Yang Chengfu's Ten Essentials insured that the practice of Tai Chi Chuan would improve people's health. It is impossible to overstate the importance of these Ten Essentials in identifying the elements that make Tai Chi Chuan a healthful practice. Without the Ten Essentials, it is doubtful that Tai Chi Chuan would be recognized all over the world as a unique exercise system that offers special benefits to those who practice it.

LOOKING THROUGH THE LENS OF SCIENCE AT THE TEN ESSENTIALS OF TAI CHI CHUAN

PART 3

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PART I I. B

Looking at: "Song yao", "Loosen the waist", continued

In the first part of this essay (Journal #18) we examined the physical properties of muscle tissue. We learned why muscle fibers produce greatest force when they are at "resting length". Understanding the biomechanics of actin and myosin filaments within muscle tissue begins to unravel the riddle of "loosen the waist": when muscle fibers loosen, i.e. return to their resting length, they become stronger because they have the greatest number of bonds between the actin and myosin filaments. To imagine what this kind of strength is like, we could imagine a piece of rope. A piece of rope has a certain amount of strength because of the way it is made. Strength, in a rope, is the ability to resist being pulled apart. Muscles, at resting length, have a similar kind of strength because of the number of actin and myosin bonds.

In the second part of this essay, we will explore the overall architecture of our body structure and discover why "loosening the waist" increases stability during movement.

On all journeys of discovery, it is best to set off with a guide. We will begin in the company of Leonardo Da Vinci, who was one of the fathers of the science of biomechanics. In his drawings and notes, he went beyond an artist's rendering of human structure. Leonardo, a natural born engineer, tried to figure out how human structure worked. He was intrigued by the versatility of the human body and sought to understand how it could move in so many different ways without falling apart. Unlike a wagon or a catapult, which had to be in a certain position to maintain structure and function, a human body could be turned upside down, or on its side, or on its belly and it could still maintain structure and function. How could the human body be so flexible, so stable and move in so many different ways? This was the question that inspired Leonardo to make a series of drawings that are referred to as his "cord drawings" and to scribble an observation in his notebook that said: "Every muscle uses its force in the line of its length." (I)

What Leonardo observed about human structure, the idea that he illustrated with his cord drawings, was that human structure was based on the physics of tension. (In the world of physics, tension, by definition, is a pulling force.) Leonardo's observation was absolutely correct but its significance was overlooked, in the Western world, for a long time.

To understand Leonardo's thinking, let's look at a structure based on the physics of tension that is familiar to all of us: a bicycle wheel. A bicycle wheel has as least 12 wire spokes which "pull" a circular tire rim toward a center hub. If all the wires exert an even pull, the wheel can maintain structure during movement and resist falling apart

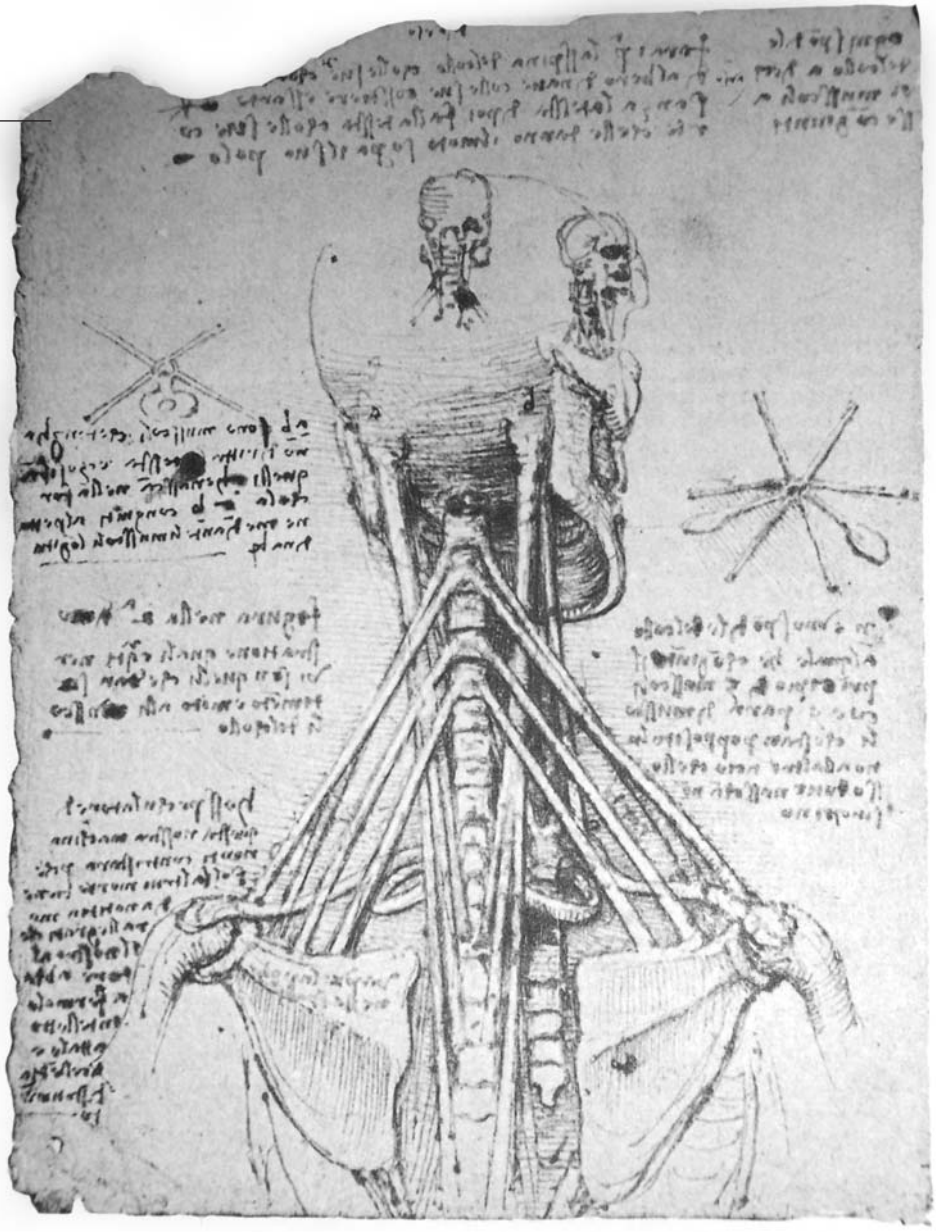

Figure 1

even under very heavy load. (We've all seen photographs from the circus of an elephant riding on a bicycle wheel) The bicycle wheel works because the hub remains suspended in the tension network of wire spokes and the compressive load, of human or elephant, is distributed around the rim of the wheel. The tension of the spokes is the support network which distributes and attenuates the compressive forces placed on the wheel. Buckminster Fuller gave this kind of structure a name; he called it "tensegrity structure", a contraction of 'tension integrity'. Other familiar tensegrity structures are tennis rackets and snow shoes and the human body. (II)

Now, let's take a look at one of Leonardo's cord drawings to see his prescient vision of tensegrity in human structure: Figure 1, of the neck.

This drawing shows that Leonardo was trying to figure out how a flexible spine could support the heavy weight of a head on top of it. In Figure 1, he shows the actions of neck muscles, exerting pulling forces along the lines of their length, to support the head in an upright position. In the little diagram sketched on the right side of the larger drawing, you can see that Leonardo drew something that looks somewhat like the spokes of a wheel. To the left of the larger drawing, he sketched a schematic diagram of the top vertebrae of the neck, the atlas. It is clear from these diagrams, that Leonardo understood the idea of tensegrity and how it applies to human structure. He understood that muscles, acting along the line of their length, stabilized human structure by applying tension from many directions, just as a bicycle wheel is stabilized by the tension of the spokes.

If we now look at Figure 2, the "waist" area of a human skeleton, we can see how the lines of force created by "sinking the hip" (back arrow) and "opening the kua" (front arrow) stabilize the lumbar spine in much the same way as the action of the neck muscles stabilize the cervical spine. In both the cervical and lumbar regions, the spine is stabilized in an upright position by the action of muscles pulling in a downward direction. We can visualize how this works if we imagine putting up a tent: we stabilize the tent by stretching cords from the center pole and staking them down to the ground. If the stakes remain firm in the ground, a network of equal pulling forces stabilizes the center pole, if one of the stakes comes loose, the tent will fall down because the forces of tension acting on it are no longer equal and balanced. (III) The example of the tent helps us understand why "sinking the hip" and "opening the kua" contribute to stability in the waist area when we practice Tai Chi Chuan.

Leonardo's drawing of the "waist" area, Figure 3, shows that Leonardo understood how the lumbar region was stabilized by the tension forces exerted by groups of muscles. In Figure 4, we can see how the lines of action of different muscle groups stabilize the lumbar region. The lower

Figure 2

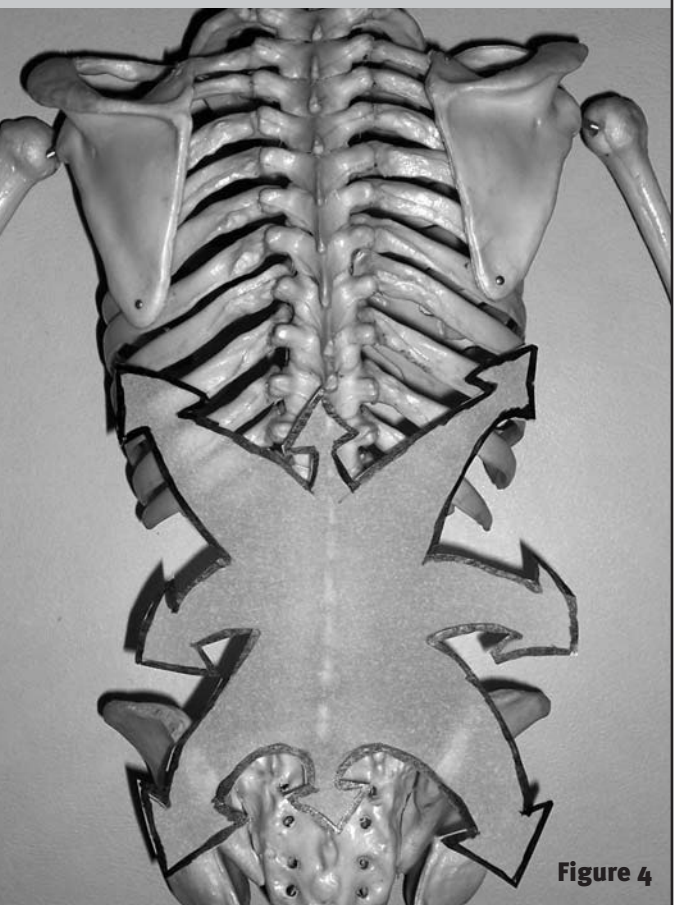

Figure 4

Figure 3

lumbar area is like the hub of a bicycle wheel suspended by the lines of action of powerful muscles groups: the latissimus dorsi reaching up toward the arms, the gluteus maximus reaching down toward the legs, the erector spinae extending up and down along the length of the spine, the internal obliques and transverse abdominals pulling toward the front of the body. (IV) The arrows placed over the skeleton in Figure 4 show the directions of force exerted by these muscle groups. The arrows also show, in a schematic way, what is meant by "loosening the waist". "Loosening" means undoing, coming to resting length. We can see that this loosening must happen in many muscle groups at the same time. "Loosening the waist" means an expansion up and down as well as side to side.

As we learned in the first part of this essay (Journal #18) one value of allowing muscles to come to resting length has to do with maximizing the strength of individual muscles. According to the principles of tensegrity structure, which we explored in this second part of "Song yao", the other value of "loosening" has to do with creating an even balance of tension. With all stabilizing muscles at resting length, they are like the spokes of a bicycle wheel, exerting the same amount of tension on the hub. Equal levels of tension, exerted by our muscles, is what stabilizes our structure and keeps it from deforming or falling apart when it is moved or placed under load.

In subsequent essays, we will explore "Hang xiong ba bei" (contain the chest and lift up the back), and "Chen zhui jian zhou" (sink the shoulder and drop the elbow) to understand how these essential principles work with the principle of "song yao" (loosen the waist) to create stability, strength, and efficiency in our practice of Tai Chi Chuan.

RESOURCES FOR THIS ARTICLE:

I. *Leonardo Da Vinci, on the human body.* O'Malley and Saunders. Pg. 88

II. *Movement, Stability, and Low Back Pain.* Vleeming, Mooney, Dorman, Snijders, Stockhart. Pgs. 159-160.

III. *Mechanical Low Back Pain.* Porterfield and DeRosa. Pg. 77

IV. *Mechanical Low Back Pain.* Porterfield and DeRosa. Pg. 67