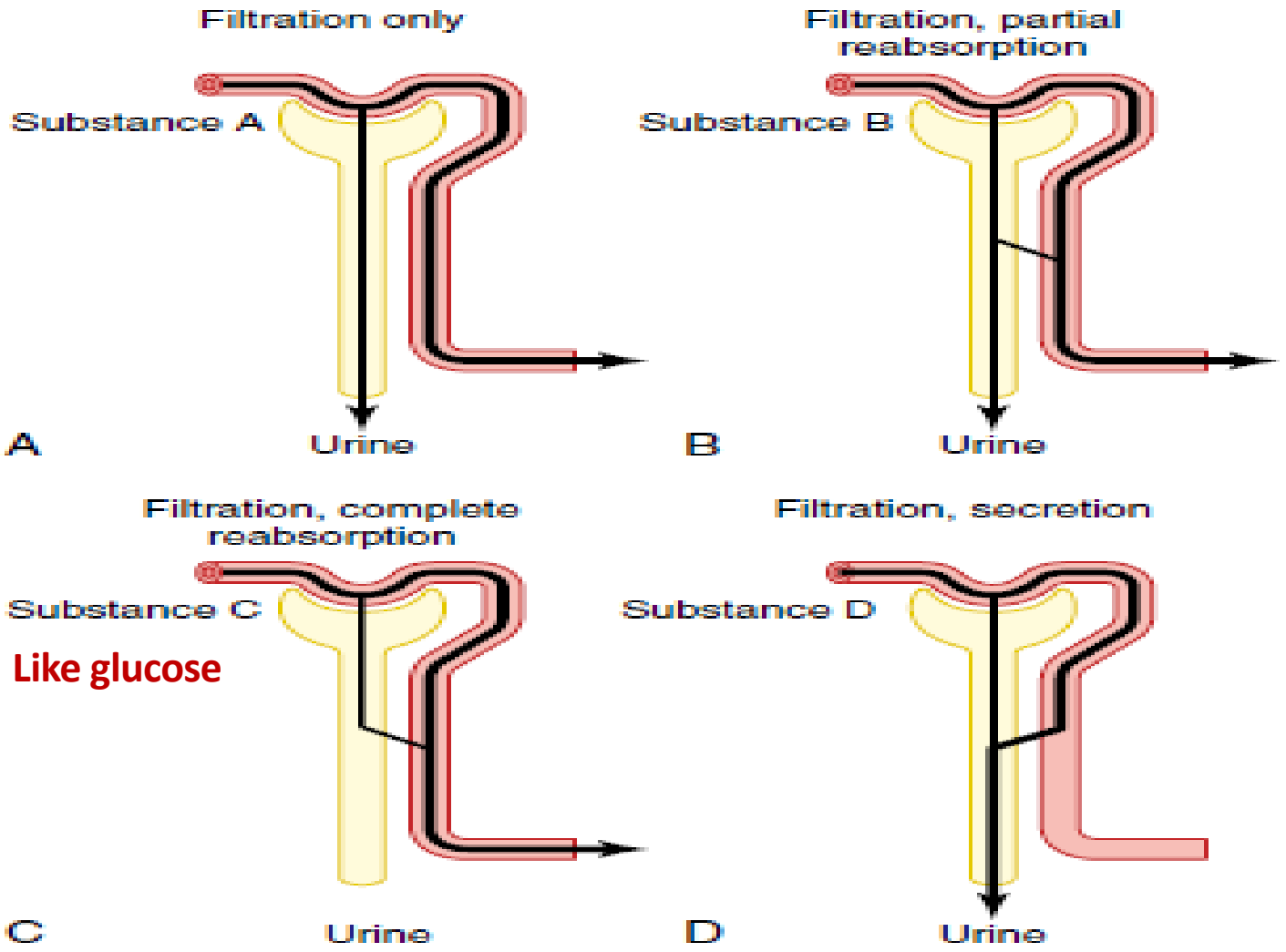
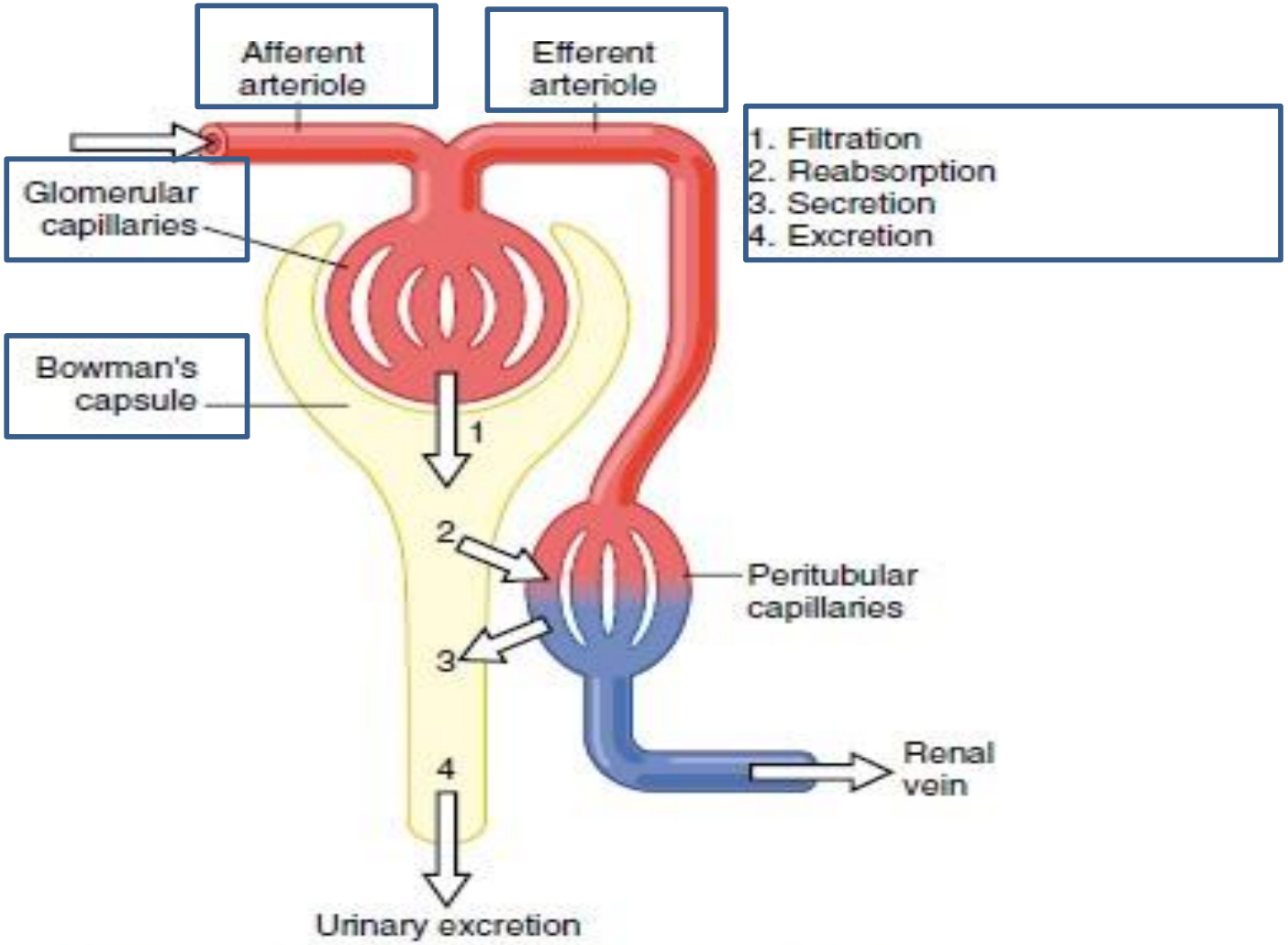


Figure 26-10 Renal handling of four hypothetical substances. *A*, The substance is freely filtered but not reabsorbed. *B*, The substance is freely filtered, but part of the filtered load is reabsorbed back in the blood. *C*, The substance is freely filtered but is not excreted in the urine because all the filtered substance is reabsorbed from the tubules into the blood. *D*, The substance is freely filtered and is not reabsorbed but is secreted from the peritubular capillary blood into the renal tubules.



Excretion = Filtration – Reabsorption + Secretion

Figure 26-9 Basic kidney processes that determine the composition of the urine. Urinary excretion rate of a substance is equal to the rate at which the substance is filtered minus its reabsorption rate plus the rate at which it is secreted from the peritubular capillary blood into the tubules.

Filtration, Reabsorption And secretion

- Reabsorption > secretion

- Secretion determines K+ and H+ Concentration
- **H+ is important for maintaining ph**
- **K+ is used for action potential of the heart**

WHY HUGE GFR

1) Most waste product removed rapidly(effective) **((metabolic waste products are toxic to the body))**

2) Allow all body fluids to be filtered and processed by kidneys many times each day (precise & rapid control of volume & composition).

- Every minute, 22% of the cardiac output goes to the kidneys, which are 1.2 L , and this volume/min is called the (Renal Blood Flow)
- Of these, 55% are plasma , which make about 660 ml , and this volume/min is called the (Renal Plasma Flow)
- Of these, only 20% of the plasma becomes filtrated, which makes about 132 ml/min, and this is the (Glomerular Filtration Rate)
- If we want to calculate the GFR per day (132*24*60) it equals 190 L/day