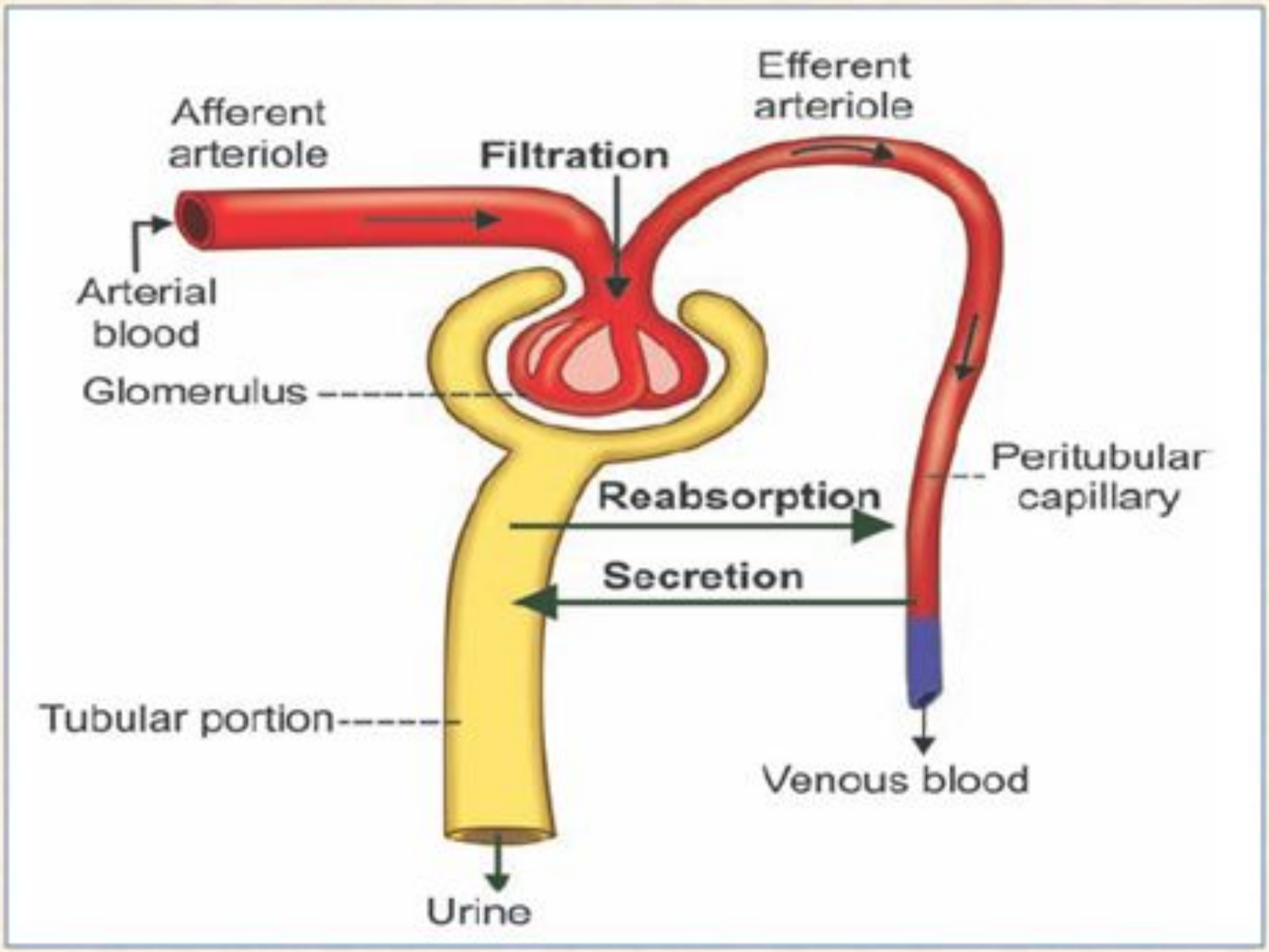
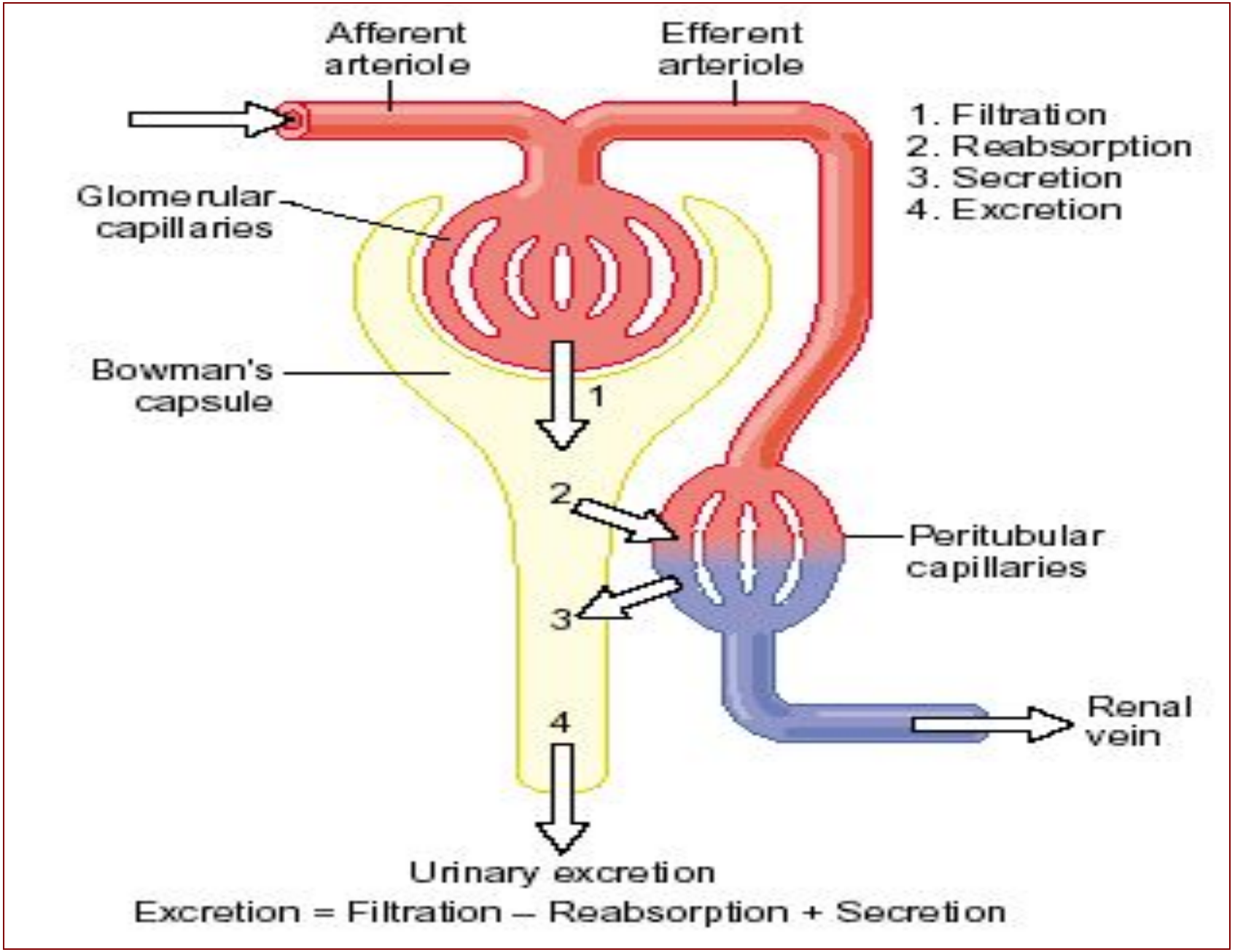
URINE FORMATION


Efferent arteriole
Afferent arteriole
Filtration
Arterial blood
Glomerulus
Peritubular capillary
Reabsorption
Secretion
Tubular portion
Venous blood
Urine

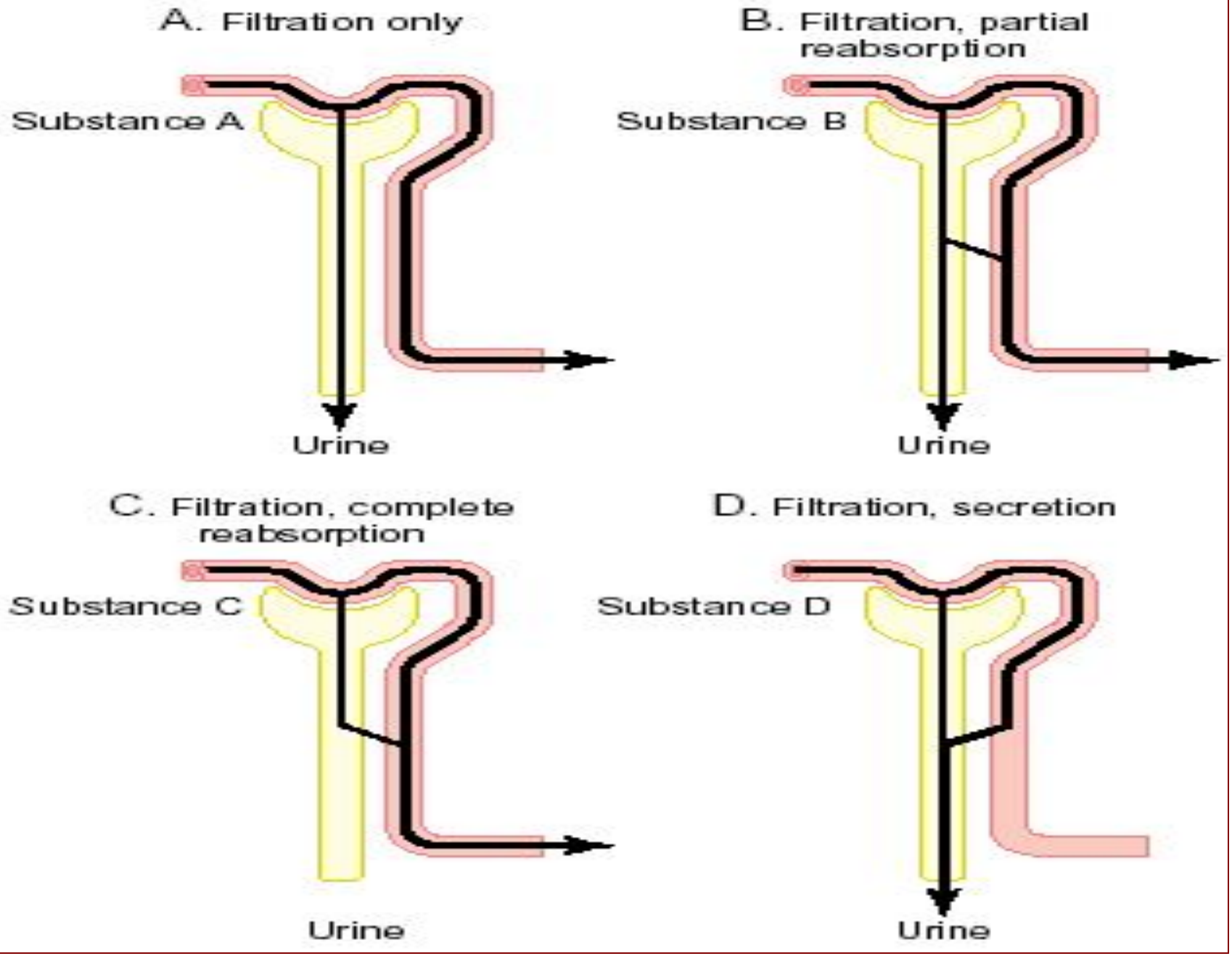

Afferent arteriole
Efferent arteriole
1. Filtration
2. Reabsorption
3. Secretion
4. Excretion
Glomerular capillaries
Bowman's capsule
1
2
Peritubular capillaries
3
4
Renal vein
Urinary excretion
Excretion = Filtration – Reabsorption + Secretion

URINE FORMATION

1) **Glomerular filtration,**
2) **Reabsorption** of substances from the renal tubules into the blood, and
3) **Secretion** of substances from the blood into the renal tubules.

- **Excretion =**

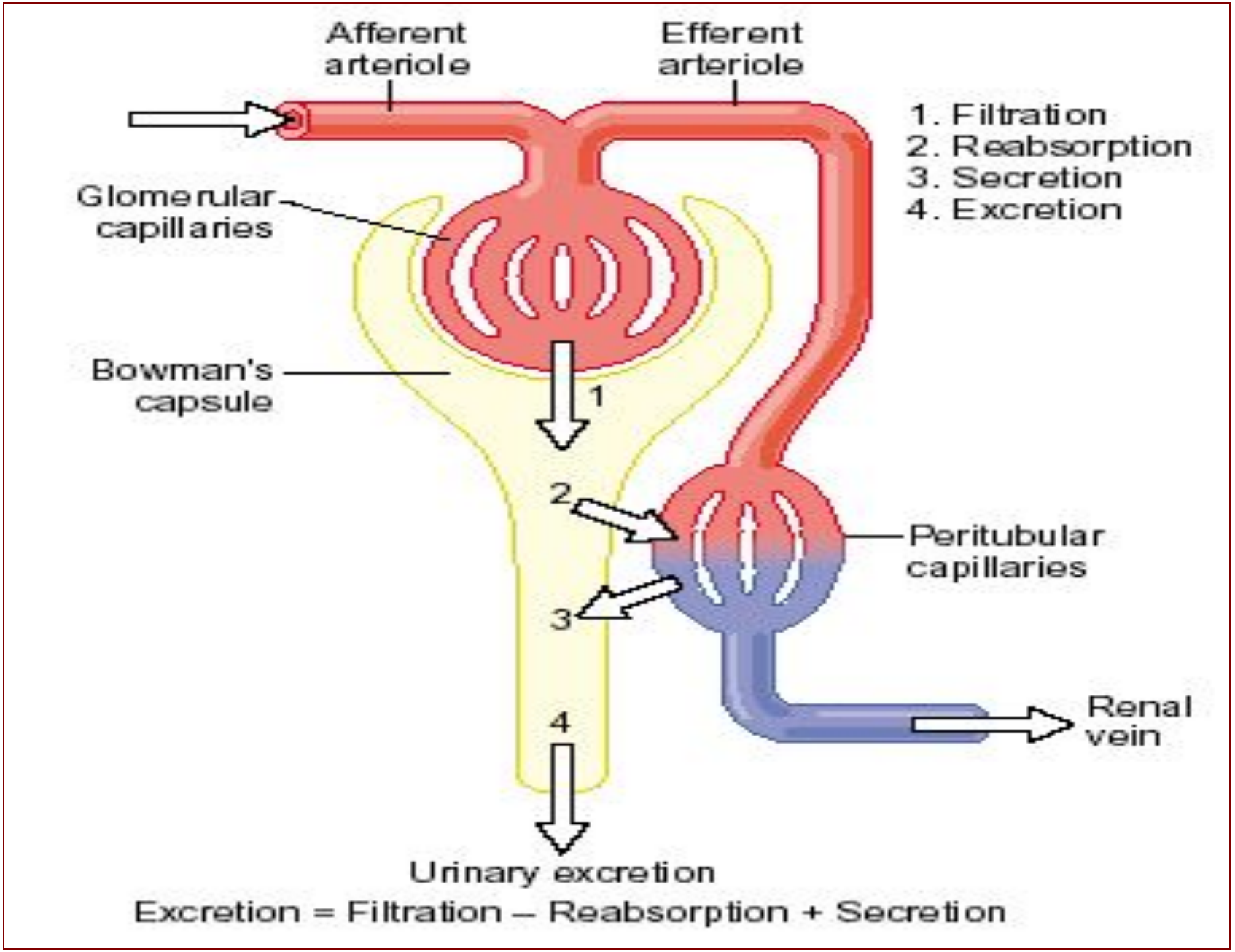
  Filtration – Reabsorption + Secretion


A. Filtration only
Substance A
Urine
B. Filtration, partial reabsorption
Substance B
Urine
C. Filtration, complete reabsorption
Substance C
Urine
D. Filtration, secretion
Substance D
Urine

1) Glomerular filtration

GFR (Glomerular filtration rate)

- Definition and value of GFR
- Structure of glomerular membrane
- Composition of glomerular filtrate
- Determinants of GFR
- Factors affecting GFR
- Auto regulation of GFR
- Measurement of GFR
- Clinical


Afferent arteriole
Efferent arteriole
1. Filtration
2. Reabsorption
3. Secretion
4. Excretion
Glomerular capillaries
Bowman's capsule
1
2
3
4
Peritubular capillaries
Renal vein
Urinary excretion
Excretion = Filtration – Reabsorption + Secretion

GFR
(Glomerular filtration rate)

- **The amount of the glomerular filtrate formed by all the nephrons of both the kidneys in one minute is called GFR.**

- In the average human adult, the GFR is about **125 ml / min. or 180 L / day**

- **Filtration fraction – The fraction of the renal plasma which is filtered at the glomerulus.**
- Renal plasma flow = 700 -750 ml /min

- Filtration fraction = GFR / RPF
- 125 ml /700 ml /min.

= 0.16 -0.20

- **16 -20% of renal plasma flow.**

Glomerular capillary membrane

- **Three layers –**

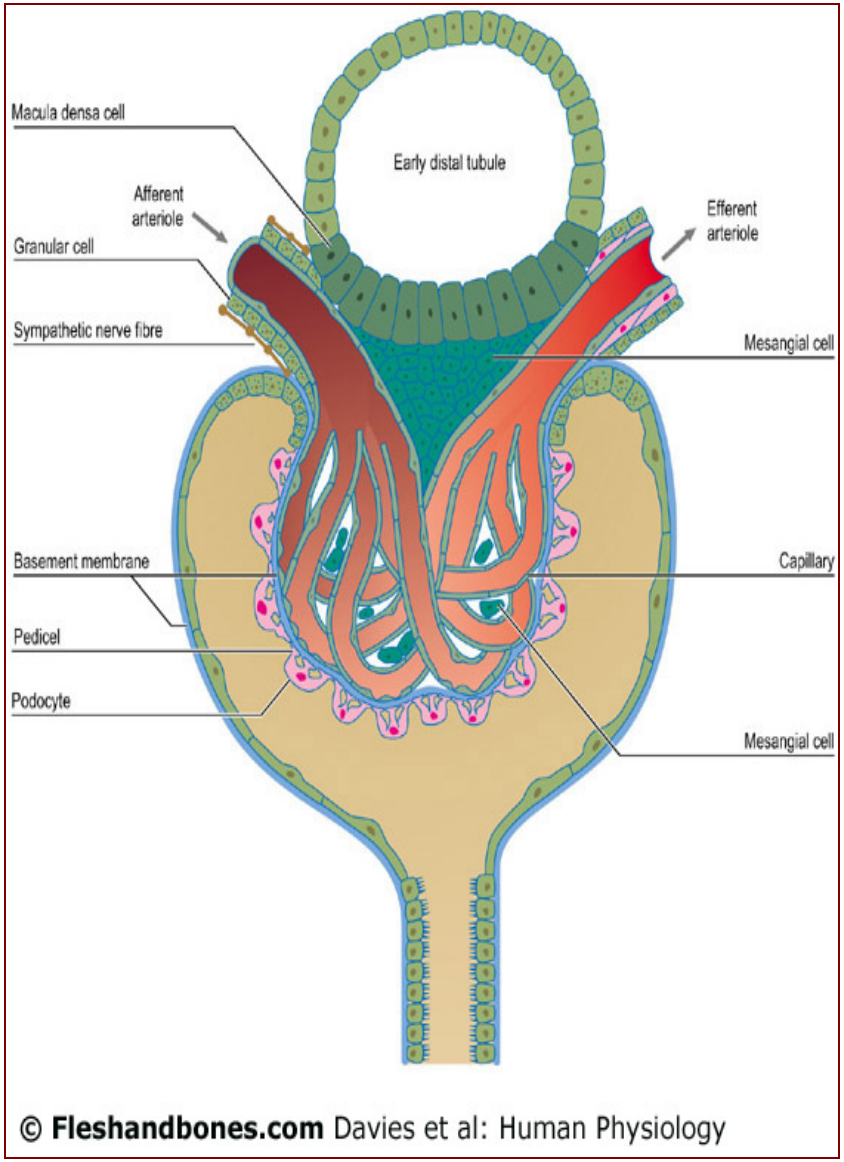
1. Endothelium of the capillary

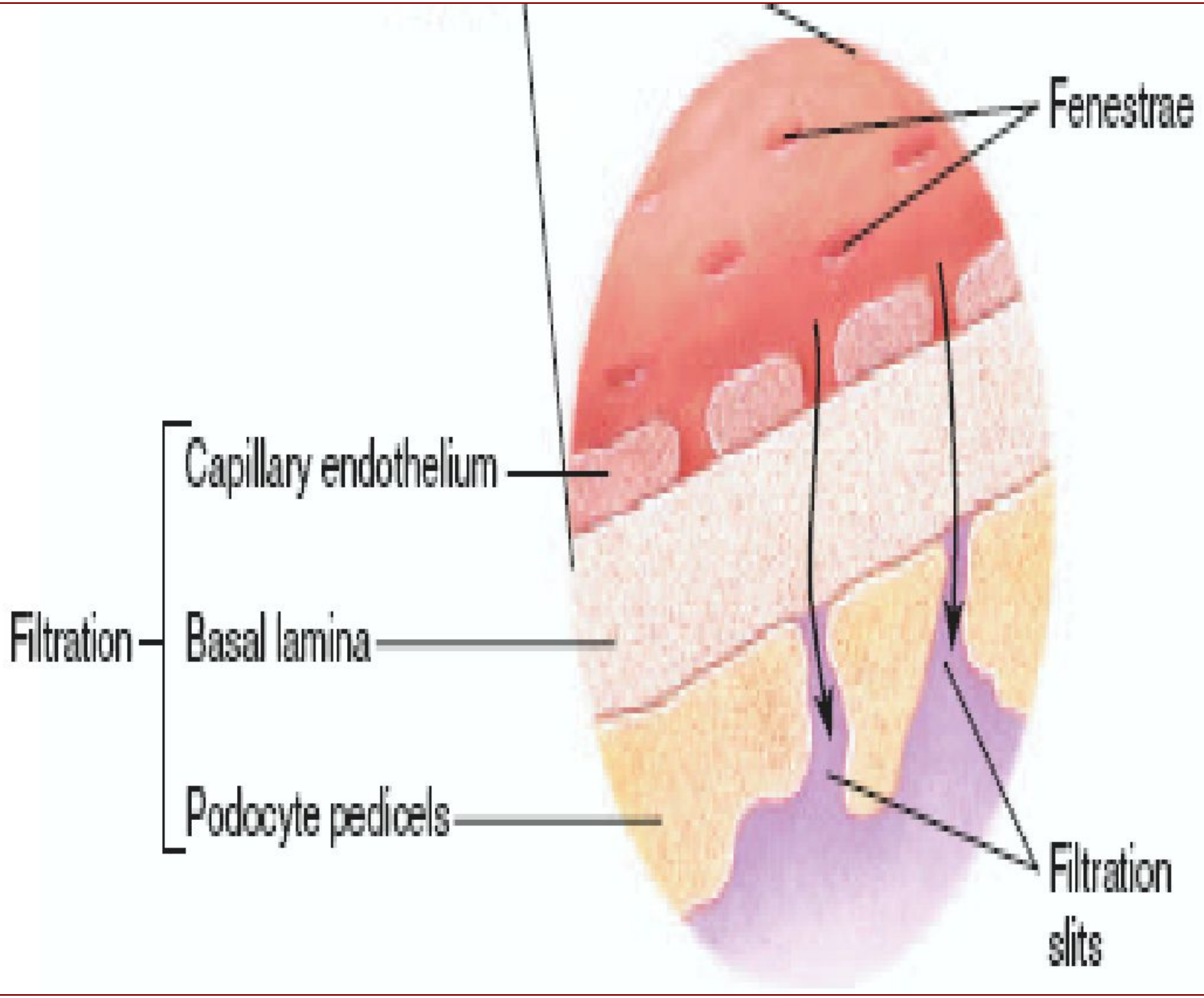
fenestra – 70-100 nm

2. Basement membrane – collagen & proteoglycan

3. A layer of epithelial cells with pedicles - podocytes

-slit pores




Fenestrae
Capillary endothelium
Filtration
Basal lamina
Podocyte pedicels
Filtration slits

Characteristics of filtration membrane

- **High permeability** = The permeability of the glomerular membrane is approx. 50 times that of the capillaries in the skeletal muscle
- GM is **selectively permeable**.
- Pore size – **8 nm**

- **Electrical charge** – pores in the filtration membrane are **negative**ly charged
- Negatively charged large molecules are filtered less easily than positively charged molecules of equal molecular size.
- **Molecular wt. --- 69000 ----- 0 permeability.**
- Albuminuria or proteinuria.

- **Composition of glomerular filtrate**

- Glomerular filtrate has almost the same composition as that of plasma

  except that

  it has no proteins and cells including red blood cells &some subs. such as calcium and fatty acids bound with proteins.

Determinants of GFR

1.Glomerular capillary hydrostatic pressure

= 45 mm Hg.

2. Glomerular capillary COP = 25 mm Hg.

3. Hydrostatic pressure of Bowman's capsule.

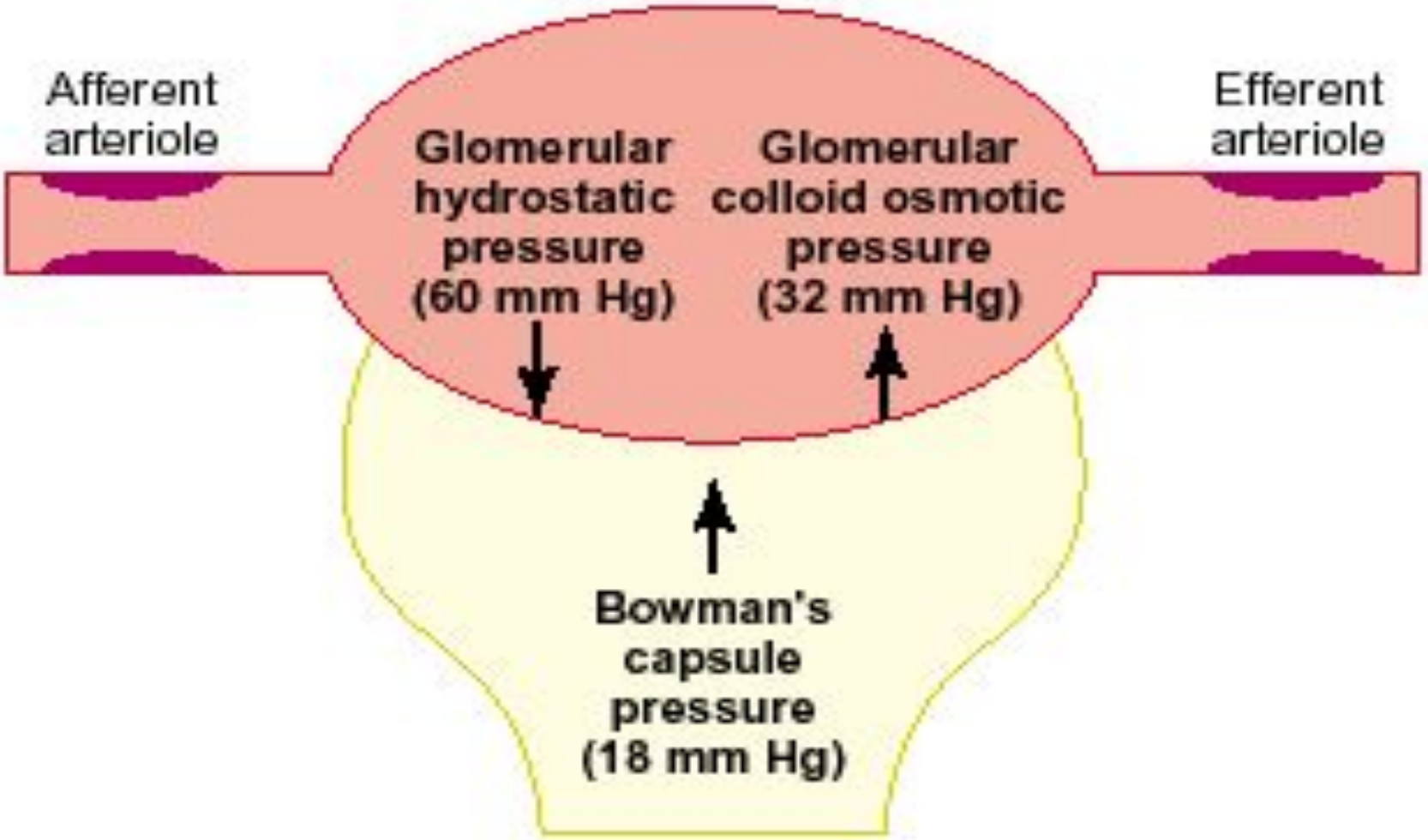
= 10 mm Hg.

4. **COP of Bowman's capsule = 0 mm Hg.**

- **Net filtration pressure**

= (Pcap –Pbow) – (COPcap – COP Bow)

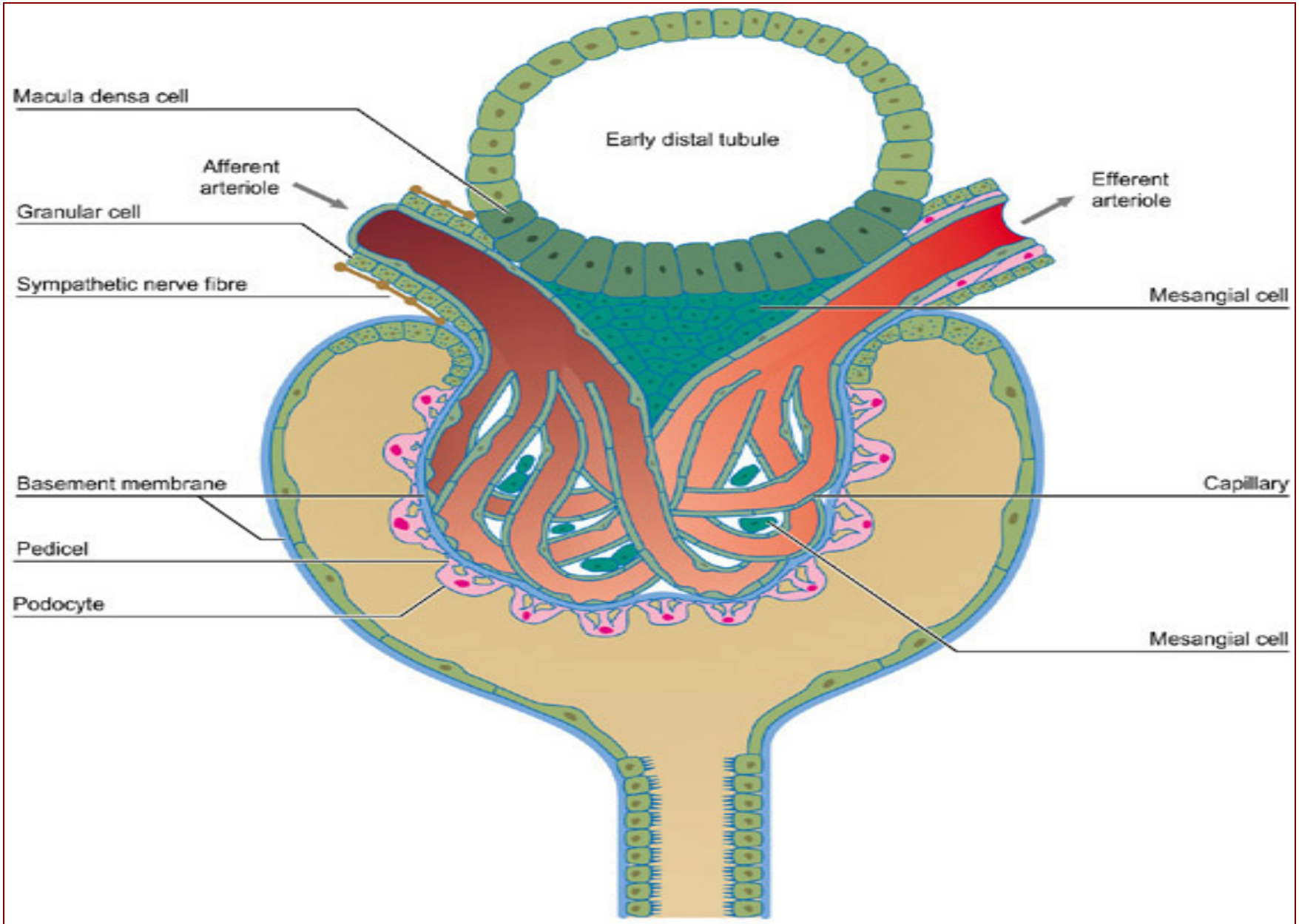
= 10 mm Hg.



Net filtration pressure (10 mm Hg) = Glomerular hydrostatic pressure (60 mm Hg) − Bowman's capsule pressure (18 mm Hg) − Glomerular oncotic pressure (32 mm Hg)

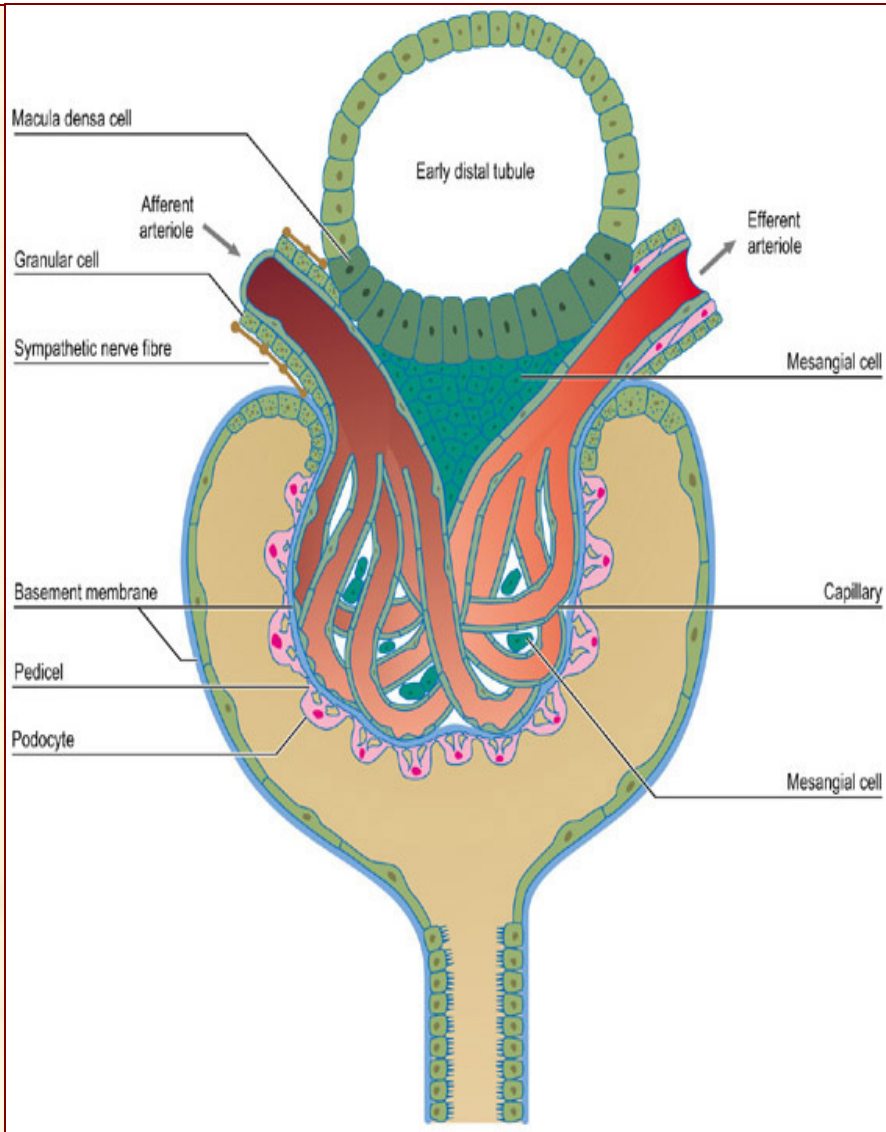
5.Glomerular capillary filtration coefficient Kf

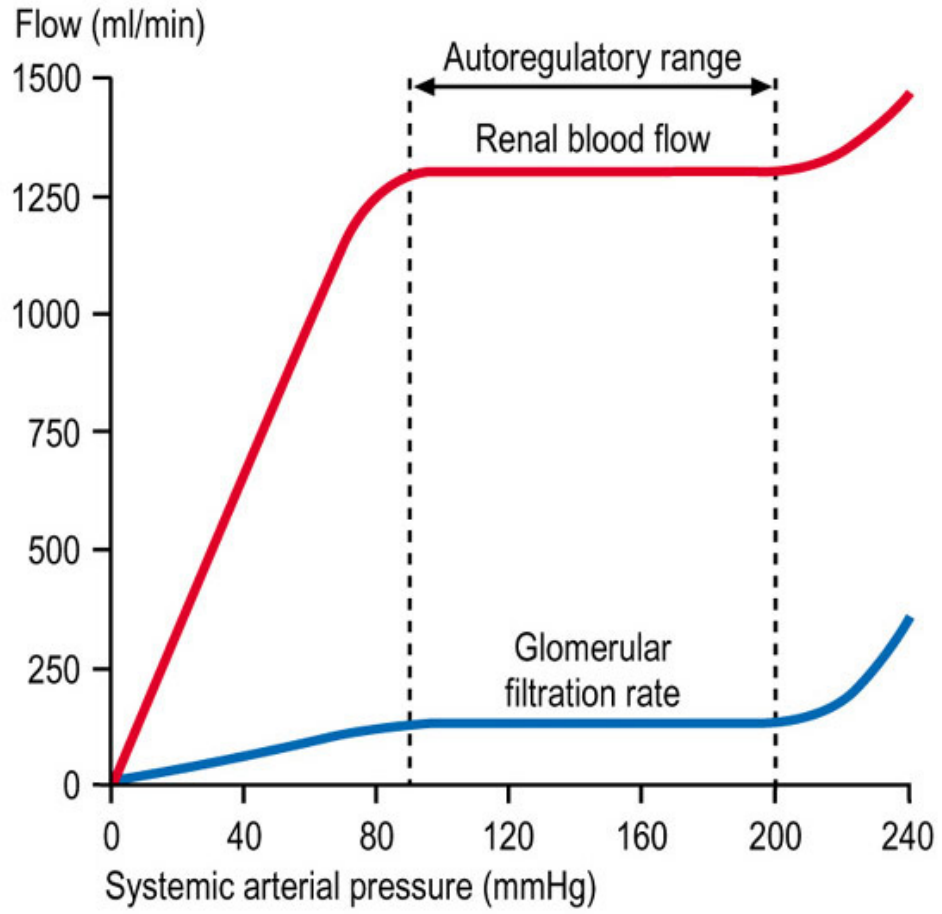
- **The Kf is a measure of the product of the permeability and surface area of the glomerular capillaries.**
- Kf = GFR / Net filtration pressure
- GFR – 125 ml / min
- Net filtration pressure – 10 mm of Hg
- Kf – 12.5 ml / min /mm of Hg.



Factors affecting GFR

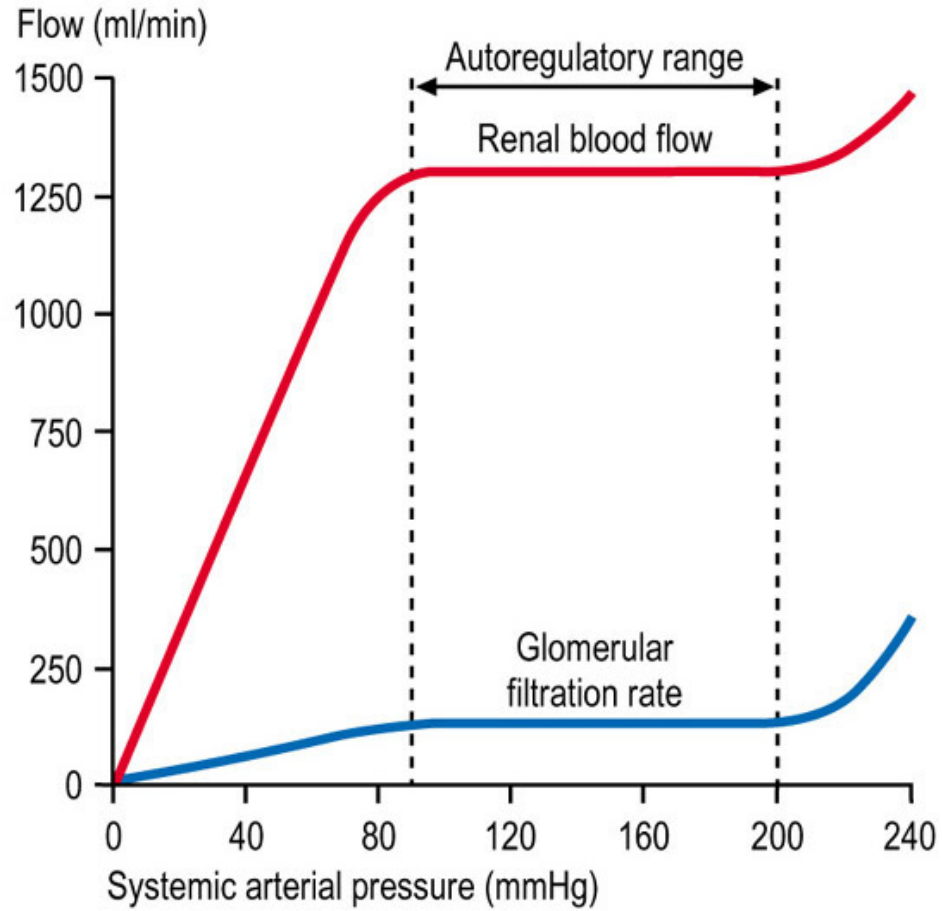
1. Capillary HP
2. Capillary COP
3. HP of Bowman's capsule
4. COP of Bowman's capsule
5. Permeability of GM
6. Size of the capillary bed
7. Arterial BP
8. RBF
9. Constriction of afferent arteriole
10. Constriction of efferent

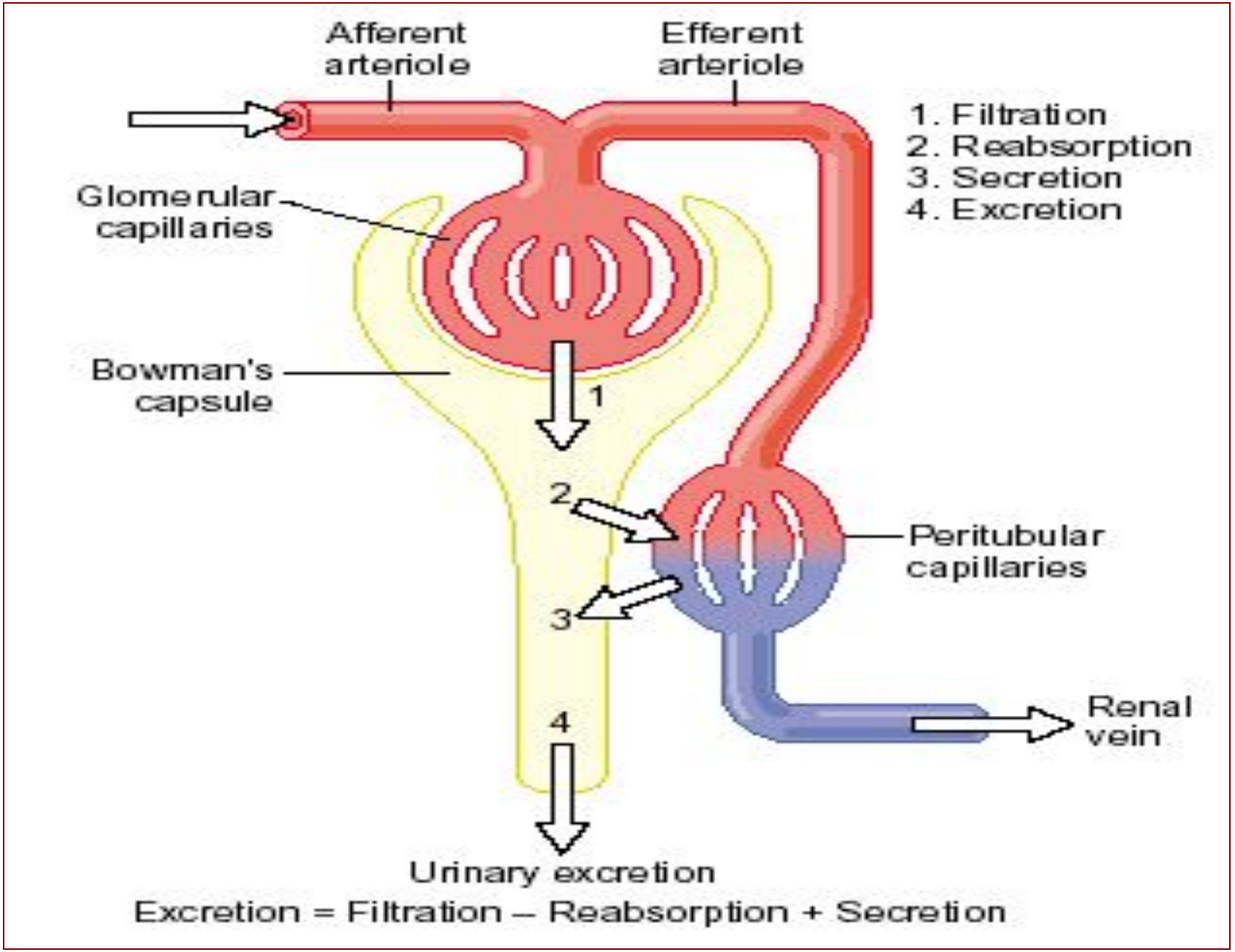




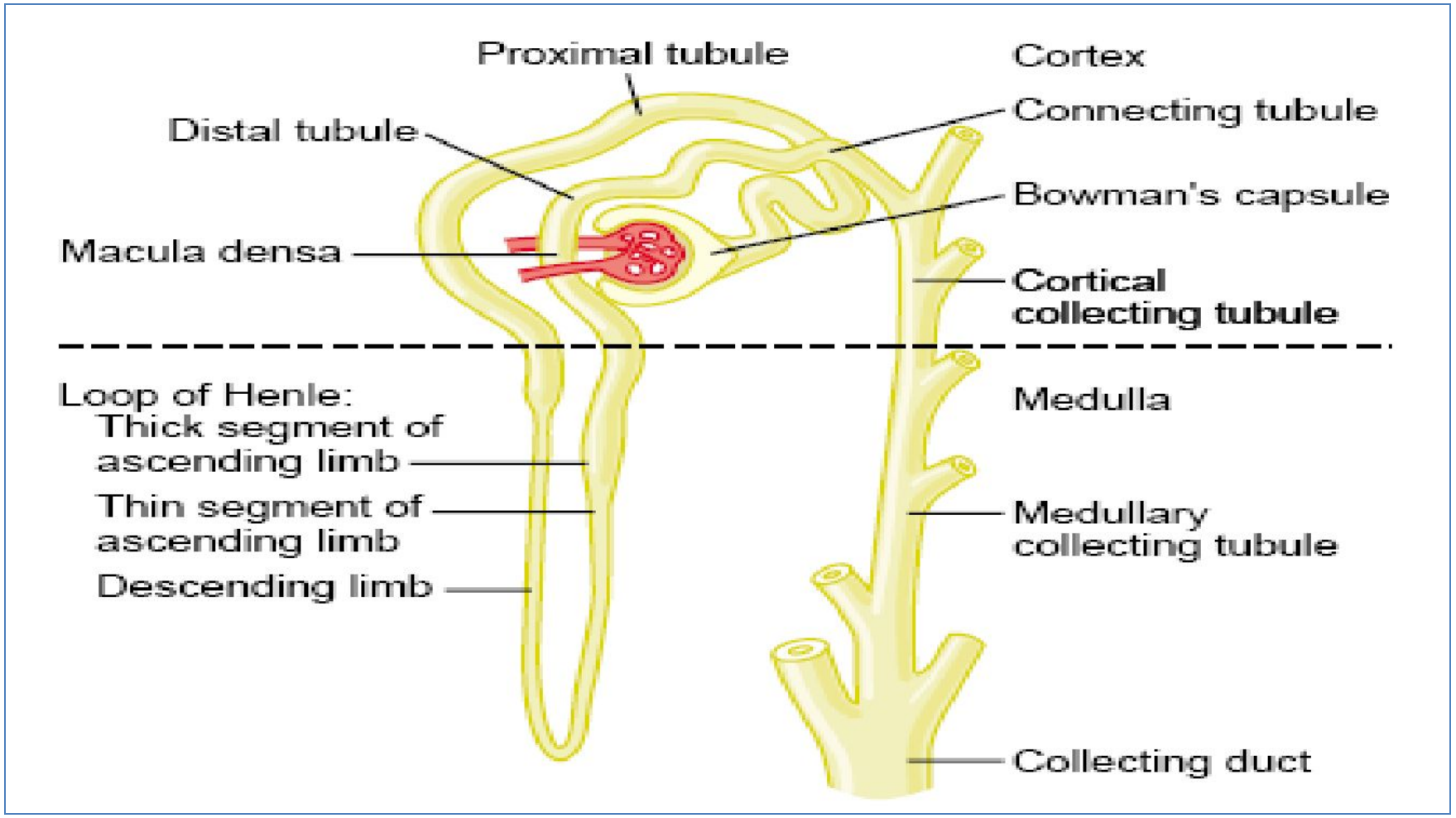
11) Auto regulation of GFR

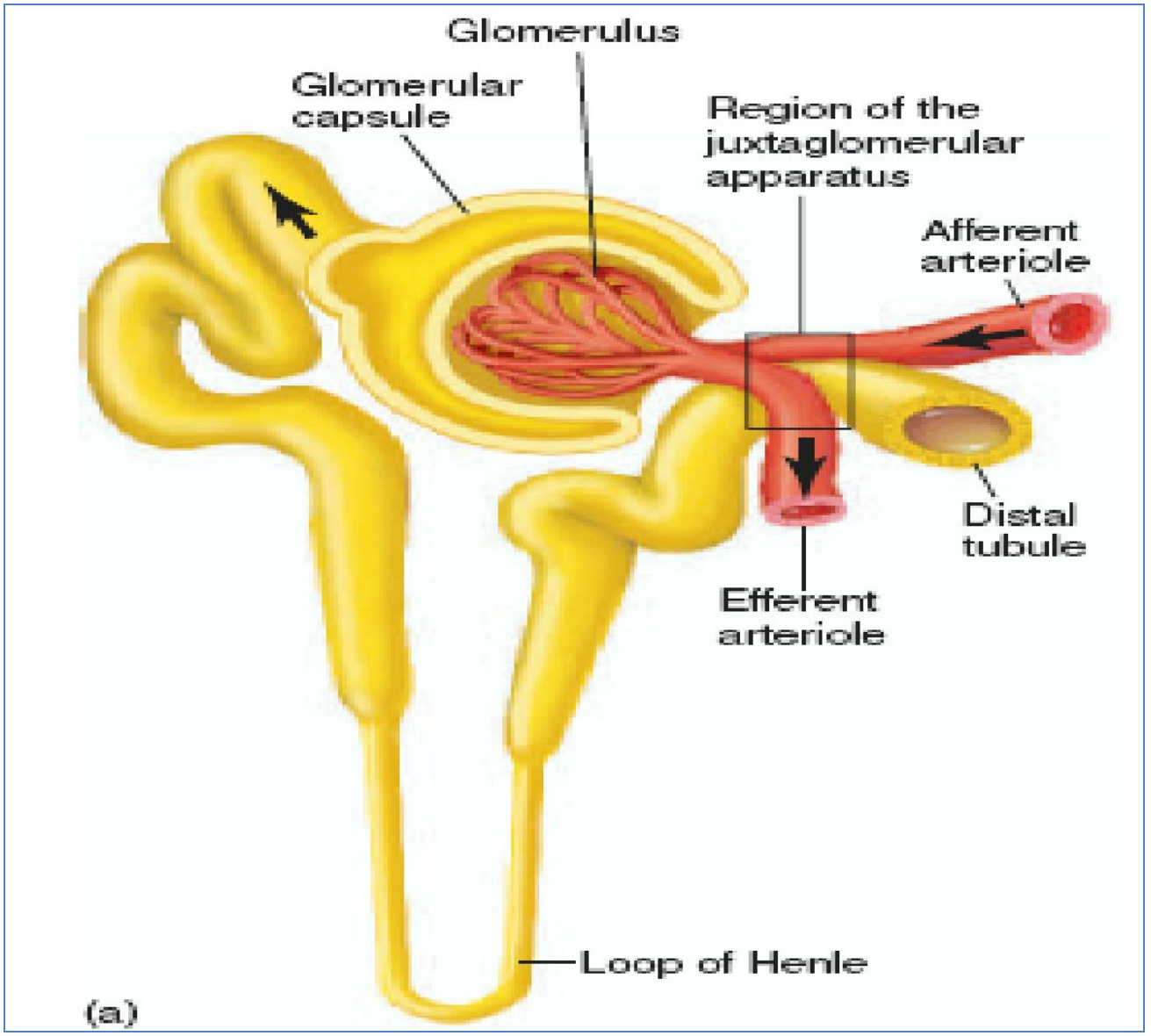
1. Glomerulotubular balance.
2. Tubulo glomerular feedback mechanism
   - Afferent arteriolar feedback mechanism
   - Efferent arteriolar feedback mechanism
3. Myogenic mechanism
4. Sympathetic stimulation.
5. Hormonal & other factors.

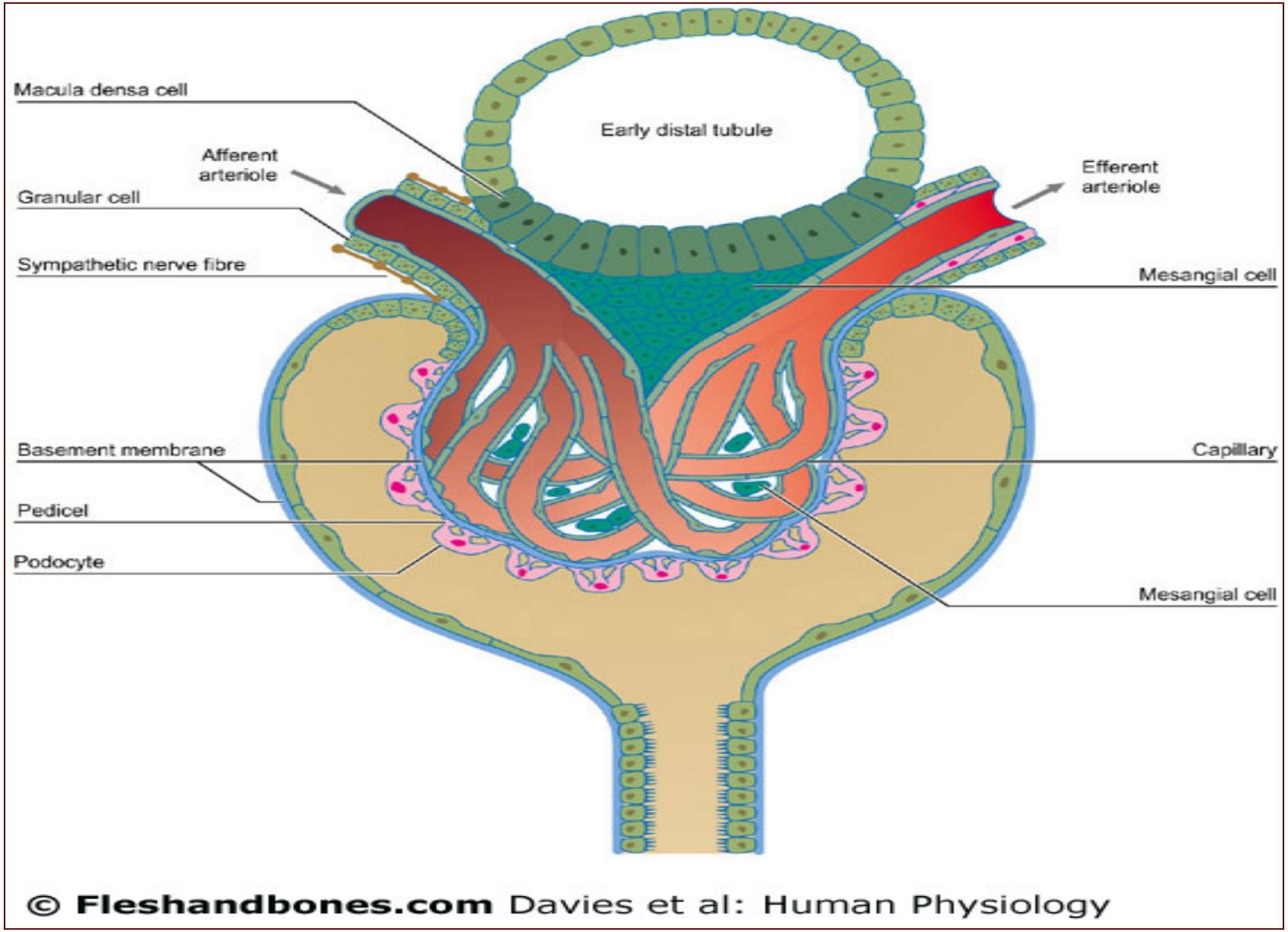


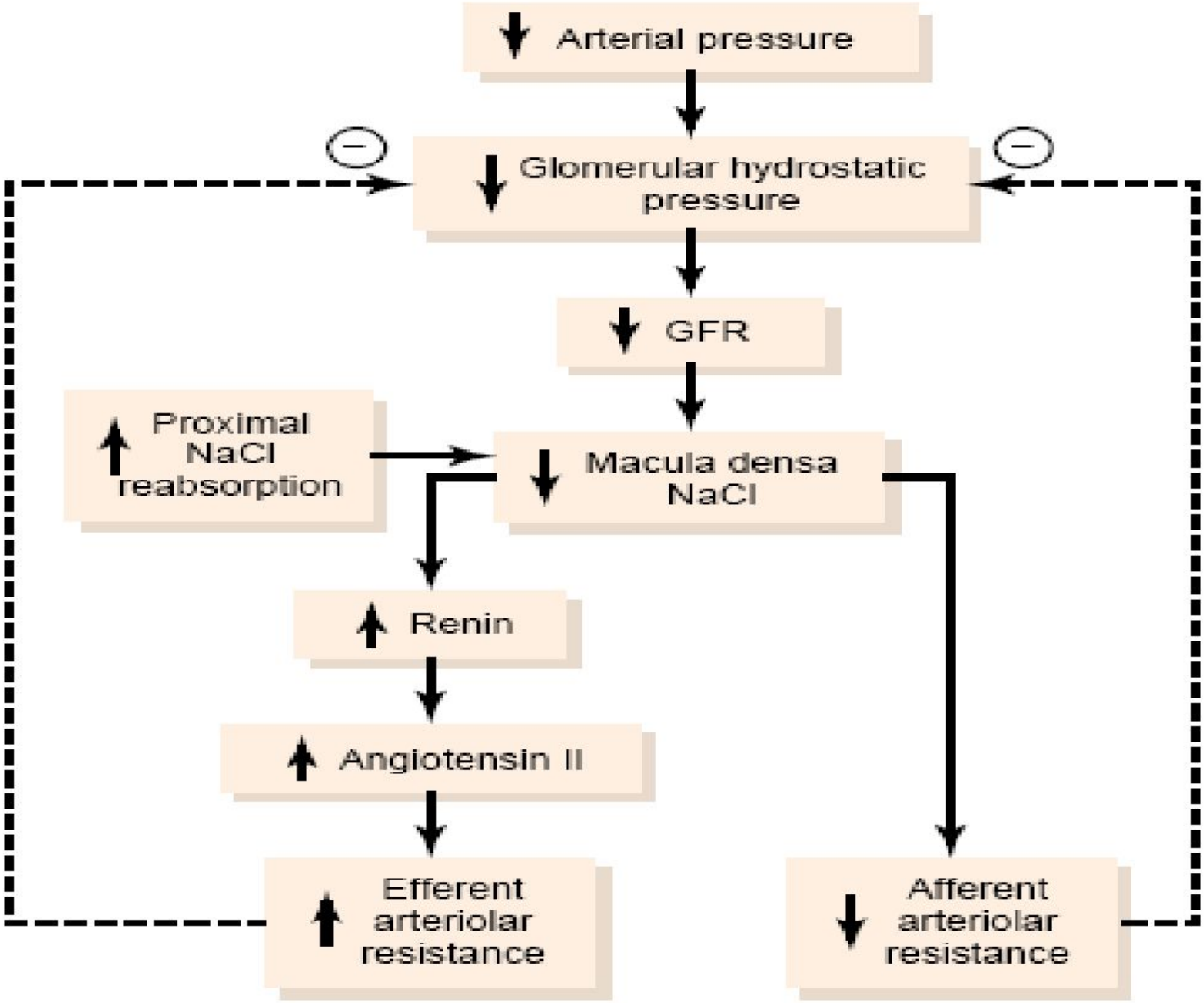

Afferent arteriole
Efferent arteriole
1. Filtration
2. Reabsorption
3. Secretion
4. Excretion
Glomerular capillaries
Bowman's capsule
1
2
3
4
Peritubular capillaries
Renal vein
Urinary excretion
Excretion = Filtration – Reabsorption + Secretion

2.Tubuloglomerular feedback




Glomerulus
Glomerular capsule
Region of the juxtaglomerular apparatus
Afferent arteriole
Distal tubule
Efferent arteriole
Loop of Henle
(a)


Macula densa cell
Early distal tubule
Afferent arteriole
Efferent arteriole
Granular cell
Sympathetic nerve fibre
Mesangial cell
Basement membrane
Capillary
Pedicel
Podocyte
Mesangial cell
© Fleshandbones.com Davies et al: Human Physiology


Arterial pressure
Glomerular hydrostatic pressure
GFR
Proximal NaCl reabsorption
Macula densa NaCl
Renin
Angiotensin II
Efferent arteriolar resistance
Afferent arteriolar resistance

Myogenic autoregulation

- Intrinsic property of vascular smooth muscle; tendency to contract when it is stretched
- Prevent overdistention of the vessel , helps prevent excessive increase in renal blood flow and GFR

- **Myogenic mechanism regulating GFR-** resist stretching during increase arterial pressure – stretch of vascular wall increase calcium ions entry from ECF into the cell – contract the cells – increase vascular resistance – decrease GFR and RBF

HORMONAL & AUTACOID CONTROL OF RENAL BLOOD FLOW

- **Norepinephrine ,epinephrine , endothelin** – constrict renal blood vessels & decrease GFR
- **Angiotensin II** - constricts efferent arterioles
  - Prevents decrease in glomerular hydrostatic pressure & GFR
- **Nitric oxide** - decrease vascular resistance and increased GFR
- **PGs** – Dilatation of aff.arterioles –increase GFR

Other factors that increase GFR

- **High protein** intake
- **High blood glucose** level in uncontrolled diabetes mellitus

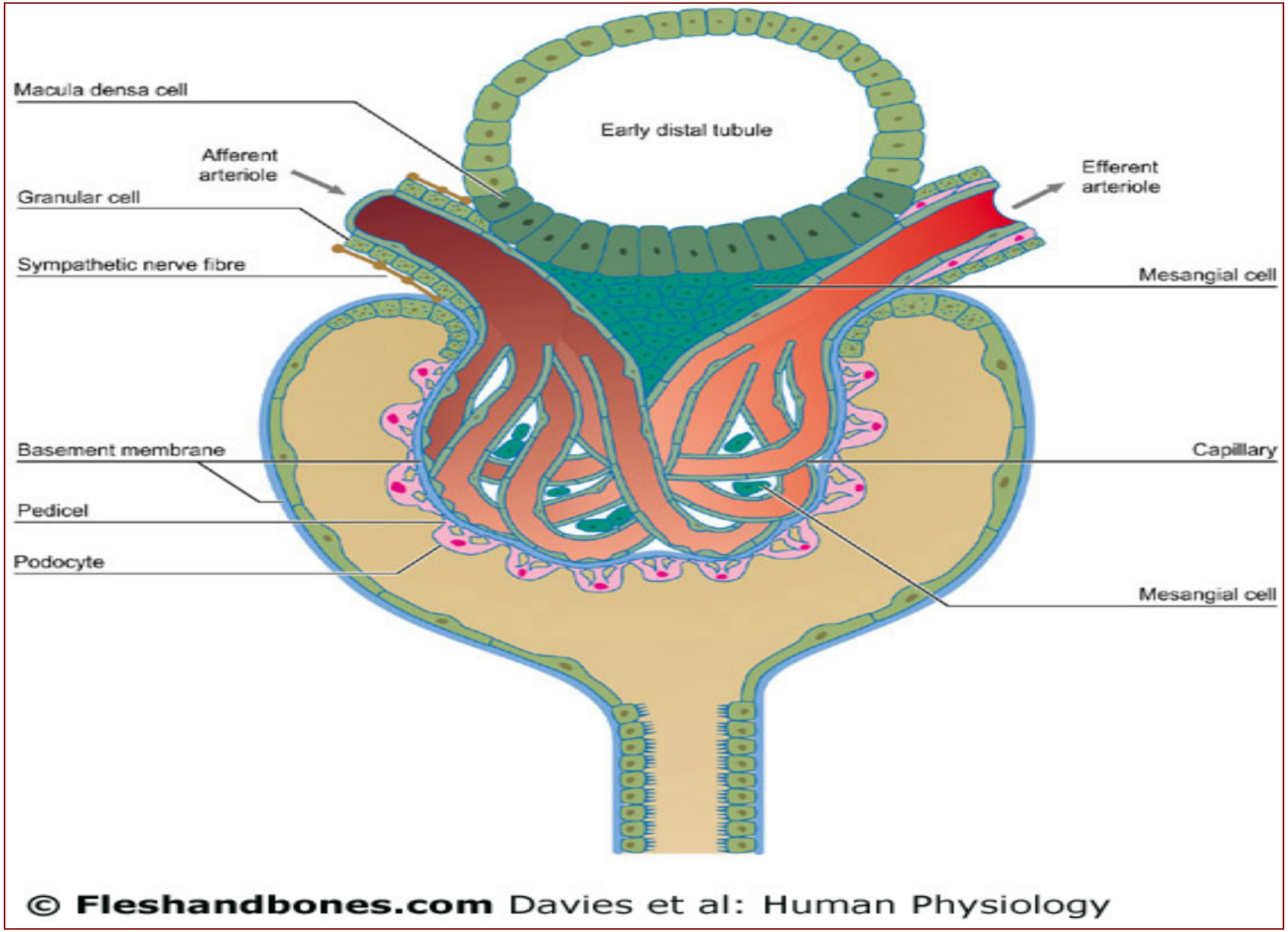
- **<u>Measurement of GFR-</u>**
- **Inulin clearance is used to estimate GFR** as it is freely filtered (filtered as freely as water) and is not reabsorbed or secreted by the renal tubules. The GFR, therefore, can be calculated as the clearance of the inulin.
- **Creatinine** and **radioactive iothalamate clearance** are also used to measure GFR.

GFR (Glomerular filtration rate)

- Definition and value of GFR
- Structure of glomerular membrane
- Composition of glomerular filtrate
- Determinants of GFR
- Factors affecting GFR
- Auto regulation of GFR
- Measurement of GFR
- Clinical

JG apparatus

- **Structure**
- **Juxtaglomerular cells**
- **Macula densa cells**
- **Lacis cells**


Macula densa cell
Early distal tubule
Afferent arteriole
Efferent arteriole
Granular cell
Sympathetic nerve fibre
Mesangial cell
Basement membrane
Capillary
Pedicel
Podocyte
Mesangial cell
© Fleshandbones.com Davies et al: Human Physiology

- Juxta glomerular cells ------ i) Renin
  - Renin Angiotensin mechanism
  ii) Erythropoietin
- Macula densa ---- Act as a sensor.
  --- Tubulo- feedback mechanism.
  ---- Secretion of thromboxane A2.
- Lacis cells -------- Secretion of PGs.

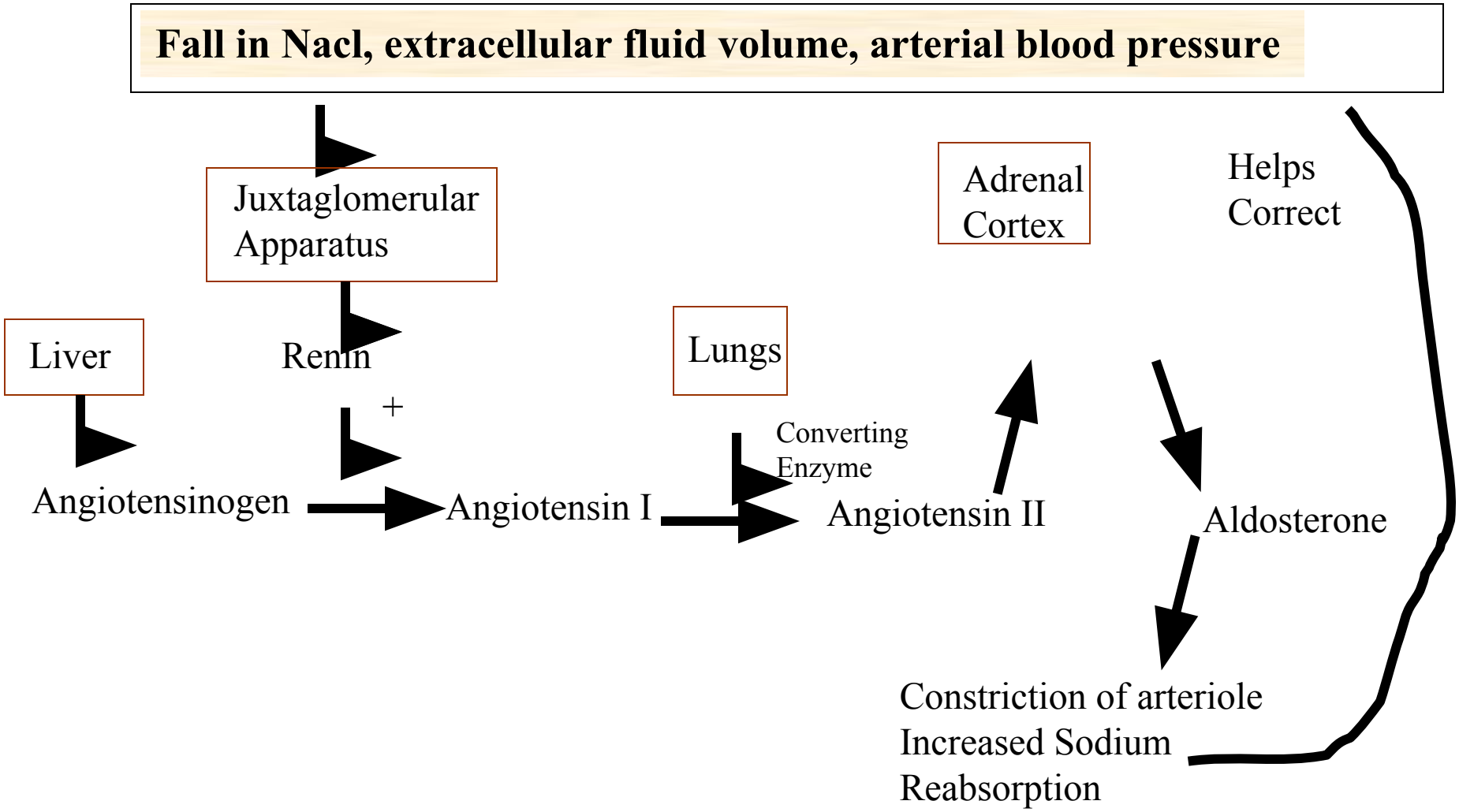
Stimuli and secretion of JG complex

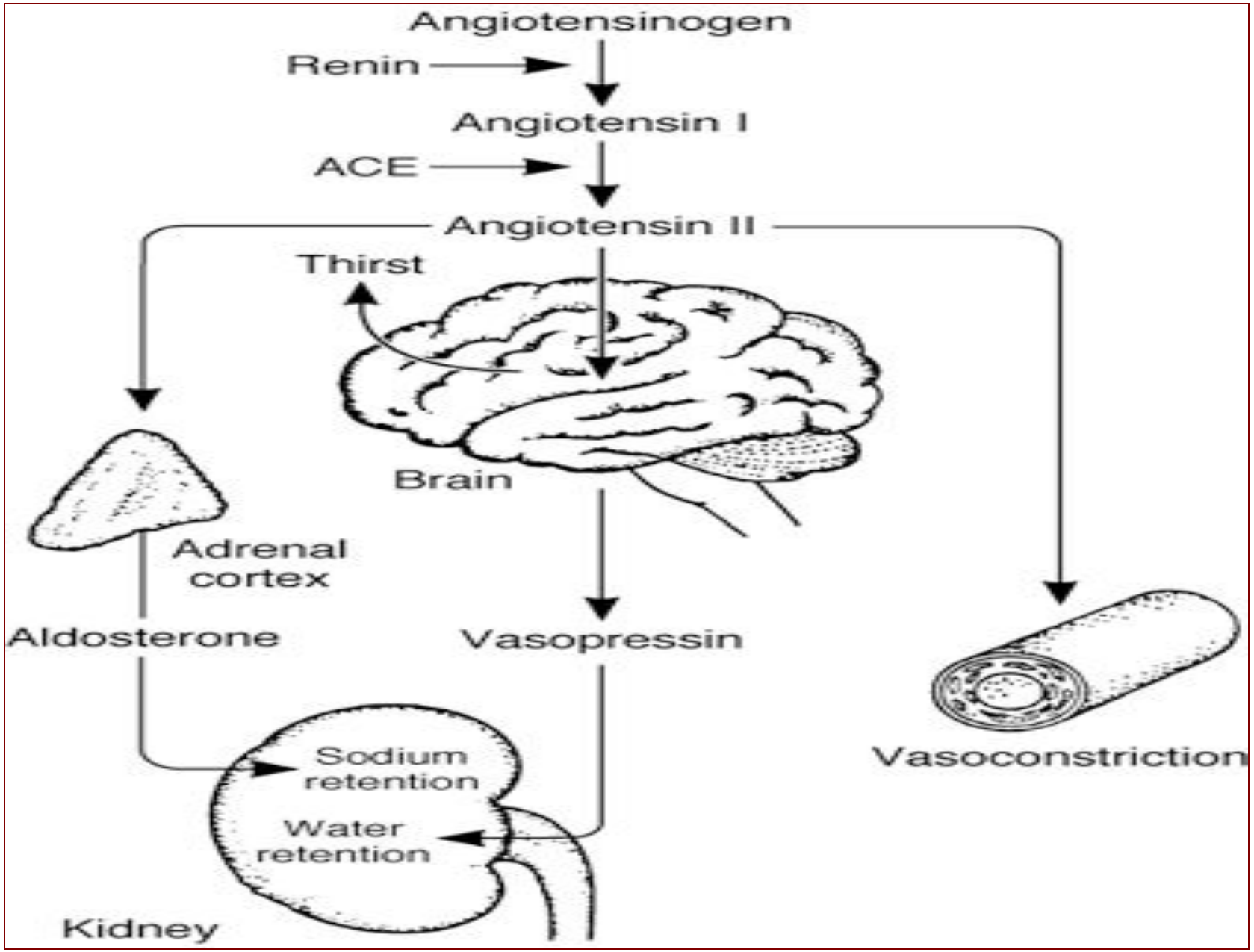
- **Renin –**
- Stimuli for renin release

1. Decrease in blood pressure
2. Reduction in ECF volume
3. Increase in sympathetic activity
4. Decreased load of Nacl at macula densa

- **Erythropoietin** – main stimulant is hypoxia

Renin-Angiotensin-Aldosterone System




Angiotensinogen
Renin
Angiotensin I
ACE
Angiotensin II
Thirst
Brain
Adrenal cortex
Aldosterone
Vasopressin
Vasoconstriction
Sodium retention
Water retention
Kidney

Function of renin angiotensin – aldosterone system

- Regulation of BP and ECF volume
- Autoregulation of GFR
- Autoregulation of renal blood flow

Tubuloglomerular feedback

- **Regulation of RBF & GFR**

- **Secretion of other substances**

  - Lacis cells ------ PGs , cytokines.

  -Macula densa cells ----- Thromboxane A2

Functions of JG complex

- Regulation of BP
- Regulation of ECF volume
- Auto regulation of GFR
- Auto regulation of renal blood flow
- Regulation of erythropoiesis