Sistema Cardiovascular
Circulação e vasos sangüíneos

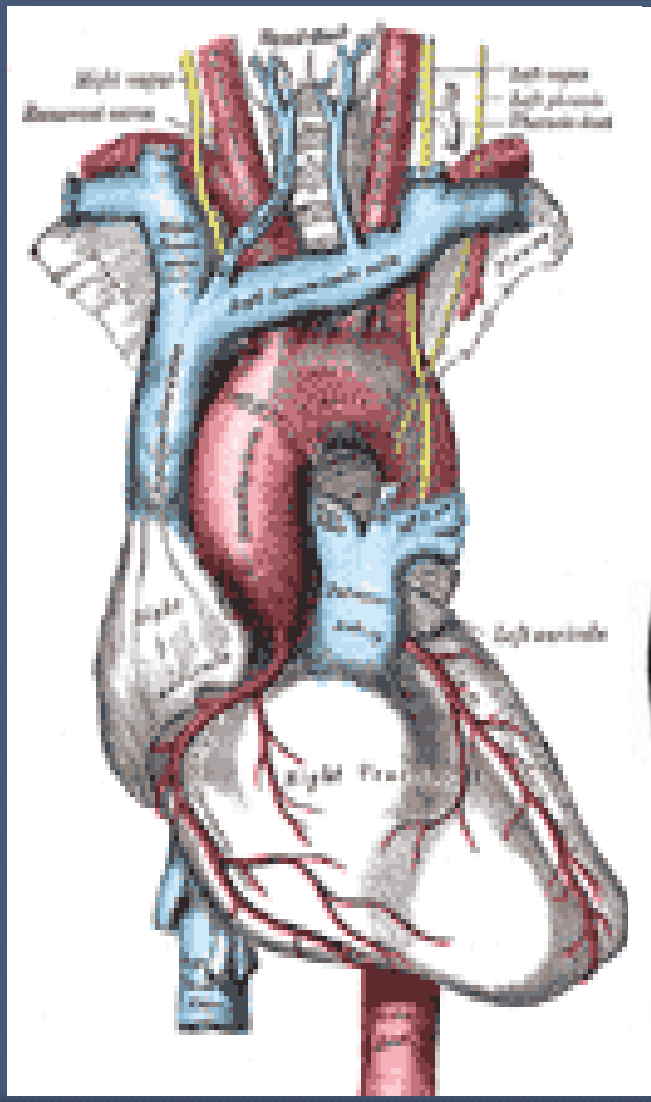
Física Médica

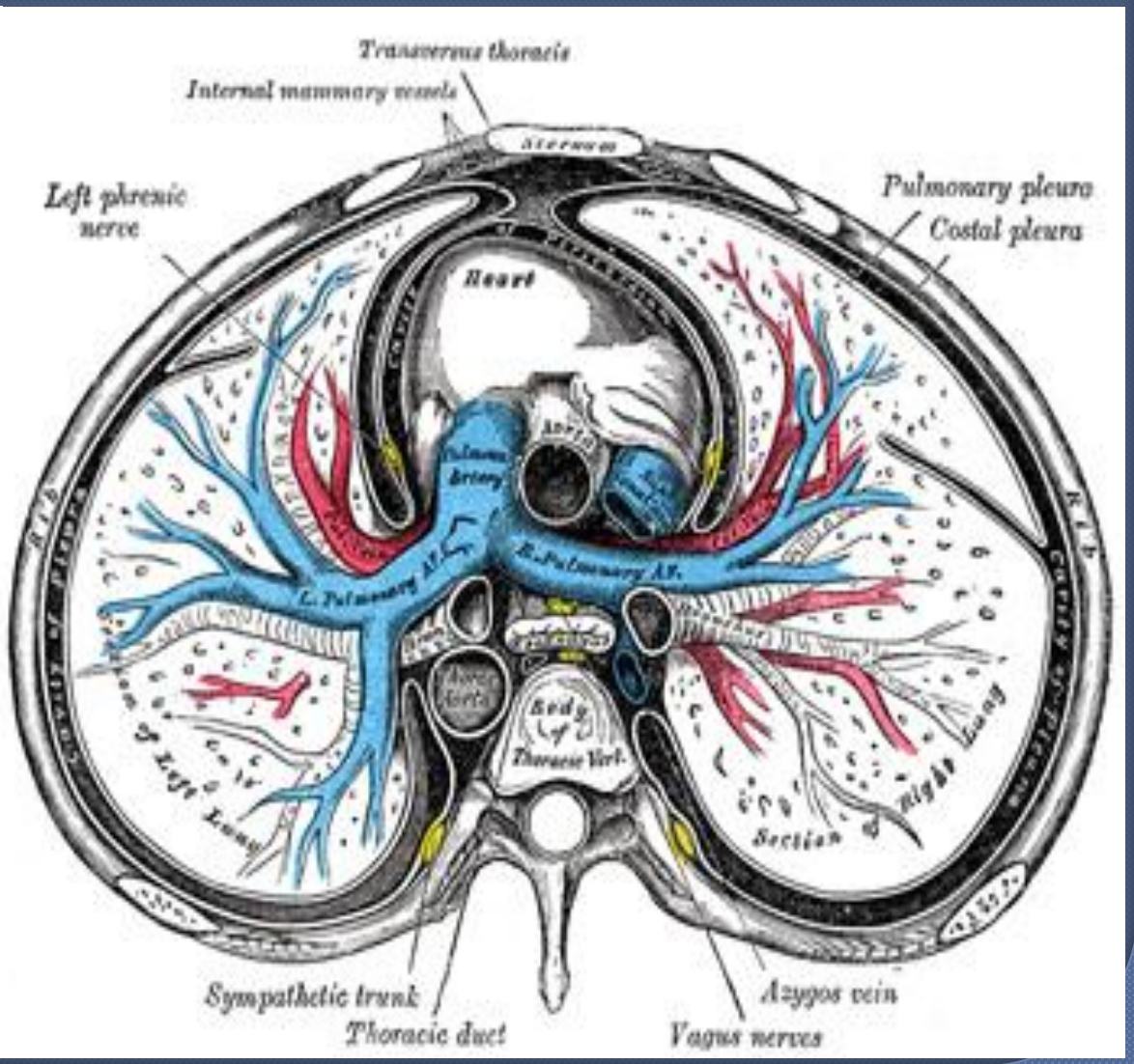
Division of Interventional Radiology
CCIFM – HC – FMRP - USP

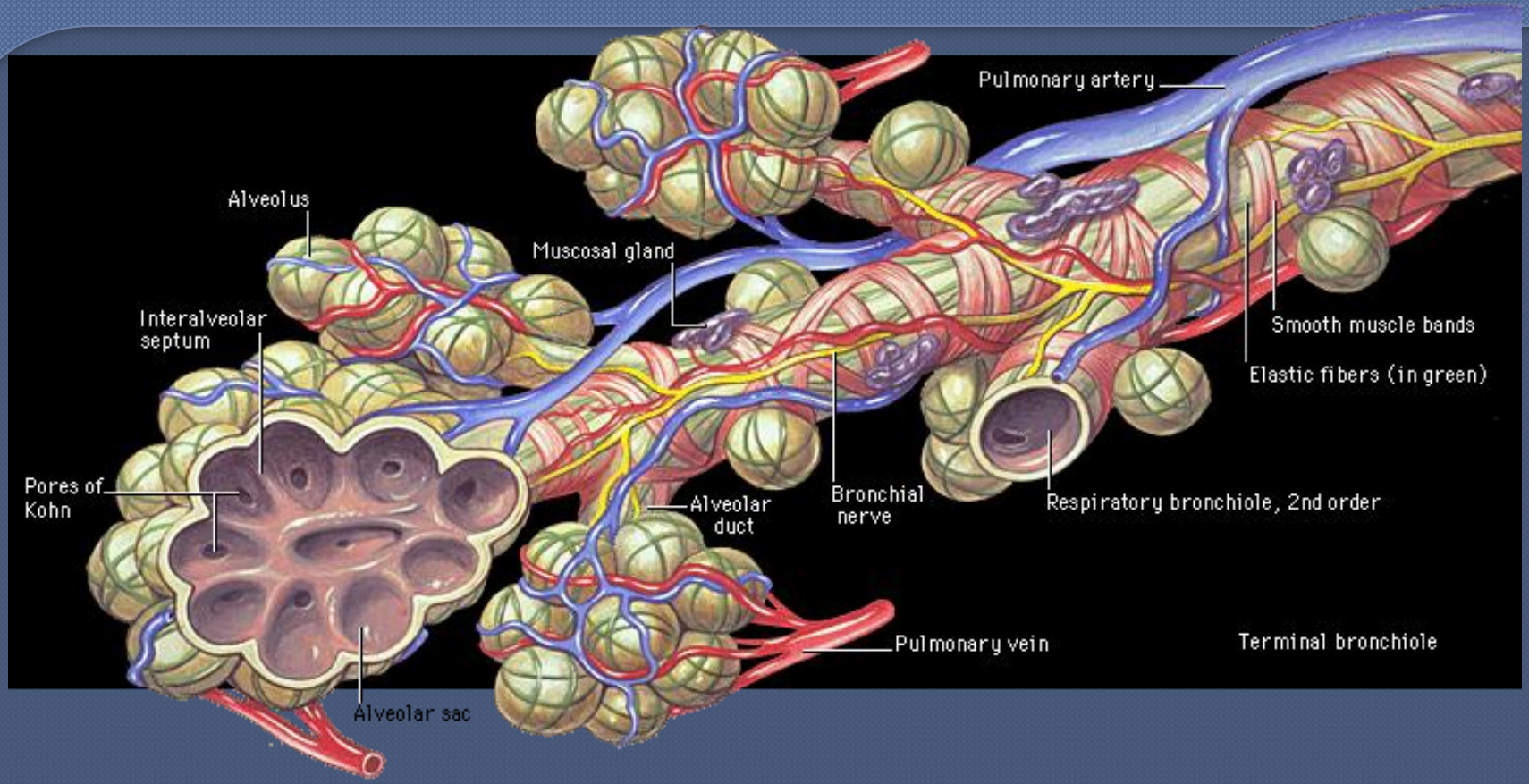
Tipos de circulação

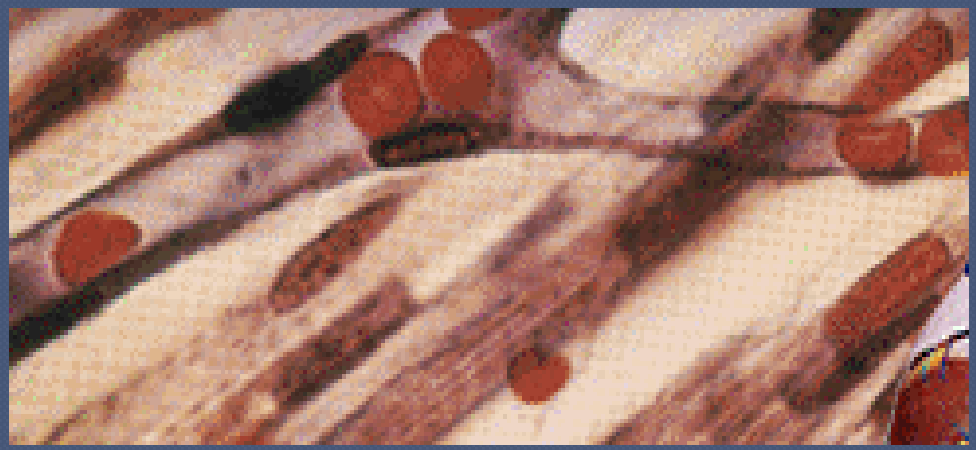
- Circulação pulmonar
  - "pequena circulação": coração - pulmão
  - Artérias contêm sangue saturado e veias sangue oxigenado
- Circulação sistêmica
  - "grande circulação": coração – tecidos
  - Artérias contêm sangue oxigenado

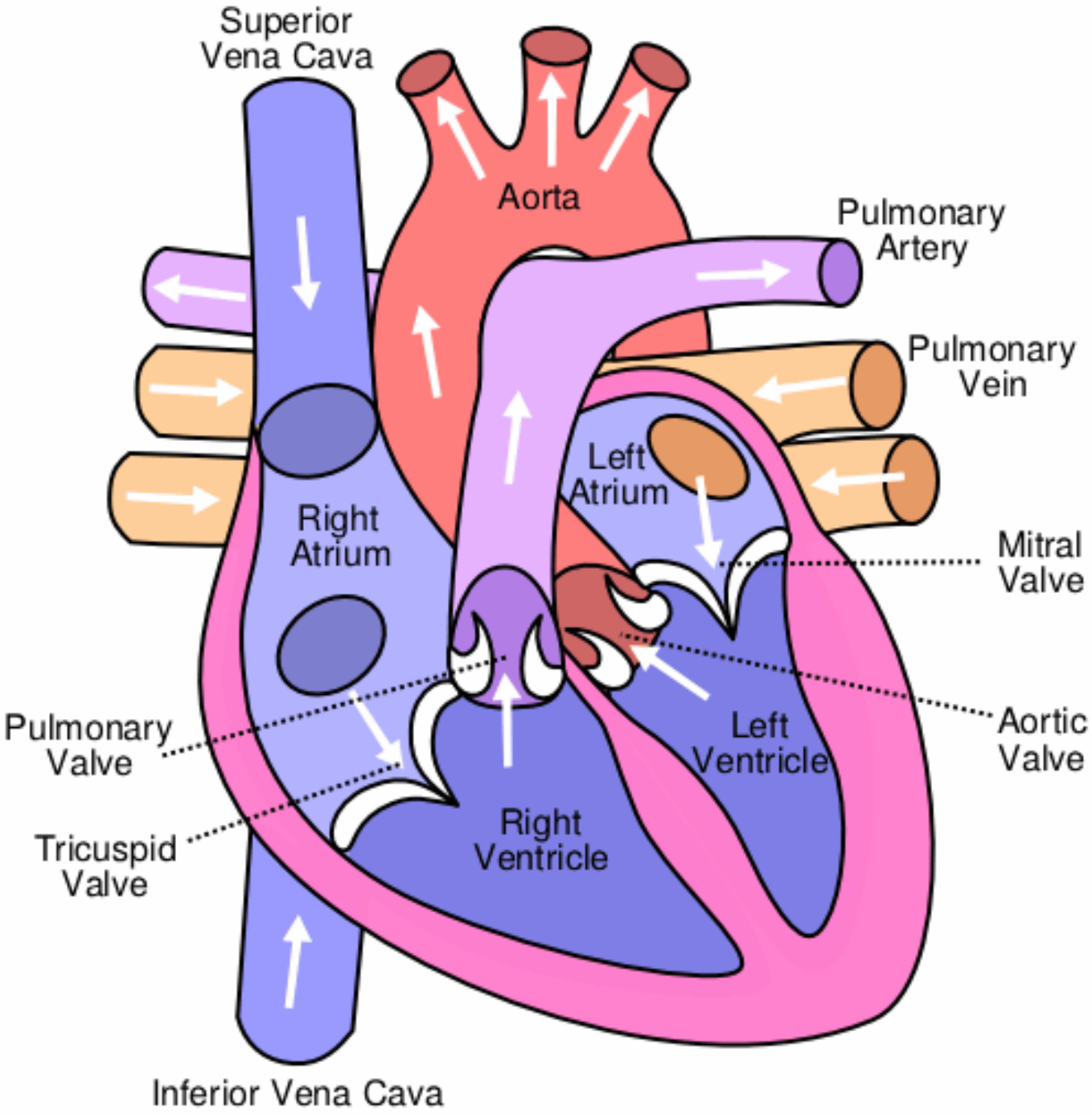
Circulação pulmonar

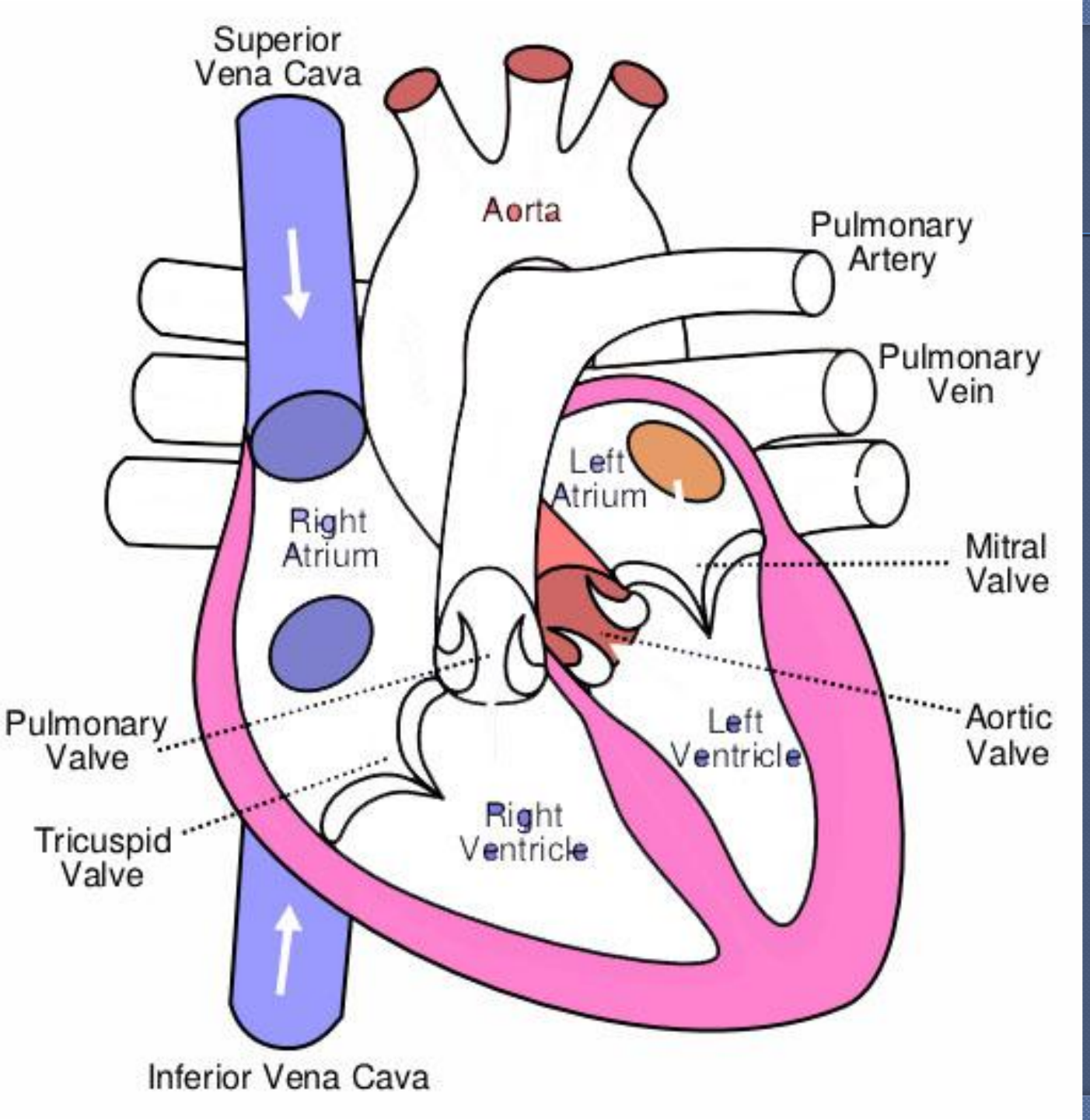


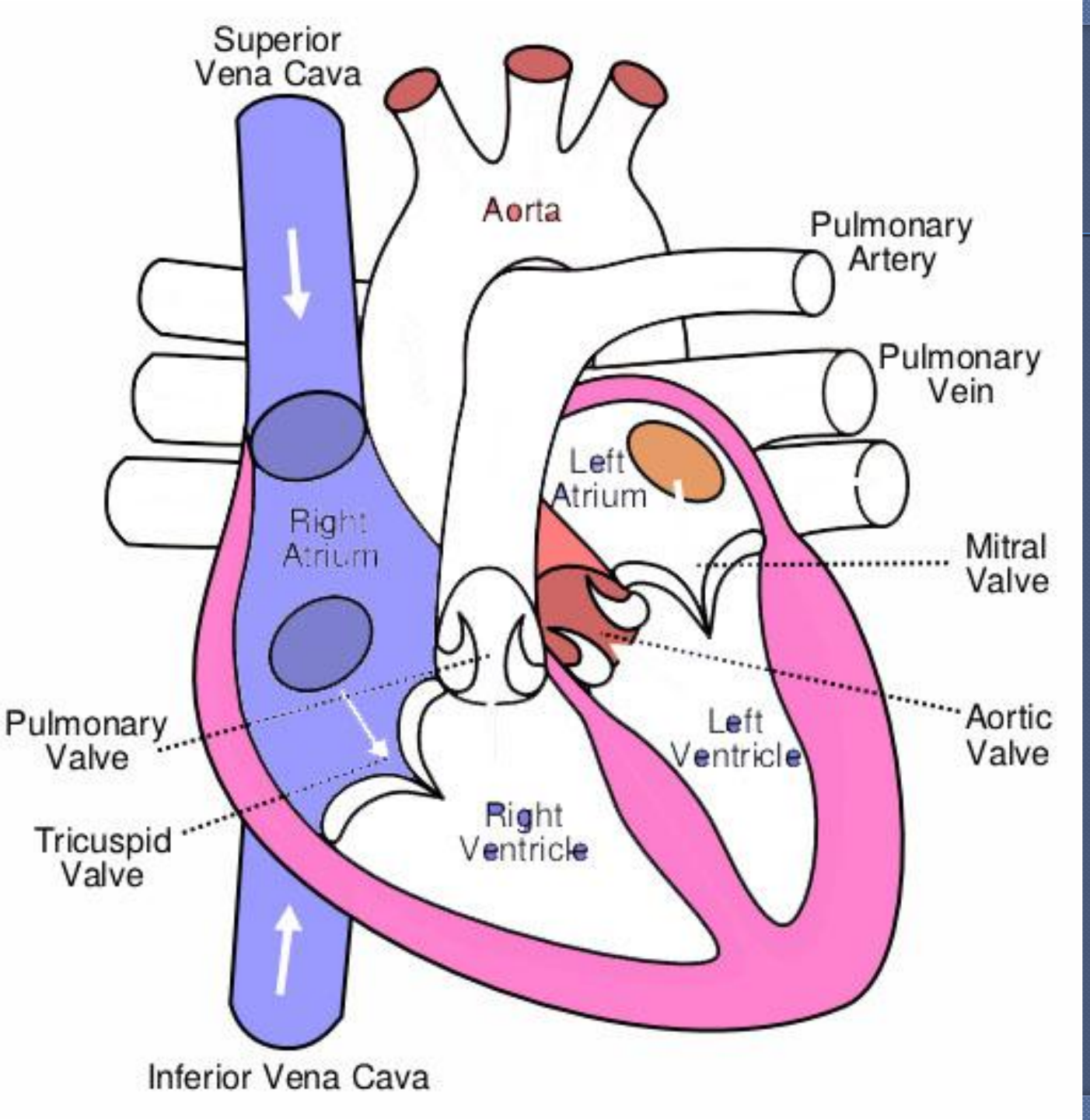


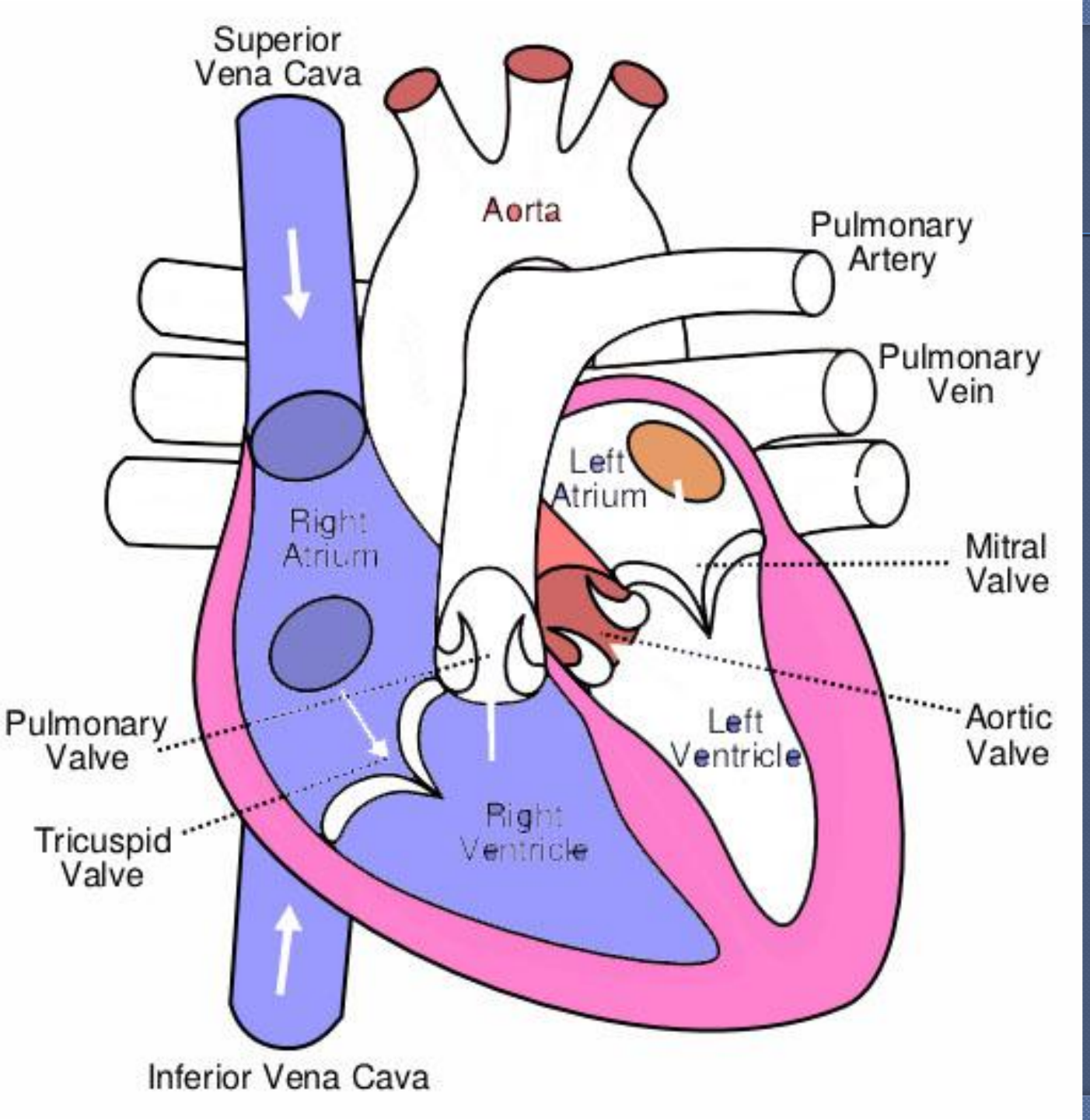

Pulmonary artery
Alveolus
Muscosal gland
Interalveolar septum
Smooth muscle bands
Elastic fibers (in green)
Pores of Kohn
Alveolar duct
Bronchial nerve
Respiratory bronchiole, 2nd order
Pulmonary vein
Terminal bronchiole
Alveolar sac

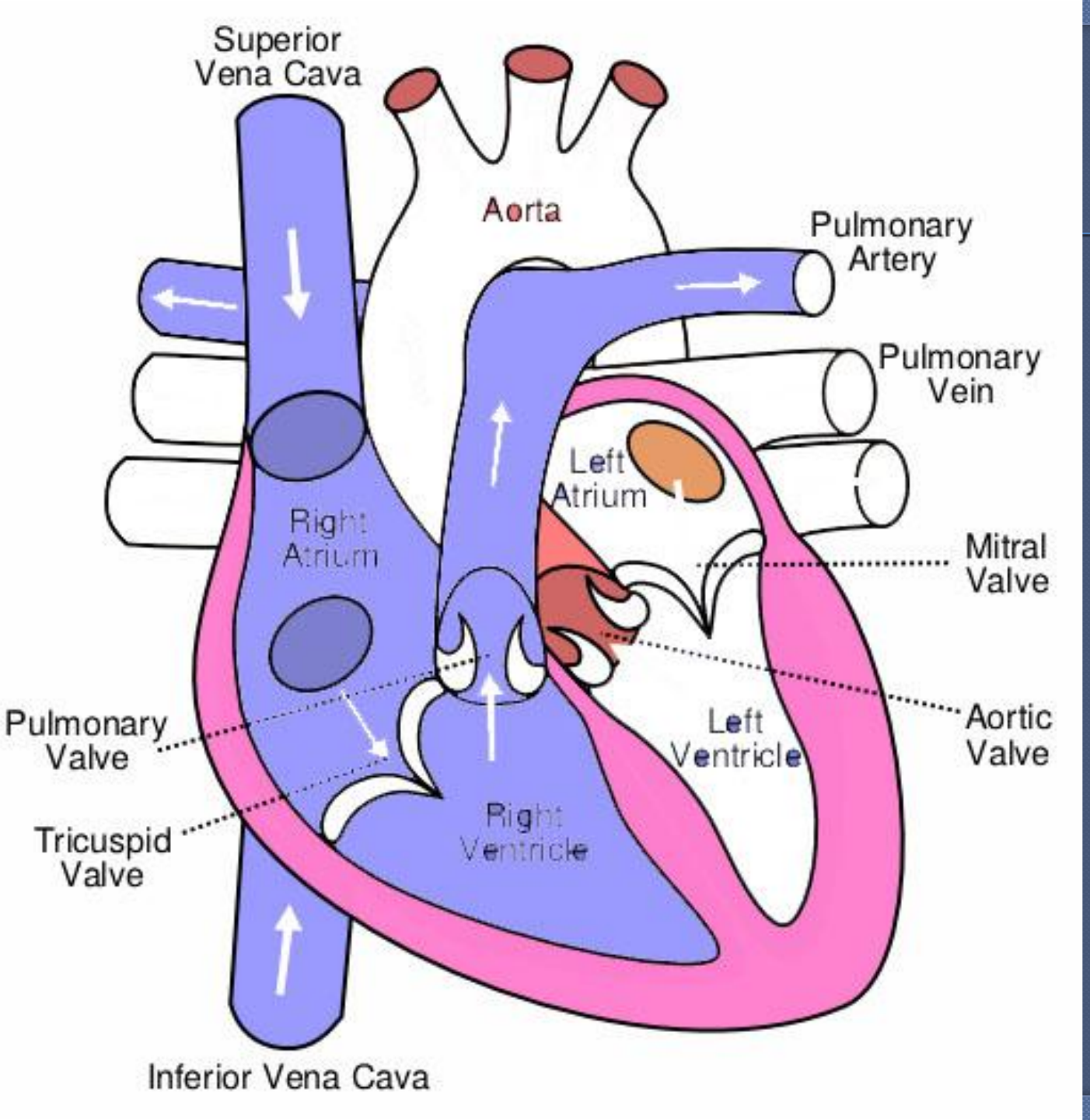


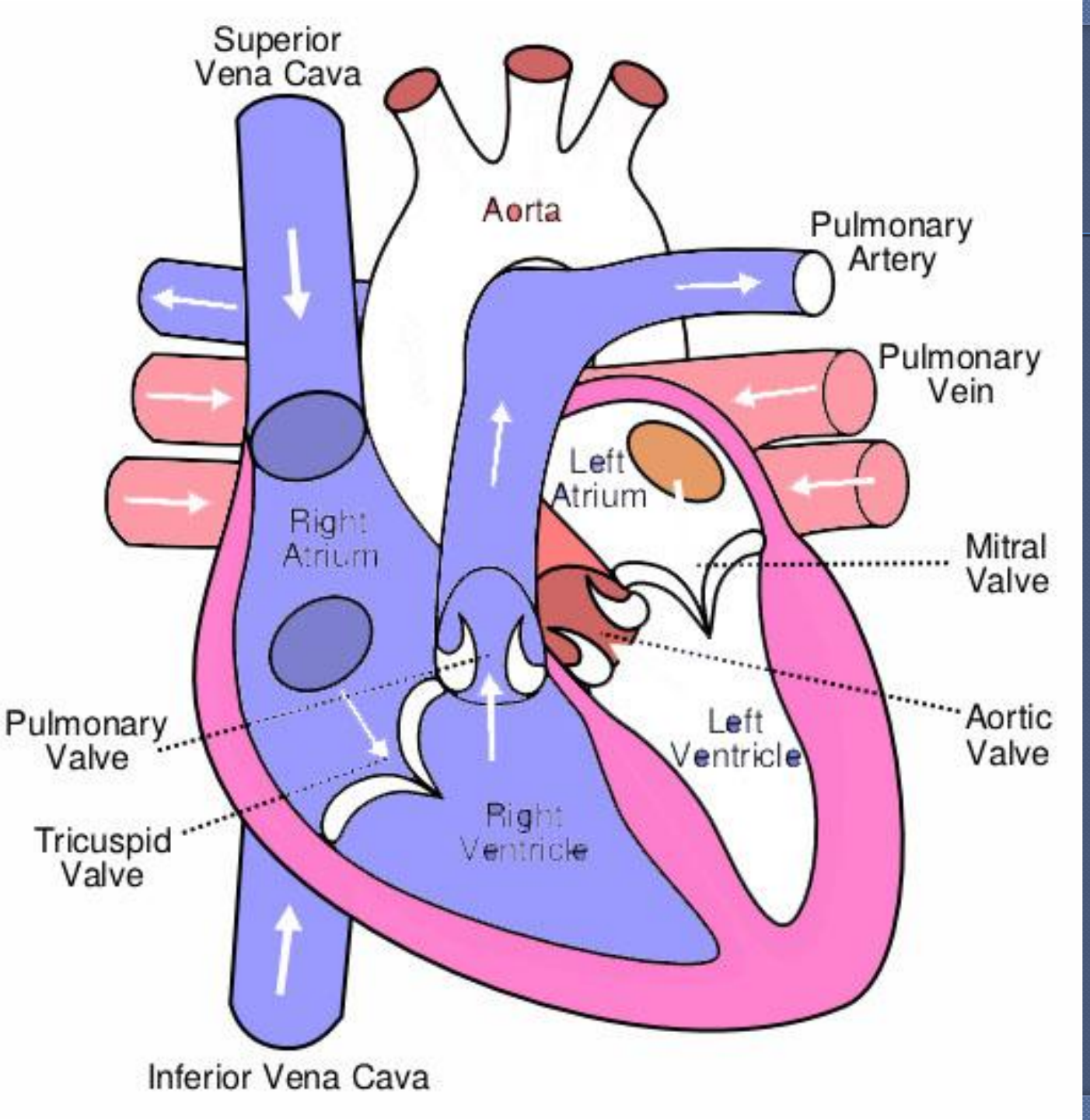

Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Tricuspid
Valve
Right
Ventricle
Inferior Vena Cava

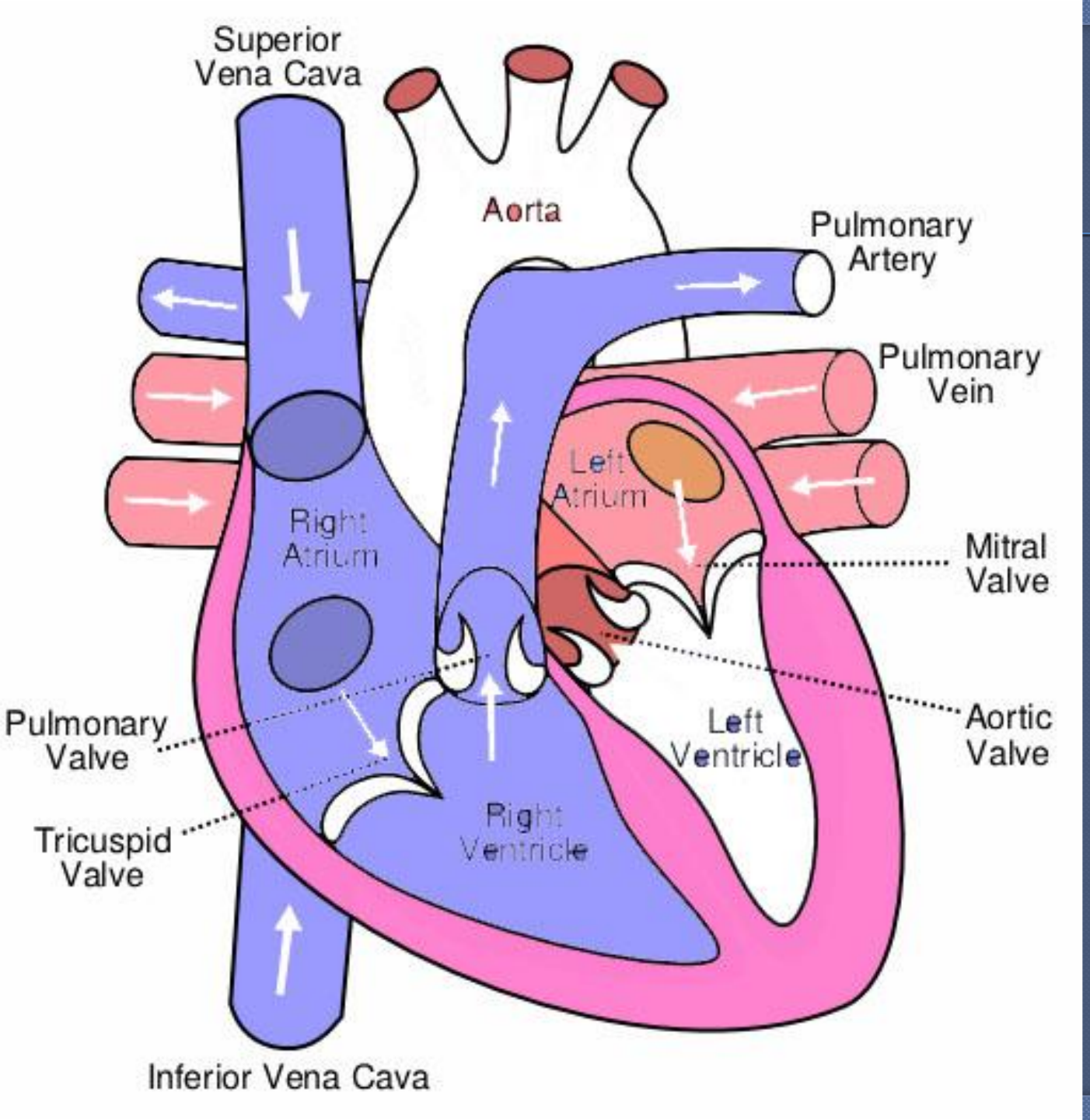

Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Right
Ventricle
Tricuspid
Valve
Inferior Vena Cava

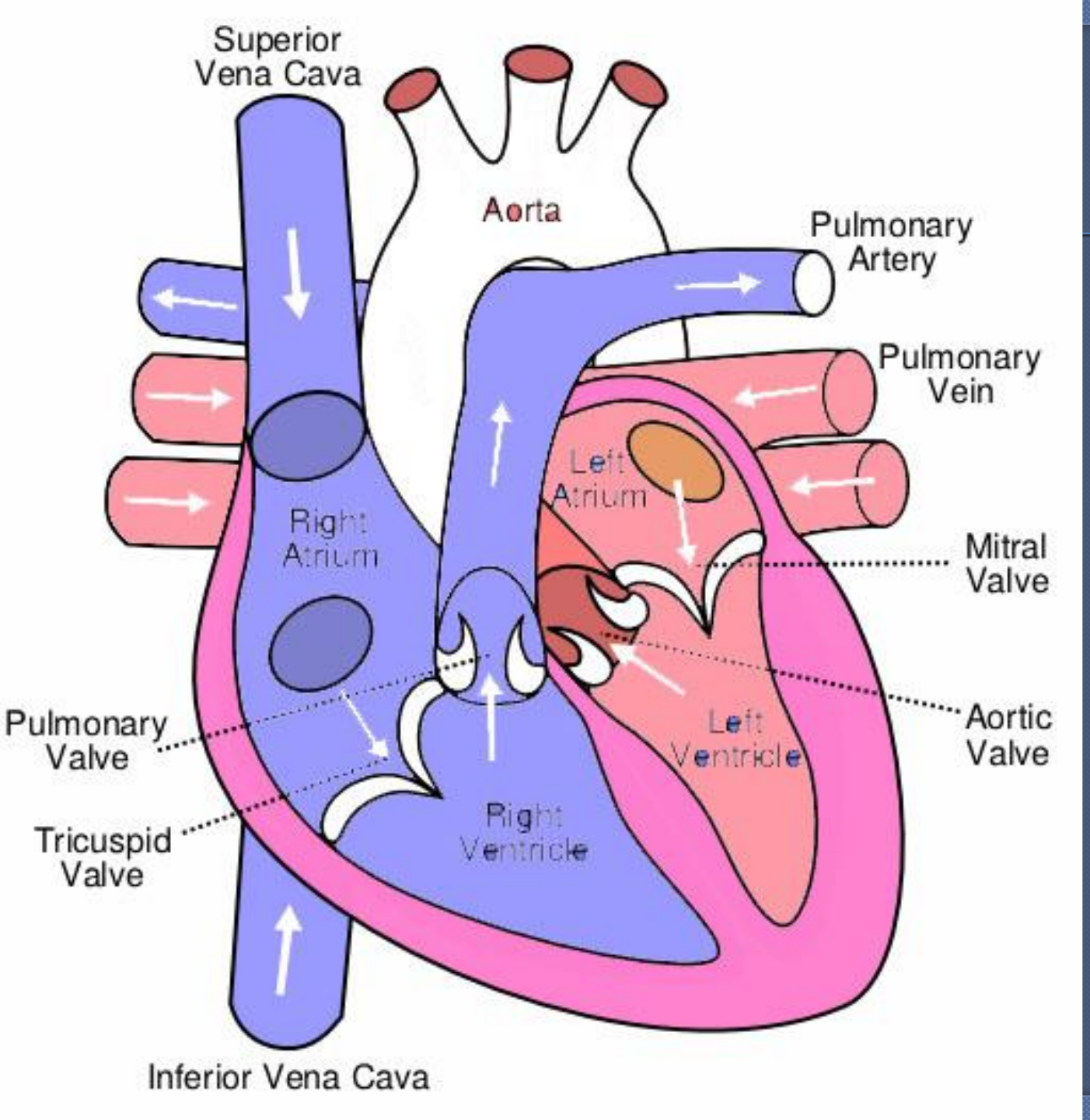

Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Right
Ventricle
Tricuspid
Valve
Inferior Vena Cava

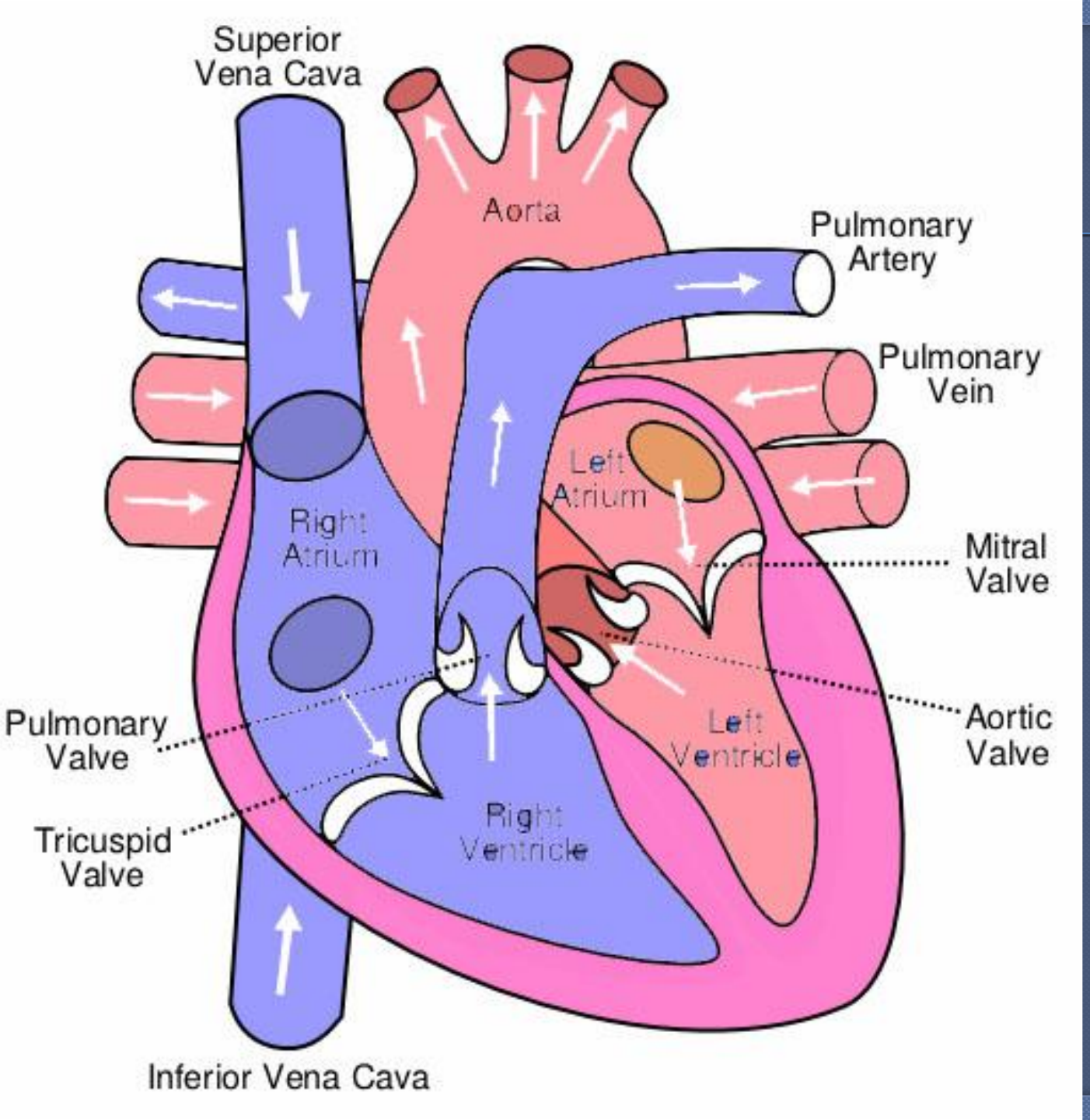

Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Right
Ventricle
Tricuspid
Valve
Inferior Vena Cava


Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Right
Ventricle
Tricuspid
Valve
Inferior Vena Cava


Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Right
Ventricle
Tricuspid
Valve
Inferior Vena Cava


Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Right
Ventricle
Tricuspid
Valve
Inferior Vena Cava


Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Right
Ventricle
Tricuspid
Valve
Inferior Vena Cava


Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Right
Ventricle
Tricuspid
Valve
Inferior Vena Cava

Anatomia do SistemaVascular

- Fatos:
  - difusao só funciona em curtas distancias
    - poucas células
  - o sistema vascular (tubular) proporciona uma via de fluxo rápido

Visão Geral

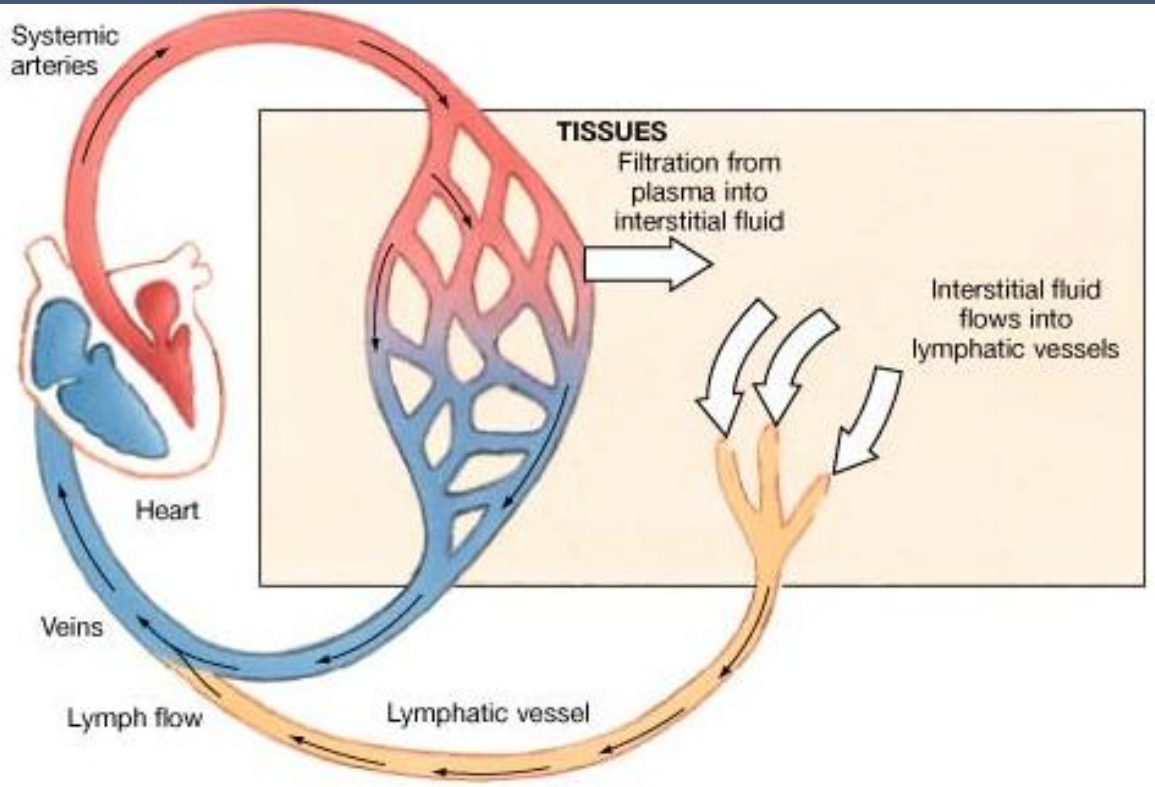
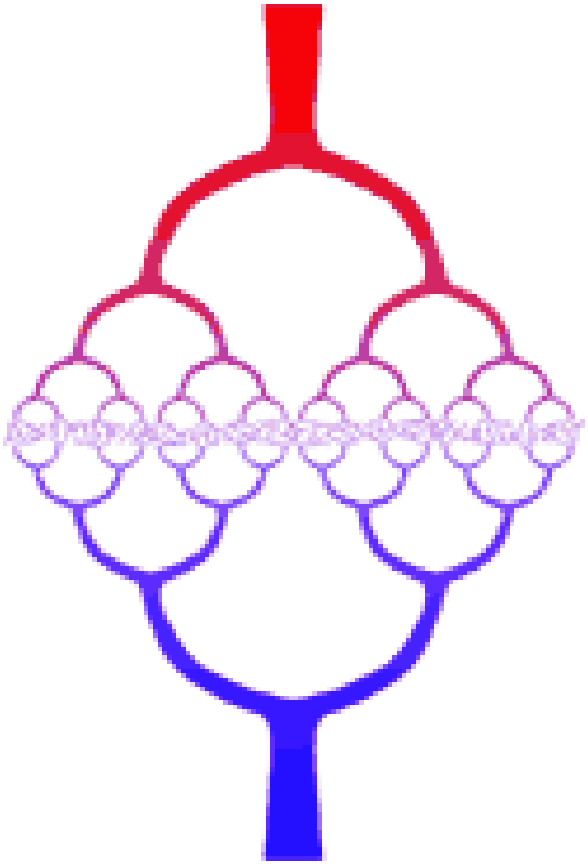


FIGURE 21-1 The Circulation of Extracellular Fluid. There is continuous movement of fluid from the plasma into the interstitial fluid at capillaries and back to the plasma via the lymphatic system.



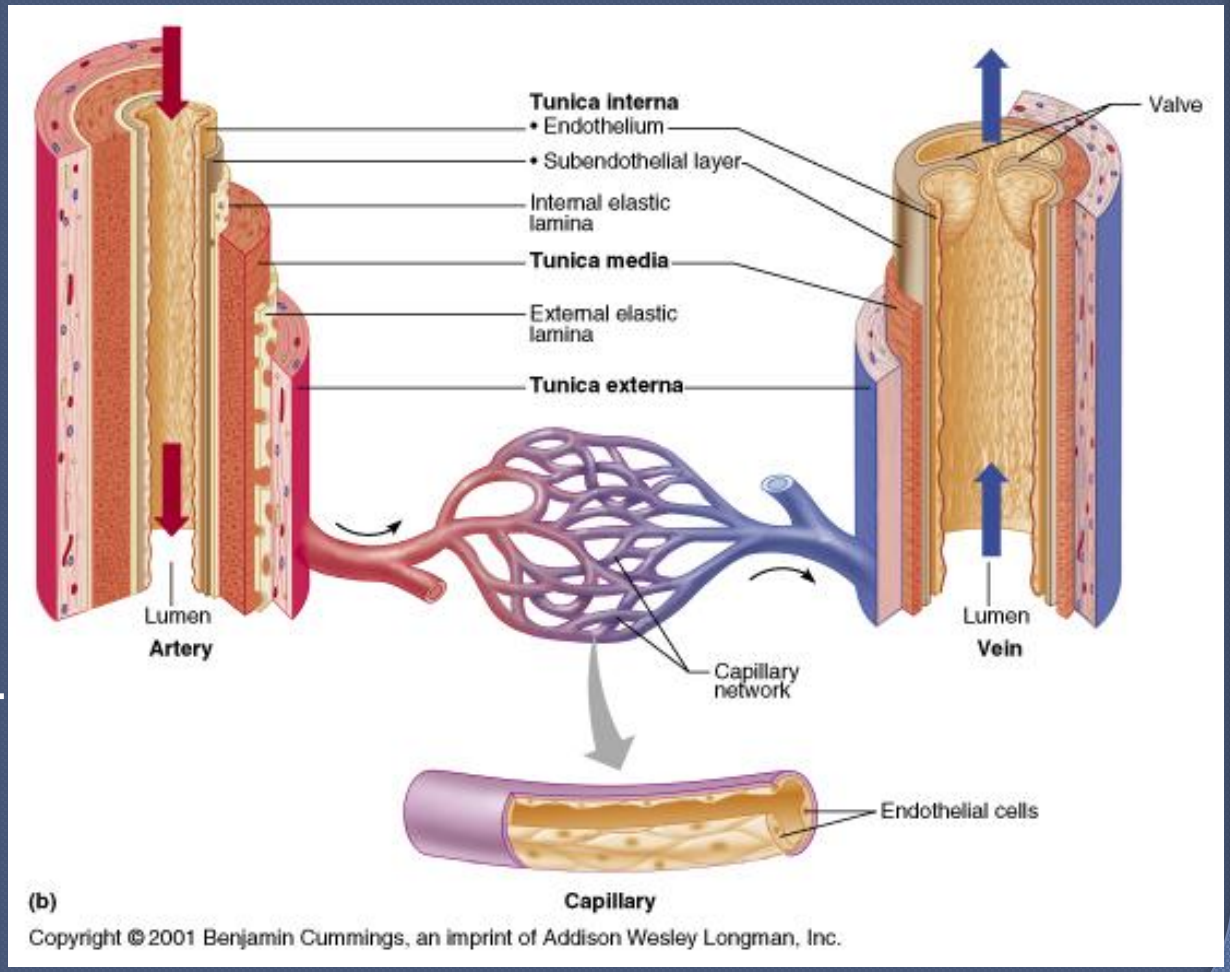
Tipos de vasos

- Artérias
- Arteríolas
- Capilares
- Vênulas
- Veias

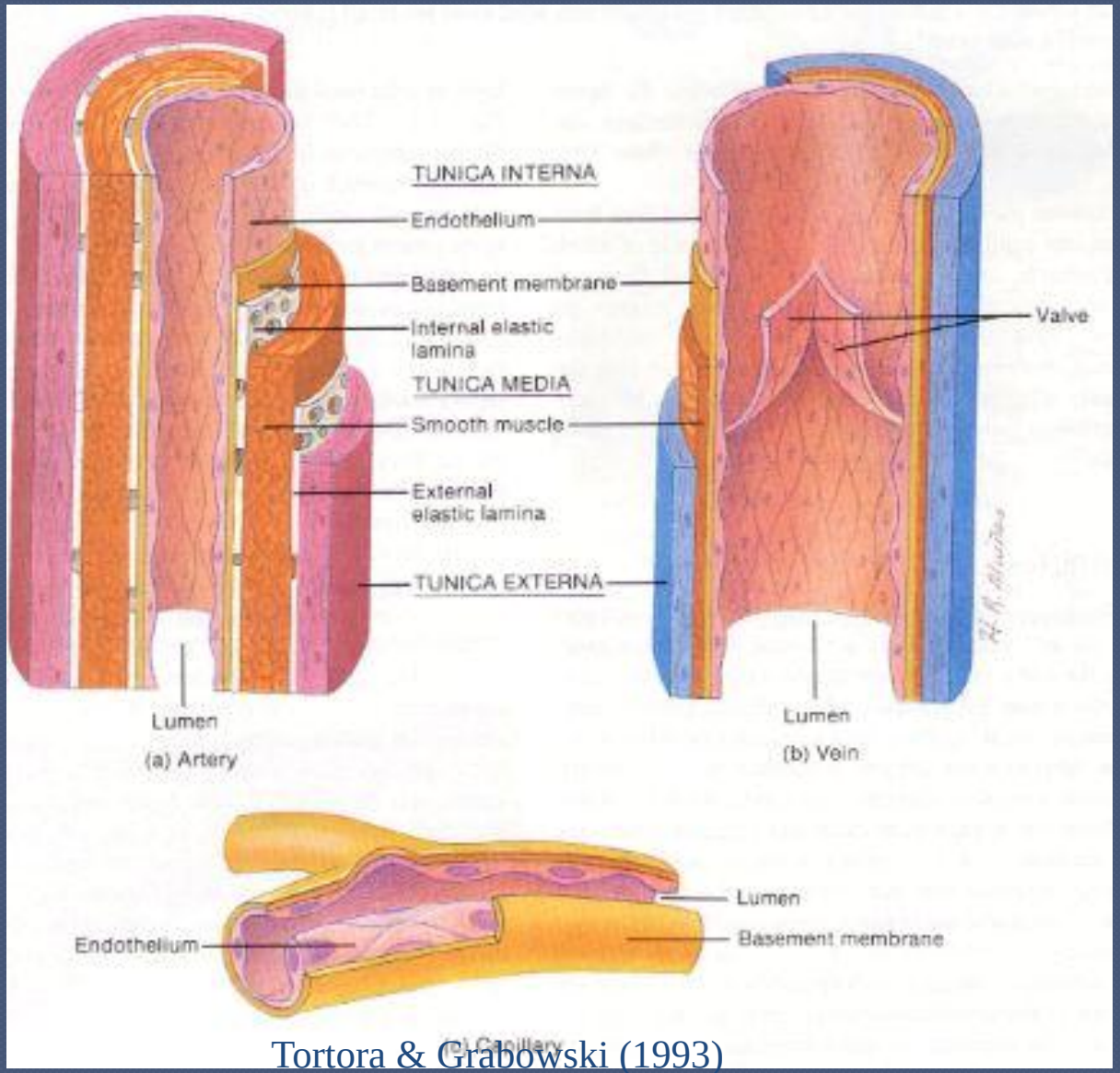
- Seios venosos
- Vasos linfáticos

Estrutura dos vasos

- tunica intima
  - revestimento endotelial
- tunica media (muscularis)
- tunica externa (adventitia)



Anatomia dos Vasos

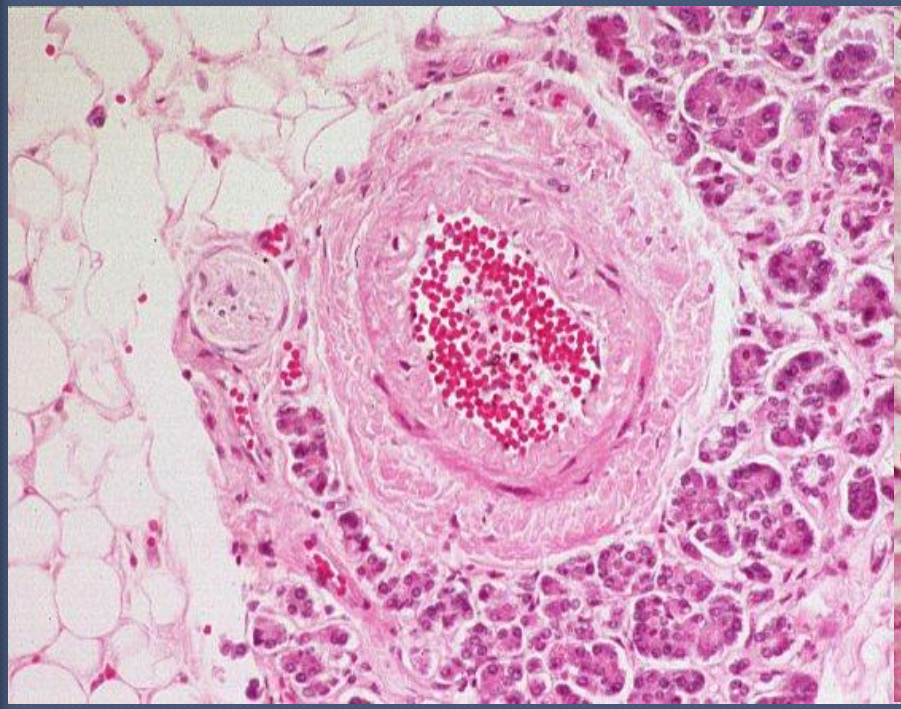


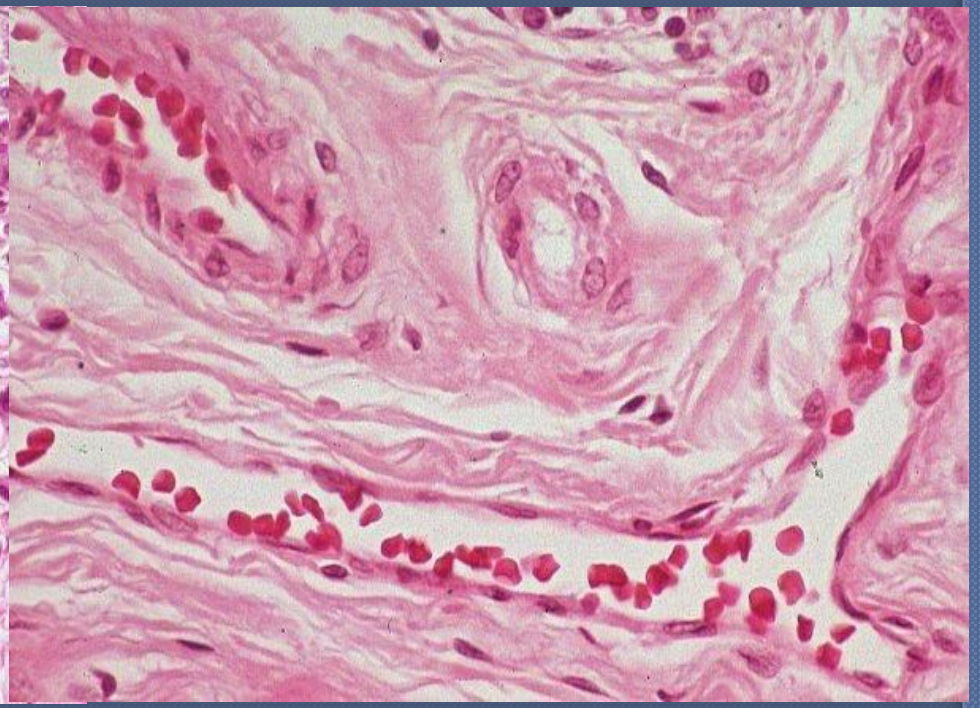
Tortora & Grabowski (1993)

Artérias

- Levam o sangue do coração p/ periferia.
- Possuem grande pressão interna e fluxo ativo.
- Possuem paredes complexas e espessas
  - **Túnica íntima: endotélio**
  - Lâmina elástica interna
  - **Túnica média muscular**
  - Lâmina elástica externa
  - **Túnica externa – adventícia**
    - Tecido conjuntivo, fibras elásticas e colágeno

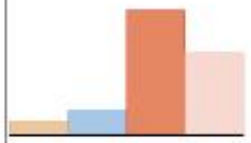
artérias





- artérias elasticas
  - aorta
    - relativamente mais elastina
    - camada muscular não responsiva
    - **vasos de conduçao**
- arterias musculares
  - relativamente mais musculo
  - diametro variavel
  - **regulam fluxo e distribuição**

TABLE 20.1 Summary of Blood Vessel Anatomy

Vessel type/ illustration	*Average lumen diameter (D) and wall thickness (T)*	*Relative tissue makeup* (*Endothelium*, *Elastic tissues*, *Smooth muscles*, *Fibrous (collagenous) tissues*)
 Elastic artery	D: 1.5 cm T: 1.0 mm	
 Muscular artery	D: 6.0 mm T: 1.0 mm	

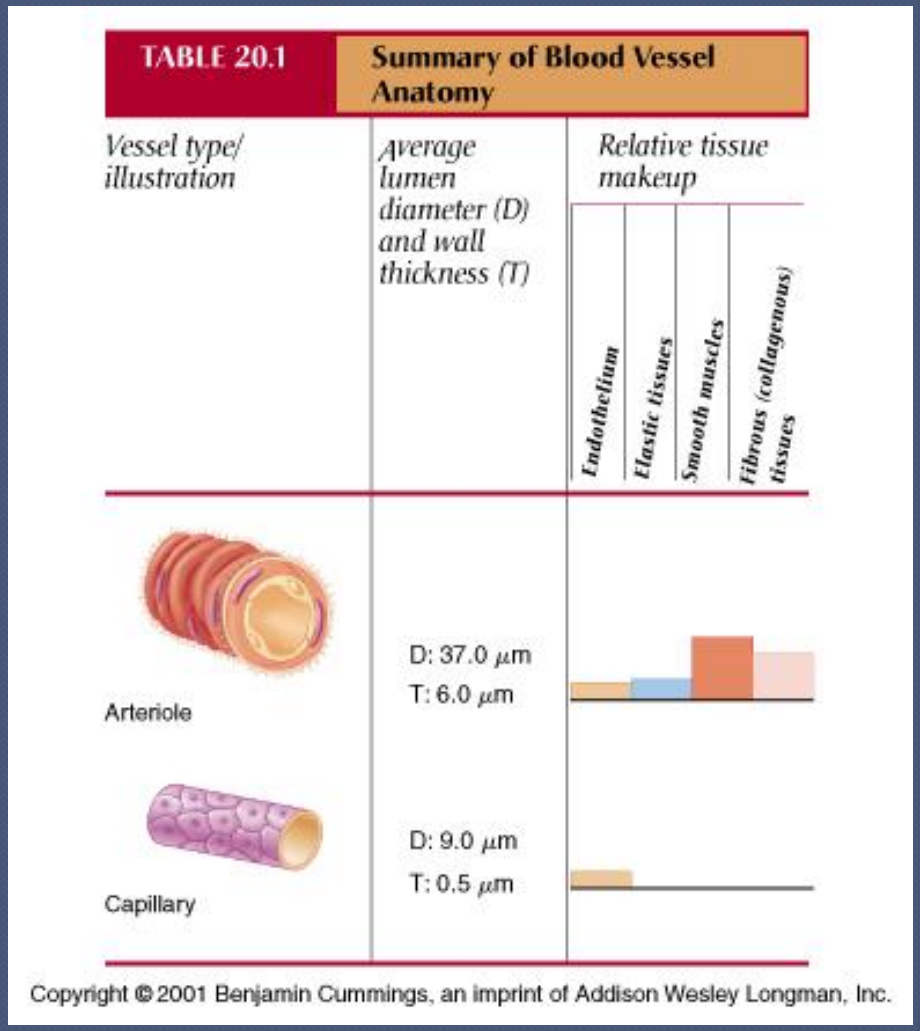
Artérias

- Nutrição pela vasa vasorum (vaso dos vasos) – localizada na túnica externa – originada do próprio vaso, geralmente
- Inervação: vasa nervorum
- Artérias grandes possuem fibras elásticas. Artérias menores possuem poucas fibras elásticas
- "in vivo" apresentam cor esbranquiçada
- Pulsam e mantêm o sangue circulando ativamente
- Regulam o fluxo variando seu grau de contração: vasoespasmo
- Redes de colaterais: circulação alternativa como mecanismo de defesa

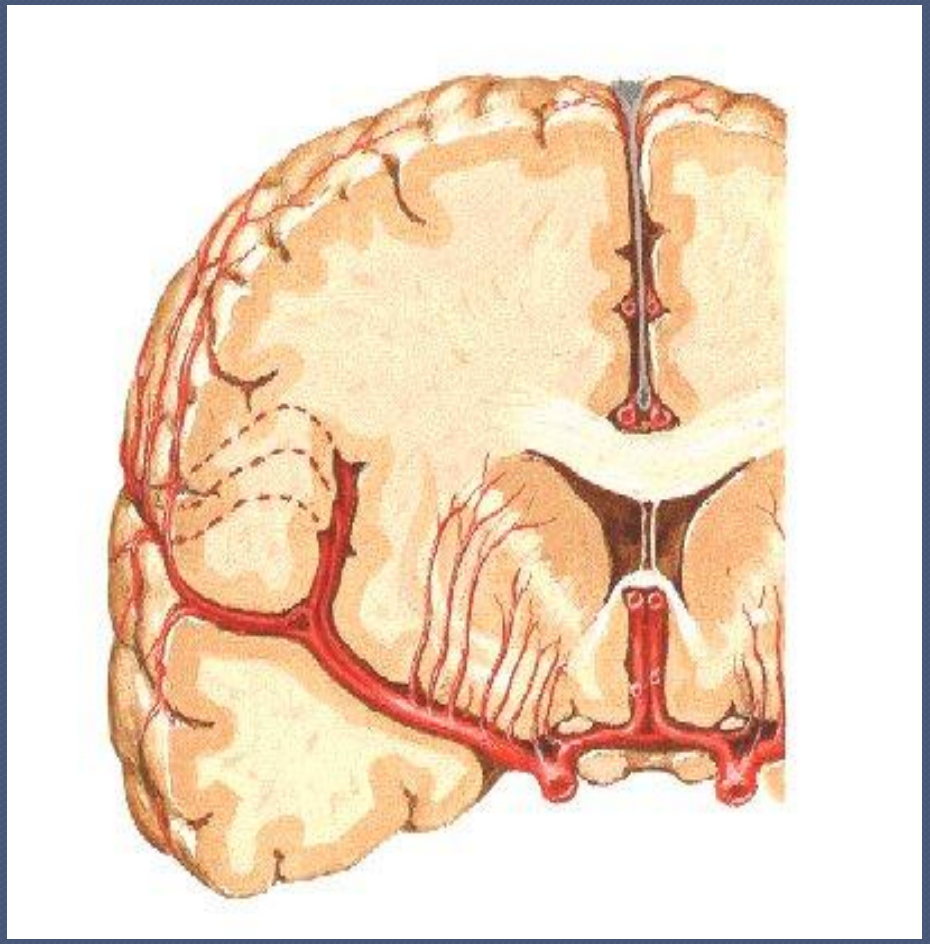
Arteriolas

- Calibre interno menor que 0,5 mm
- Túnica média espessa, praticamente sem fibras elásticas
- As menores perdem progressivamente a túnica média, até ficarem reduzidas a células musculares esparsas
- Grandes responsáveis pela resistência periférica

- Arteriolas
  - camadas reduzidas
    - fibras musculares lisas espiraladas
    - contrateis
    - controle local da distribuição
- Capilares
  - distribuição às celulas
  - ~ 1 mm
  - leitos ou redes



Arteríolas



Capilares

- Especializado em trocas com os tecidos
- Interpostos entre as arteríolas e vênulas
- Calibre reduzido: praticamente uma hemácea
- Possuem apenas camada íntima:
  membrana basal, células endoteliais e tecido conjuntivo.

Capilares são compostos práticamente de endotelio.

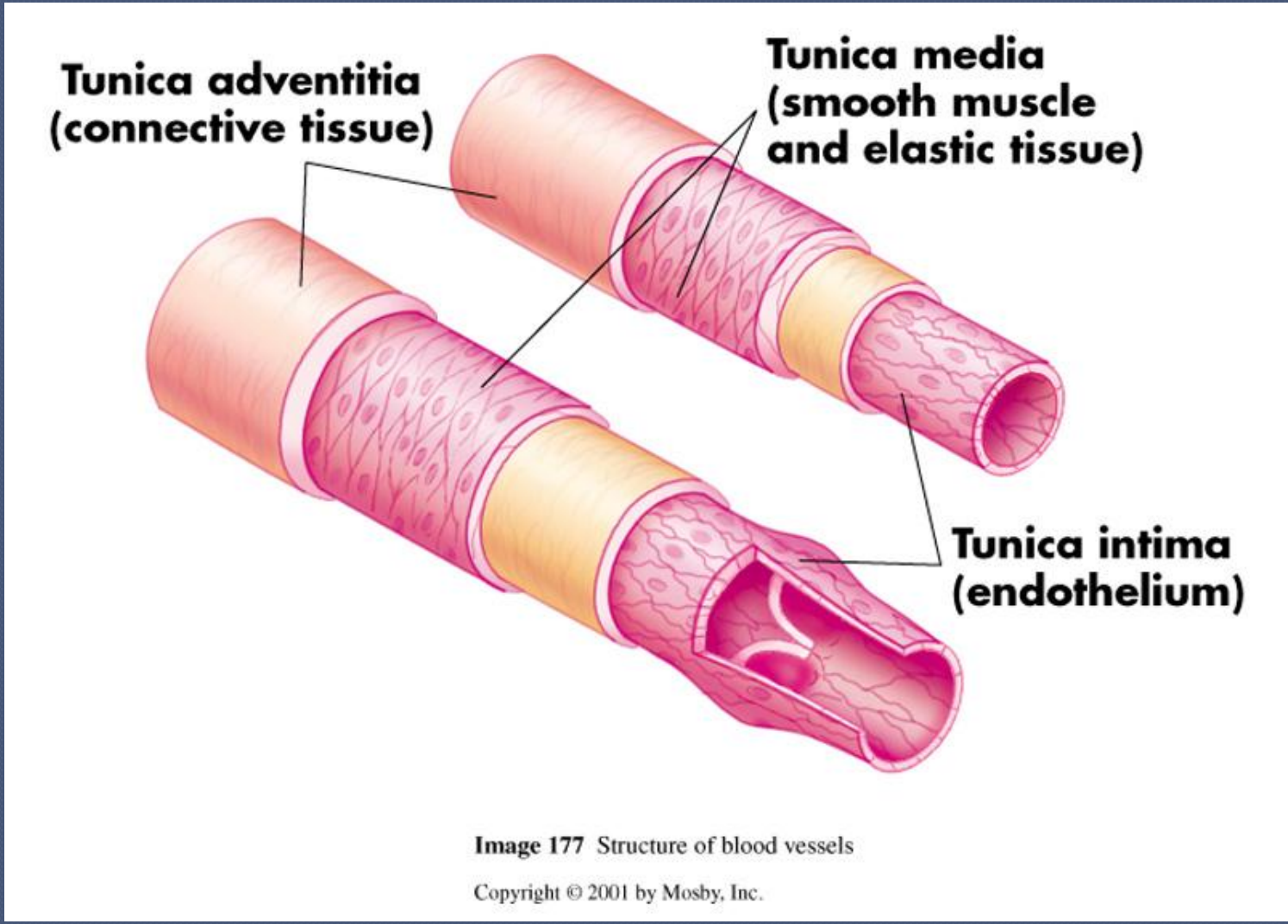
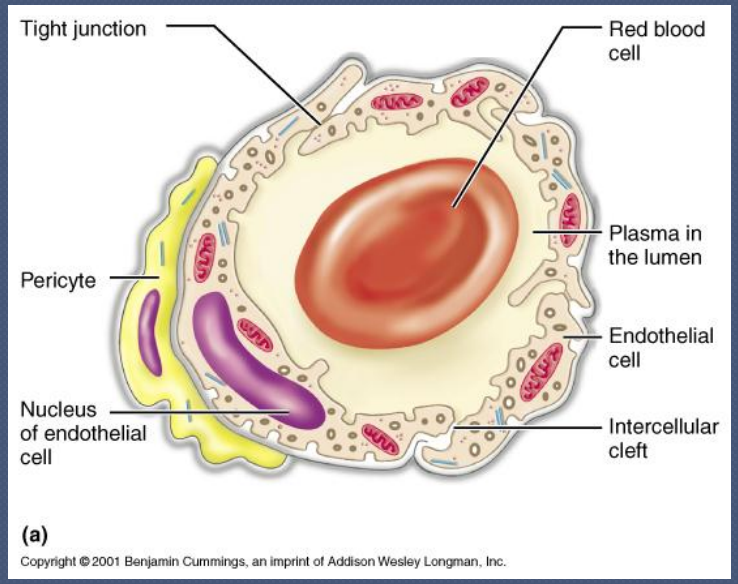


Image 177 Structure of blood vessels

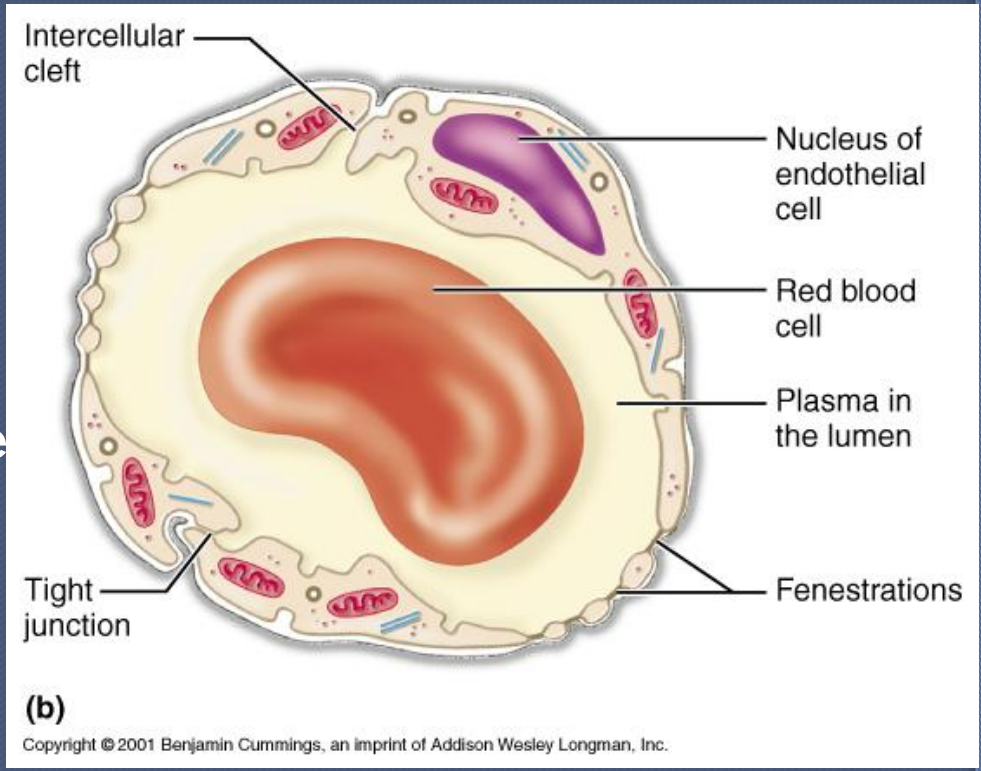
capilares

anatomia capilar

- continua
  - endotelio continuo
  - tight junctions - incompletas
    - formam gaps
  - no cérebro não há gaps = barreira hematoencefálica



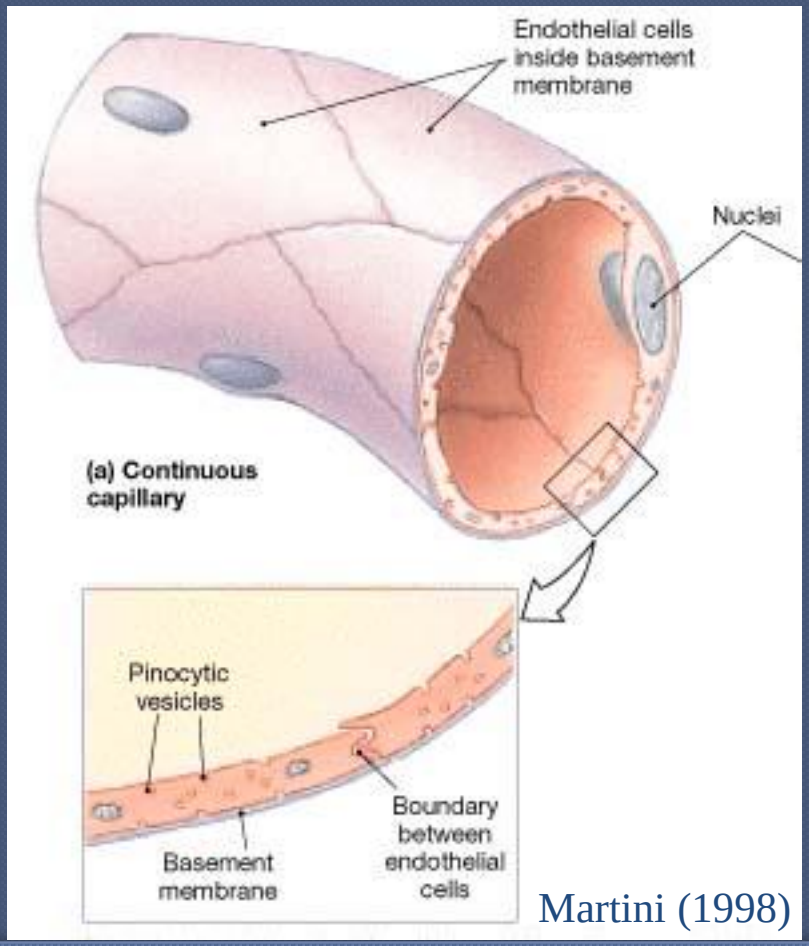
- capilares fenestrados
  - poucas tight junctions
  - permitem difusão extracapilar
    - macromoleculas
  - tecidos absorptivos ou de troca
    - rim
    - intestino



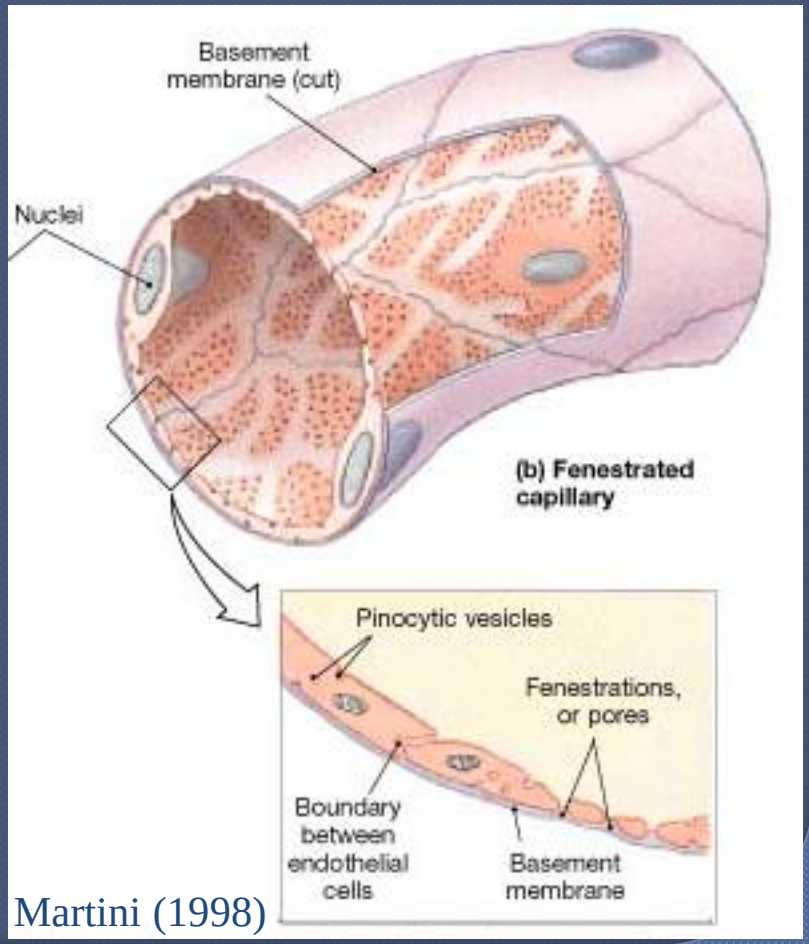
Fisiologia

- **Capilares** - Continuos

  - Fenestrados



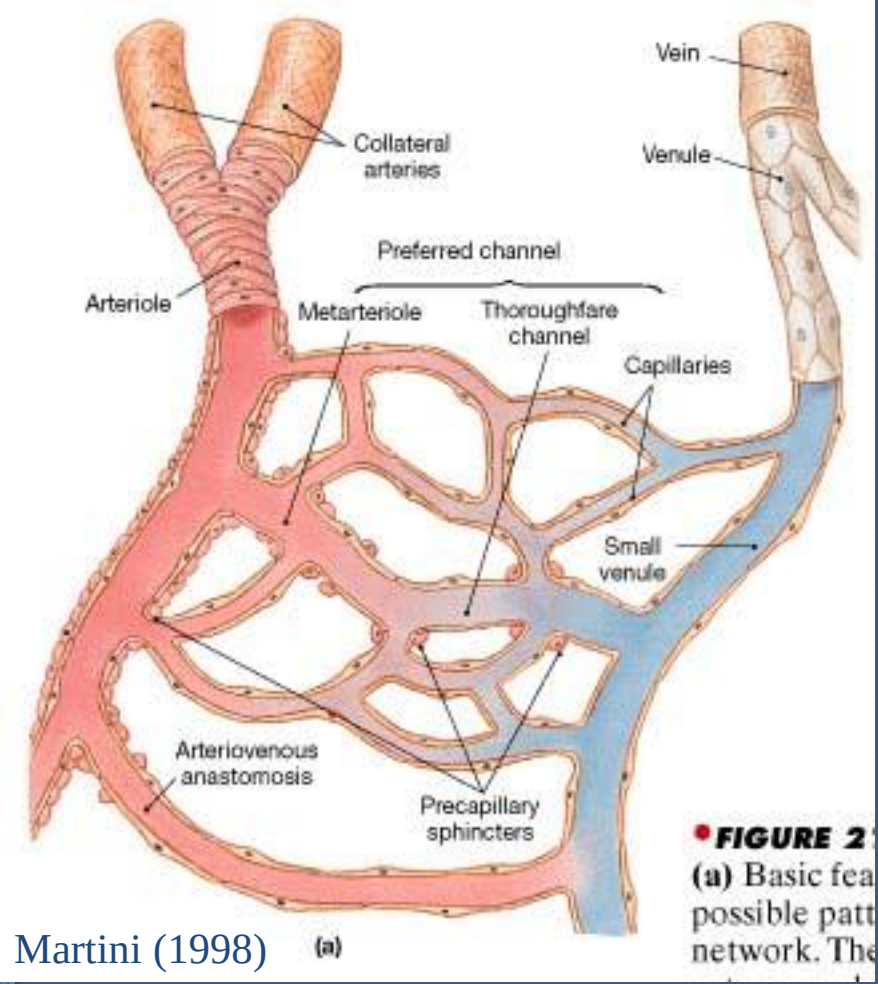
Martini (1998)



Martini (1998)

Fisiologia

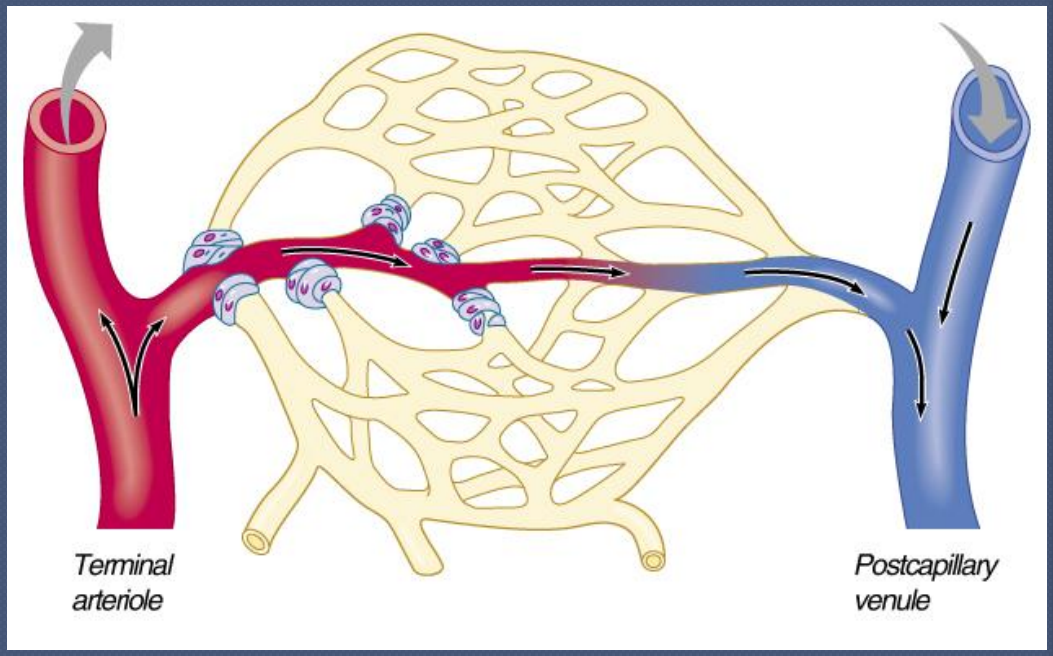
- **Leitos Capilares**

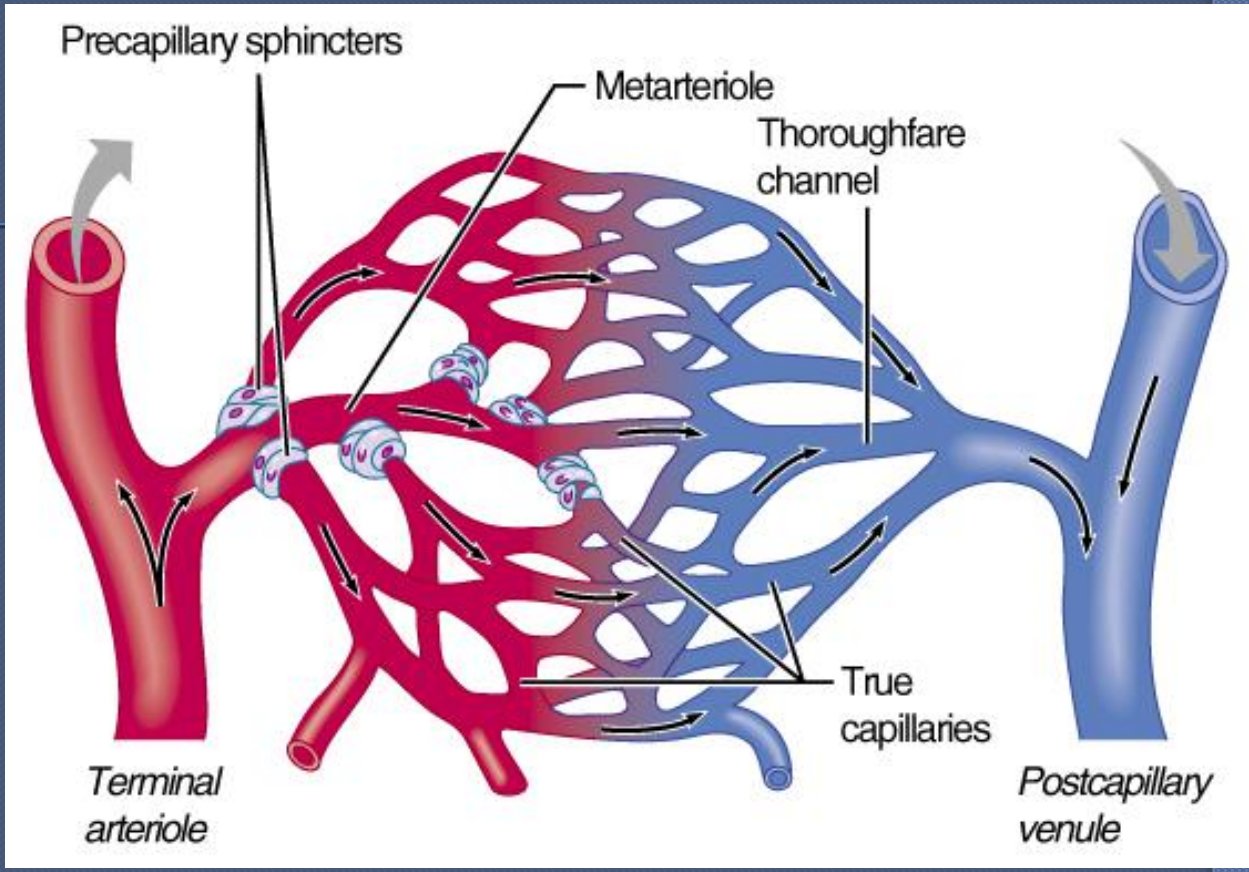


Martini (1998)

Leitos Capilares

- Distribuem sangue às células individuais
- reguladas pelo musculo liso
  - esfincter precapilar

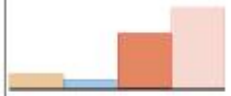




- Esfincteres abertos
  - fluxo aumentado
  - controle local ou pelo SNC

- Venulas
  - coletam sangue dos capilares
  - condução às veias
- Veias
  - conduçao ao coraçao
    - pouca constricção
  - Armazenam sangue
    - capacitancia
    - 65 % do volume total

TABLE 20.1 Summary of Blood Vessel Anatomy

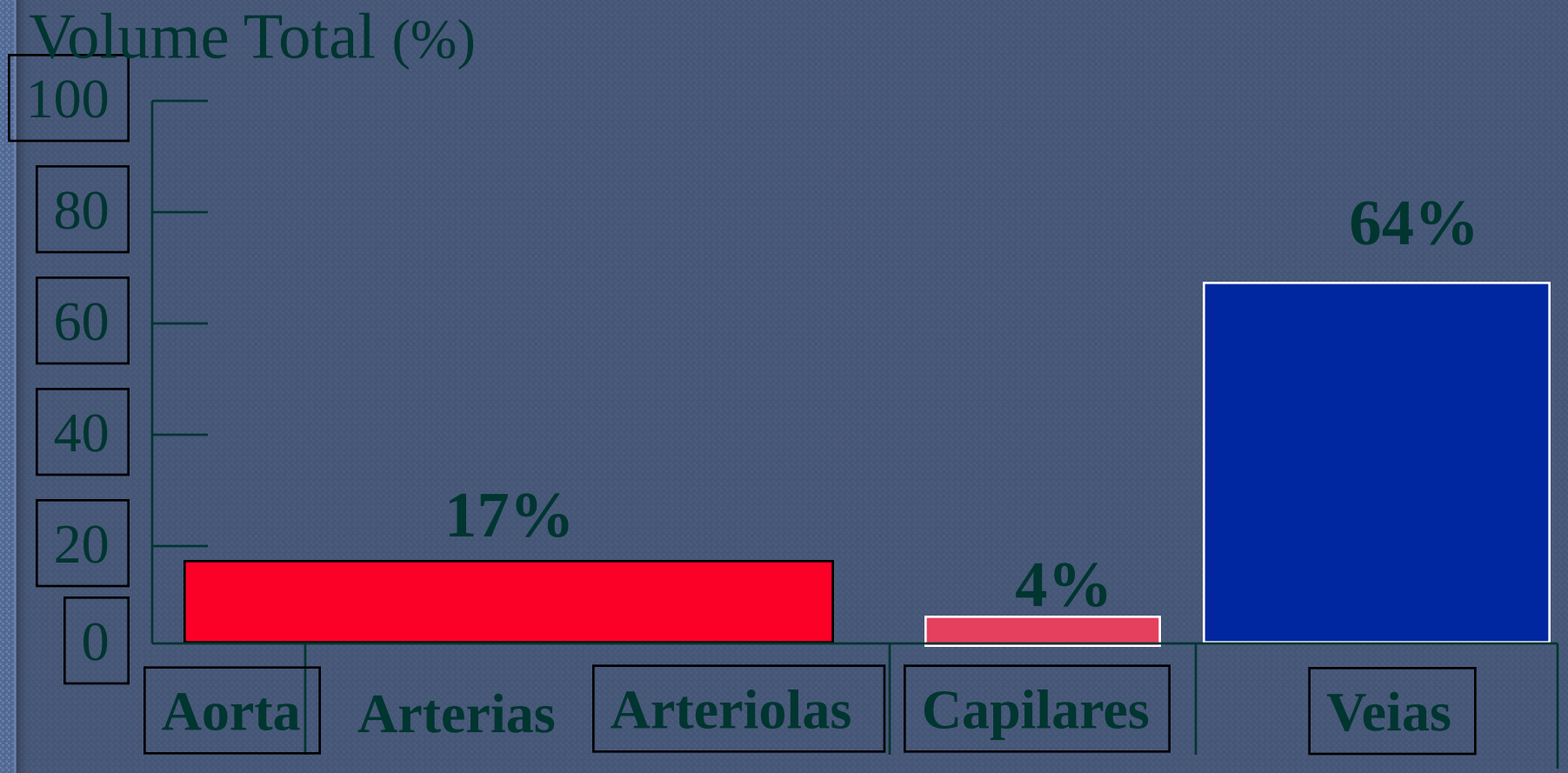
Vessel type/ illustration	*Average lumen diameter (D) and wall thickness (T)*	*Relative tissue makeup* (*Endothelium*, *Elastic tissues*, *Smooth muscles*, *Fibrous (collagenous) tissues*)
 Venule	D: 20.0 μm T: 1.0 μm	
 Vein	D: 5.0 mm T: 0.5 mm	

Veias

- Levam o sangue para o coração
- Têm parede fina e "transparente"
- Circulação passiva, dependente da musculatura estriada adjacente sem pressão ou pulsação
- Alta distensão e número maior que as artérias: compensação para fluxo lento
- Contêm válvulas, que mantêm o fluxo unidirecional, mas dependente de músculos próximos
- Algumas regiões não possuem válvulas:
  - Encéfalo e pescoço
  - Plexo venoso para-vertebral

Distribuição do Volume Sanguíneo

(Systemic Circulation) Henley 1997



Hemodinamica

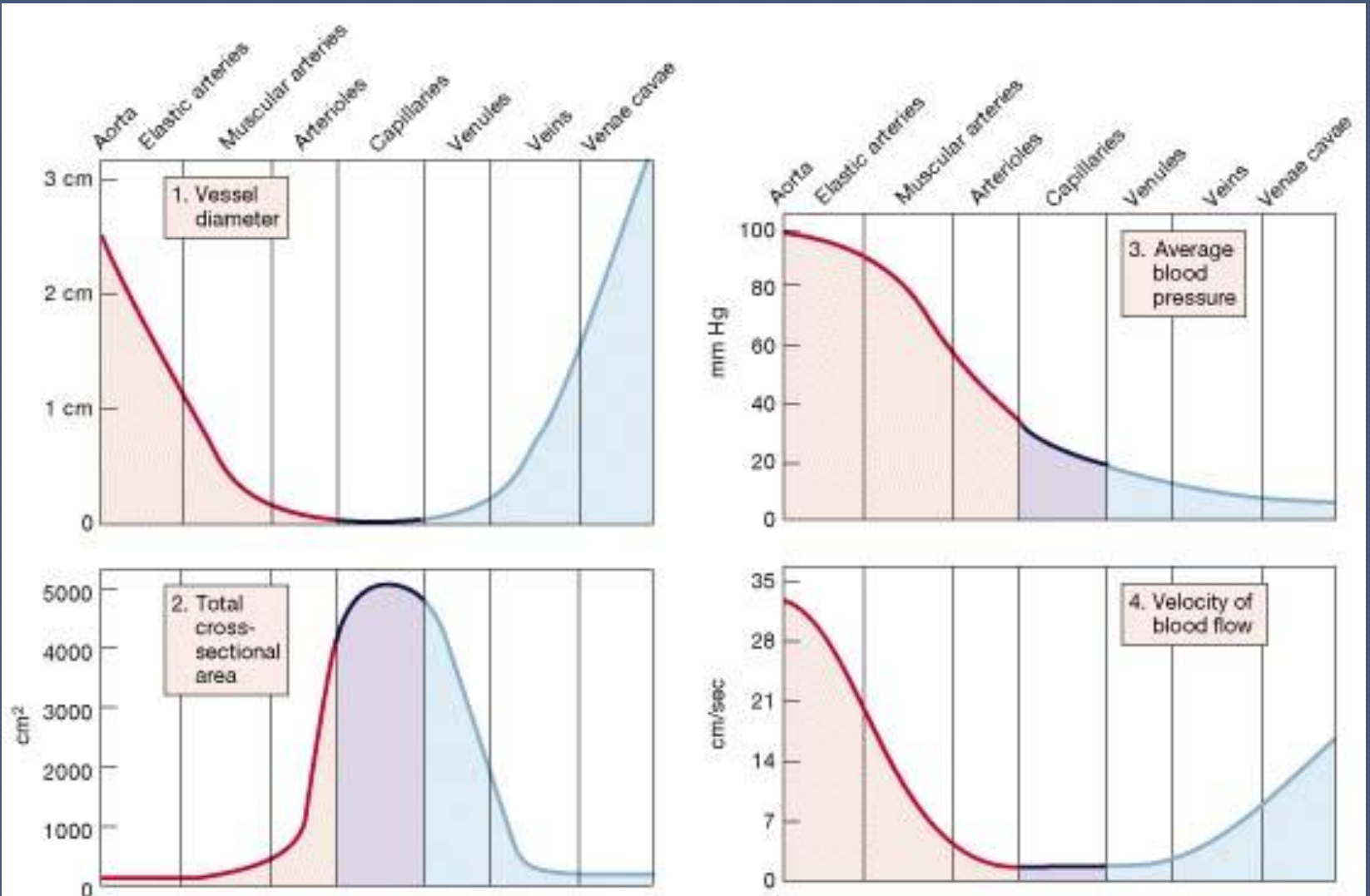
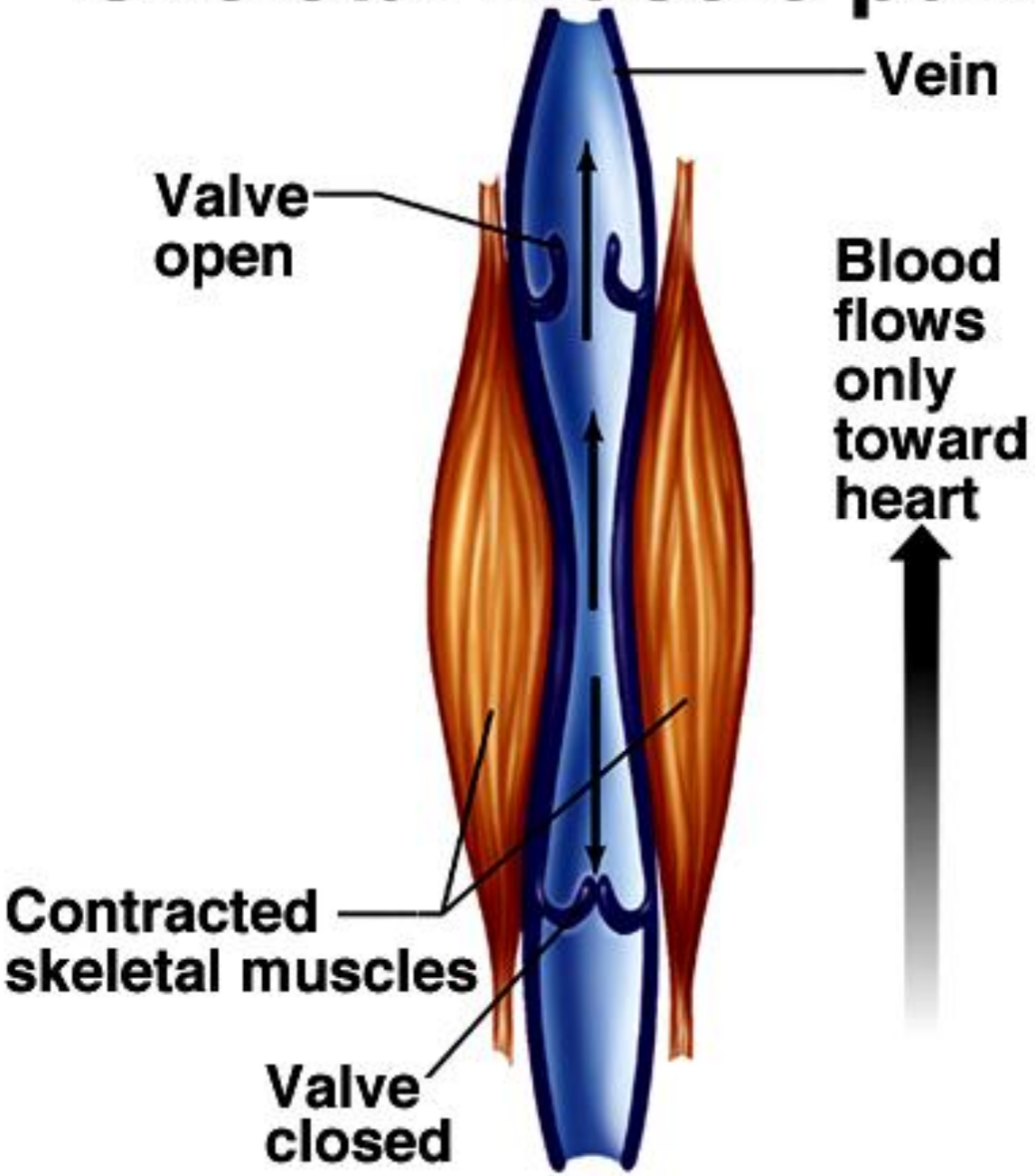
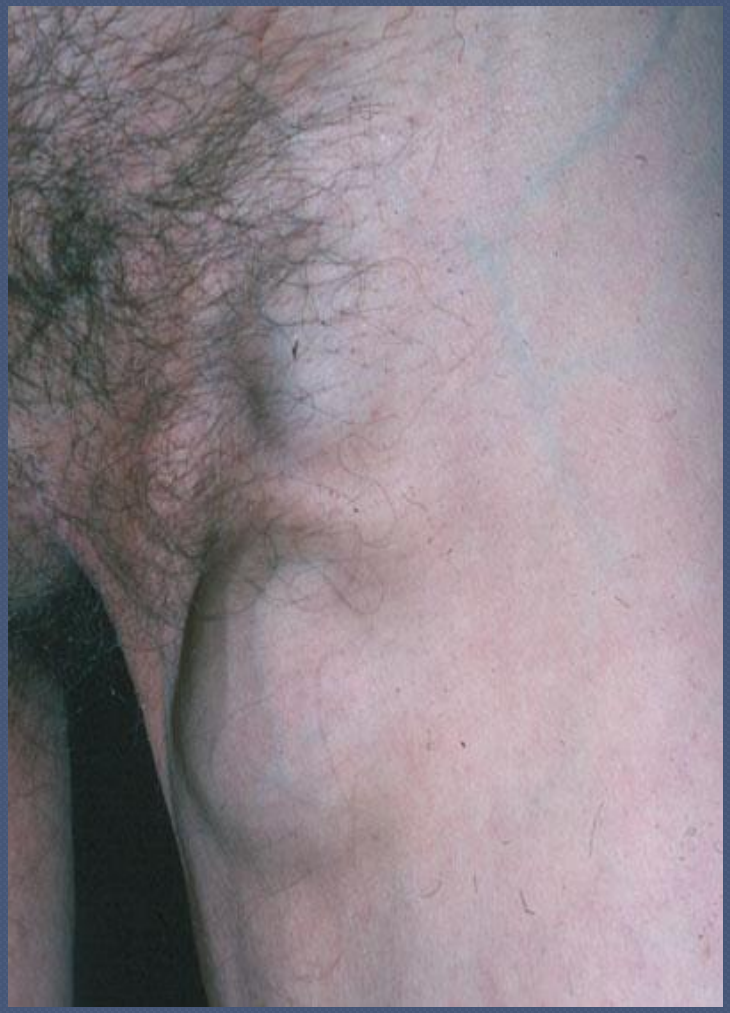


FIGURE 21-9 Relationships among Vessel Diameter, Cross-Sectional Area, Blood Pressure, and Blood Velocity

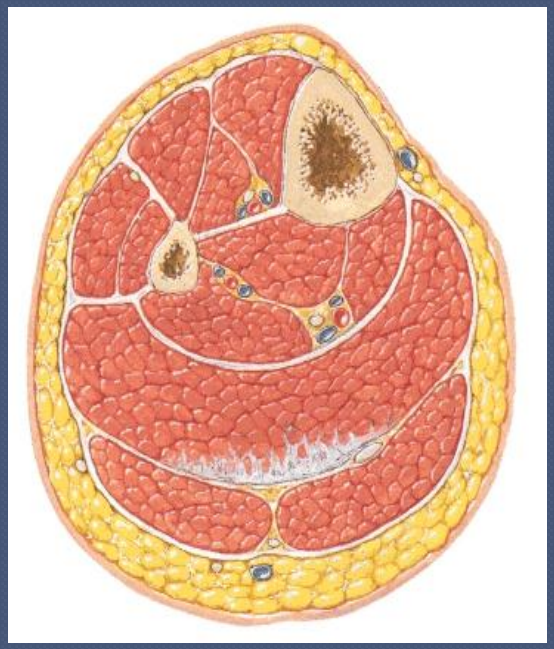
Skeletal-muscle pump

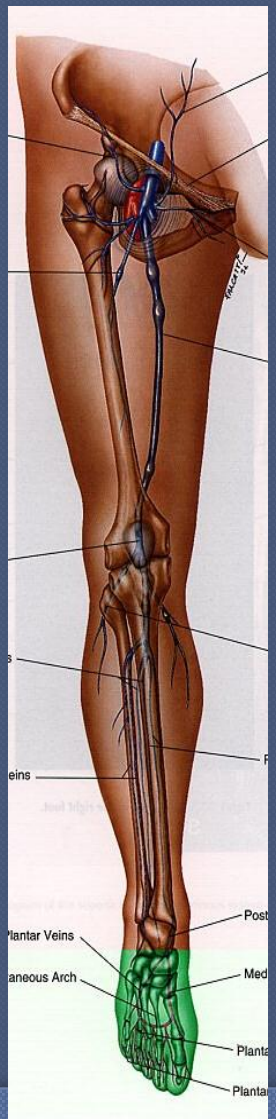


Varizes

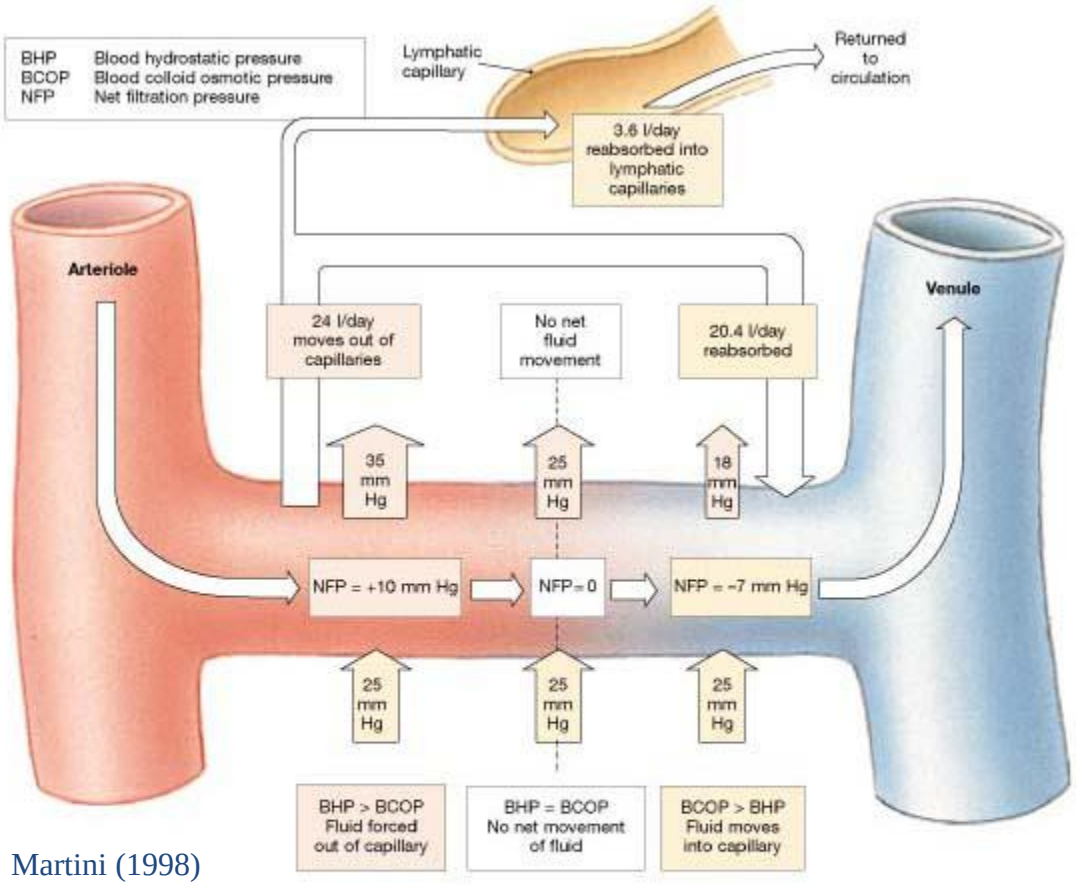


Veias profundas e superficiais





Trocas Capilares



Martini (1998)

FIGURE 21-13 Forces Acting across Capillary Walls. At the arterial end of the capillary, blood hydrostatic pressure (BHP) is stronger than blood colloid osmotic pressure (BCOP), and fluid moves out of the capillary. Near the venule, BHP is lower than BCOP, and fluid moves into the capillary. In this model, interstitial fluid osmotic pressure (ICOP) and interstitial fluid hydrostatic pressure (IHP) are assumed to be 0 mm Hg.

Net Filtration Pressure = (BHP-IHP) – (BCOP-ICOP)

Arterial end **FILTRATION**

BHP = 35 mmHg
IHP = 0 mmHg

BCOP = 25 mmHg
ICOP = 0 mmHg

Venous end **REABSORPTION**

BHP = 18 mmHg
IHP = 0 mmHg

BCOP = 25 mmHg
ICOP = 0 mmHg

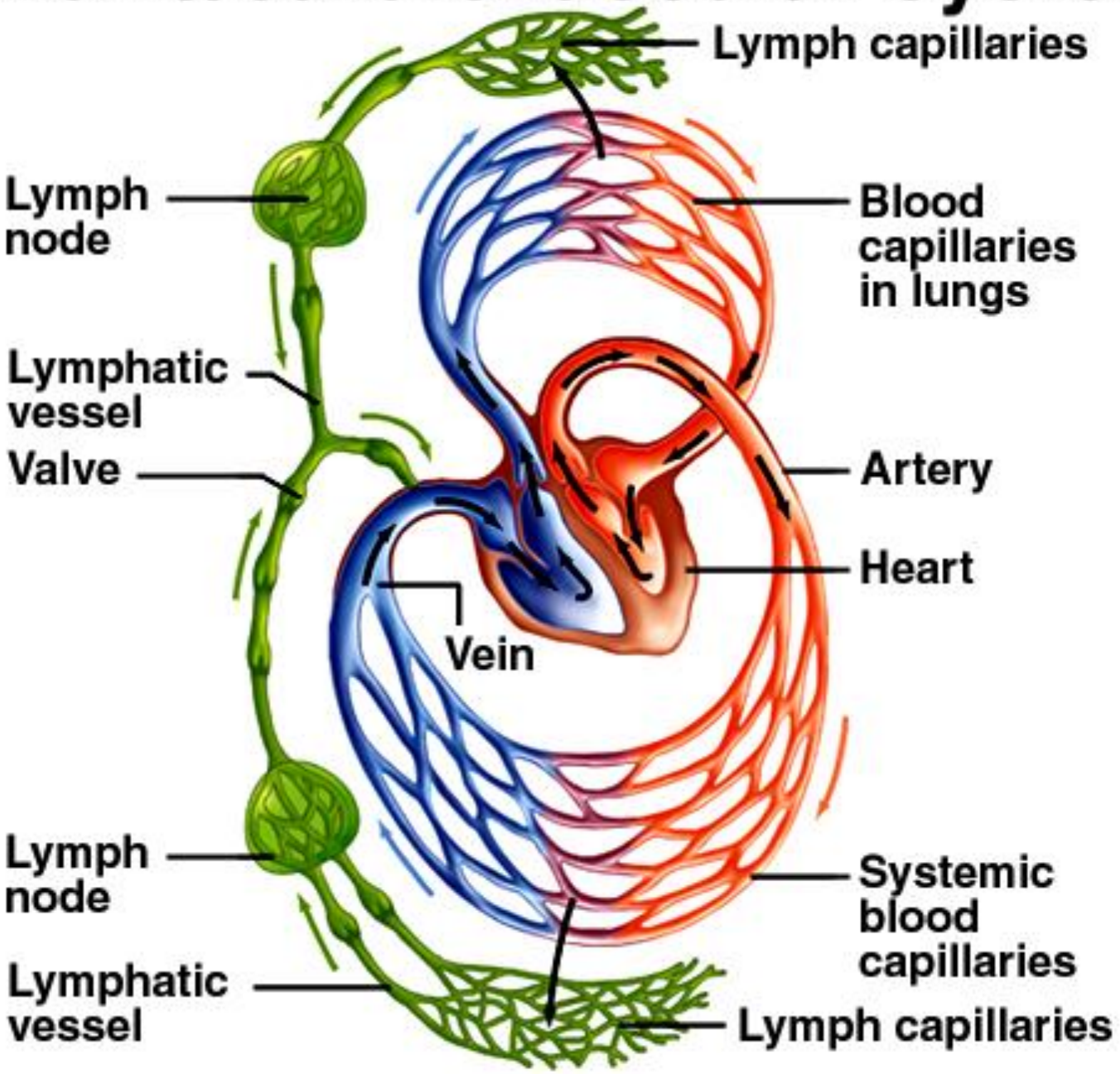
Sistema linfático

- Formado por vasos e órgãos linfóides
- Auxiliar na drenagem: moléculas grandes e linfa, com função de "filtro" e defesa

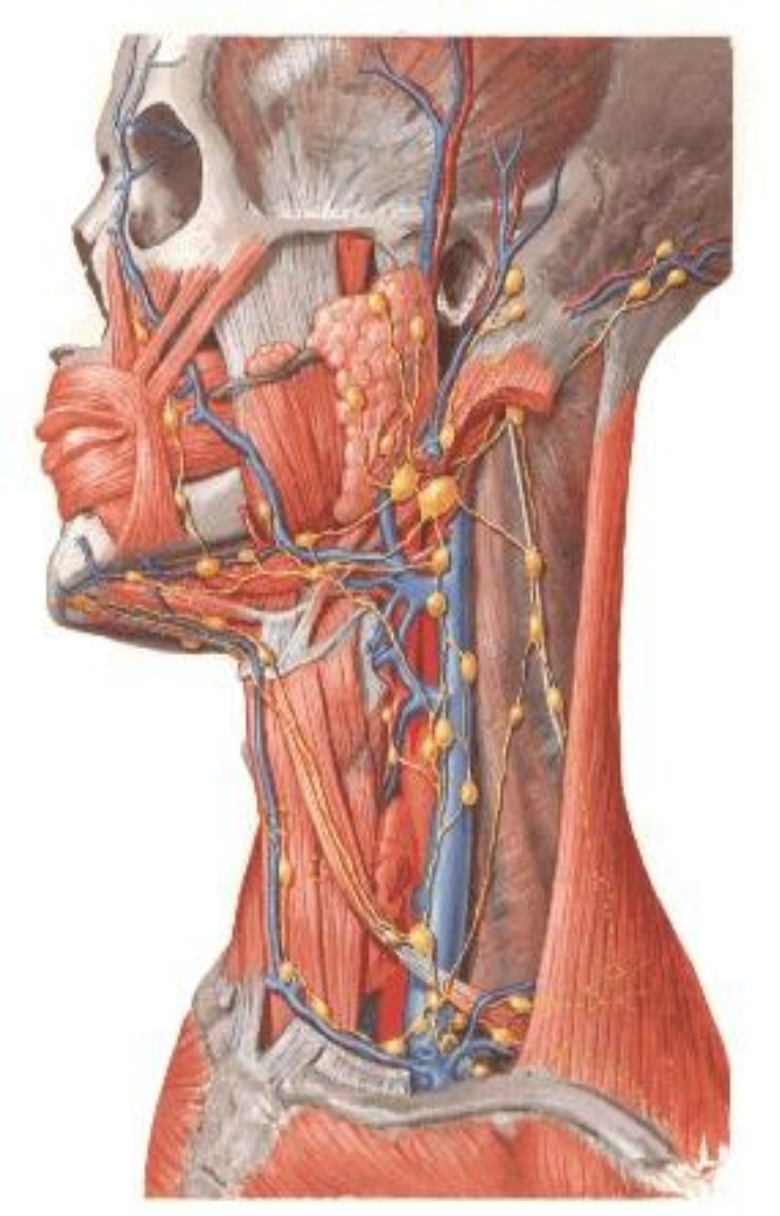
- Vasos linfáticos com válvulas, sem propulsão própria, sem "bomba"

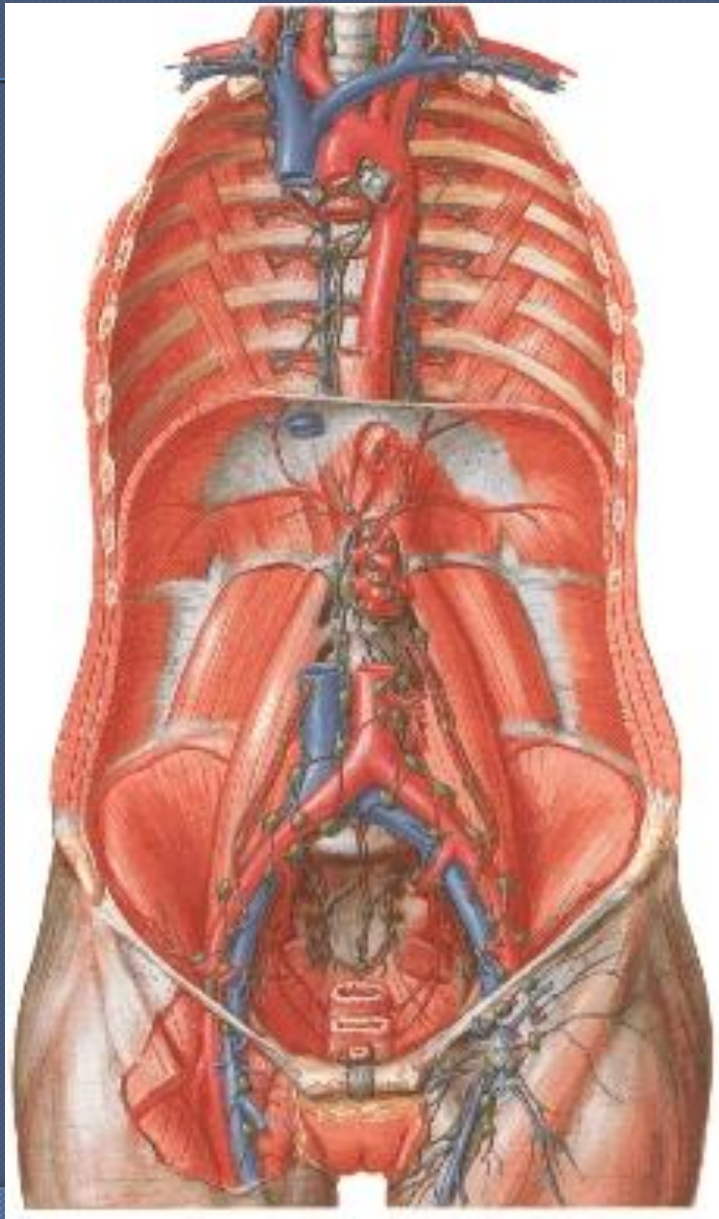
- Deságuam em veias através de grandes ductos: ducto torácico na veia subclávia E
- Linfonodos: produzem linfócitos

Lymphatic/cardiovascular system

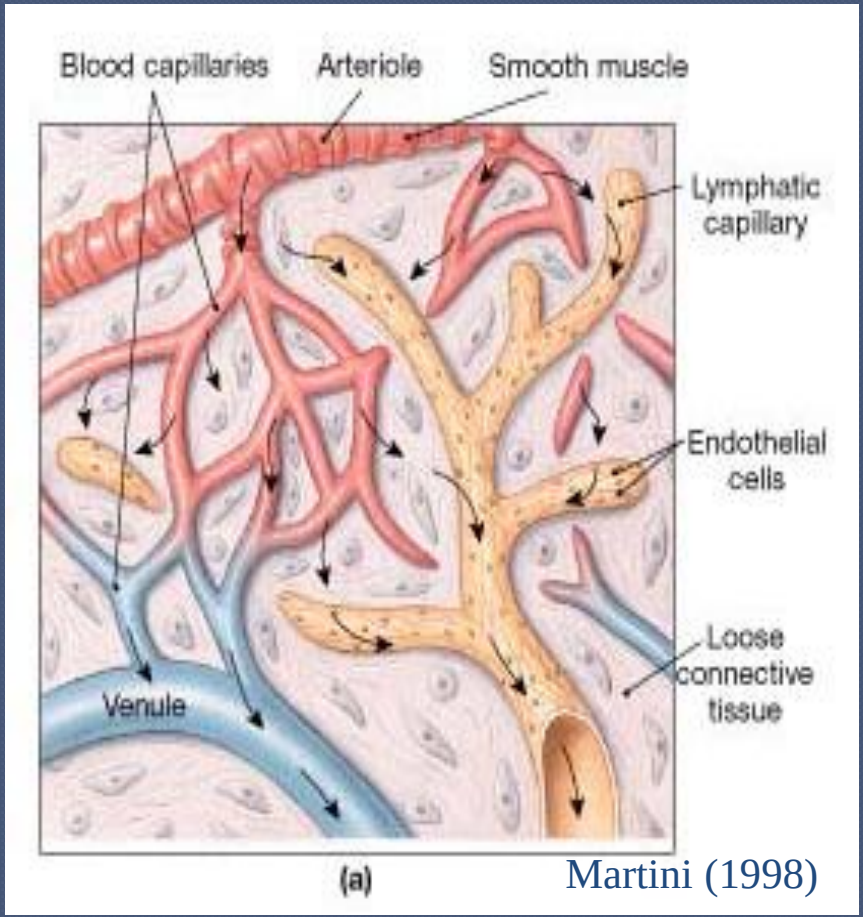


Sistema linfático

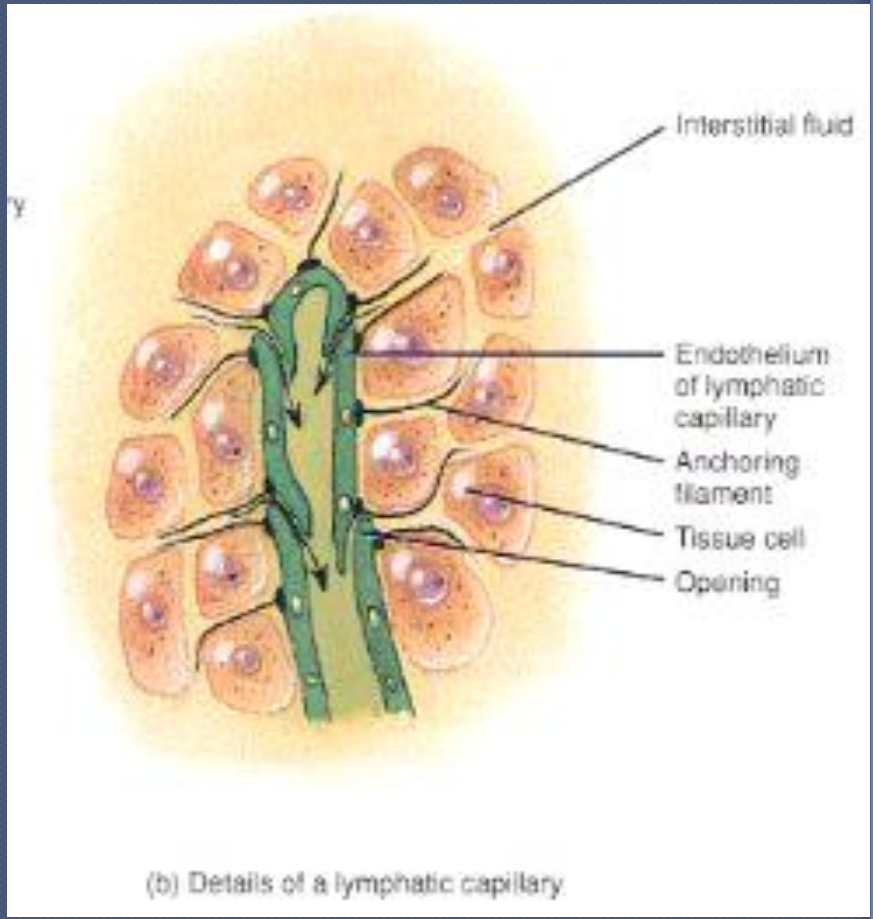




Associação Capilares Linfáticos



Martini (1998)



Tipos de circulação

- Circulação pulmonar
  - "pequena circulação": coração - pulmão
  - Artérias contêm sangue saturado e veias sangue oxigenado
- Circulação sistêmica
  - "grande circulação": coração – tecidos
  - Artérias contêm sangue oxigenado

Medida da Pressão Arterial

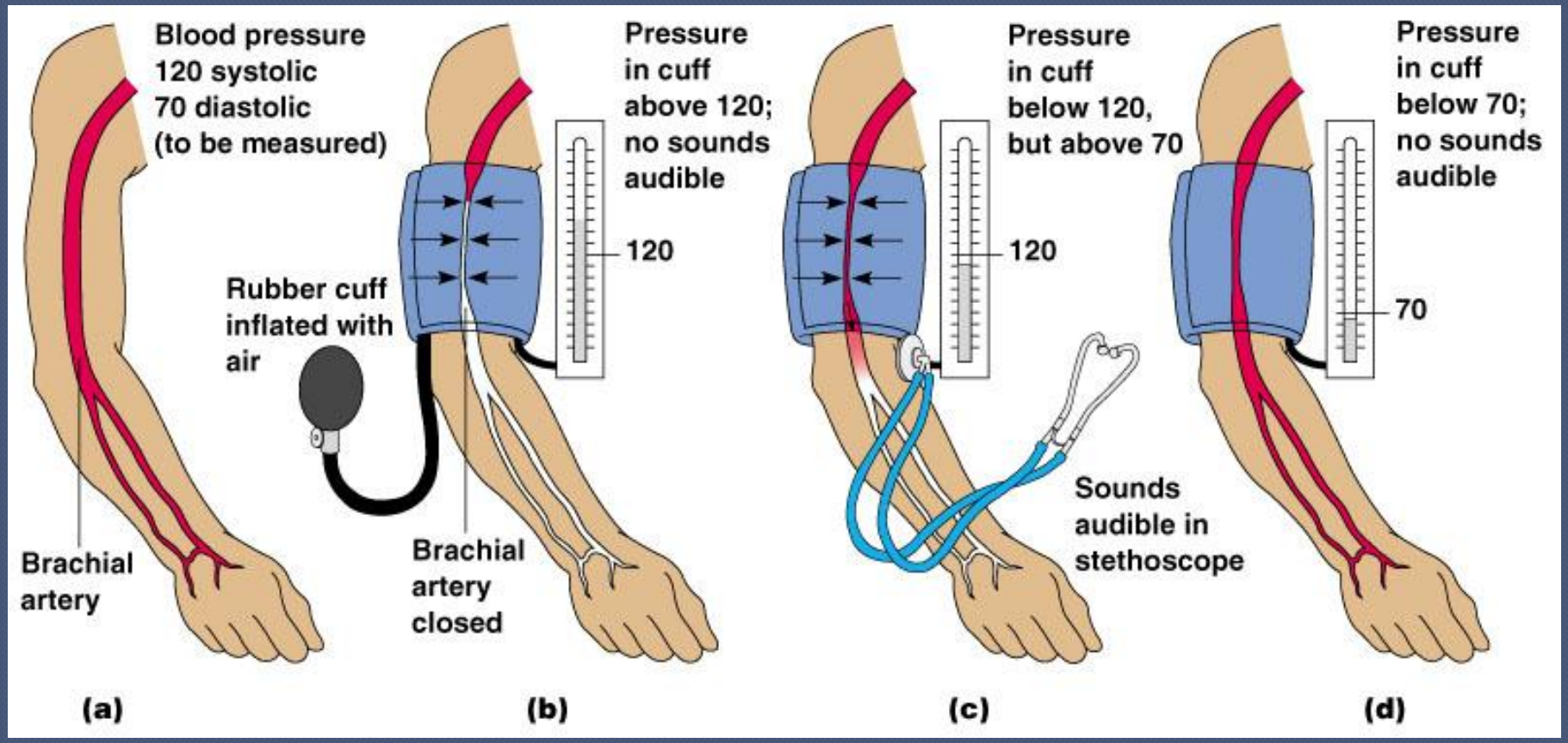
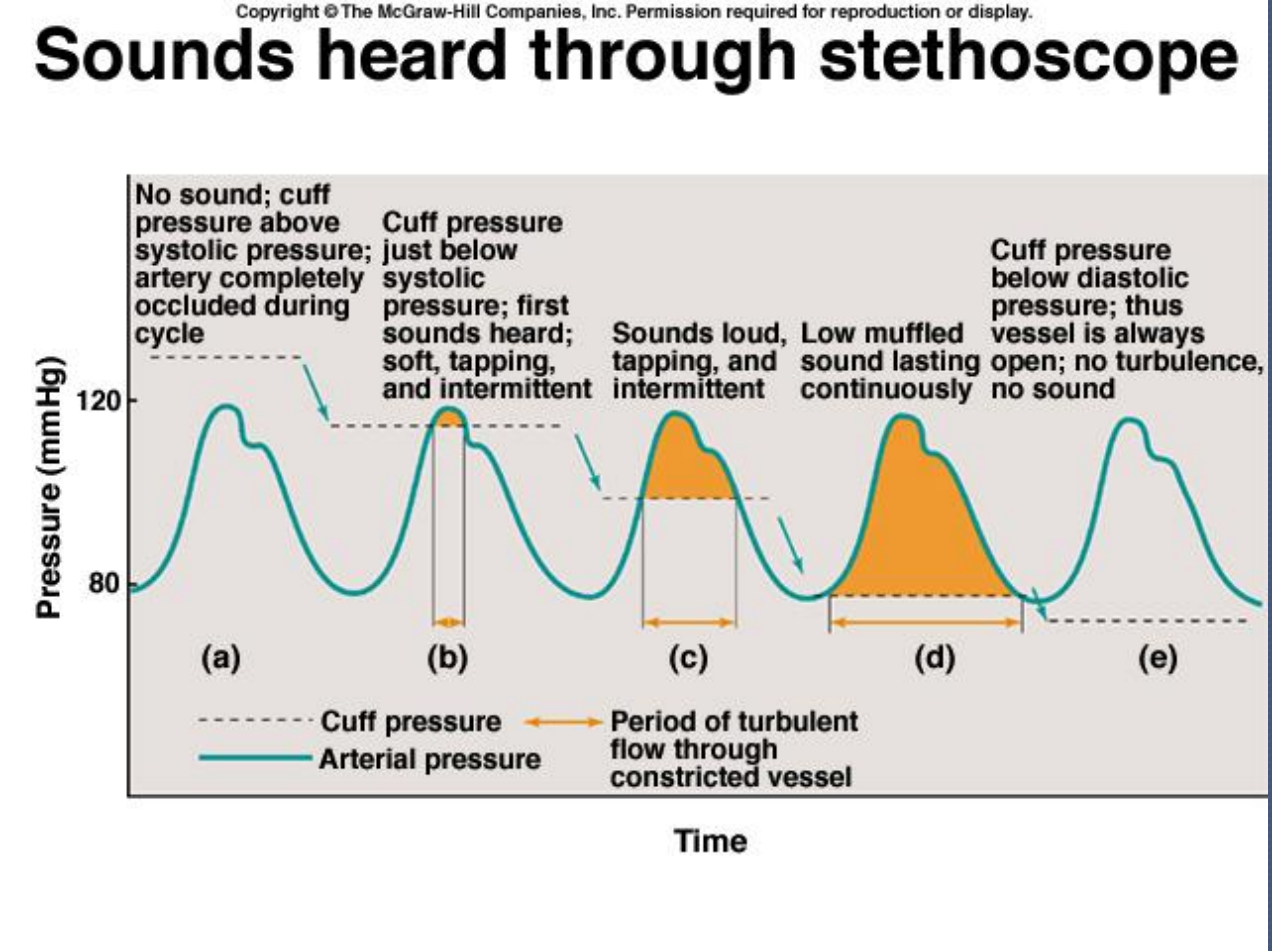


Figure 11.18

Pressão arterial



Atlas Angiográfico

Denominação

- Localização: medial, anterior, dorsal, profunda ...
- Nome do órgão irrigado: renal, hepática...
- Direção: circunflexa, recorrente ...
- Proximidade com osso: femoral, radial, ulnar...

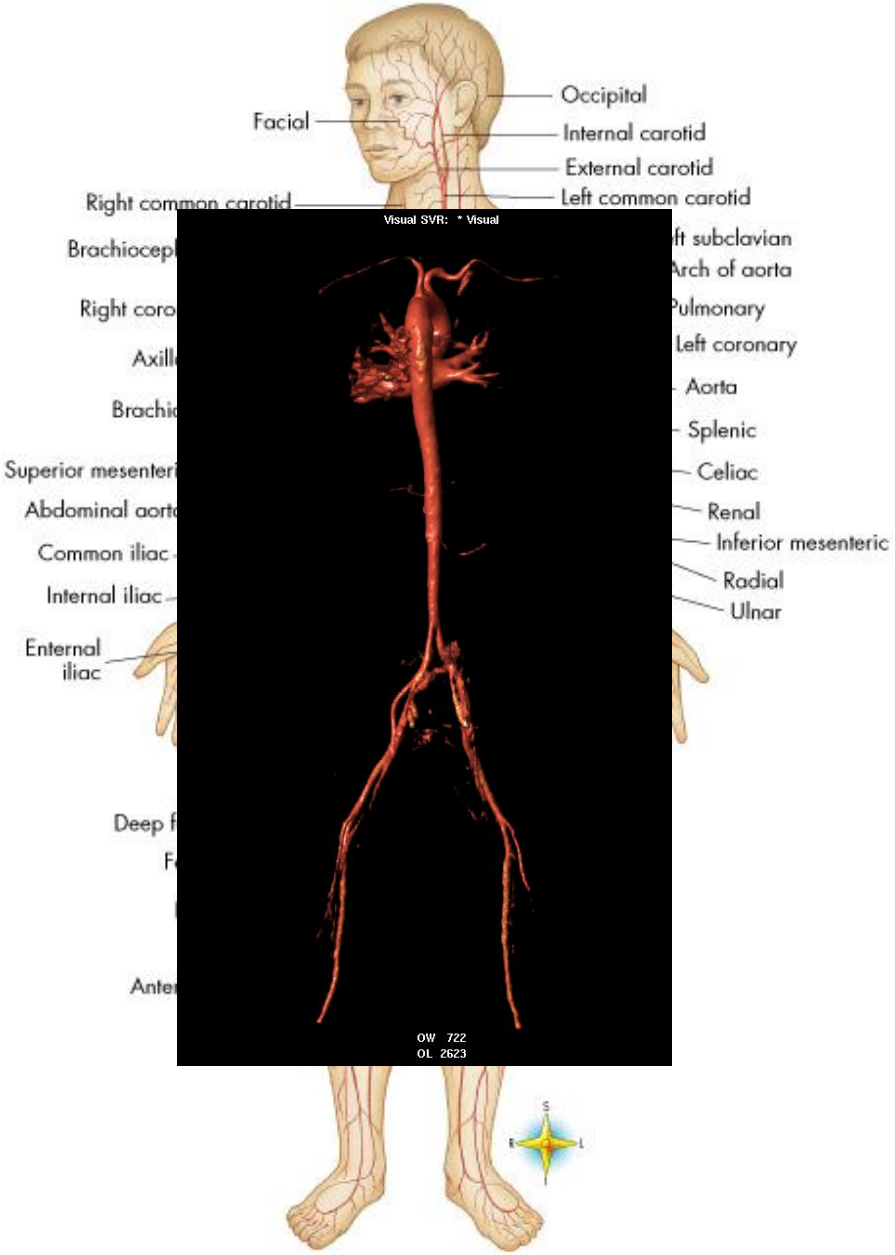


Image 179 Principal arteries of the body

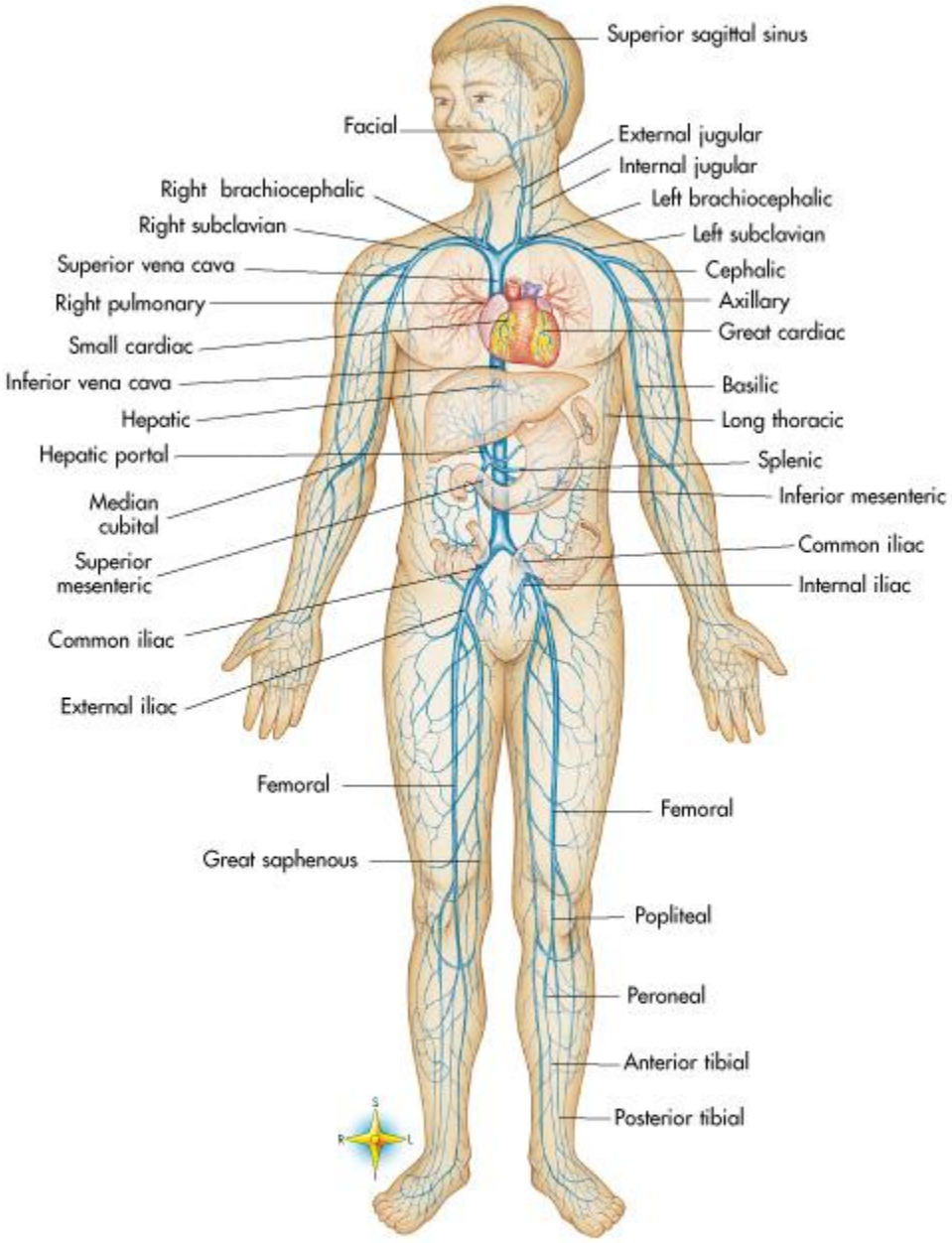
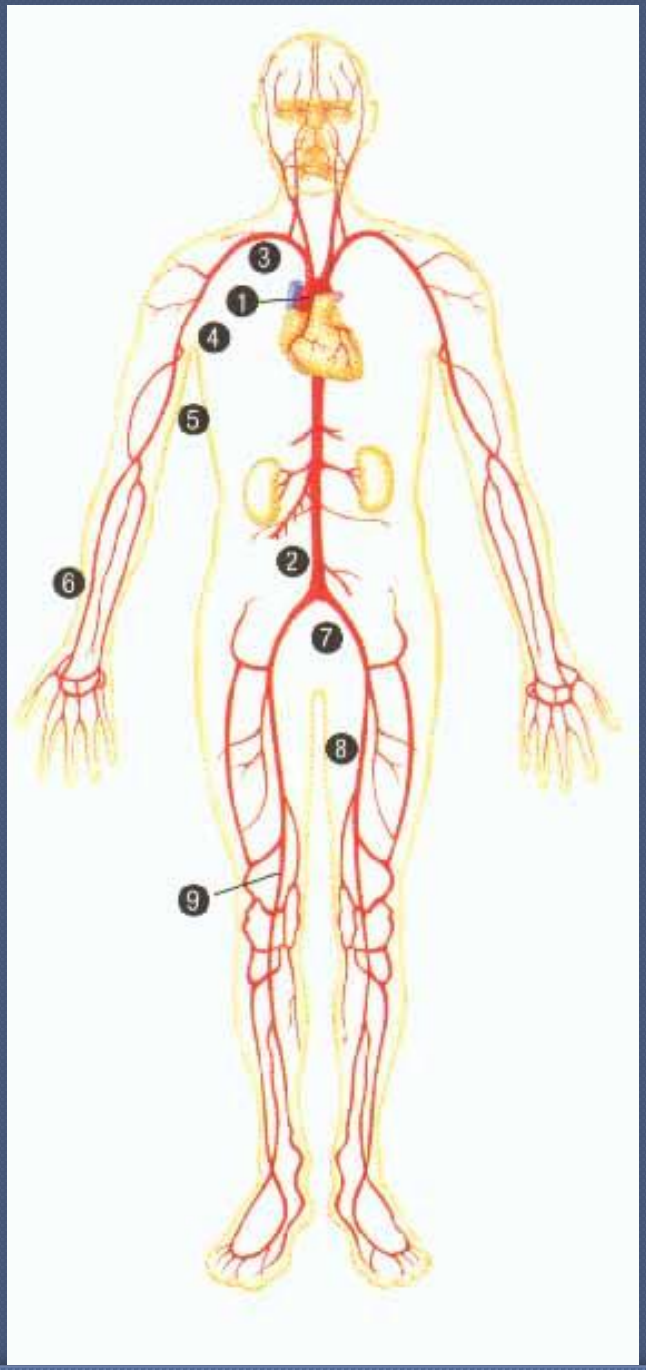


Image 183 Principal veins of the body



Arterias

1. Aorta ascendente
2. Aorta abdominal
3. Artéria Subclavia
4. Artéria Axilar
5. Artéria Brachial
6. Artéria Radial
7. Artéria Iliaca Comum
8. Artéria Femoral
9. Artéria Poplitea

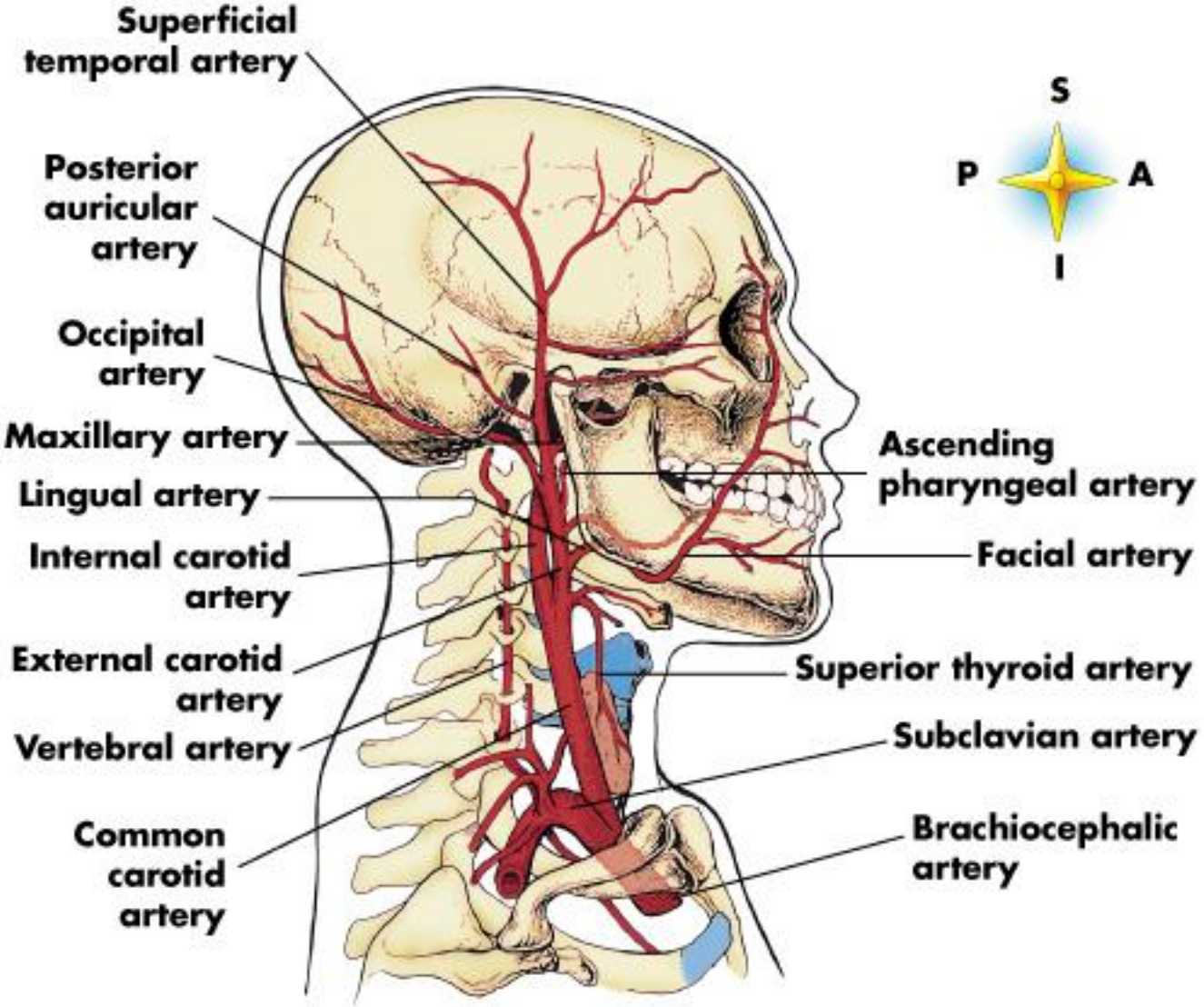
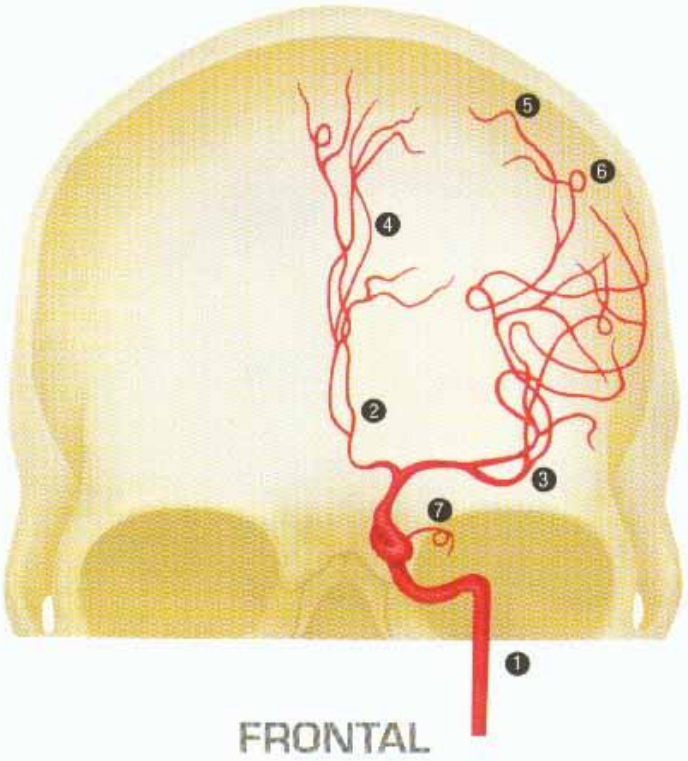
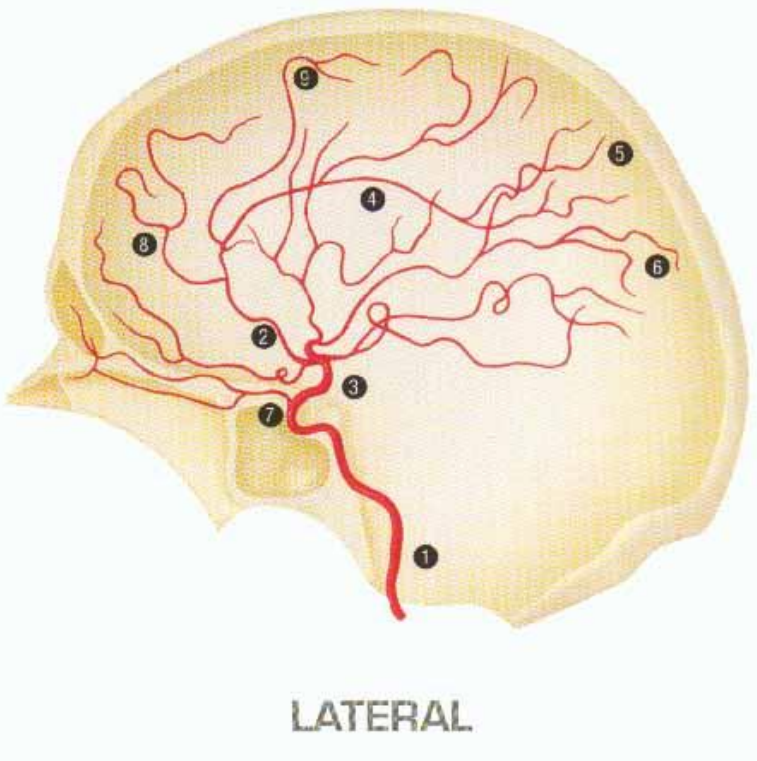


Image 180 Major arteries of the head and neck

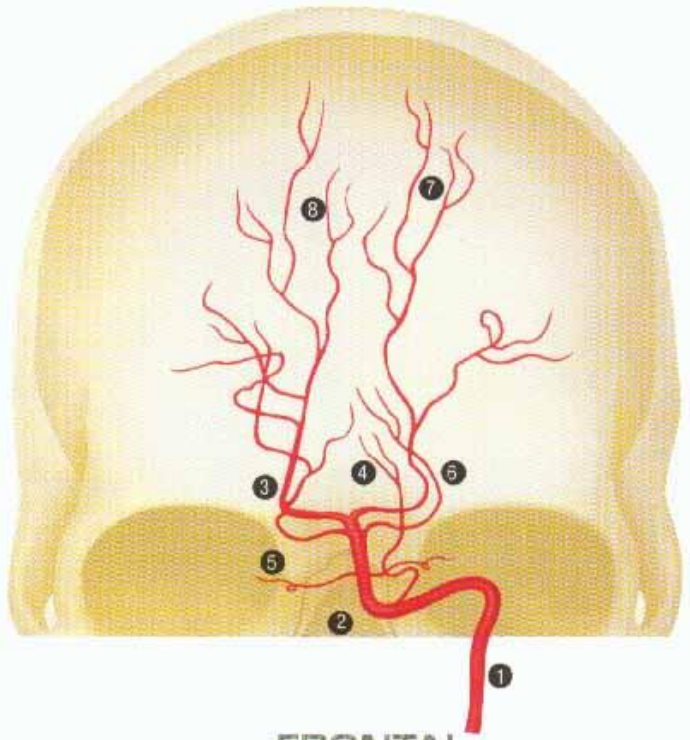
Artéria Carotida Interna

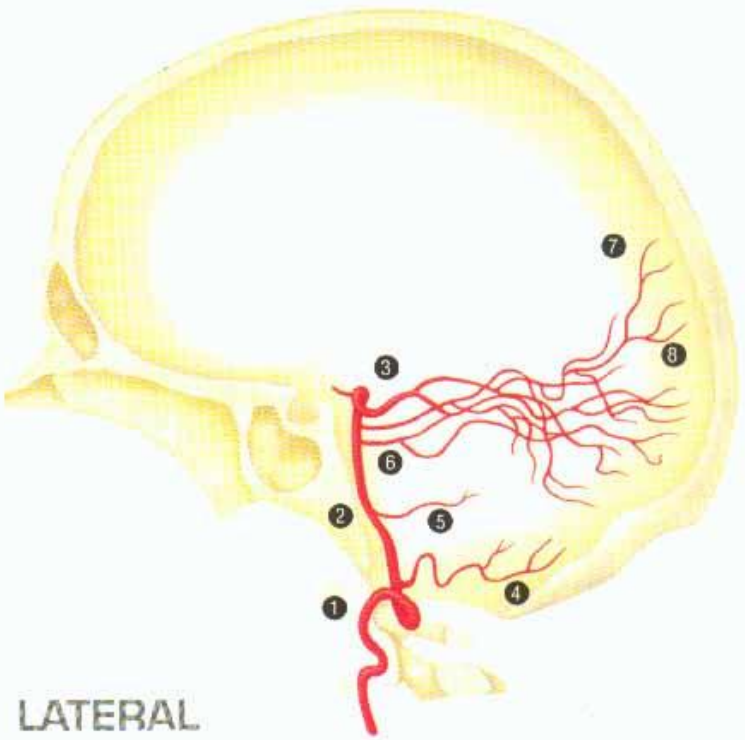




1. Internal carotid artery
2. Anterior cerebral artery
3. Middle cerebral artery
4. Pericallosal artery
5. Anterior parietal artery
6. Posterior parietal artery
7. Ophthalmic artery
8. Anterior internal frontal artery
9. Middle internal frontal artery

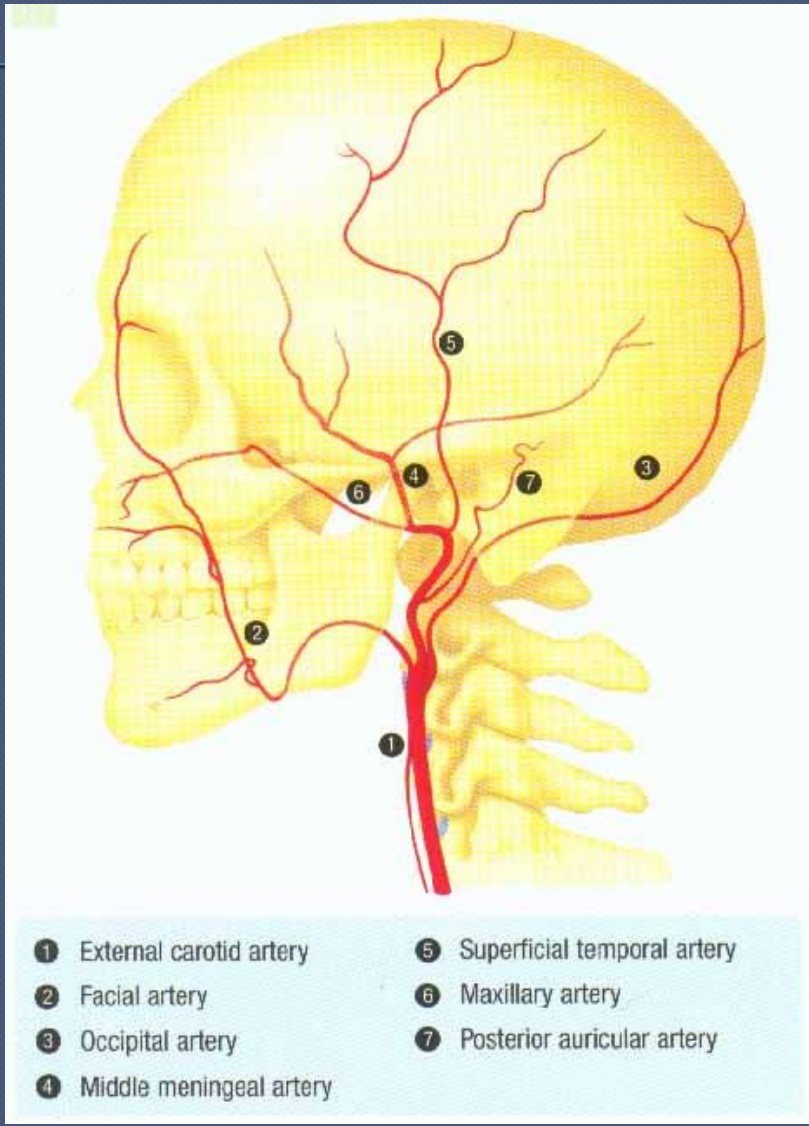
Artéria Vertebral



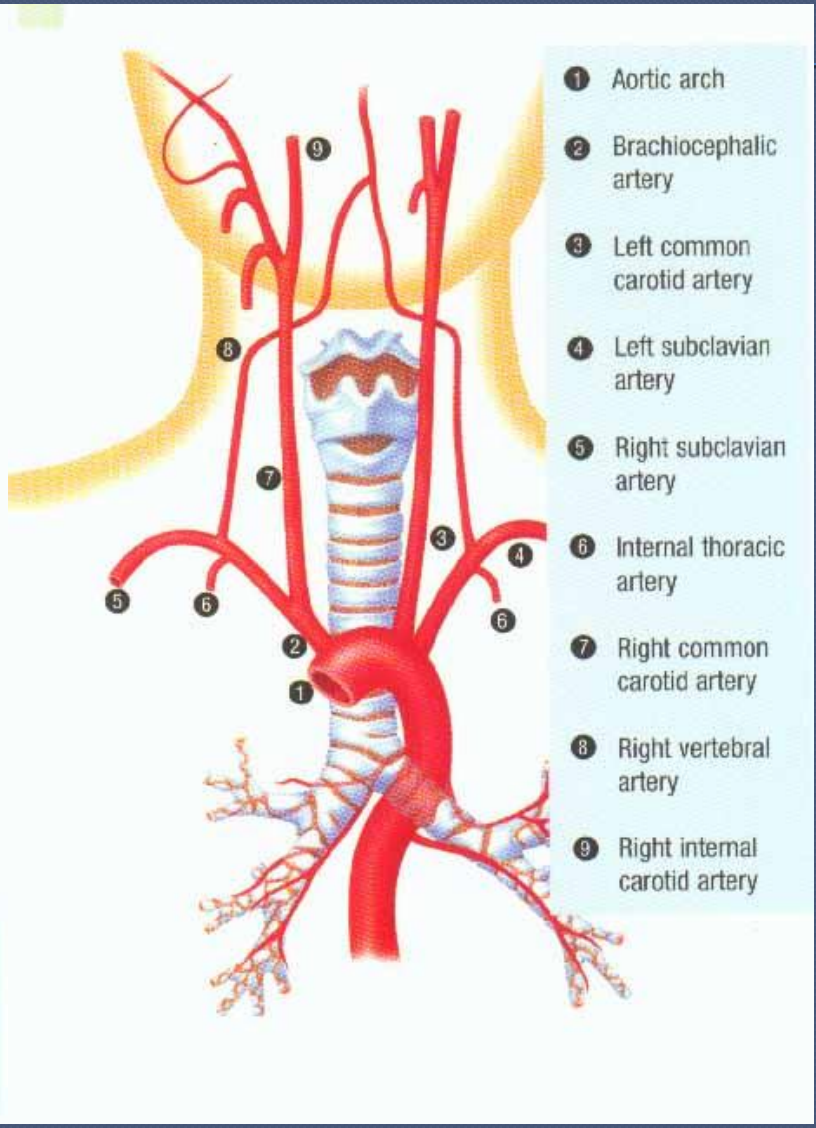


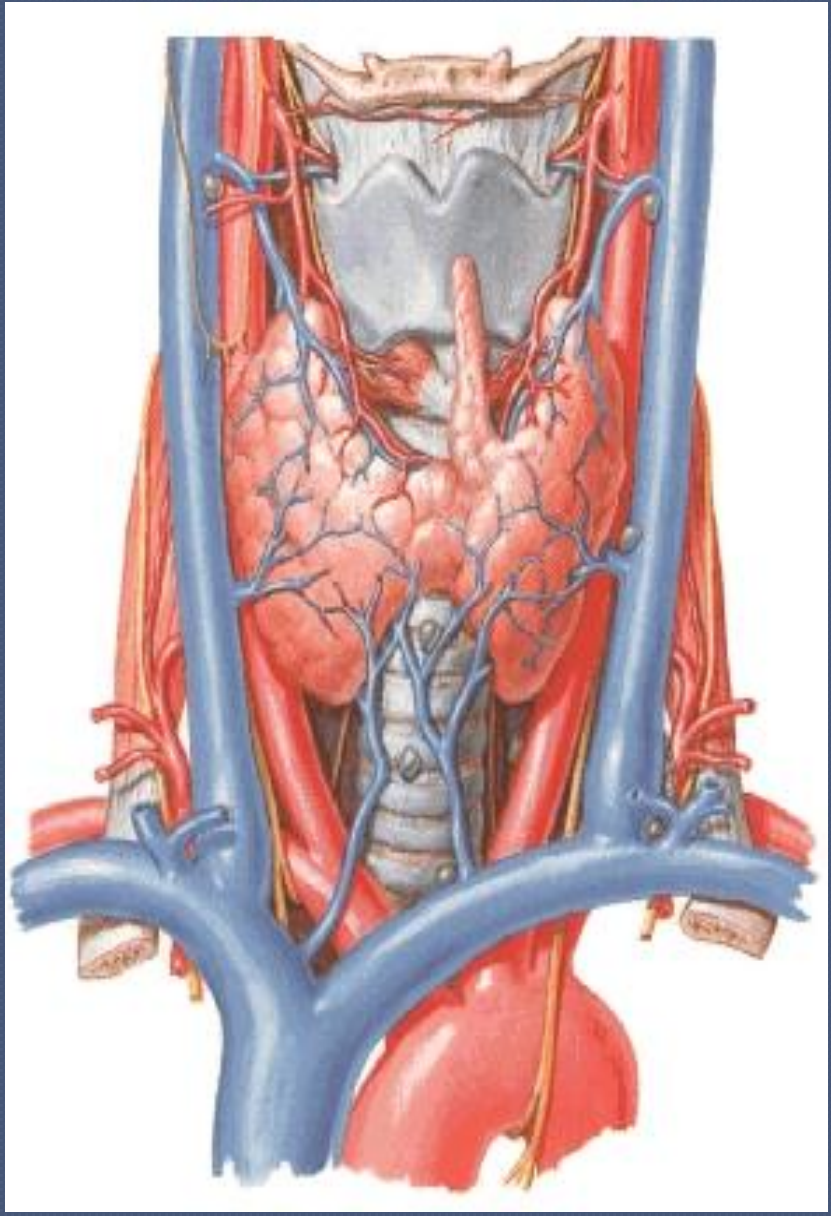
1. Vertebral artery
2. Basilar artery
3. Posterior cerebral artery
4. Posterior inferior cerebellar artery
5. Anterior inferior cerebellar artery
6. Superior cerebellar artery
7. Parieto-occipital artery
8. Calcarine artery

Artéria Carotida Externa

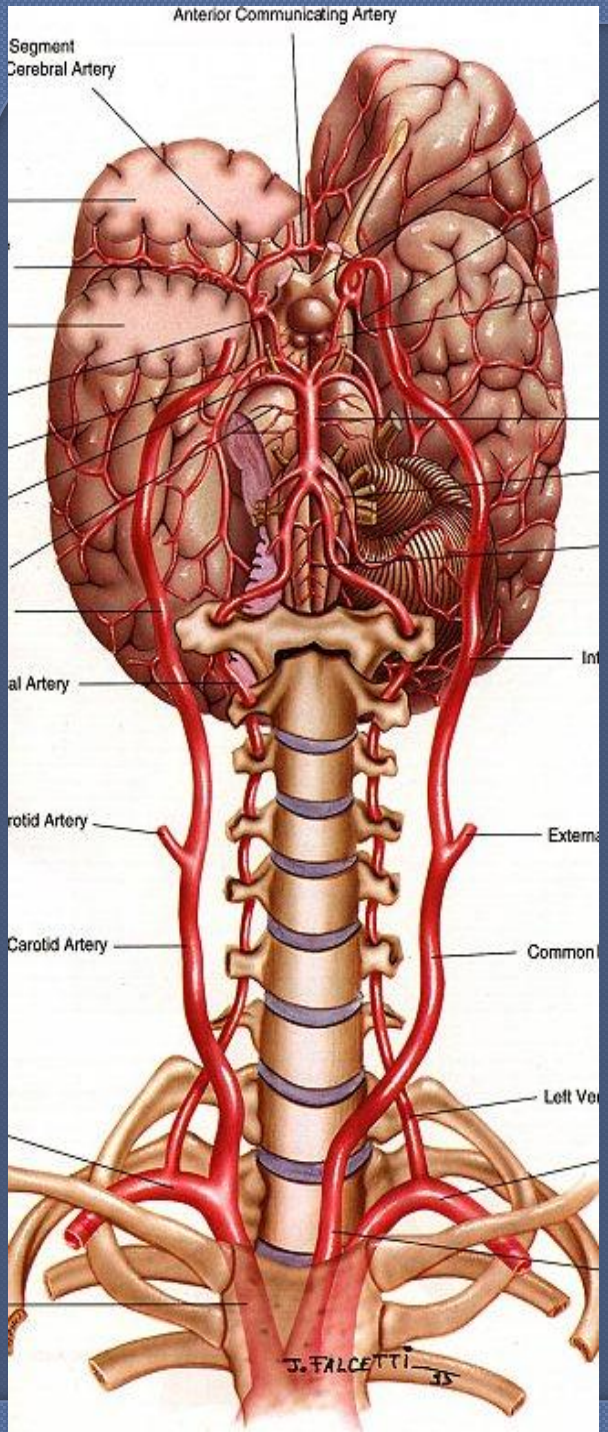


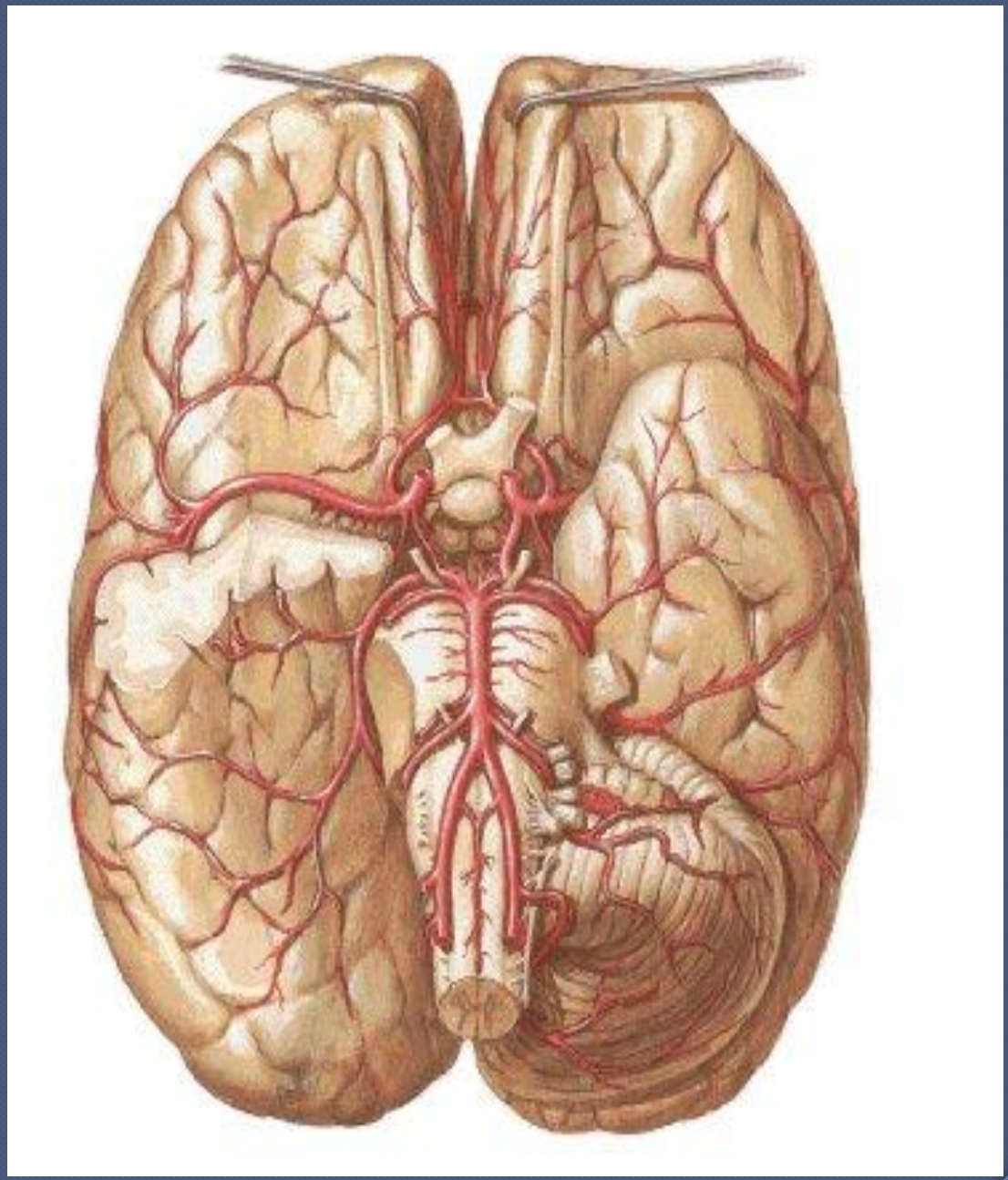
Artérias Toracicas






ARCOGRAMA


Anterior Communicating Artery
Segment
Cerebral Artery
al Artery
rotid Artery
Carotid Artery
J. FALCETTI



ANGIORRESSONÂNCIA

TOF 3D

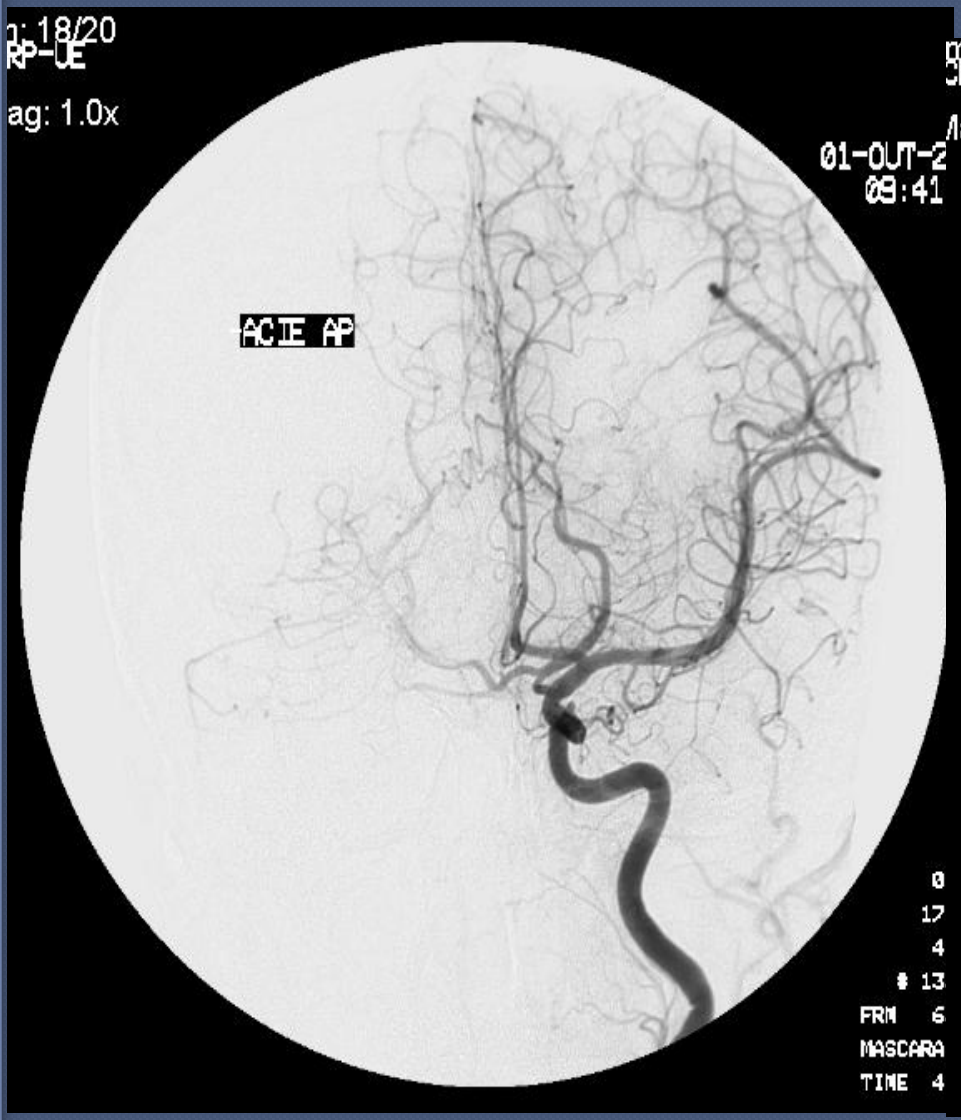
14-06-1960 003503 M
MIP/TOF/AX 30-12-1998, 15:14

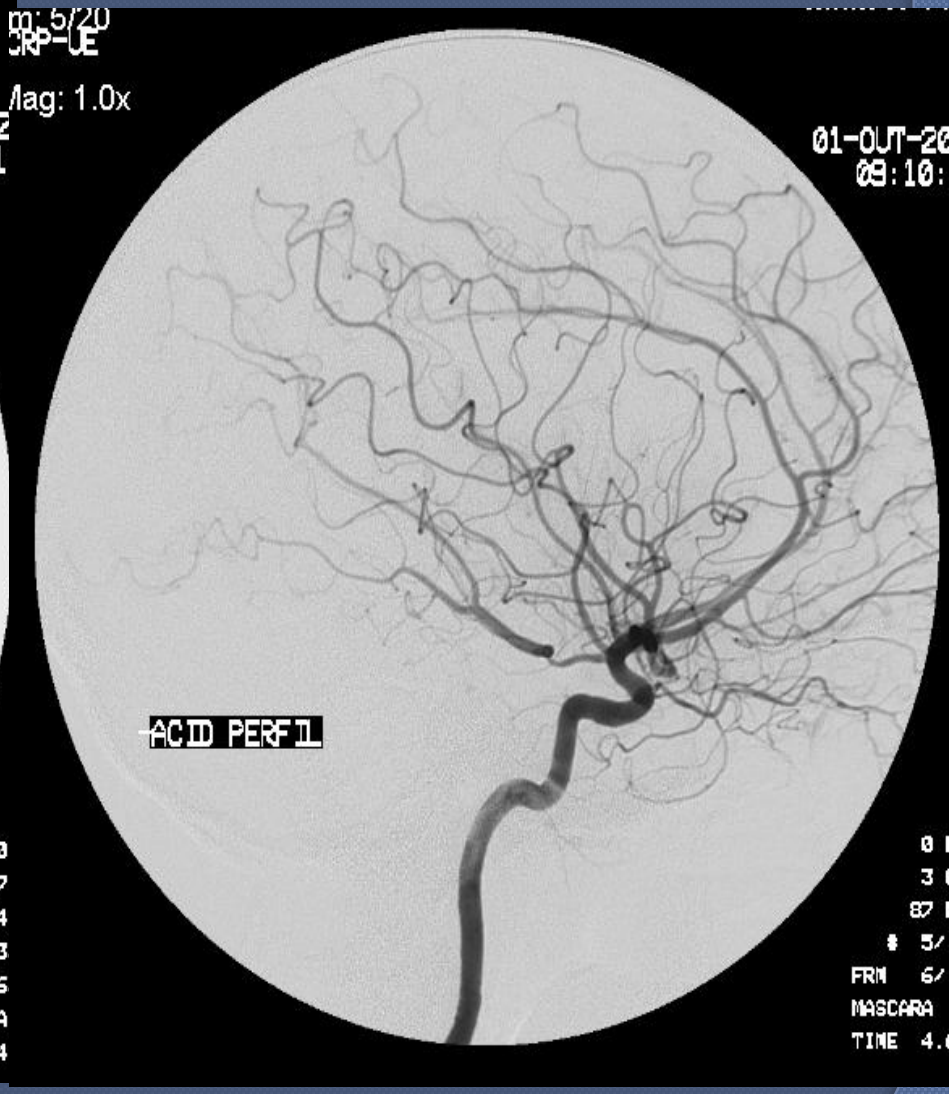
TR	22	Slice	1/9
TE	5.4	Echo	1/1
Flip	21.0		
CORONAL		RFOV 100%	NSA 2
T1-FFE/M		FOV 160/1.3	
ScTime:	06:47	THK 160/ 0.0	179/256
FC			
SAT			
AP	-1	ant	Angle AP 4
RL	4	left	Angle RL 10
FH	19	head	Angle FH -1

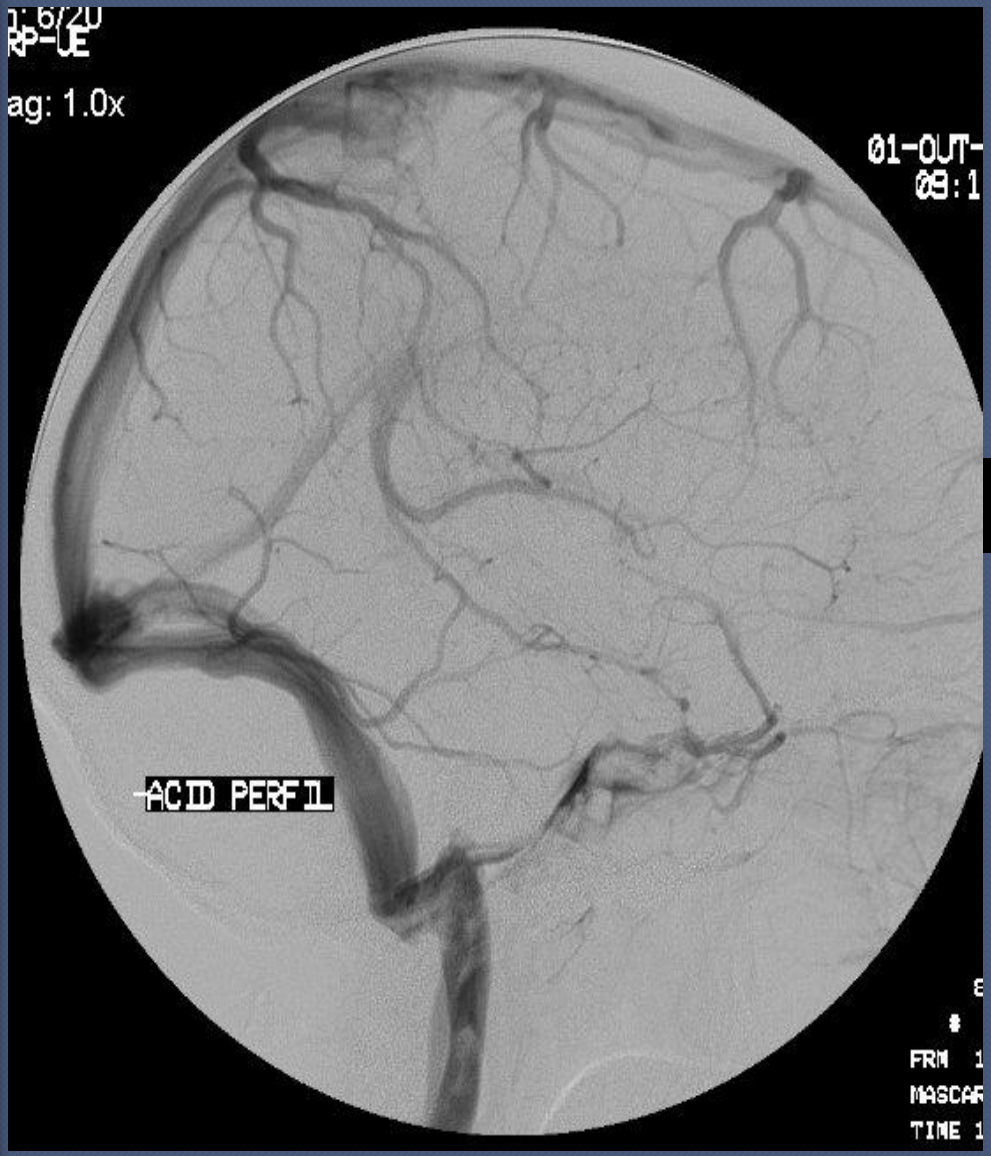
ANGIO RM DE ENCEFALO WW 1007 WL 594

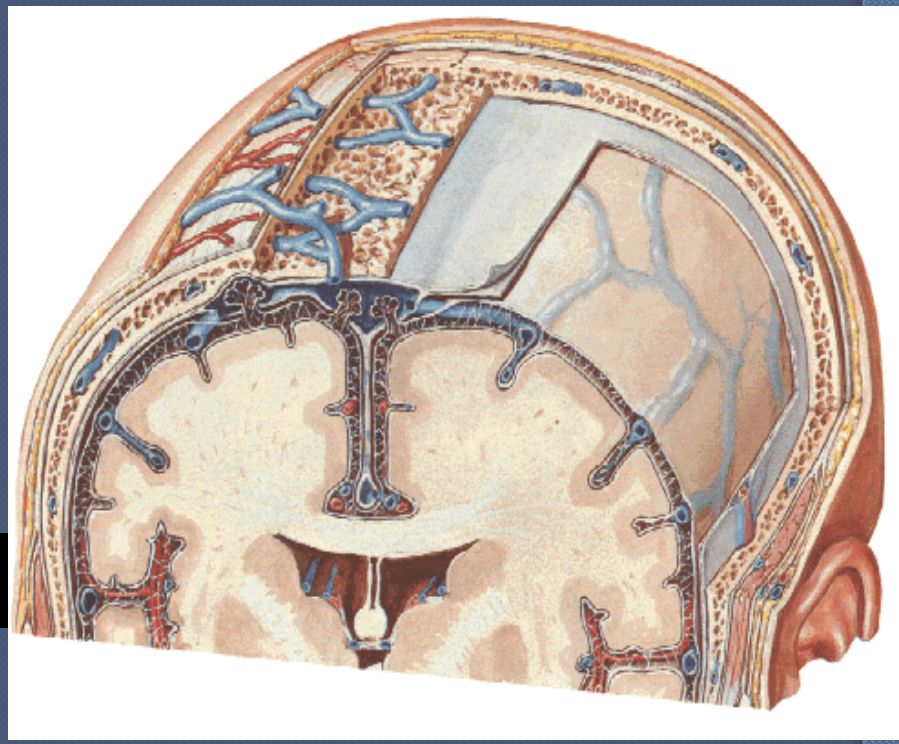
Philips Gyroscan ACS-NT

DOCUMENTA


ACIE AP
01-OUT-2
09:41
FRM 6
MASCARA
TIME 4


ACID PERFIL
01-OUT-20
09:10:
FRM 6/
MASCARA


ag: 1.0x
01-OUT-
ACID PERFIL
FRM
TIME



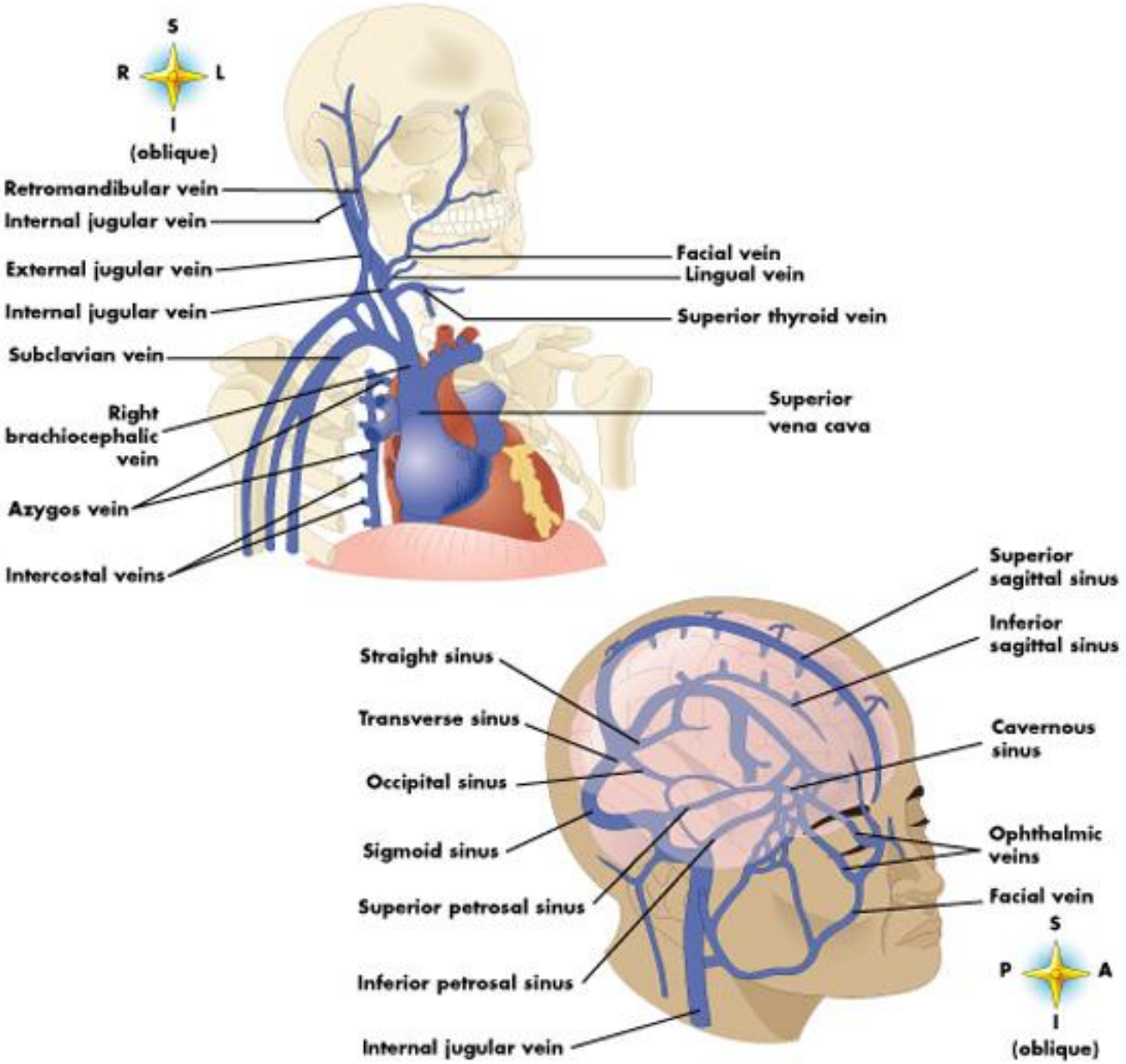
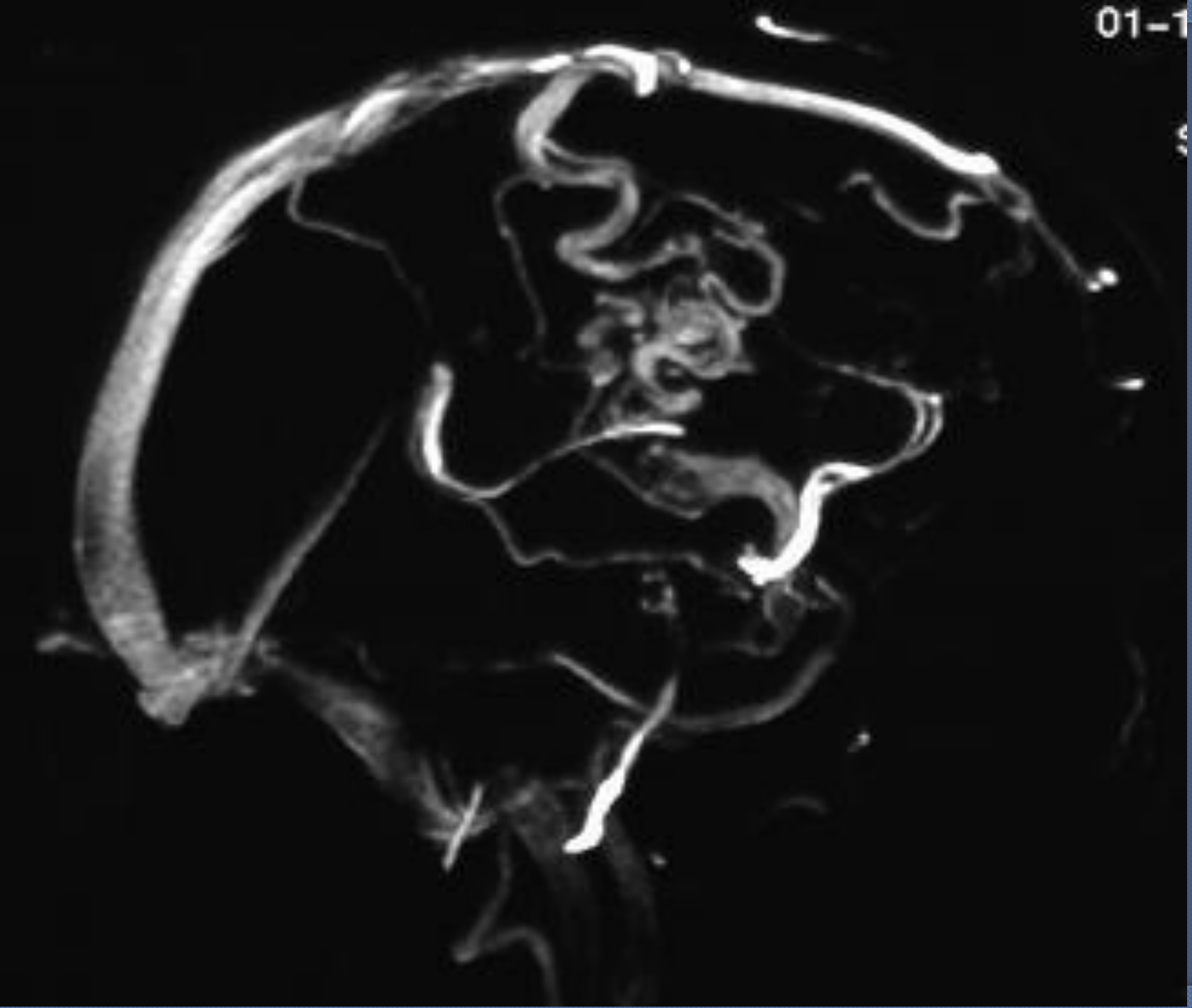
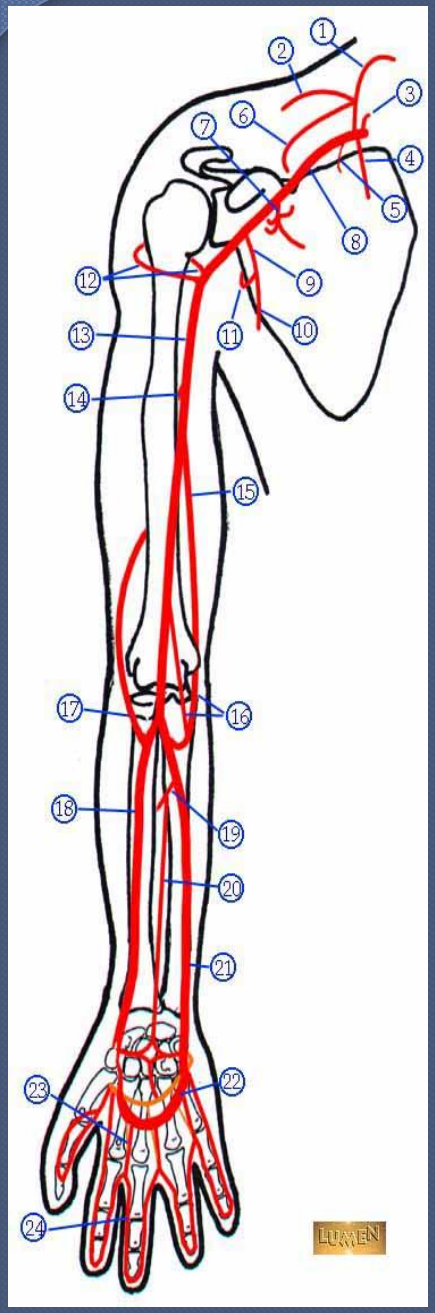
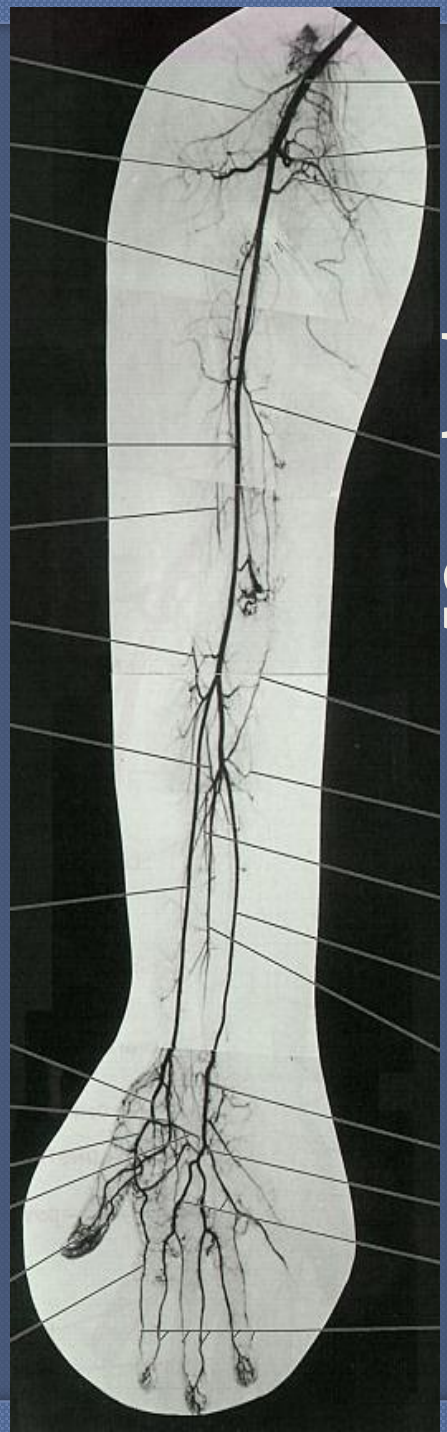


Image 184 Major veins of the head and neck



P C 2 D





Membro superior

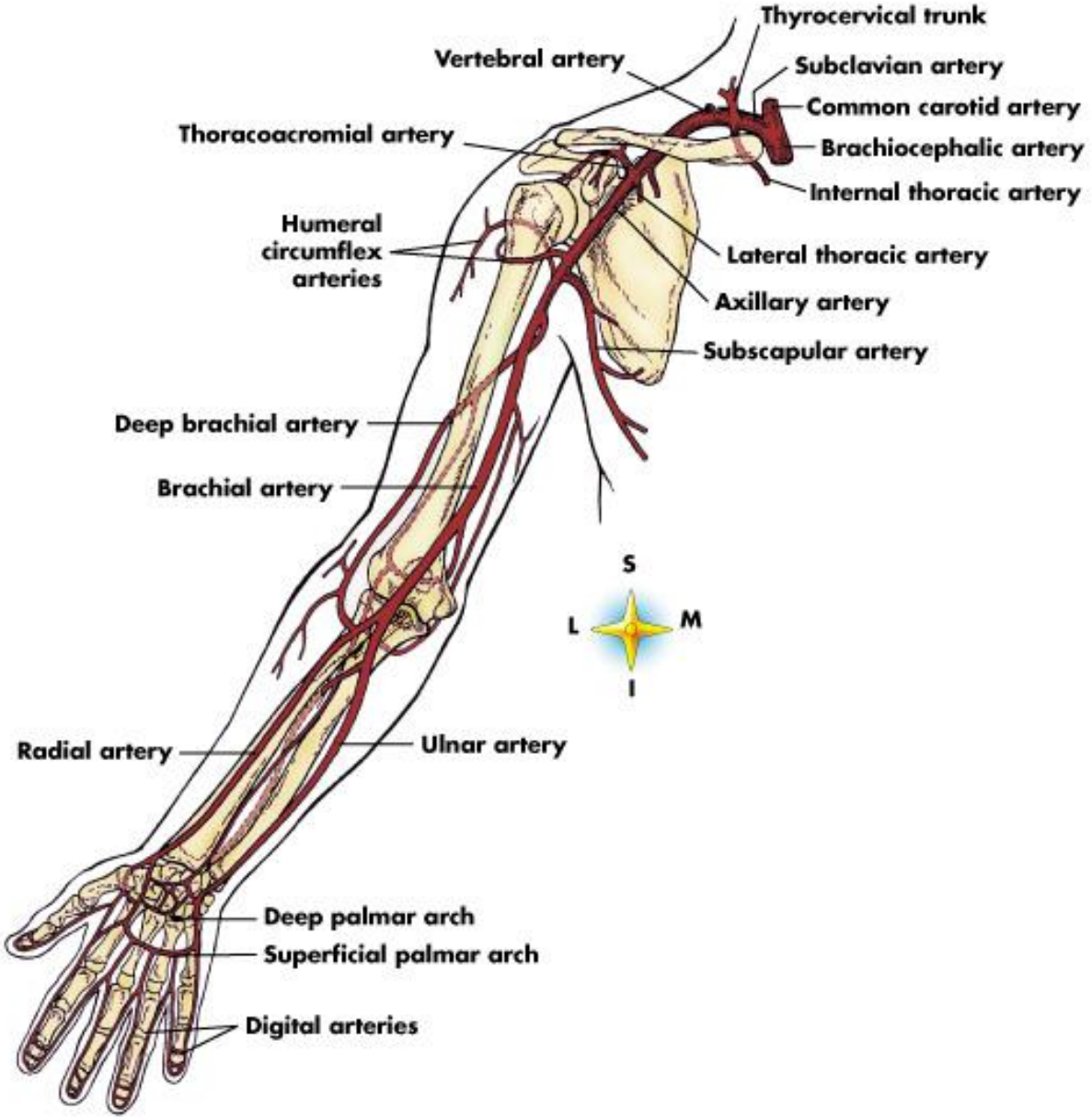


Image 181 Major arteries of the upper extremity

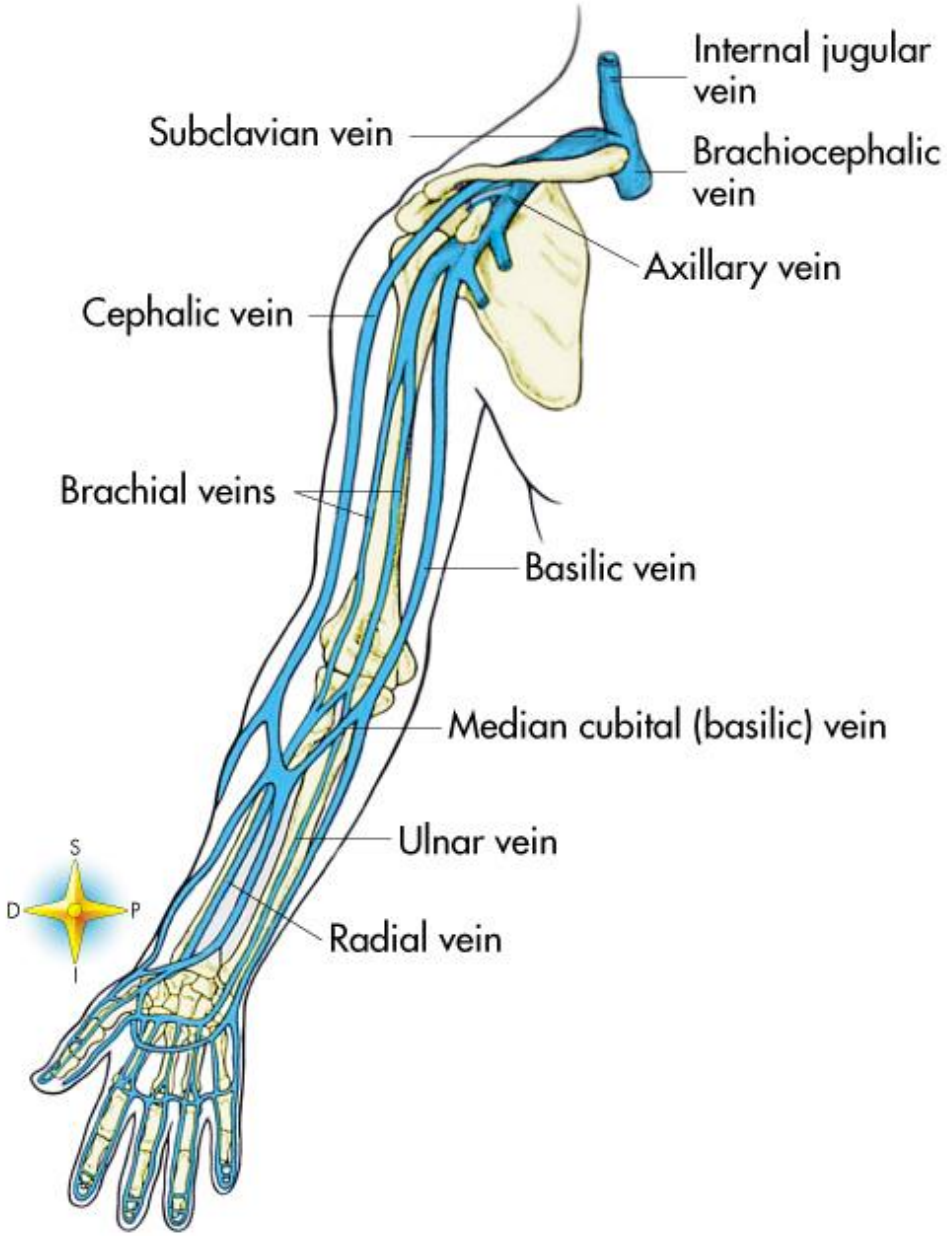


Image 185 Main superficial veins of the arm

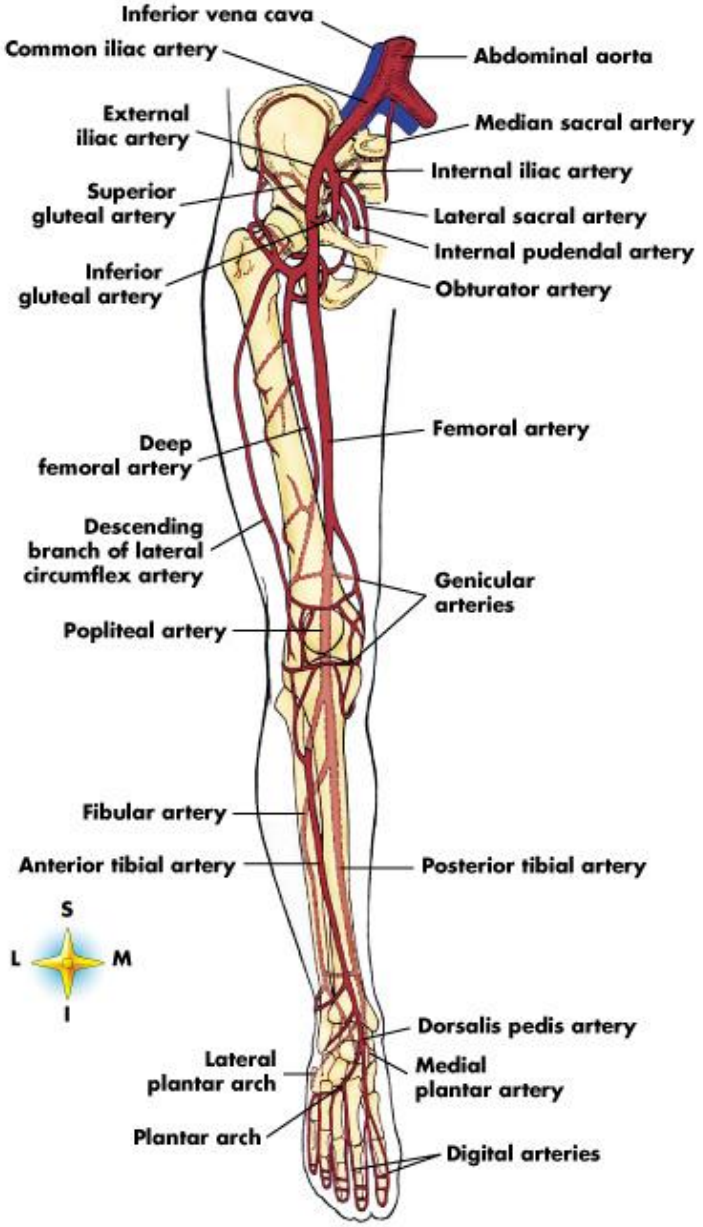
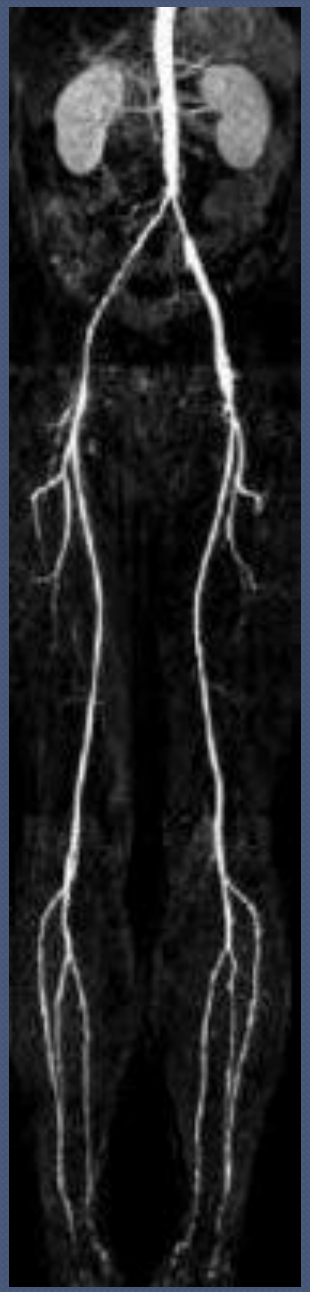


Image 182 Major arteries of the lower extremity



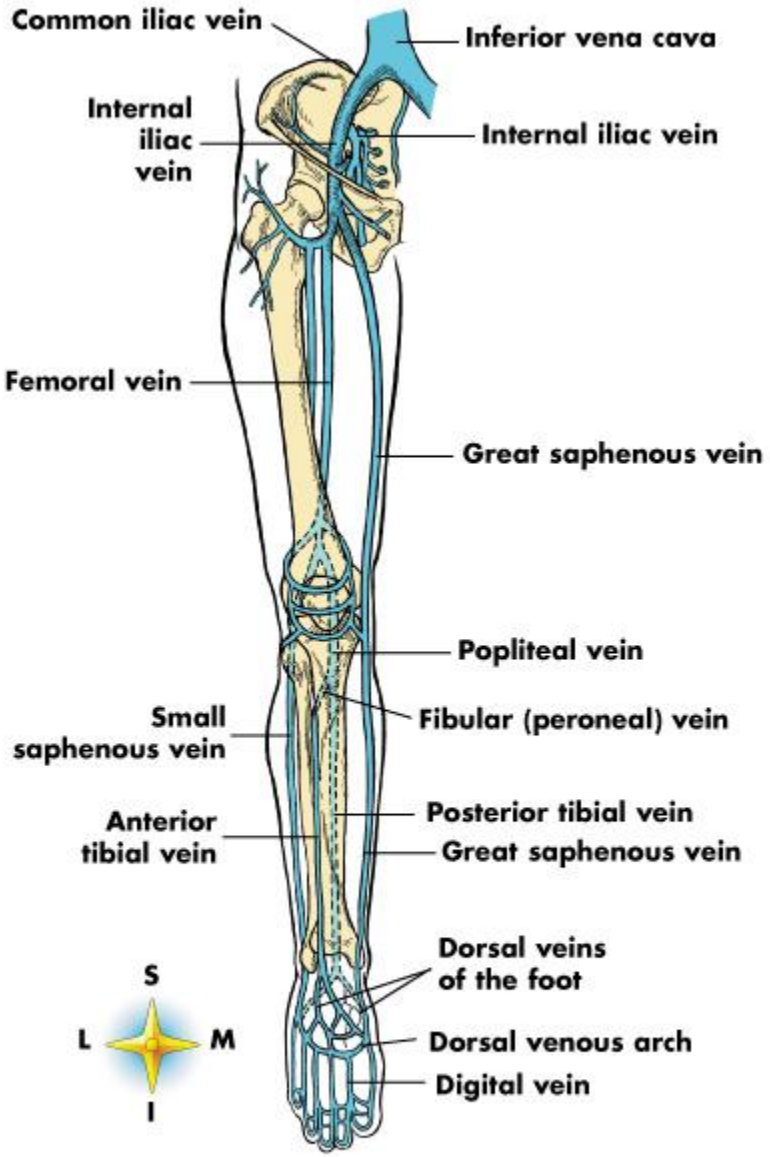


Image 187 Major veins of the lower extremity

Membro Inferior

Rotas Circulatórias

SISTEMICA

PULMONAR

HEPATICA PORTAL

FETAL

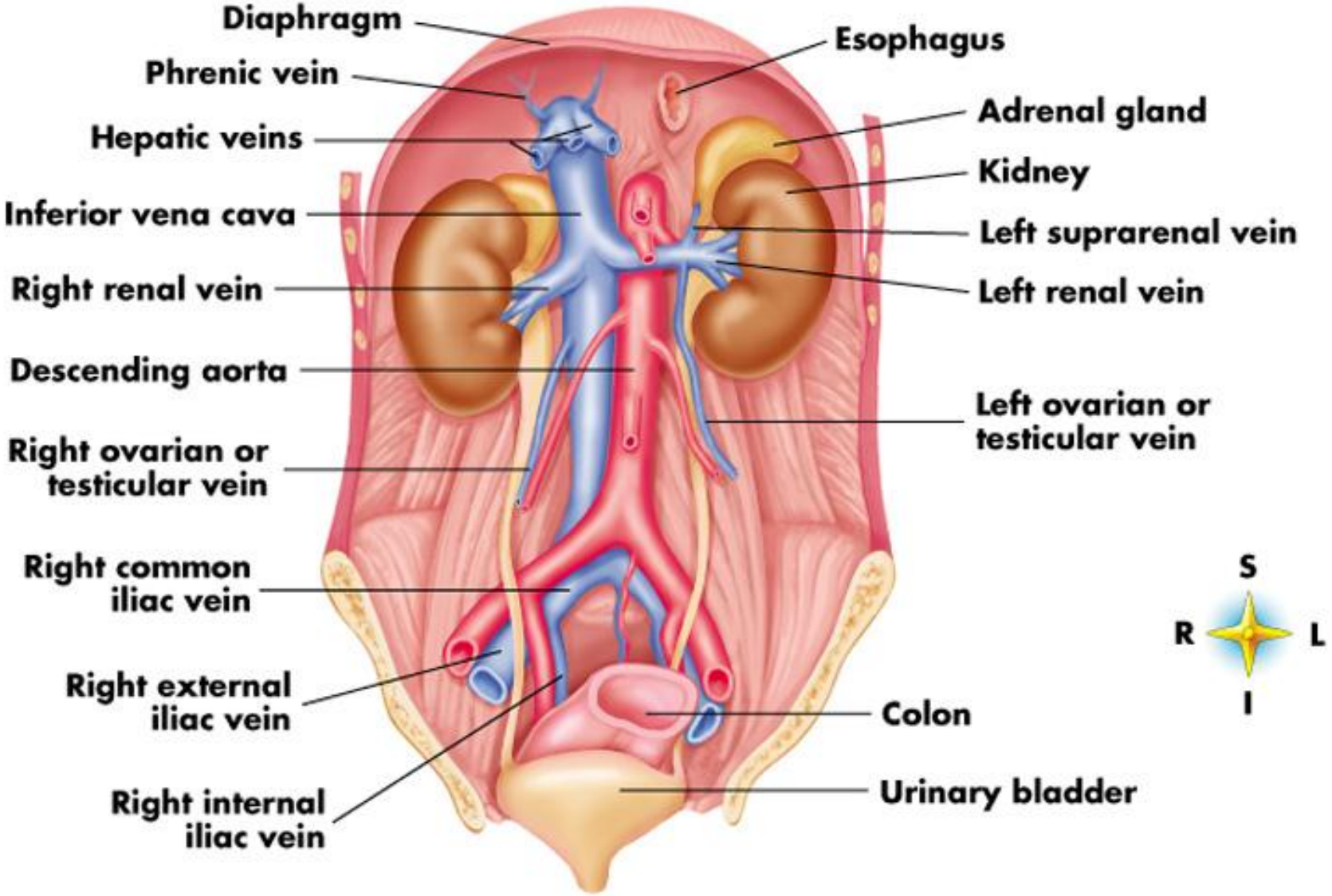
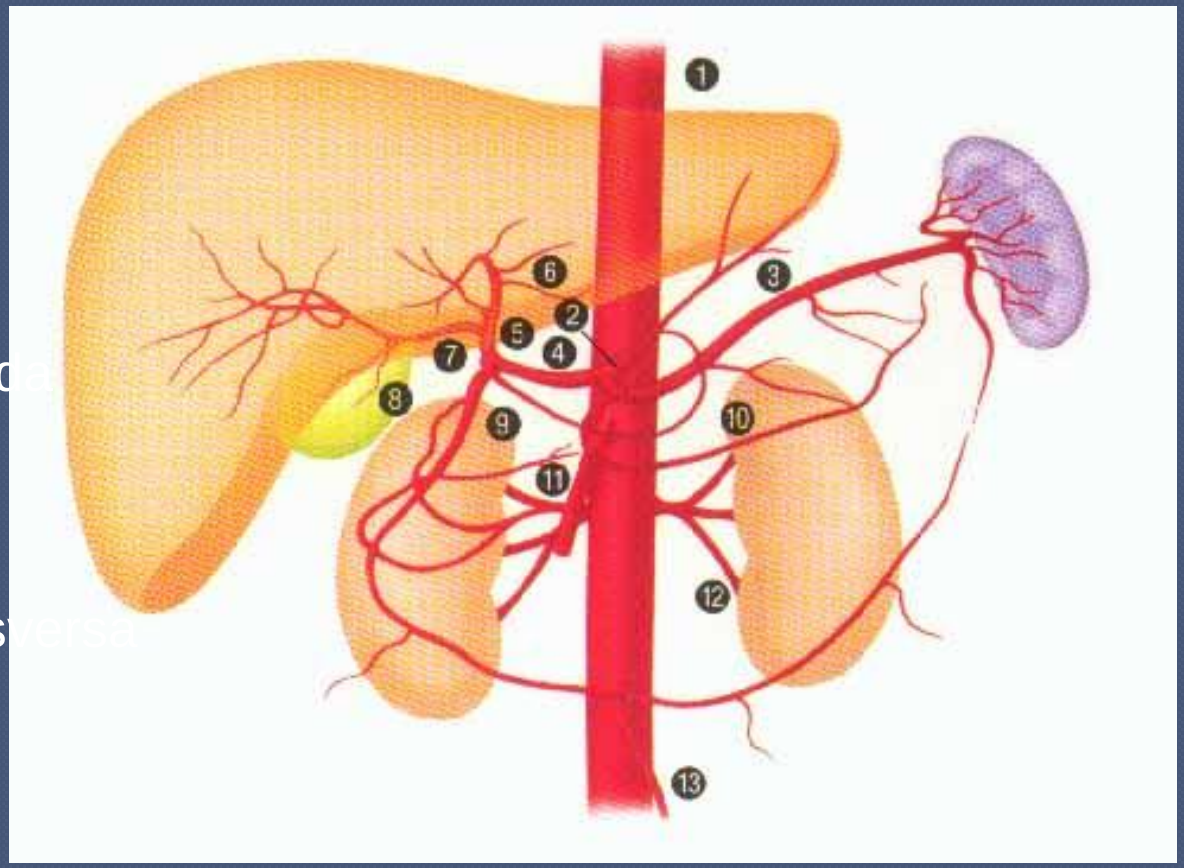


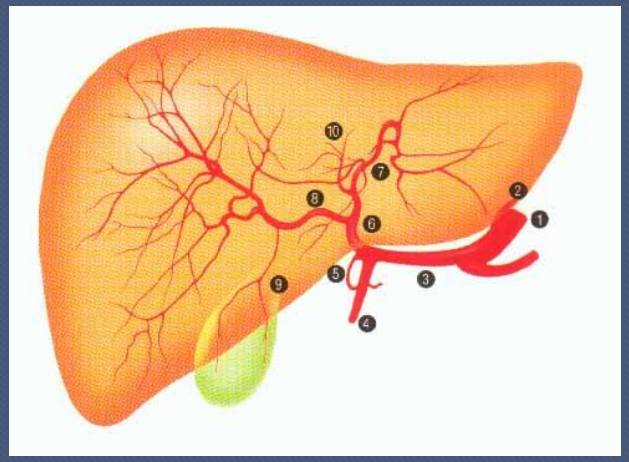
Image 186 Inferior vena cava

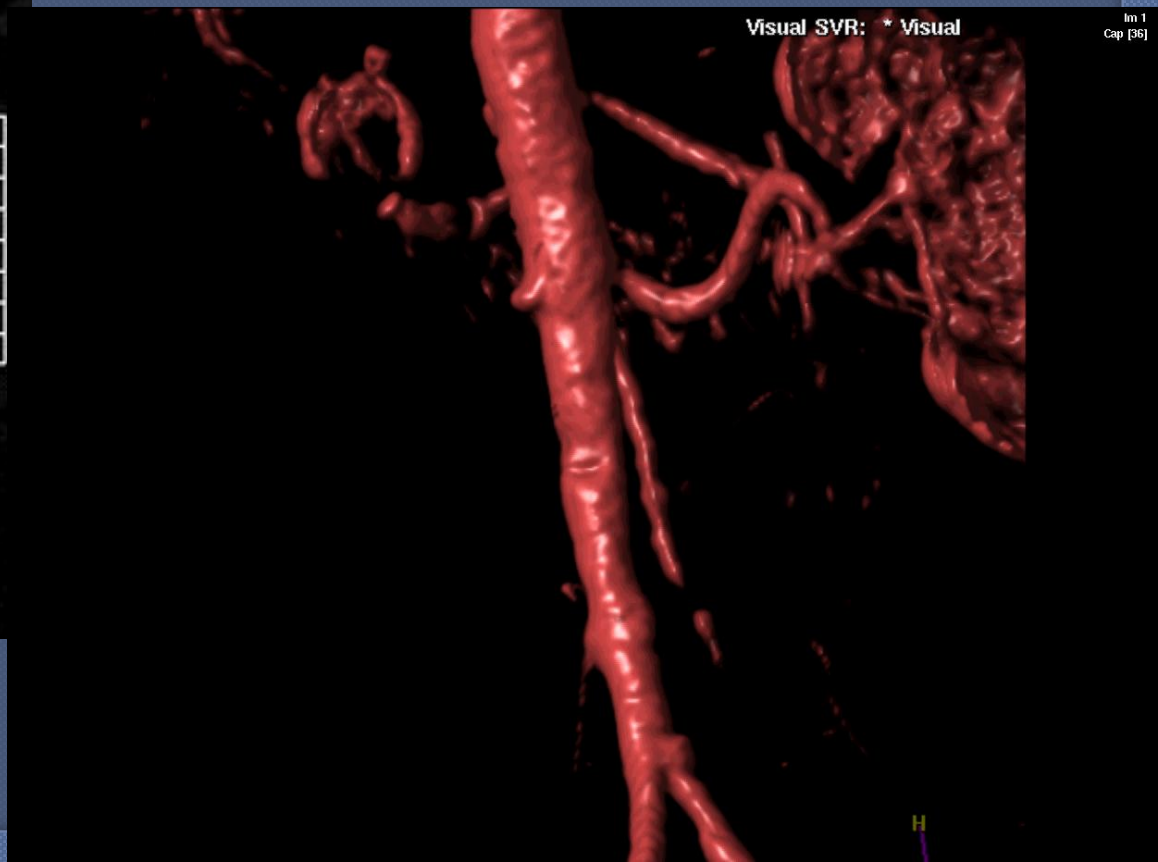
Artérias Abdominais

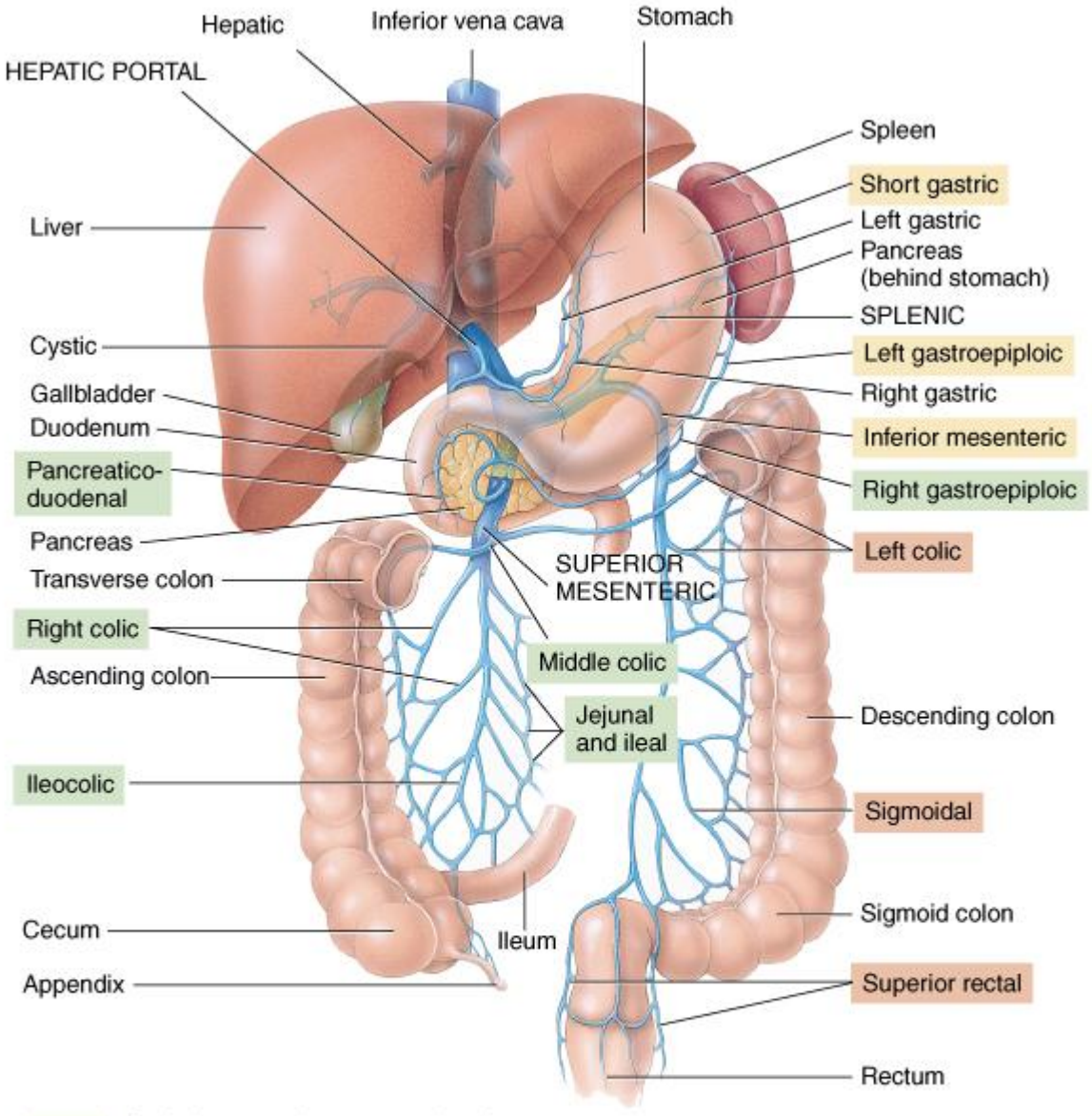
1. Aorta abdominal
2. Tronco Celiaco
3. Artéria Esplenica
4. Artéria hepática comum
5. Hepatica própria
6. Hepatica esquerda
7. hepatica direita
8. Artéria cística
9. Artéria Gastroduodenal
10. Artéria pancreática transversa
11. Mesentérica superior
12. Artérias renais
13. Mesentérica Inferior



Artérias Hepaticas e Renais

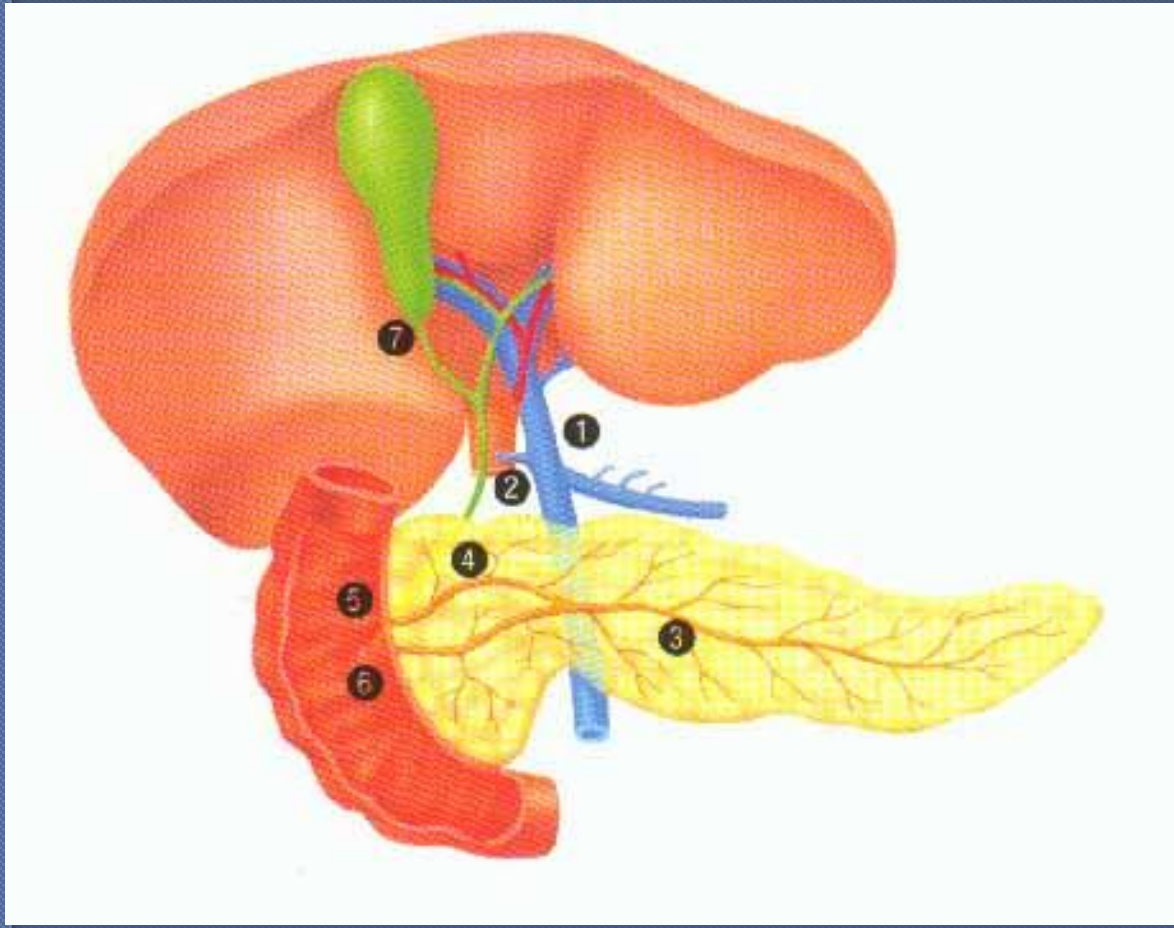






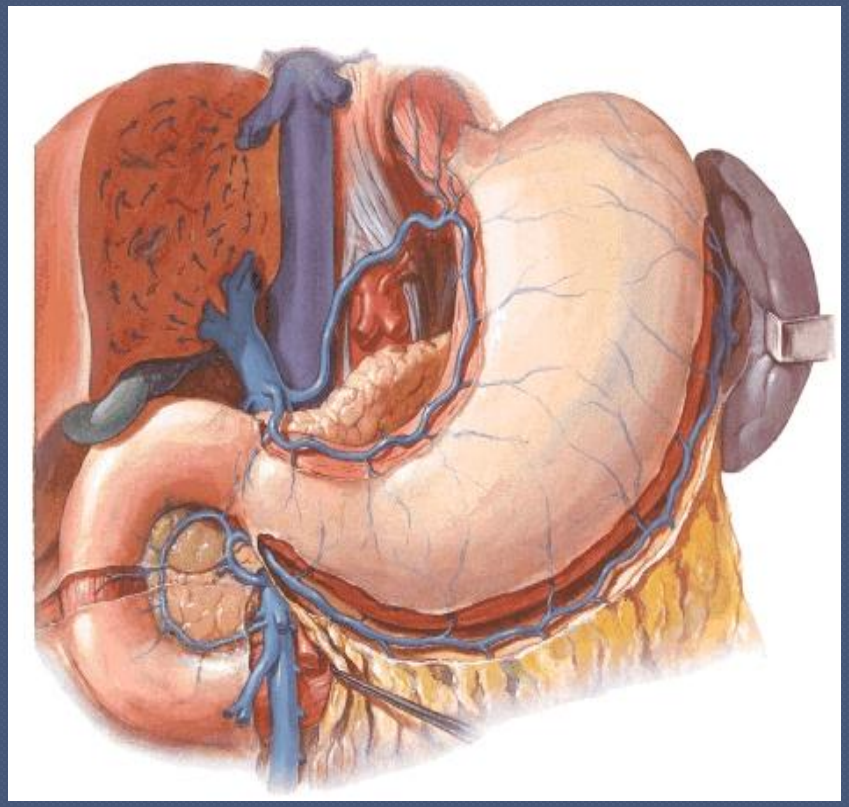
(a) Anterior view of veins draining into the hepatic portal vein

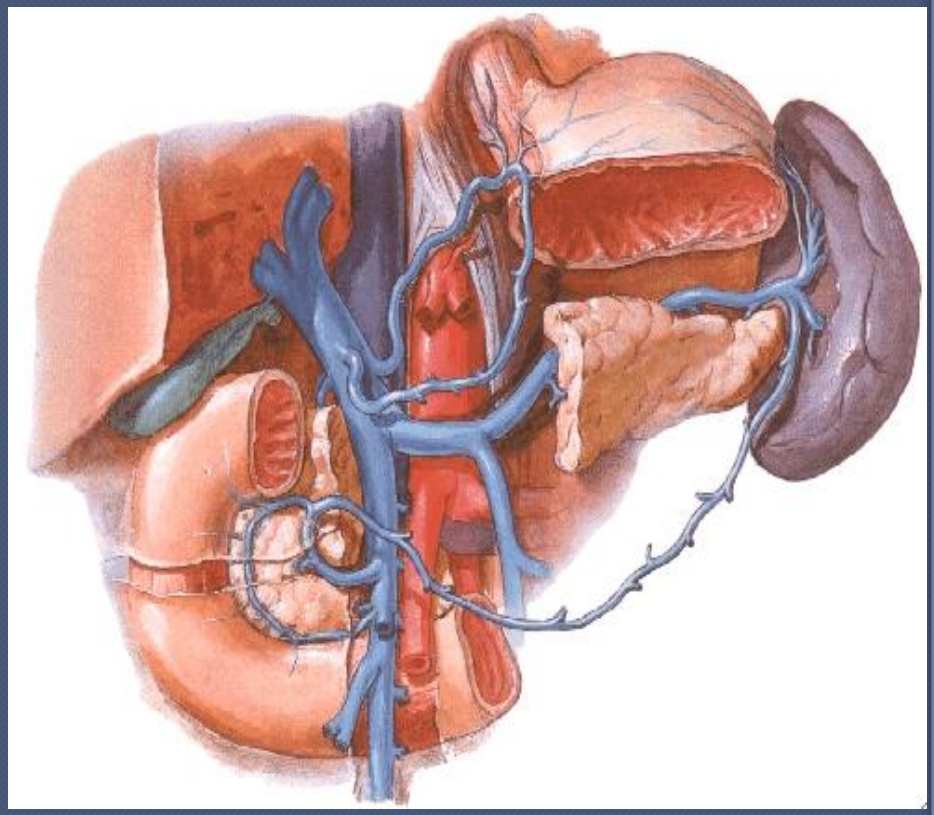
Veia Porta e Pâncreas



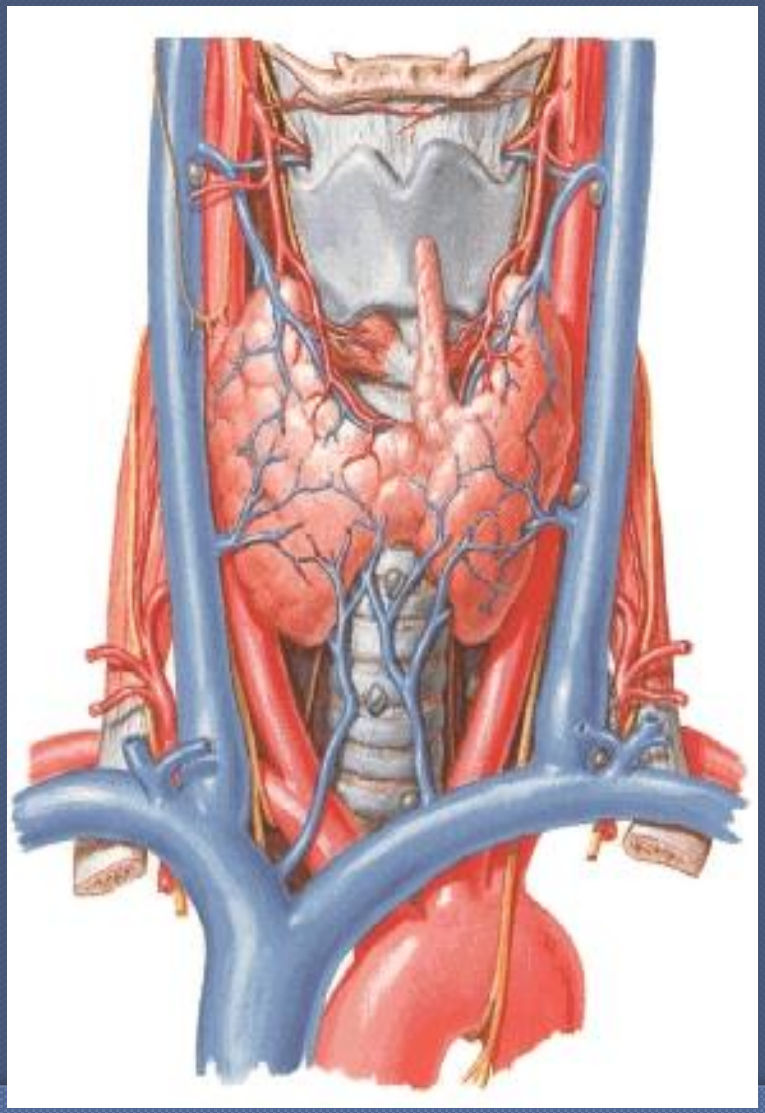
1. Portal vein
2. Common bile duct
3. Pancreatic duct
4. Accessory pancreatic duct
5. Lesser duodenal papilla
6. Greater duodenal papilla
7. Cystic duct

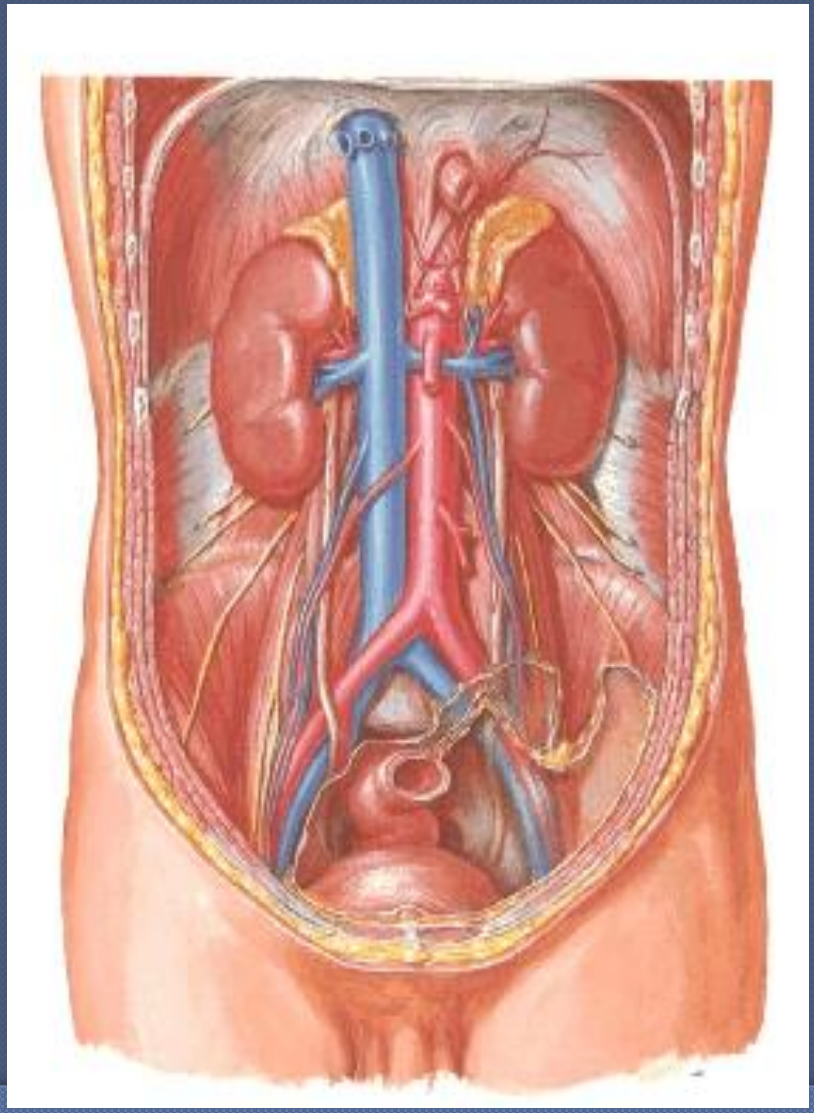
Sistema porta hepático

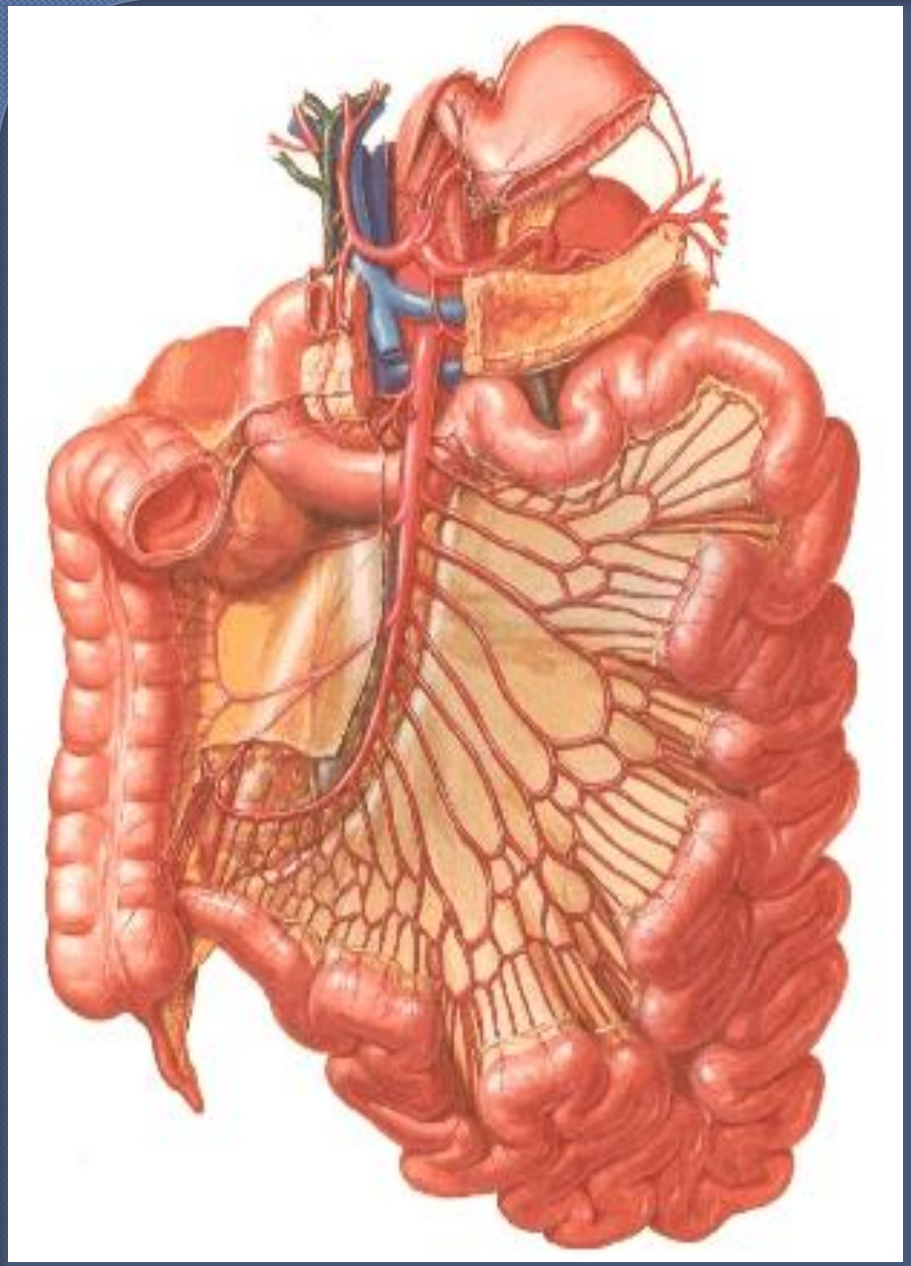


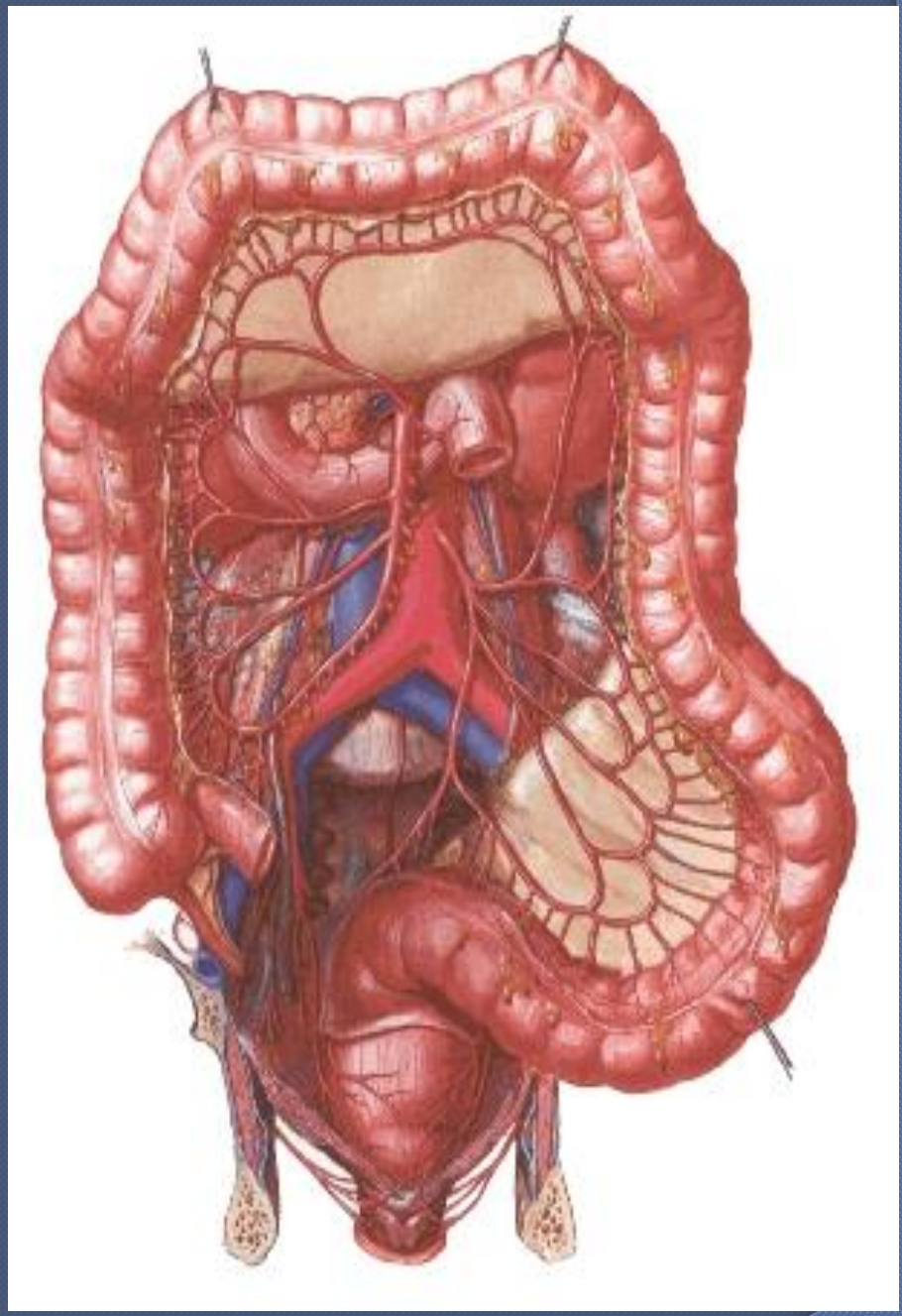


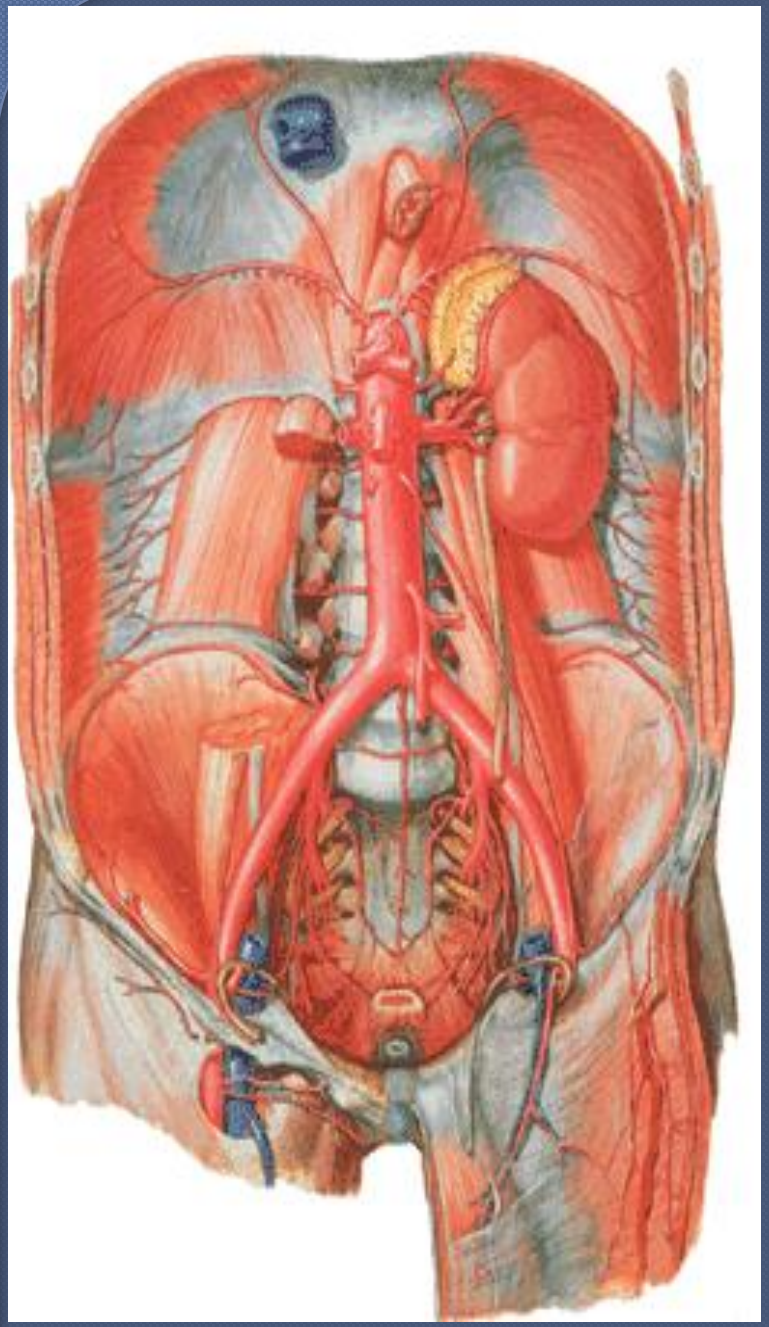
Drenagem confluente para Veia cava superior e inferior

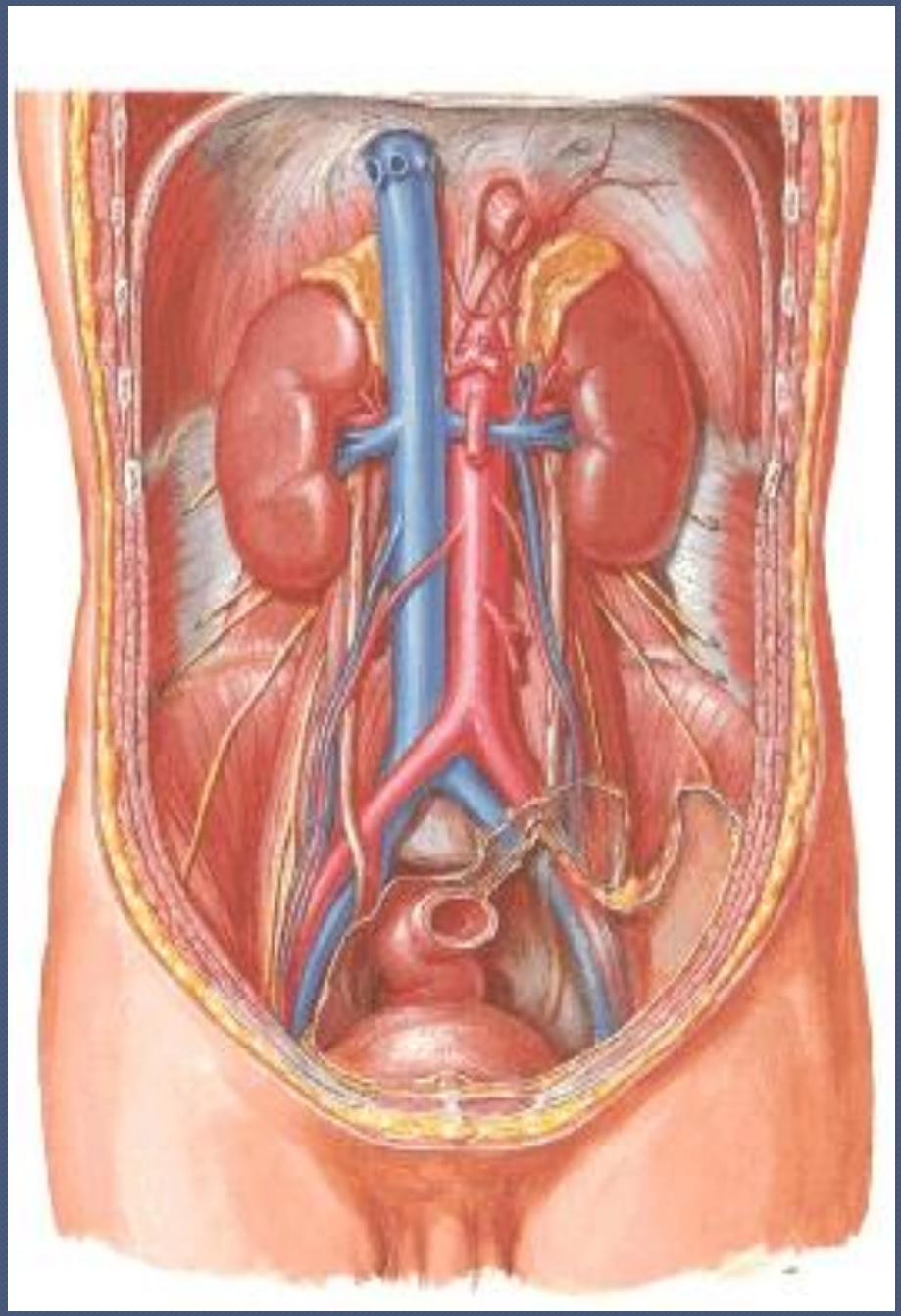


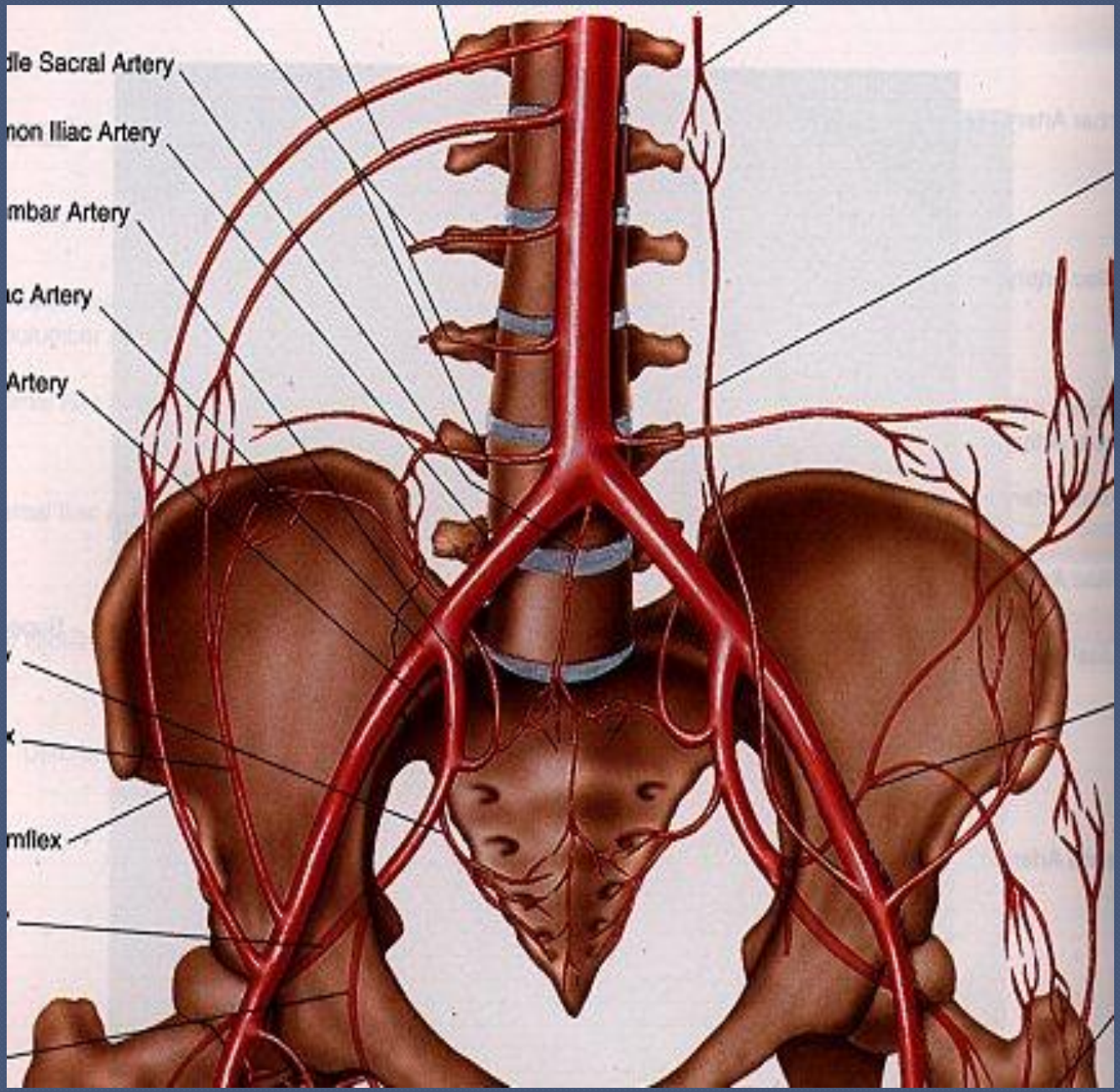











dle Sacral Artery
mon Iliac Artery
mbar Artery
ac Artery
Artery
mflex

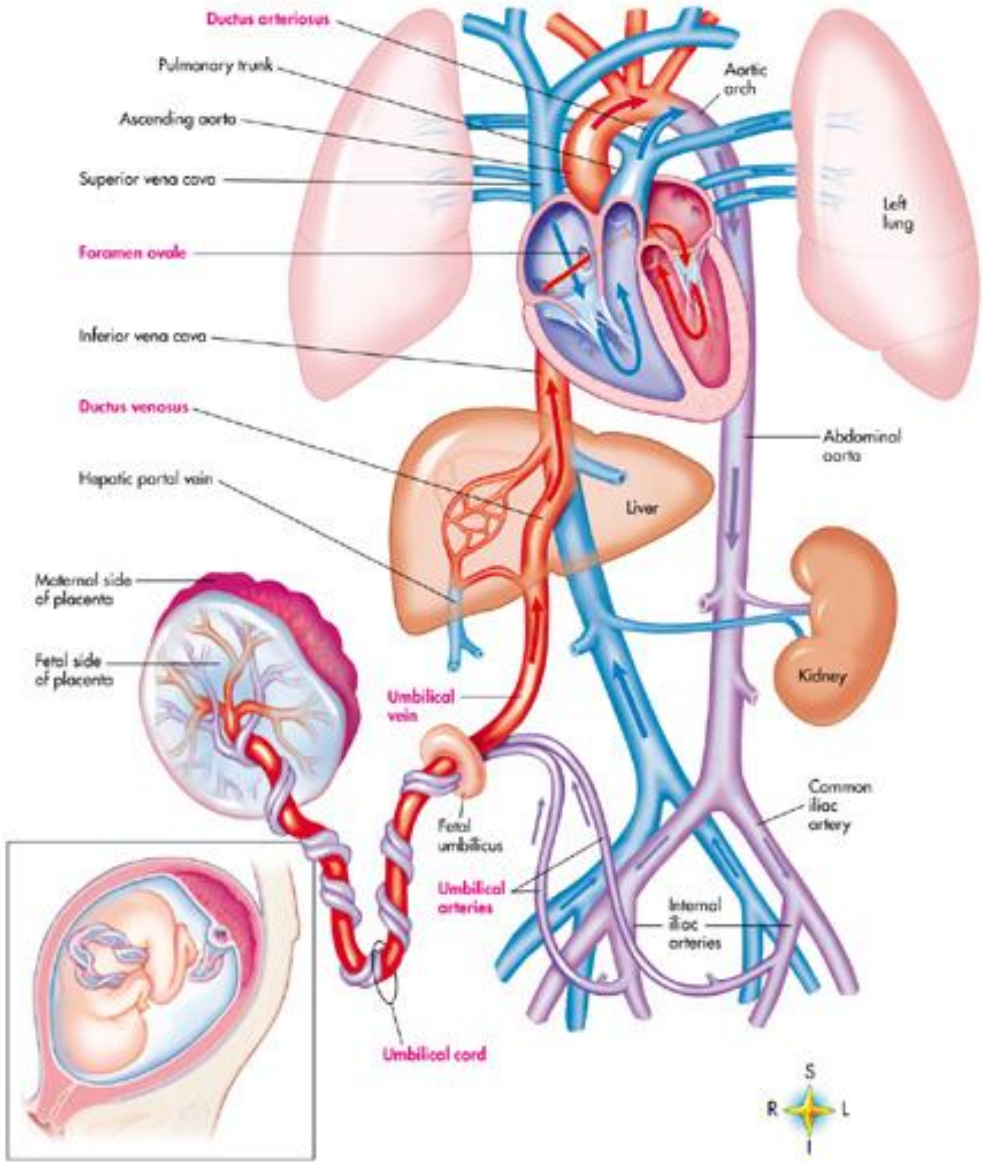
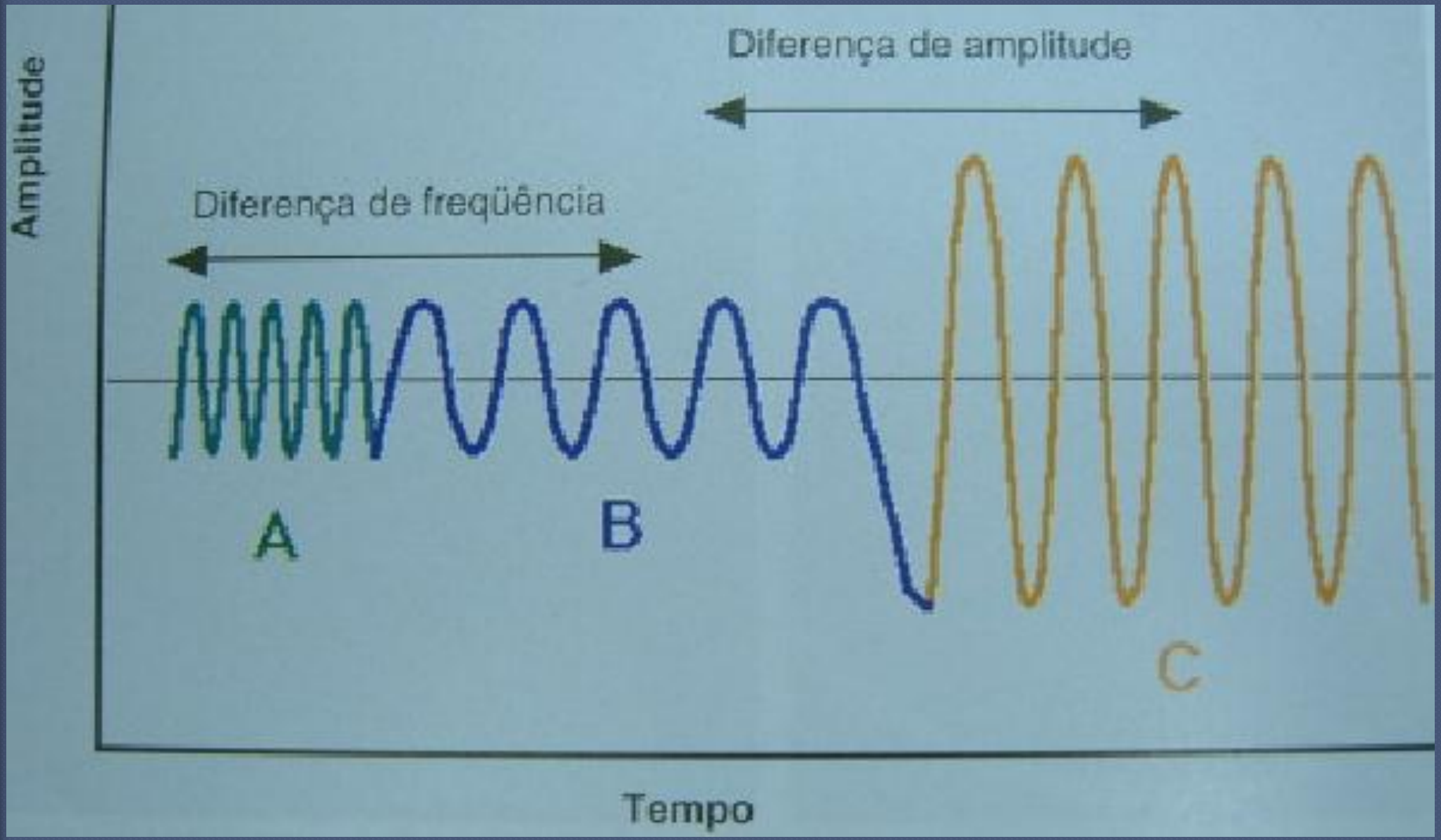
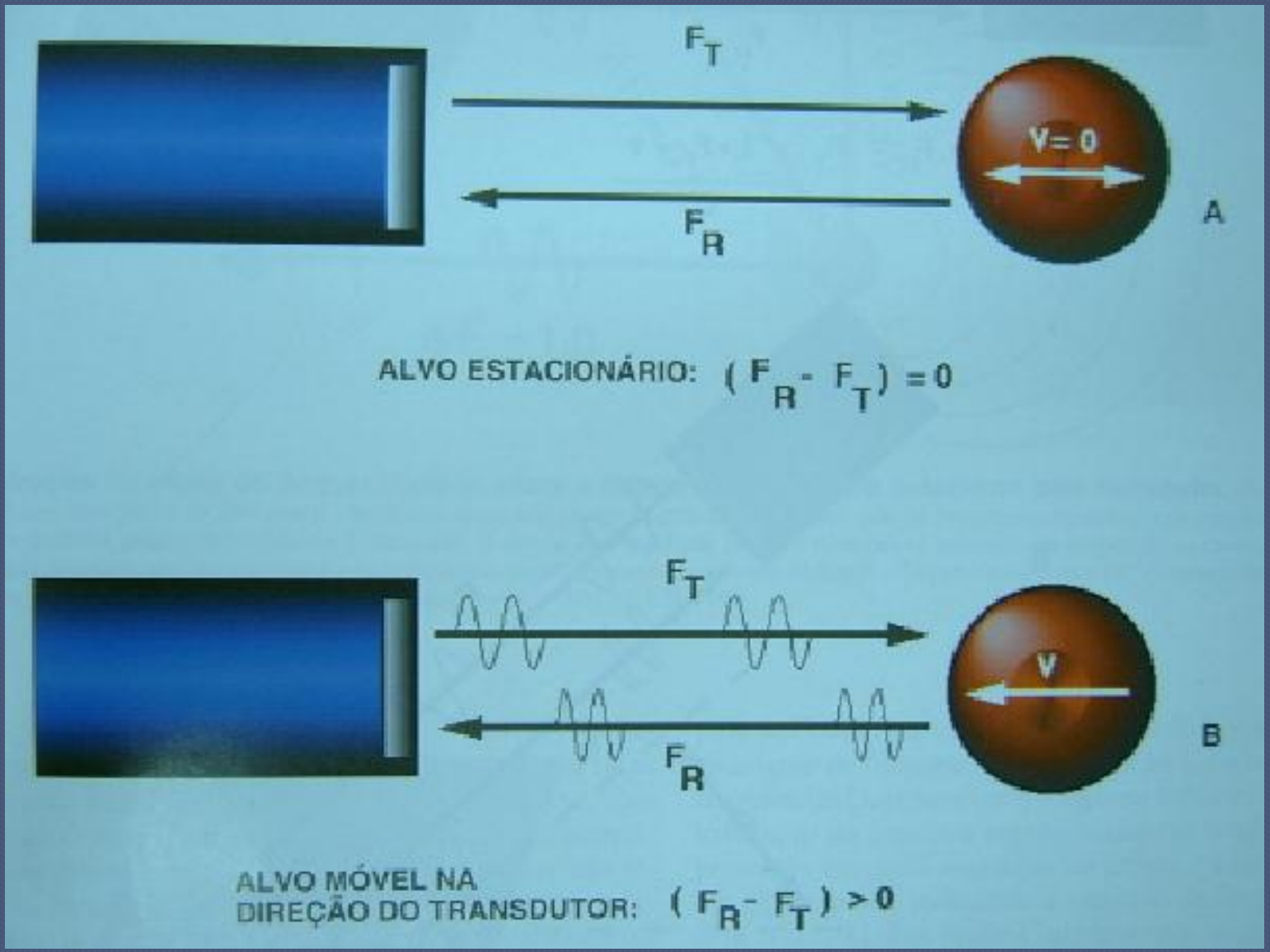
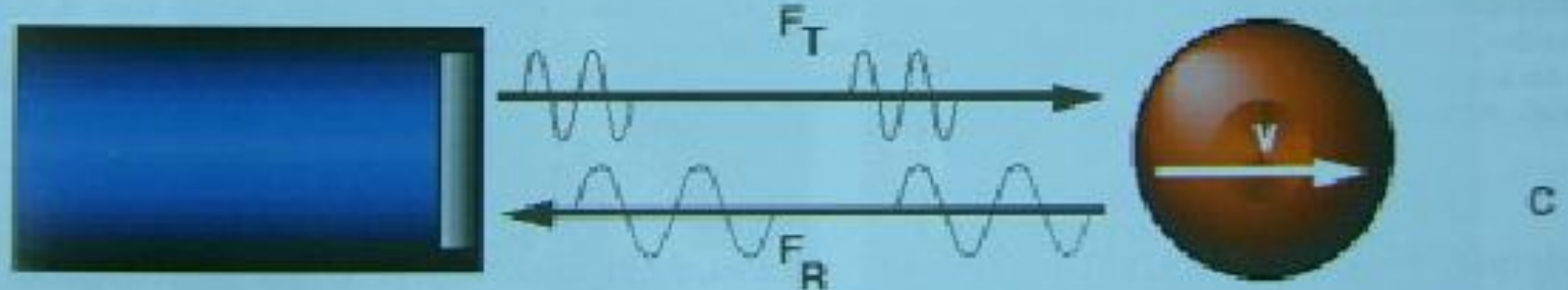


Image 188 Plan of fetal circulation

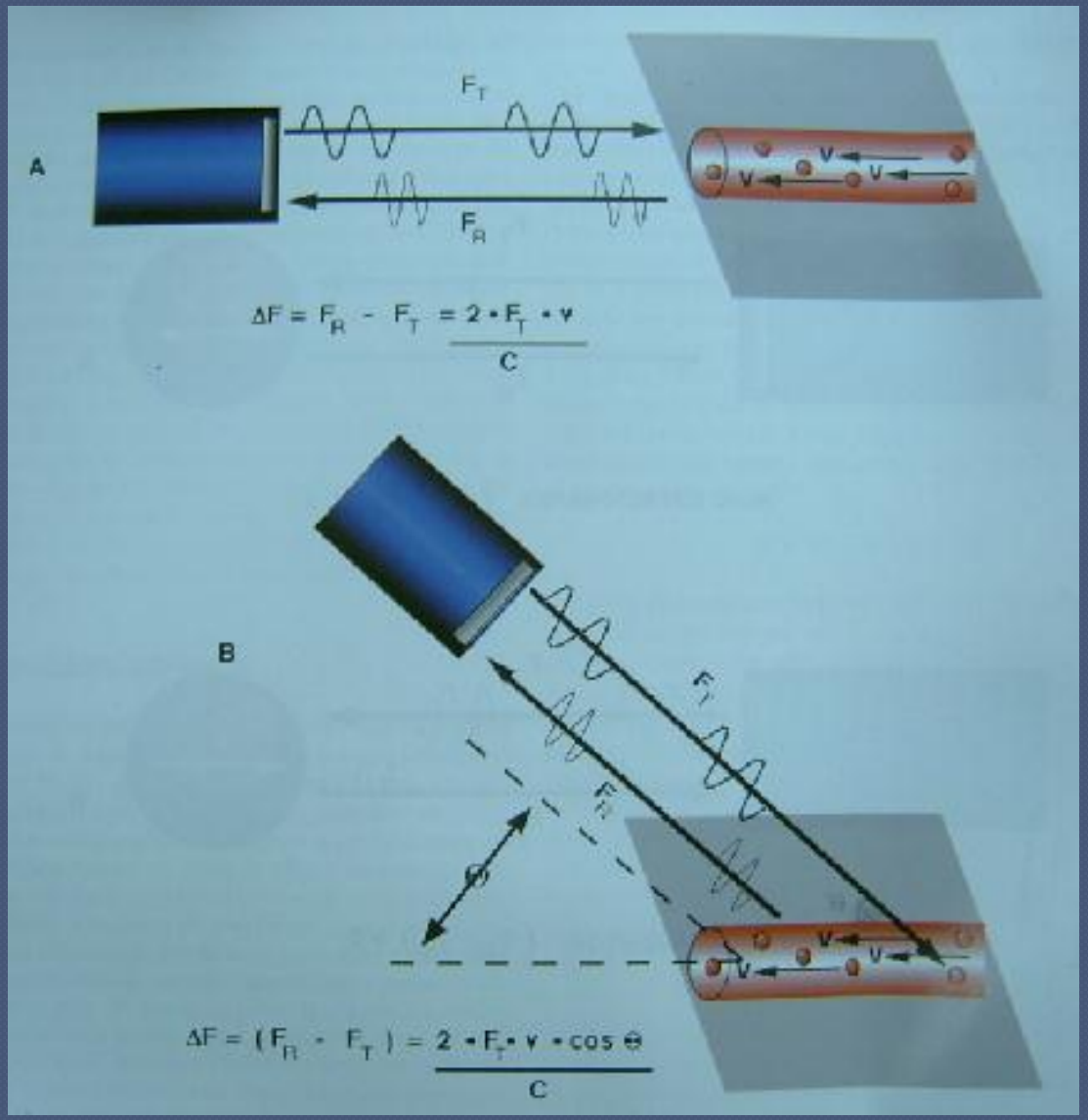
DOPPLER

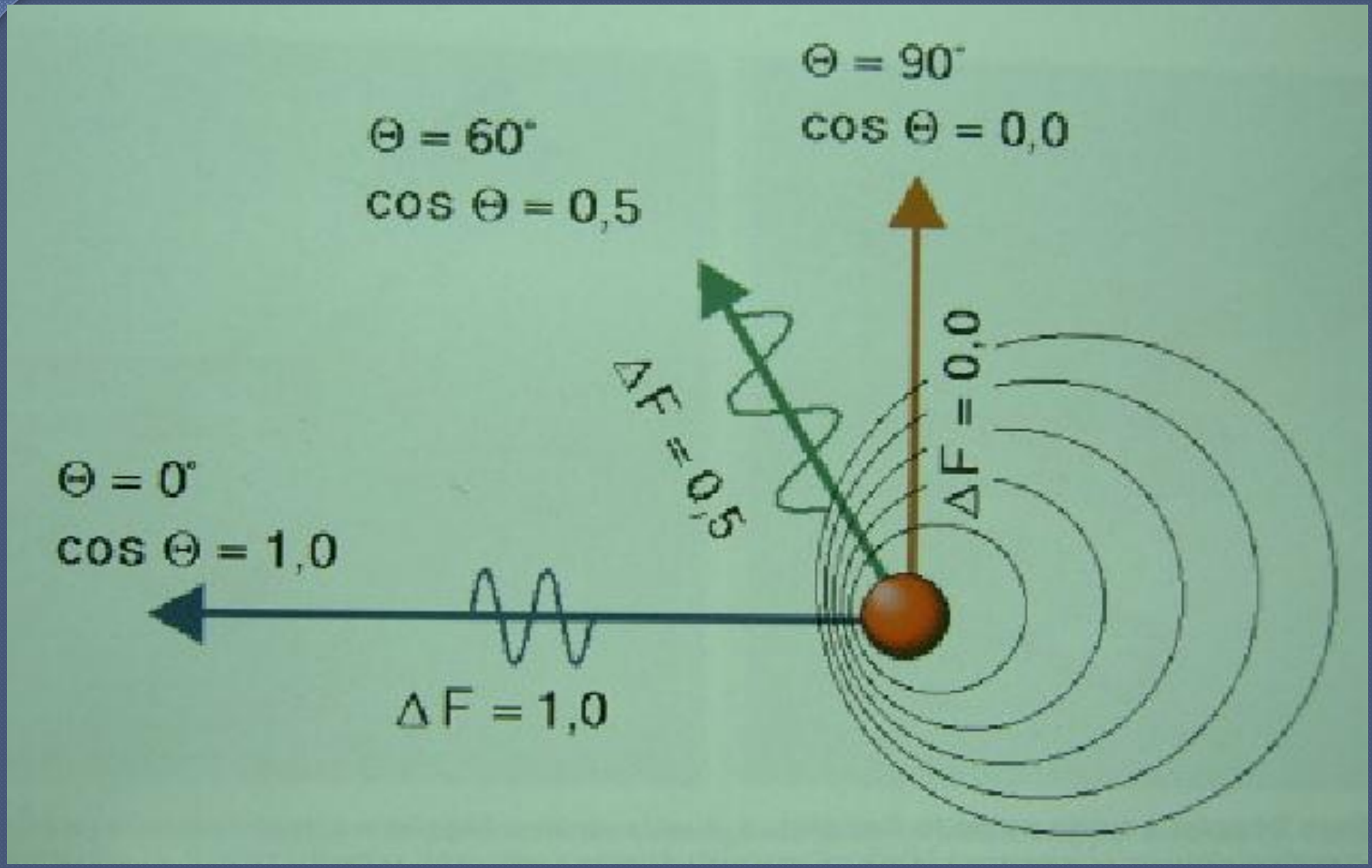

Amplitude
Diferença de amplitude
Diferença de freqüência
A
B
C
Tempo

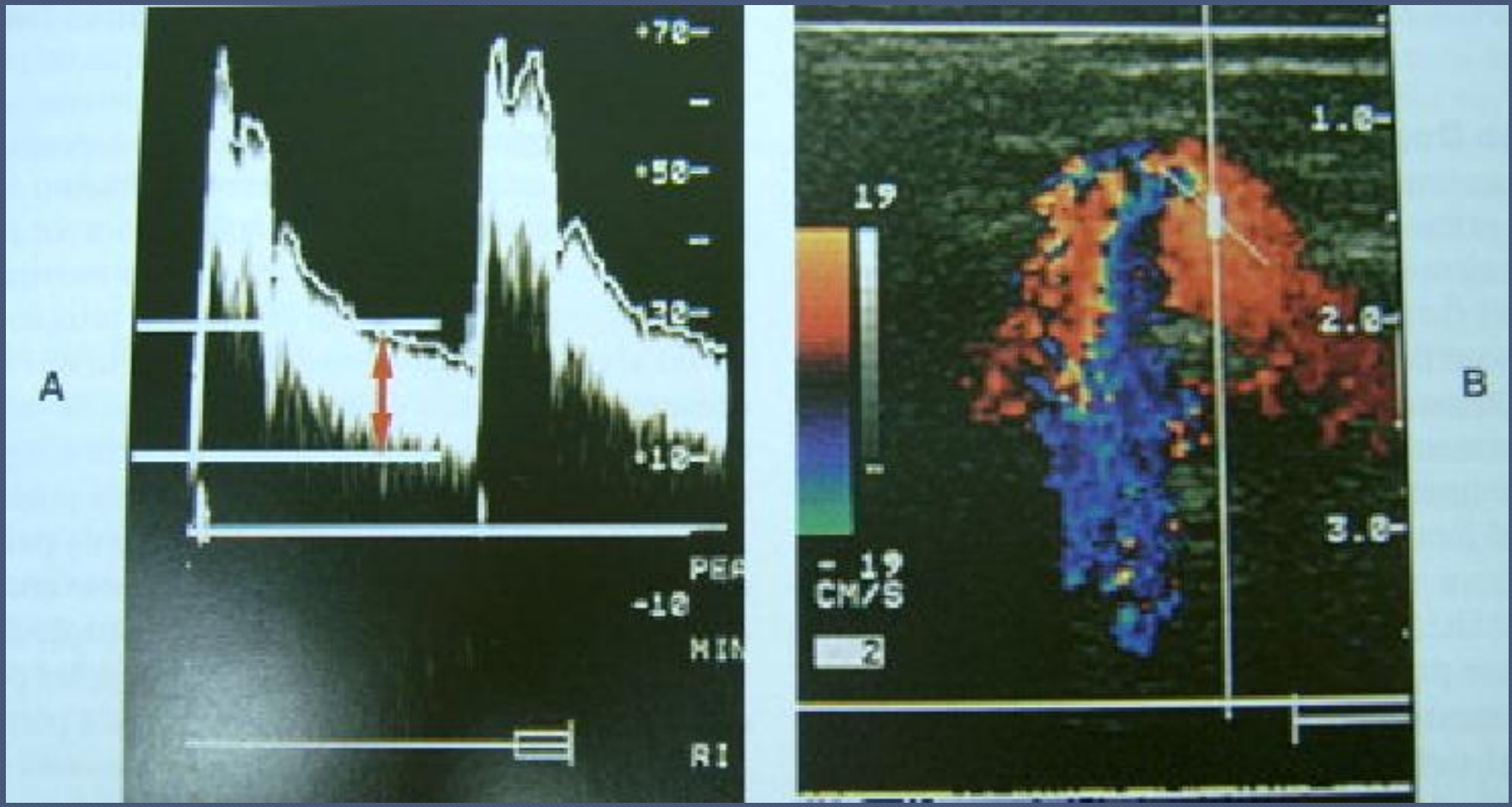

F_T
V= 0
F_R
A
ALVO ESTACIONÁRIO: $(F_R - F_T) = 0$
F_T
V
F_R
B
ALVO MÓVEL NA DIREÇÃO DO TRANSDUTOR: $(F_R - F_T) > 0$



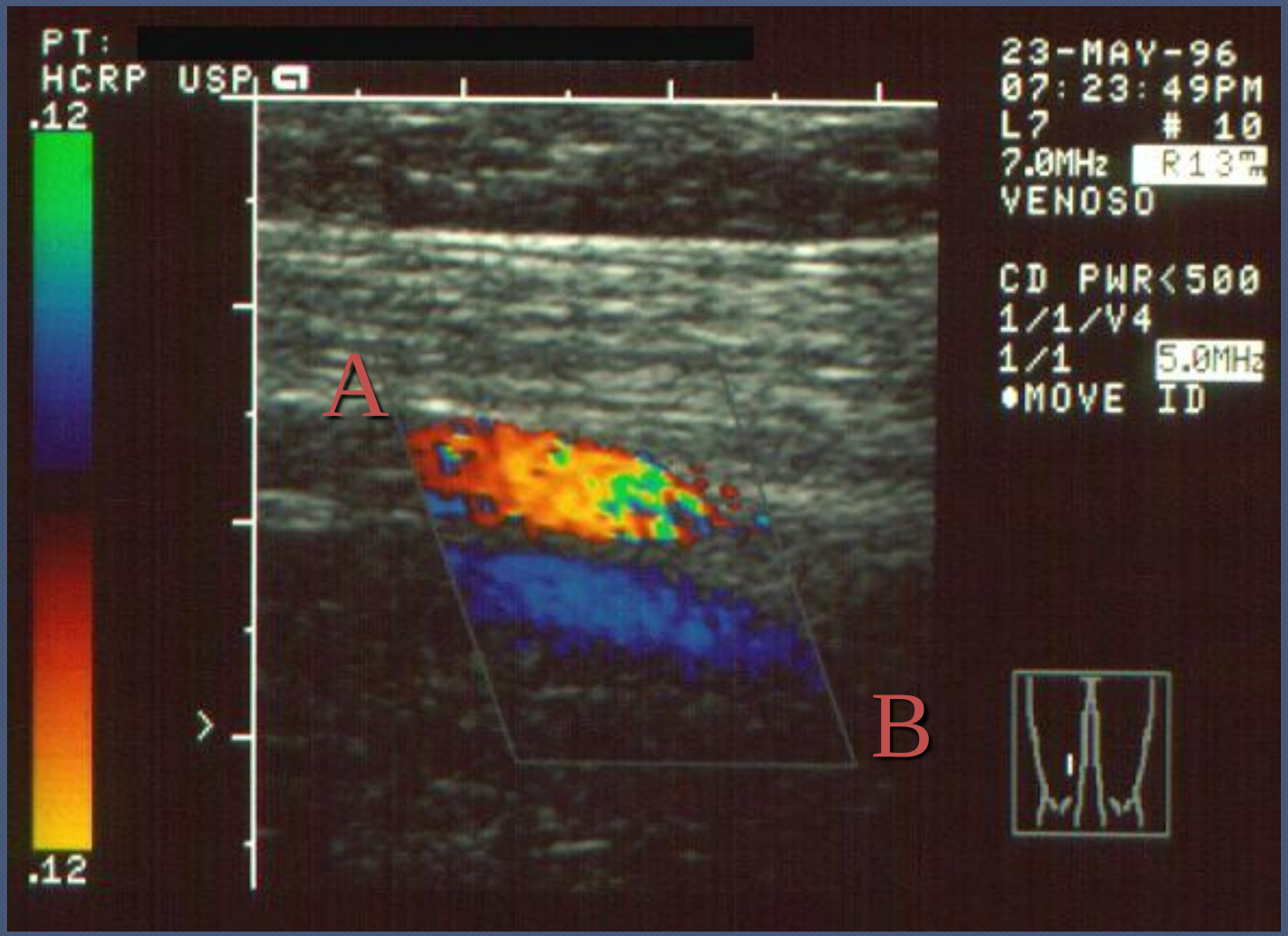
ALVO MÓVEL AFASTANDO-SE DO TRANSDUTOR: $(F_R - F_T) < 0$


A
F_T
F_R
v
v
v
v
$\Delta F = F_R - F_T = \frac{2 \cdot F_T \cdot v}{C}$
B
F_T
F_R
θ
v
v
v
v
$\Delta F = (F_R - F_T) = \frac{2 \cdot F_T \cdot v \cdot \cos \theta}{C}$

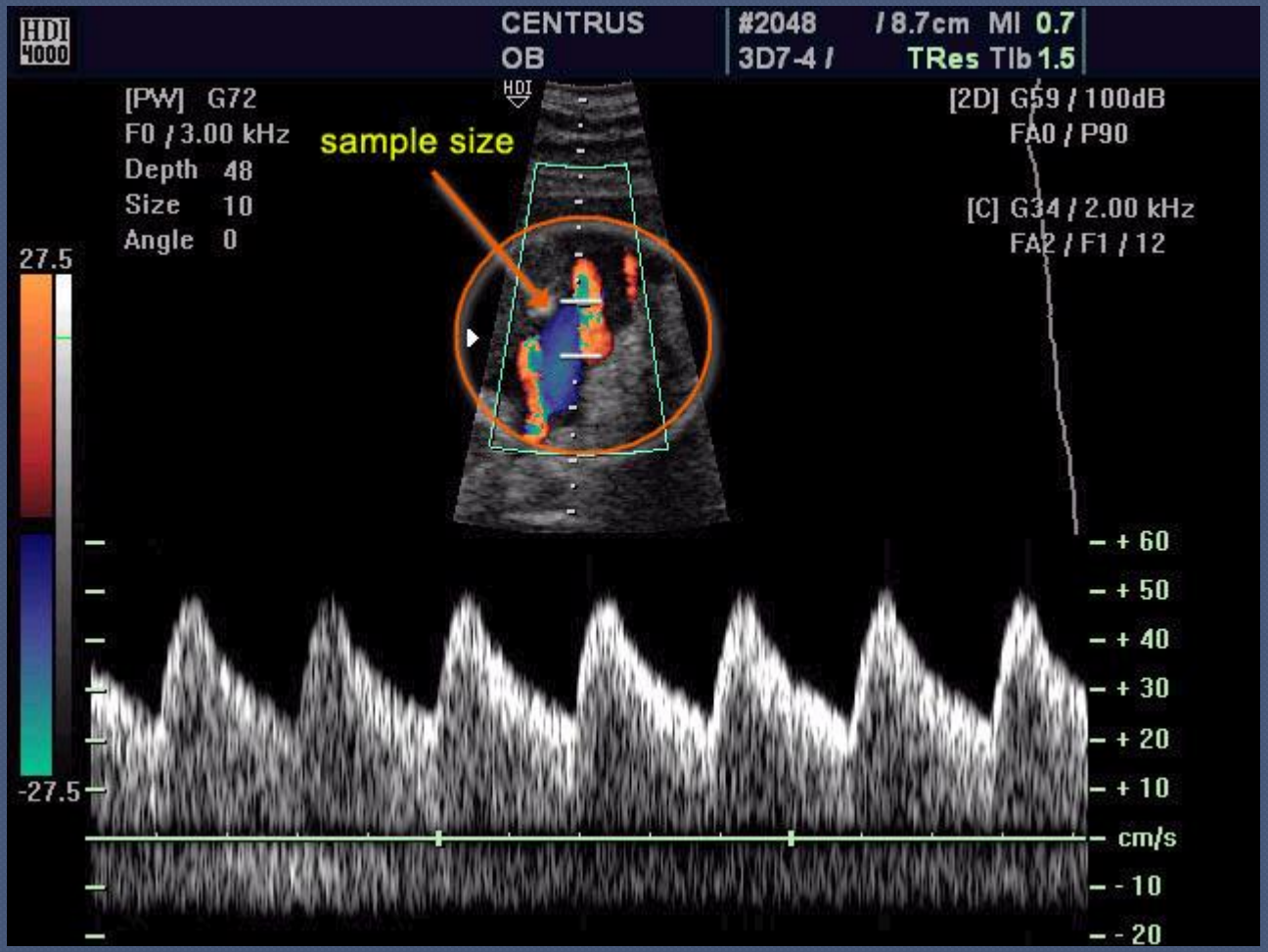

Θ = 90°
cos Θ = 0,0
Θ = 60°
cos Θ = 0,5
ΔF = 0,0
ΔF = 0,5
Θ = 0°
cos Θ = 1,0
ΔF = 1,0


A
+70
+50
+30
+10
-10
PEA
MIN
RI
19
- 19
CM/S
2
1.0
2.0
3.0
B

Sentido de Fluxo?



Amostra Artéria e Veia



Pulsatilidade

Variação Respiratória