THE RENAL SYSTEM(L2)

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Urine formation

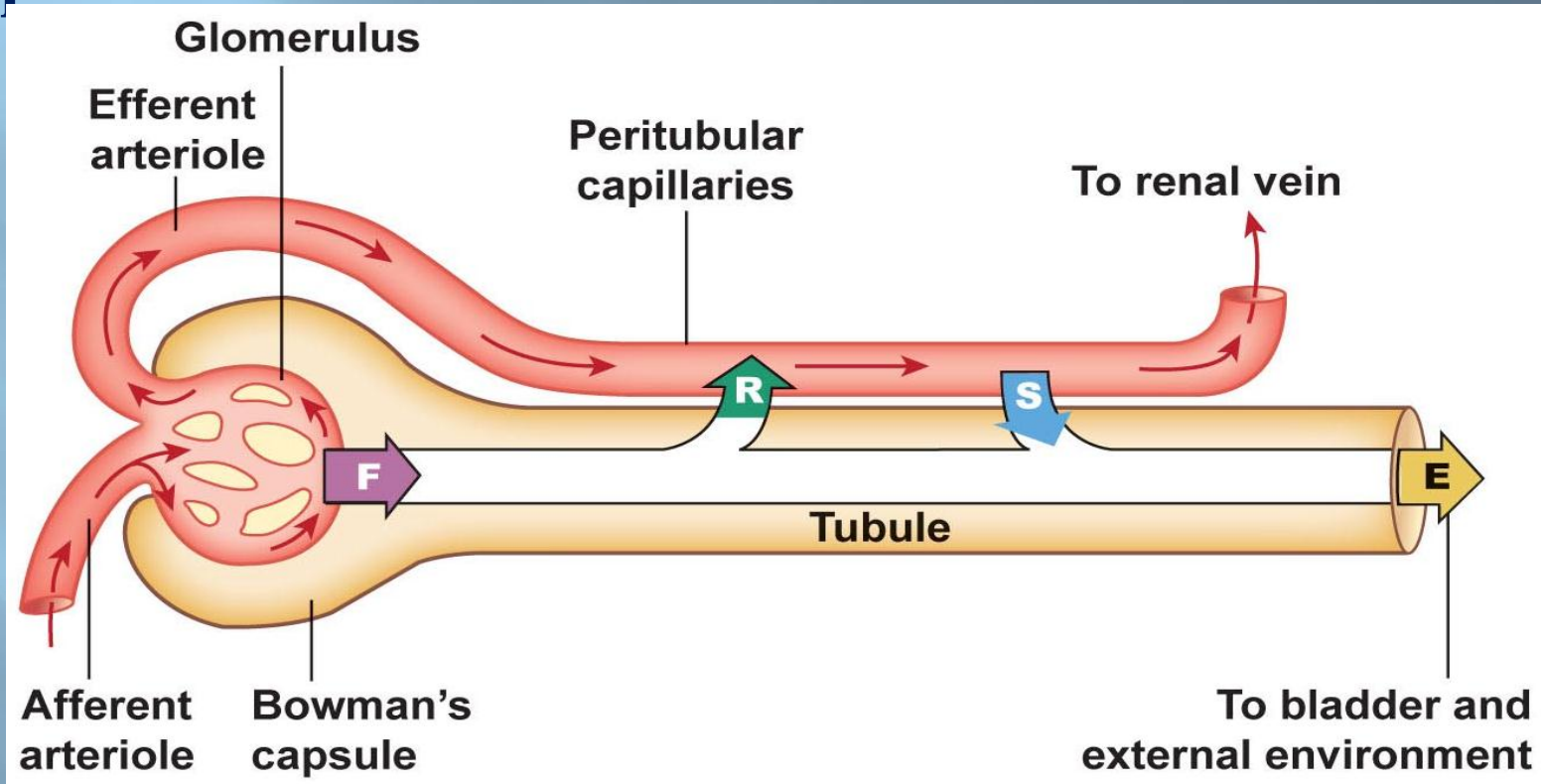
Three major processes are essential for urine formation: ***Filtration , tbular reabsorption and tubular secretion***

Filtration

F**iltration** is the movement of water and small solutes from blood flowing through the glomerulus across the filtration membrane as a result of pressure differences into the Bowman's capsule forming the **filtrate**.

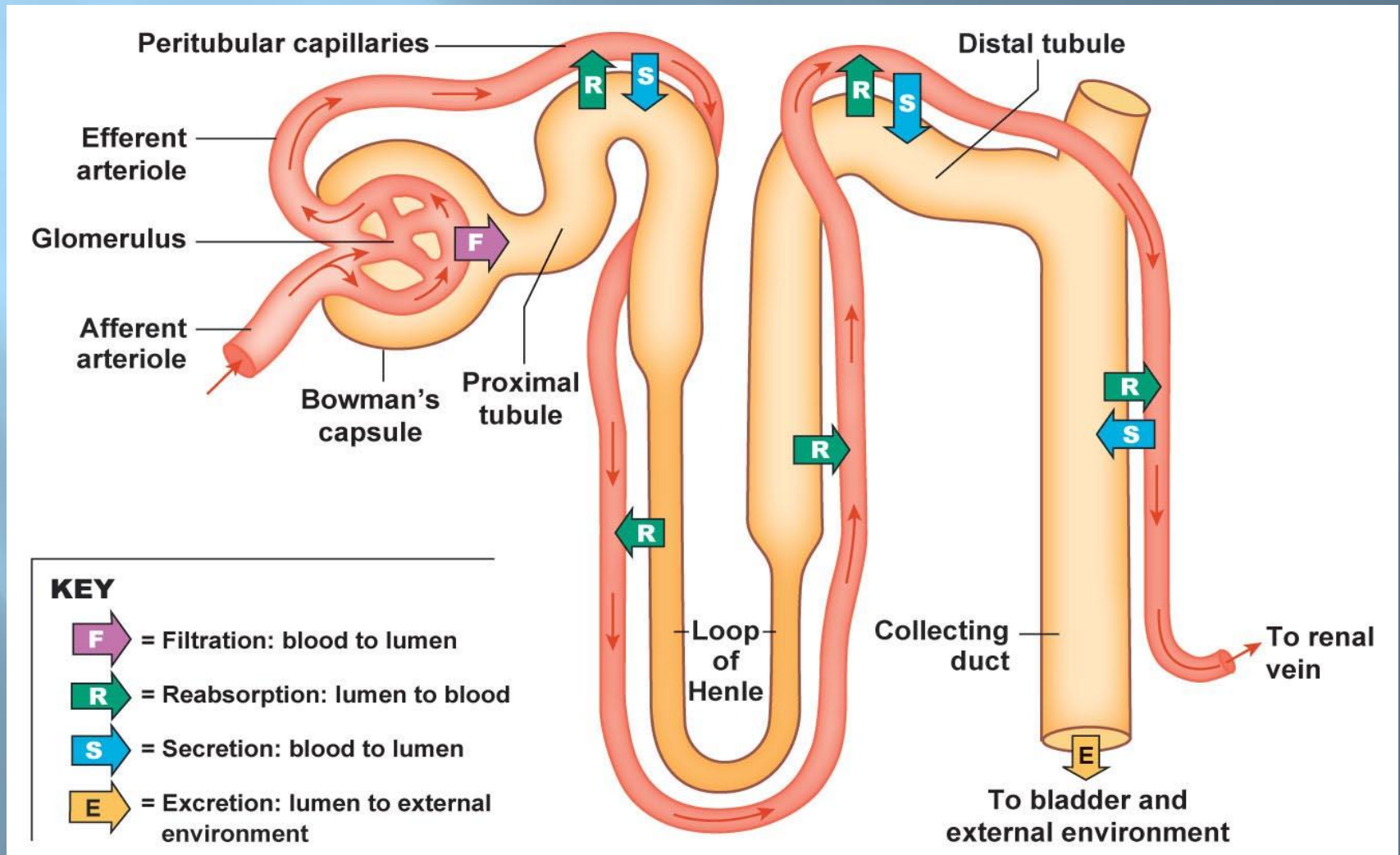
Most substances in the plasma (except for proteins) are freely filtrated ,so their concentrations in the glomerular filtrate in the Bowman's capsule is the same in the plasma.

- Glomerular Filtration
- Tubular Reabsorption
- Tubular Secretion
- Excretion



Amount filtered (F) − amount reabsorbed (R) + amount secreted (S) = amount of solute excreted (E)

Locations for filtration, reabsorption, secretion & excretion



Glomerular filtration:

first step in urine formation

- forcing of fluids and dissolved solutes through membrane by hydrostatic pressure
- same process as in systemic capillaries
- results in a filtrate
- 180 L/day, about 60 times plasma volume
- 178-179 L/day is reabsorbed (~99%)

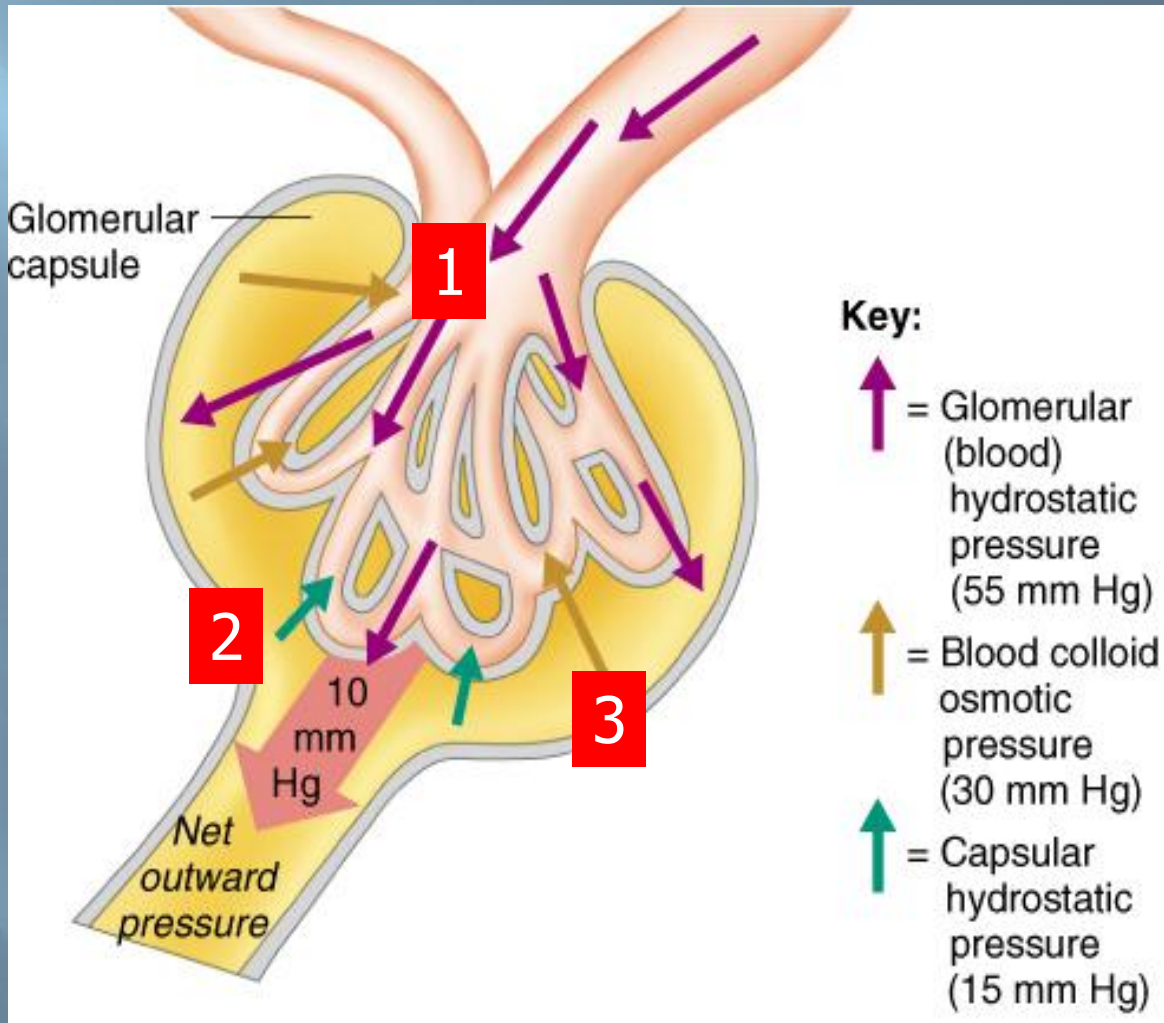
Glomerular Filtration

- 3 structural features of the renal corpuscles enhance their filtering capacity:
  1) Glomerular capillaries are relatively long which increases their surface area for filtration
  2) Filter (endothelium-capsular membrane) is thin and porous
     - Fenestrated glomerular capillaries are 50 times more permeable than regular capillaries
     - The filtration slits of the basement membrane only permit passage of small molecules
  3) Glomerular Capillary blood pressure is high – the efferent arteriole diameter is less than the afferent arteriole diameter -- increasing filtration pressure in the renal corpuscle

Glomerular Filtration

- Net filtration pressure (NFP) depends on 3 pressures:
  1) glomerular blood hydrostatic pressure (GBHP)
  2) capsular hydrostatic pressure (CHP)
  3) blood colloid osmotic pressure (BCOP)

NFP = GBHP – CHP – BCOP
10 = 55 - 15 - 30



- Occurs in the glomerulus due to
- **Filtration membrane &Net filtration pressure (NFP)** which depends on 3 pressures:
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  2) capsular hydrostatic pressure (CHP)
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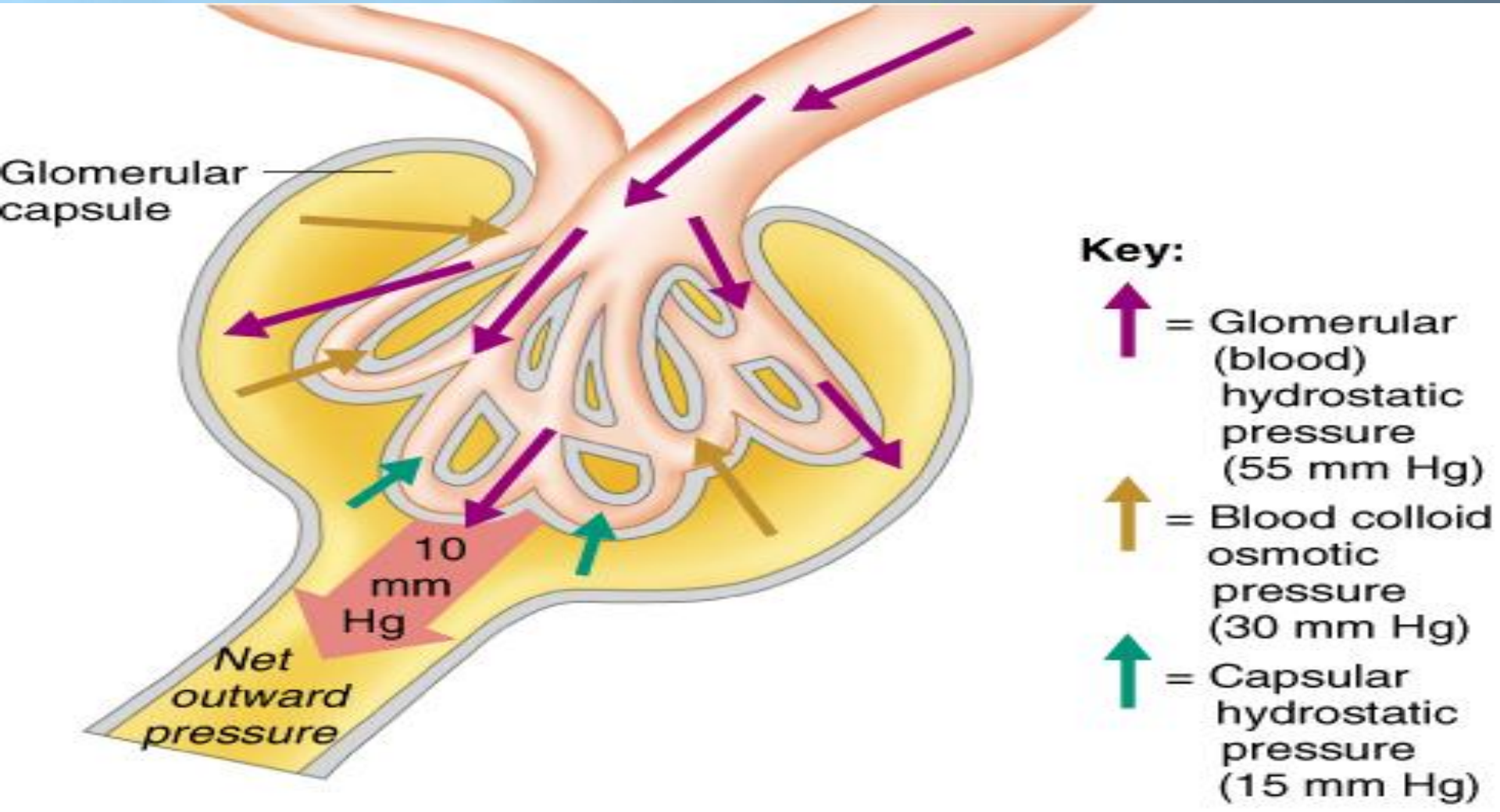

Glomerular blood flow

The part of the total cardiac output that passes through the kidney is called **renal fraction.**

The normal cardiac output is 5600ml/min, while the renal fraction is 1200 ml/min which represents 21% and varies from 12-30%.

Glomerular filtrate

Glomerular filtrate is the fluid filtrated through the glomerular membrane into Bowman's capsule.

Filtration membrane is composed of three layers ,each of these layer is several hundred times as permeable as the capillary membrane ,which accounts for the volume of the glomerular filtrate formed each minute ,but still of high degree of selectivity for the size of passing molecules.

The permeability of the G. membrane to substances of different molecular weights =

Concentration of dissolved substance on the filtrate side of the membrane

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Its concentration on the plasma side

The reasons for the **high selectivity** of the glomerular membrane are :

1-Size of the pores in the glomerular membrane is large enough to pass molecules with diameter 8 nanometers.

2-Electrical charges of the molecules .The pores are lined by glycosylated proteins which have strong negative electrical charges.

Glomerular filtrate has the same components of the plasma except it has no significant amount of proteins.

The glomerular filtration rate(GFR)

The glomerular filtration rate (GFR) is the quantity of glomerular filtrate formed each minute in all nephrons of both kidneys. It is 125ml/min in normal person.

Glomerular filtrate formed each day is 180 Lit/day; over 99% of the glomerular filtrate is reabsorbed in the tubules, while remaining is passing into the urine.

Normal plasma flow through the kidney is 650 ml /min and GFR of both kidneys is 125ml/min, so the average filtration fraction is 19%.

Factors that affect the GFR

- **GFR= Filtration pressure x Kf**
- The factors that determine the filtration pressure (glomerular pressure ,plasma colloid osmotic pressure and Bowman's capsule pressure) will determine the GFR.
- **The conditions that affect these pressures and therefore affect the GFR are:**
- **Renal blood flow**: an increase in the rate of blood flow through the nephrons increases the GFR by increasing the glomerular pressure which enhances the filtration process.
- **Afferent arteriolar constriction** decreases the rate of blood flow into the glomerulus and also decreases the glomerular pressure causing a decrease in the filtration rate.
- **Efferent arteriolar constriction** causes an increase in the resistance to outflow from the glomeruli .This increases the glomerular pressure and increase in efferent resistance causes slight increase in the GFR.

- **Sympathetic stimulation of the kidneys** causes the afferent arterioles to constrict, thereby decreasing the GFR.
- With strong sympathetic stimulation, glomerular blood flow and glomerular pressure are reduced so that glomerular filtration decreases to only a few percent of normal and the urinary output can fall to zero for as long as 5 to 10 minutes**.**
- **Arterial pressure**
- When the arterial pressure rises, afferent arteriolar constriction occurs automatically .This prevents a significant rise in glomerular pressure despite the rise in the arterial pressure. Therefore, the GFR increases only few percent even when the mean arterial pressure rises to 150 mmHg. This phenomenon is called **autoregulation.**
- An increase in arterial pressure can greatly increase the urinary output even though it affects GFR slightly.

THANKS