The Endoplasmic Reticulum

The **endoplasmic reticulum** (ER) (Figure 4.22) is a series of interconnected membranous tubules that collectively modify proteins and synthesize lipids. However, these two functions are performed in separate areas of the endoplasmic reticulum: proteins are modified in the rough endoplasmic reticulum and lipids are synthesized in the smooth endoplasmic reticulum.

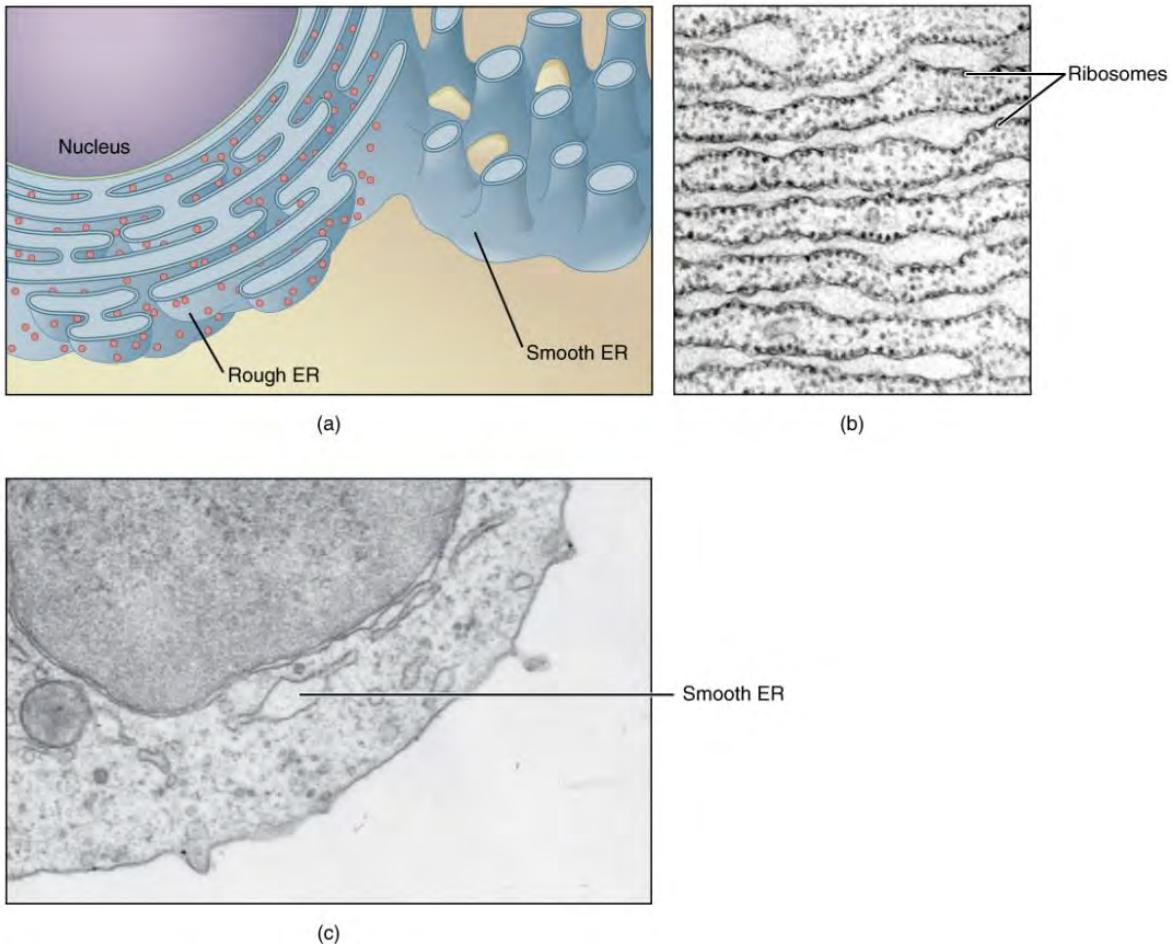

Figure 4.22 Endoplasmic Reticulum (ER) (a) The smooth and rough endoplasmic reticula are very different in appearance and function (source: mouse tissue). (b) Rough ER (source: mouse tissue). EM × 110,000. (c) Smooth ER (source: mouse tissue). EM × 110,510. (Micrographs provided by the Regents of University of Michigan Medical School © 2012 / Anatomy of Physiology OpenStax)

The hollow portion of the ER tubules is called the lumen or cisternal space. The membrane of the ER, which is a phospholipid bilayer embedded with proteins, is continuous with the nuclear envelope.

The **rough endoplasmic reticulum** (RER) is so named because the ribosomes attached to its cytoplasmic surface give it a studded appearance when viewed through an electron microscope (Figure 4.22). The ribosomes synthesize proteins while attached to the ER. The newly synthesized proteins move into the lumen of the RER where they undergo modifications, such as folding or the addition of sugars. The RER also makes phospholipids for cell membranes. If the modified proteins or phospholipids are not needed in the RER, they will be packaged within vesicles and transported to the Golgi apparatus (Figure 4.23).

The **smooth endoplasmic reticulum** (SER) is continuous with the RER but has few or no ribosomes on its cytoplasmic surface (see Figure 4.22). The SER's functions include synthesis of carbohydrates, lipids (including phospholipids), and the precursors of steroid hormones, such as cholesterol. The smooth endoplasmic reticulum also plays a role in detoxification of medications and poisons, including alcohol metabolism. Finally, the SER acts as a storage space of calcium ions, which is necessary for muscle contraction, nervous system function, and cell division.

CONCEPTS IN ACTION - You can watch an excellent animation of the endomembrane system here. At the end of the animation, there is a short self-assessment.

CAREER CONNECTION - Cardiologist

Heart disease is the leading cause of death in the United States and has been linked to sedentary lifestyles and high trans-fat diets. Heart failure is just one of many disabling heart conditions. Heart failure does not mean that the heart has stopped working; rather, it means that the heart can't pump with sufficient force to transport oxygenated blood to all the vital organs. Left untreated, heart failure can lead to kidney failure and other organ failures.

Cardiac muscle tissue comprises the heart's wall. Heart failure can occur when cardiac muscle cells' endoplasmic reticula do not function properly. As a result, an insufficient number of calcium ions are available to trigger a sufficient contractile force.

Cardiologists (cardi- = "heart"; -ologist = "one who studies") are doctors who specialize in treating heart diseases. Cardiologists can diagnose heart failure via a physical examination, results from an electrocardiogram (ECG, a test that measures the heart's electrical activity), a chest X-ray to see whether the heart is enlarged, and other tests. If the cardiologist diagnoses heart failure, they may prescribe appropriate medications, recommend a reduced table salt intake, and a supervised exercise program. Depending on the severity of the diagnosis, other treatment options may need to be explored.

The Golgi Apparatus

We have already mentioned that vesicles can bud from the endoplasmic reticulum, but where do the vesicles go? Before reaching their final destination, the lipids or proteins within the transport vesicles need to be sorted, packaged, and tagged so that they wind up in the right place. The sorting, tagging, packaging, and distribution of lipids and proteins take place in the **Golgi apparatus** (also called the Golgi body or Golgi complex), a series of flattened membranous sacs (Figure 4.23).

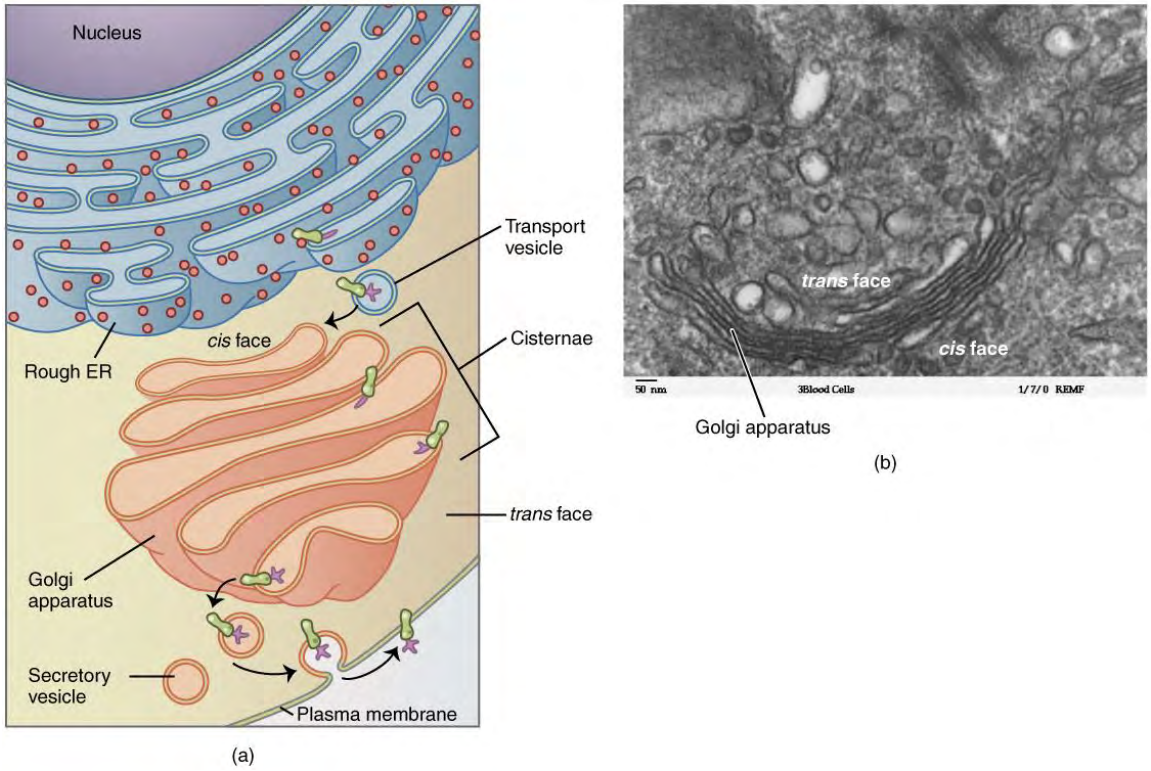

Figure 4.23 a. The Golgi apparatus b. Transmission electron micrograph of a Golgi apparatus in a white blood cell. (credit: modification of work by Louisa Howard; scale-bar data from Matt Russell / Anatomy and Physiology OpenStax)

The Golgi apparatus has a receiving face (cis) near the endoplasmic reticulum and a releasing face (trans) on the side facing away from the ER. The transport vesicles sent from the ER travel to the receiving face, fuse with it, and empty their contents into the lumen of the Golgi apparatus. As the proteins and lipids travel through the Golgi, they undergo further modifications. The most frequent change is the addition of short chains of sugar molecules. The newly modified proteins and lipids are then tagged with small molecular groups to enable them to be routed to their proper destinations.

Finally, the modified and tagged proteins are packaged into vesicles that bud from the opposite face of the Golgi. While some of these vesicles deposit their contents into other parts of the cell, other vesicles fuse with the plasma membrane and release their contents outside the cell.