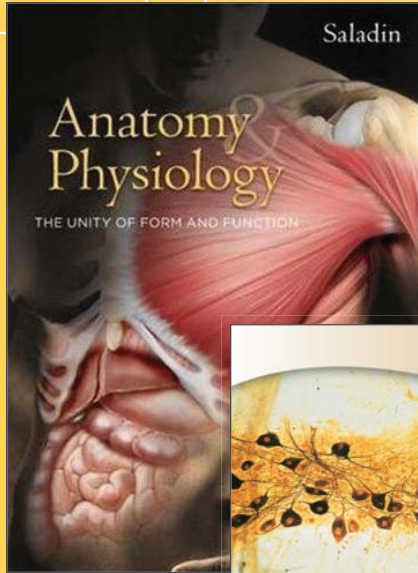




CASE STUDY:

SALADIN ANATOMY & PHYSIOLOGY

PREVIOUS



MISSION

Create accurate, high-end anatomy illustrations on a very tight schedule, using strict client guidelines.

THE CHALLENGE

When the publisher of Saladin *Anatomy and Physiology* came to Precision Graphics, they had several clear goals. The existing illustrations had been created and revised over multiple editions, so while their content was accurate, their style was inconsistent. The publisher wanted a new look for the art that surpassed what had been done in previous editions, while maintaining the established standards of accuracy. All 809 complex anatomical illustrations were to be revised, in only 9 months.

In addition to skeletons and other physical models, the art team used live models and photos to make the art as realistic as possible. This meant trying new techniques and breaking some traditional rules in order to take the art to the level the client was looking for. The team also held art critiques in which the entire team reviewed as a group each chapter's illustrations, ensuring that a consistently high-end

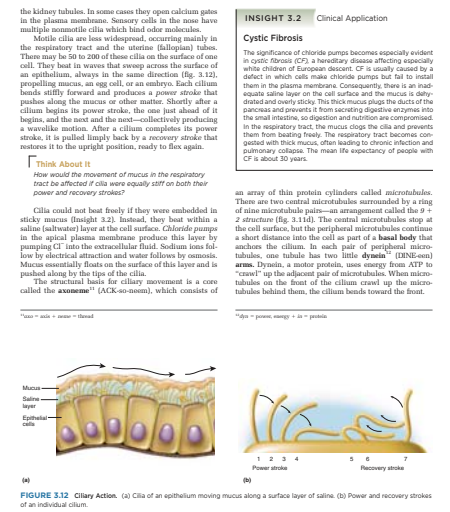
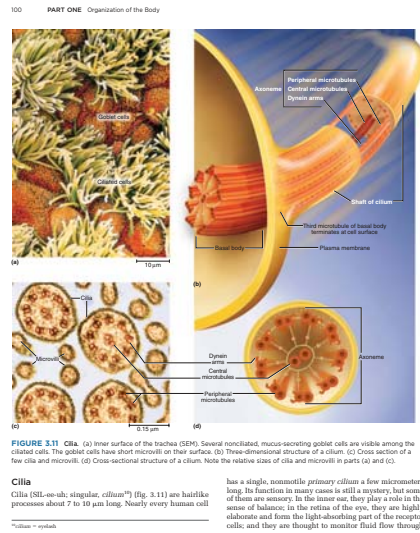
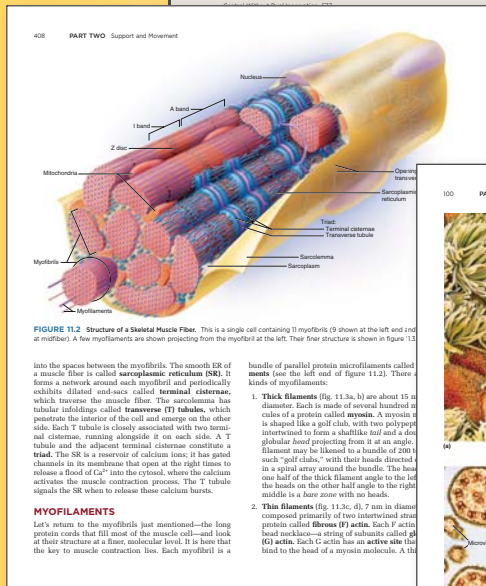
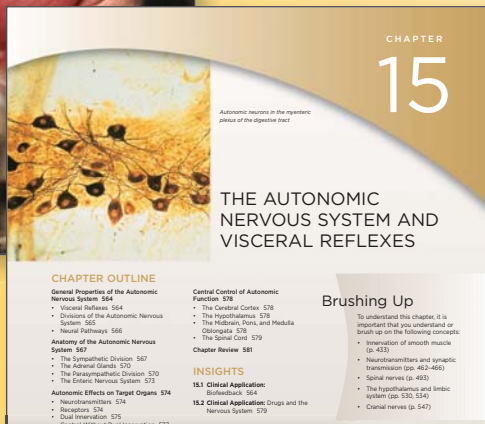


FIGURE 11.2 Structure of a Skeletal Muscle Fiber. This is a single cell containing 11 myofibrils (9 shown at the left and end at middle). A few myofibrils are shown projecting from the myofibril at the left. Their fiber structure is shown in figure 11.3

into the spaces between the myofibrils. The smooth ER of a muscle fiber is called **sarcoplasmic reticulum (SR)**. It forms a network around each myofibril and periodically exhibits dilated end-sacs called **terminal cisternae**, which surround the muscle fiber. The sarcoplasm has tubular inclusions called **transverse (T) tubules**, which penetrate the interior of the cell and encircle on the other side. Each T tubule is closely associated with two terminal cisternae, running alongside it on each side. A T tubule and the adjacent terminal cisternae constitute a **triad**. The SR is a reservoir of calcium ions; it has gated channels in its membrane that open at the right times to release a flood of Ca^{2+} into the cytosol, where the calcium activates the muscle contraction process. The T tubule signals the SR when to release these calcium bursts.

MYOFILAMENTS
Let's return to the myofibrils just mentioned—the long protein cords that fill most of the muscle cell—end look at their structure at a filar, molecular level. It is here that the key to muscle contraction lies. Each myofibril is a bundle of parallel protein microfilaments called **myofibrils**. Each is made of several hundred to a thousand of a protein called **myosin**. A myosin is shaped like a golf club, with two polypeptide intertwined to form a shaft-like tail and a distal, globular head projecting from it at an angle. Filament may be likened to a bundle of 200 to 400 such "golf clubs," with their heads directed in a spiral array around the bundle. The base of one half of the thick filament angle to the left, the heads on the other half angle to the right, resulting in a base zone with no heads.

2. Thin filaments (fig. 11.3c, d). 7 nm in diameter composed primarily of two intertwined strands of protein called **fibrous (F) actin**. Each F actin has necklaces—a string of subunits called **G (G) actin**. Each G actin has an **active site** that binds to the head of a myosin molecule. A thin

FIGURE 3.31 Cilia. (a) Inner surface of the trachea (SEM). Several nonciliated, mucus-secreting goblet cells are visible among the ciliated cells. The goblet cells have short microvilli on their surface. (b) Three-dimensional structure of a cilium. (c) Cross section of a few cilia and microvilli. (d) Cross-sectional structure of a cilium. Note the relative sizes of cilia and microvilli in parts (a) and (c).

Cilia
Cilia (SI: cilium; singular, cilium?) (fig. 3.31) are hairlike processes about 7 to 10 μm long. Nearly every human cell has a single, nonmotile primary cilium a few micrometers long. Its function in many cases is still a mystery, but some of them are sensory. In the inner ear, they play a role in the sense of balance. In the retina of the eye, they are highly elaborate and form the light-absorbing part of the receptor cells; and they are thought to monitor fluid flow through

FIGURE 3.32 Ciliary Action. (a) Cilia of an epithelium moving mucus along a surface layer of saline. (b) Power and recovery strokes of an individual cilium.

the kidney tubules. In some cases they open calcium gates in the plasma membrane. Sensory cilia in the nose have multiple nonmotile cilia which bind odor molecules.

Motile cilia are less widespread, occurring mainly in the respiratory tract and the uterine (Fallopian) tubes. There may be 50 to 200 of these cilia on the surface of one cell. They beat in waves that sweep across the surface of an epithelium, always in the same direction (fig. 3.32), propelling mucus, an egg cell, or an embryo. Each cilium bends stiffly forward and produces a **power stroke** that pushes along the mucus or other matter. Shortly after a cilium begins its power stroke, the one just ahead of it begins, and the next and the next—collectively producing a wavelike motion. After a cilium completes its power stroke, it is pulled limply back by a **recovery stroke** that restores it to the upright position, ready to flex again.

Think About It!
How would the movement of mucus in the respiratory tract be affected if cilia were equally stiff on both their power and recovery strokes?

Cilia could not beat freely if they were embedded in sticky mucus (thought 3.2). Instead, they beat within a saline (saltwater) layer at the cell surface. Chloride pumps in the apical plasma membrane produce this layer by pumping Cl^- into the extracellular fluid. Sodium ions follow by electrical attraction and water follows by osmosis. Mucus essentially floats on the surface of this layer and is pushed along by the tips of the cilia.

The structural basis for ciliary movement is a core called the **axoneme?** (AKK-oo-nem), which consists of an array of thin protein cylinders called microtubules. There are two central microtubules surrounded by a ring of nine microtubules—two an arrangement called the 9 + 2 structure (fig. 3.31d). The central microtubules stop at the cell surface, but the peripheral microtubules continue a short distance into the cell as part of a **basal body** that anchors the cilium. In each part of peripheral microtubules, one tubule has two little **dynein?** (DINE-in) arms. Dynein, a motor protein, uses energy from ATP to "row" on the adjacent pair of microtubules. When microtubules on the front of the cilium crowd up, the microtubules behind them, the cilium bends toward the front.

