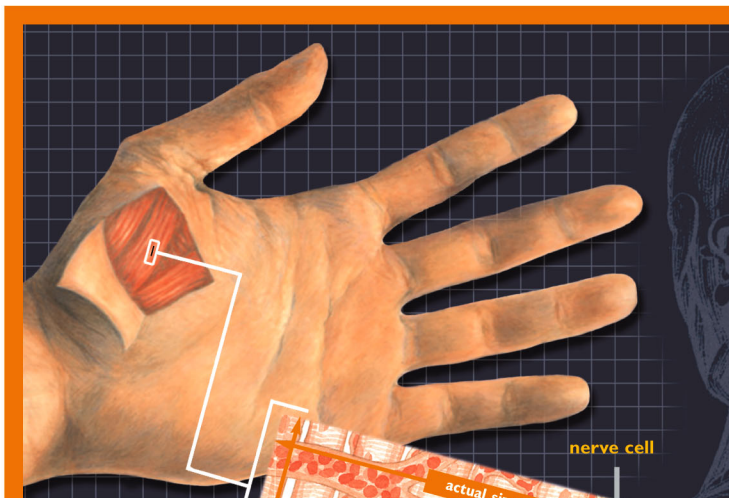
HOW DOES A MUSCLE WORK?

All muscle cells function in similar ways to turn energy into motion. Two types of proteins do most of the work, powered by an energy molecule found in all living cells.

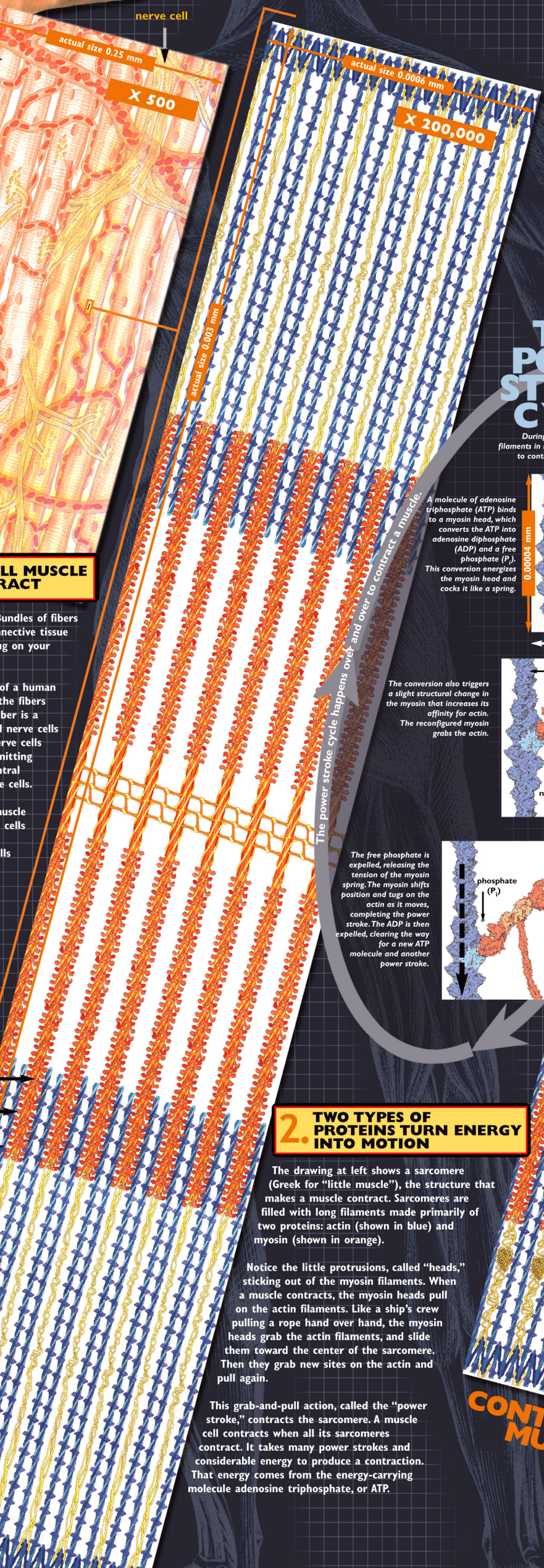


1. NERVE CELLS TELL MUSCLE CELLS TO CONTRACT

How does your hand move? Bundles of fibers bound together by dense connective tissue form skeletal muscles that tug on your bones.

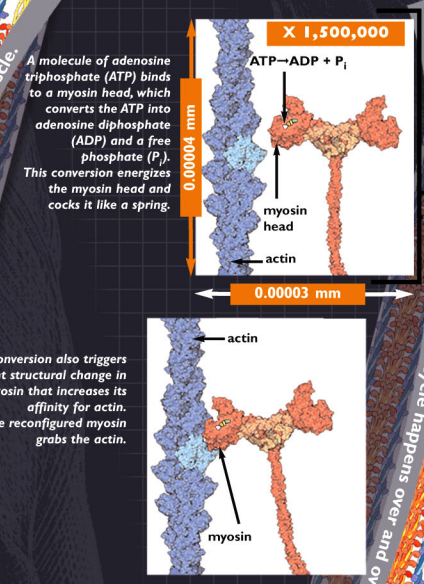
In the above magnified view of a human skeletal muscle, you can see the fibers arranged side by side. Each fiber is a muscle cell. Blood vessels and nerve cells surround the muscle cells. Nerve cells initiate contraction by transmitting chemical signals from the central nervous system to the muscle cells.

Look for the circles on the muscle cells. Those are nuclei. Muscle cells have multiple nuclei because they're formed from many cells that fuse together during embryonic development.



THE POWER STROKE CYCLE

During the power stroke cycle, filaments in muscle cells work like a ratchet to contract a muscle. Here's how.



A molecule of adenosine triphosphate (ATP) binds to a myosin head, which converts the ATP into adenosine diphosphate (ADP) and a free phosphate (P_i). This conversion energizes the myosin head and cocks it like a spring.

The conversion also triggers a slight structural change in the myosin that increases its affinity for actin. The reconfigured myosin grabs the actin.

The free phosphate is expelled, releasing the tension of the myosin spring. The myosin shifts position and tugs on the actin as it moves, completing the power stroke. The ADP is then expelled, clearing the way for a new ATP molecule and another power stroke.

The power stroke cycle happens over and over to contract a muscle.

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2. TWO TYPES OF PROTEINS TURN ENERGY INTO MOTION

The drawing at left shows a sarcomere (Greek for "little muscle"), the structure that makes a muscle contract. Sarcomeres are filled with long filaments made primarily of two proteins: actin (shown in blue) and myosin (shown in orange).

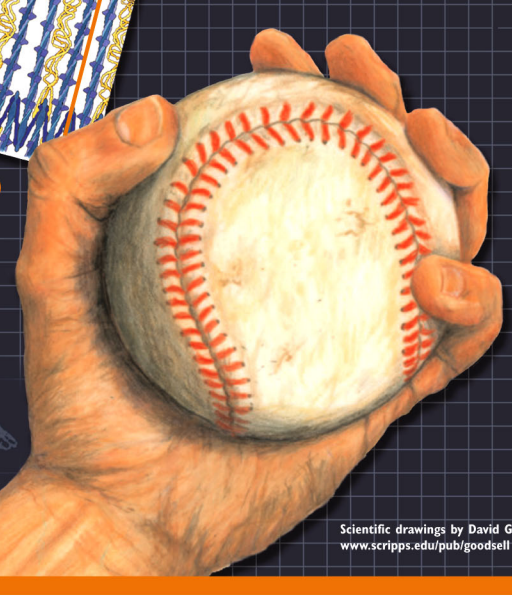
Notice the little protrusions, called "heads," sticking out of the myosin filaments. When a muscle contracts, the myosin heads pull on the actin filaments. Like a ship's crew pulling a rope hand over hand, the myosin heads grab the actin filaments, and slide them toward the center of the sarcomere. Then they grab new sites on the actin and pull again.

This grab-and-pull action, called the "power stroke," contracts the sarcomere. A muscle cell contracts when all its sarcomeres contract. It takes many power strokes and considerable energy to produce a contraction. That energy comes from the energy-carrying molecule adenosine triphosphate, or ATP.

3. TRILLIONS OF PROTEINS MOVE YOUR HAND

Most types of human cells are tiny, but muscle cells span the entire length of a muscle and can be more than a foot long. It can take trillions of myosin heads and billions of actin filaments to move one muscle. To hold a baseball, for example, about two trillion myosin heads are called into action.

Muscle contraction can't happen without ATP. But muscles also need ATP to relax. Without ATP, myosin would never release its grip on actin, and your body would become completely rigid. That's what happens when you die. Your muscles seize up in a prolonged contraction called rigor mortis.



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