

Introduzione ai vasi

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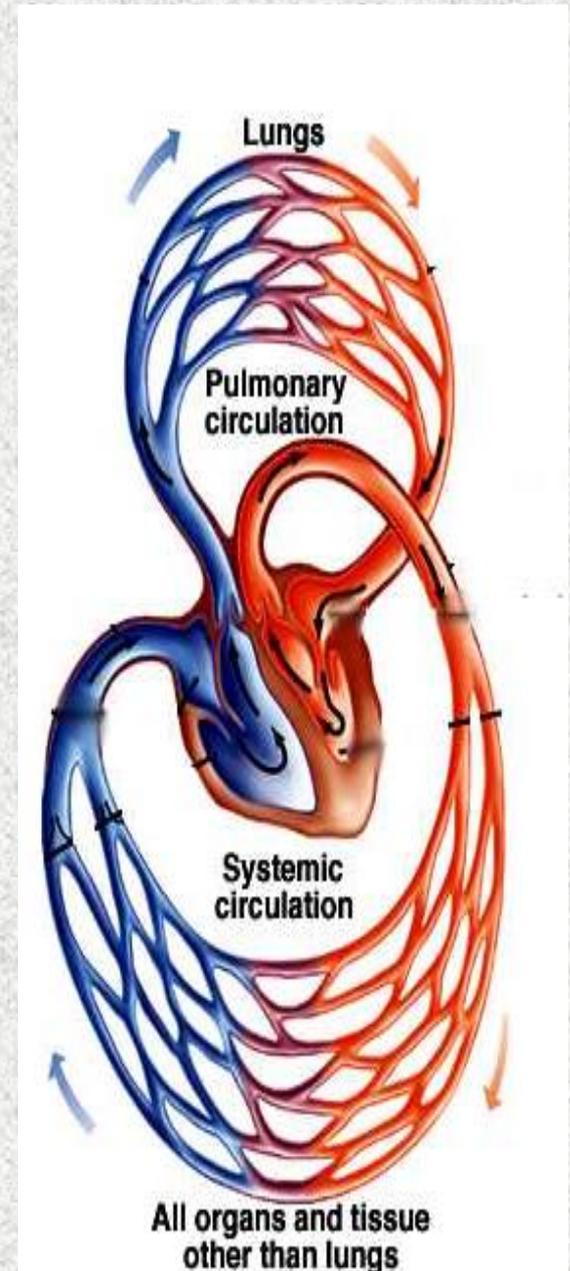
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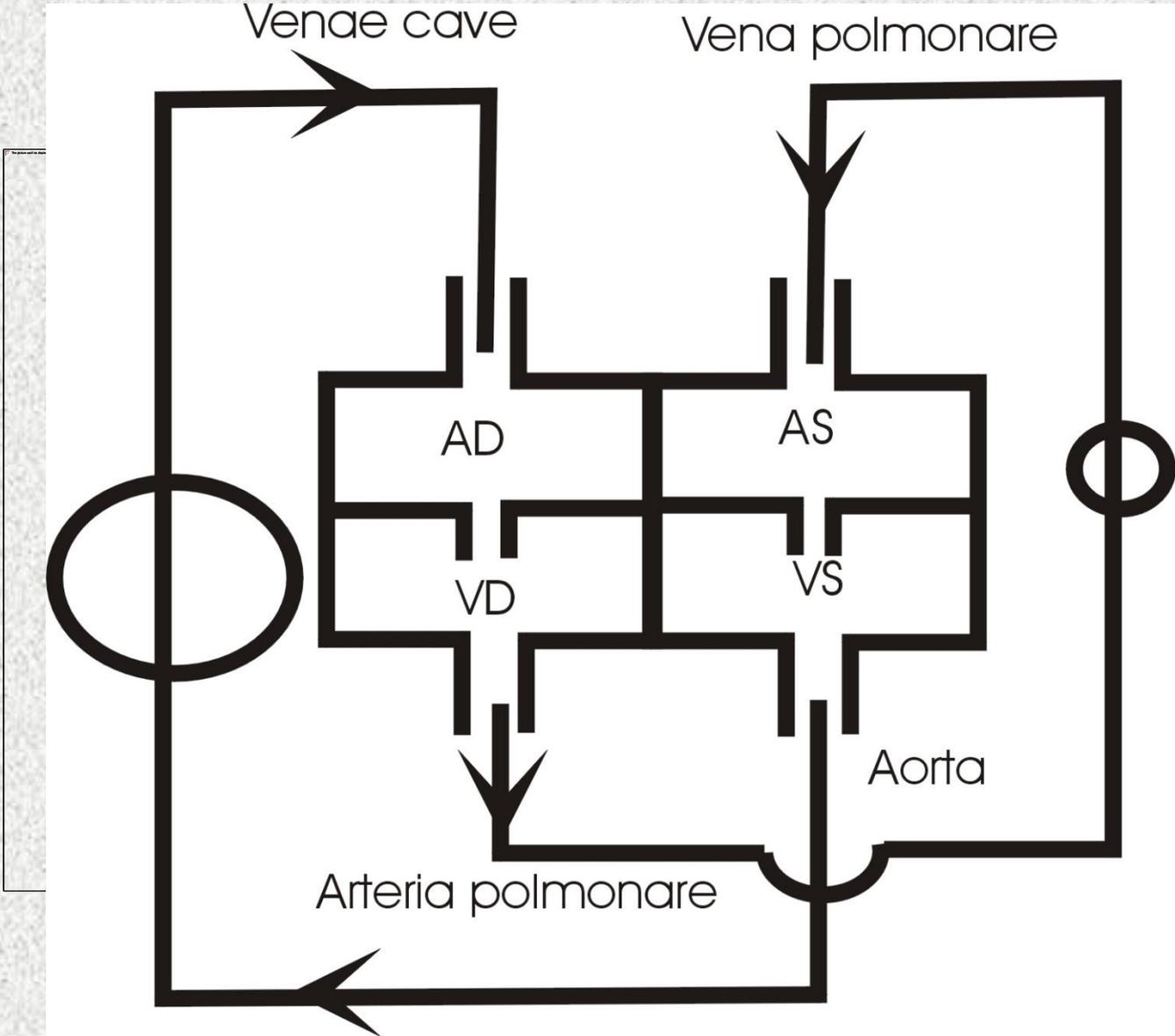
Sistema Cardiovascolare

- I vasi sanguigni formano un sistema chiuso che parte dal cuore
- E' un sistema di strutture dinamiche, che si dilatano, contraggono , pulsano e proliferano per adattarsi ai bisogni del corpo.
- La rete di distribuzione del sangue ha una lunghezza di circa 96,000 km

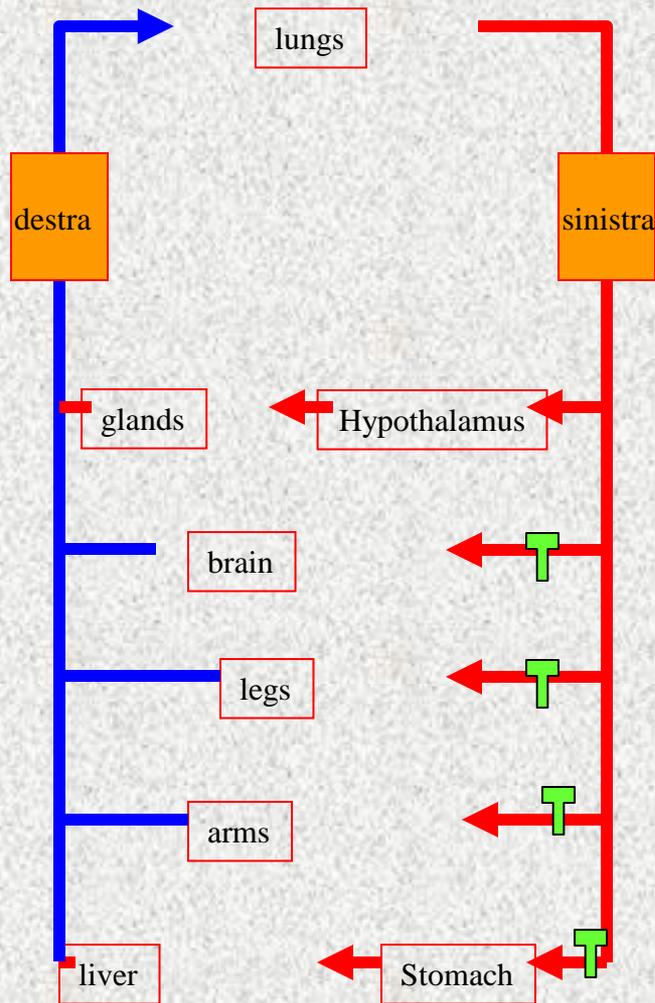
Funzioni

- **Transporto**
 - O_2 e CO_2
 - Nutrienti
 - Metaboliti
 - Ormoni
 - Calore
- **Affidabilita'**
 - Quanti battiti fa in una vita?
- **Flessibilita'**
 - Pompa puo' cambiare portata
 - Vasi possono cambiare direzione di flusso



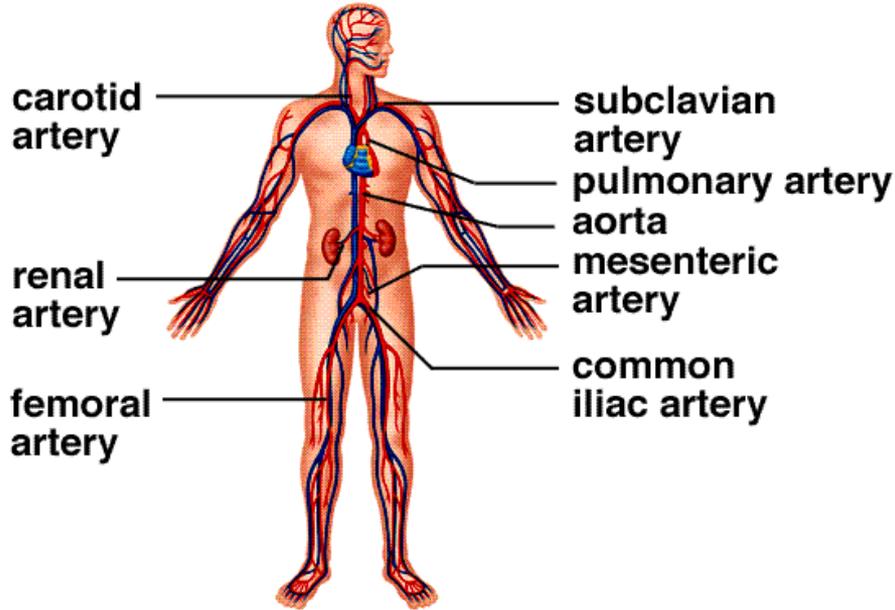


Struttura del sistema SCV

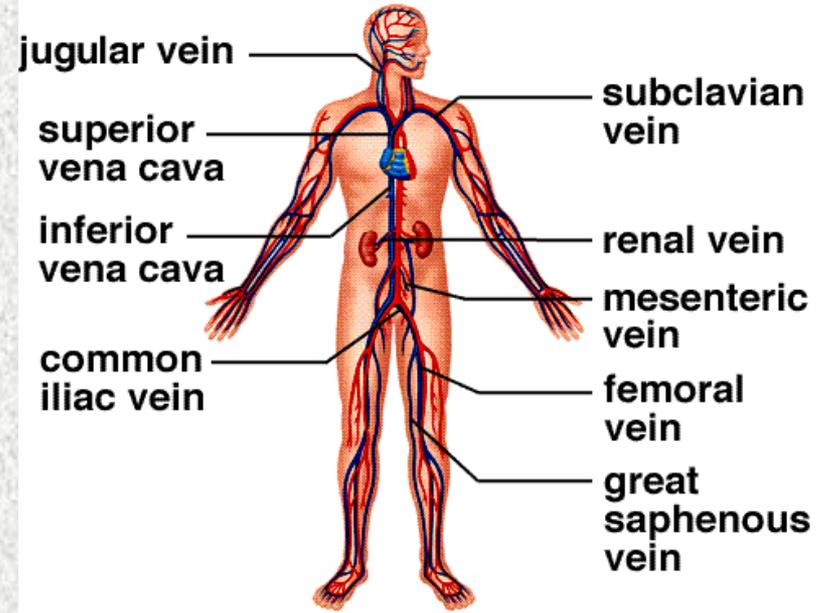


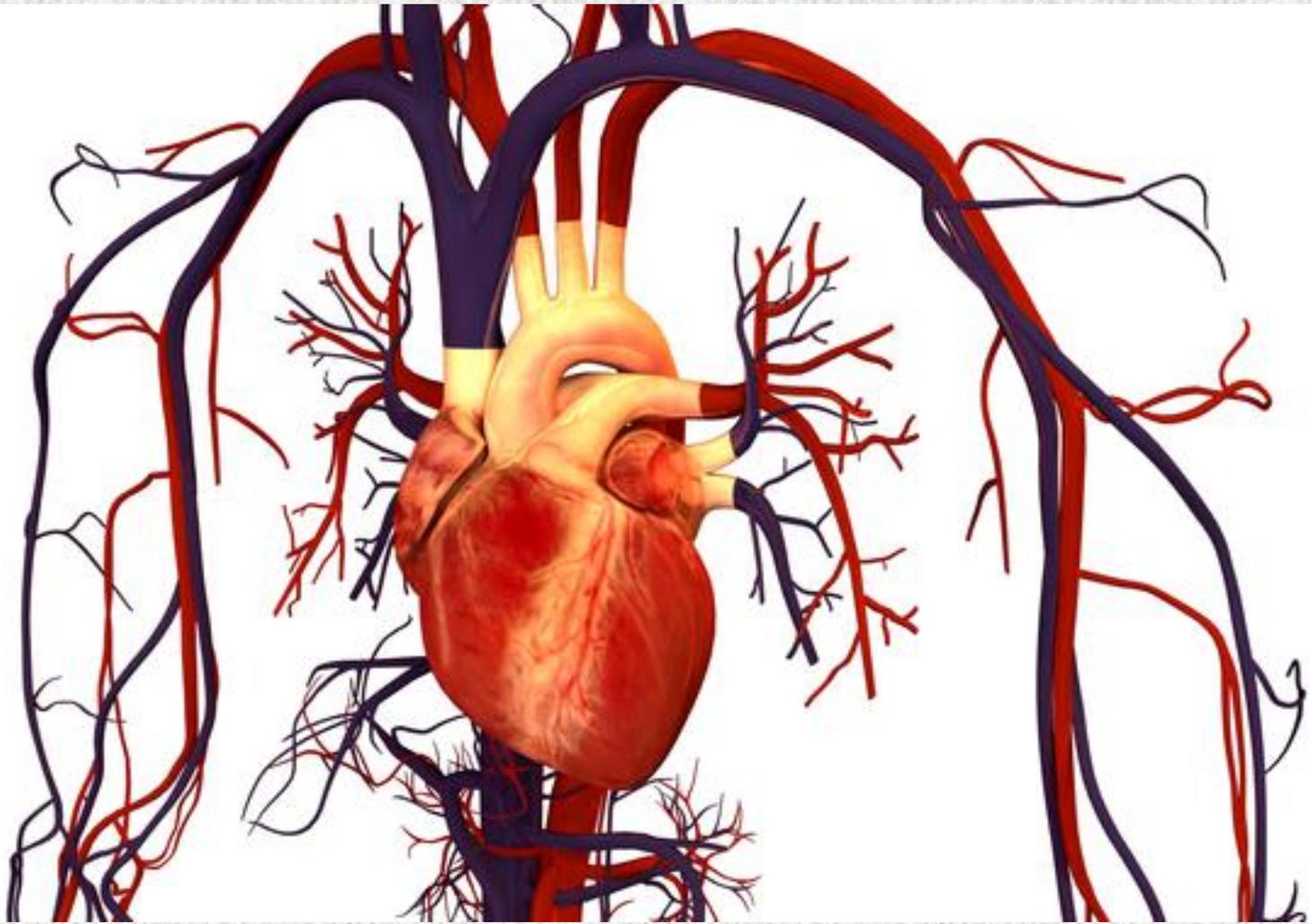
- Le pompe D e S, devono essere uguali in uscita
- I letti vascolari sono in parallelo
 - Tutti tessuti vengono ossigenati
 - In zone localizzate, il flusso puo essere ridirezionato
 - Il flusso può essere redirezionato attraverso vasocostrizione e vasodilatazione

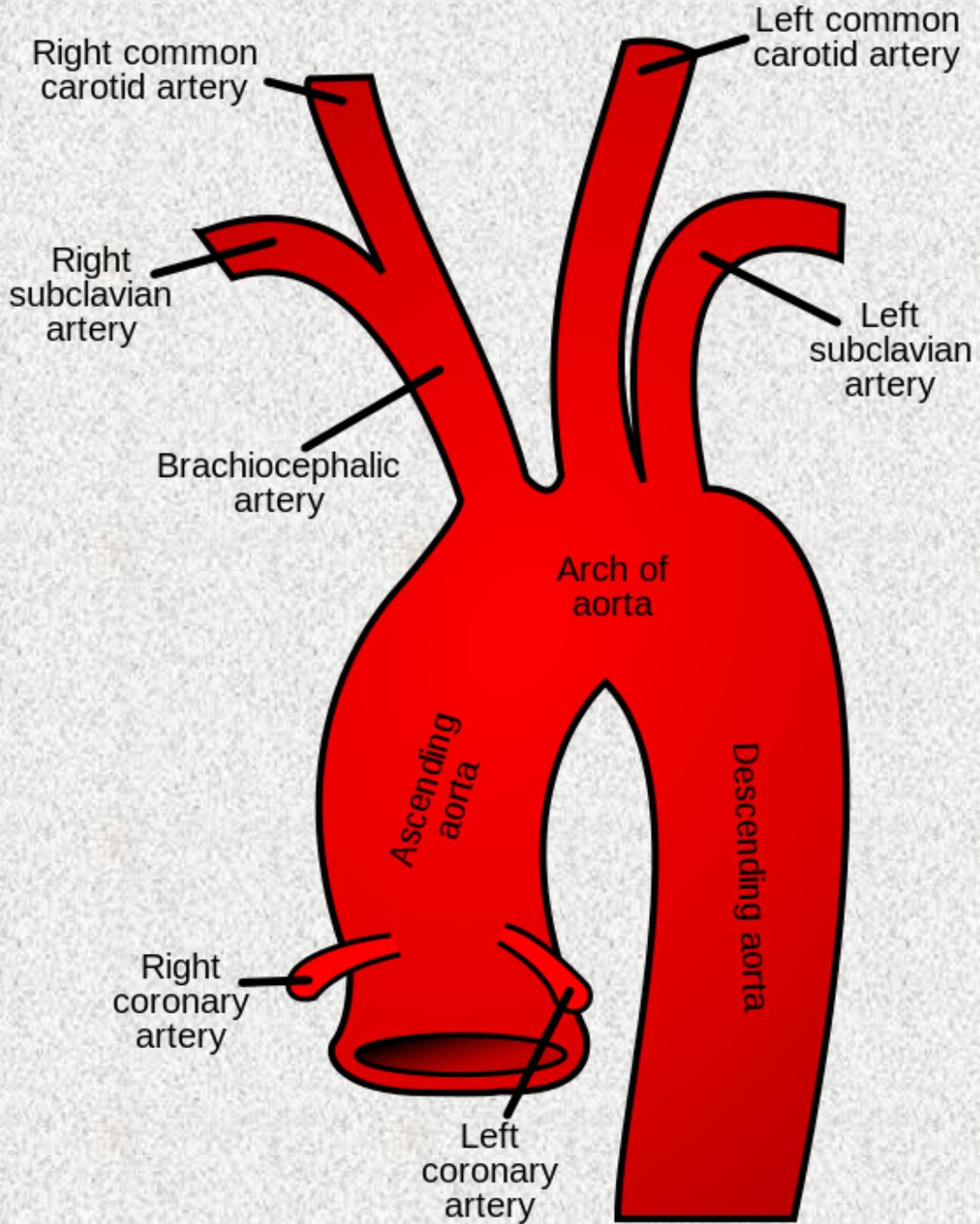
Circulatory System (Major Arteries)



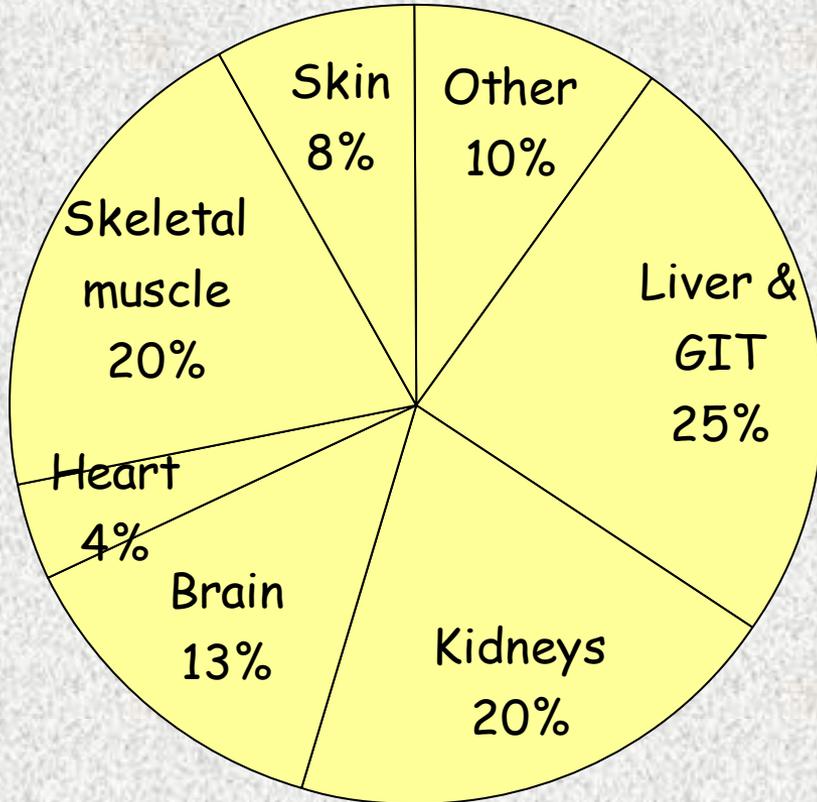
Circulatory System (Major Veins)



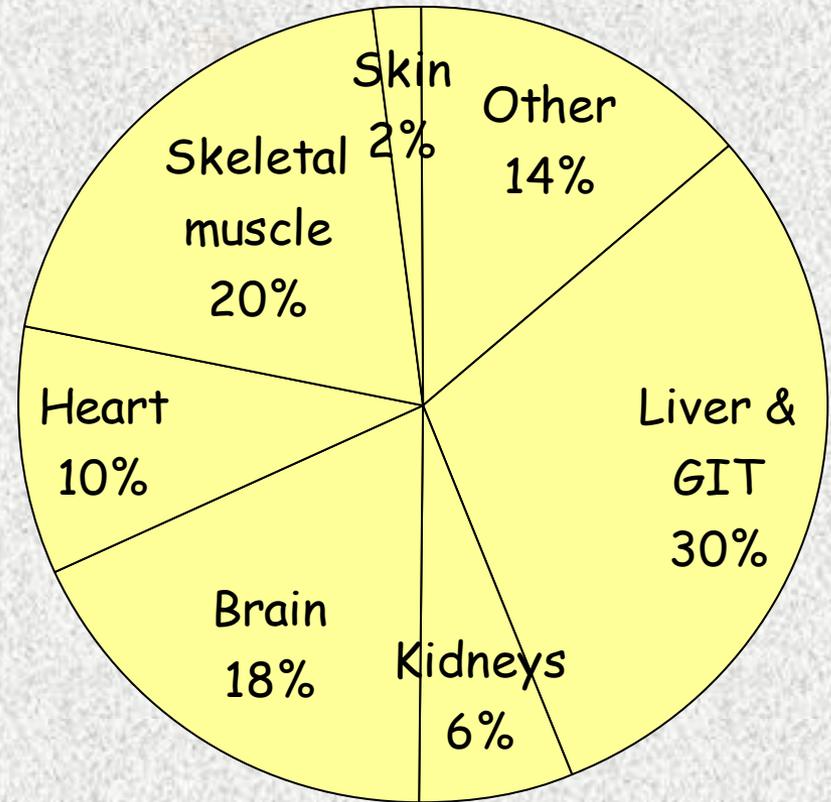




Uscita cardiaca

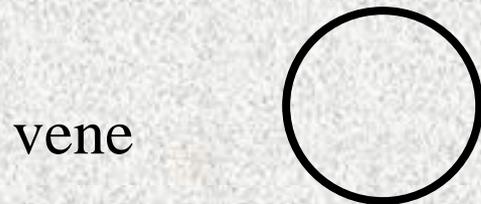
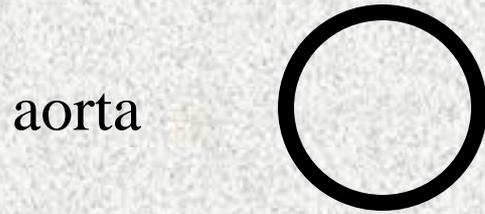


Consumo di O₂

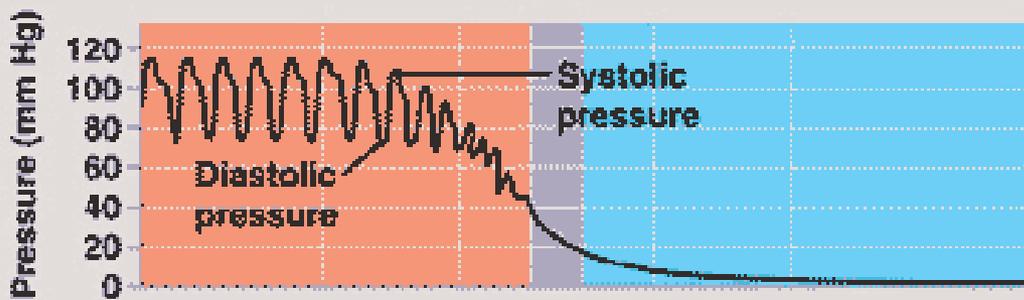
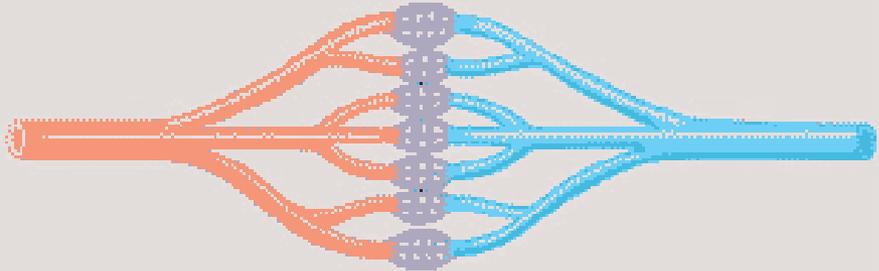
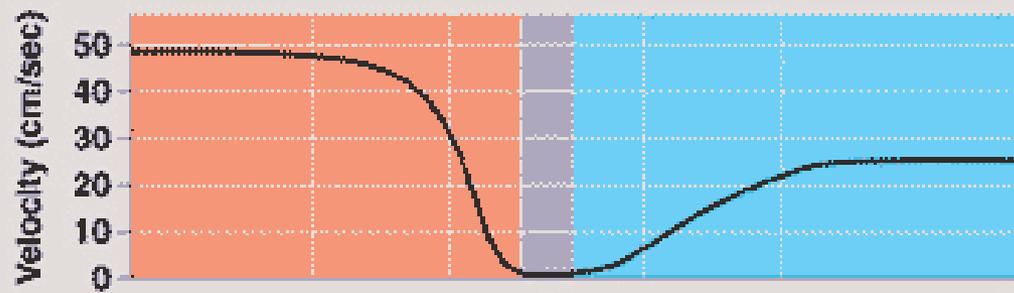
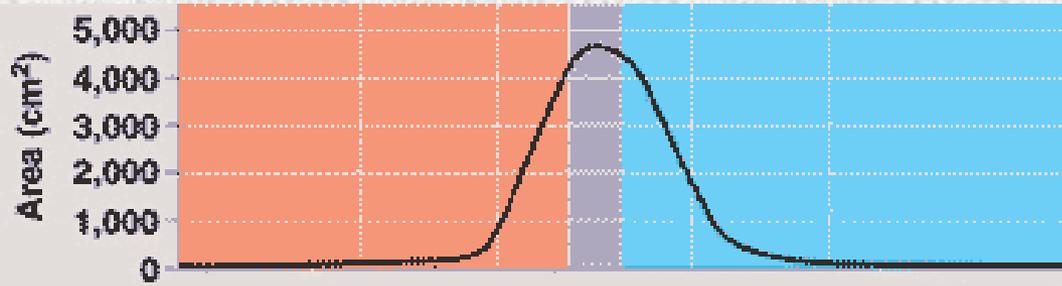


Come viene ridirezionato l'uscita durante uno sforzo fisico?

Classificazione dei Vasi



- Arterie elastiche eg aorta
 - Lume grande, parete elastica
 - Per smorzare variazioni di pressione (perche?)
- Arterie Muscolari eg altre arterie
 - Lume grande, parete forte non- elastica
 - Condotto con bassa resistenza
- Vasi con resistenza eg arterioli
 - Lume piccolo, parete spessa e contrattile
 - Possono controllare resistenza e flusso
 - Permettano la ridirezione del sangue
- Vasi di scambio, eg capillaries
- Vasi con elevata capacita' eg venule & vene
 - Lume grande, parete distensibile
 - Condotto di bassa resistenza



Aorta
Arteries
Arterioles
Capillaries
Venules
Veins
Venae cavae

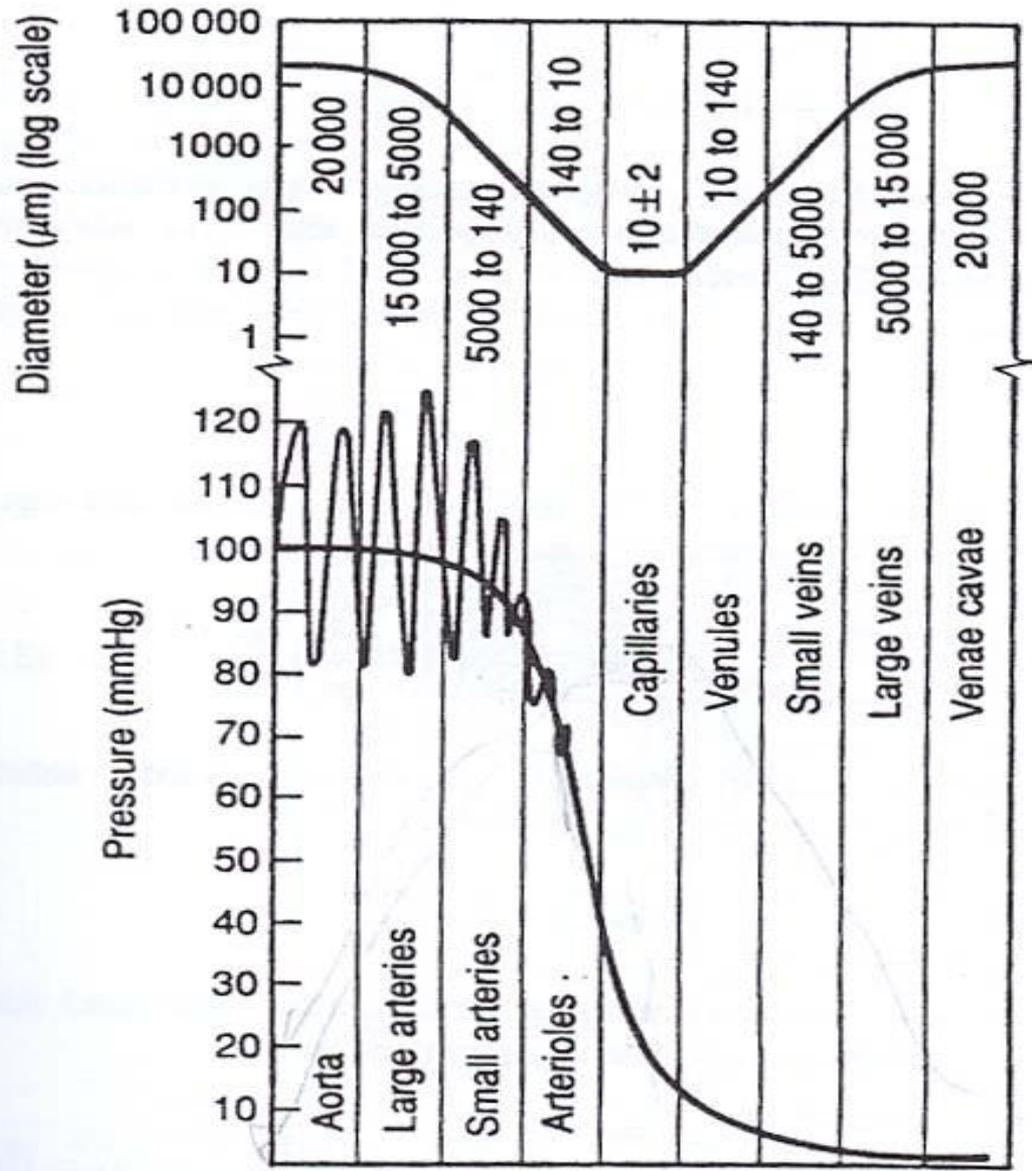


Fig. 3.4 Pressure variation in the systemic circulation.

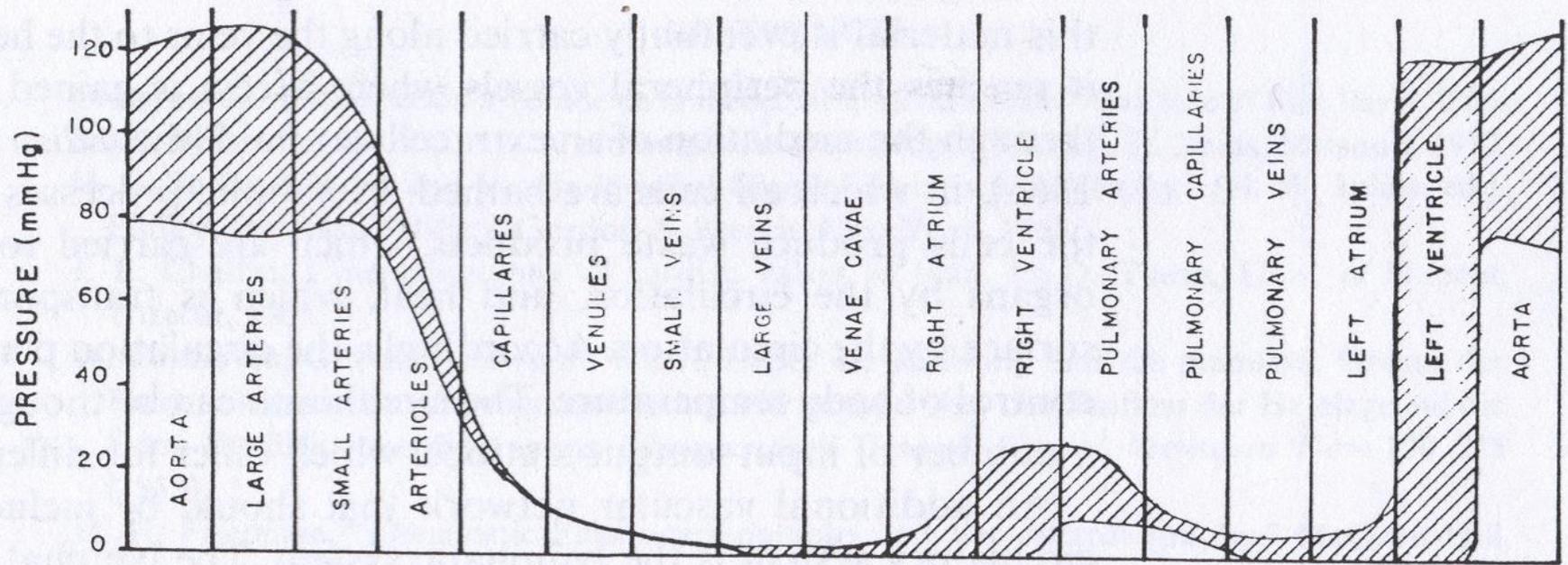
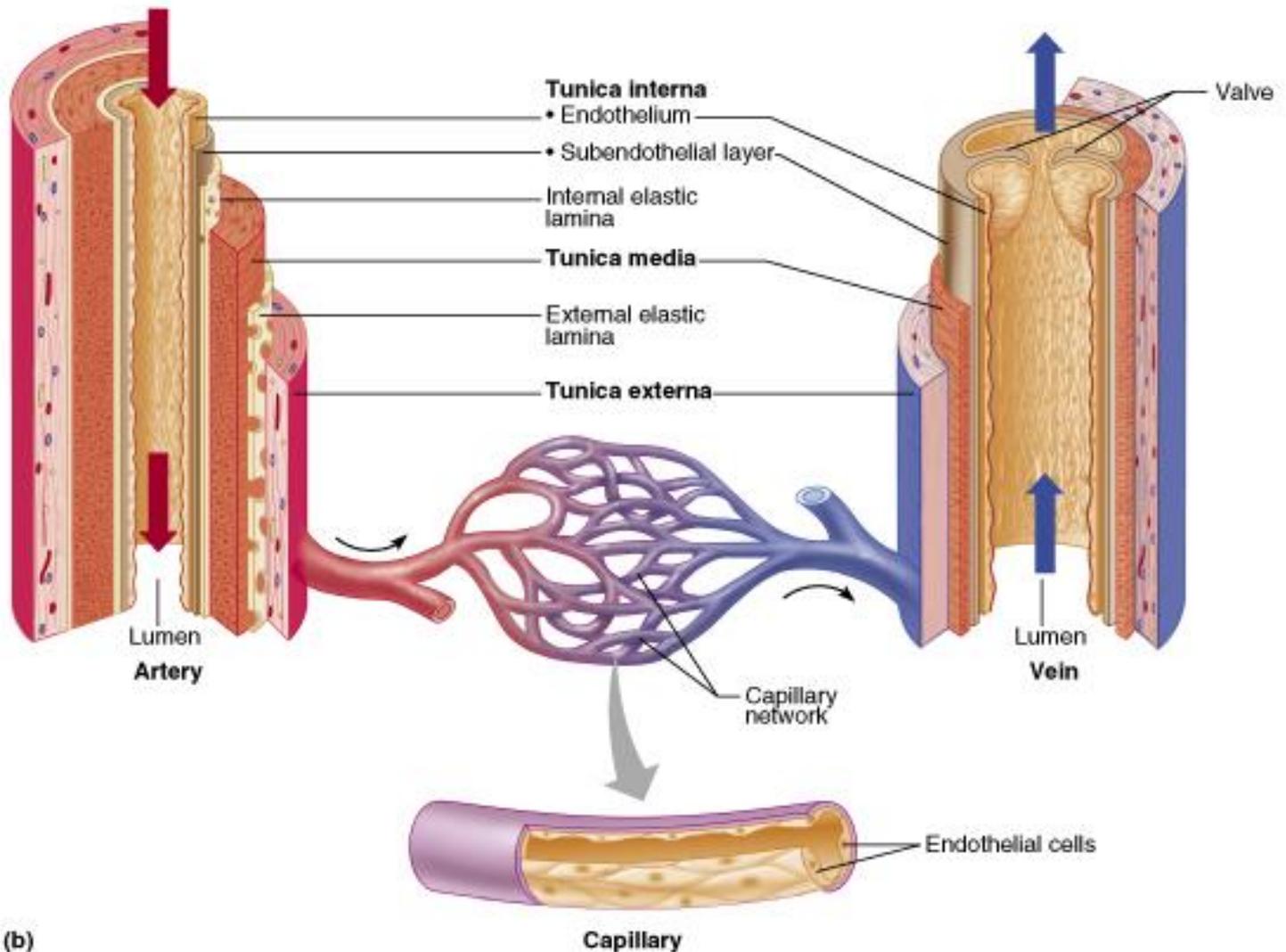


Fig. 1-8. Pressure levels, including oscillatory magnitudes, around the circuit.

Struttura dei vasi: 3 tipi

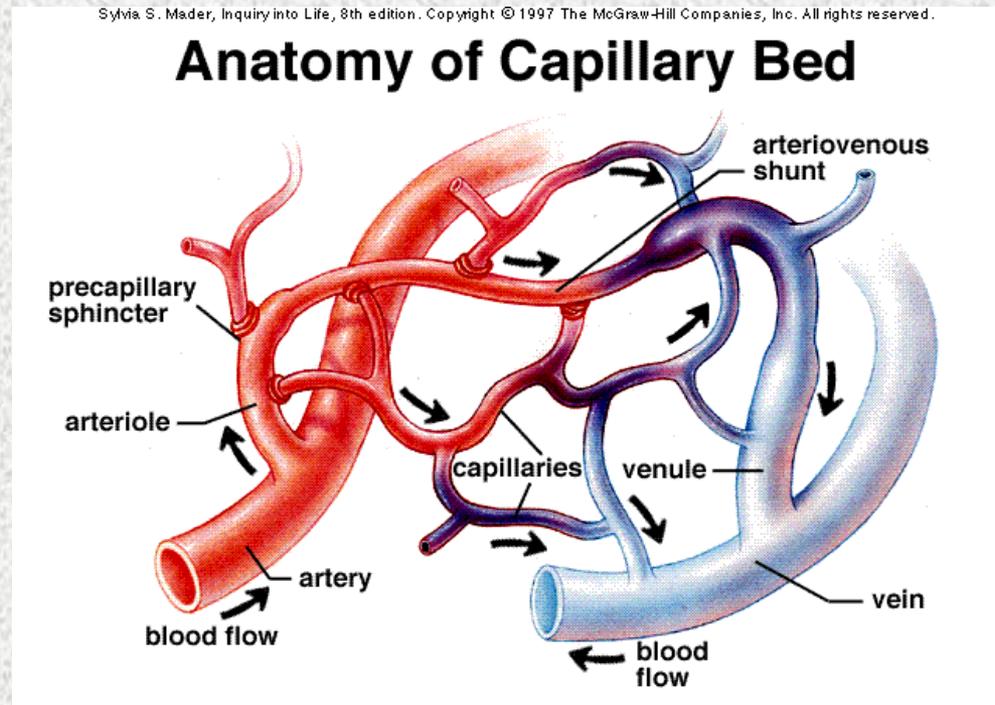
- Arterie
 - Elastiche, muscolari, arteriole
- Capillari
 - Sangue fluisce da arterioli a capillari
 - Lo scambio di O_2 occorre tra le pareti
 - Poi dai capillari passa al sistema venoso.
- Vene (hanno valvole)
 - Venule, vene piccole, medie o grandi



(b)

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- La rete parte con arterie → arterioli → capillari → venule → vene
- Solo i capillari vengono in contatto intimo con cellule e tessuti



Grandezza e Composizione

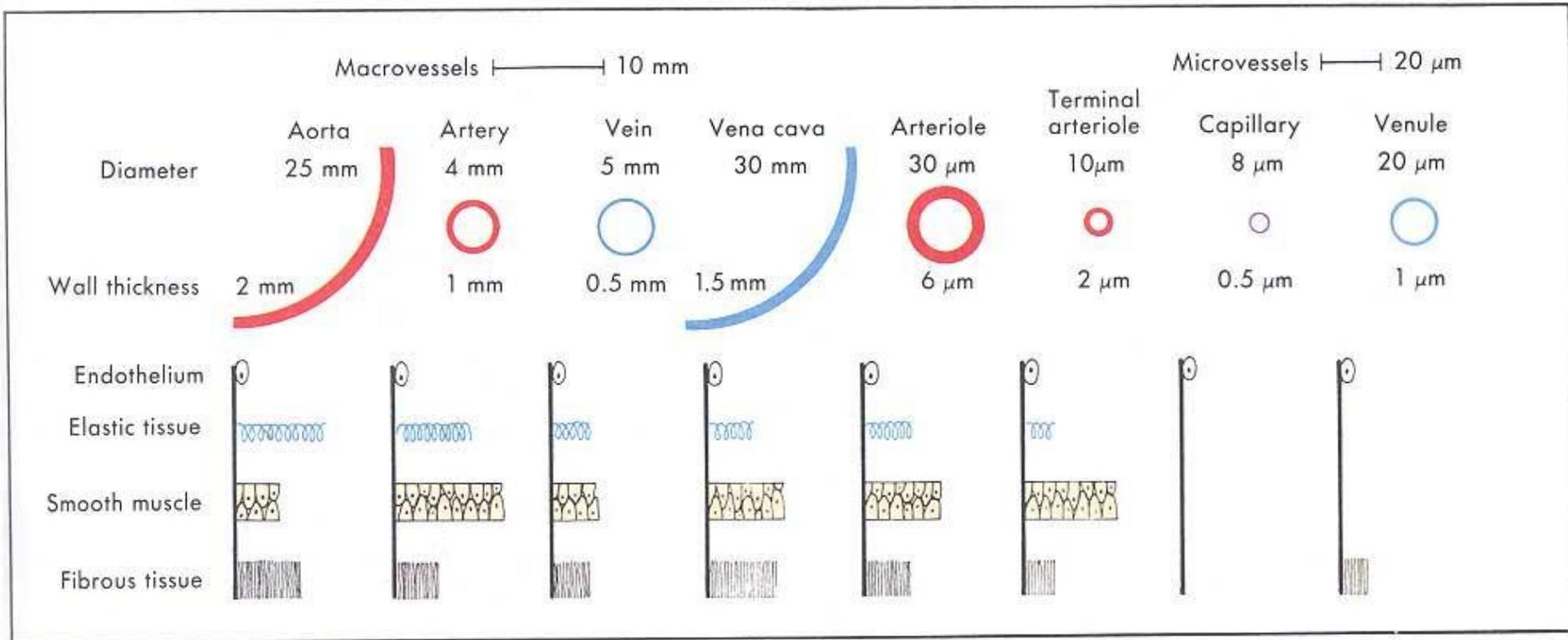


FIGURE 15-1 Internal diameter, wall thickness, and relative amounts of the principal components of the vessel walls of the various blood vessels that compose the circulatory system. Cross sections of the vessels are not drawn to scale because of the huge range from aorta and venae cavae to capillary. (Redrawn from Burton AC: *Physiol Rev* 34:619, 1954.)

Table 3.1. Some properties of the circulation and blood

Number of red blood cells (mm^{-3})	5×10^6	Specific gravity	1.06
Number of white blood cells (mm^{-3})	10^4	Heart rate (min^{-1})	60–70
Blood volume (L)	5–6	Cardiac output (L min^{-1})	5–6
Viscosity of whole blood (mPa s; cP)	3–4*	Stroke volume (mL)	70

Vessels	Diameter (mm)	Length (cm)	Wall thickness (mm)	Contained volume (cm^3 or mL)	Mean pressure (mmHg)	Average velocity (cm s^{-1})	Reynolds number	
							Average	Maximum
Aorta	25.0	40.0	2.0	100	100(av.)	40(av.)	3000	8500
Arteries	15–0.15	15.0	0.8	350	90(av.)	40–10	500	1000
Arterioles	0.14–0.01	0.2	0.02	50	60	10–0.1	0.7	—
Capillaries	0.008	0.05	0.001	300	30–20	< 0.1	0.002	—
Venules	0.01–0.14	0.2	0.002	300	20	< 0.3	0.01	—
Veins	0.15–15	18.0	0.6	2500	15–10	0.3–5	150	—
Vena cava	30.0	40.0	1.5	300	10–5	5–30	3000	—

Rapporto tra flusso e pressione

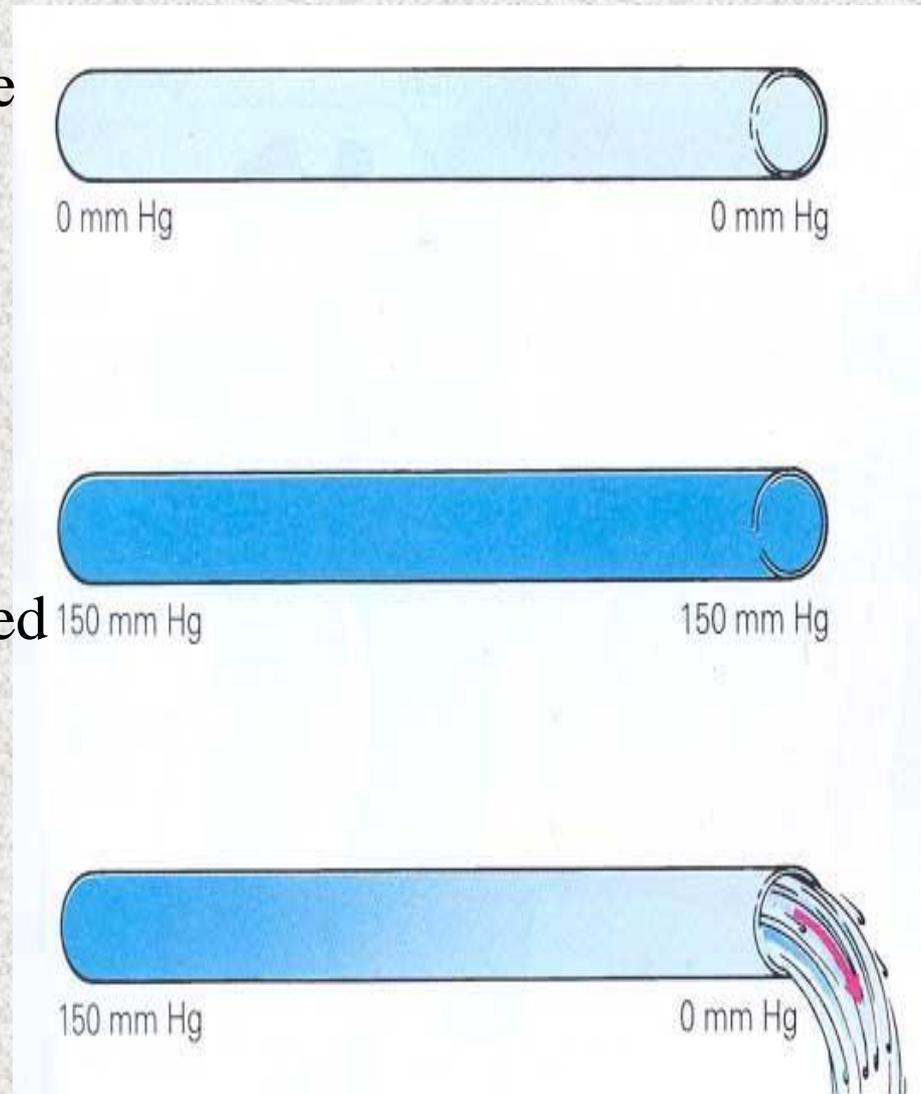
Flusso (Q) e' il volume che pass per secondo

$$\dot{Q} = \frac{\Delta Q}{\Delta t}$$

Il flusso nel sistema CVS e' dovuto alla differenza di pressione tra arterie e vene, ed e' proporzionale alla differenza di pressione.

$$\dot{Q} = \frac{P_a - P_v}{R}$$

R è la resistenza vascolare



Quindi resistenza vascolare è

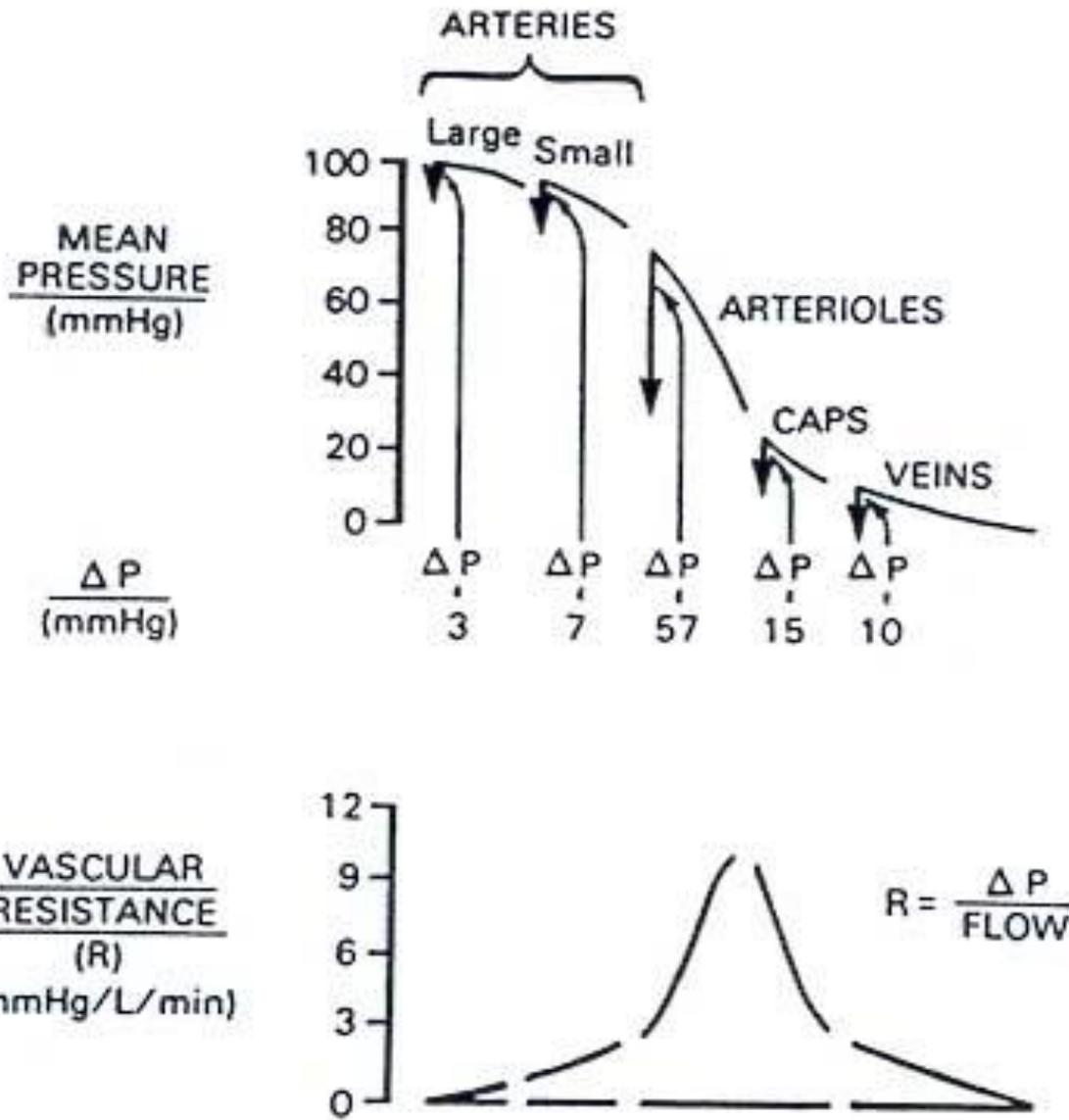
$$R = \frac{dp}{Q} = \frac{8\mu L}{\pi a^4}$$

Un piccolo cambiamento in a cambia molto la resistenza al flusso. Questo è la base di vasodilatazione e vasocostrizione. Quindi l'ipertensione può essere ridotto usando farmaci che rilassano i muscoli, diminuendo la viscosità del sangue o riducendo la quantità di sale (perché?)

È utile misurare la resistenza vascolare, ma non

- Indica il luogo della costrizione o dilatazione
- Indica la causa
- Fornisce informazione è netta non locale
- Non è capace di distinguere tra formazione di nuovi vasi, dilatazione o emorragia

Resistenza lungo il sistema vascolare



La resistenza e' massima nelle arteriole.

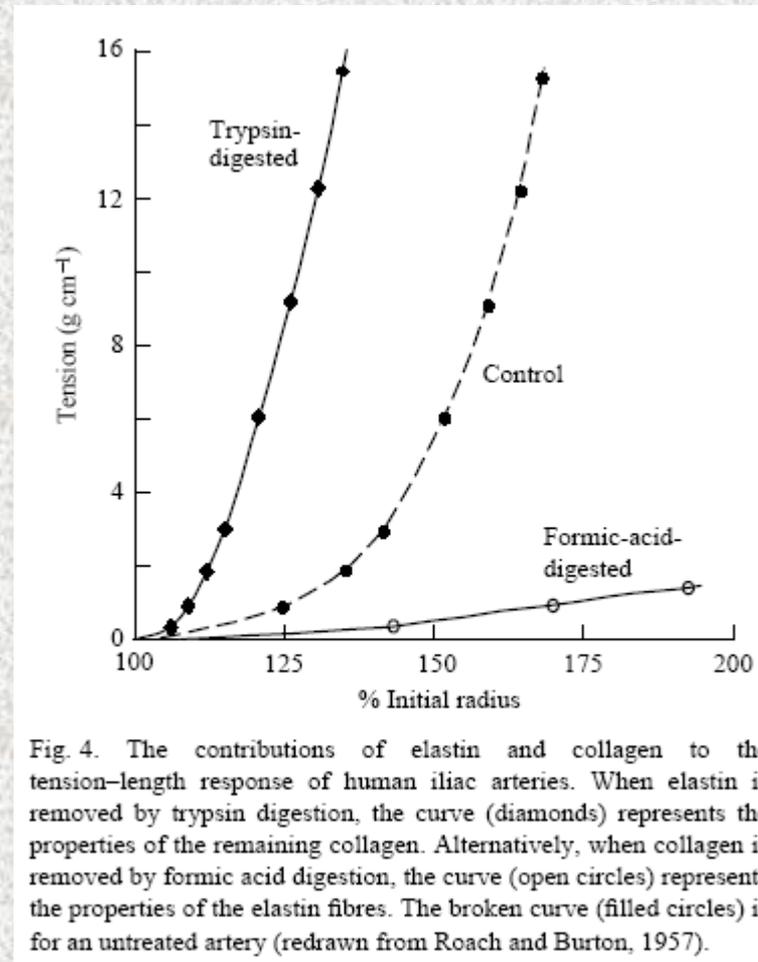
La resistenza totale e' controllata dalle arteriole.

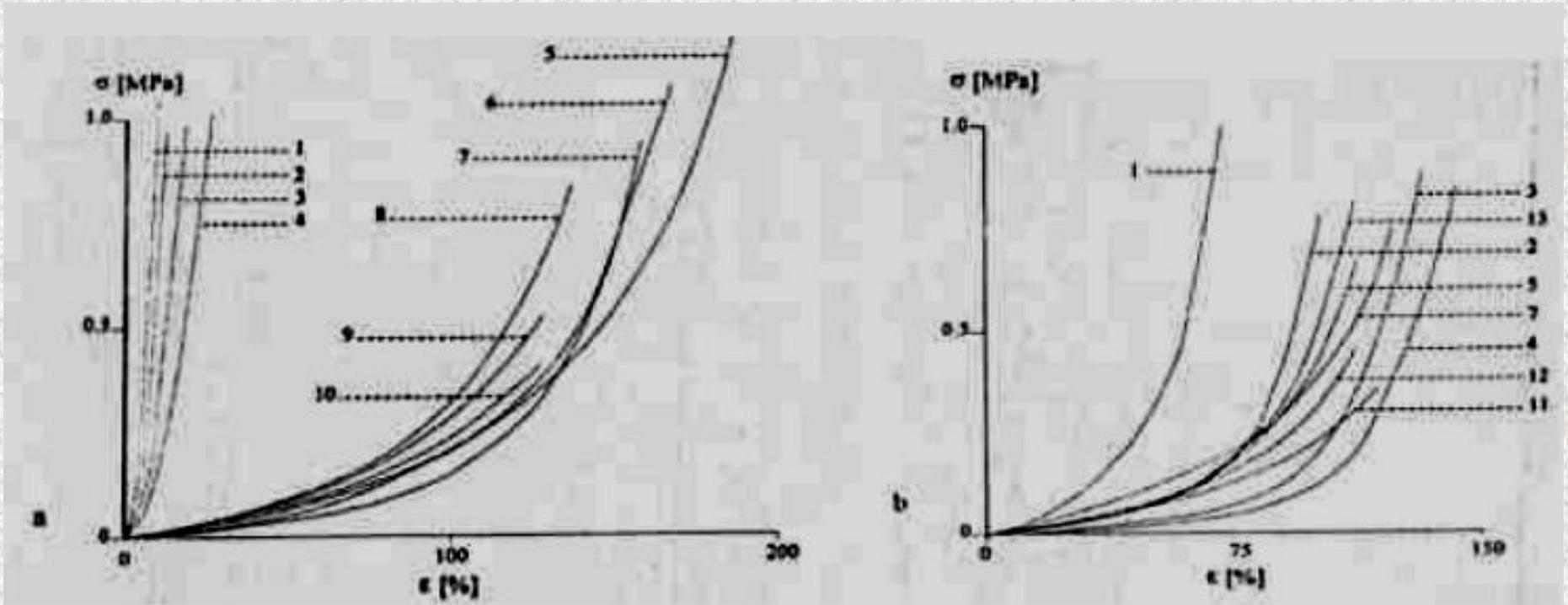
Le arteriole controllano la perfusione attraverso gli organi e la distribuzione dell'uscita cardiaca. Come?

Mechanical Properties of Blood Vessels

Blood vessels are composed of a variety of materials, principally collagen and elastin. The stress strain curve can be modeled quite well using the recruitment model.

The mechanical properties arise from the orientation of the proteins and cells in the various layers, their interaction, not possible to reproduce with synthetic materials





Blood vessels are highly anisotropic: Left: Stress strain in the circumferential direction, Right: longitudinal
 1: prosthesis in PET woven, 2: woven PTFE 3: knitted PET a; 4: PTFE knitted;
 5. iliac artery; 6: aorta
 Distal abdominal artery 7: femoral artery; 8: abdominal artery , others

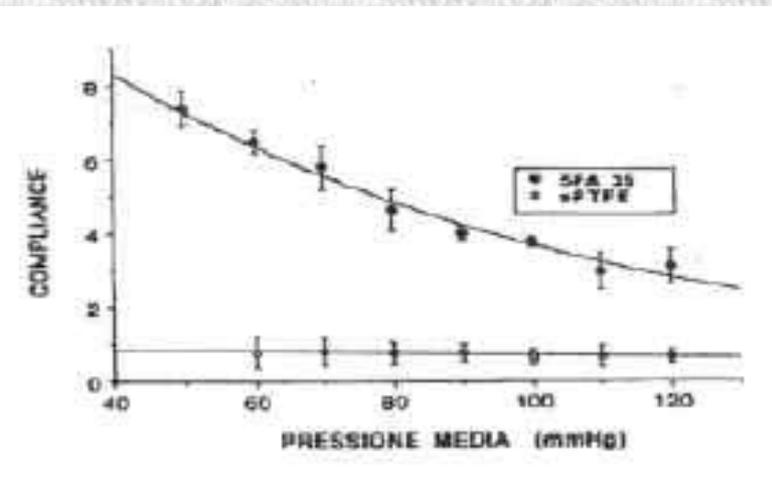
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Characterisation of vascular grafts and vessels

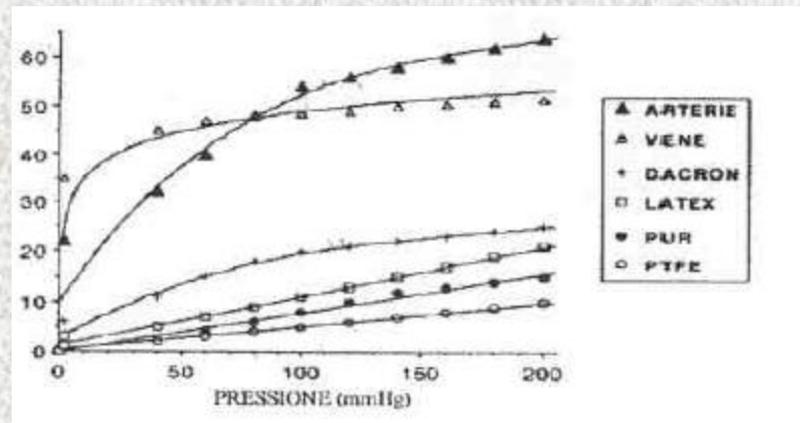
The most important parameters to consider are permeability, porosity, compliance, tensile strength, burst strength and durability.

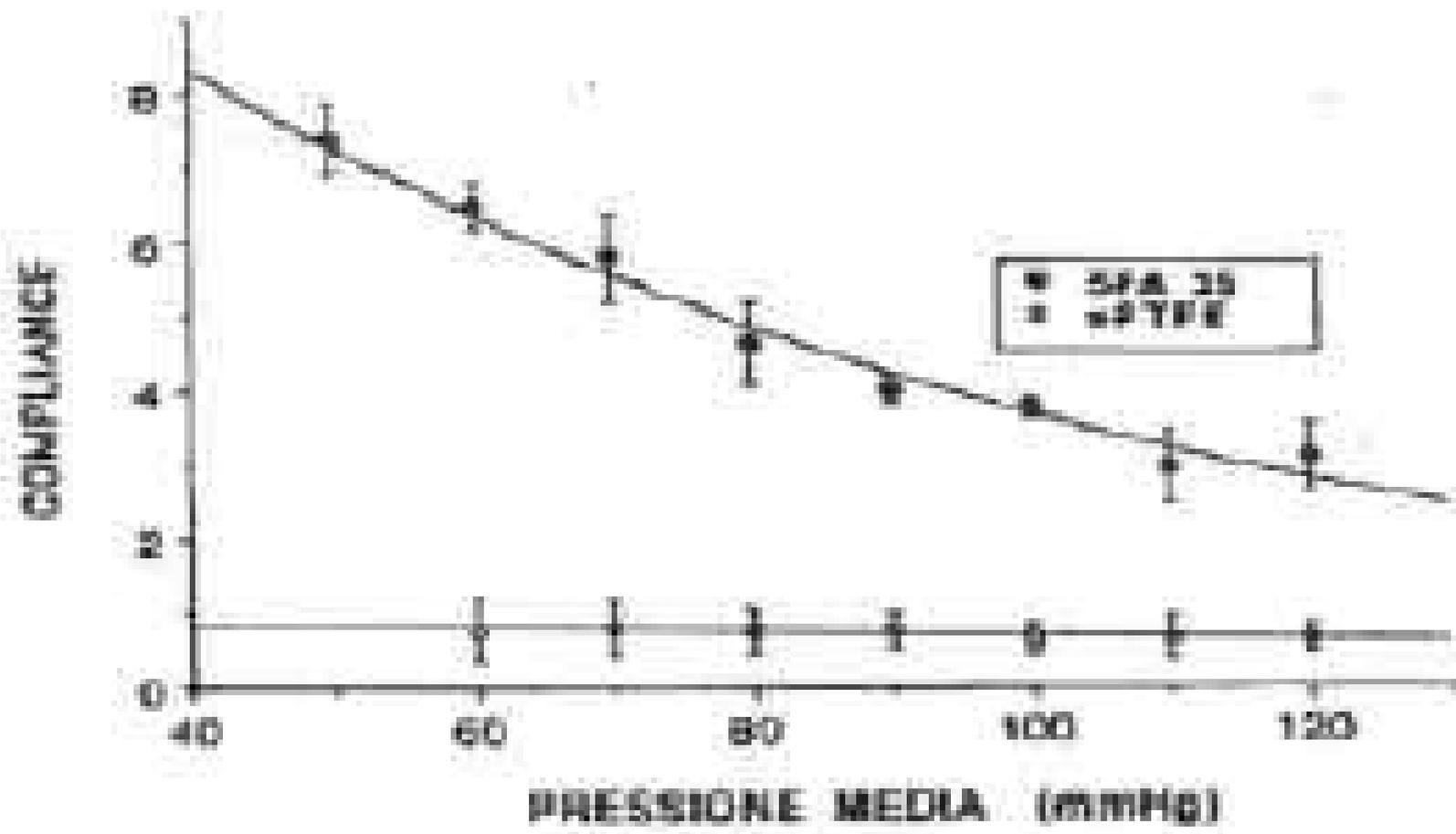
Compliance is a measure of radial distensibility of a vessel, and is the parameter which is most difficult to reproduce in synthetic materials.

Dacron	Permeabilità [ml/min*cm ²]	Precoagulazione
Protesi a rete	50÷200	No
Protesi a maglia	2000 (media)	Si
Protesi con velour	1300 (uniforme)	Si



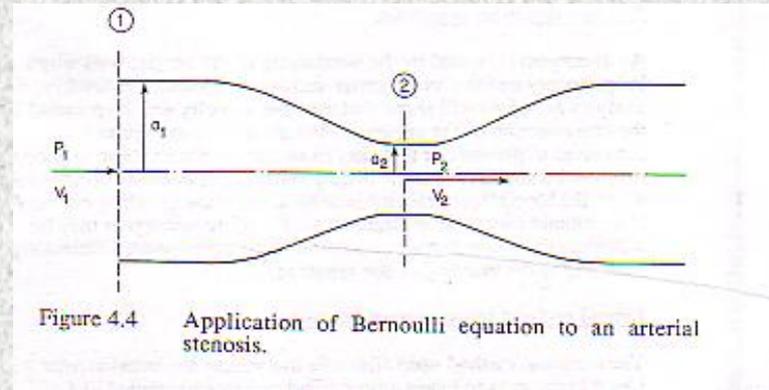
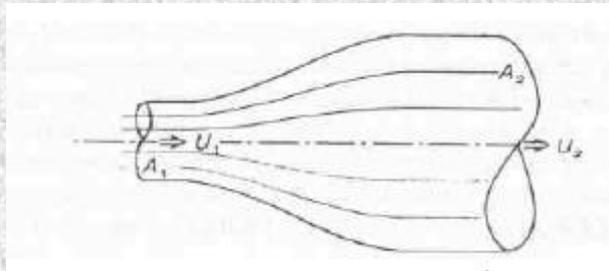
$$\frac{\Delta d}{d} \%$$



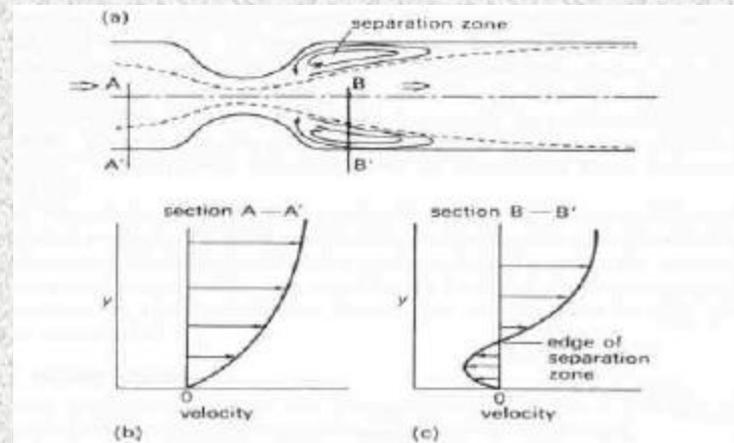
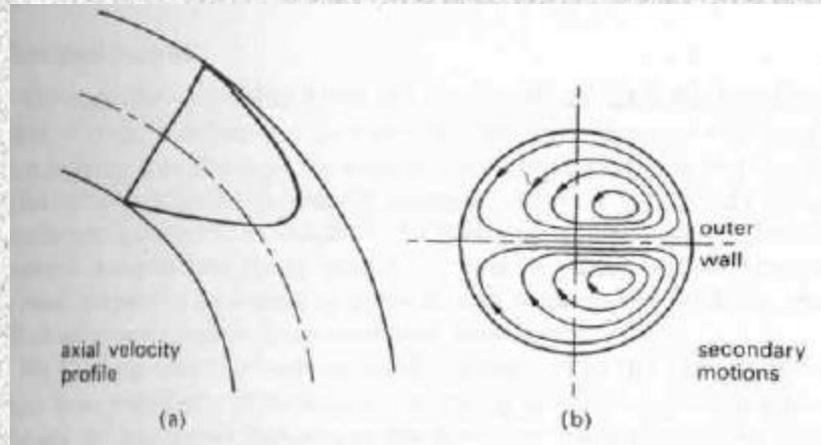


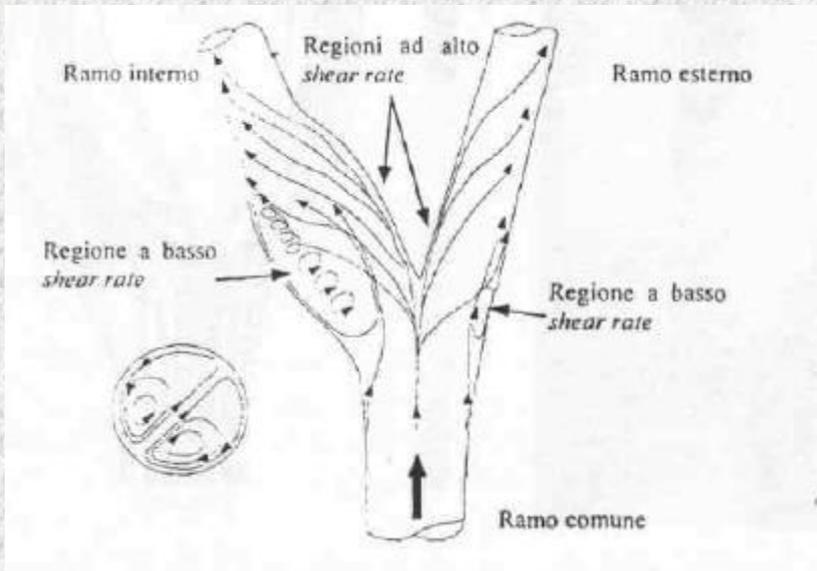
stop

Other aspects to discuss: application of Bernoulli to stenosis and aneurism



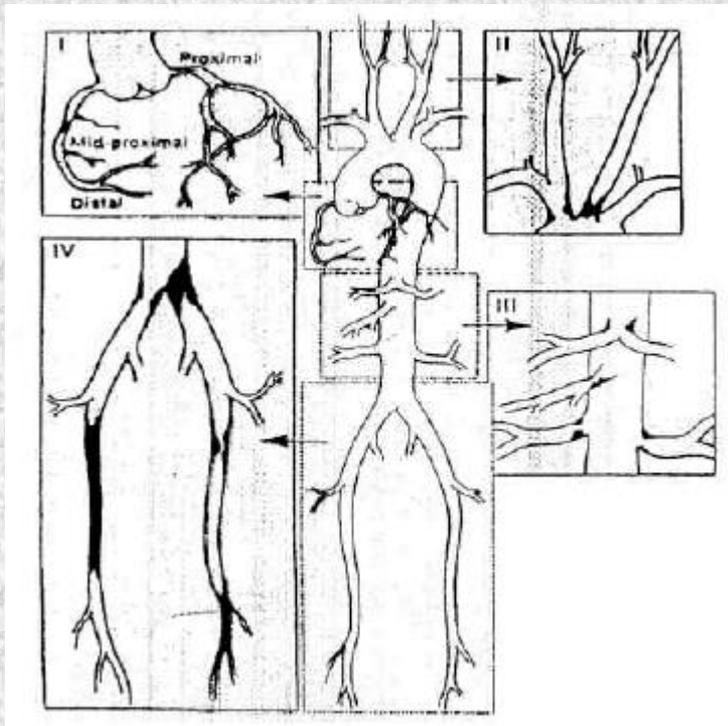
Flow with radius of curvature and flow separation



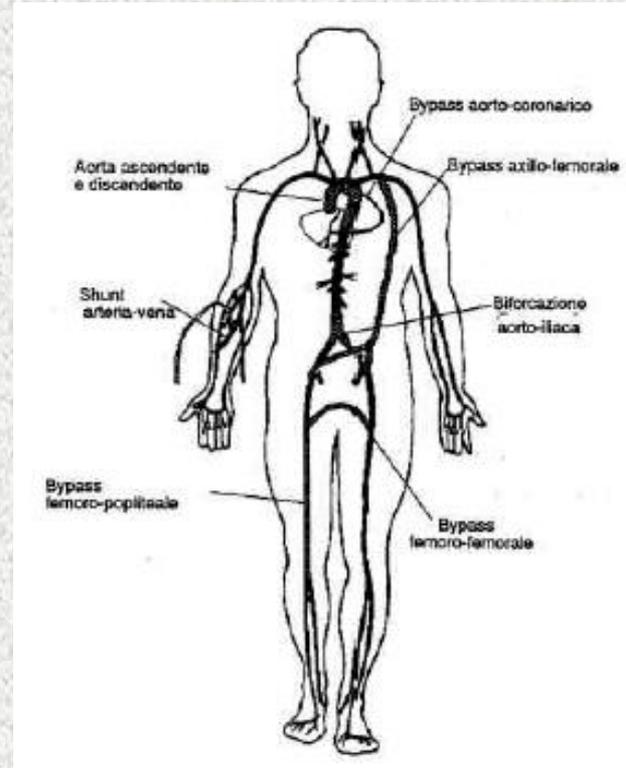


Derivation of entrance length: $x=0.03 Re^*$ radius of vessel,
calculate this for aorta and discuss

Vascular Prostheses: trauma, pathology

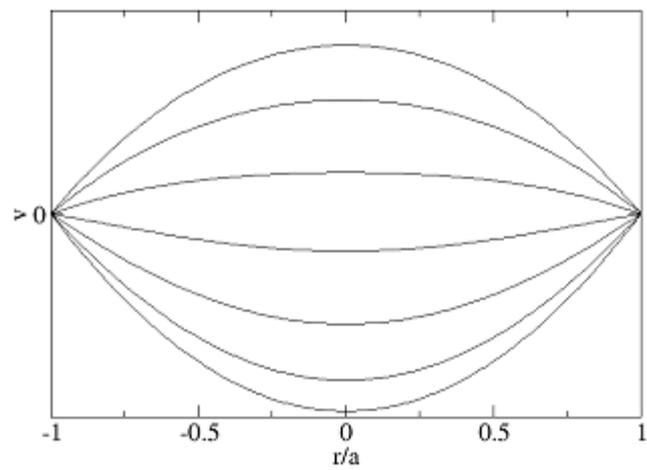


Zones most likely to suffer from plaques

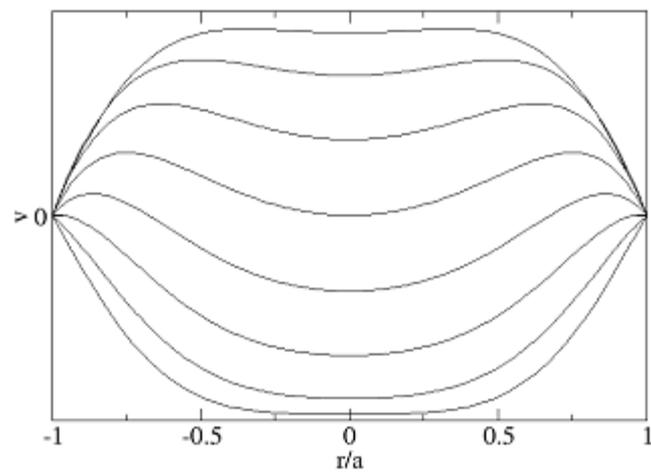


Principal sites for vascular prosthesis

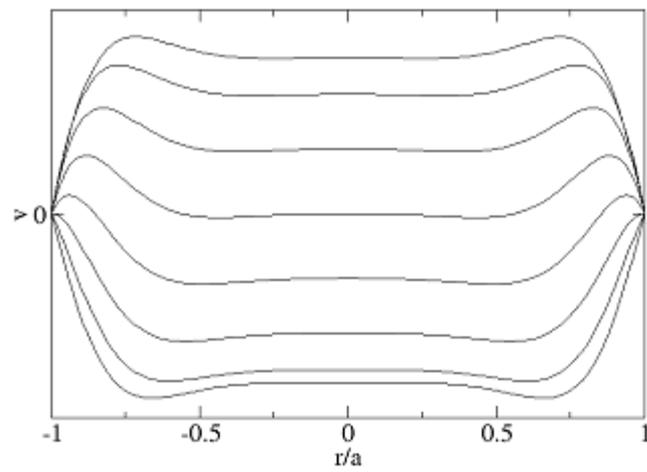
$\alpha = 1.0$



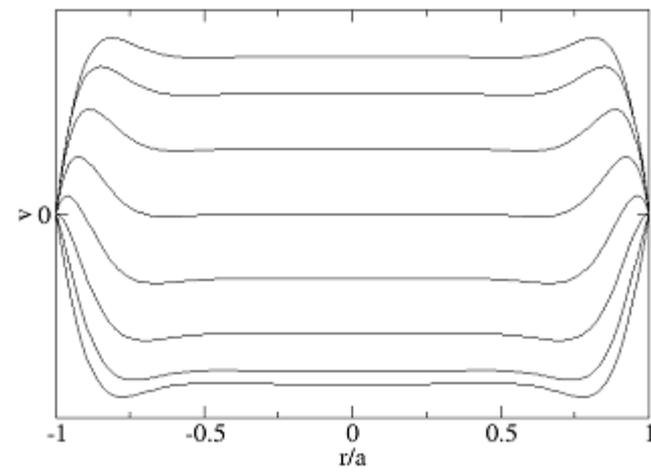
$\alpha = 5.0$



$\alpha = 10.0$



$\alpha = 15.0$



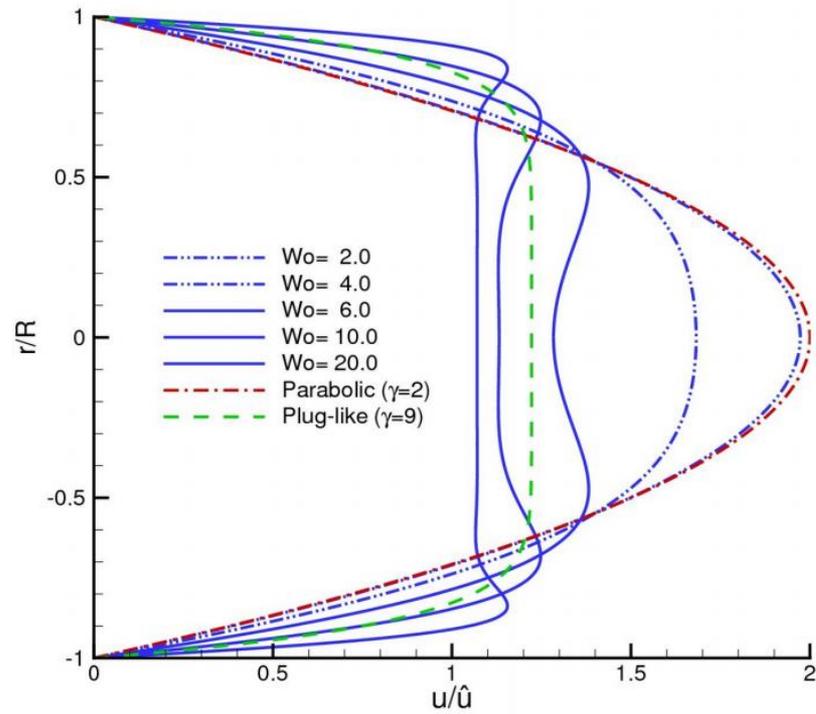


Fig. 1. Steady Hagen-Poiseuille parabolic ($\gamma = 2$) and plug-like ($\gamma = 9$) velocity profiles and five representative snapshots of the peak velocity profiles of the transient Womersley flow.

Supponendo che abbiano lo stesso modulo elastico, stimare lo sforzo sulla parete dei seguenti vasi. Spiegare il significato del segno ottenuto.

Dato che la pressione di scoppio dell'aorta e' 1000 mmHg, stimare lo sforzo di rottura del vaso.

Vaso	Diametro interno	Diametro esterno	Pressione
Aorta		3.2 cm	120 mmHg
Arteriola	1 mm	1.1mm	39 mmHg
Vena	1 cm	1.1 cm	3 mmHg