Cells of the Blood Circulation

Blood supplies oxygen, a mediator for cell energy, and conveys nutrients to tissues and removes waste products of cell metabolism toward lungs and purification organs, in addition to the convection of thermal energy. Moreover, blood transmits messengers such as hormones to target organs.

Blood is involved in body’s defense against infection, transporting immune cells and antibodies, and in repair processes after injury. The immune response yields an example of communication between and coordination of different cell types. Immunity illustrates the importance of between-cell signaling to provoke cell proliferation, differentiation, and maturation in dedicated sites, as well as migration to target loci and coordinated functioning to achieve assigned tasks.

Blood circulates from the heart through arteries into arterioles down to capillary beds. Capillaries form extensive networks for molecular exchange between blood and cells. Blood returns to the heart through venules and veins. Blood transport adapts to needs of the body’s tissues, especially growing tissues. Capillaries are able to sprout and branch to form new networks. Moreover, arteries and veins can expand and remodel.

Cells related to the cardiovascular system encompass cells of the walls of the heart and blood and lymph vessels that bring needed materials to tissues, as well as those that are conveyed in the blood stream and involved in the regulation of the blood circulation. The flowing blood conveys circulating cells that include 3 main categories of cells — erythrocytes, leukocytes, and thrombocytes — the main function of which is oxygen transport, immunity, and plug formation and activation of blood coagulation factors to limit hemorrhage, respectively. Immune cells circulate in blood flow before scouting tissues in search for possible foreign elements. Nervous cells control the activity of the cardiovascular system according to inputs provided by sensory cells of the vasculature. Even after the final stage of differentiation, cells keep a potential of flexible fate because they can be reprogrammed by a more or less small set of transcription factors.
Any cell interacts with its surrounding medium, as it emits, receives, transmits, stores, and treats information. Many cell stimuli induce signaling cascades that lead to cell responses following molecule synthesis or release from stores (Vol. 3 – Chap. 1. Signal Transduction). Hundreds of mechanical, physical, and chemical stimuli control cell function using a limited repertoire of signaling pathways that prime distinct cell responses. Signal transduction relies on multiple types of ion carriers (Vol. 3 – Chaps. 2–3) and receptors (Vol. 3 – Chaps. 6–11) located in the cell membrane. In addition, the extracellular matrix is required for the assembly of differentiated cells into a functional tissue. The extracellular matrix may also control the fate of stem and progenitor cells.

2.1 Cells of Vasculature Walls

Many types of cells are related to the cardiovascular system. A first set comprises mural cells of: (1) blood vessels, such as vascular endothelial cells and either smooth muscle cells and fibroblasts in the macrocirculation or pericytes in the microcirculation (blood vessel caliber $\mathcal{O}[1] \mu m$-$\mathcal{O}[100] \mu m$); and (2) heart, such as cardiomyocytes, nodal cells, and adipocytes.

Each cell type is characterized by appropriate features. In particular, cardiomyocyte properties include excitability, electrochemical conductibility, and contractility, as well as relaxation and repolarization capacity.

Many tissular characteristics are obtained by message exchanges between different cell types in a given tissue. Blood vessel size, thereby blood pressure, is controlled partly by interactions between vascular endothelial and smooth muscle cells.

2.1.1 Endothelial Cells

Endothelial cells are situated at interfaces between 2 types of connective tissues: (1) circulating blood in the vascular lumen and (2) subendothelial layer of the intima of large vessel walls or surrounding medium of microvessels. The endothelium, a single layer of endothelial cells (Vol. 5 – Chap. 9. Endothelium), is a specialized type of mesenchymally-derived epithelium that lines the interior (wetted) surface of the heart (endocardium) as well as blood and lymphatic vessels.

At the microscopic length scale, endothelial cells build a thin layer with corrugations (extensions toward the vessel lumen) due to the presence of cell nuclei. The wetted surface of the vascular endothelium is covered by a glycocalyx of variable height (50–500 nm) depending on water concentration. The glycocalyx that contains proteoglycans experiences friction forces. Endothelial cells are separated by clefts (length 400–450 nm, caliber 20–25 nm).