

# The Anatomy of A Muscle



Researched and Composed by Jacob Wilson, BSc. (Hons), MSc. CSCS

## He is the one.....

When Neo arose to life in the Matrix he no longer viewed his surrounding as his comrades, but rather in complete and total code. He understood the Matrix for what it really was, a computer generated world. It was the dissecting of this code that separated him from everyone, including his former self. Clearly he discovered the revelation that would allow him to conquer his enemies and take his rightful place as " The One. " I am here to tell you, that it is this same realization that will allow you to conquer the sport of bodybuilding. The day you begin to view your muscles for what they really are, is the day you will have established certain victory over them. Like the three agents, they cannot help but yield, if you know their very coding, or as the title suggests their anatomy.

---

## Overview

Most people look at muscle groups as simple structures. This couldn't be further from the truth! A muscle is one of the most complex organs in the human body. It contains thousands and thousands of cells, organelles, regulators, and protective barriers. The following will break down this structure from its most vital unit, to the units that surround it. In the end you will understand such questions as

1. Why is a muscle striated?
2. How does a muscle contract?
3. What fuels contraction?
4. Why would a muscle be flat some days and full others?
5. What are the inner workings of a muscle cell and what can I manipulate for growth?

Overall however, you will begin to view these creations as complex structures, and be able to translate this knowledge to extreme growth! Further I will refer back to this article throughout the entire anatomy section, so it is important that you grasp these concepts. In fact the anatomy section will essentially explain how to

manipulate everything you read about today. Therefore this article goes way beyond **today**, and expounds into countless other anatomical subjects!

### **Skeletal Muscle**

Muscle tissue is unique in that it has the ability to **contract** and can perform **mechanical** work. There are actually three distinctive classifications of this tissue. The first is Smooth muscle (digestive system, veins, muscular arteries), the second is Cardiac muscle (the heart) and finally what you came here today to hear about, Skeletal Muscle! This type of tissue has several significant characteristics. It can produce extreme force (mass x acceleration), is meant to move and stabilize our skeleton, is mainly controlled voluntarily and is striated! Each of these characteristics will be covered in detail.

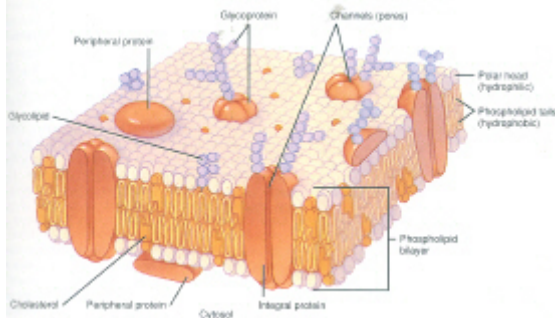
We will first cover the main unit of this tissue, which is called a *muscle cell* or *muscle fiber*. These cells are the workhorses of muscle groups and are the main target for bodybuilders as far as growth is concerned. What I will do in this article is break down the anatomy of these fibers. In addition to this, I have written a three-part article on essentially every subtype of muscle fiber and how to force these subtypes into growth. That article will not be of optimal benefit if you do not understand the inner workings of these cells. As a description, muscle fibers are long and threadlike. In fact, if you were to get a close look at your biceps you would see that it contained thousands and thousands of these threads lying parallel to each other. These fibers are longer than any other cell in our bodies. With their importance in mind, let's break down every element of a muscle cell.

### **The Muscle Cell Membrane**

Everyone has a front door to their house, and this may expound to a fence, a garage, and even an alarm system. These tools keep thieves, strangers, animals and a host of other threats out of your house. They also help to keep your valuable china, jewelry, barbells, squat rack (hey I had to mention my prized possession!) safely inside. Moreover, you have control over who you allow in through your doors, which in scientific terms, makes your house "selectively permeable." In that you "select" who is allowed in. It just so happens that our muscle cells also have a protective mechanism. This is called a cell membrane, or more specifically the Sarcolemma.

The Sarcolemma is an extremely thin (you need a microscope to see how thin!) flexible and elastic substance that completely covers the entire muscle fiber. Think of it as the saran wrap placed around the cookies on your kitchen counter (those are for guests right?). The closer you look the more complex this structure looks. The first job of the membrane is to maintain the wholeness of the cell (1). If for some reason this protective sheath were damaged to extreme levels, then the contents within would escape and the cell would die. Therefore it keeps every vital content inside. Again, think of this as a locked door keeping your precious valuables safely inside your house. Further it acts as a gateway through which substances (i.e. amino acids) can enter and leave the cell. This is selectively permeable, which means it controls what can enter or leave.

### How and Why is it Selectively Permeable?



That is an excellent question! It has to do with its make up, which is about 50 percent proteins, 48 percent lipids (mostly phospholipids) with a dash of carbs. Lipids are fatty substances and occur in two layers. The proteins that are in the bilayer float within the lipid. This is important to carrying out their functions. Picture a double layered frosting on a cake with m & m's on top. If your significant other isn't a great cook (don't tell her that!) then the frosting has a watery texture and the m & m's float across it when you carry your plate to the table. I used that example because I'm dieting and cake sounds fantastic! A better way to describe it would be to think of the proteins as floating ice bergs on a sea of lipids. In the picture above, the white bilayer is made up of lipids and the red and purple structures are proteins that serve as pores, transporters and receptors!

Lipids happen to be very insoluble to water, which is to say water cannot pass through. The lipid makeup of the membrane keeps vital watery contents inside of the cell and separates them from the watery environment outside of the cell. This is one method of selective permeability (water has to be transported in). The proteins have several jobs and as stated can move from one side of the membrane to the other. The first job is simple, protein molecules can serve as pores that allow nutrients inside of the cellular environment. This type of protein is called a glyco-protein because it is part sugar and part protein. These also act as transporters, which is to say that they bind themselves to a substance and carry it across the membrane much like a ferry takes a car across a lake. Glyco-proteins are very selective however, and only allow certain substances to pass or be transported through the membrane. They also serve as "receptors." These are able to bind with only "specific" molecules such as hormones or a nutrient that is vital to cellular maintenance. As a quick overview the cell membrane does the following:

1. Keeps vital components inside of the muscle cell, such as glycogen, atp, mitochondria, myofibrils and everything we will cover in the following paragraphs.
2. It also transports waste build up from the contractions of muscle fibers out of the cell.
3. Is permeable to nutrients that are vital to the life, maintenance and repair of our muscle cells. Such substances are amino acids, carbohydrate molecules ( glycogen stores ), oxygen etc.

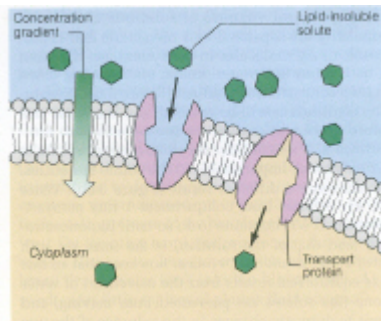
### Can You Manipulate The Uptake of Muscle Building Nutrients such as Glucose and Amino Acids?

Absolutely, but first I will explain a bit more about how the cell is selectively permeable. First I mentioned that lipids are not soluble to many molecules such as water. What is soluble can pass through the lipids however. I also explained that a membrane had pores, receptors and transporters all made out of protein molecules. This is where nutrients that cannot pass through the lipids enter into the muscle cell in a regulatory fashion. I must stress again, that the proteins responsible for regulation will only allow certain molecules to pass through the membrane. I will cover how the main processes occur:

**Diffusion** - This process is very easy to understand. It simply means that molecules move towards areas of less concentration. So let's say you finished working out and your muscle cells are dehydrated. The water outside of the cells in higher levels of concentration will move toward the areas of lower concentration until a balance has been reached! You can test this out right now using a cup of water and sugar. Place a spoonful of sugar in a plain cup of water. What happens? It starts to move toward the water with a lower concentration of sugar right? It continues busily moving until a balance has been sought. The same method of diffusion works with the pores in our cell membranes. As soon as a balance occurs, diffusion ends. Waste products will also diffuse out of the muscle fiber, when concentrations increase. And if a substance is fat soluble it can diffuse through the lipids.

**Facilitated Diffusion** - This is diffusion that is assisted by protein transports. When a needed nutrient is low in the muscle cell environment and it cannot pass through the pores, then it must be transported. This is similar to the above process except that it needs a boat to get across the plasma membrane and into the cell environment. Following a workout, when glucose concentrations are low, and you down a high carb drink, the glucose in your blood stream has a high concentration. This stimulates insulin to be secreted which thereby increases receptors known as Glucose 4 proteins to be translocated to the cellular surface. Further, muscular contraction will also stimulate these receptors. The combination of greater concentration of GLUT-4 receptors and the fact that the concentration gradient in the cell is low will cause the glucose to rapidly enter the cytoplasm.

Facilitated diffusion is shown below. The green nutrients are insoluble to lipids, they therefore must move across the membrane in a transported manner. The purple protein transporters as you can see take the nutrients, carry them across the membrane and then release them inside of the cell environment!



One surefire way to manipulate the permeability of a cell membrane is to workout. It damages the sarcolemma and makes it more permeable. This facilitates the entering in of several anabolic agents such as hormones, glucose, amino acids and

other nutrients. Also when you train, waste products build up in the cell and precious nutrients such as glucose are depleted. Therefore your muscles will suck up glucose at a much higher rate! It just so happens that glucose is vital for recovery and I will further expound on this in my muscle fiber article. This is one of the reasons that sugar is unlikely to be stored as fat following a workout. Because your muscle concentration levels are so low and permeability is increased big time! This is a second way is to increase your hormone levels.

For example, when insulin binds itself with the receptors on your cell membrane( 1 ), a host of protein transporters fly out to the top of the membrane, making it way, way more permeable! Therefore this increases the uptake of amino acids, glucose and even magnesium! Which equals immediate growth! Growth hormone is also a major player and testosterone is the grand daddy of them all. Again, following a workout, when a muscle is damaged, repair is the primary focus and receptors are extremely sensitive to hormones, which is why you will want to take advantage of the situation. It is for this reason, that future issues of the magazine will discuss how you can naturally improve specific hormone production! I will also stress how to further improve sensitivity to these hormones!

### **Journey Inside Of The Muscle Fiber!**

I just covered what a muscle fibers " gateway " was, but what exactly do you find once you have gained access? You find the cells Cytoplasm, which in regards to a muscle cell is called the Sarcoplasm. This is literally everything inside of the plasma membrane (cell membrane, or sarcolemma ) aside from the nucleus ( which will be discussed in further articles ). Using your residence as an example again, the Sarcoplasm is essentially the interior of your house and everything contained in it. These contents can be broken down into two clear areas. In order to explain this, I will compare a muscle fiber to a cigar. When you cut a cigar what do you see? Tiny threads of tobacco running the length of it correct? It is the same concept here, if you look into a muscle fiber, it will appear to be stuffed with little threads. These threads are called myofibrils and are a prime target for growth! They contain the elements that allow our muscles to contract. The second aspect we will discuss is what lies between these tiny threads. The muscle fiber is moist like the cigar. This moisture is similar to the texture of the gel you use for hair styling, and you will find it between and all around the myofibrils. It is called the cells " Cytosol " and has some very, very important features, vital to your success in this sport!

### **Cytosol Explained**

The cytosol is the intracellular fluid inside of the muscle fiber. This structure is extremely busy! It takes raw materials from the outside of the cell (passed through the cell membrane), then stores or converts those materials to useable energy. In other words this transparent gel contains such foods as amino acids for maintenance and repair, and glycogen (a complex carbohydrate) for energy. You see a muscle fiber must have a fuel source in order to contract. This is why the cytosol also has tiny organs called organelles, or microscopic organs. Perhaps the most significant of these is mitochondria, because it converts carbohydrates, and fats into ATP, which is our muscle cell's main energy currency (fuel).

Have you every wondered why your muscles are flat some days and on others full? As you recall the cytosol contains stored carbohydrates. Guess what? For every

carbohydrate gram you store an additional 2.7 grams of water! Whenever you consume plenty of carbs, your cytosol becomes saturated with them, and each carb pulls nearly 3 grams of water into this jelly environment! Therefore your muscles fill up like a balloon! You can always tell how anabolic your nutrition is by how full your muscle cells are. Usually on a cut, they become flat and your skin doesn't look very tight. This causes what I call, dieting blues. Because many athletes feel they are losing muscle, when in fact they are simply low on carbohydrate stores in their cytosol.

Just think about it...What is more impressive, a balloon filled up tightly with water, or one that is only half full? Since carbohydrates pull water inside of the cell, bodybuilders can use this to draw extra-cellular water that is outside of the muscle cell, into the cytosol before a contest or photo shoot. I'd tell you all the secrets to doing this now, but that would ruin my article on pre-contest carb manipulation! I know there are a lot of panicking dieters out there. Next time your training partner starts to panic, just tell him that he does not have enough glycogen in his cytosol.

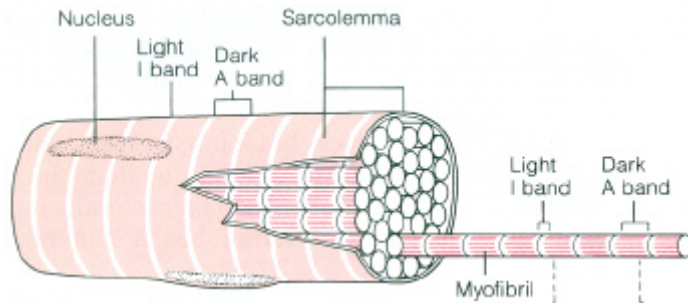
Let me also add, that these macronutrient (food) stores in the cytoplasm are very important to both training and growth! As I stated, your muscles use ATP as their fuel for both growth processes and contraction. Macronutrients are the main source of raw materials used to form ATP. Therefore, if your carb stores are low, your energy will suffer in the weight room.

**Note:** To place a functional bearing on what the cytosol and mitochondria do. I have included detailed useful descriptions about them in the muscle fiber 1-3 series. The information here, combined with that series will show you just how vital these are!

Also inside of the intracellular fluid is the Mitochondria (organelles). These are our cellular furnaces! They take the raw material inside of the cell and turn it into ATP. These tiny organs look like jelly beans spread throughout the cytosol. Let me just say this: " Your body depends on Mitochondria to produce ATP. If you cannot produce enough ATP you will lower energy levels in the weight room and eventually not be able to gain any more muscle! The opposite also holds true!

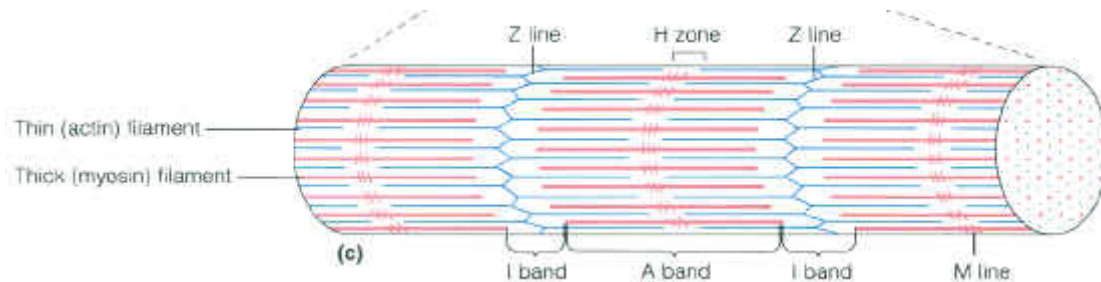
### **Myofibrils**

These are the threadlike tissue spread throughout a muscle fibers sarcoplasm. They are the contractile units of our muscles, which just shows their importance. A bodybuilder will spend most of his/her time stimulating growth and increasing the number of myofibrils in their cells! The reason for this, is that they comprise approximately 80 percent of the volume of a muscle fiber!



Using the picture as a reference, what do you notice about the myofibrils? They are made up of a series of smaller segments right!? You see those white lines? One white line (actually the black line between the white lines) to another makes up one segment of a myofibril and these are known as "sarcomeres." A sarcomere literally means "muscle segment." Therefore myofibrils, which are the functional units of skeletal muscle are made up of a chain of sarcomere units laid end to end, or "in series." This is actually very important and is one of the reasons why a person can build up the lower sections of a muscle group, such as the lower biceps. I will cover this in greater detail in my [physiological aspects of bodybuilding article](#).

What else do you notice? A series of dark and white bands correct? These dark and light bands make up each sarcomere and as they spread across a myofibril, they give it the appearance of being striped or striated, as we bodybuilders like to refer to it! The organized stripes that you are viewing are the main elements of each muscle segment, and are responsible for contraction (I will discuss how shortly)! They are actually two specific types of protein filaments or threads known as "myofilaments." Here is a closer picture (this is simply the myofibril above magnified) of what they look like:

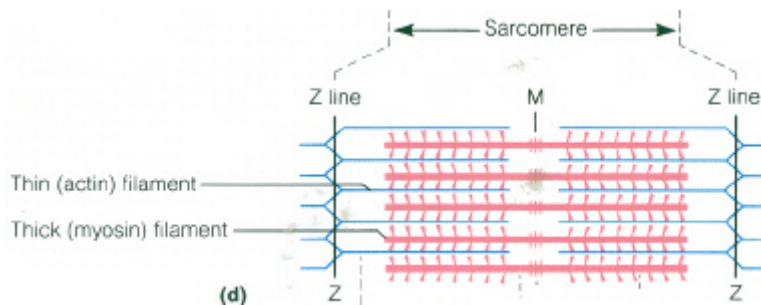


What we will do is dissect this particular structure. You can see several labels on this myofibril. There are Z-lines, I bands, A bands, M lines, actin and myosin. These can look confusing, but they are simply "labels" or "names" for the regions of each sarcomere. As I stated, there are two specific protein filaments that make up the sarcomeres and are responsible for contraction (4). The first is the blue "thin filament" called actin and the thicker (red) filament is called myosin. Again, these are protein threads. The A band is the darker section of the sarcomeres and this is where the thick myosin filaments extend all the way through and the thin actin filaments extend partway across it. Therefore the A band is where the actin overlaps the myosin proteins. The A actually stands for Anisotropic, which in German means that it appear darker as more light is absorbed. As German scientists looked through the microscope, this is what they noted and the name reflects this.

The I band is where only the actin proteins go across and meet each other, but where no thick filaments are found. In German, I stands for Isotropic and means that the area appears to be lighter as more light can go through it. The Z-line is simply a thin protein sheet that connects the actin filaments to each other and also connects each sarcomere to each other. The Z stands for Zwischenscheibe for 'between disk.' A sarcomere is everything between successive Z-Lines. The H-Zone is the spot on the A band, in which the actin proteins do not overlap the myosin proteins. The H stands for Hellerscheibe, which is German for clear disk. Finally the M line is darker because tiny protein strands connect one thick myosin filament to another. The M stands for Mittelscheibe for middle disk. To break this down into two simple sentences. The A band is darker because actin and myosin filaments overlap each other and the I band is lighter because they do not overlap each other, in turn giving a muscle fiber it's striated appearance. Furthermore all the seemingly confusing names for regions of a myofibril/sarcomere are simply labels for those regions based on how German scientists saw these regions under the microscope.

### How A Muscle Contracts

If we get a closer look at the contractile proteins (actin and myosin) of the myofibrils we can see that the process of contraction flows very nicely.

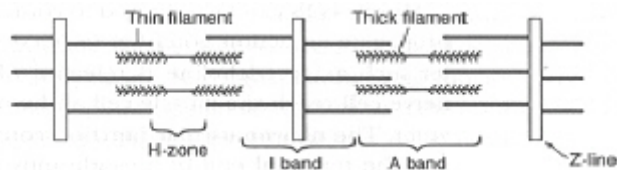


When magnified you will notice that the myosin filaments (thick) have tiny heads protruding out of them. These heads make contact with the actin filaments. Think of them as oars coming out of a boat and the actin protein as water. When your brain sends the signal for the muscle to contract, the myosin heads pull the actin proteins closer together, which in turn pulls the z-lines closer together, which in turn shortens or contracts the sarcomeres, and finally when thousands of these sarcomeres are contracting in a muscle group, the whole muscle shortens and pulls the bone that it is attached to in a the desired direction. Next time you flex your biceps, realize that your myosin heads are pulling your actin filaments closer together, which shortens the sarcomeres. Remember, sarcomeres in series are what make up a myofibril. Myofibrils are the main unit of a muscle fiber.

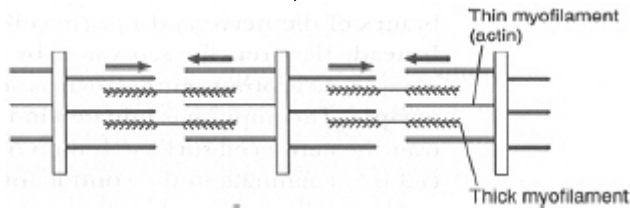
Note: For more detail on initiation of muscular contraction, see Wilson (2003, Is The All Or None Principle Applicable to An Entire Muscle?)

In order to fuel contractions, the myosin needs ATP and calcium. You see the actin proteins have binding sites that the myosin heads bind with to slide the actin molecules closer to each other. The problem is that these binding sites are covered or hidden by a protein called tropomyosin. In order to shift the tropomyosin to reveal the binding sites, calcium must be released from the muscle cells calcium

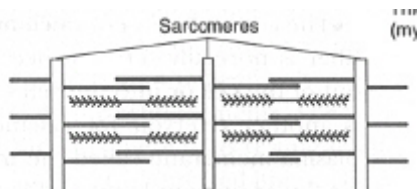
storage bin( known as the sarcoplasmic reticulum). This calcium then binds with a protein associated with the tropomyosin known as troponin, which causes the former molecule to be removed from its place on the binding site. Following this the actin can bind with the myosin heads by using ATP as its fuel. The binding of  $Ca^{++}$  serves as the molecular switch which not only removes the binding site, but triggers the breakdown of ATP to ADP + Pi. This process is called the " sliding filament " theory and was first analyzed by a man named Hugh E. Huxley (1957). It is the number one accepted theory today! Here is a review of what happens when a Muscle Contracts:



A. In a relaxed state, the thin filaments of the actin are separated.



B. When The Muscle is contracting, the thin actin filaments are sliding toward each other as the thick myosin filaments stay stationary . This causes the distance between the Z lines to decrease.



C. In a maximally contracted state, the thin filaments have overlapped one another and the sarcomeres have shortened to their maximum amount. The H zone has disappeared, and the I band has decreased in size dramatically.

The particular adaptation that bodybuilders seek is an increase in muscular size. In order to adapt to contractions a muscle fiber can increase the number of myofibrils it has, thereby increasing its contraction ability and the fibers overall size. Moreover they can add sarcomeres in series to the myofibril, which would lengthen it. All of these adaptations occur when you are lifting for " muscular hypertrophy. " This type of training is specific! In fact you have three different muscle fiber subtypes and each must be trained differently in order to stimulate hypertrophy. This is why I have dedicated three articles to this subject entitled [Muscle Fibers - An in Depth Analysis 1-3.](#)

**Veins, Capillaries and Arteries!**

Muscular contraction requires the energy contained within the ATP molecule. In order to synthesize ATP, vital nutrients such as carbohydrates are required, as well as the terminal electron acceptor oxygen. Further, metabolic waste products from muscular contraction as well as other cellular actions must be cleared out of the cell, in order to maintain proper function. Thus, muscles need a rich blood supply to deliver these nutrients. This process is carried out by blood vessels. In a general sense, a vessel is defined as a hollow utensil for carrying something: a cup, a bucket, a tube. Blood vessels, then, are hollow utensils for carrying blood. The largest of these are the arteries. They are the largest because they carry blood *directly* from the heart to the tissues and therefore must withstand the highest pressures. Capillaries are of prime concern here, as they are plentiful in muscle tissue. Think of capillaries as miniature vessels. Once the arteries carry their blood to the capillaries an exchange occurs, in nutrients and oxygen diffuse from the red blood cells into the surrounding muscle tissue and the blood cells in the capillaries then pick up the waste such as carbon dioxide. In actuality this process occurs due to concentration and pressure gradients. For example, the metabolic by product of energy production via aerobic metabolism is carbon dioxide. As blood courses through the capillaries, the gradient favors this CO<sub>2</sub> to diffuse from its higher concentration in the tissue, to its lower gradient in the capillaries. So too, the oxygen in the capillaries favors its movement toward the tissue until equilibrium is reached.

Veins are the opposite of arteries in that they carry blood back to the heart. Ever wonder why they have that cool greenish, blue color, that adds an incredible freakiness to the outer appearance of your muscles? It is due to the fact that veins in the systemic circuit carry deoxygenated blood. Hemoglobin, the molecule which carries O<sub>2</sub>, assumes a more reddish hue when bound to this molecule, and when unbound it assumes the color coursing through your veins.

Veins are very elastic to accommodate for blood flow and actually have muscle in the middle of their structure. When forced to accommodate for greater blood flows veins become stronger and can handle more blood volume. Moreover the muscle which is in the middle of the veins can be hypertrophied( 1 ) by increased circulatory needs, therefore enhancing the size of your veins! Anyone who emphasizes extreme blood pumps will increase the size and strength of their veins.

Capillaries connect a muscle to our cardiovascular system. They do contribute to the size of a muscle as well. A increased blood demand will actually cause muscle **capillarization**.

Therefore, exercises such as supersets, flexing between sets and anything that increases the blood pump will increase vascularity, muscle size and your ability to recover faster between sets! I say it will improve recovery for obvious reasons. You will have a greater ability to deliver precious nutrients and carry waste products outside of your muscles.

### **Connective Tissue - The Stuff That Puts Everything Together!**

We now have a clear anatomical understanding of the functional unit of a muscle, which is the muscle fiber. What is important to grasp is that most muscles contain hundreds and thousands of these fibers. Which means that the body must arrange them in an organized fashion in order to form a working muscle group, such as the biceps, pecs and quads! Further, we need to understand the function of a muscle

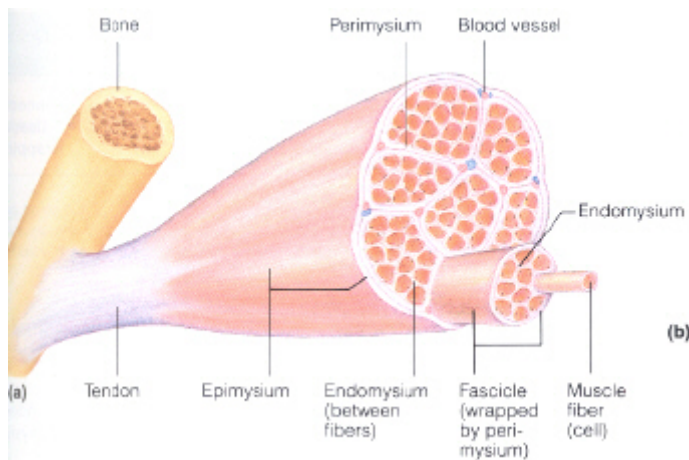
group, which essentially is to stabilize and move our skeletal system. Therefore, once these muscle cells are organized in a functional pattern they need to be attached or indirectly attached to the bone they are responsible to move.

In order to accomplish these important aspects that allow us to freely walk, talk, run and eat pizza ( like I said I'm dieting! ) our body uses connective tissue called " fascia. " An individual muscle is separated from neighboring muscles and held into place or position by layers of this fascia. In addition to holding a muscle in place, this connective tissue ( called connective because it literally binds and connects structures ) also extends away from the muscle fibers and protrudes into a cord like shape, attaching the muscle group to the bone. This extension of the fascia is called a " tendon. "

The word fascia means bundle or band and it does exactly that, it bands tissues and organs together in a collective manner. On a whole it is a very fibrous, course, flexible, and strong tissue. Just to show you how strong, a tendon, can resist 8, 600 to 18, 000 pounds per square inch! ( 2 ) That boggles the mind does it not? As does the entire human body! It is without a doubt the most amazing machine ever created!

### **Breakdown of Connective Tissues and How A Muscle Fiber Is Organized**

There are two types of fascia. The first is called superficial fascia and it lies immediately underneath the skin. This is the tissue that holds water and fat. The reason why I mention it, is obvious. From an anatomical standpoint you can see why fat obstructs your muscles form showing clearly. You have to first burn the fat from within the superficial fascia. What we are concerned with is the deep fascia, which holds the muscles together. Here is an illustration of a diced open muscle and all of its layers:



As You can see the outer most layer of the muscle is the deep fascia. Again this is very dense tissue and is strong from every direction to provide the muscle fibers with the absolute highest level of protection and mobility. You can also see that the deep fascia extends out into a cord like arrangement which is the tendon. The tendon attaches to the bone. What I am going to tell you is very important! The part of the muscle that attaches to the more fixated bone is the origin of a muscle group, and

the part of the muscle that attaches to the more moveable bone is called the insertion point. This will be elaborated on this in many articles.

I will now break down the above picture from the smallest unit to the largest.

1. Muscle Fiber - This is the functional cell of a muscle group.
2. Endomysium ( Sheath ) - Every muscle fiber is wrapped with a thin sheath or casing of connective tissue. This surrounds each muscle fiber, protects and separates it from neighboring muscle fibers( 3 ). Think of the endomysium as the casing on a pen. Inside you have the inch filled plastic containing ink. It is the functional part of the pen, but the ruff plastic around it simply protects the ink inside and makes the pen more functional for you. If the pen didn't have this, then the thin plastic would break in your book bag or brief case and probably get all over your clothes! This is essentially the same principle. The Endomysium is a sheath for the muscle fiber or container. It is very thin and hugs the fiber. However, there are other functions it is involved in. For example, it serves to insulate the muscle fiber, such that electrical impulses are contained within it( see Wilson, 2004 - Is the All Or None Principle Applicable to An Entire Muscle Group? )
3. Fascicles ( bundles ) - Fascicles are bundles of muscle fibers encased in their endomysiums. If I picked up a stack of pens and held them in a bundle, they would look like fascicles. This term literally means bundles, so these two words should stick together and you shouldn't have a problem envisioning them. I will come back to this over and over, but a muscle's overall ability and function is determined by the arrangement of these fascicles. Just hold on to that and I will address it again.
4. Perimysium - The perimysium is to the fascicles what the endomysium is to the muscle fiber. In other words each bundle of fascicles is wrapped by a strong, dense tissue called the perimysium. By the way, Peri means around! So think of this connective tissue as simply rapping around and protecting and organizing the fascicles so they can work together.
5. Epimysium - Remember a fascicle is a bundle of muscle fibers bound up in the perimysium. In order to form a muscle group you need several bundles to work together! Therefore we now take the fascicles wrapped in perimysium, bundle them up and wrap them in an even stronger and courser connective tissue called Epimysium. Epi means to surround. So this thick layer of connective tissue " surrounds " and binds together all of the bundles of muscle fibers called fascicles.
6. Finally the whole thing is covered by deep fascia which holds the muscle fiber in place. This as shown by the picture above extends out to form the tendon which is attached to the bone.

#### **Fascicle Arrangements = Biceps, Delts etc!**

The arrangement of the fascicles( within a muscle group ) will determine the overall shape and functional capabilities of the muscle group. Here is a list of the main muscle group " types " you will find in the human body.

**1. Parallel** - The name says it all! The fascicles( which are bundles of muscle fibers! ) run parallel to each other. They begin and end at one tendon to another. The biceps are a perfect example of a parallel arrangement of fascicles. They are side by side and terminate from insertion to origin.

What do you notice as far as function in muscles such as the biceps? They have a very long range of motion correct? The reason why they have such a great range of motion is due to the length of the muscle group. You see a muscle can shorten to about 70 percent of its resting length when contracted and lengthen to about 130 percent of its resting length. Therefore the longer and closer to being parallel the muscle is the greater its range of motion will be.

**2. Pennate** - The word Penna actually means feather. Pennate muscles literally look like feathers! In a parallel arrangement the fascicles are long and run between the tendons. In a pennate arrangement the fascicles are very short and attach obliquely to the tendon that runs the length of the muscle group. Obliquely essentially means slanted and to the side. Imagine the tendon as being the shaft of a feather, and the fascicles being the barbs that protrude out of the shaft.

There are three main subtypes. The first is unipennate ( one ) in which the fascicles insert into only one side of the tendon. When they insert into opposite sides or both sides they are known as bipennate ( bi meaning two ). The third is multipennate, which resembles many feathers side by side, all inserted into one large tendon. The best example of this is the deltoid muscle!

What is one thing that stands out about the deltoid and rectus femoris muscles? They are strong right!? This is because these stocky muscles can carry the most muscle fibers. Think about it, the pennate arrangement allows fascicles to pack themselves in all along the sides of the tendon, where a parallel muscle does not. However range of motion is lessened compared to parallel arrangements.

**3. Convergent** - In this type of arrangement the muscle fibers spread out over a wide area but they all converge or join together into one attachment site. The muscle fibers literally spread out like fan! One muscle that fits the bill here is the pectoralis.

The most prominent feature of a convergent muscle is its versatility! The reason for this, is that different portions of this muscle can pull in different directions!

A convergent muscle has versatility, because the stimulation of only one portion of the muscle can change the direction of pull. However, when the entire muscle contracts, its fibers do not pull as hard on the attachment site as would a parallel muscle of the same size. The reason is that the convergent muscle fibers pull in different directions rather than all pulling in the same direction.

## **Conclusion**

There was a tremendous amount of information presented today. In order to enhance your comprehension I will constantly refer back to the principles in this article and re-explain them throughout the anatomy section! Before I leave however I would like you to know the real reason why I wrote this article.....You see, I believe that you are the one!

Sincerely

Jacob Wilson [jwilson@abcbodybuilding.com](mailto:jwilson@abcbodybuilding.com)

President Abcbodybuilding / Co-Editor of The Journal of HYPERplasia Research

#### **References**

1. Frank Netter, Atlas of Human Anatomy  
CIBA-GEIGY 1989. ISBN 0-914168-19-3
2. Hollinshead and Jenkins 1986
3. Harold Ellis, Bari Logan, Adrian Dixon, Human Cross-Sectional Anatomy  
Butterworth Heinemann, 1991. ISBN 0-7506-1241-X
4. Man-Chung Han, Chu-Wan Kim Sectional Human Anatomy © the authors, 1989.  
ISBN 0-89640-165-0
5. Gray's Anatomy : The Anatomical Basis of Medicine and Surgery (British Edition.  
38th Ed); Henry Gray, et al; Hardcover