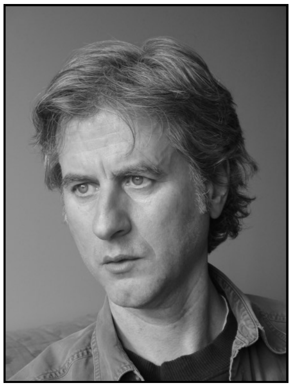
This is the first in a series of four papers based on seminars given by Dr. Dimon to Alexander audiences in London, Paris, and Amsterdam between 2008 and 2010. The second paper will be published in the next issue of AmSAT Journal.

The Organization of Movement
Four Talks on the Primary Control
Part 1: The Architecture: How Muscles Work in the Context of the Skeletal Framework

by Theodore Dimon, Jr.



Theodore Dimon, Jr.

All human movement contains a basic organizing principle, an active force that ensures effortlessness, vitality, and optimal control. This principle is the foundation for healthful functioning throughout life; it is also the basic mechanism over which we must gain control as the basis for higher levels of awareness and skill. This principle is fundamental to self-knowledge and will one day be understood as a key element in self-realization. While it is not yet widely accepted or understood by modern science, it is demonstrable and observable; and I think it can be considered among the most important principles in our understanding of the natural world. It is as central and fundamental to health as any principle taught in Western or Eastern medicine. It is the key system governing how the body is organized to move.

I am speaking about the central organizing principle in movement known to those of us who teach the Alexander Technique as the "primary control." Today there are virtually hundreds of movement and exercise methods designed to increase strength and flexibility, all of them promising improved health and functioning. As we will see in these talks, however, the basis for human as well as animal movement is a natural system that ensures effortless action without any meddling or interference from us. When this system works well, muscles do not strain but are naturally healthy and toned; joints have room and are supported so that they can work with maximum ease; breathing is full and unimpeded; vitality is heightened by improved muscle tone; and circulation is maximized by a lack of excessive contraction in muscles. In short, the key to improved movement and health is an understanding of how the body is designed to function naturally—that is, with a minimum of strain and with effortless grace based on our body's natural design. In this series of four talks, we will look at this system and see how it works, beginning with our architecture and anatomy.

The Body's Elastic Latticework

When we ask ourselves what the function of muscles is, what comes most quickly to mind is that muscles contract to produce movement. To lift a glass, walk down the street, or type a letter, we have to contract, or tighten, particular muscles; otherwise we would not be able to produce movement in space, manipulate objects, speak, or even breathe.

But movement is not nearly as simple as that, because in order to move in space or even to move an arm, we first have to maintain our skeletal structure upright in the field of gravity—in other words, we have to maintain postural support. Most of us have heard about the postural muscles that keep us upright—most notably in the neck, back, and legs. By contracting, it is said, these muscles keep the head from toppling forward, the trunk from buckling, and the legs from collapsing under us.

But exactly how do these muscles work? When you lift a phone book, muscles in your shoulder and arm contract, moving the levers of the arm. Using a great deal of force to accomplish the task is a perfectly acceptable strategy because you do not have to hold the book up for very long. If your arm tires, you can put the book down and rest your muscles. However, this strategy is not adequate for supporting our entire body in the gravitational field. To sit or stand, we must maintain the entire trunk erect for hours at a time; trying to do this by simply contracting muscles would be impossibly inefficient; and nature cannot afford to be inefficient.

How then do we maintain upright posture, if not by contracting muscles to keep from falling over? One obvious clue is the dynamic way our body parts are organized. Look, for instance, at the muscles on the nape of the neck. One of the primary functions of these muscles, which connect the back of the skull to the spine and ribs, is to keep the head from falling forward. Why do these muscles, which tend to contract if unopposed, not tighten and pull the head back? The answer is that the head is weighted forward, so that it tends to fall forward, which keeps these muscles lengthened. The neck muscles are working, but instead of forcibly pulling the skull back, they are stretched between the skull and the spine so that, even while the muscles maintain stability in the skeleton, the skeleton maintains length in the muscles (Fig. 1).

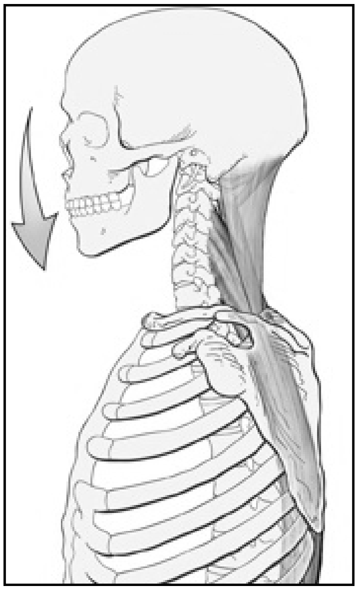


Fig. 1. Neck muscles and head balance.

Some variation of this relationship exists in virtually every part of the musculoskeletal system. Muscles everywhere in the body are kept lengthened by the skeletal system. Instead of simply contracting, the muscles are suspended within a latticework of bones while they maintain the upright stability of the trunk. This holds true for our leg muscles, our shoulder girdle, our rib cage—nowhere are muscles simply contracting against the skeleton; instead, they work in a kind of partnership with the bones to produce a latticework of support that is highly economical and efficient.

The Concept of Tensegrity

How is it possible for the body's muscles to maintain upright support by elastically stretching—or lengthening—rather than contracting—or shortening? Upright support is achieved through the activity of tensile elastic members rather than through contraction. One simple example of this is a tent with a central pole and guy wires attached from the central pole to the ground. The guy wires keep the pole from falling over, but at the same time the pole exerts stretch on the guy wires. A more complex example is a *tensegrity structure*, an architectural design featuring guy wires coupled with solid members to create structural support without any traditional pillars. When a tensegrity structure is working properly, the wires are stretched between the solid members, so that support is distributed as widely as possible (Fig. 2).

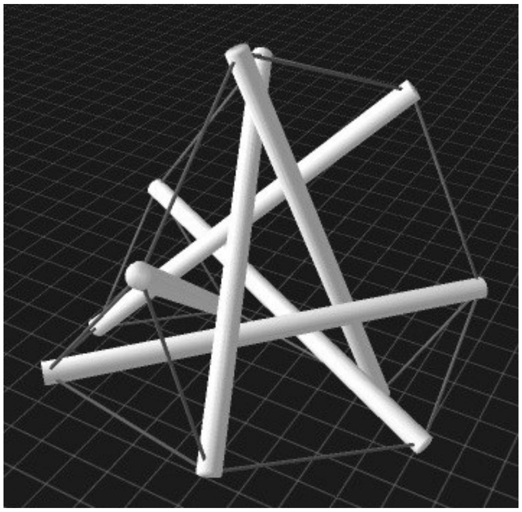


Fig. 2. Tensegrity design.

In humans, and in all land animals that must contend with gravity, we find a vastly more sophisticated variation on this approach: a varied and complex system of struts—the skeleton—maintains stretch on muscles while the elastic muscles maintain tension or tone to support the bones. This marvelously complex architectural design for upright support distributes the work of the muscles over many meters of connective and muscle tissue so that the burden does not fall on just a few muscles (Fig. 3).

The muscular system, then, is not simply an assortment of contracting muscles, but a complex system of elastic tissues that are stretched by bones, which act as counterbalances, spacers, and struts. This enables muscles to work in as efficient a manner as possible. It also enables us to maintain support in the gravitational field with a minimum of effort and strain.

This principle of effortlessness or economy of action is found throughout the animal kingdom. We are all familiar with the beautiful, effortless grace of cats, which we admire for their ease of motion. But there is hardly an animal on the planet—except perhaps for modern man—that does not exhibit its own form of grace. Wolves, beavers, birds, snakes—all seem to move with an effortless grace perfectly adapted to their environment and lifestyle; even elephants, despite their enormous size, are remarkably light-footed and efficient in their movements. In each of these creatures, muscles act in concert with the skeleton to produce an elastic/strut system that utilizes minimal muscle contraction and maximizes economy of effort.

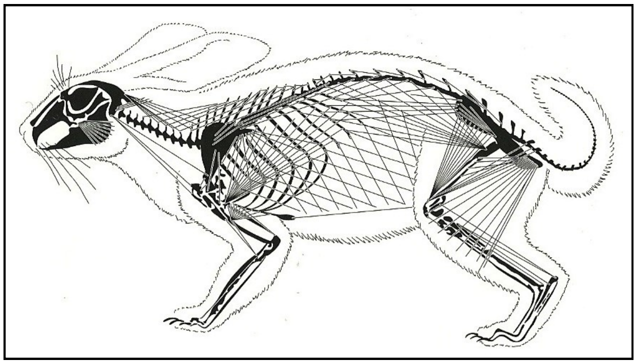


Fig. 3. Skeleton and muscle supports.

Tensegrity v. Compression Structures

Traditional structures such as columns, arches, and walls are called in architectural terms *compression structures*. Compression structures bear weight. Whether made of bricks, girders, blocks of stone, dried dirt, or concrete, they have been used for centuries in the construction of cathedrals, coliseums, temples, aqueducts, and houses of all kinds. Even an arch is a compression structure that distributes downward pressure laterally from the keystone to the base on either side.

A *tensegrity structure*, in contrast, combines compression members and tension members to produce a strong, lightweight structure. The word "tensegrity" is a combination of "tensional" and "integrity;" it is a term coined by Buckminster Fuller, who also invented and utilized the concept.[1] In a tensegrity structure, the compression members do not bear weight but rather provide opposition to the tension members, which in turn pull on the compression members.

A familiar example of this concept in action is a balloon. Gas molecules are trapped inside the balloon, expanding and pressing it outward. The envelope of the balloon, which resists being pulled apart, does not press outward like a column that supports weight, but actually pulls inward, opposing the outwardly expanding gas. This opposition between the tensile strength of the rubber skin of the balloon and the expanding gas creates a supportive structure. Tensegrity structures used in building, such as geodesic domes and tents, are not quite the same as a balloon. But as with a balloon, the compression members oppose the tensile members to produce overall support. In essence, the solid members space apart the tension or guy wires, and the guy wires pull on the solid members to create a structurally powerful system.

A tensegrity structure, then, can be defined as a continuous tensile network, interspersed with struts that create framing against which the tensile elements pull. In compression structures, the bricks or columns bear all the weight; in tensegrity structures much of the work is borne by the tensile members, which distribute the strain evenly throughout. This makes for a very efficient design that is stronger and more lightweight than walls or beams, and uses less material.

A fascinating study of tensegrity in action was recently reported in *The New York Times*. It compared European men carrying heavy loads on their backs to Kenyan women carrying weight on their heads.[2] The women, it turns out, carried 20% of their body weight with no additional expenditure of calories as compared to the men, who used far more effort. The study concluded that this was because the women altered their gait but did not alter their upright support mechanism when carrying a load on their heads, whereas the European men did alter their upright posture and therefore had to use far more muscular effort to support their packs. In essence, each woman was able to carry the weight on top of her head and vertical spine without disturbing the tensegrity design of the musculoskeletal system, so that the load was distributed over the entire tensegrity structure rather than straining particular muscles.

Struts, Spacers, and Counterbalances

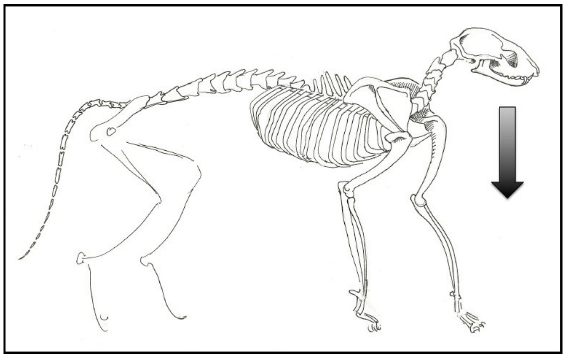


Fig. 4a. The cat's head is cantilevered and keeps the neck muscles on stretch.

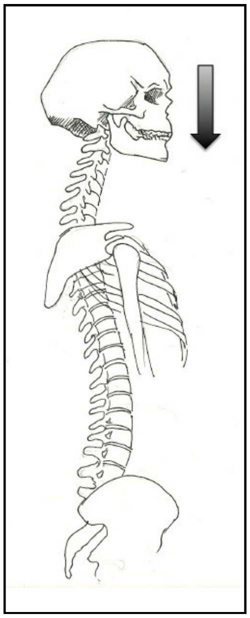


Fig. 4b. In humans, the head acts as a counterbalance that keeps the neck muscles on stretch.

Let's look in more detail at the actual arrangement of bones that enables muscles to work in an elastic way. In traditional kinesiology and physiology, muscles are seen as motors that act upon bones to produce movement—a mechanical, one-way description that does not explain how muscles cooperate with bones to produce effortless upright support.

But as we have seen, muscles act within the context of a structure that lengthens them, and what keeps them lengthening is the design of the skeleton itself. For example, let's look at the spine and skull of a cat. The cat is a four-footed animal with a long spine that is horizontal in space; the spine ends with the tail in back and begins with the skull in front. Since the cat's skull is cantilevered out in front of the spine, it tends to drop down in space, which means that the muscles and ligaments at the nape of the cat's neck must keep the head from falling (Fig. 4a). A cat has powerful neck muscles that perform that function. You will never see a cat with shortened or habitually contracted neck muscles because the skull, cantilevered at the end of the spine, exerts a continuous stretch on the muscles of the neck: the lengthening elasticity of the neck muscles is maintained by the architectural design of the cat.

In humans, muscles are stretched across skeletal parts as they are in other animals, but the situation is complicated by our upright posture. Since we are vertically poised on two feet, our spines have to lengthen and point upward. Gravity, meanwhile, pulls every part of us downward towards the center of the earth. How do we counteract this pull in an efficient way?

The human spine is vertical, with the skull sitting on top of the spine. The skull is not evenly balanced on top of the spine; it is off-balance, with more weight in front of the spine. As a result of this imbalance, the skull tends to fall or tip forward, acting as a counterbalance and exerting stretch on the muscles of the back of the neck—as in the example of the cat, but from a different direction and without as much force. In both human and cat, one part of the skeleton (the skull) moves in relation to another part (the spine) and exerts stretch on muscles (Fig. 4b).

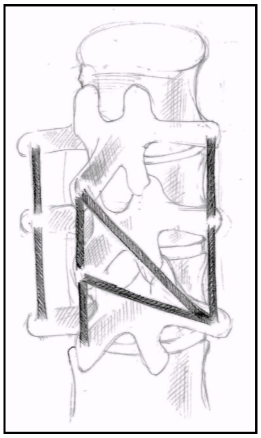


Fig. 5. The vertebrae are spacers that keep the small postural muscles stretched.

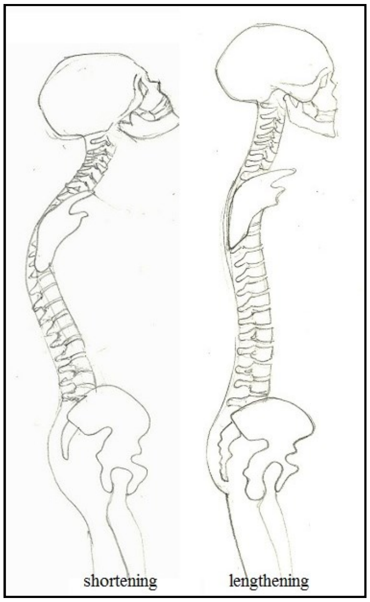


Fig. 6. The spine as a whole acts as a lengthening device.

The human spine is also very cleverly designed. First of all, the vertebrae act as spacers, keeping the small muscles of the spine stretched between the processes, or protrusions, of the vertebrae, to which they attach (Fig. 5). Second, the spine has several curves that can buckle, as when we slump. But if the head acts as a counterbalance at the top end of the spine, and the tail drops at the bottom end, the curves of the spine are reduced so that, instead of buckling, the spine actually lengthens in response to gravity (Fig. 6).

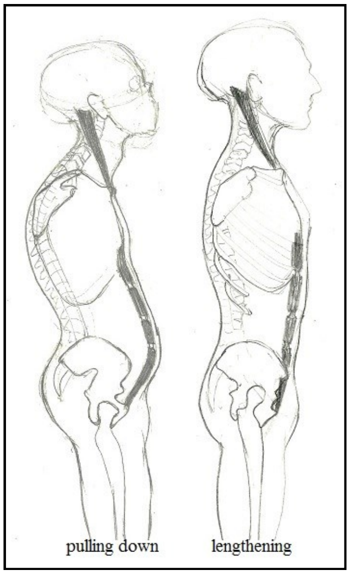


Fig. 7. Front length.

When the spine lengthens as a whole, then the muscles along the front of the torso, which are hung from above, release to allow the trunk to lengthen in front; this is true of the throat musculature as well, which is elastically slung between the skull and clavicle (Fig. 7). The same is true of the ribs: when the spine lengthens, the oblique muscles of the back and ribs also lengthen and the scapulae spread apart, so that the back actually maintains width as well as length (Fig. 8). Finally, the legs act as struts so that, instead of tightening, the long muscles of the legs are elastically maintained by the scaffolding of the skeleton.

In short, muscles are elastically stretched between bony structures. The vertebrae act as spacers so that the small muscles of the back are elastically stretched, and the spine as a whole is a spacer for the longer back muscles, which are also elastically stretched. The head goes up on top of the spine, and the pelvis drops away from the head, acting as a counterbalance at the bottom end of the spine to help maintain spinal length. The leg bones are vertically stacked, acting as struts for the leg muscles. The muscles on the front of the body hang down from the skull and let go to allow the front to be fully lengthened; the throat is also suspended from the skull. Finally, the ribs (which do not hang down as in four-footed animals but slant down to the sides) are struts to which oblique muscles attach. These oblique muscles release to allow the ribs to move freely and the shoulder girdle to spread apart, so that the entire back is stretched and elastic.

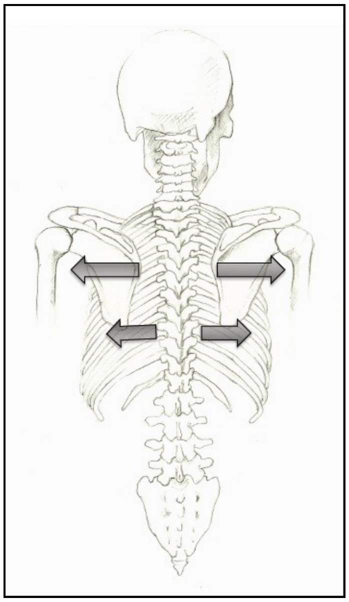


Fig. 8. Widening of the shoulder girdle and back.

Humans are tensegrity structures with multiple layers of support. At the deepest layer, the vertebrae function as spacers for the small postural muscles that support the curves of the spine, allowing it to maintain its full length. The spine, in turn, lengthens the long, powerful spinal muscles attaching to the vertebrae and the ribs. When the trunk as a whole is supported like this, the muscles of the shoulder girdle and upper arms release so that the shoulder girdle widens. The middle and outer layers of back muscles lengthen so that the back widens and fills out, and the oblique muscles of the back let go of the ribs which, acting as struts, can then move freely.

To summarize (Fig. 9):

1. The head balances forward to counteract the pull of neck extensors
2. The head goes up, the spine lengthens, and the tail drops to lengthen back muscles
3. The front of the body lengthens and the throat hangs freely
4. The shoulder girdle widens and the back muscles spread to allow the ribs to move freely
5. The leg muscles lengthen to allow the leg-bone struts to support the body

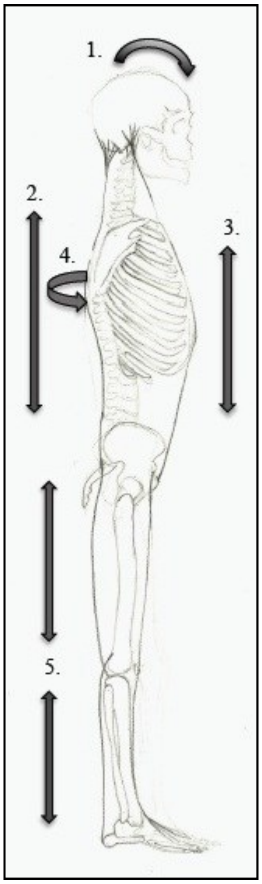


Fig. 9.
The 5 Key Elements

Elasticity and the Tensegrity Design

In order for the human *tensegrity* design to work properly, muscles must lengthen so that the entire structure can be erected and supported and the workload can be distributed over the entire network of muscles. When this happens, we get a sense of upward force without effort, of natural springiness against gravity.

As we all know, however, the system does not always work the way it is designed to work, which is where the Alexander Technique comes in. If, for instance, you pull your head back and slump while sitting in a chair, the whole system begins to collapse. Muscles that need to provide support become slack and, because we still have to support ourselves against gravity, other muscles begin to work far too much. Ligaments that are designed to limit movement and maintain the integrity of joints are not designed to carry the strain being put on them. Bones take on added strain and may become distorted if the situation continues for a long time.

The key to the human tensegrity system is muscles lengthening as they pull on bones. For this to happen, the bones move in opposition so that the muscles perform their work in the context of being stretched. The entire system then works as a tensegrity structure designed to provide support against gravity with a minimum of effort and a maximum of flexibility and mobility.

We experience this very clearly when we are in monkey position and the back is lengthening and widening. The back now feels like a continuous sheet because the load is so evenly distributed over the whole. No specific region is strained because no specific area has to absorb the entire load. The tensegrity structure is doing what it is meant to be doing: the muscles are pulling on bones, in the context of the bones opposing muscles and keeping them lengthened, which allows the entire back to function with a minimum of effort.

Anyone familiar with Alexander's work will recognize in this concept of elasticity through oppositional stretch Alexander's principle of antagonistic action, also known as "contrary pulls." Alexander discussed this principle in his 1934 lecture to the Bedford Physical Training College.[3] This concept of antagonistic action can be confusing, because the word "antagonist" is often used in physiology and kinesiology to denote how the action of one muscle opposes that of another—for instance, the action of the triceps, which extends the arm at the elbow, opposes that of the biceps, which flexes the arm. This is not what Alexander meant by the term. He was referring to the condition of a muscle that is elastically stretched at both poles, rather than contracting when performing work—and is, therefore, functioning more efficiently than a shortened muscle.

> "For a muscle to be healthy, it must function within a skeletal framework that imparts stretch, producing a lively, springy feel in the muscle."

Muscle Length and Connective Tissue

Muscles also operate more efficiently when they are lengthening. For example, many ungulates, or animals with hoofs, have a long nuchal ligament at the nape of their necks. The nuchal ligament is very elastic, so that it rebounds back when stretched. This is very useful to the animal because, it must lower its head to drink (which can be a long way in some animals!) and it requires a lot of work to raise the head again. The nuchal ligament makes the task of lifting the head easier: after the animal lowers its head to drink, the rebound energy in the ligament helps raise the head back up with a minimum of effort.

This same basic principle applies to human muscle tissue. Muscles contract and pull on bones to produce movement. But muscles are also, like the ungulate's neck ligament, quite elastic. Wrapping around the contractile fibers that make up muscle are sheaths of connective tissue; bundled together, they taper into tendons at each end of the muscle and attach to bone. The parts of the connective tissue sheaths converging into tendons at the ends of the muscle are quite strong and inelastic, but the parts of the connective tissue sheaths wrapping around the belly of the muscle are quite elastic and capable of being stretched.

This connective tissue component is a crucial part of the functional working of muscle because stretching the muscle creates a rebound potential in the muscle, or *stored kinetic energy*. This rebound potential assists the contractile portion of the muscle to contract when stretched, so that some of the muscle's ability to resist lengthening and to perform work requires no expenditure of energy. If, on the other hand, the muscle is already shortened and contracted, it has no elastic rebound or stored energy, and the muscle has to work harder to contract or to resist being pulled apart.

Lengthened muscles, then, are far more efficient than shortened ones because they store energy and enable muscle tissue, without any expenditure of energy, to support or move the bones. This is why, when we place a person in a position of mechanical advantage, the body becomes more bouncy and supported: the elastic component of the muscle tissue actually produces improved support. In contrast, loss of length in muscles means loss of spring-like support and potential energy; we can see this in the heaviness and stiffness in our legs as we age, in contrast to the spring-like legs of children. Our tensegrity design is based on length in muscles, and length actually creates more support with less energy.

Which brings us back to the body's tensegrity design. When a muscle is lengthening, the energy stored enables the muscle to support the skeletal framework more efficiently. This is what we see when we put someone into monkey: the back lengthens and the body seems to support itself better. Lengthening muscles support loads better than shortened ones.

A muscle cannot be considered healthy simply because it can perform work, because it is built up or toned, or because it has been stretched and relaxed. *For a muscle to be healthy, it must function within a skeletal framework that imparts stretch, producing a lively, springy feel in the muscle.* This can be brought about only by producing the correct relation of parts and encouraging muscles to let go of bones to produce highly efficient support with a minimum of muscular contraction. In the next installment, we will look at the crucial role of *stretch reflexes* in converting the musculoskeletal system into a spring-like framework.

Endnotes

1. See Buckminster Fuller, *Synergetics*, (New York: Macmillan Publishing Co., 1975), 372 for a definition and description of a tensegrity structure.
2. New York Times, "Slight Change in Gait Makes Burden Lighter," May 30, 1995.
3. Alexander, F. Matthias, *Articles and Lectures* (London: Mouritz, 1995), 177. See also "Introduction to a New Method of Respiratory Vocal Re-Education," *Articles and Lectures*, 43; see also editor's note #175, *Articles and Lectures*, 318.

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