GSSE Physiology: Cardiovascular

Nick Skladnev + Louise Waterhouse

a. **Cardiac electrical physiology: generation of pacemaker potentials, anatomical details, conduction speeds, ventricular action potentials**
b. **Electrocardiography: mechanism of recording, leads**
c. **Mechanical events in the cardiac cycle, pressure-volume loops, normal pressures in cardiac chambers**
d. **Fick's principle of diffusion, and its relationship to calculating cardiac output**
e. **Factors controlling cardiac output (preload, afterload, and contractility), Frank-Starling law**
f. **Anatomical/histological differences throughout the vasculature (arteries, veins, and in between), including relative contribution to contained blood volume and contribution to peripheral resistance (i.e. resistance and capacitance vessels)**

g. Principles of laminar flow; Poiseuille formula for calculation of flow through a tube; critical closing pressure within capillaries
h. Bernoulli principle: kinetic and potential energy
i. Starling forces and movement of fluid across small vessels
j. Law of Laplace, as it relates to capillaries (and can then be extrapolated to heart failure, caecal perforation in bowel obstruction)
k. Venous pressures, and changes with position; mechanism of venous return from dependent areas; mechanism of air embolism
l. Circulating and regional control of vascular resistance/arteriole calibre – including feedback mechanisms (baroreceptors) and autonomic innervation
m. Haemostasis: formation of platelet plug and coagulation cascade, important anticoagulant/fibrinolytic mechanisms (thrombomodulin, antithrombin III)

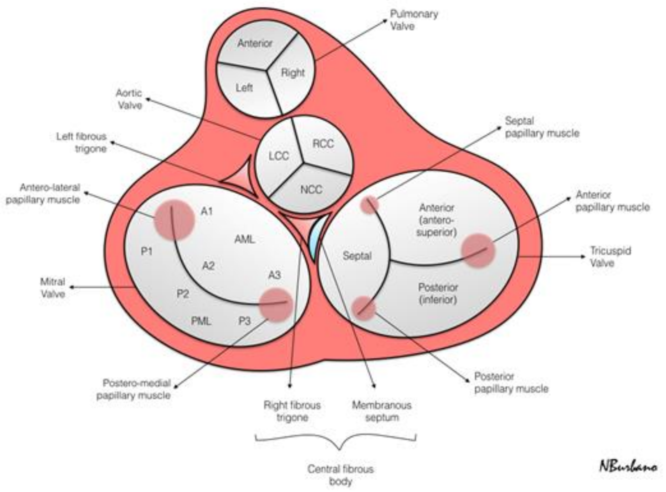


TABLE 29–1 Conduction speeds in cardiac tissue.

Tissue	Conduction Rate (m/s)
SA node	0.05
Atrial pathways	1
AV node	0.05
Bundle of His	1
Purkinje system	4
Ventricular muscle	1

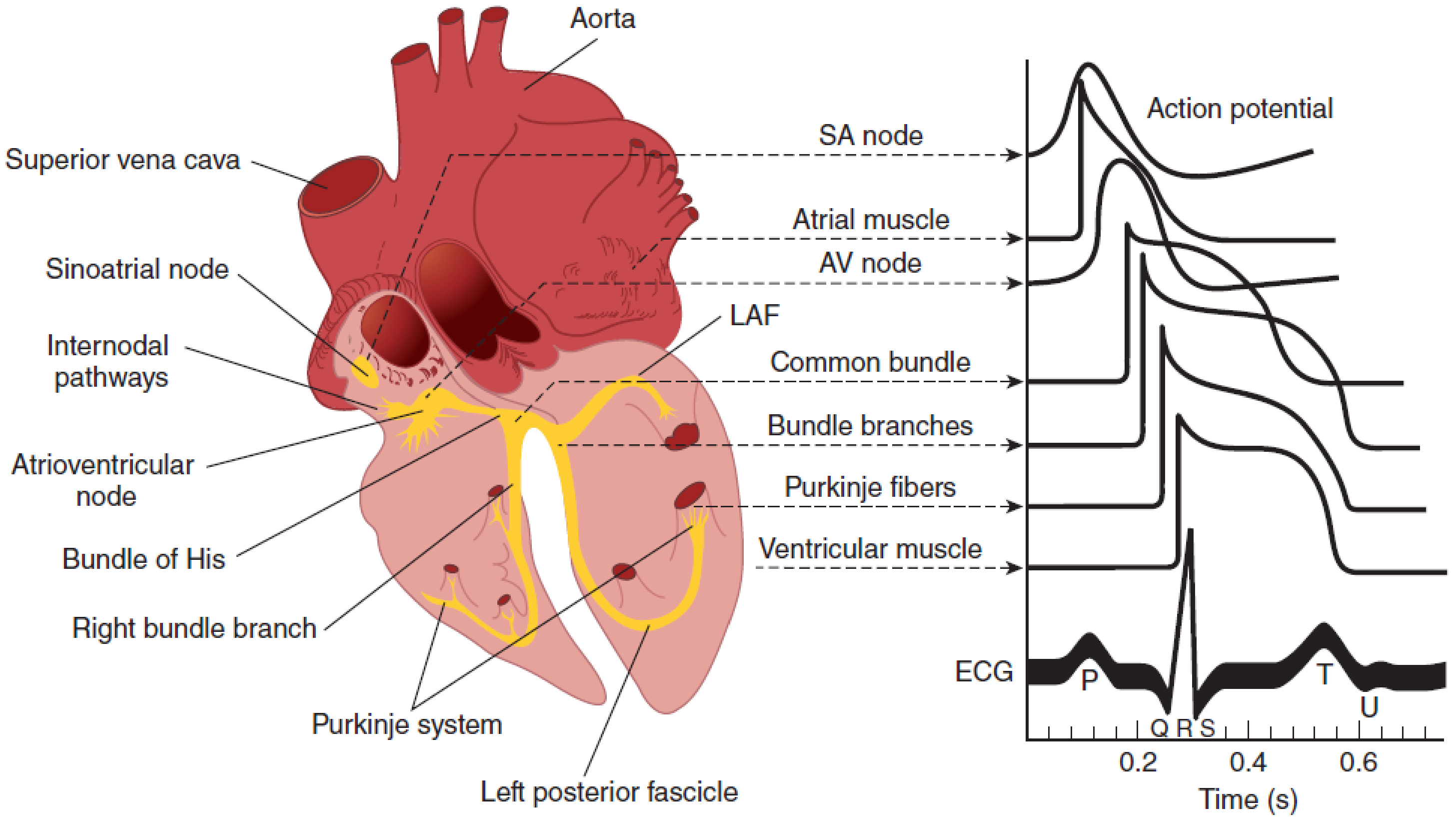
TABLE 29–2 ECG intervals.

Intervals	Normal Durations		Events in the Heart during Interval
	Average	Range	
PR interval[a]	0.18[b]	0.12–0.20	Atrioventricular conduction
QRS duration	0.08	to 0.10	Ventricular depolarization
QT interval	0.40[c]	to 0.43	Ventricular action potential
ST interval (QT minus QRS)	0.32	…	Plateau portion of the ventricular action potential

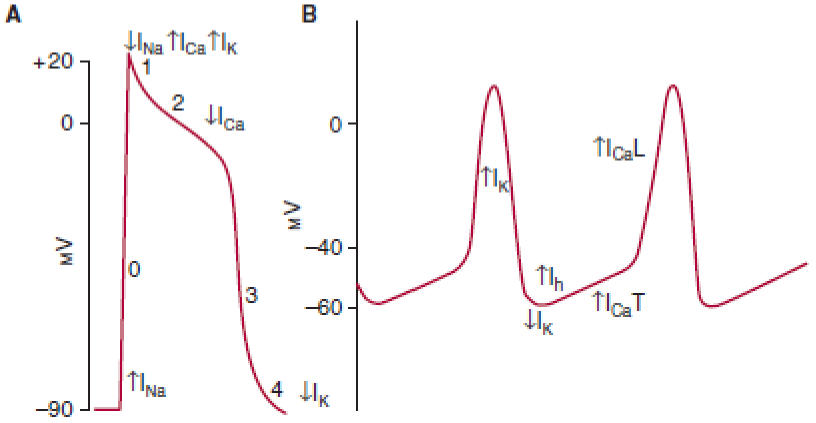
[a]Measured from the beginning of the P wave to the beginning of the QRS complex.

[b]Shortens as heart rate increases from average of 0.18 s at a rate of 70 beats/min to 0.14 s at a rate of 130 beats/min.

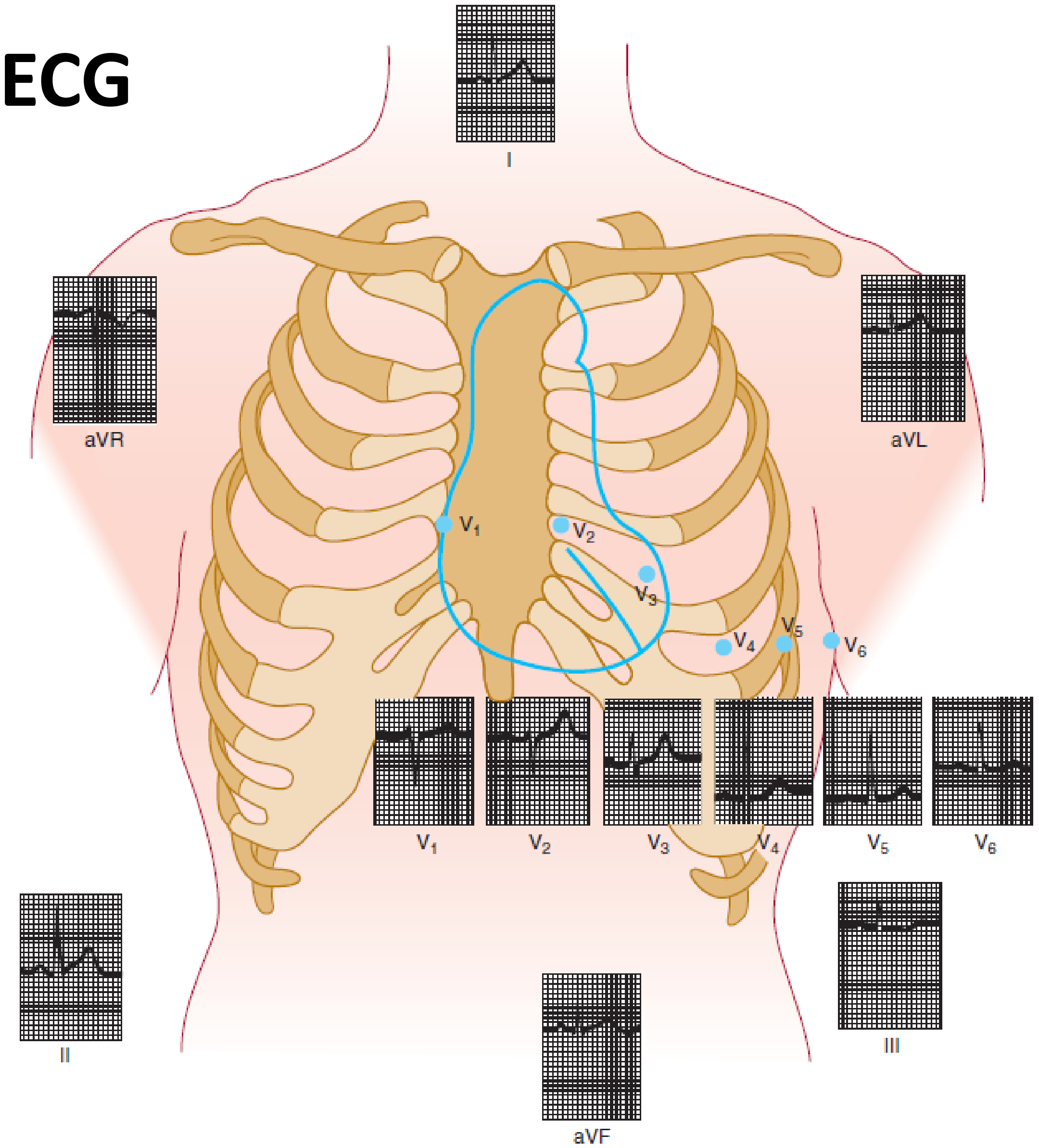
[c]Can be lower (0.35) depending on the heart rate.



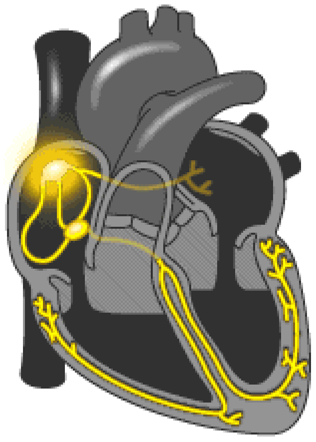
Electrophys

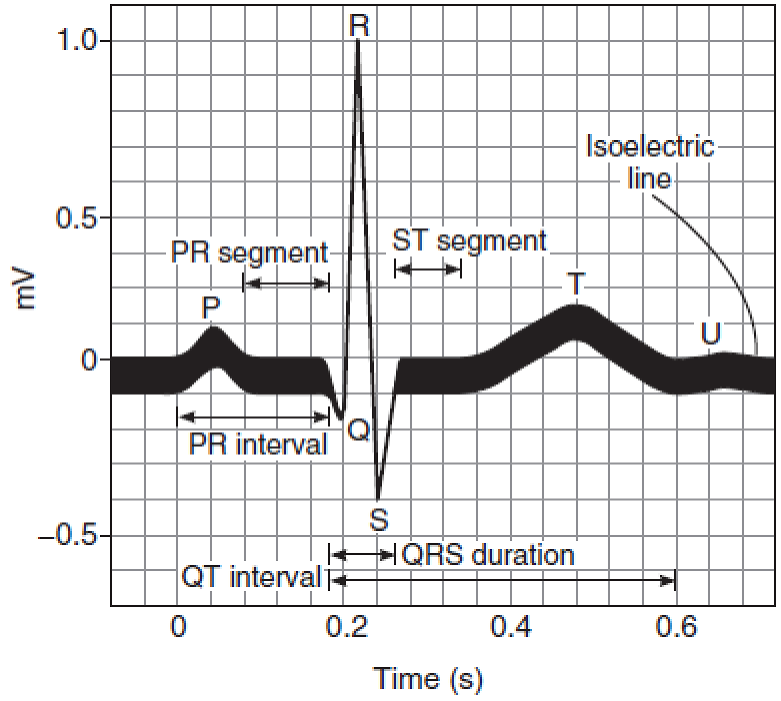


ECG

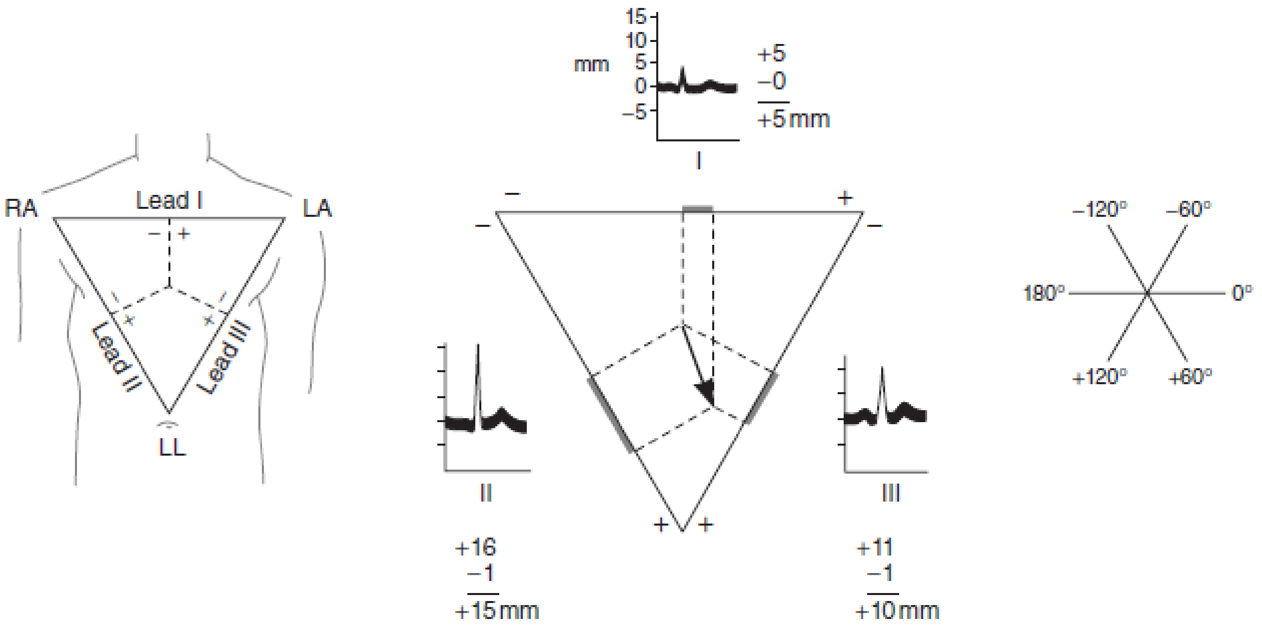


I
aVR
aVL
V1
V2
V3
V4
V5
V6
II
aVF
III





1.0
0.5
0
−0.5
mV
R
Isoelectric line
PR segment
ST segment
P
T
U
Q
PR interval
S
QRS duration
QT interval
0
0.2
0.4
0.6
Time (s)



RA
Lead I
LA
Lead II
Lead III
LL
mm
15
10
5
0
−5
+5
−0
+5mm
I
II
+16
−1
+15mm
III
+11
−1
+10mm
−120°
−60°
180°
0°
+120°
+60°

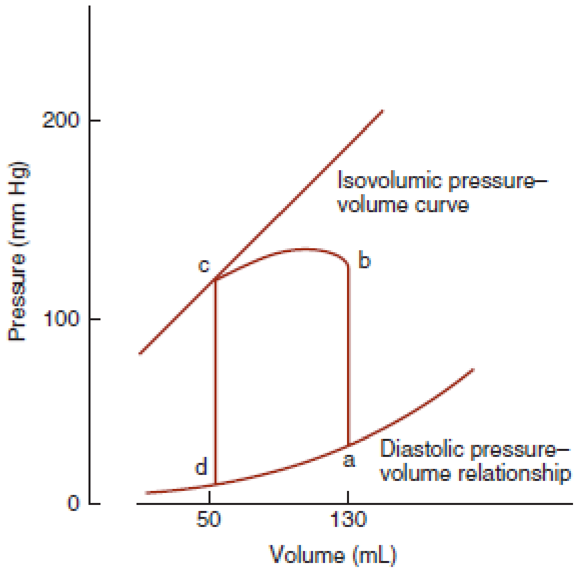
Q: Concerning the conducting system of the heart

F 1: stimulation of cholinergic vagal fibres to nodal tissue decreases potassium ion conductance

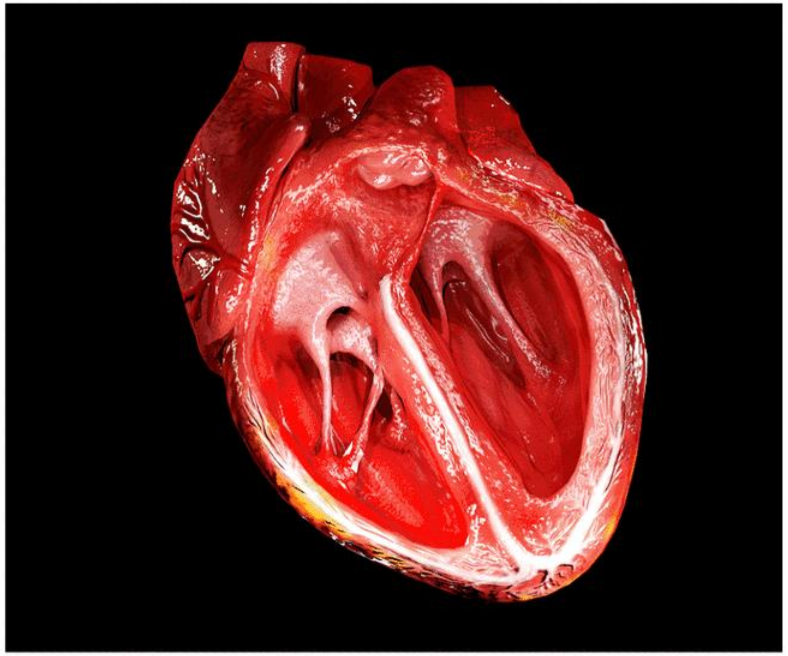
F 2: depolarization of the ventricular muscle starts on the right side of the interventricular system

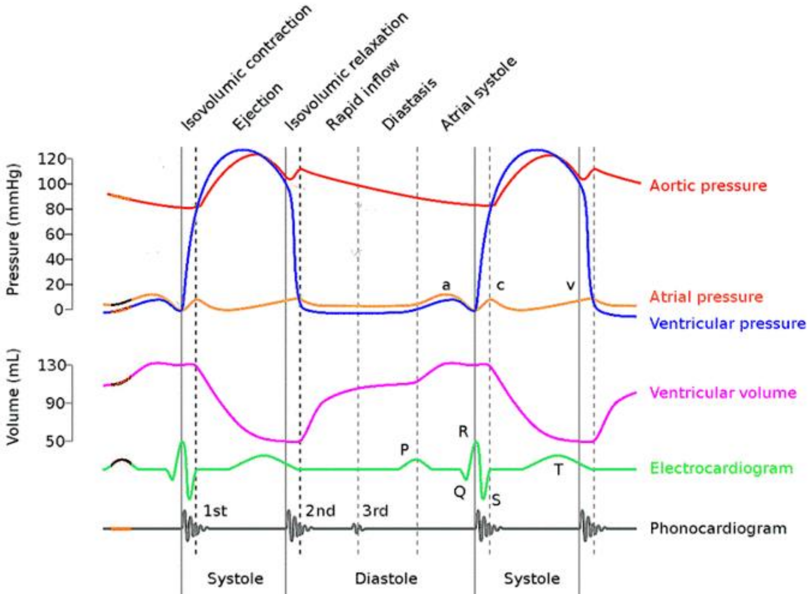
F 3: the last part of the heart depolarized is the epicardial surface of the left ventricular apex

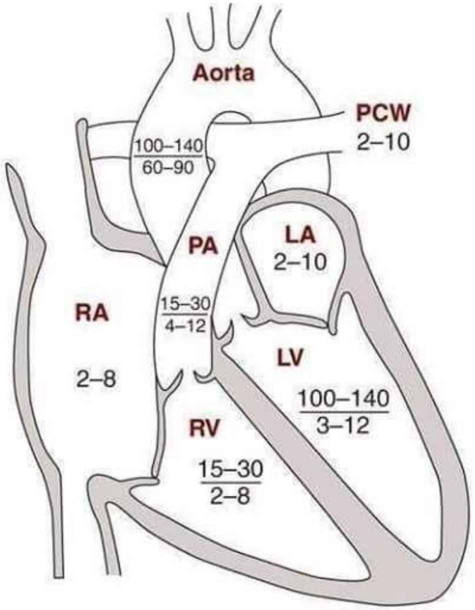
T 4: stimulation of sympathetic cardiac nerves results in increased intracellular cyclic AMP

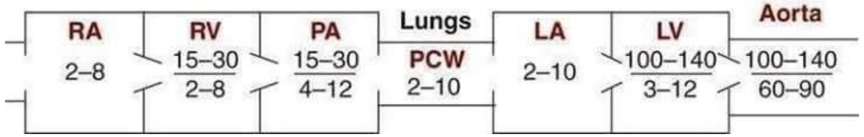


Cardiac Cycle









Q – Isometric contraction of the left ventricle

A. occurs during the first third of systole
B. involves the most rapid change in pressure per unit time in the cardiac cycle
C. occurs after closure of the aortic valve
D. is terminated at the T wave of the ECG
E. is responsible for ejection of a majority of the stroke volume

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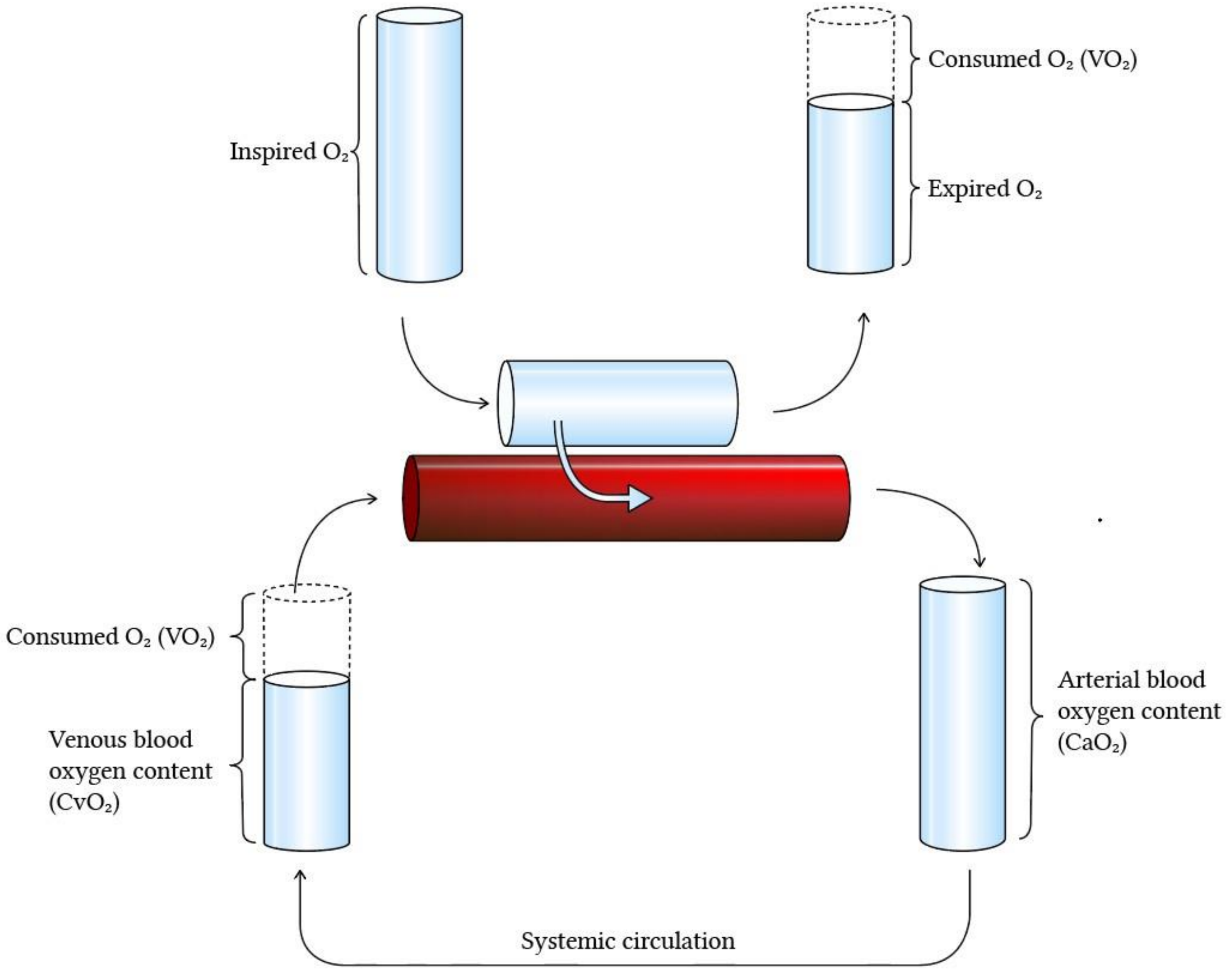
Output

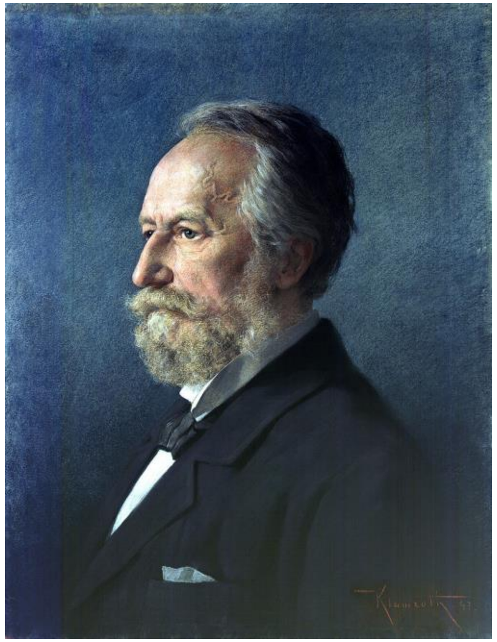
FICK'S PRINCIPLE OF DIFFUSION

Direct (blood) vs Indirect (EtCO2/SpO2)

$$\dot{V}O_2 = CO \times (C_aO_2 - C_aO_2)$$

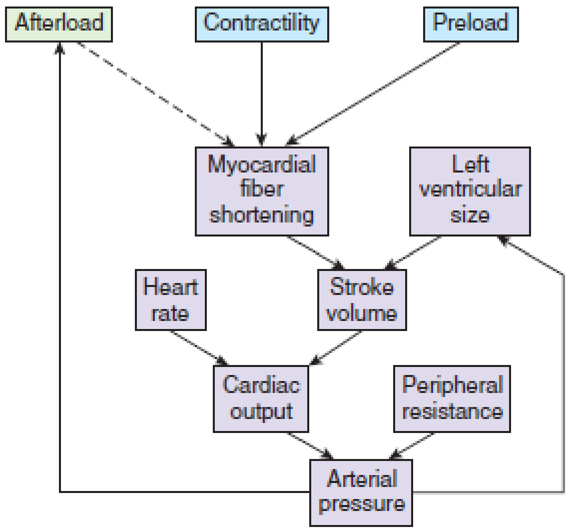


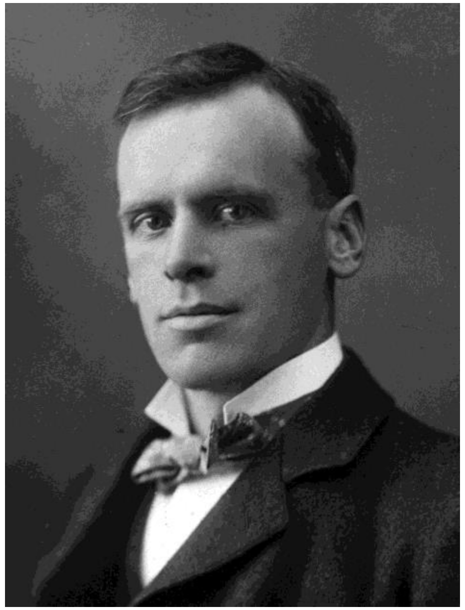
CO = SV x HR

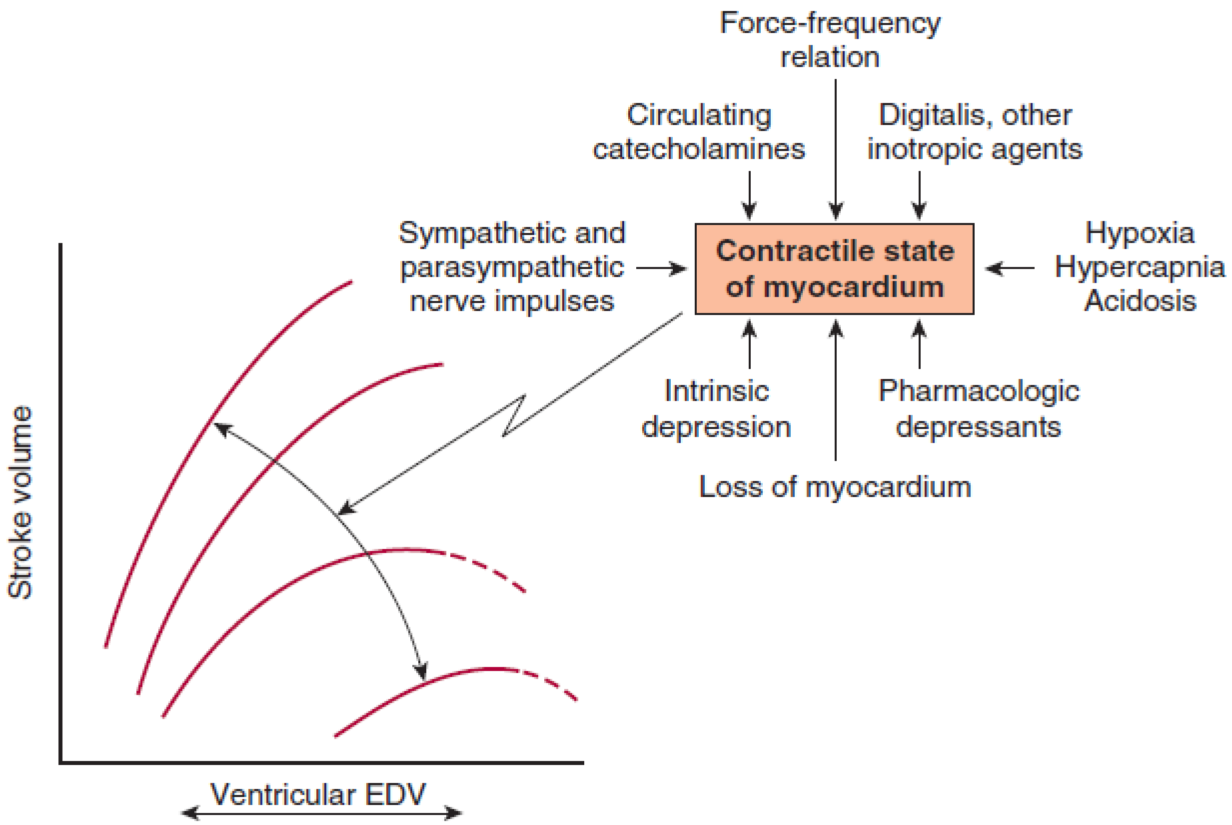


Nephew = contact lenses

Output modifiers







CO = SV x HR

Plumbing

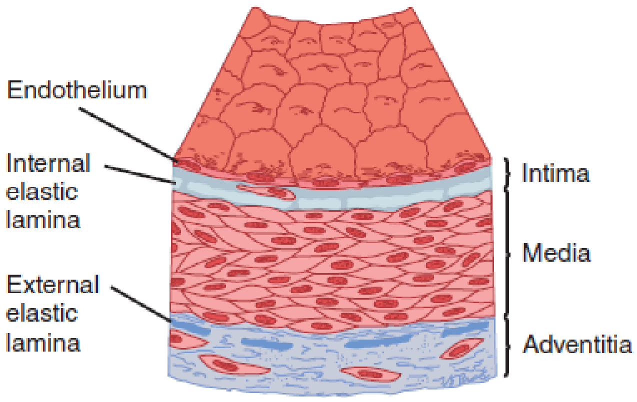
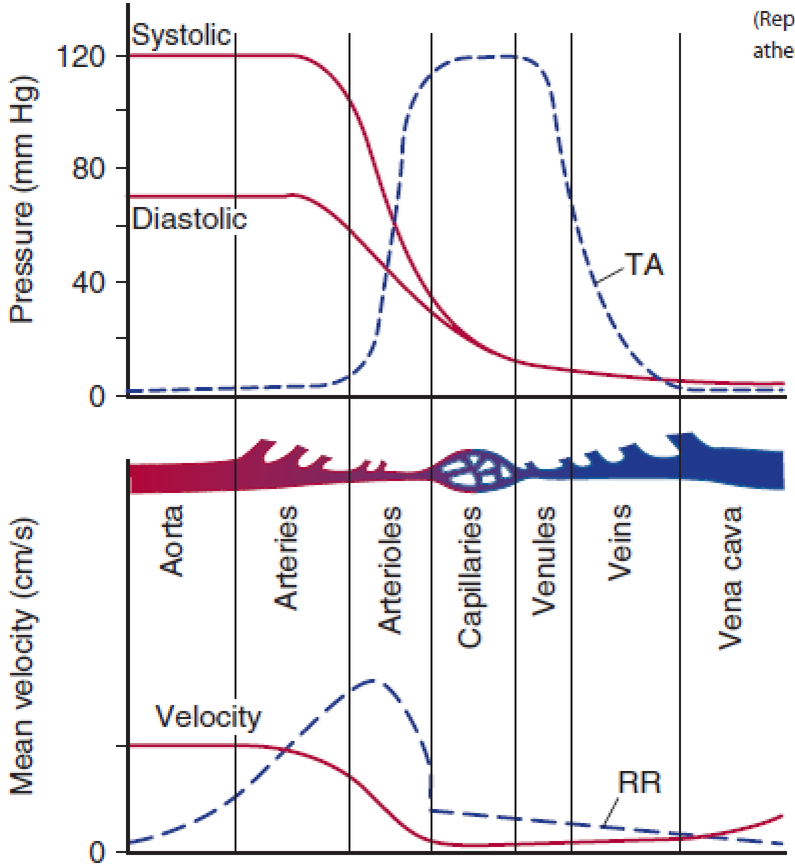


FIGURE 31–15 **Structure of a normal muscle artery.**
(Reproduced with permission from Ross R, Glomset JA: The pathogenesis of atherosclerosis. N Engl J Med 1976; Aug 12; 295(7):369–377.)

Capacitance vs resistance



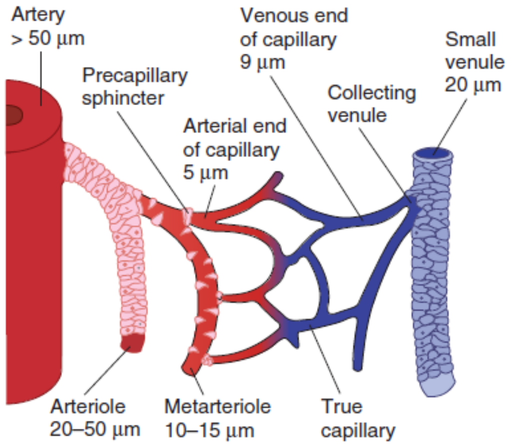


TABLE 31–9 **Characteristics of various types of blood vessels in humans.**

			All Vessels of Each Type	
Vessel	Lumen Diameter	Wall Thickness	Approximate Total Cross-Sectional Area (cm²)	Percentage of Blood Volume Contained[a]
Aorta	2.5 cm	2 mm	4.5	2
Artery	0.4 cm	1 mm	20	8
Arteriole	30 µm	20 µm	400	1
Capillary	5 µm	1 µm	4500	5
Venule	20 µm	2 µm	4000	
Vein	0.5 cm	0.5 mm	40	54
Vena cava	3 cm	1.5 mm	18	

[a]In systemic vessels; there is an additional 12% in the heart and 18% in the pulmonary circulation.