THE FASCIA AS THE ORGAN OF INNERNESS – AN HOLISTIC APPROACH BASED UPON A PHENOMENOLOGICAL EMBRYOLOGY UND MORPHOLOGY

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Abstract

Usually the fascia is described in typically anatomical terminology of spatial discrimination of structures. Fascia however is (besides of blood) one of the main appearances of the quality of 'meso', which is one of the three basic germ layers of the human organism. Actually the usual term 'Meso***derm***' is not correct, because it does not value the functional architecture of 'meso' as 'inner tissue' and being a different quality than the ectoderm and endoderm which function as body limiting dimensions (body walls). Actually it are not the viscera that represent the 'Inner' of our body organization but that is done by the 'meso' with 'fascia' and blood as major representatives. Such a (phenomenological) approach demands to understand the architecture 'of the connective tissue in the body as a whole, the analytic approach of the anatomical mind is not fitting for that. Moreover there is the quote by AT Still mentioning the fascia as the domain "where soul is dwelling". What do soul and fascia actually have to do (and have not to do) with anatomy and topography?

From the phenomenological stance one may discern everywhere in the body and in various ways two main functional tendencies in the connective tissue. Body cavities and joints e.g. represent the 'dis-connecting' and 'shaping space' quality of the meso which enables mobility; the 'connecting' quality on the other hand creates anatomical and mechanical connections between organs and body parts. In the so-called musculoskeletal system those two aspects of the connective tissue are clearly discernible. An architectural description of meso respectively connective tissue is therefore necessary, because the anatomical mind neglects the continuity of the connective tissue as integrating matrix of the body.

Such an approach also leads to an alternative architectural view of the substrate involved in the transmission and conveying of forces over synovial joints as well as to the distinction of other functional units in the locomotor system than the traditional triad of muscles, ligaments and bones (van der Wal, 2009). For example an architectural description of the muscular and connective tissue organized *in series* with each other (as to the transmission of forces) is more appropriate than the classical concept where 'passive' force guiding structures like ligaments are organized *in parallel* to actively force transmitting structures like muscles with tendons. 'Dynaments' (conceivable units of connective and muscular tissue *in series* to each other) are capable of movement and force control throughout the entire range of movement. Such a concept is also more in harmony with the emerging of fields and forces during the embryonic development of the body (as described by Blechschmidt) as well as with the modern models of *syntegrity* as organizational principle of the locomotor apparatus. In the latter model not motion but spatial posturing is the issue, performed by the architectural interaction of stiff space shaping elements (e.g. skeletal elements) and flexible connecting elements (like muscles, ligaments and 'dynaments'). This also accords with modern neurophysiological concepts where it is clear that not muscular anatomy is represented in the cerebral cortex but locomotor functionality ("the brain knows nothing about the muscles"). Muscles are not THE contractile organs, muscular tissue also represents the 'meso'-quality but in a more dynamic way than connective tissue since it is able to connect and shape space dynamically by means of contraction and relaxation. In this way muscles (or 'dynaments') control the spatial positioning of the anatomical (skeletal) elements between which they are organized.

Also the usual distinction between so-called joint receptors and muscle receptors appears in this way to be an artificial one. Mechanoreceptors (also the muscle spindles) are arranged in the context of force transmission circumstances i.e. of the *architecture* of muscle and connective tissue rather than organized along the 'classical anatomical units' like muscles, capsules and ligaments. The proprioception of ourselves as bodies with an 'inner' ('body sense') is not simply synonymous with the mechanical proprioception active in the locomotor system. The latter represents the sensing mechanism essential for the steering and the handling of forces and leads to statesthesia and kinesthesia (the sense of posture and motion). Psychological proprioception ('body sense') is a different category and may be linked with the 'meso'-dimension of our body and is therefore not topographically localized, It happens (or "dwells") in the meso. Why not extend the concept of fascia to the 'intermediate man' of 'meso'?

THE FASCIA AS THE ORGAN OF INNERNESS – AN HOLISTIC APPROACH BASED UPON A PHENOMENOLOGICAL EMBRYOLOGY UND MORPHOLOGY [1]

Introduction. What about fascia?

In the article What is 'fascia'? A review of different nomenclatures[2.] Robert Schleip et al. make proposals to review the current terminology around fascia. This issue also was a central item of the Second International Fascia Research Congress in 2009 [3] [4]. The necessity to review for example the nomenclature of fascial and connective tissue structures in the body was argued based upon the widespread diversity and inconsistency of such terms and nomenclature. In fact the anatomy of the human body is implicitly based upon the principle that names are given to discrete (this means in principle discernible and 'dissectible') topographical structures and units in the body. Connective tissue structures for example are only recognized as anatomical structures if one is able to discriminate (again: dissect) them from other structures. It is for that reason that the British edition of Gray's Anatomy [5] (this highly respected textbook of anatomy) defines fascia as "masses of connective tissue large enough to be visible to the unaided eye". This however apparently also expresses that, according to those authors, not any functional criterion is linked with the term fascia. In principle a fascia was (is) considered to be a layer of connective tissue covering, enveloping, separating discrete anatomical structures like muscles and bones. And that is how fascial layers most of the time nowadays still are named. If one for example describes and discriminates a *fascia cruris*, the definition apparently is topographical anatomical, saying this fascia is enveloping the (various anatomical elements of the) foreleg. The *fascia colli (cervicalis media)* is organized as a sheath around the so-called infrahyoid muscles. So in anatomical nomenclature names are given to fascial layers and structures based upon WHERE they are situated and organized. The term or name does not tell anything about HOW they are functionally reps. mechanically related to the underlying or neighboring tissue and structures.

If one however dissects the *fascia cruris* (or the analogous *fascia antebrachii*) one may observe and conclude that distally this fascia is loosely connected with (or shouldn't we say: 'dis-connectible' from) the underlying muscles. It therefore can be dissected easily as a separate layer or structure. In the proximal domain of the forelimbs however it is literally impossible to disconnect (dis-sect) this fascia from underlying muscles. Here one has to separate with as sharp dissection procedure the underlying and inserting (!) muscle fibers from the fascia. Here apparently the fascia is not a coverage layer but functions as a strong force transmission layer, like an aponeurosis. Aponeuroses however are well known and officially discernible anatomical structures, considered to be associated with given anatomical units like muscles, therefore recognized as auxiliary components of the related muscles. In Gray's Anatomy a kind of functional criterion is applied to discriminate between fascia and aponeuroses i.e. that "in contrast to aponeuroses, fasciae are described as connective tissue structures with an 'interwoven' arrangement of fibers". One simple look at the architecture of the fibers of *fascia cruris, fascia lata, fascia antebrachii* and more makes it

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[1] It will come out from this article that in fact "organ of Innerness" is a *contradiction in terminis.* In this article it will be argued that our 'inner' or innerness' is actually NOT re)presented by or located 'in' a particular organ or region in the body, particularly not the brain for example.

2 Schleip, R. et al., 2012, What is 'fascia'? A review of different nomenclatures, Journal of Bodywork & Movement Therapies (2012): (http://dx.doi.org/10.1016/j.jbmt.2012.08.001)

3 Huijing, P.O., Langevin, H.M., 2009. Communicating about fascia: history, pitfalls and recommendations. International Journal of Therapeutic Massage and Bodywork volume 2, number 4.

4 Findley T.W., 2009, Fascia Research II: Second International Fascia Research Congress, Tom Findley, International Journal of Therapeutic Massage and Bodywork, volume 2, number 3.

5 Standring, S (Ed.), 2008. Gray's Anatomy, The Anatomical Basis of Clinical Practice, fortieth ed,. Elsevier, Edinburgh.

evident that for those parts of these fasciae that are organized within the context of force transmission this criterion of fiber arrangement is not valid at all. [6]

Apparently it should be realized that architecture is something else than anatomy and topography. In the context of the Second International Fascia Research Congress in 2009 the research community developed new criteria and formulated the definition of fascia as "fibrous collagenous tissues which are part of a body wide tensional force transmission system". This 'new' view on fascia is inspired by recent descriptions of the fascial net in terms of **tensegrity** structures [7] [8]. Such a definition however tends to deviate in the opposite direction since the question may be raised: How should we next consider and classify covering envelops like *fasciae cervicales*? Or the visceral fasciae as the mesothelial membranes covering viscera and inside body walls (like peritoneum and pleura) often are called in the domain of osteopathy? Are those structures now no longer considered to be fascia or fasciae? Can we push such comments aside as being a purely semantic issue or is it related to a fundamental notion or even misunderstanding about the quality of the term fascia? In particular in the domain of Osteopathy the concept of fascia is on the one hand widespread and essential but on the other hand poorly defined at least according to criteria of anatomy and topography ('where') as well as according to functional criteria ('how'). Moreover in Osteopathy the concept of fascia is more or less mystified like in the often cited quote of AT Stil: "The soul of man with all the streams of our living water, seems to dwell in the fascia of the body" [9]. What a kind of organ is that, which on the one hand is considered to be the bodily substrate of osteopathic treatment and manipulation, on the other hand represents the functional substrate of a tensegrity system and last but not least moreover is considered as a kind of non- or trans-anatomical organ or system that also is considered to be a 'dwelling' for the soul? What kind of morphology and anatomy do we need to understand the functional architecture of such a multifunctional tissue or organ?

In this chapter the author will elaborate his strong conviction that only a phenomenological embryology and a holistic architectural approach of the morphology of connective tissue will elucidate the aforementioned multi-functionality of the fascia. It may come out that a thorough rephrasing of the substrate of fascia has to occur. First we will look for the functional embryology of connective tissue and fascia: where is the fascial tissue derived from and in which terms and functional modalities should the morphology of it be understood? (A. The embryonic origin and dynamic morphology of the fascia - a phenomenological approach). Next we will address our attention to the inherent impossibility to describe the functional spatial relationship of fascia and its components in proper anatomical terminology. Research will be presented that the proper way to describe the fascia is according to notions and terms of architecture and that this architecture is instrumental in the function of the fascia as organ of force transmission, movement and sensing (B. Architecture of the fascia: not only 'where' but also 'how'). Next, again based upon a phenomenological embryological view, the model will be introduced that fascia as an organ may be understood in the best way if the architecture of connective and muscular tissue is considered as one integrated dimension of the human body in broad sense (so-

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6 van der Wal, J., 2009. The architecture of the connective tissue in the musculoskeletal system e an often overlooked functional parameter as to proprioception in the locomotor apparatus. International Journal of Therapeutic Massage and Bodywork volume 2 number 4

7 Levin, S.M., Martin, D.C., 2012. Biotensegrity: the mechanics of fascia. In: Schleip, R., Chaitow, L., Findley, T.W., Huijing, P. (Eds.), Fascia e the Tensional Network of the Human Body. The Science and Clinical Applications in Manual and Movement Therapy. Elsevier, Edinburgh.

8 Robert Schleip et al. (eds.), Fascia: The tensional Network of the Human Body, Chapter 2.2: 81 – 87, Churchill Livingstone Elsevier, ISBN 978-0-7020-3425-1

9 Paul Lee, 2005, Interface: Mechanisms of Spirit in Osteopathy, Stillness Pr Llc

called 'mesodermal' germ layer) and of the postural and locomotion [10] system in narrow sense (tensegrity system) (C. Meso, fascia as well as tensegrity are about two). Last but not least and interwoven into the considerations above, the phenomenological view will be presented that the meso(derm) represents the dimension of 'innerness' in the body with the blood and the fascia as the main representatives of what could be considered as our 'inner' or 'soul' (D. The fascia as representative of the Middle and as the Organ of Innerness).

A. The embryonic origin and dynamic morphology of the fascia, a phenomenological approach.

First we will look for the functional embryology of connective tissue and fascia: where is the fascial tissue derived from and in which terms and functional modalities should its morphology be understood?
To understand where fascia is originating from, our attention should surely be addressed to the embryo. The first problem however is How do we interpret the processes that lead to the formation of a body, an organism? In the view of the phenomenologist it is nonsense that we as a whole are built from or formed by elements and parts like cells and organs. From the first day of development on we are an organism, a whole and the parts, the tissues, the organs are resulting and originating from that whole (and not the reverse). We originate from a germ not from parts, elements, organs or tissues.
So, differentiation is the leading principle of the developing embryo and since genes are in this respect not active principles, the essential question about developing tissues and organs is: **where** do they come up? What are the metabolic and morphogenetic qualities of the domains and areas where cells, tissues and organs differentiate? The principle of the morphogenetic fields is developed from the domain of developmental biology. In this principle environmental conditions (metabolism, forces exerted on cells and tissues) are much more important for the process of differentiation then topographical or anatomical criteria.

The German Embryologist Erich Blechschmidt (1914 -1992) recognized this fully when he commented the widely accepted notion that the primary differentiation of the human body is that into two respectively three germ layers. He showed that differentiations are not only the result of a gene effect, but also are brought about through growth initiated by 'extragenetic' (occurring outside the gene) information. Without this 'extragenetic' (nowadays mostly called 'epigenetic'?) information, differentiation would not begin. First he recognized that the main criteria to define certain morphogenetic fields in the embryo were related to metabolic processes which on their turn are related to the forces that are exerted within or upon the cell populations and tissues. Many of the morphogenetic fields or units that he discriminated were based upon kinetic or biodynamic ('mechanical') principles like *densation*, *dilation* and *retension* e.g. [11] Blechschmidt also was the first (and as far as I know: only) publishing embryologist who proposed to quit considering the three germ layers as three basically similar principles. Instead he discriminates between *limiting tissues* on the one hand (ectoderm and endoderm) and *inner tissue* on the other hand, with each a different significance for growth and development. So the three-layered germinal disc in the third week of human development actually is not three-layered but consists of a zone of inner tissue situated and functioning between two different layers of limiting tissue. The characteristic feature of inner tissue is that it is **in between** two limiting tissues and therefore *inner tissue* can be identified as connective tissue and best can be described as undifferentiated connective tissue (mesenchyme). The formation of the mesoderm of the

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[10] Here the term postural and locomotion system (apparatus) is preferred over locomotor system (apparatus) because the activity of motion with (by means of) our voluntary (skeletal) muscles regards much more than locomotion. Indeed a great deal of our so-called voluntary moving involves maintaining of equilibrium and stature (posture). The term system is preferred over apparatus, while the apparatus represents the anatomical substrate of bones, joints, ligaments, muscles and the term system is applied to the functioning apparatus with elements of the (central) nervous system included.
11 Blechschmidt, E. and Freeman, Brian, 2004 The ontogenetic basis of Human anatomy: a biodynamic approach to development from Conception to Birth, North Atlantic Books, Berkeley, CA. p. 62-63

endocyst disc between the two gliding layers of ectoderm and endoderm is a repetition of an earlier event seen in the whole conceptus, where *mesoblast* was formed when *ectoblast* glided away from the more slowly growing endoblast.[12]

The essential difference between a limiting tissue and inner tissue is the existence of intercellular matrix and space. Limiting tissues in principle are epithelia and between the adjacent and neighboring cells there exists no (or a virtual) intercellular space. Organs that are derived from such epithelial primordia therefore in principle do not show up intercellular space between the constituting cells. The best example of this is the nervous tissue where the glia cells nowadays are considered to be a kind of cellular connective tissue with embedding quality for the actual nervous cells (glymphatic system[13]). The three (four) principle components of an inner tissue derivative however are cells (1), intercellular space filled with an intercellular substance like ground substance (2a, glycosaminoglycanes (GAG's) en proteoglycanes) and interstitial fluid (2b) and the fibers (3), consolidations of intercellular substances as protocollagen. The cells of mesenchyme lack polarity (like epithelia) and can migrate easily in contrast to epithelial cells.

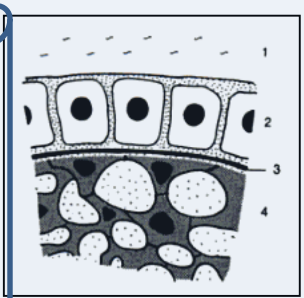


Fig. 1 Schematic diagram of the two basic tissues: limiting tissue and inner tissue. 1)

1.CAN BE OMITTED

Conception to Birth, North Atlantic Books, Berkeley

Phenomenologically therefore it is proposed here to quit the term meso**derm** and reserve the notion 'derm' for those tissues and organs that really have limiting quality and next to consider mesenchyme (mesoblast as well as 'mesoderm') as manifestations of the quality of '*meso'*. In this notion the characteristic is incorporated of 'being in between' and of '(inter)mediation'. The latter quality may be mechanically and metabolically recognized in the quality of meso as the germ layer of 'shaping space as well as connecting'. Having said this, this may lead to a deeper understanding of the organization of our body. Like we are not constituted by or the sum of parts and organs, we also are not constituted as the sum of three germ layers and their derivatives. Germ layers also represent functions and not only somatic functions but, since our whole body is a psychosomatic substrate, also have psychological (or: psychosomatic) dimensions.

What do those considerations mean for the functionality of the meso-domain? The three-layered germ disc in fact represents already the psychosomatic functional organization of our body, which is: two body walls, two limits and boundaries to the world and our environment with in-between the meso-dimension as the dimension of 'interior' or better of 'innerness'. We avoid here deliberately the notion 'inside' because it is the endodermal (later visceral) dimension which most often is considered by the anatomist to represent our 'inside dimension'. In the view we present here the anatomical 'inside' is not the same as our 'inner'. Most anatomist are convinced that the act of anatomical dissection essentially starts with the opening of the body and that by the dissection procedure the inside of the body is brought to light. Nowadays many surgical procedures are called and considered to be 'endoscopical' ('looking inside') again suggesting that behind the outer body wall, mainly represented by the (ectodermal) skin, there is the 'inner'. In the phenomenological concept of the body as

12 See footnote 8.

13 Maiken Nedergaard (2013). "Sleep Drives Metabolite Clearance from the Adult Brain". Science 342 (6156): 373–377.

presented here, there however are two body walls, two 'outsides' so to say with an 'in-between'. The first one (ecto-derm) is dominated by the functional dimension of consciousness, perception and communication with the environment and its gesture is 'bordering from' or, on the psychosomatic level, separating us from that environment in terms of space and matter. The other one (endo-derm) is represented by the metabolic, interacting dimension of digesting, excretion, gas exchange and other substance exchange with the environment. The gesture here is 'bordering to' or, on the psychosomatic level, connecting us with that material environment. In this concept the dimension of meso, the in-between is to be conceptualized as the 'real' innerness of our body. An anatomist so to say is going from out-side (parietal body wall outside) to in-side (visceral body wall inside) and passes, so to say, the Inner. Our Inner, as we experience it, is not visible for anyone else, it is an intimate experience that never by no means can be made visible to or seen by an external observer. In our proprioceptieve experience we perceive our body and its innerness as the 'obscure' and non visible 'inside'. It is always 'dangerous' and 'disturbing' when something of that inner comes to conscious perception by ourselves or an observer.

In such typical phenomenological considerations the meso is the best representative substrate of what we could describe as our proprioceptieve innerness. In this context the notion that meso with its three constituents (cells, matrix, fibers) represents the in-between, easily comes together with the functional notion of meso as the dimension of threedimensionality. While the two visceral and parietal body walls represent the twodimensionality of the limiting tissue dimension, the threedimensionality of 'meso' exhibits two functional principles: connecting and shaping space, centripetality respectively centrifugality. These two principles are polarities and as polarities they are a unity [14] [15], a oneness, like inspiration and expiration, systole and diastole are one and always together. So meso has to be understood as the in-between, breathing in the two functional acts of separating and connecting.

This may throw new light on the notion 'connective tissue'. In psychology it is well-known that binding / attaching is one and never is thinkable without the dimension of detaching / releasing on the other hand. In a similar way we have to realize that the primary function of mesenchyme and connective tissue is connecting and separating (and therefore not only connection). In all mechanical notions related to meso(dermal)-tissue one could perceive the same pattern. Likewise muscles therefore are not contractile organs letting skeletal elements e.g. approach each other, they also must be capable to relax and give in and let skeletal elements move away from each other. There exist two forces that play a role within the connective tissues and the skeletal system: traction and compression. Histologically one could discriminate in the meso also the tendencies of compaction and loosening, resulting in massive organs and tissues on the one hand and body cavities for example on the other hand. This duality may be discriminated on all levels: cartilage for example may connect by massification and compaction of the matrix (symphysis) but also it can actively create fissures as it does in articular joints. Also the important body cavities as the peritoneal cavity may be considered as joint cavities where the meso actively creates gliding spaces for mobility. Connective tissue in the musculoskeletal system can connect two adjacent zones of muscular tissue, appearing as the functional dimension of intermuscular aponeuroses meant to convey traction forces. There however also exists loose areolar connective tissue between two muscles, serving as gliding spaces like bursae or tendon sheaths in order to enable mobility.

[14] 2010, Wal, J.C. van der, 2010, Kontinuität und Konnektivität - die Architektur des Bindegewebes als Ergänzung der Anatomie der Faszien. In: Liem, Torsten an Dobler, T.K. (eds.), Leitfaden Osteopathie, Parietale Techniken, 3. Auflage: 726 – 737, Urban & Fischer.

[15] Wal, Jaap van der, 2003, Dynamic Morphology and Embryology, In: Bie, Guus van der and Huber, Machteld (eds.), Foundations of Anthroposophical Medicine, Floris Books, Edinburgh, ISBN 0-86315-417-4: 87 – 161.

To summarize it may be noted that meso-tissue in the embryo always comes up in areas (fields) where a functional in-between-dimension is needed. In the third week of human development it is the *epiblast*-epithelium (in older embryology books called the ectoderm or *ectoblast*) that differentiates into meso as soon as it becomes interspersed between already present limiting tissue layers or becomes situated underneath a limiting layer. If for example neural crest cells (cells already differentiated towards neurogenic cells) reach the domain of head, also such cells will ('have to') differentiate into in mesenchyme: the *head-mesenchyme*. Amongst others, facial structures and skull elements are derived from that as well as some types of glial cells. This derivative often is indicated as neuro-mesenchyme which in the context of the morphogenetic field concept is a non-sense terminology.

B. Architecture of the fascia: not only 'where' but also 'how''.

Next we will address our attention to the inherent impossibility to describe the functional spatial relationship of fascia and its components in proper anatomical terminology. Research will be presented that the proper way to describe the fascia is according to notions and terms of architecture and that this architecture is instrumental in the function of the fascia as organ of force transmission, movement and sensing.

Architecture instead of anatomy.

In the common sense of anatomy muscles and ligaments are working **in parallel** (Fig. 2). In this universally held model, ligaments are tough passive collagenous structures that run over a joint from the one bone to the other. When the joint is bent toward the ligament, that ligament lies passively lax near the joint capsule. The muscles – farther out from the joint and dynamically controlled by the nervous system – stabilize the joint through its full range of motion. Only when the joint is at its full extent do the ligaments come into play, tightening suddenly to prevent further extension or damage at the end range of movement.
An easy example is the elbow: We expect the biceps and brachialis to control the stability of the joint through a preacher curl. Only when we let the weights back down to full extension would the ligaments be tightened to prevent further extension of the joint. As they tighten, the nerve endings in the ligaments communicate (sometimes quite loudly) to the spinal cord, which turns the muscles off or on to prevent damage to the joint.

In our attempt the make structural sense out of the mess that the human body presents to the dissector, we slipped our scalpel around the muscles, lifted them out and cleaned them off, and gave them names like biceps and brachialis. That pesky connective tissue binds everything together anyway; what we were looking for was a coherent picture of the organs within it – and the muscles numbered among those organs we separated out.

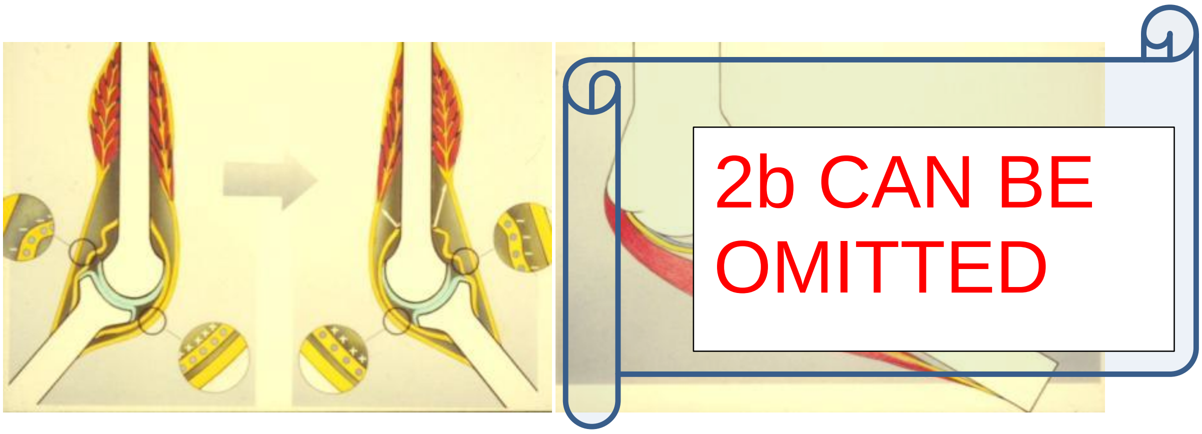


Fig. 2a and 2b. The traditional view of ligaments sees them arranged parallel to muscles and only coming into play when they are fully stretched at the end of joint range

In the exemplary case which we are dealing with in figure 2a and 2b (the m. supinator in the elbow region) the supinator muscle is the force conveying muscle and the annular and lateral collateral ligament for example are the passive force conveying ligamentous structures parallel to the muscles. This is the usually practiced concept.
If one however does not dissect structures (i.e. muscles and ligaments) but tries to dissect by means of a connective tissue sparing dissection [16] [17] or (in the modern way) reconstruct the connective tissue apparatus in a joint region from a series of histological slices or mri-scans, another organization is revealed. One will estimate the continuity of the connective tissue layers in such a region (a) and moreover unfold a more common *in series* organization of connective tissue layers and zones of muscular tissue (b). In the case of the current situation: there are **no** muscle fibers of the so-called dorsolateral extensor forearm muscles inserting to the lateral epicondyle like not any supinator muscle fiber is doing so. Instead of that a connective tissue apparatus is revealed that conveys the muscle fibers (and therefore the tensile forces) to the lateral epicondyle. This apparatus appears to be the substrate of what in the usual 'correct' anatomical approach was considered to be intermuscular septa in the area plus fascia antebrachii, lateral collateral ligament and annular ligament. As to the example of the elbow the situation appears to be like is presented in figure 3a and 3b.

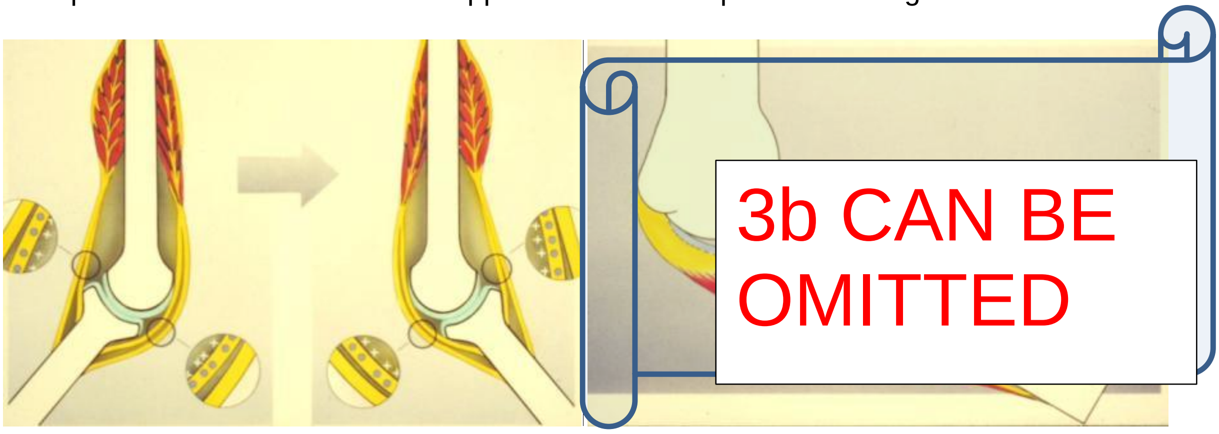


Fig. 3a and 3b. In this situation 'muscles' and 'ligaments' as well as other periarticular connective tissue (fascial layers) are actually arranged *in series* and reinforce each other. This could be called a dynament arrangement.

This appears to be mechanically a much more 'logical' situation since now the peri-articular connective tissue is organized *in series* with muscular tissue fibers and therefore may be capable of playing its mechanical role of conveying traction forces and its role as substrate of mechanoreception (proprioception) in **all** positions of the joint! In other words, muscle contractions, which tense the muscle and its myofasciae (epimysium, perimysium, endomysium, tendons but also its intermuscular septa and fascia antebrachii), also tense associated 'ligaments' because they are part of this same series of fascia in which the muscle was contracting.

This means that the ligaments, far from being active only at the moment of the greatest elbow extension in your preacher curl, are dynamically active in stabilizing the joint all through the movement, during both concentric and eccentric contraction. Such a 'muscle-ligament-combination' could be indicated as a 'dynament' (by a contraction of 'dynamic ligament'). It would be however a next conceptual error to consider that the 'muscle man' of the anatomist now has to be replaced by a 'dynament-man'. There is nowadays much evidence that actually

[16] Mameren, H. van, and Drukker, J., 1984, A functional anatomical basis of injuries to the ligaments and other soft tissues around the elbow joint: Transmission of tensile and compressive loads, Int. J. Sports Med. 5 88 -92.
[17] Wal, J.C. van der, 1988, The organization of the morphological substrate of proprioception in the elbow region of the rat, Thesis, University of Limburg, The Netherlands

hardly at any functional level the muscle can be considered as a functional entity. Modern neuroscience for example has evaluated that ‘the brain knows nothing about the muscles’ indicating that our motion organization as to task performance and also as to proprioception at the cortical cerebral level is not organized in anatomical units like muscles but in movements, patterns of movement, tasks and actions. For example, there do not exist expiration muscles only in the thoracic wall, all kinds of muscles (till even the back muscles) can be mobilized in the process of expiration, depending on the body position and the force required to expire in a given situation. Actually the ventral horn motor cells in the spinal cord represent the only and ‘last’ level where muscles are topographically represented in the CNS. Also in functioning as a moving human being it is not so that the brain ‘activates’ or controls muscles but it indirectly controls motor units. The anatomy of motor units is a transmuscular organization which is a functional hierarchy over the muscle units as well as that is represents a functional suborganization of muscles. Actually the motor units represent the physiological entity of muscle tissue.

So if here is proposed to consider that one of the basic units of the postural and locomotion apparatus in principle is represented by the dynament, this entity is not to be considered as an anatomical but rather as an **architectural** unit. Architecture is the anatomical and functional principle of the fascia (*vide supra*). In principle the units via which traction forces can be conveyed over a joint are units of muscular tissue *in series* with two connective tissue layers inserted to the related skeletal elements. So we deal here not with an organization consisted by anatomical elements but rather with an **architectural** organization which is far more functional. In fig. 4 is indicated that with the conceptual model of dynament in principle all the known ‘anatomical’ units of the postural and locomotor apparatus can be conceptualized, from ‘typical’ fleshy muscles till the ligament (as a ‘dynament without muscular tissue’). The ligament is only there a possible construction where the two opposite insertion points of the dense collagenous connective tissue structure in **all** positions of the related joint are at equal distance from each other. This makes the typical ligament rather an exception than rule.

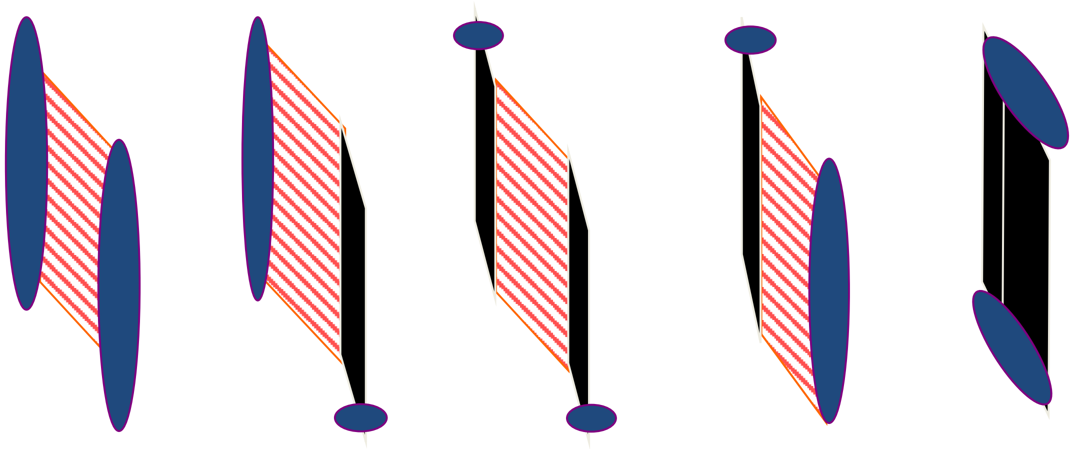


Figure 4 Dynament constructions. The pure (and rare) ligament like the cruciate ligaments is represented on the right: bone-fascia-bone. Most ‘ligaments’ however are in series in various configurations (option 1 to 4 on the left): bone-fascia-muscle-fascia- bone as in hamstrings or rotator cuffs. Actually situation 3 represents the most ‘ideal’ dynament situation: all type of muscle appearances can be conceptualized as derived from that principle.

Considerations as brought forward here redefine our whole concept of functional units within the postural and locomotor apparatus (system, PLS). Take one area where we already get the concept: the rotator cuff of the shoulder. The four muscles of the rotator cuff end distally in tendons blending with the ligamentous capsule around the shoulder. In dissection, it is quite hard to tell where the tissue stops being a tendon and starts being a ligamentous sleeve. If muscles are necessary to stabilize the loose ligamentous capsule of the very mobile shoulder joint, extend that idea to the rest of the body. While there are ligaments that are not connected to the overlying muscles – the cruciate ligaments in the knee are a prime example of ligaments as we have always thought of them – most of our named ligaments are part of the continuous dynament system.

Referring to what has been described up here about the dual functionality of fascia (connectivity and continuity) one could state that for example in the forearm two functional architectural units may be discriminated. Distally there exist indeed parts of muscle tissue with a (central) tendon, here the fascia plays its disconnecting role in the form of gliding spaces and bursae with areolar connective tissue. The force transmission connective tissue component of the fascia here is represented by a muscle unit with a centrally organized tendon. In the proximal forearm both the antebrachial flexor and extensor groups do not arise from the humeral epicondyle itself, but from ‘leaves’ of fascia that arise from the condyle. These leaves (intermuscular septa, muscle compartment walls, fascia antebrachii and so on) form the origin of the muscular slips that passes down the arm toward the wrist, narrowing to individual tendons that are attached to more specific areas at the other end. Proximally the fascia plays it connecting role and the units of force transmission are transmuscular units of muscle tissue architecturally connected with the fascia and intermuscular septa (fig 5a). The concept of the isolated ‘muscle’ makes more sense at the tendon end than it does back up at the meaty origin.

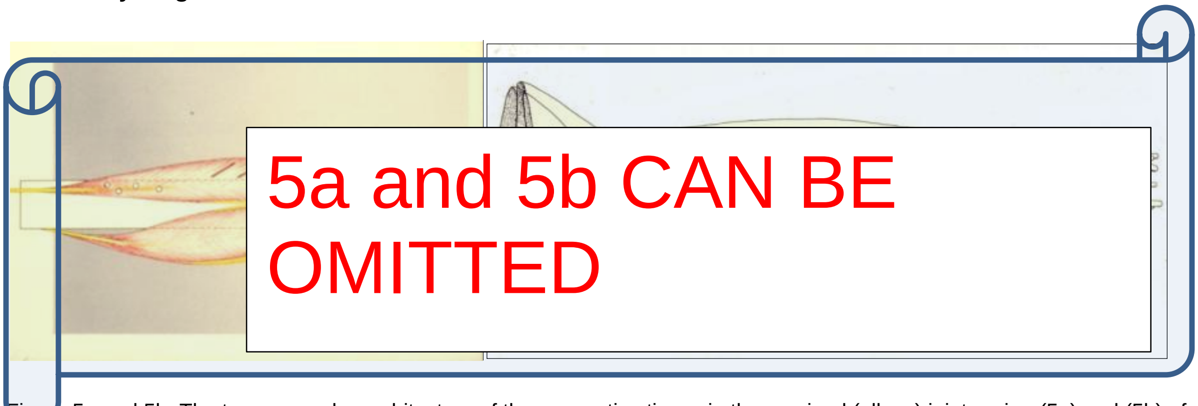


Figure 5a and 5b. The transmuscular architecture of the connective tissue in the proximal (elbow) joint region (5a) and (5b) of the spatial organization of mechanoreceptors (for proprioception) directly related to the architecture of the proximal connective tissue (fascia and intermuscular septa) and distal connective tissue (tendons).

Take the erector spinae muscles, or the muscles of the lower arm and lower leg – all these complexes arise from complex leaves of heavy fascia (dense collagenous connective tissue) that join the muscles together with each other and with the ligaments beneath them. The dynament is a much more functional way of thinking about how the body organizes movement. Even the hamstrings, those icons of singular muscles, are now understood to be both continuous with the sacrotuberous ligament, and to be complex dynaments with the string and membranes within them.
Long story short: we simply cannot divorce the muscles and ligaments. They are linked in series and part of **one** joint stabilizing and moving system. The relevant architecture of the fascia / muscle arrangement is the dynament, not the muscle.

The most important consequence of the methodological considerations above is that also in this respect again a principle of twofoldness is to be associated with the fascia. The conclusion of the first part of this chapter (when considering the phenomenology of meso) was that mesenchyme and fascia reveal two principles: connecting and shaping space, continuity and connectivity. So it is with the fascia. There are **two** forces to be dealt with in posturing and locomotion, i.e. traction and compression. In this way the triad of bones, joints (with capsules and ligaments) and muscles (or the triad of skeletal tissue, connective tissue and muscular tissue) is ‘reduced’ to a far more logical and functional principle of duality or twofoldness. Dynaments as items of architecture instead of anatomy i.e. so to say: of “how as well as where”, reconnect the classical anatomy again with the functionality of the fascia and meso.

And notions like “musculoskeletal system” in this way represent an odd and inadequate terminology.

Architecture is instrumental: fascia as the organizer of proprioception

Van der Wal [18] clearly demonstrated that not the anatomy of muscles versus ligaments and capsules is instrumental in the organization of proprioception but that the organization of the substrate of proprioception only can be functionally understood in terms of architecture and force transmission[19]. Proprioception is a sense, not a sense organ. Proprioception *sensu latu* is the body sense as psychology deals with it: the perception and awareness of the body. Many various types of sense organs and receptors contribute to this sense, not only receptors in the fascia or in the elements and tissues of the posturing and locomotion apparatus. Proprioception *sensu strictu* however is the awareness and perception of posture and motion i.e the process of conscious and subconscious sensing of joint position or motion (statesthesia and kinesthesia). Encapsulated or unencapsulated mechanosensitive sensory nerve endings (so-called mechanoreceptors) with the related afferent neurons provide the centripetal information needed for the maintenance of posture and for the control of locomotion. Considerations such as ‘architecture versus anatomy (topography)’ may *mutatis mutandis* also be applied to the spatial organization of those mechanoreceptors as the morphologic substrate for proprioception. To study the role and function of mechanoreceptors in the process of proprioception, it is important to know **where** they actually are located in such regions but also **how** they are or are not connected with the relating tissue elements. The actual spatial organization of such receptors can be better interpreted functionally when it is known how their topography is related to the architecture of the connective and muscular tissue, this means *mutandis mutandis* to the fascia.

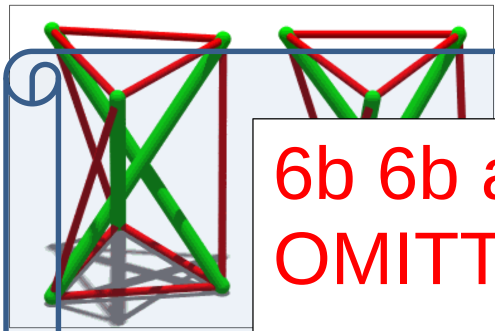
The discrimination between so-called joint receptors and muscle receptors is an artificial distinction when function is considered. Mechanoreceptors, also the so-called muscle receptors (muscle and tendon spindles), are arranged in the context of force circumstances - that is, of the architecture of muscle and connective tissue rather than of the classical anatomic entities such as muscle, capsules, and ligaments. The receptors for proprioception appear to be concentrated in those areas where tensile stresses are conveyed over the related joint or where gliding and sheering forces exert compression or stretch on the mechanoreceptors. Those receptors should not and cannot be divided into either joint receptors or muscle receptors if muscular and collagenous connective tissue structures function *in series* to maintain joint integrity and stability. In vivo, those connective tissue structures are strained during movements of the skeletal parts, those movements in turn being induced and led by tension in muscular tissue. In principle, because of the architecture, receptors can also be stimulated by changes in muscle tension without skeletal movement, or by skeletal movement without change in muscle tension. A mutual relationship exists between structure (and function) of the mechanoreceptors and the architecture of the muscular and regular dense connective tissue. Both are instrumental in the coding of proprioceptive information to the central nervous system. Conclusion of research like this may be that also proprioception is not a matter of anatomy but rather of architecture.

C. Meso, fascia as well as tensegrity are about two.

[18] Wal, J.C. van der, 2009, The Architecture of the Connective Tissue in the Musculoskeletal System—An Often Overlooked Functional Parameter as to Proprioception in the Locomotor Apparatus, International Journal of Therapeutic Massage and Bodywork (IJTMB), Vol. 2, number 4, December 2009: 9 – 23.

[19] 2012, Wal, J.C. van der, 2012, Proprioception, Mechanoreception and the Anatomy of the Fascia. In: Robert Schleip et al. (eds.), Fascia: The tensional Network of the Human Body, Chapter 2.2: 81 – 87, Churchill Livingstone Elsevier, ISBN 978-0-7020-3425-1.

Next, again based upon an phenomenological embryological view, the model will be introduced that fascia as an organ may be understood in the best way if the architecture of connective and muscular tissue is considered as one integrated dimension of the human body. This as well in broad sense (so-called 'mesodermal' germ layer) as well as of the posture and locomotion system in narrow sense (tensegrity system). An extra 'argument to consider the dynament as the principal architectural unit of the postural and locomotor system is given by the fact that it is congruent with the modern concept of tensegrity (1) as well as that it meets the observations on the development of that architecture in the human embryo (2).



6b 6b and 6c CAN BE OMITTED

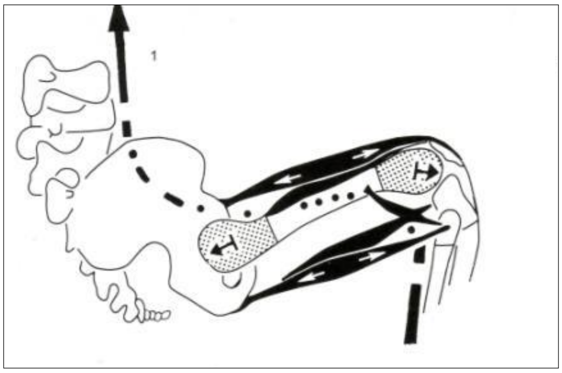
Fig. 6a A simple model of a tensegrity system

Fig. 6b A more complex and a very complex tensegrity system

Tensegrity (*tensional integrity* or *floating compression*), is a structural principle based on the use of isolated components in compression inside a net of continuous tension, in such a way that the compressed members (usually bars or struts) do not touch each other and the pre-stressed tensioned members (usually cables or tendons) delineate the system spatially. The term *tensegrity* was coined by Buckminster Fuller in the 1960s as a portmanteau of "tensional integrity". Another denomination of tensegrity is *floating compression* or, like Thom Myers quoted it on the International Congress on Osteopathy in Berlin 2014: "The skeleton as islands of compression floated in a balanced sea of tension".

In the tensegrity model two elements are working and constituting. In the above chapter it was tried to replace the classical triad of bones, joints (with capsules and ligaments) and muscles by a functional twofoldness of skeletal elements (bones) versus dynaments. Now it becomes obvious that this fits much more and better with the concept of posturing (and locomotion) in terms of a tensegrity system. Also in the robots at 'work' in our factories we deal only with two forces to control while moving and posturing the machine. That are tensile forces and compressive forces (and all variations of that like tangential or gliding forces). With the replacement of the muscle man organization by the trans-anatomical architectural organization of dynaments in relation to skeletal elements, harmony with the tensegrity model of posturing and locomotion comes up. Paraphrasing it could be stated that where the muscle man of the old anatomists was an obscure invention of a dissecting mind neglecting the architecture of fascia and connective tissue, it nowadays could be stated that the postural and locomotion system as a tensegrity model only can be understood functionally if we think the flexible architectural units of that system to be the dynaments which can adapt in any position of the stiff elements (the skeletal elements). Postural integration is the keyword for locomotion, no more or less than spatial and flexible adaptive architecture. Considering the postural and locomotion system as a tensegrity system values and is in harmony with the concept of the fascia as a body-wide interconnected tensional network with continuity and connectivity.

In this context there exists amazing congruency with how the development of the limbs and other parts of the postural and locomotion apparatus takes place in the embryo according to the concepts of Blechschmidt. Also in the spatial development of the postural and locomotion apparatus again two principles are at work, this time the actions of concentration and dilatation, stretching and compression. Fig. 7a shows the situation in a developing human foreleg in a fetus of 5 month old. On the one hand there are relatively stiff elements, in this case cartilaginous skeletal elements, products of what Blechschmidt indicates as *densation* fields (*vide infra*). They exhibit a piston-like effect in longitudinal direction on the surrounding mesenchyme. On the other hand, according to Blechschmidt, two types of fields may come up in such a stretched mesenchyme environment. And so here the qualities of muscle and (stress conveying) connective tissue structures are developing.



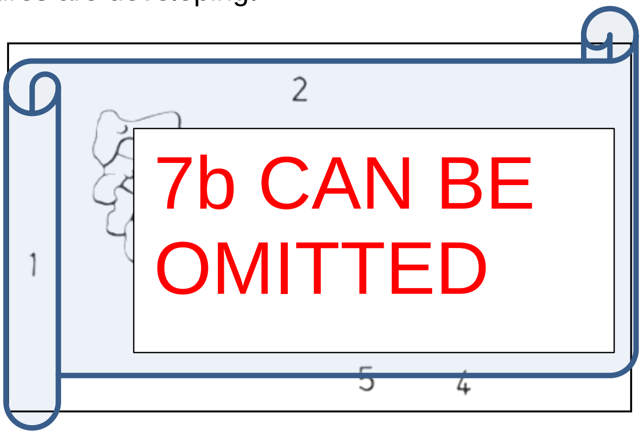


Fig. 7a. Dilation fields in the femur of a 5 month fetus. Black arrows: piston-like distusion growth of the cartilaginous femur. White arrows: dilation fields. Fig. 7b. Dilation fields in the femur of a 50-mm fetus. 1: piston-like growth of thigh bone still largely cartilaginous; 2: growth *dilation* of extensor musculature; 3: growth resistance (*retension* field) of a tendon; 4: growth flexion in the knee obeying the pull resistance of the large knee artery. Convergent arrows: restraining function of the largest artery in the popliteal fossa.

According to Blechschmidt the embryonic skeleton is formed by the loss of the intercellular liquid. Fluids diffuse, therefore the cell relations and connections are condensed. Such fields are *densation* fields. They most frequently lie deep within the inner tissue. Here the young cells are not stressed by pressure or tension in any preferred direction. They are therefore globular forming primordial cartilage. The growing cartilage cells exhibit a so-called swelling growth. By its swelling growth each cartilage exerts a (piston-like) *distusion* function leading to stretching in the adjacent tissue. In such circumstances *dilation* fields may come up. There cells are stressed by tension and dilated. Such dilated cells develop into muscle cells. It is possible therefore to deduce schematically the position of muscles biodynamically from the distusion growth of the individual cartilaginous skeletal parts. This means that the development of muscles is always dynamically passive. The active partner in this process is the distusion growth of the swelling and elongating cartilaginous skeleton portions (or, for example, the expanding epithelial intestinal tube which acquires circumferential muscle fibers).

Studies on young embryos have revealed that the developing musculature functions not by active but by passive action (fig 7b). The fundamental movements of the developing musculature are not contractions but so-called growth dilations. It can be demonstrated in all early muscles that they are formed only where the spatial conditions exist for the preferred longitudinal growth in one chief direction, where there is room for lengthening, and where the necessary physical forces are right for the formation of muscle bulges and tendons. Muscles are not formed where we might perhaps use them later on for pragmatic reasons but in an early ordered basic structure, the *dilation* fields. The transition from dilatation to contraction is rhythmical. Shortly after the first dilatations, contractions start alternating with them as a living reaction to the initial dilation. Blechschmidt: “if muscle was not stretched at first, it was not capable of shortening itself (contraction) in a later phase of the life cycle”. Inner tissue, constricted by cross compression and stretched by tension perpendicularly to it, shows biodynamically similar signs. It exerts tensile resistance and thereby functions as a restraining structure. Metabolic fields where stretched tissue develops into a restraining apparatus, represent *retension* fields. All tendons and ligaments in the human body, as well as the connective tissue guiding structures of blood vessels, are such restraining structures.

Summarizing this indicates that again two principles are working in the mesenchyme environment. On the one hand concentration and centripetality (cartilage skeletal elements, *densation*), on the other hand centering and centrifugality induced by *distusion* of the same skeletal elements leading to muscles, tendons and aponeuroses by means of the processes of *dilation* and *retension*. If one compares the architecture of a dilatation field of a muscle according to Blechschmidt including the related retension fields of the tendons, the analogy with the structure of a dynament is striking (See fig. 8). But also the congruency with the principle of tensegrity architecture of compressed members (usually bars or struts) not touching each other and pre-stressed tensioned members (usually cables or tendons), is evident. If our posture and locomotion system is organized as a tensegrity system than at least it concerns an apparatus in which the stiff components are connected with flexible connective elements (dynaments), so not by connective tissue alone. It also means that without muscle (and nerve!) tissue there is no functional fascia conceivable!

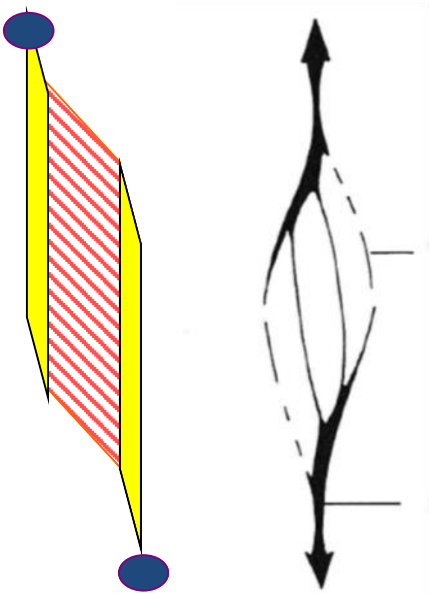


Fig. 8. Left: schematic representation of a dynament. Right: dilation field of a muscle in a longitudinal section according to Blechschmidt. The diverging arrows indicate the main direction of the dilation stress

D. The fascia as representative of the Middle and as the Organ of Innerness.

Last but not least and interwoven into the considerations above, the phenomenological view will be presented that the meso(derm) represents the dimension of 'innerness' in the body with the blood and the fascia as the main representatives of what could be considered as our 'inner' or 'soul'.

Fascia and the dimension of the Middle.

In the second week of the human prenatal development there is not a trace of meso or mesenchyme in the bilaminar disc in the center of the embryo which is considered to be the substrate for the later actual body (or: the 'proper' body). Of course there is mesenchyme active in the two week old human embryo but it exists in-between the *ectocyst* (the outer wall of the embryo derived from trophoblast) and the entity of the central bilaminar disc with yolk sac and amniotic sac (the so-called *endocyst*). As explained above, meso and mesenchyme may be considered as the functionality of mediation: connecting and shaping space. The two main derivatives of the meso (i.e. fascia and blood) exhibit this feature clearly in the way they are organized. Typical for the fascial organization is so to say that it is matrix-like: fascia is in principle is 'everywhere', be it connecting or disconnecting, it forms the matrix which embeds the organs as islands originating from ectodermal, endodermal or … mesodermal tissue. This concerns the fascia *sensu strictu* representing the connective tissue matrix of the body. As explained afore, the principle of fascia is architecture. This also is discernible in the dimension of the fascia as 'organizer' either in its often formative growth resisting quality or as pathway for the inductive organizing substances like signal proteins via the ground substance or interstitial fluid. There is evidence that in the process of differentiation and induction of tissues and organs the ground substance and interstitial fluid play an important role as to the spatial creation of gradients and concentrations of inductive substances active in the process of organ differentiation. The inductive capacity of mesenchyme to induce the of overlying and covering ectoderm and endoderm is well known .

The architecture also plays an instrumental role in force transmission as well as in the process of proprioception, as explained before. The twofoldness or duality of the fascia may also be recognized in the notion that the so called postural and locomotion apparatus actually is composed of the two elements of a tensegrity system i.e. stiff elements (here the cartilaginous or osseous skeletal elements) and the flexible adjustable elements (here the dynaments). One could talk about the fascia *sensu strictu* i.e. the connective tissue skeleton with architecture as organizing principle and about the fascia *sensu latu* i.e. the whole constellation of skeletal and dynament elements, the postural and locomotion system or apparatus as a whole and as tensegrity system.

But if one extends the concept and configuration of mediation as main function for meso and fascia, blood also could be considered as an exponent of meso, i.c. of fascia. In traditional histological categories blood was considered as a connective tissue derivative. At least the origin of blood is from the meso(derm) and the main morphological function of blood again is connecting and shaping space. Blood is not a fluid, blood is an organ or a tissue that is capable of functioning as a fluid. Therefore always the formation of the fluid cellular component of the blood and the formation of vessels containing the 'fluid tissue' go hand in hand. The matrix-aspect of the blood is discernible in the fact that actually the main and primary appearance of blood i.e. the capillaries does not have an own ('selfish') anatomy but is an architectural principle: blood is everywhere and adapts its architecture to the structures and organs of the body. More than the fascia which connects and shapes space between organs and body elements in an mechanical way, the blood does so in a dynamic and physiological way which could lead to a typical phenomenological notion like: "the blood is everywhere and nowhere, always on the move".

Also blood connects and shapes space: the appearance of blood in organisms makes it possible that distance between organs can be larger because the blood serves as the mediating organ or principle. The essential difference between plants and animals for example is the evident presence of 'something in there' which may react and from way back is recognized by us as 'soul' or 'inner'. We have already seen that the dimension of innerness in the body is not synonymous with the inside (viscera, which in principle are body wall) but with the in-between. The animal is characterized by a psychological inner, represented by a physiological inner of organs and in the embryo characterized by the inner tissue, i.e. the meso. It is not before the third week that also in the human embryo one could discriminate a morphological representation of innerness by meso organized in-between two limiting tissue or body walls. With the 'germ layer" of meso, innerness is going to be enabled.

Fascia as the organ of innerness?[20]

In the work of Andrew Taylor Still a characteristic motto is: Man is Mind, Motion. Matter: "Osteopathy is the "law of mind, matter, and motion" (Still, 1908, p.229). In his book Interface R. Paul Lee argues that with this theme A.T. Still joins may other philosophers whose image of man is based upon a view on the human being known as 'triune' or 'threefold' like Swedenborg, Steiner, Sheldrake and many others[21]. In such philosophies the human being is more than (only) a matter body, also a spiritual dimension ('mind') in the body is trying to realize and manifest itself by means of that same body. Another characteristic feature is that for AT Still form (matter) and function (mind) are intertwined inseparably: "I would say that the wisdom of God proved his highest point when it united soul and body, mind and matter, life and motion" (Still, Body and Soul of Man, 7). So in this respect the view of AT Still on the human organism could be interpreted as if we deal with a polarity ('mind' and 'matter') with a necessary interface domain in between ('motion'). In philosophies who practice similar threefold images of man (like anthroposophy) Mind (Spirit) and Matter are polarities and Soul represents the interface where the Two are inseparably intertwined. The keyword in the quoted motto of AT Still however is Motion. We learned here that indeed the central motif of meso is motion (intrinsic as well as extrinsic) and that the whole meso-dimension may be characterized as a dynamic in-between of breathing between the principles of connecting and disconnecting. Isn't this the theme of Life anyway? Life not as the duality (polarity) of Death but Life represents the breathing in-between between the two poles of Death that in the old Greek philosophy were characterized as Chaos and Cosmos and in the organism amongst others may be characterized as Form versus Process, Space versus Time? Like respiration is as well inspiration as well as expiration but on the other hand respiration as the middle of Life neither is neither inspiration nor expiration (which are the poles of Death).

The heart muscle and its function (which is NOT contraction alone!) makes evident what is meant here: the extremes of systole (contraction) and diastole (relaxation) are the poles of Death in between which Life is manifest in the act of reversion and rhythm. Another triad comes in sight in this way: Between Mind and Matter the interface is Life itself with Motion as functional manifestation, with the Middle as organizational principle and with Meso as the morphological representation of this quality! In the Middle, in the In-between, there the quality of Being, of Life is enabled! In such a context the aforementioned statement of AT Still ("The soul of man with all the streams of our living water, seems to dwell in the fascia of the body") becomes completely logic: no other place to be for the soul than the Middle and Meso! But for that it would be better to extend the concept of fascia as the system of connective tissue matrix to the fascia *sensu latu* which then also includes the postural and locomotion system as well as blood (vide supra). With on every level the theme of connecting and shaping space. In that case fascia becomes the 'organ' of MESO manifesting itself morphologically in the architecture of the connective tissues (including muscle, cartilage, bone), physiologically in the principle of motion, in connecting and shaping space on all kinds of levels, in rhythm and breathing and, last but not least, psychologically and mentally in the domain and function of 'soul'. Meso in general, fascia in particular enables Innerness, the fascia therefore as the organ of innerness, being the domain that Still was meaning when he said "The soul of man with all the streams of pure living water seems to dwell in the fascia of his body." [22]

Jaap van der Wal

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[20] See footnote 1

[21] Paul Lee, 2005, Interface: Mechanisms of Spirit in Osteopathy, Stillness Press LLC, p. 97 – 98 Summary of Mind, Motion and Matter.

[22] AT Still, in: Philosophy of Osteopathy 1899, page 165