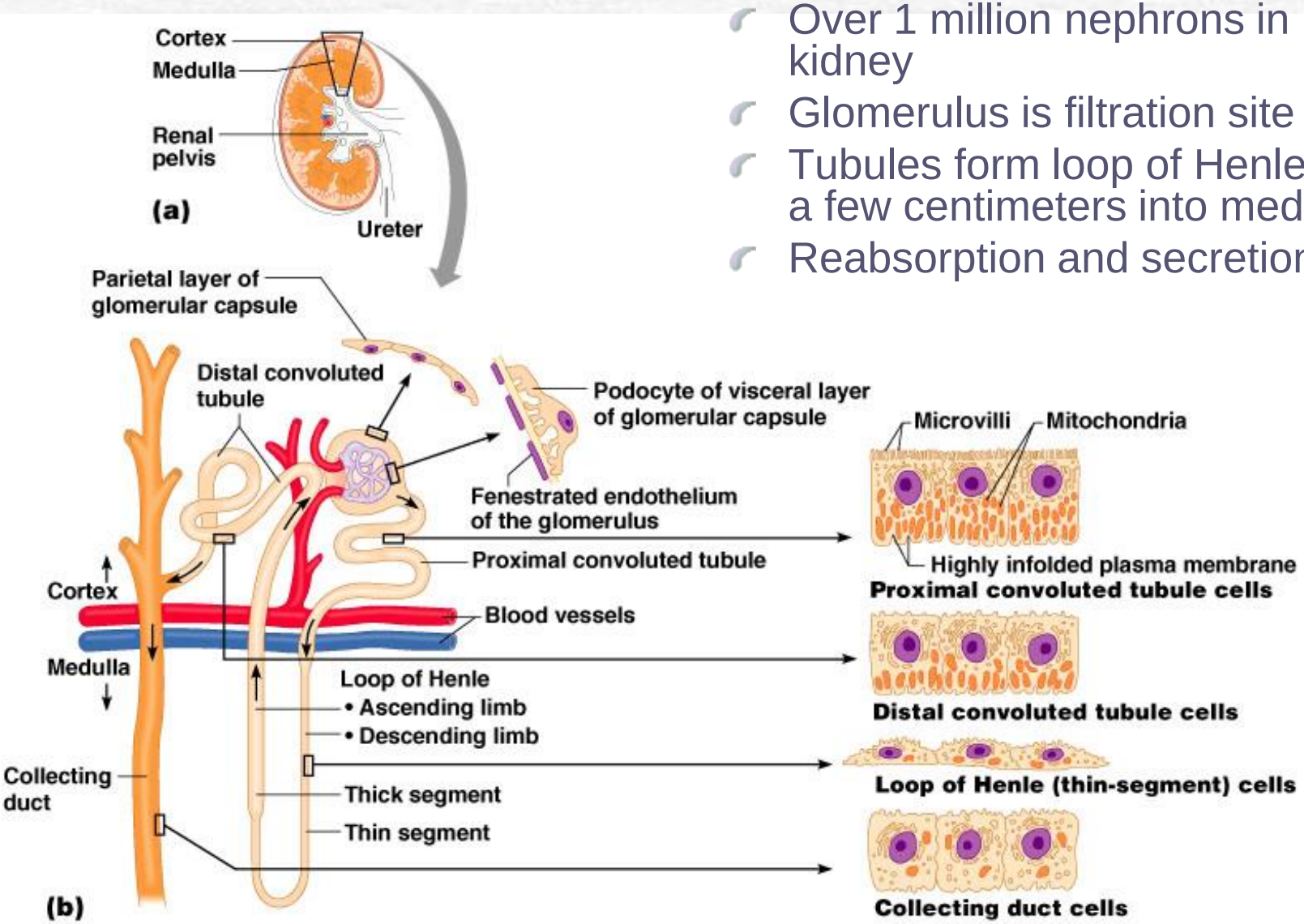
How does the kidney work? What controls the rate and concentration of urine?

- Review nephron in kidney
- Steps in urine formation and concentration
  - Glomerular filtration
  - Reabsorption
  - Tubular secretion

Nephron is functional unit of kidney

- Over 1 million nephrons in human kidney
- Glomerulus is filtration site in cortex
- Tubules form loop of Henle, extending a few centimeters into medulla
- Reabsorption and secretion in tubules



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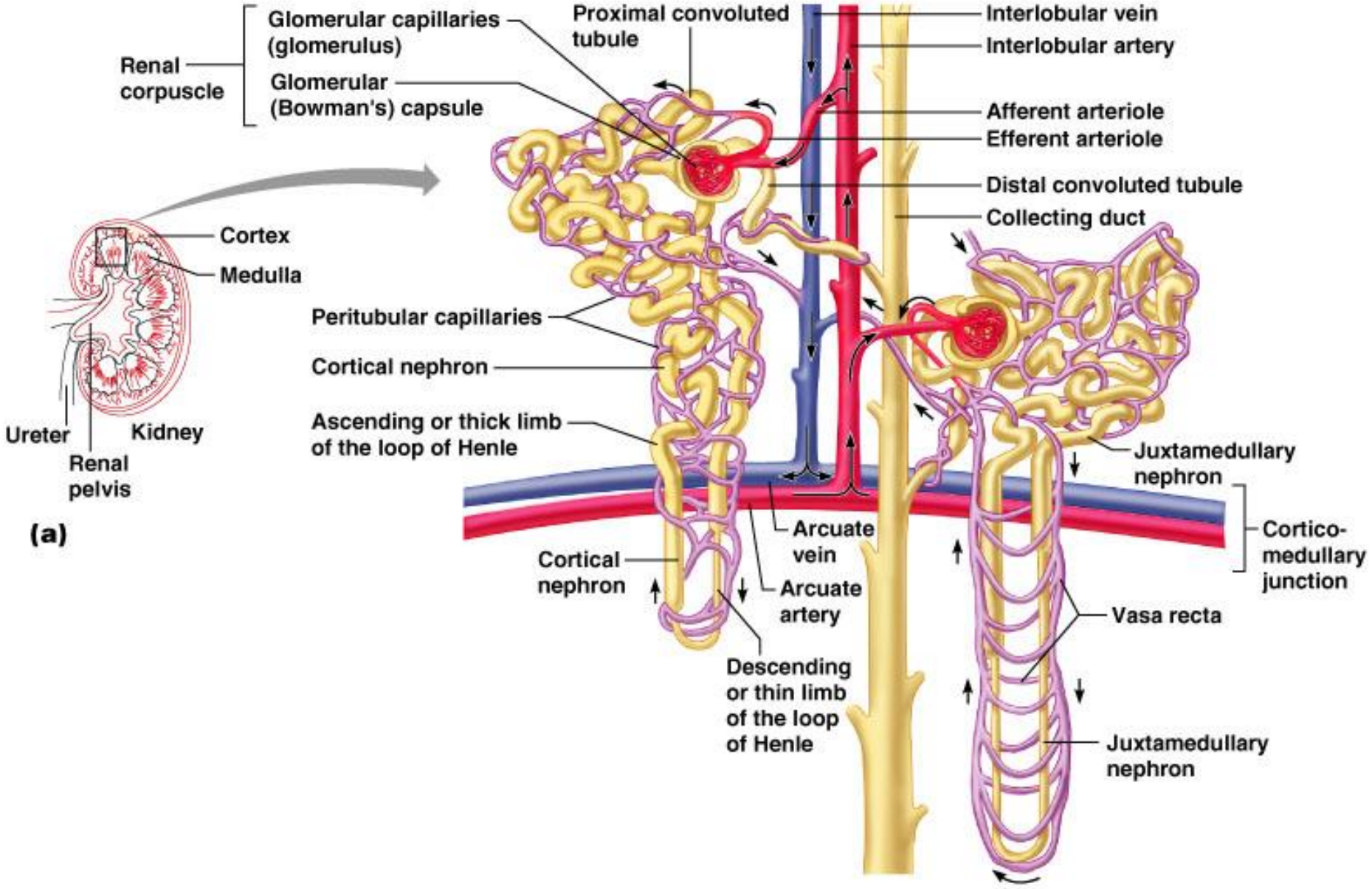
More realistic view of nephrons



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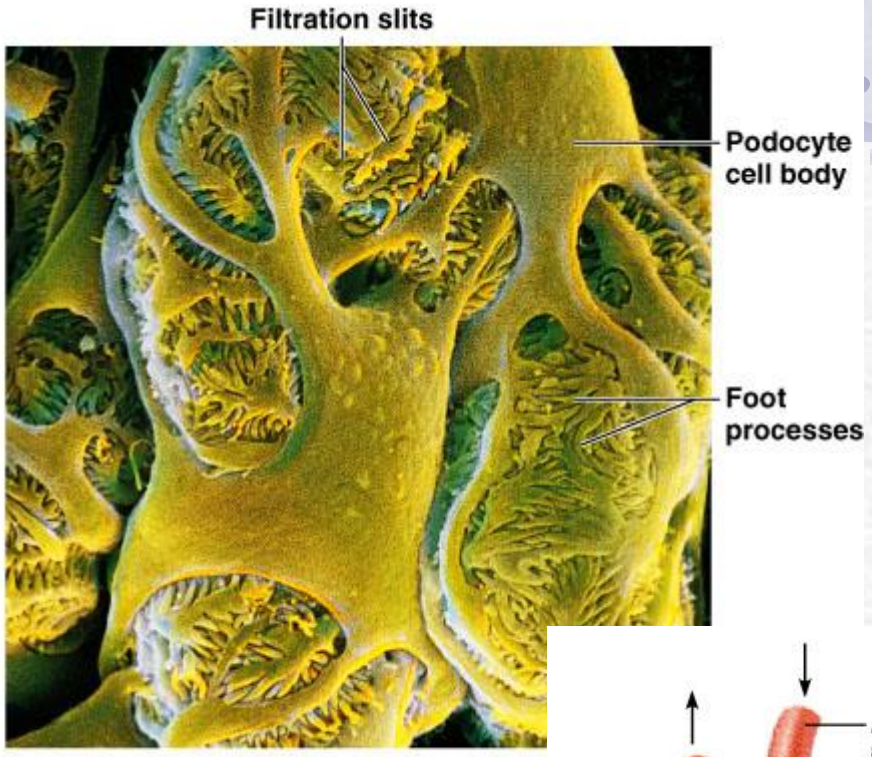
Filtration at Glomerulus

- Filtration membrane formed by podocyte cells lets all of plasma components of blood filter out of glomerular capillaries and into proximal convoluted tubule



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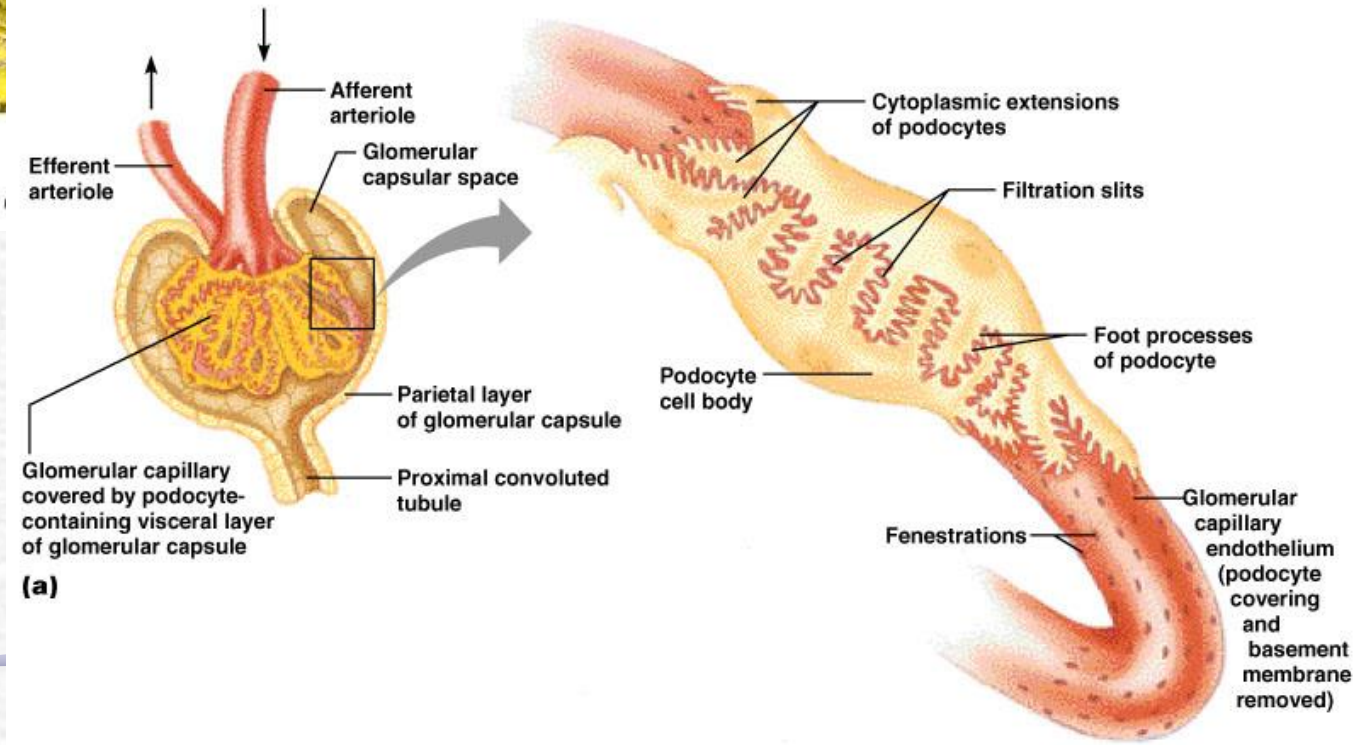

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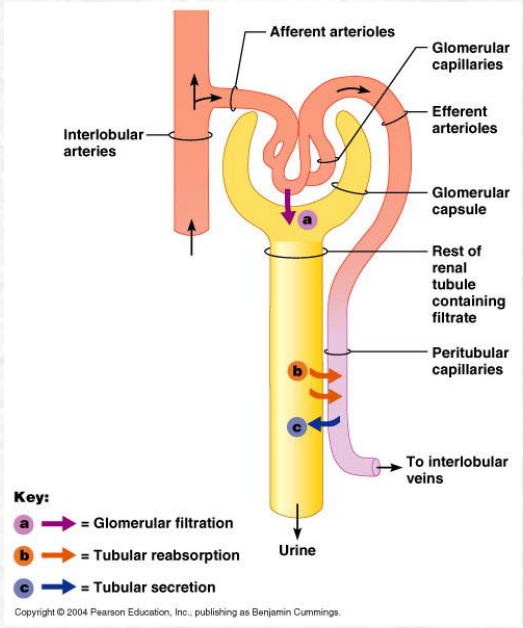
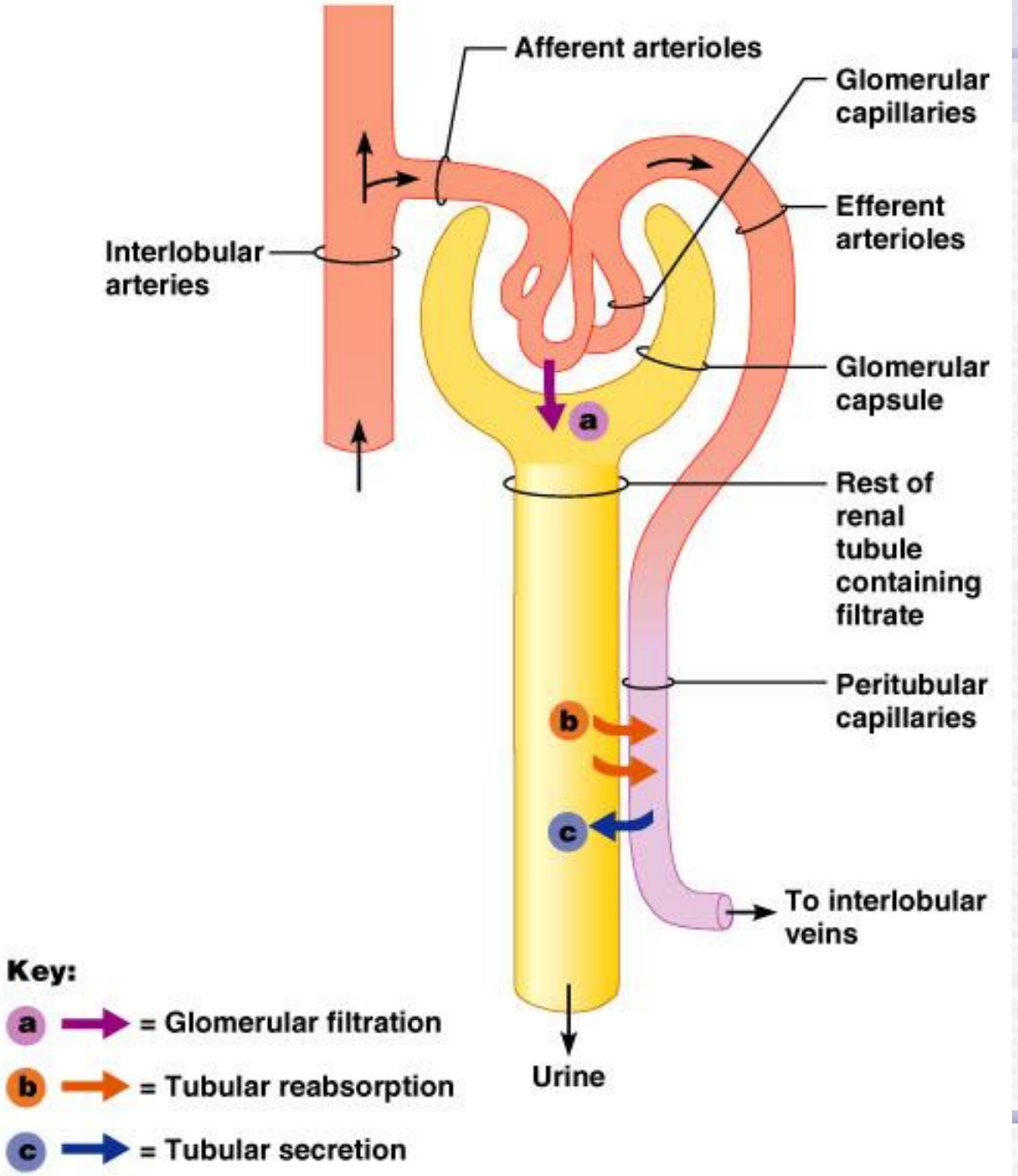
What happens to filtrate to make urine?

- Filtrate contains all non-protein and non-cellular parts of blood
  - Water
  - Dissolved ions
  - Dissolved glucose
  - Amino acids
  - Nitrogenous wastes (nitrites, urea)
  - No proteins
  - No cells



- Production of urine and thus control of blood chemistry involves three processes
  - Control over glomerular filtration rate (how fast is blood plasma filtering out of blood into tubules of kidney
  - Subsequent movement of fluid and dissolved substances out of filtrate and back into blood by reabsorption
  - Tubular secretion or further removal of certain substances from blood



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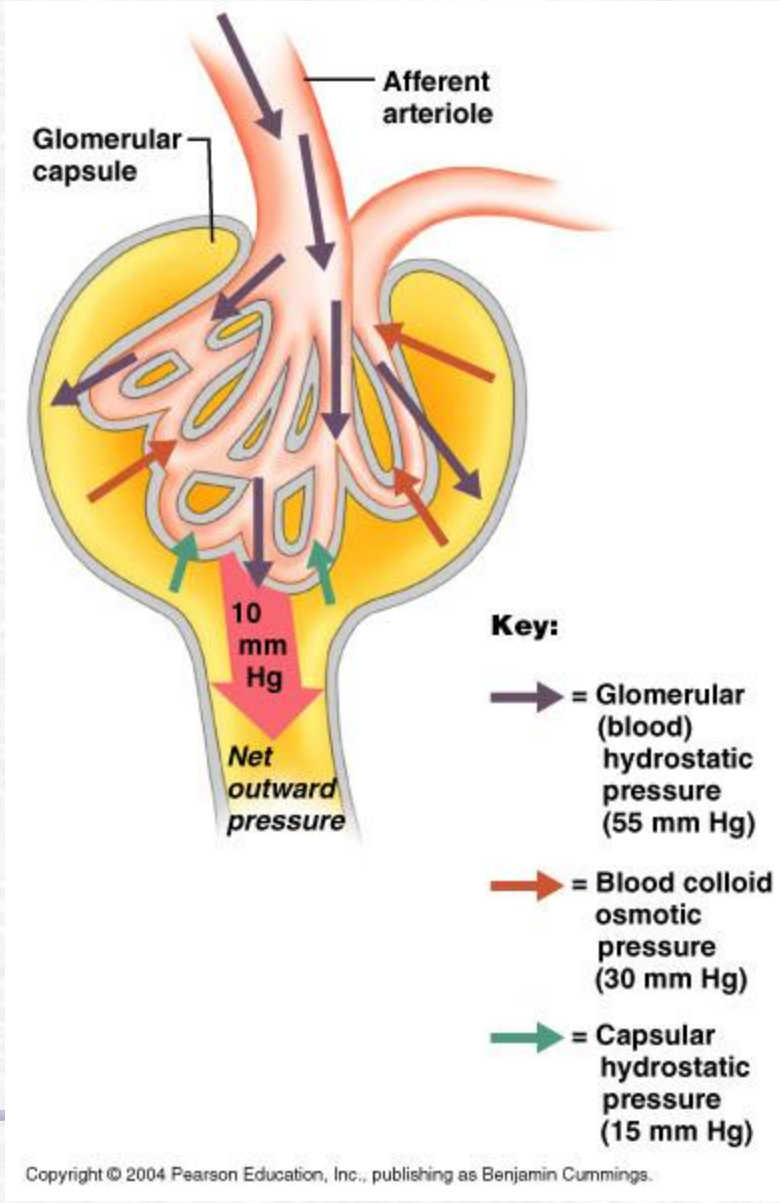
What controls glomerular filtration rate?

- Locally, glomerular filtration depends on
  - Blood pressure in glomerular capillaries
  - “Osmotic pressure” or amount of dissolved substances in blood versus amount of dissolved substances in surrounding glomerular tissues
- Local changes in kidney arterial pressure (by smooth muscles in walls of vessels vaso-dilating) is main control of glomerular filtration rate



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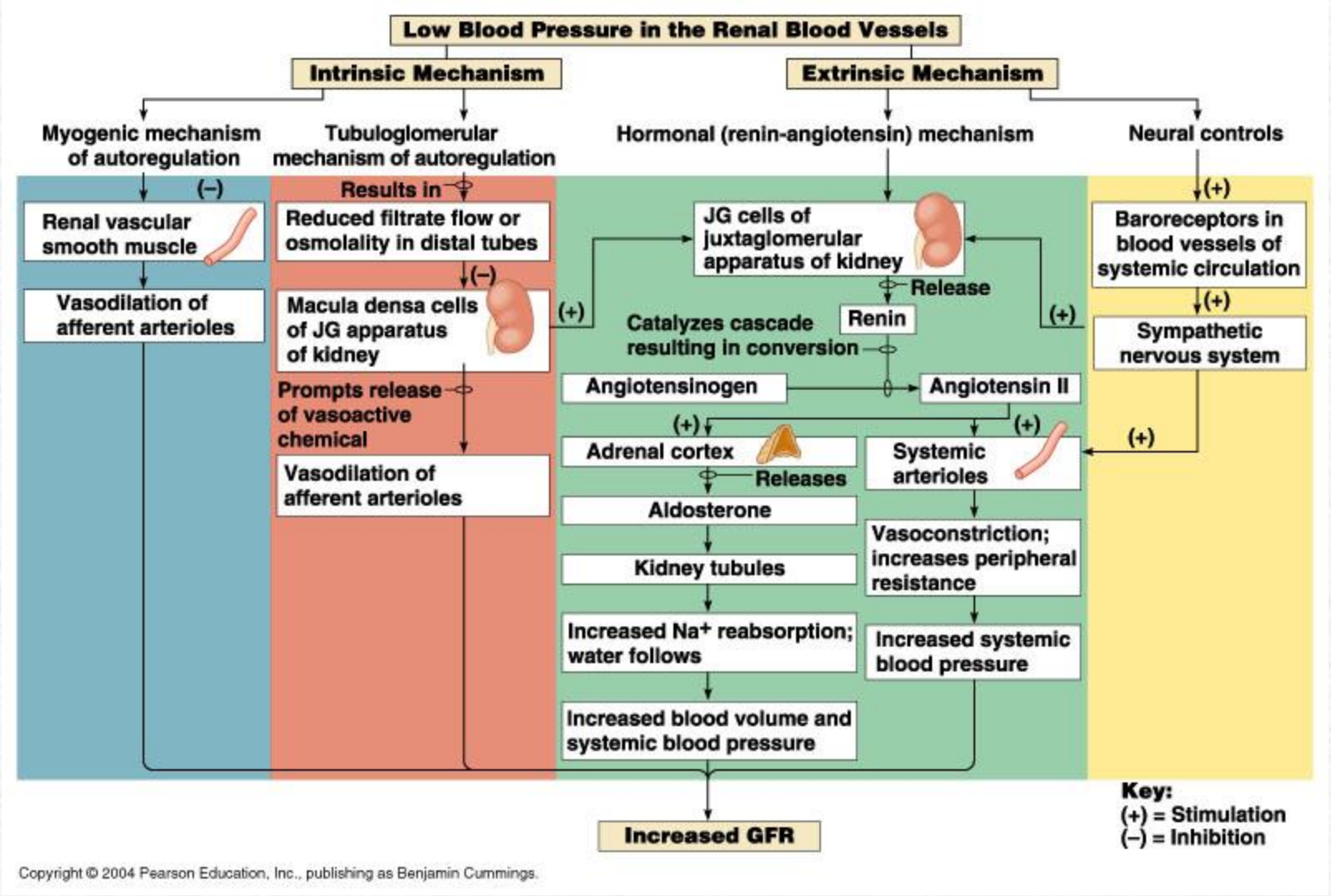
But many external factors can also control glomerular filtration rate



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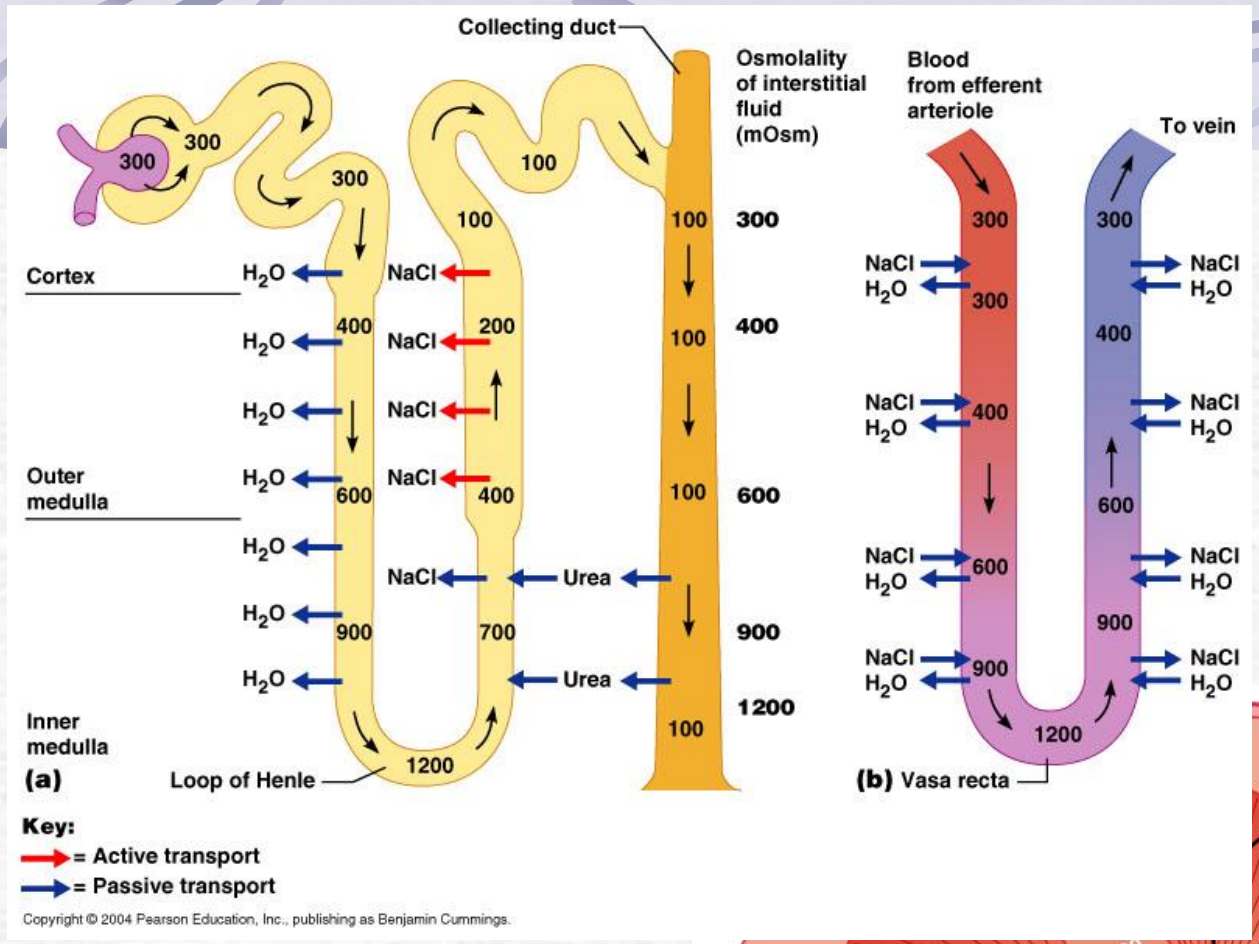
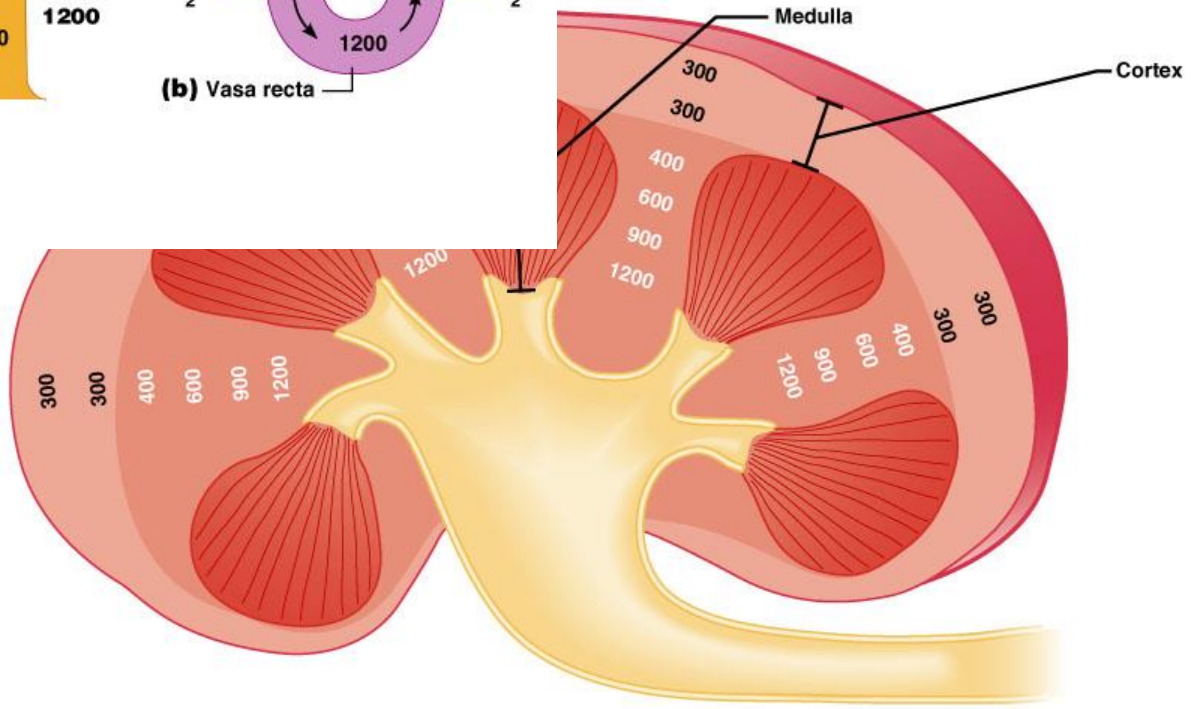
How would caffeine affect glomerular filtration rate?

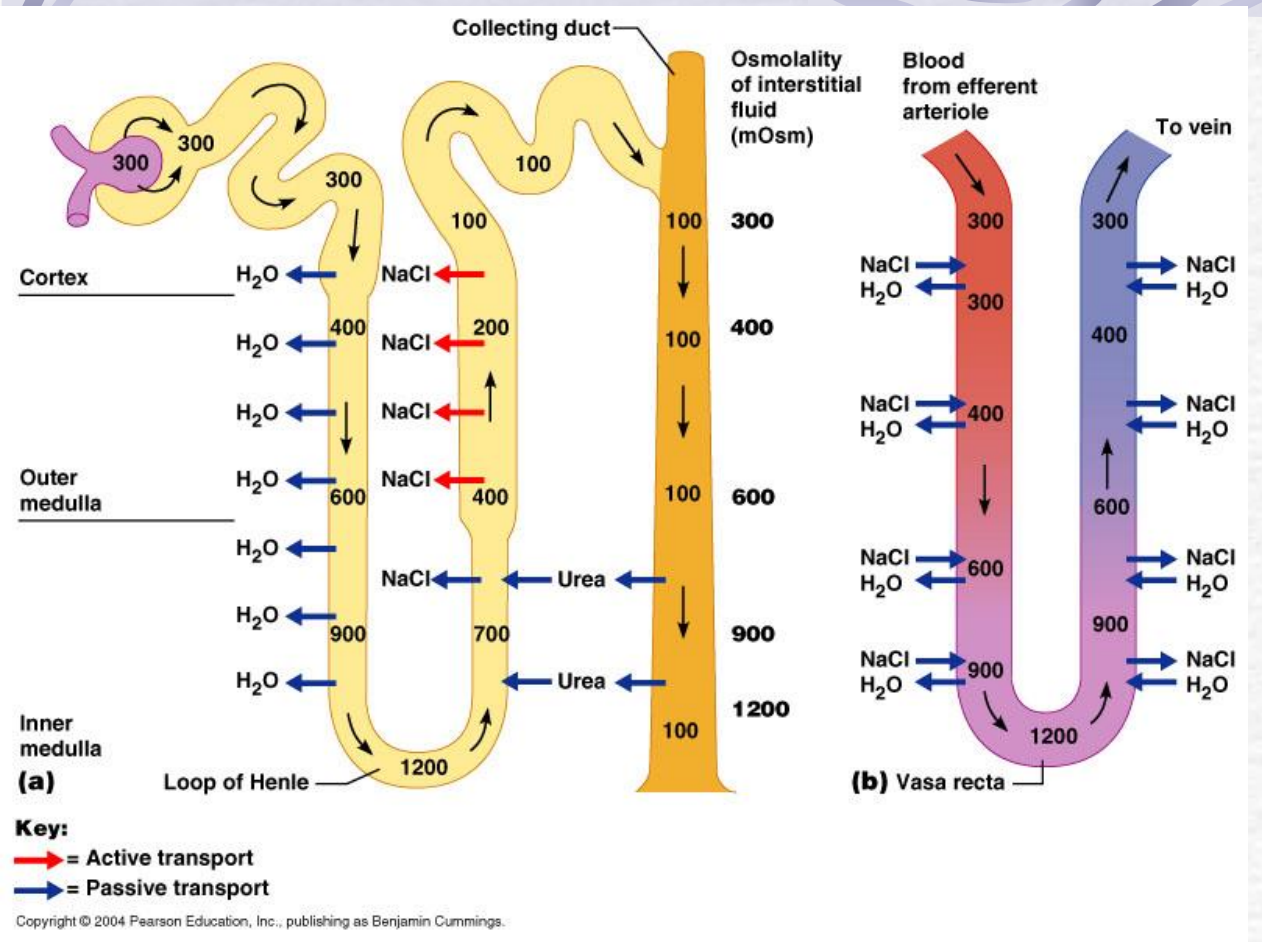
Reabsorption, or how to concentrate the filtrate into urine





Countercurrent exchange mechanism creates sodium concentration gradient throughout kidney

Reabsorption creates concentration gradient



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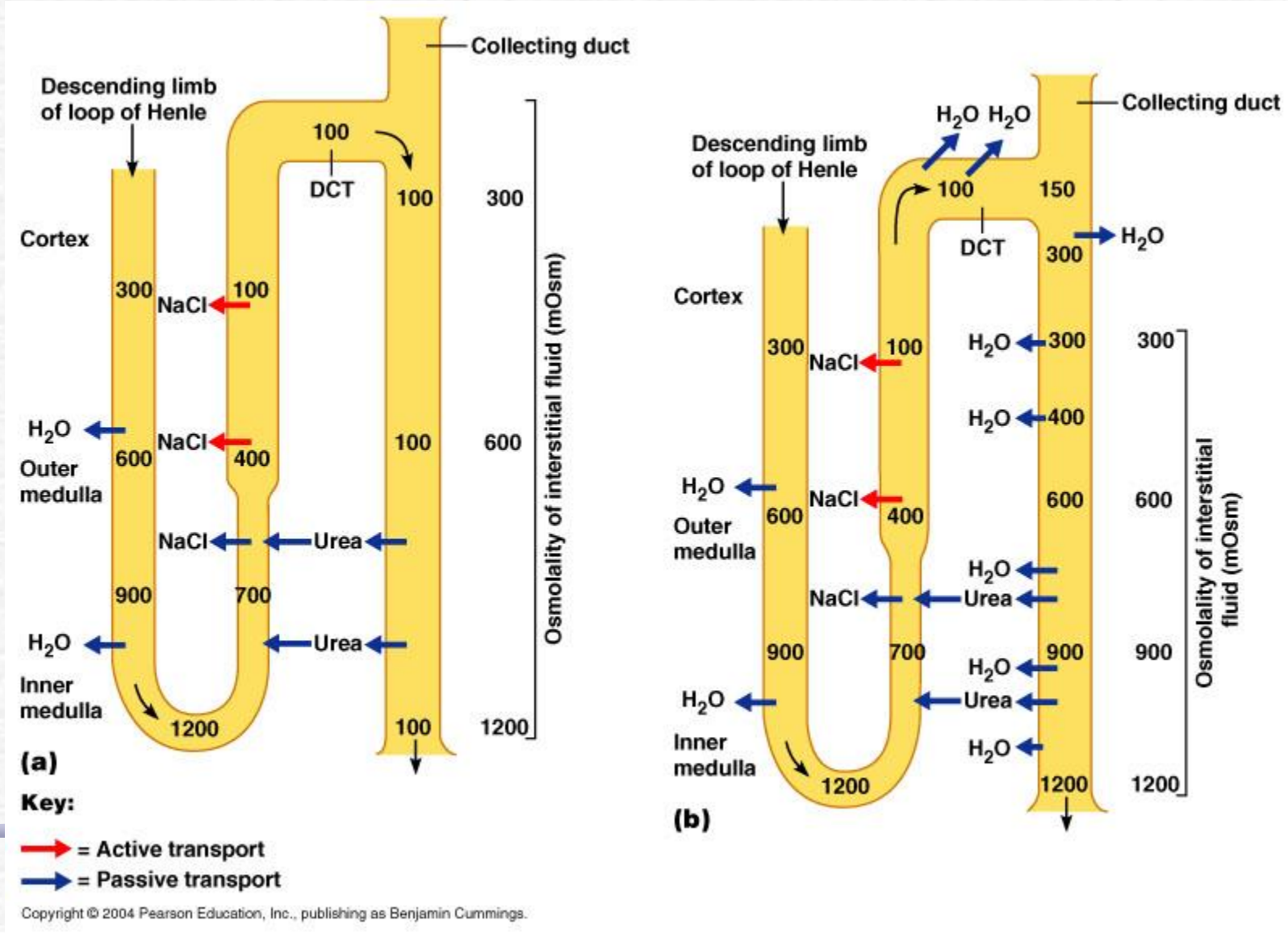
- Reabsorption of sodium creates concentration gradient
- Other substances, like glucose are also reabsorbed or pass back into blood across tubule membranes.
- Urea, uric acid and creatinine, all nitrigenous waste productrs of the body's metabolism, remain in filtrate

Changes in permeability of collecting duct produce concentrated or non-concentrated urine



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Tubular secretion

- Tubular secretion allows certain substances to be taken up directly from the blood into the tubules
- This is especially important for
  - H+ ions (thus maintaining blood pH
  - K+ ions (thus maintaining potassium balance)
  - Certain drugs that are not filtered across glomerulus

Final composition of urine depends on

- Glomerular filtration rate gives initial volume
- Amount of reabsorption of water will affect final urine volume
- Amount of reabsorption of sodium will affect final salinity or concentration of urine
- Tubular secretion may add certain other substances to urine

Signs of kidney problems

- Presence of protein or cells in urine may indicate problems with glomerular filtration
- Presence of glucose may indicate problems with tubular reabsorption or very high blood sugar levels that present full resabsorption