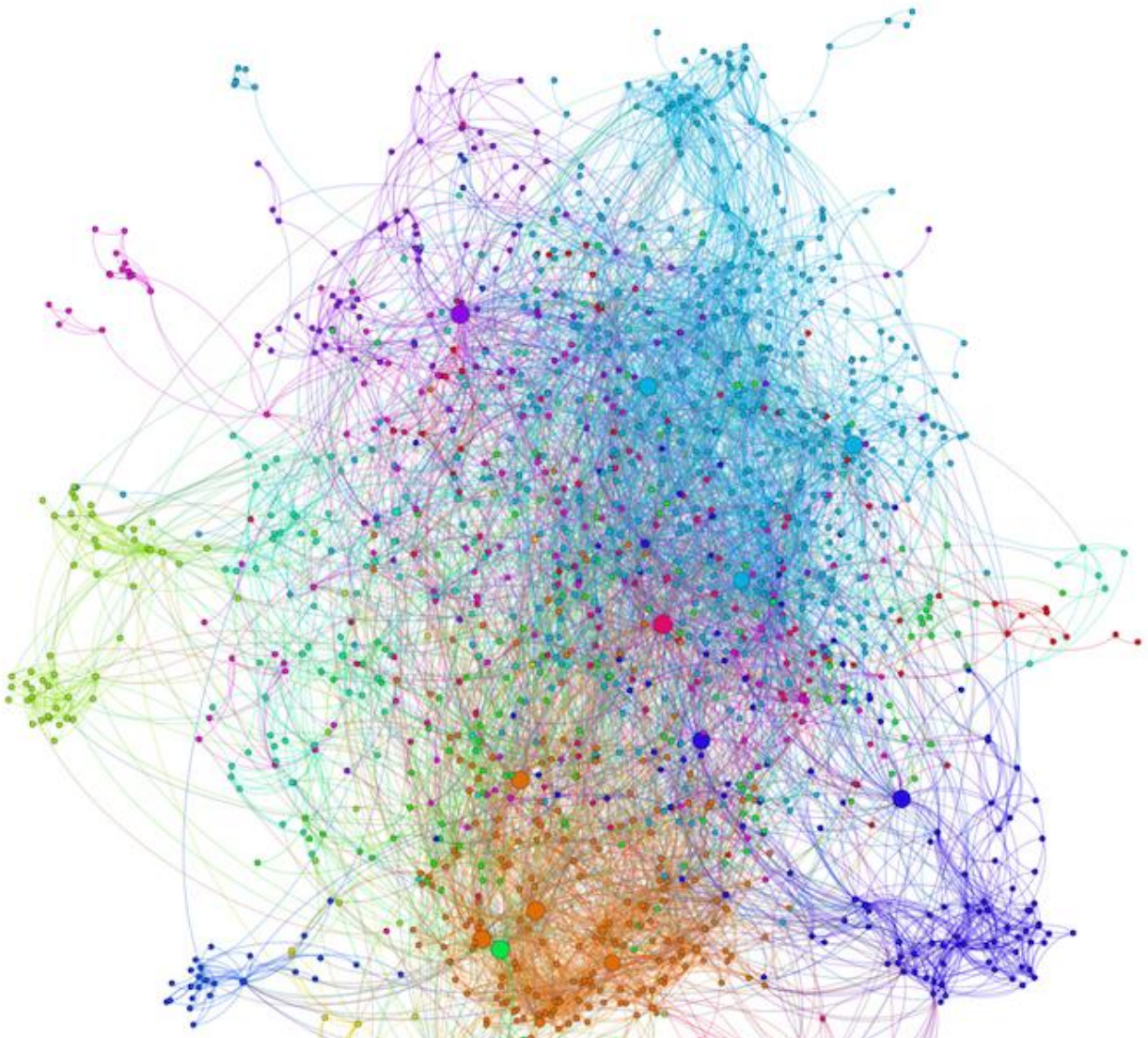

The role of the intrinsic movement of tissues and organs in osteopathy

'Should we let go of the term visceral motility as a misleading notion?'

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Abstract

After seven years of osteopathic education, when we have primarily concentrated on gaining anatomical and physiological knowledge through the light of the philosophy of osteopathy and how to embody that knowledge in osteopathic techniques, by writing this thesis we take the step to reflect on a question which kept us wondering many times during theoretical and practical lessons: 'What are the origins of the intrinsic movement in the body and how does osteopathy utilize this phenomenon?' We chose to examine this question in the view of writings of A. T. Still, as well as in the view of the current scientific research. On one hand, we analyse Still's texts and extract his views and ideas on the role of motion / movement in his pioneer holistic healing approach. On the other hand, we explore the topic of intrinsic movement in relation to the hierarchical system of the body, looking at how movement manifests itself in different dimensions: atomic, molecular, cellular, leading to tissues and finally organs. As well, we explore the topic in the light of embryological development, as the principles of organization and movement during embryogenesis literally form the organic matter into the human body and the forces behind that formation and their further role in the adult body can be interesting to consider.

The two independent lines of research finally lead us, to our own astonishment, to the same conclusion: the movement has its undoubtable place in understanding the anatomy and physiology, nevertheless behind every movement there is a force, which leaves its imprint on the tissues, whether in form, structure or way of functioning and consequently the quality of its production. Our research brought us to believe that placing the attention on the axis *force – tissue quality* can be more beneficial to osteopathic examination and treatment rather than to search for direct palpation of intrinsic movement of tissues and/or organs. Based on those realizations we raise back several questions and points to consider, for the future reader, who might pick up one of the threads and continue the research.

Samenvatting

Na zeven jaar studie van osteopathie, waarin we ons hebben geconcentreerd op het verwerven van anatomische en fysiologische kennis in het licht van de osteopatische filosofie en op hoe we deze kennis kunnen belichamen in de osteopatische technieken, nemen wij, door deze thesis te schrijven, de stap om op een vraag te reflecteren die ons vele malen bezig hield binnen de theoretische en praktische lessen: 'Wat is de oorsprong van de intrinsieke beweging in het lichaam en hoe benut de osteopathie dit fenomeen?'
We hebben ervoor gekozen deze vraag te onderzoeken vanuit het perspectief van de geschriften van A. T. Still, en eveneens vanuit het perspectief van het hedendaagse wetenschappelijke onderzoek. Aan de ene kant analyseren wij verschillende teksten van Still en extraheren wij zijn inzichten en ideeën over de rol van beweging binnen zijn baanbrekende holistische geneeswijze. Aan de andere kant onderzoeken we het onderwerp van de intrinsieke beweging in relatie tot het hiërarchische systeem van het lichaam, waarin we kijken hoe beweging zich uitdrukt in de verschillende dimensies van deze hiërarchie: atomisch, moleculair, cellulair, leidend naar weefsels en uiteindelijk naar organen. Eveneens verkennen we het onderwerp in het licht van de embryologische ontwikkeling, vanuit het idee dat de principes van de organisatie en beweging tijdens de embryogenese letterlijk de organische materie in een menselijke lichaam boetseren. En dat de krachten verantwoordelijk voor deze vorming en hun verdere rol in het volwassen menselijk lichaam interessant zouden kunnen zijn om te beschouwen.

De twee onafhankelijke lijnen van het onderzoek leiden ons uiteindelijk, tot onze eigen verbazing, tot eenzelfde conclusie: beweging heeft ongetwijfeld zijn plek in het begrip van anatomie en fysiologie, niettemin zit er achter elke beweging een kracht, die een indruk achter laat op het weefsel, ofwel in vorm, of in structuur of op de manier van functioneren en bijgevolg op de kwaliteit van zijn metabolische productie. Ons onderzoek bracht ons tot de overtuiging, dat de aandacht op de as *kracht – weefsel kwaliteit* eerder van toepassing is binnen osteopatische onderzoek en behandeling, dan op het zoeken naar een directe palpatie van de intrinsieke beweging in de weefsels en/of de organen. Uitgaande van dit besef geven we verscheidene vragen en punten ter overweging terug, voor de toekomstige lezer, die één van deze draden zou kunnen oppakken en doorgaan met het onderzoek.

Acknowledgements

During the whole process of writing this thesis, we received a lot of support and assistance from many sides.

Our gratitude goes firstly to our promotor Jeroen de Block, DO, for his patient and stimulating leadership. At the same time, we would like to thank Dr. Brian Freeman, Christian Hartmann, Hein Grapendaal, Balwina Koopal, Evelyn Keyser, DM, Tom de Jong, DO, Rik Hoste, DO and Rob Muts, DM/DO for all conversations which shifted the perspectives and for answering all our questions. We are particularly thankful to Alice Cocuelle and Jeff Rockwell for the inspiration to dive into the osteopathic world.

Special thanks belong to Lotte van Boxtel, as a first reader of the work. Your sharpness and care for each word were a huge help in the moments when we were losing the drive.

Other special thanks go to Jesper van der Molen for spending his time with us on conversations about science philosophy. You brought the idea of ‘personal science’ into this work.

The third special thanks belong to Josephine Wilschut, who managed to bring over an idea to us of how to tame our unordered minds and formulate a framework.

Our gratitude goes to Caleb Jones for sharing with us his artwork "Exploring Protein Interactions In Budding Yeast" used in the title page, as well as to a visual artist Peim van der Sloot for developing the graphic form of Shared structures with us.

Big thanks go to Karin Kocourková and Malissa Canez Sabus for helping us with ‘English issues’ and for the final proofreading of the whole text.

And of course, many, many thanks go to our families, our beloved partners and friends for their eternal support and patience during all the years of study.

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“In nature, when we try to pick out anything by itself, we find it hitched to everything else in the universe.” (Muir, 1911)

1. Introduction

We dedicated this thesis to the theme ‘intrinsic movement of tissues and organs, its origins and relation to palpation’.

1.1 Motivation

During the years of osteopathic education, students hear regularly about the phenomena of ***motility*** [1], ***motricity***, ***rhythmic impulse*** (RI), ***primary respiratory mechanism*** (PRM) in the context of expression of the organs. Those terms are used mostly in osteopathic theoretical descriptions of the different movements of organs and don’t clearly communicate their meaning to the outside (patients or non-osteopathic health professionals).
That can have several reasons. One of the crucial ones is that the term motility proves to be quite problematic on its own, even within the osteopathic community. As the master thesis on the visceral motility of Andreas Behrens (2007) shows, there is no common understanding of the term motility as a theoretical concept and palpable phenomenon. In his thesis, there were 8 osteopaths interviewed to share their views on motility. Many different concepts were suggested with their own enforcement and all different concepts seemed deeply thought of, but not much was mentioned about how to get there with one’s own palpation and what information it actually gives us. Surely that has consequences for how osteopaths relate to such a topic and the way they rely on the palpatory information they receive.
This friction is then further spread to the term PRM; some osteopathic texts describe visceral motility having a narrow relationship to PRM in the cranial field (Barral & Mercier, 2006), whereas some osteopaths take distance from this comparison. Naturally, a question occurred, how other terms, such as RI or motricity, fit into the complete picture of the motion in the body.

In general, from the collected information one gets a feeling that on one hand the osteopathic community is working hard on the theoretical enforcement of our views on the concept of different phenomena and producing quite a number of personal theoretical approaches, on the other hand there is very little feedback about the

[1] Words printed in ***bold italics*** (first use only) in the body of the text are defined in the Glossary.

practical application of these enforcements from the practitioners and how do the new enforcements inform the way of palpation and diagnostic touch. Without the clear translation of the concepts into practise and reflection on this process, we are only getting further from the essence of what the diagnostic touch can provide us.

Therefore we are led into a somewhat radical path: in order to form a proper understanding of the topic of intrinsic movement and the conditions or context within which this movement activity operates, in the frame of this thesis we let go of the usual osteopathic terminology. We do so to reconsider what the basic scientific research says about the intrinsic movement on multiple levels of the organism hierarchy and evaluate if nowadays scientific findings in this field are compatible with the osteopathic philosophy and the way of palpation as presented by the founding father of osteopathy A. T. Still.

2. Methodology

2.1 Research questions

We defined the main issue as a friction field between the growing number of scattered concepts and models on the movement behaviour of tissues and organs of the body on one hand and the holistic and unifying approach of the osteopathic philosophy of Andrew T. Still on the other one.

Out of this friction, several research questions unfolded:
• What are the origins of the intrinsic movement in the body and how does osteopathy utilize this phenomenon?
• What does the basic science say on the topic of intrinsic movement in the body and how osteopathic terms as motility, PRM, RI/CRI fit into this picture?
• How do the findings of the current basic science inform the osteopathic palpation? Is there something to gain for the osteopathic practice?
• What are the origins of life / motion/ action/ movement according to the writings of Still?
• Does Still provide a guidance to the osteopath regarding palpation with relation to the origins of the movement?
• In the light of the current scientific research, in what aspects is it relevant that the current osteopathic practise source from the teachings of A. T. Still?

2.2 Research design

Our research is designed as a literature study, supported by several interviews and conversations with different osteopaths in order to frame the collected material clearly.
The research is conducted in two lines:
• the analysis of the data of nowadays scientific research and its interpretations regarding the topic of the intrinsic movement,
• the analysis of the texts of A. T. Still regarding the topic of the intrinsic movement.

The analysis of various sources was conducted, which can be ordered as follows:
- the articles published in search engines as PubMed, researchgate.net, elsevier.com, etc.

- published theses found via osteopathic-research.com or the ones published on websites or the libraries of various osteopathic education institutions
- books
- internet websites dedicated to specific content
- personal interviews with osteopaths or other professionals.

As a starting point for this research, we used specific terms in the search engines for each chapter. The search terms are possible to subdivide into the following circles:
- movement / motion / intrinsic movement / intrinsic motion / motility / motricity
- tissue / organ development / morphology / fractal organization
- extracellular matrix / architecture / structure
- tensegrity / biotensegrity
- fluids / dynamics of fluids / fluids in osteopathy / fluid mechanics / thixotropy
- palpation in osteopathy / osteopathic diagnostic touch / mental imagery
- system theory / complex systems / complex adaptive systems
- metabolic fields / mechanical control of the tissue development / E. Blechschmidt / B. Freeman
- water / water molecule / hydrogen bond
- entropy / enthalpy / entropy in biology / entropy of living organisms
- Walter McKone / Carol Trowbridge

Regarding the research line of Still's work, five books were used:
- Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy*. Kirksville, MO: A. T. Still.
- Still, A. T. (1899). *Philosophy of Osteopathy*. Kirksville, MO: A.T. Still.
- Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy*. Kansas City, MO: A.T. Still.
- Still, A. T. (1910). *Osteopathy, research and practice*. Kirksville, MO: A.T. Still.
- Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917*. Kirksville, MO: The Thomas Jefferson University Press.

Our process is driven by questions, which were raised for the first time during the practical classes and which remained somewhat unanswered through the years of osteopathic education. Therefore it felt quite natural to take the next step in the theoretical realm to figure out a question "What is it for me which stands in the way here?" by means of collecting information from a broad variety of fields, considering

it, comparing, cross-linking and putting it on its own place within the hierarchy. We consider this thesis qualitative research. Despite there is no exact definition of what qualitative research is, we resonate with two following descriptions:

> Qualitative research consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them. [2]

> Qualitative data analysis is a symphony based on three notes: Noticing, Collecting, and Thinking about interesting things. [3]

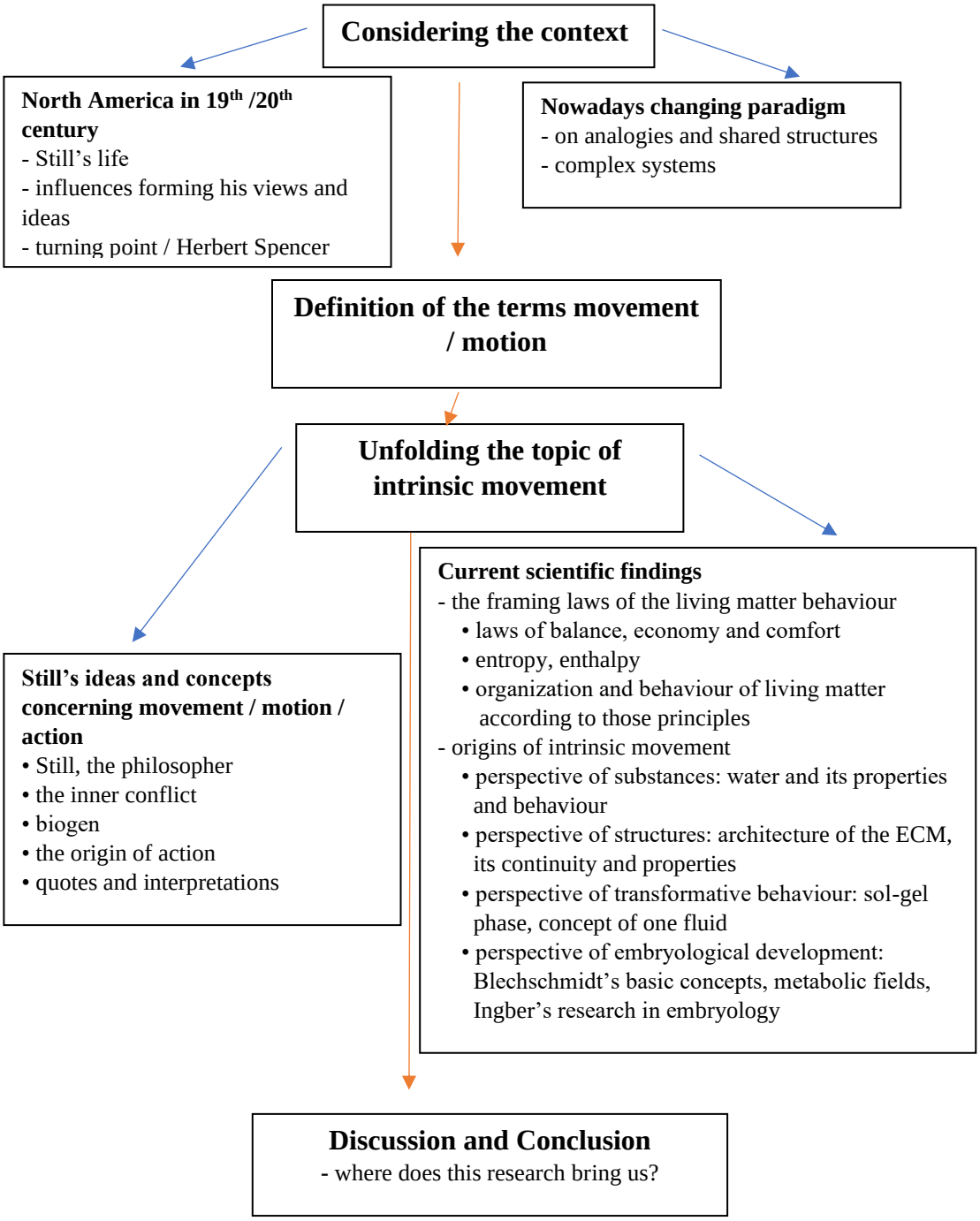
2.3 Division of tasks

As two authors of this thesis, we conducted separate research on two lines.
The research based on the analysis of Still's texts and other material about Still was conducted by Leon Katsman. His findings and interpretations are presented in chapters 3.1 and 5.1, next to numerous contributions in other chapters, bringing in a perspective from his research.
The research in the field of current science was conducted by Katerina Dietzova. Her findings and interpretations are presented in chapters 3.2 and 5.2.
Chapters 1, 2, 4, 6 and 7 were created in collaboration.

[2] Denzin, N. K., & Lincoln, Y. S. (2018). *The Sage handbook of qualitative research*. Los Angeles: Sage.; pg.43

[3] Seidel, J. V. (1998). Qualitative Data Analysis. Retrieved September 24, 2020, from http://eer.engin.umich.edu/wp-content/uploads/sites/443/2019/08/Seidel-Qualitative-Data-Analysis.pdf; pg.1

2.4 Hierarchy of the topics



3. Considering the context

We conducted the research in two different paradigms for this thesis: on one hand within the paradigm of contemporary scientific research, on the other hand within the paradigm of the pioneering research of A. T. Still in the second half of the 19th and beginning of the 20th century.
We are realizing the two very different historical, social and 'knowledge' contexts, which have a large influence on *how people deal with things in their minds*.
To acknowledge those differences, we give a short comment on both paradigms, in order to realize the ongoing motion of that paradigm, as well as to mark clearly, where we position ourselves in this motion.

3.1 Andrew T. Still in North America of the 19th/20th century

3.1.1 Still's biography

Andrew Taylor Still (A. T. Still) was born on August 6th, 1828, in Lee County, Virginia, USA. He was the third child of Abraham and Martha Still, pioneers involved in the colonization of the United States (Trowbridge, 1991; p. 20).
At that time the United States consisted only of 24 states. All located in the Eastern third of the territory. Central and Western regions were not yet colonized. Those were wild and inhospitable regions, with a very harsh climate, dominated by the animal kingdom and populated by Native American tribes.
Martha and Abraham are pioneers, very poor, living rough, uncertain lives, full of risks. Andrew's father Abraham was a Methodist pastor, itinerant preacher, physician and builder. His mother was a down to earth pioneer woman who was responsible for the education and upbringing of the nine children. Pioneering and Methodism are qualities that eventually will lead A. T. Still to conceive Osteopathy.

Still's childhood was very different from that of a city boy. Unlike the city boy, he was confronted with the life of nature:

> "…the lad of the frontier enjoys many thrilling adventures with wild animals with the city boy can know nothing save what he reads in books. If he is observing he learns more of the habits and customs of the animals he comes in

> contact with than he can gain by a course in natural history, for he has the great book of nature constantly spread before him." [4]

It is in those early days when Still started to develop his sensitivity and observation skills, for nature is the perfect learning setting.

A.T. Still's education consisted of typical school time, presence and observation skills of nature which he trained early on. Immersed in the harsh conditions of the undiscovered environment, Still developed his character. He was fond of freedom and open horizons. Learning to rely on his strength and ability to survive, he was uncovering his individualistic spirit. All those will contribute to Still's research towards Osteopathy.
During his lifetime in the Wakarusa Mission in the Shawnee settlement, where his father was assigned to as a Methodist preacher and doctor, he experienced (as an apprentice) how his father worked as a doctor he also watched how the Shawnee practiced medicine (Trowbridge, 1991; p. 41,45). It is likely that he was influenced by their traditions of shamanistic and herbal medicine, connections to spirits and ancestors, bone setting and ancient wisdom. In his biography, he mentions "the Indian's treatment for cholera was not much more ridiculous than are some of the treatments of some of the so-called scientific doctors of medicine." [5]
Still experienced two cultures simultaneously, each with their healing modalities. Native Americans and the American settlers / missionaries of Methodism. Later on, other religious groups came as the result of further settlement, such as Congregationalists, United Brethren and Swedenborgians (Trowbridge, 1991; p. 52).

On April 12, 1861, the Civil War broke out between North and South. Still Joins the Federals, where he takes an active role in the war as a surgeon. During this conflict, he notices the failings of the medical system where he witnesses many more soldiers

[4] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 34). Kirksville, MO: Author.

[5] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 67). Kirksville, MO: Author.

dying from disease and infection rather than the war wounds. “During the civil war, the soldier’s greatest enemies were not the war wounds, but disease and infection.” [6]

Still also studies mechanics to improve his work on the farm and describes several inventions. Mechanics will eventually play an important role in the development of the osteopathic concept. He is eager to develop further and uses his knowledge of mechanics to dive deeper and establish a link towards the human structure. He does not hesitate to exhume bodies of Indian natives to dissect them and to study their anatomy and mechanical functioning. Connecting the relationship between anatomy and mechanics is a revolutionary idea at the time. He becomes a pioneer in this new way of combining anatomy and physiology with the logic of mechanics.

3.1.2 Turning point

The turning point in the life of A.T. Still occurred after the war. Where he realized that the mortality is lower in regions with fewer doctors: “I began to see, during the Civil War, in that part of the States of Missouri and Kansas where the doctors were shut out, the children did not die. I began to reason as to why it was so.” [7]

In 1865, three of his children died due to cerebral meningitis. Still felt traumatized and hopeless due to the incapacity of the medical system to help his children.

> “It was when I stood gazing upon three members of my family, two of my own children and one adopted child, all dead from the disease spinal meningitis, that I propounded to myself the serious question ‘in sickness has not God left man in a world of guessing? Guess what is the matter? What to give, and guess the result? And when dead, guess where he goes.’ I decided then that God was not a guessing God, but a God of truth.” [8]

[6] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (pp. 91). Kirksville, MO: The Thomas Jefferson University Press.

[7] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 326). Kirksville, MO: A.T. Still.

[8] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 99). Kirksville, MO: A.T. Still.

This was a breaking point for Still, considering abandoning medicine, but ultimately this will prove as a powerful stimulus for his quest for another healing way.
Still wishes to acquire formal medical training and joins the college of Physicians and Surgeons in Kansas City, Missouri. But ending up not completing medical education due to his frustration with the redundancy of medical education at the time. "He had become disgusted with the teachings and did not return for his diploma. Indeed, other than being a formal diploma to hand on an office wall, a degree from one of the medical schools during the 1860s meant little." [9]

On 22nd of June, 1874 Still came to a realization of his new medical approach, which will become Osteopathy.

> "At 10:00 a.m. on June 22, 1874, an American physician, Andrew Taylor Still, experienced a life-changing revelation, one he believed could revolutionize nineteenth-century medicine." [10]

One may say that life has put him on a path of discovery which would ultimately bring Still to the footsteps of this new science.

> "My science or discovery was born in Kansas under many trying circumstances. On the frontier while fighting the pro-slavery sentiment and snakes and badgers, then later on through the civil war, and after the Civil War, until like a burst of sunshine the whole truth dawned on my mind, that I was gradually approaching a science by study, research, and observation that the world is receiving." [11]

Still was not a fan of the usage of drugs and gave up the use of those completely, promoting healing by "…adjusting the deranged, displaced bones, nerves, muscles,

[9] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (pp. 96). Kirksville, MO: The Thomas Jefferson University Press.

[10] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (pp. xi). Kirksville, MO: The Thomas Jefferson University Press.

[11] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 95). Kirksville, MO: A.T. Still..

and remove all obstructions, and thereby set the machinery of life moving. To do this is to be an Osteopath." [12]

During the 1870s, he carried out experiments with a new approach which will eventually become osteopathy. Here is a description of how he treated a child with Dysentery:

> "I placed my hand on the back of the little fellow… in the region of the lumbar and found it very warm, even hot, while the abdomen was cold… then the neck and back of his head were very warm, and the face, nose, and forehead cold… I began to work at the base of the brain, and thought by pressure and rubbing I could push some of the hot to the cold places. While so doing I found rigid and loose places in the muscles and ligaments of the child's whole spine, while the lumbar region was in a very congested condition. I worked for a few minutes on that philosophy, and then told the mother to report to me the next day… She came early next morning with the news that her child was well." [13]

His methods were not supported by the current medical society and he was not permitted to present his ideas at Baker University in Baldwin. "When I asked the privilege of explaining Osteopathy in the Baldwin University, the doors of the structure I had helped build were closed against me." [14]

Still became an expert in his field, but he was not content purely with anatomical, physiological or mechanical research. His curiosity and fire of exploration made him dive into areas of influence that would shape the future of Osteopathy.

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[12] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 360). Kirksville, MO: A. T. Still.

[13] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 120). Kirksville, MO: A. T. Still.

[14] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 112). Kirksville, MO: A. T. Still.

> "With this thought I trimmed my sail and launched my craft as an explorer. Like Columbus I found driftwood upon the surface. I noticed the course of the wind whence they came, and steered my vessel accordingly. Soon I saw the green island of health all over the seas of reason. Ever since then I have watched for the driftwood and course of the wind, and I have never failed to find the source whence the drifting came." [15]

The 30s to the 60s of the 19th century were times of discoveries and new, open ideas. Currents such as anti-slavery, anti-masonry, Swedenborgianism, mesmerism, Phrenology, and spiritualism (Trowbridge, 1991; p. 88).

3.1.3 Areas of Exploration and influence

In the following section, there are described the main influences on Still's life.

3.1.3.1 Methodism

Methodism is a Christian oriented religion, introduced by John Wesley, an English theologian (1703 - 1791). It was at the time the largest democratic protestant sect in democratic, anti-slavery - America.[16] Methodism spoke of the wrath of God against evil, judgement day and Love. Methodism shaped Still's personality, his aversion to alcohol, slavery, his interest in good education and healing that highlights health versus disease. Another source of influence was Still's father, who was a Methodist preacher.

3.1.3.2 Phrenology

Phrenology is the study of personality traits, talents, and mental abilities as a consequence of skull curvature.[17]

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[15] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 99). Kirksville, MO: A.T. Still.

[16] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 57). Kirksville, MO: A.T. Still.

[17] Bailey, R. (2019, June 25). What Is Phrenology? Definition and Principles. Retrieved October 24, 2020, from https://www.thoughtco.com/phrenology-definition-4688606

3.1.3.3 Mesmerism

Animal magnetism, also known as mesmerism, was the name given by German doctor Franz Mesmer in the 18th century to what he believed to be an invisible natural force possessed by all living things, including humans, animals, and vegetables. [18]

3.1.3.4 Swedenborgianism

Swedenborgianism was a new church movement based on intuitive knowledge and based on personal contact with the divine.[19]

3.1.3.5 Transcendentalism

"Still's world was never the same after he found himself more attuned to the thinking of the transcendentalists." [20] Transcendentalism was a 19th-century movement of writers and philosophers in New England who were loosely bound together by adherence to an idealistic system of thought based on a belief in the essential unity of all creation, the innate goodness of humanity, and the supremacy of insight over logic and experience for the revelation of the deepest truths.[21]

3.1.3.6 Herbert Spencer

Carol Trowbridge often mentions Still's connection to Herbert Spencer:

> "... Still found his personal comfort in the arms of Spiritualism, and the foundations of Osteopathy were placed firmly on the principles of evolution,

[18] Animal magnetism. (2020, October 18). Retrieved October 24, 2020, from https://en.wikipedia.org/wiki/Animal_magnetism

[19] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (pp. 88). Kirksville, MO: The Thomas Jefferson University Press.

[20] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (pp. xiv). Kirksville, MO: The Thomas Jefferson University Press.

[21] Encyclopaedia Britannica. (2020, May 27). Transcendentalism. Retrieved October 05, 2020, from https://www.britannica.com/event/Transcendentalism-American-movement

> particularly those derived from the synthetic philosophy of Herbert Spencer." [22]

Herbert Spencer was a British philosopher (founder of evolutionary philosophy) and sociologist, he was a major advocate of evolutionary theory in the mid-19th century. He tried to expand the evolutionary concept developed by Darwin at the level of Biology, to all areas of human activity. Spencer developed concepts about: cause and effect, structure and function, the holistic working of the organism and the mutual influence of the individual parts.
His first book First principles (1862) was for many, as well as for Still, a combination of the 'new Bible' and the theory of evolution, in a certain way it was somehow a way to a 'new religion'. He expanded on the relations between electrical and magnetic forces in relation to human physiology: "Spencer suggested that a change in body's internal structure, as by mechanical strain, alters its 'magnetic condition'." [23]

Still described in a familiar way in a chapter on free circulation that a free circulation is vital.

> "A healthy eye, good hearing, healthy action of brain with its magnetic and electric forces to the vital parts which sustain life, memory and reason, depend directly and wholly upon unlimited freedom of the circulatory system of nerves, blood and cerebral fluids." [24]

Spencer about evolution:

> "An integration of matter and concomitant dissipation of motion; during which the matter passes from a relatively indefinite, incoherent homogeneity to a relative, definite, coherent heterogeneity, and during which the retained motion undergoes a parallel transformation." [25]

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[22] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (pp. 120). Kirksville, MO: The Thomas Jefferson University Press.

[23] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (pp. 163). Kirksville, MO: The Thomas Jefferson University Press.

[24] Still, A. T. (1899). *Philosophy of Osteopathy* (p. 44). Kirksville, MO: A.T. Still.

[25] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (pp. 118). Kirksville, MO: The Thomas Jefferson University Press.

Spencer often mentioned the interaction between matter and the universe towards mechanical examples, such as interrelation between structure and function, specialization of individual functions, cause and effect and the interdependence of the individual parts.

Still's basic principles of Osteopathy show links to Herbert Spencer:
• The body functions as a unit.
• The body has self-healing mechanisms.
• Structure and function are interrelated.
• Abnormal pressure in one area of the body produces pressure and tension in other areas of the body. [26]

3.1.3.7 Spiritualism

Spiritualism emerged in America around the middle of the 19th century, it was linked to the Fox sisters as its founders, who claimed to have extrasensory perceptions, contacts with the spirit world, etc. [27] As well as a result of a mixture of science, materialism, phrenology, mesmerism, search for the soul (Swedenborg) and transcendentalism.

[26] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (p. 160). Kirksville, MO: The Thomas Jefferson University Press.

[27] Spiritualism. (2020, August 31). Retrieved October 06, 2020, from https://en.wikipedia.org/wiki/Spiritualism

3.2 Contemporary paradigm in progress

In this chapter, we shift the attention back to the present and demark the area where we currently stand.
During the collecting of the material for this thesis we noticed that the information and views were quite voluntarily taking a certain order and relationships, the spatial hierarchy came up in the form of the first mind map. At some point the moment came for some of *the* questions: "According to which key is this hierarchy taking its place? What is the mindset we use for the investigation of the phenomena of the intrinsic movement?"
The research led us to Newton's 'Four rules for reasoning in natural philosophy'.

3.2.1 Four rules for reasoning in natural philosophy

Four rules were introduced in Book 3 of Isaac Newton's Mathematical principles of natural philosophy in its full version in 1726.
• Rule 1 We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances [28].
• Rule 2 Therefore to the same natural effects we must, as far as possible, assign the same causes [29].
• Rule 3 The qualities of bodies, which admit neither intensification nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever [30].
• Rule 4 In experimental philosophy we are to look upon propositions inferred by general induction from phenomena as accurately or very nearly true, not withstanding any contrary hypothesis that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate, or liable to exceptions [31].

[28] Newton, I., Cohen, I. B., & Whitman, A. M. (1999). *The Principia: Mathematical principles of natural philosophy*. Berkeley: University of California Press.; p.794

[29] Newton, I., Cohen, I. B., & Whitman, A. M. (1999). *The Principia: Mathematical principles of natural philosophy*. Berkeley: University of California Press.; p.795

[30] Newton, I., Cohen, I. B., & Whitman, A. M. (1999). *The Principia: Mathematical principles of natural philosophy*. Berkeley: University of California Press.; p.795

[31] Newton, I., Cohen, I. B., & Whitman, A. M. (1999). *The Principia: Mathematical principles of natural philosophy*. Berkeley: University of California Press.; p.796

We are adding a translation into nowadays language and to a certain degree surely personal interpretation of those rules:
• Rule 1 instructs the investigator to take the simplest way of explanation possible while still maintaining truth. Certain interpretations suggest that the main point of this rule was to restrict any theory-making to information that has been gathered through experiments or other empirical observations even if only indirectly [32].
• Rule 2 states that if one cause is assigned to a natural effect, then the same cause so far as possible must be assigned to natural effects of the same kind, e.g. respiration in humans and animals [33].
• Rule 3 instructs the investigator that if there are certain qualities a body/ object possesses that cannot be varied (and that can be experimentally applied to all bodies on earth), then these qualities can be inferred to be universal of all bodies in the universe (even bodies beyond the reach of our senses).
• Rule 4 states that any stated law of physics-based upon the first three rules should be perceived as truthful, disregarding other hypotheses, until a phenomenon is introduced that proves itself as more accurate (based on the first three rules).

During our research we came across numerous research data and information, which is presented quite in one line with rule 1 and 2, let's say in line with the exclusive way of thinking. While we know that there is no discussion necessary on how Newton originally used these rules for his discoveries and why he needed them, we would like to comment on this issue from another angle.

3.2.2 Idea of shared structures: on analogies and shared forms

On one hand, the four rules speak to a certain extent about analogy as a process of transferring information or meaning from a particular subject to another or a linguistic expression corresponding to such a process [34]. While using an analogy, we are transferring the logic of a specific process from a certain phenomenon to another, e.g. similarities in manifestations across the environments, or across levels (micro to

[32] Cohen, I. B., & Smith, G. E. (2002). *The Cambridge companion to Newton*. New York: Cambridge University Press.; p.160

[33] Rules of reasoning in Philosophy. (n.d.). Retrieved June 07, 2020, from https://apex.ua.edu/uploads/2/8/7/3/28731065/four_rules_of_reasoning_apex_website.pdf

[34] Analogy. (2020, June 09). Retrieved July 17, 2020, from https://en.wikipedia.org/wiki/Analogy

macro as in fractal organization, the process of encaptic division within one environment). Generally, we use a *shared principle*.

On the other hand, there is no consideration in the four rules for the notion of the *shared form* within the manifestations of different phenomena. To demonstrate this idea, we can better use a visual metaphor:

Let us imagine an unknown object. In order to investigate it, we place it in a cube and look at it from a specific angle, analogically to observing a specific phenomenon through a specific question, we are posing. The object manifests itself in a specific way (a) (in figure 1.).

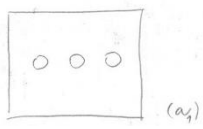

Figure 1. Manifestation (a)

We can translate that manifestation into a hypothetical object close to the perception our senses operate in (I) (in figure 2.) [35].

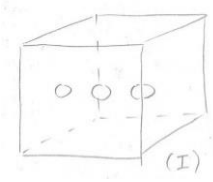

Figure 2. Object (I)

To be more accurate, we choose a different view on *all* (I) objects and what is presented to us is (a) or (b) (in figure 3.).

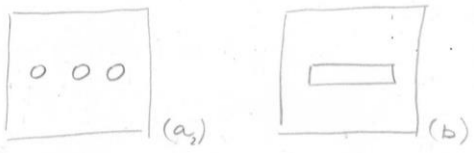

Figure 3. Manifestations (a) and (b)

In order to make sense of that, we choose yet another view, now with the outcomes (a) and (c) (in figure 4.).

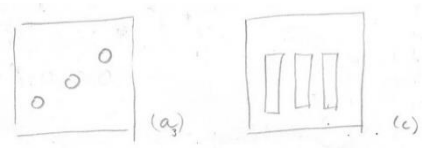

Figure 4. Manifestations (a) and

[35] According to the second rule, already at this point science is allowed to make a conclusion that all other phenomena which as well present themselves as (a), are (I).

Through realizing certain relationships and interdependence we can find out that we are actually dealing with two different objects (I) and (II), which share the way they are manifested (a) from a certain point of view (in figure 5).

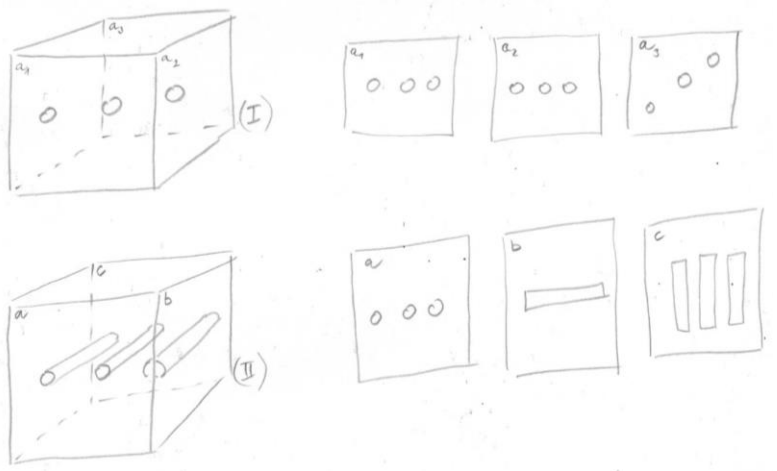

Figure 5. Objects (I) and (II) with their different manifestations (a), (b) and (c)

By further investigation, we can be presented with (d), which reveals the existence of yet another object (III) (in figure 6.).

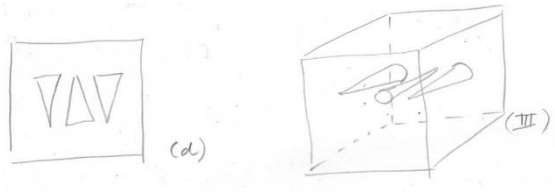

Figure 6. Object (III) with its manifestation

Object (III) shares with the object (II) multiple forms (in figure 7.).

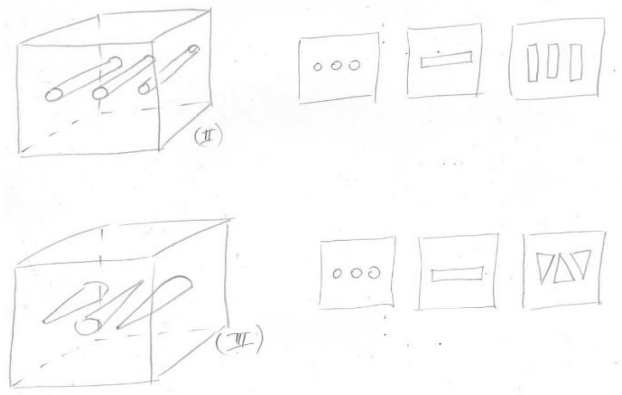

Figure 7. Objects (II) and (III)

The game of *shared forms* [36] is endless (in figure 8.).

Figure 8. Game of *shared forms*

This metaphor demonstrates that as *shared principle* bridges over the boundaries between different phenomena, the *shared form* serves independently to different principles or processes. The first one is significantly used when dealing with an 'easily isolatable' phenomenon (as Newton did for example for the problem of gravity). The second one is necessary to be taken into account when dealing with complex systems (as cells, an organism, an ecosystem, the universe).

[36] The graphics of *shared forms*: idea developed in collaboration with a visual artist Peim van der Sloot.

3.2.3 The emerging notion of complex systems

Francis Heylighen, a cyberneticist focused on the topic of emergence and evolution of complexity, pointed in his work Complexiteit en evolutie (2007) at the silent revolution in science, which is taking place for the last twenty years across the scientific disciplines: a transition from the Newtonian paradigm to the notion of 'science of complexity'.
The notion of complex systems acknowledges the value of the context, the value of the interactions between the parts, which make the whole more than the sum of all parts separately. The theory around complex systems is building upon principles and methods from a broad range of scientific disciplines and still today there is no exact definition of complexity as a whole. There are, nevertheless, specific core concepts defined, which allow a different mindset while observing the behaviour of any complex system. Here we mention the most important ones and give only a brief overview of their meaning.

3.2.3.1 Open system

A system is defined as a set of parts that are interwoven by relationships. Those relationships influence the different parts of the system. A system as a whole has its own identity, which differentiates it from its environment [37].
The sustainability of an open system is dependent on the exchange of energy, information and material substances within its own environment. That which one component of a system produces as output can serve as an input for the other components. A very complex network of interdependency can be created this way. The components of a larger system can become systems themselves, thus creating subsystems. In this way, a hierarchy occurs.

3.2.3.2 Self-organization

Complex systems have the ability to spontaneously organize themselves in ordered structures based on interactions between the different components of the system. This organization therefore emerges from local behaviour and spreads itself through the whole system from within (e.g.: molecular organisation).

3.2.3.3 Non-linearity

While the Newtonian mechanics can rely on the equal proportion between cause and

[37] Heylighen, F. (2007). *Complexiteit en Evolutie*. Manuscript, Brussel. Retrieved 2020, from http://pespmc1.vub.ac.be/books/CursusHeylighen.pdf; pg.25

effect (thus linearity), complex systems behave non-linearly: the progress of the behaviour and the final effect can proportionally be much smaller or bigger than expected from the original cause, depending on their state or context [38].

3.2.3.4 Chaos

The phenomenon chaos describes a behaviour, where a complex system shows sensitive dependence on initial conditions [39], in other words the smallest fluctuation at the origin can lead to significantly different cascades of effect and therefore it can provide very different results. One of the properties of the chaos behaviour is, that once it comes back to its original state, it could react very differently to the same impulse than the previous time.

3.2.3.5 Emergence

Emergent properties are the ones that would be not possible to deduce from the properties of the separate components of the system [40]. Those properties emerge from the interactions and interdependencies between the components of the system. This notion gives the counterweight to the notion of reductionism.

3.2.4 Relevance to the human organism

The human organism is a complex adaptive system and as such a hierarchical structure. We can observe that in two lines. On one hand ontogenetically, as a development of the hierarchy from single fertilized ovum - a cluster of cells with extra-cellular material – tissues – organs – body – consciousness, where the activity on every level of the hierarchy creates an emergent behaviour (a behaviour/ feature not predictable from the behaviour/ feature of its separate components), which always overarches the separate components in a new organism unity. On the other hand phylogenetically, as the development of a hierarchy of living organisms from atoms – molecules – protocellular forms – procaryote unicellular organisms – eukaryote unicellular organisms – eukaryote multicellular organisms – plants and animals –

[38] Complex system. (2020, August 18). Retrieved August 18, 2020, from https://en.wikipedia.org/wiki/Complex_system

[39] Complex system. (2020, August 18). Retrieved August 18, 2020, from https://en.wikipedia.org/wiki/Complex_system

[40] Heylighen, F. (2007). *Complexiteit en Evolutie*. Manuscript, Brussel. Retrieved 2020, from http://pespmc1.vub.ac.be/books/CursusHeylighen.pdf; pg.24

primates – human (– other forms to be continued), where the interaction of the component with its environment leads to cooperation and mutual dependency, thus forming a new more complex entity. Complexity is not created by adding new, not-yet-seen components but by changing the context of the separate components in any way (e.g. spatial configuration of the elements). Therefore the variety of organic matter is decomposable to only four basic elements (hydrogen, oxygen, carbon and nitrogen), as well as the architecture of the organic matter uses the same basic building principles as tensegrity and fractal organization on all levels of the hierarchy (we elaborate on that further on in chapter 5.2.1).
As a complex adaptive system, a human organism is a self-organizing entity with non-linear, chaotic behaviour which is necessary to acknowledge in all disciplines dealing with health care.

3.2.5 Relevance to the therapeutic situation

The mindset of complex systems recognizes the whole range from analogy to combinatorial game of shared forms as proposed in chapter 3.2.2. That allows a much broader source of information and the possibility to come to different conclusions regarding one phenomenon.
In fact, osteopathic diagnosis and treatment already use that broader source: an important diagnostic principle of osteopathy is to make an assessment and evaluation of the whole body on the parietal, visceral and cranial field with attention to mobility, tissues density, fascial and fluidic aspects while considering patient's psycho-emotional or social context (not reducing the diagnosis according to the complaint of the patient but rather placing the complaint in its place within the hierarchy of the patient's organism).
Osteopathic diagnosis is very familiar with the idea of shared structures: osteopaths regularly deal with the fact that the symptom doesn't reveal the essence of its cause. The symptoms of for example carpal tunnel syndrome have to be considered in very different relations dependent on the patient. At the same time, we can be quite sure to say, that each osteopath would use different pathways, different techniques to bring back the mobility into the patient's body and by doing so provide free pathways for the most efficient movement of fluids with nutrients, oxygen and toxins necessary for the recovery of the tissues, all leading to similar results concerning the recovery of the patient.

3.2.6 Relevance regarding the position of osteopathy within the medical science

In his time, A. T. Still was a renaissance figure when it comes to the field of medicine. It is clear from Still's texts that he viewed health and medicine from a whole new perspective. He saw a value in a more holistic medicine approach than the existing paradigm. In her book, C. Trowbridge mentions this several times:

> Based upon biological principles and intimately tied to the structure of the human organism, Still's philosophy of osteopathy was holistic and naturalistic, emphasizing health rather than disease. He believed that the body was perfect.[41]

> In the same way that evolution was a naturalistic approach to life, so was osteopathy a drugless, holistic, and naturalistic approach to health and disease. Still envisioned every plant and animal, including man, as a perfect biological, self-regulating mechanism, perfectly adapted for a particular function in a particular environment that was created to function perfectly without the use of internal drugs.[42]

Still, as an opponent of the traditional pharmaceutical system, chose to develop a completely new diagnostic and treatment concept based on the principles named above. His approach was not entirely fitting the regular medical and scientific paradigm of that time, yet he named osteopathy a scientific approach:

> As the science known by the name of Osteopathy is accredited to me, I suppose I am the oldest Osteopath now on earth, I also think I have given more attention to the study of the principles of this science than all persons now living combined.[43]

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[41] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* Kirksville, MO: The Thomas Jefferson University Press.; p. xii

[42] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* Kirksville, MO: The Thomas Jefferson University Press.; p. 160

[43] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy*. Kirksville, MO: A. T. Still; pg. 227

Nowadays scientific research finds itself in a time of transformation. The changing paradigm from the reductionistic to a holistic view is slowly growing through the different disciplines, including health care. Nevertheless, a large amount of research in medical care is still conducted as quantitative research, zooming in very narrowly to specific phenomena while taking the participating components out of their natural context (e.g. *in vitro* culturing). Probably it will still take time before we will be able to extend the new holistic paradigm to the daily practice of medical research and health care, where there will be the acknowledgment that interactions and interdependence are at least as important as the individual components and where one can find balanced attention to the whole versus to separate components.

3.2.7 Relevance regarding writing this thesis

To write this thesis we use the mindset of complex systems, providing us with a very broad source of information, which leads to a multi-layered search with surprising outcomes. In such a variety of information we were initially guided by the following defined questions: “What information / research do we resonate with?” and “What information engages our focus / attention and contributes to the forming of a clear mental framework for the times when we are practising osteopathy on patients?”. Through the process of collecting the material and writing the thesis, we realized how important it is to pay attention not only to the results of research but as well to the process of how the research was conducted, in order to evaluate if the obtained data can be truthfully used in a context of a living organism as well. In that sense, the importance of the question “Is this research more or less respecting the principles of life, therefore principles of osteopathy?” became the compass for ordering the collected material.

4. Defining the phenomenon of movement

The idea of the importance and power of movement, motion or flow for the living organisms is reflected in numerous popularly known quotes from across the ages.

> Panta rhei. (Heraclitus)
>
> Life requires movement. (Aristoteles)
>
> The least movement is of importance to all nature. The entire ocean is affected by a pebble. (Blaise Pascal)
>
> Nothing happens until something moves. (Albert Einstein)
>
> You guard against decay, in general, and stagnation, by moving, by continuing to move. (Mary Daly)
>
> Movement is life - life is movement. (A. Senger)
>
> Life consists of movement and movement is its essence. (A. Schopenhauer)

In all daily activities, whether professional, artistic, recreational, sportive or self-expressive including body language, we express ourselves through movement (Starosta, 2001). Executing a movement seems to be a very natural state one finds himself in. However, the idea of the matter of our own body constantly working on embodying the movement and so manifesting its own aliveness is not so obvious, even if it is the necessary base to be able to move ourselves.
In our search, we are zooming in on the level of this inner / intrinsic movement, the movement ensuring the sustainable development of our own life and the basic condition of all living organisms.

4.1 Definition of terms

movement [44, 45]

• the act or process of moving; change of place or posture
• transference, by any means, from one situation to another
• natural or appropriate motion; progress
• a system of mechanism for transmitting motion of a definite character, or for transforming motion (e.g. as the wheelwork of a watch)
• action, activity
• an act of voiding the bowels

motion [46], [47]

• the act, process, or state of changing place or position
• movement; the passing of a body from one place or position to another, whether voluntary or involuntary, opposed to rest
• change in the relative position of the parts of anything; action of a machine with respect to the relative movement of its parts
• movement of the mind; mental act, or impulse or inclination to any action
• internal activity
• in physics: Motion is the phenomenon in which an object changes its position over time. It is mathematically described in terms of displacement, distance, velocity, acceleration, speed, and time. [48]

Motion expresses a general idea of not being at rest; movement is oftener used to express a definite, regulated motion [49], especially progress in space measured by a

[44] Movement Definition and Examples - Biology Online Dictionary. (2020, June 23). Retrieved August 25, 2020, from https://www.biologyonline.com/dictionary/movement

[45] Movement. (n.d.). Retrieved August 25, 2020, from https://www.merriam-webster.com/dictionary/movement

[46] Motion Definition and Examples - Biology Online Dictionary. (n.d.). Retrieved August 25, 2020, from https://www.biologyonline.com/dictionary/motion

[47] Motion. (n.d.). Retrieved August 27, 2020, from https://www.merriam-webster.com/dictionary/motion

[48] Motion. (2020, August 26). Retrieved August 27, 2020, from https://en.wikipedia.org/wiki/Motion

[49] Movement Definition and Examples - Biology Online Dictionary. (2020, June 23). Retrieved August 25, 2020, from https://www.biologyonline.com/dictionary/movement

static spatial reference. Nevertheless, in most dictionaries the words movement and motion are stated as synonyms and as such, they are often used in the writings.

intrinsic [50],[51]
• belonging to the essential nature or constitution of a thing
• originating or due to causes within a body, organ or part
• originating and included wholly within an organ or part
• situated entirely within or pertaining exclusively to a part

As the definitions are suggesting, the meaning of the notion of *intrinsic* is determined by the dimension of the hierarchy we are referring to. During the writing of this thesis, we noticed that while certain dimensions of the human organism hierarchy are naturally quite clear, others need an explanation of where from and how did we draw the limits. We will define the precise limits of the term *intrinsic*, where needed, in the progress of the text.

4.2 The changing understanding of the phenomenon of motion

When searching in philosophy and natural philosophy in a cross-section, we can notice a certain shift of meaning in the definition of the phenomenon of motion.

Ancient Greek philosopher Aristoteles (384 – 322 BC) dedicated some thoughts and writings to the understanding of motion in his work Physics.

> Motion… neither come into being nor perishes, but instead always existed and always will exist… present in things as if it were a kind of life belonging to everything composed by nature? Indeed, that there is motion is the view of all who discuss nature, since they describe the origin of the world, and their whole study concerns coming to be and perishing – which could not exist if there were no motion. [52]

[50] Intrinsic. (n.d.). Retrieved September 17, 2020, from https://www.merriam-webster.com/dictionary/intrinsic

[51] Intrinsic Definition and Examples - Biology Online Dictionary. (n.d.). Retrieved September 17, 2020, from https://www.biologyonline.com/dictionary/intrinsic

[52] Aristotle, & Graham, D. W. (1999). *Aristotle, Physics, book VIII*. Oxford: Clarendon Press.; section 250^{b}II

Aristoteles defines motion as the actuality of the potentiality [53]. This definition is somewhat ambiguous and leads to different interpretations through the times, nevertheless philosopher Joe Sachs gives a clear example of how Aristoteles sees the role of motion in the context of life:

> There is a fish with an effective means of camouflage: it looks like a rock but it is *actually* a fish. When an actuality [= being what it is] is attributed to that fish, completely at rest at the bottom of the ocean, we don't seem to be talking about any activity. But according to Aristotle, to be something always means to be at work in a certain way. In the case of the fish at rest, its actuality is the activity of metabolism, the work by which it is constantly transforming material from its environment into parts of itself and losing material from itself into its environment, the activity by which the fish maintains itself as a fish and as just the fish it is, and which ceases only when the fish ceases to be… Nothing is which is not somehow in action, maintaining itself either as the whole it is, or as a part of some whole. [54]

The understanding of motion as a constant act of 'maintaining itself' is quite accurately mirroring the current view on the conditions of 'being alive' of living organisms, as we will elaborate on in chapter 5.2.1.2.
Aristoteles comments on the phenomenon of intrinsic movement as well:

> Of intrinsic movement... what is moved by itself is moved by nature, such as every animal. For an animal is moved by itself, and things which have their source of movement in themselves we say are moved by nature. [55]

From those statements we could imagine the understanding of all living organisms being part of a larger organism, larger living force – nature.
The philosophy of Aristoteles was still in the center of interest in the middle ages for, for example, Thomas Aquinas or several Arabic scholars, who were aiming for the synthesis of Aristotelian philosophy with their own religious teachings.

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[53] Sachs, J. (n.d.). Aristotle: Motion and its Place in Nature. Retrieved August 27, 2020, from https://iep.utm.edu/aris-mot/

[54] Sachs, J. (n.d.). Aristotle: Motion and its Place in Nature. Retrieved August 27, 2020, from https://iep.utm.edu/aris-mot/

[55] Aristotle, & Graham, D. W. (1999). *Aristotle, Physics, book VIII*. Oxford: Clarendon Press.; section 254^b

On the contrary, philosopher and mathematician René Descartes (1596 – 1650 AD) argues with the Aristotelian view and defines motion in the following way:

> Motion . . . is nothing more than the action by which any body passes from one place to another. [56]

In this statement, we can sense the divorce between the action of the movement itself and the origin of action, as well as the reduction of the term *motion* to the concrete manifestation of the motion. Where Aristoteles speaks of motion always in relation to a certain inner transformation of the object, which is possibly manifested in the materialistic world as a shift in the space, Descartes acknowledges only the aspect of the shift in space without the necessity of the inherent driving force.

Along with those lines, the mathematician and physicist Isaac Newton (1642 – 1726) developed his work, where he, amongst other things, defined the 3 laws of motion in a strictly mechanistic sense:

- Rule 1 Objects in motion (or at rest) remain in motion (or at rest) unless an external force imposes change.
- Rule 2 Force is equal to the change in momentum per change of time. For a constant mass, force equals mass times acceleration.
- Rule 3 For every action, there is an equal and opposite reaction.

4.3 Our standpoint on the term movement / motion

From the range of possible views on the term movement / motion, our orientation point is accurately expressed in writing of the Czech philosopher Jan Patočka:

> Movement isn't something external that happens to a being or a mere change of her relationships, but something internal that creates and builds the being in her existence; it is the determining of the indeterminate or not-yet-specified

[56] Descartes, Principles II, section 24 as cited in: Sachs, J. (n.d.). Aristotle: Motion and its Place in Nature. Retrieved August 27, 2020, from https://iep.utm.edu/aris-mot/

> base ground of the vital core, whose presence let develop all capabilities or forces of a certain nature. [57]

In the scope of this thesis, we will rather use the term movement to acknowledge the aspect of the regulation (as noted in chapter 4.1) and at the same time to acknowledge the importance of the spatial aspect over a time aspect, as the spatial aspect is more directly connected with the issue of palpation.

4.4 Definitions of the keywords used in Still's texts

Since the texts were written at the end of the 19th century, we can expect a certain deviation of the English language and the definitions of its words to nowadays English.
Therefore we have used the Webster dictionary from 1828 [58] in comparison to Webster dictionary from 2020 [59] to analyze and obtain the most accurate message that Still tried to deliver through his texts.

motion
- according to Webster dictionary 1828 [60]
• The effect of impulse; action proceeding from any cause, external or internal. In the growth of plants and animals, there must be a motion of the component parts, though invisible. Attraction or chemical affinity produces sensible motion of the parts of bodies. Motions of the mind ascribed to the invisible agency of the supreme Being, are called good motions.

---

[57] own translation of a citation in J. Patočka (1964), Aristotelés, jeho předchůdci a dědicové as cited in Chvátal, L. (2010). *Pohyb lidské existence. Studie k pojetí „pohybu" (kinésis) u Maxima Vyznavače (580-662)* (Unpublished doctoral dissertation). Charles University in Prague.

[58] American Dictionary of the English Language. (n.d.). Retrieved October 24, 2020, from http://webstersdictionary1828.com/

[59] Dictionary by Merriam-Webster: America's most-trusted online dictionary. (n.d.). Retrieved October 24, 2020, from https://www.merriam-webster.com/

[60] American Dictionary of the English Language. (n.d.). Retrieved October 24, 2020, from http://webstersdictionary1828.com/

- according to Webster dictionary 2020
• an act, process, or instance of changing place
• an active or functioning state or condition
• an impulse or inclination of the mind or will

action
- according to Webster dictionary 1828 [61]
• Literally, a driving; hence, the state of acting or moving; exertion of power or force, as when one body acts on another; or action is the effect of power exerted on one body by another; motion produced. Hence, action is opposed to rest. Action when produced by one body on another, is mechanical; when produced by the will of living being, spontaneous or voluntary.
• In mechanics, agency; operation; driving impulse; effort of one body upon another; as, the action of wind upon a ship's sails. Also the effect of such action.
• Quantity of action in physics, the product of the mass of a body by the space it runs through and its velocity.
• In many cases action and the act are synonymous; but some distinction between them is observable. Action seems to have more relation to the power that acts, and its operation and process of acting; and act, more relation to the effect or operation complete. Action is also more generally used for ordinary transactions; and act, for such as are remarkable, or dignified; as, all our actions should be regulated by prudence; a prince is distinguished by acts of heroism or humanity.

- according to Webster dictionary 2020
• thing done
• the accomplishment of a thing usually over a period of time, in stages, or with the possibility of repetition
• an act of will
• the bringing about of an alteration by force or through a natural agency
• the manner or method of performing

[61] American Dictionary of the English Language. (n.d.). Retrieved October 24, 2020, from http://webstersdictionary1828.com/

movement

- according to Webster dictionary 1828 [62]

• passing, progression, shaking, turning or flowing; any change of position in a material body; as the movement of an army in marching or maneuvering; the movement of a wheel or a machine

- according to Webster dictionary 2020

• the act or process of moving
• series of organized activities working toward an objective
• action, activity

electricity

- according to Webster dictionary 1828 [63]

• The operations of a very subtill fluid, which appears to be diffused through most bodies, remarkable for the rapidity of its motion, and one of the most powerful agents in nature. The name is given to the operations of this fluid, and to the fluid itself. As it exists in bodies, it is denominated a property of those bodies, though it may be a distinct substance, invisible, intangible and imponderable. It is doubted by modern philosophers whether electricity is a fluid or material substance.

- according to Webster dictionary 2020

• a fundamental form of energy observable in positive and negative forms that occurs naturally or is produced and that is expressed in terms of the movement and interactions of electrons.
• electric current or power
• a science that deals with the phenomena and laws of electricity

[62] Webster's Dictionary 1828 - Motion. (n.d.). Retrieved October 24, 2020, from http://webstersdictionary1828.com/Dictionary/motion

[63] Webster's Dictionary 1828 - Electricity. (n.d.). Retrieved October 24, 2020, from http://webstersdictionary1828.com/Dictionary/electricity

nature

- according to Webster dictionary 1828 [64]

• In a general sense, whatever is made or produced; a word that comprehends all the works of God; the universe.

• By a metonymy of the effect for the cause, nature is used for the agent, creator, author, producer of things, or for the powers that produce them. By the expression 'trees and fossils are produced by nature', we mean, they are formed or produced by certain inherent powers in matter, or we mean that they are produced by God, the Creator, the Author of whatever is made or produced. The opinion that things are produced by inherent powers of matter, independent of a supreme intelligent author, is atheism.

- according to Webster dictionary 2020

• the inherent character or basic constitution of a person or thing
• temperament.
• a creative and controlling force in the universe
• an inner force (such as instinct, appetite, desire) or essential characteristics
• the physical constitution or drives of an organism
• a spontaneous attitude
• the external world in its entirety
• original or natural condition
• a simplified mode of life resembling this condition
• the genetically controlled qualities of an organism

[64] Webster's Dictionary 1828 - Nature. (n.d.). Retrieved October 24, 2020, from http://webstersdictionary1828.com/Dictionary/nature

5. Unfolding the topic of the intrinsic movement

In this chapter, we attempt to unravel the origins of intrinsic movement from two points of view. On one hand, we focus on what are the ideas and concepts regarding the origin of life / motion / action / movement according to the writings of A. T. Still and how it reflects in his osteopathic practice. On the other hand, we research what the current science says about the origins of the intrinsic movement, its role in living organisms and how is this knowledge utilized in nowadays osteopathic practice.

5.1 Still's ideas and concepts regarding movement

5.1.1 Still as a philosopher

Still's interest in philosophy took a big part in his Medical - Osteopathic practice. His Philosophical mind was interwoven with his anatomical, physiological and spiritual reasoning. One could conclude that Still's philosophy was inspired by spiritualism, transcendentalism, Swedenborgianism, Methodism, the theory of evolution and his mechanical approach. Still notes that we know life through its manifestations and believes that by studying its events, including man, we will better understand life, this involves understanding the link between physical and spiritual:

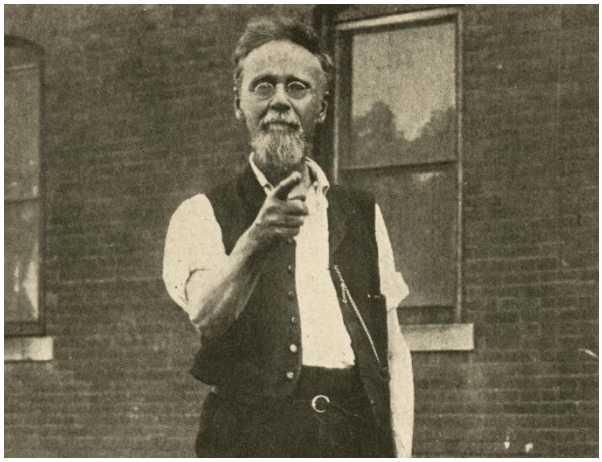

Figure 9. Andrew T. Still
retrieved from Haxton, J. (2015). Still: Through the Eyes of Ernest E. Tucker. The Osteopathyst, 3, 13.

> "If we inspect man as a machine, we find a complete building, a machine that courts inspection and criticism. It demands a full exploration of all its parts with their uses. Then the mind is asked to see or find the connection between

> the physical, and the spiritual. By nature you can reason on the roads that the powers of life are arranged to suit its system of motion." [65]

Still further mentions the union between physical and spiritual, which he finds necessary for the proper functioning of any living body:

> "The celestial worlds of space or ether-life give forms wisely constructed in exchange for the use of the material substances. Reciprocity through the governments of the celestial and terrestrial worlds is even the same, and human life, in form and motion, is the result of conception by the terrestrial mother from the celestial father. Thus we have union of mind matter, and life, or man." [66]

As a philosopher and as a doctor, Still seemed to believe in teaching his students how to *osteopathize* [67] as a method of coming to an idea, rather than giving explicit instructions:

> "It is my object in this work to teach principles as I understand them, and not rules. I do not instruct the student to punch or pull a certain bone, nerve or muscle for a certain disease, but by a knowledge of the normal and abnormal, I hope to give a specific knowledge for all diseases." [68]

He urged his students to use their creativity, not to think in closed frameworks and to open their minds.

5.1.2 Still and biogen

A.T. Still was known for his curious and adventurous nature, he did not skip the topic of the origin of life. He has been busy contemplating and philosophizing about the

[65] Still, A. T. (1899). *Philosophy of Osteopathy* (p. 195-196). Kirksville, MO: A.T. Still.

[66] Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy* (p. 251). Kansas City, MO: A.T. Still.

[67] Biogen. (2012, June 28). Retrieved October 24, 2020, from https://waltermckone.wordpress.com/osteopathy/biogen/

[68] Still, A. T. (1899). *Philosophy of Osteopathy* (p. 4). Kirksville, MO: A.T. Still.

origin of life, in his book The philosophy and Mechanical Principles of Osteopathy (chapter 11), where he dedicated a whole chapter about 'Biogen'.

The word Biogen is formed out of two elements from the Greek language:
• *Bios* for 'life' → Bios [69]
• *Genes* for 'birth, origin'. As the name suggests, this concept deals with the origin of life (movement). → Génnisi [70]

Biogen Dictionary translation according to the 1913 Webster's dictionary [71]:
• Biogen definition: Bi"o*gen (?), n. [Gr. ? life + -gen.] (Biol.) Bioplasm

• Bioplasm definition: Bi"o*plasm (bi"?*plaz'm), n. [Gr. biòs life + plàsma form, mold, fr. plassein to mold.] (Biol.) A name suggested by Dr. Beale for the germinal matter supported to be essential to the function of all living beings; the material through which every form of life manifests itself; unaltered protoplasm. → (the physical basis for life)

In his quest for knowledge, Still dives into the Biogenic concept:

> "Nobody knows the philosopher who first asked the question: 'What is life?' But all intelligent person is interested in this problem, wanting at least to know a reason tangible for which it is called 'Life'; know if life is personal or if it is organized in such a way that it can be considered as an individualized principle of Nature." [72]

5.1.3. The conflict

In this section we will present the apparent conflict Still was dealing with. A conflict that struggled to find the answer to the mystery of existence. He found himself torn between science and spirit, earthly and divine.

[69] Bible hub. (n.d.). Retrieved October 24, 2020, from https://biblehub.com/greek/979.htm

[70] γέννηση. (n.d.). Retrieved October 24, 2020, from https://en.wiktionary.org/wiki/%CE%B3%CE%AD%CE%BD%CE%BD%CE%B7%CF%83%CE%B7

[71] Webster's 1913. (n.d.). Retrieved October 24, 2020, from https://www.websters1913.com/

[72] Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy* (p. 249). Kansas City, MO: A.T. Still.

Daring to explain the origin of life by means other than divine, oppose the biblical model of creation, accepted by all at the time. The Evolutionary model clashes with the Methodist religious model. Still, finding himself in the middle, tried to find the truth throughout his lifetime. For him, the fascinating idea of Evolution, could not match his deep belief that this manifestation could only be the work of an omniscient creator:

> "I want to tell you that I worship a respectable, intelligent, and mathematical God. He knows whether the earth is going too fast or not. He didn't ask your papers to publish that he had better push the earth a little faster to let that comet go by. None of his children disobey, get drunk, or lose their minds. I make this assertion from the confidence I have in the absolute mathematical power of the Universal Architect. I have the same confidence in his exactness and ability to make, arm, and equip the human machine, so it will run from the cradle to the grave. He armed and equipped it with everything necessary for the whole journey of life to a man threescore and ten years." [73]

While Still was a big fan of Spencer, he tried to look for the answer in his writing but Spencer himself avoided claiming about the origins and took refuge in the unknown mystery:

> "An attempt to assign the causes of evolution, would manifestly be absurd, if that agency to which the metamorphosis in general and in detail is due, could either come into existence or cease to exist. The succession of phenomena would in such case be altogether arbitrary; and deductive science impossible." [74]

Spencer's modesty did not allow him to come up with any grandiose statements about the origins of existence.

> "May we not without hesitation affirm that a sincere recognition of the truth that our own and all other existence is a mystery absolutely and forever

[73] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 281). Kirksville, MO: A.T. Still.

[74] Spencer, H. (1862). *First Principles* (p. 251). London: Williams and Norgate.

> beyond our comprehension, contains more of true religion than all the dogmatic theology ever written?" [75]

As well as the origins of life, the search for origins of motion was also on Still's focus, one may say that he was torn between spirituality and science: "Right here we should ask the question, Is the action produced by electricity put in motion, or is it the active principle that comes as spiritual man?" [76]

In his texts, Still often ponders about life and the divine force which is responsible for the intertwinement of atoms, cells and matter, the connection between the earthly and heavenly and eventually for motion / movement / action. Spencer, as Still himself, was also trying to find a place for the concept of motion:

> "The conception of Motion, as presented or represented in the developed consciousness, involves the conceptions of Space, of Time, and of Matter. A something that moves; a series of positions occupied in succession; and a group of coexistent positions united in thought with the successive ones - these are the constituents of the idea." [77]

In his book The Philosophy and Mechanical Principles of Osteopathy chapter 'Biogen', Still has dedicated a whole chapter to the origins of life (motion) where he philosophizes and asks questions about the origins: "As motion is the first and only evidence of life, by this thought we are conducted to the machinery through which life works to accomplish the results as witnessed in 'motion'." [78]

Further in this thesis, we will explore this chapter and try to unveil the thoughts and dilemmas that Still encountered in his quest for knowledge.

[75] Spencer, H. (1862). *First Principles* (p. 112). London: Williams and Norgate.

[76] Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy* (p. 249). Kansas City, MO: A.T. Still.

[77] Spencer, H. (1862). *First Principles* (p. 234). London: Williams and Norgate.

[78] Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy* (p. 250). Kansas City, MO: A.T. Still.

5.1.4 Quotes and interpretations

In the following chapter, we present Still's statements which were retracted from his main literature with the focus on the origins of the movement. We extracted his original quotes with the focus on the following keywords: motion / movement / action.

The original quotes from Still will be divided into different subject groups, keywords will be highlighted and potential interpretation will be offered next to them.

5.1.4.1 Definitions of the keywords

Since the texts were written at the end of the 19th century, we can expect a certain deviation of the English language and the definitions of its words to nowadays English. Therefore we have used the Webster dictionary from 1828 [79] in comparison to Webster dictionary from 2020 [80] to analyze and obtain the most accurate message that Still tried to deliver in his texts.

The understanding of the keywords and of the main differences between the two timelines of the English language is necessary to obtain the core idea that Still was trying to deliver. We use this information later to decode the quotes from Still and provide possible interpretations for those.

For the actual definitions we refer back to chapter 4.4.

5.1.4.2 Analysis of Still's writings

We examined the following literature for the indicated keywords and chose the most adequate ones, where Still engages in philosophical and mystical monologues about the origin of motion / movement / action.

[79] American Dictionary of the English Language. (n.d.). Retrieved October 24, 2020, from http://webstersdictionary1828.com/

[80] Dictionary by Merriam-Webster: America's most-trusted online dictionary. (n.d.). Retrieved October 24, 2020, from https://www.merriam-webster.com/

It is important to mention that the interpretation of the quotes was done by Leon Katsman. “Still and his philosophy were always a source of mystery and fascination for me and therefore I decided to try and ‘decode’ the messages he left for us, the osteopaths.”
The views on Still’s texts interpretations are the writers’ and reflect his personal philosophical interpretation of the content.

The material is taken out of 4 books:
Still’s 4 original books were chosen for this thesis. The motivation for this was that those books delivered the purest form of Still’s message, without interpretations. That leaves our interpretations not biased and unique to our work.

• Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy*. Kirksville, MO: A.T. Still.
• Still, A. T. (1899). *Philosophy of Osteopathy*. Kirksville, MO: A.T. Still.
• Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy*. Kansas City, MO: A.T. Still.
• Still, A. T. (1910). *Osteopathy, research and practice*. Kirksville, MO: A.T. Still.

The collection of quotes is divided into seven sections. The first two sections (Motion in life and Superior being) are collected from 3 following books:
• Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy*. Kirksville, MO: A.T. Still.
• Still, A. T. (1899). *Philosophy of Osteopathy*. Kirksville, MO: A.T. Still.
• Still, A. T. (1910). *Osteopathy, research and practice*. Kirksville, MO: A.T. Still.

The Biogenic section is taken specifically from his book:
• Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy*. Kansas City, MO: A.T. Still.

The quotes are divided into 8 circles:
• Motion in Life
• Superior being
• Biogen
• Origin of Action (Still AT 1902, p.249-251)

• Forces combined (Still, AT 1902, p.251-254)
• Matter in the Atom (Still, AT 1902, p.254 - 255)
• The visible and the invisible (Still, AT 1902, p.256-258)
• Questions to the Osteopath (Still, AT 1902, p.266-268)

5.1.4.2.1 Motion in life

Motion plays a big part in Still's quest to understand life and the power that fuels it. Here is a collection of quotes about motion in life:

Original Quote	**Interpretation**
"Through our five senses we deal with the material body. It has action. That we observe by vision which connects the mind to reason. High above the five senses on the subject of cause or causes of this, is **motion.**" 1899 p.25	The material body (which operates through the input of 5 senses) already possesses Action. Motion (manufactured by the highest known principle) is a force (beyond the 5 senses) that causes the action.
"As **motion** is the first and only evidence of life, by this thought we are conducted to the machinery through which life works to accomplish these results." 1899 p.196	Life presents itself in the form of motion (the only evidence of life), by this law we are guided to the physical body to demonstrate the principles of life (results) through which it sustains itself. Motion is the main evidence of life and is expressed mechanically through the body.
"But we do know that life can only display its natural forces by the visible **action** of the forms it produces." 1899	Life expresses itself through means of motion. Action as an expression of life. Still

p.195	speaks about natural forces, the forces which are visible to us through the form in which these actions take place.
"It selects and adjusts and supplies life to atoms, beings, worlds and keeps them equipped with material and motion, with mind to construct and wisdom to govern all motions of the body formed by its eternal labors. Life is the God, the wisdom, the power and the **motion** of all." 1910 p.512	The highest known principle, God, regulates the princess of life. From the smallest particles (atoms) to the biggest (earth and the universe). This force of life forms matter and supplies it with motion and intrinsic abilities to govern itself.

Still speaks about the principles of life that are behind the visible and through which matter affects motion. Still addresses a deeper level of being, he ponders about the activity behind what is visible.

5.1.4.2.2 Superior being and motion

God plays a big role in Still's life, as explained in the introduction. The dilemma between the theory of evolution and the Biblical creation theory plays a big role in Still's philosophy. Here he expresses his intuition as to the origins of life / motion.

Original Quote	**Interpretation**
"We take up Osteopathy. How old is it? Give me the age of God and I will give you the age of Osteopathy. It is the law of mind, matter and **motion**.'' 1897 p.282	The principles of Osteopathy date to the onset of life. Those principles are the fundamental principles of life itself, which Osteopathy is based upon. It is the law of mind, matter and motion

	which for Still are interconnected.
"Thus an exacting God has given the command: Attention, worlds. Into line, ye suns and planets. Music by the band. Foreword, march. Left, Left, Left I Never halt, for all is in **motion** and never halted to even give birth to a baby world. Go on, and on, is the command, as seems to be from the very mouth and mind of God, as we would now express the thought, for **motion** is found in worlds and beings.'' 1897 p.236	God / Life as the master director, giving orders, instructions that manifest in motion.
"Ever since time found place for the human race, the love of life, of self and kind has caused that grand being containing Mind, Matter, and **Motion**, and given in form, 'and endowed with the attributes of God', which wants to live on and on forever.'' 1897 p.174	Since time has been linked with the human experience, The Love (of all) is presented as a catalyst that affects the Grand being (human) which is supplied with qualities of his/her creator, who wants to live forever (human wishing for health / immortality).
"When this great machine man, ceases to **move** in all its parts, which we call death, the explorers knife discovers no mind, no **motion.**'' 1899 p.27	Movement is an expression of life, this expression is absent when life is not present.
"First the material body, second the spiritual being, third a being of mind which is far superior to all vital **motions** and material forms, whose duty is to wisely manage this great	Being of mind (higher mind/ inherent intelligence) is the most fundamental quality for motion (movement/action) and matter (form). Still mentions that this higher mind is

engine of life.'' 1899. p.26	more important than the material body and the spiritual being (man). This higher intelligence whose duty is to manage the living organism.
"God manifests Himself in matter, **motion**, and mind. Study well His manifestations." 1897 p.227	Motion is presented as evidence of the Supreme Being.
"I find in man a miniature universe. I find matter, **motion**, and mind.'' 1897 p.406	The human (body) is a microcosm, containing both celestial and earthly principles.
"When the elder prays, he speaks to God; he can conceive of nothing higher than mind, **motion**, and matter." 1897 p.406	When we speak to God, we speak to these principles. Mind, motion and matter as a divine expression of God.
"If they give us health when normal action prevails and disease only when abnormal, then we are admonished to form a more intimate acquaintance with the qualities, and with all the products, when formed in this great laboratory which compounds and qualifies each substance to fill its mission of force, construction, purity and **action**." 1899 p.66,67	Still advising to form a more intimate connection with the active inherent healing qualities / forces, as well as with the product (effect) of those qualities. Through forming a deeper connection with the laboratory (the physical body) we familiarize ourselves with the inherent qualities that maintain force, construction, purity and action.

Still comes to a conclusion and realization that the power behind the motion is a higher being or a higher power that is just guiding the physical man. He emphasizes the duty of the spiritual being in guiding the material body through life and the ways

this higher being is connected to the material body. This higher, wise being which is responsible for the motion in matter, is represented in various ways in Still's texts. This power of creation is manifested from a higher wisdom. Still often mentions the 'Machine' that has internal forces and moving parts and sufficient energy to manifest motion.

5.1.4.2.3 Biogen

Still's fascination about the origins of life brought him to dedicate a whole chapter for his philosophical contemplations about it.
In the biogenic chapter, Still expresses his intuition about the spiritual nature of the universe, rather than remaining in the dialectic opposition presented by the Evolutionary and the Biblical models. Those two opposing currents blend into Still's philosophy, we can see that in his referrals in his writings.
Life needs certain conditions to manifest itself. These conditions have to come in terms, they must support Protoplasm harmony, in other words Biogen. Still emphasizes his texts about the key factors that are needed to support such a condition: function in relation to structure, energy with relation to matter and spirit with relation to tissue.

Life is feasible when fluids intermingle with ground substances, cells, vessels and nerves.

5.1.4.2.3.1 Origin of Action (Still, 1902, p.249-251)

Original Quote	**Interpretation**
"As **motion** is the first and only evidence of life, by this thought we are conducted to the machinery through which life works to accomplish the results as witness in **motion**."	*see the translation in motions in life

"But we know that life can only display its natural forces by visible **action** of the forms it produces."	*see the translation in motions in life
"Right here we should ask the question, Is the **action** produced by electricity put in **motion**, or is it the active principle that comes as spiritual man? If the latter, is useless to try or hope to know what life is in its minutiae."	Still asks what initiates the action? Electricity (see the definition) or the Spiritual (spirit) aspect of life?
"We know by experience that a spark of fire will start the principles of powder into **motion**, which, were it not stimulated by the positive principles of Father Nature, which finds this germ lying quietly in the womb of space would be silently inactive for all ages, without being able to move or help itself, save for the **motor** principle of life given by the father all **motion**."	The movement is initiated by God / Father Nature. Without this spark of life from the creator a life would not be able to manifest itself as motion.
"By nature you can reason that the powers of life are arranged to suit its system of **motion**."	Vital forces accommodate motion.
"If life is an individualized personage, as we might express that mysterious something, it must have definite arrangements by which it can be united and **act** with matter."	If we are the life, if life is presented through the human body, we might also express the highest known principle, God. The creator presents himself through action and through matter.

	*principles.
"Self-constructing and self-moving wonder known as man, wherein life and matter unite and express their friendly relation one with the other. While this relation exists we have the living man only, expressing and proving the relation that can exist between life and matter, from the lowest living atom to the greatest worlds. They can only express form and **action** by this law. Harmony only dwells where **obstructions** do not exist."	A human being is presented here as wonder where a union of forces happens and life is created. This union of matter with the life force is expressed by means of form and action. Harmony is presented as a condition for health, for this to be sustained, the movement qualities have to be optimal.
"The osteopath finds here the field in which he can dwell forever. His duties as philosopher admonish him that life and matter can be united, and that union cannot continue with any hindrance to free and absolute **motion**."	Still suggests here that the osteopath should use his philosophical mind. This is a limitless topic where he can 'dwell' (*Osteopathize*) forever, he urges the osteopath to 'think outside the box'. His duties as a philosopher are to see the union between life and matter and realize that it is possible and that such union is under the condition of a free and complete motion.

In this chapter Still deals with the origin of Action. He ponders about the origins of Action, what causes it. He speaks much about the natural forces and the observation of action through the forms it produces. Still believes that this area is an area worthwhile dwelling upon and encourages his students to be also philosophers.

5.1.4.2.3.2 Forces combined (Still, 1902, p.251-254)

Original Quote	**Interpretation**
"If a seed is planted in the earth and it obeys both the terrestrial and the celestial forces, then the result is tree. A man, biogenic **force**, means both lives in united **action** to construct all bodies in form, with wisdom to govern their **action**."	Man, a creation of nature, is a union of terrestrial and celestial. Those forces are united in action to form and construct the physical body, guided by wisdom (God).
"Biogen is the lives of the two in united **action** that gives motion and growth to all things."	Biogen is the union of forces (heavenly and earthly), those two forces produce motion. Vitality (life) is expressed by motion.
"All material bodies have **life** terrestrial and all space has life, ethereal or spiritual **life**. The two, when united, **form** man."	Life creation by a union of earthly and spiritual forces. Those two form a man when united. Still emphasizes the importance of the union. Union of all the forces, terrestrial and celestial, ethereal and spiritual forces to create life.
''Life terrestrial has **motion** and **power**; the celestial bodies have knowledge or wisdom.''	Earthly forces possess motion and power. Heavenly forces possess knowledge or wisdom. Still separates the forces here and shows us again the importance of union for life.

"Thus biogen or material life of the two obeys the wisdom of the celestial mind or life. The result is faultless perfection, because the earth-life shows in material forms the wisdom of the God of the celestial."	The spirit / celestial forces guide the terrestrial (material) in the process of life, resulting in perfection, harmony. Union, which results in life, is representing the flawless perfection of the heavenly God, the creator (spirit).

Biogen is a union of earthly and heavenly forces. In this chapter Still speaks about this union of those forces, an eternal mutual exchange that permeates all nature.

> "Thus biogen or material life of the two obeys the wisdom of the celestial mind or life. The result is faultless perfection, because the earth-life shows in material forms the wisdom of the great God of the celestial. Thus we say Biogen or dual life, that life means eternal reciprocity that permeates all nature."

5.1.4.2.3.3 Matter in the Atom (Still, 1902, p.254 - 255)

Original Quote	**Interpretation**
"That **self-moving principle** which we see in all animal bodies we call life, because we see them **move** independent of other bodies or forces."	Intrinsic force (self-moving principle) represents itself in motion, this force is independent, seen in all living bodies.
"That life **acts and moves** in that being of its own force."	The life is manifested out of an inherent force (action manifested by the highest known principle, the creator), own strength.

"Then we behold a living body, and we say, 'That body is all alive; every atom **moves'**."	The life (motion) is present on every level, even the smallest particle moves. Motion is a key principle of life.
"When matter passes beyond the degree of being atomized farther, then it is life, and it acts and forms itself to suit the body of any being or the world."	The matter is going through a transition to a point of life formation. From that point, the action is manifested and this matter is taking a form in the shape of any living being

In the chapter matter in the Atom, Still is diving into the smallest living unit within the atom. He talks about a form that is changing its shape and particles that 'decide' into what form and shape they evolve. Possibly in today's terms this could be considered to slide into the field of Quantum physics.

> "When matter ceases to be divisible, it then becomes a fluid of life and easily unites with other atoms, and is a mass or body of living matter and recrystallizes in to the form given by the parent causes. Thus man's body is a form given by celestial life to the terrestrial life that is reduced back from the living matter to a man, world, or being, with form of a being given by the celestial forces acting on living matter whilst in the living state of matter, so fine that the atoms blend and become a unit, or melt and become one being or body of living matter, with quality equal to all qualities of life, wisdom, and material substances, never to return to their original state, either as matter or life."

5.1.4.2.3.4 The visible and the invisible (Still, 1902, p.256-258)

Original Quote	**Interpretation**
"Life surely is a very finely prepared substance, which is the all moving	The life force, the highest known principle, is the force responsible for

force that moves all nature from worlds to atoms."	motion in all that is alive, from atoms to worlds.
"It seems to be a substance that contains all the principles of construction and **motion**, with the power to endow that which it constructs with the attributes necessary to the object it has formulated from matter and sent forth as a living being."	This substance (life force) contains all the principles to construct a life and create motion. This force has the power to deliver the necessary qualities of life and to form a living being.
"We speak of life, but know of it only as we see bodies move by life back of the visible matter. Does nature have a finer matter that is invisible and that **moves** all that is visible to us?"	We percept the expression of life via the motion principle. But is there an invisible force / Potency nature possesses, that is responsible for motion that we perceive?
"All **motion** is matter in action. An explosive is matter at rest, and an explosion is matter in **motion**; so of **motion** in man."	The motion is a representation of a matter in action, it can be in different states, such as rest or motion.
"What we call life is matter at **labor**; death is matter minus explosive ability and at rest. The velocity of the union of the two forces doubles the explosive power of either."	Life is a matter in motion. Death is a matter in rest, without the motion. The Union of those two forces (motion and matter) doubles the explosive power of either one.
"We see **'motionless** matter, earth, stone, and on to all visible bodies.' And we see moving matter; we say living matter. When we see dead	We differentiate between 'motionless matter' (earth, stone, etc.) and 'living matter' (moving bodies).

bodies that do not move, we say 'dead matter'. But it is dead, or it is in state of **inaction** or rest only, and waiting it's time to fall in line as living active matter that is **rested** and ready to take up the line of march and give its energies to the orders or Nature?"	We label dead bodies by 'dead matter', but is it dead or is it in a regenerative state/ waiting, to take its turn in the circle of life as a rested matter?
"Thus far we see nothing in matter but life at **rest**. Even the human body that we see every day is matter called to a halt and at **rest**."	We perceive motionless matter as life in a rest state. Just like the human body, it has to take its daily rest. Here again mentioned the importance of harmony.
"That life substance, when conducted to a higher condition of unfoldment, is ready to take its place and send the wondrous **action** of the principle known as mind."	When the conditions are right, the life force, the highest known principle, is ready to act and manifest life.

Still with his curious nature and philosophical mind, talks in this chapter about life as an invisible element. This element is able to manifest matter into a living form, with the necessary properties for function and motion. He talks about life as a substance that has the capability to move all of nature, from 'worlds to atoms'.

Still is hopeful that the osteopath will dwell in this fountain of knowledge and use this to help his fellow beings:

> "We have given few thoughts on this line of life hoping the osteopath will take up the subject and travel a few miles farther towards the fountain of this great source of knowledge and apply the results to the relief and comfort of the afflicted who came for counsel and advice."

5.1.4.2.3.5 Questions to the osteopath (Still, 1902, p.266-268)

Original Quote	**Interpretation**
"Are the human and animal forms complete as working machines?"	Is the living form (human or animal) indeed the final version of creation? Is it prepared to act? Is it ready to function / take part in life?
"Has nature furnished man with powers to make his bones; give them the needed shapes of durable material, strong in kind?"	Did nature prepare the physical body to take part in the outdoor world? Is his body strong enough to move around and endure? To handle the physical challenges?
"How will this body **move**, and where and how is the **force** applied?"	What is the mechanism responsible for the motion in the human body, what are the mechanical principles that apply to the force division?
"Where and how is this force obtained?"	The force behind the motion, the 'highest known principal', what is the source of such force? And how does it apply to motion?
"How is it generated and supplied to these parts of **motion**?"	How is the force initiated and conducted to the appropriate locations that are responsible for the performance of motion?
"Are they self-forming, or has nature prepared machinery to make them?"	Are the forces being established from innate force? Or are they originating from the superior being?

“Does animal life contain knowledge and force to construct all of the parts of one?”	Has nature intrinsic intelligence and the ability to manufacture all the necessary parts of a living being?
“Can it run the machine after it has finished it? By what power does it move?”	Can the living organism still function when this innate force is depleted? Which force is responsible for the motion?
“If it has the battery of force, where is it?”	If such force exists, where is then stored? Is there a physical / specific location?
“What does it use for force?”	In what form, shape the energy / fuel is?
“Is it electricity? If so how does it collect and use this substance?”	Is the force supplied in the form of electricity? And if so, where is it accumulated, stored? And how is it moving the machinery (body)?
“How does it convey its powers to any or all places?"	Via which pathways is this force transmitted to the right places?
“What makes it build the house of life?”	Where is the will to create life coming from?

Still brings out questions to the osteopath that he hopes the osteopath will keep in mind. Those questions bring up the same topics as described in chapter Biogen, topics such as the origin of motion, laws of life and nature. He asks about the type of force on which is fueling machinery after the machine is formed and how come that this force is available everywhere.

5.1.5 Several considerations

The Story of A.T. Still is an intriguing mixture of events, ideas, beliefs and discoveries. We have previously mentioned the major influences on Still's life, those have shaped him as a person and the outcome was the birth of Osteopathy. It seems that Still was taken by the magical mystery called life. He was determined to find the origins of it all, and specifically to our case, the origins of action, motion and movement. His life story sets him on this quest for knowledge, his upbringing, experiences in rural nature, Methodism, connection to the Native American cultures and their wisdom and more are what the school of life brought his way.

Diving to Stills literature with the goal in mind to find his views about the origins of motion has been a journey through Still's complex philosophical mind. The four books which he left behind as his legacy are a mix of spiritual, scientific labyrinth out of which we tried to find the answer to our search.

Still genially encrypts his texts with a mystical touch that makes their interpretation a challenging task and forces one to use his intuition and heart rather than his analytical mind. Perhaps this was Still's intention after all, like the pyramids in Egypt, leaving ques for mysterious and sacred knowledge behind and leaving it up to the followers to decode.

He mentions the importance of motion and that union of life and matter cannot exist if the motion is interrupted. **Motion** is the necessary ingredient for life and harmony: "Harmony only dwells where obstructions do not exist." [81]

Life remains, for Still, a mysterious thing, where one can forever dwell in. A source of energy that is responsible for all there is: "God manifests himself in matter, motion and mind. Study well his manifestations." [82]

[81] Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy* (p. 250). Kansas City, MO: A.T. Still.

[82] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 226).

5.2 Current scientific findings

This chapter is dedicated to the topic of intrinsic movement as a phenomenon taking place through the hierarchy of the body. Through thinking about the collected material, we realized that we would like to give this topic its proper place within the context of *nature*. The strategy is to work from general principles to concrete applications, step by step on every level of the hierarchy.

5.2.1 The framing laws

Before we fully step into the core of the topic of intrinsic movement, we feel the necessity to first place the phenomena of intrinsic movement into a broader frame of natural laws. Such a frame should provide a better understanding of general principles, as they are later applied to different levels of the body hierarchy. We dedicate this chapter to construct such a frame.

During our studies of osteopathy, we realized that different subjects (as physiology, biochemistry, biomechanics) refer to many different *laws of nature*: physical, chemical, biomechanical and so on and on. As we ideally would like to think in all-embracing principles, we aim to extract a more underlying essence from a number of scattered laws, something of more general use (e.g. Nature wants everything to lie flat.). Part of the philosophy of osteopathy actually provides useful leadership in this sense: the law of balance, the law of economy and the law of comfort as the *3 laws* that the organism's structure and function rely on. The *3 laws* are used for example as the mechanical principles which underlay the vertical position of the human body and as a model for adaptive posture organisation. For this thesis, however, we use them in a broader sense.
On the other hand, osteopathy strongly highlights the necessity of flow in the living body and, as osteopaths, we often refer to the statement 'panta rhei' (= everything alive is streaming) as to a fundamental phenomenon of life which we support during an osteopathic treatment.

In the following chapters, we will have a detailed look at the above-mentioned laws, their relationships and how they frame the phenomenon of movement.

5.2.1.1 The origin of the 3 laws

We define the *3 laws* as follows:
• the law of economy, which requires taking as little energy as possible for the task,
• the law of balance, ensuring the maintaining the balanced environment,
• the law of comfort, which requires choosing the pathway of least resistance.

Those *3 laws* are the basic laws of nature and biology, understood in a broad sense as a science of everything alive. Biology is thus dealing with the observation of all the life forms from very simple (as Archaebacteria) to life forms of enormous complexity (as plants, animals or humans). A question of 'how does such a complexity occur' is a central question of evolution theory and therefore indirectly of biology as well, as the biologist Theodosius Dobzhansky expressed in his essay Nothing in Biology Makes Sense Except in the Light of Evolution (Flatscher & al., 2008).

The evolution theory sees the development of life forms as a process, where an organism starts to exhibit a new behaviour (thus a new function) through interaction with another organism or with its environment, which wouldn't be possible for the organism alone without such interaction. Thus, a new dimension of behaviour is created and all participants contributing to that new behaviour create a new entity. The emergent behaviour is however not predictable from the behaviour of the original parts. At the same time, the original parts keep their own, already existing, functioning and don't give up their own identity for the new function. In such a way, a hierarchy is created where every new dimension contains and utilizes the functions of its previous dimensions. An important feature of this process is the 'being on the edge of chaos' thanks to the unpredictability of the emergent behaviour with each newly occurring dimension. With growing dimensions, the matter of the organism is growing as well. The organization of the organic matter follows certain basic rules, namely the laws of balance, economy and comfort and as such, they are the base ground for the morphology of the organism.
The natural processes of the body, occurring as various emergent behaviours during the ever-growing complexity of life forms, are processes making sure that we are going to survive. Therefore they can be seen as processes that maintain our own health.
As osteopathy claims to be the concept, which respects the self-healing forces of the body, together with that, osteopathy ought to respect (and study) these processes of the body and their evolution. In this context, we understand that the philosophy of

osteopathy adopts the principles of the evolution theory [83].
In his texts, Still emphasizes several times that "the mechanical principles on which osteopathy is based are as old as the universe" [84] which reflects the influence of Herbert Spencer's work (as elaborated on in chapter 3.1.3.6).

The laws of balance, economy and comfort can provide an umbrella for understanding most of the physical or chemical phenomena playing a role in the physiology and histology of the tissues. To name some examples: diffusion and osmosis and its relation to metabolism of the cell, osmotic pressure and hydrostatic pressure; behaviour of fat and water, their interaction and its relation to the establishment of different environments in the tissues; the architectonic build-up of the cell structures, tissue structures, build up and coherence of the organism as a whole.

5.2.1.2 Entropy and enthalpy

After anchoring the *3 laws* in the philosophy of osteopathy, a question occurs how to place the statement 'panta rhei' in a clear relationship with the *3 laws*. To a certain degree, the laws are even suggesting that any situation always tends towards stillness in contrast to the constant movement of 'panta rhei'. In order to define this relationship more accurately, we propose to include the notions of entropy and enthalpy.

There are two forces described which drive physical changes and chemical reactions: entropy and enthalpy. *Entropy* can be described as the number of possible configurations of a system's components that is consistent with the state of the system as a whole [85], in other words as a degree of randomness in the system. For a visualization of this concept we refer to the analogy proposed in the article Introduction of entropy [86]. *Enthalpy* is defined as a thermodynamic quantity

[83] Muts, R. (2020, August 19). Vraag over osteopathie wetten [E-mail to the author].

[84] Still, A. T. (1910). *Osteopathy, research and practice* Kirksville, MO: A.T. Still.; p.v

[85] Introduction to entropy. (2020, May 06). Retrieved July 16, 2020, from https://en.wikipedia.org/wiki/Introduction_to_entropy

[86] Introduction to entropy. (2020, May 06). Retrieved July 16, 2020, from https://en.wikipedia.org/wiki/Introduction_to_entropy

equivalent to the total heat content of a system [87], in other words it can be described as energy deposited in the thermodynamic system. It is equal to the internal energy of the system plus the product of pressure and volume.

Physical changes and chemical reactions proceed spontaneously in order to minimise enthalpy and maximize entropy [88]. Changes and reactions, where the entropy is increased and enthalpy decreased at the same time, are irreversible. Those changes, going towards the maximum entropy and minimum enthalpy, are ultimately leading towards a system with maximum *stability* (where the laws of balance, economy and comfort are in theory finally fulfilled!). However, the living organism is dying somewhere on the way towards this point because of the incompatibility of this process with 'being alive'.

For living systems it is crucial, that they are able to locally decrease their entropy [89]. As this process goes against the spontaneous order, a certain amount of energy has to be invested in this. Living organisms generate energy from nutrition (in the case of plants from solar energy). This energy is in turn invested in a large number of different metabolic processes, which are ensuring the relative stability of the different environments within an organism (e.g. intracellular, extracellular). However, this stability is built up in an 'on the edge of chaos' manner; in other words certain metabolic processes of the cell (e.g. action of the sodium-potassium pump) are aiming to create a disbalance, a tension between the intracellular and extracellular environment in order to ensure specific directionality of the metabolic exchange. The fact that the nutrients and products of the metabolism stream in a certain way and not 'anyhow' is in fact a constant work of the organism on decreasing its entropy. Regarding the topic of the intrinsic movement, the continuous sequence of the single metabolic actions with a certain directionality, a spatial organization, mirrors the concept of metabolic fields of Erich Blechschmidt. We elaborate further on this topic in chapter 5.2.2.4 of the thesis.

[87] Enthalpy: Definition of Enthalpy by Oxford Dictionary on Lexico.com also meaning of Enthalpy. (n.d.). Retrieved July 16, 2020, from https://www.lexico.com/en/definition/enthalpy

[88] Stubbings, J. (n.d.). Spontaneous Reactions: Enthalpy and Entropy Chemistry Tutorial. Retrieved July 17, 2020, from https://www.ausetute.com.au/spontaneous.html

[89] Not to contradict the second law of thermodynamics (= the global disorder has to increase), they can do this on one condition: there must be a corresponding increase in entropy somewhere else to compensate, for example by an interaction with its surroundings: releasing heat.

5.2.1.3 Relation of entropy to the 3 laws

Respecting those interpretations, we can imagine the situation in which a living organism finds itself: captured between a global tendency towards entropy and the absolute fulfilment of the *3 laws* on one hand and continuous, ant-like work on a very local level, whose numberless single actions are over and over again undermining the global process towards maximum entropy on the other hand. For the sustainability of the life of the organism, the constant local work is executed with respect to the *3 laws* as defined in chapter 5.2.1.1.

The *3 laws* have complex reciprocal relationships: balance ensures more economical pathways, spending less energy brings more comfort, comfort is an expression of balance. In situations where the balance of this triangle cannot be reached, the adaptation of the organism takes place in order to guard its own comfort (as a place of the least resistance). Even if that solution costs locally more energy, it is more economic to the organism as a unity.

We can rely on those *3 laws* concerning the organization and architecture of the solid and liquid substances in all living organisms and concerning the movement within that organization.

5.2.1.4 Basic organizational principles and their relation to the framing laws

Regarding the topic of the intrinsic movement, we would like to highlight some of the natural organization principles and behaviours outflowing from the laws mentioned above. As a specific law draws the limit in a specific aspect, we can imagine that the final framing of the organism's behaviour is a result of some synergistic and some antagonistic forces. In this chapter we select certain physiological processes and behaviours and present them in their relationship to entropy, enthalpy and the *3 laws*.

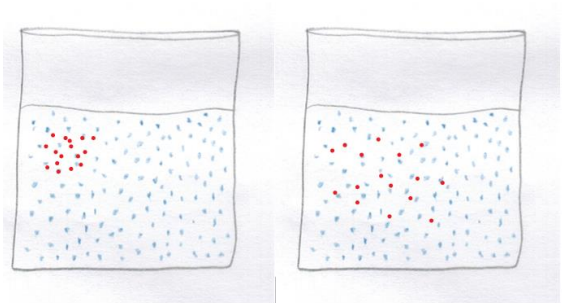

Figure 10. Diffusion
author image

5.2.1.4.1 Diffusion

Diffusion is a process of spontaneous spreading of particles in space. This process is driven mostly by a

concentration gradient; particles spread across space until the gradient is the same at all places. This behaviour is following the rules of entropy and enthalpy: during the process the degree of randomness is growing and the internal energy is decreasing. The process leads to the absolute economy, balance and comfort. Diffusion is one of the basic principles for the movement of the solid substances in the tissues on a local level.

5.2.1.4.2 Osmosis

Osmosis is a process of spontaneous spreading of the solvent in space. In the context of living organisms it is driven by a concentration or pressure gradient. The process is analogous to the principle of diffusion. Osmosis is one of the basic principles for the movement of the liquids in organisms.

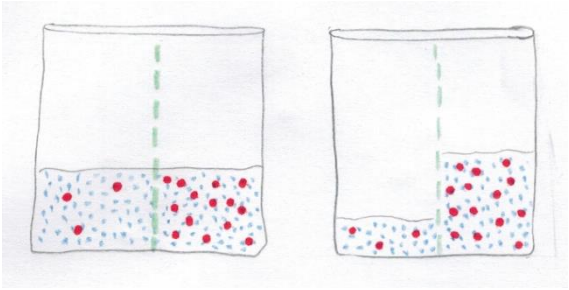

Figure 11. Osmosis
author image

5.2.1.4.3 Polarity

The phenomenon of polarity refers to the way attractive forces of electrons are distributed within a field of an atom. The electrical charge of the electrons is distributed asymmetrically, which results in an electrical dipole moment (a constant spatial vector). Very generally described,

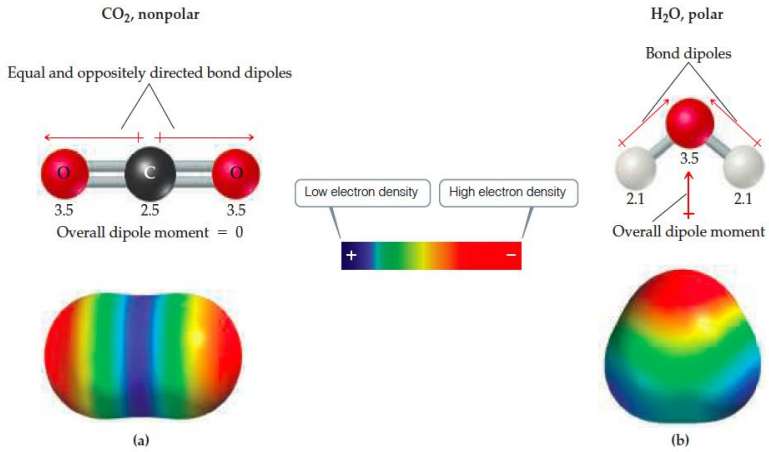

Figure 12. CO2, a nonpolar molecule, and H2O, a polar molecule. The numbers are electronegativity values for these two atoms
retrieved from Textbook-specific videos for college students. (2020). Retrieved September 28, 2020, from https://www.clutchprep.com/chemistry/practice-problems/111613/co2-a-nonpolar-molecule-and-h2o-a-polar-molecule-the-numbers-are-electronegativi

by this phenomenon an atom is driven to look for other atoms to complement and neutralize his electrical charge. By that complementation, he gains more stability and by that comfort in that marriage. Polarity underlies a number of other phenomena in physics such as solubility or surface tension. These properties are characteristic for water, the most abundant substance of any living organism. In the context of living organisms, the properties of hydrogen bonds are very crucial for the solubility and movement of water-based liquids.

5.2.1.4.4 Principle of close-packing, geodesic geometrics and formation according to platonic solids

Figure 13. The five Platonic solids inscribed in spheres. From left to right: the tetrahedron, the octahedron, the cube, the icosahedron and the dodecahedron.
retrieved from Tavakoli, A., & Gisin, N. (2020). The Platonic solids and fundamental tests of quantum mechanics. *Quantum*, *4*, 293. doi:10.22331/q-2020-07-09-293

Close-packing is an organizational phenomenon, where particles in the form of equal spheres (e.g. atoms), take the most economical arrangement in space driven by attraction and repulsion forces. The most efficient arrangement is such, where the connection between two points is established over the shortest path. The smallest units of such an arrangement are described as platonic solids: regular symmetrical objects with equal faces and equal angles, their faces identical in shape and size, where each vertex is a meeting point of an equal number of faces. There are 5 objects meeting these conditions (named platonic solids, figure 13.) and their arrangement is mirrored in nature in structures of inorganic crystals. On the other hand, two of such arrangements, tetrahedron and icosahedron, are mirrored in structures of living organisms.
The structure of a tetrahedron (figure 14.) occupies the smallest proportion of unit space, minimum volume within maximum surface area and as such is the most

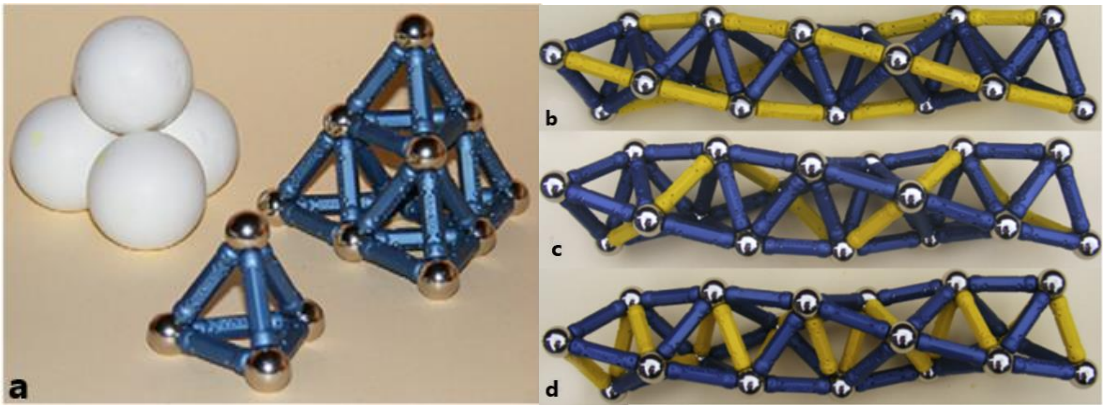

Figure 14. Closest-packing of spheres forms a tetrahedron (a), **right-handed tetrahelix** (dark/blue) showing: (b) 3 long right-handed helixes (yellow); (c) 2 medium left-handed helixes; (d) 1 short right-handed helix. retrieved from Scarr, G. (2010). Simple geometry in complex organisms. *Journal of Bodywork and Movement Therapies, 14*(4), 424-444. doi:10.1016/j.jbmt.2008.11.007; pg. 428
and Scarr, G. (2011). Helical tensegrity as a structural mechanism in human anatomy. *International Journal of Osteopathic Medicine, 14*(1), 24-32. doi:10.1016/j.ijosm.2010.10.002; pg. 27

economical structure. In general, molecules automatically assume a state of minimal-energy as they balance the attraction and repulsion forces of the atoms they consist of.

Structure of icosahedron (figure 15.) has the largest volume in relation to the surface and this way can fill out space to an optimum by 'close-packing' [90] and as such is an ideal structure for depositing other substances or materials. By arranging 12 icosahedra around a central point, a new icosahedron is created on a larger scale. In living organisms, this property is reflected as a self-similarity principle in their build-up. At the same time, the icosahedron is one of the basic

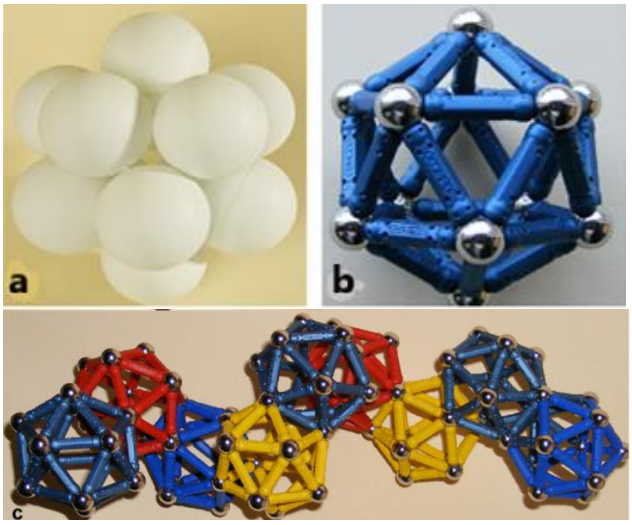

Figure 15. Close-packing around a central space (a) **forms an icosahedron** (b) with hexagonal outline, (c) icosahedral helix retrieved from Scarr, G. (2010). Simple geometry in complex organisms. *Journal of Bodywork and Movement Therapies, 14*(4), 424-444. doi:10.1016/j.jbmt.2008.11.007; pg.433,435

[90] Pflüger, C. (2008). *The Meaning of Tensegrity Principles for Osteopathic Medicine* (Unpublished master's thesis). Donau University Krems. Retrieved July 19, 2020, from http://www.osteopathic-research.com/paper_pdf/Pflueger.pdf; pg.51

structures exhibiting the principles of tensegrity (Buckminster Fuller, 1975, as cited in Pflüger, 2008).
The most efficient close-packing configuration is a helix and as such, it is understandable that it should be a common structural shape. Most (if not all) molecular helixes are geometrically related to the tetrahelix and icosahedron [91].

5.2.1.5 Behaviour of the organic matter and the relation to the framing laws

Based on those general principles we can follow the further nuanced organization of the substances on a larger scale.

5.2.1.5.1 Behaviour of fat and water in their interaction

Due to the polar property of water and the non-polar property of fat, the two matters don't interact with each other. To be able to form a homogenous substance, water molecules would have to break their hydrogen bonds and that would cost energy. Instead they choose a more economical solution: to interact with their own sort, which leads to a situation of the most comfort: a fat drop staying together in a pool of water. Based on this principle, the barriers can be created by a bilipid layer in the otherwise homogenous hydrophilic environment and by that a unique organization can be observed: units can be formed by means of lining with the fatty layer (forming of cells), which have the ability to maintain a different environment in relation to the outside. Such an organization brings the opportunity to work against the rule of entropy as mentioned before. The establishment of different environments ensures the exchange (movement) between them.

5.2.1.5.2 Tensegrity

The concept of tensegrity (abbreviation for tensional integrity) was suggested for the first time by architect Buckminster Fuller in 1975. Tensegrity describes a structural-relationship principle in which structural shape is guaranteed by the finitely closed, comprehensively continuous, tensional behaviours of the system and not by the

[91] Scarr, G. (2011). Helical tensegrity as a structural mechanism in human anatomy. *International Journal of Osteopathic Medicine, 14*(1), 24-32, doi:10.1016/j.ijosm.2010.10.002; p.27

discontinuous and exclusively local compressional member behaviours [92]. In other words, it is a system built up from 2 types of elements: compression struts (discontinuous) and tension cables (continuous), put together in such a way, that there is a balance accomplished between tensional and compressive forces ensuring the stability of the structure (figure 16.). The adaptability is ensured by the flexibility of the tension cables and the discontinuity of the compression struts. The stability of the structure is maintained by pre-stress if larger flexibility is needed or geometrically through triangulation where a maximum of stiffness is required [93].

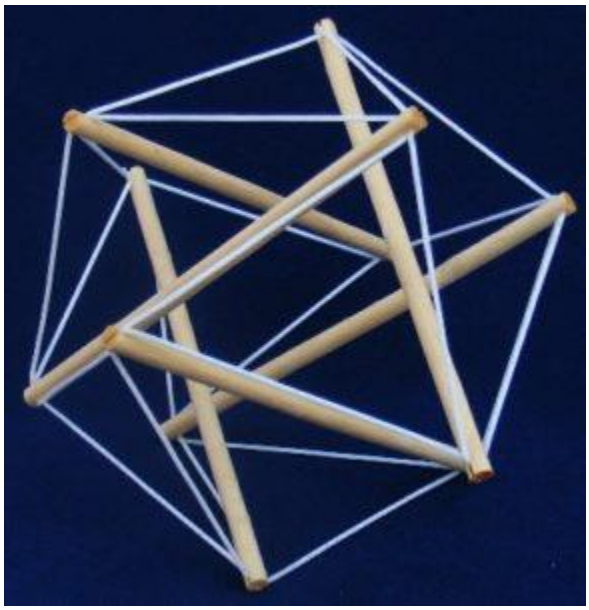

Figure 16. Tensegrity model
retrieved from Scarr, G. (2020, April 06). The barre essentials of life. Retrieved October 22, 2020, from http://www.tensegrityinbiology.co.uk/biology/

Tensegrity structures are very economic thanks to their balanced situation, and at the same time highly adaptable to pressure. The property of pre-stress ensures that, when even when the smallest amount of pressure is applied, the adaptation takes place equally across the whole structure to ensure the most comfort possible for every part of the structure equally. At the same time, their energy-efficient configuration is maintained, even during such changes in shape (Scarr, 2011).
Edmondson (1992) stated:

> Those structures are not new but they are everlasting laws of nature. These principles can be found everywhere in nature, in every possible dimension.

[92] Fuller, R. B. (1975). *Synergetics: Explorations in the geometry of thinking*. New York: Macmillan; p.1

[93] Pflüger, C. (2008). *The Meaning of Tensegrity Principles for Osteopathic Medicine* (Unpublished master's thesis). Donau University Krems. Retrieved July 19, 2020, from http://www.osteopathic-research.com/paper_pdf/Pflueger.pdf; pg.30

> Fuller did not copy the principles from nature but he translated them into mathematical principles and this way made them comprehensible. [94]

The applications of tensegrity principles to biological systems are thoroughly researched by Donald Ingber, who dedicated his carrier to mapping nature's use of the tensegrity principle in living organisms, mainly on the cellular level: the way the cytoskeleton and the extra-cellular matrix (ECM) are built up, its mechanical connection with the cell membrane and the cell nucleus, and the interdependency of those structures.
Thanks to the ongoing research we can trace the presence of the tensegrity concept across the whole hierarchy of living organism, where both the tension and compression elements utilize the structure of helix as described above. Such a helical tensegrity organization can be observed in 'molecular anatomy' (the build-up of microtubules, microfilaments and intermediate filaments in the cell – F. F. Sadoc and E. A. Lord as cited in Scarr, 2011), micro-anatomy (where microfilaments serve as a tensile component, microtubules as a compression component and intermediate filaments serve as a mediator between the two; between the tensegrity systems of two neighbour cells or cell and ECM as researched by Ingber, Chen, Stamenovic, Davies and others) as well as in macro-anatomy (architecture within the bones - Chen & Ingber, 1999; the architecture of the fascio-skeletal apparat – Ingber, Oschman as cited in Pflüger, 2008; Levin, 1990 as cited in Tozzi, 2014). Based on this description we can deduce that, on different levels of the hierarchy, specific components can assume different roles in the tensegrity system (for example a cell on its own is a tensegrity structure and contains both compression and tension components, while within a higher dimension a cell assumes the role of a tension component opposed to compression component of the collagen of the ECM). This kind of adaptability across the hierarchy ensures the force transmission across the hierarchy in the structures.

The study of Huang, Sultan & Ingber (2006) suggests that tensegrity principles are one of the conditions for being able to build up any hierarchical system, thus it is one of the conditions for the evolution of living organisms:

> Tensegrity is used at all size scales in the hierarchy of life, and it may have played an important role in the mechanism by which hierarchical self-

[94] Edmondson (1992) as cited in Pflüger, C. (2008). *The Meaning of Tensegrity Principles for Osteopathic Medicine* (Unpublished master's thesis). Donau University Krems. Retrieved July 19, 2020, from http://www.osteopathic-research.com/paper_pdf/Pflueger.pdf; pg.19

> assembly of inorganic components and small organic molecules led to formation of living cells. …from the perspective of organismal biology, linking tensegrity-based structural networks and physical constraints to cell fate regulation is a central requirement for the evolution of organisms of increasing size that cannot rely solely on chemical interactions with their environment for control of their behaviour. Living cells and tissues must deal with macroscopic physical phenomena such as mechanical forces, including tension, compression, shear, surface tension, and osmotic stresses. These physical signals can regulate specific modes of cell behaviour…[95]

5.2.1.5.3 Principal of encaptic division and self-similarity

The principle of encapsis, as a repetition or recapitulation of a certain phenomenon that took place earlier on a larger scale, is described by E. Blechschmidt as one of the ontogenetic principles. In his words, processes that originally occurred in the whole occurs subsequently in one of the parts [96]. Recapitulation can be understood both in terms of space and time.

Such development results in a phenomenon of fractal organization [97]. The essential characteristic of fractals, as described by James B. Bassingthwaighte, Larry S. Liebovitch and Bruce J. West (1994), is that as finer details are revealed at higher magnifications the form of the details is similar to the whole: there is self-similarity [98]. The phenomenon Blechschmidt described in his work overlaps with what Bassingthwaighte, Liebovitch & West (1994) point out as one of the possibilities of arriving to a fractal, that is: a single process may start at one scale and then extend to other scales [99]. Examples of such processes can be branching of vessels, air ducts in

[95] Huang, S., Sultan, C., & Ingber, D. E. (2006). Tensegrity, Dynamic Networks, and Complex Systems Biology: Emergence in Structural and Information Networks Within Living Cells. *Topics in Biomedical Engineering International Book Series Complex Systems Science in Biomedicine,* 283-310. doi:10.1007/978-0-387-33532-2_11; pg. 306

[96] Freeman, B. (2016). *Journal of Clinical Developmental Biology, 1*(1), 1-5. Retrieved September 02, 2020, from http://schoolbiosynthesis.es/wp-content/uploads/2017/03/Art.-The-Conceptus-and-its-Parts-Ontogenetic...-Brian-Freeman.pdf; pg.3

[97] …yet it is not the only way how a fractal organization occurs.

[98] Bassingthwaighte, J. B., Liebovitch, L. S., & West, B. J. (1994). *Fractal physiology*. New York: Oxford University Press.; pg.3

[99] Bassingthwaighte, J. B., Liebovitch, L. S., & West, B. J. (1994). *Fractal physiology*. New York: Oxford University Press.; pg.286

lungs, ductuli in glands or calyces of kidneys. Such branching processes leads to a specific inner architecture where the continuing growth results in the collapsing of the growing linear structures at their 'weakest' points (in one line with the laws of economy, balance and comfort) and thus re-organizing itself for better sustainability of the growth according to the access to the nourishment and waste deposit possibilities. Bassingthwaighte, Liebovitch & West (1994) state that self-similarity is produced if the same rule is applied over and over again and that such mechanisms are local because each part of the structure interacts repeatedly with itself but not with other parts of the structure [100]. Following this statement, if a living organism applies the rules of economy, balance and comfort over and over starting from the local levels, there is no other way than to arrive to the more or less fractal organization of the organic matter in the body, mirroring the growing complexity of the organism. The underlying pattern gets its variations from different external stimuli, as at different locations there are different physical forces, different hydrostatic pressure, chemical interactions, growth factors, changes in oxygen supply or electrical fields at play (Bassingthwaighte, Liebovitch & West, 1994). In order to visualize this phenomenon properly, we can take an example of geological processes: carbon layers deposited in the earth were exposed through the ages to different forces, heat or pressure which had an influence on the inner arrangement between the atoms. Thus, the external

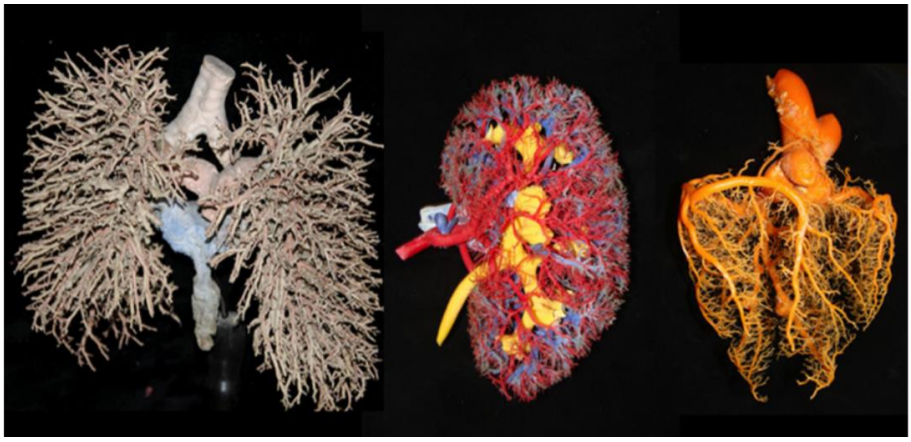

Figure 17. Examples of "tree-like" fractal anatomic systems. From left to right: bronchial tree, renal vascular and urinary systems, and heart coronary system. By kind concession from Prof. Dr. Manfred Tschabitscher (Centre for Anatomy and Cell Biology, Medical University of Vienna, Vienna, Austria).
retrieved from Ieva, A. D., Grizzi, F., Jelinek, H., Pellionisz, A. J., & Losa, G. A. (2013). Fractals in the Neurosciences, Part I: General Principles and Basic Neurosciences. *The Neuroscientist, 20*(4), 403-417. doi:10.1177/1073858413513927; pg. 5

[100] Bassingthwaighte, J. B., Liebovitch, L. S., & West, B. J. (1994). *Fractal physiology*. New York: Oxford University Press.; pg.287

forces carry through the variations in morphology: whether graphite (charcoal) or diamond is created.
In living systems, the outcomes of the interactions between the formed matter and the external forces are described within the evolution theory as emergent behaviours and they finally lead to the various morphology and form of the body tissues.

5.2.2 Origins of intrinsic movement

While studying the basic laws of nature, we encountered numerous phenomena and behaviours inviting us to be pondered over. Each of those is taking place in a different dimension of the hierarchy of the human organism and can be viewed somewhat separately from the context, depending on which *perspective* we use to observe it. We would like to elaborate on different *perspectives,* keeping in mind that they don't exclude each other, rather co-exist in an interdependent relationship. Nevertheless, the pinpointing of the single phenomenon within the hierarchy of the organism can contribute to the accuracy of the therapist's focus and touch.

5.2.2.1 Perspective of substances and bonds

There are four elements essential for the form and function of the human organism: hydrogen (H), oxygen (O), carbon (C) and nitrogen (N). Other elements are present as well, but in much less amount, as for example sulphur (S) as a building block in proteins or various minerals (Ca, Mg, K, Cl, etc.) as co-enzymes for metabolic processes.
All those elements can interact with each other through bonds they are creating and by doing so build up a whole range of substances from the simple (water) to the most complex molecules (proteins, nucleic acids). In organisms, there are several types of bonds: covalent bonds and electrostatic interactions (= ionic bonds) considered as the strong bonds and hydrogen bonds and van der Waals interactions considered as the weak bonds. The fragility of weak bonds has a consequence for the fluid behaviour of substances of living organisms.

5.2.2.1.1 Water

Water (H_2O) is the most common molecule of the human organism; it creates approximately 98-99% of all molecules and 70 – 93% of the weight of most of our organs (Mitchell, Hamilton, Steggerda & Bean, 1945). Water serves as a solvent for most of the substances being transported through the human organism and the majority of the chemical reactions taking place during metabolism involve molecules dissolved in water.

5.2.2.1.1.1 Architecture of water

A molecule of water consists of one oxygen atom and two hydrogen atoms bound with a covalent bond [101]. The oxygen with its 6 electrons in the outer ***valence shell*** strives for stability and is ready to accept and share 2 electrons offered by other atoms; in the case of water from 2 hydrogen atoms. In principle, the electrons in the outer valence shell are organized in 4 pairs. After accepting the 2 electrons from 2 hydrogen atoms, the oxygen possesses 2 non-bonding pairs and 2 bonding pairs, which repel each other due to their negative charge. As a result the molecule spontaneously organizes itself in a somewhat distorted tetrahedral arrangement, where the angle between the 2 hydrogen atoms is 104,5° (figure 18.). Due to such an arrangement, where the non-bonding pairs are more negatively charged, the distribution of the positive and negative charges is not equal even if the molecule as

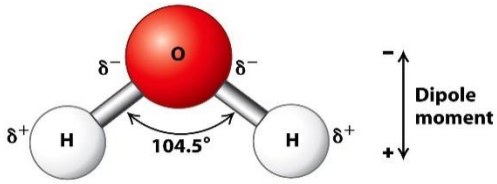

Figure 18. Water molecule
retrieved from Water Structure & Properties: Molecule & Physical Properties: A Level. (2020, March 27). Retrieved September 28, 2020, from https://alevelbiology.co.uk/notes/water-structure-properties/

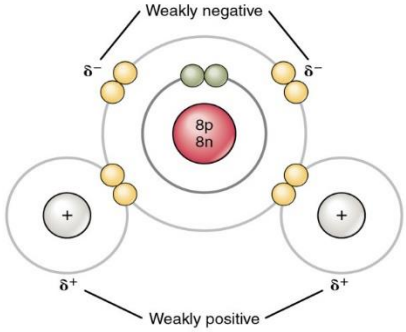

Figure 19. Planetary model of the water molecule
retrieved from OpenStax, L. (n.d.). Anatomy and Physiology I. Retrieved September 28, 2020, from https://courses.lumenlearning.com/ap1/chapter/chemical-bonds/

[101] Covalent bonds between atoms emerge as atoms are always striving for the most stability; that means to have 8 electrons in its outer valence layer, in case of hydrogen 2 electrons. That is reached by sharing the missing electrons with another atoms.

a whole is neutral. Such a property is called polarity.

However, this state of stability is far from static. The act of sharing the electron means that while the electron is spinning around the core of the hydrogen atom, a certain amount of time it spends in the outer valence shell of the oxygen and a certain amount of time out of the oxygen shell (figure 20.). Such a transition happens a couple of times per second. With this oscillatory action, the form of the water molecule changes (figure 21.): when in the shell of oxygen, its negative field expands more and the hydrogen atoms are pushed slightly towards each other. At the same time the positive charge of the hydrogen atom is exposed. While the electron finds itself beyond the valence shell of oxygen, the negative charge of the oxygen pole decreases, the negative charge of the hydrogen atom increases, which leads to their stronger repulsion and a bigger angle between the 2 hydrogen atoms. In general, oxygen being the larger molecule with a larger mass has the shared electron in its outer valence shell more times than beyond.

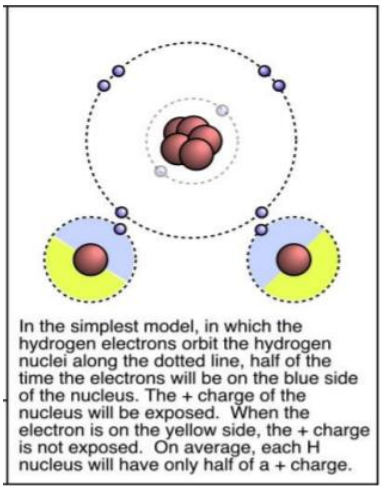

Figure 20. Model of a water molecule
retrieved from Delange, C. (2015). *THE ROLE OF "WATER" IN THE BODY and the Relevance to Osteopathic Treatment* (Unpublished master's thesis). Académie Sutherland d'Ostéopathie du Québec. Retrieved July 19, 2020, from http://www.academiesutherland.com/pdfs/Carla_Delange.pdf; pg.14

From such a model we can deduce that as the plane of oscillation of the shared electron is different every time, the distribution of the charges within the molecule is changing in space and time rhythmically, which leads to a kind of

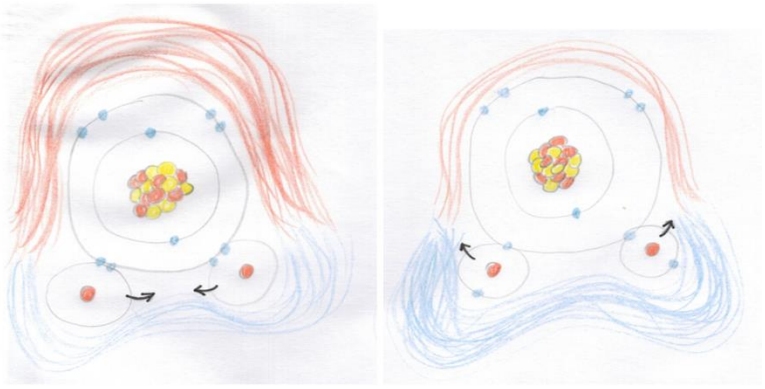

Figure 21. 'Breathing' of a water molecule
author image

breathing behaviour. Besides that, the property of polarity exhibits its own oscillatory behaviour as well.

5.2.2.1.1.2 Dissolving property and polarity of water

The polar behaviour of a water molecule is a result of the uneven distribution of charges within the molecule. Such property enables the other polar (= hydrophilic) substances to interact with the charges of the water molecule, whereas non-polar (= hydrophobic) substances cannot interact. This behaviour is a base for forming the ***bulk water***, the water molecules interact with each other through hydrogen bonds. The same is valid for forming solutions when ionic bonds of other polar molecules are overruled by the weaker but more abundant hydrogen bonds of water. In living organisms it is necessary that biological molecules occur in the form of a solution since nearly all metabolic reactions are dependent on the dissolving properties of water.

5.2.2.1.1.3 Hydrogen bonds

Hydrogen bonding occurs when an atom of hydrogen is attracted by a rather strong force to two (groups of) atoms instead of only one, such that it may be considered to be acting as a bond between them [102]. It can be seen as a positively charged interlink between two relatively negatively charged atoms. In comparison with covalent bonds or ionic bonds, they are considered weak bonds, but their abundance in bulk water is able to overrule ionic bonds in salt solutions for example. In comparison to other strong bonds, they stretch over a longer distance. Hydrogen bonds in bulk water are spatially organized in tetrahedral form and very dynamic, maximum lifetime is up to a second.

Hydrogen bonds are essential for the architecture of proteins and DNA, where they especially serve as an attraction force for maintaining specific spatial organization.

[102] Chaplin, M. (n.d.). Water Structure and Science. Retrieved August 01, 2020, from http://www1.lsbu.ac.uk/water/water_structure_science.html

5.2.2.1.2 Organic molecules

Living organisms consist of organic molecules, complex structures built up primarily from hydrogen (H), oxygen (O), carbon (C) and nitrogen (N). The backbone of those molecules is based on carbon, which is able to provide 4 covalent bonds and thus an opportunity for a big variety. According to their properties, organic molecules can be classified into several groups: carbohydrates, proteins, lipids and nucleic acids. In the frame of this thesis, we will not be going into the general knowledge about their structure and importance for human physiology; rather we point out specific properties of some of them in connection to the topic of extra-cellular matrix architecture, further elaborated in chapter 5.2.2.2.

5.2.2.1.2.1 Carbohydrates

Carbohydrate molecules consist of carbon, hydrogen and oxygen atoms. They are strongly hydrophilic due to the many polar hydroxyl groups (-OH), which bind to the water molecules through the hydrogen bond. Carbohydrates create only about 3% of the body weight, they appear in the form of glycosaminoglycans (GAG's) or glycoproteins in the ECM or as a part of the glycocalyx of the cells.
GAG's are one of the components of proteoglycans that are linked to hyaluronic acid chains in ECM (figure 22.). They are able to bind a big amount of water molecules, which is essential for the transport of the nourishment and waste substances in the ECM, as well as for the coherence of collagen fibres, elastin fibres and the cells in ECM. At the same time, the amount of water bound in GAG's gives the connective tissue a certain volume. Due to the chemical variety of the GAG's, the ECM exhibits different water-binding properties and thus different ***viscosity*** and ***permeability***.

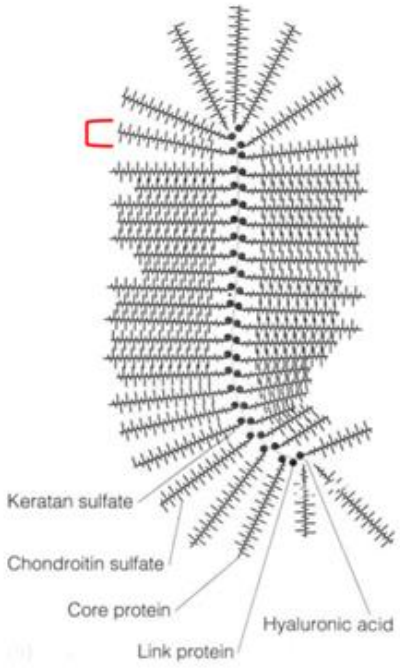

Figure 22. Proteoglycan structure
retrieved from Vaňhara, P. (2014). Connective tissue, not only a tissue glue…. Retrieved October 03, 2020, from https://is.muni.cz/el/med/jaro2014/VSHE0221p/um/Connective_tissue_I_ENG_2014.pdf

Glycoproteins consist of globular protein with branched carbohydrates chains. They serve as a sort of glue in cell-cell, cell-fibre or cell-ECM connection, therefore essential for the mechanotransduction. This aspect will be discussed in more depth in chapter 5.2.2.2.1.1.

5.2.2.1.2.2 Proteins

Protein molecules are chains of amino acids organized in complex spatial structures, which are essential for their functionality as well. They exhibit hydrophilic properties. Proteins create approximately 15-20% of the body weight, in the form of building material in the cells (cytoskeleton elements), in connective tissue (fibres), as well as in the form of enzymes, immunoglobulins, receptors in cell membranes or transport substances in the blood.

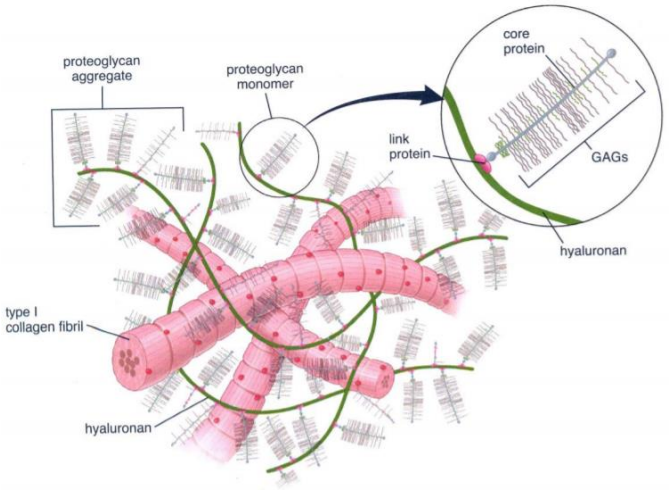

Figure 23. Composition of amorphous ground matrix
retrieved from Vaňhara, P. (2014). Connective tissue, not only a tissue glue…. retrieved October 03, 2020, from https://is.muni.cz/el/med/jaro2014/VSHE0221p/um/Connective_tissue_I_ENG_2014.pdf

The architecture of the cytoskeleton elements as actin and myosin filaments, microtubules and intermediate filaments and the ECM fibres as collagen, elastin, etc. is an essential network for the transmission of forces with their velocity and direction. This aspect will also be discussed in more depth in chapter 5.2.2.2.1.1.

5.2.2.2 Perspective of structures

In this chapter we outline the architecture of the ECM and cytoskeleton, their continuity, as well as the properties of this network and behaviour of liquids inside. We describe the embedding character of the ECM for the cells of mesenchymal as well as the ***limiting tissues*** (entoderm) and the importance of its mechanical continuity for the movement and force transfer across the tissues of the body.

We avoid the complete description of the physiological functioning of ECM, we rather point out the continuity and context with its surroundings, keeping in mind the topic of intrinsic movement.
It is probably necessary to say that in this chapter, more than concentrating directly on the issue of the movement or flow itself, we rather observe the way the structures are built up. The specific structure architecture, the used materials and their properties enable them to manifest the flow or forces (thus movement) which are projected on them in the present as well as they were in the past.

Within this chapter, several dimensions of the hierarchy are included: a dimension of cellular organelles and their metabolic products (clusters of organic molecules with own emergent behaviour), a dimension of cells delimited by the membrane (clusters of cellular organelles separated from the matrix environment), a dimension of tissues (clusters of cells in the ECM with its own emergent behaviour). Nevertheless, the architecture of the extra-cellular matrix in continuity with the cytoskeleton, as described below, is utilized by processes of higher dimensions of the hierarchy as well. That means that the network accepts different stimuli on autocrine, paracrine, endocrine and neurocrine levels. In the frame of this chapter, by the term *intrinsic* we refer to the processes up to the level of tissues respecting their own autonomous stability regulation. Communication on autocrine, paracrine and partly endocrine levels are processes taking place on the tissue level, whilst the ECM works as a kind of filter for the coming stimuli. The filter limits variable or unpredictable environmental stimuli thereby reducing the demands on tissue and cellular processes; by limiting the signals to the cell, it provides a sort of 'memory bank' of possible instructions [103]. Brand (1992) developed a hypothesis of autonomous informational stability around this phenomenon.
Neurocrine and partly endocrine communication surely utilize the whole architecture through influencing the contractility of the actin fibres, which leads to a movement as well (e.g. contraction of skeletal muscles, contraction of smooth muscles in peristalses or gland ejection sometimes referred to as motricity) together with the force re-distribution across the hierarchy within this tensegral system and all its consequences. Nevertheless, in the frame of this chapter we consider that the extrinsic

[103] Brand, R. A. (1992). Autonomous informational stability in connective tissues. *Medical Hypotheses, 37*(2), 107-114. doi:10.1016/0306-9877(92)90050-m; pg.111

movement, as the stimuli come from behaviour, in the hierarchical frame, beyond the tissue structures.

5.2.2.2.1 Architecture of the extra-cellular matrix and its continuity

The extra-cellular matrix (ECM) can be seen as a negative outcast of the body tissues after we removed all the cells. It is a surprisingly extended area in the mechanical continuum from top to toe; it is the only organ that has direct contact with all of the parts of the body [104] and where the information transfer is very fast across long distances. The ECM is the place for an exchange of the nutrients and waste products between cells, capillaries and lymph vessels, it contains nerve endings, embeds the cells of all the limiting tissues, contains the immune cells and as such contains a large number of hormones and other signalling chemicals (Lee, 2008).

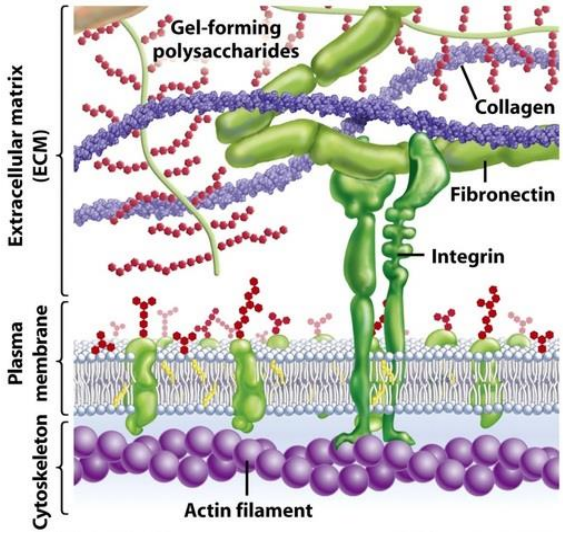

Figure 24. The extra-cellular matrix
rretrieved September 04, 2020, from http://apbiocellorganelles.weebly.com/ecm.html

From the evolutionary point of view, the ECM developed as the integrator of the cells into tissues [105] and is thus exhibiting emergent behaviours on that new dimension. New cell specializations occur within the ECM, which are only relevant in the context of tissue, as for example organization of the ECM into a ***basal membrane***, the orientation of the cells within the tissues, etc. (Ettinger & Doljanski, 1992).

[104] Oschman, J. L. (2009). Charge transfer in the living matrix. *Journal of Bodywork and Movement Therapies, 13*(3), 215-228. doi:10.1016/j.jbmt.2008.06.005; pg.217

[105] Ettinger, L., & Doljanski, F. (1992). On The Generation Of Form By The Continuous Interactions Between Cells And Their Extracellular Matrix. *Biological Reviews, 67*(4), 459-489. doi:10.1111/j.1469-185x.1992.tb01190.x; pg.464

5.2.2.2.1.1 Organization of the ECM network

The ECM consists of three basic components: fibres (collagen, elastin, fibronectin, reticulin, etc.), ground substance (proteoglycans, glycoproteins) and water and its form can be described as a three-dimensional spider web or a scaffold. The ECM is a product of the fibroblasts, connective tissue cells, which are producing the fibres and ground substance as a part of their metabolism. The ECM holds a mechanical continuity with the cytoskeleton of cells deposited in the ECM through membrane proteins integrins. The ECM shows its own tensegrity with reticulin and elastin fibres as tensional elements and ground substance and non-distensible collagen as compression-resistance element [106].

The cytoskeleton is a three-dimensional network formed by the interweaving of filaments (actin, intermediate filaments) and tubular proteins (microtubules). They are all protein structures deposited in the cytoplasm of the cells: flexible actin fibres occur mainly under the surface of the cell membrane, intermediate filaments create structures from the central line of the cells towards the cell-cell or cell-ECM junctions and microtubules form stable structures from the centriole next to the cell nucleus towards the periphery of the

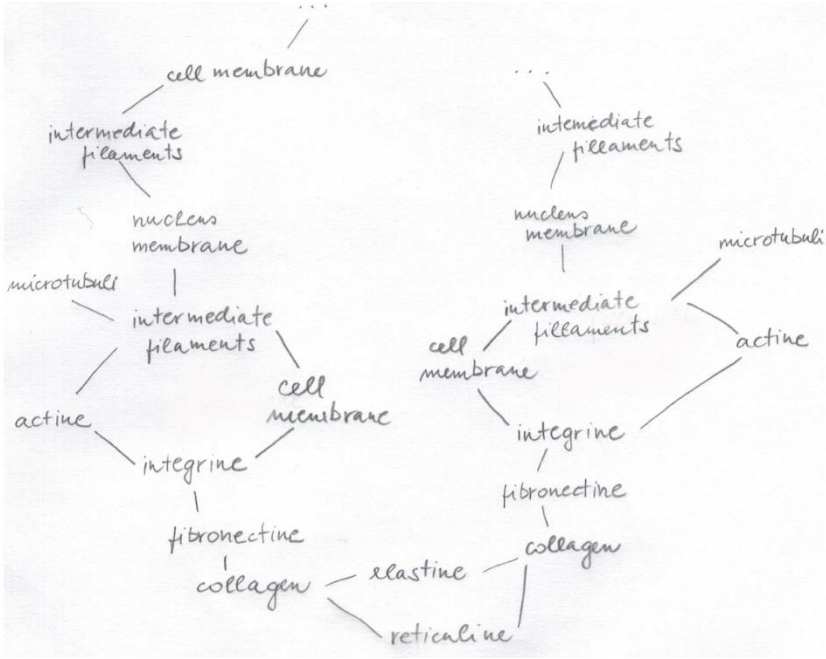

Figure 25. Cell – ECM continuity
author image

[106] Tadeo, I., Berbegall, A. P., Escudero, L. M., Noguera, R., & Alvaro, T. (2014). Biotensegrity of the Extracellular Matrix: Physiology, Dynamic Mechanical Balance, and Implications in Oncology and Mechanotherapy. *Frontiers in Oncology, 4*. doi:10.3389/fonc.2014.00039; pg.2

cell. Cells exhibit their own tensegrity organisation with actin as a tensional element, microtubules as compression elements and intermediate filaments as mediators between those two components (Pflüger, 2008). At the same time, intermediate filaments connect actin filaments and microtubules with the nucleus and cell membrane.

From such a description of continuity (figure 25.), we can turn the perspective around: rather than considering the cells as basic units of tissues, one could instead highlight the importance of *the underlying fibrous network* as a basic tissue material, where the lipid cell membranes serve only as 'subdividers' of this continuous environment in order to organize the work-to-be-done against the entropy into smaller, more effective units. James L. Oschman (2009) names this *the living matrix* and defines it as the continuous molecular fabric of the organism, consisting of fascia, the other connective tissues, extracellular matrices, integrins, cytoskeletons, nuclear matrices and DNA [107]. Zooming in to this level of magnitude, we can consider the continuity of the cytoskeletal structures and ECM structures as a tensegrity organization itself, where cytoskeletal structures serve as the

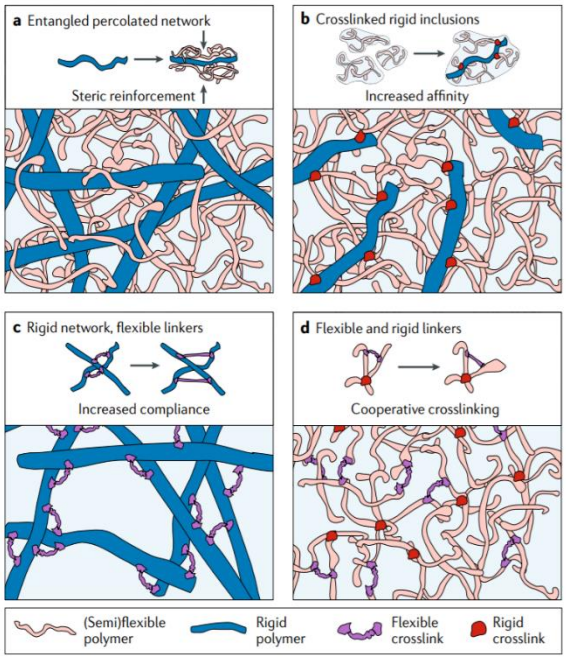

Figure 26. Mechanical synergy in multicomponent biopolymer networks
Composite networks offer additional degrees of freedom in mechanical function. Even simple combinations of rigid and flexible polymers and crosslinks produce diverse mechanical behaviours. a) In the absence of crosslinks, a dense background of flexible polymers can increase the rigidity of a second component by steric reinforcement. b) In composite networks, synergistic effects can occur even when one of the networks is not fully percolated. Here, rigid inclusions act as crosslinkers, which can make deformations of a second component more affine (uniform). c) Flexible crosslinkers can act as shock absorbers by increasing the compliance of a rigid network. d) Multiple crosslinkers with different rigidities can cooperate to fine-tune the mechanical response of a network. Panel c is adapted with permission from Ref. 197, APS. Panel d is adapted from Ref. 198, CC-BY-4.0. retrieved from Burla, F., Mulla, Y., Vos, B. E., Aufderhorst-Roberts, A., & Koenderink, G. H. (2019). From mechanical resilience to active material properties in biopolymer networks. Nature Reviews Physics, 1(4), 249-263. doi:10.1038/s42254-019-0036-4; pg. 10

[107] Oschman, J. L. (2009). Charge transfer in the living matrix. *Journal of Bodywork and Movement Therapies, 13*(3), 215-228. doi:10.1016/j.jbmt.2008.06.005; pg.215

tensional elements (which is reflected in the high adaptability of the cell shape) and the ECM structures as the compression elements due to the properties of the highly represented collagen fibres and ground substance (Tadeo, Berbegall, Escudero, Noguera, & Alvaro, 2014).
This tensegral *living matrix* is described by various researchers (Chen & Ingber; Stamenovic; Bissell, Hall & Parry; Bissell & Barcellos-Hoff; etc.) as a regulatory system of all cell functions, being responsible for changes in gene expression and protein production, signal transduction, cell growth, differentiation, proliferation, apoptosis as well as alterations in cell shape and movement. Based on those findings, the research of the principles of tensegrity in those areas explains how the cytoskeleton transfers mechanical signals into biochemical answers; this procedure is called mechanotransduction [108]. In such a network the mechanical stimulus can travel over long distances, ensuring an immediate answer of cells not only locally. At the same time, chemical reactions proceed much quicker and well-regulated if they take place in a structured framework (Oschman, 2006, as cited in Pflüger, 2008).

5.2.2.2.1.2 Specific structural properties of the ECM network

• Organization in microvacuoles

According to Bordoni, Marelli, Morabito & Sacconi (2017) ECM is not organized in fascial layers, but rather as sliding inseparable units of polyhedral shape (microvacuoles), which are containing liquids and depositing the cells (connective tissue cells as well as lining cells) inside them (figure 27.). At the same time, the surgeon Jean-Claude Guimberteau (as reviewed in Pflüger, 2008) states in his work that these structures, being mainly polygons, can be converged towards icosahedra or other geometric shapes despite their chaotic distribution. As specific fibers slide against each other, microvacuoles are constantly changing shape and position, which triggers the neighboring microvacuoles to adjust their shape as well (Guimberteau, Delage, Mcgrouther & Wong, 2010).
On one hand, such a three-dimensional interwoven network creates all the structure of connective tissues, as bones, muscles, tendons, blood vessels and lymph vessels. The form of those tissues is taking over the shape of the form of its ECM structure. At the

[108] Pflüger, C. (2008). *The Meaning of Tensegrity Principles for Osteopathic Medicine* (Unpublished master's thesis). Donau University Krems. Retrieved July 19, 2020, from http://www.osteopathic-research.com/paper_pdf/Pflueger.pdf; pg.34

same time, in the neighborhood of ***lining tissues*** the specialized interwoven network of the ECM (called basal membrane) is creating an embedding structure for the ***epithelial cells*** of the lining tissues which is determining the tissue and organ architecture [109]. In their review, Ettinger & Doljanski (1992) state that without a present moldable three-dimensional organization of the ECM, the epithelial cells of limiting tissues (as in mammary or other glands) don't fully differentiate, nor develop into tissue with its specific architecture. In certain sense, such a close-knit relationship of epithelial cells and the ECM embedding architecture reflects the earlier mentioned concept of perceiving *the living matrix* across the cell and the ECM as a continuous tissue material, thus one unity. Keeping this unity in mind, together with the tensegrity principals, the osteopathic community might want to reconsider the statement that osteopathic treatment is dealing with connective tissue only.

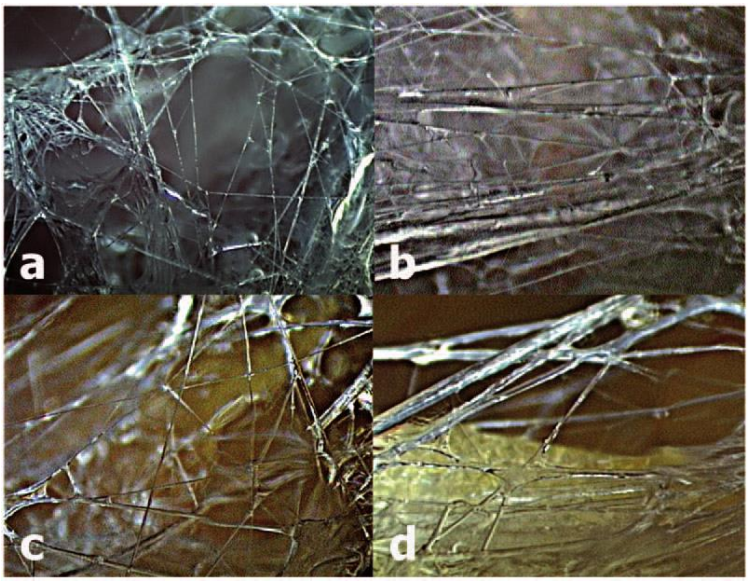

Figure 27. Evidence of microvacuolar systems at other body sites.
(a) Scalp. (b) Neck. (c) Scapula. (d) Between rectus abdominus muscle and subcutaneous fat.
retrieved from Guimberteau, J. C., Delage, J. P., Mcgrouther, D. A., & Wong, J. K. (2010). The microvacuolar system: How connective tissue sliding works. *Journal of Hand Surgery (European Volume), 35*(8), 614-622. doi:10.1177/1753193410374412

• Self-similarity

The ECM exhibits the self-similar organization across several magnitudes, thus is able to re-distribute forces through those magnitudes (Oschman, 2006 as cited in Pflüger, 2008; Bordoni, Marelli, Morabito & Sacconi, 2017). Such a view is

[109] Ettinger, L., & Doljanski, F. (1992). On The Generation Of Form By The Continuous Interactions Between Cells And Their Extracellular Matrix. *Biological Reviews, 67*(4), 459-489. doi:10.1111/j.1469-185x.1992.tb01190.x; pg.471

supported by the findings of earlier mentioned Jean-Claude Guimberteau and his statement that the microvacuoles can be converted to icosahedra. As 12 icosahedra can form a single larger icosahedron, we can anchor the idea of a fractal organization of the ECM to the fractal organization of icosahedra. This kind of organization creates a functional interdependence across the body hierarchy, and so for example between functions of gross anatomic structures and to the metabolic activity of the cells.

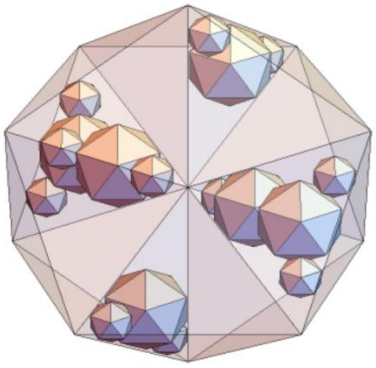

Figure 28. Icosahedron fractal
retrieved from Kabai, S. (2007, April 27). Wolfram Demonstrations Project. Retrieved September 08, 2020, from https://demonstrations.wolfram.com/IcosahedronFractal/

• Anisotropy and disorder

The fibers of the ECM exhibit anisotropy in their properties, a condition where a measured property is different in different directions [110]. Thus, the neighbouring fibrils may react differently to an identical stimulus. Taking into consideration the earlier mentioned organization in microvacuoles and the properties of self-similarity and tensegrity, such an interwoven network of fibers is seen as an instantly highly adaptable, perfect functional chaos, where it is not possible to determine the motion vectors of the different fibrils, which differ in behaviour and orientation [111].

• Direction of fiber's growth

Collagen, elastin and other structural proteins display polarity within its molecular structure: one periphery of the tubular structure is negative, the opposite is relatively positive. Molecules of collagen line up so that the positive charges lie in the direction of the organism's growth, development, and forces for healing [112]. According to the study of Harnagea & al. (2010), the collagen fibrils in muscular fascia display an

[110] Bordoni, B., Marelli, F., Morabito, B., & Sacconi, B. (2017). The indeterminable resilience of the fascial system. *Journal of Integrative Medicine, 15*(5), 337-343. doi:10.1016/s2095-4964(17)60351-0; pg.339

[111] Bordoni, B., Marelli, F., Morabito, B., & Sacconi, B. (2017). The indeterminable resilience of the fascial system. *Journal of Integrative Medicine, 15*(5), 337-343. doi:10.1016/s2095-4964(17)60351-0; pg.337

[112] Lee, R. P. (2008). The Living Matrix: A Model for the Primary Respiratory Mechanism. *Explore, 4*(6), 374-378. doi:10.1016/j.explore.2008.08.003; pg.375

organization in domains, with groups of fibers with the same polar orientation and others in the opposite one [113].

5.2.2.2.1.3 Other properties of the ECM network

• Piezoelectricity

According to the research of A. Pischinger (as cited in Lee, 2008), the matrix is piezoelectric, integrating electrical and mechanical functioning. R. Paul Lee summarizes the results of Pischinger's research:

> Applying an electric stimulus to the matrix causes mechanical motion (vibration) and applying physical force (stretch, compression, or torsion) generates electricity. The matrix is a semiconductor, that is, electrons are equally shared by all the structural proteins and other charged elements in this complex meshwork. Energy fluctuations spread rapidly through the matrix through changes in liquid crystalline water. The energy transmissions are used by the cells as information. [114]

The study of Grodzinsky (1983) added explicitly that this electric potential can possibly account for a modulating mechanism of cells behaviour along common biochemical and mechanical pathways [115].

• Viscoelasticity

The viscoelastic property [of the ECM] relies on the interdependence between the architecture and composition of the connective tissue and water content [116]. Viscous materials resist deformation (strain) when a mechanical load is applied. Elastic materials are load-dependent, but not time-dependent, and return to resting length

[113] Tozzi, P. (2015). A unifying neuro-fasciagenic model of somatic dysfunction – Underlying mechanisms and treatment – Part I. *Journal of Bodywork and Movement Therapies, 19*(2), 310-326. doi:10.1016/j.jbmt.2015.01.001; pg.318

[114] Lee, R. P. (2008). The Living Matrix: A Model for the Primary Respiratory Mechanism. *Explore, 4*(6), 374-378. doi:10.1016/j.explore.2008.08.003; pg.375

[115] Tozzi, P. (2015). A unifying neuro-fasciagenic model of somatic dysfunction – Underlying mechanisms and treatment – Part I. *Journal of Bodywork and Movement Therapies, 19*(2), 310-326. doi:10.1016/j.jbmt.2015.01.001; pg. 318

[116] Woo & al., 1997; Guilak, 2000 as cited in Tozzi, P. (2015). A unifying neuro-fasciagenic model of somatic dysfunction – Underlying mechanisms and treatment – Part I. *Journal of Bodywork and Movement Therapies, 19*(2), 310-326. doi:10.1016/j.jbmt.2015.01.001; pg.315

when the mechanical load is removed. Generally, the stronger and more rapidly that a load is applied to organic materials, the more rigidly will the tissue respond, up to the point when the elastic potential of tissues is exceeded and a plastic deformation occurs [117]. Thanks to the ECM composition including both types of materials, the mechanical load / deformation will lead to a different response of the tissues depending on the amount as well as endurance of the load. The quality of the response depends on the cross-links (as depicted in figure 26.) in between the collagen molecular packing [118].

• Thixotropy

The term thixotropy was first suggested by H. Freundlich when his colleague noticed that cell protoplasm becomes more liquid if shaken for a period of time. Originally, it described the transition between the ***sol-gel phase*** when induced artificially. Nevertheless, the phenomenon of thixotropy was already known at that time as a naturally occurring phenomenon as well. The precise changes in the microstructure of the thixotropic liquids underlying this phenomenon are still unclear, but generally we can imagine, that while applying mechanical stress (flow, shearing, shaking), specific very weak bonds between the particles are broken and consequently the liquid appears more fluid. With the period of time in rest, the weak bonds are recuperated and the liquid assumes its original thickness.

The phenomenon of thixotropy applies to some liquids in the human body: among others cytoplasm and ground substance of the ECM. This is an important discovery, if we consider that both in the intracellular and extracellular environments the shearing forces are evoked by any contractile action (actin-myosin interaction under the cell membrane, elastin recoil in ECM, etc.). Any such a mechanism generating sufficient shearing forces would independently cause a sol-gel transition [119]. Carla Delange (2015) summarizes the research of Kerst & al. on this topic in a way, that directly addresses the issue of the intrinsic movement:

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[117] Jäger, 2005 as cited in Tozzi, P. (2015). A unifying neuro-fasciagenic model of somatic dysfunction – Underlying mechanisms and treatment – Part II. *Journal of Bodywork and Movement Therapies, 19*(3), 526-543. doi:10.1016/j.jbmt.2015.03.002, pg.5

[118] Puxkandl, 2002 as cited in Tozzi, P. (2015). A unifying neuro-fasciagenic model of somatic dysfunction – Underlying mechanisms and treatment – Part I. *Journal of Bodywork and Movement Therapies, 19*(2), 310-326. doi:10.1016/j.jbmt.2015.01.001; pg.315

[119] Kerst, A., Chmielewski, C., Livesay, C., Buxbaum, R. E., & Heidemann, S. R. (1990). Liquid crystal domains and thixotropy of filamentous actin suspensions. *Proceedings of the National Academy of Sciences, 87*(11), 4241-4245. doi:10.1073/pnas.87.11.4241; pg.4245

> Cytoplasm and suspensions of actin exhibit complex fluid behaviours that likely play a role in cytoplasmic streaming, movement of vesicles through the cytoplasm and bulk flow. The cytoplasm and actin solutions are shear thinning, which show a constant shear stress for flow rates. They interpret their findings to explain that high flow rates do not necessarily require large forces and a small difference in the concentrations of filaments can account for flowing or nonflowing cytoplasm. [120]

5.2.2.2.2 Capturing water

In the ECM, we can find up to 20 litres of water with solutes and 99% of the water molecules are bound to strongly hydrophilic GAG's through hydrogen bonds, which ensures the volume of the tissues and a sort of cushion-like protection for the cells. That bondage, however, is far from static, since a lifetime of a hydrogen bond is up to one second and the molecules of water behave according to the principles of diffusion, osmosis and other forces. The speed of their movement in the ECM is measured from 0,1-4 μm/s; for comparison in capillaries it is around 50 000 μm/s (Mayer-Fally & Knox, 2019). Such a speed is ideal for an exchange of solutes within a condition, where the volume of the tissues has to be stable. Water enters the ECM by hydrostatic pressure from capillaries, can enter and exit the cells through aquaporins and leaves to capillaries under the osmotic pressure or through lymph vessels (Bhave & Neilson, 2011).

Besides the GAG's, proteins in the ECM bind water molecules as well, in a quite specific manner. In the proximity of protein structures, water tends to behave as a crystalline liquid (Tozzi, 2014). This state of water organization has different structural properties than bulk water, forming highly ordered, chain-like filaments that hold the proteins together via hydrophilic interactions of the hydrogen bonds [121]. Sasaki (1984) stated that such a hydrogen-bonded network creates a pathway for fast conduction of protons, that can serve as a channel of communication and energy flow

[120] Delange, C. (2015). *THE ROLE OF "WATER" IN THE BODY and the Relevance to Osteopathic Treatment* (Unpublished master's thesis). Académie Sutherland d'Ostéopathie du Québec. Retrieved July 19, 2020, from http://www.academiesutherland.com/pdfs/Carla_Delange.pdf; pg.78

[121] Leikin & al., 1993 as cited in Tozzi, P. (2014). Does fascia hold memories? *Journal of Bodywork and Movement Therapies, 18*(2), 259-265. doi:10.1016/j.jbmt.2013.11.010; pg.263

[122] which in principle is much quicker than neural conduction. Those findings bring the confirmation of, at that time, controversial conclusions of Albert Szent-Györgyi, who thoroughly studied the electrical properties of the ECM as well. He stated:

> Molecules do not have to touch each other to interact. Energy can flow through the electromagnetic field… The electromagnetic field, along with water, forms the matrix of life. Water can form structures that transmit energy. [123]

In summary, while electrons flow through the protein backbone (electricity), protons flow through the water layer and various degrees of coupling between electron and proton flows are possible [124]. Every process following a mechanical or metabolic force occurring anywhere in the organism produces a characteristic pattern of vibrations that travel widely, distributing regulatory information [125]. In a certain sense, we can consider the flow of electrons and protons as an expression of tissues through movement, however a complete overview of the mechanisms is beyond the scope of this thesis.

Nevertheless, the research of electromagnetic properties of the body tissues and its application on therapy in case of injuries, chronic pain, inflammations, etc., is a rapidly growing field and goes very far in their implication. According to Oschman (2009), the charge transfer is used in therapy by athletes with acute injuries and till now has promising results.

At the same time, part of contemporary osteopathic literature sees this phenomenon as a possible model for information transfer between the osteopath and the patient (Anstey, 2009). We would suggest remaining this somewhere in the middle, as we believe that mechanical, chemical and electromagnetic factors (and any other factors still to be found) use different pathways of expression, but still work in synchronicity

[122] Oschman, J. L. (2009). Charge transfer in the living matrix. *Journal of Bodywork and Movement Therapies, 13*(3), 215-228. doi:10.1016/j.jbmt.2008.06.005; pg.221

[123] A. Szent-Györgyi (1988) as cited in Oschman, J. L. (2009). Charge transfer in the living matrix. *Journal of Bodywork and Movement Therapies, 13*(3), 215-228. doi:10.1016/j.jbmt.2008.06.005; pg.221

[124] Oschman, J. L. (2009). Charge transfer in the living matrix. *Journal of Bodywork and Movement Therapies, 13*(3), 215-228. doi:10.1016/j.jbmt.2008.06.005; pg.221

[125] Oschman (2009), as cited in Tozzi, P. (2014). Does fascia hold memories? *Journal of Bodywork and Movement Therapies, 18*(2), 259-265. doi:10.1016/j.jbmt.2013.11.010; pg.262

for the well-being of *one* entity, the living organism. Quite in parallel to what the embryologist B. Freeman stated:

> Blechschmidt himself commented many times that one approach to human development can never deny another, and that both mechanical and chemical approaches must end up being consistent because it is always the one living entity at the core of the investigation... The best results in an … investigation will be achieved if the living state is unaltered by the investigation. When this happens, the two approaches (biochemical and biomechanical) will merge… Perhaps by then there will be other approaches too, such as bio-electromagnetic. [126]

5.2.2.2.2.1 Interstitial flow and shear forces

The behaviour of water in the ECM, as described at the beginning of chapter 5.2.2.2.2, establishes a certain interstitial flow. Thus, the interstitial flow can be defined as fluid flow through a three-dimensional matrix, around interstitial cells such as fibroblasts, tissue immune cells and adipocytes… which generally flows with a much slower velocity [than a vascular flow] because of the high flow resistance of the extracellular matrix and which moves around the cell-matrix interface in all directions [127]. Interstitial fluid flow plays a significant role in the mass transport: it is needed to drive protein transport from the blood to interstitial cells because proteins are too large to readily diffuse the distances between blood capillaries (as distances optimized for the transport of oxygen and other small molecules to cells) [128]. Besides that, through applying shear forces, interstitial fluid flow also provides a specific mechanical environment that is important for the physiological activities of interstitial cells [129] as an ability of cells to proliferate, differentiate, to form functional structures,

[126] Lewis, J. (2010). Brian Freeman speaks to John Lewis. Retrieved August 03, 2020, from http://www.drawingonanatomy.com.au/newsD/32NewsletterAutumn10.pdf; pg.6

[127] Rutkowski, J. M., & Swartz, M. A. (2007). A driving force for change: Interstitial flow as a morphoregulator. *Trends in Cell Biology, 17*(1), 44-50. doi:10.1016/j.tcb.2006.11.007; pg. 44

[128] Rutkowski, J. M., & Swartz, M. A. (2007). A driving force for change: Interstitial flow as a morphoregulator. *Trends in Cell Biology, 17*(1), 44-50. doi:10.1016/j.tcb.2006.11.007; pg. 44

[129] Yao, W., Li, Y., & Ding, G. (2012). Interstitial Fluid Flow: The Mechanical Environment of Cells and Foundation of Meridians. *Evidence-Based Complementary and Alternative Medicine, 2012*, 1-9. doi:10.1155/2012/853516; pg. 1

and release chemical mediators [130]. Such shear forces have an effect of mechanical stress directly on the cell membrane or on the glycocalyx of the cell membrane which is further connected to the contractile elements of the cytoskeleton. At the same time, shear forces affect the distribution and further spreading of pericellular proteins (autocrine and paracrine signals) bound to the cell receptors (Rutkowski & Swartz, 2007). By such effects, the cells / tissues are driven to certain mechanical and chemical responses, which in short term ensures ***homeostasis*** on the level of tissues and in long term plays role in tissue morphogenesis, function and remodeling [131].
The study of Yao, Li, & Ding (2012) further describes the supporting factors of the interstitial flow: according to their research, the interstitial flow takes place preferably parallel to capillaries, using their directional stream force as a stimulus for own flow in the adjacent ***interstitium***. Since the capillaries are sometimes further apart from the lymphatic vessels, the unabsorbed fluid can travel relatively long distances.
Rutkowski & Swartz (2007) add some other supporting factors for the interstitial fluid flow as skeletal motion as well as more subtle motions such as arterial pulsation, breathing and organ movement.
In the study of Mercola (2003) the mechanisms of interstitial fluid flow are also described to play an important role in embryogenesis, which we elaborate on further in chapter 5.2.2.4.3.

5.2.2.2.3 Several considerations concerning the intrinsic movement

• We can consider the constant polymerization on one side and depolymerization on the other side of the microtubules, collagen and other organelles as a process with a certain directionality as the flux of material substances occur towards the side of polymerization.

• Concerning our objective of the movement, it is interesting to consider that on a structural level the form of a tensegrity helix already suggests a natural continuation and flow on multiple levels of the body hierarchy. The helical structures in and

[130] Yao, W., Li, Y., & Ding, G. (2012). Interstitial Fluid Flow: The Mechanical Environment of Cells and Foundation of Meridians. *Evidence-Based Complementary and Alternative Medicine, 2012*, 1-9. doi:10.1155/2012/853516; pg. 7

[131] Rutkowski, J. M., & Swartz, M. A. (2007). A driving force for change: Interstitial flow as a morphoregulator. *Trends in Cell Biology, 17*(1), 44-50. doi:10.1016/j.tcb.2006.11.007; pg. 44

outside of the cells (cytoskeleton fibres, collagen fibres, etc.) can serve as highways for the movement of the liquid substances across space. The network of such helical structures is highly interwoven with a seemingly illogical, chaotic arrangement. However as mentioned before, surgeon Jean-Claude Guimberteau (as reviewed in Pflüger, 2008) observes the structural and functional similarity with icosahedra or other geometric shapes despite their chaotic distribution. With its geometry, the icosahedron allows the filling of space under the most effective conditions and thus the distribution of the liquids in such a frame would display certain organization. Since water-based liquids are incompressible according to the law of Pascal, the movement of their volume in a certain directionality can be considered as a palpable phenomenon.

• According to several studies (Schleip & al., 2005; Hinz and Gabianni, 2003) fascia shows certain contractile capabilities, which is assigned to the properties of myofibroblasts (connective tissue cells mostly derived from fibroblasts, which are modified under mechanical tensions and the influence of specific cytokines [132]). Myofibroblasts are capable of producing long-lasting isometric contractions that are transmitted to the matrix and linked to the stress fibres. The matrix as an embedding tissue for the muscle cells transfers these forces on the cytoskeleton of these cells, causing a change in a muscle tone in rest and general musculoskeletal dynamics (Tozzi, 2015a). Contractility of the fascia, as a dynamic phenomenon, causes shear forces in the interstitium, which contributes to the local homeostasis (as described in chapter 5.2.2.2.2.1). On the contrary, if the fascia loses its dynamicity and finds itself in a state of permanent contraction, the shear forces are less present, thus the interstitial flow is hindered, which affects the nutrient flow from the capillaries to the cells as well as the homeostasis of the interstitial space.

• Passive or active application of shear forces, including oscillation, vibration or shaking, can have a positive effect on the state and function of the ECM as a dynamic mediator between bloodstream and cells, and thus can have a positive effect on functions of tissues and organs. That can be considered as an ‘automatic benefit’ of osteopathic palpation applicable to any tissue of the body. Tozzi (2015b) recommends the use of vibratory and oscillatory techniques, besides the constant

[132] Desmouliére & al., 2005 as cited in Tozzi, P. (2015). A unifying neuro-fasciagenic model of somatic dysfunction – Underlying mechanisms and treatment – Part I. *Journal of Bodywork and Movement Therapies, 19*(2), 310-326. doi:10.1016/j.jbmt.2015.01.001; pg. 315

sliding techniques, in situations when the interstitial fluid dynamics need to be improved such as in the case of fibrotic tissue.

We discuss the possible consequences of these considerations in chapter 6.

5.2.2.3 Perspective of transformative behaviour

We dedicate this chapter to the description of two phenomena, which could be considered as manifestations of dynamic forces in the body: phenomena of gelation and solation of the ECM and circulation of *one* fluid (being transmuted multiple times during its journey through the body). Both phenomena are interdependent, have a reciprocal relationship to a certain extent, because in the end there is one coherent dynamic force in the body, being modulated by different material environments, different opposing friction forces in different tissues or parts of the body.

5.2.2.3.1 Sol-gel transformation

The specific architecture of the ECM with its properties, as described in chapter 5.2.2.2.1, is a stage sight for the phenomenon of sol-gel phase transformation, a change in viscosity. Changes in viscosity appear as variations in the swelling of the hyaluronan [133] and other glycosaminoglycans of the matrix or as variations in the polymerization of the matrix macromolecules [134]. The sol-gel phase transformation is linked with the ***flexion-extension phase*** of the primary respiratory mechanism. Osteopath Jennie Anstey (2009) made an accurate summarization in her thesis:

> The flexion phase of the primary respiratory mechanism is the sol phase. The cerebrospinal fluid accumulates in the ventricles, aspirates peripheral fluids, increasing the electrolytes in the ECM.… The extension phase of the primary respiratory mechanism is the gel phase. The cerebrospinal fluid moves more

[133] Marlowe RL, Hoppe A, Rupprecht A & al. (1999) as cited in Lee, R. P. (2008). The Living Matrix: A Model for the Primary Respiratory Mechanism. *Explore, 4*(6), 374-378. doi:10.1016/j.explore.2008.08.003; pg.375

[134] Lee, R. P. (2008). The Living Matrix: A Model for the Primary Respiratory Mechanism. *Explore, 4*(6), 374-378. doi:10.1016/j.explore.2008.08.003; pg.375

peripheral in the ECM, diluting the water and creating a more electronegative environment. [135]

During the gel phase, water flux comes in the ECM from capillaries under the hydrostatic pressure in waves mirroring the heart rate (60 – 100 beats per/min) or alongside the perineurium of the spinal nerves from the vertebral column in waves mirroring the PRM (2,5 cycles p/min) (McPartland & Skinner, 2005). Water molecules undergo the process of osmosis, being attracted by the strongly negatively charged GAG's, where they consequently bind and therefore the substance of the ECM thickens and water molecules with solutes and nutrients have more difficulty to flow. At the same time, consequently to the flux of water, the calcium in the ECM gets diluted. A lower concentration of calcium leads to higher polymerization of the matrix macromolecules, therefore to a higher viscosity (Lee, 2008). While entering the sol phase, the decreased levels of calcium in the ECM is now in contrast with the calcium levels in the proximity of the cells. The bound water leaves

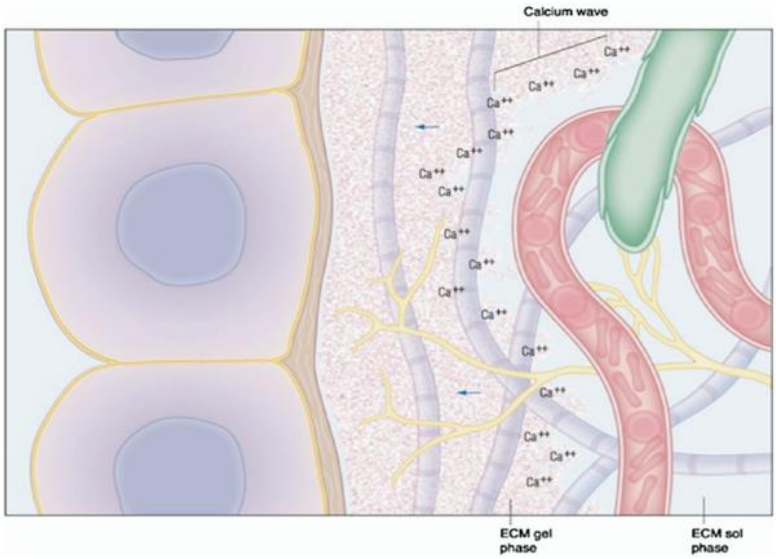

Figure 29. A diagrammatic representation of the theoretic model of a normal phase transition occurring in the extracellular matrix. Parenchymal cells on the left require a liquid phase of the matrix in order to receive nutrients from the capillary (red structure on the right) and to discharge waste to the terminal lymphatic vessel (green structure on the right). A gel phase of the ground substance is depicted in the extracellular matrix adjacent to the parenchymal cells and a liquid phase adjacent to the capillary. In-between, a wave of calcium ions is seen moving from right to left, which is changing the phase of the ground substance. Reproduced, with permission, from Lee.22
retrieved from Lee, R. P. (2008). The Living Matrix: A Model for the Primary Respiratory Mechanism. *Explore*, *4*(6), 374-378. doi:10.1016/j.explore.2008.08.003; pg.376

[135] Anstey, J. (2009). *Hands-on Healing: The Patient-Osteopath Interaction* (Unpublished master's thesis). Académie Sutherland d'Ostéopathie du Québec. Retrieved September 25, 2020, from http://www.academiesutherland.com/pdfs/Thesis_Jennie.pdf; pg.62

the GAG's, following the ion concentration, for the next relatively negatively charged object, which is the cell membrane. Consequently, the calcium concentration in the ECM increases again, which correlates with the depolymerization of the matrix. The matrix is free for the water flow with nutrients, which follows the high calcium concentration by the cell membranes. As water leaves the ECM, calcium levels there increase and at the same time GAG's are again more negatively charged being ready for another flux of water. The whole sol-gel transition enters the next cycle.
It is necessary to say that the swelling of the GAG's during the gel phase is opposed by the hydrostatic pressure provided by the very little distensible collagen fibers, which have direct interaction with the core proteins of proteoglycans (Bhave & Neilson, 2011). The collagen matrix and GAG's bound within proteoglycans are closely intertwined and thus the hydrostatic pressure response to the swelling is immediate. In normal conditions (as opposed to pathological situations such as inflammations), as long as the tension in the matrix is maintained by fibroblasts, the volume changes are very minimal, controlled by osmotic, hydrostatic, and electrochemical forces [136]. For a more precise visualization of the whole process, we can add the fact of the relatively short duration of the hydrogen bonds, which occur and disappear constantly. Thus the level of activity, constant rearranging of the water molecules taking place in the ECM, is very high.

5.2.2.3.2 Circulation of one fluid

Stepping a level higher in the hierarchy, from tissues to organs and their connections, in this dimension we consider the fluids to be the carrier of the intrinsic movement or expression here. While thinking about dynamic forces of fluids in the body from an embryological point of view, it is clear that all the fluids have the same origin: they are products of the metabolic activity of the cells. All the fluids are originating in the cell protoplasm (Jealous, 2010) since the human organism has its origin in a one-cell ovum. James Jealous describes that protoplasm holds a livingness that has a decision-

[136] Aukland A., Wiig H., Tenstad O. & Renkin E.M. (1997), as cited in Bhave, G., & Neilson, E. G. (2011). Body Fluid Dynamics: Back to the Future. *Journal of the American Society of Nephrology, 22*(12), 2166-2181. doi:10.1681/asn.2011080865; pg.2171

making capacity [137], thus often is spoken of the fluid with the potency.
However, thinking about the adult body scheme of circulation, this concept of unity in fluids quite easily gets lost. Based on a schematic sketch (figure 30.), we would like to highlight this unity and further elaborate on its dynamizing mechanisms.

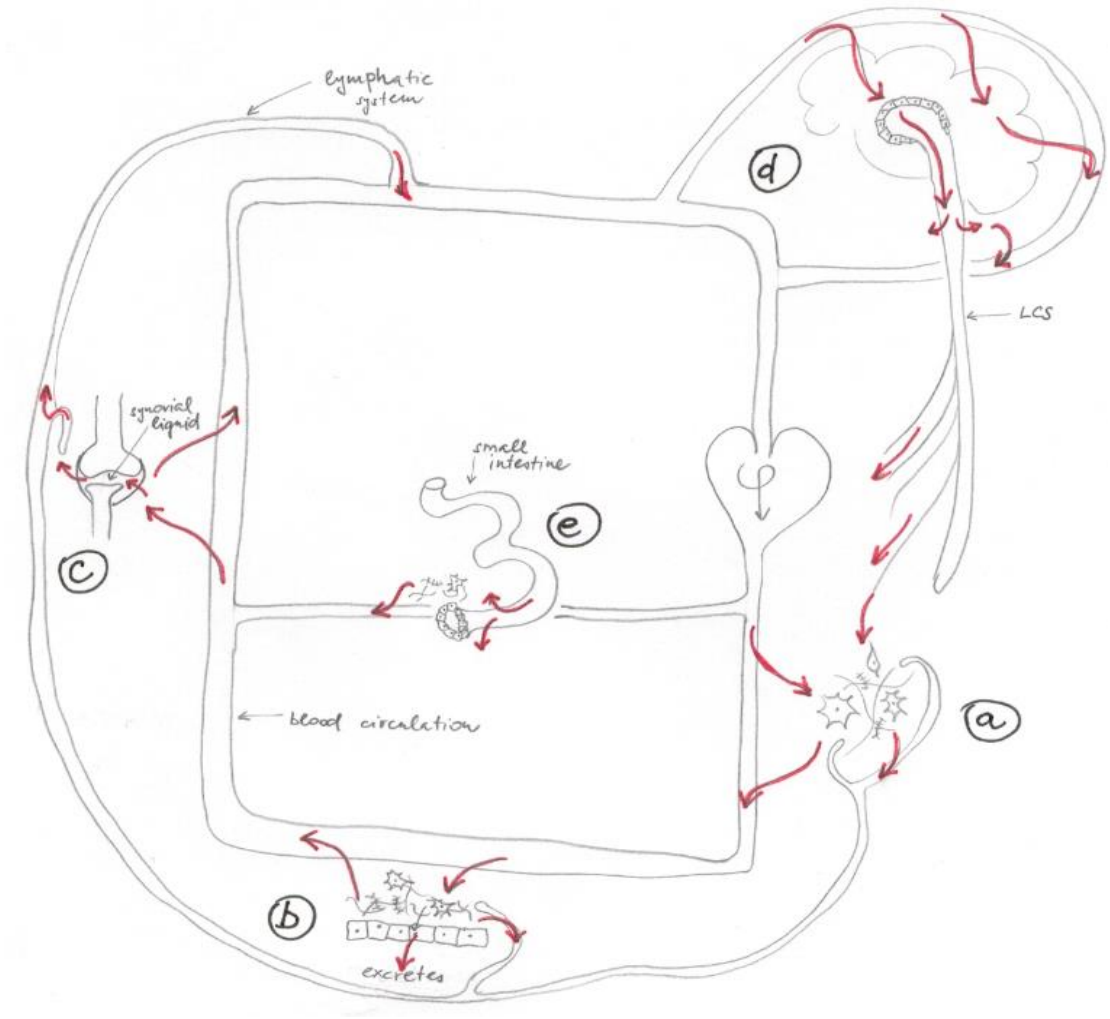

Figure 30. Unity of fluids
author image

[137] Jealous, J. (2010). BLECHSCHMIDT: AN EMBRYOLOGY SUITED TO OSTEOPATHY. *SUTHERLAND CRANIAL COLLEGE Magazine*, (32), 10-11. Retrieved October 7, 2020, from http://drawingonanatomy.com.au/newsD/32NewsletterAutumn10.pdf; pg.11

a) Blood plasma except for the albumin from capillary blood leaves to the interstitial spaces, carrying nutrients (glucose, oxygen, etc.) under hydrostatic pressure. Water, oxygen, nutrients, electrolytes can enter the cells, urea as a metabolic waste is collected outside of the cells. Water can leave the interstitial space to the capillary veins under the osmotic pressure of the albumin, or via the lymph back to blood circulation.

b) Similar to a), water with nutrients continues to enter the cells of the limiting tissues, which further transmute the material and excrete their metabolites as mucus, gal, milk, sweat, pancreatic juices, alveolar liquid, etc. By urine, the principal is similar only the process of filtration is very elaborated. Those excretions are leaving the body.

c) Similar to b), the synovial membrane cells take up material from the ECM and produce the synovial fluid, which is by movement pressed out of the joint space to the ECM. From the ECM it can be taken up to capillary veins or via lymph back to the blood circulation.

d) The arteries bring nutrients to the brain, embedded in the connective tissue sheet called pia mater. Under hydrostatic pressure, the water with nutrients leaves through the aquaporins of the astrocytes to the neurons, the neuron's metabolites with the waste is then taken back via astrocytes to the veins or lymphatics (system of glymphatics). The lining tissues of the ventricles and canalis centralis of the spinal cord are nourished the same way and their produced metabolites (water with electrolytes, proteins, etc.) are collected in the ventricles, named liquor cerebrospinalis (LCS). LCS has a very accurate composition, which is guarded by the active metabolic exchange of the ependymal cells (Freeman, 2010). LCS is further flowing out of the ventricles through the foramina Luschkae and Magendie to the ***subarachnoid space*** and on one hand further resorbed to the venous system of the brain through arachnoid granulations, on the other hand follows the subarachnoid space alongside the spinal cord and further through the space between endoneurium and perineurium of the spinal nerves into the peripheries of the body to be resorbed by the ECM alongside the nerve pathway.

e) Water and nutrients (sugars, minerals, proteins, lipids, etc.) are absorbed by the limiting tissue of the intestinum and colon through different manners. Water is absorbed by the mechanism of osmose, reacting to the high levels of sodium in the

small intercellular spaces between the enterocytes. High concentrations of sodium are a result of the activity of the sodium/potassium pump on the basolateral side of the cell. Water can pass the tight junctions between the epithelial cells or pass transcellular (follow the ions absorption to the cell at the apical side and out of the cell at the basolateral side) (Kamm, 2002). Either way, the water is absorbed into the ECM and from there can enter the blood circulation.

5.2.2.3.3 Several considerations concerning the intrinsic movement

From the description above we can see that the fluid system behaves as continuity, but it also shows locally very different dynamics and a very complex feedback system. We see this as a manifestation of the principle that every level of the hierarchy keeps their own, already existing, functioning and doesn't give up their own identity for the new function (as discussed in chapter 5.2.1.1).
By looking at the dynamics of the fluid at all the levels, step by step, starting from the atomic level, we can see the basic flow in the polarity of the water molecules as well as the oscillatory behaviour of the electrons being shared between the hydrogen and oxygen leading to the 'breathing pattern' of water (discussed in chapters 5.2.2.1.1.2 and 5.2.2.1.1.1, respectively). One step higher in the hierarchy, the polarity ensures the interaction of the water molecules with other organic substances, where the properties of the hydrogen bonds make it a very unstable, thus fluid, situation (as discussed in chapter 5.2.2.1.1.3). Stepping onto the level of cell organelles and consequently level of cells, the flow of water becomes regulated by the semipermeable membrane and mechanisms for maintenance of specific ion concentrations in the separate intra- and extra-organelle / intra- and extracellular environment. On the level of cells and the ECM (thus tissues), the mechanism of the flow of water is described in chapter 5.2.2.3.1. On the level of organs, the fluid flow with nutrients gets another shape: the blood circulation with certain pressure and the act of the heart contraction.
The research shows that only the vascular compartment is actively [centrally] regulated, whereas homeostasis of the significantly larger extravascular ECF [extra-cellular fluid], particularly the interstitium, depends primarily on local autoregulation

[138]. The connective tissues show autonomous informational stability (Brand, 1992), which means that tissues keep their own existing functions and thus dynamic to a certain extent, even if an emergent behaviour (being a development of closed blood circulation in this case) comes with another, more spectacular forces. As well, overall in tissues the cell volume regulation is put to the hands of the extracellular tonicity (Bhave & Neilson, 2011), which shows that the ECM with its dynamics regulates the homeostasis on the level of tissues.
The autonomous regulation on the level of tissues shows us that the flow dynamics in tissues cannot be dependent on blood circulation and its pressure, but had its own dynamics already developed before the first heartbeat of the embryo. The blood circulation and its own regulation came only later as an emergent behaviour of the growing complexity of the system.

From an embryological point of view, the movement of any material in the embryo is a result of a metabolic flow. The metabolic products of certain cells are used as nutrients by other cells, establishing the paracrine communication. Cells and cell aggregates undergo changes in shape, position and density through ***biodynamic*** forces, all achieved by a flux of those fluids. We elaborate on the embryological aspect further in chapter 5.2.2.4.

5.2.2.4 Perspective of embryological development

In the osteopathic community there is no consensus about the involvement of the ***biokinetic*** forces during embryological development, nor about the idea that the forces involved in embryological development become the healing forces in adult life and therefore are important for every osteopath to consider. That may be a result of the nowadays mostly chemical-genetic focus of embryology, which leaves out the participation of biokinetic forces on human development. However, we would like to consider the more biodynamic approach as proposed by embryologists Erich Blechschmidt, Raymond F. Gasser and Brian Freeman.

Brian Freeman comments on this topic:

[138] Bhave, G., & Neilson, E. G. (2011). Body Fluid Dynamics: Back to the Future. *Journal of the American Society of Nephrology, 22*(12), 2166-2181. doi:10.1681/asn.2011080865; pg.2171

> …the dynamic forces that lead to the genesis of structures and organs and their physiological response patterns to stimuli, these forces continue in some way even after the structure is complete. I also think that disruption in the course of completing these structures, or disruption to the cyclical oscillation of opposing forces, sets in train a new response in the human that may manifest as a congenital anomaly or some other sort of pathology. [139]

An anatomist, embryologist and phenomenologist Jaap van der Wal (2000) expresses a similar view:

> The forming forces through which the body, body parts and organs gain their form and character, those forming forces come, so to speak, 'free' on a physiological and psychological level when the self-forming is more or less finally crystallized. [140]

Both statements reflect the view that the same forces operating in an adult human organism (for example metabolism) were always present, from the stage of a fertilized ovum till the stage of fully developed human, only being manifested on different levels. Erich Blechschmidt stated that there is no stage in human development prior to which one could claim that a being exists with non-yet-human individuality [141]. The idea of the fertilized ovum, as one of many occurrences of the fully human forms with their own functions, can be considered as a truly holistic view.

5.2.2.4.1 Blechschmidt's biodynamic approach

Erich Blechschmidt dedicated his research to human development at the earliest stages. He worked out a large number of highly precise reconstructions of human embryos and by doing so, he was able to follow the gradual placement and displacement of different structures. He assumed, having a background in physics,

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[139] Lewis, J. (2010). Brian Freeman speaks to John Lewis. Retrieved August 03, 2020, from http://www.drawingonanatomy.com.au/newsD/32NewsletterAutumn10.pdf; pg.7

[140] own translation of a citation in Wal, J. V. (2000). Embryo in Beweging en Eurythmie. Retrieved August 03, 2020, from https://www.embryo.nl/upload/documents/artikelen-embryosofie/Embryo%20in%20Beweging%20en%20Eurythmie%202000%20NL%20artikel.pdf; pg. 3

[141] Blechschmidt, E. (2004). *The ontogenetic basis of human anatomy a biodynamic approach to development from conception to birth*. Berkeley, CA: North Atlantic; pg.7

that all movement originates in physical force, which led to the idea of biokinetics. Based on that assumption and adding the context of time and the relation to other developing structures, he developed a biodynamic approach to the interpretation of the ever-changing form of the developing embryo.
To summarize the whole concept of Erich Blechschmidt is beyond the scope of this thesis, nevertheless we would like to highlight certain views of his on embryological development regarding the topic of the origins of the intrinsic movement.

5.2.2.4.1.1 Blechschmidt's basic concepts

- According to Blechschmidt's research the genes are not the motors of development and therefore do not themselves evoke the characteristics of the differentiated organism; there is no direct connection between the genes in a nucleus and the form of the whole cell [142], thus form of tissues or organs. The whole process of differentiation of a human organism is dependent on the biodynamic forces. Thus, *differentiation is an outside-to-inside process*, where the genetic material encased in the cell nucleus is reacting to the state and forces of the environment and leads to the expression of only certain genes. At the same time, the external physical forces are forming the shape of the cell membranes, influencing the general shape of the cells and their organelles, distribution of fluids in and outside of the cells and therefore affecting the variety in density or permeability of different areas [143]. Differentiation is not a mechanical but biomechanical and consequently a biodynamic process requiring the metabolism of living cells [144].

- The ***metabolic flow movement*** *in cells is a precursor of directions of the material movement during executing its function.* As an example, the direction of the electrical impulses in neurons is based on the direction of the metabolic flow in its early development.

[142] Blechschmidt, E. (2004). *The ontogenetic basis of human anatomy a biodynamic approach to development from conception to birth*. Berkeley, CA: North Atlantic; pg.17

[143] Such a view is almost half a century later supported by the research into tensegrity in biological systems and its role in the force and information transfer intra- and extracellularly.

[144] Blechschmidt, E., & Gasser, R. F. (2012). *Biokinetics and biodynamics of human differentiation: Principles and applications*. Berkeley, CA: North Atlantic Books; pg. 190

- *The growth movement is a predecessor of functional movement observed by an adult human.* We can observe this phenomenon in the most diverse functions of the human body: peristalsis, blinking of the eyelid, use of vocal cords, mimic expressions of the face, the direction of bending in the joints, the action of inhaling and exhaling, etc.

- *Growth functions precede all higher functions* [145], such as later functions of mobility, functions of sensory organs, functions of visceral organs, etc. It doesn't occur during the embryological development that an organ or structure is (even temporarily) without a function. All tissues have a function at all times; the development of structure and function of an organ is interdependent.

- Cells and cell aggregates undergo changes in shape, position and density through biodynamic forces, all achieved by movements of fluids. Such a fluid movement is ordered and organized.

- Development of position, form and structure emerge in unity as forming movements or forming functions. Movements of molecular and submolecular materials, otherwise invisible, express themselves as the forming movements [146]. According to these observations, Blechschmidt described several *metabolic fields* as regions characterized by spatially ordered metabolic movements involving ensembles of cells growing at differential rates as each part gradually takes up its final position, form, and internal structure [147]. We will discuss the concept of metabolic fields further in chapters 5.2.2.4.1.3 and 5.2.2.4.1.4.

- Active migration of germ cells during the embryological development of humans doesn't occur (Freeman, 2003). The illusion of cell migration arises when attention is focused on the cellular aspects of development rather than on the global aspects [148]. With the evaluation of the movement of a specific aggregate of cells in its context (mainly the forces of the global growth movement of the embryo), it becomes clear

[145] Blechschmidt, E. (2004). *The ontogenetic basis of human anatomy a biodynamic approach to development from conception to birth*. Berkeley, CA: North Atlantic; pg.5

[146] Blechschmidt, E. (2004). *The ontogenetic basis of human anatomy a biodynamic approach to development from conception to birth*. Berkeley, CA: North Atlantic; pg.22, 23

[147] Lewis, J. (2010). Brian Freeman speaks to John Lewis. Retrieved August 03, 2020, from http://www.drawingonanatomy.com.au/newsD/32NewsletterAutumn10.pdf; pg. 4

[148] Freeman, B. (2003). The active migration of germ cells in the embryos of mice and men is a myth. *Reproduction, 125*(5), 635-643. doi:10.1530/reprod/125.5.635

that the cells are carried, left behind, grown over or anchored and therefore directionally dependent on another structure even if temporarily.

5.2.2.4.1.2 The origins of the kinetic activity in the one-cell ovum

Blechschmidt's investigations led him to an opinion, that even the very first subdivision of a fertilized ovum is possible to interpret as a biokinetic event. As oxygen approaches the cell membrane, cytoplasmic substances attracted by the possibility of an oxidation process move towards the membrane. The metabolic processes involving oxygen happen primarily inside the cell under the cell membrane, promoting the growth of the membrane and the cytoplasm directly under. Such growth is most probably not equal and leads to the attempt to redistribute the pressure and the concentration of substances, thus to a movement of cytoplasm. Due to the differences in the amount of pressure of the fluid on the cell membrane, the membrane caves and the first sign of a cleft appears (figure 31.). Due to the promoted growth of the membrane, the cleft can continue until it meets the membrane on the other side. At the same time and in case that the ovum is fertilized, the pronuclei of the sperm cell and the ovum are being moved toward each other, most probably by the movement of the cytoplasmic fluid. When they merge, their chromosomes are lined up in one plane and are ready to be divided. The subdivision is complete.

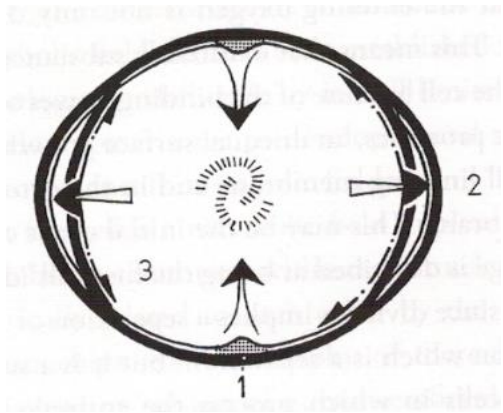

Figure 31. Fertilized human ovum with capsula pellucida. Even the one-cell ovum represents a metabolic field with aligned metabolic movements. The outlined arrows (near 2) indicate the changes in shape in the area of the arising poles of the ovum. The tailed arrows (near 1) and the half-headed arrows (near 3) show metabolic movements perpendicular and parallel, respectively, to the cell limiting membrane. The arrows represent an intracellular circuit from the nucleus to the cell limiting membrane and vice versa. Chromosomes are shown diagrammatically in the center.
retrieved from Blechschmidt, E., & Gasser, R. F. (2012). Biokinetics and biodynamics of human differentiation: Principles and applications. Berkeley, CA: North Atlantic Books.; pg. 6

Such an observation proposes an idea of an intracellular circulation as a spatially ordered movement due to metabolic processes (figure 32.), thus an early metabolic field. It shows that growth and differentiation are only possible under the condition of the exchange of material. Therefore development does not begin from the inside (by

genetic information) but externally [149]. An external piece of information, as a developmental stimulus, has primarily an effect on a cell membrane, activating the metabolic circuit and the movement of the cytoplasm and by that moving the pronuclei towards each other and promoting the growth of the membrane and thus division.

Taking this view to an extreme it leads us to a hypothesis, that the difference with the regular interpretation of the embryological development would be, that **every** human ovum (fertilized and not fertilized) released by ovulation goes through the early metabolic processes, but the not fertilized ones are in the course of their short lives not able to sustain their metabolism due to the missing half of the genetic information.

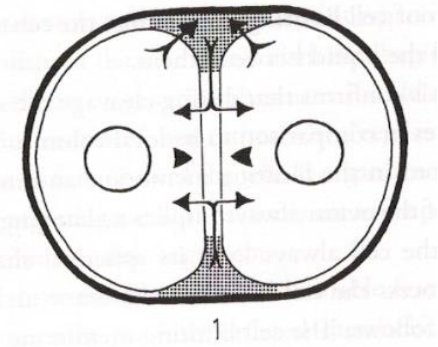

Figure 32. Formation movements of the ovum at the end of the first subdivision. The unity of the cell aggregation is preserved by means of the metabolic movements. The tailed arrows show metabolic movements parallel and perpendicular to the cell limiting cell. The arrowheads represent the reciprocal pressure of the cells to each other which results from metabolic movements. retrieved from Blechschmidt, E., & Gasser, R. F. (2012). Biokinetics and biodynamics of human differentiation: Principles and applications. Berkeley, CA: North Atlantic Books.; pg. 6

5.2.2.4.1.3 Early metabolic fields

Early metabolic fields arise during early development and are mainly the result of the cell metabolic processes and the fluid movements in and outside of the cells, enabling cell nourishment and getting rid of their waste. The biokinetic forces are based on the different rates of growth of the cells of different germ layers, keeping proximity to the nourishment source and on the adjustments of hydrostatic pressure and osmolarity in the tissues. These situations bring about certain frictions between cells or aggregates of cells, which leads to specific shaping and structure of the tissues. Series of events involving the ectoderm (creation of ***notochord***, rotation and closure of neural tube, creation of early peripheral nerves, etc.), entoderm (rotation and closing of the gut tube, etc.) and mesoderm (rise of mesoderm, creation of ***somites***, creation and restraining function of blood vessels, etc.) are described as early metabolic fields.

[149] Blechschmidt, E., & Gasser, R. F. (2012). *Biokinetics and biodynamics of human differentiation: Principles and applications*. Berkeley, CA: North Atlantic Books; pg.6

5.2.2.4.1.4 Late metabolic fields

Brian Freeman (2010) defined late metabolic fields as three-dimensional regions or ensembles of cells with similar shape and similar metabolism containing spatially ordered metabolic movements; such fields usually do not have sharp boundaries and are already concerning more differentiated complex structures. They appear as a manifestation of a unique biodynamic situation at a specific time at a specific place and as such can be temporary; some fields occur in reaction to a previous field in the region. Blechschmidt described 8 different metabolic fields. We give a very limited overview of each of them.

• Corrosion field

Such a field is established by pressing together 2 epithelial layers, which results in the formation of a thin double-layered membrane. Due to this pressure the extracellular fluid leaves the region and the epithelial membrane loses its nourishment, which leads to necrosis of the cells. Corrosion fields can be found in both early and late development, for example in the area between the entoderm and invaginating ectoderm layer creating the ***axial process*** or during the development of the urogenital system between the mesonephric tubules and the mesonephric duct.

• Loosening field

The loosening field is an area with a high proportion of intercellular liquid, where the waste products of the cellular metabolism are flowing. With an ongoing production, the liquid vesicles grow and fuse. The dynamic liquid put against the more solid background of the cells forms the ***primordia*** of the blood vessels in this way.
A special type of loosening field is a suction field, where the expansive growth in certain areas causes a vacuum zone in the neighboring area. That leads to caving of the lining tissue and proliferation of its cells inwards. The suction field underlies the development of the lungs and all exocrine and endocrine glands.

The following fields are involved in the development of the connective tissue:

• Densation field

This zone occurs in the ***mesenchymal tissues***, where the proportion of water in relation to cells changes significantly in favor of the cell part. A densation field occurs in places with a specific context: the cells are not directly pushed against each other but rather ‘hoarded’ by the growth of their neighbors into a somewhat limited area. Thus the cells gain a spherical shape (because the previous situation of the

directional pull is lifted) and can quite freely proliferate, which contributes to enough pressure for the interstitial liquid to leave to the peripheries. The tissue characteristic of the high density of the spherical cells is the first step in the creation of the cartilage tissue and is found in the development of tracheal rings, early differentiation of the ribs or differentiation of a nasal septum.

• Contusion field

This field is found in the central zones of the densation fields, where the spherical cells undergo a gradual compression force from opposite directions and are therefore flattened in one plane. The cells assume a disc-like shape by losing a big amount of their water. Contusion fields are the next step of the cartilage creation to be found for example in all the skeletal primordia of the spine and limbs.

• Distusion field

This zone occurs on the peripheral edges of the contusion fields. Disc-like cells of the contusion field gain a very high osmolarity by losing their part of water, which is being pressed out to the peripheries. Due to the high osmolarity, the cells on the edge of the contusion field having the access to the water, reabsorb the liquid and swell up into a spherical shape. In this way, a layer of cartilage is formed (producing a stretch in a longitudinal axis) with surrounding tissue being more solidified. The stretch leads to the reaction of the surrounding tissue to create a counter-pull and this leads to the creation of ligaments as restrainers (discussed below in the retension field). The distusion field is yet another step in the development of cartilage in the areas of the growth cartilage in the bones.

• Retension field

Zone of cells which is growing at a slower speed than the neighboring cells in a distusion field, find themselves in a situation of being stretched longitudinally and narrowed by compression in the two other directions. Such a field doesn’t easily yield and so provides a restrain of growth. At the same time, due to the transverse compression, a protein liquid is being squeezed out of the cells. This precollagen liquid flows in the intercellular spaces and by the temperature of 37 degrees polymerizes into collagen fibers aligned with the direction pull. Retension fields lead to the development of tendons, retinacula or (sometimes temporary) ligaments with a restraining or anchoring function.

• Dilation field
Such fields occur in mesenchymal tissues when a longitudinal stretch is executed without the element of the transverse compression. Cells in the dilation field become thin and elongated but keep their proteins intracellularly. Those fields are found in the primordia of the smooth muscles around the expanding endoderm tube, primordia of the skeletal muscles in the somites, etc. and primordia of the heart muscle.

• Detraction field
Detraction fields are the latest to appear in the course of human development. They occur in the zones where first a significant hardening of the ground substance takes place. Mesenchymal cells then slide on this hardened surface, which creates friction and even more fluid is leaving such a zone. With such a gradual process most of the water is squeezed out of the ground substance and the ossification process takes place.

5.2.2.4.2 Blechschmidt and Ingber

As far as the references in the studies and articles of Ingber can tell, there is no direct connection between him and Blechschmidt and yet they state similar findings:

> Thus the form of the organism differentiates directly under biodynamic forces, not chemical genetic information. (Blechschmidt [150])

> Taken together, this work confirms that mechanical forces generated in the cytoskeleton of individual cells and exerted on ECM scaffolds, play a critical role in the sculpting of the embryo. (Ingber [151])

And both raise similar demands on the direction of future research in that area:

> Blechschmidt himself commented many times that one approach to human development can never deny another, and that both mechanical and chemical approaches must end up being consistent because it is always the one living

[150] Blechschmidt, E. (2004). *The ontogenetic basis of human anatomy a biodynamic approach to development from conception to birth*. Berkeley, CA: North Atlantic.; pg. 18

[151] Inber (2006) as cited in Pflüger, C. (2008). *The Meaning of Tensegrity Principles for Osteopathic Medicine* (Unpublished master's thesis). Donau University Krems. Retrieved July 19, 2020, from http://www.osteopathic-research.com/paper_pdf/Pflueger.pdf; pg. 42

> entity at the core of the investigation. However, the biomechanical/biodynamic approach is more basic because it provides the spatiotemporal reference framework in which all the separate chemical entities must cooperate. (Freeman [152])

> The discovery of the importance of cell shape and cytoskeletal tension for control of cell-cycle progression requires that we place what we have learned about biochemical mechanisms of cell-growth regulation within a larger frame of reference that also takes into account cellular architecture, micromechanics and structural complexity. (Huang & Ingber [153])

In his research, Ingber departs from the concept of tensegrity and focuses on the role of mechanical forces that are generated in the contractile actin cytoskeleton of living cells and that act on the adhesions of these cells to neighboring cells and to the ECM [154]. In the study *Mechanical control of tissue and organ development* (2010) Mammoto & Ingber describe how both traction forces exerted locally by single cells and more generalized mechanical forces resulting from tension generated within the cytoskeletons of large groups of cells in tissues and organs are central to the control of tissue pattern formation during virtually all stages of embryogenesis.
In the frame of the above-mentioned study, they describe several types of mechanical forces involved in embryonic development:
• spring forces, which are generated when an actin bundle returns from a compressed or stretched state into its normal length with a certain momentum;
• osmotic pressure, when water drawn into cells mechanically influences the membrane tension, the cell shape or reactivity of the transport membrane channels of the cells;
• surface tension, particularly in the early stages of the development, when embryonic tissues behave as liquids governed by an effective surface tension, which is

[152] Lewis, J. (2010). Brian Freeman speaks to John Lewis. Retrieved August 03, 2020, from http://www.drawingonanatomy.com.au/newsD/32NewsletterAutumn10.pdf; pg.6

[153] Huang & Ingber (1999) as cited in Pflüger, C. (2008). *The Meaning of Tensegrity Principles for Osteopathic Medicine* (Unpublished master's thesis). Donau University Krems. Retrieved July 19, 2020, from http://www.osteopathic-research.com/paper_pdf/Pflueger.pdf; pg. 43

[154] Mammoto, T., & Ingber, D. E. (2010). Mechanical control of tissue and organ development. *Development, 137*(9), 1407-1420. doi:10.1242/dev.024166; pg.1407

determined by differences in intercellular adhesion and cytoskeletal prestress [155];
• tensional forces, traction and prestress, generated by the interdependence of the cytoskeleton and ECM. Those forces are necessary for the cell shape stability and mechanotransduction;
• shear stress, as a friction force exerted by the fluid movement against a more solid cell surface.

According to their study, the event of the metabolic activation of the ovum can be reached by both chemical stimuli (an increase of calcium in the cytoplasm) and mechanical stimuli (mechanical tension, change in osmotic or hydrostatic pressure). Concerning following events of the first subdivision of the ovum, it was confirmed that the orientation of the ***spindle axis*** and cell divisions is governed by the spatial distribution of the ECM adhesions that resist cell traction forces, and not by chemical signals generated in response to the ECM binding (Thery & al., 2005 as cited in Mammoto & Ingber, 2010). Thus, the act of polarization of cells is a result of the mechanical traction forces affecting the cytoskeleton.
Further, their study suggests that phenomena in early embryonic development as the asymmetric division of the cells, gastrulation, dorsal closure of the neural channel, etc. are taking place under interplay of both chemical and biomechanical control and that, on the other hand, cell shape transformations occur due to cells that exert traction forces on the neighboring cells or the ECM.
In later embryonic development, the development of organs is likewise taking place under mechanical forces (e.g. development of kidneys under the shear forces, epithelial cell differentiation and morphogenesis in glands development under the tensional forces, lung maturation under the atmospheric post-natal pressure force, etc.)
In the conclusion of their study Mammoto & Ingber (2010) state that

> …mechanical stresses have been shown to function as informative signals that produce specific changes in molecular biochemistry and gene expression through the process of cellular mechanotransduction…. Cell-generated tensile forces alter the chemical signals that are conveyed by cells, in addition to producing the distortion of neighboring cells and ECM molecules that

[155] Mammoto, T., & Ingber, D. E. (2010). Mechanical control of tissue and organ development. *Development, 137*(9), 1407-1420. doi:10.1242/dev.024166; pg.1407

propagate mechanochemical signaling over long distances, thus driving tissue patterning and organ formation at the scale of the whole embryo. [156]

5.2.2.4.3 Interstitial flow in embryogenesis

In chapter 5.2.2.4.1.1, we refer to one of the basic Blechschmidt's concepts that states: cells and cell aggregates undergo changes in shape, position and density through biodynamic forces, all achieved by movements of fluids. Such a fluid movement is ordered and organized.

The study of Rutkowski & Swartz (2007) brings some concrete points to this concept. Similar to Blechschmidt's findings, they describe the interstitial flow in embryo, before a vascular system is developed, as a flow that is driven through the differentiating cell mass and that is necessary for the proper development [157] pointing out that interstitial flow can impart shear stress on the cell surface, which, as a mechanical stimulus, can itself drive embryonic cell differentiation and determine lineage fate and could be responsible for shaping organs [158]. They support these statements by highlighting the studies of Mercola (2003) and Nonaka & al. (2002), which examined the role of monociliate cells in the embryonic node (a structure located at the anterior tip of the primitive centerline). Generally, the vortical movement and direction of inclination of the cilia on these cells generate the leftward movement of fluid across the node[159] which leads to the asymmetric flow transport and blending of morphogens (signaling factors for the cells). That causes an asymmetric gene expression of the cells and (together with the shear stress and other mechanical forces) ultimately leads to the left-right asymmetry of the organs (in which the heart is on the left, the liver on the right, etc.)[160].

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[156] Mammoto, T., & Ingber, D. E. (2010). Mechanical control of tissue and organ development. *Development, 137*(9), 1407-1420. doi:10.1242/dev.024166; pg. 1416

[157] Rutkowski, J. M., & Swartz, M. A. (2007). A driving force for change: Interstitial flow as a morphoregulator. *Trends in Cell Biology, 17*(1), 44-50. doi:10.1016/j.tcb.2006.11.007; pg. 45/46

[158] Rutkowski, J. M., & Swartz, M. A. (2007). A driving force for change: Interstitial flow as a morphoregulator. *Trends in Cell Biology, 17*(1), 44-50. doi:10.1016/j.tcb.2006.11.007; pg. 46

[159] Mercola, M. (2003). Left-right asymmetry: Nodal points. *Journal of Cell Science, 116*(16), 3251-3257. doi:10.1242/jcs.00668; pg. 3252

[160] Rutkowski, J. M., & Swartz, M. A. (2007). A driving force for change: Interstitial flow as a morphoregulator. *Trends in Cell Biology, 17*(1), 44-50. doi:10.1016/j.tcb.2006.11.007; pg. 46

5.2.2.4.4 Several considerations concerning the intrinsic movement

Generally, we realized that investigations in metabolic fields teach us about the importance of the external stimulus and its aspect of velocity, force magnitude and direction leading to tissue characteristics as form, tension or density. Analogically, in a post-embryonic development through our adult life we are dealing with different external impacts, which have an influence on the quality of our tissues. Within that realization, we highlight several specific points and further discuss the possible consequences of these considerations in chapter 6.

• In cases of lasting mechanical stress, it is received by collagen fibers and further transferred through the tensegrity mechanism to fibroblasts. The fibroblast cells are then mechanically stimulated to change their shape, thus reorganizing their cytoskeleton and cytosol, including the volume. At the same time, on the fibroblast cell membrane the process of mechanotransduction is activated which leads to modulation of gene expression (Chiquet, 1999, as cited in Tozzi, 2014). That leads to lasting changes in fibroblast cells concerning shape and function as well as the quality of their products as collagen, elastin, reticuline and ground substance, thus to the tissue characteristics as a whole: density, tension or viscosity.
This process can be observed by osteopathic diagnostics as tissue hypertension or rigidity, but it actually is comparable to the processes of cell differentiation taking place in late metabolic fields as described by E. Blechschmidt.
At the same time, the magnitude and the place of impact of mechanical forces as produced by movement, strain or postural habits are decisive for the architecture of the ECM and its fiber orientation. Collagen is deposited along the lines of tension imposed on or expressed in connective tissues at both molecular and macroscopic levels [161].

• The concept of Blechschmidt's metabolic fields as a development of position, form and structure emerge in unity as forming movements or forming functions (as discussed in chapter 5.2.2.4.1.1). Thus, during the ever fluent embryological development the current form is an expression of physiological homeostasis being reached every moment on the level of function and arising structure. This principle doesn't disappear once the embryological development of the human is complete, we

[161] Tozzi, P. (2014). Does fascia hold memories? *Journal of Bodywork and Movement Therapies, 18*(2), 259-265. doi:10.1016/j.jbmt.2013.11.010; pg.260

can let this principle overarch the whole period of life: the optimal functions are executed by structures, which are in their optimal form.
Such an interdependency reminded us of one of the osteopathic principles as proposed by current literature: structure and function are reciprocally interrelated [162], only the term form is not mentioned. However, while researching Still's texts we noticed that he refers to the term form much more than to the term structure. We are aware that this topic brings us somewhat further from the central focus on intrinsic movement, however, we consider this quite an important realization and would like to elaborate on it in chapter 6.

• While studying the work of Blechschmidt and especially the metabolic fields, we realized that it is necessary to consider embryological development consequently according to the hierarchy of the body. Thus there is a difference between embryological growth expressed by force in movement in tissues (e.g. connective tissues) and organs (e.g. visceral organs), where the layering of the tissues or the eventual growing of limiting tissue and connective tissue into each other lead to contradictory embryological forces within one organ. At the same time, we would like to highlight the necessity to pay attention to the accurate reference points while studying the embryological development of the organs and their, so to speak, spatial embryological movement. With the accurate reference points, the source of the movement can correctly be placed within the whole (e.g. concerning the relative ascension of the kidneys, or the relative drawing back of the gut tube, etc.)

[162] This statement is one of the 4 tenets of osteopathic medicine, according to American Osteopathic Association and largely taken over for purposes of public communication as well as used in osteopathic education.

6. Discussion

In this chapter, we make an attempt to translate the findings of our theoretical research and analysis into a more practical realm. We draw conclusions from our two separate lines of research and make a link between them. In the end, that brings us to formulate several points for consideration.

• As discussed in chapter 5.2.2.4.4, the study of embryology on the level of tissues and the level of organs brought an important realization.
The literature study brought us enough evidence that there is a definite sense of directionality in tissues, which developed with a clear growth direction, as for example the upper and lower limbs. The restraining factor of the blood vessels leads to the spiral growth of the connective tissue, where the differentiation of the cells takes place according to their more central or more peripheral placement within the limb. As discussed in chapter 5.2.2.4.4, such directionally clear growth forces lead to the specific deposition of collagen and other fibers in the ECM of the tissues. The ECM is disorganized and anisotropic on the level of microvacuoles (with its polygonal organization), nevertheless according to the mechanical stress, the build-up of multiple microvacuoles takes the form of the helix, as discussed in chapter 5.2.2.2.3. If we add the fluidic element and the rhythmical filling of this organization with water, as discussed in chapter 5.2.2.3.3, that gives us a clear palpable model possible, in body parts as limbs. However, based on the findings summarized in chapters 5.2.2.1.1.1, 5.2.2.2.2 and 5.2.2.3.3 we would see it more in the sense of volume change (expansion and retraction) of the helical structure as a whole, possibly to be described as a directionally not entirely settled lemniscate movement. Scientific research confirms such a palpatory phenomenon as well: a helical component is observed within the soft tissues of the extremities (Sergueef, 2007), the stated directions are however contradictory in several studies. According to Scarr, a normal pattern exhibits right-handed helical motion in the limbs on the left side, and left-handed helical motion on the right, although current anatomical knowledge is unable to explain this [163]. According to Paoletti (2006), on lower limbs external rotation should be predominant, on upper limbs internal rotation should be predominant.

[163] Scarr, G. (2011). Helical tensegrity as a structural mechanism in human anatomy. *International Journal of Osteopathic Medicine, 14*(1), 24-32. doi:10.1016/j.ijosm.2010.10.002; pg.26

However, the situation is very different on the level of visceral organs. In the first place, on a histological level visceral organs are composed of several layers of tissues, where each is a result of a metabolic field on its own with a specific direction orientation. As an example of the complexity, we can take the gut tube with its limiting tissue embedded in the anisotropic ECM, with the three separate muscle layers with three different directions reflecting the three respective directions of the embryonal growths, and an anisotropic fascial layer of the visceral peritoneum. Another example is the development of the liver, resulting from the meeting of the proliferating limiting tissue originating from the gut tube from one side and the mesenchymal cells of the septum transversum meshing in the lining cells from the opposite side. Besides that, unlike in the limbs, the growth directions of the organs were and still are a subject of misunderstanding and disagreement, not only in the osteopathic community, as discussed in chapter 5.2.2.4.4. Blechsmidt's and Freeman's research clearly showed that an active movement of cells, aggregates of cells and organs is an illusion (as discussed in chapter 5.2.2.4.1.1), which can be prevented by work with accurate reference points and a proper comparison of differential growths.
In this light, we find it very unwise to speak of the concept of visceral motility which is based on the embryological growth movements of the organs. In their work Barral & Mercier (2006) state that the embryologic theory of the visceral motility postulates that the axes and directions motions remain inscribed in visceral tissues [164]. We agree with that statement fully, however in our opinion that phenomenon cannot be afterwards reduced to an image of a clear rhythmical 'back and forth' movement on the level of the organ, mirroring the somewhat questionable embryological growth movement of the organ as a whole, while disregarding the embryological forces on the level of the tissues, next to the other considerations from across the hierarchy as the dynamics of the fluidic aspect as discussed in chapter 5.2.2.3.1 or the oscillating behaviour of water as discussed in chapter 5.2.2.1.1.1. Based on our research we believe that the forces taking place in the visceral field are not to be tamed in a quantitative model, but they should be respected as specific forces acting in the hierarchy and be treated as such. We will elaborate on this in the following point.

• While collecting the material for this thesis, we didn't realize right away where would the study of the complex systems and the evolution theory (as a concept of

[164] Barral, J. P., & Mercier, P. (2006). *Visceral manipulation*. Seattle: Eastland Press.; pg.7

hierarchical organization with an emerging behaviour on every new level) bring us. An obvious observation was that for A. T. Still the evolution theory seems to be a crucial material, which has a value not only as a theoretical concept to understand the origin of life (as described in chapter 3.1.3.6) but as well as a certain mental frame used during the diagnostic palpation and the osteopathic treatment. In his texts, Still pays attention to different dimensions, from atomic to cosmic, as well as he questions the forces behind the forms and behaviour of the elements on that level. At the same time, he describes his inner process of 'tuning in' during the osteopathic palpation as aligning the focus with a specific dimension:

> Draw your mental *microscope*, raise it to its greatest power as you read the specifications for this unique building. [165]
> … I wish to drop further hunting for parts and details of the machinery, and place my *telescope* on a more elevated position for general observation, in order to obtain greater knowledge of the "hows and whys" of the working of this product of the mind of the Infinite. [166]

Besides that, Still explicitly emphasizes in his texts the necessity for proper visualization of anatomical structures, as well as physiological processes:

> An osteopath must know the shape and position of every bone in the body, as well as that part to which every ligament and muscle is attached. He must know the blood and the nerve supply. He must comprehend the human system as an anatomist should, and also from a physiological standpoint. He must understand the form of the body and the workings of it. That is a short way to tell what an osteopath must know. [167]

[165] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* Kirksville, MO: Author.; pg.204

[166] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* Kirksville, MO: Author.; pg.193

[167] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* Kirksville, MO: Author.; pg.277

This recommendation to visualize the “living anatomy” is a valuable and important one, yet research on this topic is quite seldom because of its ungraspable subjective nature.

On the contrary, only after long pondering on the findings of our research, we realized a possible answer to one of our research questions: How to understand the phenomenon of RI (the rhythmic impulse of the brain cells as well as any other cells of the body), which, according to different studies, was measured as an oscillation cycle (according to McPartland & Skinner (2005) the results showed 6-12 cycles/min.), but could be never sufficiently attributed to any physiological phenomenon.
As described in a previous point of the discussion, there are multiple activities taking place on several dimensions of the hierarchy: the breathing-like behaviour within a water molecule (as described in chapter 5.2.2.1.1.1), constant rearranging of the water molecules within the ECM–cell continuity (as described in chapter 5.2.2.2.2), cell metabolic processes and the consequent flux of material and fluids according to the shifting concentrations, activity of the electromagnetic fields correlating with the wide-spreading oscillations of the fibers /liquid crystalline structures (as described in chapter 5.2.2.2.2) and other, earlier not mentioned phenomena as an activity of the nervous system, etc. Each of those activities produces certain cycles / patterns on their own level. Those patterns co-exist and can express themselves simultaneously in mutual interaction, creating harmony.

In the light of this new realization, we can sharpen Still’s previously mentioned palpation strategies of using the *microscopes* (in order to zoom in) and *telescopes* (in order to zoom out). Based on the broad anatomical and physiological knowledge with its hierarchy, every osteopath can make every time again an educated decision about which observed phenomena need a microscope examination (as pinpointing a specific fascial layer, articular mobility in a specific joint, etc.) and on the contrary which phenomena are an expression of the life in a hierarchy (as phenomena of RI / CRI, etc.), where the focus on the detail brings the examiner away from perceiving the phenomenon as a whole, in its unity and harmony.

• In chapter 5.2.2.4.4 we discuss Blechschmidt’s ideas on the interdependence of position, structure and form in relation to forming functions and the possible analogy to Still’s ideas on form and function.
Analyzing Still’s texts, we realized that he uses the term form in a slightly different

manner than would be a nowadays interpretation. We choose two statements for all the examples, which reveals it clearly:

> …man's body is a form given by celestial life to the terrestrial life… [168]
> …life can only display its natural forces by the visible action of the forms it produces. [169]

The term form is used as something living and can be understood as a unique result of a unique meeting of everlasting forces. Still uses the term form on all levels of the hierarchy, he refers to organs and their form, to form and action of atomic matter, as well as forces giving life and form to the human body as a whole. He refers to the form as to living anatomy, anatomy in its progress, anatomy in its maintaining itself through physiology to form a human organism. On the other hand, the term structure is used in a more materialistic sense, referring to how a certain part of the body is built-up for example. Based on that we formulate our interpretation of the relationship between structure and form as follows:

> The form is a momentary expression of a force that fertilizes a structure. In the form, the uniqueness of every human is reflected, whereas a focus on structure reflects the unicity of all humans.

The interest of Still in how a person is dealing with a sickness, rather than to treat a sickness, is very clear from all of his texts. In this light, we could argue, that however important it is to be educated in the anatomy and physiology of structures in order to understand their origins and blueprint, doesn't osteopathy praise itself for approaching each patient as a specific individuum and therefore should acknowledge the inseparability of the triangle form – function – structure?

Taking into consideration that force (expressed in movement) is a predetermination of the structure, its quality and the quality of its metabolic production, there is a strong suggestion there to use an analogous approach for the osteopathic treatment: to use force expressed in movement in order to lift the impact of the existing mechanical stress or strain to let the structure regain its form, quality and quality of its

[168] Still, A. T. (1902). *THE PHILOSOPHY and MECHANICAL PRINCIPLES of OSTEOPATHY*. Kansas City, Missouri.: HUDSON-KIMBERLY PUB.; pg. 137

[169] Still, A. T. (1902). *THE PHILOSOPHY and MECHANICAL PRINCIPLES of OSTEOPATHY*. Kansas City, Missouri.: HUDSON-KIMBERLY PUB.; pg. 134

metabolism.
That leads us to a realization that the concept of mobility evaluation used in osteopathic diagnosis is incomplete considering the possible range of impacts of mechanical forces on different levels in the hierarchy of the body (from metabolism to tissue quality to local and global tensegral forces) and therefore it could be structurally broadened to involve the aspect of the tissue quality as well.
Without any ambition to give a complete overview of existing models of such an osteopathic assessment, during our literature search we came across some information on this topic. Nowadays osteopathic literature works with the term TART, as a model for the palpatory evaluation. In this model, the somatic dysfunction is claimed to be detected by palpation of at least two out of four cardinal clinical signs: tenderness (T), asymmetry (A), range of motion abnormality (R), and tissue texture changes (T) (Fryer, 2016). The aspect of tissue quality is fully anchored in this model.
To give a counterpoint to the 'model-creating necessity', we would like to mention the research of an osteopath Myron C. Beal, who examined osteopathically (only by palpation assessment) a large group of patients. His interest was if the osteopathic examination has a diagnostic value by cardiovascular and gastrointestinal diseases. According to the results, in 76% of the cases the underlying cardiovascular or gastrointestinal condition could be traced by the altered muscle tension and tissue quality in the thorax region as well as decreased range of motion of the costovertebral joints (Beal, 1983). Chaitow (2002) summarizes the focus of Beal's palpatory assessment as follows:

> Beal insists that investigation should also pay attention to the various soft-tissue layers: 'The skin for changes in texture, temperature and moisture; the subcutaneous tissue for changes in consistency and fluid; the superficial and deep musculature for tone, irritability, consistency, viscoelastic properties, and fluid content; and the deep fascial layers for textural changes.' [170]

Such a description suggests that focusing primarily on mobility / range of motion is reducing 'the material to be pondered about', as A. T. Still referred to it. In other words, by disregarding the tissue quality (texture, consistency, viscoelastic properties,

[170] Chaitow, L. (2002). Osteopathic Assessment and Treatment of Thoracic and Respiratory Dysfunction. *Multidisciplinary Approaches to Breathing Pattern Disorders*, 131-172. doi:10.1016/b978-044307053-2.50010-1; pg.138

fluid content, etc.) we lose the thread leading us to the forces which are / were at play in the patient's body, thus we lose the thread leading us beyond the symptom.

• In the light of bringing attention to the tissue quality, we realized this can have consequences for a mental alignment while palpating the PRM as a sol-gel transition in the tissues. This might be a purely personal discovery, nevertheless, reformulating the palpation of PRM in tissues as palpation of tissue quality changes instead of palpation of movement can bring new possibilities on how to relate to the phenomenon of PRM in practice.

• In chapter 5.2.2.2.1.2 we mention anisotropy and disorder of fascia as one of the functional properties of fascia / ECM. The fascial tensegral continuum from micro to macrolevels works ideally as a highly adaptable and most efficient force transmitter only when strongly disorganized. If the degree of the fiber chaos is lower, for example as a result of one-sided mechanical stress causing a specific fiber orientation, the flexibility of the microvacuoles decreases, which leads to the thickening of the fiber layers and forming of densification or fibrosis (Bordoni, Marelli, Morabito & Sacconi, 2017). Such a disturbance in the omnidirectional continuity leads to disturbances in the force transmission through the tensegrity structures of the body from top to toe as well as across the hierarchy of the body. Normally, if on a macroscopic scale a mechanical strain is applied, which distorts the extracellular matrix and the cytoskeleton of cells, the system reacts on a smaller scale and certain molecular components change their biochemical activity [171]. The reduced force transmission across the hierarchy, from macro to micro to molecular level, provides enforcement to the concept of the mutual interdependence of dysfunctions found on different fields (the parietal, visceral or cranial) or found within the various aspects as the mobility, tissues density and in fascial or fluidic aspects. In other words, on a parietal level applied mechanical forces can be translated into changes in the range of motion or position, as well as in changes in metabolism, blood circulation, lymph streaming, proper innervation, etc.
The same principle can be considered as a frame for osteopathic treatment as well: any applied force can influence any part of the entire system, from whole-body to the cellular, and vice-versa, via a non-linear distribution of forces, in such a way that

[171] Pflüger, C. (2008). *The Meaning of Tensegrity Principles for Osteopathic Medicine* (Unpublished master's thesis). Donau University Krems. Retrieved July 19, 2020, from http://www.osteopathic-research.com/paper_pdf/Pflueger.pdf; pg.27

local stimuli invariably lead to global reorganization [172]. The focus of the treatment is to gain the balance omnidirectionally, in more abstract words: to gain a state in which, on different levels of hierarchy, all activities manifested through movement express themselves as a harmony.

• In his literature, A.T. Still speaks extensively about the 'invisible, underlying force of life, 'divine power', that underlines all living matter, the same force that is responsible for action, motion, movement.
In his texts, we see a diverse usage of terms, such as indweller, operator, the spirit of man, the essence, self-moving principle, the secret of God, power of Life, the principle of mind, unerring Deity, Nature's laws, superior Being, spiritual Being and more. This striking variety of terminology shows us Still's currents of thought and philosophy when it came to this mysterious force, whose working he was trying to comprehend. It's noticeable in Still's writings that he does not doubt that such force exists, he feels an undeniable connection to it.
During the search for the origins of motion in Still's texts, it became more and more clear that the focus of Still does not lay in the phenomena of action, motion and movement. It seems that the curious nature of Still pulled him as expected, deeper into the core of the matter. It is clear from his texts that this deep interest led him to the core of existence, a topic which kept him busy since he encountered Spencer and his Evolution theory, and that seems to be the force which is the origin of action, motion and movement.
This 'highest known principle' often appears in Still's writings, it becomes clear to us that Still believed in this force despite the conflict which he had when the Evolutionary model clashed with the Methodist religious model.

> "As life, the highest known principle sent forth by nature to vivify, construct and govern all beings, it is expected to be the indweller and operator, and one of the greatest perceivable and universal laws of nature. And when it becomes necessary to break the friendly relation between life and matter, nature closes up the channels of supply." [173]

[172] Chen and Ingber (1999), Tozzi, P. (2014). Does fascia hold memories? *Journal of Bodywork and Movement Therapies, 18*(2), 259-265. doi:10.1016/j.jbmt.2013.11.010; pg.262

[173] Still, A. T. (1899). *Philosophy of Osteopathy* (p. 179). Kirksville, MO: A.T. Still.

This force, the highest known principle, which accompanies a living being throughout its life and when the right time comes ("when it becomes necessary"), this force "breaks the friendly relation" and so goes on the circle of life and death.
When closely examining his texts and philosophy, it is clear to us that Still chose to work with that force, the highest known principle.
Notably, Still was an opponent of the mainstream medical approach and believed that man possesses the divine healing forces which God inherited him (the highest known principle).

Therefore this 'highest known principle', 'force' is also taking the main role in the healing process according to Still:

> "Man wants to take the reins of the universe into his own hands. He says in case of fever he must assist nature by administering ipecac and other febrifuges. But by doing this he is accusing God of incapacity. You may be sure the Divine intelligence failed not to put into the machine of man a lever by which to control fever. The Lord never runs out of material; He constructs lawyers, musicians, mechanics, artists, all the useful men, while I suppose fools are made out of the leavings." [174]

As we mentioned in chapter 3.1.2, Still was working with this force, which seems to come naturally to him, here is a description of how he treated a child with Dysentery:

> "I placed my hand on the back of the little fellow… in the region of the lumbar and found it very warm, even hot, while the abdomen was cold… then the neck and back of his head were very warm, and the face, nose, and forehead cold… I began to work at the base of the brain, and thought by pressure and rubbing I could push some of the hot to the cold places. While so doing I found rigid and loose places in the muscles and ligaments of the child's whole spine, while the lumbar region was in a very congested condition. I worked for a few minutes on that philosophy, and then told the

[174] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 372). Kirksville, MO: A.T. Still.

> mother to report to me the next day… She came early next morning with the news that her child was well." [175]

Still concludes that life, although we know it only through its manifestations, seems to be the *force* which animates all nature:

> "We speak of life, but know of it only as we see bodies move by life back of the visible matter. Does Nature have a finer matter that is invisible and that moves all that is visible to us? Life surely is a very finely prepared substance, which is the *all-moving force* of Nature, or that force that moves all nature from worlds to atoms. It seems to be a substance that contains all the principles of construction and motion, with the power to endow that wish it constructs with the attributes necessary to the object it has formulated from matter and sent forth as a living being." [176]

A question arises: Do we learn as Osteopaths to work with this *force*?

• As we just pointed out, A.T. Still is mentioned as an extraordinary man with extraordinary healing skills. Still said to have mastered the art of anatomy, physiology and other science-based applications at the time, which he used to diagnose and treat his patients.
Additionally, Still seemed to possess some exceptional extrasensory capabilities, C. Trowbridge mentions in her book:

> "Before William Roentgen's discovery of the X-ray machine, visualization, good observation skills, a delicate sense of touch -and that perpetual image- were the only tools Still had to assist him in detecting the abnormal from the normal. He also claimed to see aura around all of his patients - vibrations emanating from the body - giving him additional clues about his patients' conditions."[177]

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[175] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 120). Kirksville, MO: A.T. Still.

[176] Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy* (p. 256). Kansas City, MO: A.T. Still.

[177] Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917* (pp. 176). Kirksville, MO: The Thomas Jefferson University Press.

Knowing that few questions arise: Does it take extrasensory skills to be an osteopath? Does one have to have a philosophical mind to be able to perform as Still had in mind?

• All the clues indicate to us that Still had an exceptional approach to exercise and deliver his healing method. From using the force to embracing the philosophical mindset, from dwelling in the endless fountain of knowledge to seeking the union between terrestrial and celestial realms and from dissection room to the physiology books.
Still wishes that the osteopath works with this 'highest known principle' and makes use of it but as mentioned before he leaves no instructions. In the section 'questions to the Osteopath', he asks very specific questions. Questions that suggest that the osteopath should deal and work with these forces and make use of them for the benefit of his patients.

> "We have given a few thoughts on this line of life, hoping the osteopath will take up the subject and travel a few miles farther towards the fountain of this great source of knowledge and apply the results to the relief and comfort of the afflicted who come for counsel and advice." [178]

Not only Still leaves no guidelines behind when it comes to techniques, he also urges the osteopath to be more than just a manual therapist, he urges the osteopath to be a philosopher. All the above-mentioned points are critical to consider and re-evaluate the nowadays osteopathic education model.

Questions arise: Is the current osteopathic education following the footsteps of A. T. Still? Are the students of osteopathy being given the right guidelines also on the spiritual path? Is this model of osteopathic education the same model that Still envisioned? Is it sufficient to merge osteopathy with science only or should a more holistic educational approach be included? Is osteopathy compatible with the 'mainstream' scientific paradigm, or should osteopathic schools also look into the alternative healing sector?

• Still's approach, his personality and the factors that shaped him, eventually gave birth to a healing art, philosophy and medical science in the shape of osteopathy.

[178] Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy* (p. 258). Kansas City, MO: A.T. Still.

For him osteopathy was not just a therapeutic approach that he wanted to be adopted commercially, it was clear from his writings that osteopath should be more than just a therapist. He was both a practitioner and a philosopher, for him the search did not end at the borders of the physical body and went beyond to the divine, celestial dimension. He, therefore, developed an approach where there was no separation between the material, physical, spiritual and philosophical levels.

> "The osteopath finds here the field in which he can dwell forever. His duties as a philosopher admonish him that life and matter can be united, and that union cannot continue with any hindrance to free and absolute *motion*." [179]

We clearly can tell that Still's legacy to the osteopath should also contain the philosophical mind. It seemed very essential to him.
The question asked hereby: does nowadays osteopath have the tools to *osteopathize* [180] ? Do the current educational facilities provide such skills?

[179] Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy* (p. 250). Kansas City, MO: A.T. Still.

[180] We refer to the term *osteopathize* as defined in chapter 5.1.1.

7. Conclusion

The research of the topic of intrinsic movement in the human body as a hierarchical system brought us into an unexpected place: despite how firmly we were originally holding the idea of the intrinsic movement of tissues and organs as a direct palpatory phenomenon for an osteopath to feel, during the process of writing this thesis it somewhat dissolved in our hands.

After exploring the movement phenomenon in the human body as a complex system with its hierarchical organization and integrating our findings with the concept of embryogenesis as a process driven by the biodynamic forces, we came to a realization, that movement has its undoubtable role in living organisms, in their 'living anatomy'. Nevertheless, for a palpating osteopath it is probably more beneficial to keep in mind that behind every movement there is a force that leaves an imprint on the tissues, whether in form, structure or way of functioning and consequently the quality of its production.
At the same time, the analysis of Still's texts brought similar conclusions: on one hand, the term *force* as a force behind every movement / motion / action is very important, on the other hand the freedom of movement / motion of the fluids of the body is the basis for the expression of the inherent self-healing forces. Nevertheless, for the palpating osteopath it is the evaluation of the *form* of tissues and organs which is leading him to the cause of its abnormality.
By re-integrating the term *form*, the interdependent triangle structure – function – form is created which is analogous to one of Blechschmidt's basic concepts of embryogenesis, that is: 'development of position, form and structure emerge in unity as forming movements or forming functions'. Considerations about the form of tissues and organs can be, in nowadays osteopathic practice, translated into considerations about *tissue quality*.

Our research posed to us several questions as well:
Does it make sense to study different movement phenomena (as RI, PRM, motility) in the context of the hierarchical organization of the body in order to provide a holistic image of such phenomena?
Does the focus on tissue quality rather than on mobility bring the practising osteopath closer to the idea of *osteopathizing*?
Is the principle of *osteopathizing* transferable as a concept in osteopathic education?

It is clear from the writings of A.T. Still that for him the origins of motion are manifestations of the highest known principle, the invisible, underlying force of life. Although the message we perceived from Still is clear, it remains hard to grasp and somewhat difficult to be applied on nowadays scientific approach, in our case the medical research.
Despite this seeming incompatibility, we see a high value in Still's writings as they engage and encourage the osteopathic mindset to go and explore beyond the familiar scientific dimensions and expose the reader to another manner of working and thinking: to *osteopathize*.

"Here you lay aside the long words and use your mind in deep and silent earnestness; drink deep from the eternal fountain of reason, penetrate the forests of that law whose beauties are life and death." [181]

[181] Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy* (p. 179).

Glossary

axial process: a part of the ectoderm which is invaginated into the inner tissue of the entocyst disc; by its retarded growth the axial process obtains importance for the total folding of the entocyst disc

basal membrane: a thin sheet of specialized extra-cellular matrix adjacent to any lining tissue (epithelium, endothelium and mesothelium)

biodynamics: dynamic aspects of forces acting in ontogeny, with respect to the fluctuating mechanical equilibrium of metabolic processes in the developing organism

biokinetics: the kinetic, spatio-temporal aspects of the development of the organism

bulk water: water of a certain volume where water molecules exhibit certain organization and behaviour; a term used to oppose other organization of water molecules while in interaction, which can change its properties

epithelial cells: cells of lining tissue originated in ento- / ectoderm

flexion – extension phase: refers to the expression of the mobility of the synchondrosis spheno-basilaris under the influence of the fluctuation of the LCS

gel – sol phase: a phenomenon of rhythmical change in viscosity of the extra-cellular matrix in relation to rhythmical changes of flexion – extension phase of PRM

homeostasis: the tendency towards a relatively stable equilibrium between interdependent elements, especially as maintained by physiological processes

interstitium: a network of collagen fibers and fluid-filled spaces that surrounds the effective cells of the tissue or organ

limiting tissues: in early development, the intervening layer of usually wedge-shaped cells between a fluid on one side and inner tissue on the other; can be seen as an equivalent term to ectoderm and entoderm

lining tissue: tissue formed by a coherent row of cells lining a space or cavity; can have an origin in ectoderm or entoderm forming an epithelium (inner lining of the gut tube, glands, etc.) or in mesoderm forming an endothelium (inner lining of vessels) or mesothelium (a lining around body cavities)

mesenchymal tissues: embryonal inner tissue, embryonal mesoderm

metabolic flow movement: submicroscopic material movement in a morphologically definable metabolic field

motility: term used in regular medicine for the phenomenon of gut peristalsis; it is used in osteopathy as well but with a different meaning. Generally could be described as an expression of cells, tissues and organs in the form of intrinsic movement, nevertheless the different attempts to enforce this phenomenon by e.g. the events in embryological development, etc. lead to different concepts and made the use of this term quite ambiguous even within the osteopathic community.

motricity: movement expression of contractile elements of the tissue / organ affected by a motor impulse sent efferently down a nerve

notochord: the column of cells arising from the axial process

permeability: refers to characteristics of tissue determined by the ratio of water and matrix in the connective tissues; with higher water content and lower matrix content the permeability increases

primary respiratory mechanism: the effect of *Breath of life* on one's anatomy and physiology being manifested through five aspects: the fluctuation of LCS, the motility of central nervous system, behaviour of reciprocal tension membrane, the mobility of cranial bones and involuntary mobility of the sacrum in respect to the ilia. Its rhythm is described around 2,5 cycles p/min.

primordia: a temporary formation that is a prerequisite for the determination of later developmental processes

rhythmic impulse: palpable rhythmical movement described as an expression possibility of PRM; according to current studies the CRI phenomenon is still poorly understood and its origin remains unknown

somites: the rounded, block-like appearance of the body wall in the back of the embryo manifesting the subdivision of paraxial mesoderm in a vertical sense

spindle axis: the axis of the spindle apparatus, which appear by stretching the space between two centrioles of the centrosome during the cell division

subarachnoid space: space between arachnoid sheet and pia mater in the cranium and vertebral column, it is filled with LCS

valence shell: the outer shell of the atom where the valence electrons are orbiting, ready to be shared with other atoms. In order to gain the most stability, each atom desires to have 8 electrons in its valence shell.

viscosity: refers to characteristics of tissue determined by the ratio of water and matrix in the connective tissues; with lower water content and higher matrix content the viscosity increases

Bibliography

American Dictionary of the English Language. (n.d.). Retrieved October 24, 2020, from http://webstersdictionary1828.com/

Analogy. (2020, June 09). Retrieved July 17, 2020, from https://en.wikipedia.org/wiki/Analogy

Animal magnetism. (2020, October 18). Retrieved October 24, 2020, from https://en.wikipedia.org/wiki/Animal_magnetism

Anstey, J. (2009). *Hands-on Healing: The Patient-Osteopath Interaction* (Unpublished master's thesis). Académie Sutherland d'Ostéopathie du Québec. Retrieved September 25, 2020, from http://www.academiesutherland.com/pdfs/Thesis_Jennie.pdf

Aristotle, & Graham, D. W. (1999). *Aristotle, Physics, book VIII*. Oxford: Clarendon Press.

Bailey, R. (2019, June 25). What Is Phrenology? Definition and Principles. Retrieved October 24, 2020, from https://www.thoughtco.com/phrenology-definition-4688606

Barral, J. P., & Mercier, P. (2006). *Visceral manipulation*. Seattle: Eastland Press.

Bassingthwaighte, J. B., Liebovitch, L. S., & West, B. J. (1994). *Fractal physiology*. New York: Oxford University Press.

Beal, M. C. (1983). Palpatory testing for somatic dysfunction in patients with cardiovascular disease. *Journal of AOA, 82*(11), 822-830.

Behrens, A. (2007). *Visceral Motility: Which osteopathic approaches are there, and how are they implemented ?* (Unpublished master's thesis). Donau Universität Krems. Retrieved July 19, 2020, from http://www.osteopathic-research.com/paper_pdf/BehrensAndreas.pdf

Benias, P. C., Wells, R. G., Sackey-Aboagye, B., Klavan, H., Reidy, J., Buonocore, D., Theise, N. D. (2018). Structure and Distribution of an Unrecognized Interstitium in Human Tissues. *Scientific Reports, 8*(1), 1-8. doi:10.1038/s41598-018-23062-6

Berg, J. (2002, January 01). Chemical Bonds in Biochemistry. Retrieved July 27, 2020, from https://www.ncbi.nlm.nih.gov/books/NBK22567/

Bhave, G., & Neilson, E. G. (2011). Body Fluid Dynamics: Back to the Future. *Journal of the American Society of Nephrology, 22*(12), 2166-2181. doi:10.1681/asn.2011080865

Bible hub. (n.d.). Retrieved October 24, 2020, from https://biblehub.com/greek/979.htm

Blechschmidt, E. (2004). *The ontogenetic basis of human anatomy a biodynamic approach to development from conception to birth*. Berkeley, CA: North Atlantic.

Blechschmidt, E., & Gasser, R. F. (2012). *Biokinetics and biodynamics of human differentiation: Principles and applications*. Berkeley, CA: North Atlantic Books.

Bordoni, B., Marelli, F., Morabito, B., & Castagna, R. (2018). A New Concept of Biotensegrity Incorporating Liquid Tissues: Blood and Lymph. *Journal of Evidence-Based Integrative Medicine, 23*. doi:10.1177/2515690x18792838

Bordoni, B., Marelli, F., Morabito, B., & Sacconi, B. (2017). The indeterminable resilience of the fascial system. *Journal of Integrative Medicine, 15*(5), 337-343. doi:10.1016/s2095-4964(17)60351-0

Brand, R. A. (1992). Autonomous informational stability in connective tissues. *Medical Hypotheses, 37*(2), 107-114. doi:10.1016/0306-9877(92)90050-m

Chaitow, L. (2002). Osteopathic Assessment and Treatment of Thoracic and Respiratory Dysfunction. *Multidisciplinary Approaches to Breathing Pattern Disorders*, 131-172. doi:10.1016/b978-044307053-2.50010-1

Chaplin, M. (n.d.). Water Structure and Science. Retrieved August 01, 2020, from http://www1.lsbu.ac.uk/water/water_structure_science.html

Chemical Composition of the Body - Biology Online Tutorial. (2020, August 11). Retrieved October 15, 2020, from https://www.biologyonline.com/tutorials/chemical-composition-of-the-body

Chemical polarity. (2020, June 05). Retrieved July 16, 2020, from https://en.wikipedia.org/wiki/Chemical_polarity

Chen, C. S., & Ingber, D. E. (1999). Tensegrity and mechanoregulation: From skeleton to cytoskeleton. *Osteoarthritis and Cartilage*, *7*(1), 81-94. doi:10.1053/joca.1998.0164

Chvátal, L. (2010). *Pohyb lidské existence. Studie k pojetí „pohybu“ (kinésis) u Maxima Vyznavače (580-662)* (Unpublished doctoral dissertation). Charles University in Prague.

Cohen, I. B., & Smith, G. E. (2002). *The Cambridge companion to Newton*. New York: Cambridge University Press.

Complex system. (2020, August 18). Retrieved August 18, 2020, from https://en.wikipedia.org/wiki/Complex_system

Delange, C. (2015). *THE ROLE OF “WATER” IN THE BODY and the Relevance to Osteopathic Treatment* (Unpublished master's thesis). Académie Sutherland d'Ostéopathie du Québec. Retrieved July 19, 2020, from http://www.academiesutherland.com/pdfs/Carla_Delange.pdf

Denzin, N. K., & Lincoln, Y. S. (2018). *The Sage handbook of qualitative research*. Los Angeles: Sage.

Dictionary by Merriam-Webster: America's most-trusted online dictionary. (n.d.). Retrieved October 24, 2020, from https://www.merriam-webster.com/

Diffusion. (2020, June 23). Retrieved July 16, 2020, from https://en.wikipedia.org/wiki/Diffusion

Douglas, R. (2017, January 31). A nine-year-old boy with wonky teeth. Retrieved July 17, 2020, from https://www.linkedin.com/pulse/nine-year-old-boy-wonky-teeth-max-girardin/

Douglas, R. (2017, January 31). The Philosophy and Mechanical Principles of Osteopathy. Retrieved July 17, 2020, from https://www.linkedin.com/pulse/philosophy-mechanical-principles-osteopathy-max-girardin

Encyclopaedia Britannica. (2020, May 27). Transcendentalism. Retrieved October 05, 2020, from https://www.britannica.com/event/Transcendentalism-American-movement

Enthalpy: Definition of Enthalpy by Oxford Dictionary on Lexico.com also meaning of Enthalpy. (n.d.). Retrieved July 16, 2020, from https://www.lexico.com/en/definition/enthalpy

Entropie. (2020, June 12). Retrieved July 17, 2020, from https://cs.wikipedia.org/wiki/Entropie

Entropy and Life. (2013, February 14). Retrieved July 17, 2020, from https://letstalkaboutscience.wordpress.com/2013/02/14/entropy-and-life/

Ettinger, L., & Doljanski, F. (1992). On The Generation Of Form By The Continuous Interactions Between Cells And Their Extracellular Matrix. *Biological Reviews, 67*(4), 459-489. doi:10.1111/j.1469-185x.1992.tb01190.x

Flatscher, M., Girardin, M., Kaschowitz, G., Liem, T., McKone, W. L., Nagel, M., . . . Wührl, P. (2008). *Theorien osteopathischen Denkens und Handelns*. Stuttgart: Hippokrates.

Freeman, B. (2003). The active migration of germ cells in the embryos of mice and men is a myth. *Reproduction, 125*(5), 635-643. doi:10.1530/reprod/125.5.635

Freeman, B. (2010, July 3/4). *Human Embryology from a Biodynamic Perspective*. Lecture, Bath, UK.

Freeman, B. (2016). The Conceptus and its Parts: Ontogenetic Recapitulation in Early Human Development. *Journal of Clinical Developmental Biology, 1*(1), 1-5.

Fryer, G. (2016). Somatic dysfunction: An osteopathic conundrum. *International Journal of Osteopathic Medicine, 22*, 52-63. doi:10.1016/j.ijosm.2016.02.002

Fuller, R. B. (1975). *Synergetics: Explorations in the geometry of thinking*. New York: Macmillan.

Geodesic geometry. (n.d.). Retrieved July 16, 2020, from https://encyclopediaofmath.org/wiki/Geodesic_geometry

Guimberteau, J. C., Delage, J. P., Mcgrouther, D. A., & Wong, J. K. (2010). The microvacuolar system: How connective tissue sliding works. *Journal of Hand Surgery (European Volume), 35*(8), 614-622. doi:10.1177/1753193410374412

Heylighen, F. (2007). *Complexiteit en Evolutie*. Manuscript, Brussel. Retrieved 2020, from http://pespmc1.vub.ac.be/books/CursusHeylighen.pdf

Huang, S., Sultan, C., & Ingber, D. E. (2006). Tensegrity, Dynamic Networks, and Complex Systems Biology: Emergence in Structural and Information Networks Within Living Cells. *Topics in Biomedical Engineering International Book Series Complex Systems Science in Biomedicine,* 283-310. doi:10.1007/978-0-387-33532-2_11

Intrinsic Definition and Examples - Biology Online Dictionary. (n.d.). Retrieved September 17, 2020, from https://www.biologyonline.com/dictionary/intrinsic

Intrinsic. (n.d.). Retrieved September 17, 2020, from https://www.merriam-webster.com/dictionary/intrinsic

Introduction to entropy. (2020, May 06). Retrieved July 16, 2020, from https://en.wikipedia.org/wiki/Introduction_to_entropy

Jealous, J. (2010). BLECHSCHMIDT: AN EMBRYOLOGY SUITED TO OSTEOPATHY. *SUTHERLAND CRANIAL COLLEGE Magazine,* (32), 10-11. Retrieved October 7, 2020, from http://drawingonanatomy.com.au/newsD/32NewsletterAutumn10.pdf

Kamm, R. D. (2002). Cellular fluid mechanics. *Annual Review of Fluid Mechanics, 34*, 211-232. Retrieved October 14, 2020, from www.annualreviews.org

Kerst, A., Chmielewski, C., Livesay, C., Buxbaum, R. E., & Heidemann, S. R. (1990). Liquid crystal domains and thixotropy of filamentous actin suspensions. *Proceedings of the National Academy of Sciences, 87*(11), 4241-4245. doi:10.1073/pnas.87.11.4241

Kraml, M. M., & Besse, J. (2019). The Role of Mental Imagery in Osteopathic Palpation: A qualitative study. *European Journal of Osteopathic Research, 1*(1), 17-27. doi:10.35740/ejor.2019.1.1.3

Lee, R. P. (2008). The Living Matrix: A Model for the Primary Respiratory Mechanism. *Explore, 4*(6), 374-378. doi:10.1016/j.explore.2008.08.003

Lewis, J. (2010). Brian Freeman speaks to John Lewis. Retrieved August 03, 2020, from http://www.drawingonanatomy.com.au/newsD/32NewsletterAutumn10.pdf

Losa, G. A. (2016, November 10). Fractals and their contribution to biology and medicine. Retrieved September 02, 2020, from

https://www.medicographia.com/2013/01/fractals-and-their-contribution-to-biology-and-medicine/

Mammoto, T., & Ingber, D. E. (2010). Mechanical control of tissue and organ development. *Development, 137*(9), 1407-1420. doi:10.1242/dev.024166

Mayer-Fally, E., & Knox, C. (2019). The River of Life: Flüssigkeiten in der Osteopathie. *DO - Deutsche Zeitschrift Für Osteopathie, 17*(02), 4-11. doi:10.1055/a-0830-3482

McPartland, J. M., & Skinner, E. (2005). The biodynamic model of osteopathy in the cranial field. *Explore, 1*(1), 21-32. doi:10.1016/j.explore.2004.10.005

MEFANET, S. (n.d.). Entropie živých systémů. Retrieved July 17, 2020, from https://www.wikiskripta.eu/w/Entropie_%C5%BEiv%C3%BDch_syst%C3%A9m%C5%AF

Mercola, M. (2003). Left-right asymmetry: Nodal points. *Journal of Cell Science, 116*(16), 3251-3257. doi:10.1242/jcs.00668

Mewis, J., & Wagner, N. J. (2009). Thixotropy. *Advances in Colloid and Interface Science, 147/148*, 214-227. doi:10.1016/j.cis.2008.09.005

Mitchell, H. H., Hamilton, T. S., Steggerda, F. R., & Bean, H. W. (1945). The chemical composition of the adult human body and its bearing on the biochemistry of growth. *Journal of Biological Chemistry, Vol.168*, 625-637. Retrieved July 27, 2020, from https://www.jbc.org/content/158/3/625.full.pdf

Motion Definition and Examples - Biology Online Dictionary. (n.d.). Retrieved August 25, 2020, from https://www.biologyonline.com/dictionary/motion

Motion. (2020, August 26). Retrieved August 27, 2020, from https://en.wikipedia.org/wiki/Motion

Motion. (n.d.). Retrieved August 27, 2020, from https://www.merriam-webster.com/dictionary/motion

Movement Definition and Examples - Biology Online Dictionary. (2020, June 23). Retrieved August 25, 2020, from https://www.biologyonline.com/dictionary/movement

Movement. (n.d.). Retrieved August 25, 2020, from https://www.merriam-webster.com/dictionary/movement

Muts, R. (2020, August 19). Vraag over osteopathie wetten [E-mail to the author].

Newton, I., Cohen, I. B., & Whitman, A. M. (1999). *The Principia: Mathematical principles of natural philosophy*. Berkeley: University of California Press.

Oschman, J. L. (2009). Charge transfer in the living matrix. *Journal of Bodywork and Movement Therapies, 13*(3), 215-228. doi:10.1016/j.jbmt.2008.06.005

Paoletti, S. (2006). *The fasciae: Anatomy, dysfunction and treatment*. Seattle: Eastland Press.

Pflüger, C. (2008). *The Meaning of Tensegrity Principles for Osteopathic Medicine* (Unpublished master's thesis). Donau University Krems. Retrieved July 19, 2020, from http://www.osteopathic-research.com/paper_pdf/Pflueger.pdf

Philosophiæ Naturalis Principia Mathematica. (2020, June 30). Retrieved July 17, 2020, from https://en.wikipedia.org/wiki/Philosophi%C3%A6_Naturalis_Principia_Mathematica

Rules of reasoning in Philosophy. (n.d.). Retrieved June 07, 2020, from https://apex.ua.edu/uploads/2/8/7/3/28731065/four_rules_of_reasoning_apex_website.pdf

Rutkowski, J. M., & Swartz, M. A. (2007). A driving force for change: Interstitial flow as a morphoregulator. *Trends in Cell Biology, 17*(1), 44-50. doi:10.1016/j.tcb.2006.11.007

Sachs, J. (n.d.). Aristotle: Motion and its Place in Nature. Retrieved August 27, 2020, from https://iep.utm.edu/aris-mot/

Scarr, G. (2011). Helical tensegrity as a structural mechanism in human anatomy. *International Journal of Osteopathic Medicine, 14*(1), 24-32. doi:10.1016/j.ijosm.2010.10.002

Seidel, J. V. (1998). Qualitative Data Analysis. Retrieved September 24, 2020, from http://eer.engin.umich.edu/wp-content/uploads/sites/443/2019/08/Seidel-Qualitative-Data-Analysis.pdf

Sergueef, N. (2007). *Cranial Osteopathy for Infants, Children and Adolescents*. Churchill Livingstone.

Shaban, M. (2019, July 07). Newton's "Four Rules of Reasoning" in Philosophy. Retrieved July 17, 2020, from https://blogofthecosmos.com/2016/01/27/mortals-rejoice-at-so-great-an-ornament-of-the-human-race/

Shea, M. J. (2013). *Biodynamic Craniosacral Therapy, Volume Five*. North Atlantic Books.

Sibbings, D. (2016). *Die Entwicklung des Verständnisses von „Palpation“ in der historischen osteopathischen Literatur von A.T. Still, W.G. Sutherland und R. Becker* (Unpublished master's thesis). DAOM, Münster.

Spencer, H. (1862). *First Principles*. London: Williams and Norgate.

Spiritualism. (2020, August 31). Retrieved October 06, 2020, from https://en.wikipedia.org/wiki/Spiritualism

Starosta, W. (2001). SCIENCE OF HUMAN MOVEMENTS – MEANING, NAME, DIRECTIONS OF DEVELOPMENT. *JOURNAL OF HUMAN KINETICS, 6*, 3-22.

Still, A. T. (1897). *Autobiography of Andrew T. Still: With a history of the discovery and development of the science of osteopathy, together with an account of the ... School of Osteopathy*. Kirksville, MO: A.T. Still.

Still, A. T. (1899). *Philosophy of Osteopathy*. Kirksville, MO: A.T. Still.

Still, A. T. (1902). *THE PHILOSOPHY and MECHANICAL PRINCIPLES of OSTEOPATHY*. Kansas City, Missouri.: HUDSON-KIMBERLY PUB.

Still, A. T. (1902). *The Philosophy and Mechanical Principles of Osteopathy*. Kansas City, MO: A.T. Still.

Still, A. T. (1910). *Osteopathy, research and practice*. Kirksville, MO: A.T. Still.

Stubbings, J. (n.d.). Spontaneous Reactions: Enthalpy and Entropy Chemistry Tutorial. Retrieved July 17, 2020, from https://www.ausetute.com.au/spontaneous.html

Tadeo, I., Berbegall, A. P., Escudero, L. M., Noguera, R., & Alvaro, T. (2014). Biotensegrity of the Extracellular Matrix: Physiology, Dynamic Mechanical Balance, and Implications in Oncology and Mechanotherapy. *Frontiers in Oncology, 4*. doi:10.3389/fonc.2014.00039

Tozzi, P. (2014). Does fascia hold memories? *Journal of Bodywork and Movement Therapies, 18*(2), 259-265. doi:10.1016/j.jbmt.2013.11.010

Tozzi, P. (2015). A unifying neuro-fasciagenic model of somatic dysfunction – Underlying mechanisms and treatment – Part I. *Journal of Bodywork and Movement Therapies, 19*(2), 310-326. doi:10.1016/j.jbmt.2015.01.001

Tozzi, P. (2015). A unifying neuro-fasciagenic model of somatic dysfunction – Underlying mechanisms and treatment – Part II. *Journal of Bodywork and Movement Therapies, 19*(3), 526-543. doi:10.1016/j.jbmt.2015.03.002

Trowbridge, C. (1991). *Andrew Taylor Still 1828-1917*. Kirksville, MO: The Thomas Jefferson University Press.

Venegas-Gomez, A. (2014). The Thermodynamics of the living organisms: Entropy production in the cell. doi:10.13140/2.1.1573.7284

Wal, J. V. (2000). Embryo in Beweging en Eurythmie. Retrieved August 03, 2020, from https://www.embryo.nl/upload/documents/artikelen-embryosofie/Embryo%20in%20Beweging%20en%20Eurythmie%202000%20NL%20artikel.pdf

Webster's 1913. (n.d.). Retrieved October 24, 2020, from https://www.websters1913.com/

Yao, W., Li, Y., & Ding, G. (2012). Interstitial Fluid Flow: The Mechanical Environment of Cells and Foundation of Meridians. *Evidence-Based Complementary and Alternative Medicine, 2012*, 1-9. doi:10.1155/2012/853516

γέννηση. (n.d.). Retrieved October 24, 2020, from https://en.wiktionary.org/wiki/%CE%B3%CE%AD%CE%BD%CE%BD%CE%B7%CF%83%CE%B7

Bibliography of used figures

Burla, F., Mulla, Y., Vos, B. E., Aufderhorst-Roberts, A., & Koenderink, G. H. (2019). From mechanical resilience to active material properties in biopolymer networks. *Nature Reviews Physics, 1*(4), 249-263. doi:10.1038/s42254-019-0036-4

ECM. (n.d.). Retrieved September 04, 2020, from http://apbiocellorganelles.weebly.com/ecm.html

Guimberteau, J. C., Delage, J. P., Mcgrouther, D. A., & Wong, J. K. (2010). The microvacuolar system: How connective tissue sliding works. *Journal of Hand Surgery (European Volume), 35*(8), 614-622. doi:10.1177/1753193410374412

Haxton, J. (2015). Still: Through the Eyes of Ernest E. Tucker. *The Osteopathyst, 3*, 13.

Hou, S. (2016, April 16). Fibrous Gel. Retrieved September 04, 2020, from https://openwetware.org/wiki/Fibrous_Gel,_by_Singyuk_Hou

Ieva, A. D., Grizzi, F., Jelinek, H., Pellionisz, A. J., & Losa, G. A. (2013). Fractals in the Neurosciences, Part I: General Principles and Basic Neurosciences. *The Neuroscientist, 20*(4), 403-417. doi:10.1177/1073858413513927

Jones, C. (2014). Exploring Protein Interactions In Budding Yeast. Retrieved October 26, 2020, from http://allthingsgraphed.com/2014/09/25/yeast-protein-network/

Kabai, S. (2007, April 27). Wolfram Demonstrations Project. Retrieved September 08, 2020, from https://demonstrations.wolfram.com/IcosahedronFractal/

OpenStax, L. (n.d.). Anatomy and Physiology I. Retrieved September 28, 2020, from https://courses.lumenlearning.com/ap1/chapter/chemical-bonds/

Scarr, G. (2010). Simple geometry in complex organisms. *Journal of Bodywork and Movement Therapies, 14*(4), 424-444. doi:10.1016/j.jbmt.2008.11.007

Scarr, G. (2020, April 06). The barre essentials of life. Retrieved October 22, 2020, from http://www.tensegrityinbiology.co.uk/biology/

Tavakoli, A., & Gisin, N. (2020). The Platonic solids and fundamental tests of quantum mechanics. *Quantum*, *4*, 293. doi:10.22331/q-2020-07-09-293

Textbook-specific videos for college students. (2020). Retrieved September 28, 2020, from https://www.clutchprep.com/chemistry/practice-problems/111613/co2-a-nonpolar-molecule-and-h2o-a-polar-molecule-the-numbers-are-electronegativi

Vaňhara, P. (2014). Connective tissue, not only a tissue glue…. Retrieved October 03, 2020, from https://is.muni.cz/el/med/jaro2014/VSHE0221p/um/Connective_tissue_I_ENG_2014.pdf

Water Structure & Properties: Molecule & Physical Properties: A Level. (2020, March 27). Retrieved September 28, 2020, from https://alevelbiology.co.uk/notes/water-structure-properties/

What are anchoring junctions? (2018, February 05). Retrieved September 03, 2020, from https://www.mechanobio.info/what-is-mechanosignaling/what-are-cell-cell-adhesions/what-are-anchoring-junctions/

Wong, E. V. (2020, August 15). 13.1: Introduction to Extracellular Matrix and Cell Adhesion. Retrieved September 29, 2020, from https://bio.libretexts.org/Bookshelves/Cell_and_Molecular_Biology/Book:_Cells_-_Molecules_and_Mechanisms_(Wong)/13:_Extracellular_Matrix_and_Cell_Adhesion/13.01:_Introduction_to_Extracellular_Matrix_and_Cell_Adhesion