

Physiology of the Heart

- The heart pumps approximately **6 quarts** of blood through the blood vessels over **1,000 times** every single day.
- 6 quarts per day x 1,000 = 6,000 quarts per day
= 1500 gallons of blood per day

Physiology of the Heart

What makes the heart beat?

- Unlike **skeletal** muscle cells, which must be stimulated by nerve impulses before they will contract, **cardiac** muscle cells can and do contract **spontaneously and independently** of nerve impulses.

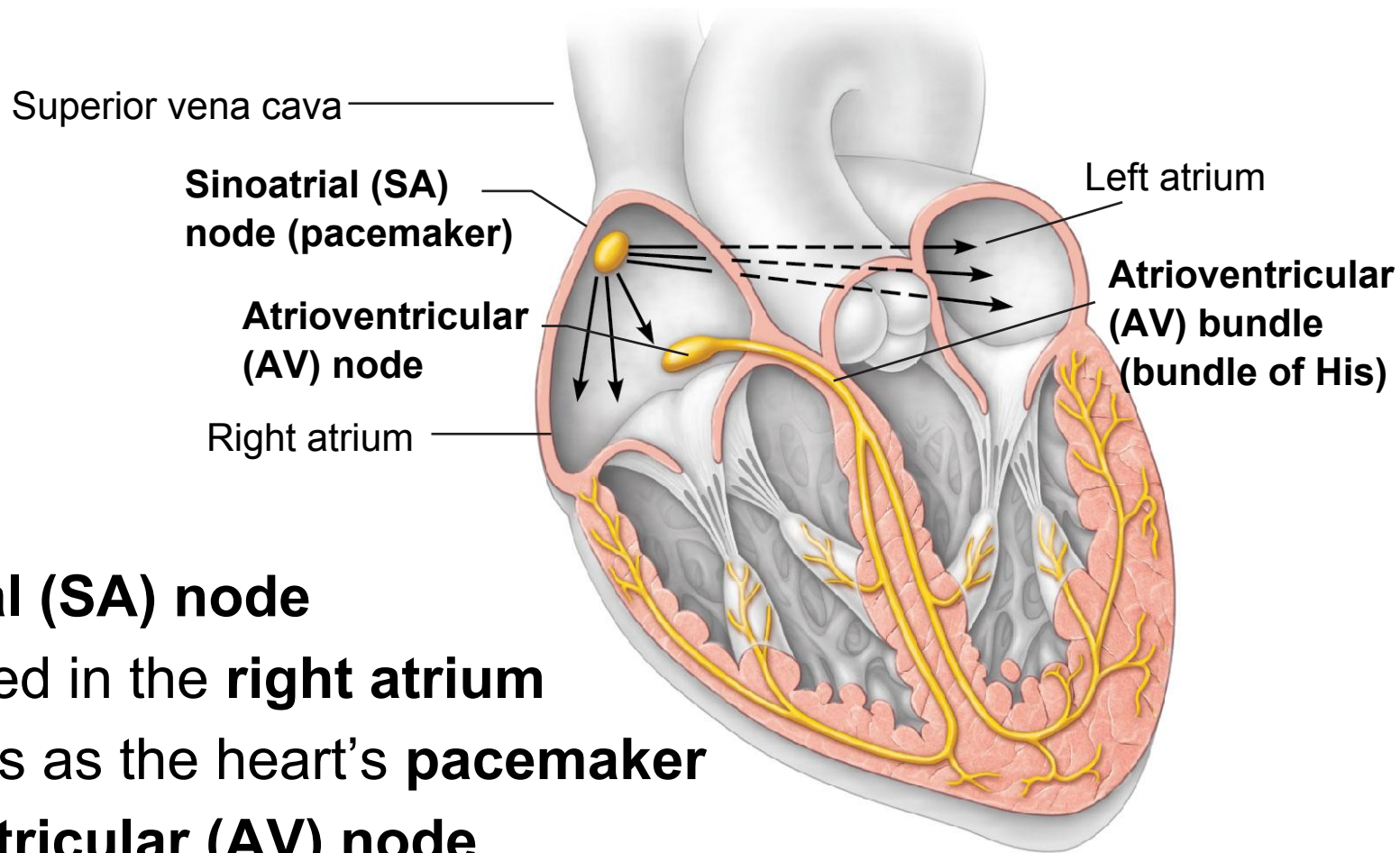
Physiology of the Heart

- Although cardiac muscle can beat independently, the muscle cells in **different areas of the heart have different rhythms**.
 - **Atrial cells** beat 60 times per minute
 - **Ventricular cells** beat 20–40 times per minute
- Without some type of unifying control system (**intrinsic conduction system**), the heart would be an **uncoordinated and inefficient** pump.

Intrinsic Conduction System of the Heart

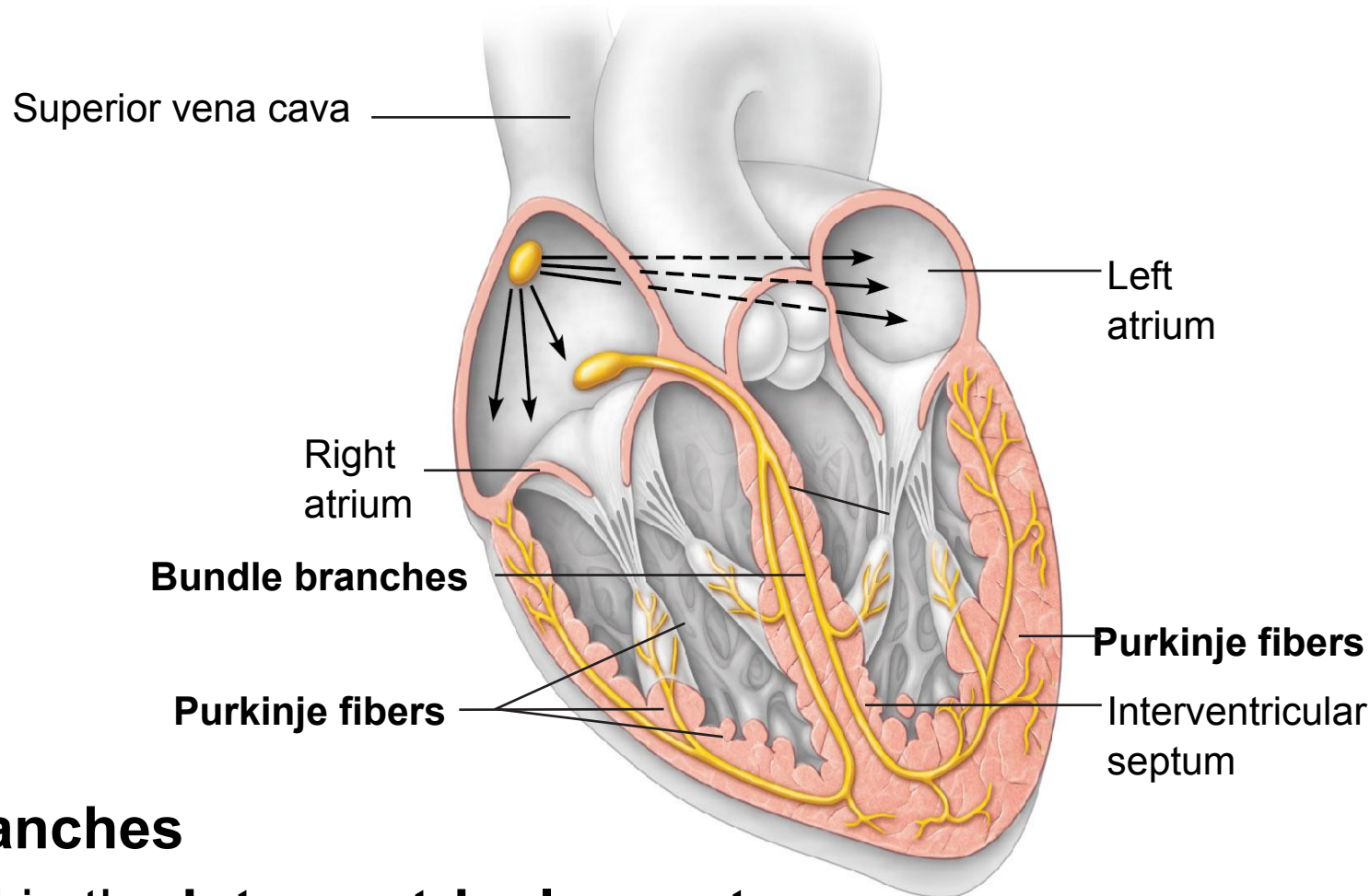
- Sets the **heart rhythm**
- Composed of **special nervous tissue**
- Ensures heart muscle depolarization in **one direction only (atria to ventricles)**
- Enforces a heart rate of **75 beats per minute**

Structures of the Intrinsic Conduction System



- **Sinoatrial (SA) node**
 - Located in the **right atrium**
 - Serves as the heart's **pacemaker**
- **Atrioventricular (AV) node**
 - Located at the **junction of the atria and ventricles**
- **Atrioventricular (AV) bundle (bundle of His)**
 - Located in the **superior interventricular septum**

Structures of the Intrinsic Conduction System

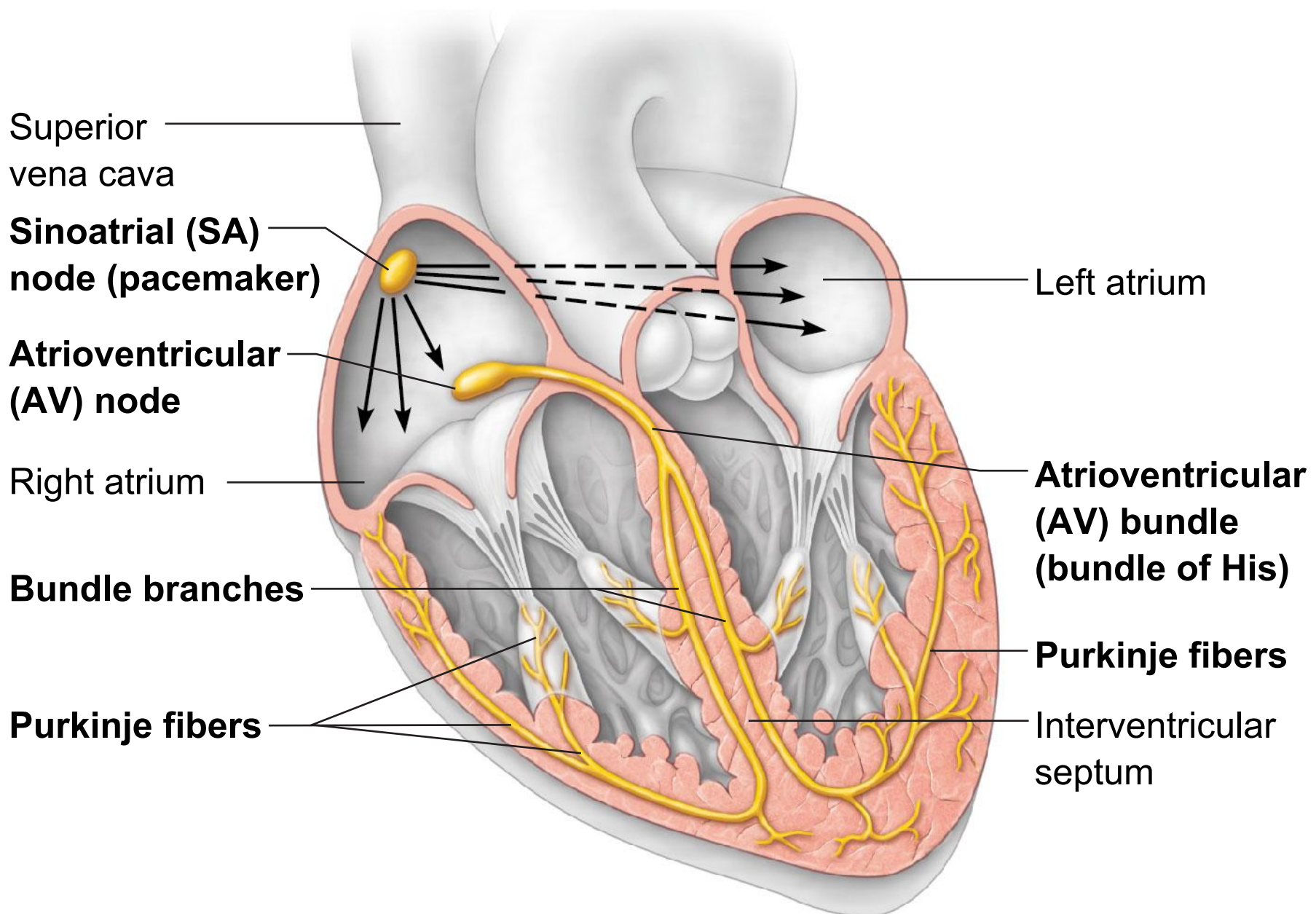


- **Bundle branches**

- Located in the **interventricular septum**

- **Purkinje fibers**

- Located within the **myocardium of the ventricle walls**



Superior
vena cava

**Sinoatrial (SA)
node (pacemaker)**

**Atrioventricular
(AV) node**

Right atrium

Bundle branches

Purkinje fibers

Left atrium

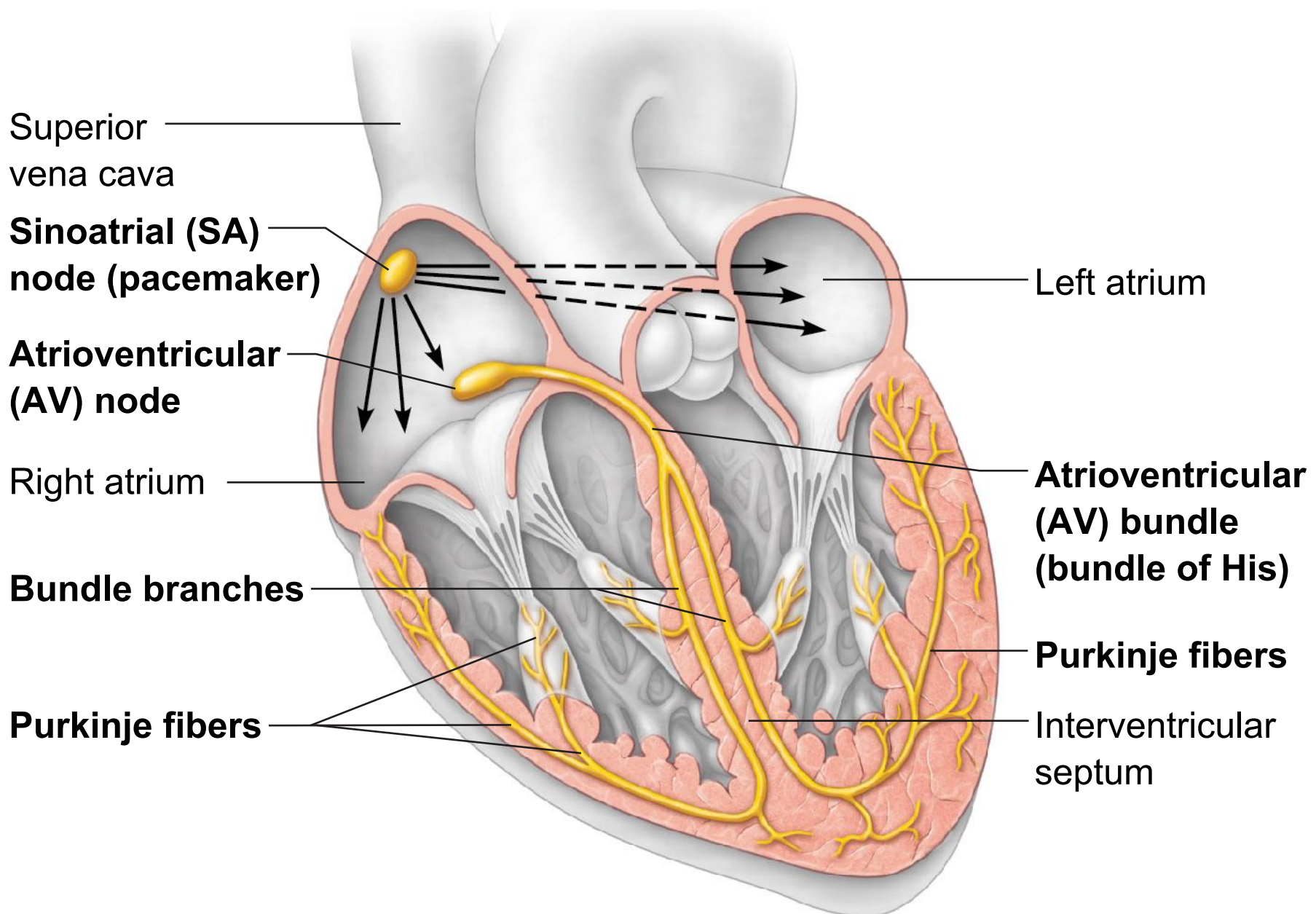
**Atrioventricular
(AV) bundle
(bundle of His)**

Purkinje fibers

Interventricular
septum

Events of Intrinsic Conduction System

1. The **SA node** starts each heartbeat
 - SA node has the **highest rate of depolarization**, so it sets the pace (pacemaker)
2. Impulse spreads through the **atria to the AV node**
3. **Atria contract**
4. At the AV node, the **impulse is delayed** briefly
5. Impulse travels through the **AV bundle, bundle branches, and Purkinje fibers**
6. **Ventricles contract**; blood is ejected from the heart



Superior
vena cava

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Influence of Autonomic Nervous System

- Heart contraction does **NOT** depend on nervous system
- Heart rate **CAN** be changed **temporarily** by the autonomic nervous system
 - **Parasympathetic** nerves decrease heart rate
 - **Sympathetic** nerves increase heart rate

Cardiac Cycle

- The **cardiac cycle** refers to one complete heartbeat, in which **both atria and ventricles contract and then relax**
 - Systole = **contraction**
 - Diastole = **relaxation**
 - Examples
 - Atrial systole = **atrium contract**
 - Ventricular diastole = **ventricles relax**

Cardiac Cycle

- Atrial Diastole
 - Heart is **relaxed**
 - Pressure in heart is **low**
 - Atrioventricular valves are **open**
 - Blood flows passively **into the atria and into ventricles**
 - Semilunar valves are **closed**

Cardiac Cycle

- Atrial Systole
 - Ventricles remain in **diastole**
 - Atria **contract**
 - Blood is forced **into the ventricles to complete ventricular filling**

Cardiac Cycle

- Isovolumetric Contraction
 - Atrial **systole** ends
 - Ventricular **systole** begins
 - Intraventricular pressure **rises**
 - AV valves **close**
 - For a moment, the ventricles are **completely closed chambers**

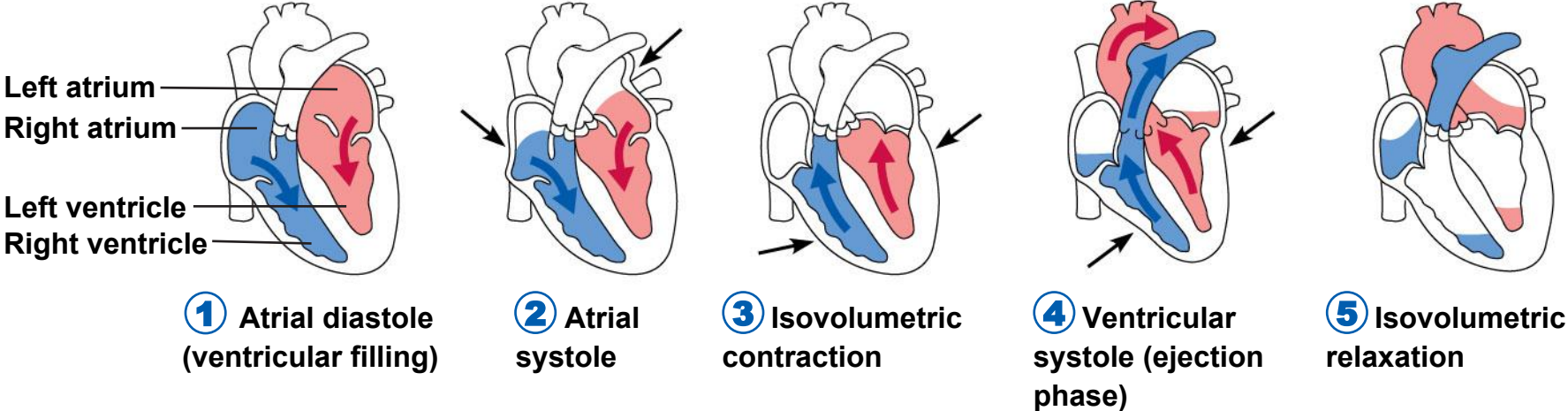
Cardiac Cycle

- Ventricular Systole
 - Ventricles continue to **contract**
 - Intraventricular pressure now **surpasses** the pressure in the major arteries leaving the heart
 - Semilunar valves **open**
 - Blood is **ejected from the ventricles**
 - Atria are **relaxed and filling with blood**

Cardiac Cycle

- Isovolumetric Relaxation
 - Ventricular **diastole** begins
 - **Pressure falls** below that in the major arteries
 - Semilunar valves **close**
 - For another moment, the **ventricles are completely closed** chambers
 - When atrial pressure increases above intraventricular pressure, the AV valves **open**

Cardiac Cycle



Heart Sounds

- Lub - longer, louder heart sound
 - Caused by the **closing of the AV valves**
- Dup - short, sharp heart sound
 - Caused by the **closing of the semilunar valves**