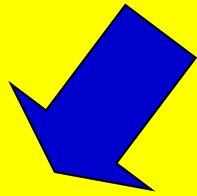


**How you remove  
wastes from your body**

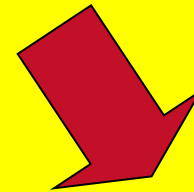
**EXCRETORY SYSTEM**

**Excretion:** waste removal from  
body

Kidneys: Unique Problem



Keep **Good**  
Things



Get Rid of  
**Bad** Things

**in blood**

How the kidneys do this:

- 1. Filtering**- everything except blood cells & protein (big)
2. Bad things → out with urine
- 3. Recycling** (reclaiming):  
Good things → back to blood

**Bad** things (waste): your kidneys  
remove

Example: **urea** from breakdown of  
protein

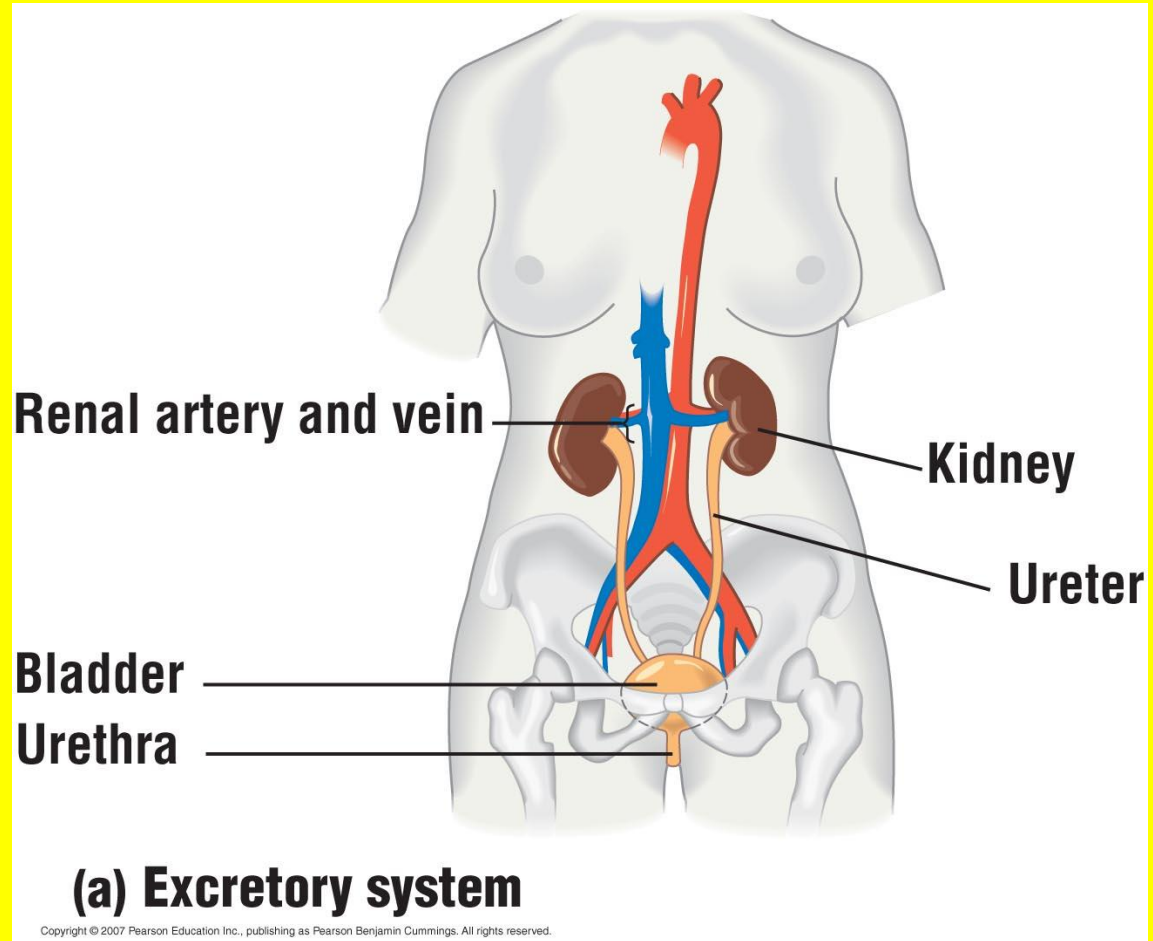
**Good** things: reclaimed

Example: **H<sub>2</sub>O, glucose, amino  
acids**

**50 gallons**  
of **blood**:  
pumped  
through  
kidneys/day

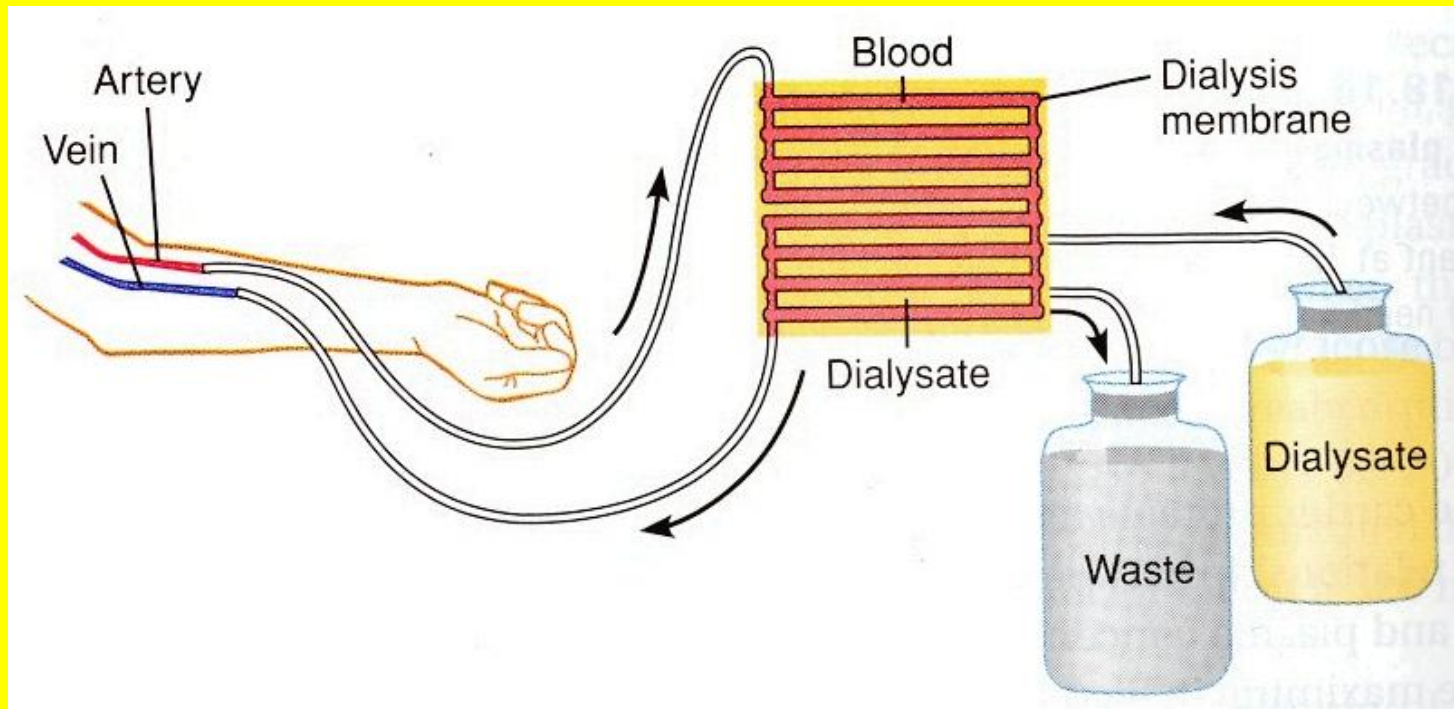
**1/2 gallon**:  
waste + H<sub>2</sub>O

leaves body as **urine**



Damage to kidneys (**failure**): poor filter

**Dialysis machine:** filter/remove wastes



# Kidney Dialysis

- **Kidney disease > 60% caused by hypertension & diabetes**
- **Toxic wastes build up**
- **Dialysis (separation): 3X/week  
each 4-6 hr**
- **Patient blood → artery → tubes**  
↓  
**selectively permeable  
membrane**

# Kidney Dialysis

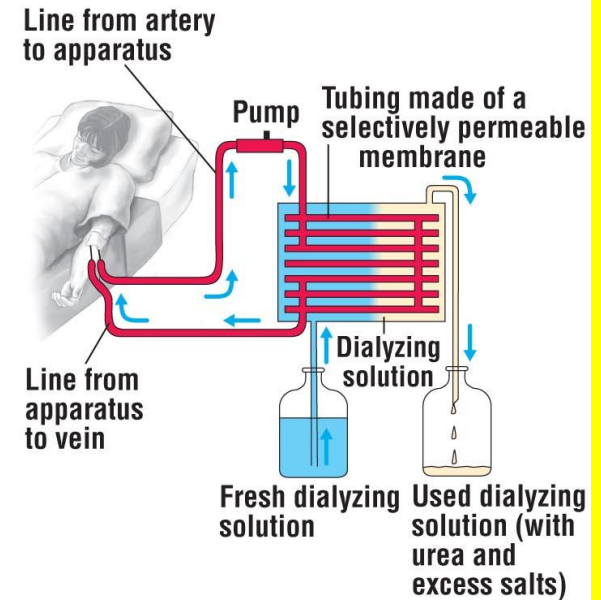
- **Good things added: bicarbonate ions**

**(blood pH)**

- **Wastes: discarded**



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# Kidney Transplantation

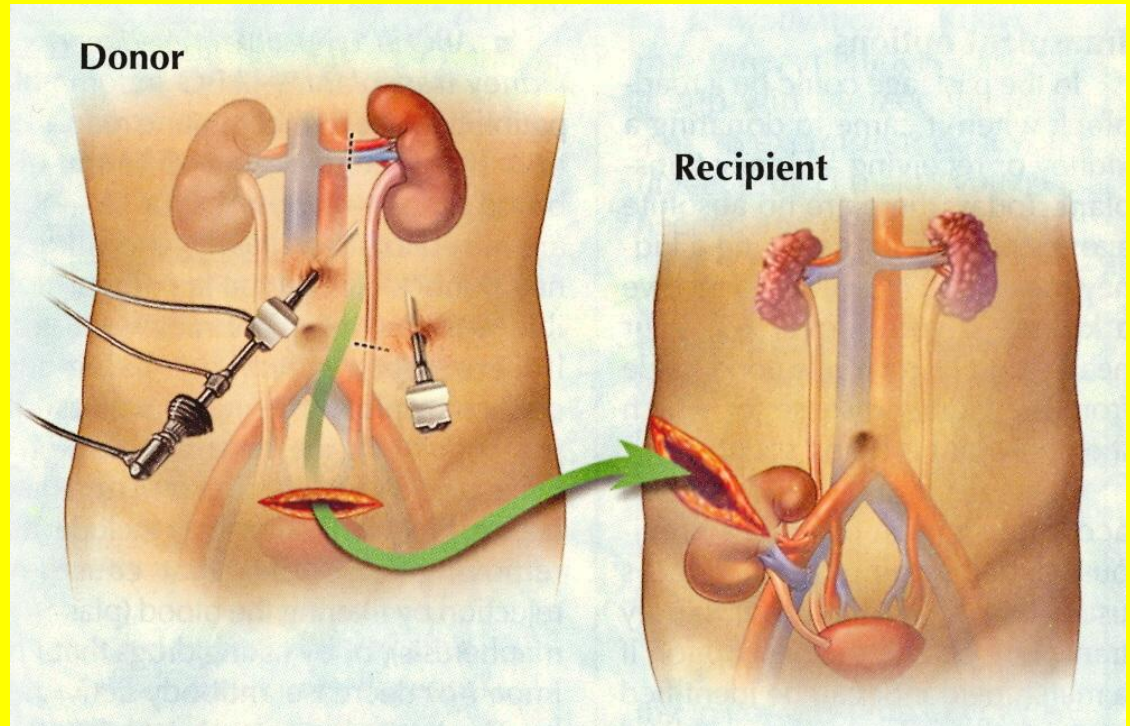
2009: 78,000 people- waiting list

1. Best donor (kidneys last longer):  
living, **matching** (family) donor
2. Unrelated living donor
3. Deceased donor

Newer technique: **“preconditioning”**  
transplant recipient’s blood before  
operation: cleanse of **antibodies**  
(cause of rejection)

Newer surgery  
on **donor**:

Laparoscopic  
Nephrectomy  
(small cut in  
**abdomen**)





Remove kidney → **recipient**

“New” kidney starts working  
immediately

- Many donated kidneys still working > 25 years
- **Donor:** normal life span
- Remaining kidney “compensates” for loss of donated kidney

# "KIDNEY SWAP"

New England people- Kidney Disease:  
3-5 year wait for **cadaver kidney**

- Second problem: incompatible donor
- **Alternative:** NE Kidney Exchange Program (Newton)
- Computerized data pool
-  Likelihood match,  Donation time

Other things your kidneys do:

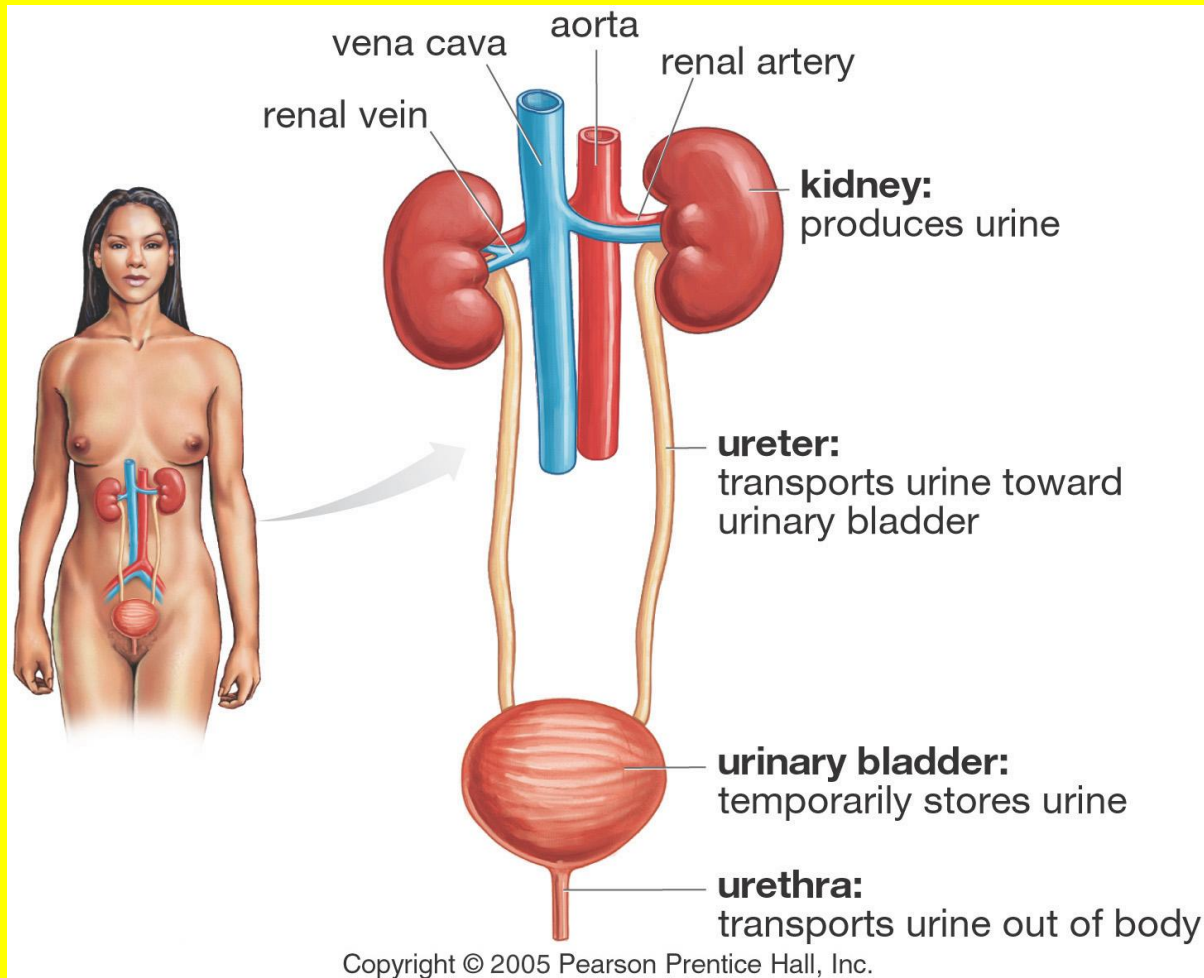
1. Control your **blood volume**:

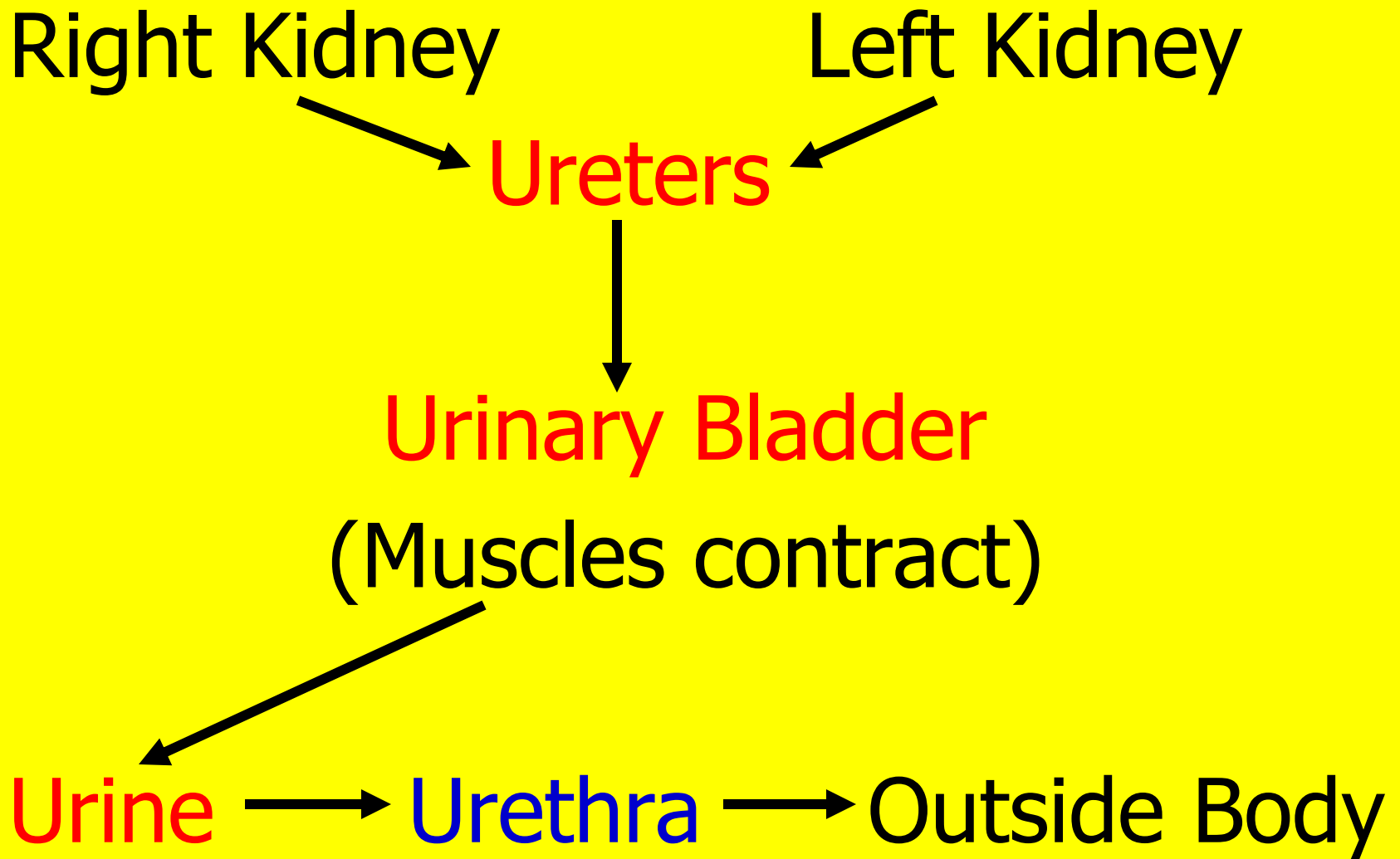
+/- H<sub>2</sub>O

2. Control **ion balance** in your body  
(**sodium, potassium**)

3. Help keep blood **pH** normal

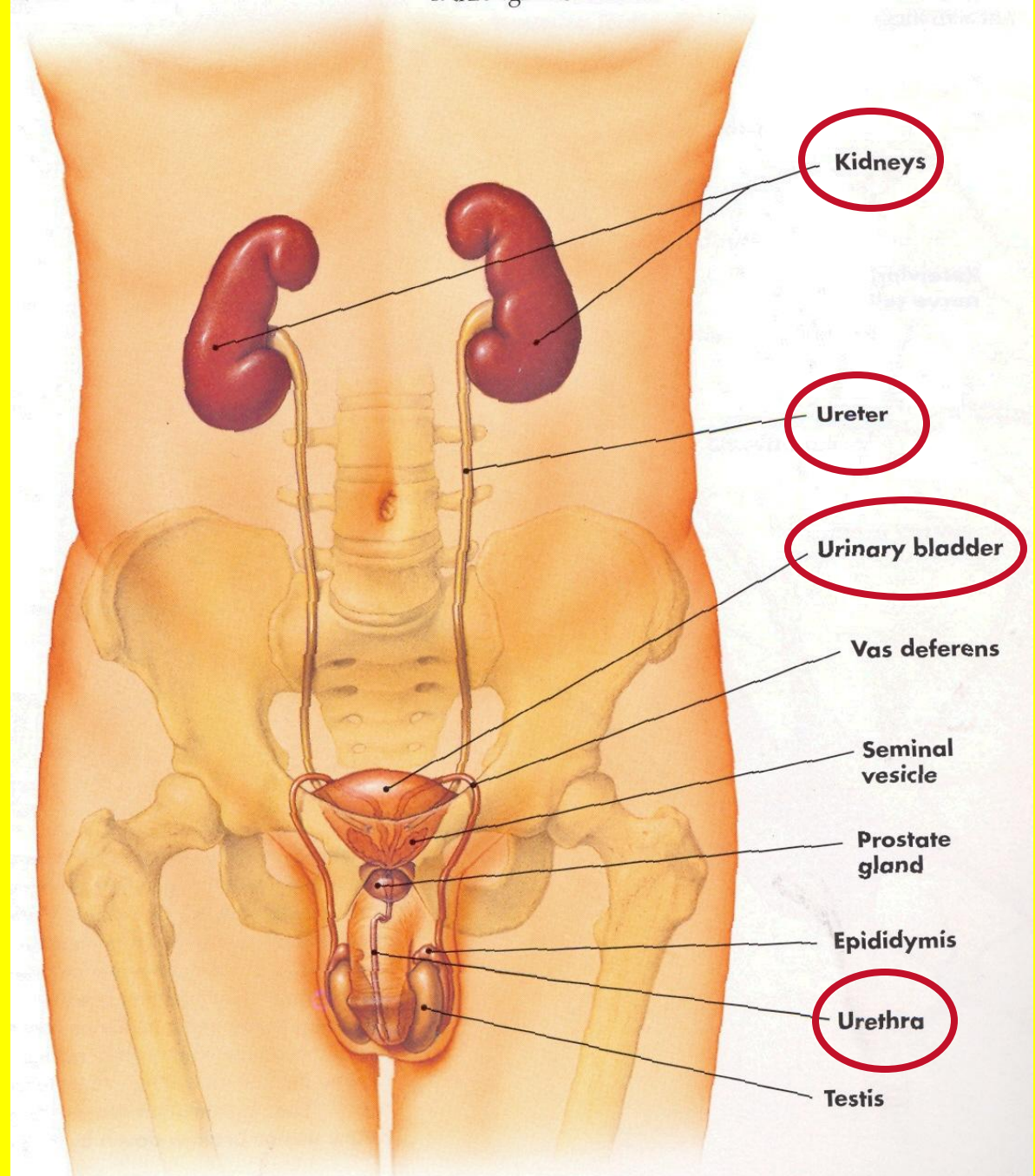
# Urinary system: 2 kidneys: filter blood, produce urine





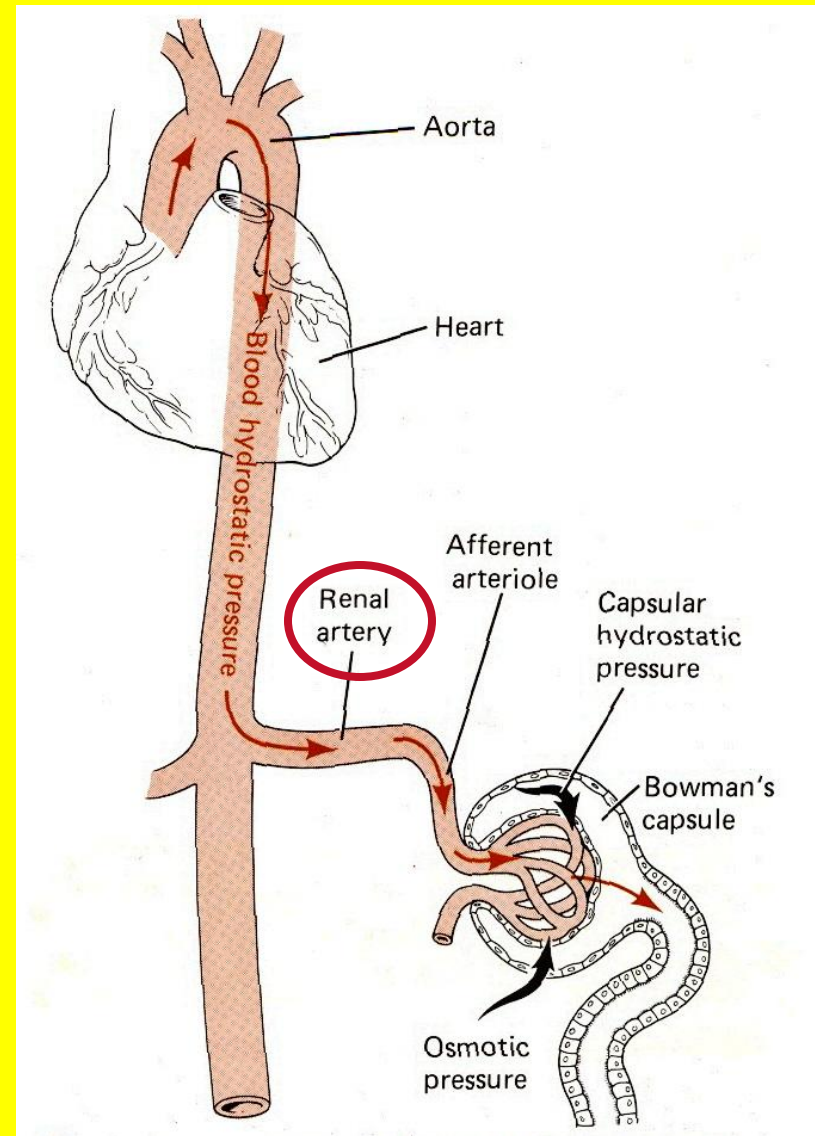


# Male Urinary System



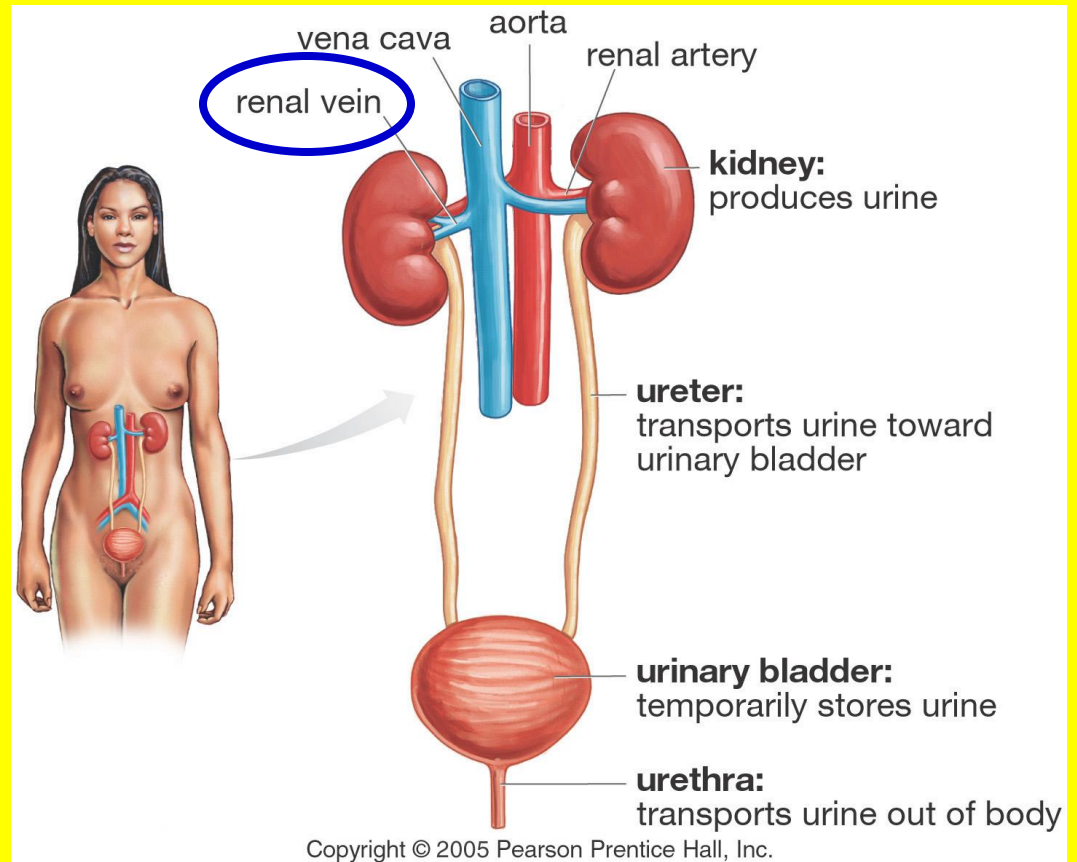
# How the kidney filters: **big picture**

1. Blood **into** kidneys:  
**renal artery**  
from aorta
2. Blood  
filtered



3. Blood **out**  
of kidneys:  
**renal vein**

4. **Cleaned**  
blood  
returned  
to **heart**

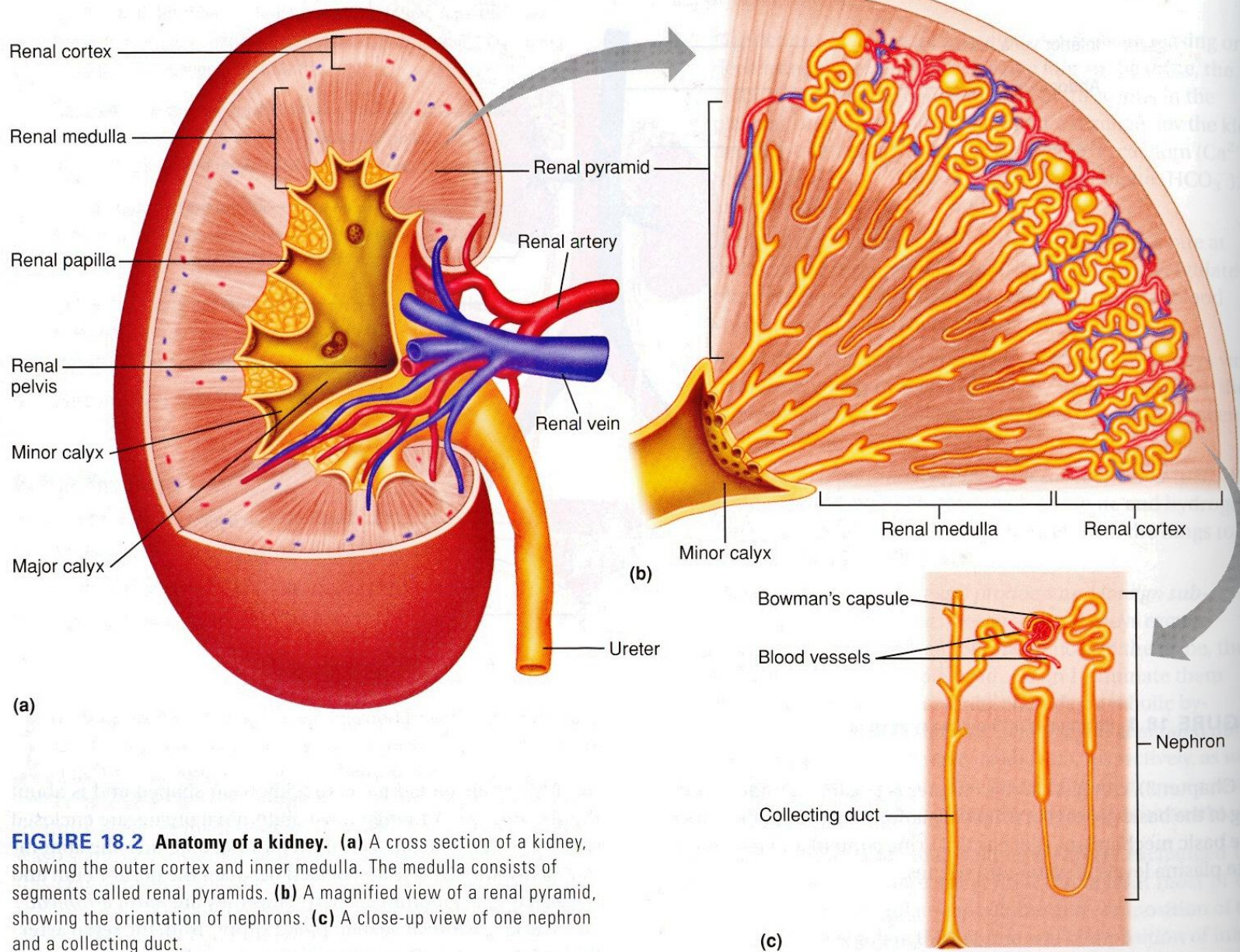


How kidneys filter blood: the **little picture**

Little filtering units: **nephrons**

1.25 million = each kidney





**FIGURE 18.2 Anatomy of a kidney.** (a) A cross section of a kidney, showing the outer cortex and inner medulla. The medulla consists of segments called renal pyramids. (b) A magnified view of a renal pyramid, showing the orientation of nephrons. (c) A close-up view of one nephron and a collecting duct.

# Nephron

Parts:

1. Bowman's capsule

Collects

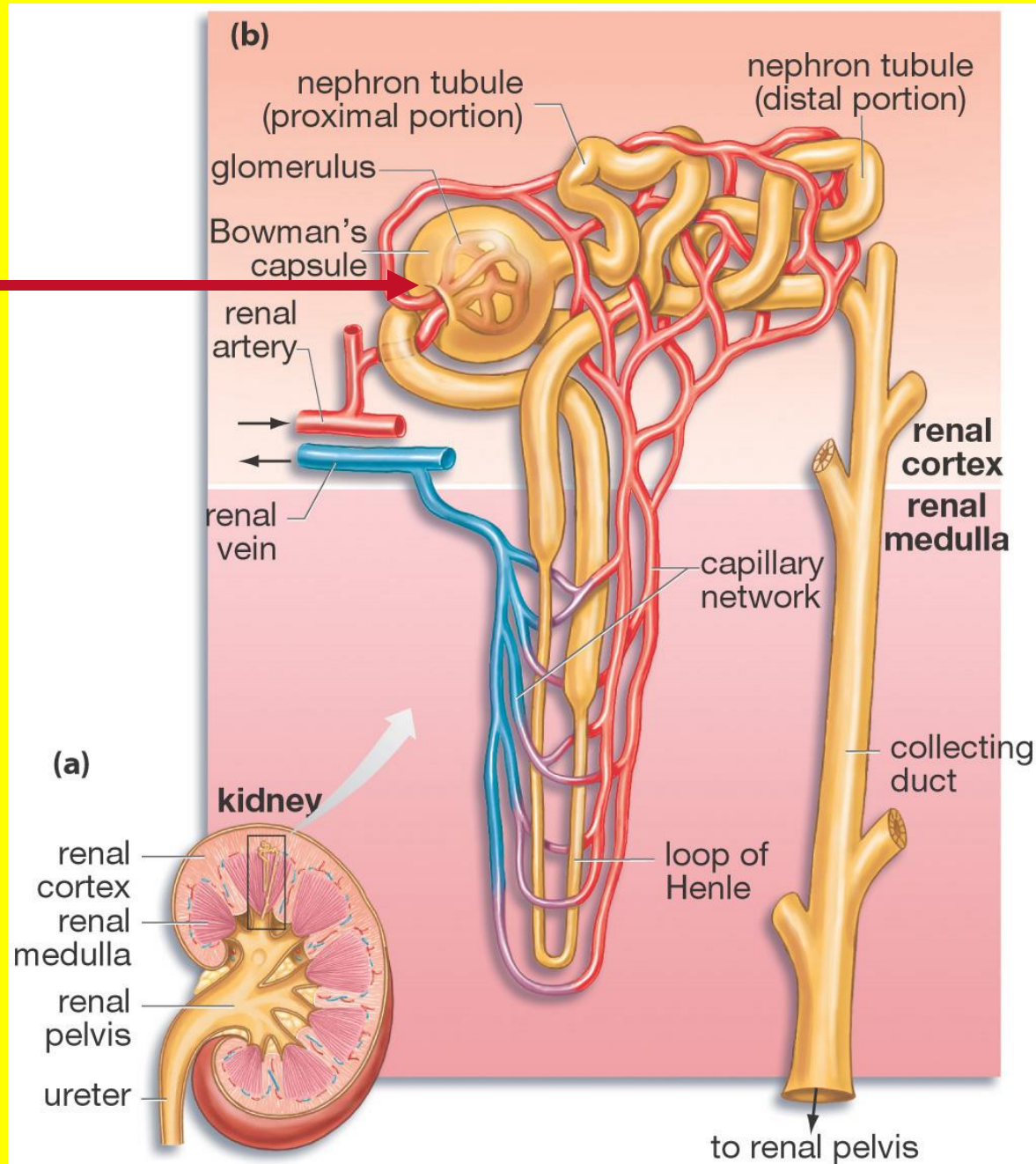
Filtered

Blood

Plasma:

Good + Bad

Things



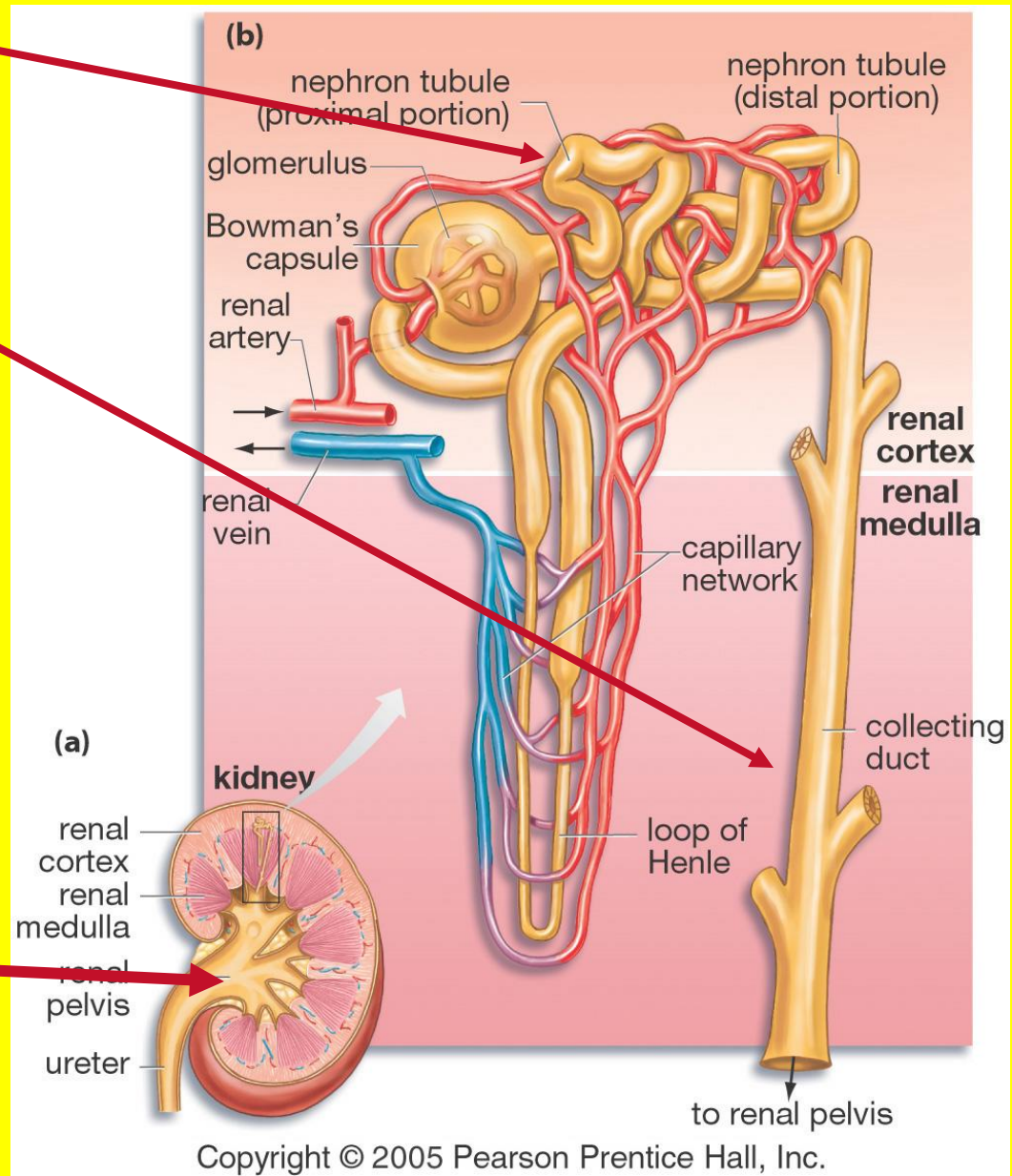


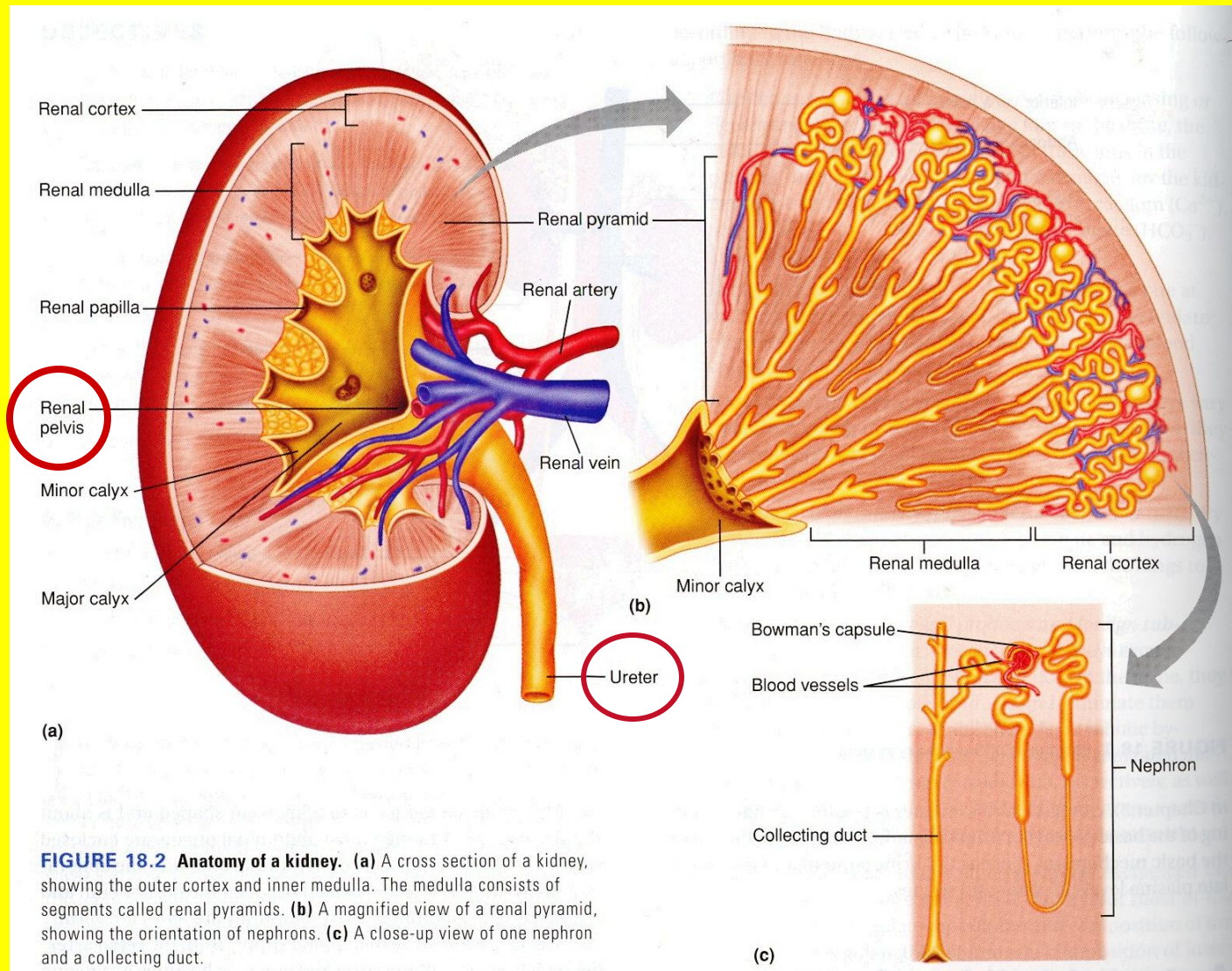
2. Complex,  
twisted tubes

3. **Collecting  
duct:** final  
urine collected

4. Many  
collecting ducts

Send urine to  
**renal pelvis**  
(cavity)





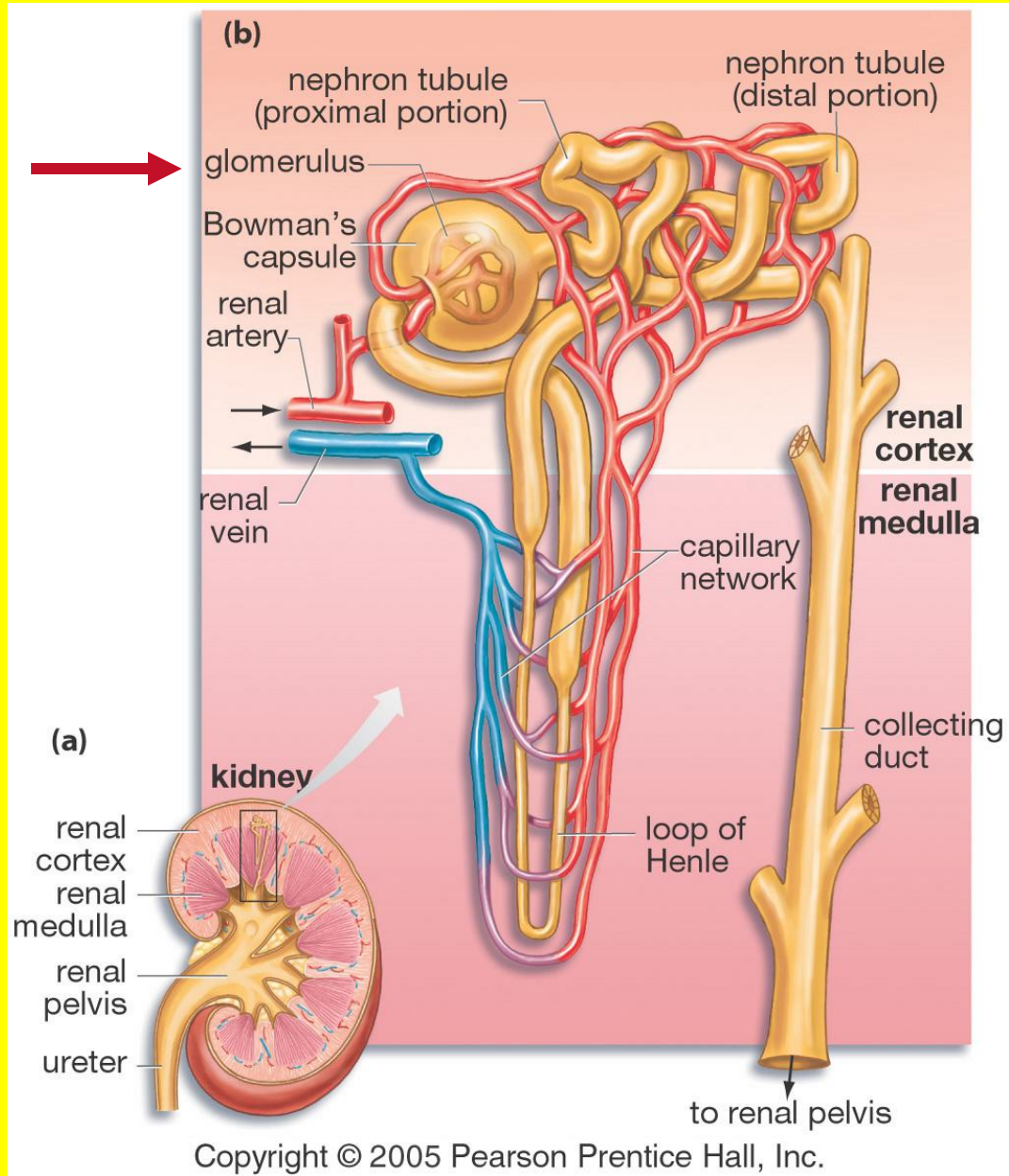
**FIGURE 18.2 Anatomy of a kidney.** (a) A cross section of a kidney, showing the outer cortex and inner medulla. The medulla consists of segments called renal pyramids. (b) A magnified view of a renal pyramid, showing the orientation of nephrons. (c) A close-up view of one nephron and a collecting duct.

5. Renal pelvis → urine → ureter



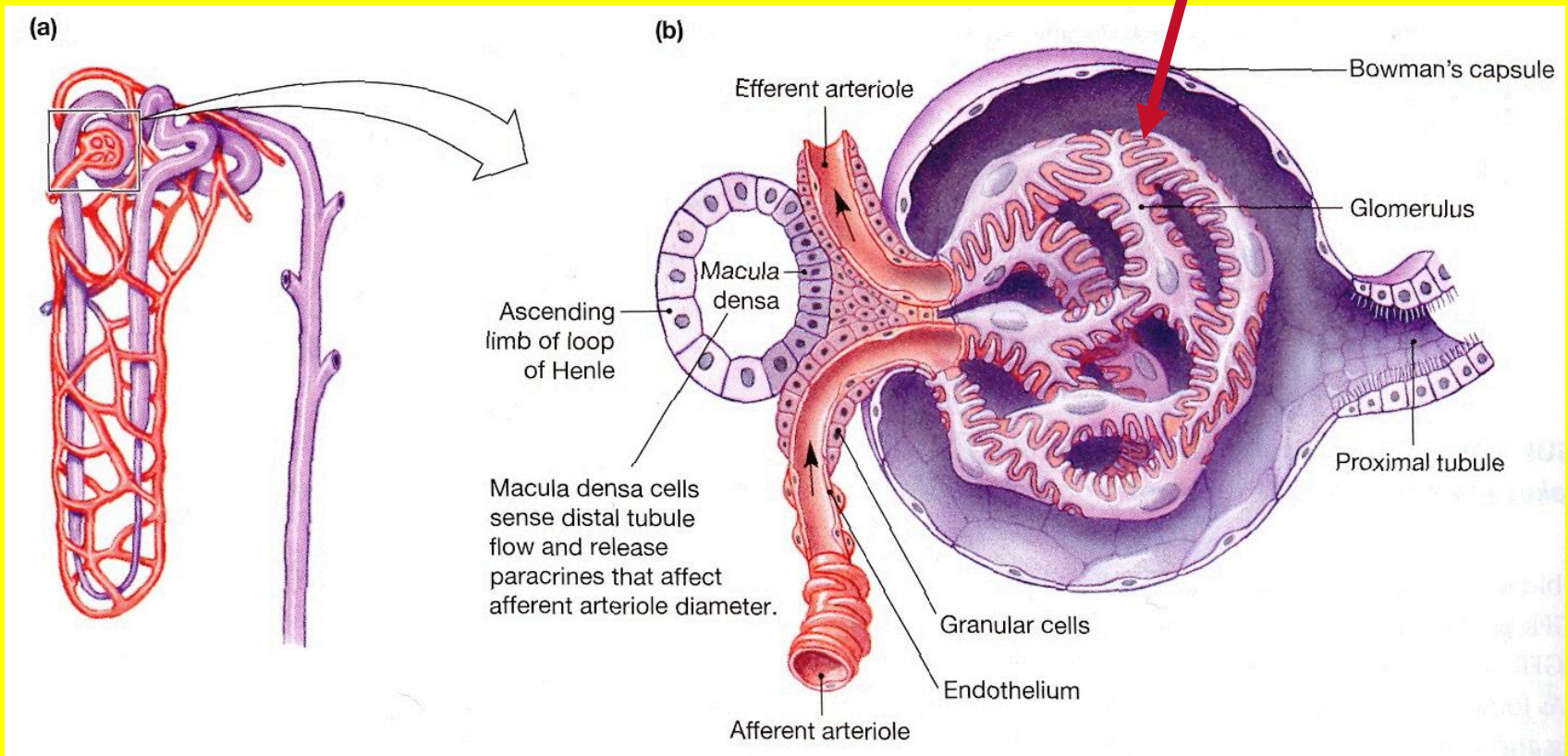
6. Blood into nephron from renal artery  
(arteriole)

7. Blood forms ball of capillaries:  
**Glomerulus**  
(porous)



# Close up view: **glomerulus**

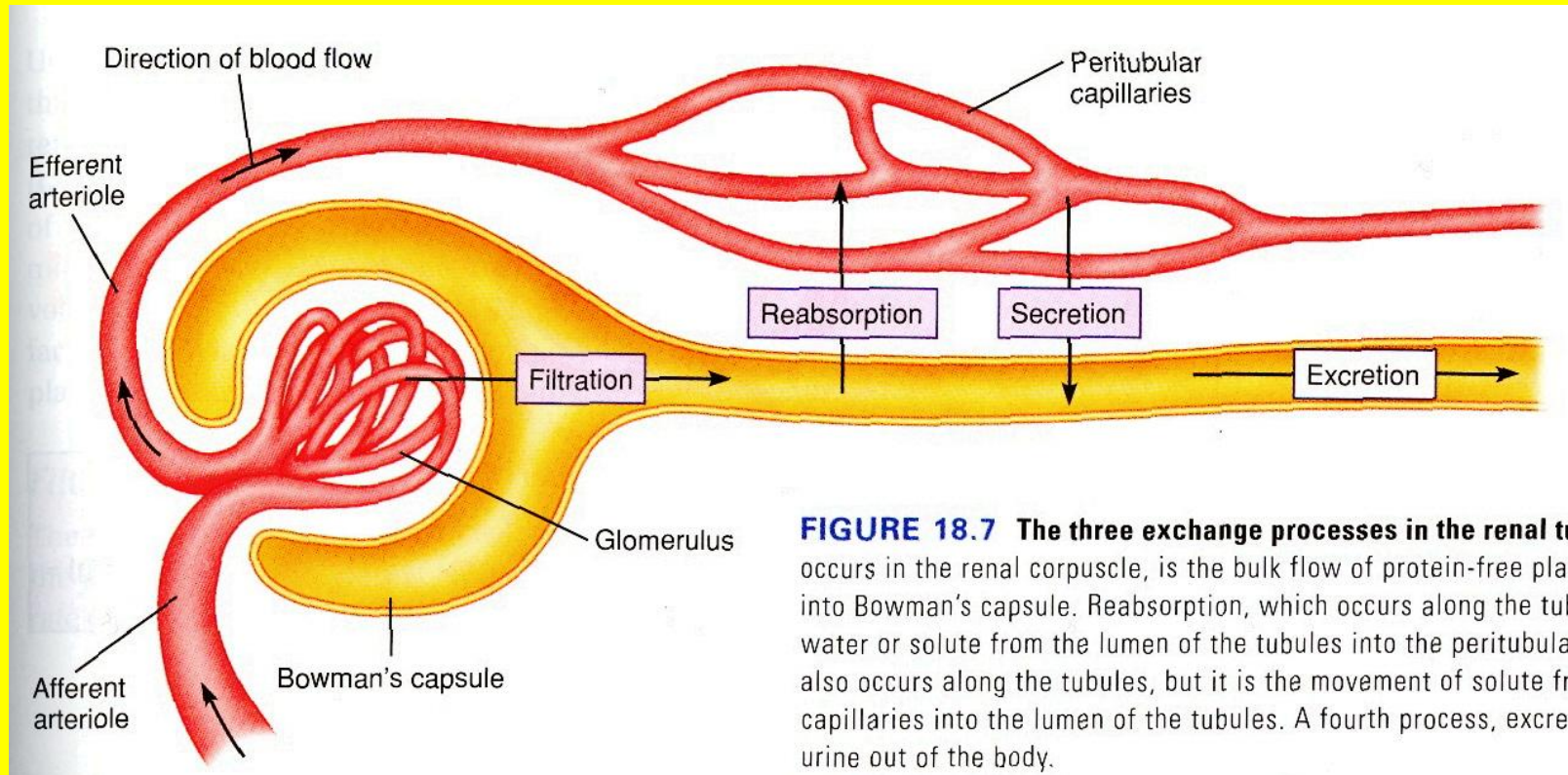
## **Blood under pressure**



## Glomerulus blood under pressure:

1. Small molecules leak out: H<sub>2</sub>O, glucose, sodium, potassium, vitamins
2. Also leaking out: metabolic wastes:
  - A) Urea- from protein breakdown
  - B) Creatinine: waste product from muscle contraction

### 3. Big things: proteins, blood cells: don't leak out- stay in blood

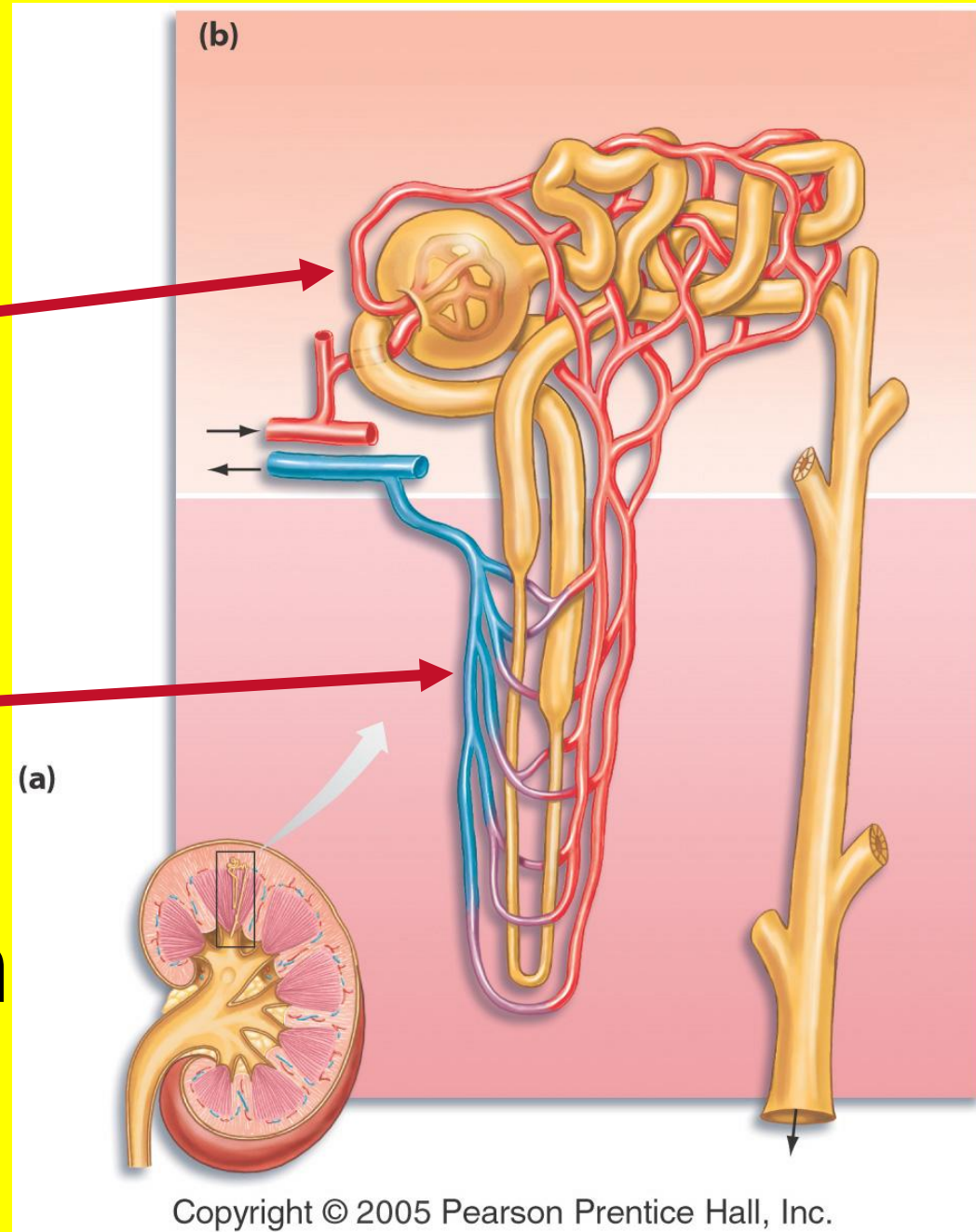




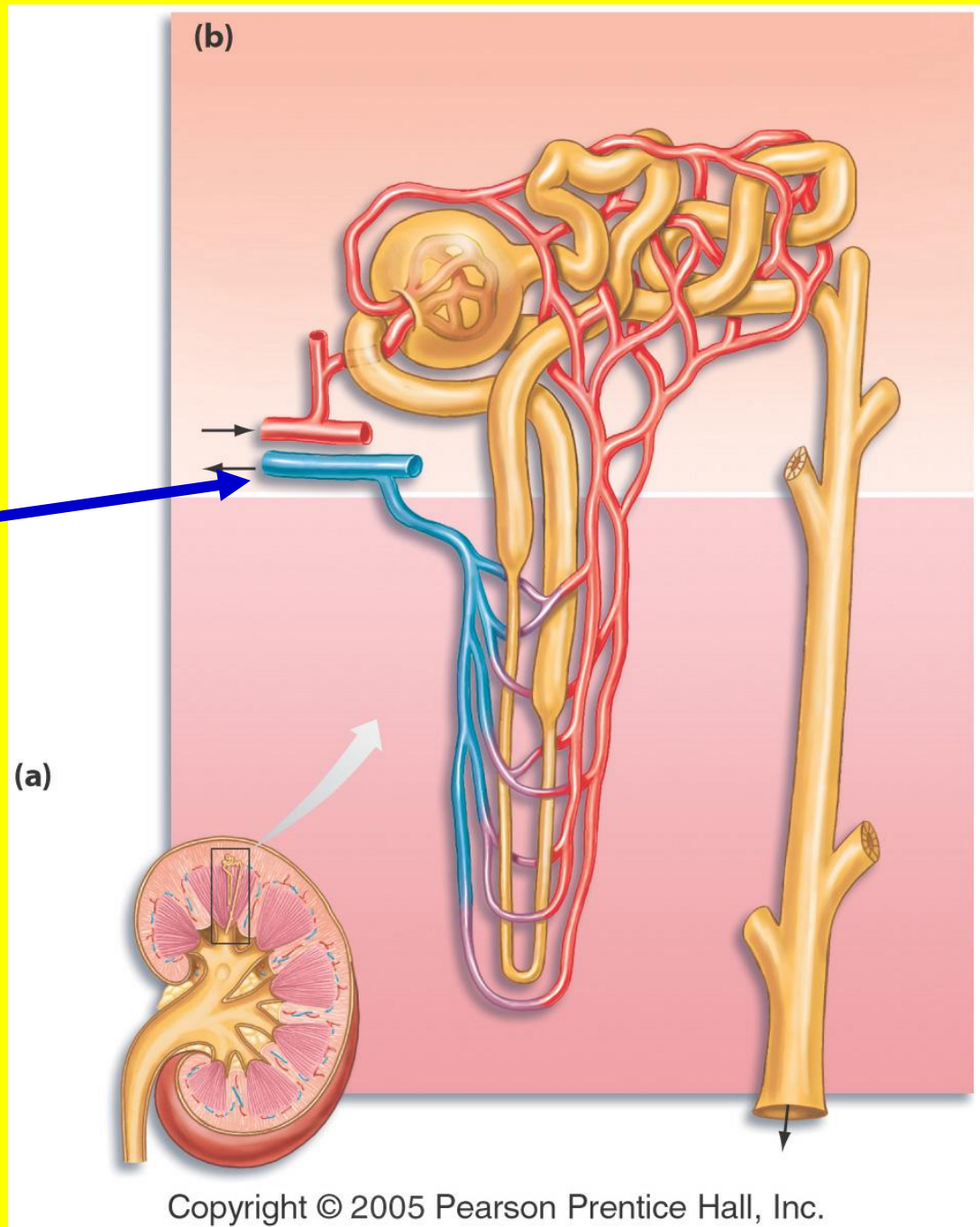
4. **Glomerulus**  
(capillaries)

form **arteriole**:  
exits Bowman's  
capsule

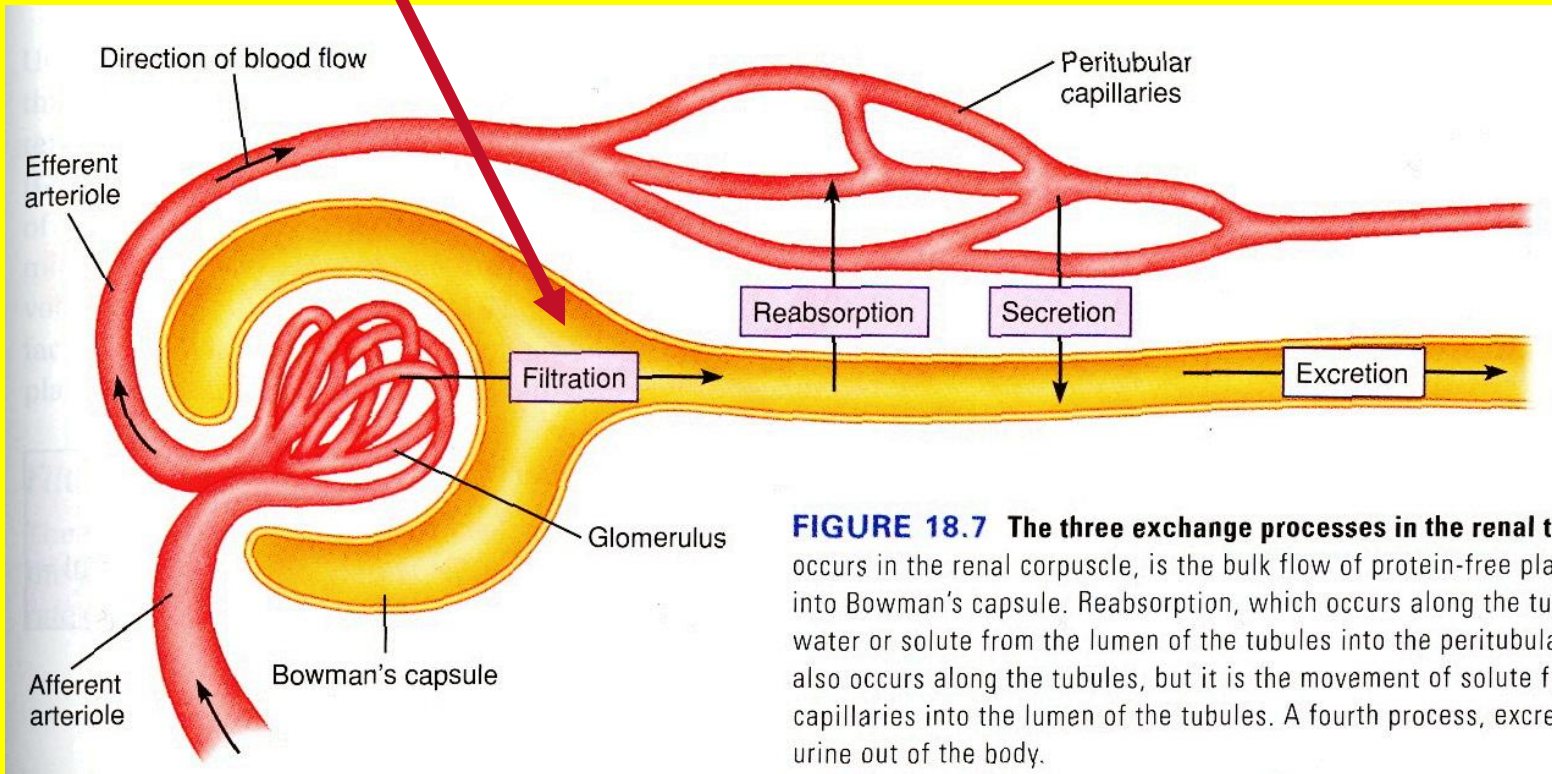
5. 2d **capillary**  
**network** formed  
around nephron



6. Finally,  
capillaries  
form  
small vein:  
blood  
returned  
to heart



This was **filtration** by nephron:  
**filtering** blood: 1<sup>st</sup> thing kidney  
does

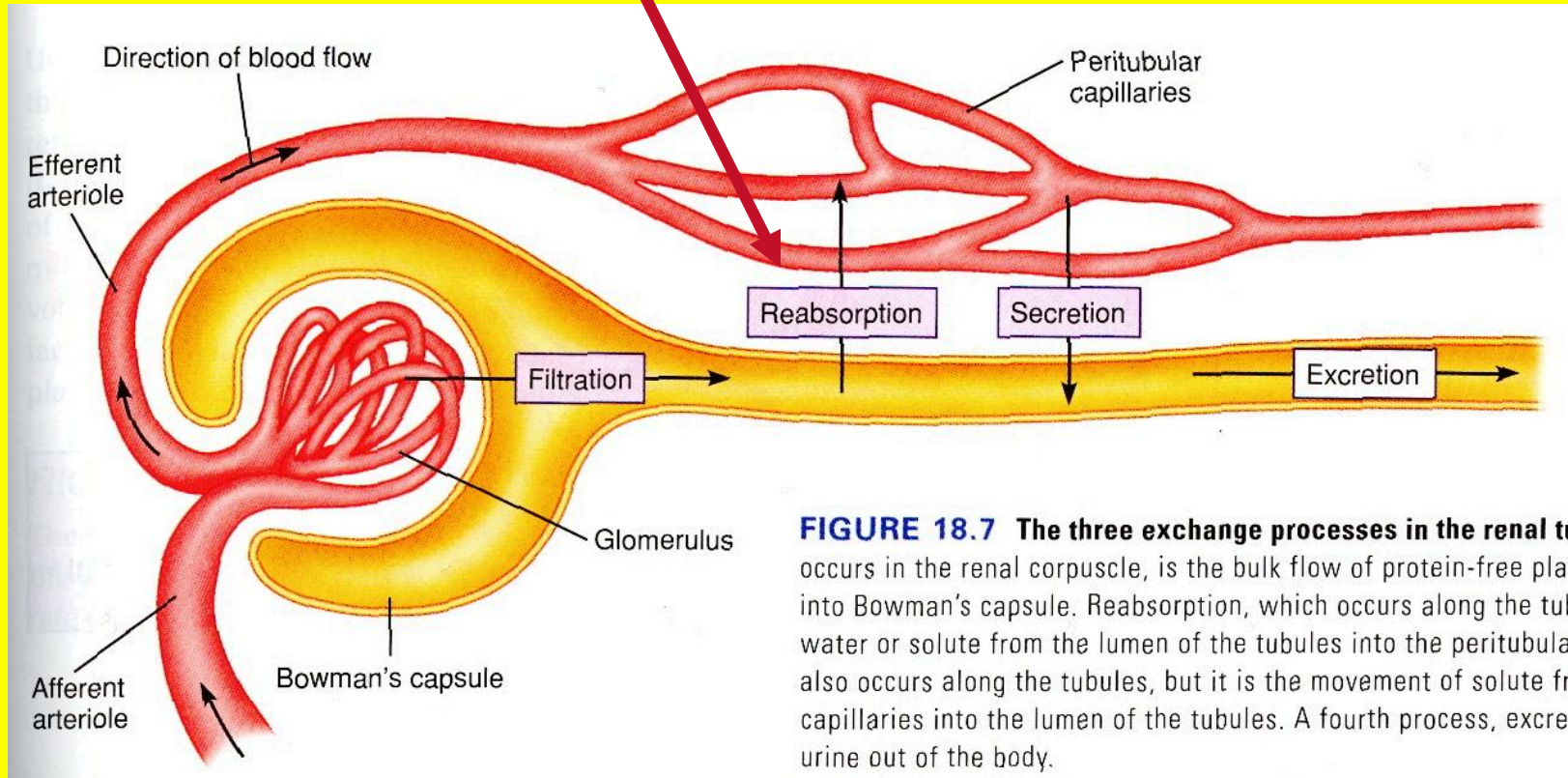


**FIGURE 18.7** The three exchange processes in the renal tubule. Filtration, which occurs in the renal corpuscle, is the bulk flow of protein-free plasma into Bowman's capsule. Reabsorption, which occurs along the tubules, is the movement of water or solute from the lumen of the tubules into the peritubular capillaries. Secretion also occurs along the tubules, but it is the movement of solute from peritubular capillaries into the lumen of the tubules. A fourth process, excretion, is the removal of urine out of the body.



# 2d thing kidney

does: **Reabsorption:** save good things

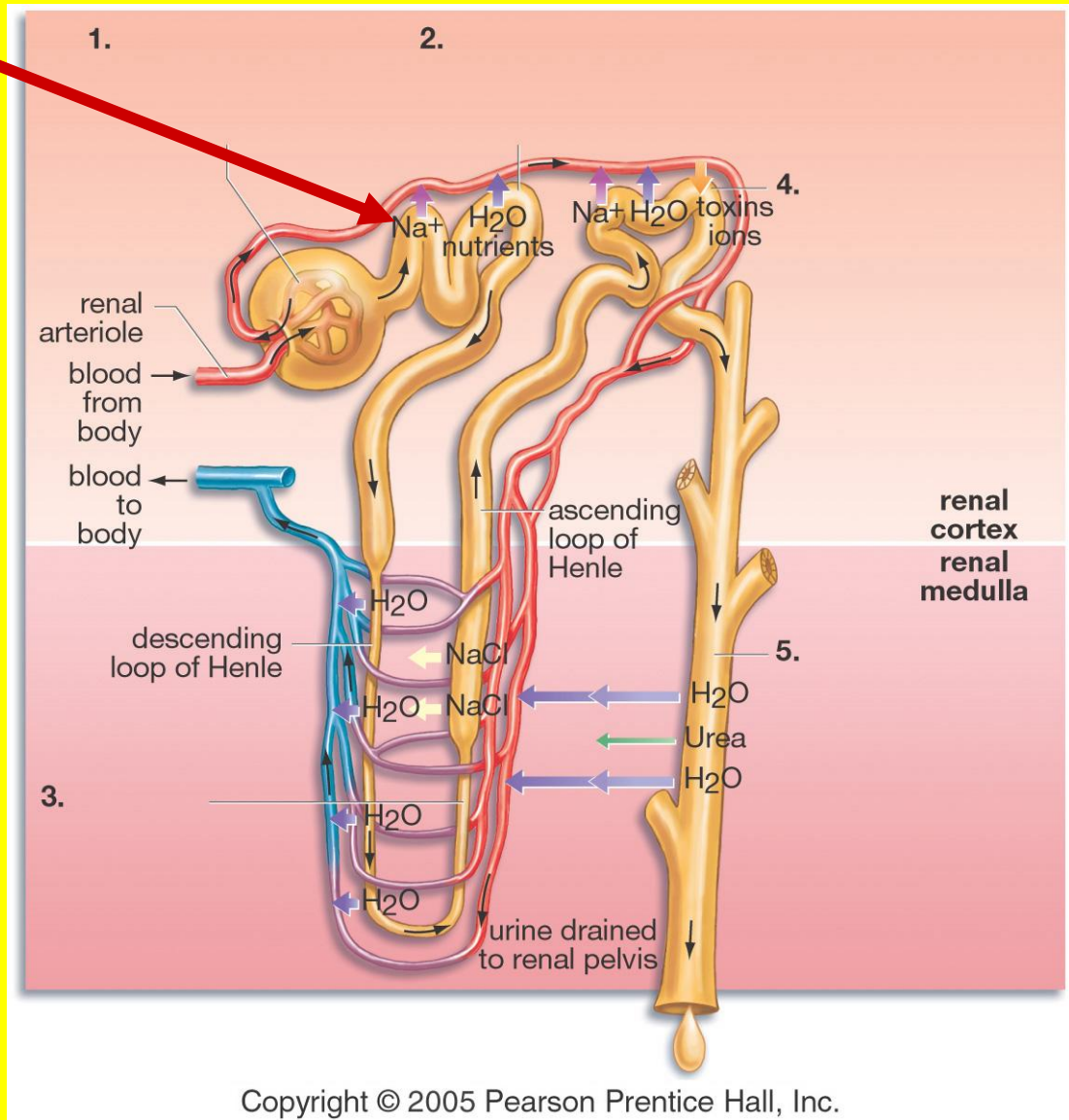




1. Cells in tubes actively pump sodium to outside of tube

2. Sodium moves into capillaries

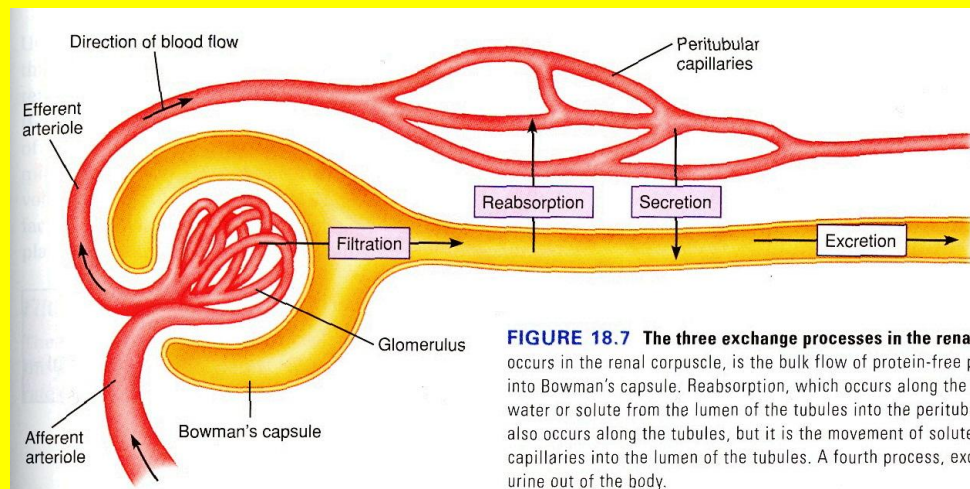
3.  $H_2O$  follows the sodium (osmosis): into capillaries



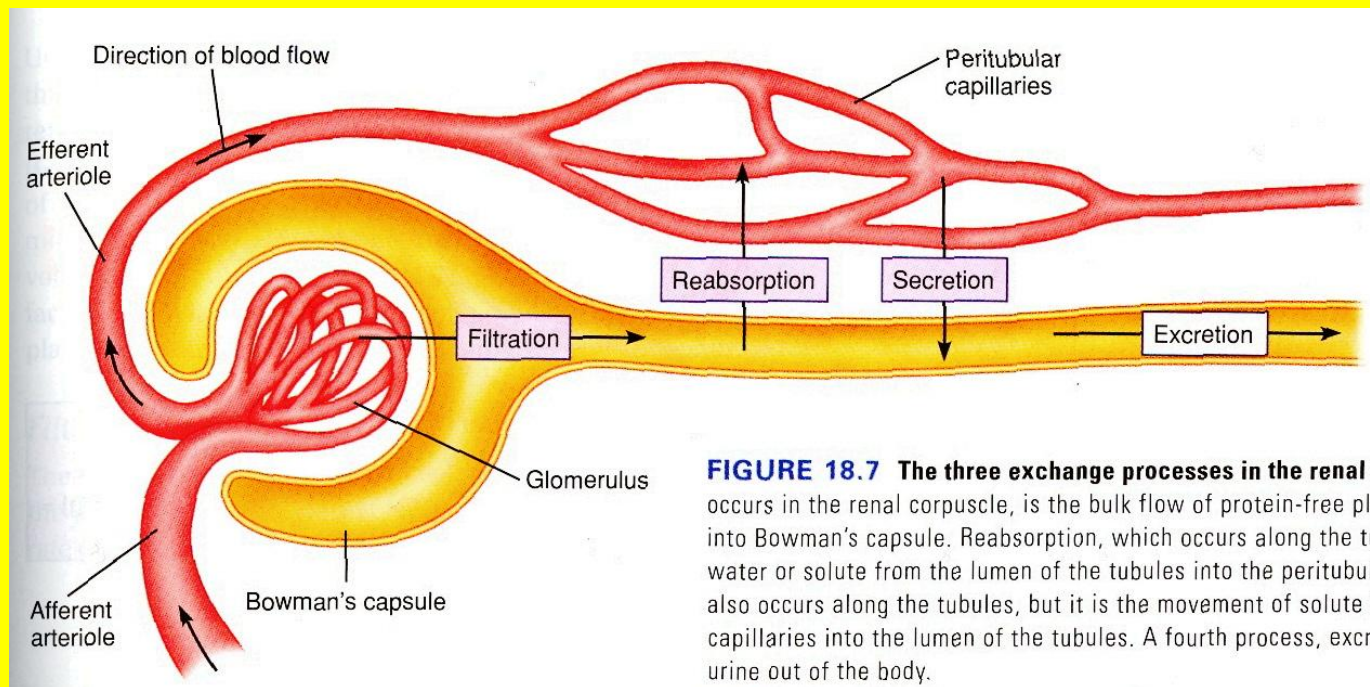
H<sub>2</sub>O lost during filtration + **glucose**  
+ **nutrients**: **reclaimed** back into  
blood

This is **REABSORPTION**

Wastes: most **urea** in tube **not**  
reabsorbed: pass out → urine



3<sup>rd</sup> thing kidney does: **Secretion**  
(to release)  $H^+$  (balances blood pH), Potassium, Drugs, Poisons:  
Move: capillaries  $\rightarrow$  tubes  $\rightarrow$  urine



# 4<sup>th</sup> thing kidney does: **concentration**

More **sodium**

Pumped out-

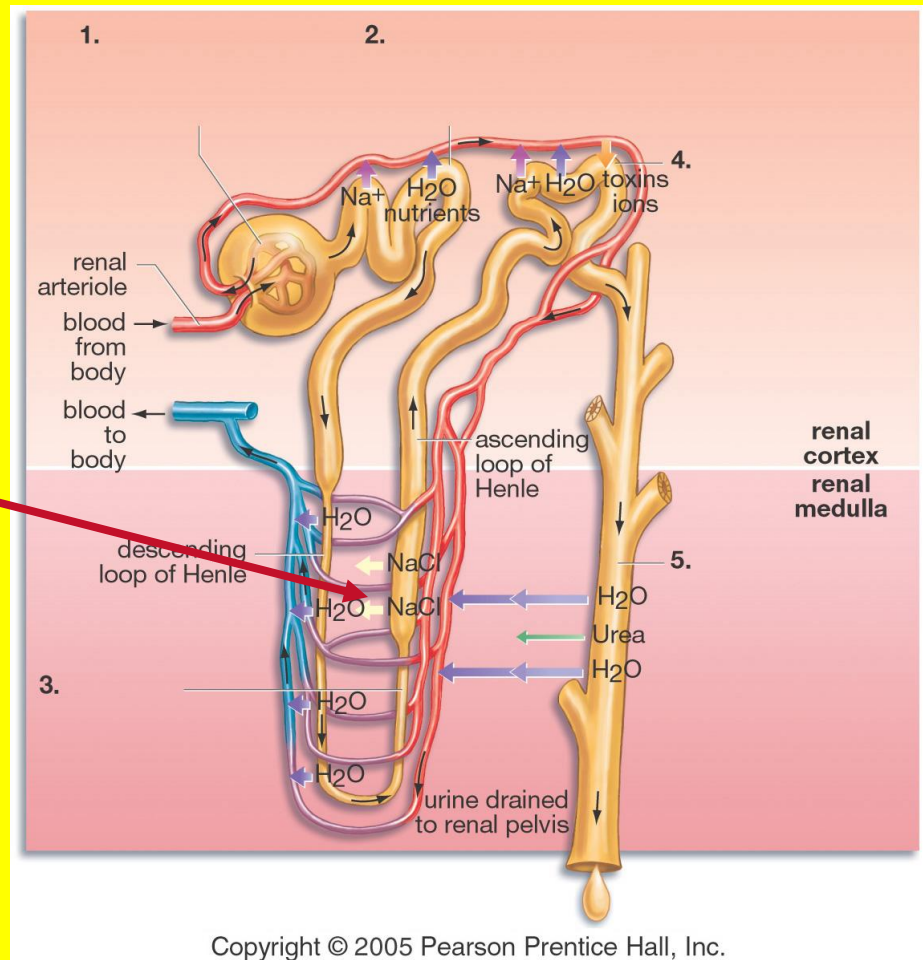
end tube

moves into

**capillaries-**

H<sub>2</sub>O follows:

moves into **blood**



**Concentration:** you save **99%** of  
H<sub>2</sub>O filtered

You produce **concentrated** urine:  
wastes + some water

Very important for land animals:  
**H<sub>2</sub>O conservation-** prevents us  
from drying out

# Summary 4 things your kidneys do:

#1 **Filter** everything except protein & blood cells

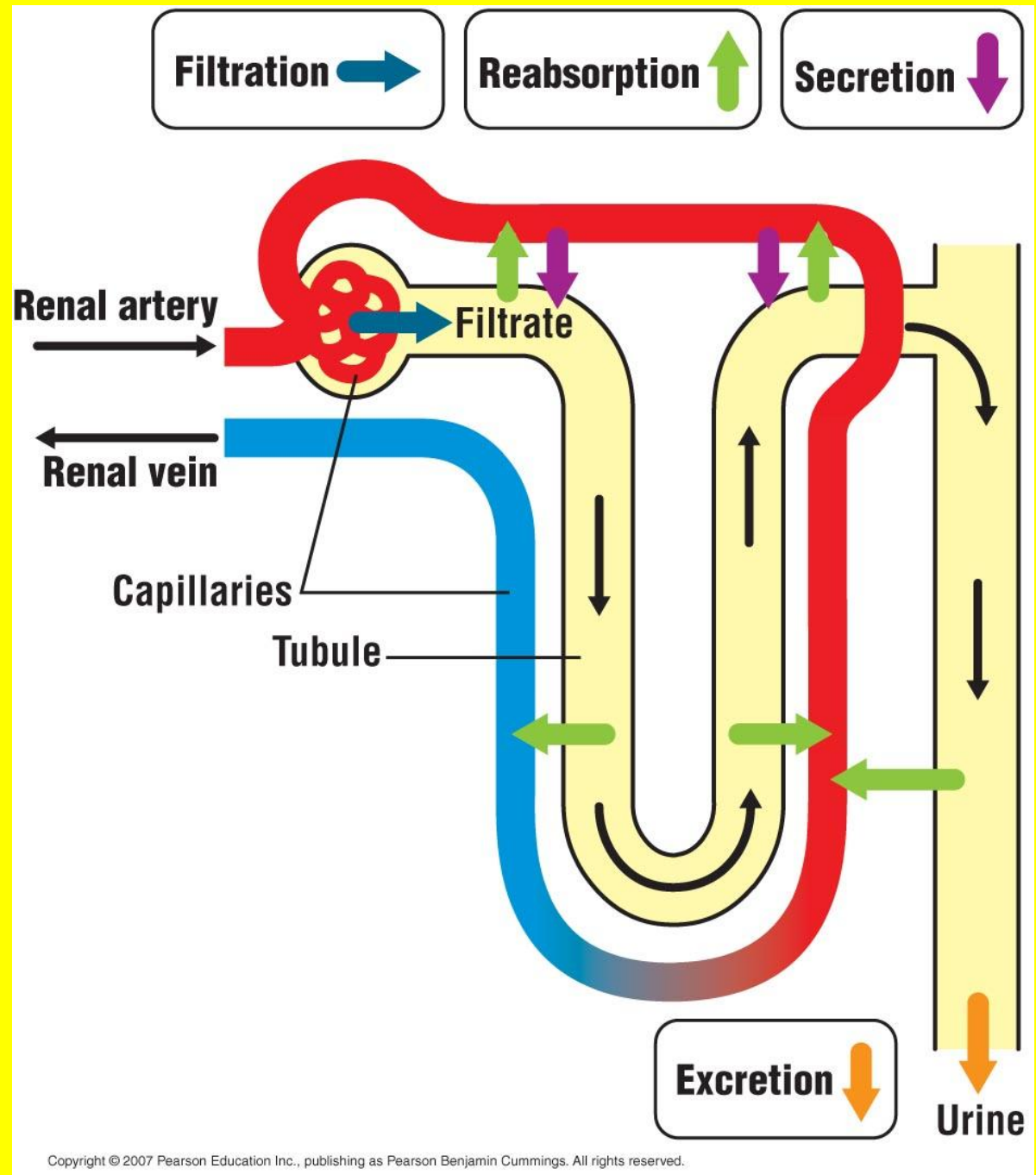
#2 **Reabsorb**: H<sub>2</sub>O, sodium, glucose, vitamins

#3 **Secrete**: H<sup>+</sup> & potassium from blood → tubule

#4 **Concentrate**: save H<sub>2</sub>O, concentrate wastes → urine  
**(Excretion)**



# Summary



# Kidneys & sodium/potassium balance

- Our kidneys evolved: **conserve sodium & excrete potassium** (homeostasis)
- Prehistoric diet



Today's diet: **overloads** kidney's  
with salt

Our kidney's have not adapted

"modern" diet: result- **hypertension**

# Natural way to control blood pressure

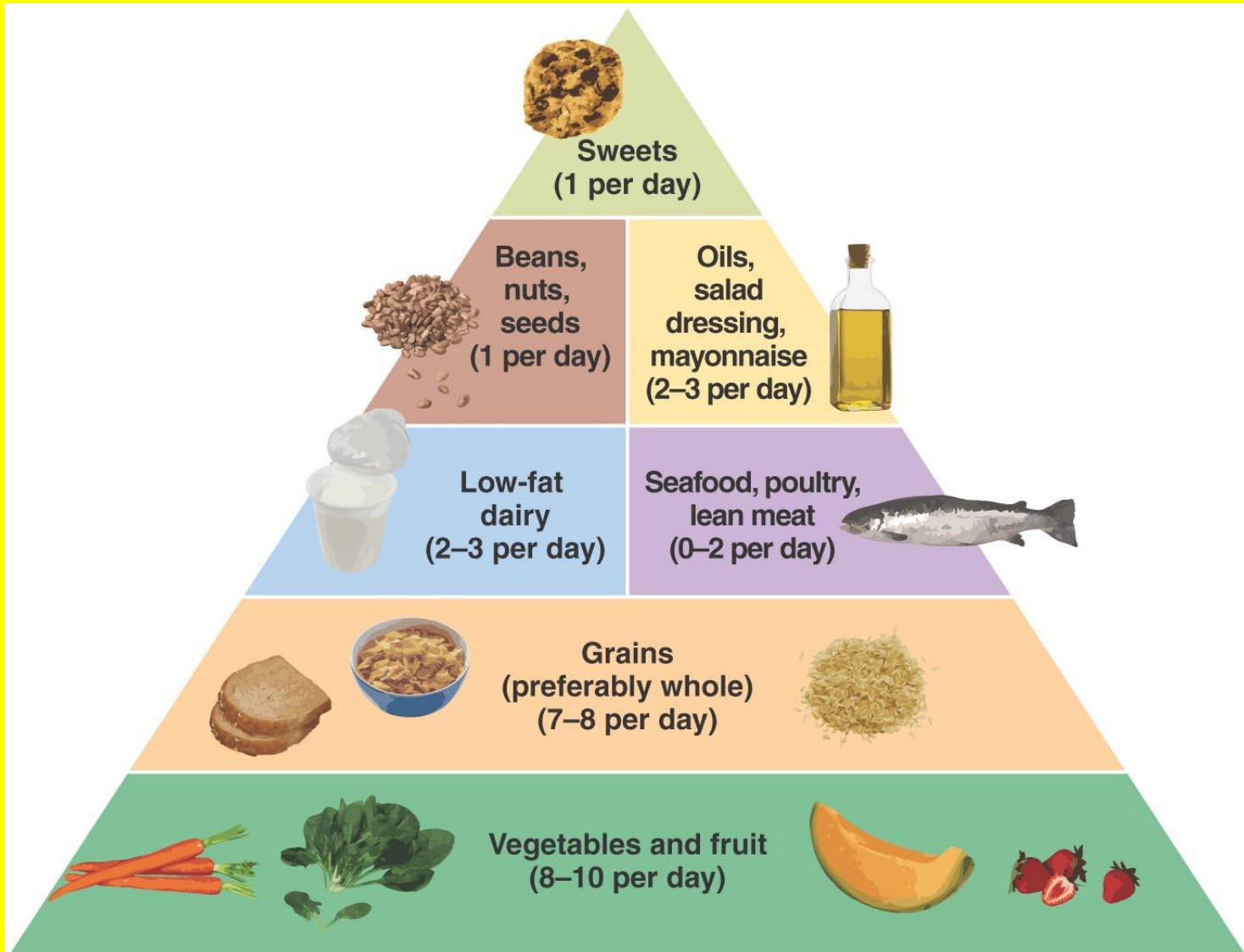
- Return to **caveman** diet
- Dietary Approaches to Stop Hypertension (**DASH**) Eating Plan
- National Heart, Lung & Blood Institute

# DASH

- ↑ Fruits & veggies
- Low fat milk (calcium) products
- Eat more: poultry, fish, nuts
- Eat less: red meat, sugar in processed foods/drink

**If all Americans ate DASH:  
dramatic drop in heart  
attacks/stroke**

# DASH DIET



What controls how much  $H_2O$  you lose in your urine?

Walking- desert

Drinking

many glasses

$H_2O$

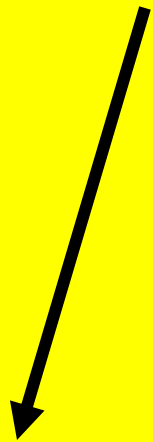
**Your body adjusts**

Concentrated

Dilute yellow

yellow urine

urine



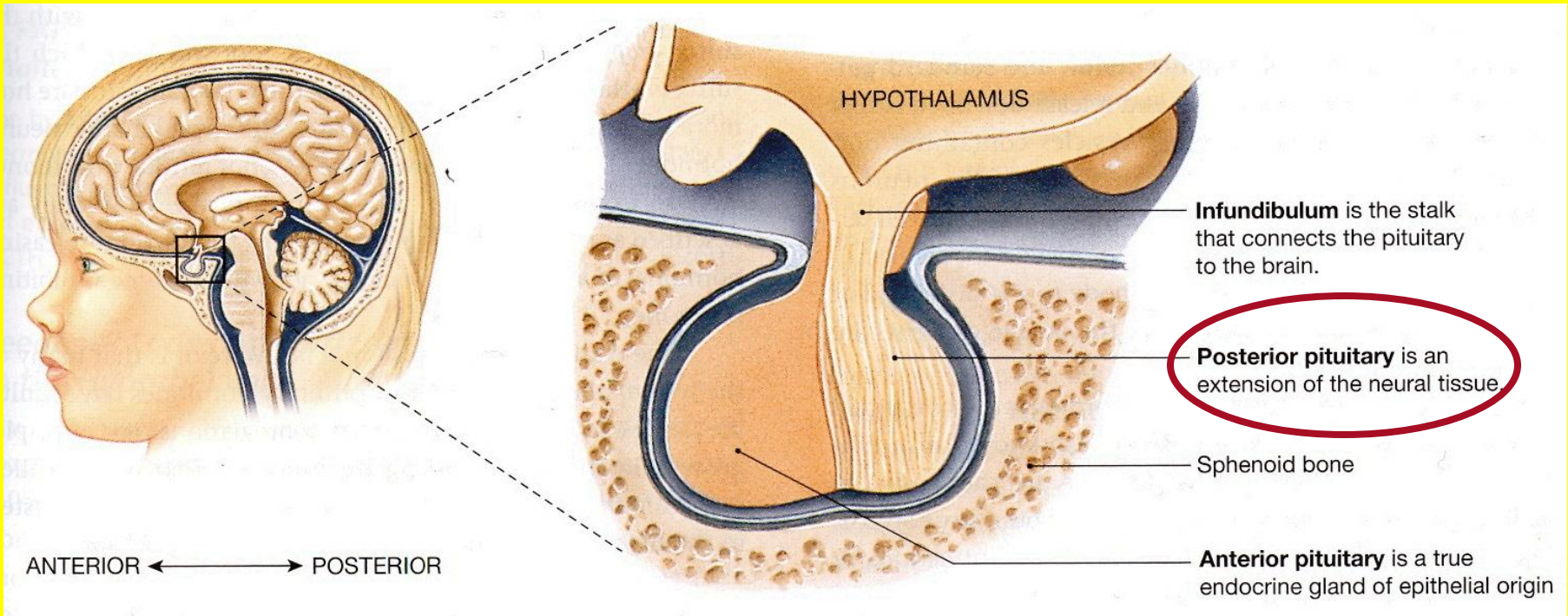


## In **Nevada Desert:**

1. Lose H<sub>2</sub>O- breath, sweat
2. ↓ **Blood volume** (concentrated)
3. Brain (**hypothalamus**) detects change blood volume
4. Signals → **pituitary gland**

**Antidiuretic Hormone (ADH)**





**Diuretic** = ↑ urine secretion

## **Antidiuretic Hormone**

- Makes tubules/collecting ducts more **permeable** to water
- Water moves into blood
- Result: more H<sub>2</sub>O in blood, urine-concentrated
- Important: **saves** body water- desert

# You arrive at **Las Vegas Hotel-thirsty**

- Drink several bottles H<sub>2</sub>O
- ↑ **Blood volume**
- H<sub>2</sub>O comes in from intestine
- Pituitary ↓ **ADH**
- Nephron tubules/collecting duct **less permeable**
- More H<sub>2</sub>O **leaves** → urine

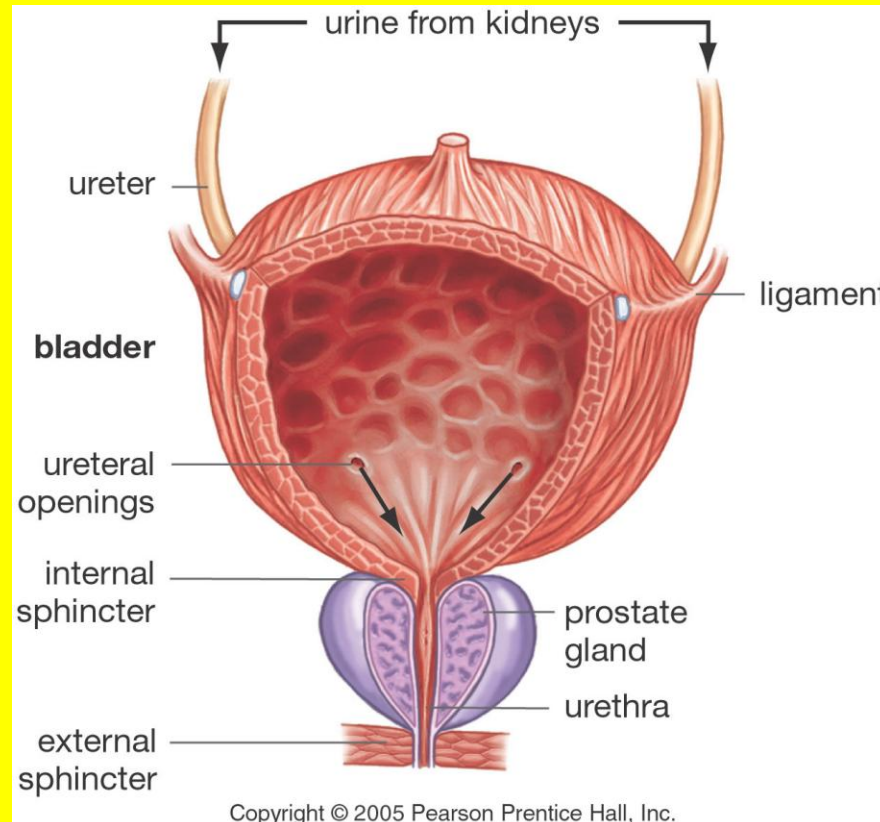
Drink 12 ounces

Beer or Water

- Beer- more urination
- Alcohol: ↓ ADH production
- Alcohol = diuretic
- ↑ Urine secretion
- Dehydrating effect part of hangover

To the outside.....

Urine → **ureters** → **urinary bladder**  
holds 27 ounces





**Urethra:** from bladder to outside

Men: 7-8 inches- through penis

Women: ~ 1 inch

**Prostate gland:** produces fluid for semen

Prostate: below

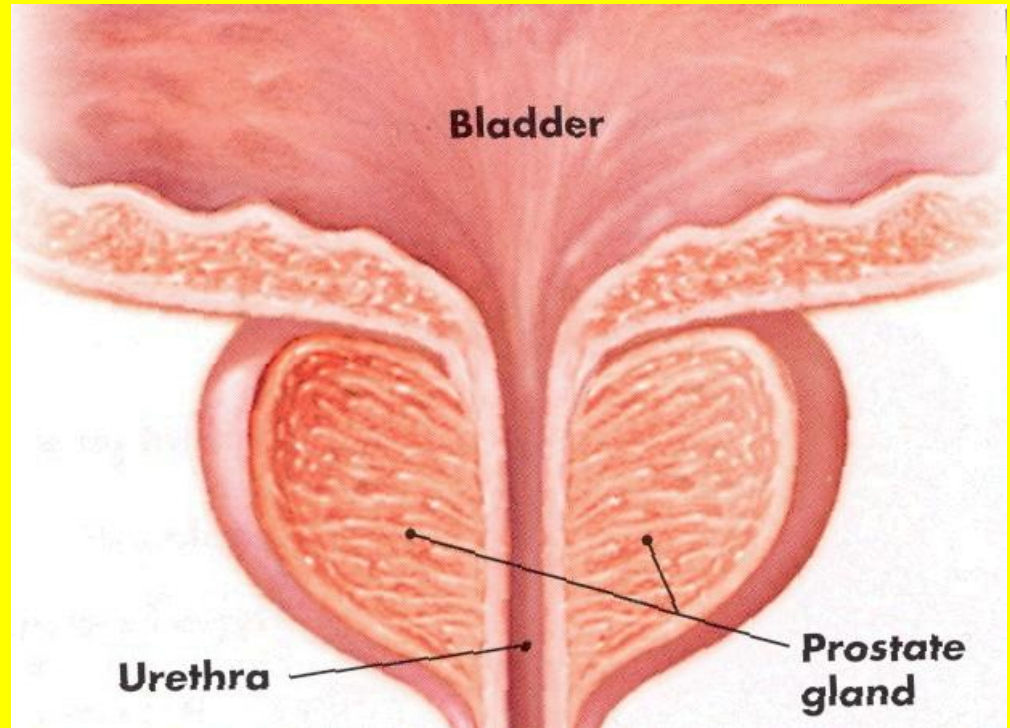
bladder,  
surrounds

**urethra-**

**Enlarged**

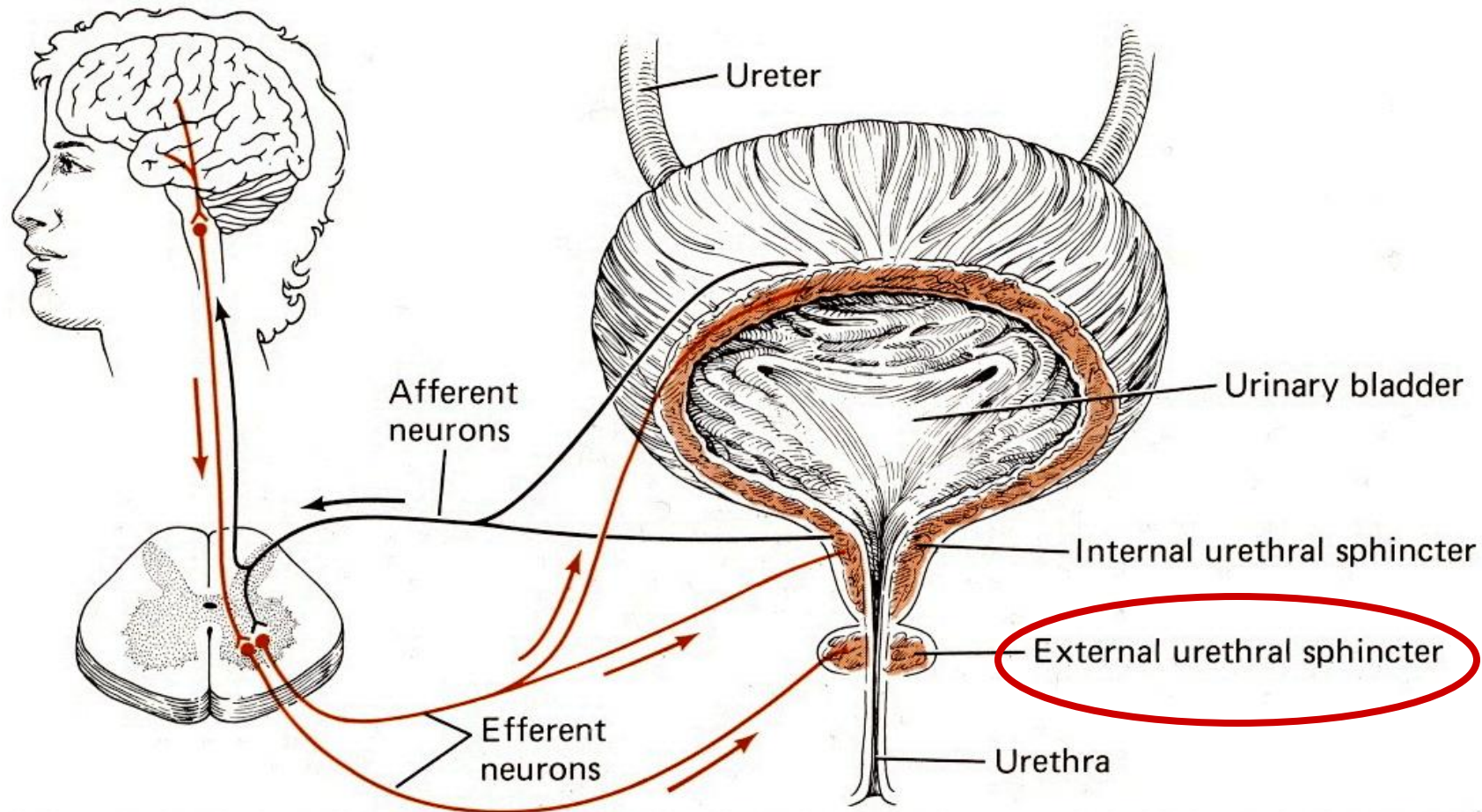
**Prostate**

↓ Urine Stream

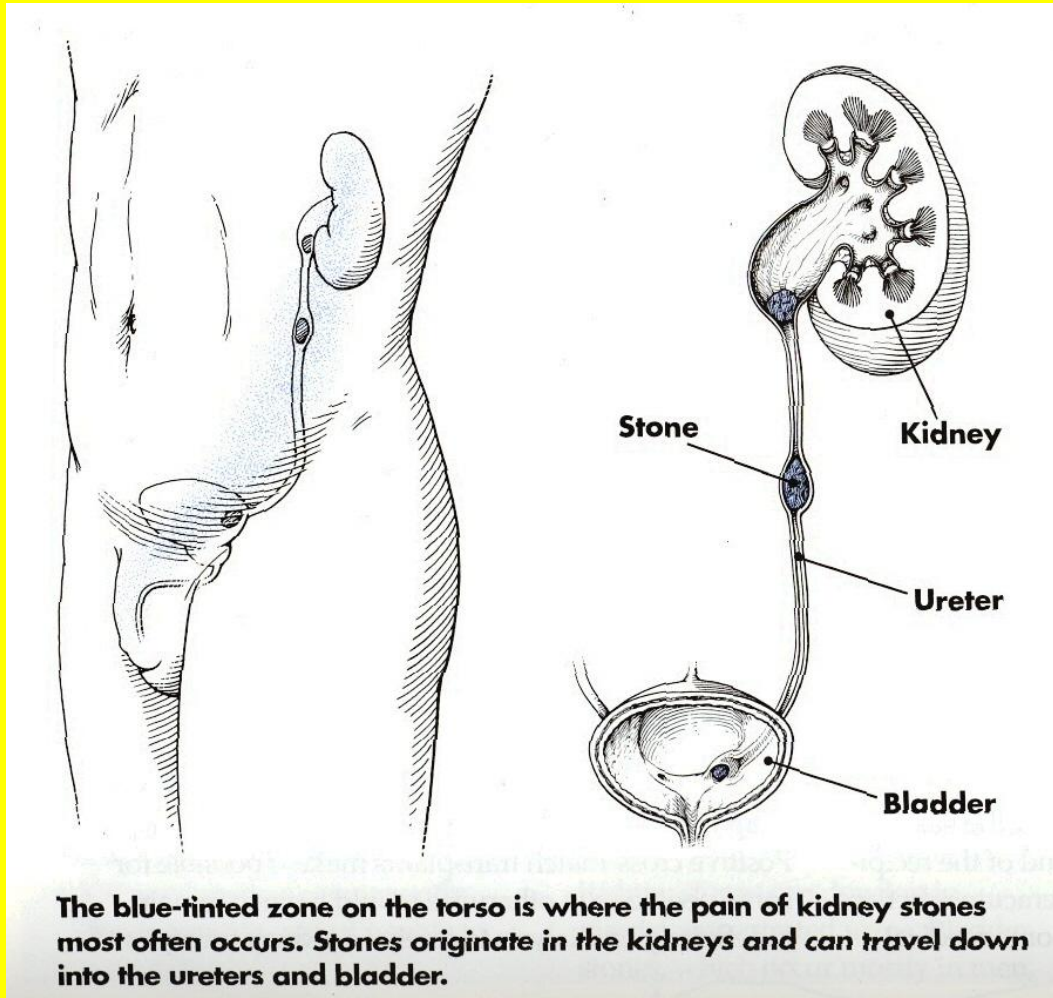


# Urination

- Urethra: has **sphincter** muscle around it: **voluntary control**
- When bladder has 7 ounces urine:
- **Stretch receptors**- wall of bladder  
"urge to urinate" ← brain ↙
- Sphincter muscle **relaxes**, bladder muscle **contracts**: urine passes out of body (1/2 gallon/day)



# Kidney Stones: detected 7000 year old mummies



# Kidney stones: more common men

- **Concentrated urine:** crystal formation: **calcium, uric acid stones**
- Small → pebble
- Very painful
- Occur in tubules, collecting ducts, ureters
- Can **block** urine flow if big



# Treatment:

1. Drink fluids- pass stone
2. Surgery
3. Medicine: to **relax** smooth muscles: pass stone
4. **Shock waves**: you sit in tub of water: machine- high energy shock waves: pulverize stones

SPECIAL FEATURE

# Skipping Stones

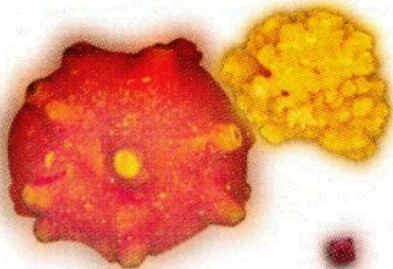
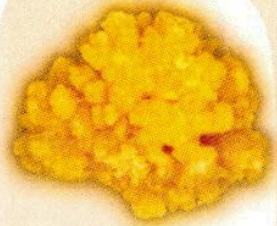
HOW TO AVOID KIDNEY STONES

BY DAVID SCHARDT

**I** felt like I had been shot," remembers 59-year-old Bethesda, Maryland, writer Ron Collins. "One moment I was standing, then all of a sudden I was lying on the floor in agony. I had no idea what was going on. I was absolutely helpless."

In excruciating pain in his lower abdomen, Collins was rushed by his wife to the hospital emergency room, where he was diagnosed with a kidney stone and admitted for treatment.

"The experience humbled me very quickly," he says. "I'll never forget it."



# Kidney Stones (calcium oxalate)

## **Risk Factors**

- Men 2X risk
- Overweight
- Diabetes
- “Stone belt”: people in Southeastern US: ↑ 20% risk: related-sweating, more concentrated urine?
- ↑ Grapefruit juice, ↑ stones
- ↑ Megadoses of Vitamin C

After the stone has passed  
into urine

- Drink enough fluids
- ↓ Salt in diet
- Children ↑ animal protein & salt  
↑ stones
- Coffee drinkers: ↓ risk

# Good Bacteria

Many kidney stones: calcium oxalate

Oxalate: spinach, beets, nuts

*Oxalobacter formigenes* in intestine

Digests oxalate

People ↑ *Oxalobacter* ↓ Kidney stones

# Urinary Tract Infections

More common **women**

- **90%** due to **E. Coli** (colon bacteria)
- Anus close to urethra: bacteria multiply
- Result: bladder infection (**cystitis**) & urethra infection (**urethritis**)



# Urinary Tract Infections

Other causes- bacteria infections

1. Sexual intercourse
2. Pregnancy
3. Urinary obstruction

## Cranberries/cranberry juice

**10** ounces/day: protection

Prevent growth E. Coli and attachment to urinary bladder

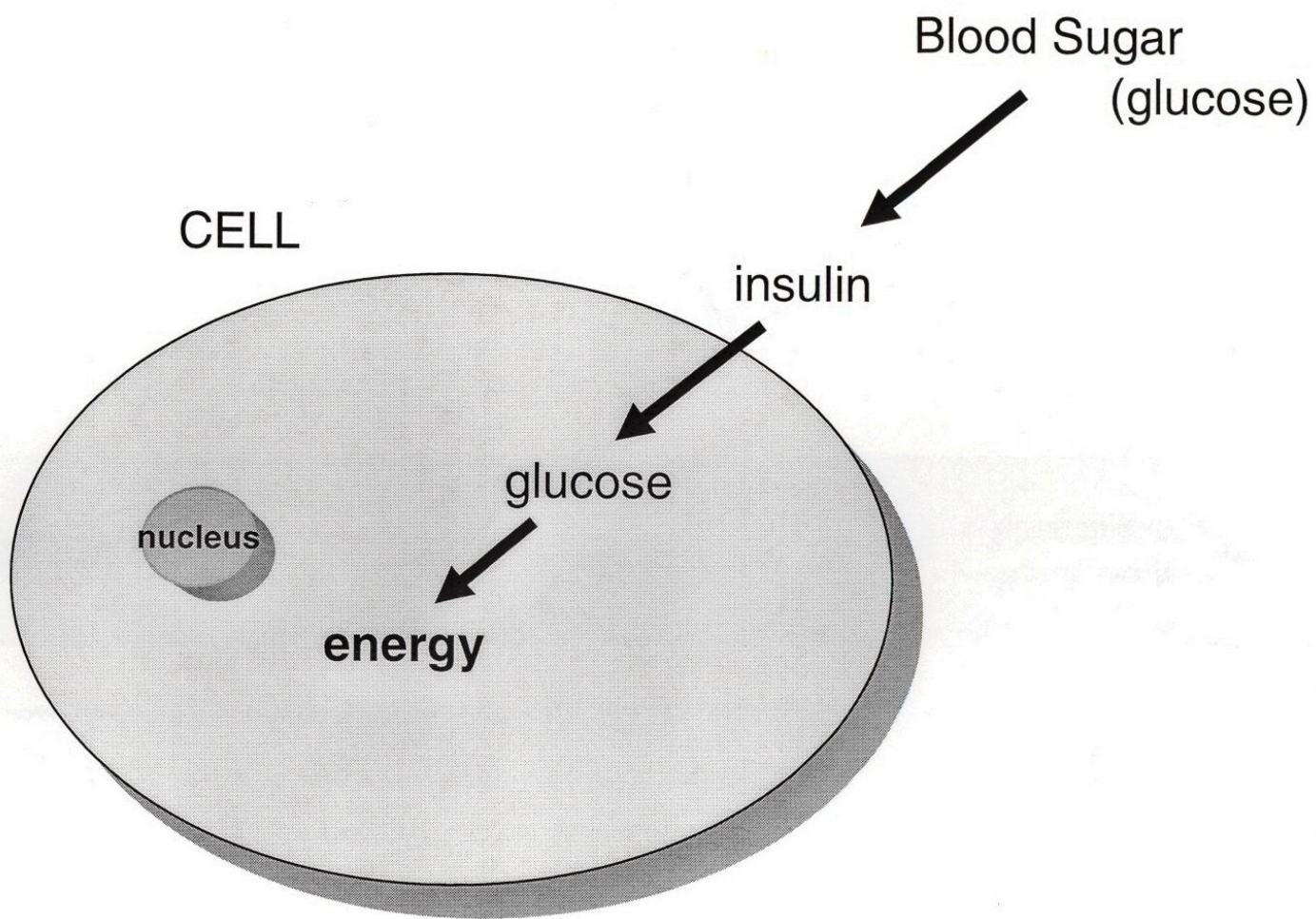
**DIABETES**

# What is diabetes?

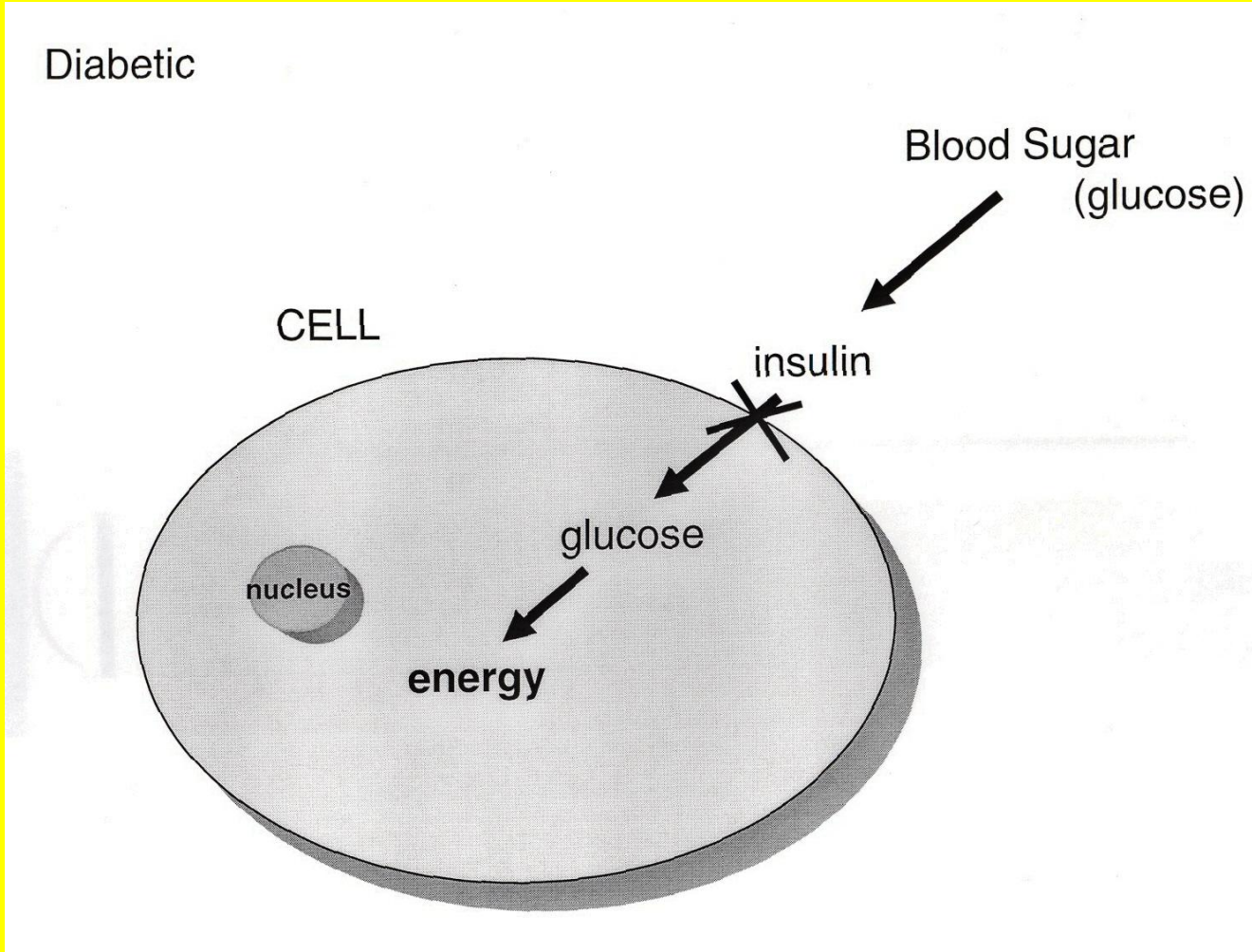
- Diabetes mellitus
- Diabainein (Greek)= “to pass through”
- Mellitus (Latin)= “sweetened with honey”
- **Glucose spills into urine**
- Sweet urine- ants

# Diabetes

- Consistently ↑ blood glucose
- Result of:
  - 1) ↓ insulin from pancreas  
and/or
  - 2) ↓ insulin sensitivity  
(responsiveness) by body cells  
**“insulin resistance”**



# "Starvation in the midst of plenty"



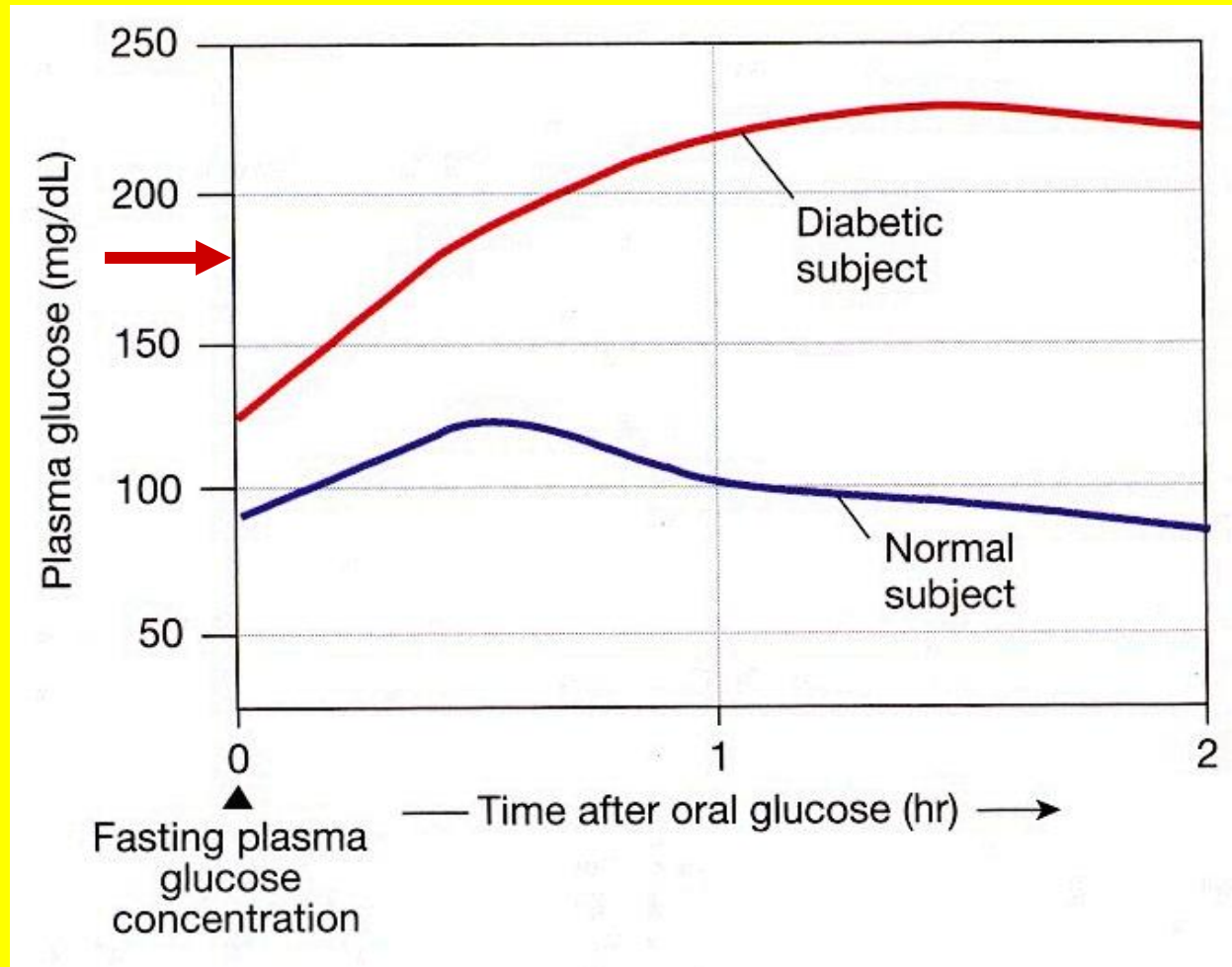


## Symptoms (warning signs): diabetes

- 1. Frequent urination**
- 2. Excessive thirst**
3. Extreme hunger
4. Unusual weight loss
5. Increased fatigue
6. Irritability
7. Blurry vision

Normal Blood Glucose: **80-100 mg**

Renal Threshold Glucose : **160-180 mg**





At **renal threshold**:

Glucose **filtered** > Glucose  
**reabsorbed**

**Spillover** → **urine** (wasted energy)

# Diabetes

- Without glucose, body breaks down (partially) **fat**- energy   
ketones (acids)
- Brain, other tissues- adapt to use **ketones** for **energy**
- Excessive ketones  urine  
(test kit)

# Diabetes

- Ketones: ↑ acidity of blood  
**(ketoacidosis)**
- Rapid/deep breathing, very thirsty, urination, loss appetite
- **Fruity breath odor**
- Weakness, fatigue, confusion
- Severe dehydration, coma, death
- **Requires immediate treatment**