How Do Strength and Mass Increase?

As you remember from chapter 1, several adaptations to strength training occur in the central nervous system and in the muscle cells.

In people who are new to strength training or haven't engaged in strength training for a few months or longer, muscle strength increases soon after training begins. That increase in strength has nothing to do with an increase in contractile proteins and everything to do with increased recruitment of motor units. As the nervous system recruits more motor units, force production (strength) increases because more muscle cells are involved in each contraction. With time, muscle cells adapt to the continuing stress of strength training by creating more proteins (actin, myosin, troponin, tropomyosin, titin, and many others), and muscle mass increases. How much muscle mass is added as a result of strength training depends on the factors shown in figure 6.1.

The most obvious influence on the amount of muscle mass developed as a result of strength training is genetics. It's obvious that some people do not have the genetic predisposition to add large amounts of muscle mass, whereas others do. The extent to which a person can add muscle mass is primarily determined by genotype (inherited genetic makeup), which establishes an upper limit of sorts for muscle mass and all other characteristics of cells, a good example of how nature determines what nurture can accomplish. However, everyone can add mass and increase muscle strength with the proper training program. That's because phenotype is determined by the interaction of genotype and environment. In the case of muscle mass, environment includes factors such as extent of physical activity in childhood, age of starting strength training, duration of strength training, diet, and current methods of strength training. Age and sex also play roles.

Training of any sort alters phenotype, at least until training ceases and the adaptations disappear. The stimulus of strength training is intended to provoke an adaptive response: the addition of proteins to muscle cells that enable greater force production as well as an increase in the size of individual cells and consequently the entire muscle. Strength training triggers signals within the muscle cell that stimulate the nuclei to churn out more contractile proteins that are then added to the cell. In other words, effective strength training causes an increase in muscle protein synthesis, proteins produced through the interaction of the cell's signaling molecules with the DNA in the many nuclei within each muscle cell. Genotype determines how responsive muscle nuclei will be to strength training and therefore how many new muscle proteins will be added before reaching the upper limit imposed by genotype.

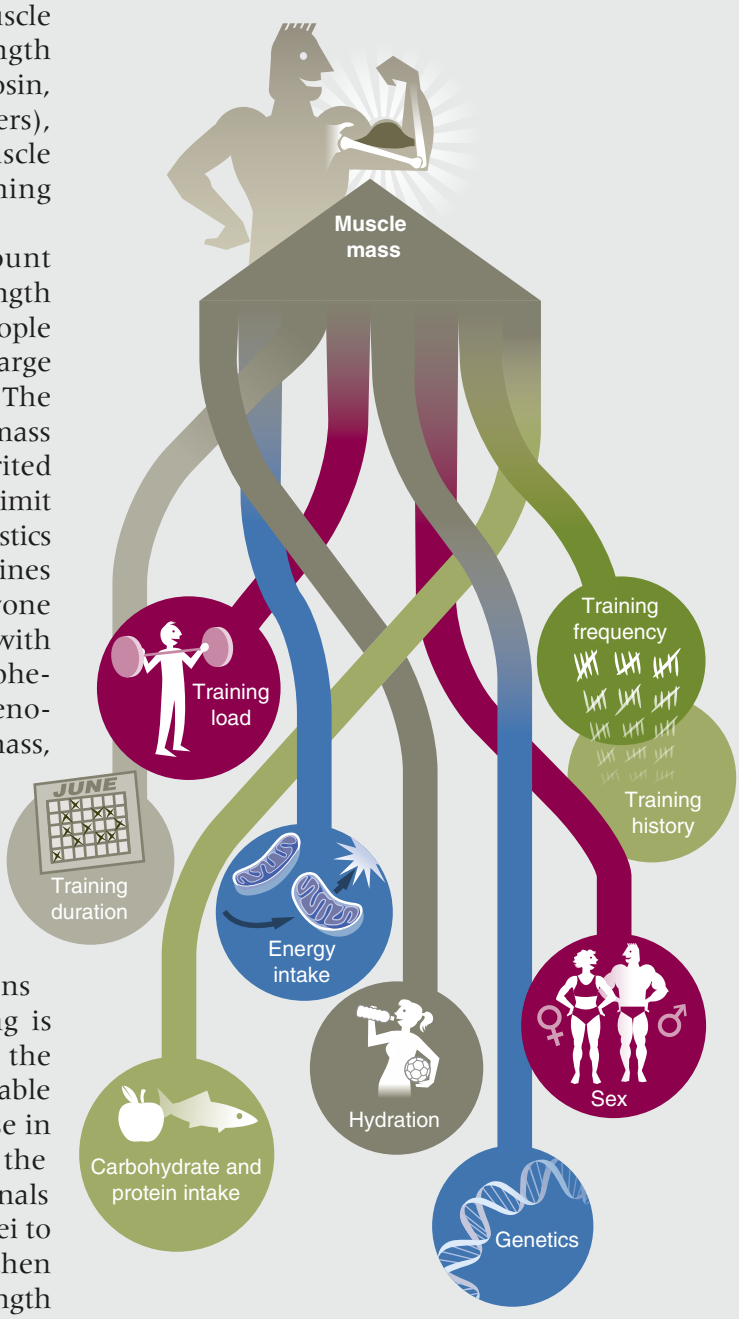

FIGURE 6.1 Factors that influence muscle mass.

Adaptations to Strength Training

- More motor units recruited
- Greater stimulation frequency of motor units
- More synchronous recruiting of motor units
- Reduced inhibition of motor units
- Increased size of muscle cells (hypertrophy)
- Possibly a small increase in number of muscle cells (hyperplasia)
- Increased bone mineral density and bone strength
- Increased strength of ligaments and tendons

Causes of Hypertrophy

- More contractile proteins (actin and myosin)
- More structural proteins
- More sarcoplasm
- More myofibril units
- More connective tissue
- More intracellular water
- More muscle cells (maybe)