Your Blood & Cardiovascular System

Cardiovascular system:

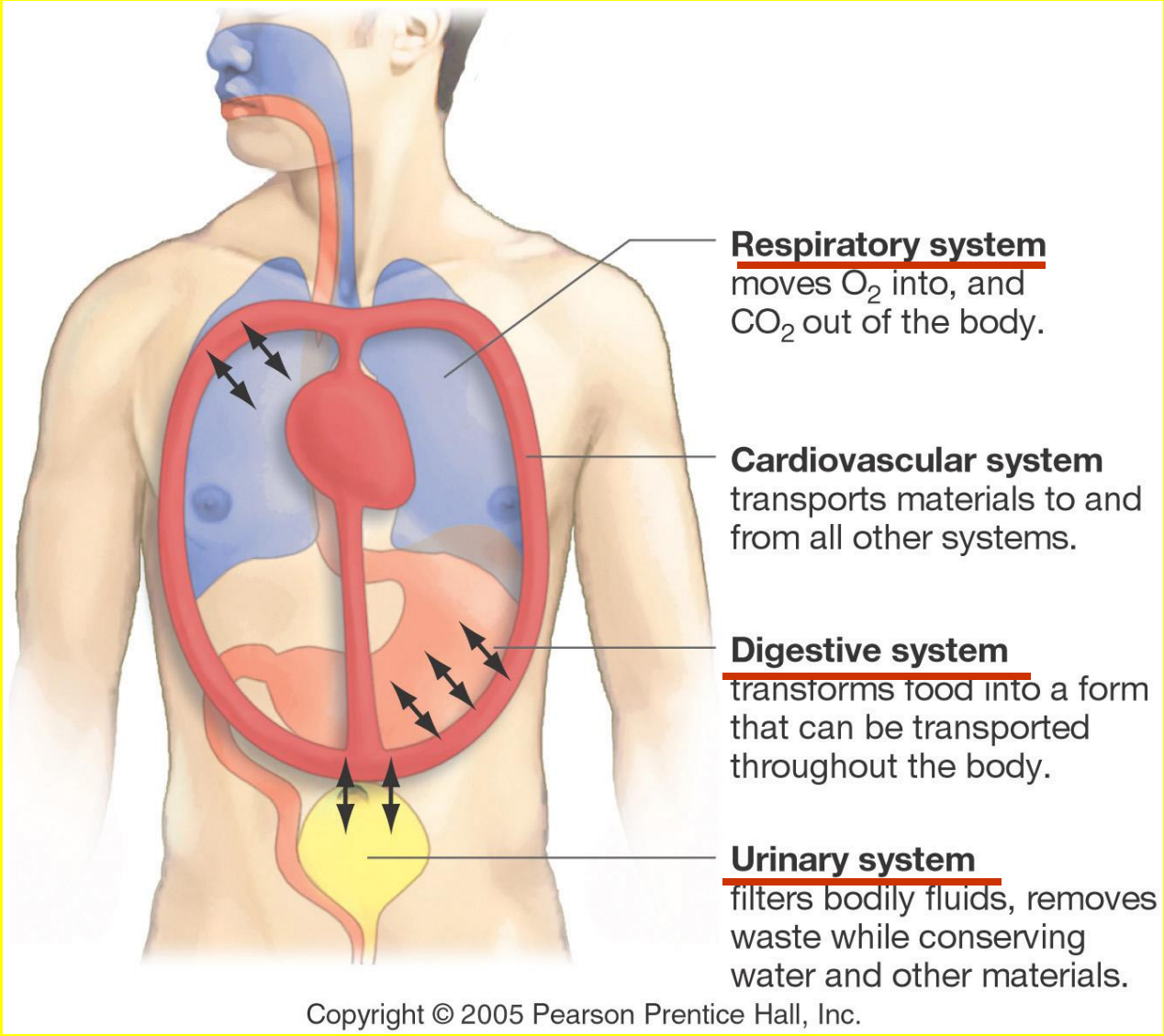
- Heart
- Blood vessels
- Blood

Major function:

Carry gases, nutrients, wastes

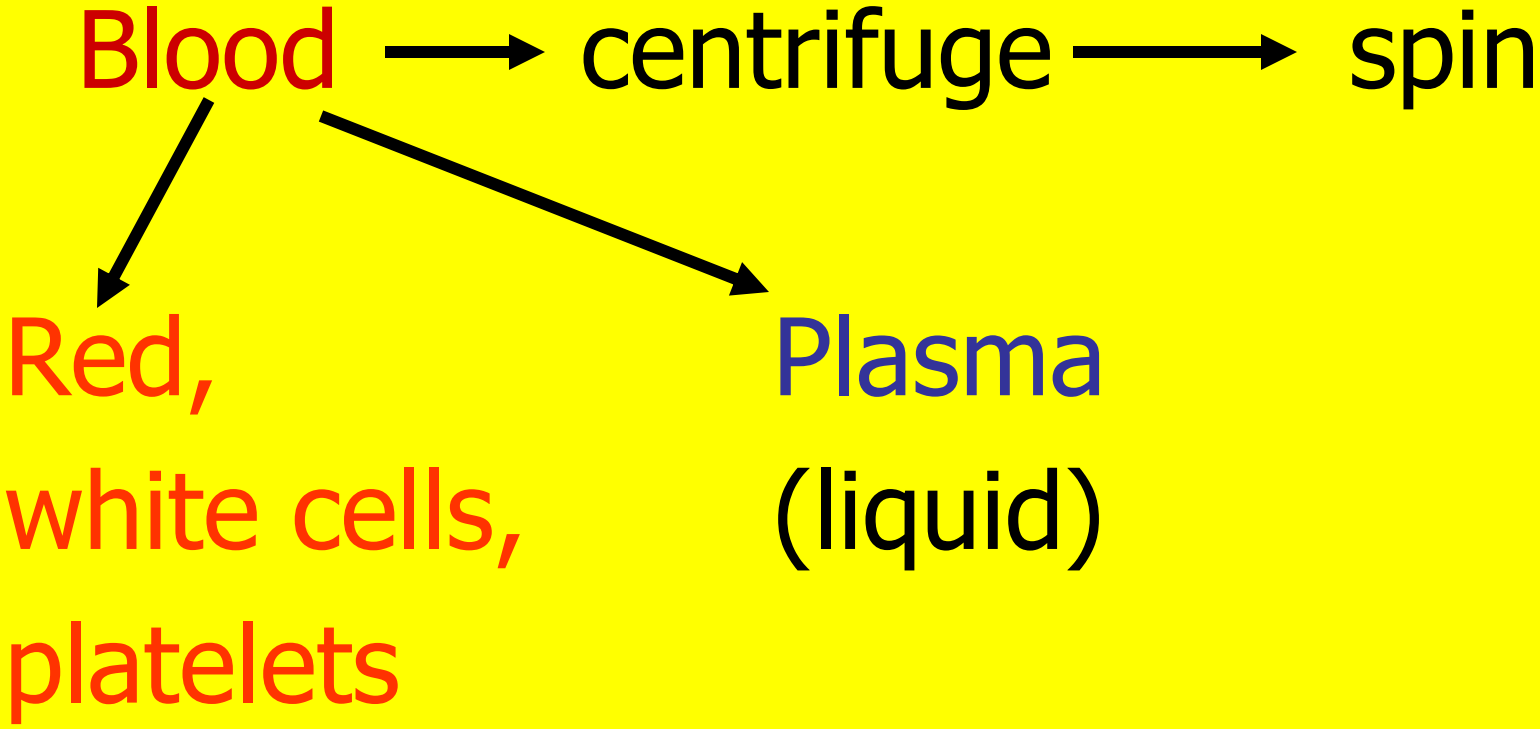
1 place ⟶ another place in body

- Cardiovascular system: critical for **3** other systems



What's carried in your blood?

1. Cells: red, white, platelets
2. Nutrients: glucose, amino acids, fats
3. Vitamins: A, B, C, D, E, K
4. Wastes: urea, CO_2
5. Gases: O_2, CO_2
6. Hormones: insulin
7. Proteins: hemoglobin


Blood
centrifuge
spin
Red,
white cells,
platelets
Plasma
(liquid)

Red Blood Cells (RBC's)

- Contain hemoglobin
- Carry O_2: Lungs → Tissues
- CO_2 (cell respiration)

carried in plasma + hemoglobin

Exhaled ← lungs

RBC: cell membrane + hemoglobin

- No nucleus
- Biconcave shape
- Live **120** days
- Wear out:

Trapped in liver, spleen, bone marrow: destroyed-phagocytes: parts recycled

RBC’s, white blood cells, platelets: produced from **stem cells** in red blood marrow

White blood cells (WBC's)

- Important: your immune system
- Travel in blood → Tissue- site of injury/invasion bacteria/viruses/ foreign organism

Platelets: not cells- parts of cells: contain enzymes

Important: blood clotting: temporary plug in injured blood vessel

Followed by clotting process-

permanent plug

Plasma: 92% water

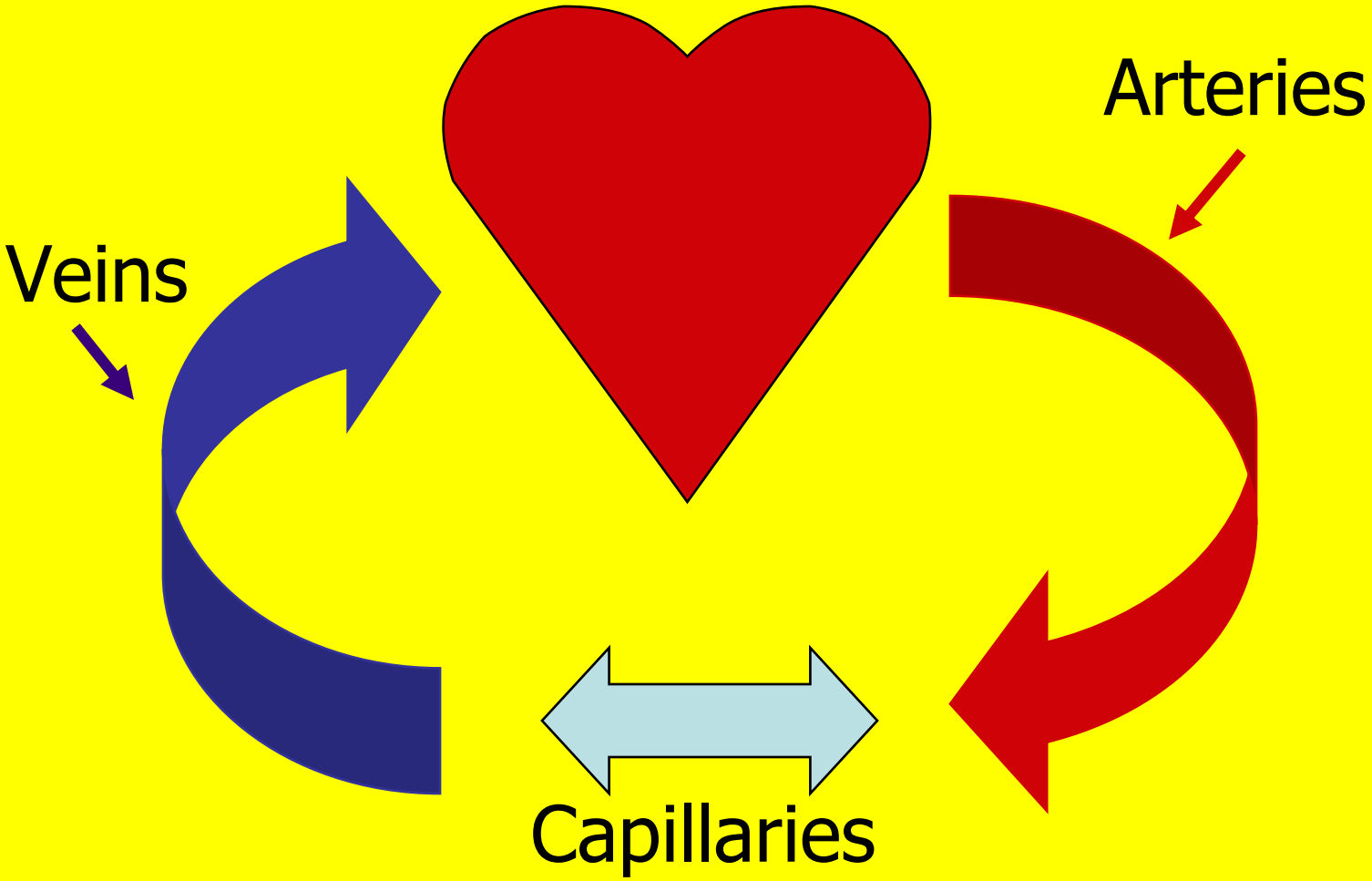
Plasma proteins

1. Albumin (liver): carry hormones & fatty acids
2. Fibrinogen (liver): important-clotting process
3. Immunoglobulins= antibodies

   Attack foreign proteins/disease causing organisms
4. Lipoproteins: carry fat: LDL & HDL

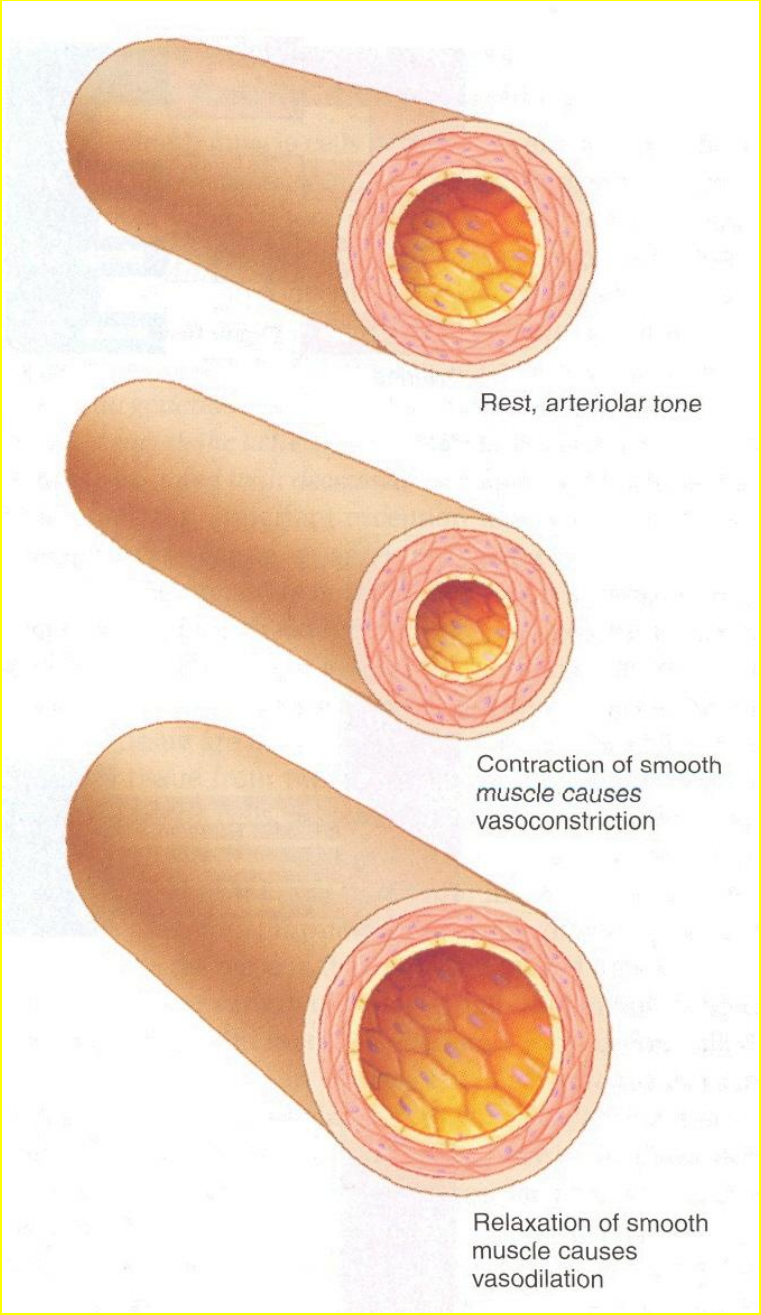
Blood vessels: different size tubes- like plumbing pipes

Draw the circulatory system

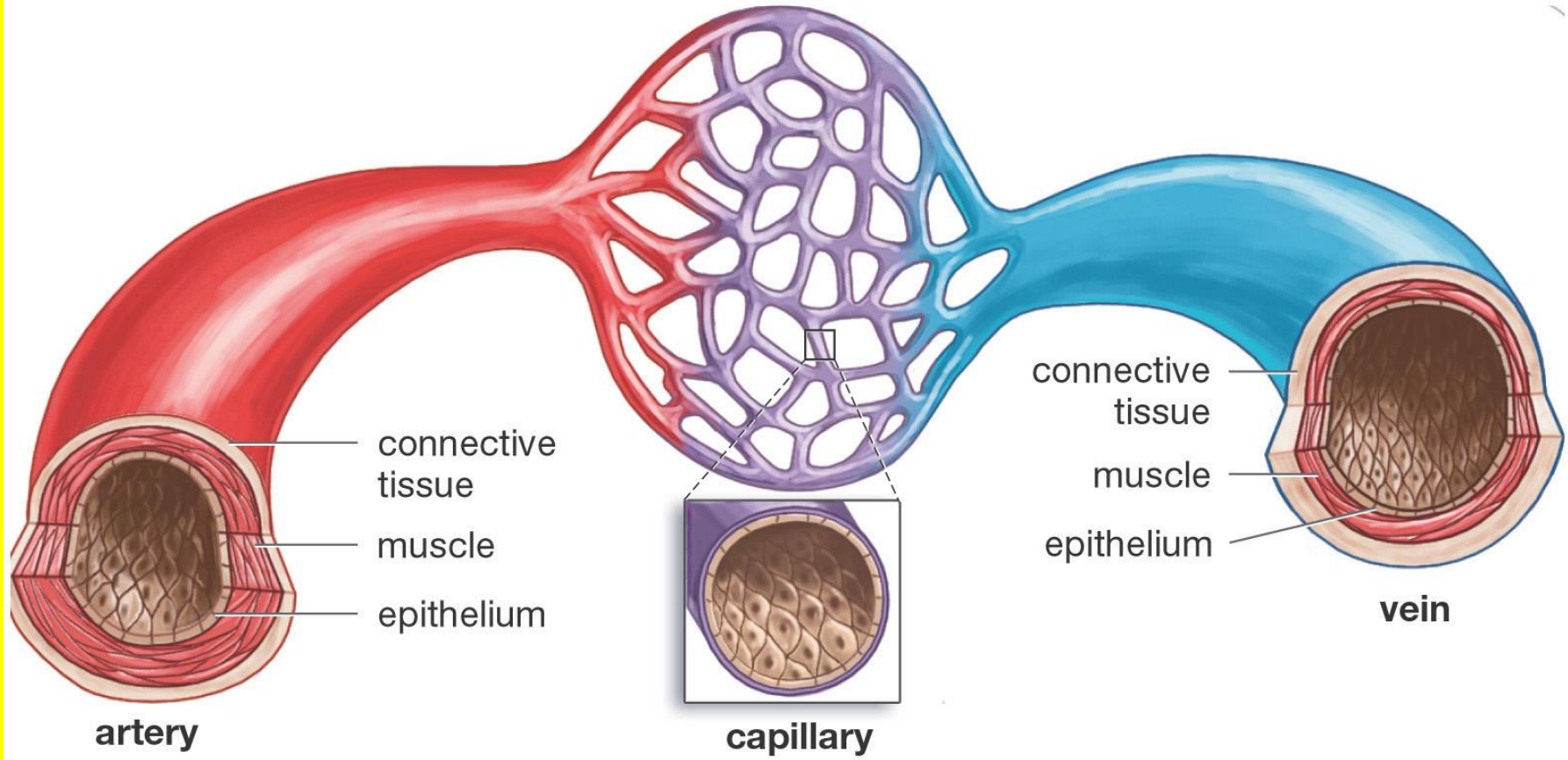


Blood vessels: can change diameter: nerve impulses smooth muscle cells in walls

1. **Vasoconstriction**: smaller
2. **Vasodilation**: larger


Rest, arteriolar tone
Contraction of smooth muscle causes vasoconstriction
Relaxation of smooth muscle causes vasodilation

1. Arteries: carry blood away from heart A=AWAY
2. Connect to capillaries: walls- single layer of cells: O_2 & CO_2 move in & out of tissues
3. Veins: return blood back to heart



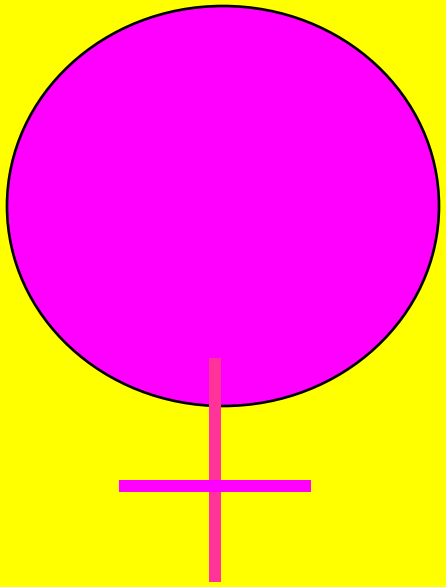
Pulse: Throbbing- expansion/contraction of artery in time with heartbeat

Resting Heart Rate: rate needed to supply tissues at rest

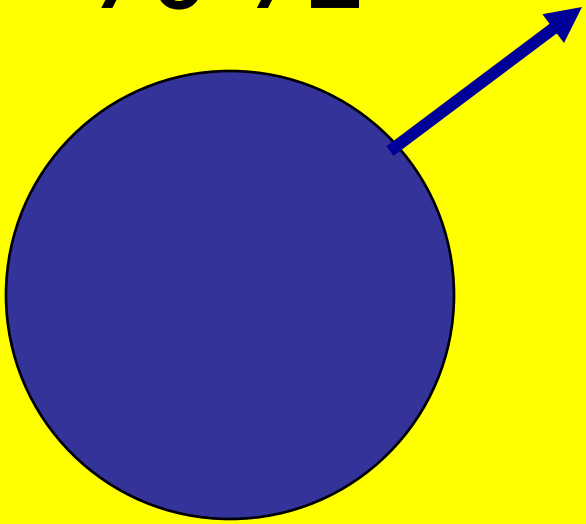
- Measure- morning before getting up
- Aerobic exercise: ↓ resting rate

Pulse rate (beats/minute)

78-82



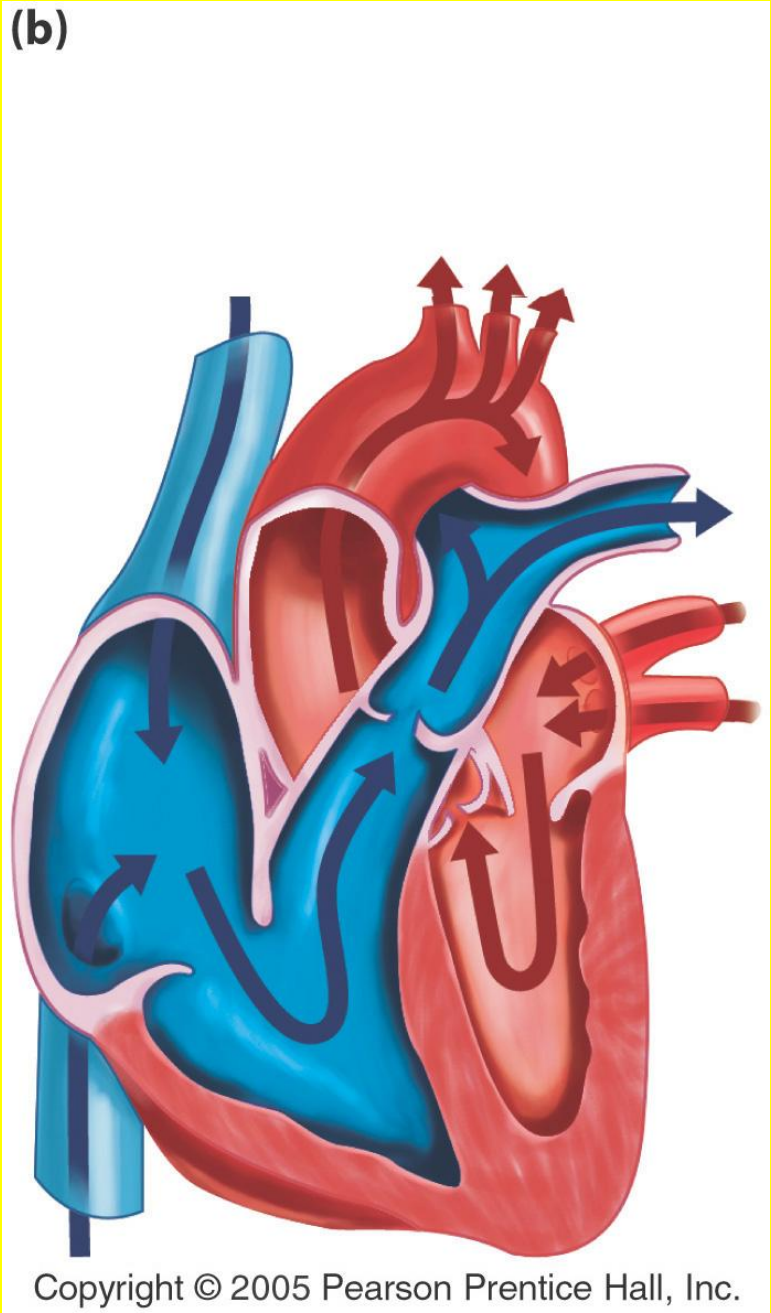
70-72



Your heart

2 upper chambers: right & left **atria**

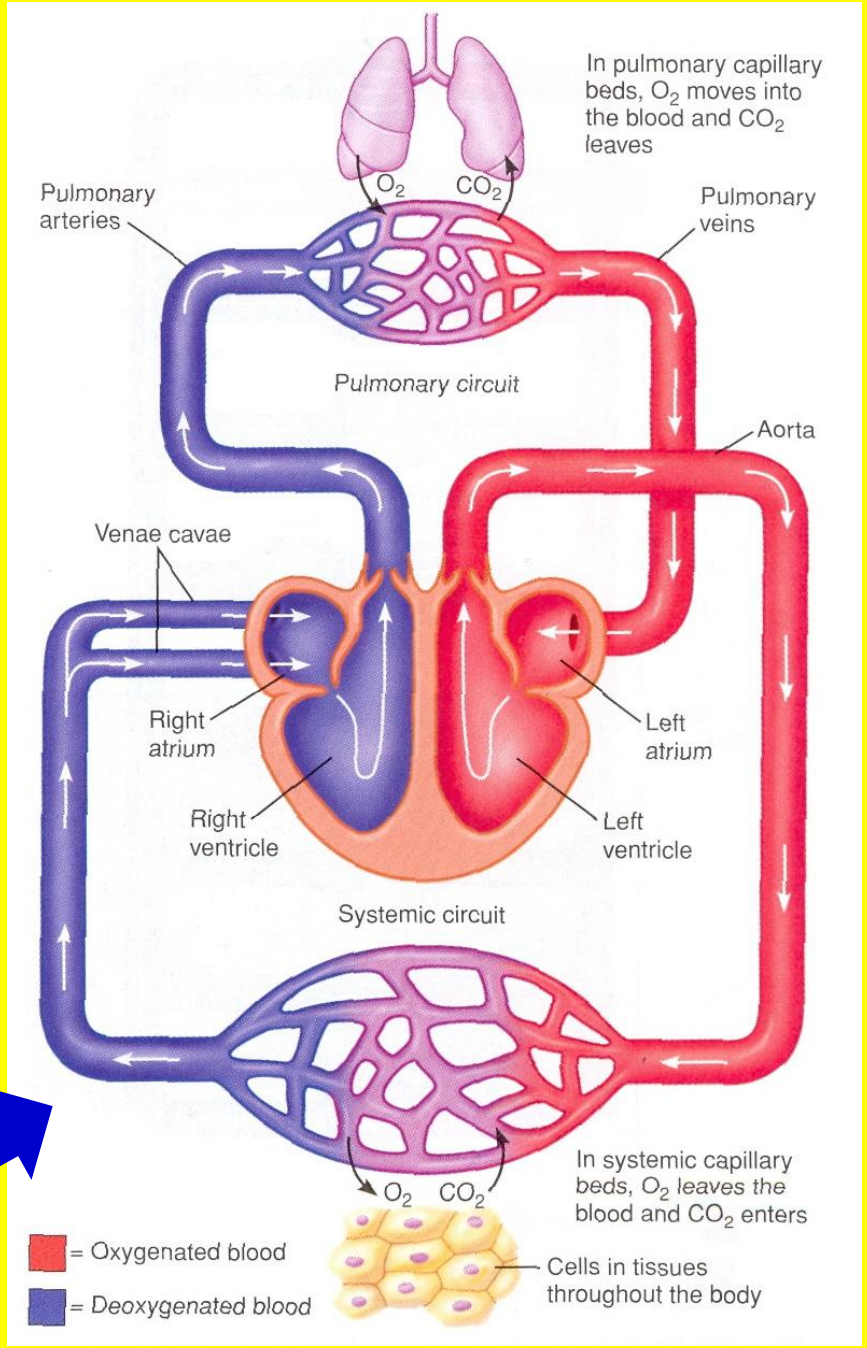
2 lower chambers right & left **ventricles**



Pretend you are a single red blood cell

Trace your movement though the circulatory system

- Right atrium to right ventricle
- Right atrium
- 2 vena cava (large veins)
- Blood in veins- returning from tissues- darker red (deoxygenated)



Valves close- no backflow

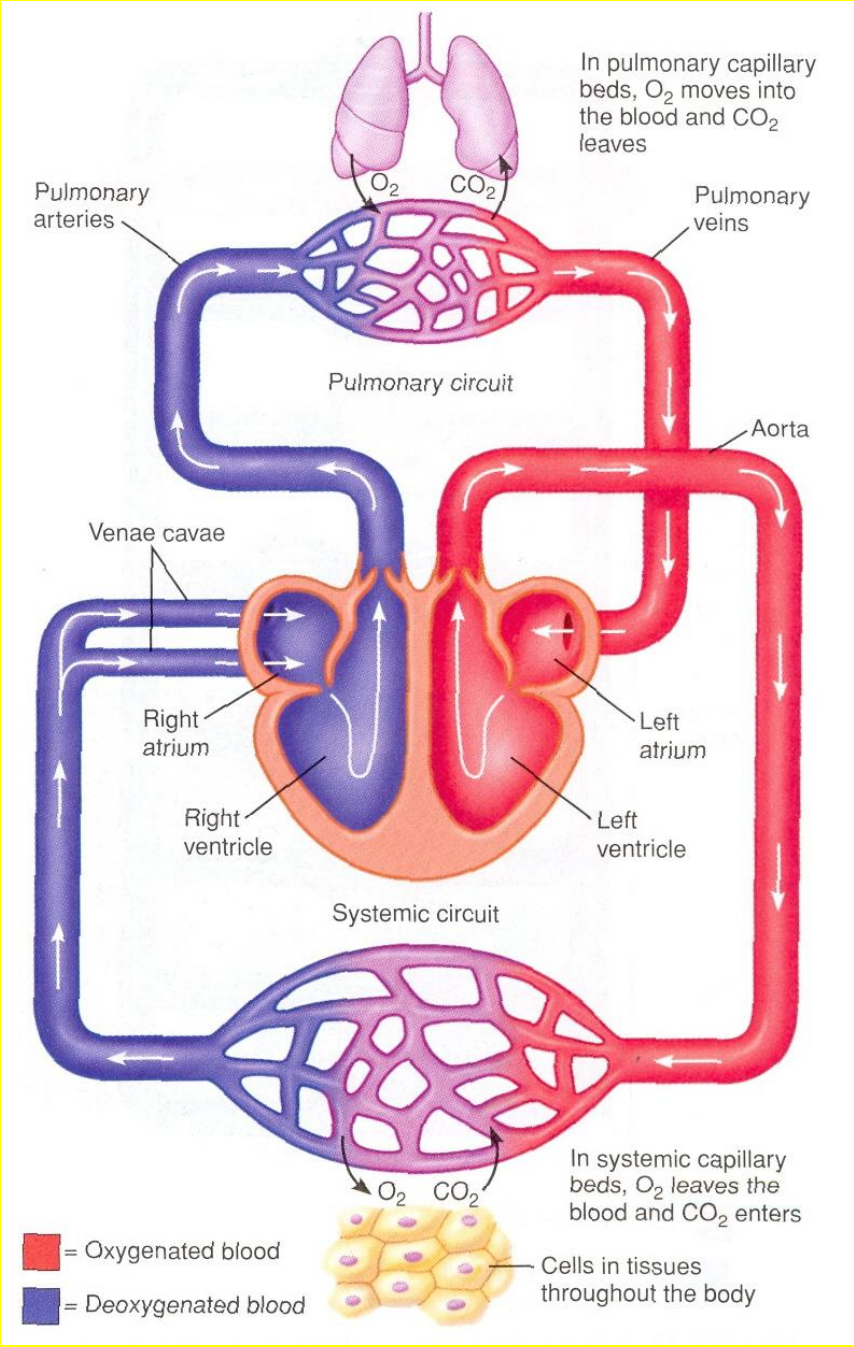
↓

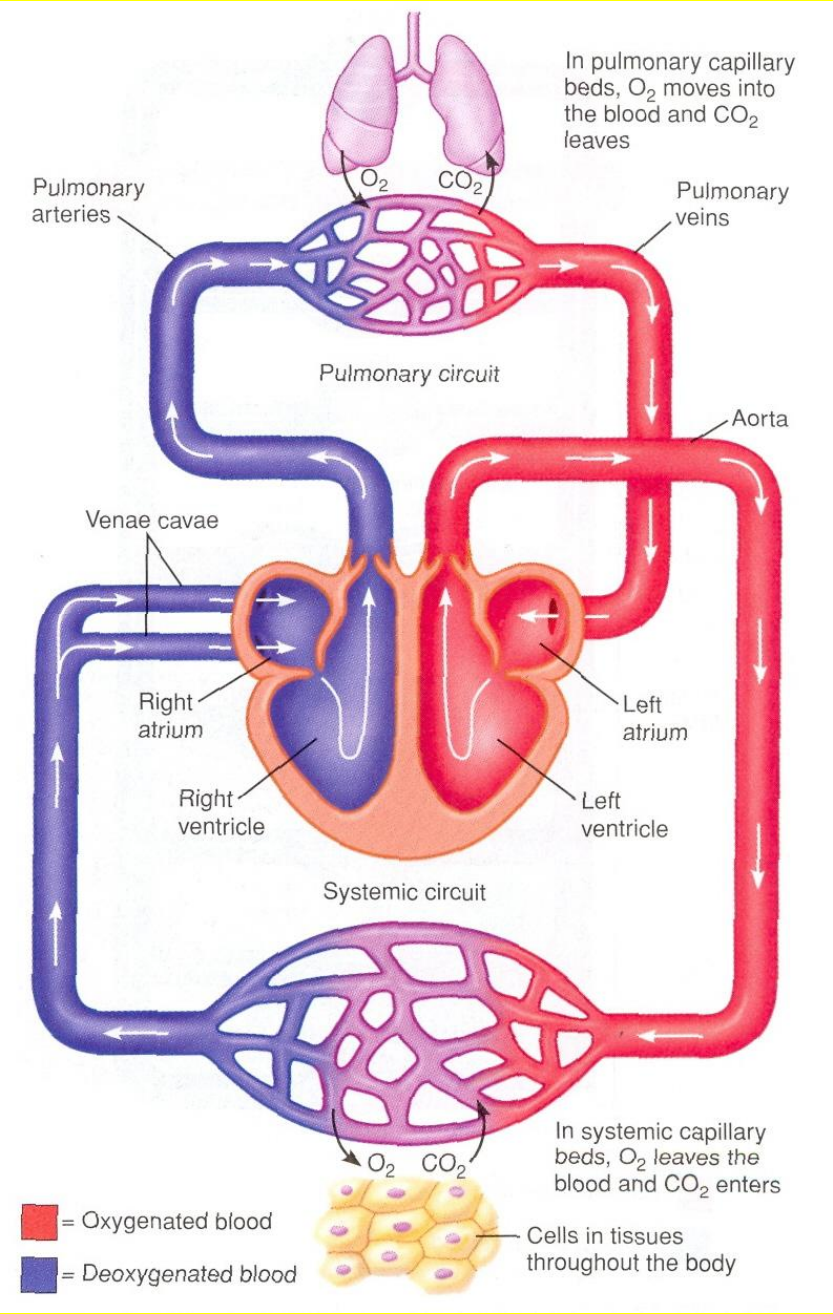
Right ventricle: blood to lungs

↓

Give up CO_2

Pick up O_2



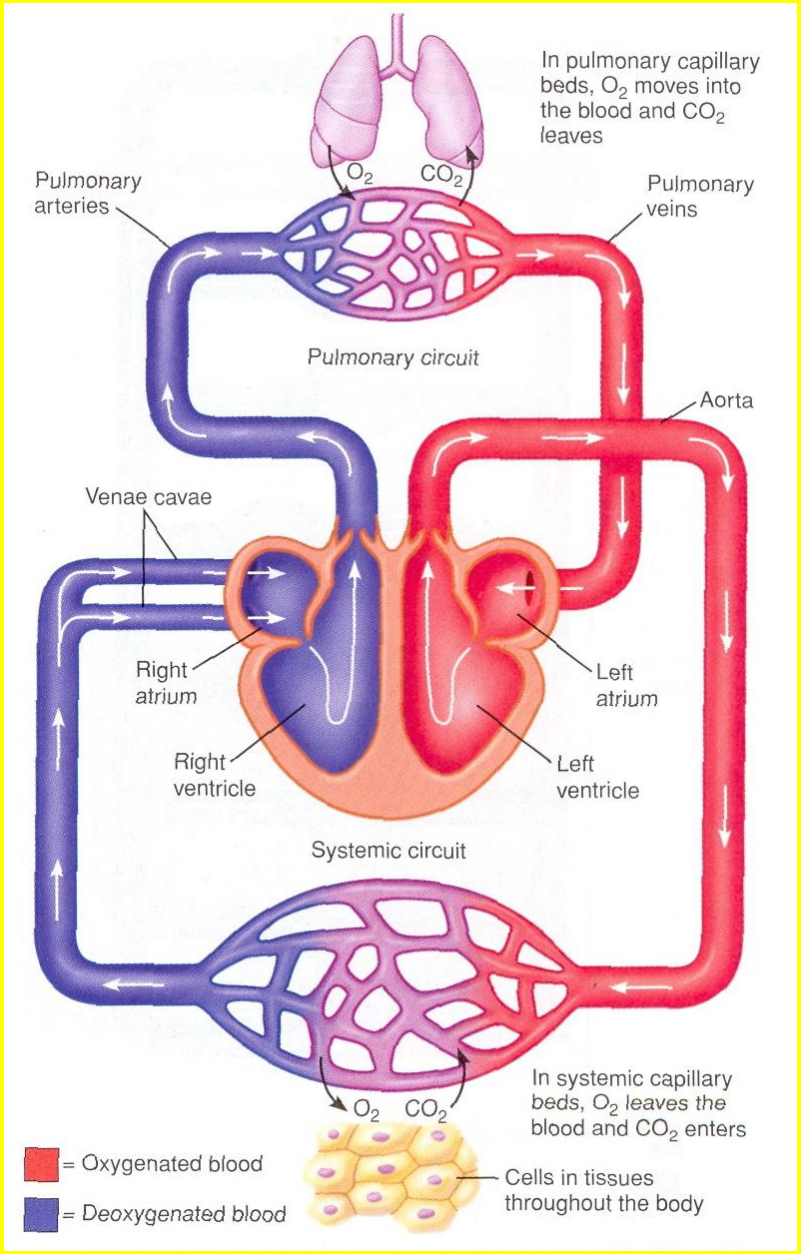


Blood (redder-oxygenated) returns to **left atrium**

↓

left atrium to left ventricle

Values: ~~backflow~~



Left ventricle to aorta (large artery)

valves: ~~backflow~~

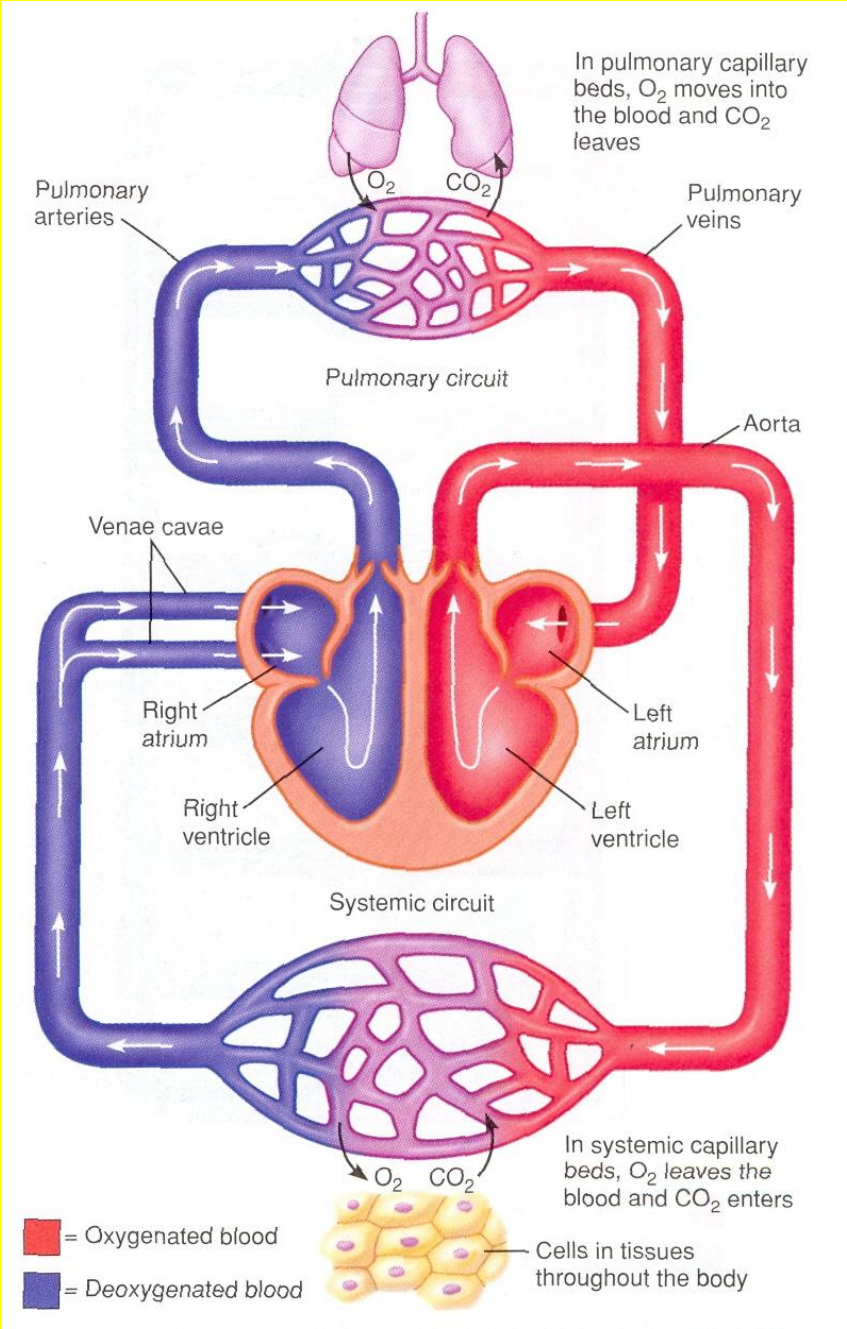
↓

Blood to head & entire body

↓

Supply tissues O_2

End in capillary bed where you started



Artery

↓

Arteriole

↓

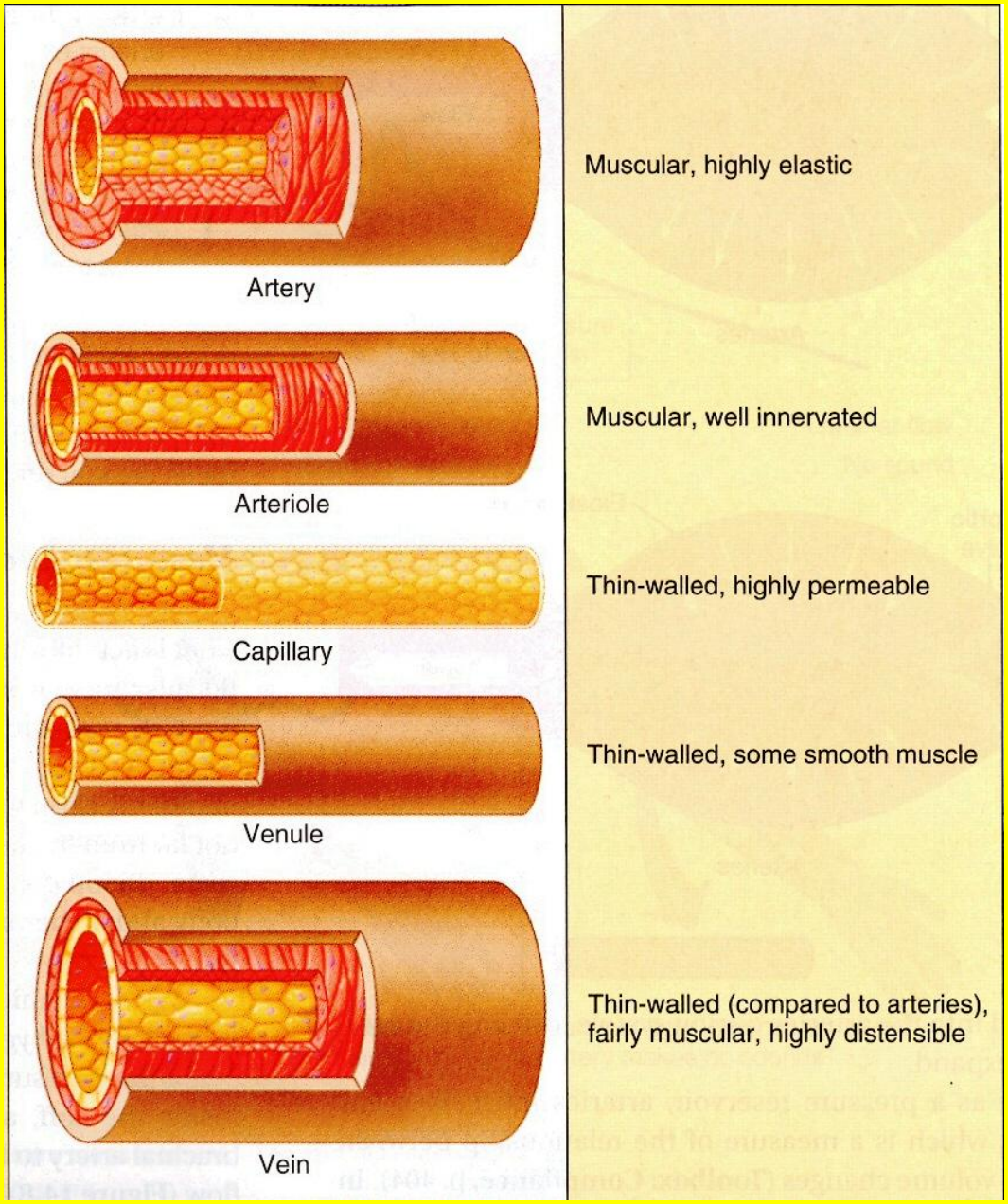
Capillary (bed)

↓

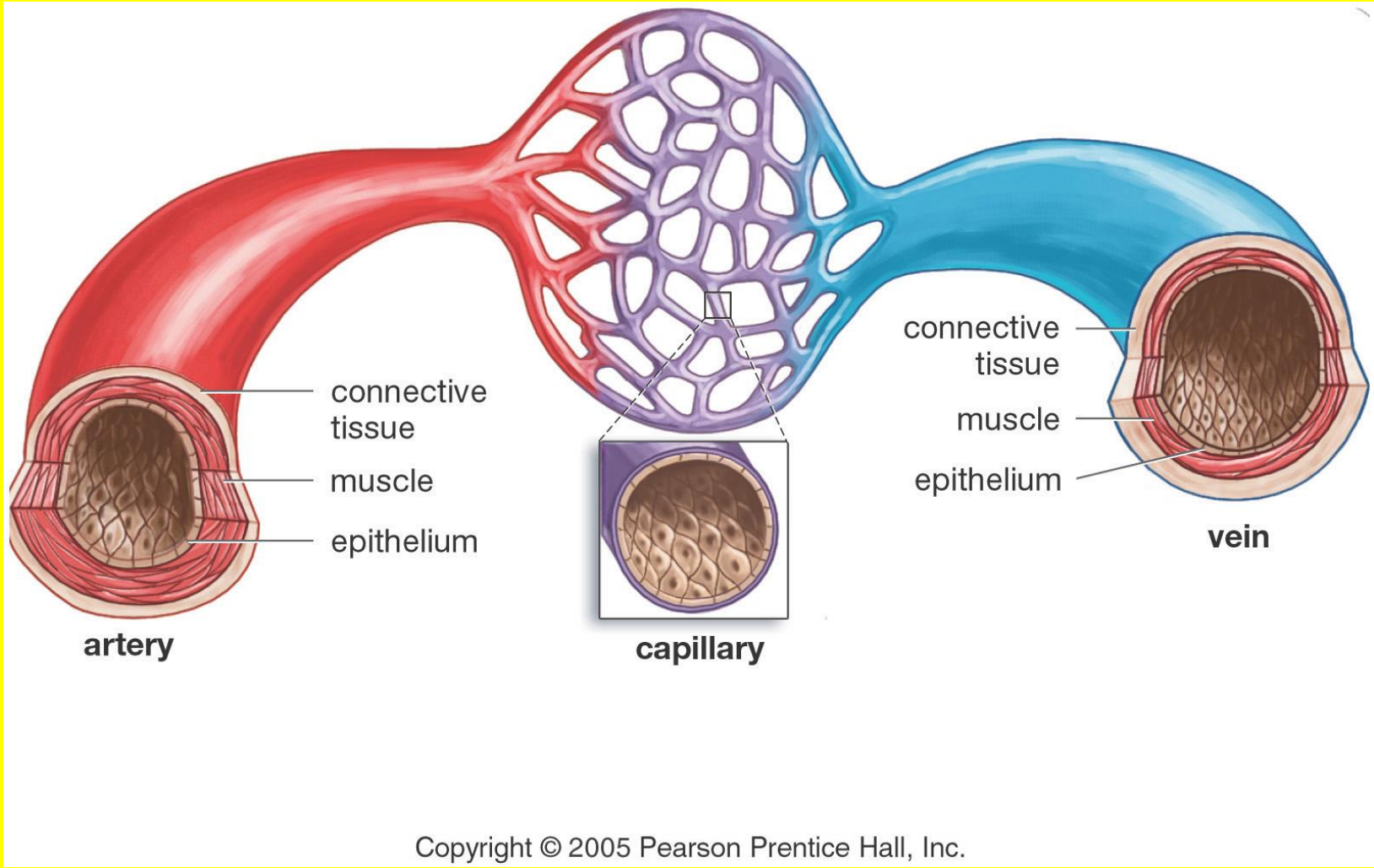
Venule

↓

Vein

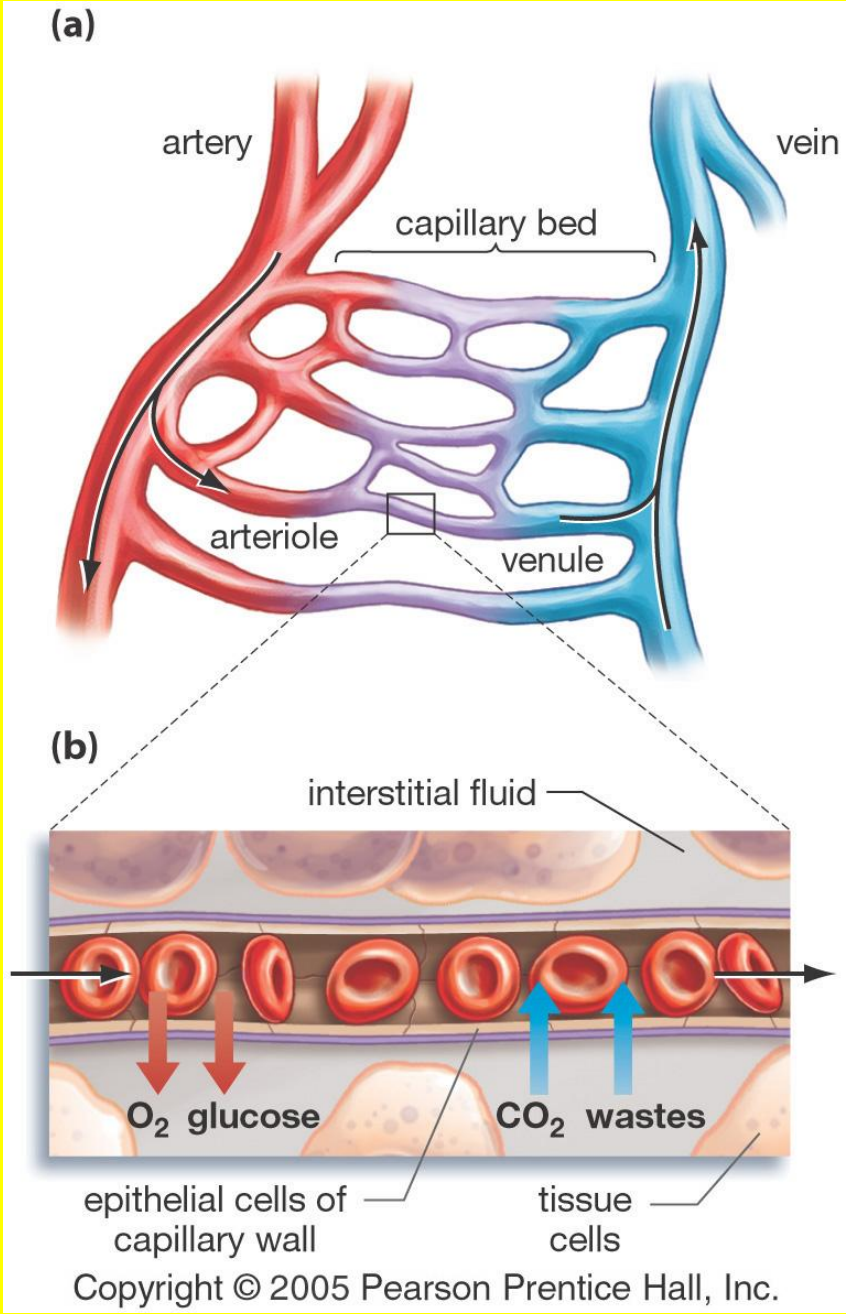


Capillary bed: where the **action** is in all tissues

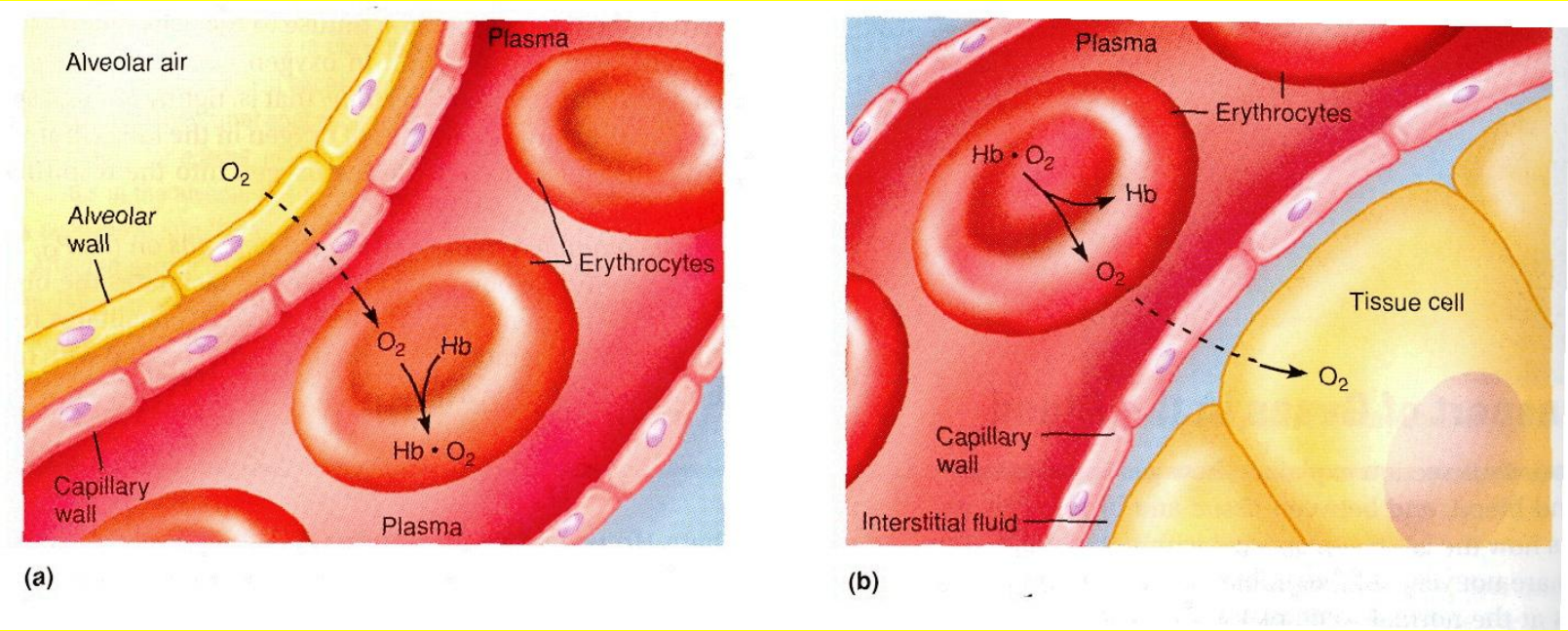


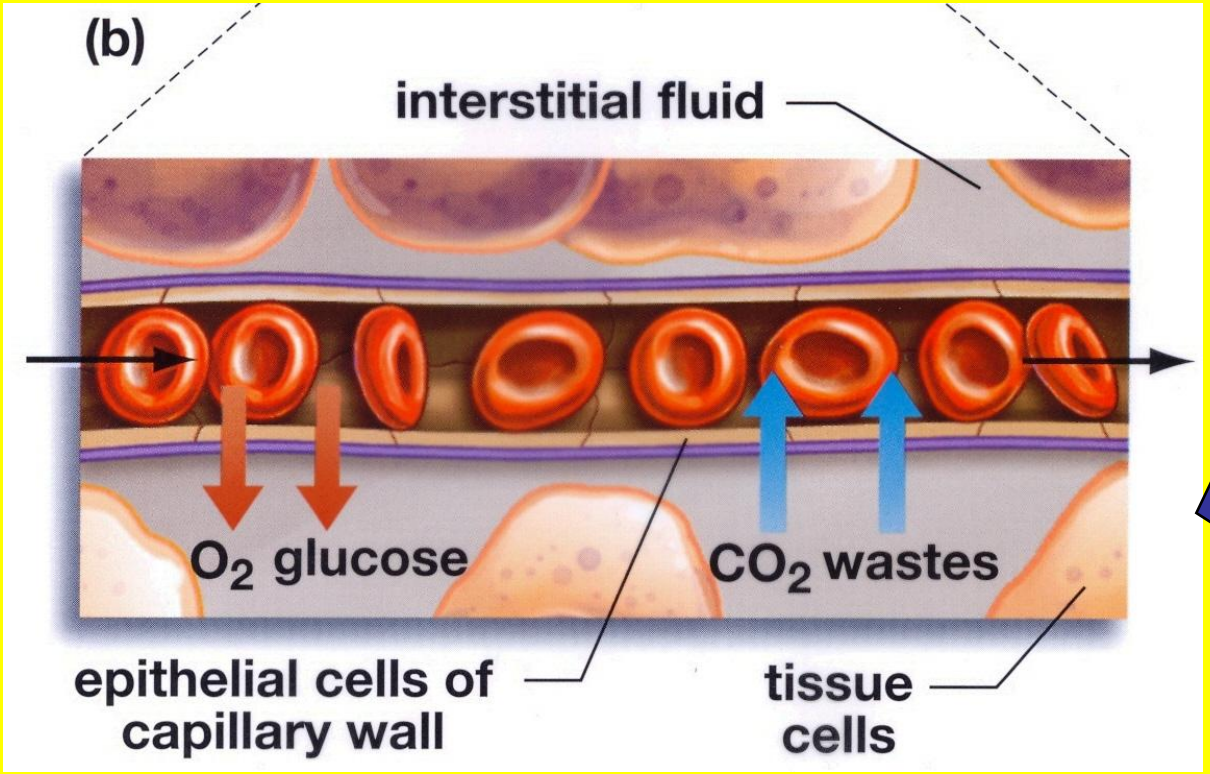
Capillaries: small, very thin-walls: single cell layer RBC's move through single file

O_2, glucose diffuse from inside capillary to fluid surrounding cells → cells for metabolism: Energy & ATP's



O_2, glucose diffuse from high concentration (blood) to lower concentration (cells): **concentration gradient**

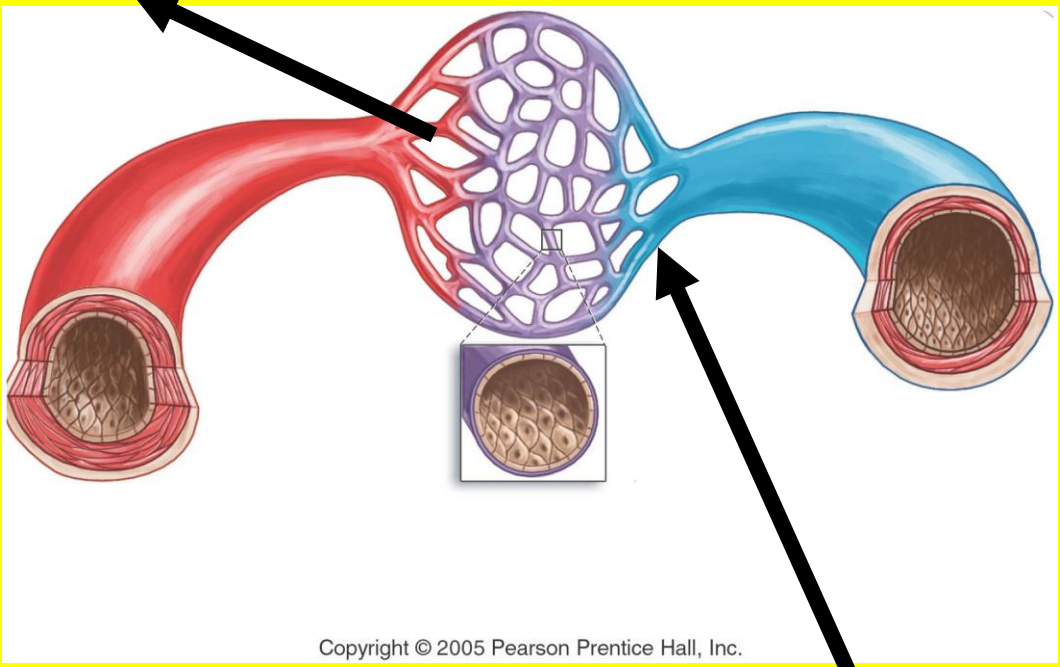




CO_2 (waste from cell respiration) diffuses from cells to blood in capillaries → lungs (high → low)

Capillary walls: "selectively permeable": allow H_2O to move in and out but fewer proteins (too big)

At this end (high pressure)- water moves out of capillaries to cells



At this end (lower pressure)- water moves back into capillary blood by **osmosis**

Blood pressure in veins: **low**

How does blood get back to heart?

Answer: your skeletal muscles- when they contract: squeeze veins- helps blood move back to heart

Valves in veins prevent backflow

Varicose veins:

defective veins-

backflow of blood

Pregnancy, jobs

people standing

all day, obesity

William Harvey: discovered circulatory system: 1628

Demonstrated **valves** in **veins**

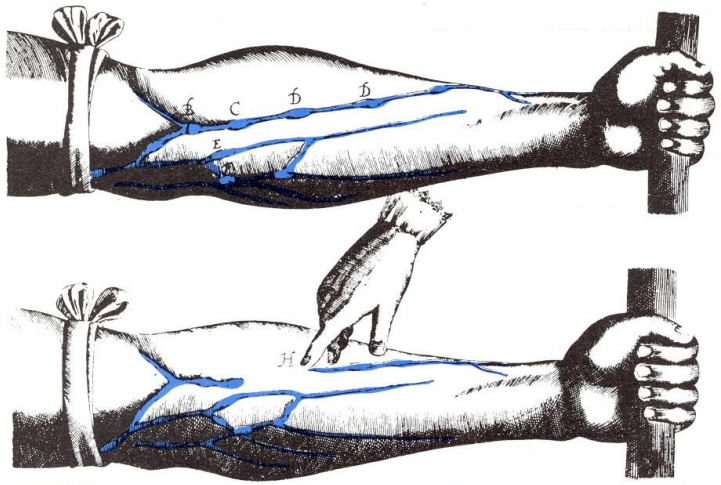


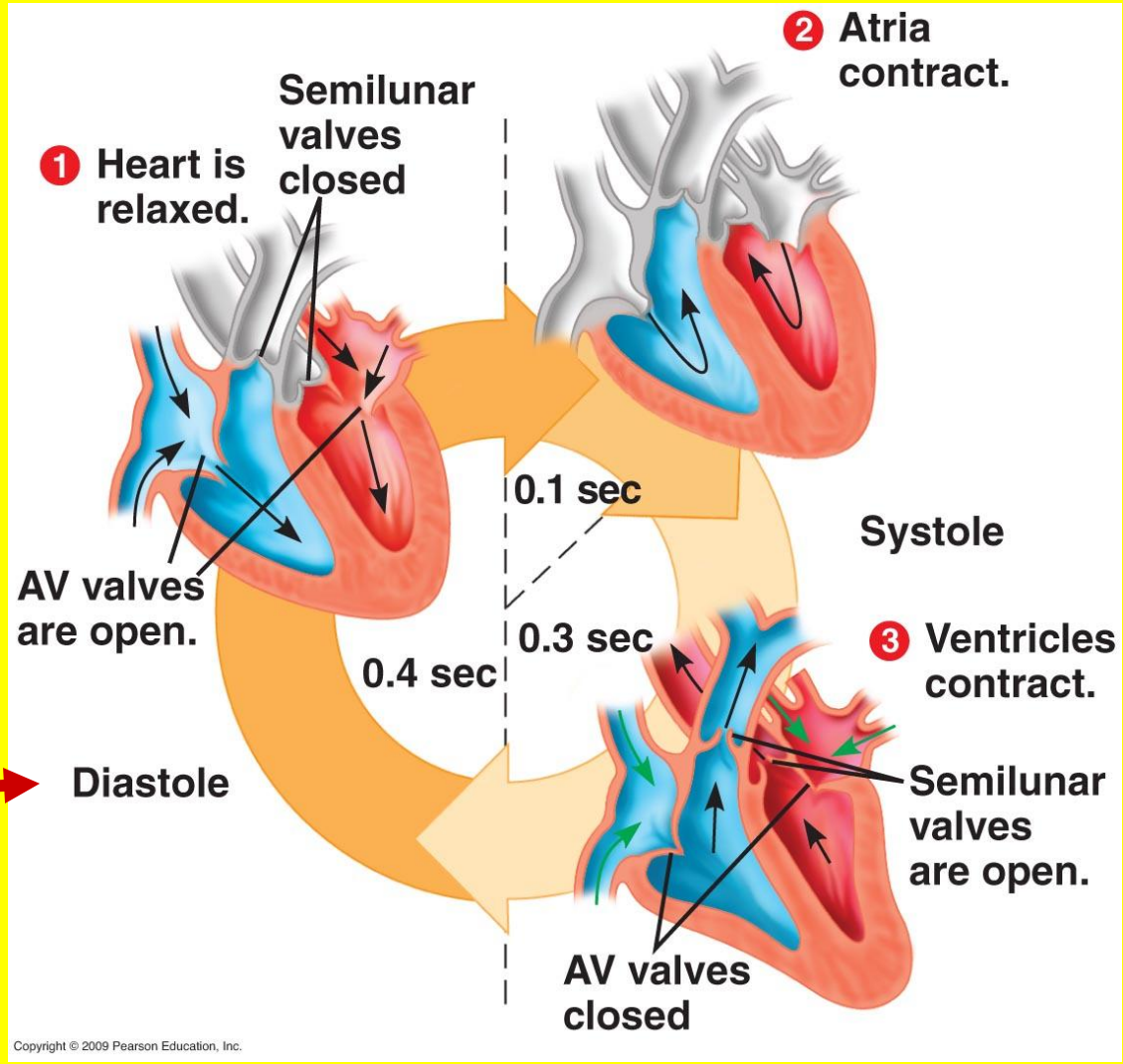
Figure 14.1 William Harvey Demonstrating the Role of the Veins. Harvey displayed the veins and their valves by dissection of animals and by tying ligatures around the arms of humans. Ligatures blocked the return of venous blood to the heart, allowing the veins and valvular areas (B, C, D, E, and F) to swell with blood. When Harvey pressed his finger on a vein and slid the finger toward the heart, blood flowed through the valves, and the vein refilled from below. But when he slid the finger away from the heart (H), blood was stopped at each valve, and the vein did not refill. He concluded that the valves allow blood to flow only toward the heart. (Photograph © 1959, Parke-Davis Division of Warner-Lambert Co.; drawing from W. Harvey, *de Motu Cordis,* 1628, opp. p. 56, the Granger Collection.)

How your heart beats

Pumping
(contraction)
and filling
(relaxation)
= cardiac
cycle

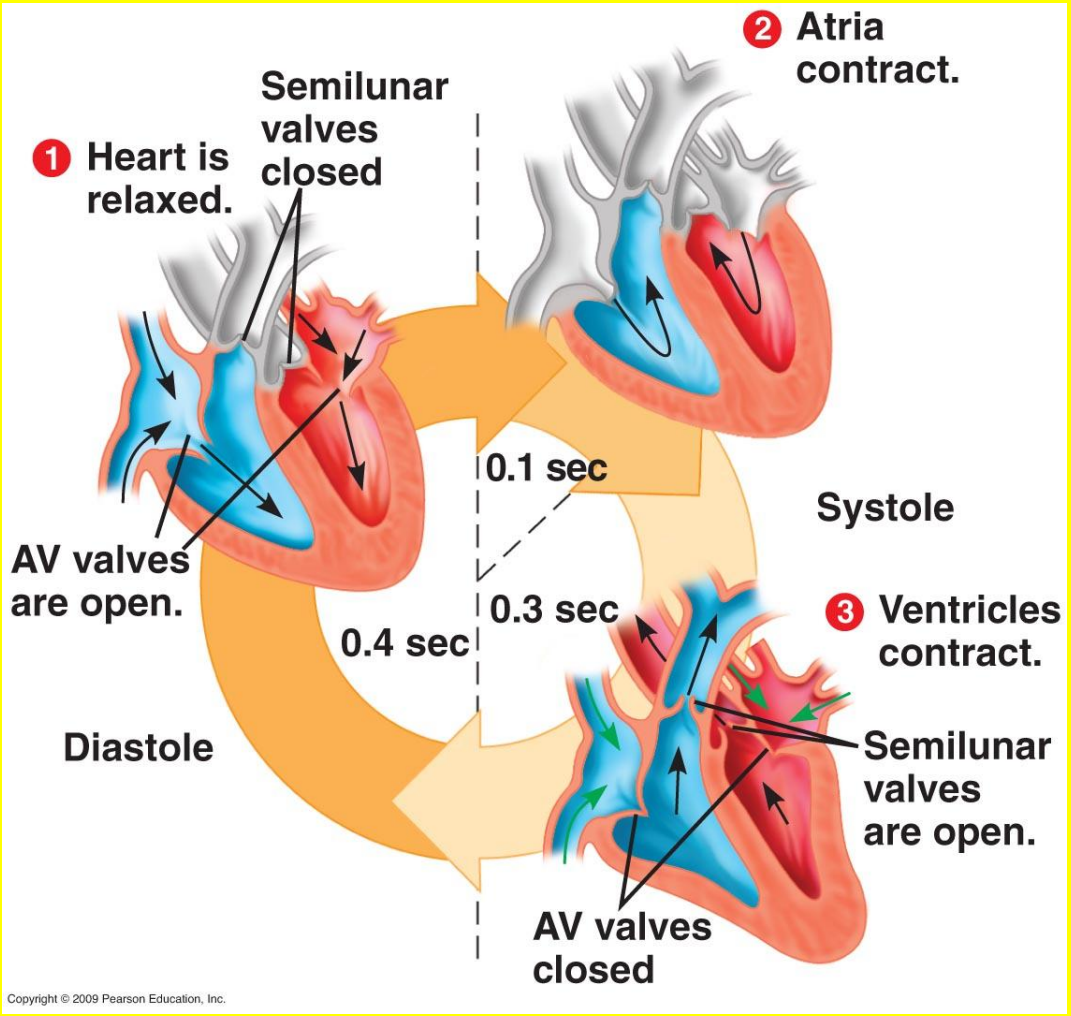
Heart Rate:
~ 72
beats/min

1. Entire heart relaxed:
Diastole
"filling phase"
0.4 sec



Blood flows into all 4 chambers **"AV"** valves between atria & ventricles: open

Ventricles: fill with blood



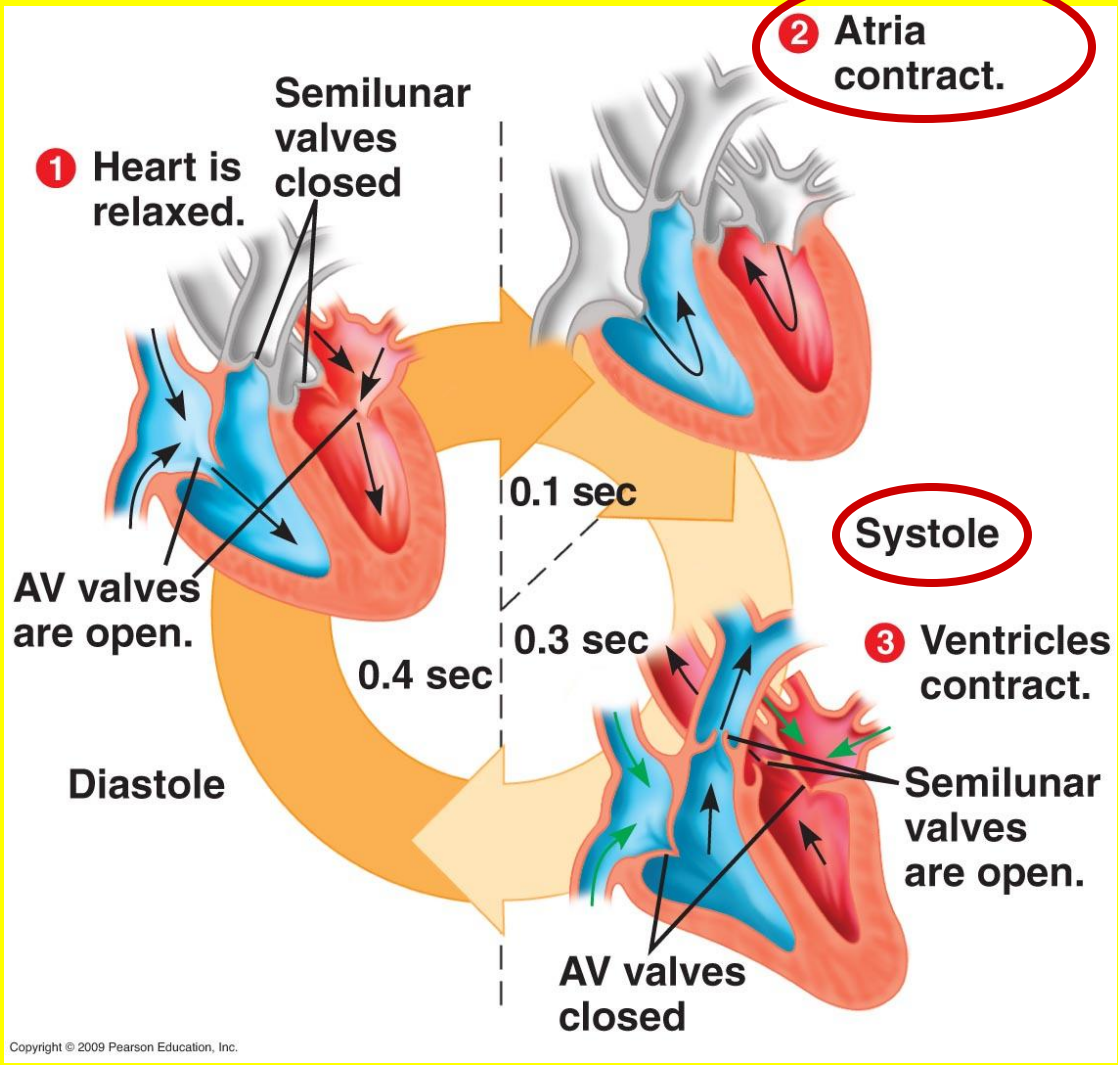
Systole:

"contraction Phase"

First: 0.1 sec contraction-

of atria:

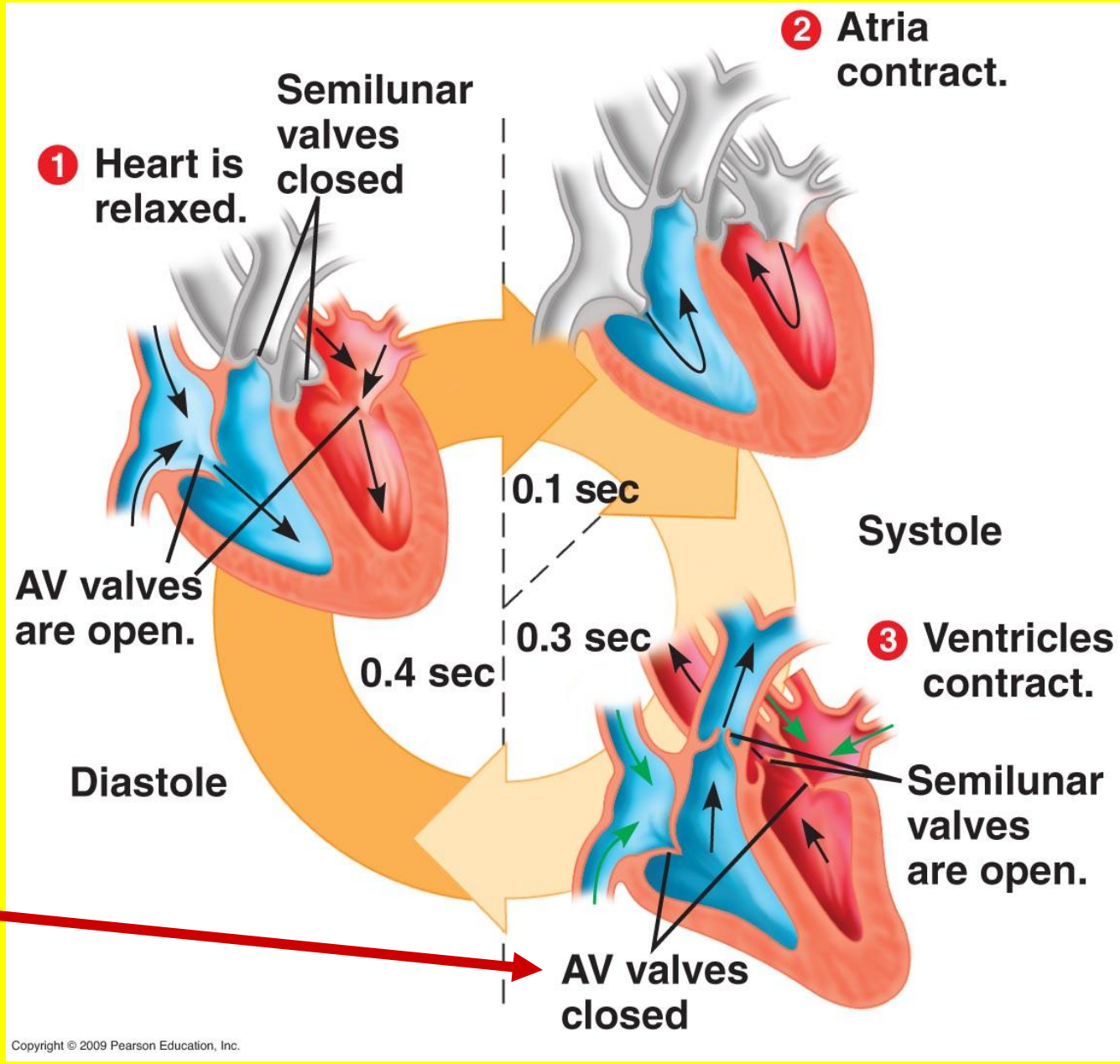
ventricles fill completely



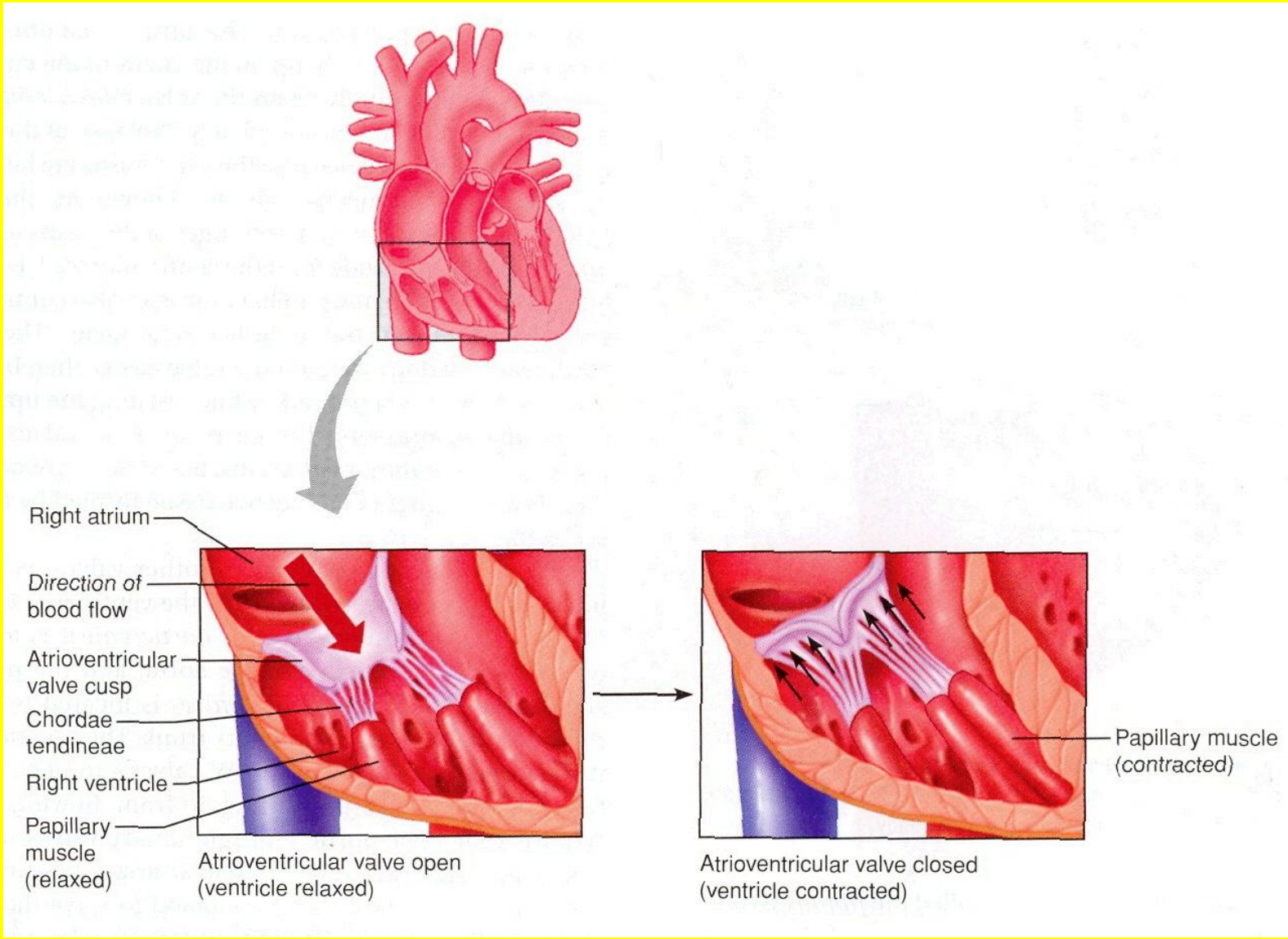
2d part:

Ventricles contract (0.3 sec)

AV valves close

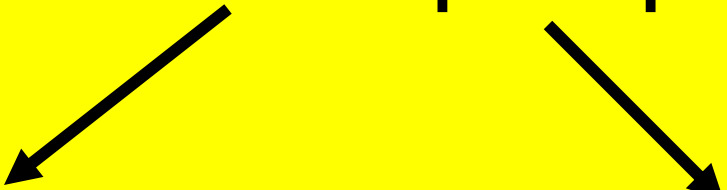


"AV" Valves Opened and Closed



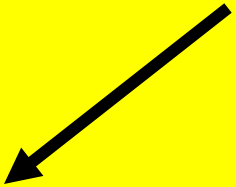
"Semilunar" (half-moons) valves

open: Blood pumped



Right Ventricle

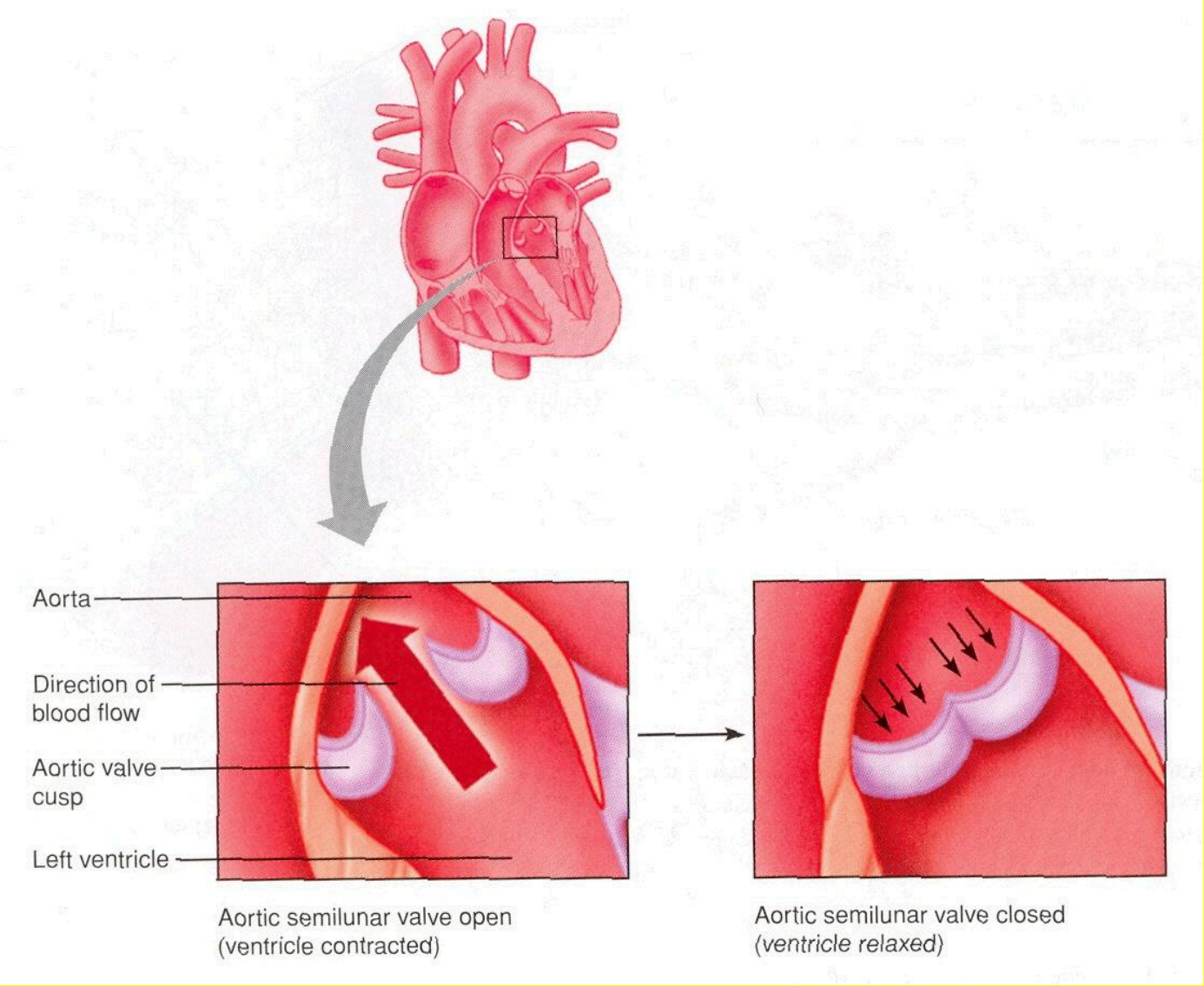
Left Ventricle



Lungs

Aorta & rest of body

Semilunar Valves opened and closed



Each ventricle
Pumps
~ 70 ml blood/beat:
Cardiac output

Well- trained athlete:
stronger/enlarged
heart
↑ **Cardiac Output**

Heart murmurs:

valves don't close properly- blood turbulents

Heart sounds:

lub & dup

valves closing

Lub: AV

Dup: Semilunar

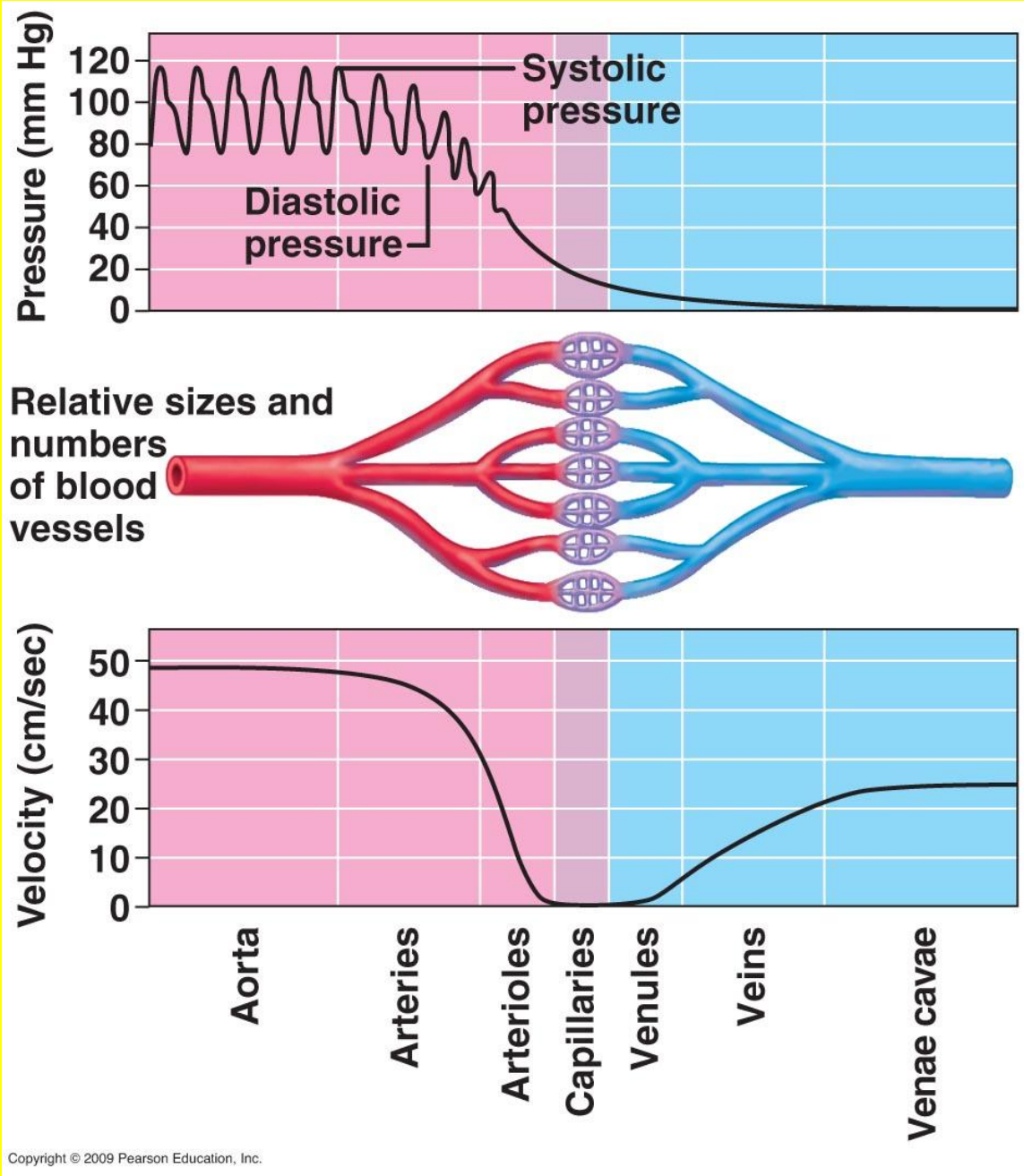
Blood Pressure: depends on

A) Volume blood pumped by heart
B) Resistance to blood flow: blood vessels

Systolic pressure: ventricles contract: blood flow from big aorta to small arterioles: creates pressure

Arterioles: elastic ⟶ **stretch**

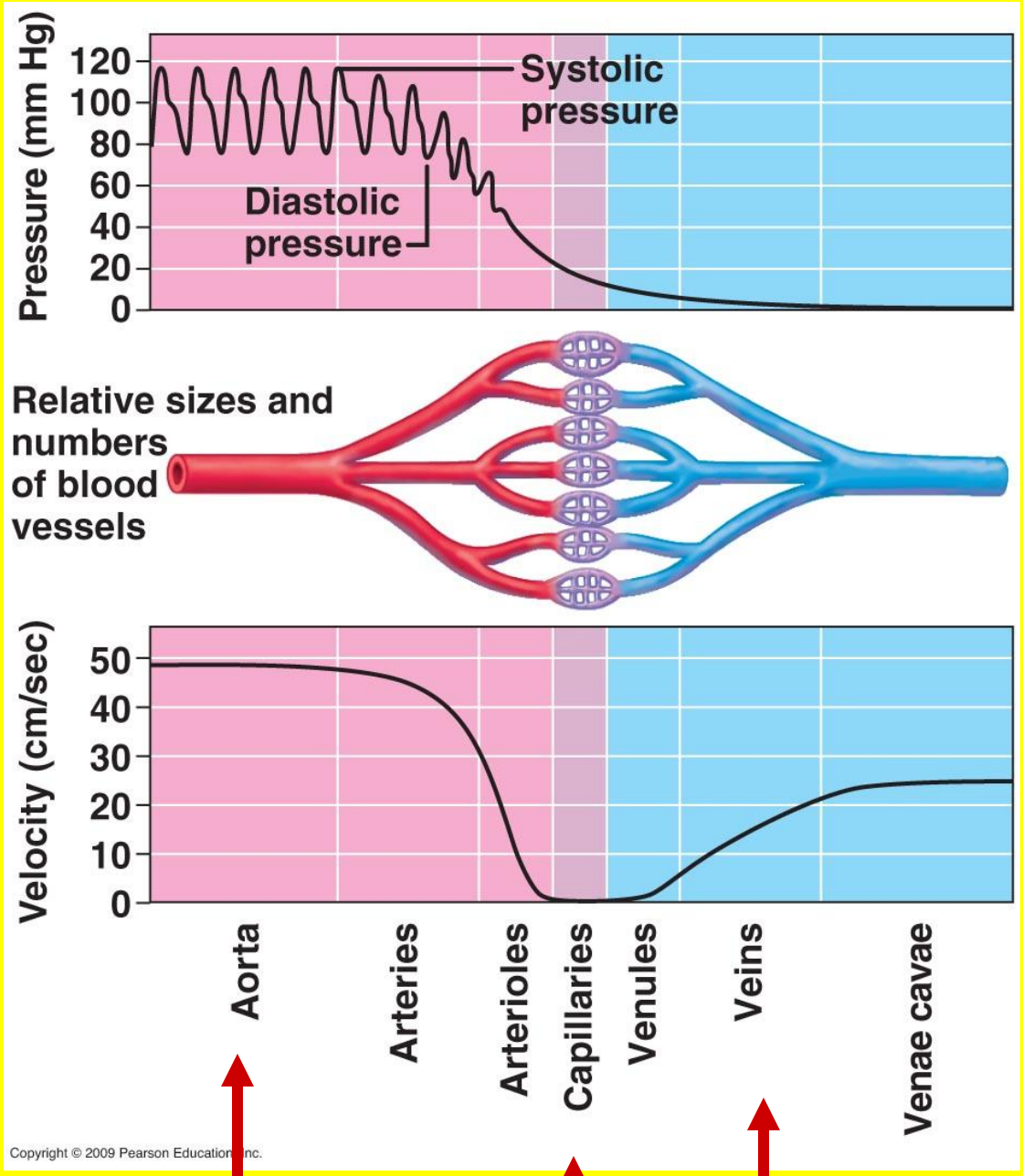
Diastolic Pressure: arterioles "snap back" ↓ pressure



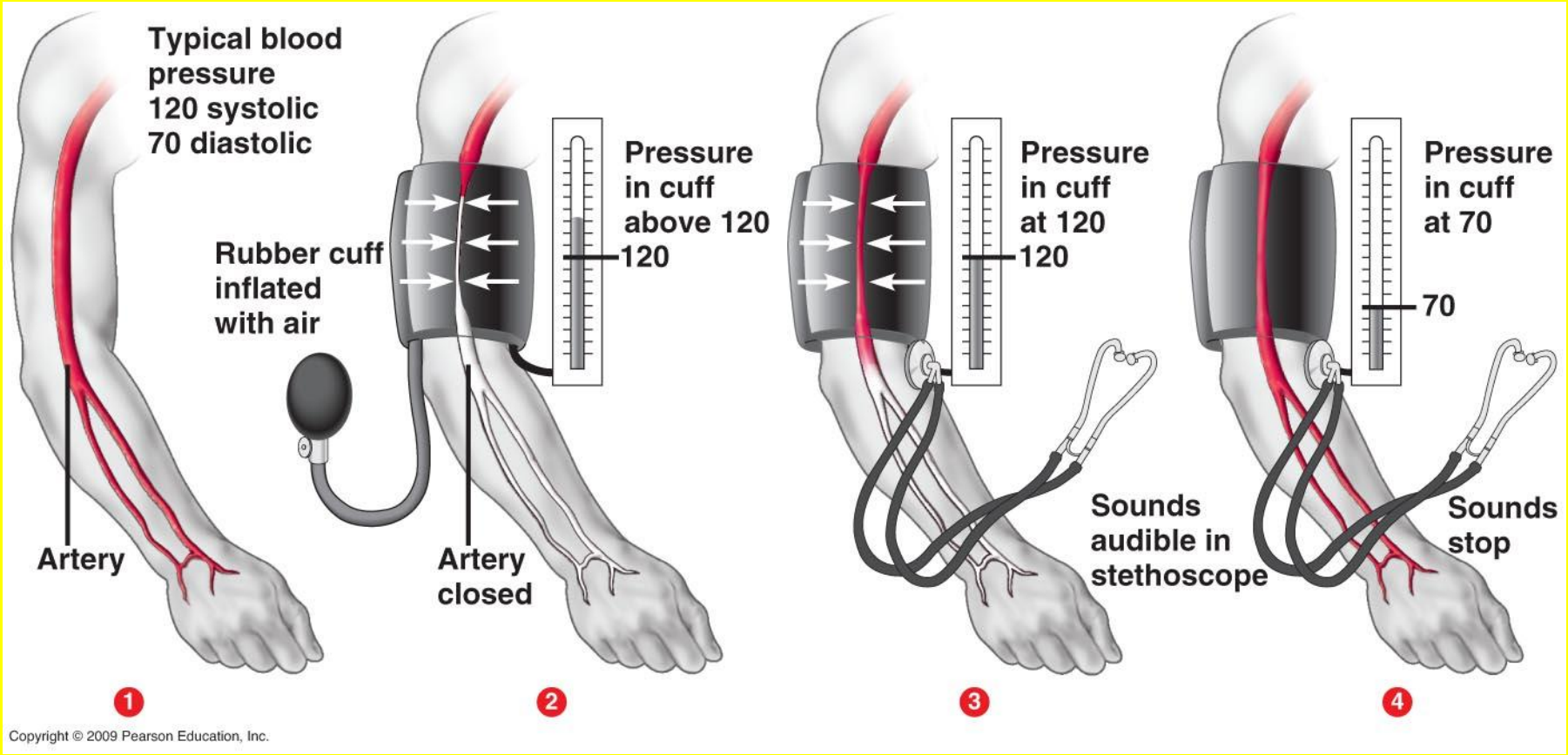
Blood Velocity

(speed)

- High in aorta
- Slow-Capillaries
- Speeds up-veins



Blood Pressure Measurement



- Wrap cuff- upper arm & inflate
- Cuff pressure closes artery: cuts off blood flow
- Listen with Stethoscope

- **Deflate cuff**
- Hear 1st sound: blood spurts through constricted artery= systolic pressure

- Continue to deflate, hear blood flow
- Sound **stops**: even blood flow
- Artery pressure > cuff pressure
- **Diastolic pressure**

Cardiac muscle cells:

- "inherent" ability

to beat (contract & relax) without nervous system

- Heart can beat in lab dish

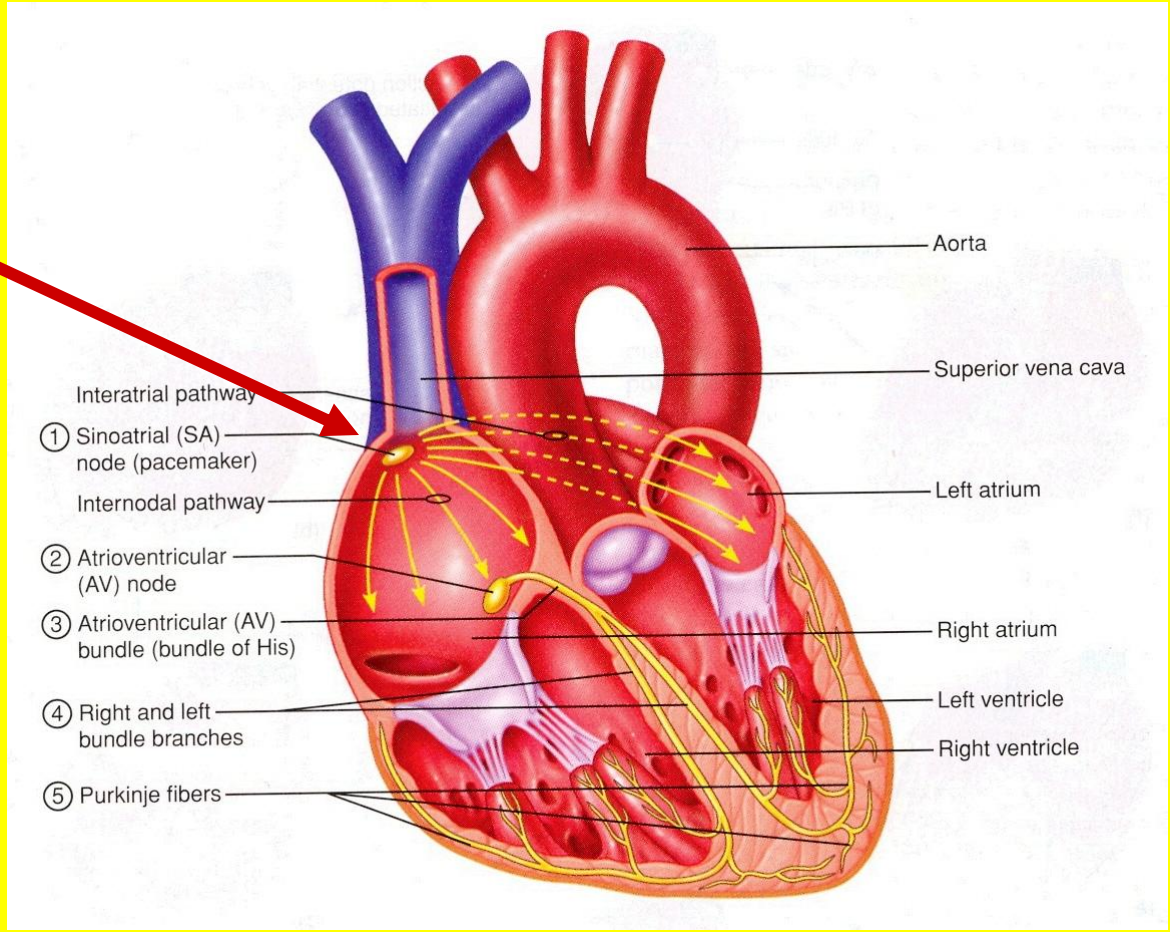
Heart also has
2 sets of nerves:
Speed up or Slow
Down

Hormones
(epinephrine) also
affect heart rate

What sets pace of Heart?

Pacemaker: Sinoatrial node

Upper right wall- Right atrium



SA node

1st Signals

↓

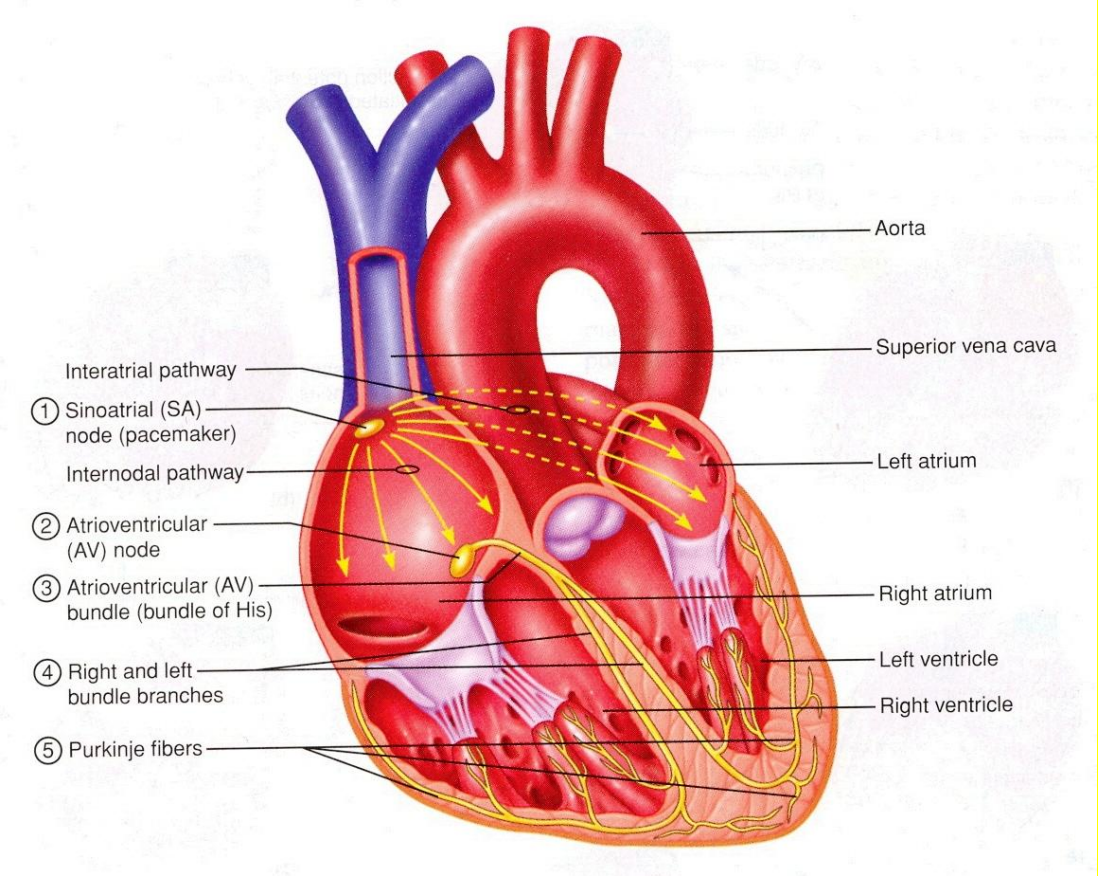
Right atrium

&

Left atrium

↓

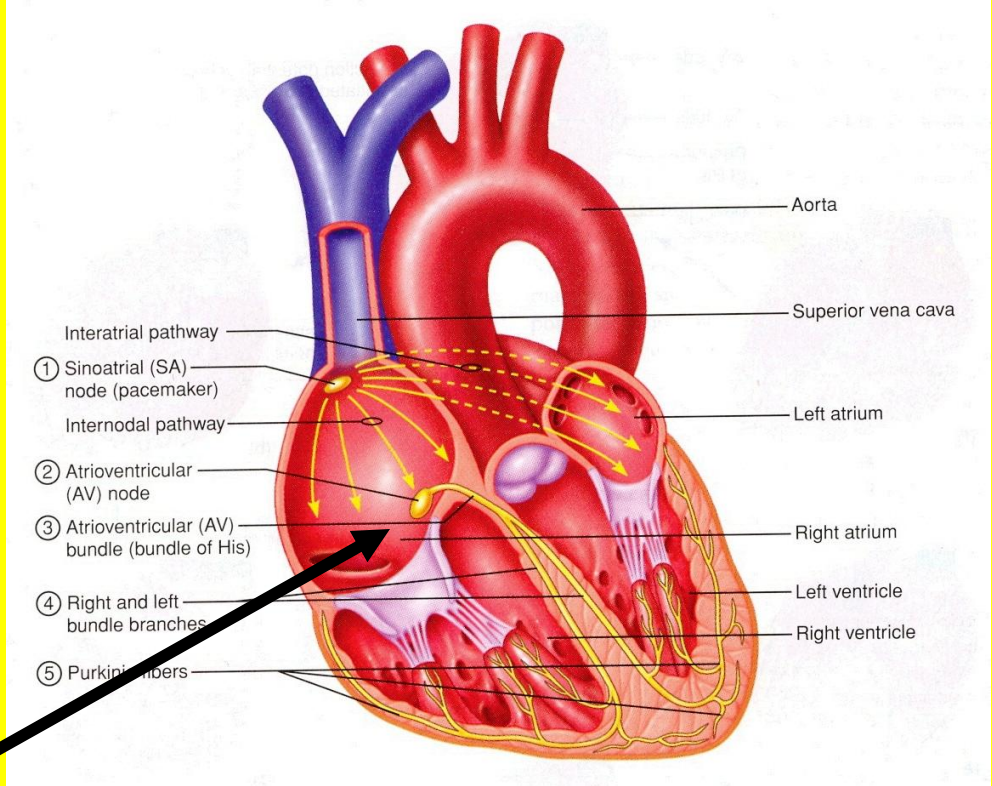
Contract together



2d signals

Relay point

Atrioventricular (AV) Node



AV Node

↓

Heart **apex**:

Spread up

Walls

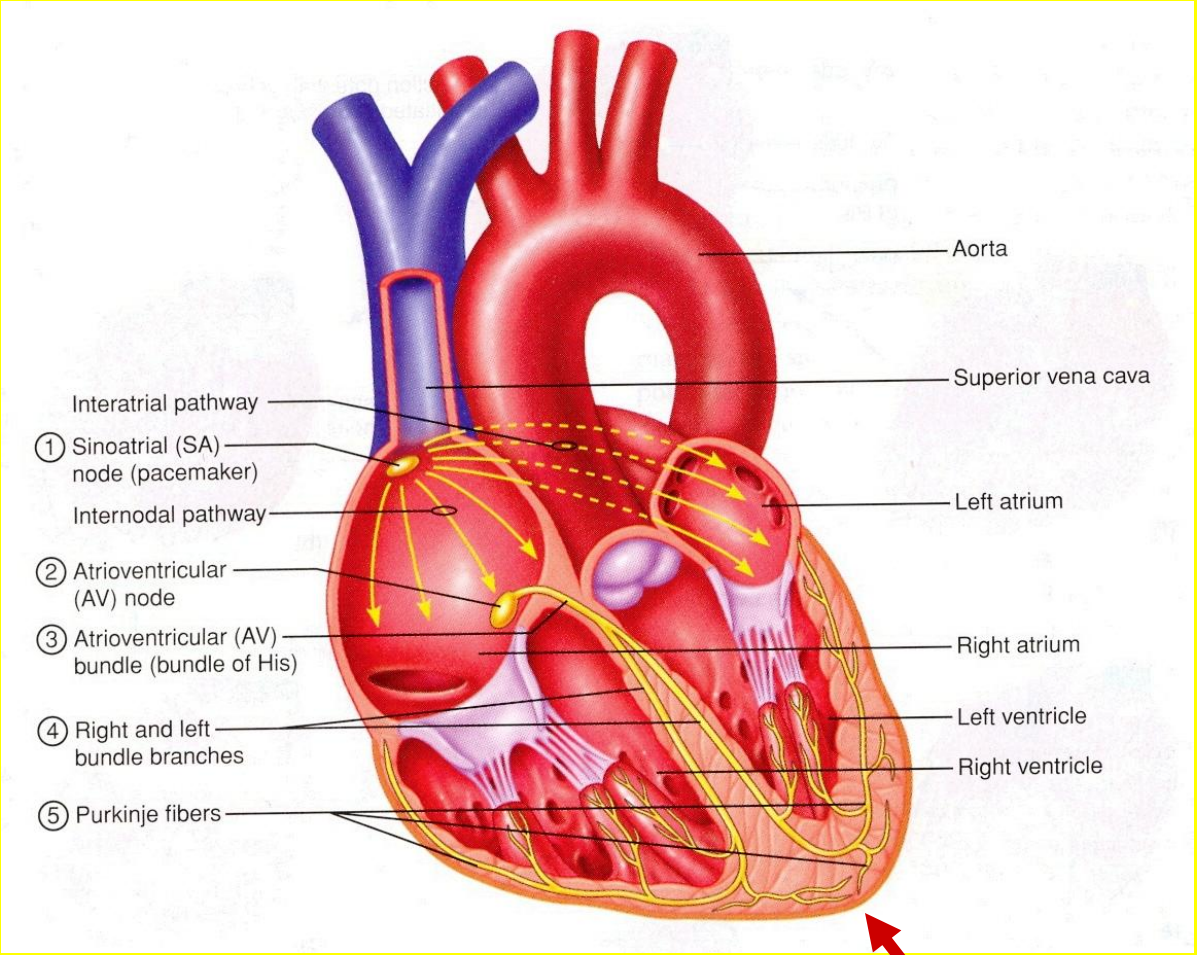
↙ ↘

Right Left

Ventricles

↓

Strong **Contractions**

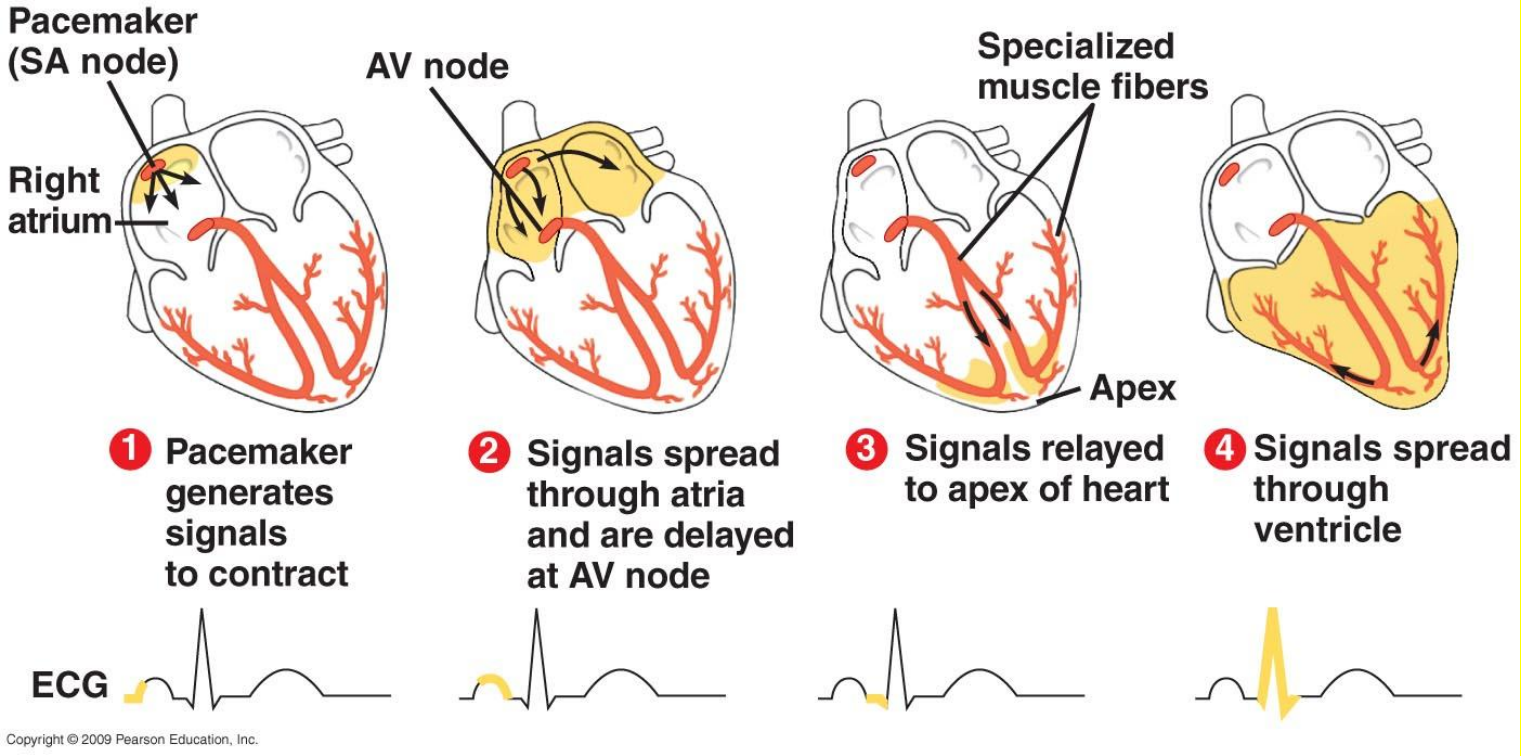


Electrical Signals
in **heart:**
electrical
changes
in **skin**
record:
Electrocardiogram
(ECG, EKG)

See electrical events in heart

Detect abnormal electrical activity

arrhythmias- abnormal heart rhythms



Heart attack:

Abnormal rhythm

of ventricles

"Ventricular

Fibrillation"

(bag of worms)

Defibrillators

Electric shocks to chest

Re-set heart electrical system

Artificial Pacemakers

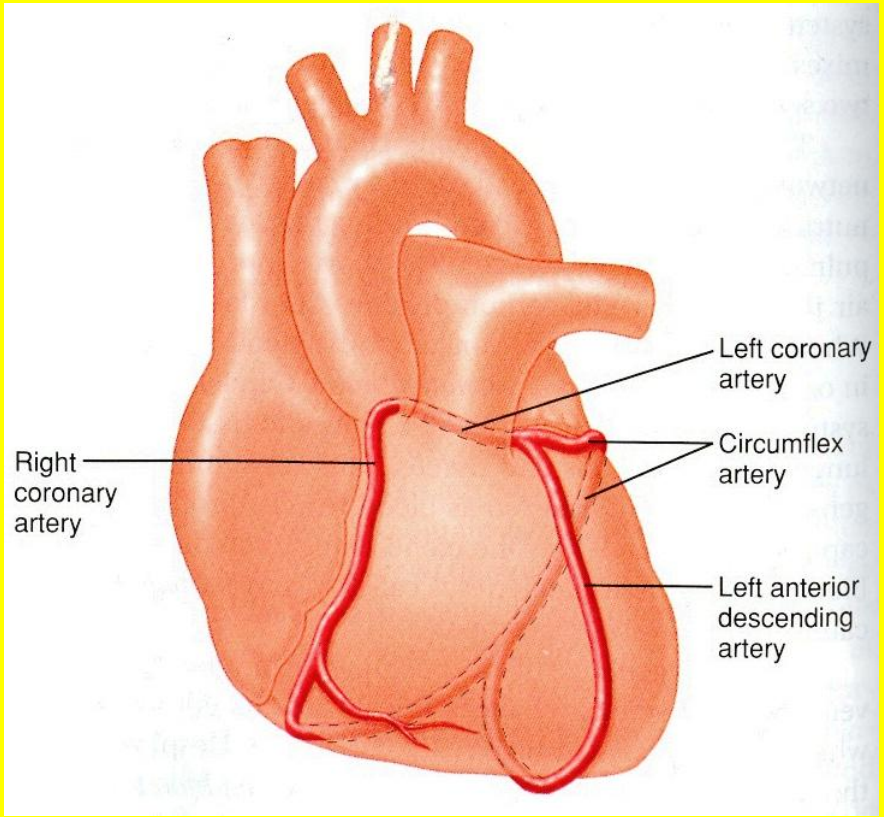
If heart doesn't
keep normal
rhythm
Surgically
implanted
near heart
battery, signals:
normal heart beat

Defibrillators also implanted

1. Detect abnormal rhythms
2. Send jolt to heart
3. Restore rhythm

Cardiovascular Disease

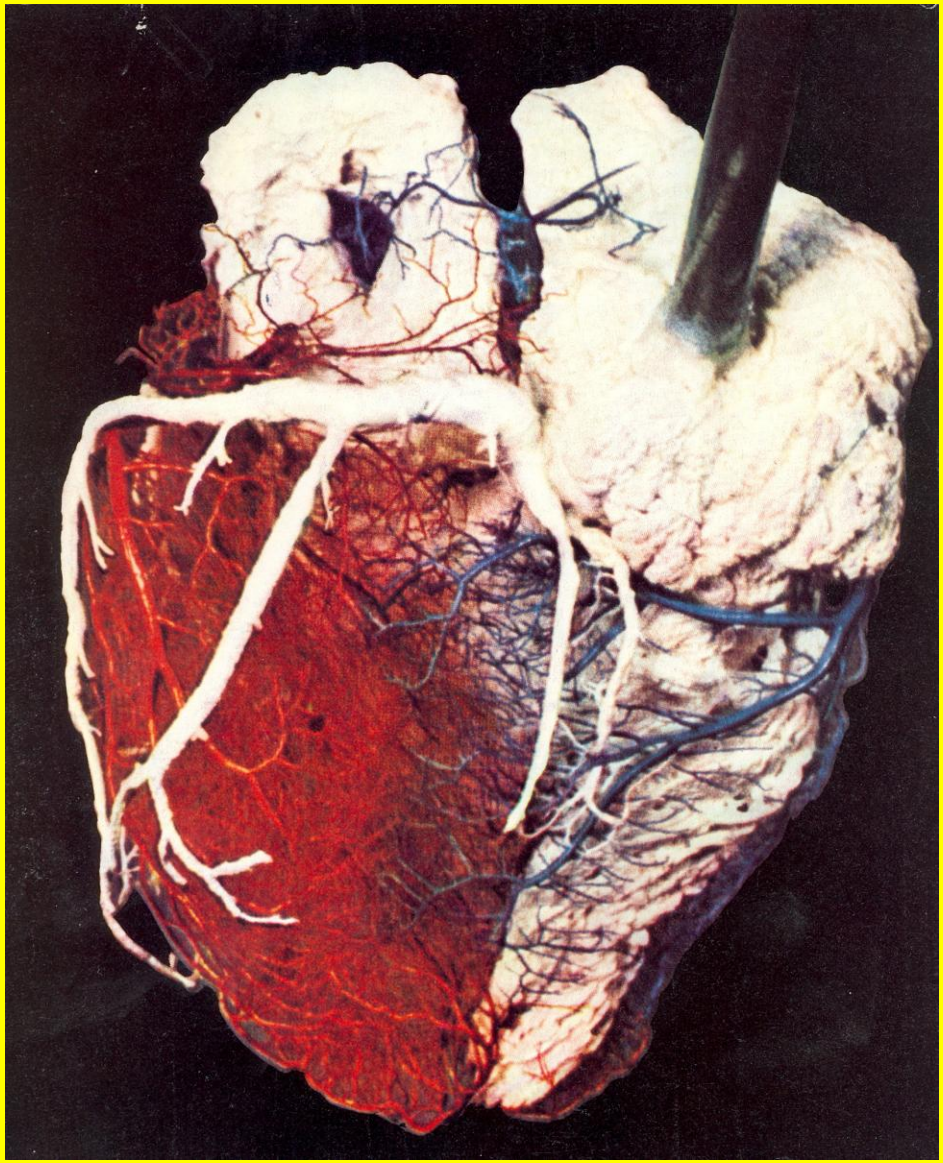
- Heart takes care of itself first
- 2 arteries: blood from aorta to heart muscle (myocardium) Supply O_2 + glucose



Coronary arteries:

branches form coronary circulation

"coronary"- Latin for "crown" – encircles heart



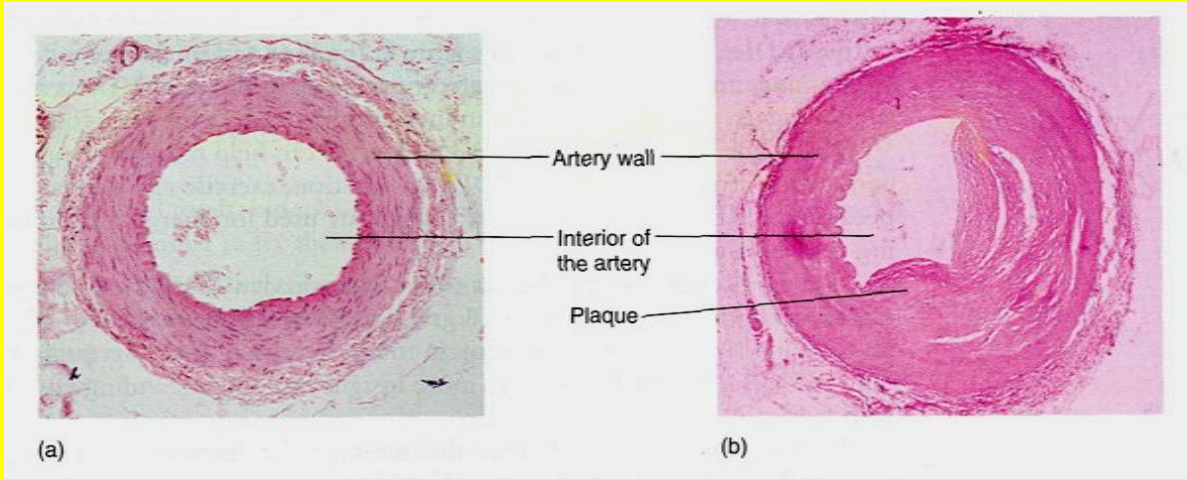
Beginning in children (5-12 years) see thickenings & fatty streaks in **coronary arteries**

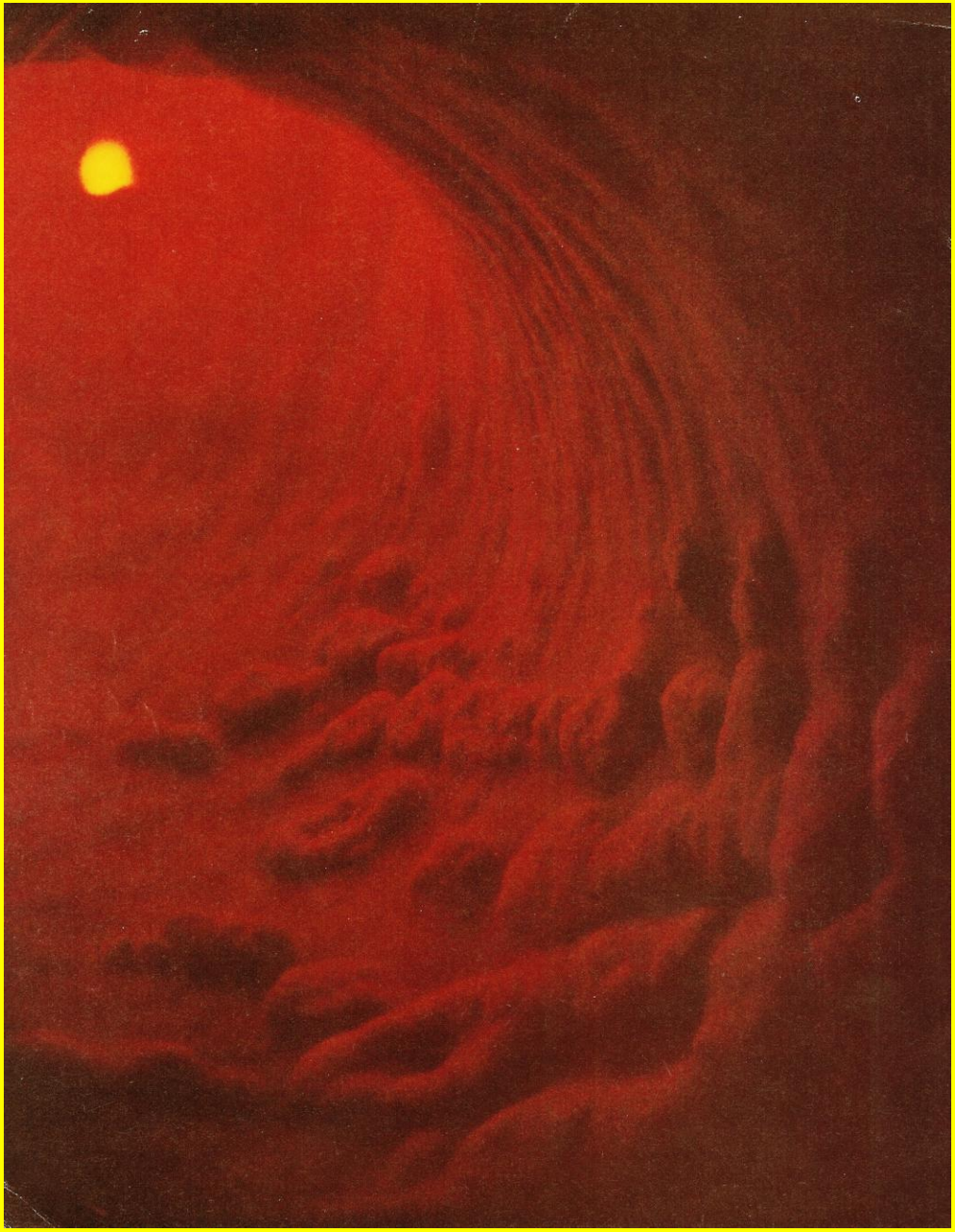
Disease process: **atherosclerosis**-

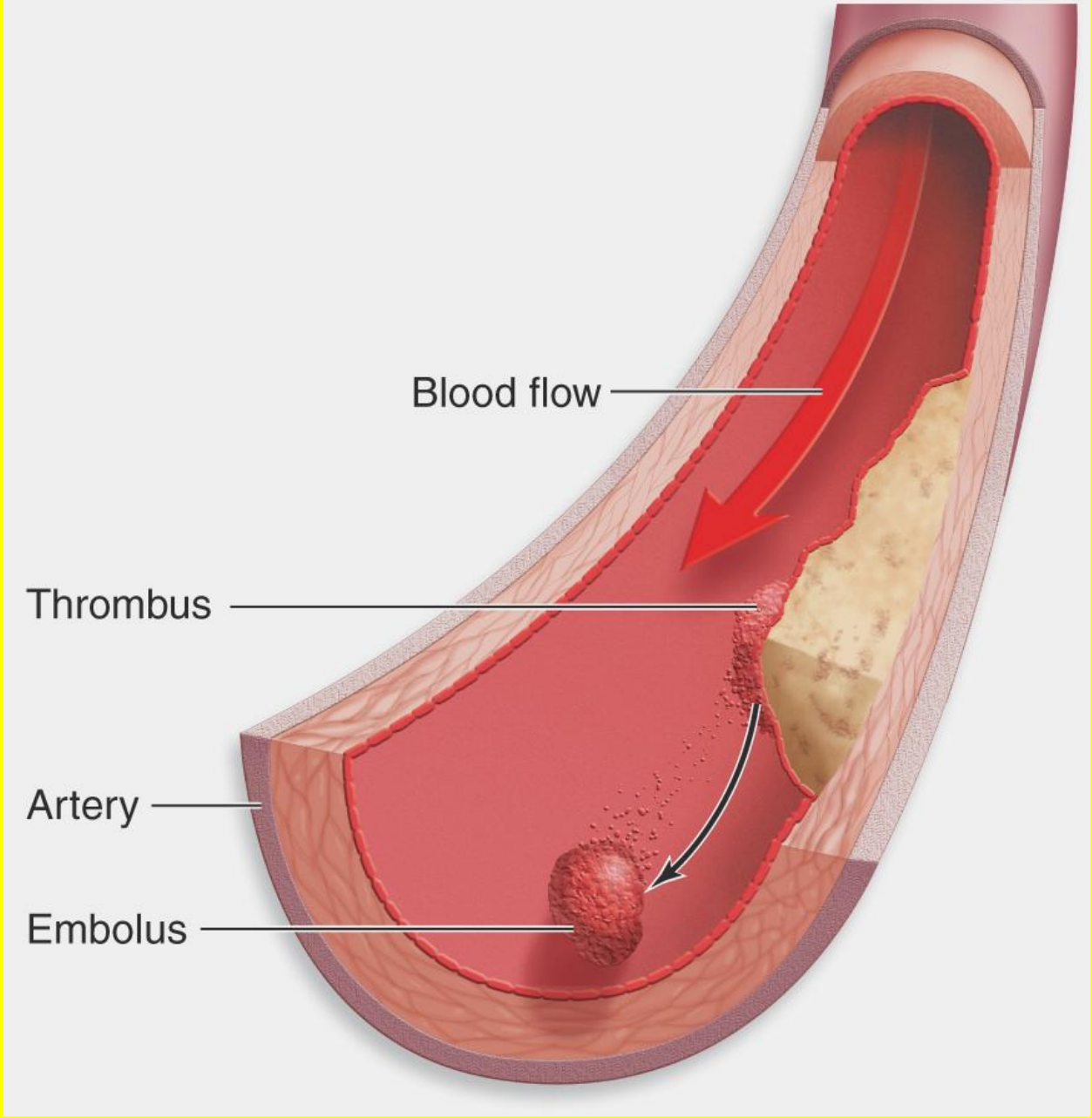
Accumulation of lipids (cholesterol), protein, calcium, scar tissue in arteries

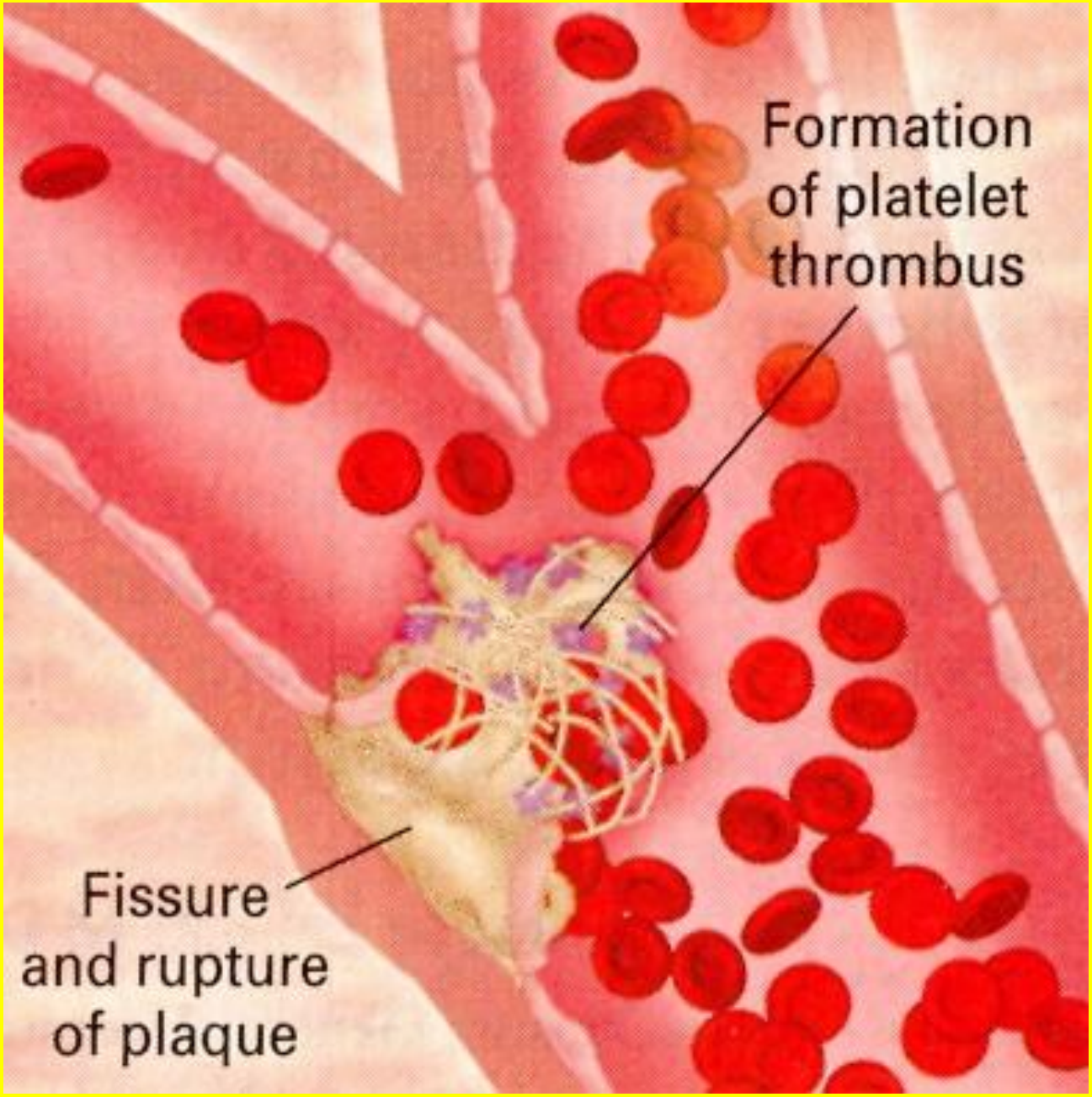
Going on **quietly** in you now

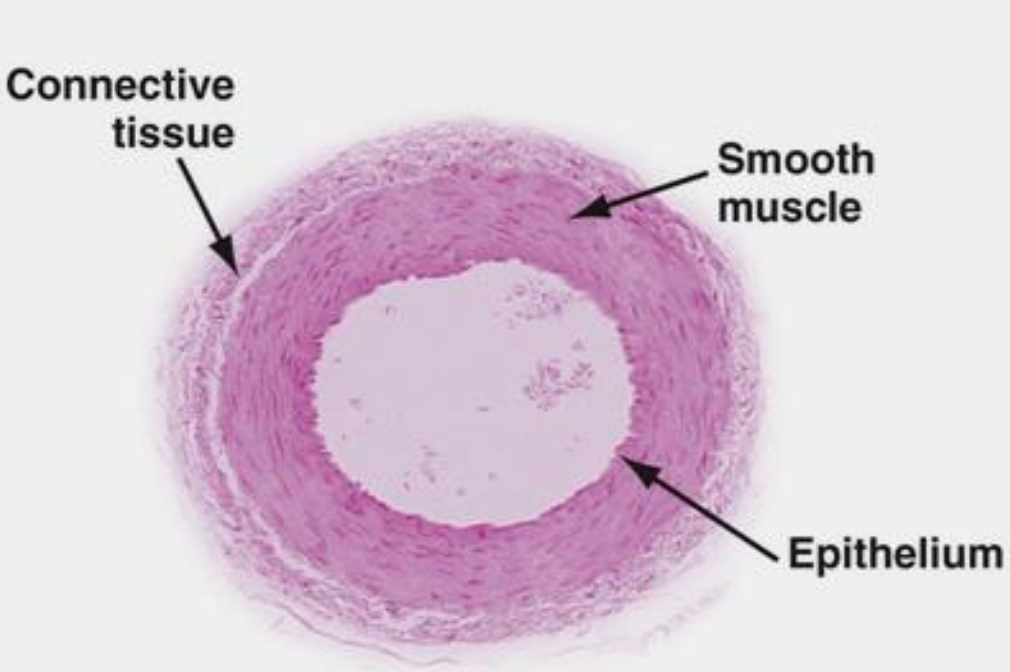
Also in arteries of brain, arms, legs



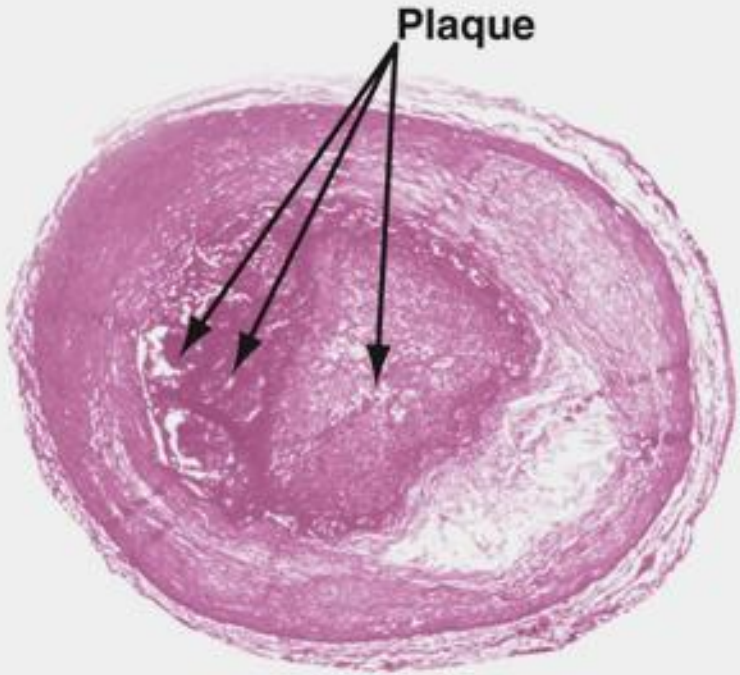





Formation
of platelet
thrombus
Fissure
and rupture
of plaque



Normal artery



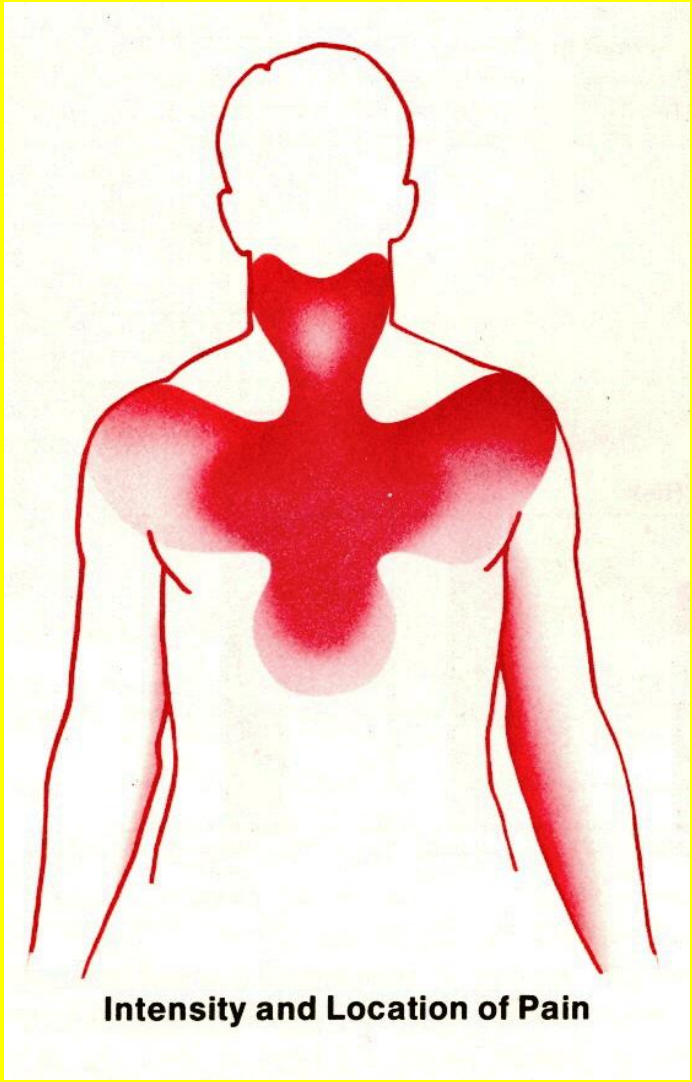
Artery partially blocked by plaque

Can cause **heart attack**: coronary arteries in heart

Heart attack: Warning signs

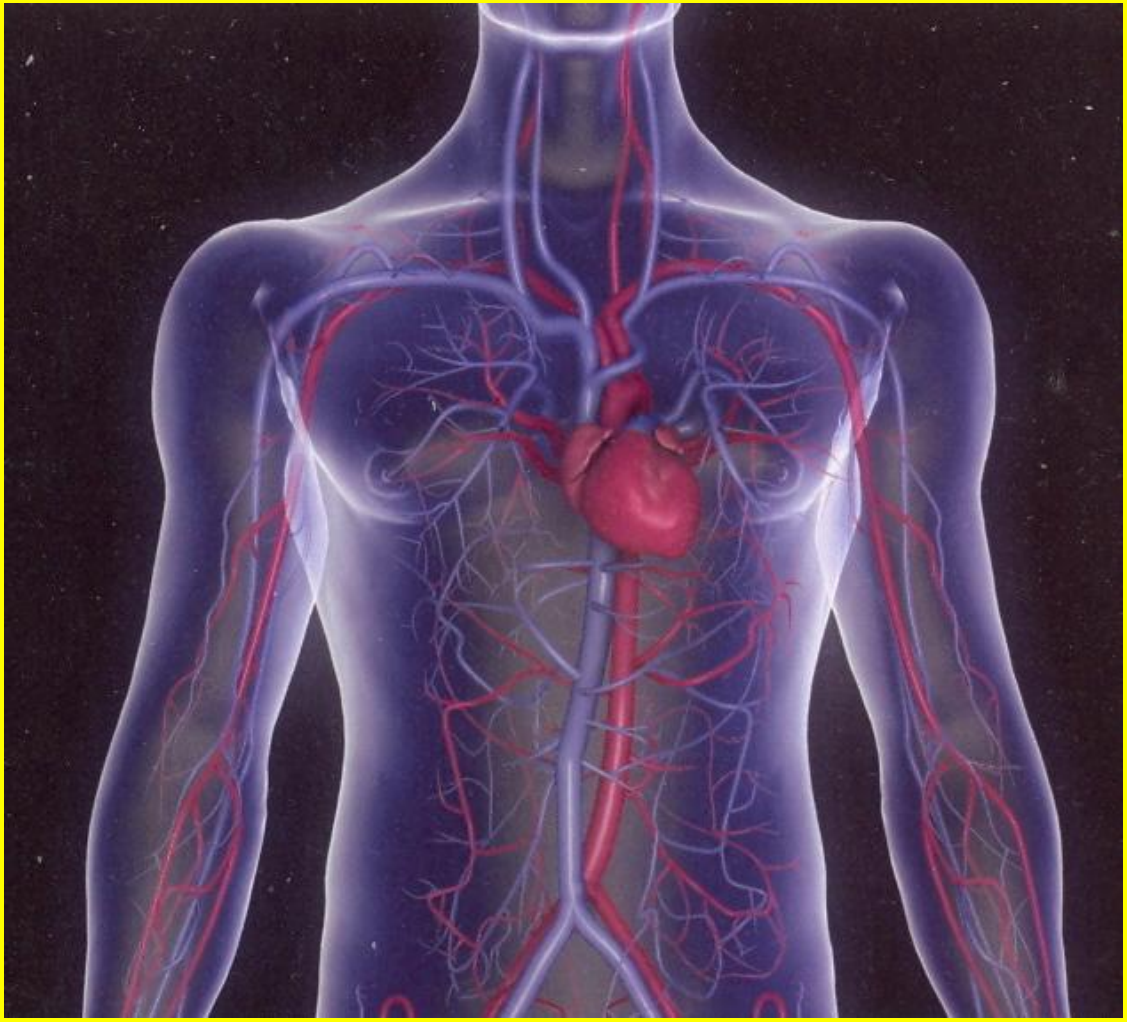
- Heavy pressure, fullness, squeezing pain in center of chest
- Pain may spread: arms, back, neck, jaw, or stomach
- Cold sweat
- Nausea and vomiting
- Lightheadedness

Heart Attack Pain: may spread

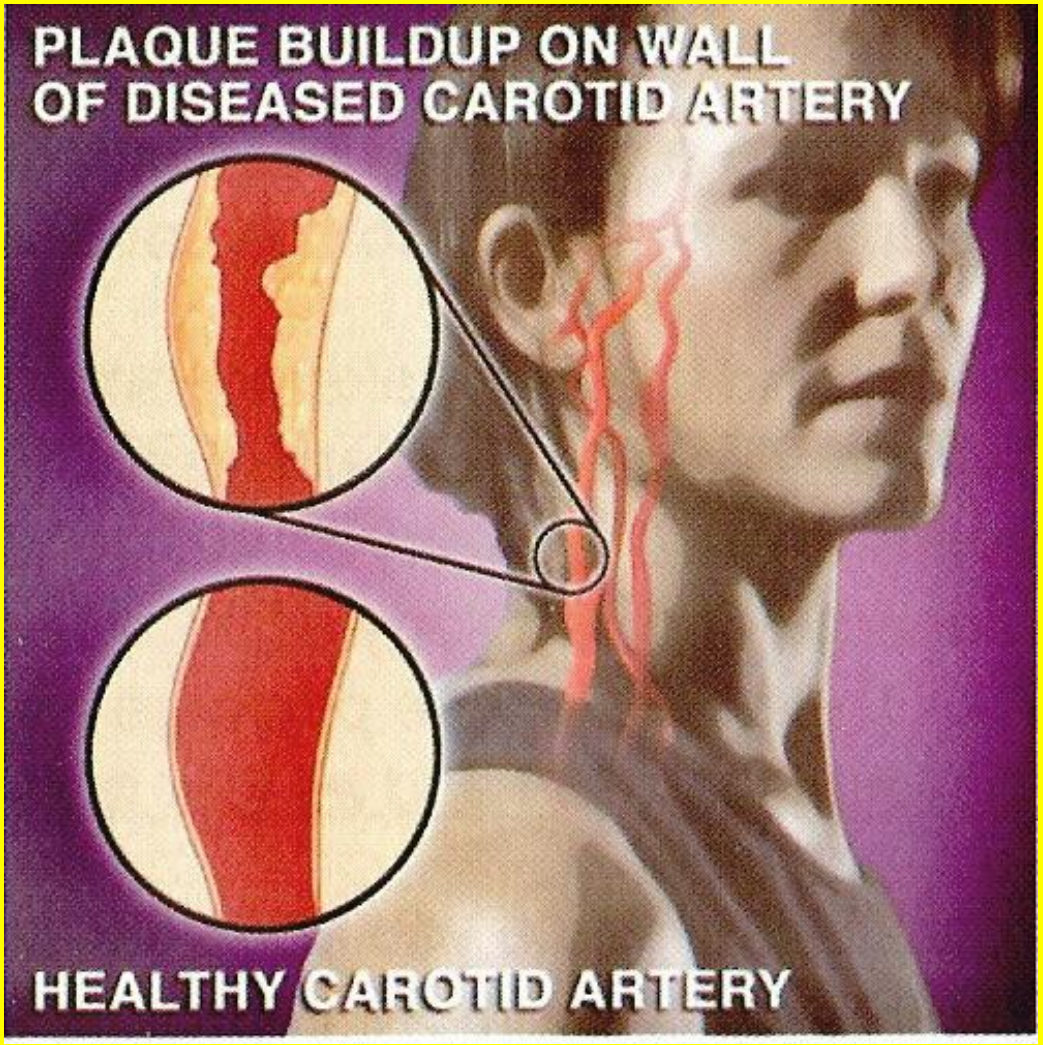


Heart attacks: more common morning, on birthdays

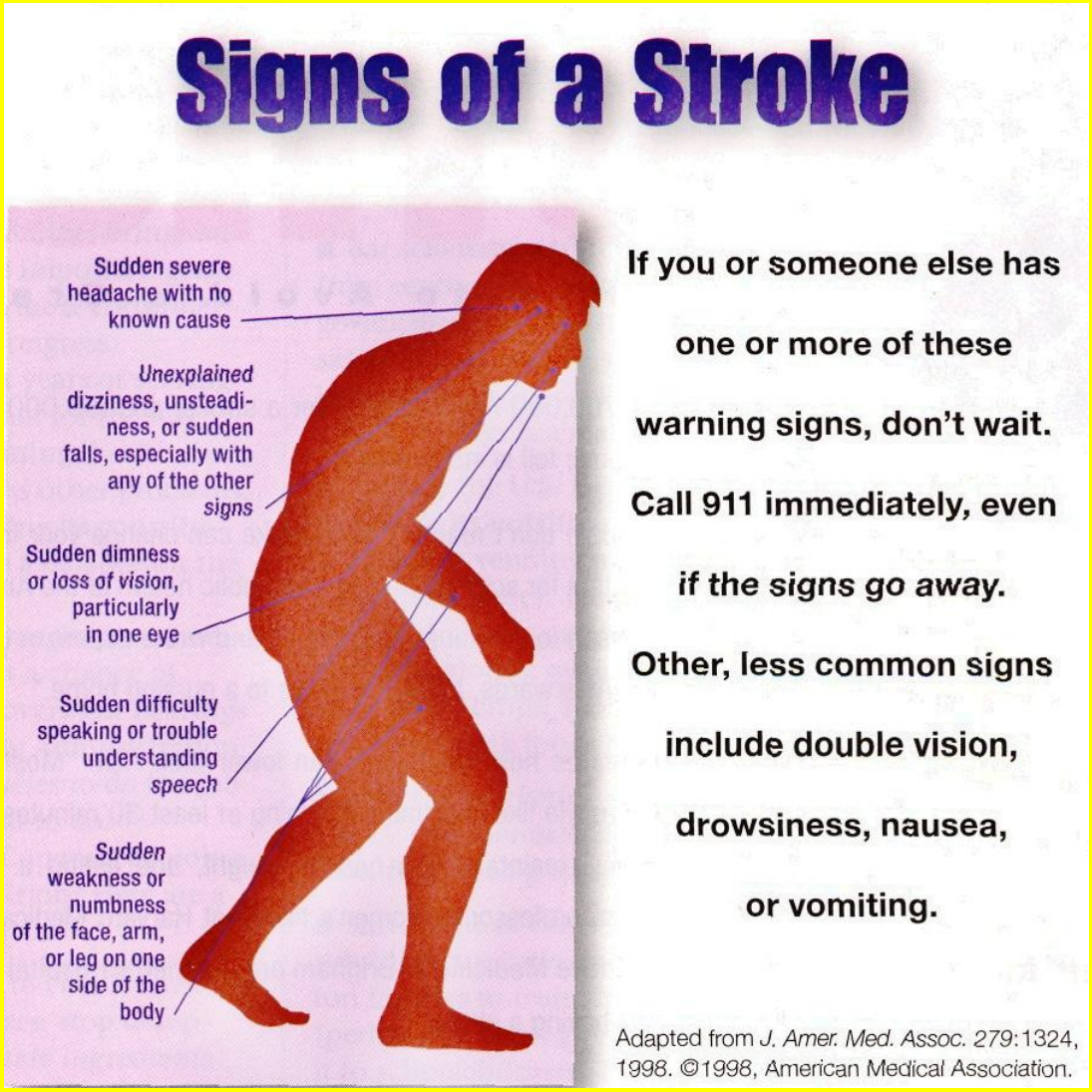
Peripheral Artery Disease



Blockage of neck carotid arteries



Stroke: arteries in brain



Heart Disease Risk Factors

1. Men > Women
2. Family history: early heart attacks
3. Age
4. Genetics: African Americans (high blood pressure), Mexican and native Americans (obesity & diabetes)

Heart Disease Risk Factors

5. Smoking
6. Blood lipids ↑ LDL ↓ HDL
7. High Blood pressure
8. Diabetes
9. Obesity
10. Sedentary Lifestyle
11. Job stress

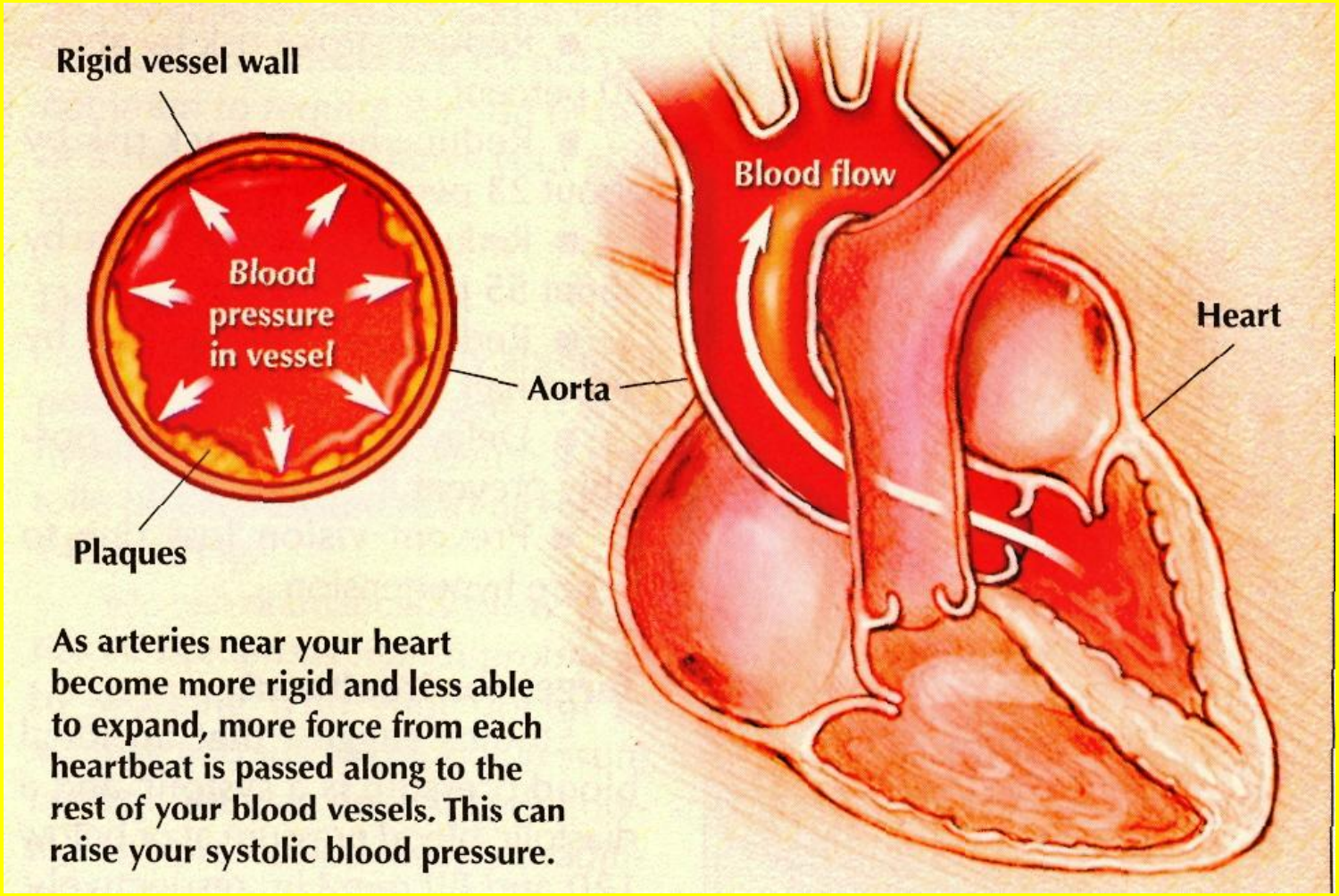
Heart Disease Risk Factors

12. Diet & Exercise

Saturated (animal) fat, trans fat, cholesterol, salt

Fiber, fruits & veggies, exercise

High Blood Pressure



Know these numbers

	Systolic/Diastolic
Normal	120/80
Pre-hypertension	121-139/81-89
Hypertension	**140/90** or >

Systolic: heart pumping

Diastolic: heart relaxing

DIETARY GUIDELINES SODIUM & POTASSIUM TOO MUCH & TOO LITTLE

TOO MUCH SALT (SODIUM)

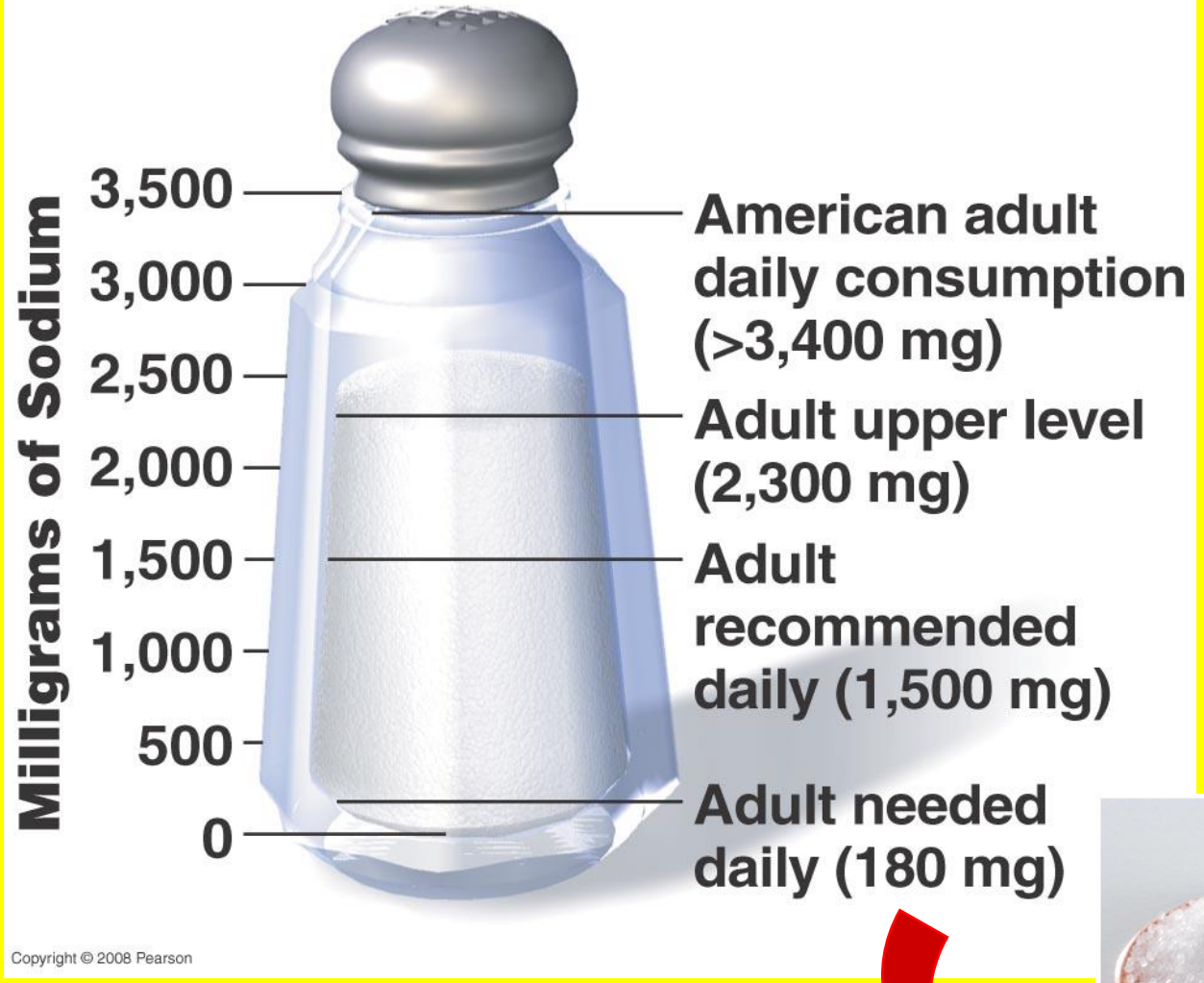
- ↑ Blood pressure
- ↑ Heart attack (#1 killer)
- ↑ Stroke (#3 killer)
- ↑ Heart failure
- ↑ Kidney Disease

Where does sodium come from?

12%: naturally- foods

11%: you- salt shaker

77%: **processed foods**- added by companies



↑ Kidney stones US children (2008)

Oxalates (food) binds to calcium → stone

2 risk factors:

1) not enough drinking of fluids

2) too much **salt**

Tessa Cesario

11 years old

Potassium & Blood Pressure

Potassium: **Anti-salt**

- ↓ Blood pressure
- ↓ Risk- stroke
- ↓ Kidney stones
- ↓ Bone loss

Recommendation: **4,700** mg/day

Average American: ½ this amount

Simple way: better balance

↓ Added salt/processed foods

↑ Fruits & veggies (low sodium, high potassium)

Cold Therapy: Therapeutic Hypothermia

"Quasi-hibernating" state

1999: 29 year old woman doctor falls into river in Norway while skiing

- Carried by currents- stuck in ice flow
- 1 hour later: rescued- no heart beat
- Temperature 57° F
- CPR → 9 hours treatment → slow warming
- 60 days- intensive care
- Back to work: 5 months, skiing year later

What happened to her body?

- Body cooled
- Cells need less O_2
- Metabolism ↓ 10% of baseline value
- She was in **"suspended animation"**
- Between **life and death**

Cooling Treatment: Medical Applications

- Today- induced mild hypothermia for delicate heart, brain, spinal cord surgery
- Cooling techniques: cooling blankets, ice packets, circulating ice cold saline, cooled blood through heart-lung bypass machine
- Body cooled to 60 ° F: heart stops beating **(cardiac standstill)**

Hypothermia: reduces clotting, slows metabolism, ↓ O_2 demand

After surgery: heat exchanger on heart-lung machine:

slowly raises

body temperature

Emergency Applications

- Some hospitals put comatose cardiac arrest patients **"on ice"** after heart re-started
- Reduces brain damage, reduces inflammation after resuscitation

January 2008

Directive:

NY City

ambulances:

Take **cardiac**

arrest patients to

hospitals with **Cooling Therapy**

available: to protect the **brain**

even if not nearest hospital

Cocaine mimics heart attack

Hospital emergency rooms admitting young people:

Chest pain, shortness breath, anxiety, palpitations, dizziness, nausea, heavy sweating

- All heart attack symptoms
- But without heart disease **risk factors**
- Cause: cocaine use (↑ B.P., heart rate, vasoconstriction)
- Real heart attack vs. cocaine use: important differences in treatment