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THE BASICS OF FUNCTIONAL ANATOMY

CONNECTIVE TISSUE

It is fitting that we begin our exploration of anatomy with the tissue that exemplifies the interconnected nature of all of our "parts"—the connective tissue. The very structure of connective tissue compels us to acknowledge that the slightest and most subtle change in one area of the body necessarily has an impact on the whole. A small movement in the big toe is like a fly landing on a spider web. When the fly hits the web, vibrations are sent through the web all the way to the other end, where the spider sits and waits. A small movement of the big toe affects the foot, ankle, and conceivably even the position of the pelvis. The toe is connected to all of these parts by a web of connective tissues.

Perhaps you have never heard of connective tissue. It can be difficult to visualize, but the fact is that the following parts of your body are *all* connective tissue:

- Bones
- Cartilage
- Muscles
- Fascia
- Tendons
- Ligaments
- Scar tissue

How is connective tissue important to yoga? It is a key component of our flexibility. Other components help to determine flexibility as well, including the muscles, skeletal system, and nervous system, which tell the muscles what to do, and we will discuss these components in depth. But for now we will explore connective tissue.

So, what is this stuff? Connective tissues are comprised of two proteins, collagen and elastin. Collagen is known for its strength. Elastin, as you may have guessed from its name, is elastic; it's the more pliable and resilient stuff. Put them together in varying proportions and densities

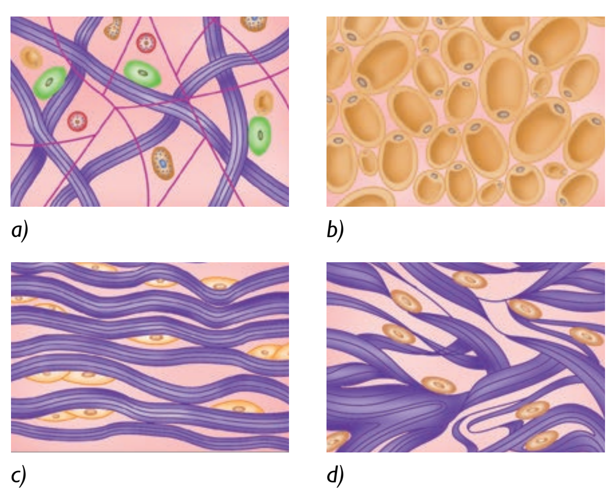

Figure 1.1: *The structure of the different types of connective tissue; a) loose connective tissue (areolar), b) loose connective tissue (adipose), c) dense regular connective tissue, d) dense irregular connective tissue.*

and you get the amazing array of connective tissues we find throughout the body.

Ligaments and Tendons

The denser and stronger the tissue, the more collagen is involved. Ligaments and tendons are made up of a higher proportion of collagen fibers (relative to elastin) and their fibers are tightly packed together. They are very strong. In fact, it is often said that ligaments and tendons have a tensile strength equal to steel cable of the same size. This is what makes them ideal tissues to accomplish their different functions.

Ligaments allow for and restrict movement in different directions. They are always situated around the junction between two bones. In other words, you find ligaments at joints or articulations. Because their collagen proteins are packed together so densely, they don't have a direct blood supply. There is no artery that burrows its way deep into the core of a ligament. The sheath of tissue encasing the ligament delivers the necessary nutrients for function and healing. This lack of blood supply is one of the main reasons ligaments do not normally heal when torn.

Tendons are similar to ligaments but perform a different function. Tendons are actually the ends of muscles that attach to the bones. They connect muscles to bones and allow the muscle to contract and move the bone at a joint in a particular way. Both are made of similar proportions of collagen and elastin and therefore have similar strengths.

Fascia

There are three main divisions of fascia in the body. Superficial fascia lies just under the skin and contains the fat cells that help maintain body temperature at the surface. Visceral fascia surrounds and suspends the organs, not just in the gut but also in the heart and lungs.

The last is the type we're most interested in: the deep fascia, which surrounds all of the muscles. You can think of the fascial system as a body glove or stocking. The stocking is not only on the surface, but also wraps around deeper structures such as muscles, arteries, veins, and bones. Each of these structures has their own layer of connective tissue. Each muscle, artery, vein, and bone is joined to one another through even more connective tissue. The spider web is an excellent analogy. All of these attachments

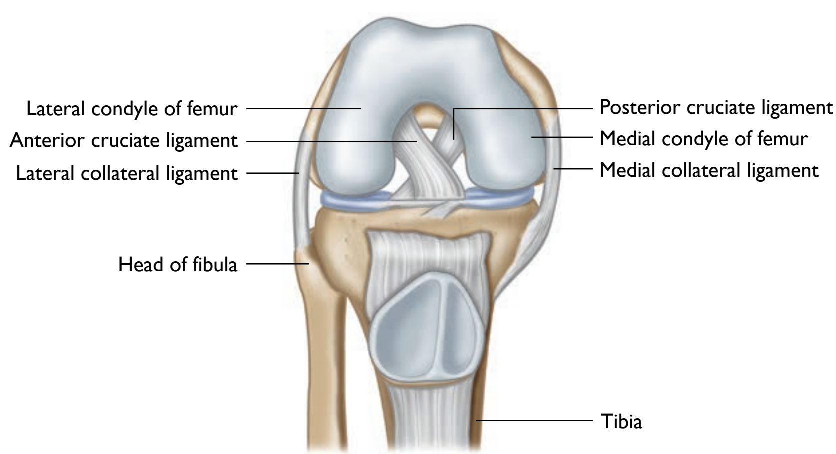

Figure 1.2: *Ligaments are like straps that bind the end of two bones together, stabilizing, allowing or restricting movement in different directions.*

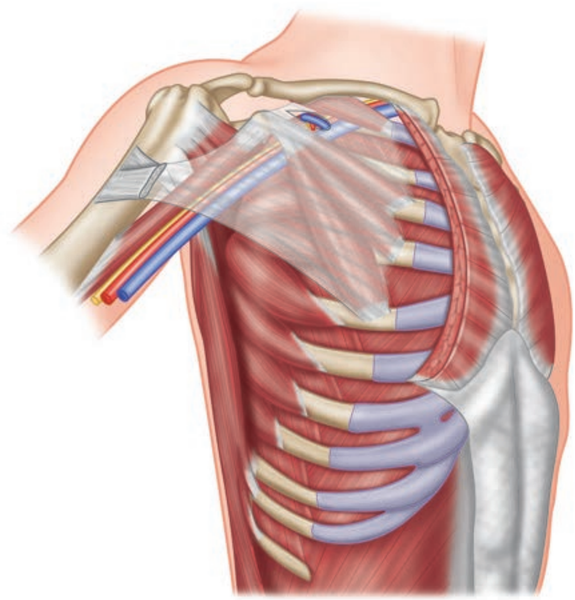

Figure 1.3: *Fascial sheath.*

create a web of tissue that wraps around one structure and then heads off to wrap around another structure and another and so on. The entire body is actually connected by this ubiquitous web of connective tissue. There is an abundance of connective tissue fully integrated into our muscles. It surrounds the muscles on a cellular, fascicle (bundle of cells), and overall muscle-belly level.

To maintain our integrated point of view, remember that we use the separate terms, muscle and fascia, to describe two parts of a single unit. To think of them as separate is not realistic or beneficial to our understanding of the body in a truly integrated way. Think of it like a peanut butter and jelly sandwich. You have peanut butter on one piece of bread and jelly on the other. Once you put those two pieces of bread together, you have the sandwich. You can talk about the peanut butter and the jelly as individual parts of the sandwich, but it's impossible to separate them. Similarly, talking about a muscle or fascia as if they are two things that can be separated is not realistic. Therefore, we can use more sophisticated language and refer to muscles as myofascia. "Myo" refers to muscle and well, the rest is obvious—fascia.

The integration does not stop here. Because the tendons, ligaments, and tissue wrapping the bones are all connective tissue, the interaction and integration are fantastic. There is no obvious end to a tendon as it weaves its way into the connective tissue layer around the bone. Nor is there any obvious starting or stopping point to ligaments as they weave into bone tissue. When you see a picture of a knee with many tendons, ligaments, and the joint capsule all coming together, it is difficult to see obvious divisions between structures. All of these connective tissue combinations make possible the amazing display of movement we find not only in yoga but in other disciplines like dance, biking, and skiing, as well.

When connective tissue is freer, bones and posture shift into a more optimal position. By releasing long-held tensional patterns, the body and the mind are more at ease. Yoga is a great way of manipulating these tissues. By using the strength of some muscles to lengthen others, or by using the ground or gravity as resistance, we can actively lengthen our connective tissues. As a result, we can realign our own skeleton.

Integrating into the Muscular System

Let's take a closer look at the muscular system. First, let me ask you a question: What do you think muscle is made of? If you're struggling to come up with an answer, let's take it from another angle. What happens when you pull or tear a muscle, for example, your hamstring? What do you think that means, literally? It probably means you tore some muscle fibers, right?

Okay, let's say you tore a muscle fiber. What is a muscle fiber? If you look at the construction of a muscle, you find two types of proteins (actin and myosin) sitting in a long row. These proteins are waiting for the nervous system to send a signal to release calcium and cause these two types of protein to become attracted to one another like magnets. This is the basis for muscular contraction—the introduction of calcium molecules to two proteins that cause them to become attracted to one another.

Let's come back to what you find when you look at the structure of a muscle. What is it that holds these proteins in a row and allows them to contract in a particular direction? Connective tissue. In this case, we could be more specific and say *fascia*. At this layer of a muscle, a group of fibers are joined together to make a muscle cell. These muscle cells are like the pieces of pulp in a citrus fruit, each of which has its own layer of skin. In the muscle fibers, the "skin" is a layer of fascia surrounding them called the endomysium.

When you take a group of these muscle cells, bundle them together and wrap them with another layer of fascia, called the perimysium, you get what we call a fascicle. This is like the wedge in a citrus fruit, which is a group of pieces of pulp. Finally, you have the muscle itself, which is a bundle of fascicles surrounded with yet another layer of fascia called the epimysium. This last layer of fascia is like the peel of our citrus fruit.

Now back to our original question. What is a muscle made of? Layers and wrappings of fascia around proteins. So, really, muscles are made of connective tissue. Therefore, when you tear a hamstring, you are actually tearing connective tissue.

The integrated perspective that we're developing gives us a more complex and dynamic understanding of movement. We now know that contractions are not simply a row of proteins getting closer together and shortening the muscle. We know that each contraction intimately involves the fascial tissue surrounding those proteins. The health of the fascia is one factor that can impede

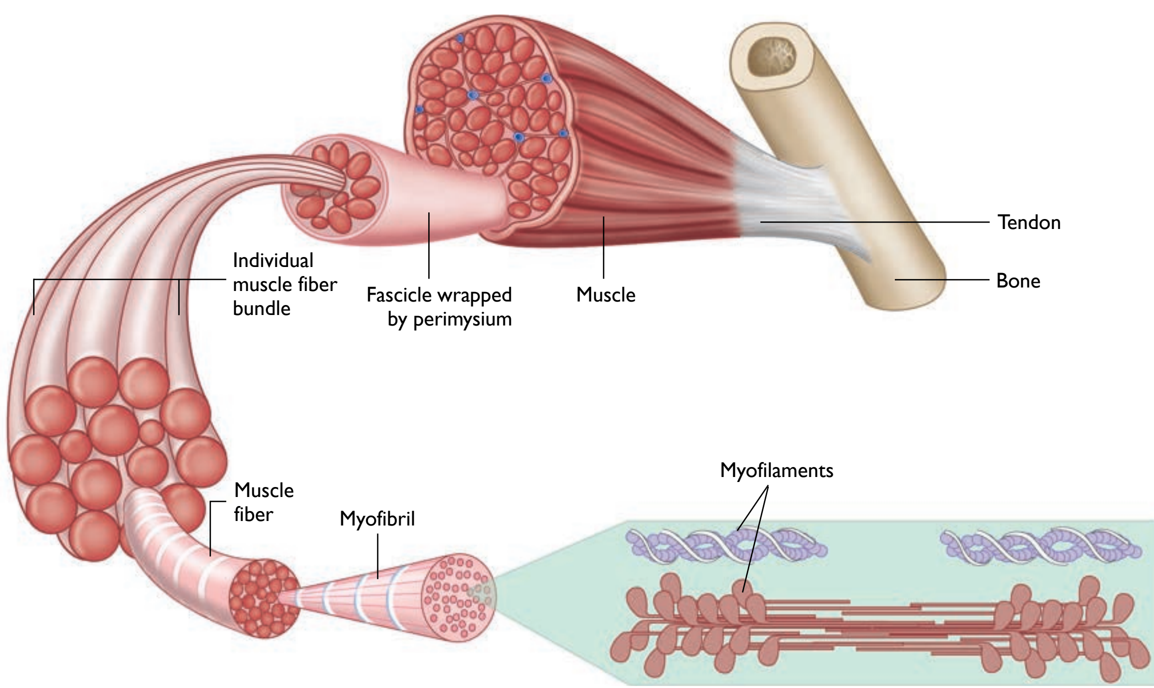

Figure 1.4: *Image of muscle layers with connective tissue.*

muscle function. The fascia and muscle together comprise one unit. When you are talking about lengthening a muscle in an *asana*, you are also talking about lengthening the fascia that's surrounding it. Our muscles and fascia are inseparable.

There are other ways in which the fascia can get "hung-up" and stuck together. The fascia separates and divides all of the muscles from one another. By its very nature, separating them is also a way of connecting them together, because the fascia is simply making divisions within the whole. It is possible that where these "individual" muscles are separated from one another they get stuck together.

This can happen as a result of too much movement, not enough movement, or an injury. For instance, moving too much could include lifting weights. Connective tissue has the ability to respond to stress that is placed on it locally. When lifting weights, the connective tissue has to adapt and change to the increased strength in the muscles. It does this by laying down new fibers of connective tissue and becoming denser, so that it can deal with the new amount of strength in that tissue.

Not enough movement means that the muscle begins to atrophy and weaken. In this case, the connective tissue is not pressed to stretch and shorten in any meaningful way. It consequently tightens up, along with the muscle that is no longer at optimal health.

An injury can also cause changes in the connective tissue. When scar tissue is created, it can change the amount of tension in an area of fascia. This can cause it to be glued together with the adjacent layer of fascia of the next muscle. This means a loss of independence of those two separate muscles. The two layers of fascia that sit there can no longer move easily relative to one another.

The hamstrings are a common example of this occurring due to overuse and not as a result of scar tissue. The hamstrings contract hundreds of times a day, even just in walking. It's common for these muscles to be tight on the average person. Some of that has to do with the amount of walking, sitting, and even sports activities that lead to generally tight hamstrings as they contract over and over again.

As a result, these three individual muscles can easily become "glued" to one another over time. When we say *glued together* we mean that the layers of connective tissue that separate and divide them also connect them together. If they become stuck together, they cannot function independently to their best capacity. Nevertheless, we don't require fine motor skills when using our hamstrings; they're built for power. So we won't necessarily notice how stuck together they could be, that is, until we try to stretch them. Then we wonder how our hamstrings got so tight! Part of it is simply muscular use and how that relates to the nervous system and tension. The other part is how the connective tissue has responded to stimulation: one way is by making the hamstrings grow together, reducing the individualization of these three muscles.

If this same level of stickiness happened in smaller muscles, such as those that move our fingers, we could have a problem. Fine motor skills would become difficult, since we need more individualization of the muscles that move our fingers than we do in our hamstrings to move the knee and hip joints.

FUNCTIONS OF THE MUSCULAR SYSTEM

There are technically four basic functions of the muscular system. They are movement, production of heat, guarding entrances to the body, and maintaining posture. Relative to yoga, we will focus on how the muscular system relates to movement.

Many aspects of the muscular system can be helpful to our overall understanding of movement. First and foremost is location and function of the various muscles in our body. It is not the intention of this book to teach the location and function of every single muscle in the body, but we will look at some specifically. I also want to help you understand concepts and principles that you can apply to any muscle to better understand its function. We will talk about various types of muscle contractions. We will even explore how gravity and body position affect which muscles work in different situations.

Finally, weaving its way into the muscular system is the nervous system, which tells the muscles what to do and how much tension to have.

It is easy to get lost in oversimplification within the muscular system. I hope, rather, to expand your knowledge of the muscular system and move you away from a false notion of separation. This will further enhance your understanding of the beauty and dynamics of this complex system.

Muscle Names

Knowing the names of the muscles will provide valuable information about their function, location, size, shape, or number of parts. Rather than shutting off your brain when you see a complicated anatomical term, think about what it means.

Let's consider a few examples. Take the adductor longus, a muscle in the thigh. What do we know about this muscle based only on its name? Well, it functions as an adductor, that is, it pulls the associated body part towards the center of the body. What does longus mean? Naturally it means *long*. The adductor longus is the longest of the adductor muscles.

Similarly, we learn a lot about the biceps brachii (a muscle in the arm) from its name. "Bi" means two. "Ceps" refers to divisions or, as we sometimes say, "heads" of a muscle. Brachii refers to the upper arm, sometimes called the brachium. The biceps is a two-headed muscle located on the upper arm. Now the trapezius. This is a large muscle shaped like a trapezoid on our back. So it is named for its shape. This is also true of the rhomboids, which are located on the upper back.

You might have noticed another similarity between anatomy and yoga. In the same way that *asanas* are named based on their shape, how they mimic animals, or the quality of the posture, muscles are also named for a reason; those I have mentioned are only a few. This should give you a sense of how to consider muscle names with an eye to learning about their function and other important information.

Understanding Muscle Function

We often see muscle function taught based on points of origin, insertion, and action. For instance, the biceps brachii originates on the coracoid process of the scapula and the supraglenoid tubercle of the scapula. It inserts on the large bump called the radial tuberosity.

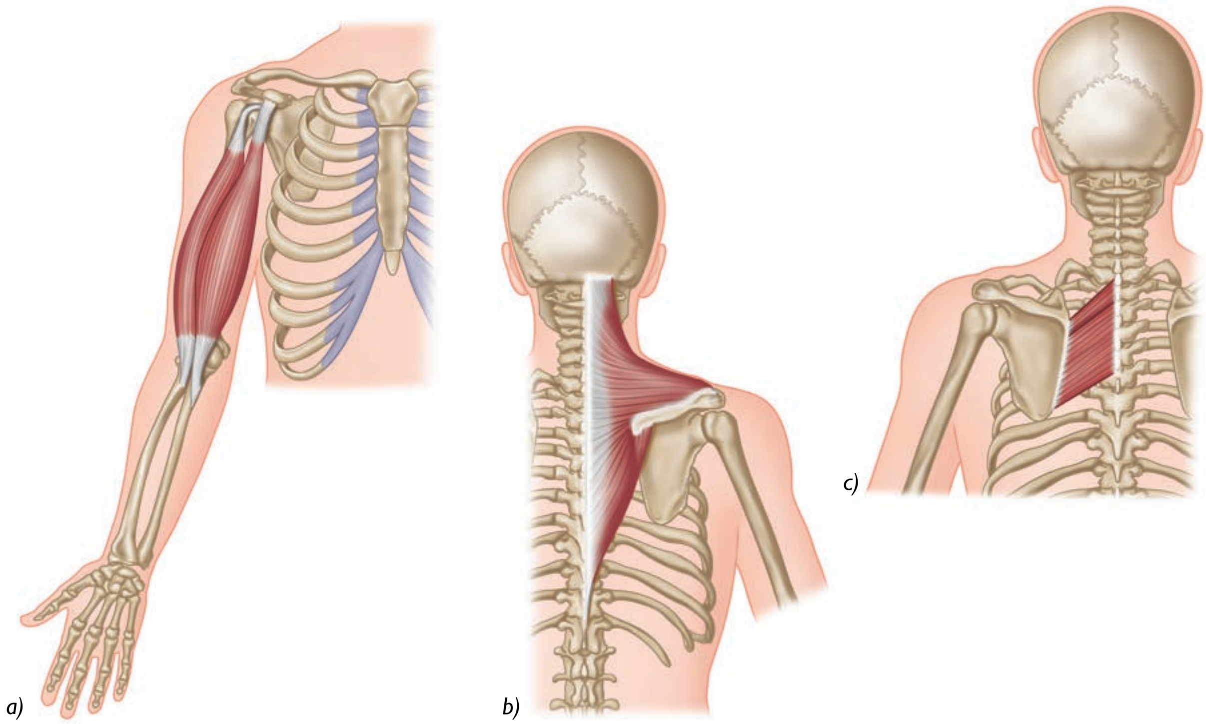

Figure 1.5: *Note the division of the biceps (a), as well as the shapes of the trapezius (b), and rhomboid (c) muscles.*

Its action is to rotate the forearm so that the palm is facing up (supination) and to bend the elbow (flexion). When thinking of muscle function this way, the origin is considered the more stable of the two bones and the insertion the more moveable. When the muscle contracts, the insertion moves towards the origin and the elbow and forearm supinate and/or flex.

However, when we discuss the origin, insertion, and action of a muscle, we are referring to it from the "anatomical position." Anatomical position looks like yoga's *Tadasana*, with the person standing erect, palms of the hands facing forward. All references to movements of flexion, extension, abduction, adduction, and rotation begin and end at the anatomical position. Although this isn't a surprise, it is potentially problematic. For instance, what if I am not initiating a movement from the anatomical position? (In real life, after all, we rarely find ourselves beginning each movement from here.) What if I'm in a backbend, or lying on the floor, or upside down in a forearm balance? Does this change the way the muscles function? The answer to that question is *yes*.

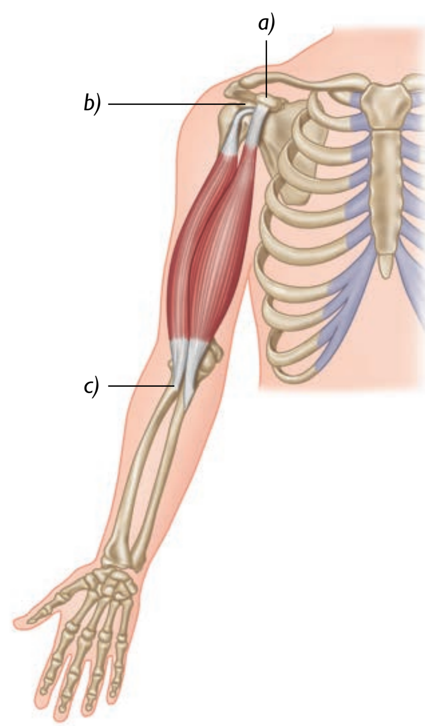

Figure 1.6: *Biceps brachii – the three elements: a) coracoid process, b) supraglenoid tubercle, c) radial tuberosity. Imagine how the forearm is moved relative to the more stable shoulder girdle.*