2.4.3

Capillaries

As mentioned above, capillaries are the smallest vessels in the human body, with an interior diameter roughly equivalent to the width of a single erythrocyte at 5-10 μm. Widespread branching creates a capillary network capable of carrying blood to within 1 mm of almost every human cell. There are an estimated 10 billion capillaries in the body, each 1.1-millimeter-long which if stretched end to end would equal 25,000 miles. Accordingly, capillaries lie very close to one another arranged in complexes throughout the body known as **capillary beds.**

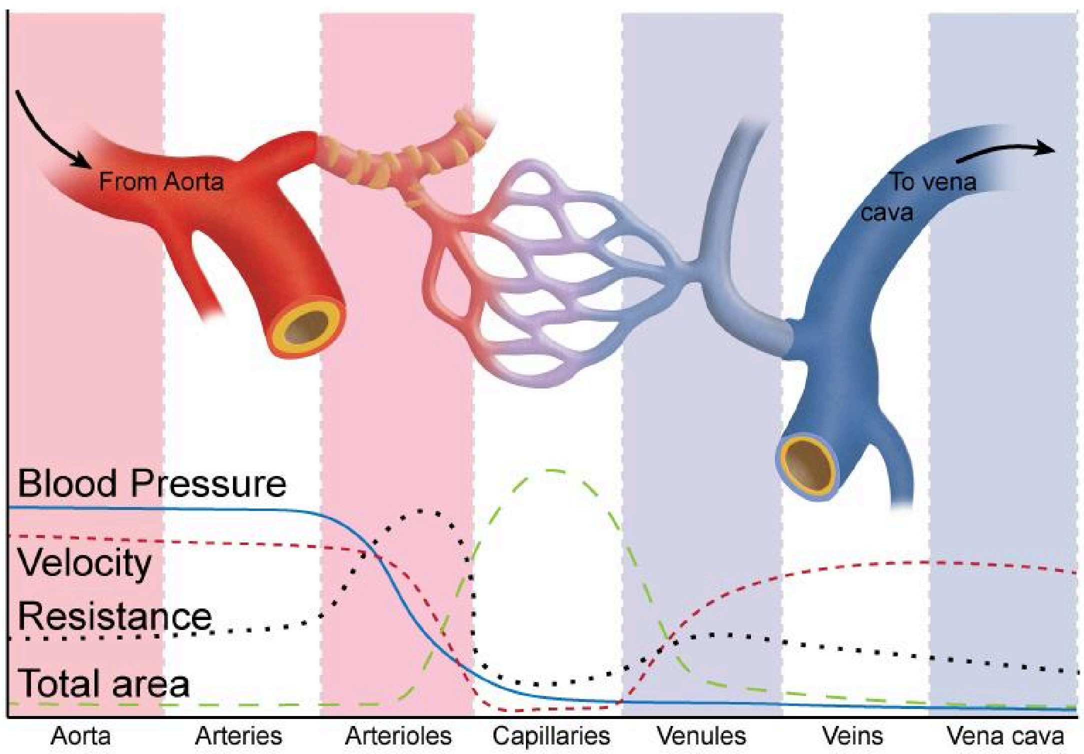
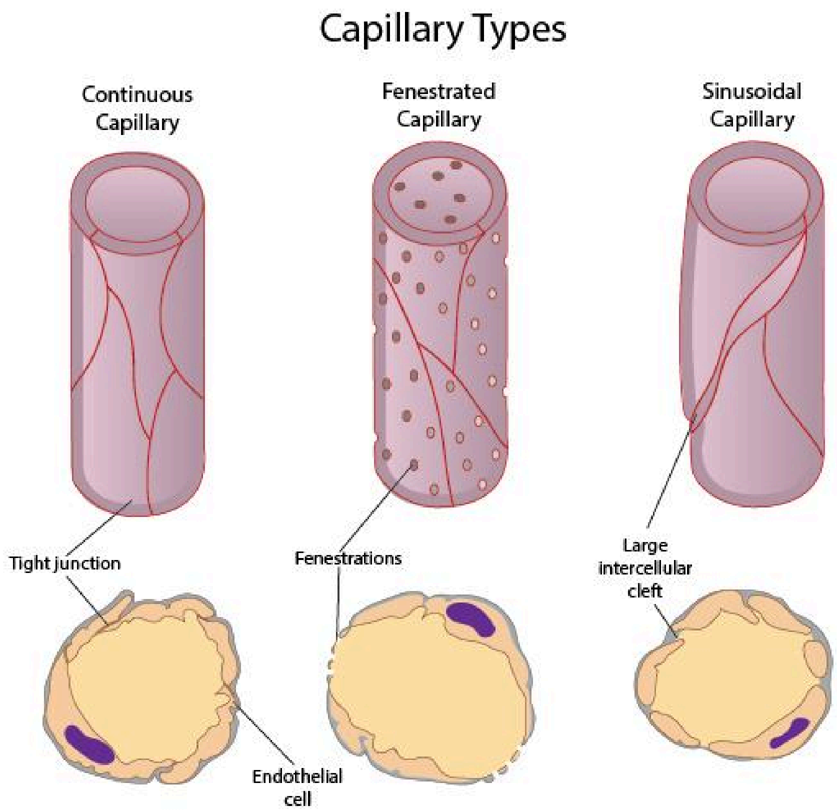


Image created at BYU-Idaho by Nate Shoemaker Spring 2016

Owing to this widespread branching, the total area of vasculature within the capillary network greatly exceeds that of the arterial network that supplies them. Consequently, as the total area of vasculature increases, the velocity and pressure of the blood decreases. This decreased velocity allows more time for the diffusion of oxygen, nutrients, and waste products to occur between capillaries and the tissues they support.

Capillary Structure and Types

Three main types of capillaries exist within the human body based on their permeability to substances departing and entering the bloodstream. These three types are known as continuous, fenestrated, and sinusoidal capillaries.



Continuous, Fenestrated and Sinusoidal Capillaries.
Image created at BYU-I Fall 2013

Continuous Capillaries

The endothelial tissue of continuous capillaries is arranged with virtually no gaps between individual cells. This allows continuous capillaries to be impermeable to polar molecules and in some cases even water. Continuous capillaries are the most common type in the body and are located in kidneys, nervous system, muscle, fat, heart and a number of other tissues throughout the body.

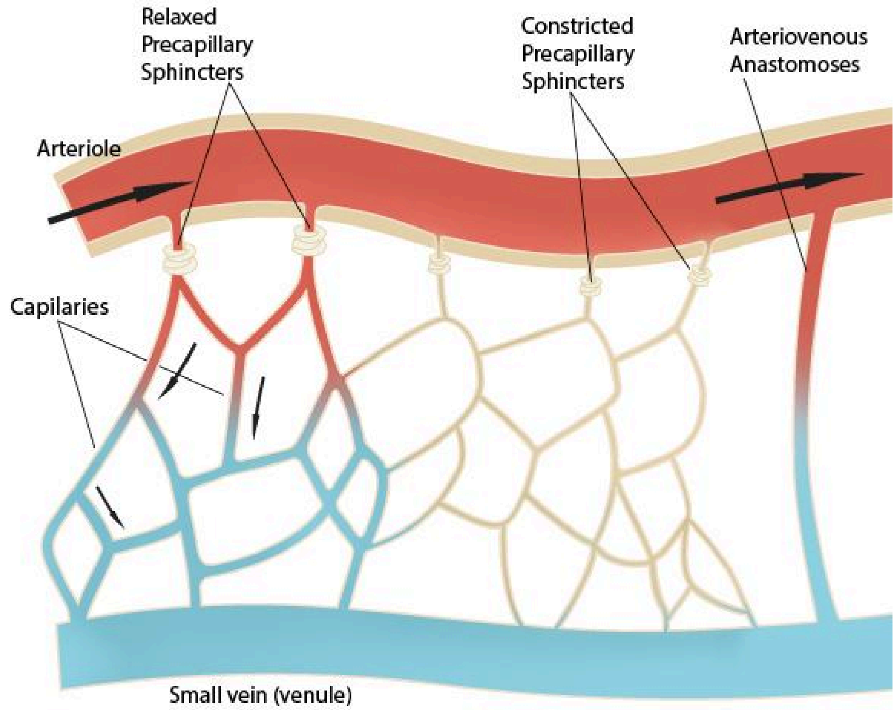
Fenestrated Capillaries

The endothelial tissue of fenestrated capillaries is also arranged in a tight weave, but comparatively large pores known as **fenestrae** occur within the individual cells. Fenestrated capillaries primarily supply tissues which require a high level of permeability for accelerated diffusion such as the intestines, and kidney glomeruli. Fenestrae size varies depending upon tissue type. The size of the fenestrae determines the size of the substances that can pass in and out of the bloodstream.

Sinusoidal Capillaries

Sinusoidal capillaries are similar to fenestrated capillaries but are larger in diameter and are arranged in a looser weave to allow the presence of gaps between individual cells. These capillaries are found in tissues such as endocrine glands, which require permeability to large molecules.

A **Sinusoid** is a special type of capillary bed, found in the bone marrow, spleen and liver. These capillaries possess very large gaps between individual cells. The gaps are large enough that all the components of blood freely pass.



Precapillary Sphincters.
Image created at BYU-Idaho Fall 2013

As blood flows from an arteriole into a capillary bed, the vascular organization and structure is different from tissue to tissue. For example, unique to the mesenteric microvasculature (i.e. the capillary beds of the intestines) are the presence of **precapillary sphincters,** concentric layers of smooth muscle located at the arteriole end of each capillary bed. These sphincters control the amount of blood that enters the mesenteric microvasculature. These precapillary sphincters have not been found in any other tissue capillary networks (Sakai, 2013).

When the sympathetic nervous system is activated during times of "fight and flight" responses, muscular arteries and arterioles constrict. This constriction is necessary to increase blood pressure (upstream of the constriction), but at the same time it can greatly reduce blood pressure and blood flow (down-stream of the constriction). Thus arterioles also rely on local products that are increased during metabolism like CO_2, acid and adenosine to stimulate relaxation. The effects of metabolic waste products overrides the sympathetic response to constrict arterioles in the area. This is advantageous during exercise because the circulatory system is able to increase blood flow to the metabolically active tissue (local products) while decreasing blood flow almost everywhere else (sympathetic nervous system). This ability for tissues to regulate their blood flow based off of metabolic need is called **autoregulation.**

Capillaries and Temperature Regulation

Another example of unique capillary organization is found in skin and mucus membrane microvasculature where capillaries play an important role in temperature regulation. Upstream of the capillary beds in these tissues are special blood vessels known as **arteriovenous anastomoses** that shunt blood flow directly from arterioles into small veins, avoiding capillary networks almost entirely. These structures are typically short with a thick tunica media (smooth muscle) and are heavily innervated by sympathetic neurons. They are most prevalent near the capillary networks of the hands and feet and play a significant role in regulating body temperature. When we think of physiological thermoregulation, we often think of shivering and sweating as the main mechanisms of action. These processes require a lot of energy to carry out and are therefore less ideal for regulating temperature within a person's thermoneutral zone (i.e. temperature range where sweating nor shivering occurs). Arteriovenous anastomoses enable fine tuning of our body temperature, this way people don't immediately start shivering when the A/C in their apartment turns on, or break out into sweat when walking a short distance. In other words, arteriovenous anastomoses make you more energy efficient (Wallace, 2016).

References:

Sakai T. and Hosoyamada Y. Are the predcapillary spincters and metarterioles universal components of the microcirculation? An historical review. J Physiol Sci. 2013; 63:319-331.Wallace L. Arterio-venous anastomoses in the human skin and their role in temperature control. Temperature. 2016; 3(1):92-103.