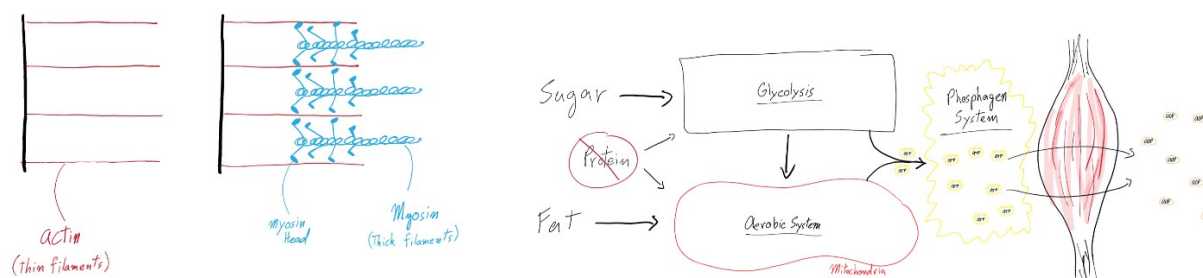


Muscle Types- Sprinter vs Miler

Every muscle in your body is made of millions of individual muscle cells or fibers. Not all fibers are equal. We touched on this in the last two chapters (Muscles and Energy Systems), but today we are going to really dive in (sorry about the pun). Today we will start to see **what is different between “sprinters” and “milers.”**

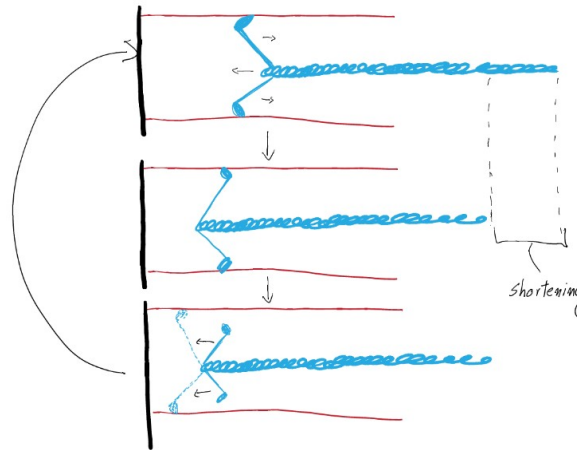
The Spectrum: Fast vs. Slow Twitch Fibers



In the Muscles chapter we talked about the machinery it takes to allow muscles to get shorter, specifically actin, myosin, and myosin heads. In the Energy Systems chapter we talked about how those machines are fueled, and saw that muscles (and most other cells) use a hybrid system of engines to generate energy, stored as ATP. To understand what we are talking about you have to remember this one fact: **Not all myosin heads are the same, and different muscles fibers get most of their energy from different engines.** And because the two main energy systems (glycolysis and aerobic) use different fuels to burn (sugar and fat), those fibers will store those fuels differently too. It is easiest to think about “what is this fiber trying to do” and “what does it need to do it.” Here is a summary table:

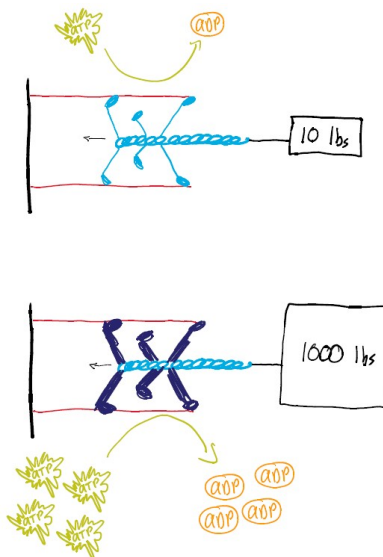
	The Goal	Myosin Head	Mitochondria	Fuel	Chicken	Power Graph
Fast Twitch Fibers	Move heavy stuff for a short Time		Small, few	Sugar	White Meat	
Slow Twitch Fibers	Move light stuff for a long Time		Large, Many	fat O ₂	Dark Meat	

As you can see, there are **three main factors that determine what kind of muscle fiber** you have: what type of myosin head you have, the major energy system used, and what fuel is stored. Let's look at each part of the muscle fiber and put the pieces of the puzzle together, starting with myosin heads. Remember, these are the proteins responsible for the “pulling” action that allows muscles to shorten.

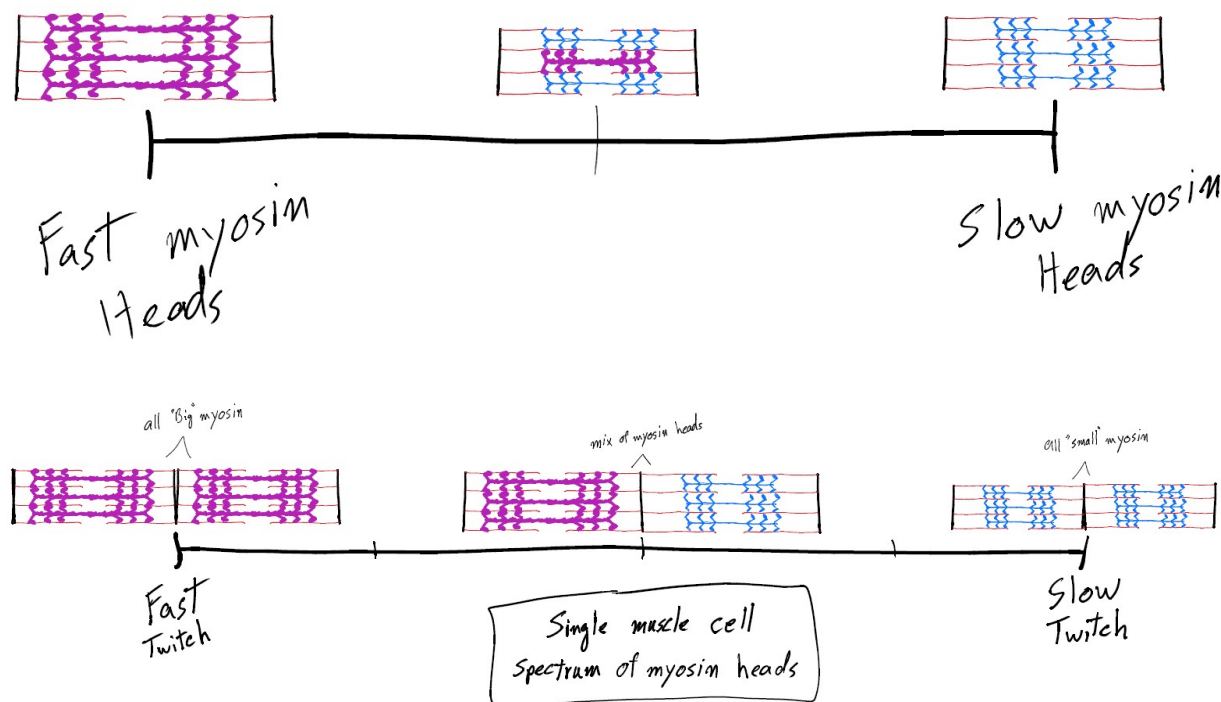


Fast twitch fibers, aka... fast fatigable, aka... fast glycolytic, aka... type I fibers. As these names suggest focus on shortening quickly and with a lot of force, but they don't last very long. These fibers focus on developing **myosin heads that burn through ATP at a huge rate**, and allow the muscle to shorten at maximum speed and power. This is great for sprinting.

Slow twitch fibers, aka... slow oxidative, aka... postural, aka... type II fibers. These fibers on the other hand focus on shortening slowly and with very little force. They have **myosin heads that use up ATP slowly, but can maintain their contraction for a long time**. Perfect for the mile.



It is easiest to think about just two extreme types of myosin heads, slow and fast. But **in reality there is a whole spectrum of possible myosin heads that lie in between the extremes of fast and slow**. On top of that, inside a single muscle cell can be any combination of different myosin heads, not just one type. This **allows a single muscle cell to have any capability it wants**: slow, fast, or something in between simply by having a different combination of myosin heads. This is one of many factors that explains why there is a difference between sprinters and milers.



Tangent: Don't be fooled into thinking fast twitch fibers mean "fast moving limbs." There is a lot more that goes into that. The big difference in fast and slow fibers is how heavy an object they can move, and how long they last.

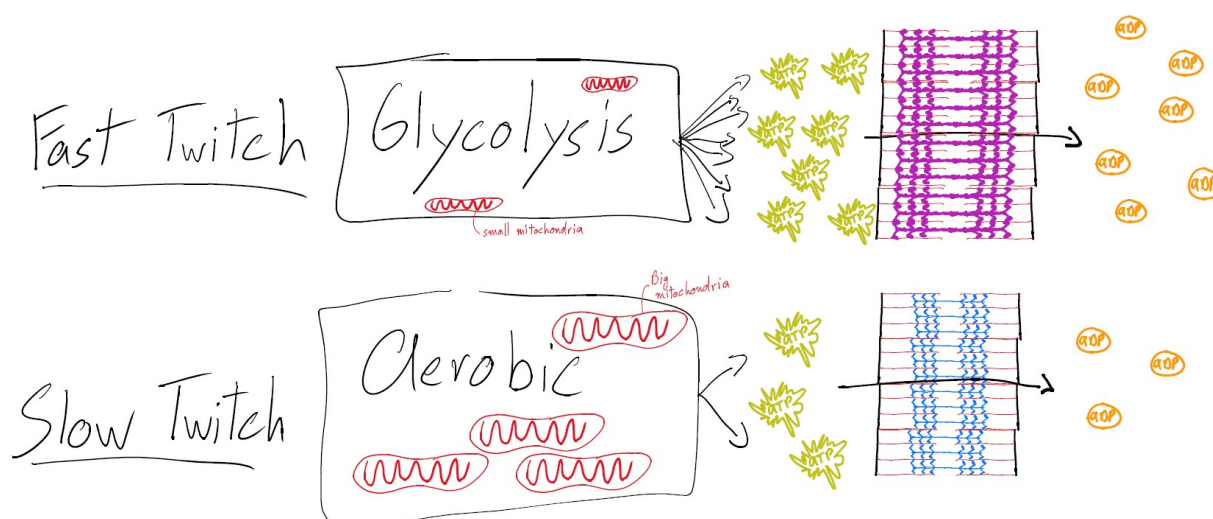
Since different muscle types will use ATP at different rates, it becomes **important for that muscle cell to modify its energy systems in order to keep up with the ATP demand and be as efficient as possible** at the same time. Just a reminder, glycolysis (part of the anaerobic system) uses sugar to produce a lot of ATP quickly, but has the downfall of also producing lactic acid. The aerobic system (using mitochondria) uses sugar and fat to produce a steady supply of ATP at a slower rate.

	<u>Fuel</u>	<u>Duration</u>	<u>Byproducts</u>	<u>O₂ used?</u>	<u>Trainable?</u>
Glycolysis	Sugar	30-40 minutes	Lactate	nope	Yup-sprinting
Aerobic	Pyruvate + Fat	Forever	CO ₂ +H ₂ O	Yup	Yup-distance

Fast twitch muscles burn a lot of ATP quickly, and it needs to be replaced just as fast. This is why **fast twitch muscles have very well developed glycolysis energy systems**. Because glycolysis is basically a set of enzymes, a well-developed system has a lot of these enzymes floating around allowing them to burn through a lot of sugar quickly. Because fast twitch fibers rely mostly on glycolysis, **they have a tendency to overload themselves with lactic acid quickly, otherwise known as fatiguing**. Ever wonder why

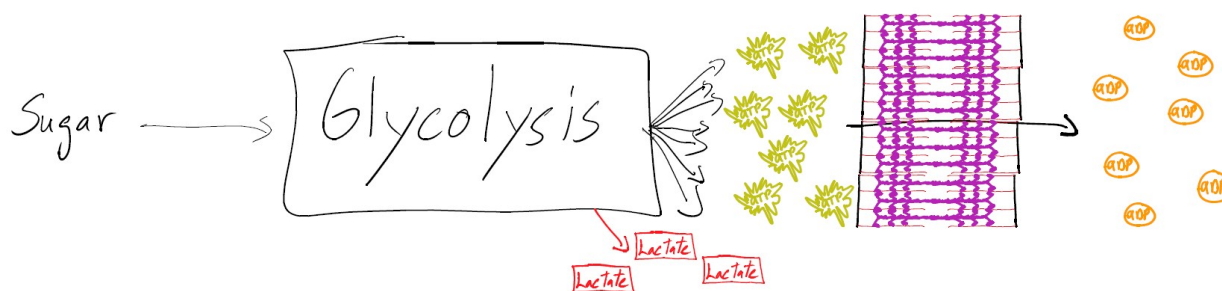
those “lazy” sprinters need so much rest after doing a 25? Most probably have a lot of fast twitch fibers full of lactic acid that need their sweet time to process and return to normal.

Slow twitch fibers don't use up as much ATP, so they can rely on the slower and more efficient aerobic energy system. This **means slow twitch fibers have many mitochondria that are also larger than normal**. They have glycolysis enzymes too, but not as many as fast fibers. Because of the combination of “weak” myosin heads and highly efficient mitochondria, swimmers with a lot of slow twitch fibers tend to be slower, but can hold that speed for a long time... aka “milers.”



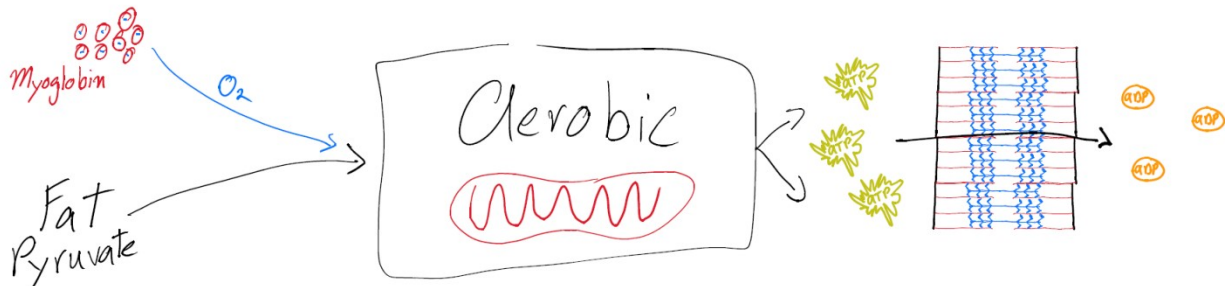
So far we have talked about the machinery and energy system differences between fast and slow twitch fibers, now we need to understand the **difference between white and dark meat chicken**. Yes, you have white and dark meat too. Since different energy systems use different fuels, those muscle fibers will store the fuel they use most.

Fast twitch fibers mainly use glycolysis, which only uses sugar. These fibers will have **high stores of sugar (called glycogen), and less fat inside the muscle cell**. This is white meat. Because stored sugar has a tendency to be surrounded by water which takes up space and adds a lot of weight, the muscle cell is **limited on how much it can store**. During swimming workouts, these fibers will run out of sugar in about 30 minutes. That's why sprinters have a lot of trouble going fast at the end of workouts, even if workout was “easy.”

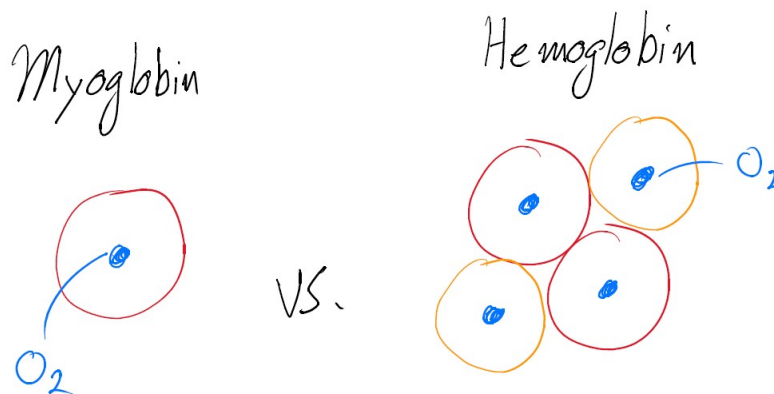


Slow twitch fibers mainly use mitochondria, which uses a lot of fat. These fibers will have **high stores of fat inside the cell**. And because mitochondria rely on oxygen to do their fuel burning, they have a

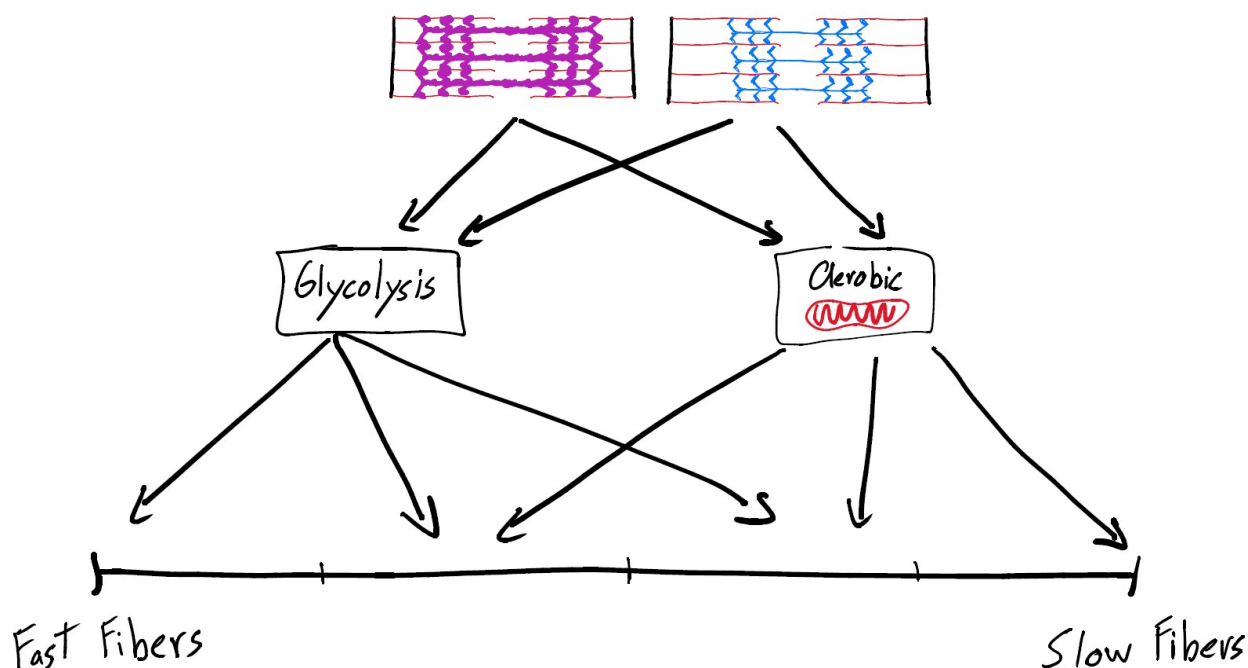
specialized protein called **myoglobin** that can store oxygen inside the muscle cell. If you thought hemoglobin and myoglobin sound the same, you probably figured out they do the same thing: store and move oxygen. Hemoglobin is what gives blood its red color, and the same happens with myoglobin, making these muscle fibers the dark meat chicken.



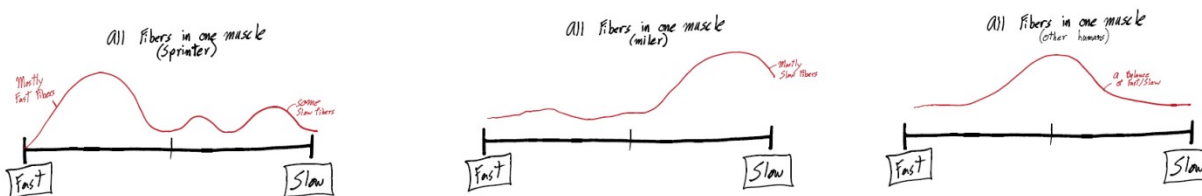
Tangent: If you think about it, the parts of the chicken that are dark or white meat makes sense. Breast meat on a chicken doesn't do much. At best they can "fly" about 10 feet to get away (sprinting). The legs, however, are constantly working and moving the chicken around all day, which is why they are dark meat, containing lots of myoglobin and are much more fatty (yum).



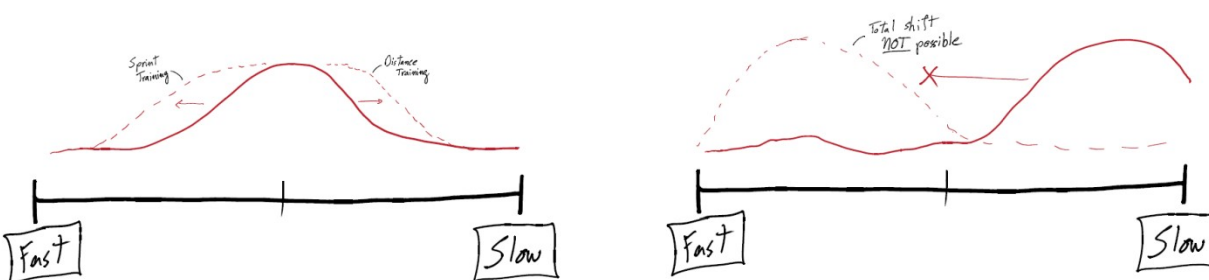
Those are the main physical differences between fast and slow twitch muscle fibers: myosin head types, energy system preference, and fuel storage (there are “software” differences too, will talk about in Motor Unit chapter). While it is easiest to think of muscle fibers being either fast or slow, **the reality is that there is a spectrum of what a muscle fiber can be**, and this spectrum depends on mixing and matching the factors we talked about. The terms we use: fast twitch, fast fatigable, slow twitch, type I fibers, type IIa, type IIb, type IIx... these are all man made “lines in the sand” to help us talk about different muscle fibers. Your body doesn't draw lines, it just makes muscle fibers that end up being somewhere on the spectrum. So don't be fooled, it is easy to talk “fast vs. slow,” but it's a little more fuzzy than that.



On the large scale, every muscle is made of millions of muscle fibers, and each fiber is somewhere on the spectrum of fast to slow twitch. If a person has more fast twitch fibers, their whole muscle will act like one big fast twitch muscle with all the advantages and disadvantages that go with that. Same goes for slow twitch and everything in between. Here are some examples of muscle type distributions in sprinters, milers, and most other people.

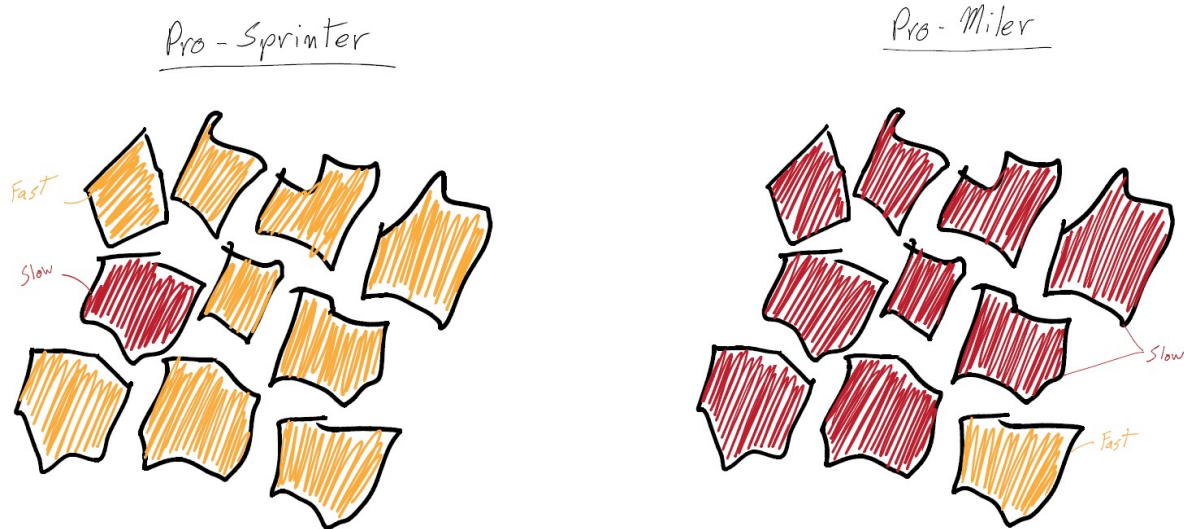


Where you fall on the spectrum of fast to slow fibers is mostly based on genetics and is present at a young age. **With training, a single muscle fiber can “slide” along this scale, but it can never totally change!** More on this coming up, but for now let us look at something you can control.



Number of Fibers vs. Size of Fibers

Say we take a sample of 10 muscle cells from the biceps of a sprinter and a miler and look at the cells in cross section. Let's also pretend that all fibers are either totally fast or totally slow twitch... no spectrum. What would we see? Probably something like this:

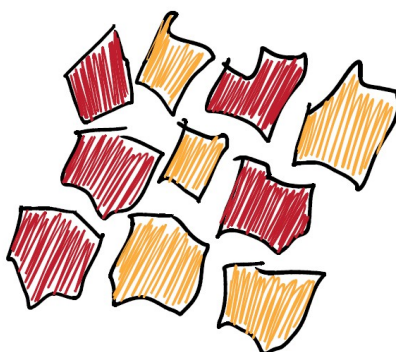


We expect a world class sprinter to have more fast twitch fibers than slow twitch, and the reverse for a world class miler. In other words, out of 10 muscle cells, a sprinter might have up to 9 fast fibers, and 9 slow fibers for the miler. Obviously having a lot of one type of muscle fiber can give you a leg up on the competition in certain races, and these **world class athletes tend to start their lives with muscle fibers that are skewed towards one end of the spectrum**. This “skewedness” generally applies to all the muscles of the body for that person.

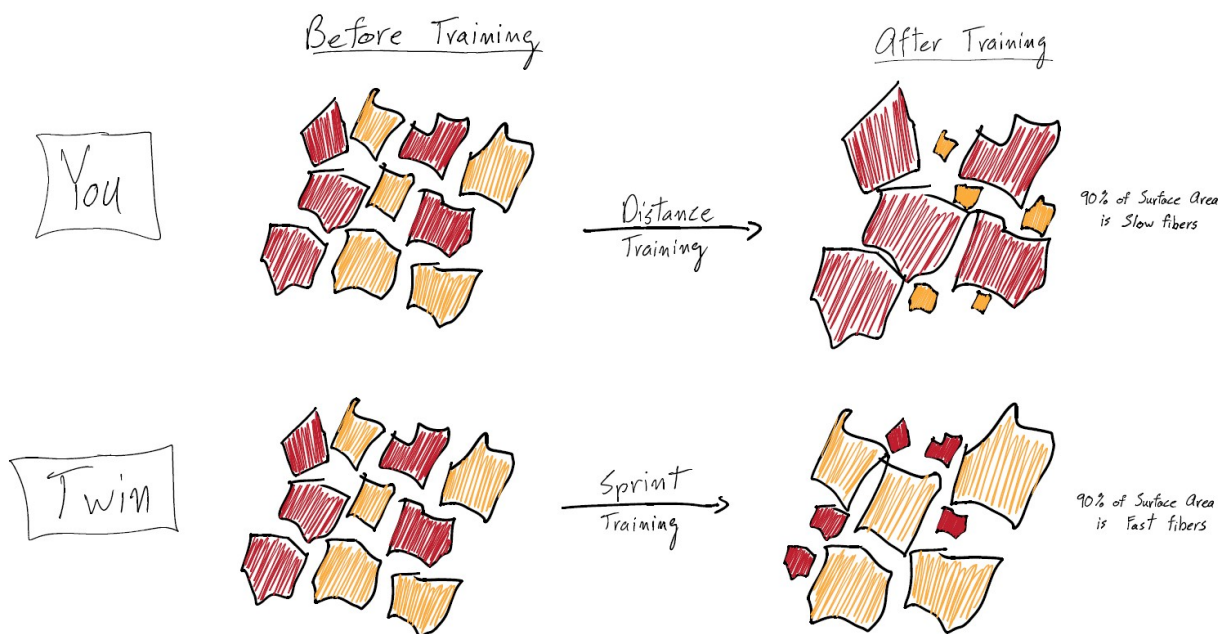
Tangent: The total number of muscle cells is generally the same between people and cannot be increased. Even with heavy weight lifting, the number of muscle cells stays the same, it's just that each cell can change size and ability with training.

Percentage of fiber type is one way of measuring whether a person is more a sprinter or miler, but the size of the fibers is also important. Let's use a training story to tell this tale. You and your imaginary identical twin started out in life like most other people, with 5 fast and 5 slow twitch fibers.

You and twin starting
Fibers



You intelligently decide to become a swimmer and your twin decides to run in a straight line for 10 seconds at a time. Later on you each become elites in your respective events. You are now a boss at the 400 IM and your twin is a 100 meter dash running phenom. How? You each started with the same muscle fiber percentage, so how could you both be good at distance and sprinting events? What most likely happened was that **your 5 slow fibers got trained more and grew more than your fast fibers and took over most of the actual muscle mass**. Same with your twin, but with the opposite fiber type. Even though you both still have 5 slow and 5 fast fibers, because the 5 you trained are a lot bigger, your muscles now look like this:



This is one of the many ways your body adapts to training, and we will only mention it here. **The big take away is that the total surface area of fast and slow twitch fibers probably means more than how many individual fibers you have in terms of real world muscle activity.** That means you may have started with only 5 fast fibers, but with training, those 5 can grow and take over 90% of the muscle mass you have. Now I am just making up these numbers to illustrate a point. What this means for you is:

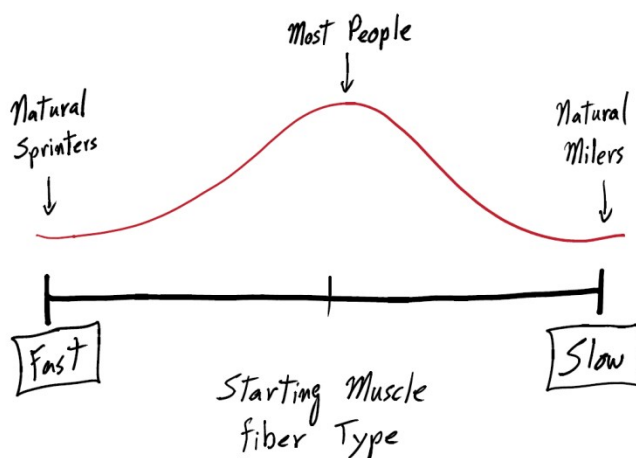
Hard work beats talent when talent doesn't work hard!

Starting life with a high percentage of either fast or slow fibers will give you a leg up and an advantage, otherwise known as **“natural talent.”** But just because you start life as a normal person, doesn't mean you can't be a great swimmer. Not to mention there are plenty of races that need a balanced ratio of fast to slow. **Remember “the swimmer does not choose the event, the event chooses the swimmer.” Don't fight your destiny!**

Changing-ish your Muscle Type

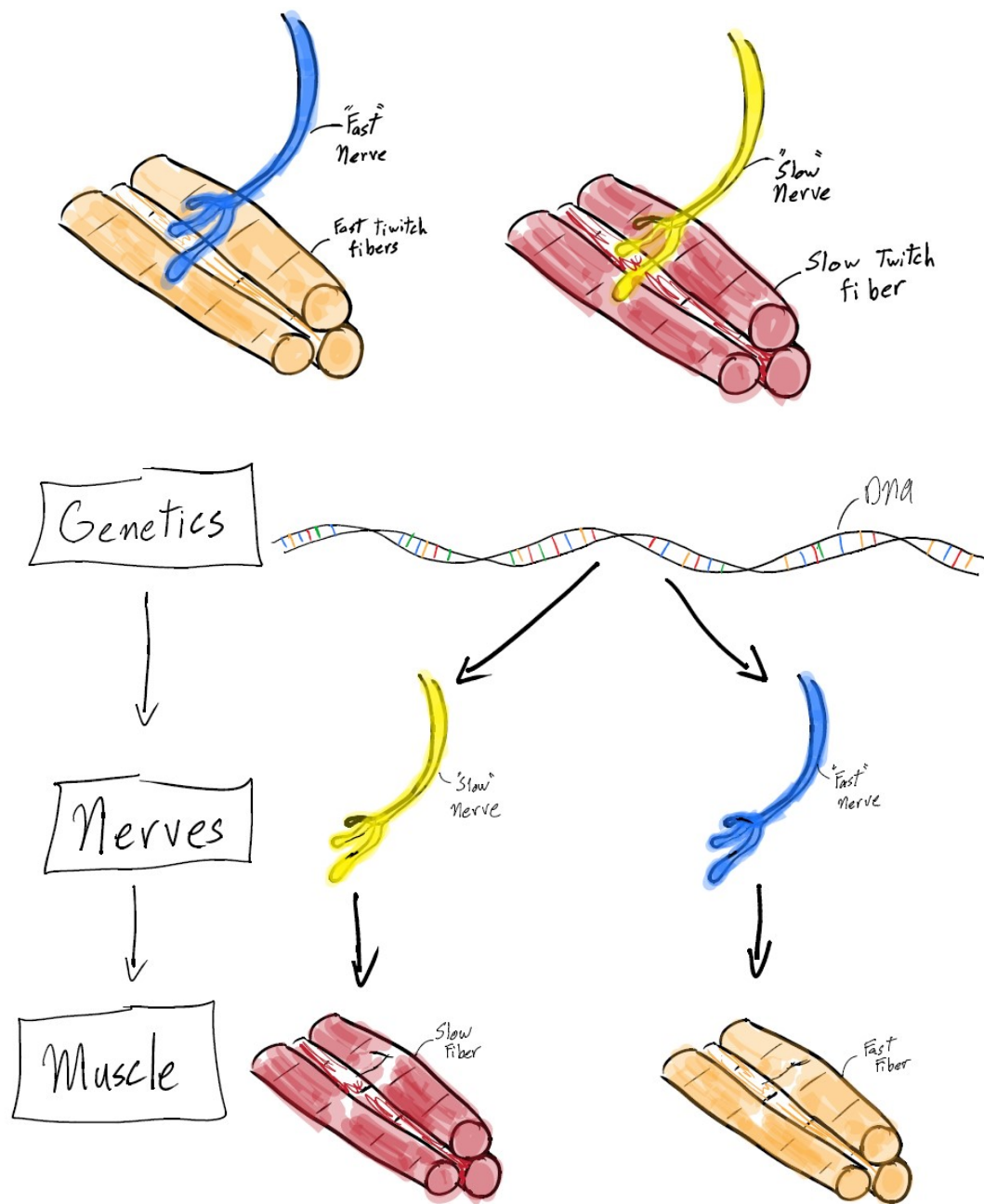
We talked about the differences between fast and slow twitch muscle fibers, but **how did this all get started?** Is it random which fibers become what? Is it how you trained as a kid? Is it all genetics? Let's figure it out.

If you took muscle samples from everyone in the world (swimmer or otherwise) you find that on average people have about a 50/50 ratio of slow to fast fibers (let's ignore the size of the fibers for now). Of course there is a whole spectrum and you will find some people with a skewed ratio. **This “skewedness” is determined by genetics, and we think it is present from birth** (we don't know for sure because it is a little un-ethical to take muscle samples from babies and then train them a certain way to see whether it changes or not).

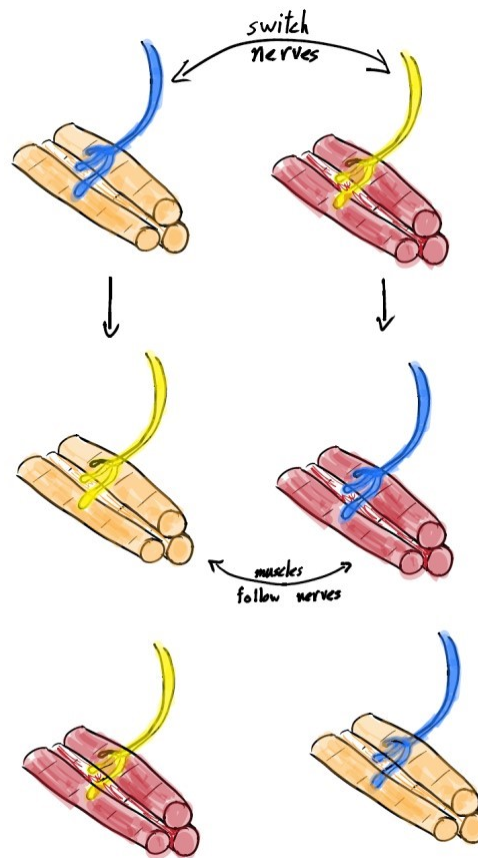


As you can see in the graph, elite 50 freestylers start out skewed towards having more fast twitch fibers, while all other swimmers start out skewed towards slow twitch, and this is based on genetics. You've seen those swimming families where the parents were collegiate 200 butterflyers, and now all their kids just so happened to be good at the same race. We can assume that this family is born with a majority of their muscle fibers in the slow twitch category, which is great for long distance flying.

If we look closer, what we find is that **the nerves attaching to those muscle fibers are controlling what type they become.** Here is what I mean: Some nerves (and I mean one nerve cell, not a whole bundle of nerves) only want to control slow twitch fibers, while other nerves only want to control fast twitch fibers. **If a nerve is designated “slow twitch,” then the muscle it attaches to will become a slow twitch fiber, and the same with “fast twitch” nerves.** The nerves will send signals to the muscles cells it attaches to and change what myosin heads and energy systems it has to follow suite with the nerve. So really, genetics control what kind of nerves you have, which then control what kind of muscle types you have.



So...how do we know this exactly? An experiment was done where the nerves of each muscle fiber type (slow and fast) were detached and switched places. The nerve on the fast fiber was connected to a slow fiber, and the nerve on the slow fiber was attached to the fast fiber. Without training, without supplements, without anything but time, **the muscle fibers with their new nerves switched sides** and turned into the fiber their nerves wanted them to be.



Tangent: The experiment was performed on small groups of cells extracted from animals and maintained in a petri dish.

Besides re-writing your genetic code, this is the only way to totally switch a fiber type, and no...we can't do it to you either...yet. Training can "slide" your muscle fibers along the spectrum of fast to slow, but you can never make a permanent switch. Not even illegal supplements will change a fast fiber to a slow fiber. **The best you can do is train your fibers to handle distance or sprinting races better, but eventually you will hit a limit.** Speaking of limits, genetics not only determines where you start but how far you can slide too. World class athletes start with a skewed fiber type distribution, and then they can train those fibers to a greater degree than an average person (more in BOS-II).

Tangent: Most muscles in the body start out with similar percentages of fast and slow fibers. But some muscles with very specialized movements can be very skewed. The soleus (which is part of your calf muscle) is responsible for a lot of walking, so it is almost 100% slow twitch fibers no matter who you are.

