General Biology 1
BIO1201 RM 1021
Syllabus & Textbook:
https://openlab.citytech.cuny.edu/oer-biology/lecture-schedule/

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Grade Breakdown:

Lecture (60%)
Exams (4): **22.5% Each**
Pop Quizzes (?): **10% Average**

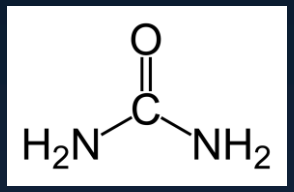
Lab (40%) – Lab Instructor

Letter Grade	Numerical Ranges
A	93-100
A-	90-92.9
B+	87-89.9
B	83-86.9
B-	80-82.9
C+	77-79.9
C	70-76.9
D	60-69.9
F	59.9 and below

Body Fluid Regulation & Excretory Systems

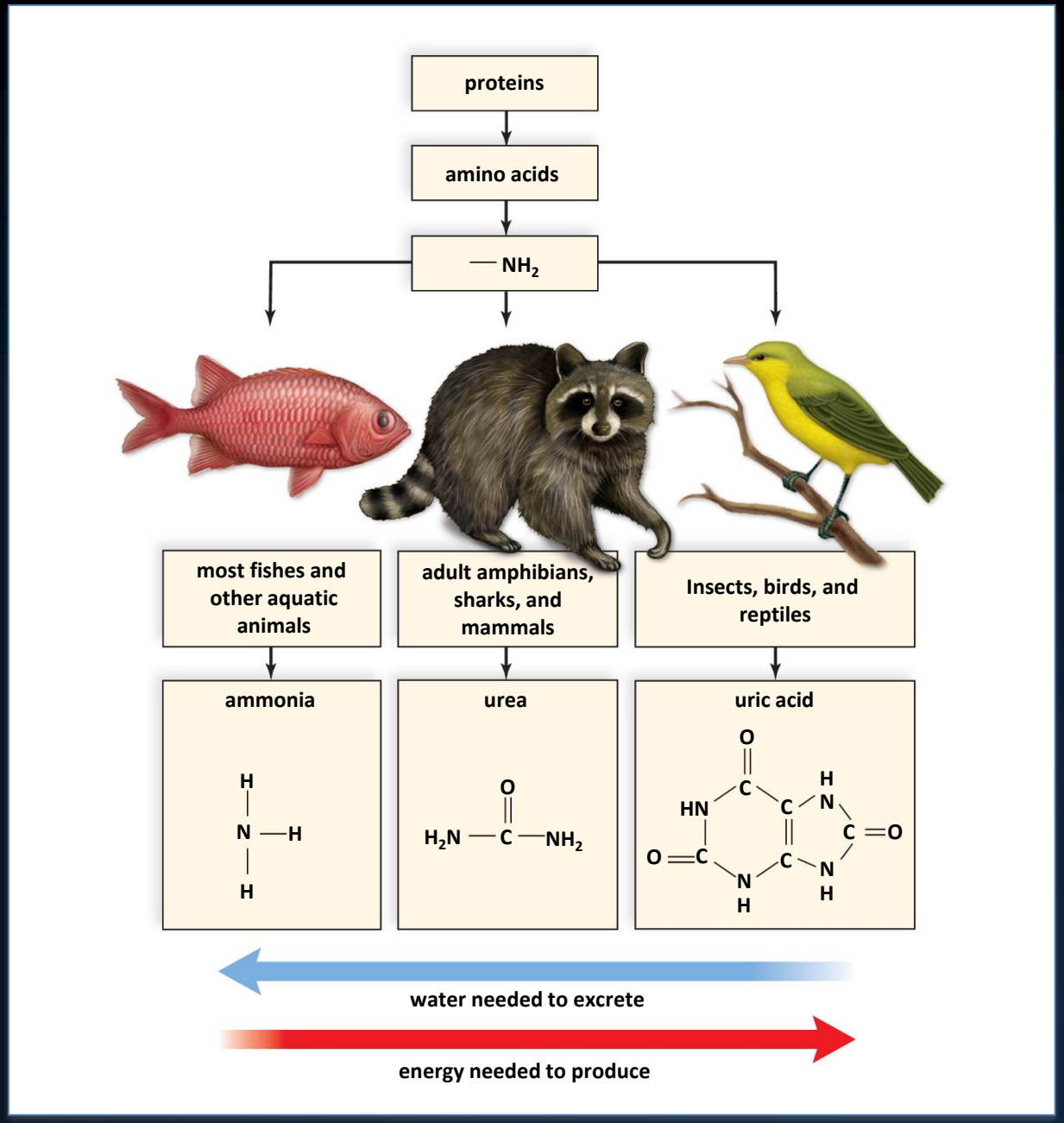
Nitrogenous Waste Products

- **Catabolism of amino acids** and nucleic acids results in **ammonia**
  - High solubility permits it to be excreted directly by many aquatic animals
  - Terrestrial animals must convert ammonia to urea or uric acid
    - **Urea** causes loss of much water per unit of nitrogen
      - Mammals and amphibians
      - Must drink lots of water



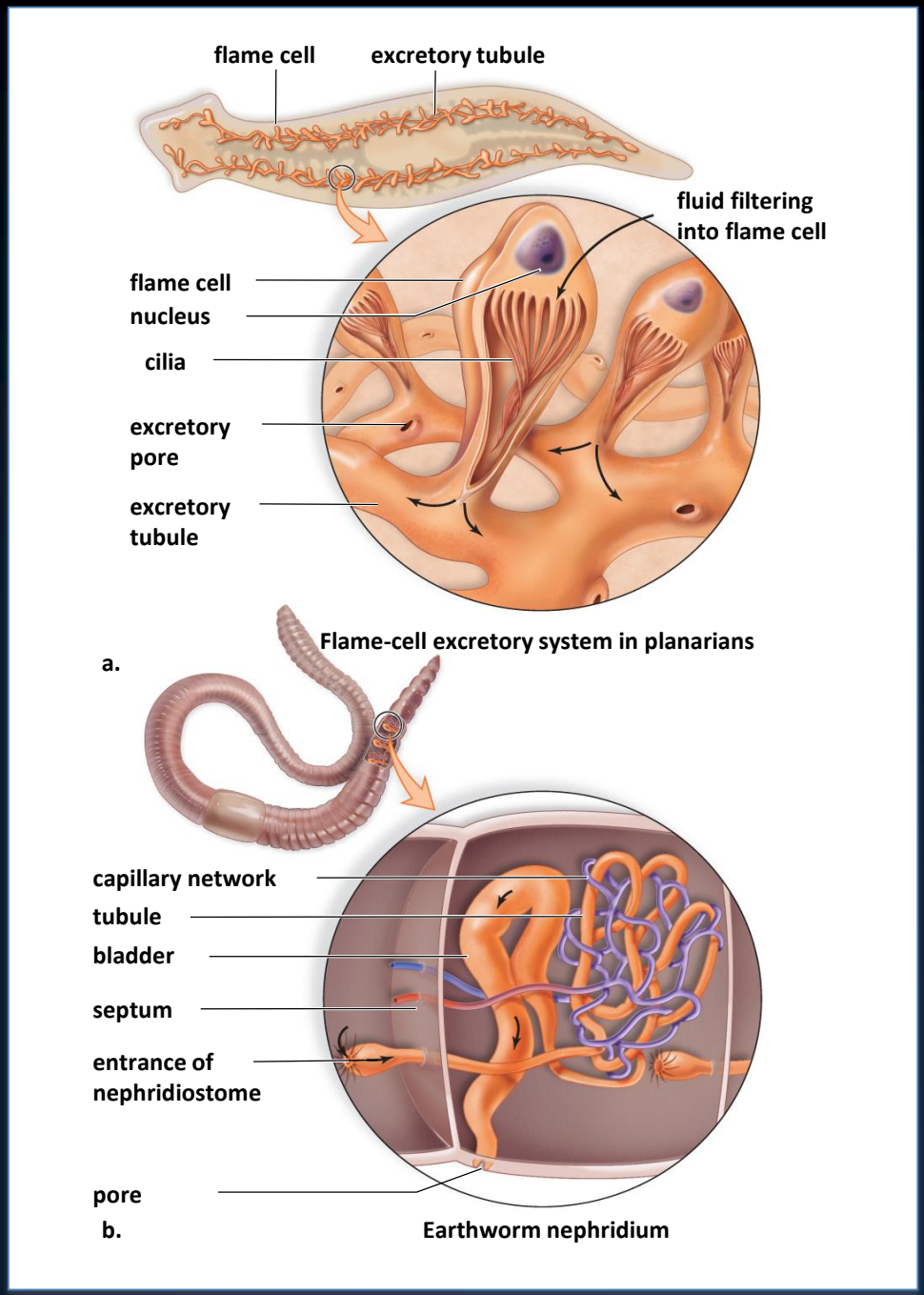
    - **Uric acid** requires much less water per unit of nitrogen excreted
      - Reptiles, birds, and arthropods
      - Allows invasion of drier habitats far from standing water

Nitrogenous Wastes



Excretory Organs in Invertebrates

- Most animals have tubular excretory organs
  - Regulate the water-salt balance of the body
  - Excrete metabolic wastes into the environment
    - Flame Cells in Planarians
    - Nephridia in Earthworms
    - Malpighian Tubules in Insects



Question

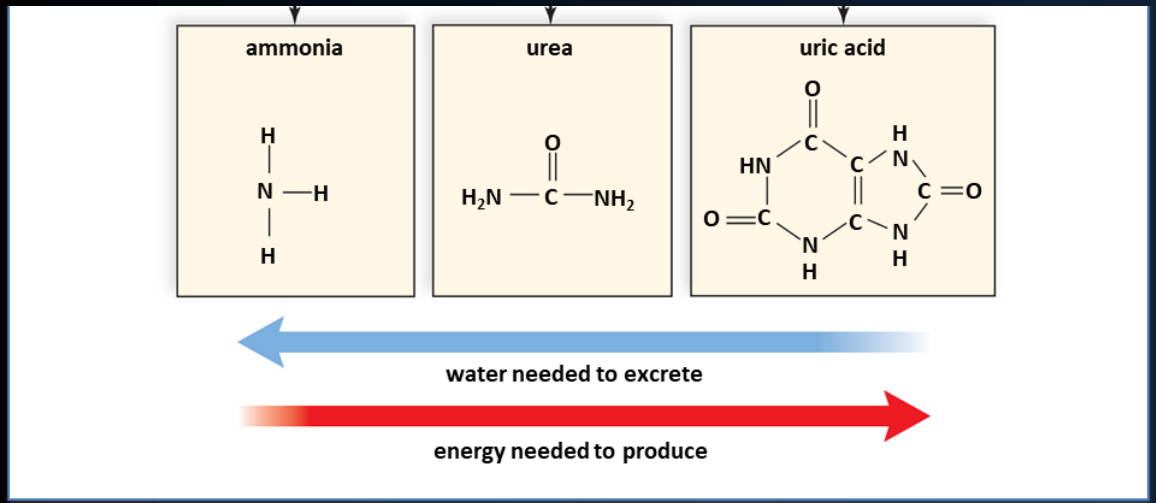
The advantage of excreting wastes as urea rather than as ammonia is that

A. urea is far less toxic than ammonia.

B. less nitrogen is removed from the body.

C. urea requires more water for excretion than ammonia.

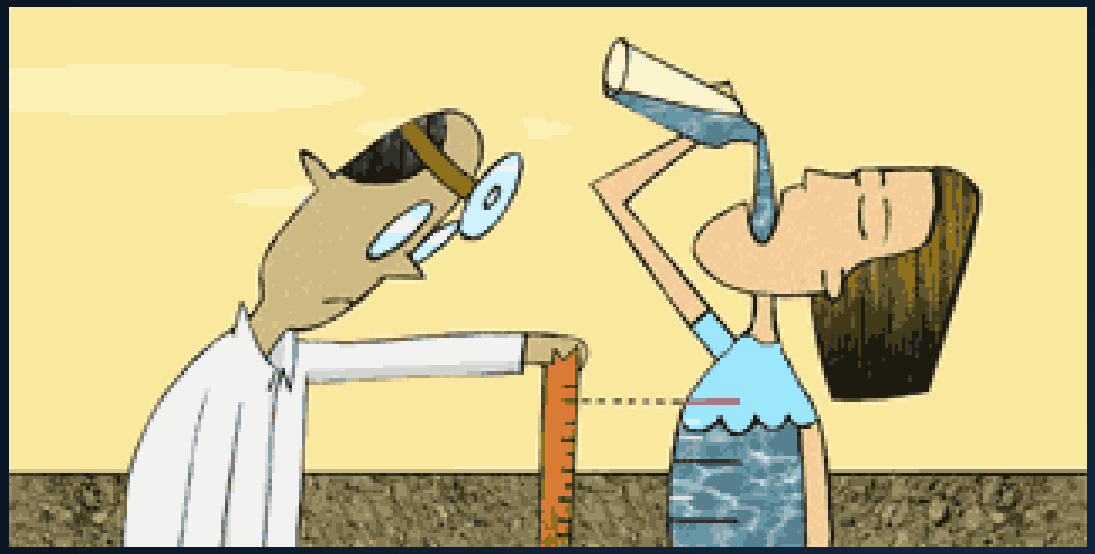
D. urea does not affect the osmolar gradient.



Ammonia is more water soluble and also more **toxic than** either **urea** or uric acid but it is energetically **less** expensive.

Body Fluid Regulation

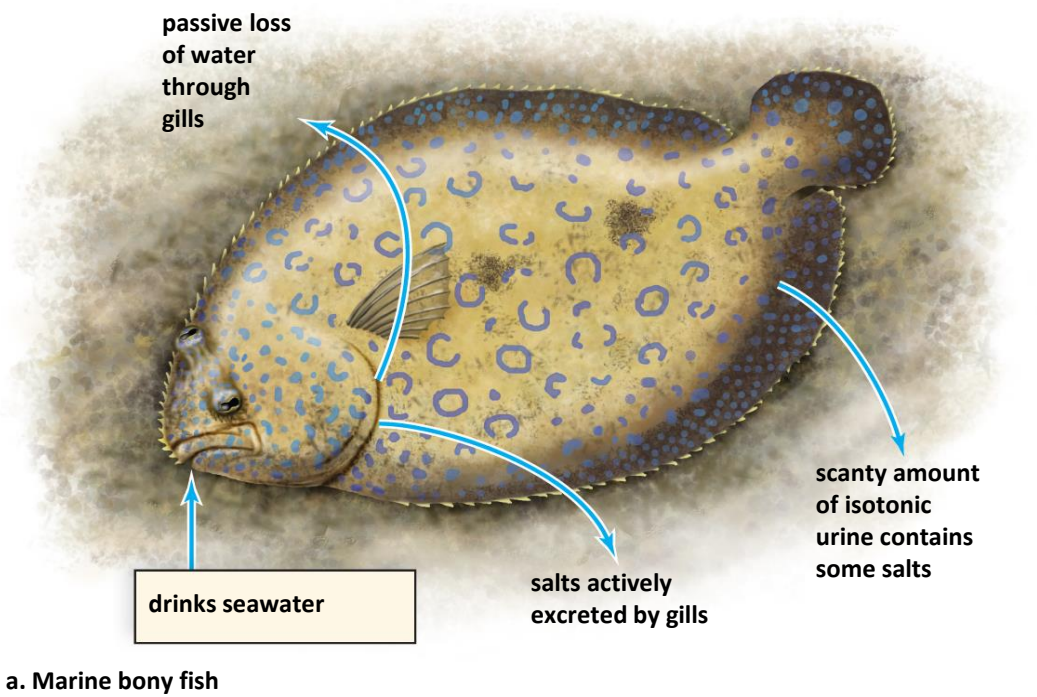
- An excretory system regulates body fluid concentrations
- Dependent upon concentration of mineral ions such as sodium and potassium
- Water can enter the body through:
  - Drinking
  - Food
  - Metabolism



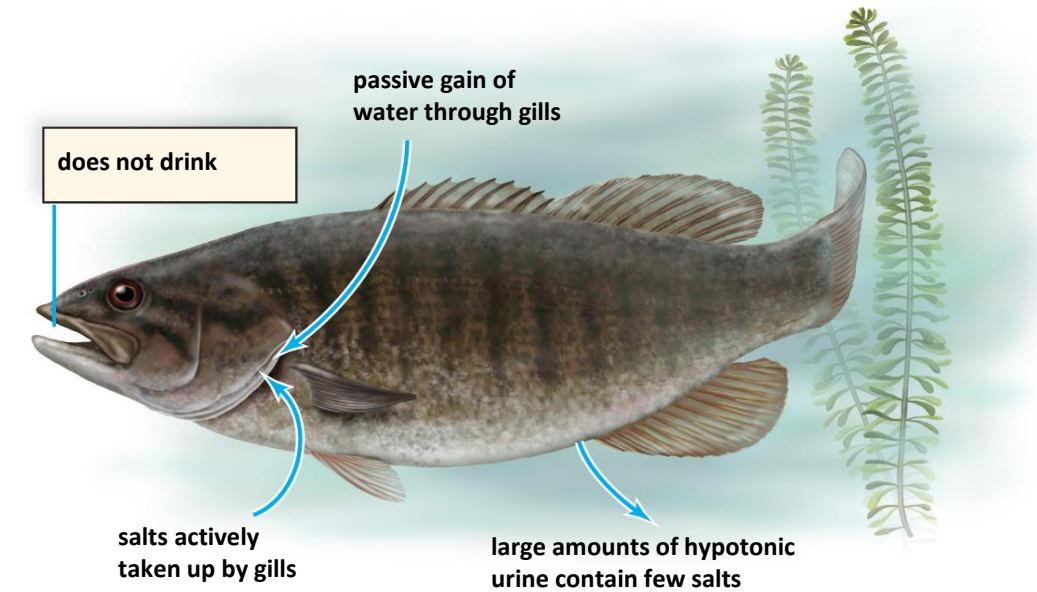
Body Fluid Regulation

- Water tends to move into the region with the lowest water concentration
  - Marine environment
    - High concentration of dissolved salts
    - Tends to promote the osmotic loss of water, and
    - The gain of ions by drinking water
    - Marine invertebrates nearly isotonic to seawater
    - Blood of cartilaginous fishes contains enough urea to match the tonicity of sea water
  - Fresh water environment
    - Tends to promote a gain of water by osmosis, and
    - A loss of ions as excess water is excreted

Body Fluid Regulation in Bony Fishes



a. Marine bony fish



b. Freshwater bony fish

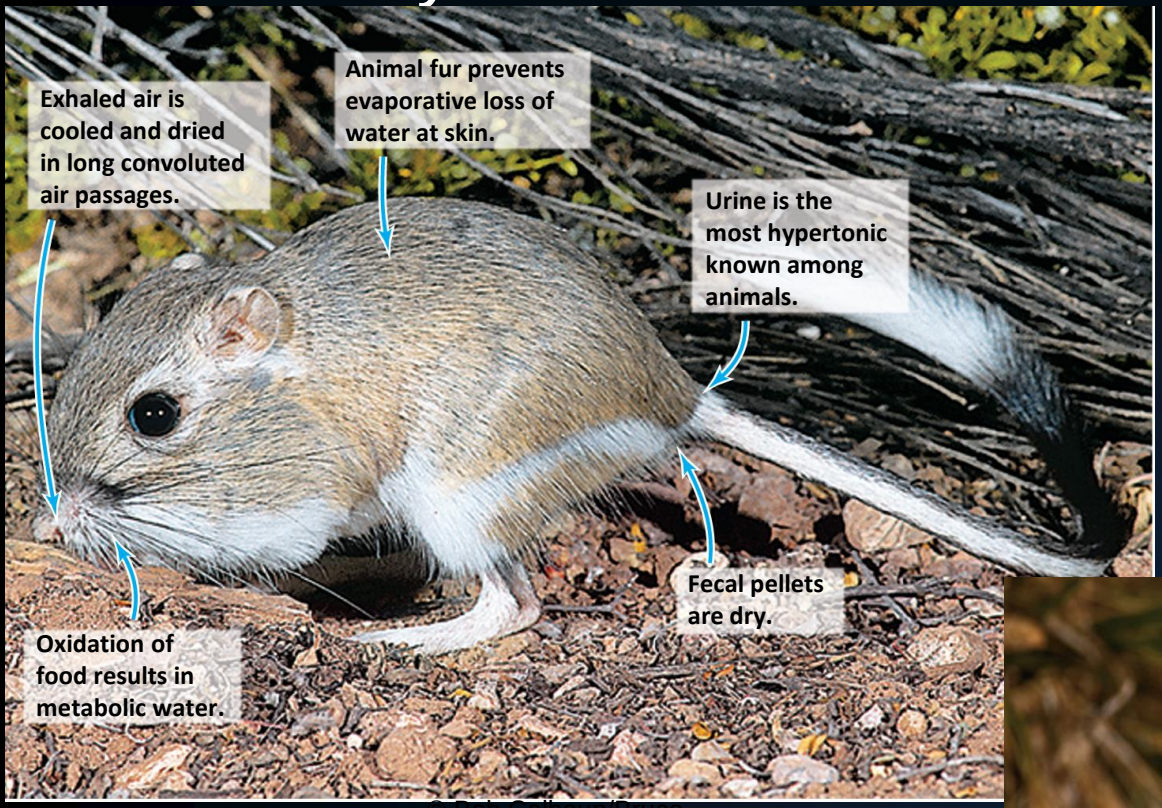
Aquatic Animals

- Bony Fishes
  - Body fluids of bony fishes with only moderate amount of salt
  - Marine bony fishes
    - Body fluids hypotonic to sea water
    - Passively *lose* water through gills
    - Must constantly drink seawater to compensate
    - Excess salt ions actively transported back into seawater through the gills
  - Freshwater bony fishes have opposite problem
    - Body fluids hypertonic to fresh water
    - Passively *gain* water through gills
    - Eliminate excess water through copious hypotonic urine

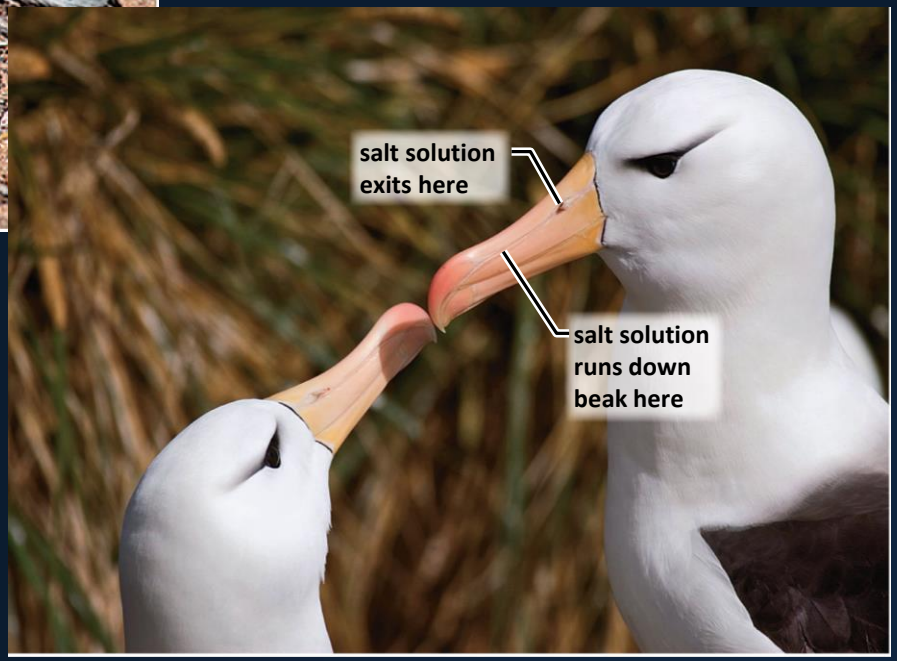
Terrestrial Animals

- Terrestrial animals lose water through excretion and respiration
- Must drink water to make up for loss
  - Some reduce water loss by excreting nitrogen as relatively insoluble uric acid
  - Certain animals also have a highly convoluted nasal passage with a mucous membrane surface (salt excretion)

Adaptations of a Kangaroo Rat to a Dry Environment



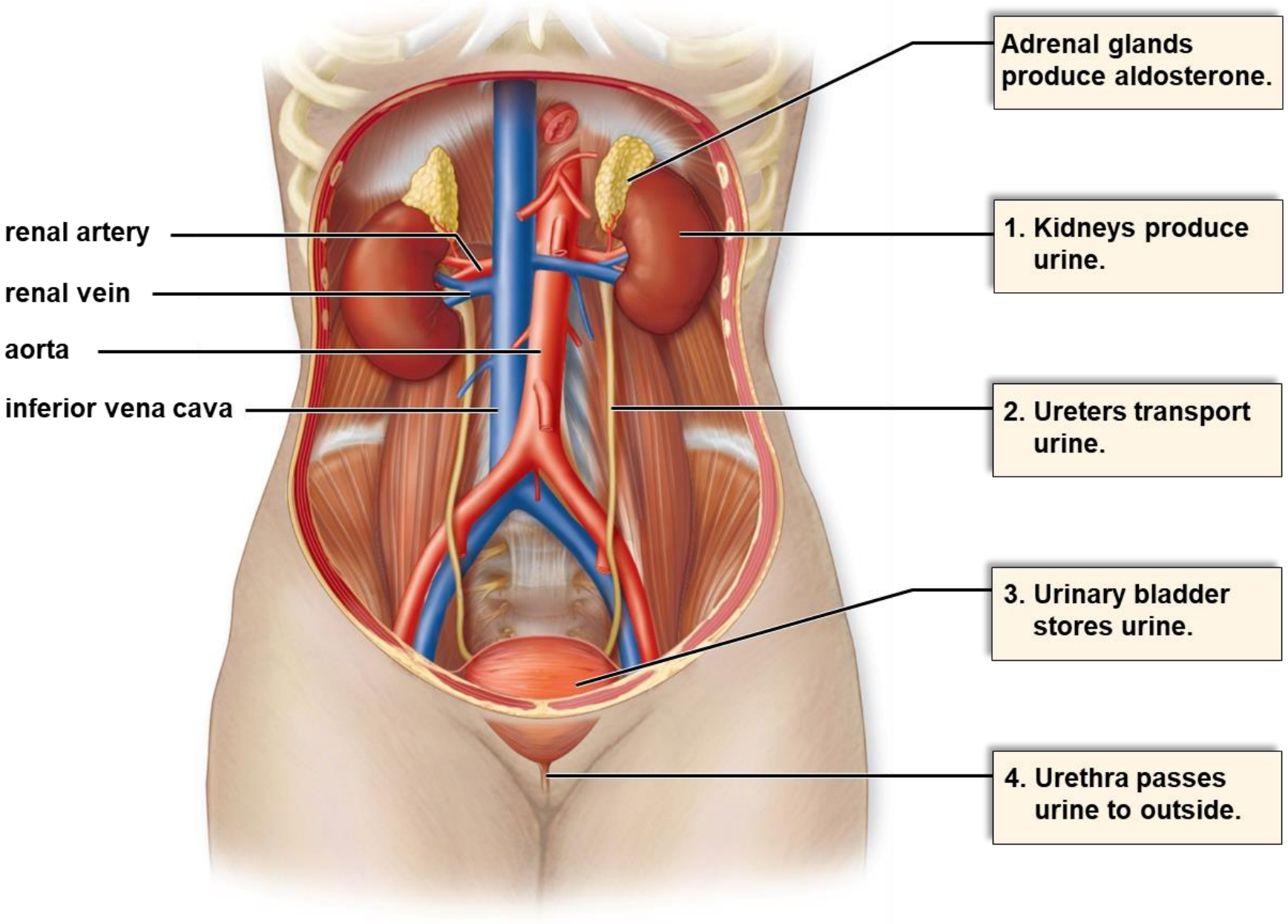
Adaptations of Marine Birds to a High Salt Environment



Urinary System in Humans

- Human kidneys
  - Located on either side of vertebral column, just below the diaphragm
    - Each connected to a **ureter**
    - Conducts urine from the kidney to the **urinary bladder**
  - Urine voided through **urethra**
    - Tube between bladder and exit

Overview of the urinary system

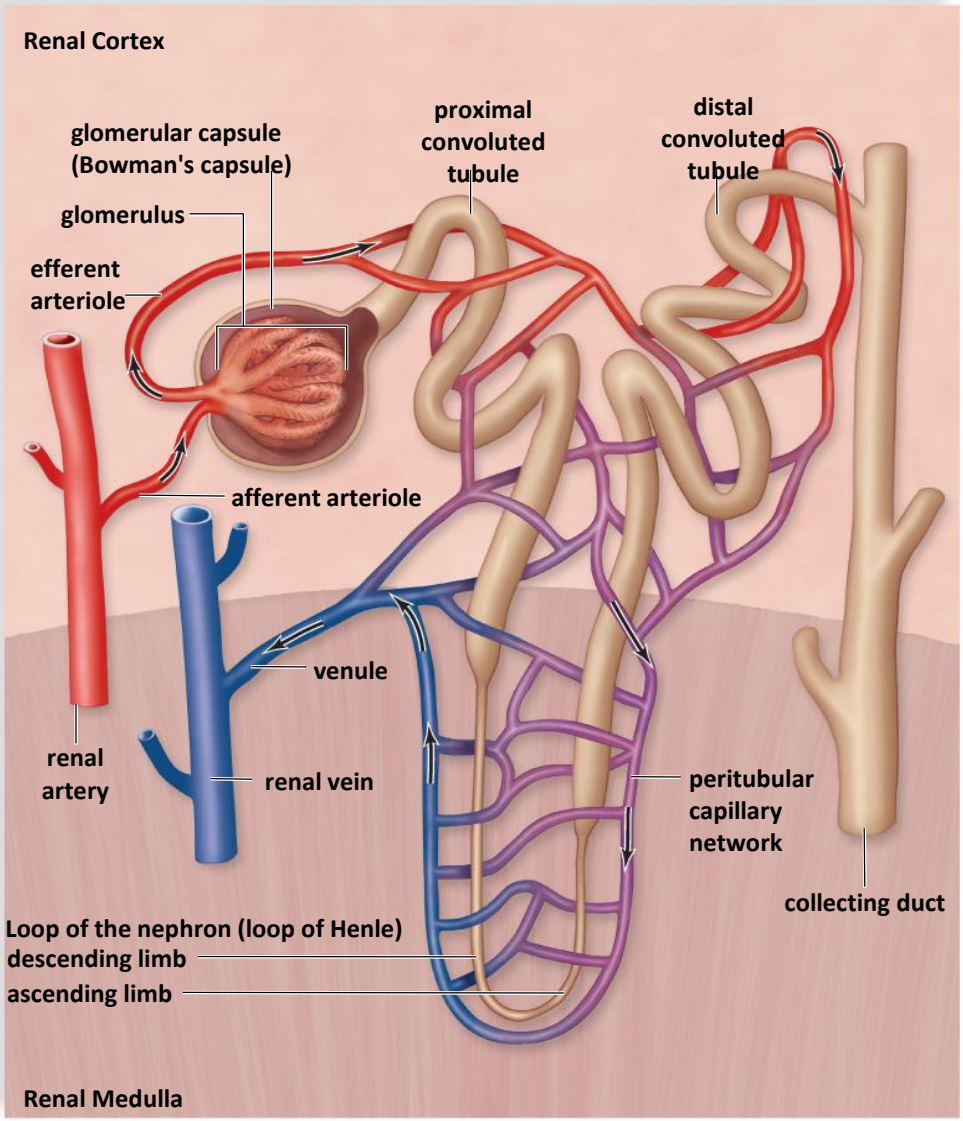


Nephrons

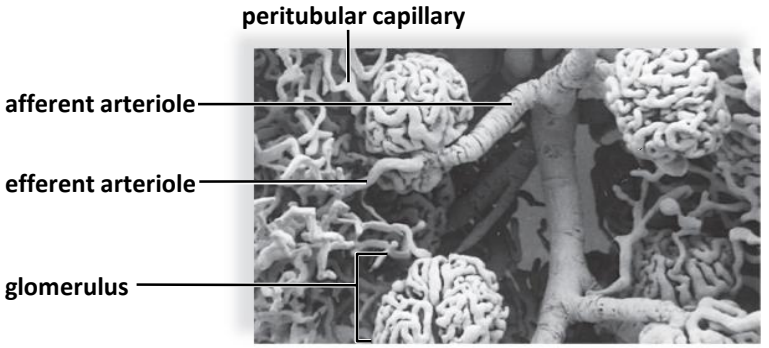
- Each kidney composed of many tubular nephrons
- Each nephron composed of several parts
  - Glomerular capsule
  - Glomerulus
  - Proximal convoluted tubule
  - Loop of the nephron
  - Distal convoluted tube
  - Collecting duct

https://en.wikipedia.org/wiki/Bowman%27s_capsule

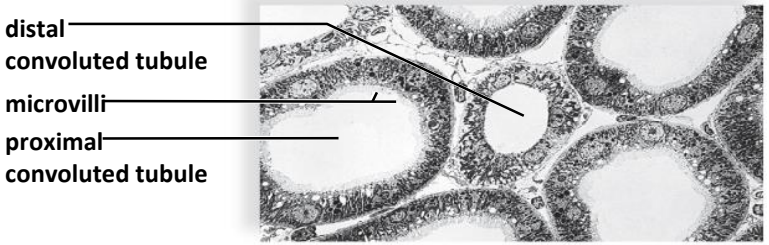
Nephron Anatomy



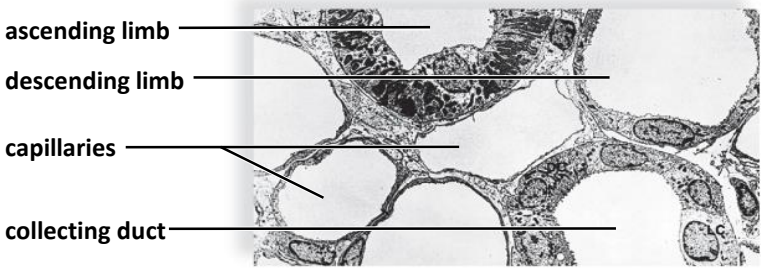
a. A nephron and its blood supply



b. Surface view of glomerulus and its blood supply

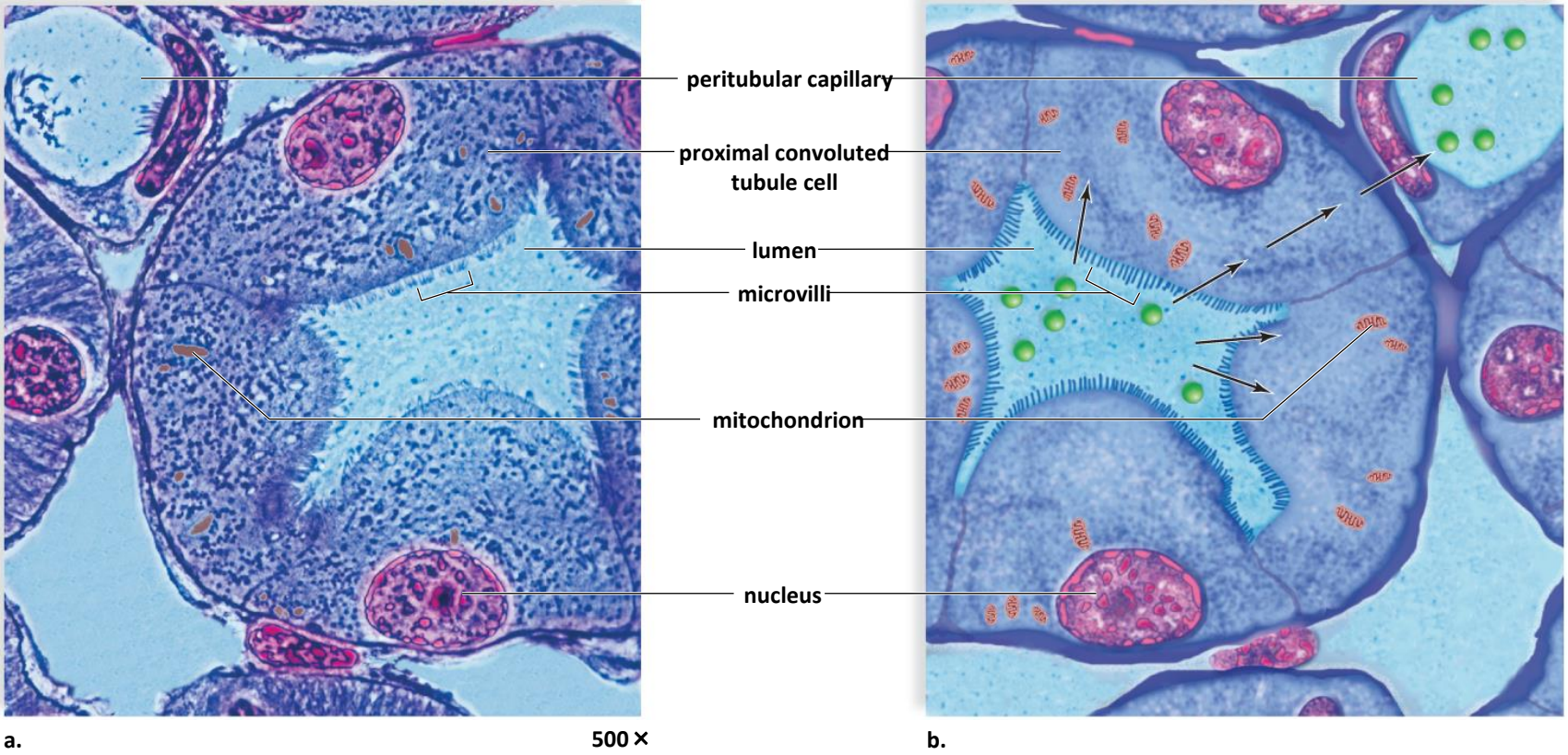


c. Cross sections of proximal and distal convoluted tubules



d. Cross sections of a loop of nephron limbs and collecting duct. (The other cross sections are those of capillaries.)

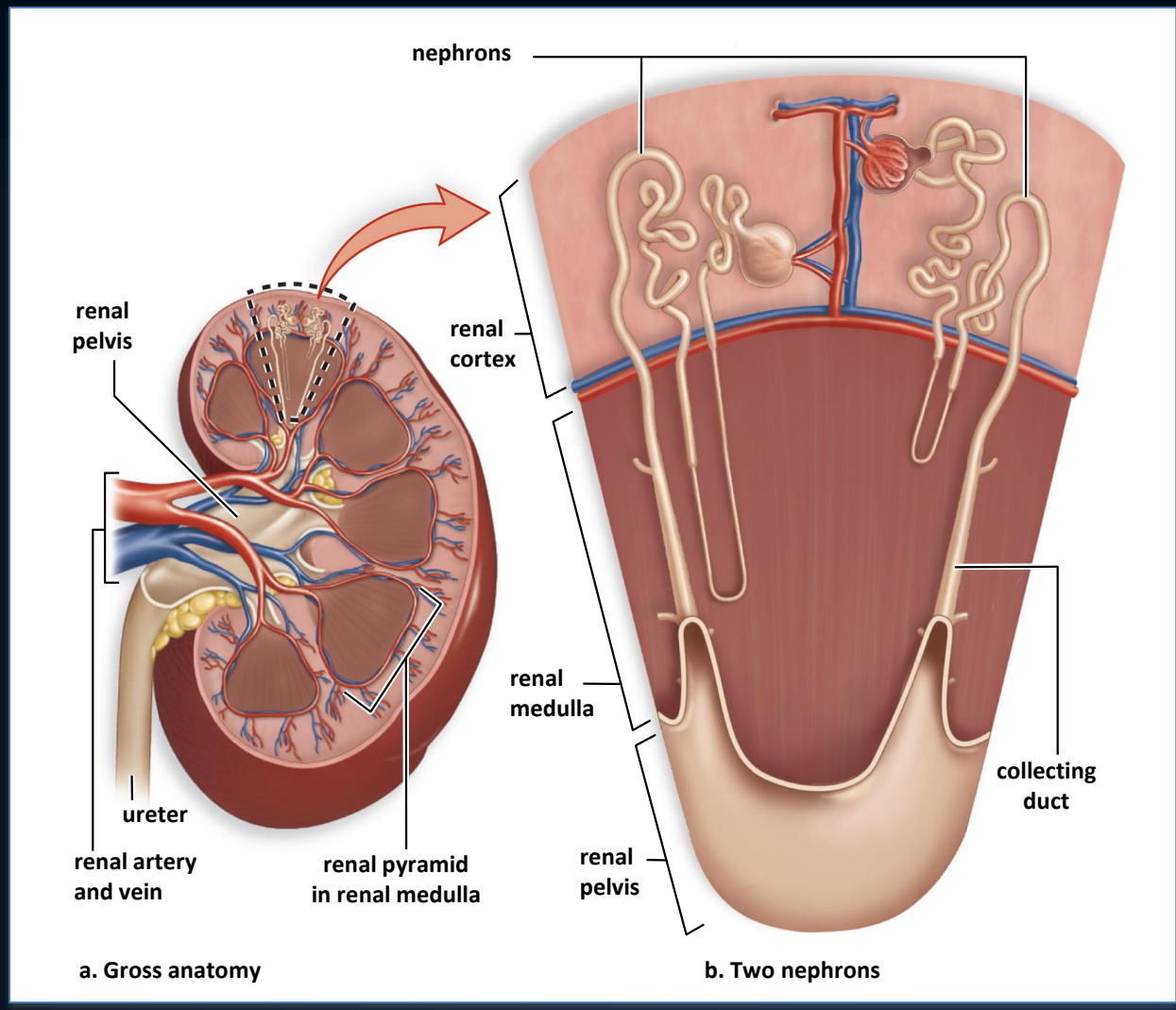
Proximal Convoluted Tubule



Kidneys

Macroscopic & Microscopic Anatomy of the Kidney

- Renal cortex
  - Outer region
  - Granular appearance
- Renal medulla
  - Cone-shaped renal pyramids
- Renal pelvis
  - Hollow-chambered innermost part of the kidney



Question

What is the functional unit of the kidney?

A. Cortex

B. Nephron

C. Proximal tubule

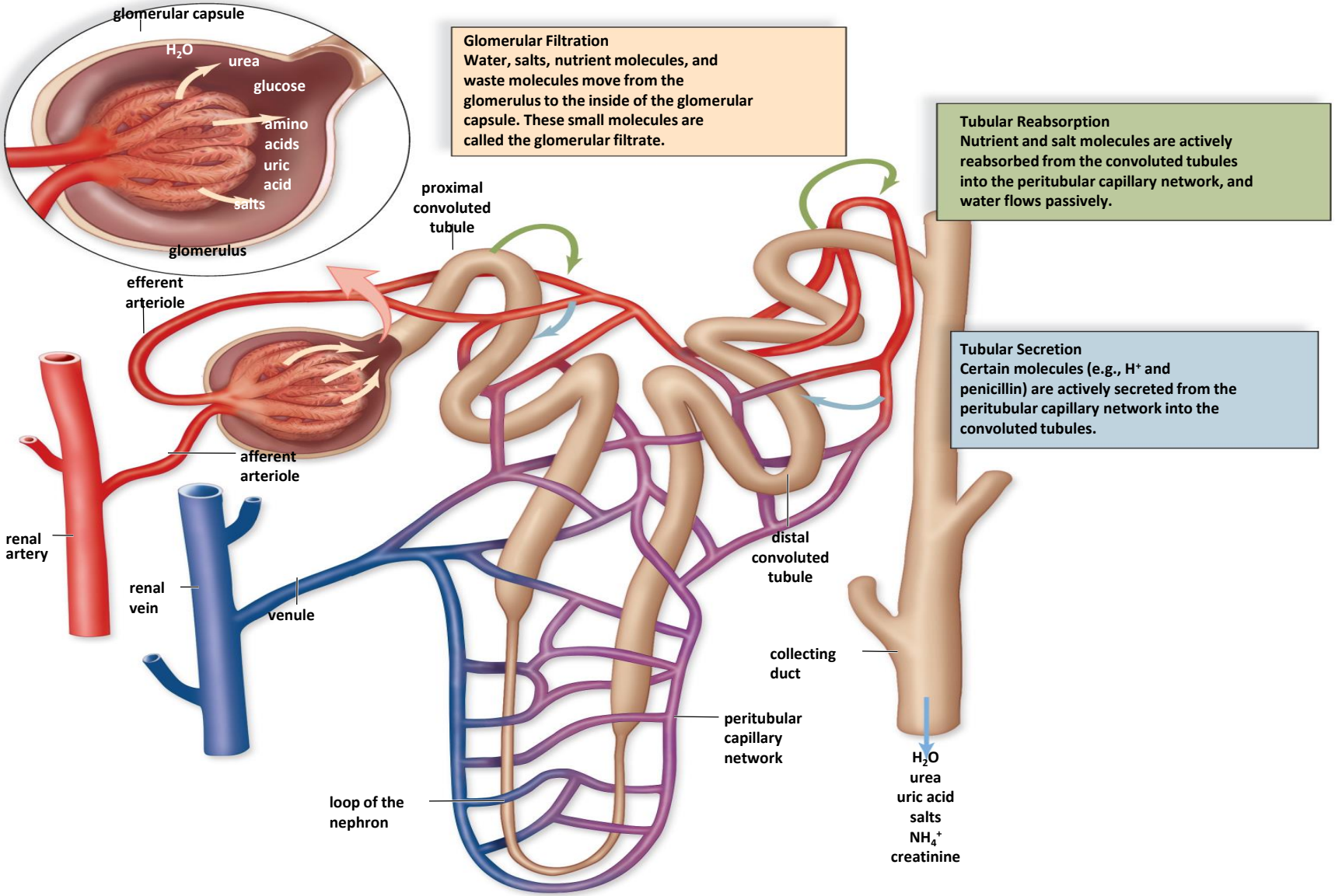
D. Glomerulus

E. Bowman’s capsule

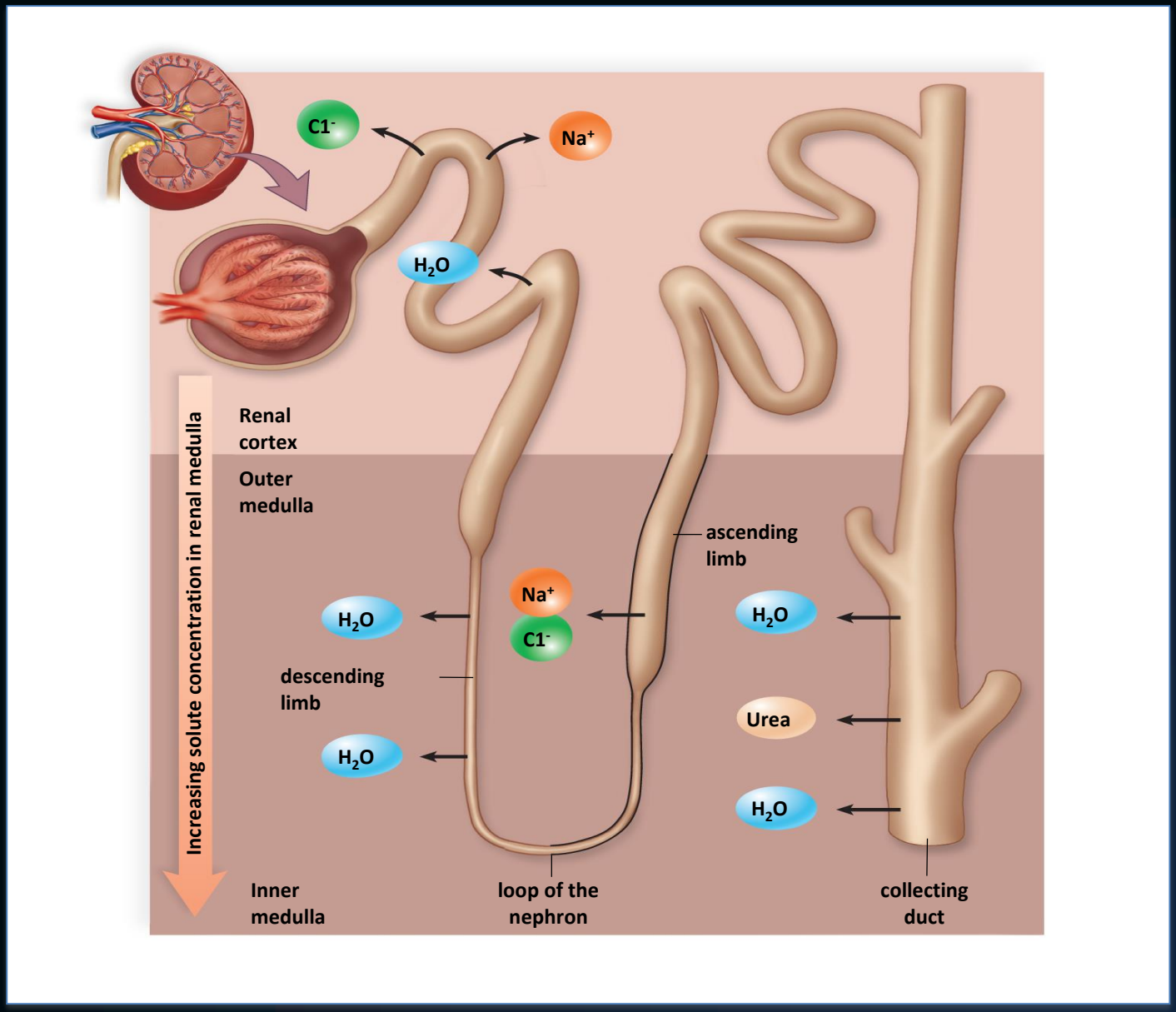
Urine Formation

- Urine production requires three distinct processes:
  - **Glomerular filtration** in glomerular capsule
  - **Tubular reabsorption** at the proximal convoluted tubule
  - **Tubular secretion** at the distal convoluted tubule

Processes in Urine Formation



Reabsorption of Salt and Water



Urine Formation and Homeostasis

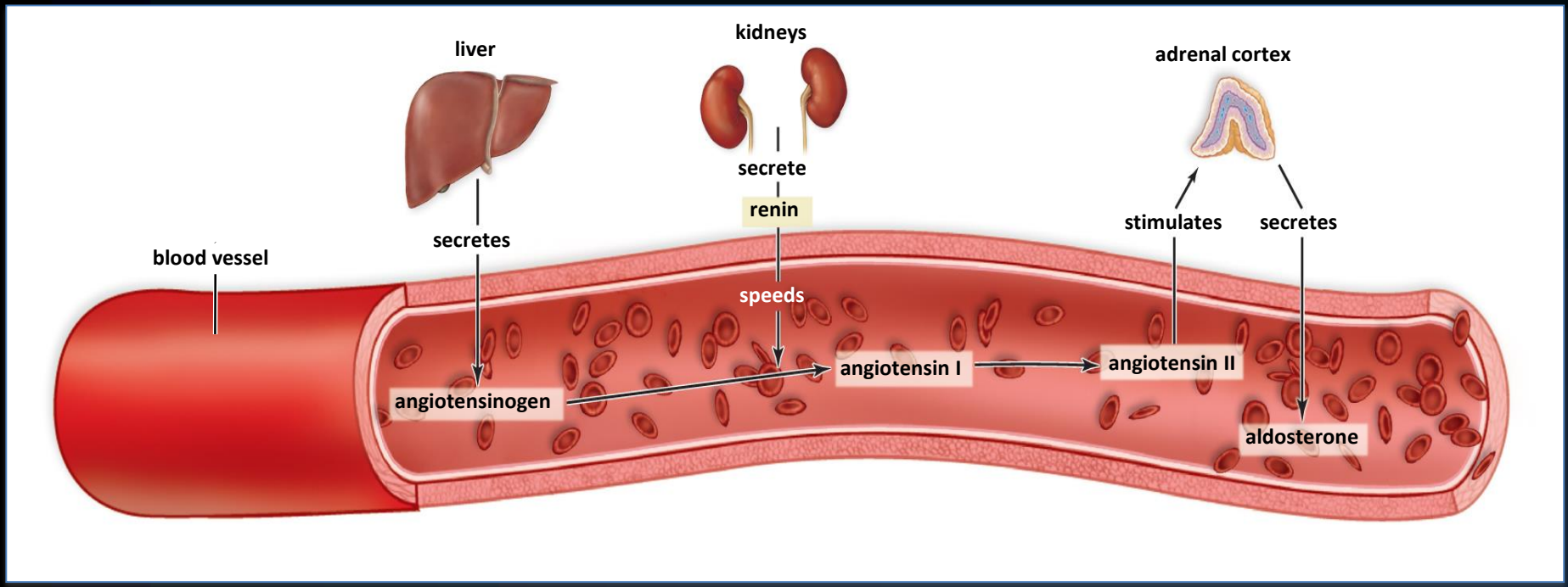
- Excretion of **hypertonic** urine
  - Dependent upon the reabsorption of water
  - Absorbed from
    - Loop of the nephron, and
    - The collecting duct
  - Osmotic gradient within the renal medulla causes water to leave the descending limb along its entire length

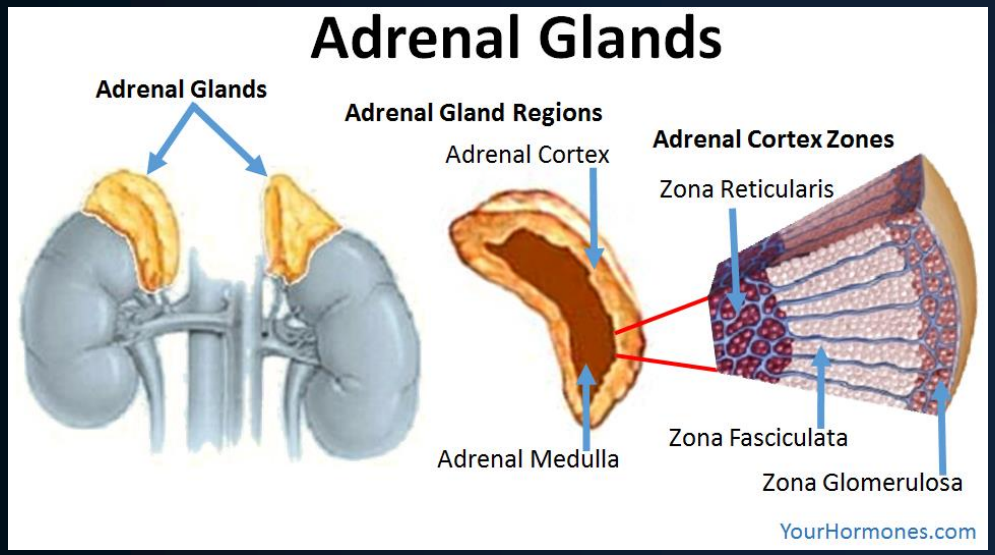
- Antidiuretic hormone (ADH)
  - Plays a role in water reabsorption
  - Released by the posterior lobe of the pituitary gland (brain)

Maintenance of Blood pH, Osmolarity, Volume and Pressure

- More than 99% of **sodium** filtered at glomerulus is returned to blood at the distal convoluted tubule
- Reabsorption of sodium (/water) regulated by hormones
    - Aldosterone
    - Renin (made by adrenal glands when blood pressure is low)
    - Atrial Natriuretic Hormone (ANH) (made by heart when blood volume is high)
- pH adjusted by either
  - The reabsorption of the bicarbonate ions, or
  - The secretion of hydrogen ions

The Renin-Angiotensin-Aldosterone System





Adrenal cortex

- Outer portion of the adrenal glands
- Produces hormones that provide a long-term response to stress
- Two major types of hormones
  - Glucocorticoids
    - regulate carbohydrate, protein, and fat metabolism.
    - suppress the body's inflammatory response.
    - e.g., cortisol and cortisone
  - Mineralocorticoids
    - regulate salt and water balance.
    - e.g., aldosterone (targets the kidney)

What are the organs of the urinary system?

- Kidneys (2) – bean-shaped, fist-sized organ where urine is formed
- Ureters (2) – small, muscular tubes that carry urine from the kidneys to the bladder
- Bladder (1) – expandable organ that stores urine until it is expelled from the body
- Urethra (1) – tube (longer in men than women) that carries urine from the bladder to the outside of the body

What are the functions of the urinary system?

1. Excretion of metabolic wastes
2. Maintenance of water-salt balance
3. Maintenance of acid-base balance
4. Reabsorb filtered nutrients and synthesize vitamin D
5. Hormone secretion: renin (water salt balance) and erythropoietin (EPO)

[Lance Armstrong]

1. Excretion

- Mostly of nitrogenous wastes
  - Urea is made by the breakdown of amino acids in the liver.
  - Uric acid is made by the breakdown of nucleotides.
  - Creatinine is made by muscle cells from the breakdown of creatine phosphate.

2. Maintenance of water-salt and 3. acid-base balance

- These are homeostatic mechanisms.
- Water-salt balance helps to maintain blood pressure.
- The kidneys excrete hydrogen ions and reabsorb bicarbonate ions; this acid-base balance helps maintain a blood pH of 7.4 .

4. Hormone secretion

- Renin – secreted by the kidneys to allow the adrenal glands to secrete aldosterone to help regulate water-salt balance

- Erythropoietin – secreted by the kidneys to stimulate red blood cell production when blood oxygen is low

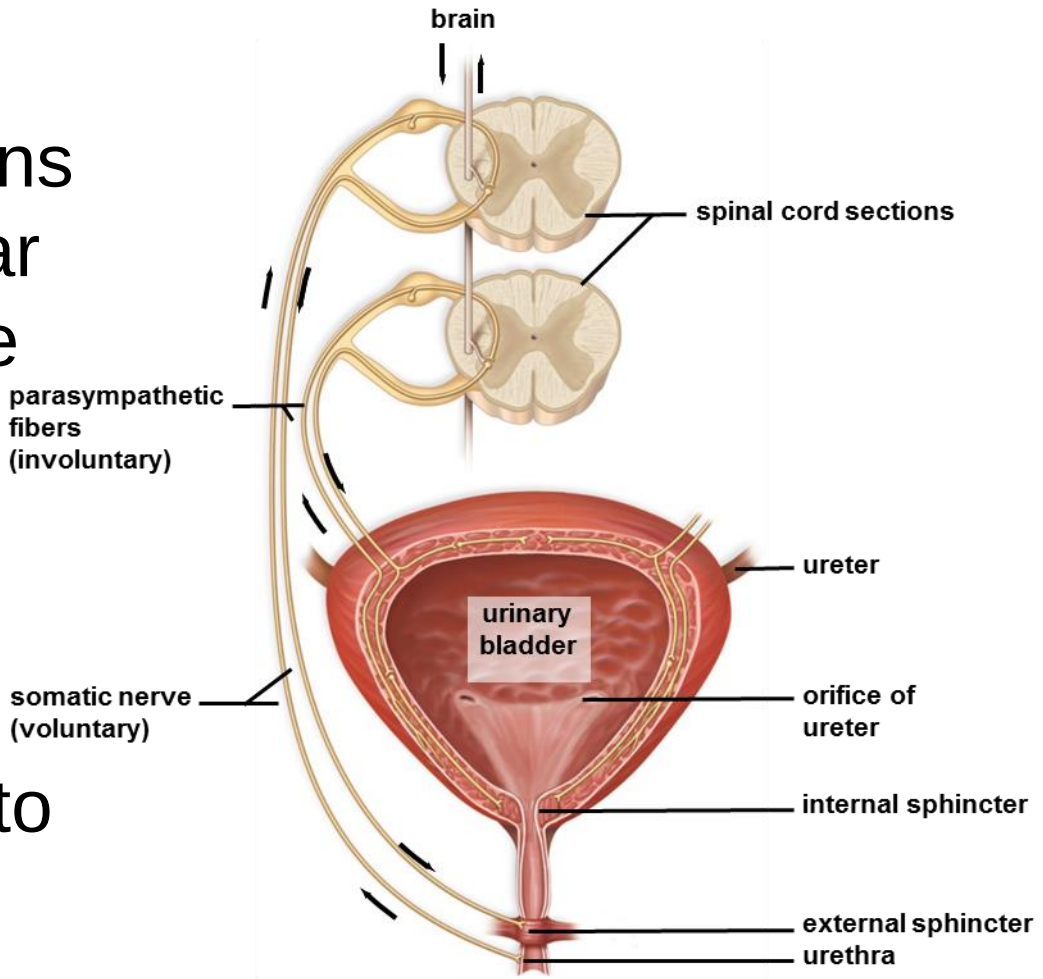
5. Reabsorb filtered nutrients and synthesize vitamin D

- The urinary system is responsible for reabsorbing filtered nutrients.

- Vitamin D is a molecule that promotes calcium absorption from the digestive tract.

How does the urinary bladder work?

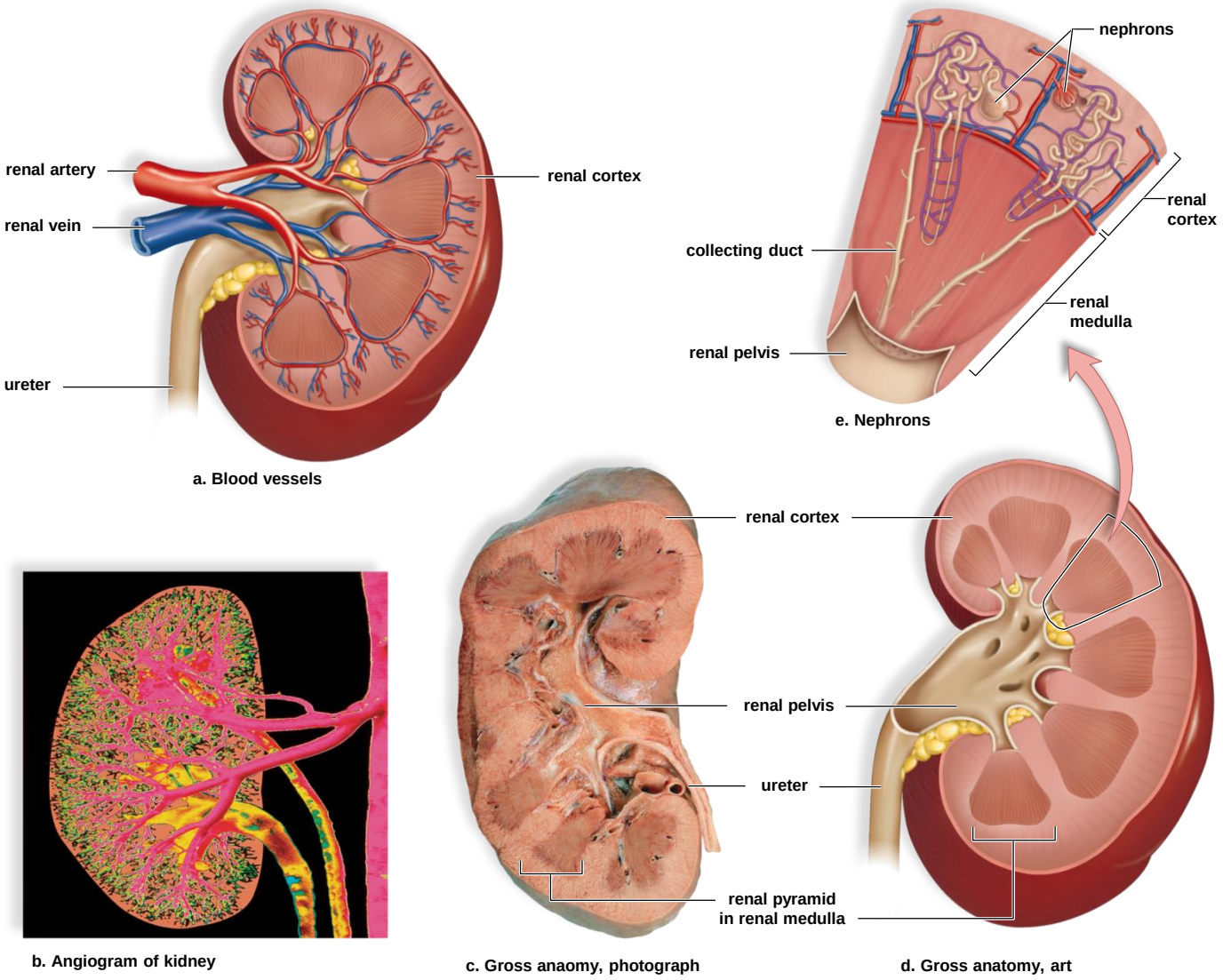
- It stores urine, sphincters keep it closed.
- Expandable wall contains a middle layer of circular fibers of smooth muscle and 2 layers of longitudinal smooth muscle.
- Filling activates stretch receptors which signal to spinal cord.



What are the 3 regions of the kidney?

- Renal Failure – Kidney Failure
- 1. Renal cortex – an outer granulated layer
- 2. Renal medulla – cone-shaped tissue masses called renal pyramids
- 3. Renal pelvis – central cavity that is continuous with the ureter

Anatomy of the kidney

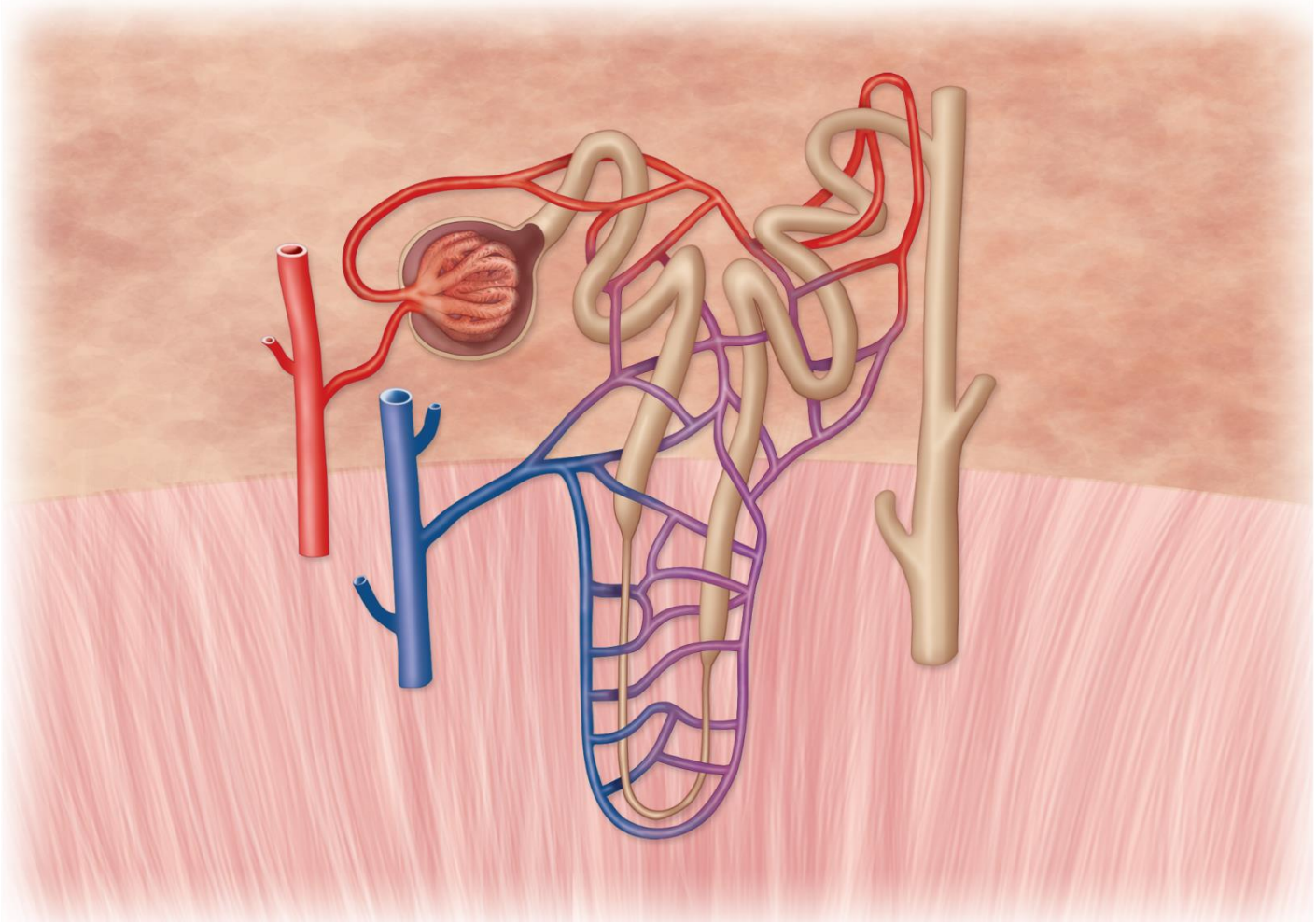


11.3b: © James Cavallini/Science Source; 11.3c: © Ralph Hutchings/Visuals Unlimited/Corbis

Figure 11.3 The anatomy of a human kidney.

What are nephrons?

- Microscopic functional unit of the kidney that produces urine > 1 million per kidney



Anatomy of a nephron

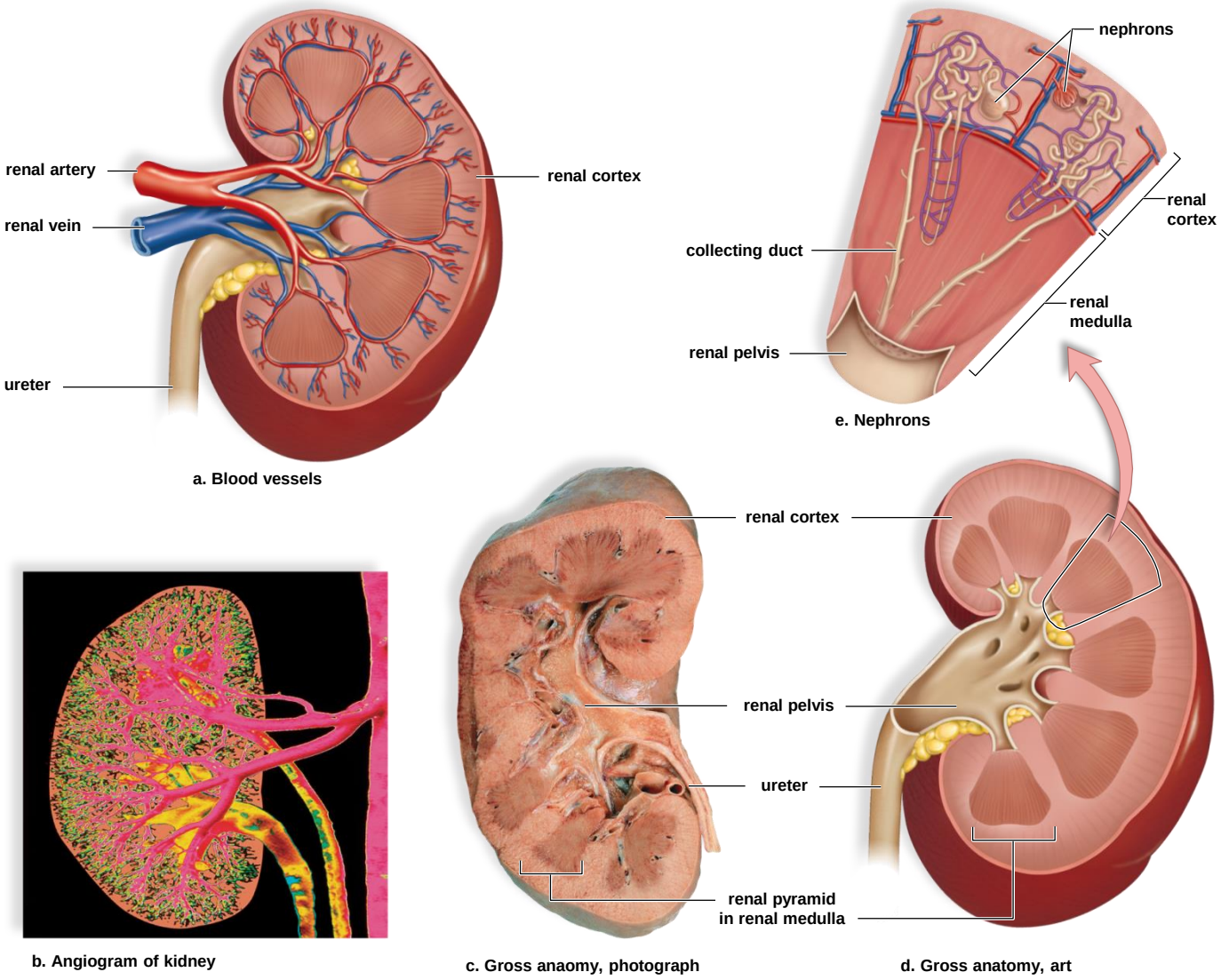
- Glomerulus – a knot of capillaries inside the glomerular capsule where pores produce a blood filtrate
- Proximal convoluted tubule – epithelial layer with a brush border of microvilli to allow reabsorption of filtrate components
- Loop of Nephron– U-shaped structure that has a descending limb to allow water to leave and an ascending limb that pushes out salt

Anatomy of a nephron

- Distal convoluted tubule – made of epithelial cells rich in mitochondria and thus is important for movement of molecules from the blood to the tubule (tubular secretion)

- Collecting ducts – several nephrons share a collecting duct which serve to carry urine to the renal pelvis

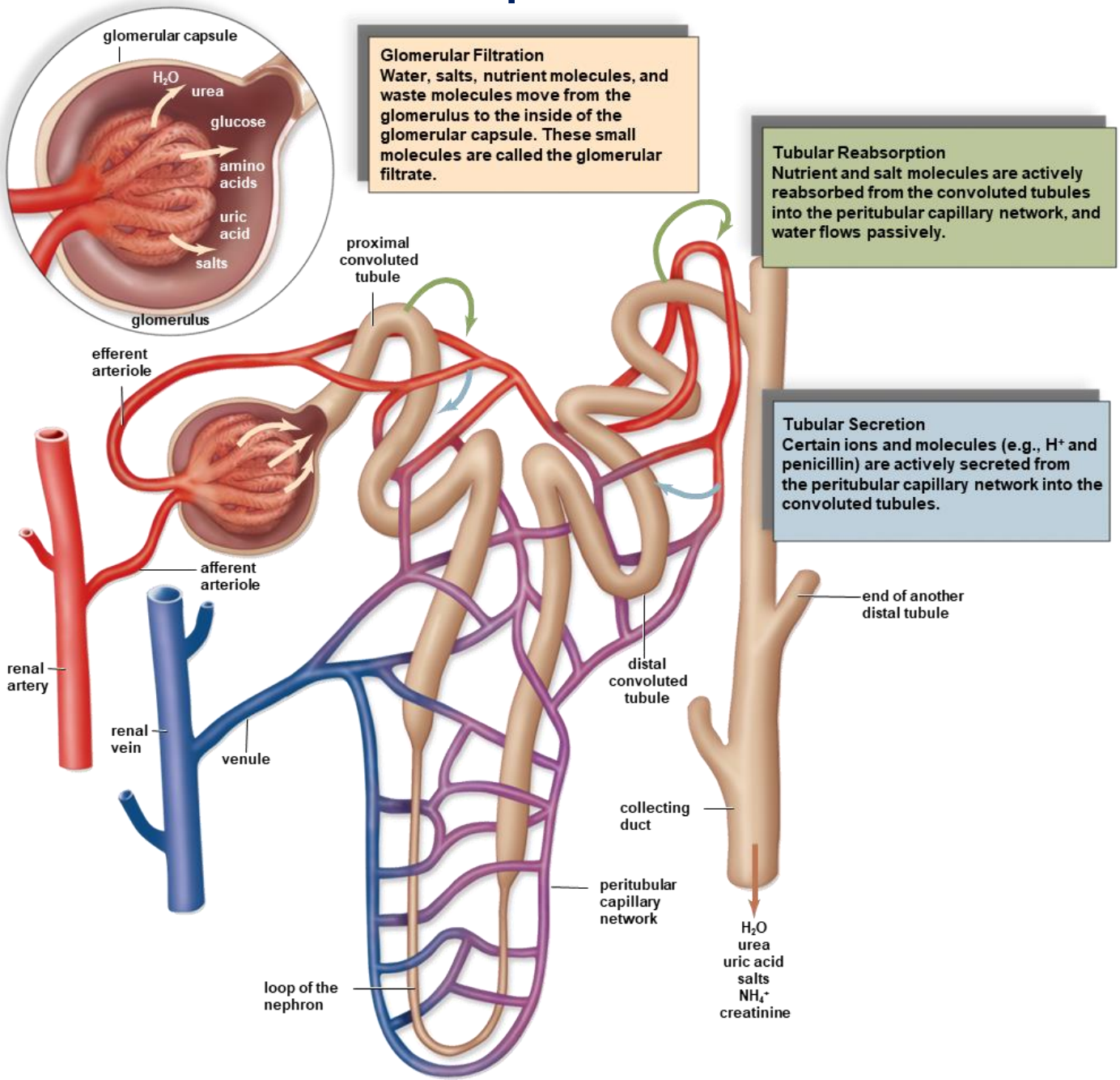
Where are nephrons stored?



11.3b: © James Cavallini/Science Source; 11.3c: © Ralph Hutchings/Visuals Unlimited/Corbis

Figure 11.3 The anatomy of a human kidney.

How does the nephron form urine?



What are the three processes in the formation of urine?

- Glomerular filtration
- Tubular reabsorption
- Tubular secretion

Glomerular filtration

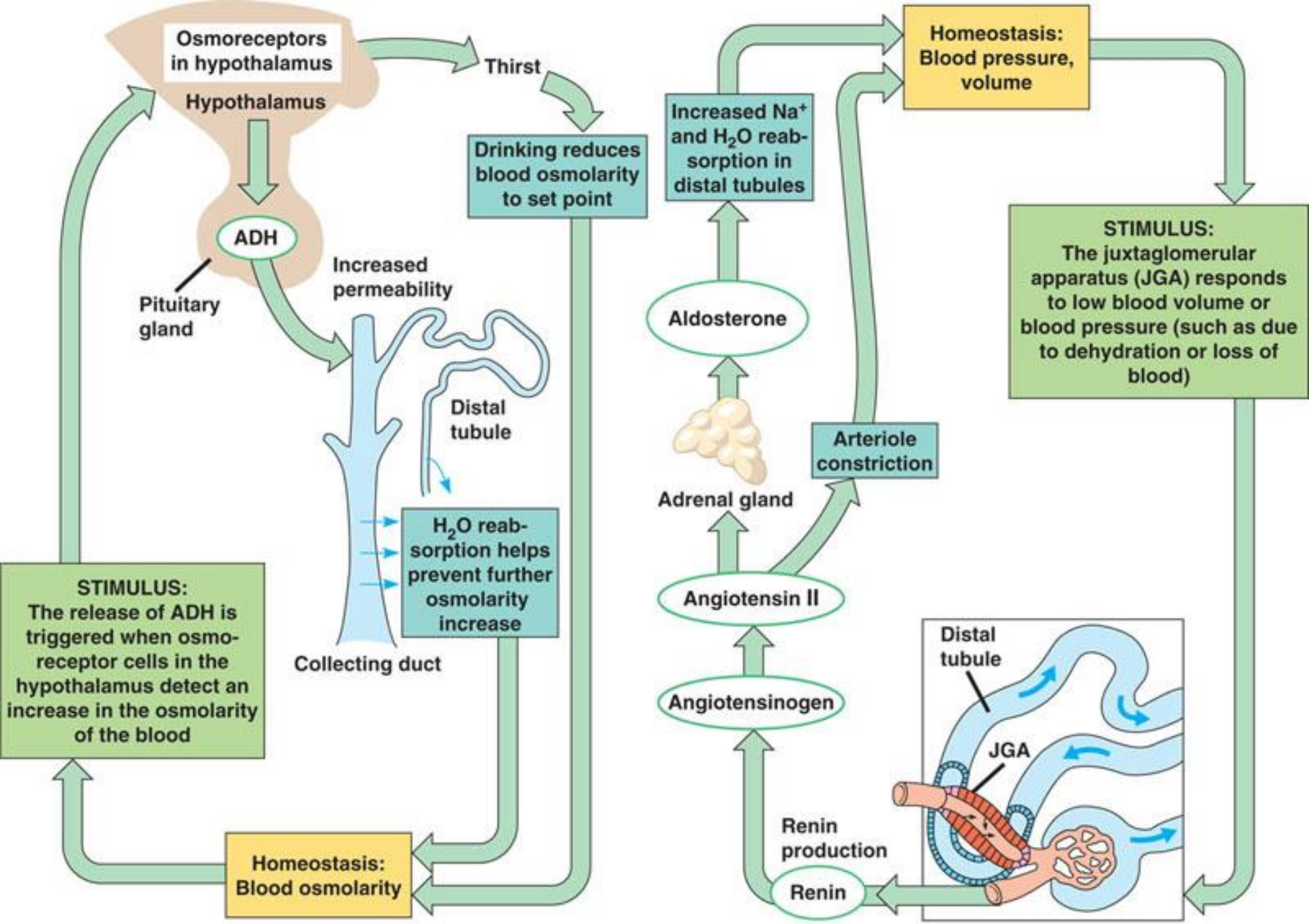
- Water and small molecules move from the glomerulus to the glomerular capsule, while large molecules and formed elements remain in the glomerular blood.

Filterable Blood Components	Nonfilterabe Blood Components
Water	Formed elements (blood cells and platelets)
Nitrogenous wastes	Plasma proteins
Nutrients	
Salts(ions)	

Tubular reabsorption and secretion

- Many molecules and ions are reabsorbed from the nephron into the blood.
- Tubular secretion is a second way to remove substances such as drugs, H^+ and creatinine from the blood.

Reabsorbed Filtrate Components	Nonreabsorbed Filtrate Components
Most water	Some water
Nutrients	Much nitrogenous waste
Required salts (ions)	Excess salts (ions)



https://en.wikipedia.org/wiki/Atrial_natriuretic_hormone

Question

What would account for increased urine production as a result of drinking alcoholic beverages? (when you're old enough to do so, of course!)

A. increased retention of glucose and amino acids
B. decreased amount of antidiuretic hormone (ADH)
C. increased blood pressure
D. increased reabsorption of water in the proximal tubule

Don’t give alcohol to puppies