Blood Supply

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Blood

- The brain is ~2% of the total body mass, yet it uses ~20% of the total blood of the body.
- The whole body has ~5L of blood; the brain has ~1L of that blood.
- ~750-1000ml of blood flow through the brain per minute.
- The brain is metabolically very active.

Blood

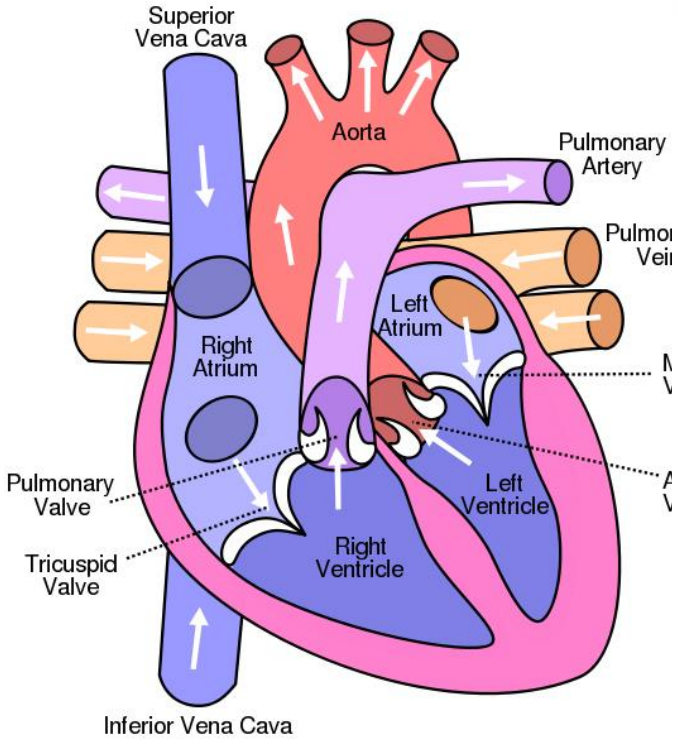
Blood includes:

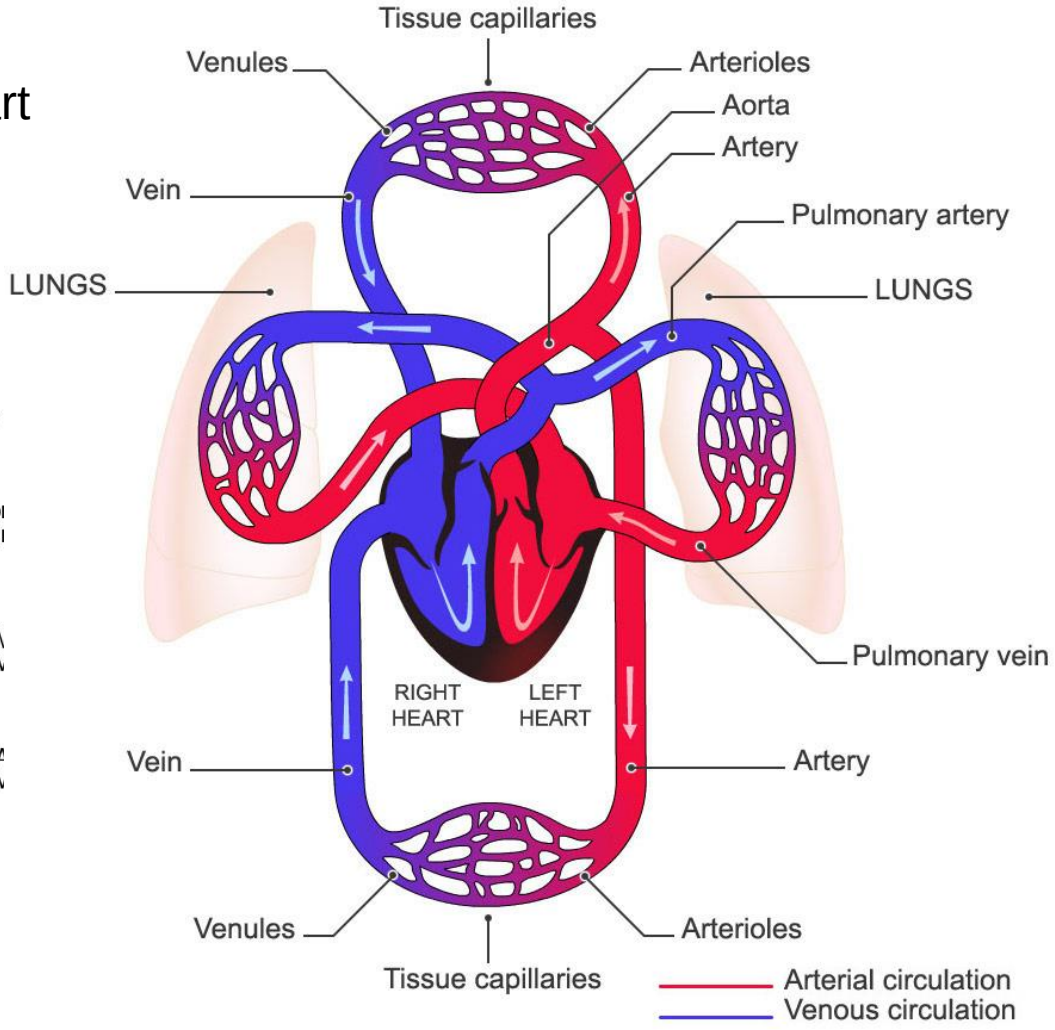
- Cells
  - White blood cells (immune functions)
  - Red blood cells (carry oxygen)
- Clotting factors (platelets & fibrinogens)
- Serum (liquid)
  - Water
  - Ions and minerals
  - CO_2
  - Nutrients (glucose)
  - Antibodies
  - Hormones
  - etc…

Circulatory System

Circulation:

- Blood high in CO_2 and low in O_2 returns from the body to the heart via the vena cavas into the right atrium.

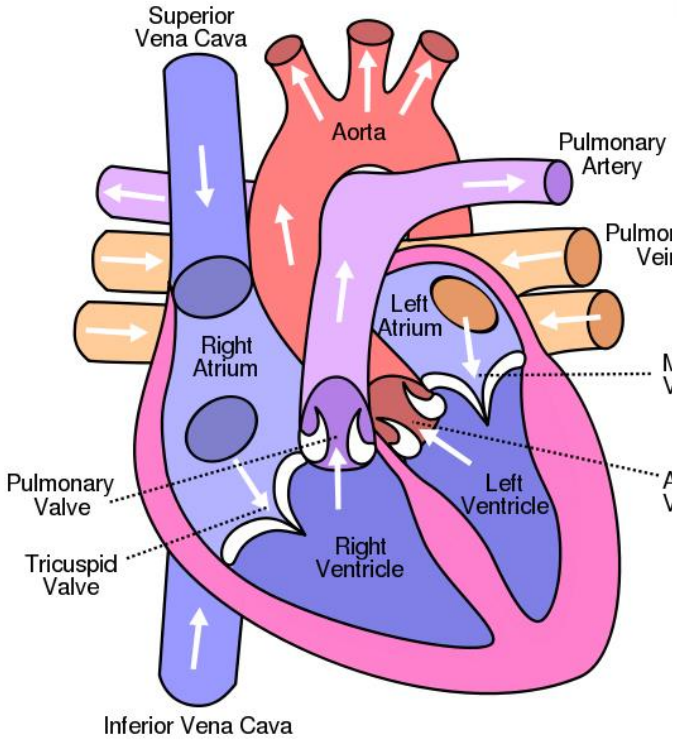


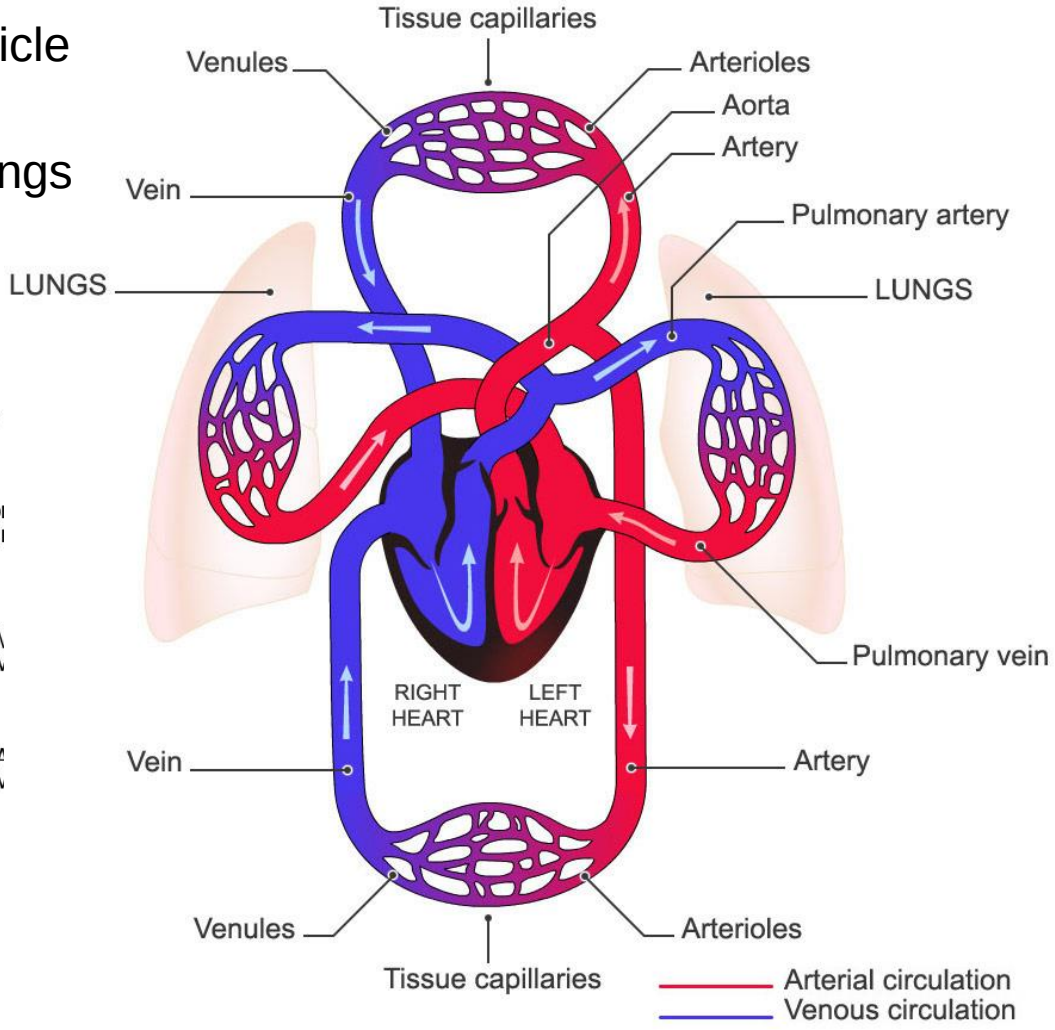


Circulatory System

Circulation:

- Blood next enters the right ventricle of the heart.
- It is pumped from there to the lungs via the pulmonary arteries.

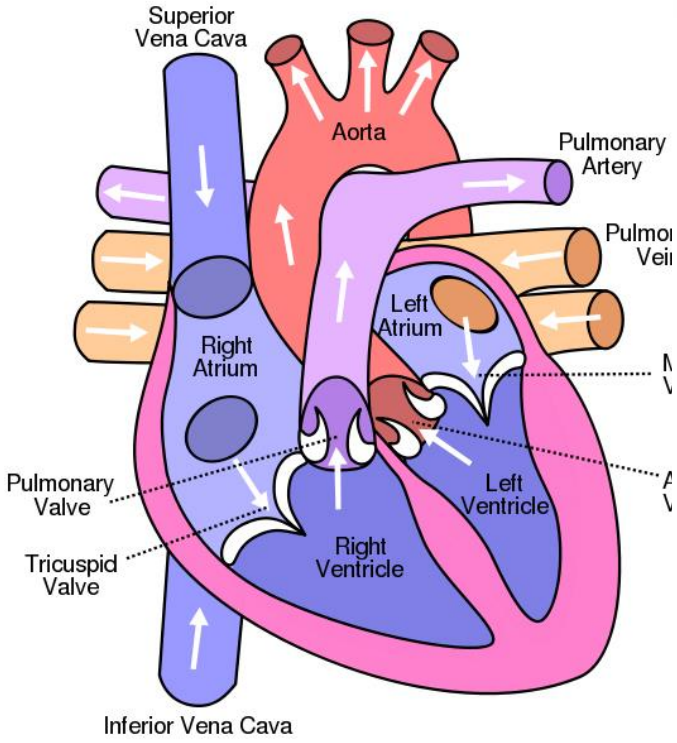


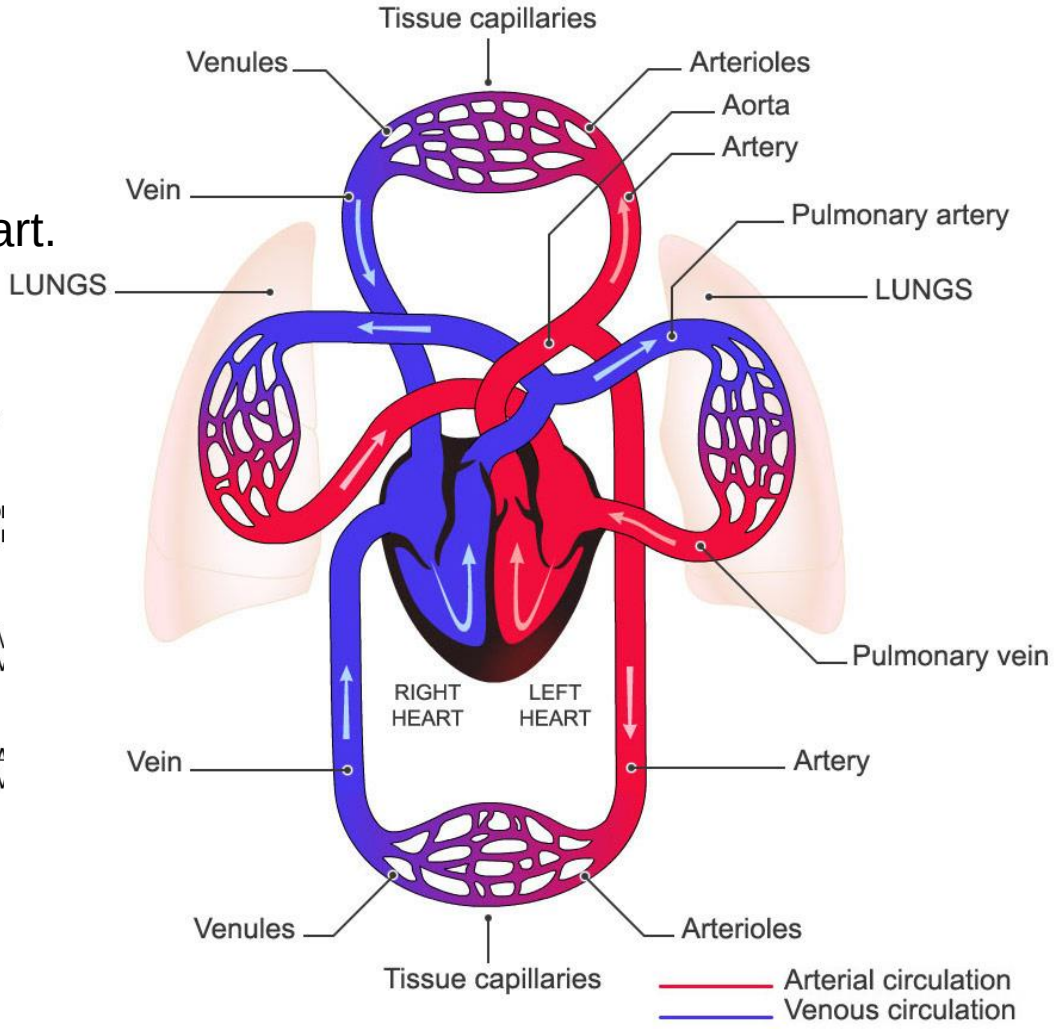


Circulatory System

Circulation:

- In the lungs, CO_2 in the blood is exchanged for O_2.
- Blood returns via the pulmonary veins to the left atrium of the heart.

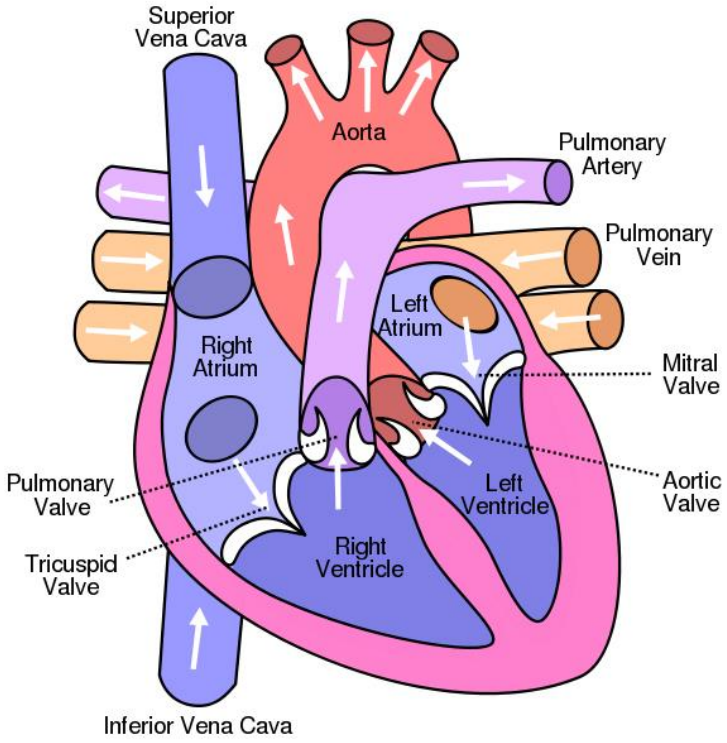


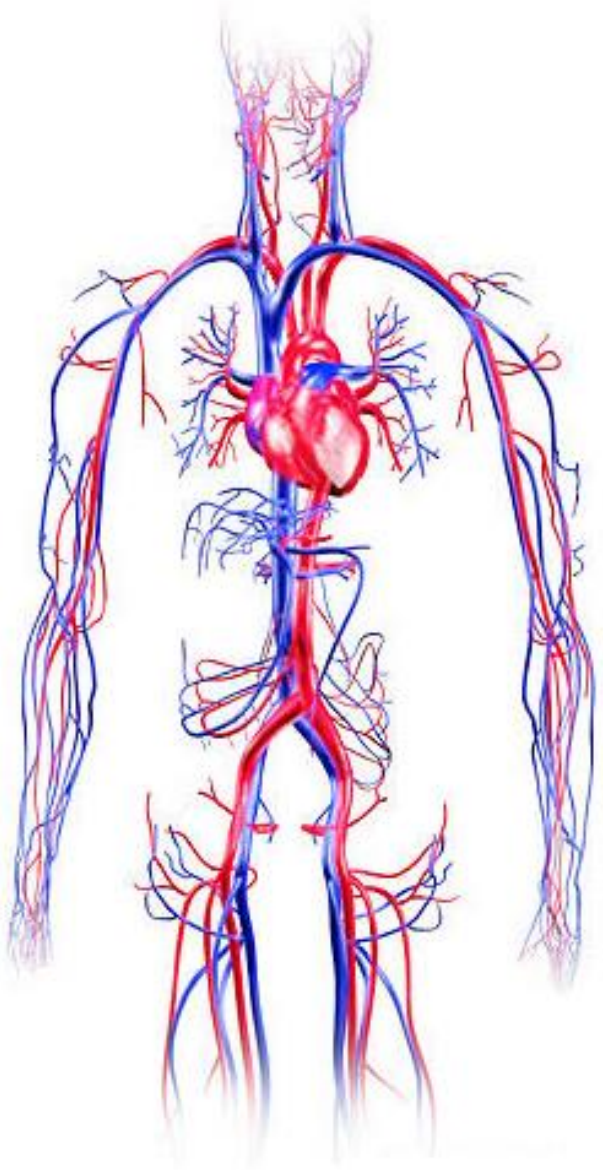


Circulatory System

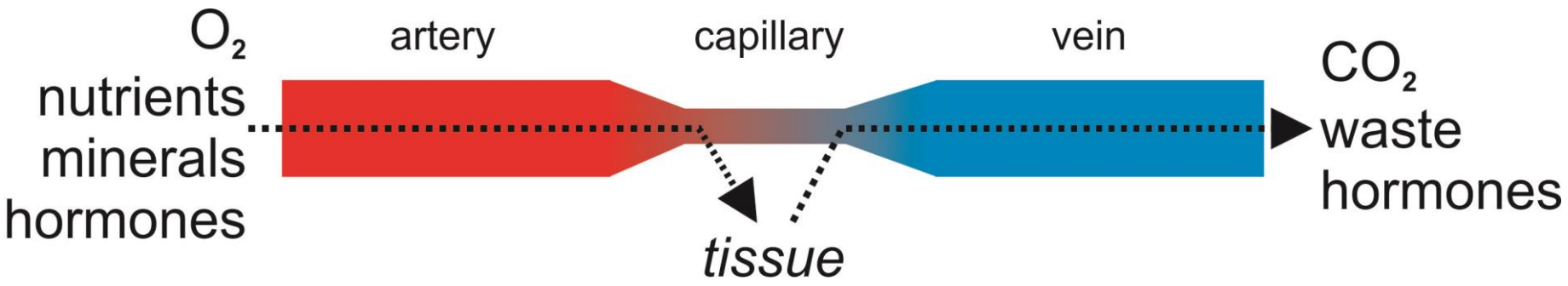
Circulation:

- Blood next enters the left ventricle of the heart.
- From there, blood high in O_2 is pumped out to the body via the aorta.





Circulatory System

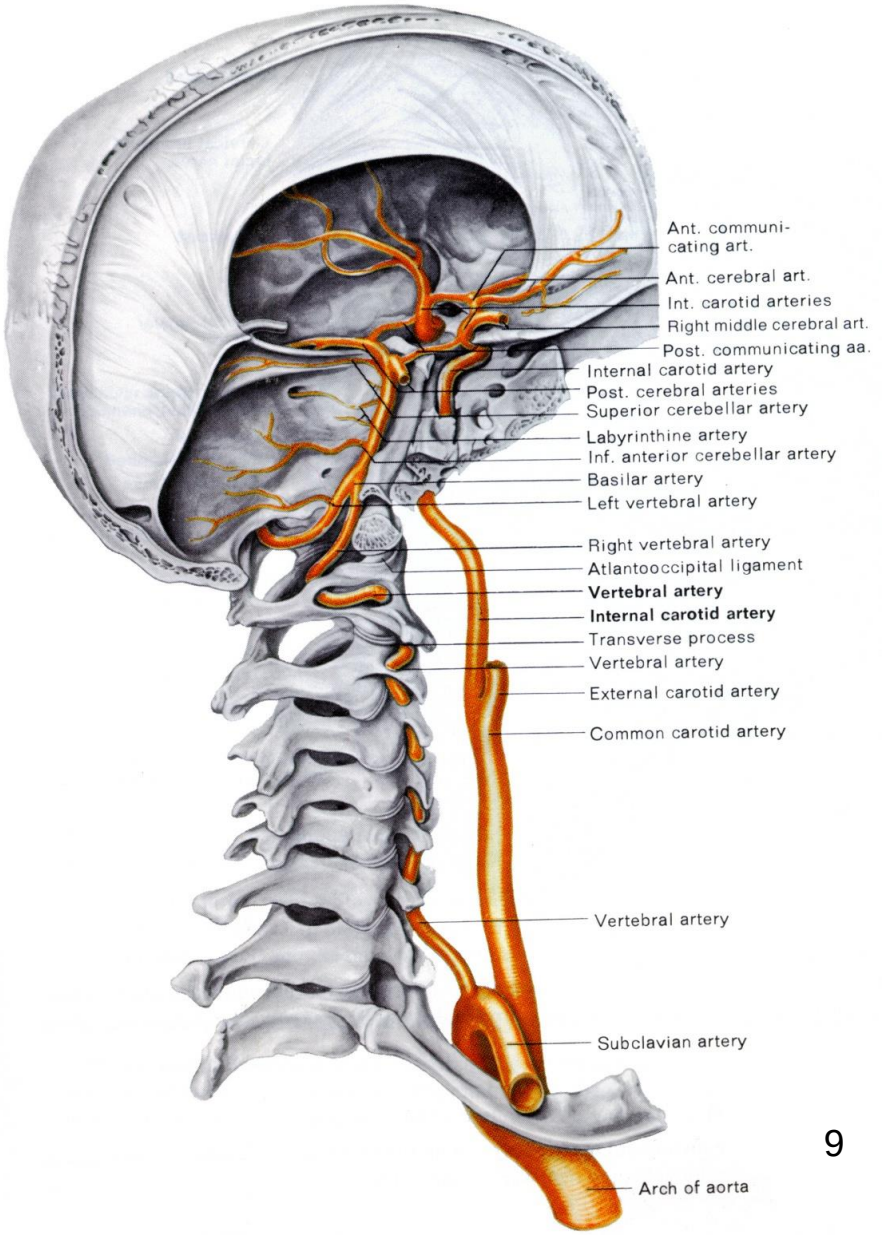


Blood Supply for the Brain - Arteries

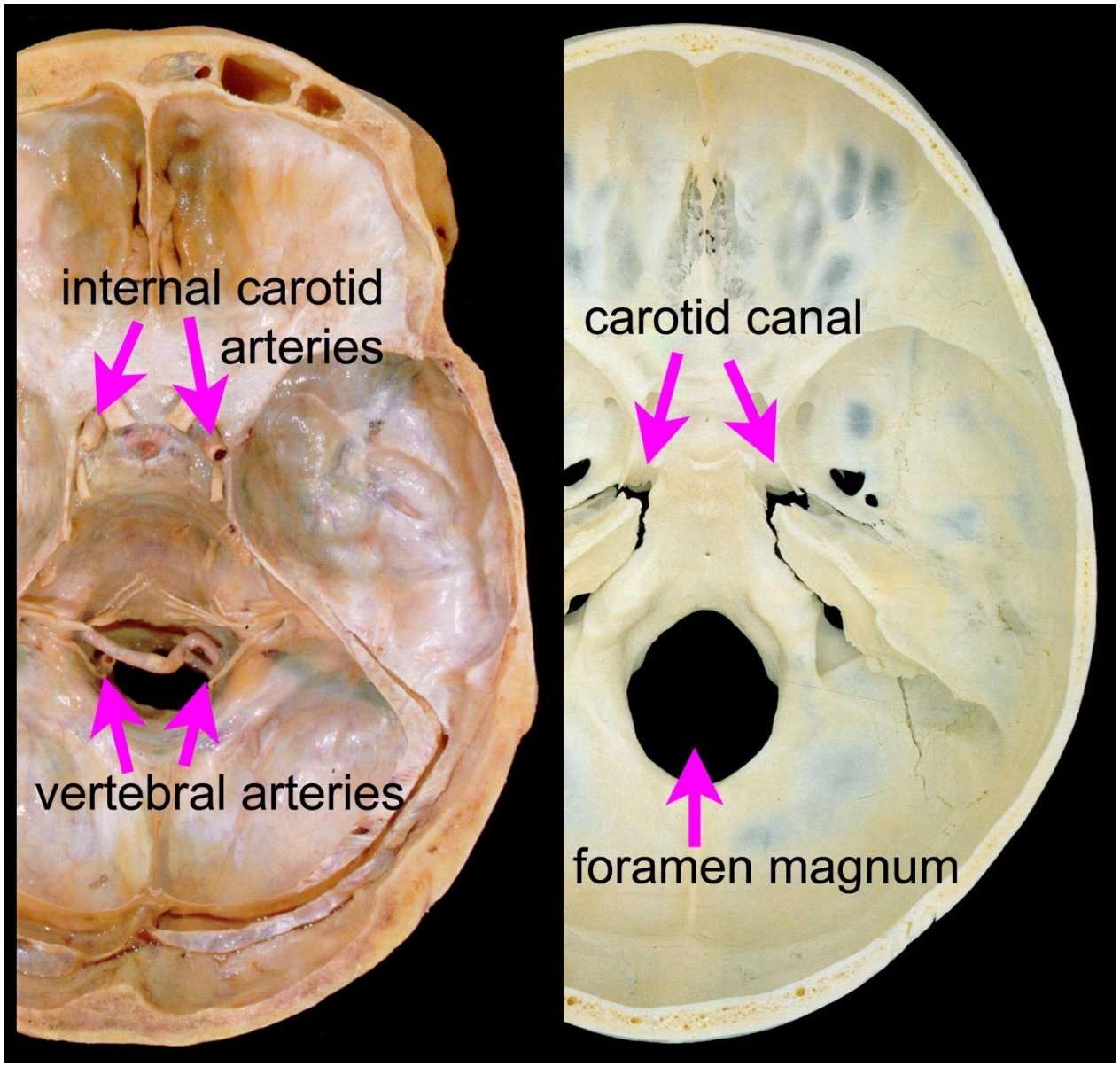
Two major pairs of arteries supply the brain:

- Internal cartoid artery (x2), which enters the cranium from the front of the neck.

- Vertebral artery (x2), which enters the cranium via the foramen magnum.



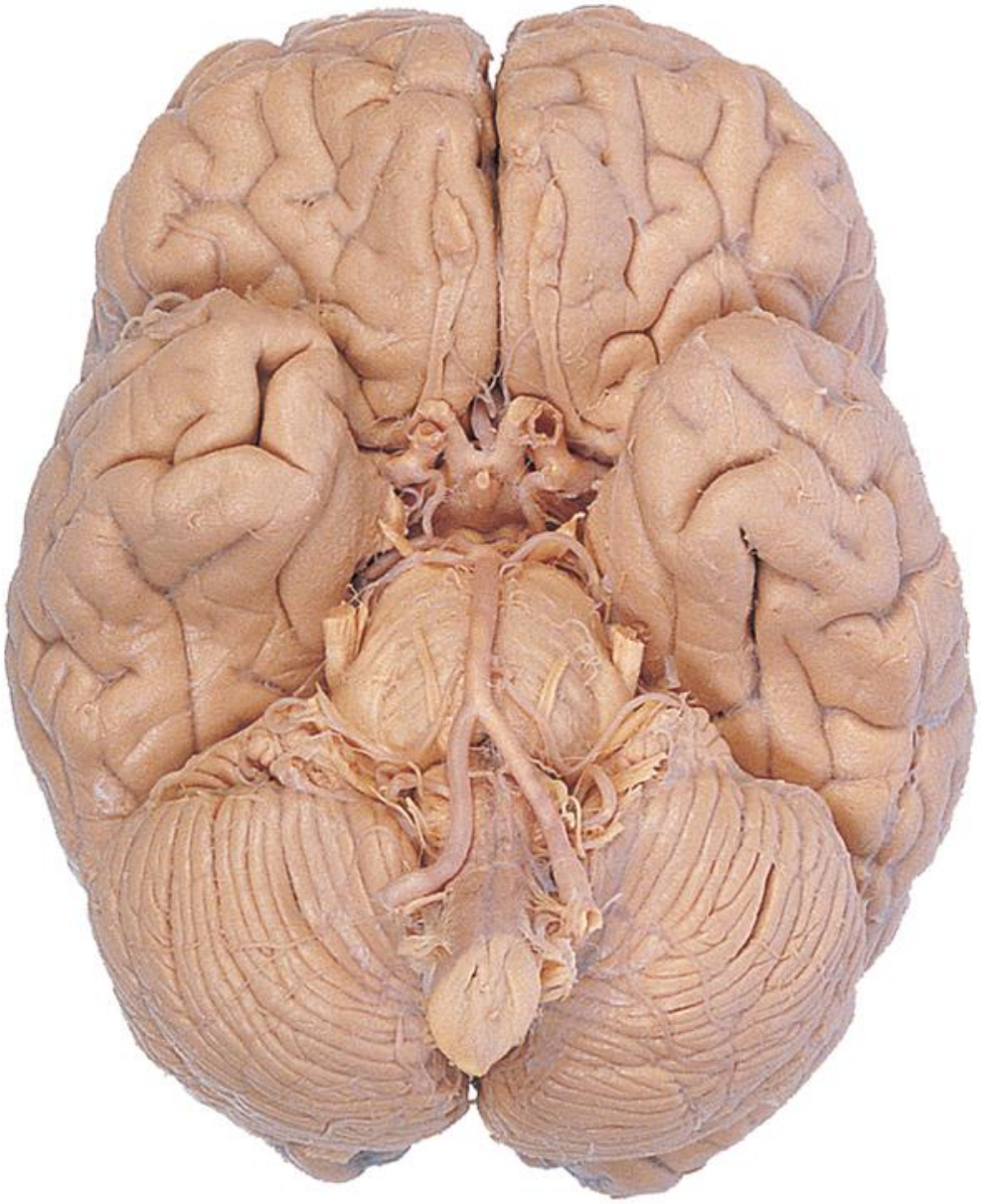
Blood Supply for the Brain - Arteries



Blood Supply for the Brain - Arteries

- In the cranium, the two vertebral arteries join to form the basilar artery.

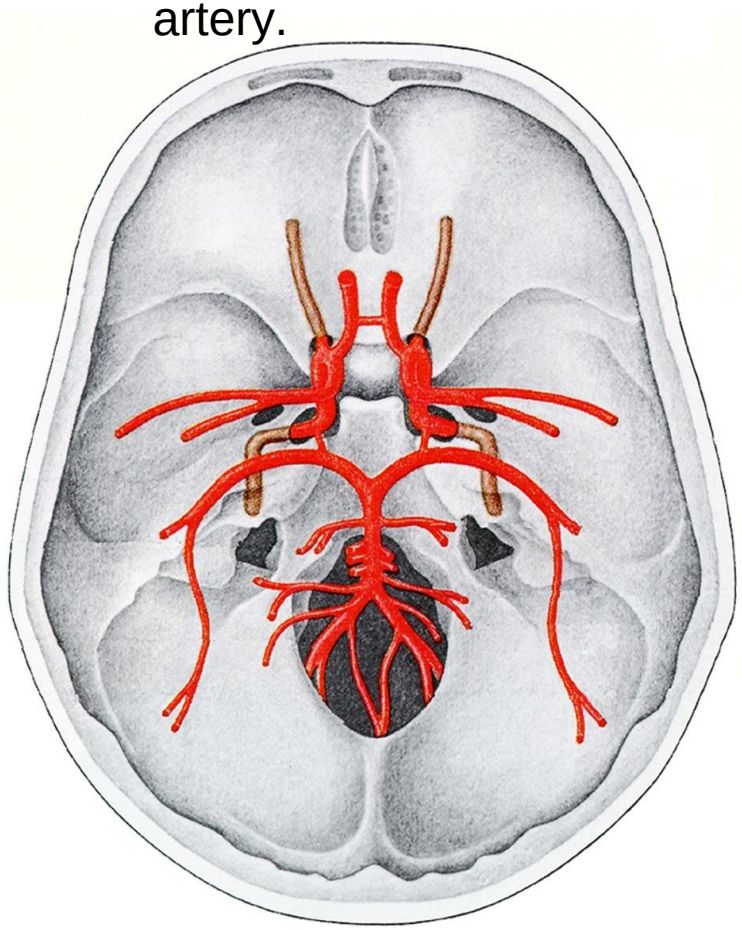
- Branches from the two internal carotid arteries and the basilar artery join to form the circle of Willis.

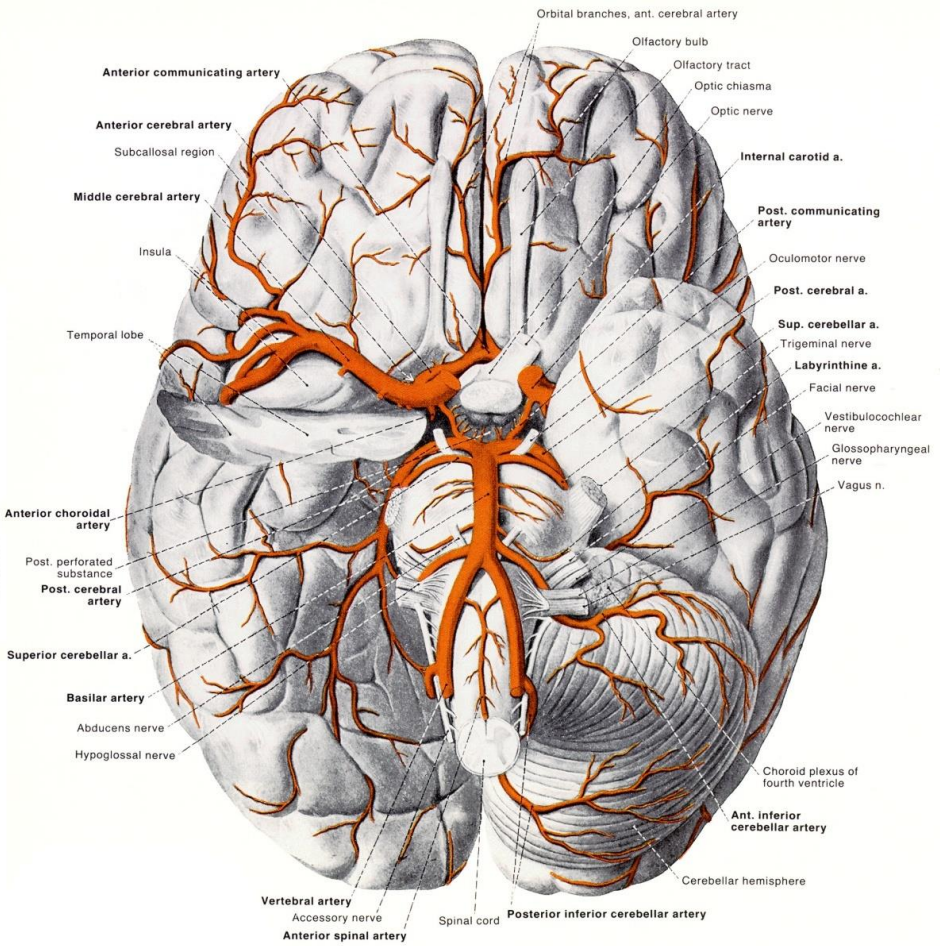


Blood Supply for the Brain - Arteries

Circle of Willis:

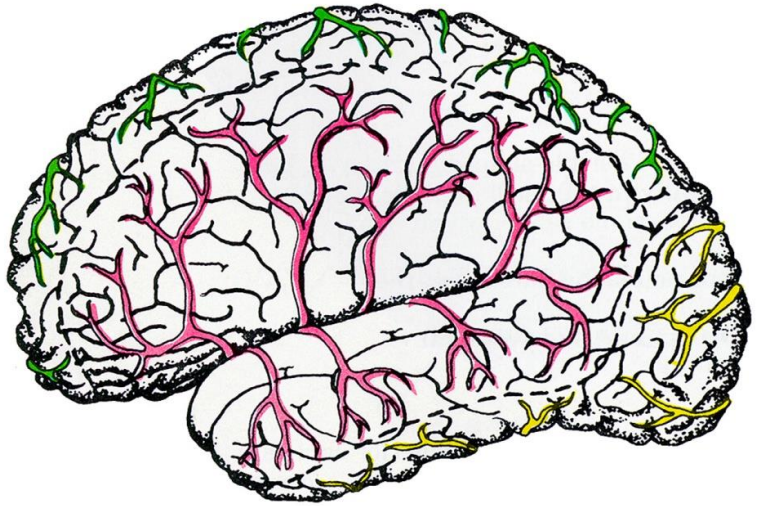
- Anterior and middle cerebral arteries are the largest branches of the internal carotid arteries.
- Posterior cerebral arteries are the largest branches of the basilar artery.

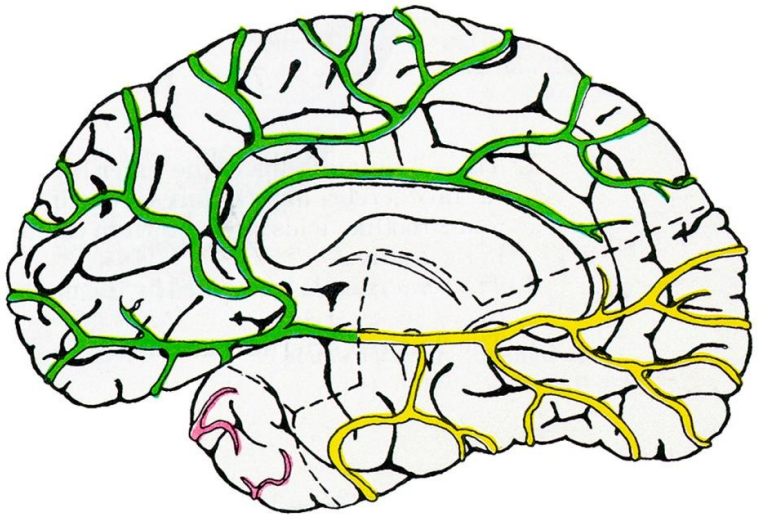


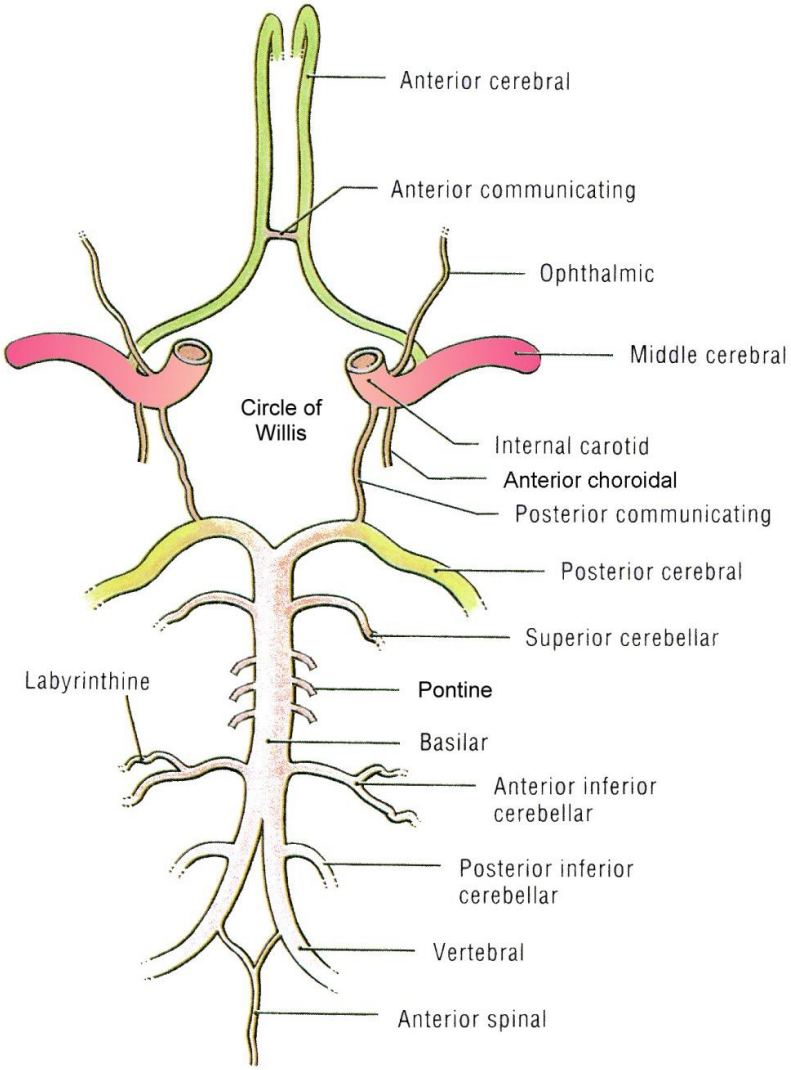


Blood Supply for the Brain - Arteries

- Branches of the internal carotid arteries supply more anterior brain regions.
- Branches of the vertebral arteries supply more posterior brain regions.





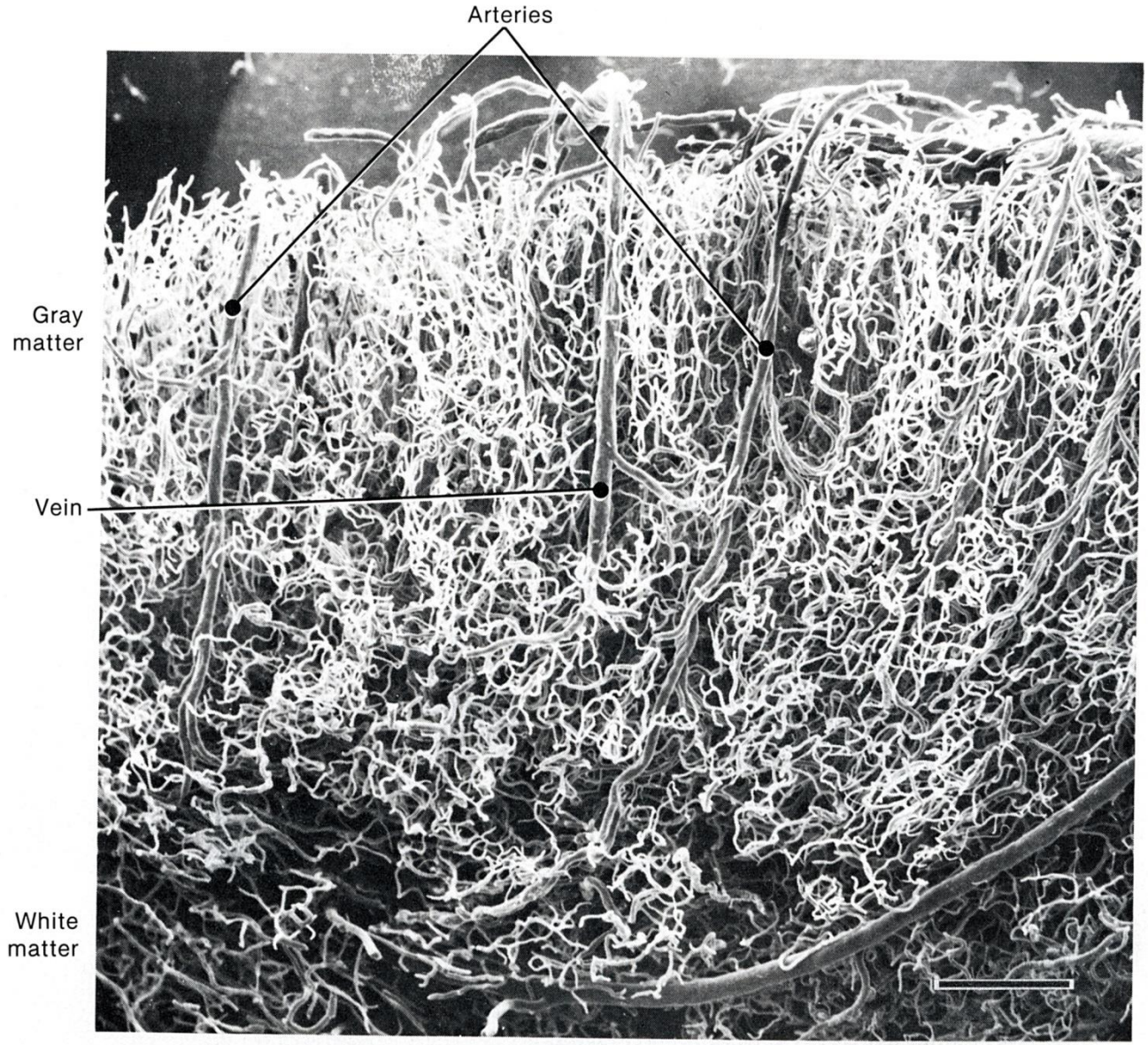


Blood Supply for the Brain – Arteries & Veins

- The major arteries and veins of the brain run in the subarchnoid space.

- Smaller branches penetrate into the brain and are invested by pia for a short distance.

Blood Supply for the Brain – Arteries & Veins



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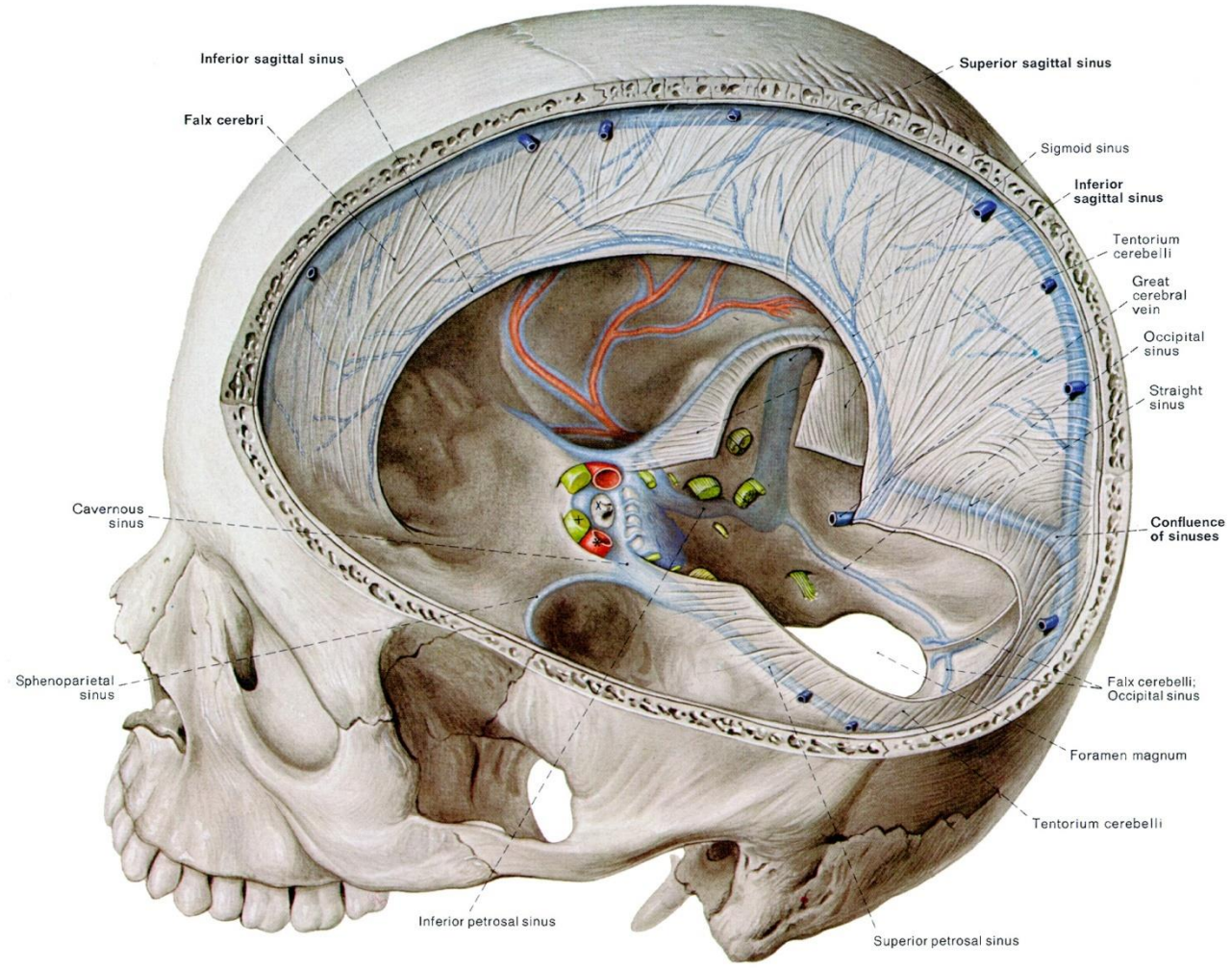
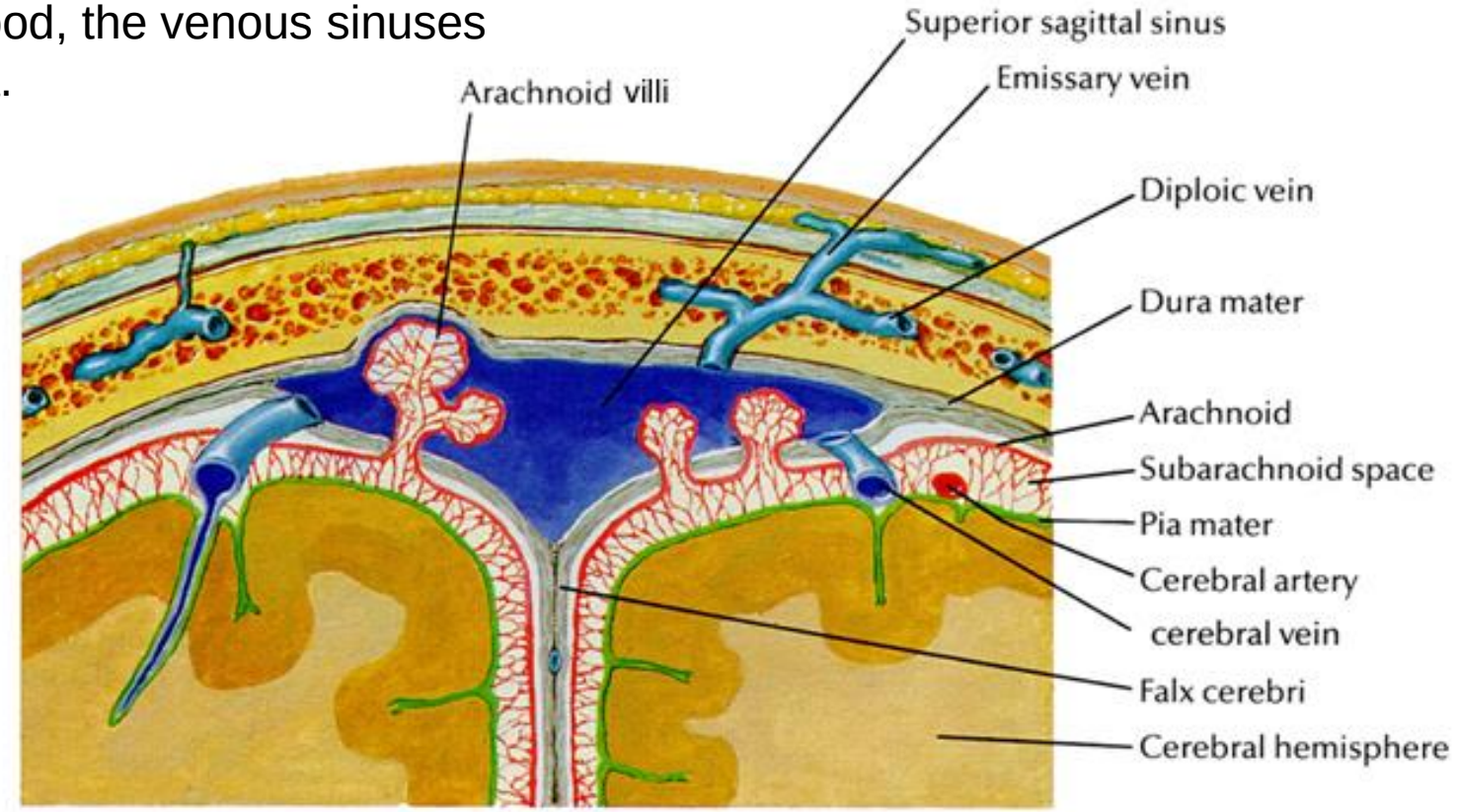
Blood Supply for the Brain - Veins

- The veins from the brain drain mainly into the dural venous sinuses.



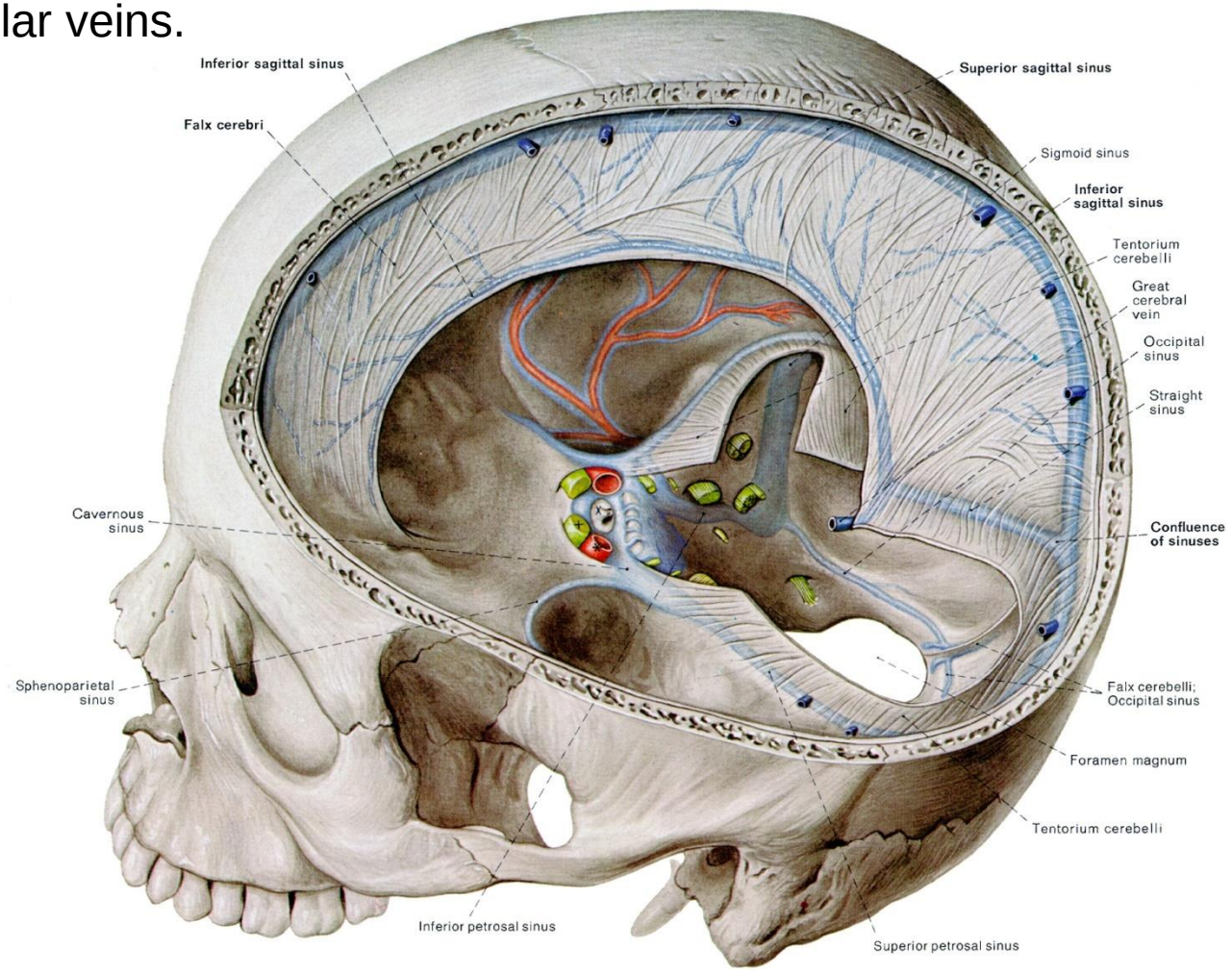
Blood Supply for the Brain - Veins

- In some regions, the dura is split forming a chamber filled with venous blood, the venous sinuses of the dura.

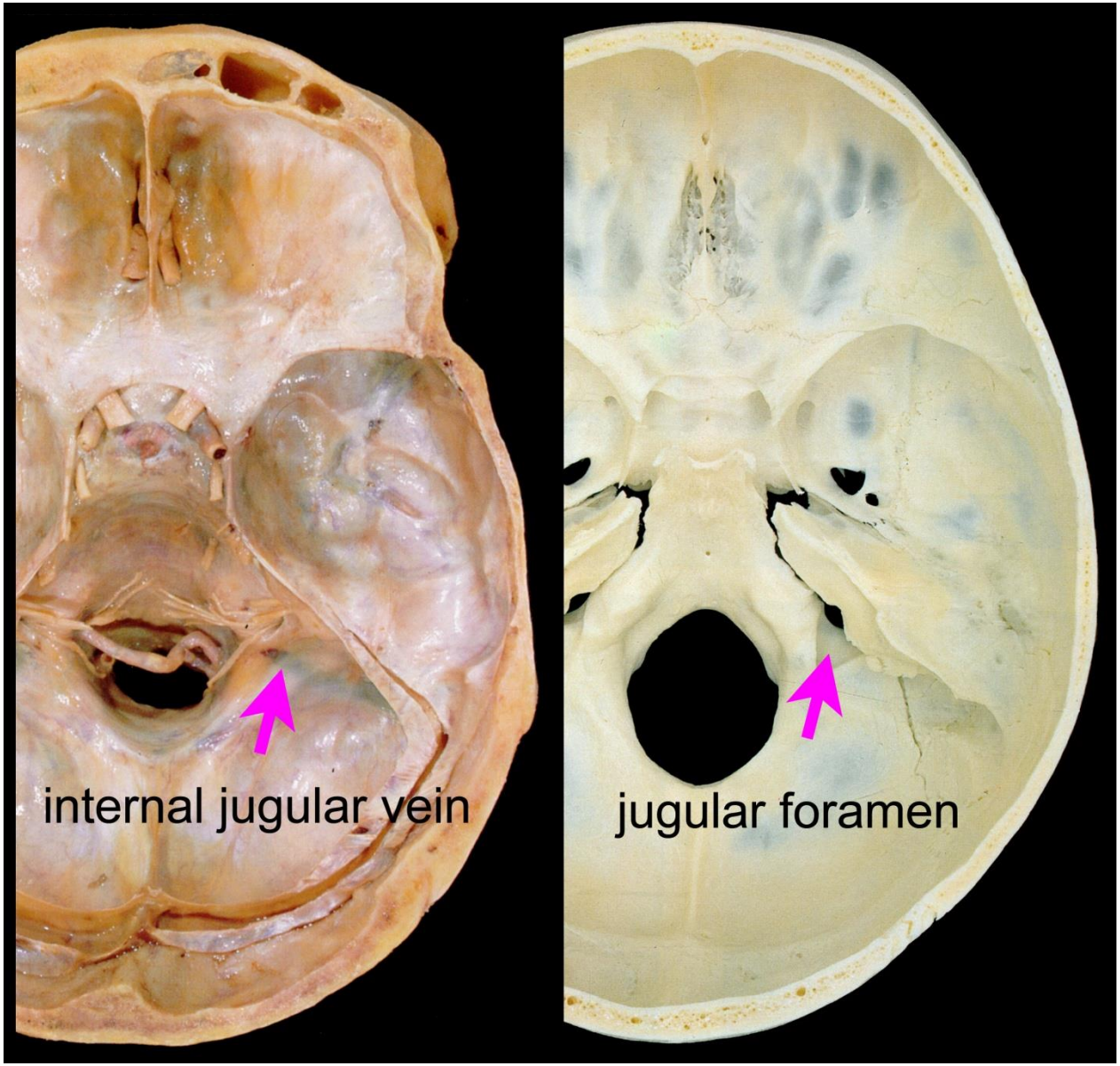


Blood Supply for the Brain - Veins

- The dural venous sinuses collect on the floor of the cranium and form the internal jugular veins.

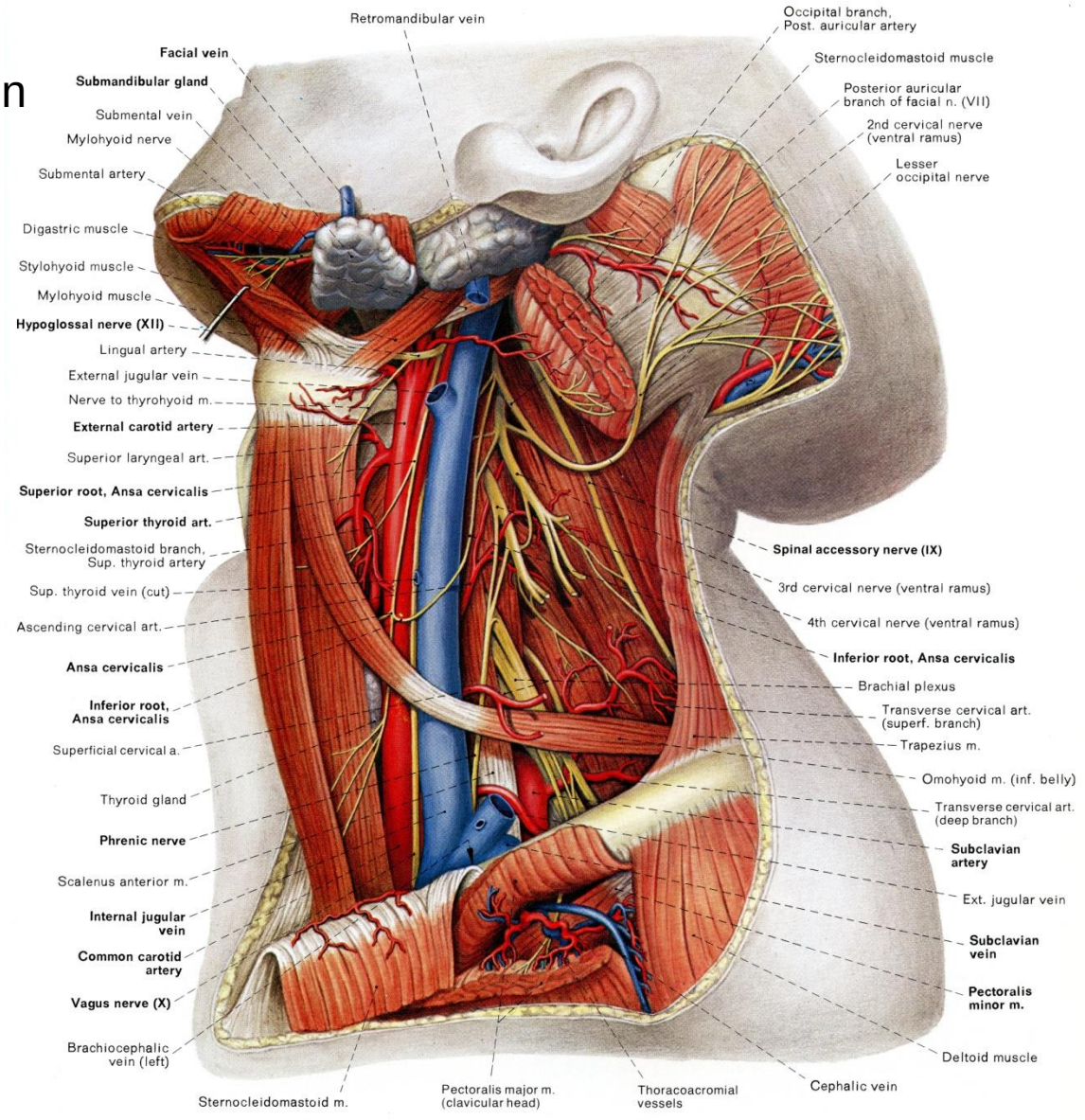


Blood Supply for the Brain - Veins

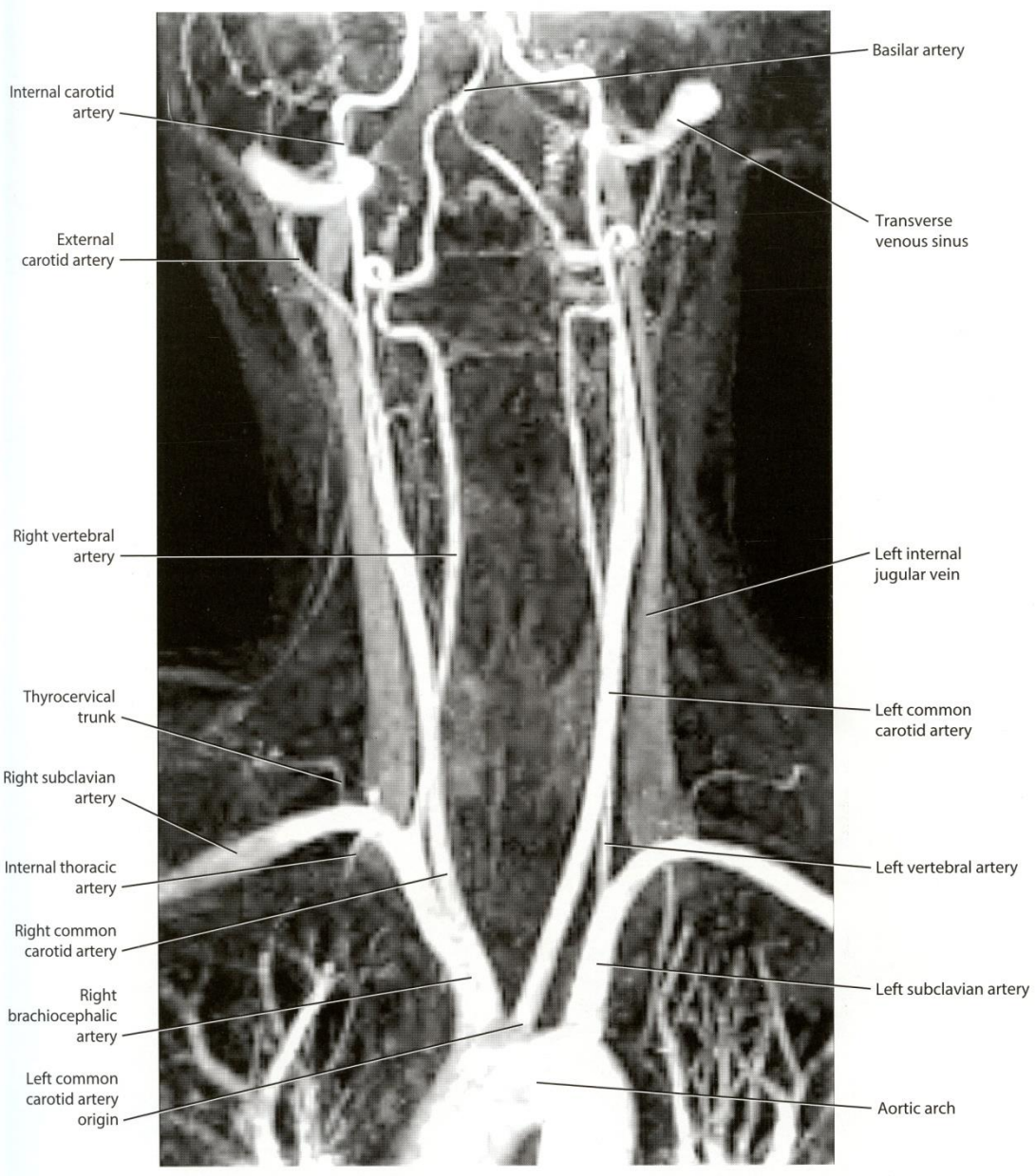


Blood Supply for the Brain - Veins

- The internal jugular veins run in the anterior neck.



Blood Supply for the Brain – Arteries & Veins



[MRI with contrast medium in the major vasculature to the head]

Regulation of Blood Flow

- Blood flow to the various regions of the brain is constantly adjusted based on local neuronal activity.

- Astrocytes and neurons release factors that locally increase blood flow.

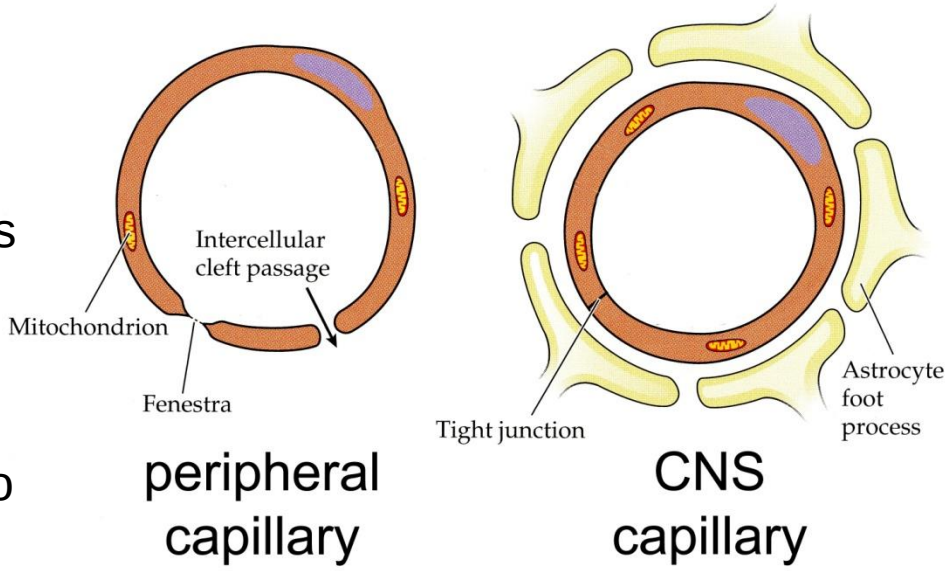
Regulation of Blood Flow

- Video of vasodilatation in the retina following local activation by light:

By Dr. Eric Newman

Blood-brain Barrier

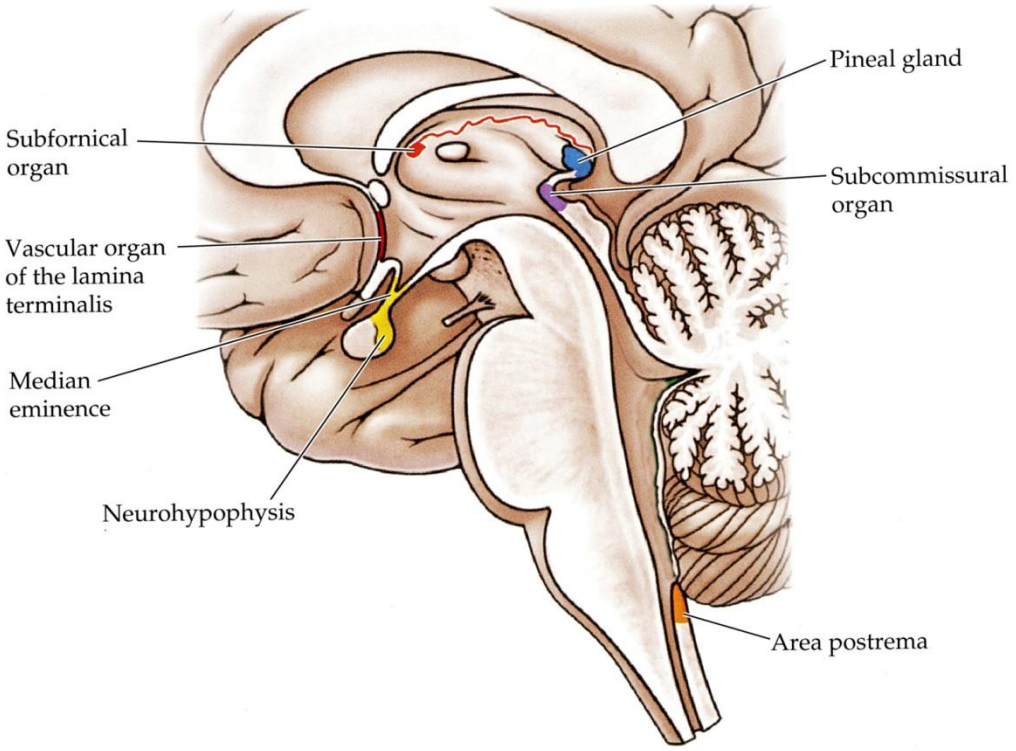
- Capillaries in the brain are not as permeable as they are in other parts of the body. This blood-brain barrier serves to regulate what gets into and out of the brain.
- Endothelial cells that line the capillary wall are tightly adherent to one another by ‘tight junctions’.
- Endfeet of astrocytes surround the capillaries and further regulate what can pass.



Blood-brain Barrier

Some brain regions do not have a complete blood-brain barrier, including:

- Pineal gland (in roof of diencephalon), which releases melatonin into the blood.
- Portions of the hypothalamus and pituitary gland, which release regulatory hormones into the blood.
- Circumventricular organs in the ventricles that sense the composition of blood.



Blood-brain Barrier

- The BBB complicates formulating therapeutic drugs that can get into the brain.

Hypoxia

- Suffocation or asphyxia results in a loss of oxygen supply to the brain…hypoxia.

- Brain hypoxia will result in death in ~7 minutes.

- Common causes include:
  - Drowning
  - Chocking on food
  - Carbon monoxide (CO) poisoning
  - Electrical shock (e.g. lightning)
  - Plastic bags
  - Inhalation of vomit, often when inebriated
  - Drug overdose

Stroke

- A stroke or loss of blood supply to the brain also results in hypoxia.
- A stroke results in death of brain tissue.
- A stroke typically involves a smaller artery, and the region of the brain served by that artery is affected.
- Since different brain regions have different functions, the behavioral manifestation of the stroke depends on its location.

Stroke

Types of strokes:

- Ischemic stroke – due to a blocked artery
  - Thrombosis (clot)
  - Atherosclerosis (hardening of the arteries - accumulation of cholesterol and cells in plaques)

- Hemorrhagic stroke – due to a burst artery
  - Aneurysm (thin vessel wall)
  - Arteriovenous malformation (artery to vein shunt)

Stroke

Stroke symptoms – typically sudden onset:

- Headache, often severe
- Change in sensory perception (hearing, taste, touch, etc.)
- Loss of balance or coordination
- Muscle weakness (one body region on one side)
- Numbness or tingling sensation
- Difficulty speaking

Symptoms depend on site of stroke.

Stroke

Risk factors for stroke:

- High blood pressure (#1 by far)
- High cholesterol levels
- Diabetes
- Smoking

Stroke

Good cardiorespiratory fitness significantly reduces the chance of stroke. This effect is long lasting. (i.e. Good fitness in midlife reduced the chance of stroke through the rest of life even when the level of fitness was lost.)

Pandey et al., 2016

Trauma

- Trauma to the head can tear an artery and result in loss of blood supply to an area of the brain.