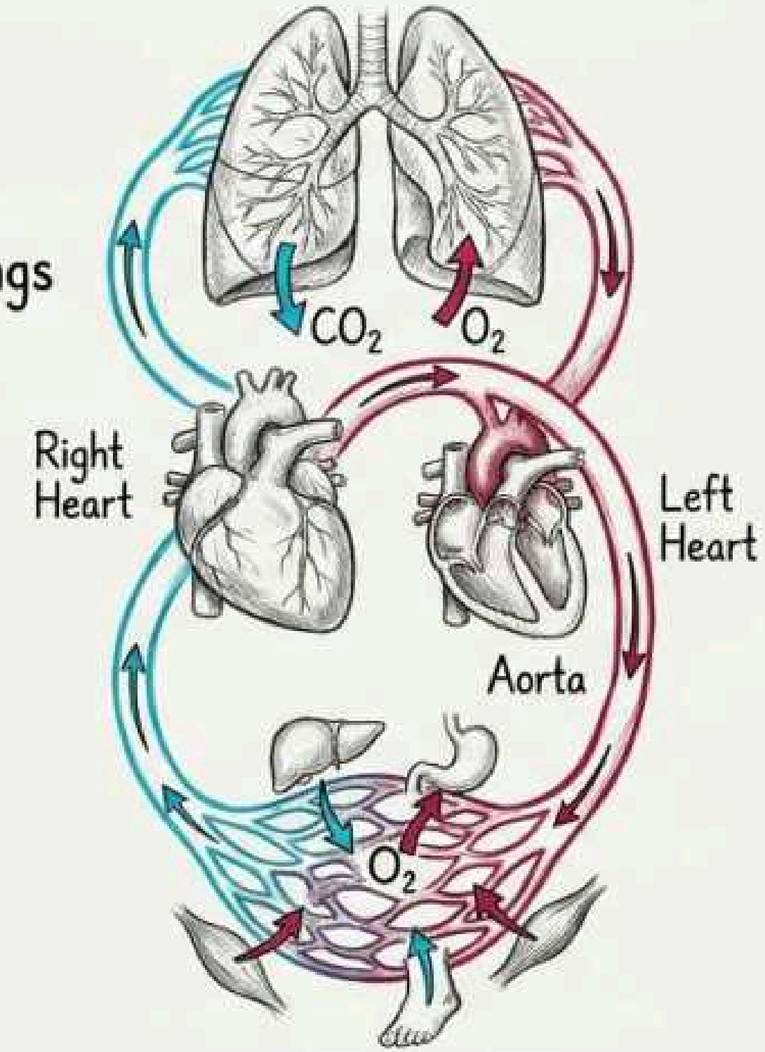
The Heart and Circulation: Two Pumps in Series

Right Side: Receives systemic blood → Lungs

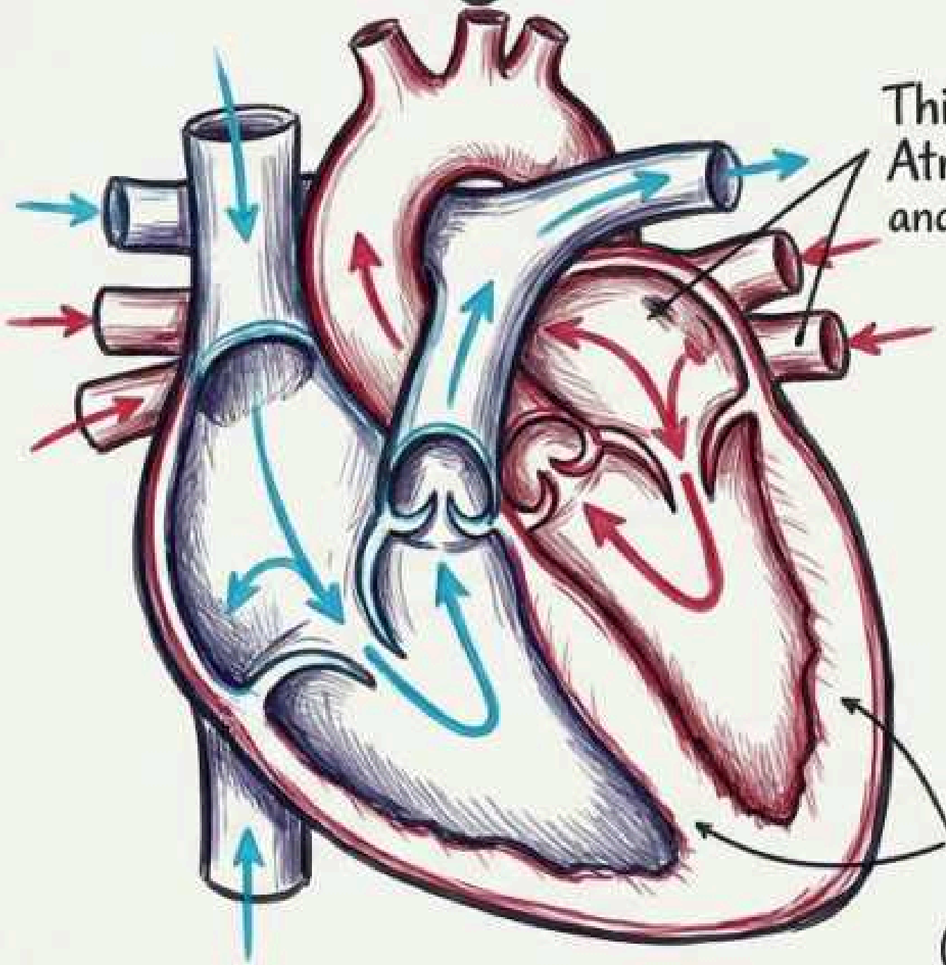


Left Side: Receives pulmonary blood → Aorta → Body

Series Circuit = Equal Output. Over time, Volume Right must equal Volume Left.

Gemini Notebook

Anatomy of the Pump: Chambers and Valves



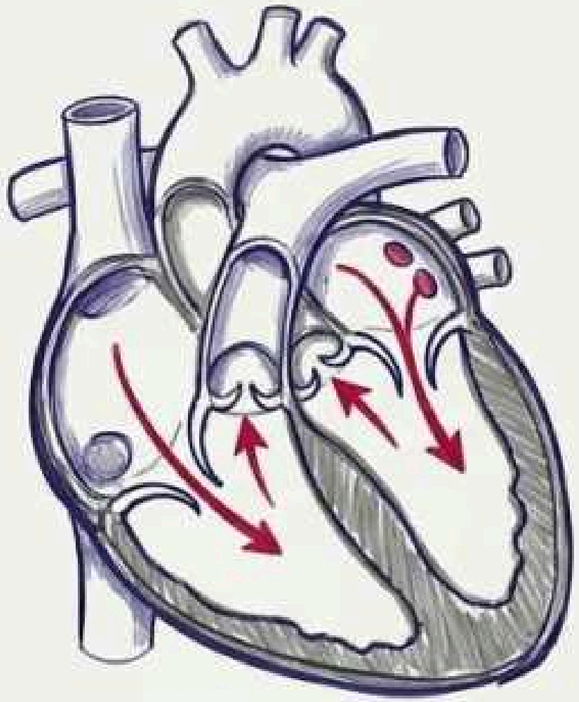
	Right Heart	Left Heart
Inlet (Atria to Ventricles)	Tricuspid	Mitral
Outlet (Ventricles to Exits)	Pulmonary	Aortic

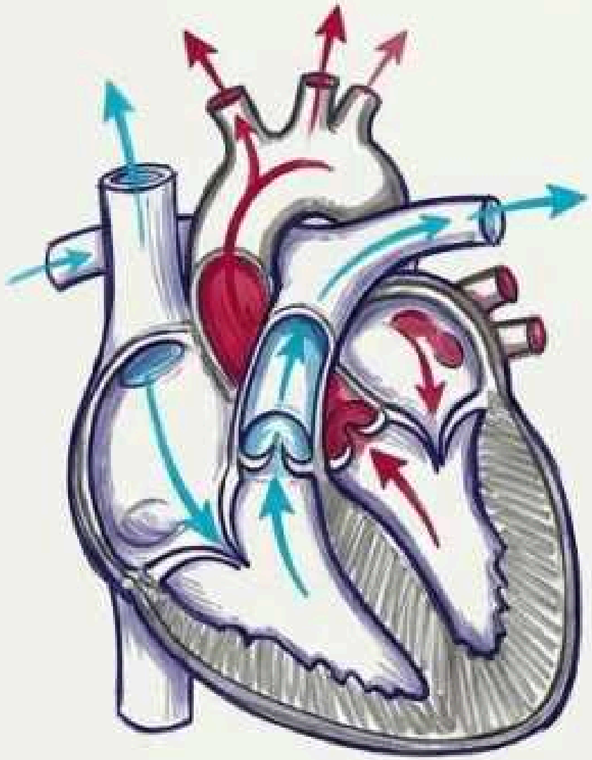
Four valves keep blood moving in one direction.

Gemini Notebook

The Cardiac Cycle & Heart Sounds

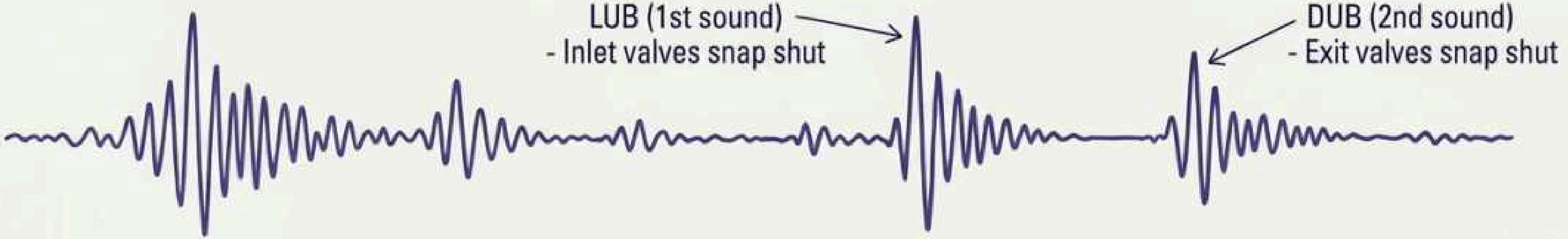
¶ 1.3





Diastole (Ventricles relax + fill)

Systole (Ventricles contract + pressure spikes + blood ejected)



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Cardiac Output (CO)

¶ 1.4

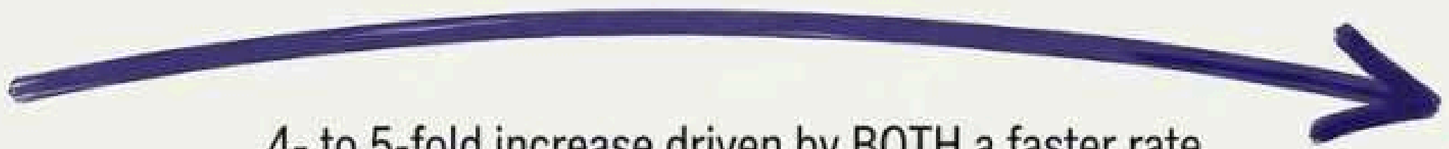
$$CO = HR \times SV$$

[CO = Cardiac Output (Volume pumped per minute)]

[HR = Heart Rate (Beats per minute)]

[SV = Stroke Volume (Amount ejected per beat)]

Adult at Rest →
~5 Litres/min



4- to 5-fold increase driven by BOTH a faster rate (increasing HR) and a larger stroke volume (increasing SV).

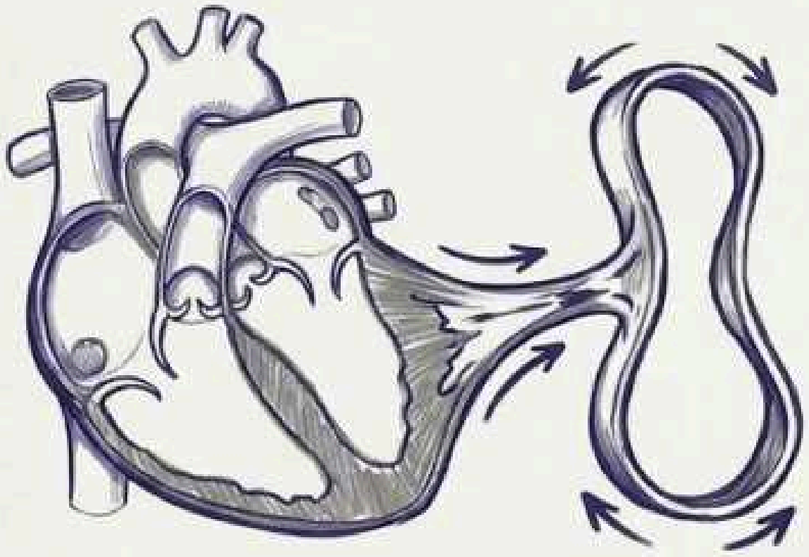
Hard Exercise →
20-25 Litres/min

Gemini Notebook

Three Determinants of Stroke Volume

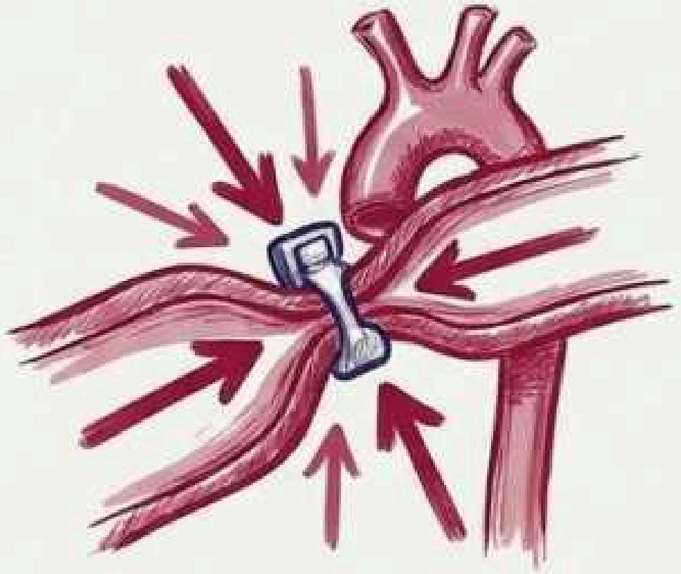
¶ 1.5

1. Preload



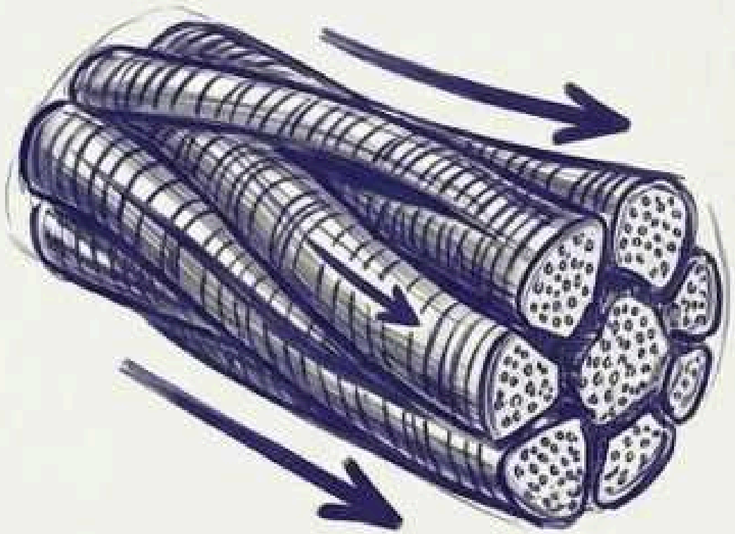
How much the ventricle is filled before it contracts.

2. Afterload



The resistance the ventricle must pump against (mainly arterial blood pressure).

3. Contractility



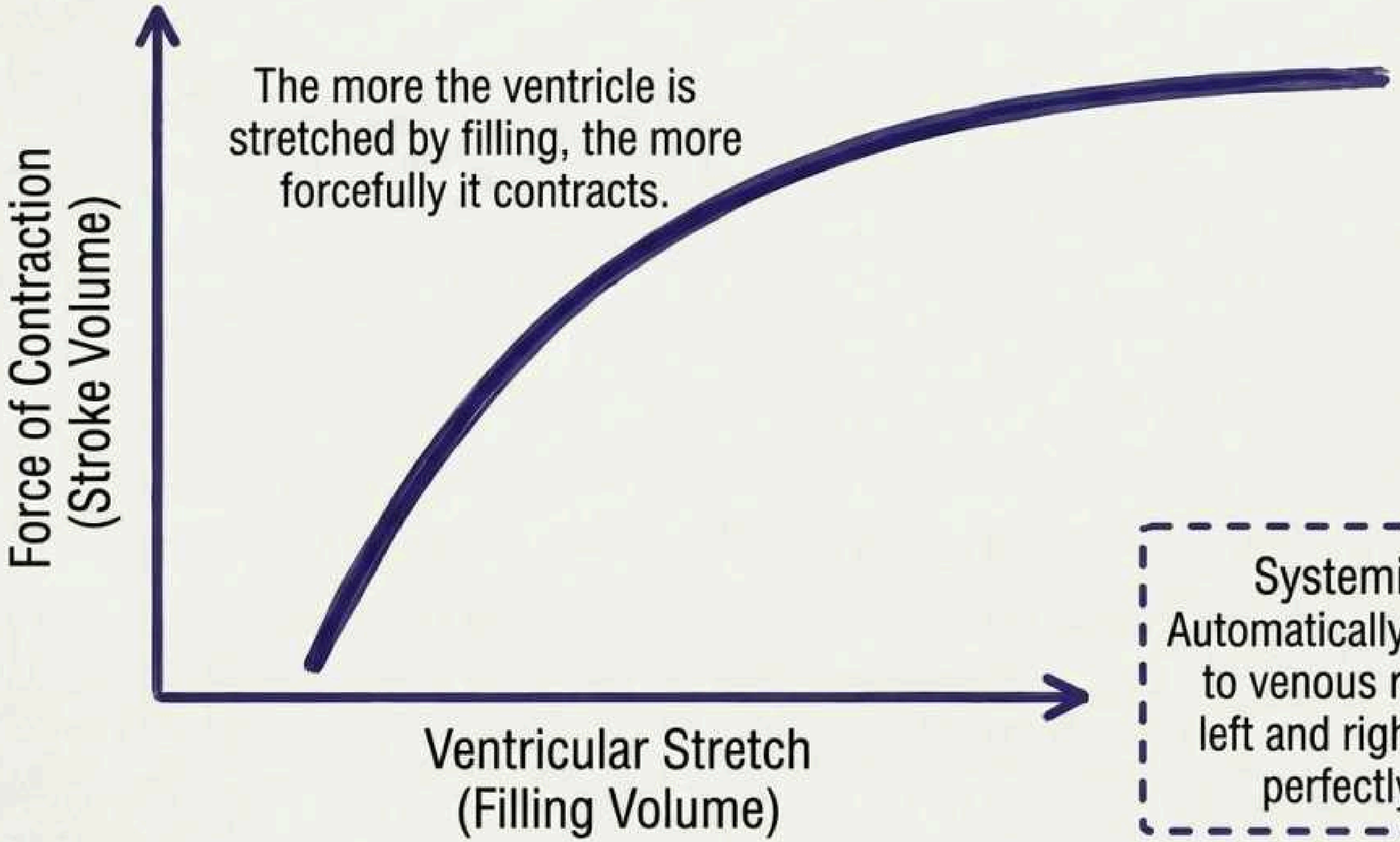
The inherent strength of the heart muscle's contraction at a given filling.

Many diseases and pharmacological drugs act by changing one of these three determinants.

Gemini Notebook

The Frank-Starling Mechanism

¶1.6



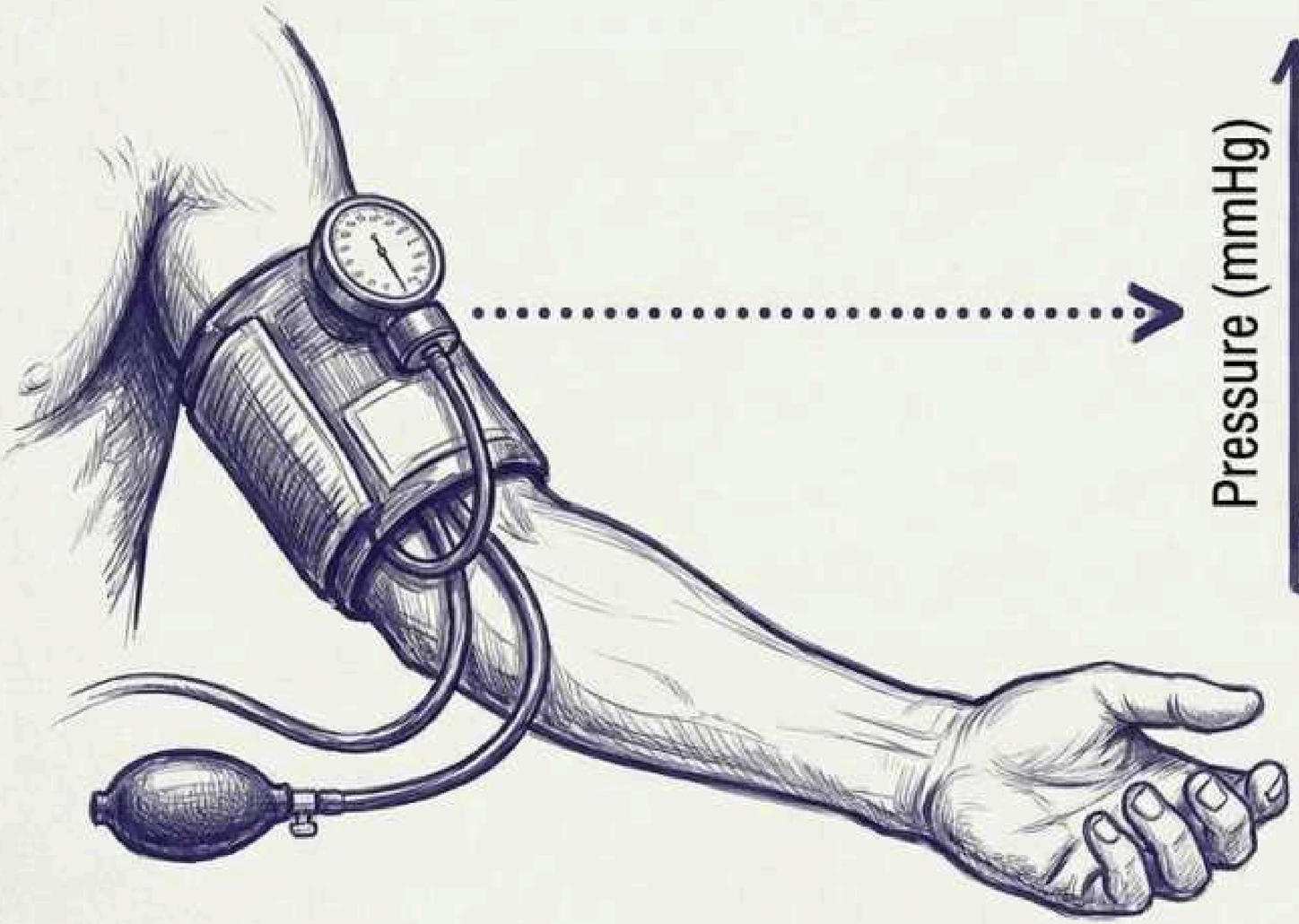
Systemic Purpose:
Automatically matches output to venous return, keeping left and right heart pumps perfectly balanced.

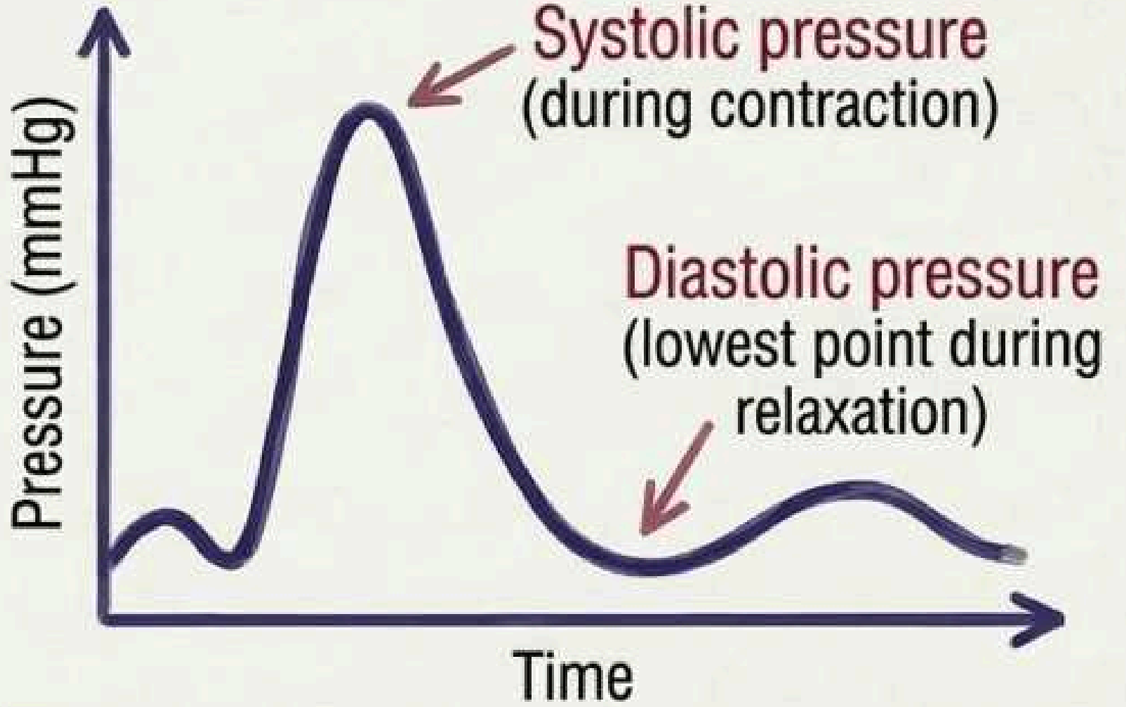
Gemini Notebook

Arterial Blood Pressure

¶1.7

Produced by the heart pumping blood into arteries that resist its flow.





120 / 80 mmHg

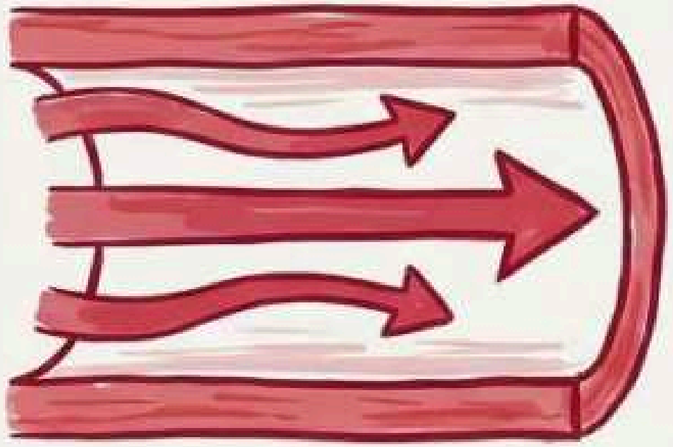
(Systolic / Diastolic)

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Vessel Resistance and Flow

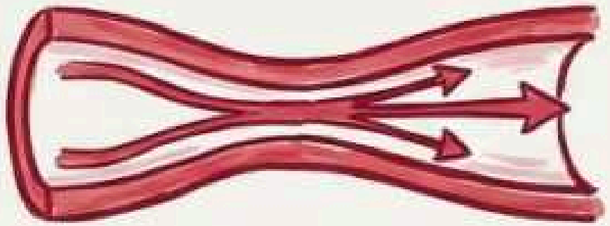
Flow depends on Pressure difference vs. Resistance.

Resistance is proportional to $\frac{1}{\text{radius}^4}$



Tube A: Radius r

Halving the radius increases resistance ~16-fold.



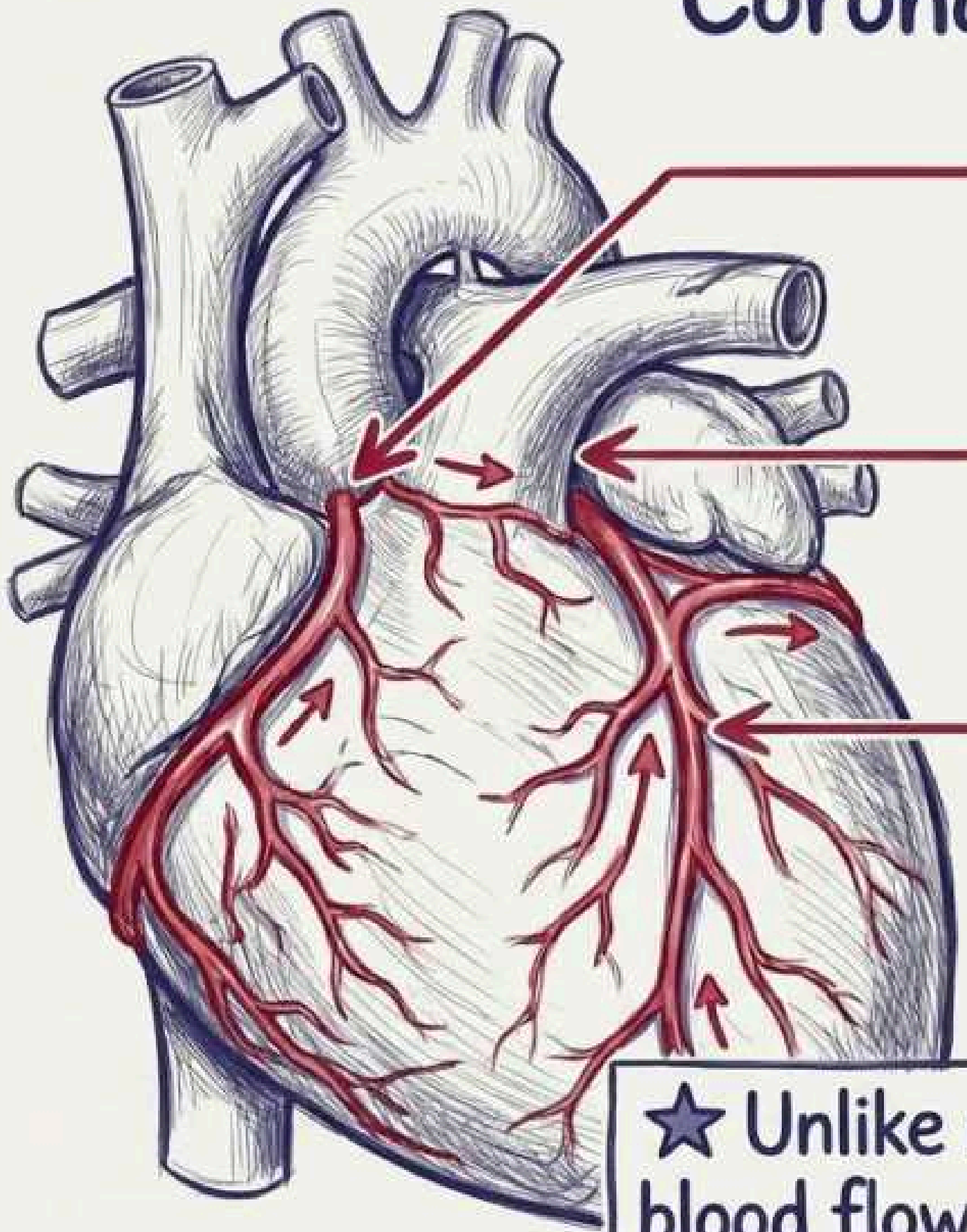
Tube B: Radius $\frac{1}{2}$r

Small changes in arterial width (from muscle tone or disease) cause massive effects on blood pressure and flow.

Gemini Notebook

Coronary Blood Supply

¶ 1.9



Branches directly from the aorta, just above the aortic valve.

Left Coronary Artery (LCA): Supplies front and side.

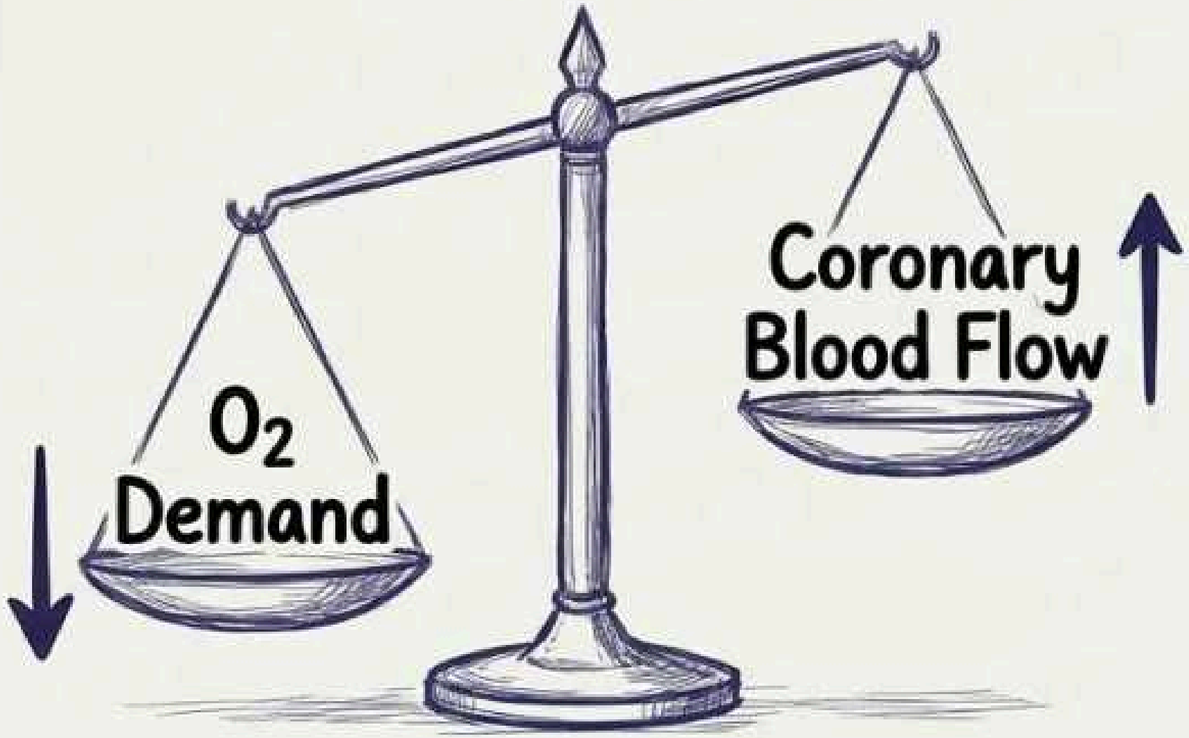
Right Coronary Artery (RCA): Supplies right side and back (in most people).

★ Unlike most organs, the heart receives most of its blood flow during **diastole**, when the muscle relaxes.

Gemini Notebook

Oxygen Extraction & Angina

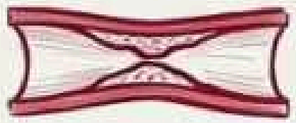
¶ 1.10

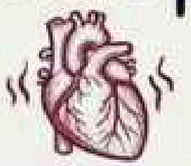


The Constraint: Heart muscle extracts ~100% of available O_2 from the blood even at rest.

The Solution: To get more O_2 during exercise, coronary blood flow must increase (flow is the only lever).

Narrowed arteries (plaque) → Limited maximum flow → O_2 starvation during work → Angina (ischemic pain)





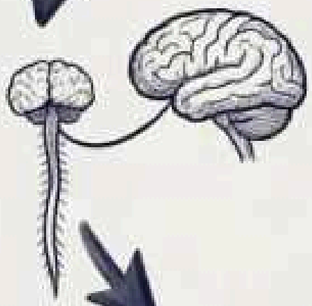
Gemini Notebook

Continual Regulation of Circulation

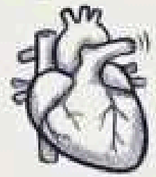
Short-Term Control (Seconds)



Sensors:
Baroreceptors (pressure sensors in neck/aorta)



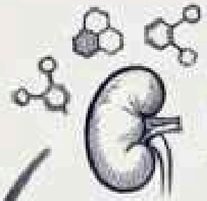
Controller:
Autonomic Nervous System



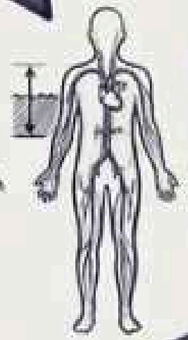


Effectors:
Instant adjustments to heart rate and vessel tone

Long-Term Control (Hours/Days)



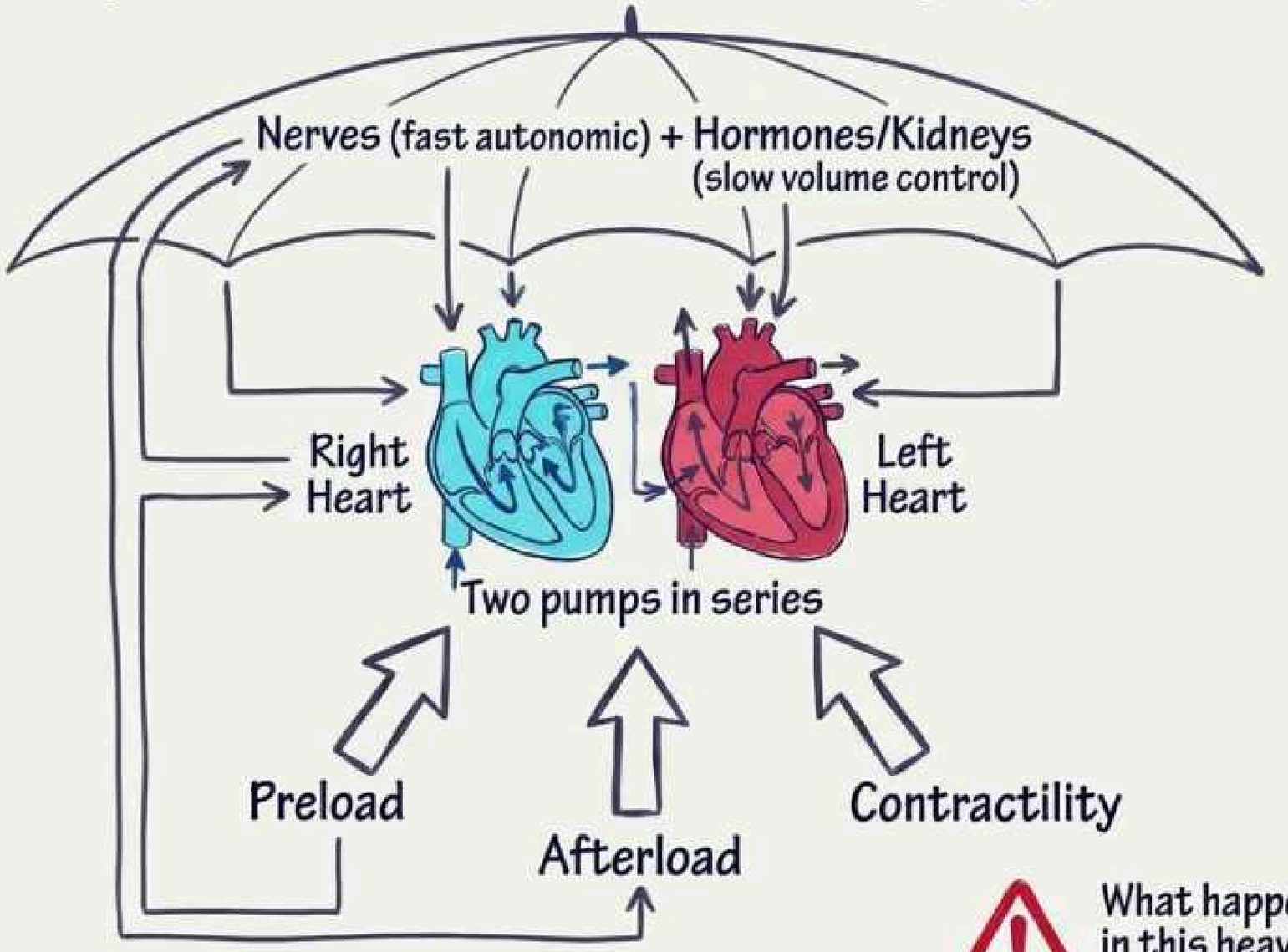
Controllers:
Hormones and the Kidneys



Effectors:
Adjustments to total blood volume in the circulation

Gemini Notebook

Synthesis: The Circulatory System



What happens when the pressure in this heavily regulated system is set too high?

Gemini Notebook