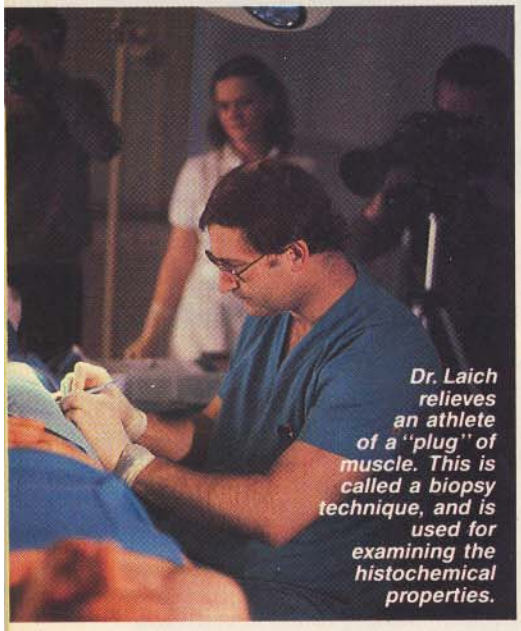
FIBER-SPECIFIC

That's what your training should be for maximum results!

By Bill Laich, MD, PhD



Dr. Laich relieves an athlete of a "plug" of muscle. This is called a biopsy technique, and is used for examining the histochemical properties.

Dr. Bill Laich practiced medicine in Europe before coming to the United States to work with me at the Craft Center's Division of Sport Sciences. His work in the field of peak performance biochemistry is legendary around the world, including the Eastern Bloc countries. After he received his MD, he went on to receive his PhD in this unbelievably complex field. Dr. Laich, however, has a unique ability to bring this complex but vital information on sports biochemistry down to a level of total simplicity and in-the-trenches usefulness. I know of precious few individuals with such a talent, let alone such a vast storehouse of functionally explicit knowledge. He has been asked by Joe Weider to explore the biochemistry of bodybuilding in a series of articles over the next several issues.

Frederick C. Hatfield, PhD
Director, Craft Medical Rehabilitation Center

Many other types of athletes nowadays train with weights to get bigger and stronger, but only bodybuilders end up *looking like bodybuilders.* Weightlifters, shot-putters, discus throwers and other strength and power athletes develop big muscles, but not the kind of refined physiques you see on good bodybuilders. Boxers, gymnasts, swimmers and water polo players may look muscular and show a lot of definition, but the look of massive, ripped-up muscularity attained by a competition bodybuilder is unique in all of sports.

Bodybuilders develop a unique look because they follow a unique training and diet regimen. The concept of specificity of training provides that *specific types of physical training yield specific results.* So to look like a gymnast, train and eat like a gymnast; and to look like a bodybuilder, train and eat like one.

So the first goal of any training program is to build a significant amount of muscle size — and muscle size is best defined by looking at these parameters:

1) about 25–30% is composed of *myofibrils,* which are better known as contractile proteins such as actin, myosin, troponin and tropomyosin

2) about 20–30% comes from *sarcoplasm,* that gelatinous liquid in which all of the intracellular components of the muscle fiber are floating

3) about 10–20% is the mass of *mitochondria,* the special "energy factories" within each cell

4) the remaining percentage applies to *viscoelastic components,* along with capillaries, fat deposits, glycogen, connective tissue and other subcellular components.

Over the years, as bodybuilders have come to understand more about muscle structure, they have adopted the following general principles:

1) To hypertrophy muscle fiber, to make it bigger and stronger, train with heavy weights, low reps (6–8), fewer sets and plenty of rest between those sets. (See Victory guide found in the Victory series of food supplementation to enhance training success for further information.)

2) To increase endurance factors such as mitochondrial mass, blood supply and glycogenation, train with lighter weights, higher reps and more sets and limit the amount of rest between sets to induce depletion and allow for subsequent supercompensation.

Or, put another way, the most accepted approach to training nowadays is to hypertrophy the muscle fibers — increase all of the components of muscle — by using highly specific adaptive stress.

This training prescription is true as far as it goes. But it also leaves some very significant factors out of the equation. For example, there is the matter of *muscle fiber types.* Most bodybuilders are aware of the two basic types of muscle fibers — fast twitch and slow twitch, white and red fiber, the former designed to contract with maximum speed and power for a short time, and the latter to contract at a slower speed and with less power but able to continue its contractions for extended periods of time.

Given the fact that there are more than one kind of muscle fibers, each with its own nature and characteristics, it follows that there must be more than one way to train muscle in order to make it bigger and stronger. In fact, this information suggests a whole host of questions, such as:

1) Can you actually make both white and red fibers bigger by the appropriate kind of training?

2) Assuming you can indeed enlarge both white and red fibers through training, is it easier to make one kind of fiber bigger than the other?

3) To get the best results, how does the way you train one kind of fiber

differ from the way you train the other?

4) To be a great bodybuilder, is it necessary to be genetically gifted with more of one kind of fiber than another? If so, which kind? And how much?

5) What about specific bodyparts? Is it possible to have a preponderance of one kind of fiber in one part of the body and of a different kind in another part? If so, how can you tell which bodypart is mostly red fiber and which is mostly white? And how do you design a training program to take this difference in fiber distribution into account?

To answer these questions, let's take a closer look at the nature and function of the different kinds of muscle fiber. To begin with, while there are indeed two basic kinds of muscle fiber type, there are also five subtypes, which also need to be considered in designing an effective bodybuilding program. Anaerobic fibers (Type II, fast-twitch, white) fall into subtypes B, A and C. Aerobic fibers (Type I, slow-twitch, red) are subtyped as either B or A. (See Figure 1.)

FIGURE 1: MUSCLE FIBER TYPES

ANAEROBIC			AEROBIC	
TYPE II — FAST TWITCH			TYPE I — SLOW TWITCH	
WHITE			RED	
Subtype B	A	C	B	A (rare)
(ATP, CP) [Alactic]	Glycogen (Carbs) [Lactic]		Beta-Oxidation (Fat)	

Let's take each of these subtypes and examine them in more detail:

Type II-B is the fastest and most explosive of the fast-twitch muscle fibers. It comes into play only when you train with 100%, all-out intensity and at maximum speed. It uses the adenosine triphosphate (ATP) and creatine phosphate (CP) stored in the muscle cell for fuel, and the metabolization of these substances does not result in any buildup of lactic acid. However, since supplies of these energy sources are extremely limited, Type II-B fibers run out of fuel after only about 10 seconds of continuous effort. Like the other fast-twitch subtypes, Type II-B does not require the use of oxygen to produce energy, so it is classified as *anaerobic.*

Type II-A is a fast-twitch fiber that uses an anaerobic process to break down glycogen, synthesized from dietary carbohydrate, to produce ATP to fuel muscular contraction. Given the greater availability of glycogen in the muscles, the II-A fiber can continue to produce powerful contractions for something like a full two minutes. However, one of the byproducts of this kind of energy metabolism is the production of lactic acid. The accumulation of lactic acid gradually blocks the activity of the regulating enzymes in the glycolitic pathway which supplies energy for this type of activity. Lactic acid buildup partially accounts for the "burn" and fatigue you feel in the muscles toward the end of a particularly intense set.

Type II-C fiber is a kind of undifferentiated fiber that is intermediate between the fast-twitch and slow-twitch fiber. As a result, it can take on the characteristics of either, depending on the kind of training it is subjected to. This type of fiber is fast twitch and is high in oxidative capacity.

Type I-B, the most common slow-twitch fiber found in the body, is a red, slow-twitch fiber that depends primarily upon the beta-oxidation process of fat breakdown to fuel its contractions. This process is an aerobic one (which means it uses oxygen) that is able to provide a steady, long-term source of energy for muscular contraction. However, this energy is produced by the breakdown of fat through the process of beta-oxidation occurring inside the mirochondrial matrix rather than the metabolism of glycogen which occurs in the sarcoplasm. This energy supply is delivered to the site of muscular activity at a relatively slow rate, so that aerobic activities that depend upon it must take place at a low-level of intensity so as not to outrun the biochemical efficiency of the delivery system. However, the aerobic system is so effective and efficient that the well-trained athlete can continue that activity for surprisingly long periods of time.

Type I-A fiber is a slow-twitch, aerobic fiber that is actually exceedingly rare and is found only in athletes like ultramarathoners and some triathletes whose incredibly high-volume activities are designed to go to the limits of human endurance. Type I-A fibers differ from Type I-B fibers in that they possess more abundant lipids (for energy) and oxidative enzymes.

A few other characteristics of anaerobic and aerobic muscle fibers should be noted:

1) Both fiber types have the capacity for both aerobic and anaerobic energy production. Anaerobic fibers are not completely anaerobic, they are predominantly anaerobic, and aerobic fibers are predominantly rather than exclusively aerobic. In each case, what determines whether the fiber will draw its energy from aerobic or anaerobic sources is whether the enzymes present are more active in the aerobic or anaerobic pathways. (See Figure 2.)

FIGURE 2:
Relative Characteristics of Enzymatic Activities of Fast- and Slow-Twitch Muscle Fibers

	Myosin ATPase	Anaerobic Enzymes	Aerobic Enzymes
Fast-Twitch	1.0	1.0	1.0
Slow-Twitch	0.4	0.5	1.5

2) At 100% intensity, all the fibers are working all the time. However, depending on how long the activity continues, the body relies on one fiber type or another disproportionately to overcome the resistance involved. So *Type II-B fiber does a predominant* amount of the work for about 10 seconds. When that is exhausted Type II-A takes over, and after about two minutes, as the fuel for that fiber subtype runs out, the aerobic fibers come progressively more into play.

3) Both types of fiber grow bigger and stronger when subjected to adaptive overload. However, white fibers are approximately 22% bigger in diameter than red fibers to begin with.

4) Fiber can actually switch type to some degree, depending on the kind of training it receives. That is, you can develop greater endurance capacity in white fiber and increase the strength and power of red fiber by specific types of training programs. However, it is much easier to produce changes in the aerobic direction. That is, you can increase the endurance capacity of a strength or speed athlete with relative ease, but it is much more difficult to build the strength and speed capacity of an endurance athlete. However, in increasing a strength athlete's endurance, you do so at the expense of his strength or speed.

The anaerobic, fast-twitch system, although faster and more powerful, is much more primitive than the aerobic system. It was developed very early in

the history of living organisms, back when oxygen was a highly toxic element to life.

However, although red fiber is primarily designed for endurance activity and is smaller than white fiber, as mentioned above it can be made bigger, stronger and faster, when trained in a highly specific way. In fact, since all bodybuilders possess a certain amount of red fiber, *they must be able to force an adaptive response in red fiber as well as white in order to create a totally developed physique.*

However, to be effective at developing one kind of fiber or another, the training involved must be *fiber-specific.* That is, the kind of training program that most efficiently hypertrophies white fiber is not the same as that which hypertrophies red fiber. And until bodybuilders understand the difference, they will not be able to create a training program that will allow them to fully develop every muscle in their bodies.

The variables involved in creating these fiber-specific programs include those already familiar to experienced bodybuilders:

1) Amount of weight used
2) Number of reps
3) Number of sets
4) Amount of rest between sets

Training, frequency, intensity & duration

and one that too many bodybuilders are not sufficiently aware of:

5) *Speed and explosiveness of repetitions*

To illustrate how differential speeds of movement stimulate different responses, here's an example. Two groups of athletes do squats five times a week, with one group doing heavy squat movements slowly, at a rate of something like 30 degrees per second, while the other group performs the lift with a lower weight and more rapidly, at closer to 100 degrees per second. Both groups are elite athletes, with a good development of both white and red fiber to begin with. At the end of three months of this kind of training, you'd see selective hypertrophy of the white, fast-twitch fiber in the group performing the squats quickly. In the group doing the movement slowly, you'd see the opposite — the red fiber hypertrophied.

In explosive movements, speed is necessary, but not enough. Accelerating the weight upward as fast as possible, right from the first instant of the concentric part of the movement, vastly increases the amount of power generated. *Power* is defined as: the weight times the distance the weight moves divided by the time it takes to perform the rep. You need to lift fast, but the weight you're lifting has to be heavy enough. If the weight used is too light, little power is generated; if the lift is too slow, again you don't develop enough power.

In practical terms, you select a weight you can normally do eight repetitions with, lower it as you normally would and then explode it upward as hard as you can (being careful, of course, not to lose control of the weight in the process). If you can do 6–7 explosive reps but find you have to slow down for the eighth, you've achieved about the ideal power output.

Muscle tissue is cross-sectioned and stained with myosin-ATPase at different pH values to expose fast, slow, and intermediate-twitch fibers, a technique essential in training and technique analysis.

Muscle tissue stained with Hematoxyline-Eosine reveals the sarcoplasmic and contractile components of muscle, as well as all the peripherally located nuclei.

Red fiber hypertrophies to the greatest degree in response to heavy, low-rep training, just as white fiber does. But since slow-twitch (red) fiber is aerobic in nature, the way you force it to do most of the lifting during intense, low-rep sets is by *cutting down the amount of rest period between the sets.* Without at least two minutes to rest between sets, the white fibers in the muscle cannot sufficiently recuperate but the red fibers can, which makes this kind of training *red-fiber specific.* Rest for two minutes or more between sets, however, and your white fibers will have had time to recuperate, making these sets *white-fiber specific.*

To sum up the difference between the way you train white fiber and red fiber:

WHITE FIBER

To hypertrophy white (anaerobic, fast-twitch) fiber:

1) Use heavy weight.
2) Use explosive movements that generate maximum power.
3) Do relatively few sets (3–5) in the 6–8 rep range.
4) Rest a full two minutes or more between sets for full recuperation of the fast-twitch fibers (3–5 minutes is not uncommon).

RED FIBER

To hypertrophy red (aerobic, slow-twitch) fiber:

1) Use heavy weight.
2) Keep your sets in the 6–8 rep range.
3) Keep the rest periods between sets down to one minute or less.
4) Do more sets (5–8) than when training white fiber.
5) Lift as explosively as you can, but don't expect to achieve the same level of power in your lifts as when doing white-fiber specific training.

You can program these different types of sets into your workouts a number of different ways:

- You can do full-rest, white-fiber specific sets at the beginning of your workout, then follow them with a series of limited-rest, red-fiber sets, taking advantage of the natural fatigue of the fast-twitch white fibers.
- You can cycle the two types of sets, doing white-fiber training in one workout, red-fiber training in another.
- You can combine the two types of training, using techniques like the Stripping Method — hit the white fiber with 6–8 heavy reps, strip some weight off the bar after these reps and continue doing more reps. Your white fiber will be doing the majority of the work at the beginning of a set like this and the red fiber at the end.

Of course, total bodybuilding training requires that you also work your muscles aerobically, that is, do relatively high-volume reps and sets with moderate to light weight and minimum rest to develop aspects of total muscle volume like mitochondrial mass. But *too much* of this kind of training, especially when combined with high levels of additional, nonweight-training aerobic activity, is a mistake for two reasons:

1) The lower-frequency signals sent out by the nervous system to activate red fiber seem to have an inhibitory effect on the development of white fiber, resulting in some degree of atrophy of the white fiber when too much of the low-frequency stimulation is present.
2) With training programs that in-

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to pay close attention to what you're doing when you're putting those dumbbells back on the rack. For the same reason we want to avoid overrotating our lower back with twisting movements you see so many people doing with a broom handle across their shoulders. The lower back is designed to rotate only 30 degrees. Any more than that and you are stressing the disks and ligaments.

Along with lifting technique, form is critical to injury prevention. The lower back is strong and stable when it is held in a tightly arched position. If you do bent-over barbell rows or T-bar rows and use so much weight that your back is rounded, you're asking for trouble since this position puts tremendous stress on the ligaments and tissues.

Even if you use the correct form, the possibility of injury still exists, especially when you're lifting heavy. If you exceed the tissue's capacity, something's gotta give. If you refer to the chart on disk pressures, you'll see that when you're seated, the disk is under much greater stress than when you're standing, so remember that body position can also contribute to overload. Fortunately the most common injury in our sport is a lower back muscle strain, or a sprain of the spinal ligaments. Although both can be quite painful, with proper rest and care, they quickly heal.

In the future we'll look at more active means of preventing a lower back injury by strengthening the muscles and maintaining proper spinal care. □

HOW ABOUT A GOOD STIFF BELT?

Just about everybody you see in the gym these days wears some kind of lifting belt. In fact, lifting belts have even become a fashion statement. What people don't understand is that, while a lifting belt is a valuable tool that no bodybuilder should be without, it is not something that should be worn at all times.

Wearing a belt helps keep the lower back straight and supported. This helps maintain the protective lower back arch when doing deadlifts or squats, for example. A belt can also limit excessive or potentially dangerous lower back movement as when doing a sloppy set of cheat curls. But the real reason that a belt adds stability is it increases the intra-abdominal pressure, thereby supporting the spinal column from the inside. This happens because the weight-bearing vertebral bodies are located more in the center of the abdomen than most people think. Increased abdominal pressure pushes inward on the spine from all directions, which gives added stability.

It makes sense to wear a belt when doing squats, deadlifts, overhead presses, or heavy standing calf raises, for example. Wearing a belt throughout the entire workout, though, especially if worn tightly, may be counterproductive. You may not need it all the time and you definitely don't want to wear it when it would limit the desirable part of the movement on such exercises as abs (yes, I've seen people wear a belt when doing ab work) or hyperextensions. Even between sets of heavy squats, the belt should be loosened to allow for better circulation and ease of breathing.

— *T.D.*

HOW MUCH PRESSURE ON YOUR DISKS?

We want to keep the disk as healthy and injury free as possible. If we don't we're in for some real pain and possible nerve dysfunction. This is how much pressure a disk is subjected to in various circumstances.

BODY POSITION	PRESSURE ON THE DISK
Lying down	100 pounds
Sitting upright	300 pounds
Lifting 40 pounds with knees bent	400 pounds
Lifting 40 pounds with knees straight	900 pounds

Why is the pressure so much when you're seated? Because the supporting muscles are less active and therefore the disks have to take on more of the load. Keep in mind that the stiff-legged deadlift, especially if the back is rounded, shifts the center of gravity forward and makes for poor leverage. This puts a lot of pressure on the disks. — *T.D.*

MUSCLE FIBERS

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volve extremely high or excess amounts of aerobic activity, the red fiber involved tends to *cannibalize* the white fiber for needed energy and nutrients, with consequent white fiber atrophy.

Another common concern of bodybuilders is whether or not they have the right kind, distribution and proportion of muscle fiber to succeed in the sport. Certainly, in some sports preponderance of one type of fiber or another makes all the difference. Weightlifters, for example, depend upon being able to recruit huge amounts of muscle fibers in one powerful burst, so they would obviously need to have a disproportion of white, fast-twitch fiber available to accomplish this task.

Marathon runners, on the other hand, although they may benefit from having some white fiber available for a last-minute "kick" to the finish line, obviously depend almost entirely on red, slow-twitch fiber to sustain them over a two-hour-plus period of running.

However, since bodybuilders do not need to be especially strong nor have huge amounts of endurance, and since both fast- and slow-twitch fibers are capable of being hypertrophied by the proper kind of training, *there is no reason to believe at this point that any particular kind of muscle-fiber distribution is necessary to success in bodybuilding competition.*

What is important, however, is that bodybuilders fully develop all their muscles — whatever kind of muscle fiber, white or red, they happen to have in each muscle group — with these considerations:

1) Bodybuilders whose physiques are of predominantly different types of muscle fiber will have to train with different kinds of programs for optimum results.

2) Since the distribution of muscle fiber is usually different in different parts of the body, to get the maximum of development bodybuilders have to

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determine the approximate ratio of red-to-white fiber in each major bodypart and develop a program to work each muscle group in a highly specific fashion.

The speed capacity of muscle fiber is limb specific. For example, many baseball pitchers can throw 95 mile-per-hour fast balls but can't run very fast. Or a boxer may keep throwing "punches in bunches" for 10–12 rounds without letting up, but lack a knockout punch — showing he has more red fiber in his physical makeup than white, and thus more endurance capacity than the ability to generate sheer power. We've always known that athletes of similar size and body type can differ tremendously in abilities such as speed or endurance, but it wasn't until we began to see the importance of fiber type on performance that we began to better understand why.

Along the same lines, a particular bodybuilder might have a preponderance of white fiber in some muscles but a greater proportion of red fiber in others. Ideally, a good portion of his white fiber training should therefore consist of heavy, explosive movements, with lots of rest between sets. But if he trains his red fibers the same way, he'll be stimulating growth predominantly in the relatively sparse white fiber rather than the abundant red fiber population. For his red-fiber bodyparts, he'd do better to rely more on heavy sets done one after another with a minimum rest, forcing the aerobically talented red fiber to do most of the work.

A lot of bodybuilders don't make this kind of adjustment. If one bodypart responds particularly well, the tendency is to train all the other bodyparts the same way. Which, as we can see, may be a very big mistake.

There isn't any quick and simple way to determine what kind of muscle fiber predominates in your physique or each of your bodyparts, short of undergoing multiple muscle biopsies and complex histochemical studies. In practical terms, bodybuilders should begin by doing a total program that includes *all* these styles of training (which is what the Weider Holistic Technique is all about) and establish by trial and error which approach yields the best results for each muscle group and then alter the proportion of training — how much for white fiber, and how much for red — accordingly.

Ultimately, it isn't the type of fiber or the proportion of one fiber to another that determines whether or not

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you have the makings of a champion bodybuilder. Rather, assuming your workouts are as effective and as fiber specific as you can make them, it is *what your fast- or slow-twitch fiber DNA instructs your muscles to do in response to the stimulation of that training.* That is, whether you have the necessary genetics to respond to the specificity of training for building all types and subtypes of muscle.

Actually, there may be some reason to believe that the instructions for muscle building buried deep within your DNA may not be as immutable as once thought. Imagine the possibilities if you could actually alter and to some degree reprogram your DNA, to put it into a kind of overdrive that could redefine and expand the limits of your genetic potential!

An interesting idea — and one that we will explore in detail in a future issue of MUSCLE & FITNESS. □

Dr. Bill Laich is known internationally as the leader in the fields of high performance biochemistry and biomechanics for elite athletes. He is the Director of the Sports Sciences Laboratories at the Craft Medical Rehabilitation Center in Reseda, California.

For questions and comments contact Dr. Bill Laich, Director of Sport Science and Research, The Craft Center, 18618 Sherman Way, Reseda, CA 91335, phone (818) 705-0777.