"Houston is full of murderers, mosquitoes and Methodists."

T. H. House, 1839

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Assistant Professor

University of Texas Health Science Center at Houston
and Texas Heart Institute at St. Luke's Episcopal Hospital
Houston, Texas, USA

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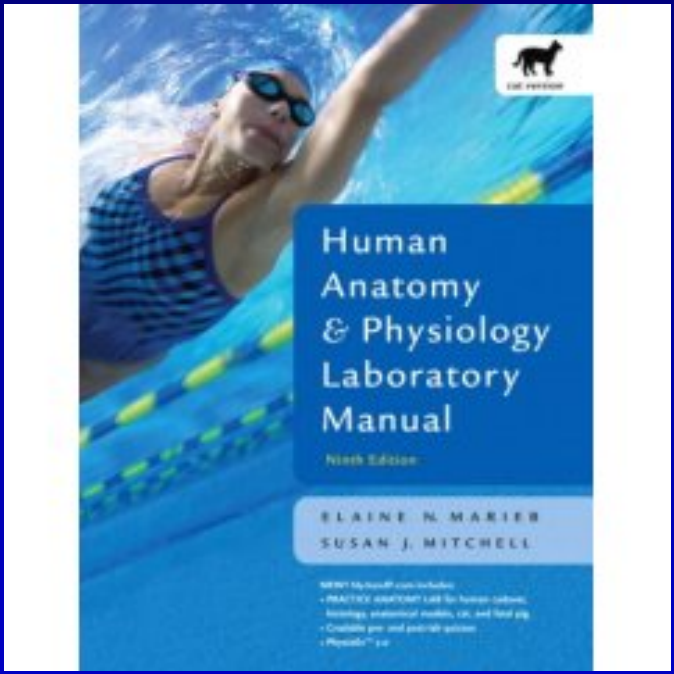

Human Anatomy and Physiology Lab Manual, Cat Version (9th Edition) (Spiral-bound)
by Elaine N. Marieb (Author), Susan J. Mitchell (Author)

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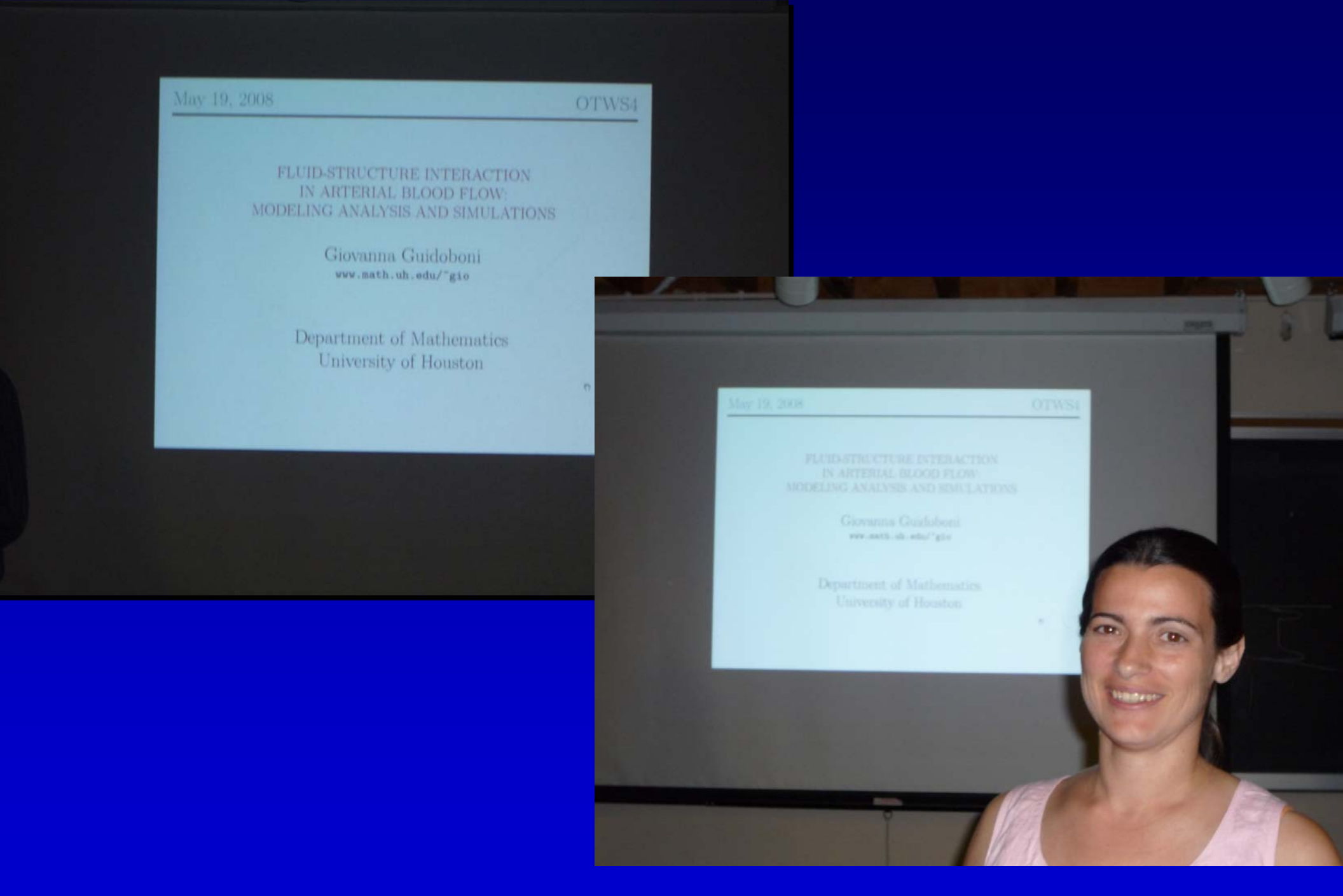
women's luncheon


NOTHING IS TOO WONDERFUL
TO BE TRUE.
FARADAY


May 19, 2008
OTWS4
FLUID-STRUCTURE INTERACTION
IN ARTERIAL BLOOD FLOW:
MODELING ANALYSIS AND SIMULATIONS
Giovanna Guidoboni
www.math.uh.edu/~gio
Department of Mathematics
University of Houston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IPAM

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The Cardiovascular System

Pump

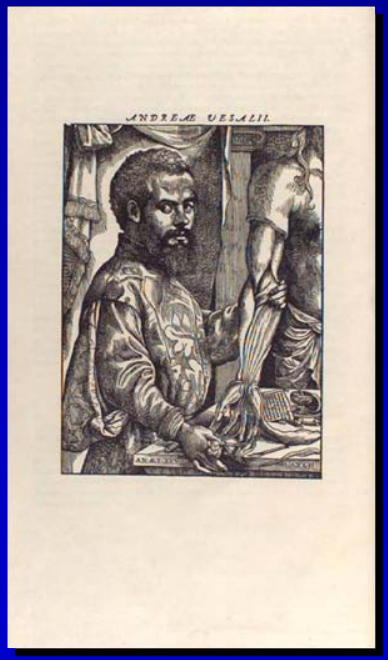
Pipes

Fluid

4.Clip external heart 4/9

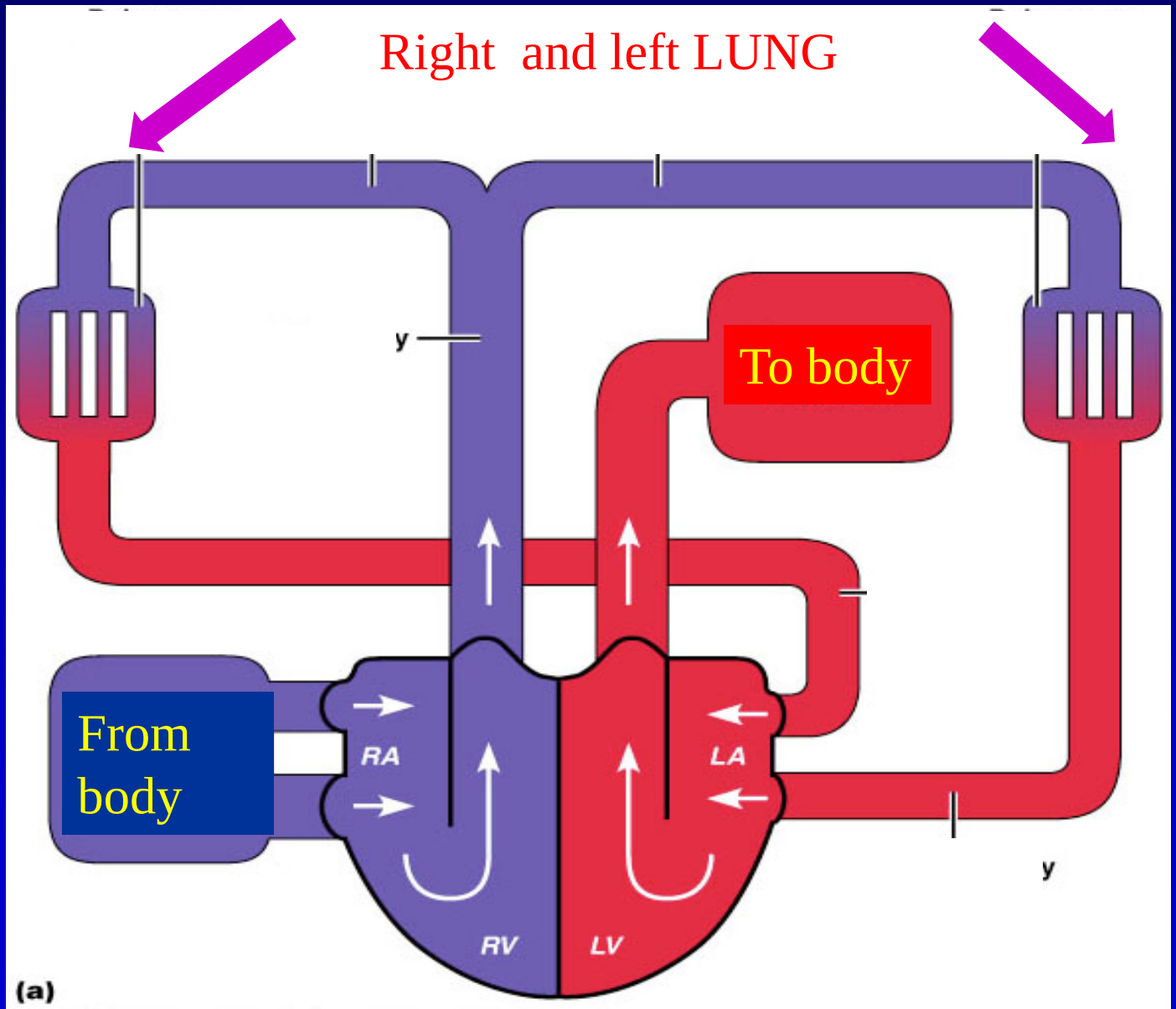
Physiology and Medicine in Antiquity and the Renaissance

Title page to the first edition of Vesalius'
De Humani Corporis Fabrica, 1543



Andreas Vesalius (1514-64) Professor of Anatomy at the Univ. of Padua, Italy

How is the CVS built?



Pump - Heart

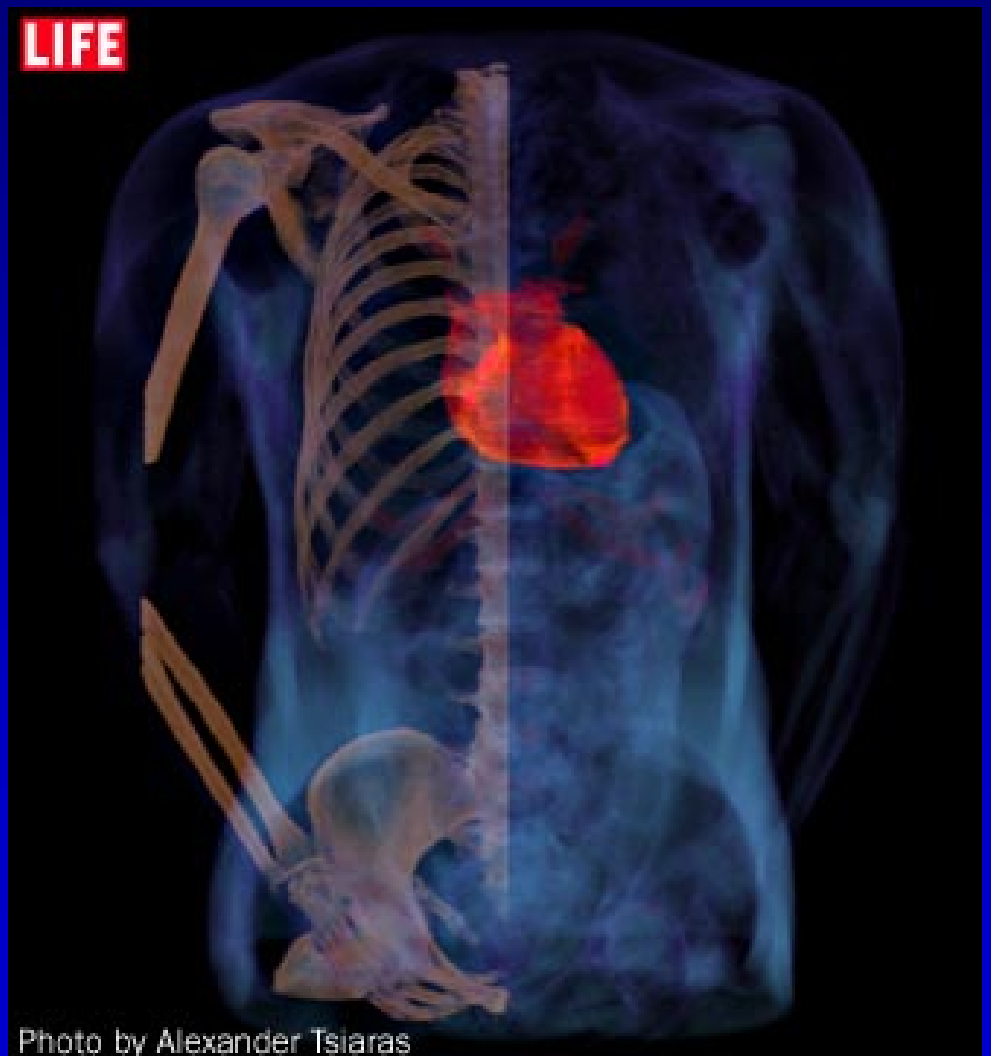
Pipes - Vessels

Fluid - Blood

5.Clip external heart 5/9

The Cardiovascular System

The center is the Heart



Heart~ Engine

The human heart can be compared to the engine of a car—both are power units that keep bodies moving.

Your heart works as a pump that pushes blood to the organs, tissues, and cells of your body.

The blood pumped by the heart delivers oxygen and nutrients to every cell and removes the carbon dioxide and waste products made by those cells.

The heart in the ancient world 3000-525 BC

*The **heart** was the source of good and evil within a person, the moral awareness and centre of thought that could leave the body at will, and live with the gods after death, or be eaten by Ammut as the final death if it failed to weigh equally against Ma'at.

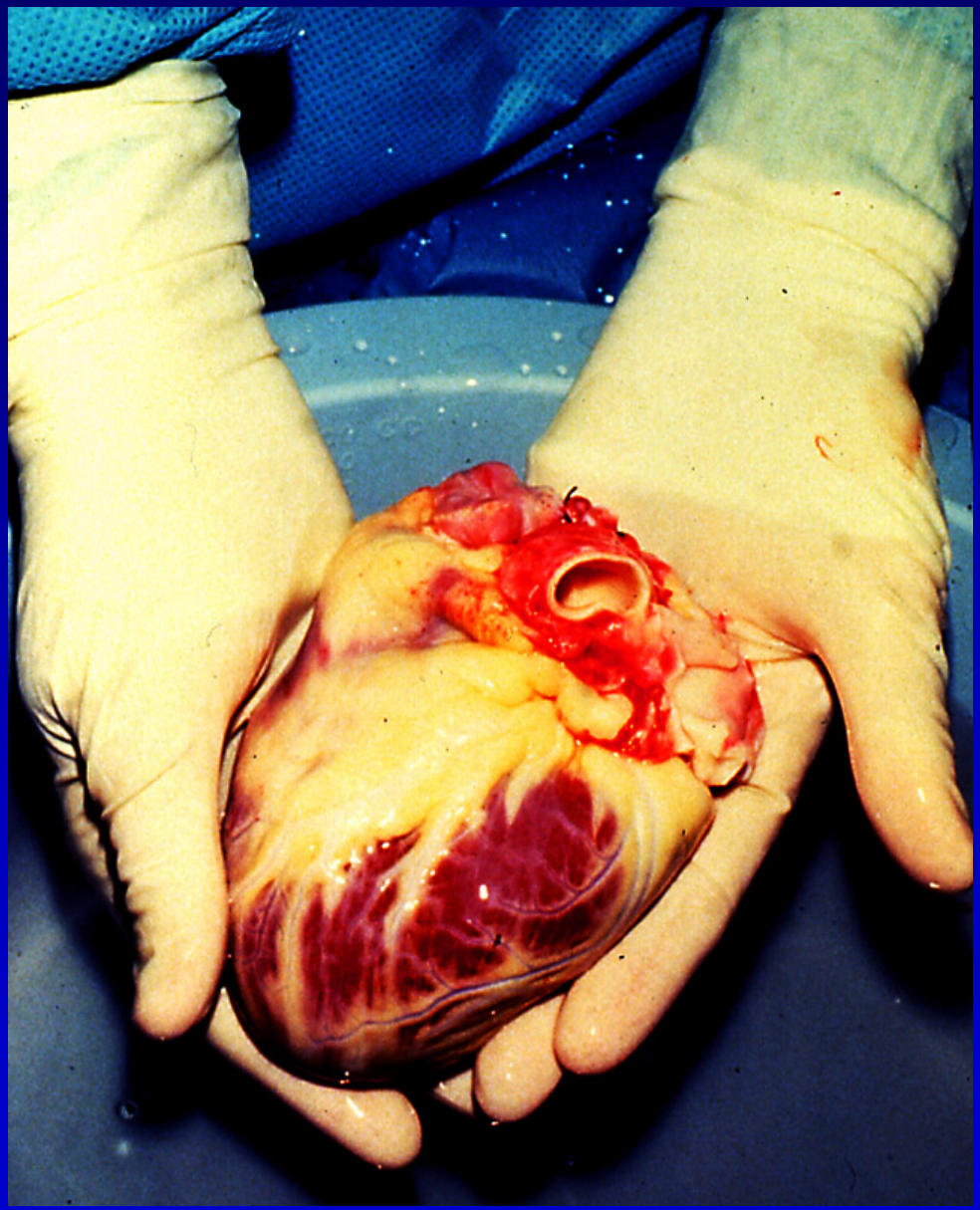
Ammut.
She was the Egyptian demoness of punishment.
Known as the 'Eater of Hearts', 'The Devourer' and 'Great of Death'

Ma'at .

She was the Egyptian goddess of truth, order, balance, justice and harmony.

*The Ancient Egyptian Concept of the Soul *by Caroline Seawright*

How is the heart build?

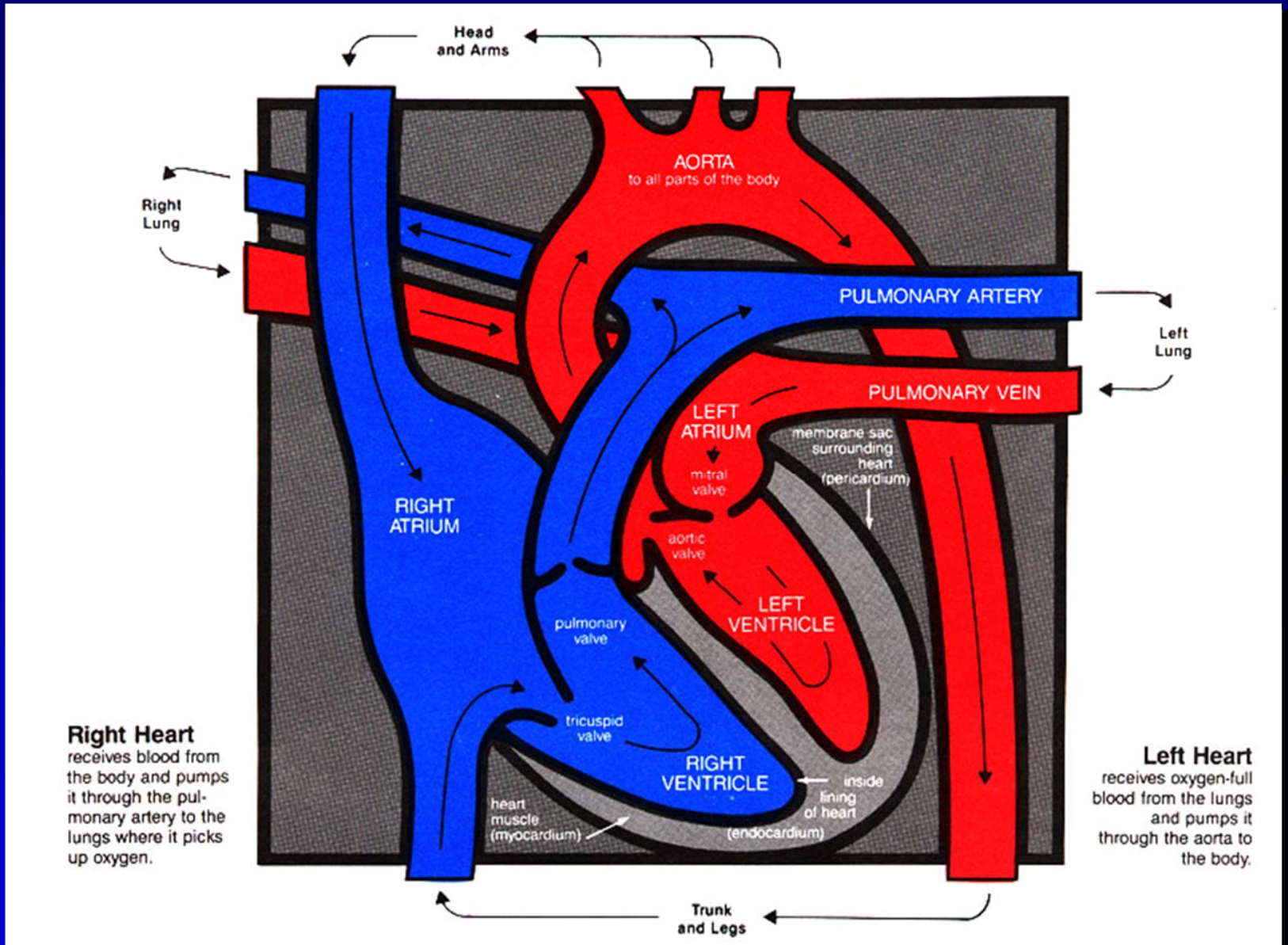


How is the heart build?

4 chambers

4 valves

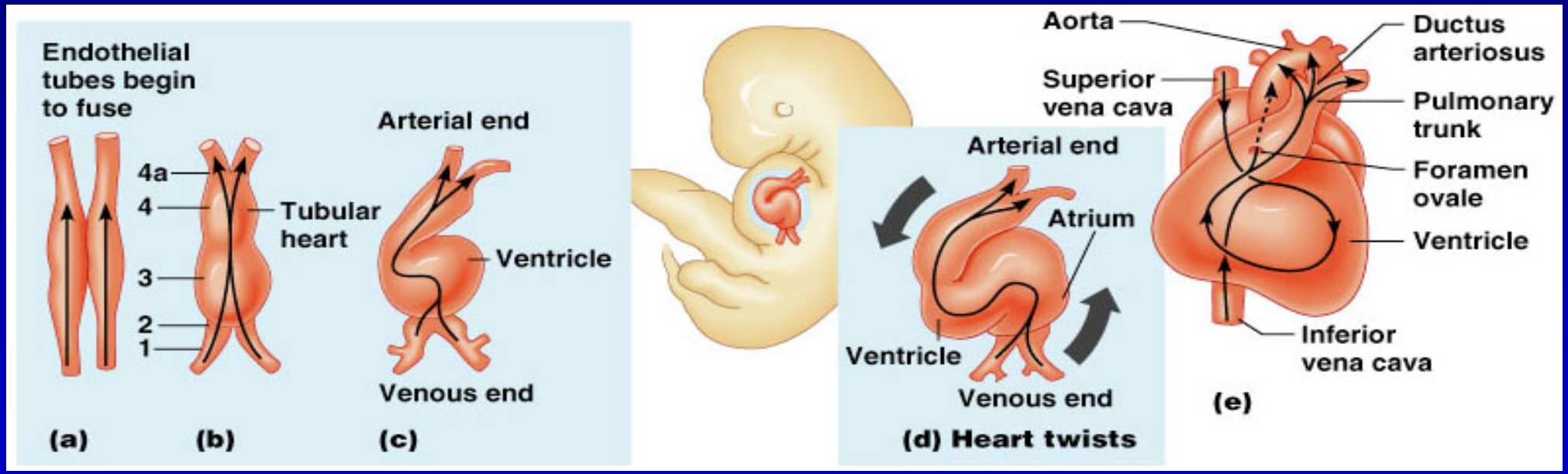
4 Vessels



Developmental Aspects of the Heart

4 chambers

2 chambers: ATRIA



2 chambers: VENTRICLE

http://www.indiana.edu/~anat550/cvanim/htube_overview/htube_overview.ht

4 Vessels

From the heart :

Arteries

Pulmonary Artery

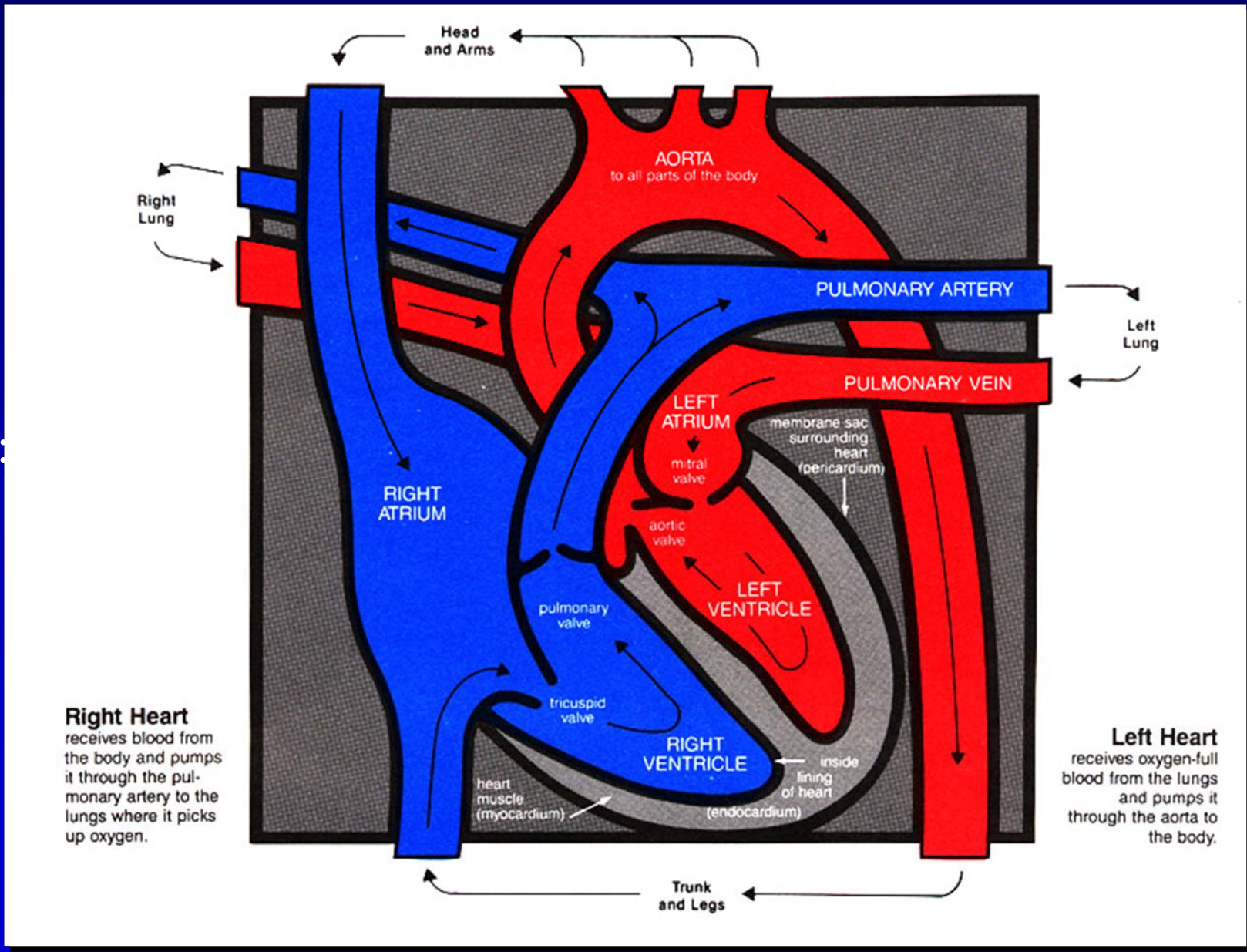
Aorta

Towards the heart :

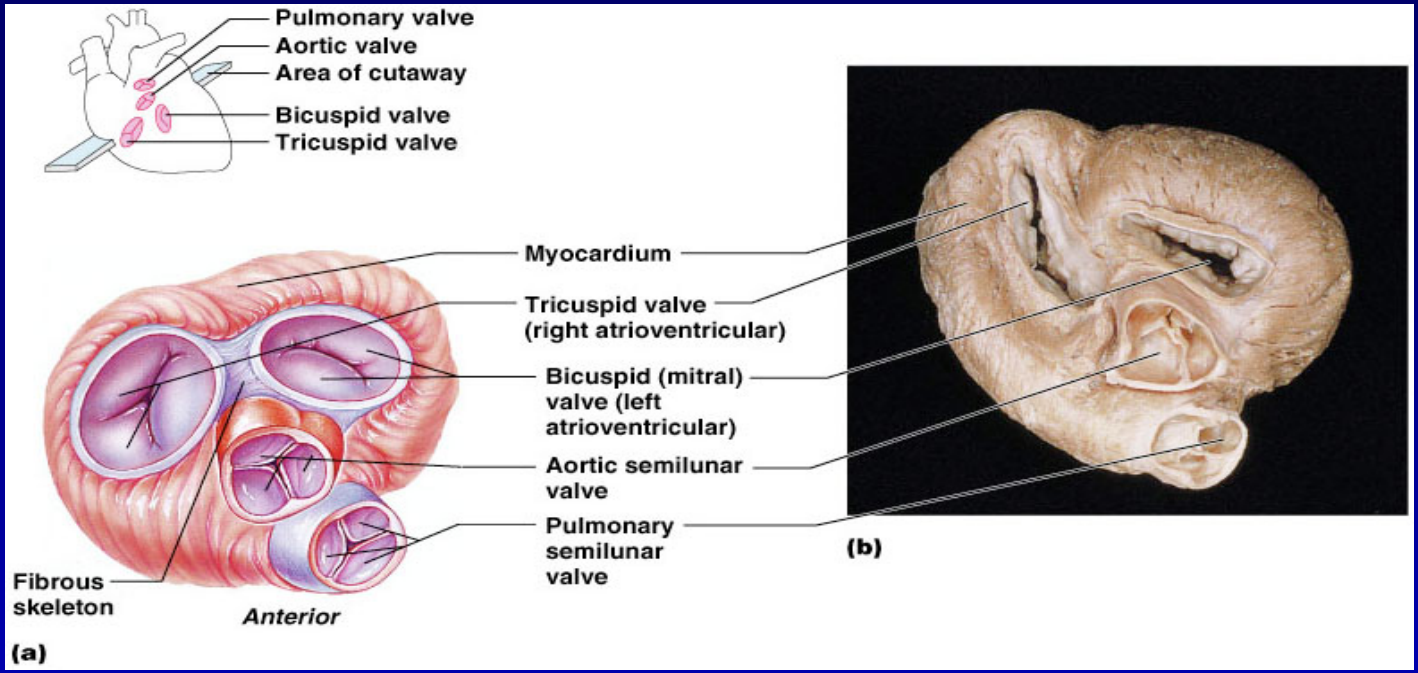
Veins

Pulmonary Vein

Vena cava



4 Heart Valves

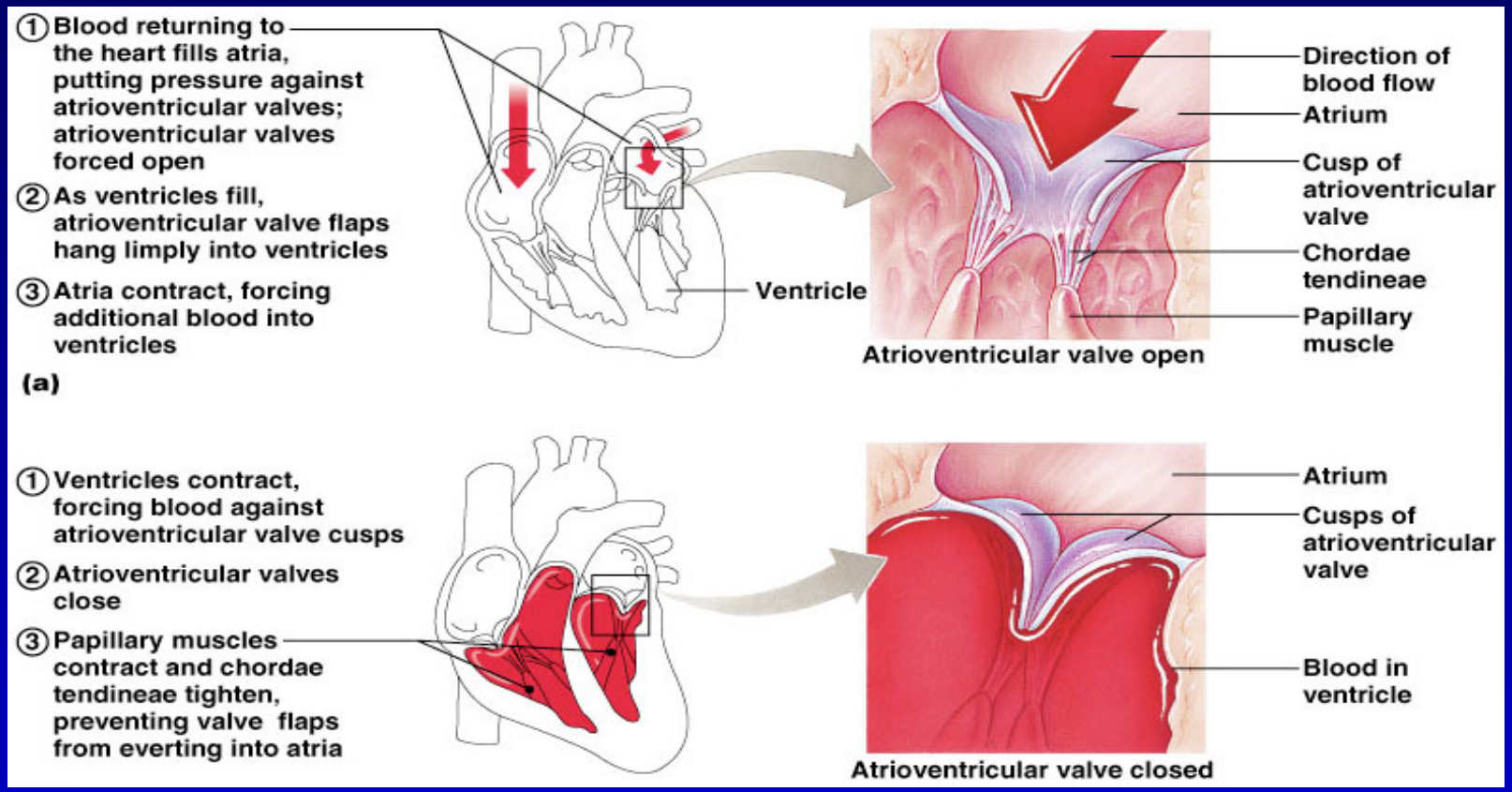


Heart valves ensure unidirectional blood flow through the heart

- 2 Atrioventricular valves : between atria , ventricles
  - Tricuspid valve (right)
  - Mitral valve (left)

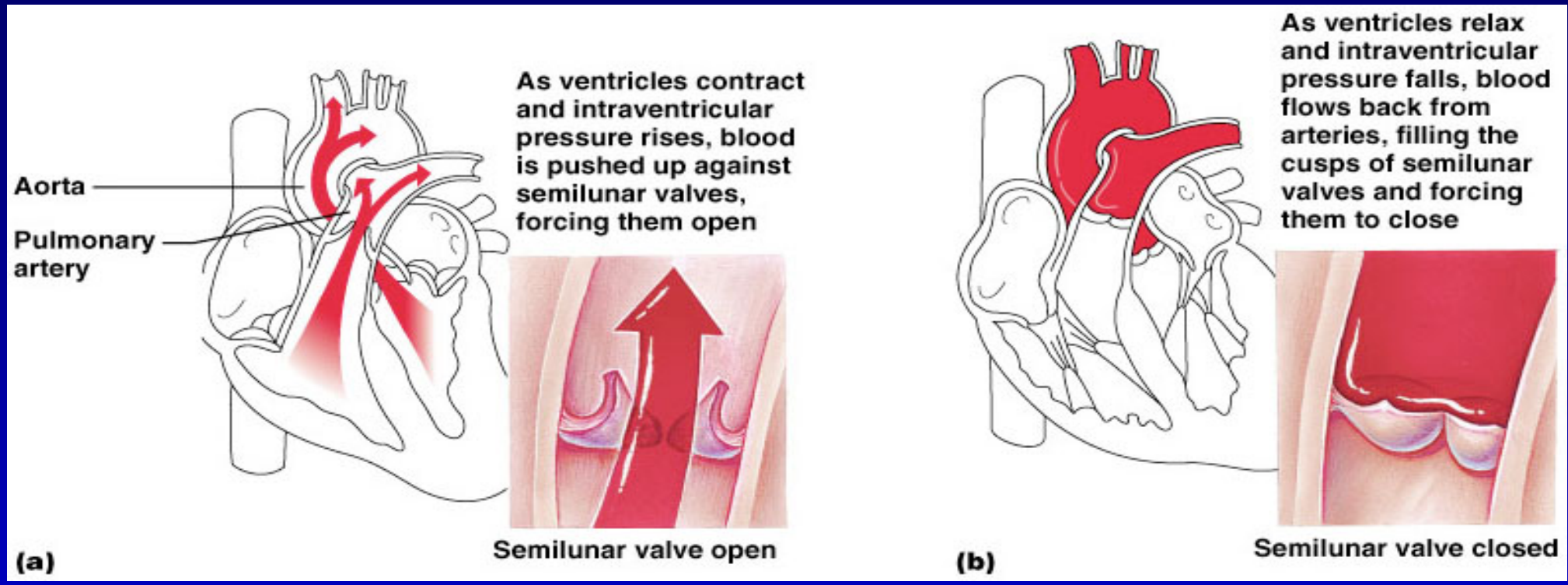
- 2 Semilunar valves:
  - Aortic valve : between left ventricle and aorta
  - Pulmonary valve: between right ventricle pulmonary artery

Atrioventricular Valve Function



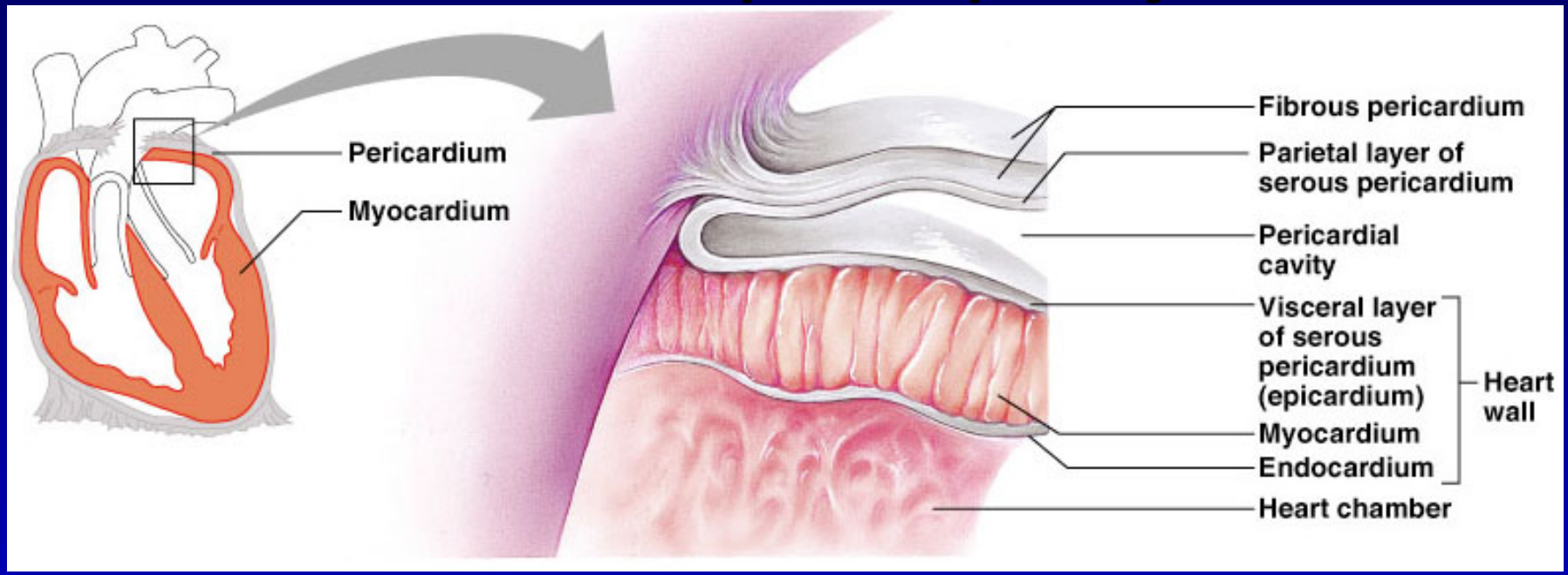
- **Tricuspid valve**
- **Mitral valve**
  - **AV valves prevent backflow into the atria when ventricles contract**

Semilunar Valve Function



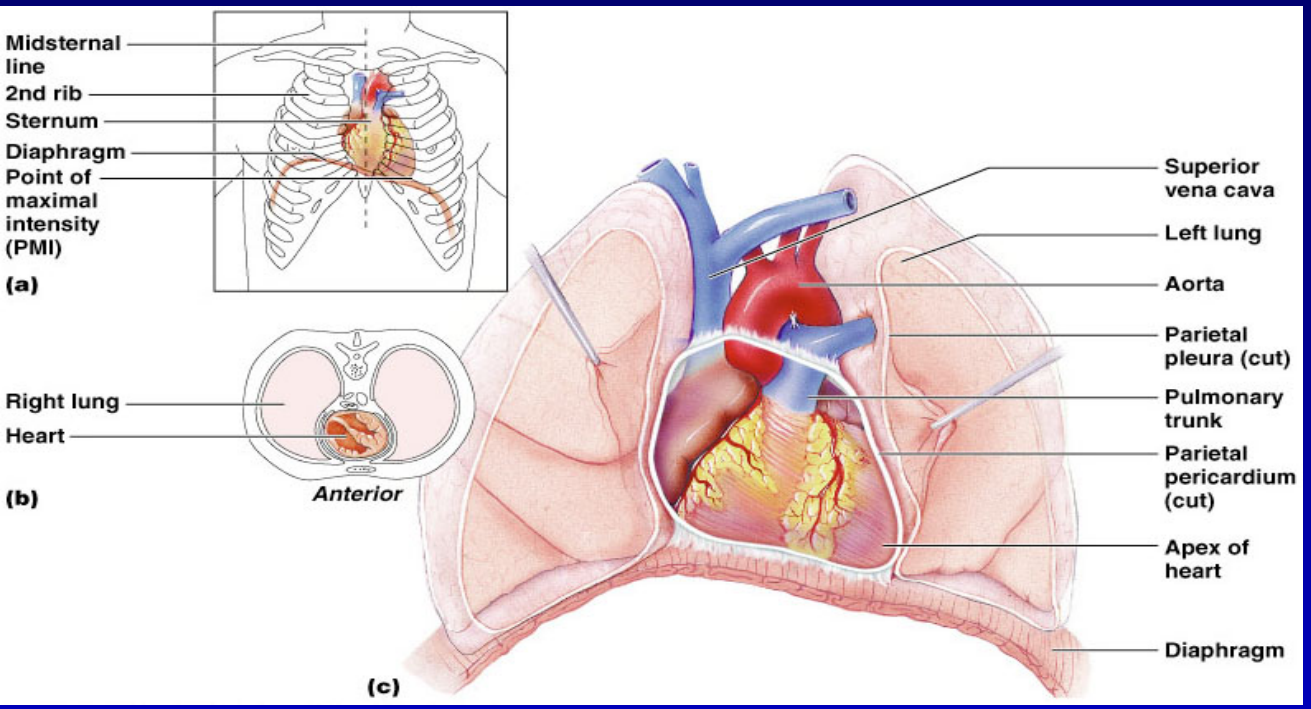
- **Aortic valve**
- **Pulmonary valve**
  - **Semilunar valves prevent backflow of blood into the ventricles**

Heart Wall : peri, epi, myo, endo



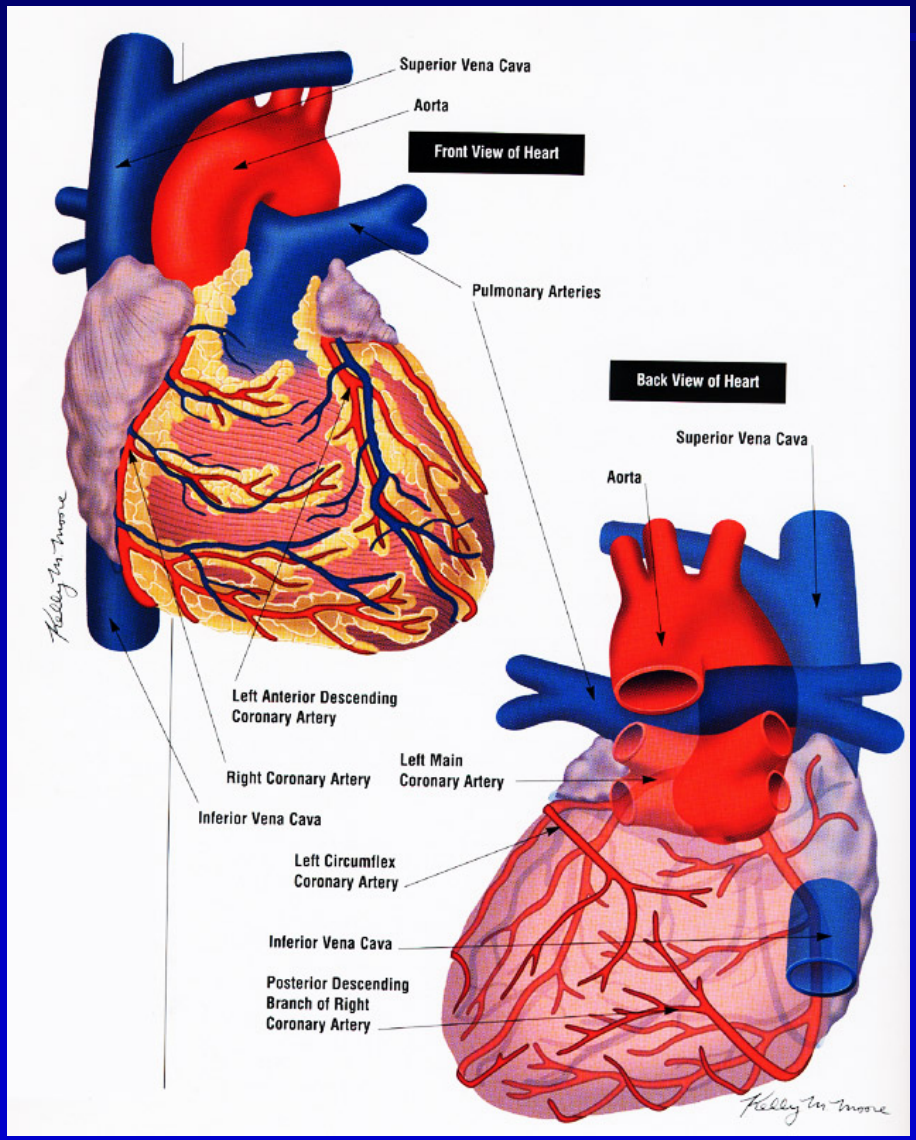
- Pericardium- external layer
- Epicardium – visceral layer of the serous pericardium
- Myocardium – cardiac muscle layer forming the bulk of the heart
- Endocardium – endothelial layer of the inner myocardial surface

Heart Anatomy



- Approximately the size of your fist
- Location
  - Superior surface of diaphragm
  - Left of the midline
  - Anterior to the vertebral column, posterior to the sternum

How is the Heart nourished?

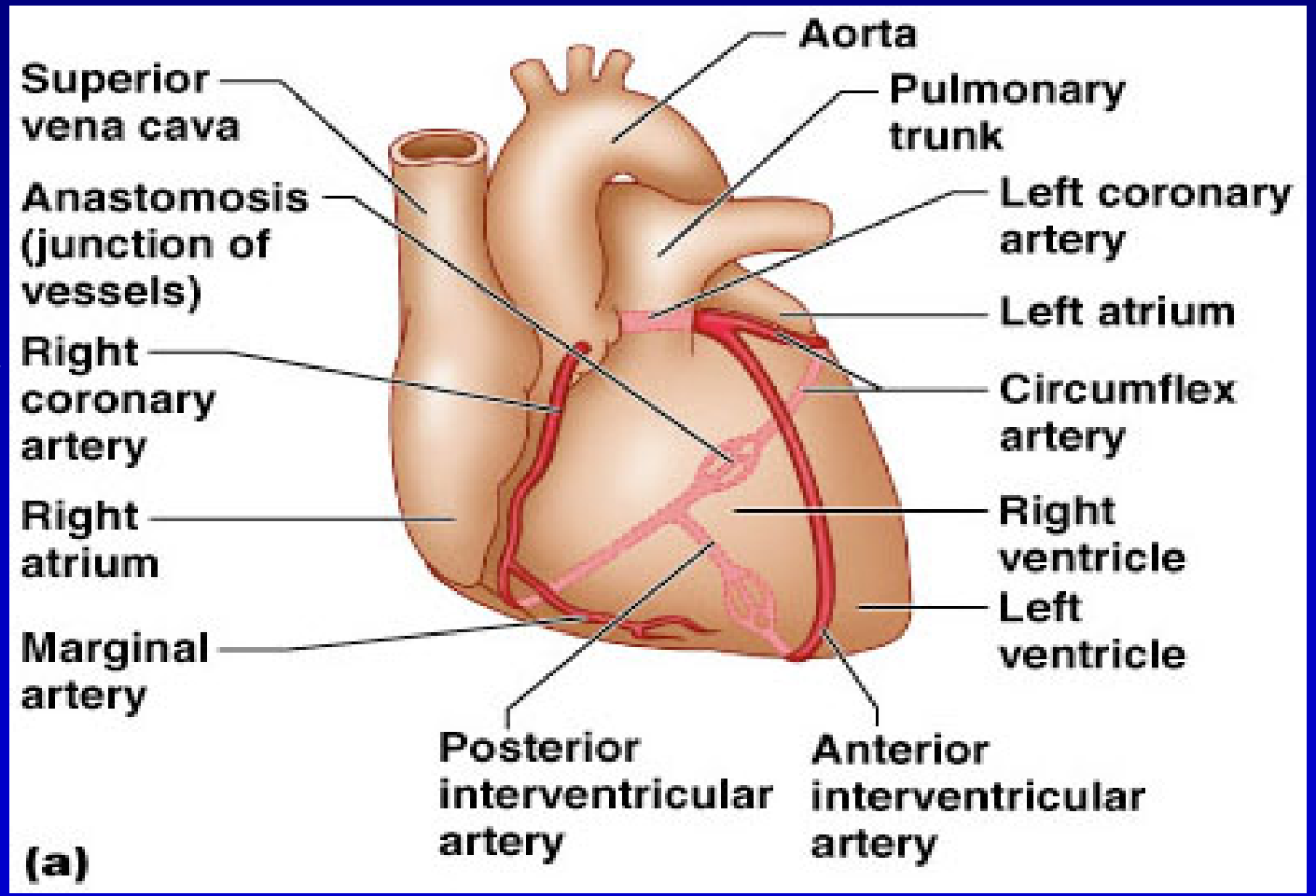


Coronary Circulation

supplies heart muscle

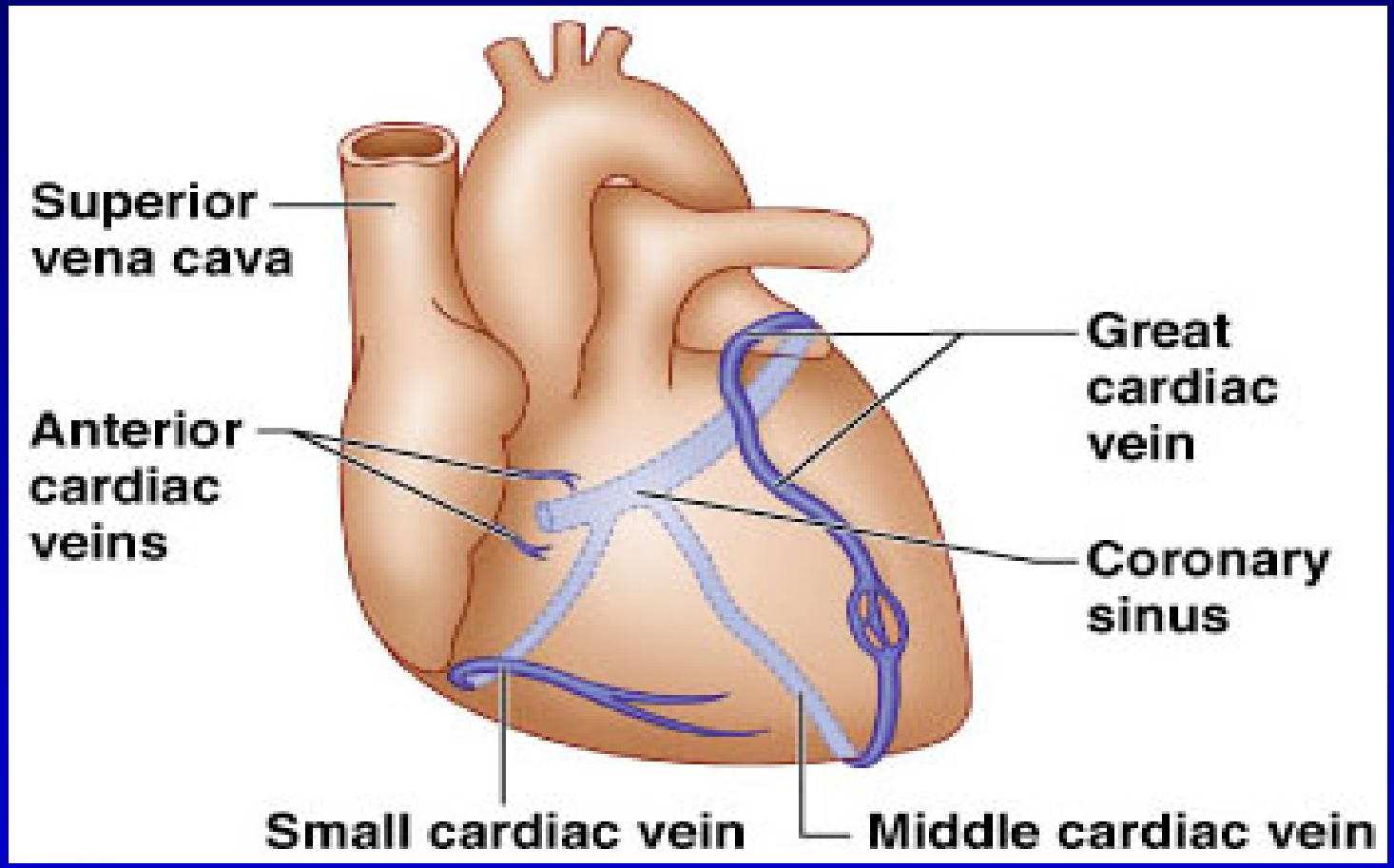
Coronary Circulation: Arterial Supply

RIGHT coronary artery

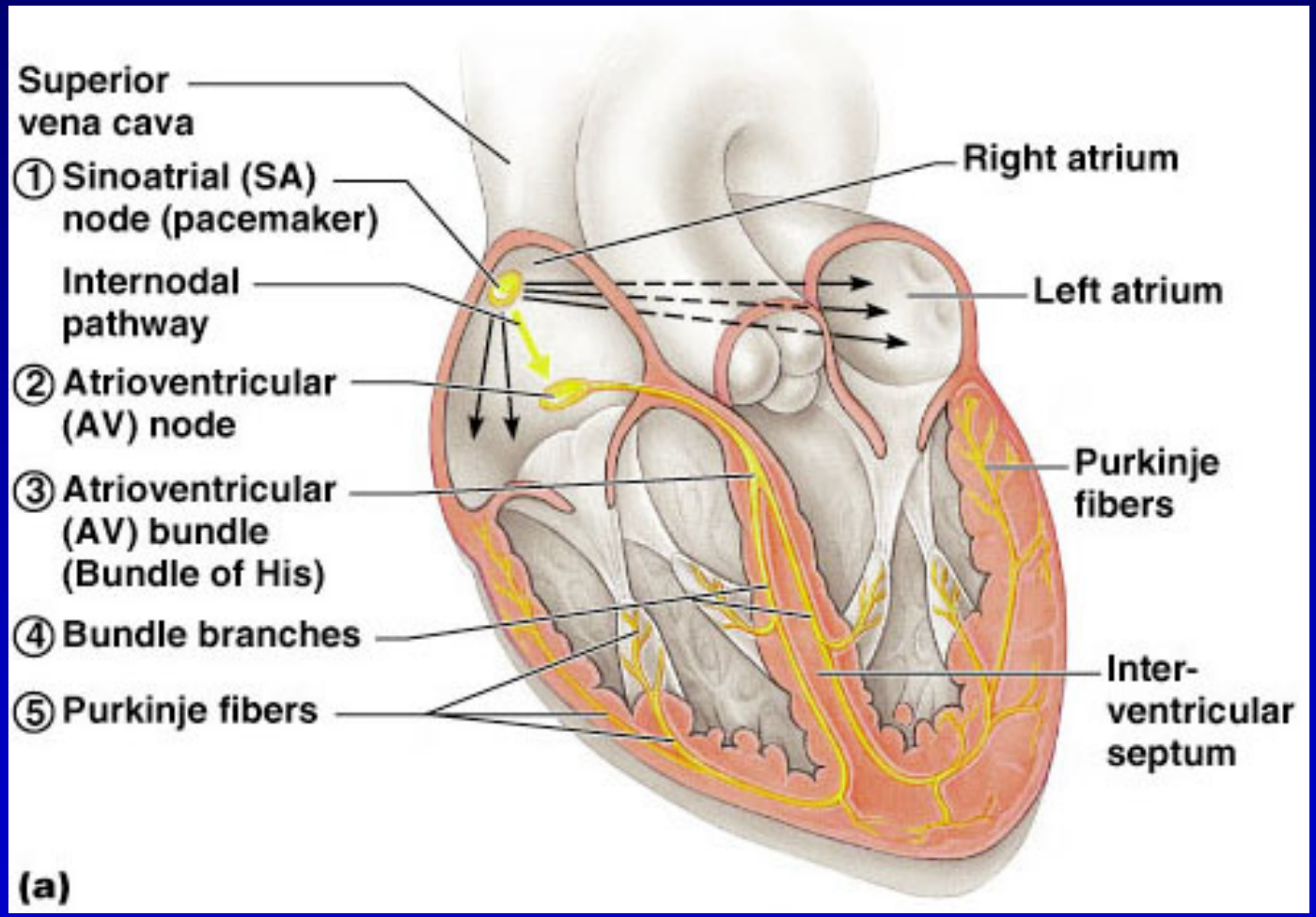


LEFT coronary artery

Coronary Circulation: Venous Supply



Who makes the heart beat?

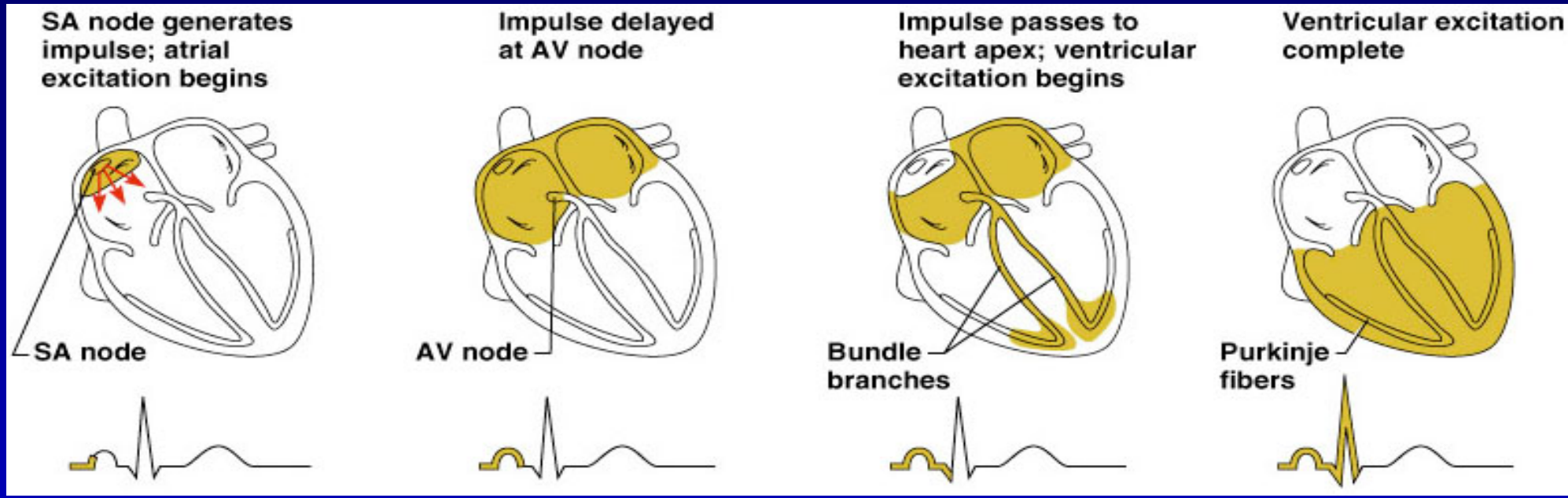


Intrinsic Conduction System

Beats per minute
= Heart beat
= Heart rate
= Pulse

Normal:
60-80 bpm

Heart Excitation Related to Electro Cardio Gram



ECG

P wave corresponds to depolarization of SA node

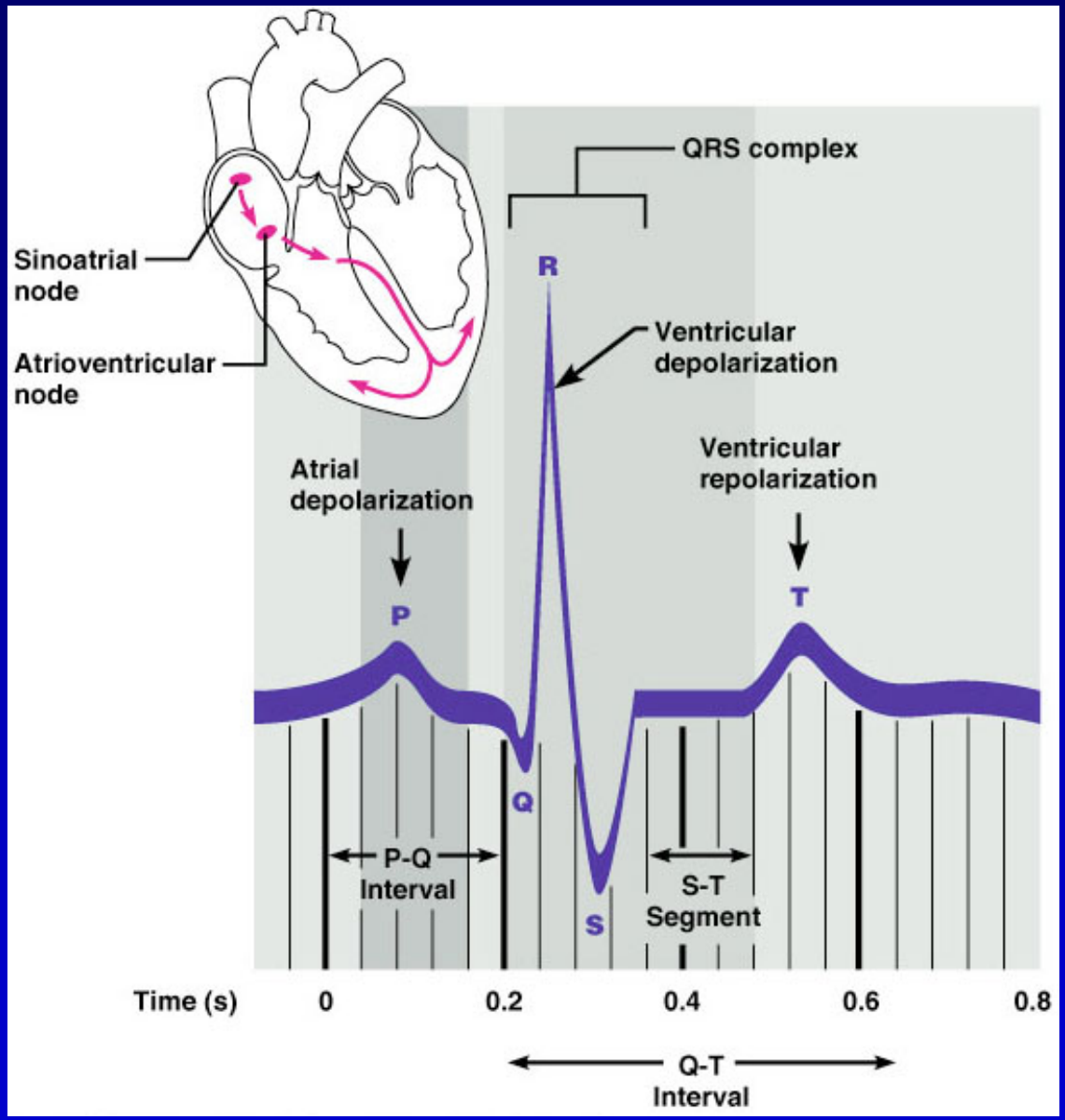
QRS complex corresponds to ventricular depolarization

T wave corresponds to ventricular repolarization

Atrial repolarization record is masked by the larger QRS complex

Clip : 5. Intrinsic system ECG

ECG



Clip: Intrinsic system :4 Pathway of depolarization 4/8

Cardiac Cycle

- Cardiac cycle refers to all events associated with blood flow through the heart
  - Systole – contraction of heart muscle
  - Diastole – relaxation of heart muscle

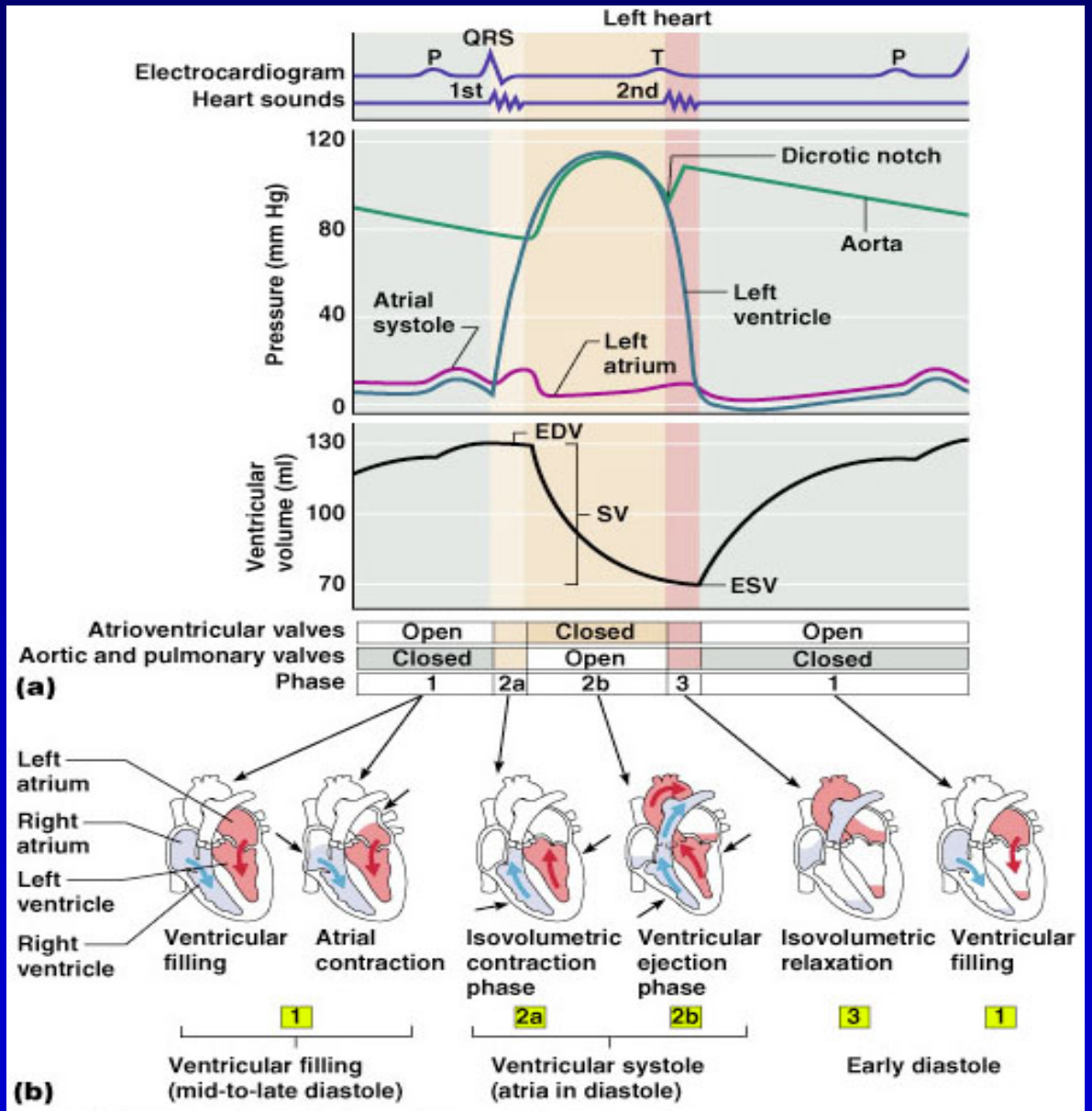
Phases of the Cardiac Cycle

- Ventricular filling – mid-to-late diastole
  - Heart blood pressure is low as blood enters atria and flows into ventricles
  - AV valves are open, then atrial systole occurs

Phases of the Cardiac Cycle

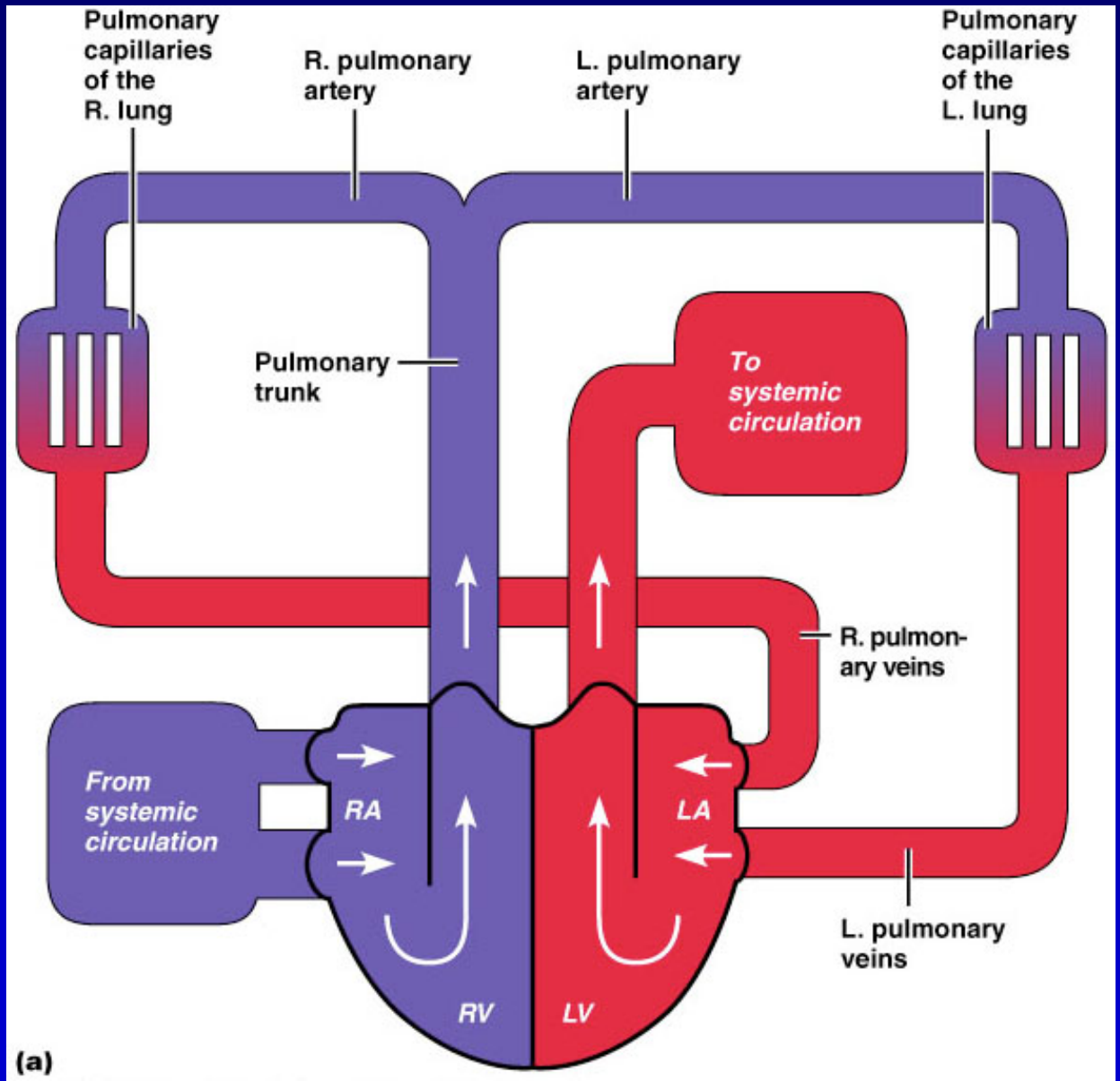
- Ventricular systole
  - Atria relax
  - Rising ventricular pressure results in closing of AV valves
  - Isovolumetric contraction phase
  - Ventricular ejection phase opens semilunar valves

Phases of the Cardiac Cycle



Clip 4 Overview of Cardiac Cycle 4/20

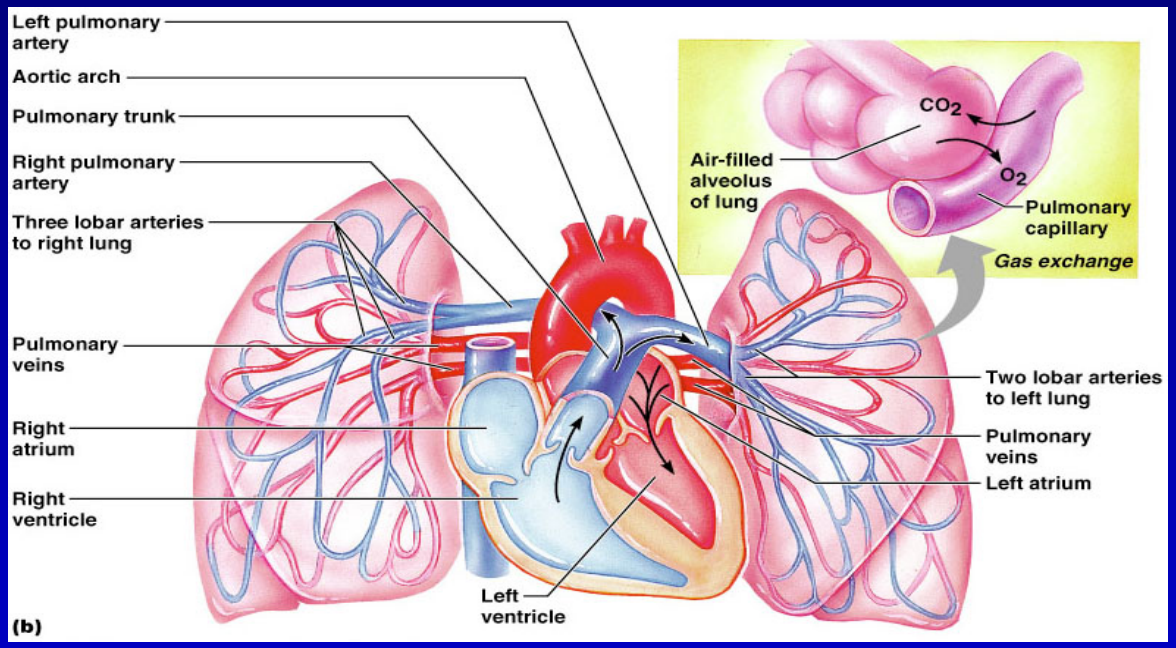
2 Circulatory Pathways



The vascular system has two distinct circulations

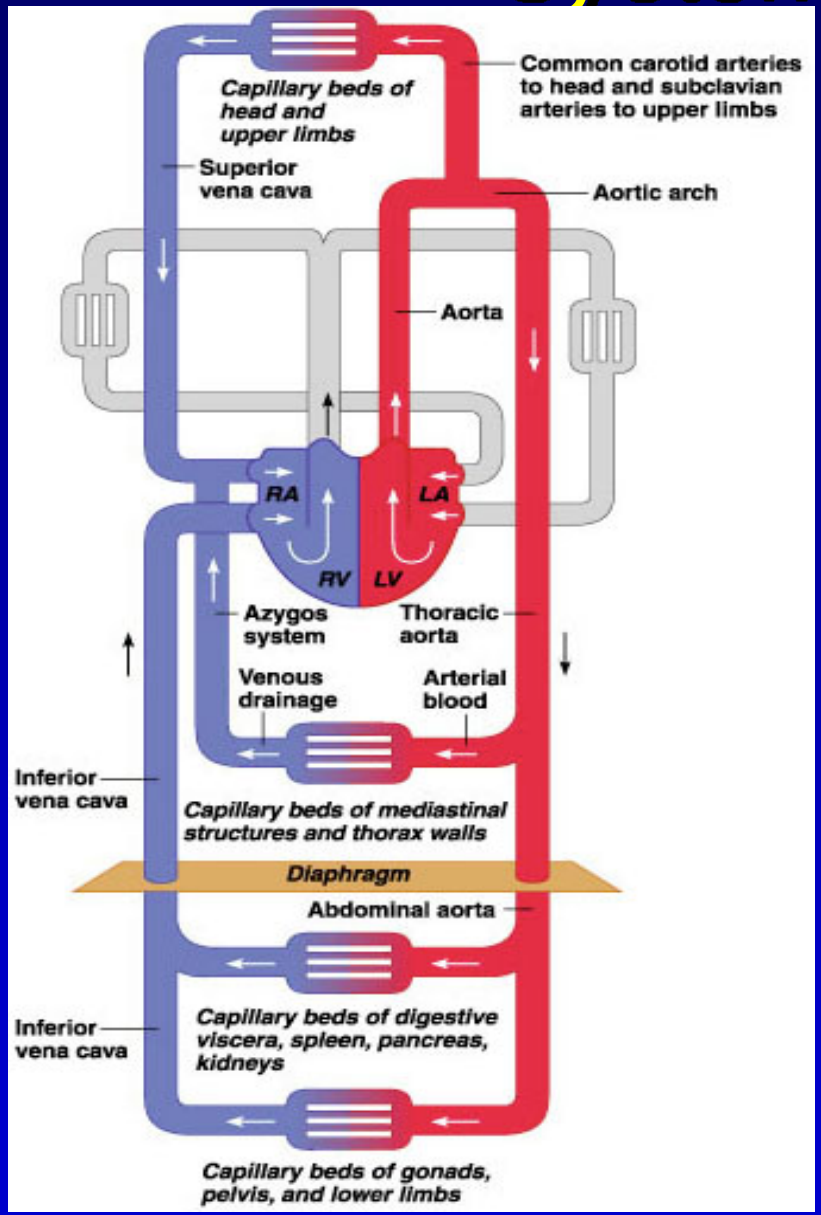
- Pulmonary circulation
- Systemic circulation

Pulmonary Circulation



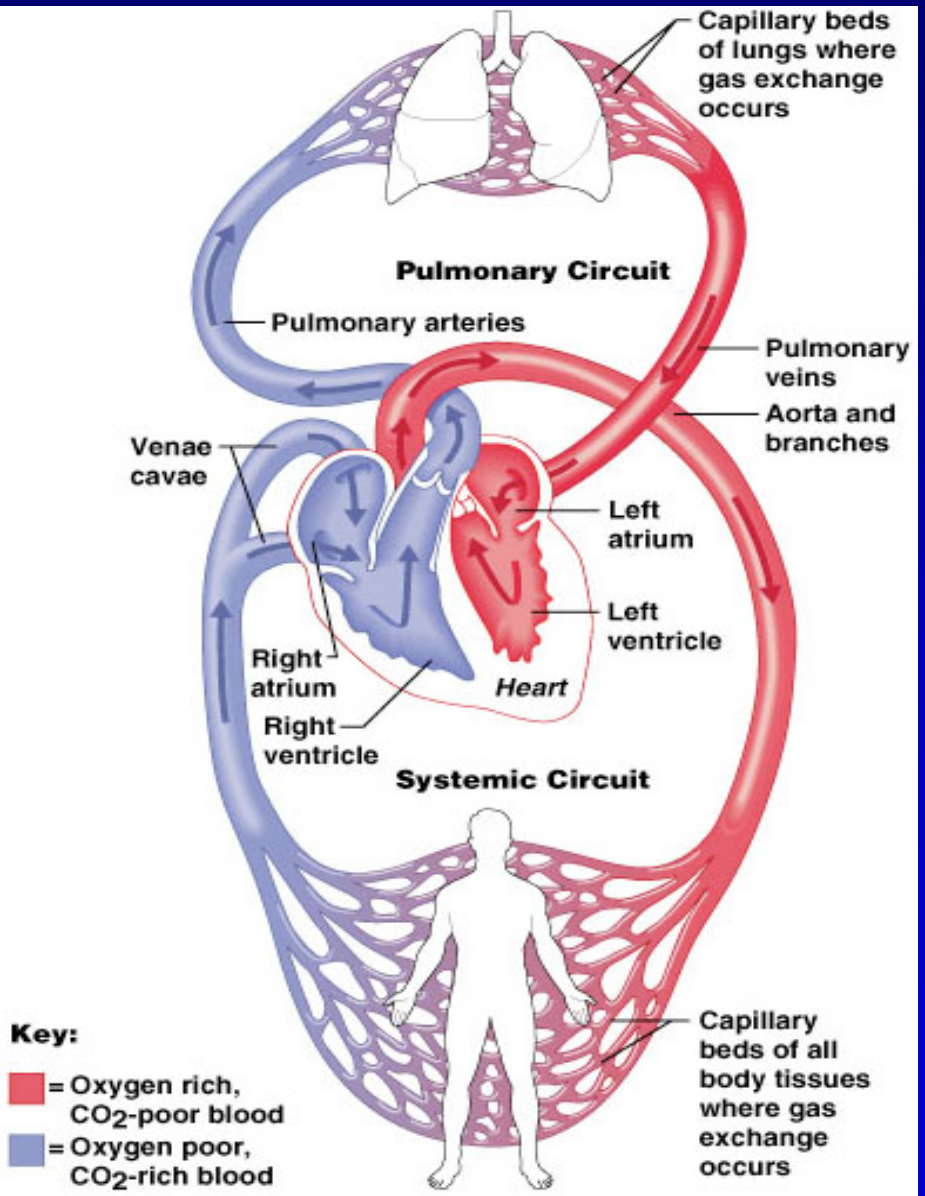
short loop that runs from the heart to the lungs and back to the heart

Systemic Circulation



routes blood through a long loop to all parts of the body and returns to the heart

Pathway of Blood Through
Heart and Lungs



Right atrium → tricuspid valve → right ventricle

Right ventricle → pulmonary semilunar valve → pulmonary arteries → lungs

GAS EXCHANGE

Lungs → pulmonary veins → left atrium

Left atrium → bicuspid valve → left ventricle

Left ventricle → aortic semilunar valve → aorta

Aorta → systemic circulation

4 Vessels

Towards the heart :

Veins

Pulmonary Vein

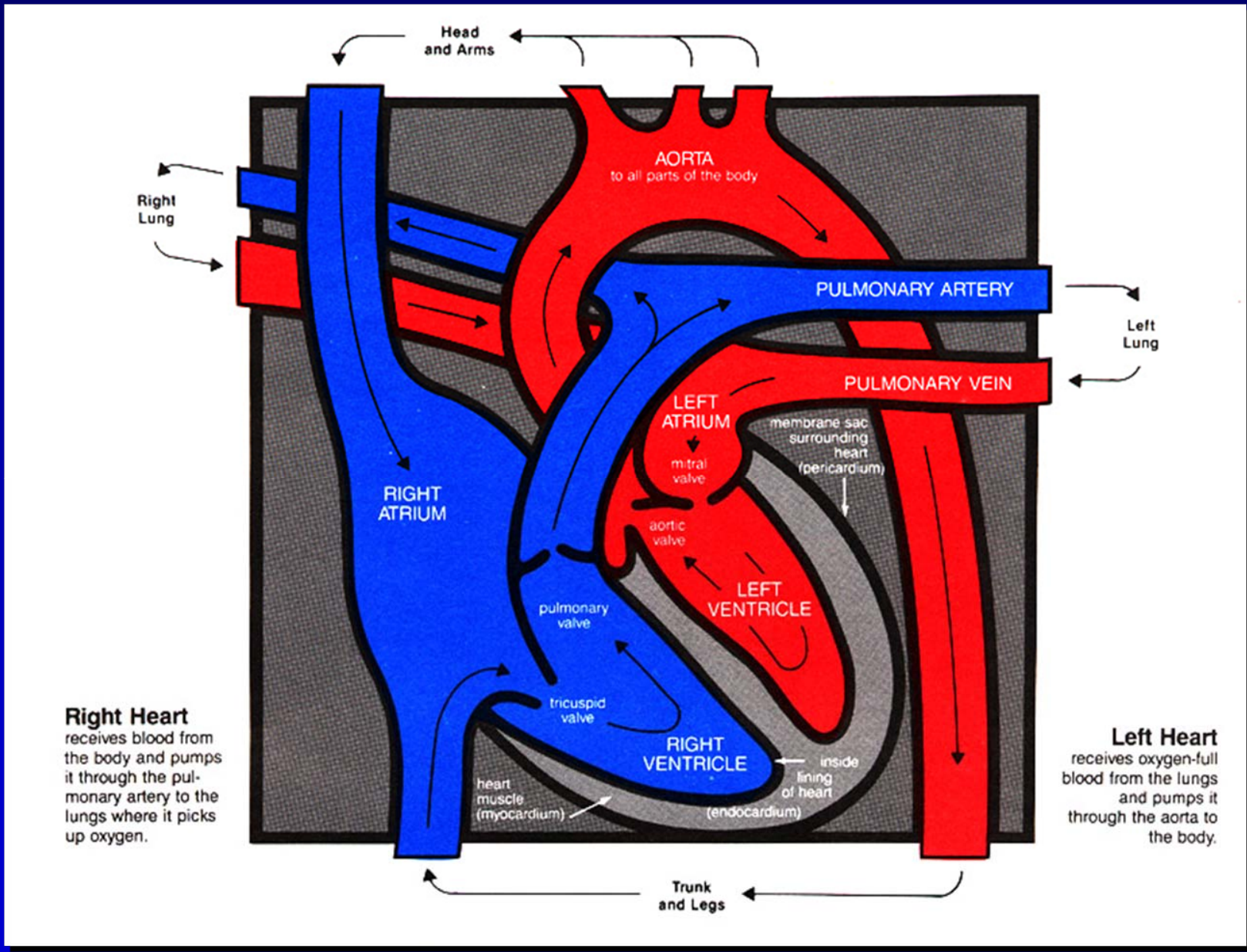
Vena cava

From the heart :

Arteries

Pulmonary Artery

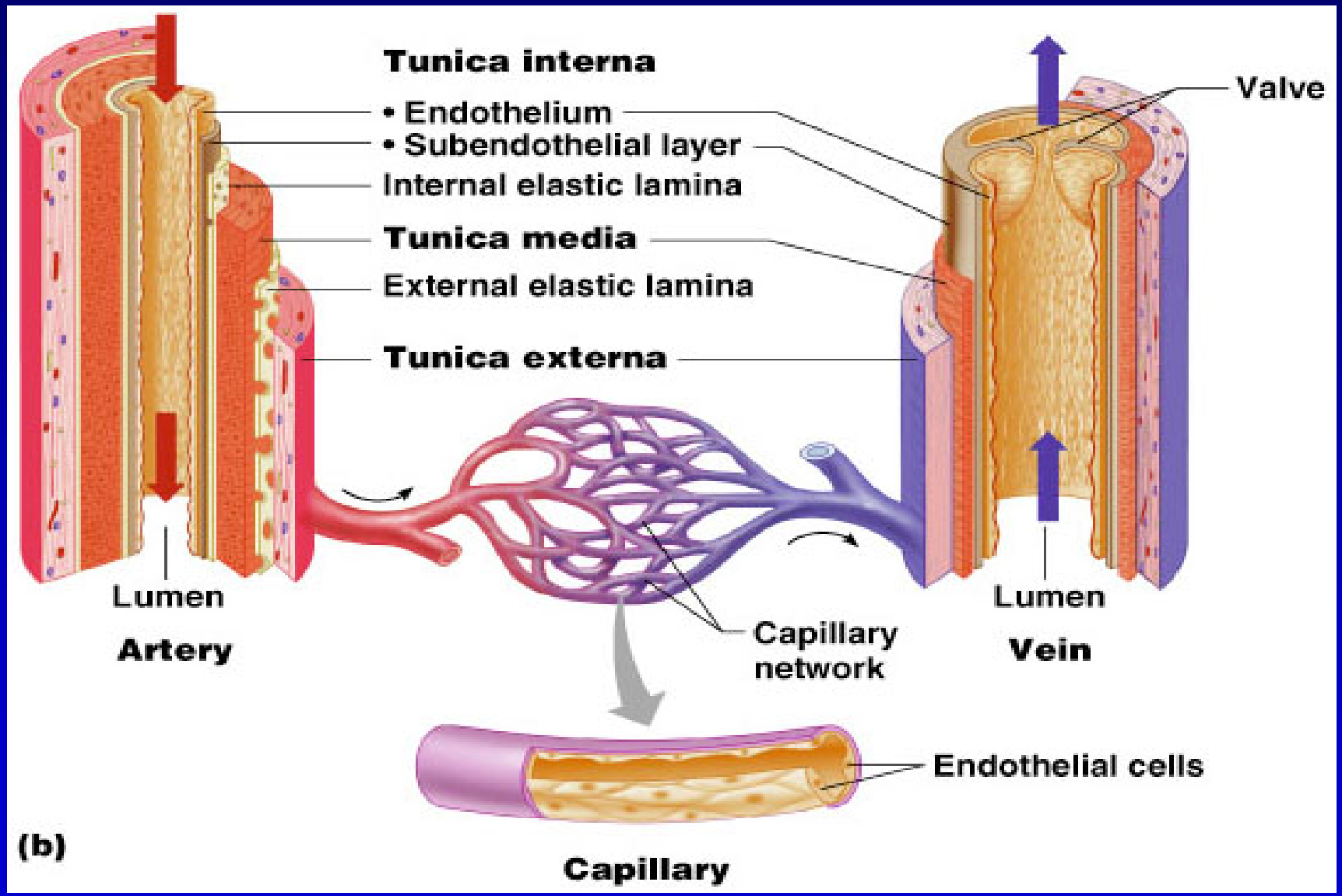
Aorta



What is the difference between Arteries and Veins

- Arteries and veins are composed of three tunics –
  - Interna- endothelium- blood contact
  - Media- muscle- contraction
  - Externa- protect and reinforce vessels contain vasa vasorum
- Lumen – central blood-containing space surrounded by tunics
- Capillaries are composed of endothelium with sparse basal lamina

Generalized Structure of Blood Vessels



What are the differences between Arteries and Veins ?

	Arteries	Veins
Delivery	Blood pumped into single systemic artery – the aorta	Blood returns via superior and interior venae cavae and the coronary sinus
Location	Deep, and protected by tissue	Both deep and superficial
Pathways	Fair, clear, and defined	Convergent interconnections
Supply/drainage	Predictable supply	Dural sinuses and hepatic portal circulation

Veins

- Veins have much lower blood pressure and thinner walls than arteries
- To return blood to the heart, veins have special adaptations
  - Large-diameter lumens, which offer little resistance to flow
  - Valves (resembling semilunar heart valves), which prevent backflow of blood

Arteries

- Thick-walled arteries near the heart; the aorta and its major branches
  - Large lumen allow low-resistance conduction of blood
  - Contain elastin in all three tunics
  - Withstand and smooth out large blood pressure fluctuations
  - Allow blood to flow fairly continuously through the body

Blood Pressure (BP)

- Force per unit area exerted on the wall of a blood vessel by its contained blood
  - Expressed in millimeters of mercury (mm Hg)
- The differences in BP within the vascular system provide the driving force that keeps blood moving from higher to lower pressure areas

Systemic Blood Pressure

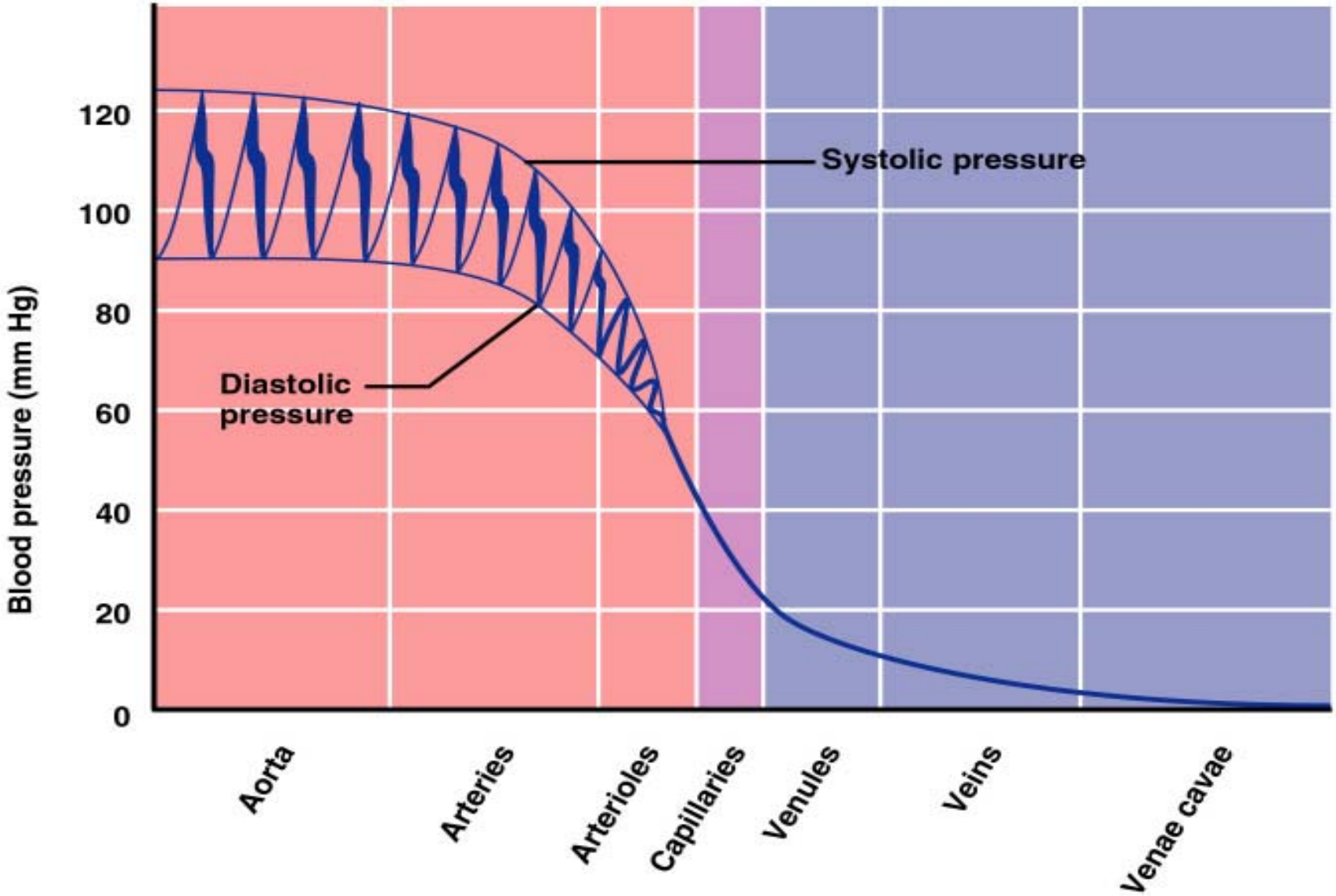
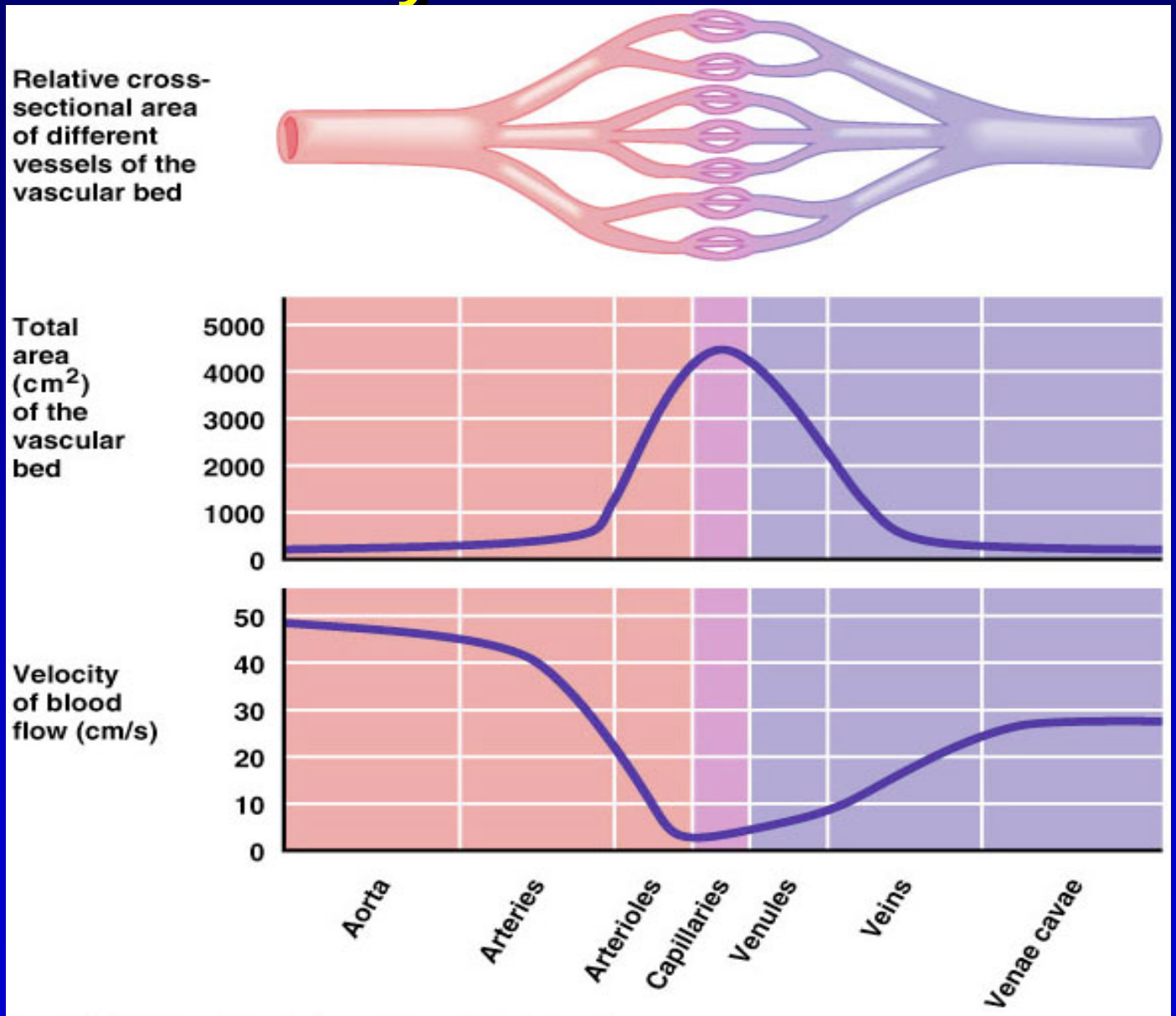


Figure 19.5

Blood Flow

- Actual volume of blood flowing through a vessel, an organ, or the entire circulation in a given period:
  - Is measured in ml per min

Velocity of Blood Flow

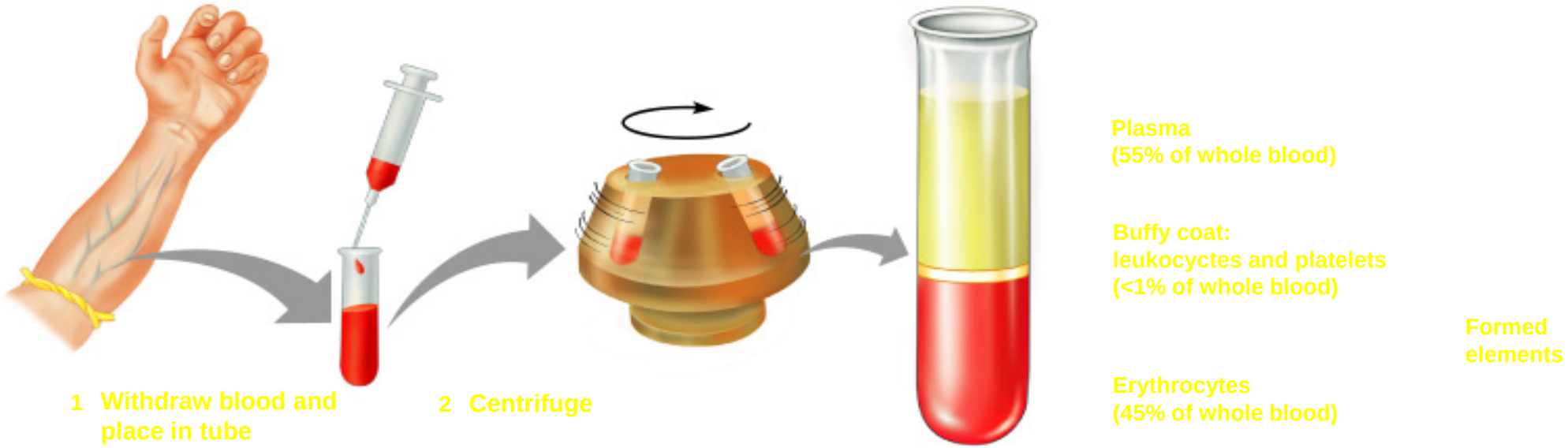


Resistance

- Resistance – opposition to flow
  - Measure of the amount of friction blood encounters as it passes through vessels
  - Generally encountered in the systemic circulation
  - Referred to as peripheral resistance
- The three important sources of resistance are :
  1. total blood vessel length
  2. blood vessel diameter
  3. blood viscosity

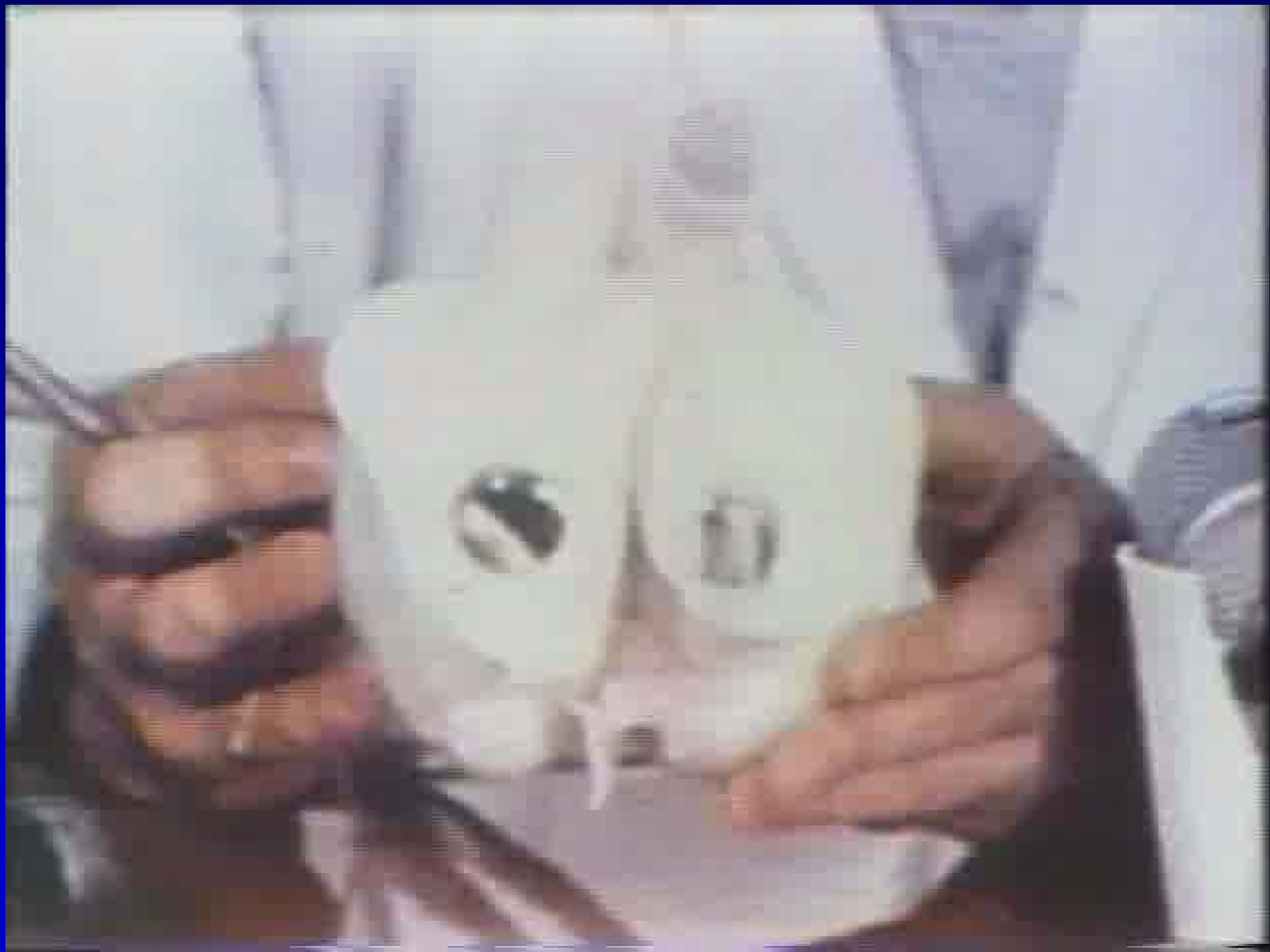
blade — to lose blood.
"If yew cut yore fanger
it's gonna *blade*."

Components of Whole Blood



- Blood is the body's only fluid tissue
- It is composed of liquid plasma and formed elements
- Formed elements include (determine blood viscosity):
  - Erythrocytes, or red blood cells (RBCs)
  - Leukocytes, or white blood cells (WBCs)
  - Platelets
- Hematocrit – the percentage of RBCs out of the total blood volume

Denton Cooley & Mike DeBakey
100 years old



Thank you

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Texas Heart Institute

832-355-3633

Summary: Anatomy & Physiology

- 4 chambers: left and right atrium and ventricle
- 4 Valves: TV, MV, AV, PV
- 4 Vessels: VC, Pulmonary Vein, Pulmonary Artery , Aorta
  - Arteries , Capillaries , Veins
- Pulmonary and Systemic circulation
- Blood

Use of Autologous Auricular Chondrocytes for Lining Artificial Surfaces: A Feasibility Study

Timothy Scott-Burden, PhD,* Jennifer P. Bosley, BS, Doreen Rosenstrauch, RN, MD, Kimberly D. Henderson, BS, Fred J. Clubb, Jr, DVM, PhD, Harald C. Eichstaedt, MD, Kazuhiro Eya, MD, Igor Gregoric, MD, Timothy J. Myers, BS, Branislav Radovancevic, MD, and O. H. Frazier, MD

Cardiovascular Surgical Research Laboratories, Vascular Cell Biology Laboratory, and Department of Cardiovascular Pathology, Texas Heart Institute at St. Luke's Episcopal Hospital, and The University of Texas Health Science Center at Houston, Houston, Texas

Background. Auricular elastic cartilage is a potential source of autologous cells for lining the luminal surfaces of cardiovascular prostheses. We tested this potential in vitro and in vivo using a left ventricular assist device (LVAD) and a calf model.

Methods. In vitro, auricular cartilage was harvested from the anesthetized ear of a calf, isolated, and cultured on tissue culture dishes. Primary chondrocytes were typed by immunocytochemistry, transferred into culture media, passaged twice, and seeded onto the blood-contacting luminal surfaces of four LVADs (HeartMate; Thoratec Corporation, Woburn, MA). Seeded cell linings were preconditioned under simulated flow conditions to promote cell adhesion to luminal surfaces. Seeding efficiency and cumulative cell loss under flow conditions were quantitated. In vivo, one of the four autologous chondrocyte-lined and preconditioned LVADs was implanted into the tissue-donor calf; run for 7 days; explanted; and evaluated grossly, by scanning electron microscopy, and by transmission electron microscopy.

Results. The efficiency of seeding chondrocytes onto the luminal surfaces of the four LVADs was 95.11% ± 4.23% (n = 4). Cumulative cell loss during preconditioning under flow conditions in vitro did not exceed 12% (n = 4). After 7 days of in vivo implantation, the luminal surfaces of the implanted LVAD demonstrated an intact, strongly adherent cellular lining.

Conclusions. Auricular elastic cartilage is a ready and easily accessible source of chondrocytes whose ability to produce collagen II and other important extracellular matrix constituents allows them to adhere strongly to the luminal surfaces of LVADs. The simple method of isolating and expanding auricular chondrocytes presented here could be used to provide strongly adherent autologous cell linings for LVADs and other cardiovascular devices. If and when chondrocytes can be genetically engineered to produce antithrombogenic factors and then used to line the luminal surfaces of LVADs or other cardiovascular prostheses, they may be able to improve the hemocompatibility of the blood–biomaterial interface in such devices. Our successful feasibility study in a calf model warrants further studies of this concept in vivo.

(Ann Thorac Surg 2002;73:1528–33)

The use of endothelial cells as autologous cell lining has been shown to improve the biocompatibility of cardiovascular prostheses [1]. Nevertheless, the ability of endothelial cells to adhere to the artificial surfaces in such devices is poor. When exposed to physiologic flow conditions, they slough off easily [2]. One successful alternative has been to use autologous smooth muscle cells that adhere better to biomaterials and that have been genetically engineered to produce nitric oxide so as to improve the hemocompatibility of the blood–biomaterial interface [3].

However, the process of harvesting, isolating, and cultivating both endothelial cells and smooth muscle cells from autologous vessels is invasive and time consuming. In contrast, auricular chondrocytes are abundant, readily accessible, and easily and efficiently harvested. One potential source of chondrocytes is auricular cartilage, which can be harvested by a minimally invasive technique that preserves cell viability, decreases surgical time, and minimizes postoperative complications [4]. In vivo, chondrocytes are naturally nourished by diffusion and produce substantial amounts of extracellular matrix components [5]. Therefore, cultured chondrocytes may offer a more efficient and less invasive means of covering artificial surfaces with a viable and adherent cell layer. Furthermore, if the chondrocytes are genetically engineered to act like endothelial cells, then they might also improve the hemocompatibility of blood–biomaterial interfaces.

As the first step in proving the feasibility of this concept, we harvested, isolated, and cultured auricular

Accepted for publication Dec 3, 2001.

*Doctor Scott-Burden passed away on April 19, 2000.

Address reprint requests to Dr Frazier, 1101 Bates Ave, Suite 1937, Houston, TX 77030; e-mail: Doreen.Rosenstrauch@uth.tmc.edu.

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Chondrocytes

seeded onto CV Device

implanted into Calf

for Seven days