Adaptation is defined as a change in structure, function, or form that improves the chance of survival for an organism contained within a specific environment. Inflammation, changes in reduction/oxidation pathways, immune alteration and tissue repair are just some of the reactions and biological processes associated with the effects of training, the outcome of which lead to the desired objective of fiber remodeling (hypertrophy or improved twitch response).

## How Muscles Grow

Through the use of an electron microscope, muscle biopsy and radioactive tracing techniques, research scientists are able to look at muscle to determine how it responds to the influence of exercise and load stress. Before a muscle gets bigger or stronger, you have to influence the genes inside the nucleus of each muscle cell. This is achieved through both training AND diet (environment).

Gene expression is altered by satellite cells, which re-enter the cell cycle in response to various levels of exercise and fitness activity. These satellite cells alter gene expression according to the amount and form of stress imposed on muscle, thereby affecting its size and shape. Micronutrients can also influence genetic expression, in that the presence or absence of specific vitamins, minerals, fatty acids or amino acids (and the coenzymes they affect) can improve or hinder satellite cell formation and thus influence how muscle fibers respond.

### Check This Out

***mTOR*** *(mammalian target of rapamycin) holds one of the keys to muscle building. When mTOR is activated, it causes muscle cells to increase protein synthesis which leads to skeletal muscle hypertrophy. mTOR is regulated by fasting, high intensity exercise and BCAA's.*

Muscle tension and muscle torque provide the force-generating capacity that powers intense muscle contraction. Muscles get bigger when the number of myofibrils inside them increases, and this adaptation depends on the availability of specific amino acids, hormones and enzyme chemistry, all of which play a role in protein synthesis.

Muscle cells have many nuclei, which control the rate of protein synthesis. Proteins are put together from amino acids on the surface of structures in the cell called ribosomes. This process is controlled and managed through genetic transcription and translation. Within four days of a workout, it's possible to identify genetic changes within the cell that alter muscle fiber contractility. The effects of these changes are initiated the minute you start training and begin to reverse and slowly regress (move backwards) after more than 72 hours of downtime (no training).

Muscle hypertrophy is also influenced by neural activation, muscle stretch, muscle recoil and elasticity. Plyometrics, jumping exercises and speed training are known to enhance neural activation even more so than intense over-load lifting.

*[plyometrics] exercises that test and enhance elasticity and recoil of muscle tissue.*

The rate of protein synthesis is also influenced by the rate at which amino acids enter the cell. Most amino acids enter muscle cells with assistance from insulin via the action of a "sodium pump". Insulin metabolism combined with growth hormone, insulin-like growth factors (somatomedins) and several androgens (testosterone, DHEA, androstenedione) greatly influence the entire process. This is why many athletes use anabolic steroids; however, the natural athlete can also influence the turnover rate of protein in favor of muscle accretion (buildup) by adjusting food compo-

sition, training correctly and taking advantage of special dietary supplements. The physiological effects of steroid use are discussed at length in Module Eight.

Most skeletal muscles contain a mixture of muscle fiber types, and their proportion is influenced mainly by genetics, the action of the muscle and adaptation to physical activity and exercise. For instance, endurance exercise such as long-distance running or cycling, can cause a gradual transformation of type IIb fibers into type IIa fibers. The reverse is also true with strength/speed event training, such as powerlifting. Muscle biopsies on sprinters and strength-trained athletes show high proportions of well-developed fast-twitch fibers.

Unless you're extremely active and stimulate muscle growth through resistance training, the total number of skeletal fibers you are born with will most likely never change, although muscle fibers do decay and wither away over time if not routinely stimulated, so we can influence their function, strength and size through lifestyle.

However, if you do train with intensity, there is evidence in animal studies that under the right conditions with the correct stimulation, muscle fibers can actually "split" forming two new separate fibers. Another way muscle can grow besides the way it normally thickens (hypertrophy) is through a phenomenon called hyperplasia. This involves the recruitment of satellite stem cells in the muscle to grow new fibers, but this kind of growth is not possible to induce without very heavy, intense exercise.

We are born with specific numbers and types of muscle fibers. Training specificity dictates, along with optimum nutrition and rest, how the body responds and adapts to our environment. However, the single greatest determinant of potential muscular development is still a function of choosing the right parents. Woody Allan could never be an Arnold Schwarzenegger, but he could still develop or build his body "up" with the right training to a level far beyond the state he normally presents. And Arnold would never be where he is today if he had not taken his genetics to the level he achieved through many years of intense bodybuilding combined with pharmaceutical support.

*Do you know what your genetic potential is?*

There is no doubt that some of the best athletes in the world are often gifted from the start; yet, genetics (however important) is still only one of several variables that influence athletic success. Many athletes throughout history have succeeded without any obvious genetic advantages because they were able to work through their limitations by concentrating on others variables such as skill training, hypnosis or a burning desire to succeed.

## Utility of Muscle

Skeletal muscle possesses three levels of functional ability:

1. Concentric or positive contraction (isotonic)
2. Static contraction (isometric)
3. Eccentric or negative contraction (isotonic)

Skeletal muscle is attached to bone indirectly by means of strong, non-elastic fibrous tissue called tendons. Tendons transmit the force produced by muscle and help reduce excessive strain on muscle. A tendon attached to a stationary bone that doesn't move and that