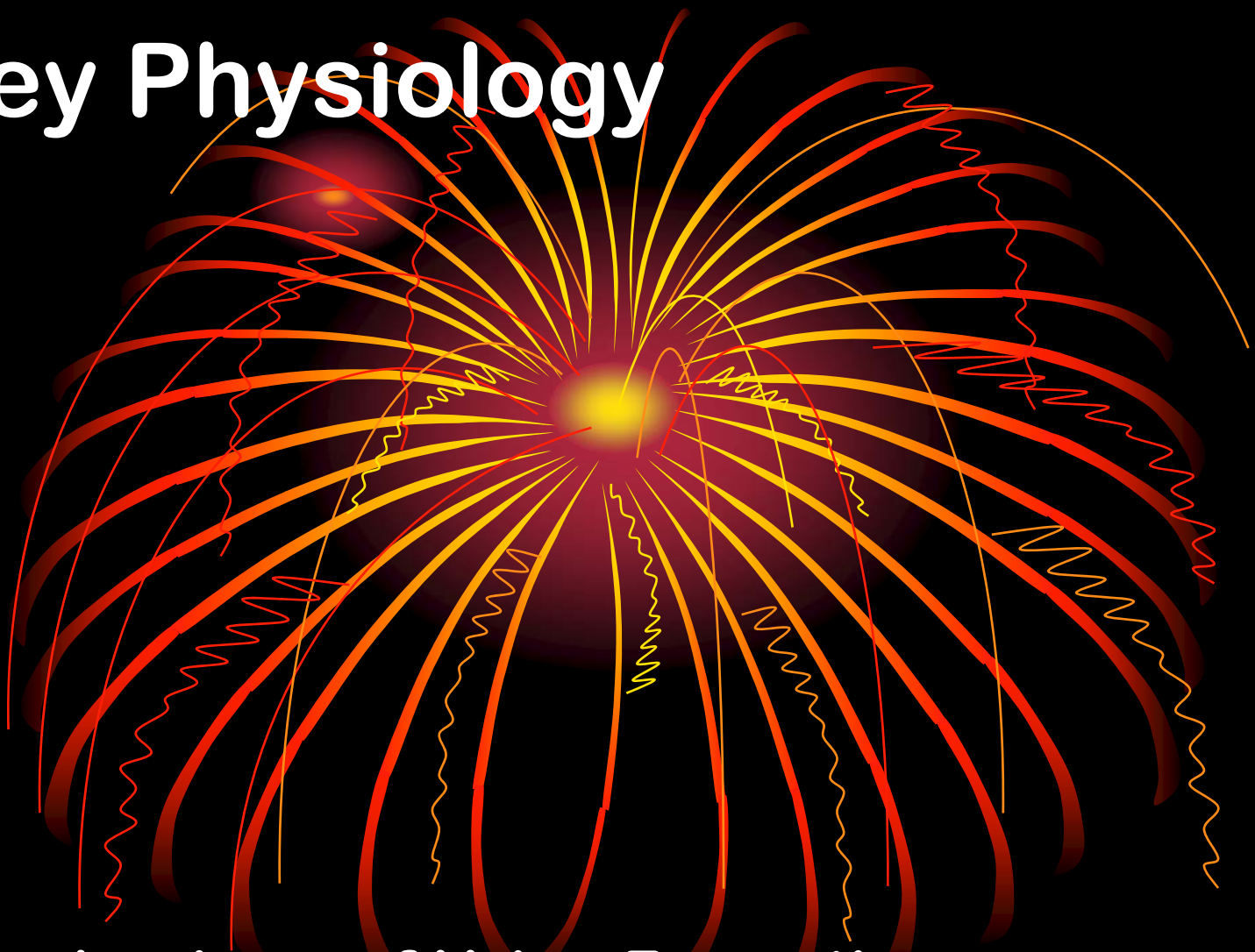
Kidney Physiology



Mechanisms of Urine Formation

TUBULAR SECRETION

Eunise A. Foster Shalonda Reed

The purpose of tubular secretion

- To dispose of certain substances that are bound to plasma proteins.
- To eliminate undesirable substances or end products that have been reabsorbed by passive processes.

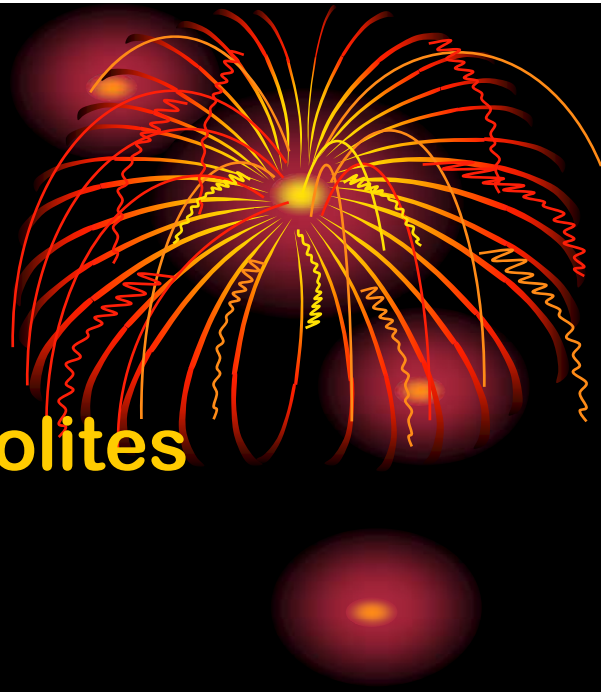
The purpose of tubular secretion continued…

- To rid the body of excessive K+
- To control blood pH; when blood pH approaches the alkaline end of its range, C1^- is reabsorbed instead of HCO^3-, which is allowed to leave the body in urine.

Can you name them??

Name two types of subtances that are not readily filtered by the kidneys and must be secreted.

ANSWER



Certain drugs and metabolites

Metabolites include:

H+

K+

NH^4

creatinine

QUESTION??

What substances are reabsorbed by passive processes?

ANSWER

Urea and Uric Acid

Regulation of Urine Concentration and Volume

- Discusses the concentration of urine and how much is produced.

- the volume of urine that we excrete everyday is a reflection of how much extracellular fluid and sodium our bodies have to spare

Regulation of Urine Concentration and Volume, cont.

- **The kidney tubule regulation of the salt and water in our bodies is the most important factor in determining urine volume**

Regulation of Urine Concentration and Volume, cont.

- Too much water and salt in our bodies is dangerous and too little water and salt in our bodies is dangerous. Therefore, the level of water and salts excreted in urine - the urine volume - is adjusted to the needs of the body.

Regulation of Urine Concentration and Volume, cont.

- under optimum conditions, the body produces urine at a rate of about 1 ml/min.

Regulation of Urine Concentration and Volume, cont.

- The kidneys regulate urine concentration and volume by countercurrent mechanisms.

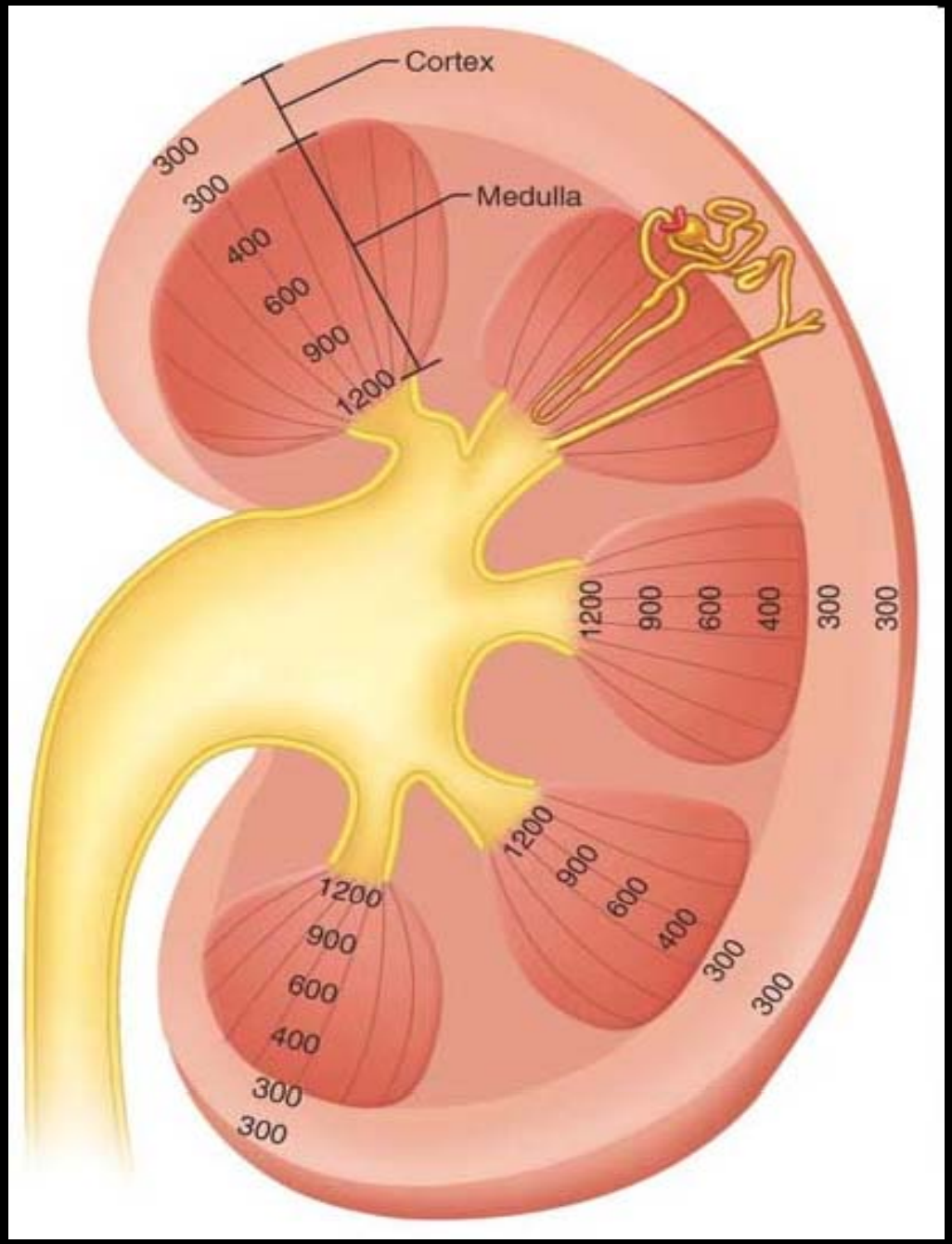
- Countercurrent mechanisms establish and maintain osmotic gradiant throughout the kidney that allows urine concentration to vary dramatically.

Regulation of Urine Concentration and Volume, cont.

COUNTERCURRENT MECHANISMS ARE:

1) The interaction of the flow of filtration through the ascending and descending limbs of the loops of Henle

2) The flow of blood through the ascending and descending portions of the vasa recta blood vessels.



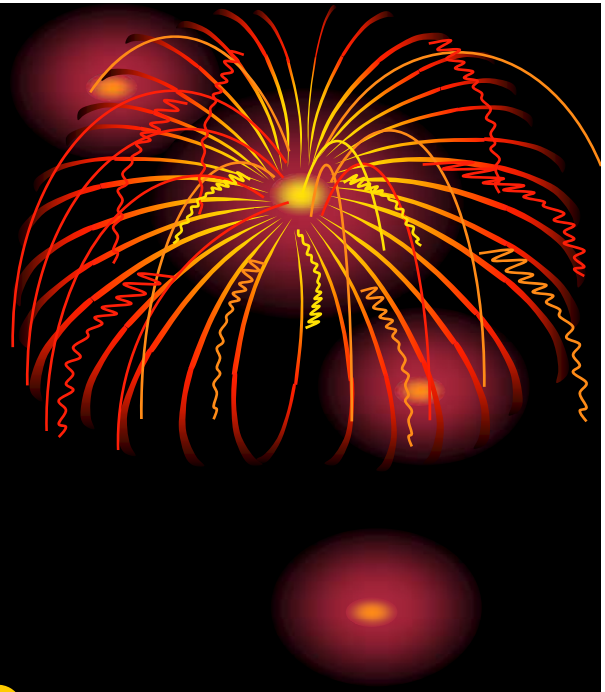
The osmolality of the interstitial fluid in the renal cortex is isotonic at 300 mOsm, but the osmolality of the interstitial fluid in the renal medulla increases progressively from 300 mOsm at the corticomedullary junction to 1200 mOsm at the medullary-pelvis junction. One greatly enlarged nephron and its collecting duct are depicted to show their positions relative to the medullary gradient.

QUESTION ??

Which mechanism does filtrate flows thru?

A. **Loops of Henle**
B. **Vasa Recta**

ANSWER



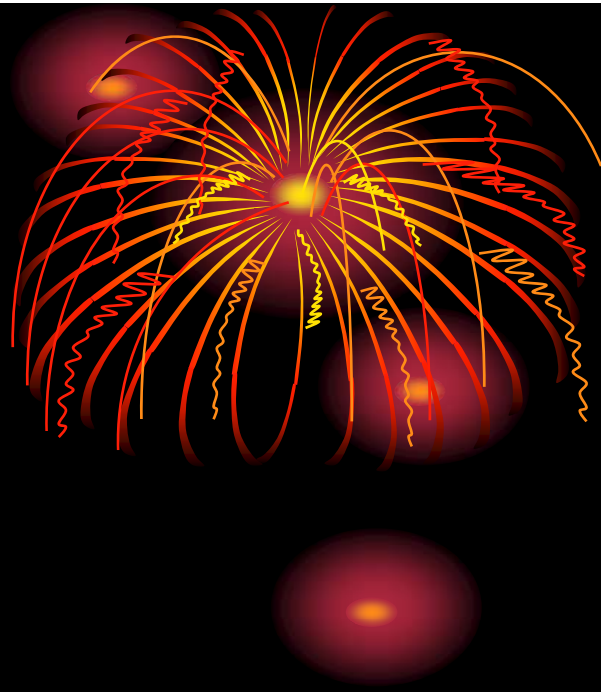
Loops of Henle

QUESTION??

Which mechanism does blood flow thru?

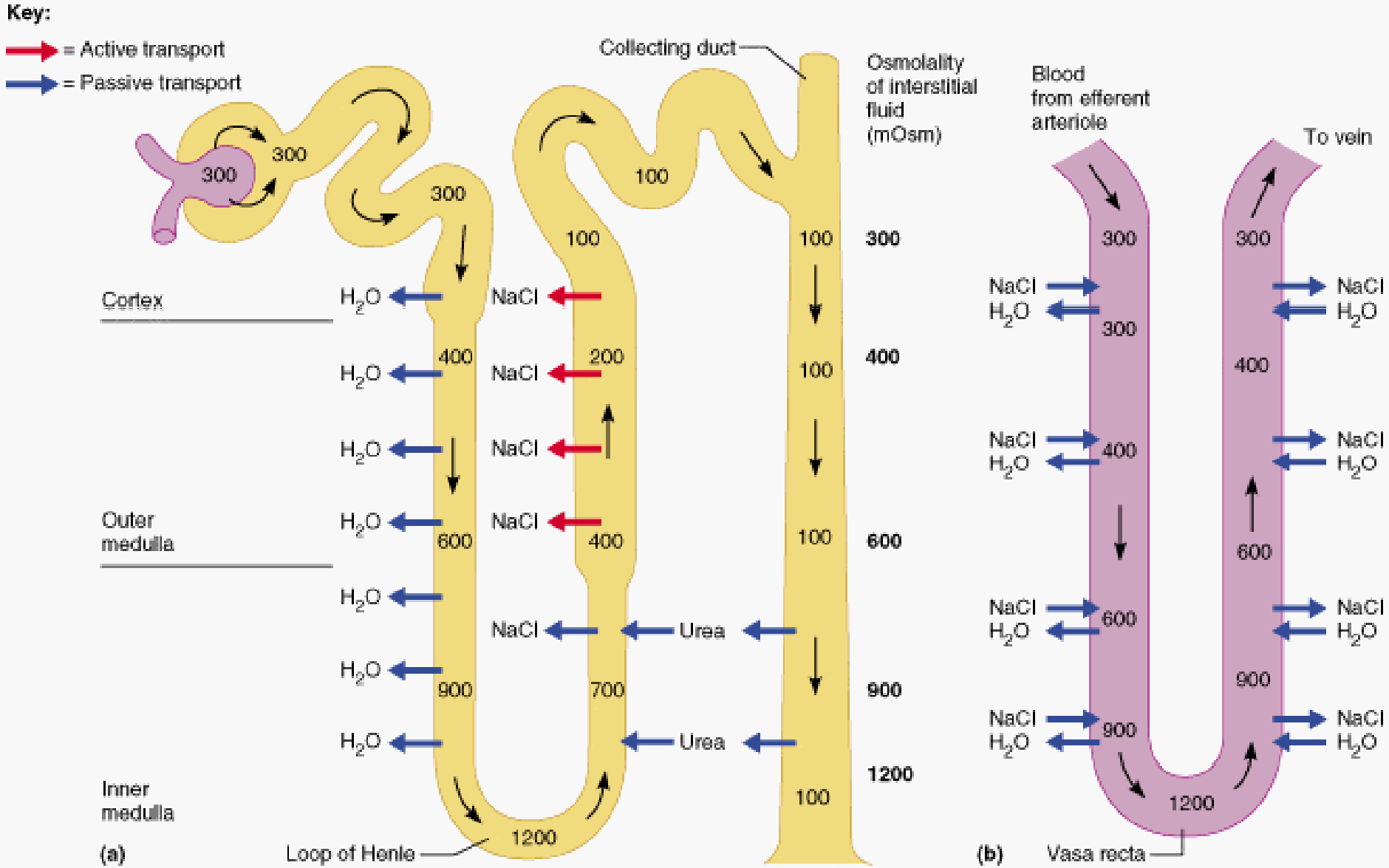
A) Loop of Henle
B) Vasa Recta

ANSWER



Vasa Recta

The Countercurrent Multiplier



The Countercurrent Multiplier

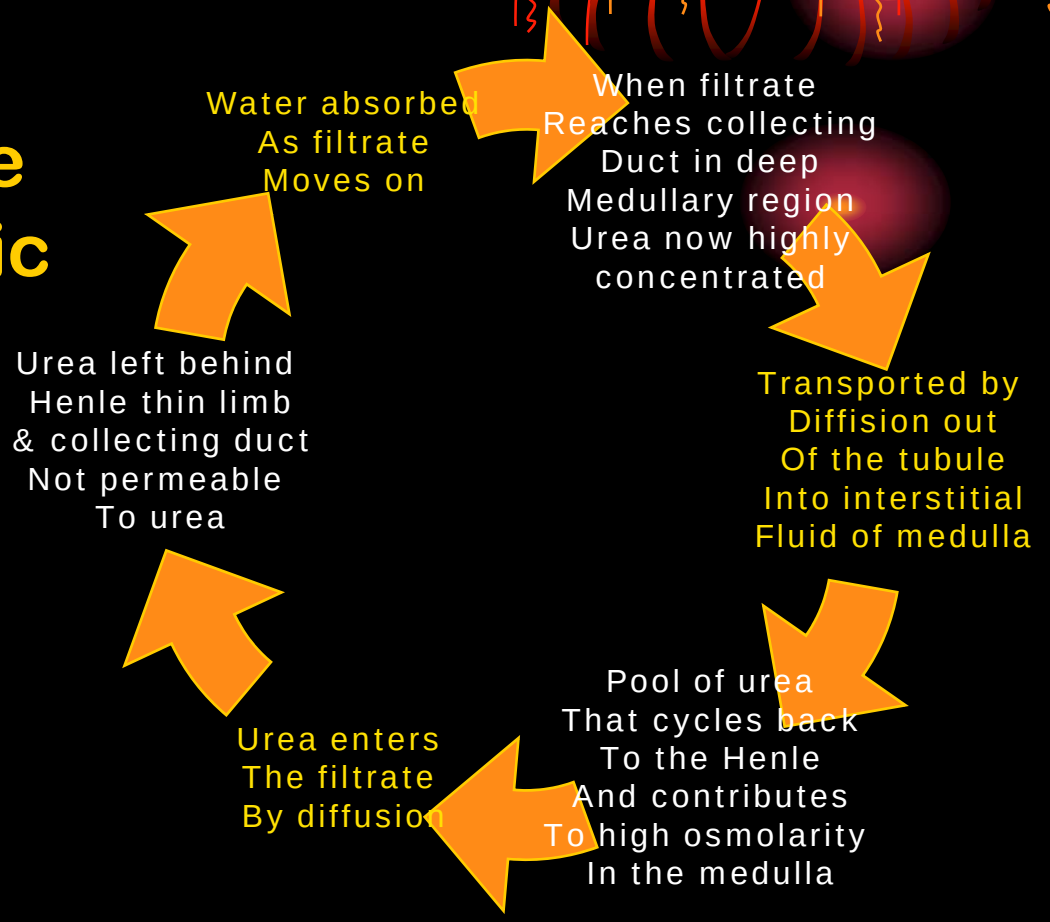
1)The descending limb of the loop of Henle is impermeable to solutes but permeable to water

2)The ascending limb is permeable to solutes, but not to water

- Water going out produces salty filtrate that the ascending limb uses to raise the osmolality of the medullary insterstitial fluid. Positive feedback is established

The Countercurrent Multiplier - Loop of Henle

3)Urea recycling contributes to the medullary osmotic gradient



The Countercurrent Exchanger - Vasa recta

- Maintains osmotic gradiant established by the cyling of salt while delivering blood to cells in the area.
- Because the vessels receive only about 10% of the renal blood supply, blood flow through the vasa recta is sluggish.
- Vasa recta is permeable to water and NaC1
- As the blood flows into the medullary depths, it loses water and gains salt (becomes hypertonic).
- As the blood emerges from the medullary area to the cortex, the process is reversed: it picks up water and looses salt.
- The system does not create the medullary gradient but it protects it by preventing rapid removal of salt from the medullary interstitial space, and by removing reabsorbed water.

Antidiuretic Hormone (ADH) Facts

- Stimulates excretion of highly concentrated urine enhances urea transport in the medullary collecting duct.
- Enhances urea recyling, enhances the medullary osmotic gradient and enables more concentrated urine to be formed
- Inhibits diuresis (urine output)
- With maximal ADH secretion, up to 99% of the water in the filtrate is reabsorbed and returned to the blood, and half a liter per day of highly concentrated urine is excreted.
- Release of ADH is enhanced by any event that raises plasma osmolality above 300 mOsm such as sweating or diarrhea, or greatly reduced blood volume or blood pressure.

For Your Information

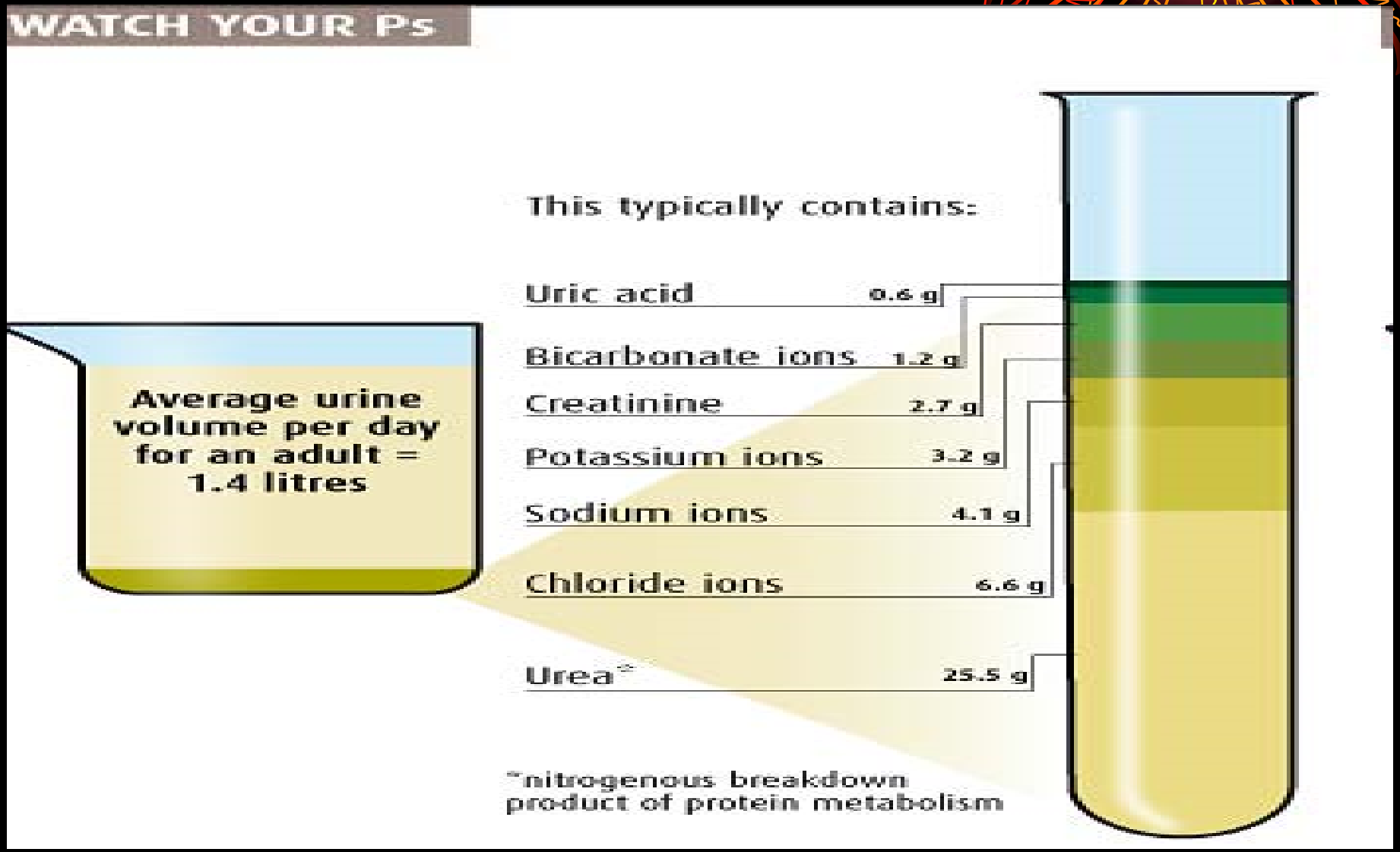
- The ability of our kidneys to produce concentrated urine is critically tied to our ability to survive without water.

Formation of Dilute urine and concentrated urine

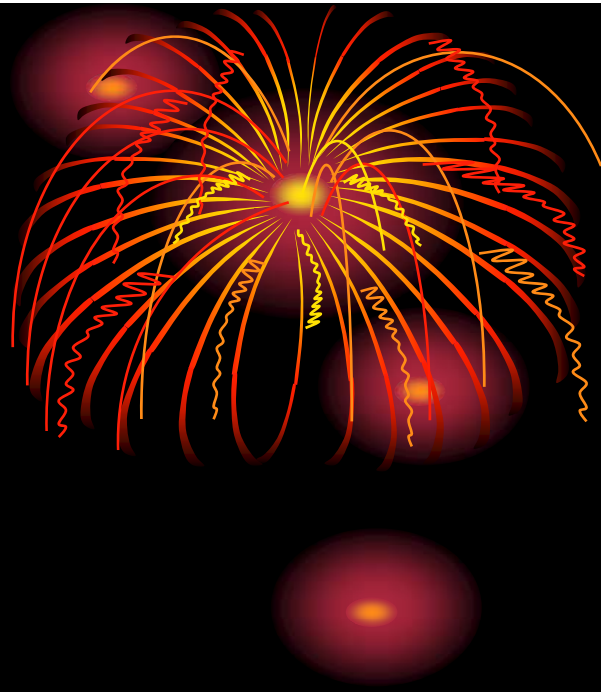
- In the absence of antidiuretic hormone (ADH), dilute filtrate produced by the countercurrent mechanism remains dilute as it passes through the collecting duct.

- The presence of ADH, cencentrated urine is excreted. Consequently water rapidly leaves the filtrate in the collecting duct.

Contents of Urine Water



Diuretics



Chemicals that Enhance Urinary output

- **Alcohol**
  - a sedative
  - Inhibits release of ADH
- **Caffeine**
  - Increases urinary Flow
  - Inhibits Na^2 reabsorption
- **Rx for**
  - Hypertension
  - Or edema of
  - Congestive Heart failure

Renal Clearance

- Refers to the volume of plasma that is cleared of a particular substance in a given time, usually 1 minute.
- Renal clearances are done to detect glomerular damage and follow the progress of renal disease
- The renal clearance is calculated from the following equation:

$$RC = UV/P$$

u = concentration of the substance in urine
v = flow rate of urine formation
p = concentration of the substance in plasma

Urinary Physiology

Glomerular Filtration

Definitions:

Filtration

- The physiological process of mechanically seperating liquid from undissolved particles by passing it through a semi permeable membrane with pores small enough to prevent the passage of the undissolved particles.

Glomerular filtration

- The passive process by which water and small molecules are forced trhough fenestrations within the renal corpuscle and into the capsular space. The main driving force is the glomerular blood hydrostatic pressure measured by the creatinine clearance test.

Definitions cont...

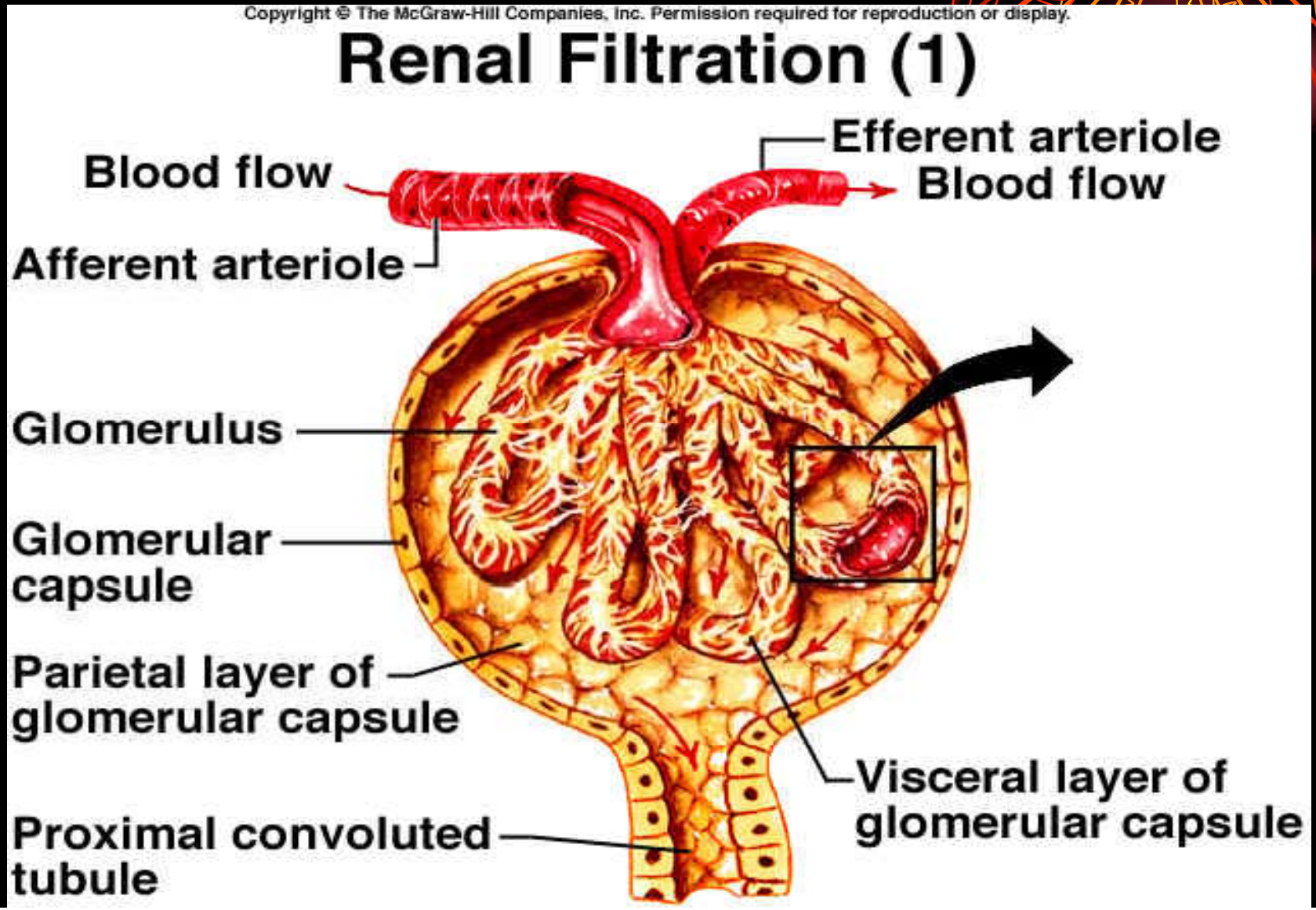
Glomerular filtrate

- Protein poor fluid transferred in the capsular space of the renal corpuscle as a result of glomerular filtration. Consists of water and small dissolved solutes

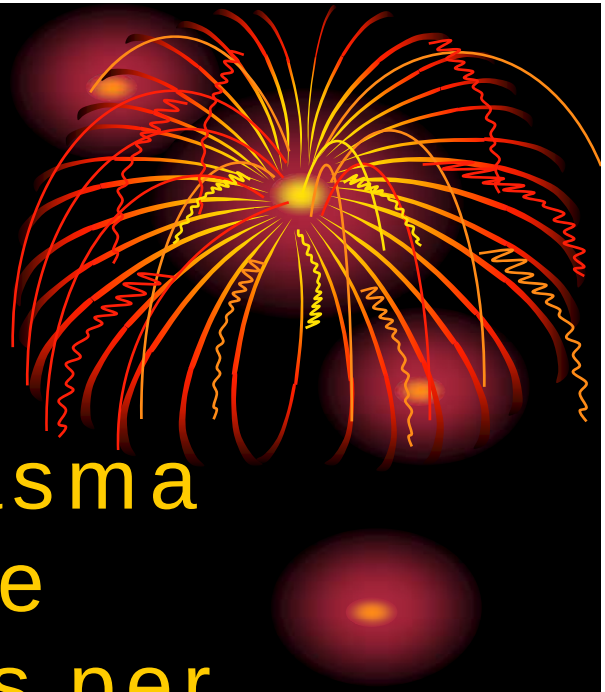
Net filtration pressure

- The dynamic equilibrium force which may be measured in the capsular space of the renal corpuscle which determines how much water and soltutes leave blood in the glomerulus.

Structures within the Bowmans Capsule



What is GFR?



- The total amount of plasma filtrate formed by all the nephrons of the kidneys per minute
- It is used to evaluate the kidneys ability to remove waste products from the body.

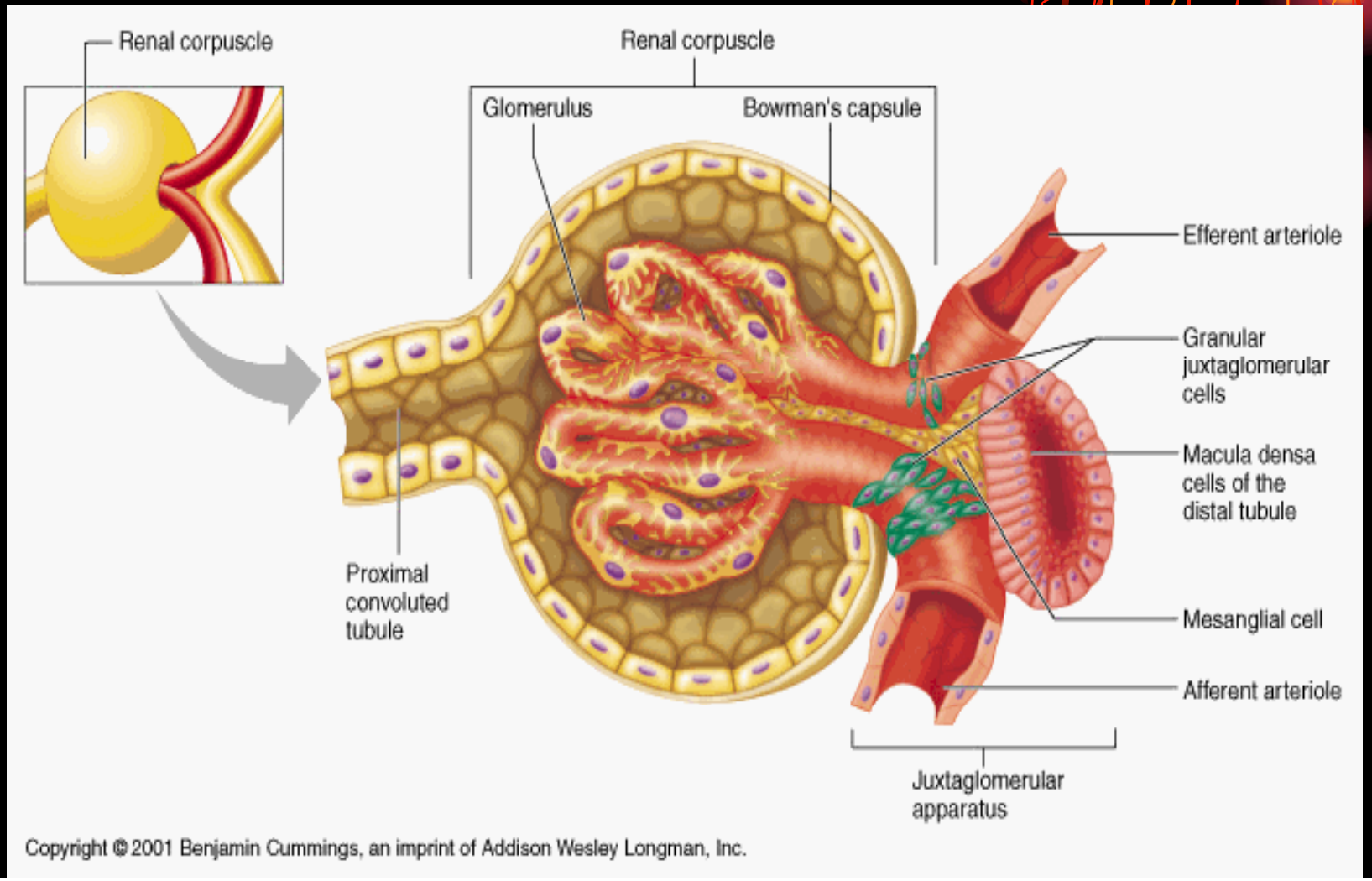
What is it used for?

- GFR is used to screen for early signs of kidney damage and, in those already diagnosed with kidney disease (nephropathy), signs of further deterioration of kidney function

How it works

- Blood enters the kidneys through arteries that branch inside the kidneys into tiny clusters of looping blood vessels. Each cluster is called a glomerulus, which comes from the Greek word meaning filter. There are approximately 1 million glomeruli, or filters, in each kidney. The glomerulus is attached to the opening of a small fluid-collecting tube called a *tubule*. Blood is filtered in the glomerulus, and extra water and wastes pass into the tubule and become urine. Eventually, the urine drains from the kidneys into the bladder through larger tubes called *ureters*

Structure



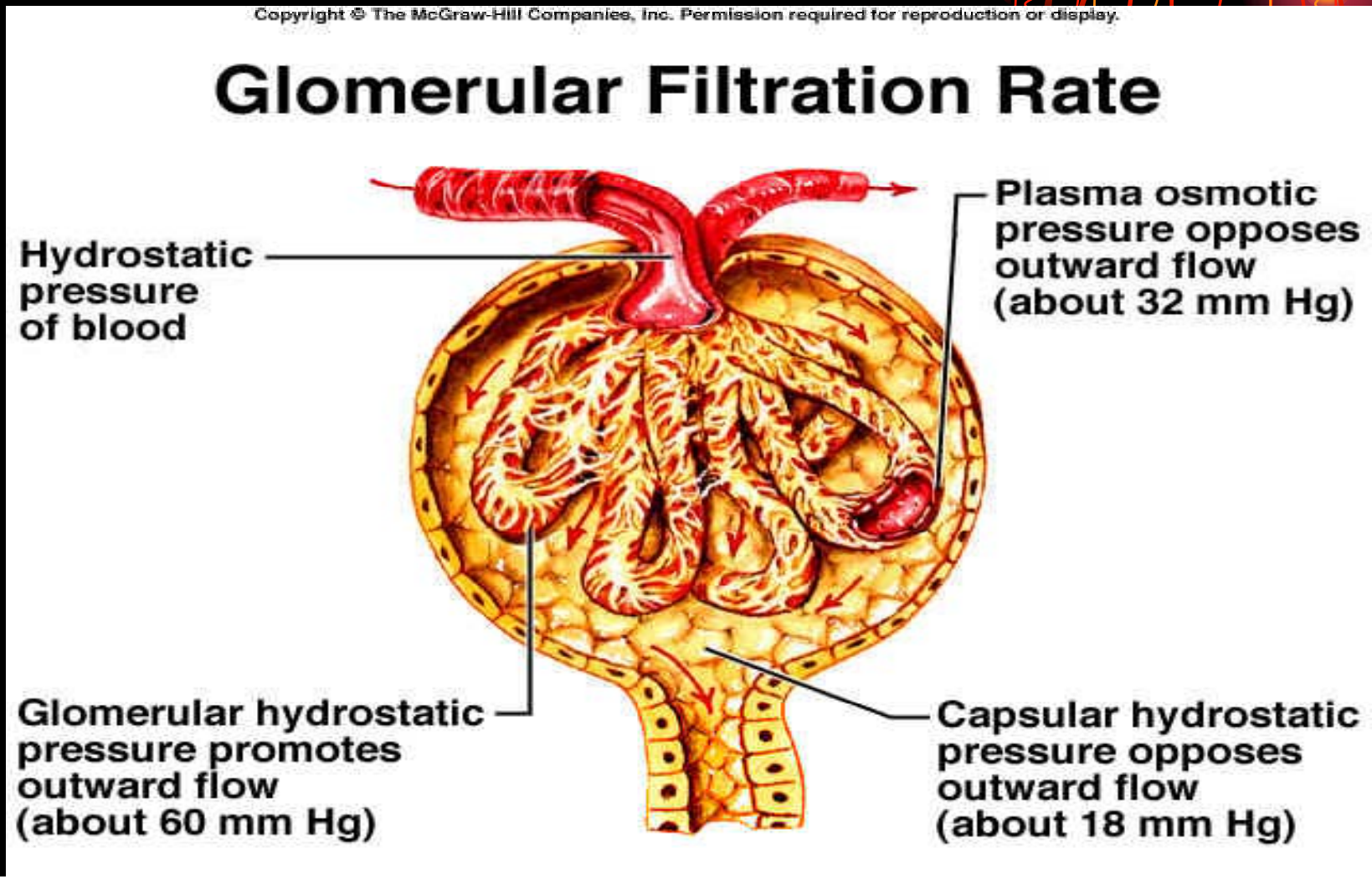
How is GFR determined?

- The total surface area available for filtration
- The permeability of the filtration membrane
- The net filtration pressure

Net filtration pressure

- Difference between pressure forcing fluid into the glomerular space and pressures resisting filtration
- Forces in – forces out

GFR fills the capsular space and is formed by a net filtration pressure (NFP) of 10mmHg



GFR determination con't

- Normally total surface area and permeability do not change in healthy individuals, though they can be changed by injuries and disease processes; therefore, the body normally adjusts GFR by adjusting net filtration pressure in the kidneys
- GFR is proportional to net filtration pressure; it is measured by a variety of clinical tests known as renal clearance studies, of which the creatinine clearance test is the most popular; a typical GFR in healthy individuals is 120-125 mL/min

Factors affecting GFR

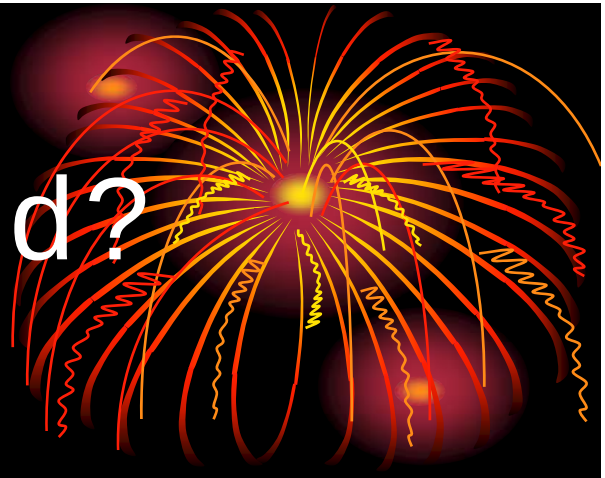
Increase

- Dietary protein intake
- Ketoacidosis
- Hyperglycemia (high blood sugar)
- Pregnancy

Decrease

- Vascular diseases
- Congestive heart failure
- Sodium and water depletion (dehydration)
- Hemorrhage
- Vigorous exercise
- Shock

How is it measured?



- GFR cannot be directly measured. Instead, it is estimated from the measurements of other body waste products.

- These measurements may include:
- *Cystatin C* test
- Serum creatinine test
- Creatinine clearance test