Arild Hafstad

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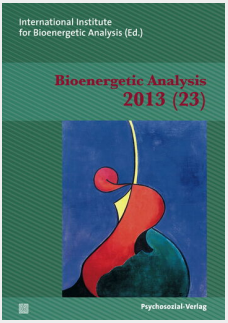

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The Merciless God of Gravity and the Organism's Humble Reply

Arild Hafstad

Thrown into a world ruled by Gravity – a blessing or a curse?
Standing on two feet is a new awakening.
Standing on my own two feet is gaining strength from within.
Living from inner balance is gaining Selfhood.

Abstracts

English

Gravity is one of the four basic forces in nature. Life forms must adapt to gravity pull. This paper addresses two questions: 1. *In life forms, how does gravity work and how is it basically handled?* 2. *What are the advantages of gravity integration, the organismic response we have inherited from nature?* Historical contributions from A. Lowen, P.M. Helfaer, S. Keleman and Ida Rolf along with new knowledge are shortly reviewed. The principle of *biotensegrity* is presented as a feasible mechanism for organismic anti-gravity regulation. Implications for the field of bioenergetics at both the cell level and for the human organism as a whole are presented. *What are the advantages of gravity integration, in the form of biotensegrity?* Tensegrity structures in the body have the valuable property of self correction in response to gravity. By serving as a soft yielding response, tensegrity manages to integrate gravity as a resource for vitality and energetic economy. Also it promotes organismic unity and is involved in the healing function of bioenergetic flow and pulsation. This examination shows above all one crucial fact: Since human beings stand erect on two feet, variation in postural *balance* becomes a variable that makes a great difference. Balancing capacity is a resource that makes a difference from the individual cell to the person as a whole. We may suspect that even at the level of *Social Self* balancing capacity is a source of integration and healing.

Key Words: Gravity adaptation, Tensegrity, Bioenergetic economy, Self Regulation, Organismic balance

German

Die Schwerkraft ist eine der vier grundlegenden Kräfte in der Natur. Alle Lebensformen müssen sich an die Wirkung der Schwerkraft anpassen. Dieser Beitrag widmet sich zwei Fragen: 1. Wie wirkt die Schwerkraft auf lebendige Organismen und wie gehen diese grundsätzlich damit um? 2. Welches sind die Vorteile einer Integration der Erdanziehungskraft als natürliche und erblich angelegte organismische Reaktion? Frühere Beiträge von A. Lowen, P.M. Helfaer, S. Keleman und Ida Rolf werden zusammen mit neueren Erkenntnissen kurz referiert. Das Prinzip der "Biotensegrität" wird als ein wirksamer Mechanismus organismischer Regulation gegen die Schwerkraft vorgestellt. Implikationen für die Bioenergetik, sowohl auf der Zellebene als auch für den menschlichen Organismus in seiner Gesamtheit werden erwähnt. Welche Vorteile bietet die Integration der Schwerkraft in Form von "Biotensegrität"? "Tensegritäts"-Strukturen im Körper haben die wertvolle Eigenschaft der Selbstkorrektur als Reaktion auf die Schwerkraft. Indem sie als eine weiche, nachgiebige Antwort funktioniert, gelingt es der "Tensegrität", die Schwerkraft als eine Quelle von Vitalität und energetischer Ökonomie zu integrieren. Auch fördert sie die organismische Einheit und ist an der heilenden Funktion bioenergtischen Fließens und Pulsierens beteiligt. Die vorliegende Untersuchung zeigt vor allem ein zentrales Faktum: Da menschliche Wesen aufrecht auf zwei Füßen stehen, werden Unterschiede in der posturalen Balance zu einer sehr bedeutsamen Variable. Die Fähigkeit, sich im Gleichgewicht zu halten, ist eine Ressource, die von der individuellen Zelle bis hin zur gesamten Person eine Rolle spielt. Wir dürfen annehmen, dass sogar auf der Ebene des sozialen Selbst, die Fähigkeit, sich immer wieder ins Gleichgewicht zu bringen, eine Quelle der Integration und Heilung darstellt.

French

La gravité est une des quatre forces de base dans la nature. Les formes de la vie doivent s'adapter à la force de la gravité. Cet article pose deux questions: 1. *Comment, dans les formes de vie, la gravité fonctionne-t-elle et comment est-elle traitée?* 2. *Quels sont les avantages de l'intégration de la gravité, et de la réponse organismique que nous avons hérité de la nature?* Les contributions historiques de A. Lowen, P.M. Helfaer, S. Keleman et Ida Rolf en même temps que le nouveau savoir sont brièvement repris. Le principe de la *biotensegrity (?)* est présenté comme une mécanisme possible pour la régulation de l'antigravité organismique. Les implica-

tions pour le champ de la bioénergie au niveau à la fois de la cellule et à celui de l'organisme humain comme un tout sont présentées. *Quels sont les avantages de l'intégration de la gravité, dans la forme de la biotensegrity?* Les structures de la tensegrité dans le corps ont la propriété précieuse de s'auto-corriger en réponse à la gravité. En étant utile comme réponse conciliante, la tensegrité parvient à intégrer la gravité comme une ressource de vitalité et une économie d'énergie. Il promeut également l'unité organismique et participe à la fonction de guérison de la pulsation et du flux bioénergétique. Cette observation montre avant tout un fait capital: depuis que les êtres humains se tiennent debout sur deux pieds, la variation dans *l'équilibre* postural devient une variable qui fait une grande différence. L'aptitude à l'équilibre est une ressource qui fait une différence de la cellule individuelle à la personne comme un tout. Nous pouvons imaginer que même au niveau du *Self Social* la capacité d'équilibre est une source d'intégration et de guérison.

Spanish

La gravedad es una de las cuatro fuerzas básicas en la naturaleza. Los organismos han de adaptarse a la atracción de la gravedad. Este artículo desarrolla dos preguntas: 1. ¿En los organismos, cómo actúa la gravedad y como se maneja?2. ¿Cuales son las ventajas de la integración a la gravedad, la respuesta organísmica que hemos heredado de la naturaleza? Se revisan las aportaciones históricas de A. Lowen, P.M. Helfaer, S. Keleman e Ida Rolf, junto con aportaciones nuevas. El principio de biotensegridad se presenta como un mecanismo capaz para la regulación organísmica antigravitatoria. En el campo de la Bioenergética, hay implicaciones tanto a nivel celular como del organismo en su conjunto. ¿Cuales son las ventajas de la integración de la gravedad, en forma de biotensegridad? Las estructuras de Tensegridad en el cuerpo tienen la valiosa propiedad de la autocorrección como respuesta a la gravedad. Utilizándose como una suave y flexible respuesta, la tensegridad es capaz de integrar la gravedad como una fuente de vitalidad y de economía energética. También promueve la unidad organísmica y está relacionada con la función sanadora de la pulsación y el flujo bioenergético. Este reflexión muestra fundamentalmente un hecho crucial: Desde que los humanos se sustentan de pie, la variación en el equilibrio postural se convierte en una variable que implica una gran diferencia. La capacidad de equilibrio es un recurso que diferencia la célula individual de la persona como totalidad. Podemos pensar que incluso a nivel del Self Social, la capacidad de equilibrio es una fuente de integración y curación.

Italian

La gravità è una delle quattro fondamentali forze naturali. Le forme di vita debbono adattarsi alla pressione gravitazionale. Questo scritto affronta due problemi: 1 – Come funziona e soprattutto come viene gestita la gravità nelle forme di vita? 2 – Quali sono i vantaggi dell'integrazione gravitazionale come risposta organismica che abbiamo ereditato dalla natura? Vengono trattati brevemente, insieme a nuove conoscenze, i contributi storici di A. Lowen, P. M. Helfaer, S. Keleman e di Ida Rolf. Viene presentato il principio di *biotensecrità* come meccanismo utilizzabile per la regolazione anti gravità del corpo.Vengono presentate le implicazioni che ha nel campo dell'analisi bioenergetica sia a livello cellulare che a livello dell'organismo umano nel suo insieme. Quali sono i vantaggi dell'integrazione della gravità, nella forma della biotensecrità? Le strutture di tensecrità presenti nel corpo hanno la preziosa proprietà di autocorrezione in risposta alla gravità. Funzionando come una delicata risposta di cedimento, la tensecrità agisce per integrare la gravità come risorsa per la vitalità e l'economia energetica. Promuove inoltre l'unità dell'organismo ed è coinvolta nella funzione curativa del flusso e della pulsazione bioenergetica. Questo scritto presenta soprattutto un aspetto cruciale: da quando gli esseri umani stanno eretti su due piedi, la variazione nell'equilibrio posturale assume una rilevanza tale da fare la differenza. La capacità di mantenersi in equilibrio è una risorsa che appare importante sia per la singola cellula che per l'intera persona. Possiamo ipotizzare che anche nella capacità di bilanciamento del Sé sociale sia fonte di integrazione e cura.

Portuguese

A gravidade é uma das forças da natureza. Todas as formas de vida têm que se adaptar a essa força. Este artigo trata de duas questões: 1. *Como atua a gravidade nas diferentes formas de vida, e como se lida com ela?* 2 – *Quais as vantagens da integração da gravidade, a resposta organísmica herdada da natureza?* Contribuições históricas de A. Lowen, P.M Helfaer, S. Keleman e Ida Rolf são revistas juntamente com um novo conhecimento. Apresentamos o princípio da *biotensintegridade* como um mecanismo viável para a regulação orgânica anti-gravidade. Apresentamos as implicações para o campo da Bioenergética a nível celular e para o organismo humano como um todo. *Quais as vantagens da integração da gravidade na forma de biotensitegridade? Estruturas* de *tensintegridade* têm a propriedade de auto-correção frente à gravidade. A *tensintegridade* age, como uma resposta suave, no sentido de integrar a gravidade como um recurso de vitalidade e economia energética. Promove, também, unidade

organísmica e está envolvida na função de cura do fluxo e pulsação bioenergéticos. Este exame nos mostra um fato crucial: desde que os humanos ficaram eretos sobre seus pés, a variação no *equilíbrio* postural torna-se uma variável de grande influência. A capacidade de equilibrar-se é um recurso que faz a diferença, da célula individual para a pessoa como um todo. Podemos suspeitar que, mesmo a nível da capacidade social de auto-equilíbrio, é um recurso de integração e cura.

Introduction

Just like the life-giving oxygen, taken in by our breathing, gravity is always here and as such, easily forgotten. In this paper I will attempt to bring gravity into our focus and ask how it really works on us. Then I want to investigate how we adapt to gravity as human beings. In particular, I like to look at how gravity and adaptation to gravity are involved in bioenergetic processes.

Gravity is one of the four basic forces in nature. The electromagnetic, the strong and the weak nuclear forces are the others. Gravity is an *energy* that draws molecules and masses towards other physical masses. The attractor force is proportional to the amount of mass. The earth is the mass that attracts us most, so we are pulled in the direction of the core of the earth. To see its force, hold a bottle of water and release it from your hand. See how it falls to the ground and is shattered by *the energy released* from gravitational pull. Humans have about the same mass/weight ratio as the bottle. If you stumble and fall you experience the released gravitational energy when you hit the ground. Inside us all the liquids in our body are attracted towards the ground. The liquids would make our feet look like big balloons if it was not contained and prevented from pouring down. What opposes gravitation? Nothing really can, the only rearrangement possible is to distribute its effects more evenly. So the problem is only half solved since by redistributing the liquids, we create an *internal pressure* equal to the energy of the gravitational pull. Multidirectional pressure inside a container adds to the unidirectional pressure toward the earth. This has a bioenergetically interesting effect: *Containing pressure is containing energy*. By containing energy it is transmuted from the distant pull of the core of the earth to an energy owned by you and me. Is it a blessing or a curse? It might become integrated as a bioenergetic resources or it can be a slow working stress – creating slow or sudden breakdown. We are under real and constant pressure. Only creatures living in waters can escape its pull since water pressure partially neutralizes its effect. For all life on land, gravity has to be handled right now with an organismic answer, *a response*. If this response is insufficient, gravity has the upper hand, burdening and demanding and even deforming or breaking the organism down.

On the other hand, if gravity is met with an effective organismic response, gravity is integrated with the *form* of the organism and its *bioenergy*. The mastering of gravity then *turns into an advantage*, a resource in the life process. More specifically, what is shaped and constantly renewed is a precise and sensitive balancing and utilizing of the gravitational energy within all aspects of the organism (Keleman 1971). This sensitive balancing ideally aligns the body segments nicely and economically. However, misalignments do happen in us all, creating various contracted postures that we need to study (Schroeter & Thompson 2011).

In my opinion, there are at least six questions about gravity that beg to be answered within a bioenergetic framework:

1. In life forms, how does gravity work and how is it basically handled?
2. What are the advantages of gravity integration, the organismic response that are operating?
3. Are there any specific characteristics of how gravity is integrated in the Human form?
4. What are the consequences for Human bioenergetic dynamics and its effect on human vitality and development?
5. What kind of role does gravity integration play in development of the Self, is it just a curious detail or of major importance?
6. How and to what extent is gravity integration a source of energy for personal fulfillment?

These are the questions I set out to explore. Thematically, the questions easily group into three pairs. The four last questions have to be set aside for the time being.

Gravity never rests or grants anyone the slightest break from it. Let us investigate how the world of living forms, including ourselves found a way of obeying the merciless *commandment* from the God of Gravity: *"Find a way of living with me or cripple and perish"*.

Several persons have addressed this issue. Alexander Lowen (1958, 1972, 1988), Stanley Keleman (1971, 1975) and Ida Rolf (1977) were in the front.

Alexander Lowen started in the late 1940's to develop his concept of *grounding,* which I believe was a major breakthrough in understanding human nature. Lowen said that the energy swings between the two ends of the organism. "This swing as the basis of the reality principle is the cornerstone of all bioenergetic principles and therapy" (Lowen 1958). He states that it is as if the energy of the human lifts the whole front end of the organism off the ground and brings the posterior limbs into a new and different contact with the earth. Grounding is the foundation for a sound sense of reality. In the grounded state the legs are able to vibrate, the feet are felt and sensitivity for

one's own being is improved. The bioenergy system is also grounded like an electrical circuit, allowing discharge through the ground. At the same time there is a deep fear in humans to let down and to fall (Lowen 1988). He saw that humans in their hope for improvements and restitution create a swing of energy upwards away from the ground, which leads to a temporary state of elation. But this upward pull is bound to collapse sooner or later. Bioenergetically, the collapse leads the upward driven energy back to the center of the organism. "Keep down and allow a movement towards the earth and the lower half of the body", he said. This will disrupt the elation-collapse dynamics. One can only allow this if there is *a feeling* of standing on solid ground. I believe this is the same thing as finding peace with gravity. The sense of reality rests on feeling the impact of gravity. Related to this is the ability to feel the impact of gravity in the center, which is the lower belly. Lowen said that in a grounded state, the legs and feet become active, felt organs of contact. He considered the lower belly "the seat of Life". Feeling this seat of life is the basis for "inner directedness" and the capacity for faith as a deep inner conviction. According to Lowen, only such faith has true sustaining power (1972, pp. 49–50). Grounding is essential to selfhood. When the person has the capacity for grounding, this allows for streaming and melting sensations deep within the organism, a sure sign of vitality. Grounding serves to release or discharge the excitation of the human organism. When grounded, due to the dynamics of charge/discharge, one can experience an energetic pulsation up and down in the body. Lowen even stated: *"this upward surge of feeling from ones roots in the ground is the bodily counterpart of all spiritual feeling. It's the basis of all religious experience. It is the miracle of life moving against gravity and feeling its own surging force"* (Lowen 1972, p. 57).

Philip Helfaer (1998/2006) follows Lowen's description and attempts to describe in more detail some of the energetic relationships and developments related to grounding.

Helfaer used the term *pulsatory grounding wave.* Grounding "is a way of describing and conceptualizing a pulsatory wave that is the energetic foundation for the integration of the upright human organism standing in its environment. Grounding describes the organism's energetic relation to the ground, that is, to the stress of gravity."

The conditions for the pulsatory wave in standing are different from when lying down. In standing, an excitatory wave pulsates between the head and tail while simultaneously forming an energetic relation with the ground. Standing in the stress of gravity, the organism must inevitably mobilize whatever character traits are present. This represents an extra expenditure of energy and a source of energy drain. Also, it represents a distortion of the relationship to the ground and therefore to reality. Vitality, grounding and the sense of reality, are based on having liveliness and charging ability at both ends of the energetic swing between pelvis and head, and between

pelvis and feet. The head and pelvis function as two containers. They can build up and hold energy until the right moment for action and discharge. Helfaer stated that *grounding, sexuality and selfhood are functionally and developmentally interrelated*.

Stanley Keleman (1971, 1975) was one of the early students of bioenergetics. He saw deeply into the human *form*, pointing out the significance of gravity in forming human structure and energetic flow. He sensed that the upright position evokes a condition of *instability and unsureness*. He thought that *the gaps between* stability in standing and in walking became an evolutionary origin of consciousness. Consciousness he wrote, *"is the pause between actions which is intensified by man's unstable erectness"* (1971, p. 8). The unsureness of the vertical position is difficult to bear, creating rigidities that produce fantasized security. Maturation and personal growth is contrary to this, based on *feeling the unsureness* of the erect position and a growing into the feeling of somatic life: *"Life lives itself as it expresses itself in the experiencing, developing deeper and deeper contact with itself and with the world"* (1971 p. 9). Keleman personally experienced that discovering anti-gravity dynamics was opening the process of finding aliveness. There is an experience of *"being held off the ground and at the same time a going-toward-the-ground. It is a dynamic pulsatory to-and-fromness that is the essence of being erect and moving"* (1971, pp. 9–10). Aliveness can only come by accepting insecurity and discontinuities in life. Aliveness to him was sensed as streaming in the core, which he compared to "deep, hot coals".

Ida Rolf (1977), another pioneer (Fahey 1989) developed a method of connective tissue correction known as *Structural Integration* or "Rolfing". She repeatedly stated that "*gravity is everything*" giving it decisive importance for human life. She said we need to make peace with the energy field of gravity. This energy can enhance or dissipate the energy of the individual. You cannot change the energy field, but *you* can change. Her basic understanding was that when the body works appropriately, the force of gravity can flow through. Such "flowing through" is healing. Creating an inner feeling of balance is essential to this process. It opens a more subtle and integrated awareness of being oneself. Rolfers are working to align the body segments and restore normal tone in connective tissue allowing alignment of body masses.

Other forms of somatic therapies have long put some emphasize on gravity and the dynamics of human verticality. Some of these are the Alexander technique (Dimon 1999), Osteopathy (Barral & Croibier 1999, Lee 2005) and basic body knowledge (Dropsy 1975).

These are some of the old contributions. Are there any new? Not only brain research (Damasio 2010) but also other branches of science come to our aid and bring news for bioenergetics. Contemporary cell-physiology sometimes refers to *the bioenergetic functions of the cell*, meaning mitochondria energy production (Cooper & Hausman

2009). Cell physiology is starting to integrate a field called *biotensegrity* (Ingber 2008), showing the impact of tension induced regulation in cell functioning. Also, rapidly developing new research in genetics, has confirmed that *gene-expression is influenced by gravity, movement, breathing, emotions and stress* (Bauer 2004, Cooper & Hausman 2009, Ingber 2008). These new findings document mechanisms that are relevant for bioenergetic theory. The Bioenergetic view has been confirmed by clinical observations and to some degree by research (Gudat; Ventling; Koemeda-Lutz & Peter; 2002); Nickel M. et al. (2006). Still, Bioenergetic Analysis is often quickly refuted by critics as speculative. So now is a good time for a fresh look at some findings relevant to the bioenergetic viewpoint.

One hypothesis I advocate is that gravity is an *organismic stimulant*. Observations of humans living under weightless conditions on board space vehicles have shown that we actually need gravity for physiological homeostasis. Calcium deposits in bone structure break down if the pull of gravity is absent. Also, if we are deprived of sufficient standing and upright movement, the long term effect may be osteoporosis and posture collapse. Usually, we recover quickly from such a condition as soon as we resume the vertical position of standing. Standing up against gravity then, constitutes an indispensible natural stimulation of the human species (Falk, K. 2002).

Even standing unbalanced will by and by have local deforming effects on tissue supporting posture. Standing balanced means actually feeling and responding momentarily with precision to gravity. It is clear then, that *we need gravitational stimulation* to trigger organismic maintenance of form and function. It is crucial that we can *feel* the just right balance so that we can help ourselves in getting the right stimulation. The *cultivation of felt balance* can be a valuable aid. In my own life and therapeutic practice I have come to value these observations. It has helped in shaping my understanding and practice of bioenergetic therapy and the development of the *Lively Column Exercises,* reported in an earlier paper (Hafstad 2008).

Genetics, learning and gravity

The adaptive solution to the problem of gravity has a common core shared by all species living on land: *All species grow supporting tissue*. To grow supporting tissue, animals use calcium deposits and proteins (mostly collagen) while plants utilize starch. Still, the function is the same – to build structure that can sustain gravity and other pressures. In addition to this common base, species may have particular genetic solutions to the problem of gravity specific to the physiology and habitats of the species. For instance, early human species like the Australopithecus and Homo-erectus must

have revised their genetic structure as they evolved to stabilize the upright posture that Homo sapiens has inherited (White, T. D. et al. 2009). Also, the epigenetic program that is activated as a child learns to get up on two feet must have been revised. Still, as bioenergetic therapists reading the body, we know that there is a lot of room for *life impact* to play a significant role in the shaping of posture. Oh, so many individual ways of carrying the body around! All individuals must find their own way to handle the problem of gravity in their life (Keleman 1971). The complexity of this response is ours, in every moment of our living and throughout life. Gravity however, never lets us escape the consequences of our bearing and gait.

There is one lesson laid down in every land-based organism. In every plant or animal the most energy saving basic arrangement is to raise some rigid structure or skeleton *precisely* against the direction of gravity pull. This is the first remedy to prevent disorganizing and possibly lethal effects of gravity. It is however not a sufficient solution, since other pressures like those created by wind, growth, movement and the structure of the organism, creates *other pressures that mix with gravity pull*. Even trees with a stationary trunk must have additional lateral arrangements to support its branches and leaves and to handle the horizontal impact of windy weather. Not only the macrostructure of an organism but also organs, tissues, cells and cell organelles must structure themselves to handle gravity *and* the pressure from movements and waves always running through the organism. The supportive elements therefore, must be multidirectional to meet the challenge from gravity and other pressures. What are they? How are they built? Is there a mechanism for weaving supportive tissue? Before looking into this theme I like to note two issues relevant for human beings and bioenergetics.

Gravity and human bioenergetics

First, consider the laws of energy. As mentioned at the beginning, there are four energy forces known: electromagnetic energy, a weak and a strong nuclear energy and finally – gravity. The concept of energy in physics, states that energy cannot be destroyed, only transformed. All four forms of energy can manifest themselves in the world as radiation, heat, movement, tension and electric charge. Any energetic form can get transformed into the others and so make a foundation for life processes. Energy is the basis for life. The ways the organism incorporates energetic transformations *is* bioenergy.

Secondly, we may notice that the activity of gravity underlies *bioenergetic economy*: To "fine tune" balancing of body masses in relation to gravity pull is crucial for energetic economy and energy regulation. The poorer the alignment and the more off-centered

a person becomes – the more energy and effort are required just to sustain a posture. Energy is stolen from other life tasks and breeds rigidity and tension. We lose emotional stability, ease, freedom, choice and power of judgment. Life gets heavy and it adds to negative feelings about life.

On the other hand, standing centered and well balanced stimulates processes needed for sound functioning of cells, organs and the person. Since we can observe that not only gravity but also *emotional burden* influences the human posture, it is clear that gravity gets into a complex involvement with the self. So cultivating a balanced posture may improve homeostasis and self-regulation. We can gain in vitality and selfhood.

Multidirectional supportive elements or "the architecture of life"

A major leap forward in enlightenment concerning *the basic mechanisms of counter gravity regulations* was provided by Donald E. Ingber MD, PhD in his 1997 article[1]: "*The Architecture of Life",*(Scientific American jan.1997, 49–57). Ingber discovered what he thought was an underlying principle in nature. He described a specific rule of self-assembling or self-organizing found from the molecular to the macroscopic level of any organism. He discovered this *rule of forming*, by influence from an architect, Buckminster Fuller. Fuller had made what he called *tensegrity* structures in buildings and the artist Kenneth Snelson made sculptures based on the same principle. However, it was Ingber who saw a parallel between certain buildings, sculptures and the biological world.

What Is Tensegrity?

The architect Buckminster Fuller was studying tension distribution in building construction. The term *tensegrity* does not refer to ordinary building principles but to buildings that can be very strong and stable by using lighter materials and less of them. Such a building constitutes "*a system that stabilizes itself through distribution of tensional and compressive forces balanced within the building"*. Ingber became interested in tensegrity in the1970s when his studies in biology made him understand that living forms also have an architectural aspect. Since the molecules and cells that

1 My presentation below is mostly based on this article so I will not make references in every instance. References to other sources are shown in the usual way.

form our tissues are continually removed and replaced – it is *the maintenance of pattern*, he thought, that constitute what we call life. One thing he observed in the general structure of cells was that

> "It is not the strength of the cell walls but the way the entire structure of the cell distributes and balances mechanical stresses, that makes it stable, and so becomes an integrated and flexible building module for the organism. This property is established through the principle of tensegrity".

We have seen so far that gravity is the main source of mechanical stress in land based life forms. Tensegrity structures are uniquely equipped to handle such stress. They are made of two basic components. The *first element* is a basic *tension bearing framework* made up of rigid sticks or struts, each of which can bear tension *and* compression[2]. Gravity is the basic energy these elements are dealing with. These structures are connected into triangles, pentagons or hexagons, and each stick is oriented to constrain each end to *a fixed position*, thereby assuring the stability of the structure. The *other elements of tensegrity structures are* strings that can be tensed but not compressed, much like the strings of guitars. These qualities give the system a capacity for *flexible self adjustment*. The strings stabilize themselves through a phenomenon known as pre-stress. While the sticks are structural members that can bear tension and compression, the strings are entirely different by only *bearing tension*. Even before these strings are subjected to variation in external force, they are *pre-stressed by a certain tonus*.

Tensegrity structures are built of elements that create a three dimensional space (tension and compression bearing sticks) and some elements that keep spaces together (pre-stressed strings) creating a stress-distributing integrated whole. The figure 1 is an example of the most simple tensegrity structure.

These *counteracting forces, which equilibrate throughout the structure*, are what enable it to stabilize itself. The organized whole holds an evenly distributed tensional tone. It has tension and integrity combined to form tensegrity. Tensegrity structures of both categories share one critical feature, which is that *tension is continuously transmitted across all structural members*. When a part increases its tension there will be an equal tension increase in the rest of the system, but divided on the other parts. This global increase in tension is followed by an increase in compression within certain sticks dependent on their position in the structure. In this way, the structure stabilizes itself through an energetic principle that Fuller described as:

2 Tension is energetic charge created by stretch and contraction, while compression is energetic charge from pressing together (my comment).

Continuous tension and local compression

Such combination is not found in ordinary buildings, since they get most of their stability from compression by the force of gravity. An interesting aspect of tensegrity forms is that *they spontaneously place their elements along the shortest and most direct paths between adjacent members,* creating three dimensional forms. When the shortest possible lines between two points are on a curved surface, they spontaneously arrange *geodesically.* They form like geodesic domes (figure 2). This is often the case in biological systems.

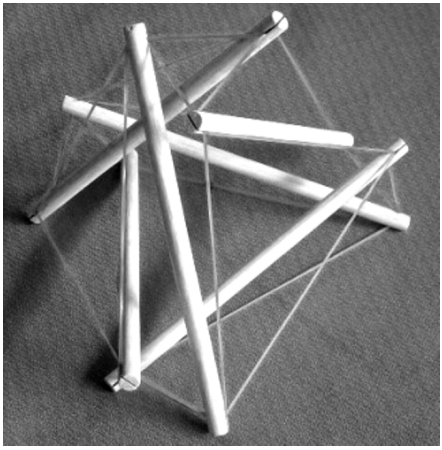

Figure 1: Simple tensegrity structure

Tensional forces naturally transmit themselves over the shortest distance between two points, so the members of a tensegrity structure find the optimum position for handling stress. For this reason, tensegrity structures offer a maximum amount of strength for a given amount of building material and energy expenditure.

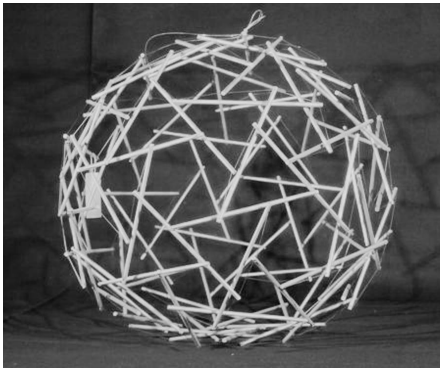

Figure 2: Geodesic dome

Biotensegrity

When tensegrity operates within life forms, it is called *biotensegrity*. The first indications that biological systems may be organized according to tensegrity occurred when Ingber and associates did cell physiology research at Harvard. Since understanding of cell processes is basic to bioenergetics, let's have a look at the cell level.

Tensegrity structures of the living cells

It's been known for decades that cells have their own connective tissue made up of *cytoskeleton, microfilaments, intermediate filaments and microtubules*. Since the 1970s it is known that cells act and interact mechanically (Cooper & Hausman 2009), (Ingber 1997). The cells connective tissue has an active role in controlling cell shape, cell regulation and gene expression. Knowledge is rapidly surfacing in this field (Cooper & Hausman 2009).

In a study in the 1990s, Ingber made a simple tensegrity model to mimic how cells keep their form from within. He made a structure of six wooden sticks and the same number of elastic strings. He also placed a similar model, as the cell nucleus, within the one that represented the whole cell. To mimic cytoskeletal connections between the nucleus and the cell, he stretched strings from the surface of the large structure to the smaller one inside. When he pushed down this cell model with his hand, it was for a moment forced into a flattened pile of sticks and string. *As soon as the pressure was removed, the energy stored in the tensed filaments caused the model to spring back to its original, roughly spherical shape.* Later he showed experimentally that his construction mimicked the known behavior of living cells: Cells change shape when they are subject to external pressure and this response is transferred to the nucleus. Internal connective tissue makes the cell adapt to external pressure, just to *regain* its form when the pressure leaves. This happens continuously in organisms *without damaging the tissue*. The cell nucleus and DNA is subject to the same response. Further, the outside anchors of the cell are pulled so that outside structures respond too, making the form of the cell and surrounding tissue a two way street. We can recognize a bioenergetic aspect of these observations. When we move or are emotionally moved, waves and pulses are continuously transmitted through the tissues, making cells change and regain shape. These are movements of bioenergy transmission. Waves are always going through healthy tissue, changing frequencies and amplitudes with our behavior and states.

A closer look at the cells tensegrity structures

Inside the cell, a crisscross network of contractile microfilaments extends throughout the cell, exerting contractile tension. They pull the cell's membrane and all its internal constituents toward the nucleus at the core and tend to round the cell geodesically (see figure 2). Opposing this *inward pull* are compressive elements, some from outside the cell and some operating inside. The compressive structures inside the cell can be either microtubules or large bundles of cross-linked microfilaments

within the cytoskeleton. The third component of the cytoskeleton is the integrators. These are the intermediate filaments, connecting microtubules and contractile microfilaments to one another as well as to the surface membrane and the cell's nucleus. They also act as wires, stiffening the nucleus and stabilizing cell shape. At the cell surface we also find *receptors* that can produce immediate structural changes deep inside the cell. By this arrangement the cell and the nucleus can immediately align in the direction of pull. So the cell, like the organism as a whole, can produce changes in state and shape. It can contract, expand, be flexible or rigid, elongate, round, etc. The cell can, by means of tensegrity, immediately adapt to pull in a way that is basically soft and refined. First, it can allow deep impact and then, redirect energy from one source to all directions, resulting in maximum energy distribution.

From this description we may conclude that cells are adapted to answer the demands of gravity. They respond in a "humble" way that smoothly distributes unidirectional gravity into tensional multi-directionality. In this way the burden is transformed into manageable levels of charge. Is it possible that this low level charge can be converted into various energetic forms?

From gravity to bioenergy

To investigate this we may chose to ask: Can gravitational mechanics enter into the world of biochemical processes? Can gravity become integrated into the processes of chemical transformations?

Gravitational pressures become a continuous tension through the body structure and reach into the cell interior, since the microfilaments and cytoskeleton are in direct connection with the connective tissue of the whole body. Tensions and compressions of bones bearing body weight are spread in waves through all connective tissue. The collagen sheets wrapping bones, muscles and organs and the fine spindle like network between the cells called the *extracellular connective tissue matrix*, makes a web reaching into all tissue. Collagen fibers have little elasticity and are electrically charged. The waves of gravitational pull are charging these structures with electrical and mechanical tension that spreads through the whole web. The web is a tensegrity structure.

How do these waves enter into the cells? Cells are anchored by *focal adhesions* in the extracellular matrix. Contractile microfilaments in the cell respond to external tension through these anchoring points by shortening and tensing. When the wave reaches the cells external anchors, the charge is directly transmitted to the cell interior: Inside the cell, microtubules are compressed at their ends by the pull of surrounding contractile microfilaments. This compression prepares a road to integrate mechanics

and biochemistry at the cellular and even molecular level. So what is the next step? We have already seen the cell's cytoskeleton change form by shifting physical forces transmitted across the cell surface. *This is the key. Cytoskeleton changes modify many of the enzymes and other substances that control protein synthesis, energy production and growth in the cell*. For instance, blood pressure and gravitational compression in bones influence genetically coded synthesis of proteins relevant to the regulation of the circulatory system and the skeleton (Cooper & Hausman 2009). To conclude, changing cytoskeleton form translates mechanical energy into biochemical processes and by that is establishing *a bioenergetic switch between gravitational and biological energy*. In a sense, this means that humans carry *a small scale dynamo inside the cells. The dynamo is able to convert gravitational energy into a kind of nutrition for bioenergetic processes, or simply stated* – gravity becomes a source of aliveness.

This mechanism can influence *gene expression* in a profound way. Chen, et al (1997), did an experiment in which living cells were forced to take on different shapes, spherical or flattened, round or square. By modifying the shape of the cell, they could *switch cells between different genetic programs*. Cells that spread flat became more likely to divide, whereas round cells that were prevented from spreading activated the programmed death known as apoptosis. When cells were neither too extended nor too retracted, they neither divided nor died. Instead they went on in a steady state manner. Thus, mechanical restructuring of the cell and cytoskeleton can be decisive to the fate of the cell. Very flat cells, with their cytoskeletons stretched, signal that more cells are needed to cover the surrounding substrate as in wound repair and that cell division is needed. Rounding indicates that too many cells are competing for space and that some cells must die. In between these two extremes, the cell is told to go on with "business as usual". Gravity can influence basic homeostatic processes in the cell governed by genetic programs.

From cell to organism influence

We have seen that gravity influence reaches into the cells and stimulates deep changes. Can these changes in cell state start a wave in the other direction, modifying the state of the whole organism? Here is one example: Many different types of tissue cells, including muscle, cartilage, blood vessels and skin, evoke a response known as *linear stiffening*. If you pull on your skin, for example, you may feel the resistance increase with the pressure you apply. Increasing external force is met with *increasing resistance*. Ingber explains that when the stress applied to integrins (molecules that go through the cell's membrane and link the extracellular matrix to the

internal cytoskeleton) increase, the cells respond by becoming stiffer and stiffer, just as whole tissues do. The local stress applied makes more of the contractile microfilaments rearrange themselves *in the direction of the applied stress.* Since gravity is constantly tugging on the organism, rearrangement occurs spontaneously to meet this force, making cells stiffen in the direction towards the earth and regulate tissue development to sustain the pressure. So we see that cells clearly adapt to pressure by growing molecular structures to sustain the way gravity influences the organism. Stiffened cells affect the whole web of the organism through the tensegrity principle of *tensing continuously and compressing locally*. They signal outwards, tensing the surrounding tissue and ultimately the whole organism. So the next time we touch a client, the pressure we apply at one spot may have a general effect at a very basic organismic level. If a person has a distorted posture, gravity impact will be unbalanced and distortion builds into the structure through linear stiffening.

When a mixture of gravity impact and emotionally induced tension patterns enters into a cell, their *combined pressure* will modify structure at the cellular level. The cell interior and the cell nucleus are at the same time monitoring and responding inward and outward. Stiffening in fear and receiving disharmonious physical shock waves will directly influence the cells and make them tense. The organism naturally stiffens to meet an expected shock (Lowen 1972). If one remains in the stiffened position, the organism does not relax and the impact of combined shock and fear is not disrupted. Locking the knees and tensing the anti-gravitational supportive muscular system more than required by gravity alone, is a response to the fear of falling when in danger. It easily becomes built into the tensegrity structures, incorporating a character pattern. Then the natural response of giving in is blocked and so are the roads to natural discharge. The functions of grounding are impaired. This kind of stiffening creates insensitivity and distortions of the natural response to gravity. At the level of individual cells, fear of letting down blurs the response to gravity. It seems to me that we now may have an explanation for our somatic character formation (Lowen 1988) ready at hand.

To sum up, physical and emotional pressure change cytoskeletal geometry, affect biochemical reactions and alter gene expression of the cell, even at the level of activating major gene programs. Gravity enters into the core of life-processes and bioenergetic processes. At every moment there is a whole-part tensional dynamic between the organism and the cells, where the cells immediately sense pressures humans are going through and even can make major adaptations. We are just beginning to learn what kind of advanced homeostatic control is operating at the cell level. Of course, the pathway of gravitational influence on life processes is only one of several influences incorporated into cell homeostatic response. For instance, different organismic states

are adjusting chemical and neuronal signals to the cells. These adjustments release chemical compounds across the cell walls and inside the cells to modify the cell state.

The intimate interaction between cells and the condition of the organism predicted by bioenergetics is confirmed by these observations.

At the organism scale

In human biotensegrity the skeleton is the compression and tension bearing structure, while the compression adjusting strings are made of connective tissue and muscles combined (Cooper & Hausman 2009).

According to the research of Ingber and his associates, biotensegrity is manifested *at all levels of the organism*, from molecules to the whole acting organism (Ingber 1998). Later investigations have confirmed the generality of biotensegrity in biology (Levine 1995, 2007). Through tensegrity, refined changes are established *below* the level of neuronal control. Many structural needs and solutions are spontaneously met by emergent self organization. Counterbalancing gravity establishes integrity. All parts and levels are adjusted through tensegrity and give the organism an option to unify as a whole. This fits well with the bioenergetic understanding that "energy flows were it can" and that the organism has a great capacity for instant self adjustment and healing if it is not interfered with from above. Also in physiotherapy and osteopathy it is well known that a tensional release in one body part can eliminate a symptom on the opposite end of the body (Meyers 2001).

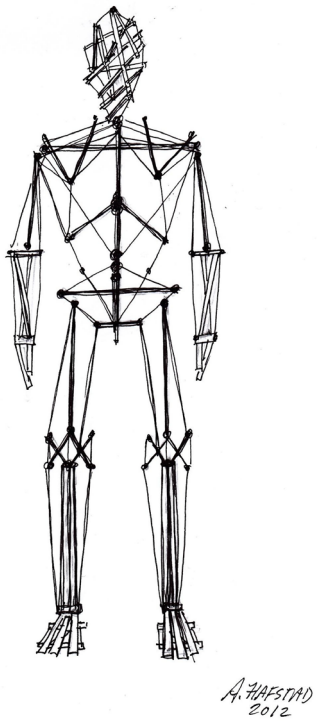

Figure 3: tentative tensegrity model of the human body

Gravity demands a response and biotensegrity organizes such an adaptive response. *"Thus, from the molecules to the bones and muscles and tendons of the human body, tensegrity is clearly nature's preferred building system"* (Ingber 1997). It is clear

that tensegrity is an elegant and powerful mechanism for organismic regulation that solves organismic needs before the nervous system intervenes. Even more, it represents a mechanism for a) bioenergetic economy; b) a speedy line for communication between parts and levels; c) a means for organismic integrity that in many ways are more efficient than the nervous system; d) its flexible structure participates in organismic pulsation and aliveness. Waves reverberate easily through tensegrity systems. Ingber found that tensegrity structures function as *coupled harmonic oscillators*. DNA, nuclei, cytoskeletal filaments, membrane ion channels and entire living cells and tissues *exhibit characteristic resonant frequencies of vibration*. Transmission of tension through tensegrity lines provides a means to distribute forces to all interconnected elements and, at the same time to *tune* the whole system as one. As Alexander Lowen pointed out from the 1950s, (Lowen 1988 a, b) the human organism is such a pulsating vibrant system.

We have seen how a basic principle in nature – tensegrity – constitutes a basis for the human energetic system where gravity plays a fundamental role. Lowen was first to put major emphasize on gravity when he introduced the principle of grounding as basic to human health and vitality. Let's consider a person.

Eve is in good balance. She stands well in her feet. The left and right are symmetrical. While she stands, body segments are aligned so gravity compression runs straight through her middle axis. From the viewpoint of tensegrity, she keeps most of the tension-compression bearing near the midline and in the lower part of the body. This means that most tension-compression is received by the bones, cartilages, and discs in feet, ankles, legs, pelvis, sacrum and the lower vertebrate. By standing so well, these structures receive a maximum of gravitational impact. They are charged up with high tension-compression. Her bones are not simply stiffened calcium structures. They are alive with some flexibility, filled with blood and cell producing marrow. They are heated from within since their metabolic activity is high. Bones have nerve ends attached. They are made of busy working cells that respond to pull in the ways we have seen above, that is, quickly adapting internal pressure; turning gravitational pressure into biochemical processes; getting the genes into expression; transmitting pulses to the tension bearing strings and sending harmonic oscillations through all connective tissue and muscles attached to the bones. So Eve holds a good charge at the bearing core. She is very vital and full of energy. Tendons and tiny muscles close to the skeleton are tension bearing strings that aid balancing against gravity. She is well balanced and makes adjusting movements with ease. This comfortable state is continuous with all tension bearing strings in her body, playing soft music on them, entering into the cells. The more peripheral bigger muscles can join in the orchestra, be available for free expressions and swift spontaneous movements.

The tensegrity model shows us human dynamics. A strong "core tension-compres-

sion charge" due to refined balancing against gravity will stimulate vitality at the core and be followed by a comfortable level of tension in the strings of muscles and connective tissue. The cells hear sweet music coming and thrive. I guess Ida Rolf (1977) would have said that the gravitational energy is allowed to go through.

When balancing against gravity is less refined or even chronically distorted, the dynamics change.

Adam got a scoliosis from losing a rib bone. It constantly brings him off-balance to the left. The gravity impact gets more diffuse and less centered, so the core tension-compression charge is reduced; the core is less stimulated, less vital; the tensional pulses from the core structure get more jerky and unstable. Supportive strings close to the core must increase their tension to secure stability and carry more of the gravitational burden. Supportive strings close to the missing rib tend to stiffen and send tensional waves to all other strings, increasing the general tension at all levels. The rest of the strings in peripheral muscles and in connective tissue tune in by tensing up. The tone of their vibrating oscillations becomes disharmonic. The cells tense too.

The interplay of tensegrity dynamics at different scales

The principle of tensegrity needs clarification at one point. The general tensegrity principle of *continuous tension and local compression* is a vague formulation. In bioenergetic analysis it is a basic observation that tensional levels through the human organism have variations and they even may seem discontinuous. There can be strong local variations and striking differences. These observations do not need to contradict what has been said so far if we consider the following examples. Think of a tensegrity structure with 10 elements and the tension of one element is incidentally doubled. The rest of the elements will distribute the same tension between them, meaning an average of $^1/_9$ of the tension increase for each. In addition, if you have ever put up a tent and tensed one of the strings attached to the ground, the rest of the tension lines in the tent will straighten up, but with variations. I guess the same will apply to the human body.

We have seen at the macro level that tensegrity can describe a basic mechanism for a person to keep his posture. It has a distinct dynamic. Tensegrity can help explain why a person is more or less rigid, more or less flexible and how central and peripheral aspects interplay. We can see that tensegrity brings a direct line between cell function and overall function – between strain-level functioning in the person and strain-level functioning at the cell level. The overall tensional aspect of a person might have its counterpart at the cellular level. It is a major breakthrough in a unified view of the human being to identify such a powerful pathway of unity.

In this paper I have attempted to answer two questions.

1. In life forms, how does gravity work and how is it basically handled?

I conclude that gravity is a major force in life that demands an organismic response. Biotensegrity is a strong candidate for serving as a basic way of organizing this response.

2. What are the advantages of gravity integration and the organismic responses that are operating?

We have seen that tensegrity has an inherent self corrective ability. Once the human organism is placed in its gravitational axis, it will inherently self-correct to find the most economic positioning of its parts. It works for alignment. Tensegrity serves as a soft yielding response, as an answer to gravity. It allows integration of gravity as a resource for vitality and energetic economy. Also, it promotes organismic unity and is involved in the healing function of bioenergetic flow and pulsation.

Still, we have seen that different misalignments are the usual state of affairs in humans (Schroeter & Thompson 2011). Also it is true that character traits always get mobilized when we stand (Helfaer 1998). Apparently, tensegrity self adjustment will never be enough to bend us into shape. Still we may ask – can we find a way to make more room for tensegrity self-correction? I believe one answer can be found in cultivating the sense of balance. Balancing capacity is a resource that makes a difference to the individual cell and to the person. Since humans stand erect on two feet, postural balance becomes a variable that make a great difference. Sensing balance is sensing the axis of gravity. It is an inner bodily sense.

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Arild Hafstad was born in 1957 in Oslo, Norway, where he lives and works. Graduate psychologist 1983, clinical psychologist 1988, chief psychologist 1988–1993. Full time private practice from 1993. C.B.T. in 2004. President in the Norwegian Society for Bioenergetic Analysis 2006–2010. Assistant trainer in BA training group 2007–2010. Published in the European Journal of Bioenergetic Analysis 2008. Board member in The Norwegian Forum for Character Analysis. He is conducting workshops in Bioenergetic Analysis.