To know all of a bone in its entirety would close both ends of an eternity.
AT Still, Autobiography of Andrew T. Still

EVIDENCE-BASED OSTEOPATHIC PHILOSOPHY:

AN INDUCTIVE PARADIGM OF MEDICINE

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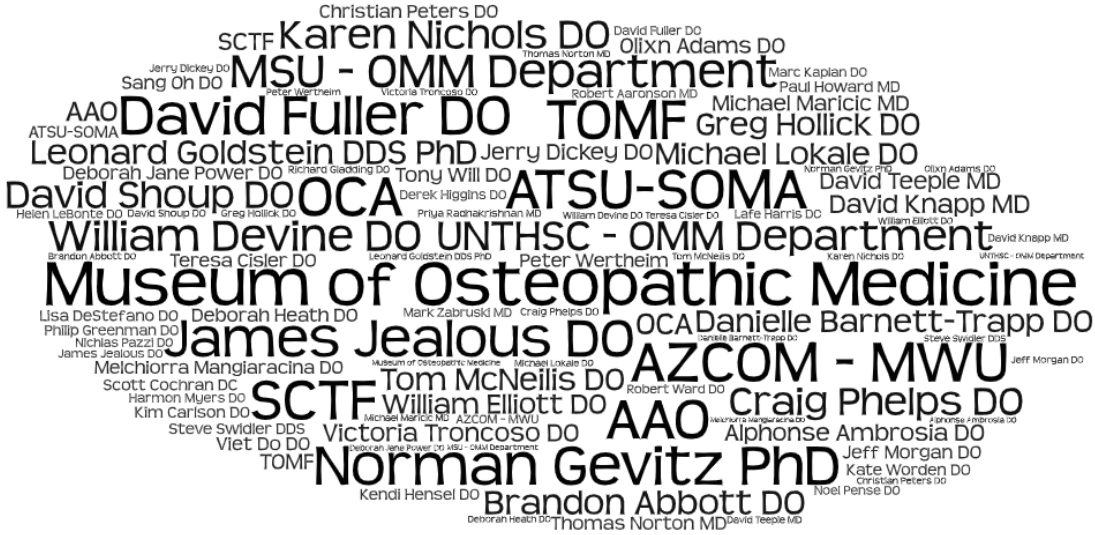
First e-book edition, 2023.

The views expressed within this work are solely the author's and do not reflect the opinions and beliefs of another party.

Disclosures: No financial interests or relationships to disclose.

Acknowledgements



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Forward – The Time to Act Is Now

DO's have a valuable opportunity to reinvigorate their professional identity and start a new journey forward into a flourishing future. In the past decades, DO's have successfully expanded their profession by embracing evidence-based medicine, increasing the annual number of DO graduates and participating in the same residency and fellowship programs as MD's. However, in focusing on these goals, the Osteopathic profession may have lost touch with their professional identity which is rooted in historical Osteopathic philosophy. A sense of identity is essential to a sense of wellbeing, of health, within both individuals and professions. When something has lost touch with its identity it is no longer aware of itself, no longer can care for itself, doesn't know if it is healthy or sick. Organizations without an identity do not offer a sense of purpose to their members and joining such organizations is pointless, a waste of valuable energy and time. If the term "Osteopathic" is enigmatic or uncertain, and lacks a clear identity, the American Osteopathic Association could be renamed the American Enigmatic Association, or the American Uncertainty Association.

As written by Norman Gevitz, PhD, "…an overriding question that osteopathic medicine needs to answer is whether it can carve out for itself a continuing and distinctive role in the American health care system and maintain its professional autonomy."[1] DO's can definitively answer this question by actively embracing a clear identity that unites the Osteopathic profession. With a clear identity and understanding of their role in the health care system and the wider society, the Osteopathic profession will be well positioned to respond to future challenges and opportunities including the impact of artificial intelligence and other technology on medical practice, and the effect of wider forces such as the environment and economic conditions on patient health. By creating a strong sense of membership, of inclusion in something worthwhile that goes

beyond the individual, DO's will be better able to successfully advocate for themselves in public policy debates and in the allocation of resources.

A clear identity for the Osteopathic profession must blend current evidence-based medical practice with historic Osteopathic philosophy. While most current evidence is deductive and narrowly applied to specific circumstances, Osteopathic philosophy provides an inductive framework in which to arrange individual facts, allowing a more useful conceptualization of current evidence to emerge. General and broad concepts such as life and health that are central to healthcare can be discussed in an evidence-based way. To paraphrase an old saying, Osteopathic philosophy helps us to see the forest, as well as the trees.

Osteopathic philosophy reveals that all medical care involves the body's structure. During a clinical exam, DO's use a stethoscope to listen to the structure of the body as a pulmonary wheeze indicates bronchoconstriction, a cardiac murmur indicates an abnormally structured valve, and a carotid bruit suggests narrowing of the artery. Abnormal lung sounds are followed up by a chest Xray which also evaluates the structure of the lung to identify areas where structure has been lost, such as an infiltrate. As the lung is an aggregation of inert carbon, hydrogen, oxygen and other atoms, all diagnosis of the lung evaluates the structure of the matter that forms the lung. Even labs, such as CBC and CMP, evaluate the structure or composition of the blood which itself is an aggregation of inert atoms. All diagnosis tries to identify disrupted structure in the body, and all forms of healing try to restore more normal, more functional structure to the body. This understanding is the heritage of the Osteopathic profession and is fully consistent with current evidence.

This text is offered as a bridge for current and future DO's, as evidence-based physicians, to establish a clear professional identity by returning to their historical roots, Osteopathic

philosophy. DO's and DO students must either celebrate their professional identify, or risk becoming a forgotten footnote in American medical history. By getting involved in local, state, and national Osteopathic professional organizations and by integrating Osteopathic concepts into their specialties and areas of practice, DO's and DO students can restore their identity and energize their profession. Osteopathic philosophy is not an archaic mystery to be forgotten, but rather the historical foundation of a future-oriented professional identity that should be celebrated.

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Summary of Evidence Based Osteopathic Tenets

Organisms/Life Forms are Aggregations of Matter in Motion

Organisms, or life forms, are aggregations of inert environmental matter (atoms and molecules) that has existed in the environment in forms such as water and carbon dioxide for billions of years. All life forms are primarily made of the same material: atoms of carbon, hydrogen, oxygen, nitrogen, and other elements. The differences between life forms results from differing arrangements of atoms within molecular structures that are aggregated to form organs, tissues, fluids, and other material components of each organism.

Life Expresses a Force That Puts Inert Environmental Matter in Motion

Life can be described as the sum of the homeostatic processes within a life form that exert a force to pull together, to aggregate, environmental matter to form a life form, an organism, a body. Matter, composed of atoms and molecules, cannot move without the influence of a force. In other words, the matter aggregating an organism does not self-assemble, just as the Moon would not orbit the Earth without the effect of gravity. While life does put inert matter into motion when aggregating an organism, the atoms involved do not change in the process. Life performs work to change the molecular structure of absorbed matter to form specific structures within the body, and to excrete matter back to the environment.

Death is the End of Homeostasis Leading to Complete Structural Entropy within the Life Form

Death is the ultimate proof that life expresses a force on environmental matter to aggregate a body. When an organism dies, the matter of which the organism is aggregated is no longer influenced by life's homeostatic forces. As a result, the formerly structured atoms and molecules aggregating the organism become completely entropic, all structures within the organism break down, and the matter of which those structures had been composed returns to the environment.

The Structure and Function of an Organism's Aggregated Matter are Related

Structure and function are linked in many scientific disciplines, and the structure of the aggregated matter within the organism determines its function. Matter aggregated in normal structure by the normal operation of life's homeostatic processes results in normal function of the organism. This concept applies to the both the internal functions of the organism which aggregate matter to form the organism (i.e., the formation of a femur), and the external functions which allow the organism to normally relate to its environment (i.e., walking on the femur). As structure improves or degrades, so does function; the reverse is also true, as function improves or degrades, so does structure.

Life is Health

The state of health is defined by the normal operation of life's homeostatic systems that absorb, excrete, and change the molecular structure of environmental matter to aggregate a normally structured and functional organism. The atoms and molecules that have been absorbed are aggregated in the normal structure of the organism resulting in normal function of the organism, both internally within the organism and externally in how the organism relates to its environment. This applies to all material components of the organism.

Morbidity Results from Loss of Structure Within an Organism

Morbidity results from the entropic loss of structure within the aggregated matter forming an organism, thus negatively affecting the organism's function. Morbidity can result directly from an external force such as a fall that disrupts an organism's structure or indirectly from a disruption of preexisting homeostatic process that results in abnormal aggregated structure. Morbidity does not result in a new homeostatic system in the body; either preexisting homeostatic processes are maintaining the organism's aggregated structure or they are not. As a result, all losses of structure

within the matter aggregated to form the organism are entropic, in other words are without an internal order, and lead to decreased function.

Detecting structural disorder, or entropy, within the formerly organized material structure of an organism is the foundation of all diagnostic modalities, including the clinical exam (visualization, auscultation, palpation, deep tendon reflexes, and others), imaging (X-ray, CT, MRI, US, DEXA), electrodiagnostics (EKG, EEG, NCS/EMG), and labs (CBC, CMP, lipids, cerebrospinal fluid, and others.) Based on the conceptualization of morbidity as structural entropy within an organism, pathology is the study of linking patterns of structural entropy, of disorder, within a life form's formerly organized aggregated matter with some level of dysfunction to establish a diagnosis.

Healing is a Return of Normal Homeostasis, Structure, and Function

When the structure of an organism is returned to normal, morbidity resolves and health is restored, both internally in homeostatically aggregating normal material structures and externally in interacting with the environment. Healing can occur either directly by restoring structure within the organism or indirectly by restoring the function of abnormal homeostatic systems that aggregate the normal structure of the organism. Healing ultimately results from the restoration of normal, preexisting structure and function within the organism.

No current form of healing creates a new homeostatic system in the body, whether pharmaceutical, surgical, manipulative, dietary, exercise or other. Any form of healing that creates a new homeostatic system in the body would be similar to a functional genetic mutation in the process of evolution that results in the aggregation of a new structure (ie a new protein) that would have a new function.

Healing, or the return to normal structure and function of the matter aggregating the body, can be perceived through clinical exam (i.e., when a pulmonary wheeze or cardiac murmur resolves), imaging (i.e., a bone fracture returns to normal appearance on X-ray), other diagnostic modalities (i.e., when an EKG normalizes or a PHQ-9 score improves), and palpation (i.e., when a physician can palpate the matter aggregating the body moving in space to return to normal structure and function).

CHAPTER 1 – Osteopathic Philosophy

The founder of Osteopathy, Andrew Taylor Still, experienced an insight in the late 1800's that led to a new perceptual understanding of life, health, morbidity, and healing (LHMH) and a new approach to clinical diagnosis and treatment. Over time, this insight developed into the foundation of Osteopathic philosophy. AT Still's clinical activity based on this insight resulted in the successful care of patients, and led to the establishment of the first Osteopathic medical school, the American School of Osteopathy, and the Osteopathic profession. More than 100 years later, much of Still's language expressing Osteopathic philosophy appears to the modern reader as subjective overgeneralizations expressed in vague language. As explained by Korr, due to historical circumstances and timing Still's "principles could only be expressed as aphorisms, embellished perhaps with conjectures about their biological basis."[1] With subsequent advances in science, perhaps the time has come when Still's principles can be supported and exemplified by reviewing current evidence.

To begin the process of melding the historic language of Osteopathic philosophy with current evidence-based terminology, below is a selection of AT Still writings that expresses the basic concepts of Osteopathic philosophy:

- *… life is matter in motion.*[2]
- *To find health should be the object of the doctor. Anyone can find disease.*[2]
- *When all parts of the human body are in line we have health. When they are not the effect is disease. When the parts are readjusted disease gives place to health. The work of the osteopath is to adjust the body from the abnormal to the normal, then the abnormal conditions give place to the normal and health is the result of the normal condition.*[3]

- *If health is perfect, it only proves perfect harmony in the physiological action of the body in all its parts and functions. Any variation from perfect health marks a degree of functional derangement in the physiologic department of man. Efforts at restoration from the diseased to the healthy condition should present but one object to the mind, and that is to explore minutely and seek the variation from normal.*[2]

AT Still also wrote, "To know all of a bone in its entirety would close both ends of an eternity." [4] To help pursue this goal of knowing a bone in its entirety, and to outline how Osteopathic philosophical principles are supported by current evidence and can be applied to all aspects of current medical care, this paper will generally focus on the elemental metal, calcium, and its role in bone formation.

A wide review of current literature was performed to identify current evidence relating to:

1. the physics of matter in motion,
2. the formation of matter,
3. the distribution of matter throughout the universe,
4. the formation of molecules.
5. the relationship between molecular structure and function,
6. the beginning of life,
7. the state of health,
8. the aggregation of bone,
9. morbidity in bone,
10. bone healing,
11. and the decomposition of bones after an organism's death.

Inductively linking these discrete, deductive facts will clearly explain Osteopathic philosophy, revealing a new evidence-based perception of LHMH. Additionally, Osteopathic philosophy points toward a new paradigm of science, exploring what within life forms may not be composed of matter.

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CHAPTER 2 – Physics and The Formation of Environmental Matter

To begin the process of reviewing how life forms or organisms are formed through the aggregation of environmental matter by life's homeostatic processes, a brief review of the physics describing the motion of matter is necessary. In both AT Still's writings and this work, "matter" refers to "atoms" and "molecules." A central tenet of modern physics is that matter does not move until influenced by a force; matter within a life form is also subject to this rule. A "force", like gravity or electromagnetic fields, is defined as "strength or energy exerted or brought to bear: cause of motion or change: active power."[1] "Work" is defined as, "an activity in which one exerts strength or faculties to do or perform something,"[1] or more specifically the transfer of energy by a force acting on an object as it is displaced. Homeostatic processes within life forms express a force that performs work on absorbed environmental matter, either by moving matter through space or changing matter's molecular structure. Atoms are neither created nor destroyed by these homeostatic processes, rather the molecular structure of absorbed matter is changed.

While matter appears solid and enduring to our senses, atoms are aggregations of energy particles that did not always exist. Current evidence suggests that matter was formed following the Big Bang when quarks and other elementary particles bonded together, or aggregated, to produce protons and neutrons, the building blocks of atomic nuclei. After the first atomic nuclei formed, electrons became trapped in orbits around the nuclei to form atoms, the first forms of matter, mostly helium and hydrogen. All the other types of atoms in existence were formed later from existing helium and hydrogen through the process of fusion generated by the extreme gravitational force within collapsing stars called supernova.

> Present observations suggest that the first stars formed from clouds of gas around 100-200 million years after the Big Bang. Heavier atoms such as carbon, oxygen and iron [and calcium], have since been continuously produced in the hearts of stars and catapulted throughout the universe in spectacular stellar explosions called supernova.[2]

Supernova explosions result in the formation of a nebula, a vast cloud of new forms of atomic matter, including calcium, that had been aggregated through fusion reactions.[3] Our Solar System (including the Sun, the planets, moons, comets, asteroids, objects in the Oort Cloud or Kuiper Belt) was formed when a nebula (the Solar Nebula), within which calcium was widely distributed, collapsed due to explosion of another nearby supernova[4]. Calcium has been found on every planet human beings have explored in the Solar System. Calcium is the fourth most common element in lunar dust[5], has been identified remotely on Mars,[6] and is the fifth most abundant metal in the Earth's crust composing up to 4.2% of the crust by weight.[7]

Once atoms, such as carbon, hydrogen, oxygen, and calcium, have been formed, the next step in aggregating a life form is the formation of molecules, essentially arrangements of atoms in a specific structure. The first molecule to form after the Big Bang has been theorized to be helium hydride, a combination of helium and hydrogen, and was recently identified astronomically. Helium hydride (HeH+) is thought to be integral in the development of the first hydrogen molecule which is composed of two bonded hydrogen atoms: $HeH^+ + H = He + H^2$.[8] While atoms themselves do not change when aggregated into a molecule, through the formation of new arrangements of atoms within molecular structures, a near-infinite variety of molecules has been formed.

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CHAPTER 3 - Life Forms Are Aggregations of Environmental Matter

A review of current knowledge related to LHMH inductively leads to the theory that life forms are aggregations of inert matter originating from the environment. The atoms within all life forms existed on Earth in forms such as air, soil, and water for hundreds of millions of years before current evidence shows that life first appeared on Earth. Additionally, a life form grows by absorbing and retaining matter from the environment; "growth" is a measure of the ongoing absorption and retention of environmental matter that is aggregated for form the body, the life form, the organism. As Newton's First Law suggests that matter cannot move without an outside force, technically speaking life expresses a force on inert matter to aggregate a body. As observed by AT Still, life indeed puts "… matter in motion."[1]

Life on Earth is thought to have begun between 3.7 and 4.2 billion years ago, per evidence found in seafloor-hydrothermal vent-related precipitates in Quebec, Ca.[2] Current theories on the origin of life are varied and often involve the random formation of an RNA or RNA-precursor molecule that developed a new function of self-replication, it could make copies of itself. Essentially, these theories suggest that life began secondary to changes in the molecular structure of existing inert matter on Earth that led to a new, self-propelling, sustained chain-reaction in matter. This explanation also attributes the sentience or consciousness seeming present in higher life forms as a product of this sustained chain-reaction in matter. Proponents of this theory acknowledge that many other preconditions are necessary, including the availability of sufficient inert environmental matter of the correct atomic or molecular structure to "feed" the self-replication process.[3]

A force was expressed upon pre-existing, inert environmental matter that changed its molecular structure to a configuration where self-replication could occur. Whether the force

originated from matter moving in Earth's environment from the influence of tides, lightning, wind, and the like, or from another currently unidentified source, the resulting change in molecular structure was linked with a change in molecular function. The interrelationship between structure and function is widely recognized in Osteopathy and other scientific disciplines, including biosciences and engineering.[4] The structure and function of matter are integrally related.

While most current evidence related to life's homeostatic processes could be described as "matter moving matter," or one atom hitting another to cause motion, early embryologic processes appear to show aggregated matter moving without a clear source of that motion. As described in 2021:

> At the forefront of this self-regulatory capacity [within embryos], we can find the concept of self-organization, which explains the emergence of order as a complete autonomous process without invoking external organizational causes. For a long time, self-organization was looked upon with skepticism in developmental biology, but increasing evidence has shown that, during embryonic development, tissues can organize independently of exogenous signals (Marcon and Sharpe, 2012; Schweisguth and Corson, 2019). In recent years, it has been shown that three-dimensional cultures of stem cells can spontaneously form complex biological structures that resemble organs (organoids) and embryos (embryoids). These discoveries have prompted a renaissance of the concept of self-organization. We are currently faced with the challenge of reconciling new evidence for embryonic self-organization with classical knowledge of developmental biology.[5]

Experiments *in vitro* involving embryonic components have resulted in the apparent "self-assembly" of structures, however the formation of these embryos was not ideal, and the

development of final structures was incomplete.[6] These results may suggest that critical factors in embryogenesis have not been identified, and can be said to be present *in vivo* but not *in vitro*.

Current evidence shows that once a life form absorbs environmental matter, homeostatic processes work to alter the matter's molecular structure (if a molecule) and aggregate the matter to form a body. Photosynthesis provides a well-known example of this process within plants. Photosynthesis depends on the availability of environmental photons, the energy particles that make up light, and is an example of the interaction between "matter" and "a non-material force" to fuel life's homeostatic processes. Though photons are not matter, they do exert a force on matter, as in the retina of the eye producing the visual sense, and in plants during the process of photosynthesis.

"Ogygenic photosynthesis involves the conversion of water and CO_2 into complex organic molecules such as carbohydrates and oxygen…. The two processes [the "light" and "dark" reactions] can be summarized thus:… H_2O + light + CO2 = CH_2O + O_2."[7] Note that in this reaction, no carbon, oxygen, or hydrogen atoms are created or destroyed. Rather, molecules of environmental matter (water and carbon dioxide) are structurally rearranged to form different molecules (oxygen and carbohydrates). Oxygen is excreted by the plant to the environment, while carbohydrates are retained within the plant. The different carbohydrates produced, such as glucose, starch, and cellulose, each have a different molecular structure and serve different functions within the plant, including the aggregation of the plant's roots, stem, branches, leaves, fruit, and other structures. Additionally, carbohydrates can be molecularly changed into other molecules such as fats and proteins that serve other functions in the plant.

Returning to our example of calcium, plants absorb calcium from the Earth's soil through their roots, either through the cytoplasm of cells linked by plasmodesmata (the symplast) or

through the spaces between the cells (the apoplast) and is delivered to the shoot (the stem) by the xylem.[8] Note that a force is necessary to move the calcium from the soil into the plant, whether passively through a diffusion gradient established within the plant or through active cellular absorption. After absorption into the plant, the calcium atom is incorporated into the plant's metabolic processes or into the formation of the plant's body, whether root, stem, or leaf. Plants are made of matter that they have absorbed from the environment.

Humans absorb ingested calcium their digestive tract's gastrointestinal lining via two possible routes that are like the two absorption paths in plants. The paracellular pathway (between the gastrointestinal cells) is passive, depending on a diffusion gradient, and is the predominant route when the calcium concentration in the intestinal lumen is high (ie after a meal rich in calcium). In the active transcellular pathway, a calmodulin-actin-myosin I complex binds calcium which then moves by micro vesicular transport to the basolateral area of the cell. Calcium then binds to calbindin and is carried away from the cell's microvilli region. As the calbindin-calcium complex dissociates, the now free intracellular calcium is actively transported extracellularly [for use within the life form] via the cell's sodium-calcium (Na-Ca) exchanger.[9]

A human embryo obtains calcium from its mother through placental calcium transfer. After being absorbed through the mother's gastrointestinal tract, calcium circulates in the mother's vascular system, and is transferred to the embryo through the placenta via "… the syncitiotrophoblast and proceeds through a sequence of events consisting of facilitated apical entry through a calcium transport channel, a cytosolic diffusion of calcium bound to calbindin and finally, basolateral extrusion of calcium ions through a plasma dependent ATP-ase."[10]

Note that all the components involved in absorbing calcium from the environment, the plant roots and xylem, the cell walls and microvilli, the intracellular fluid, the calmodulin-actin-

myosin I complex, the calbindin, the microvesicles, the syncitiotrophoblast, and the Na-Ca exchanger, have also been formed from previously absorbed environmental matter. If any of the homeostatic processes that produced these organs or tissues were disrupted, these structures would have an abnormal structure thus disrupting the absorption of calcium from the environment and likely resulting in morbidity in the life form.

The continued absorption of environmental matter by life forms is necessary to replace previously aggregated matter that was excreted or lost in another manner from the life form. Daily dietary requirements reflect the need to replacing matter within the body due to constant cell turnover and loss through other mechanisms. As far as cell turnover, enterocytes survive for less than a week, red blood cells for 120 days, adipose cells for 12 years and muscle cells for up to 50 years. Overall, approximately 1 percent of the cells in a body are replaced daily.[11]

While the average adult human body contains approximately one kilogram of calcium that has been absorbed from the environment, of which 99% is stored in the bones[12], the human body is not perfectly efficient in retaining calcium. After consuming 1000 mg of calcium, an adult human absorbs approximately 200 mg in total.[13] Following absorption through the gastrointestinal tract, calcium circulates within the body within tightly controlled concentration levels to perform many functions including bone formation. Calcium that circulates in the blood stream is filtered through the kidney where more than 95% is reabsorbed (60% is reabsorbed passively in the proximal tubules and 15% is reabsorbed through paracellin-1 (claudin-16)).[14] Even when working ideally, approximately five percent of circulating calcium within the human body returns to the environment through the renal system, thus requiring the continued intake of replacement calcium as part of our daily dietary requirements. Life forms are aggregations of inert environmental matter.

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CHAPTER 4 – Health is Uninterrupted Homeostasis

Health was described by AT Still as, "…perfect harmony in the physiological action of the body in all its parts and functions."[1] A life form's homeostatic processes could be described as expressing a force that aggregates a body from available, preexisting environmental matter. Currently identified homeostatic processes either absorb, excrete, or perform work on the molecular structure of absorbed environmental matter to aggregate and maintain specific material structures within the life form with specific functions, such as bones, muscles, kidneys, retinas, serotonin, blood, cerebrospinal fluid, and white blood cells. When these homeostatic processes operate normally to aggregate normal structures within the body, the life form is considered "healthy." A useful example of this concept is provided by calcium's role in bone formation and maintenance.

Bone development begins embryologically through the activity of two types of cells within the body, osteoblasts and osteoclasts, which are involved in bone formation and bone dissolution respectively, a constant ongoing process.[2] Osteoblasts synthesize bone matrix in two main steps. Initially, osteoblasts form a collagen matrix or framework for the bone by secreting collagen proteins and proteoglycans which are molecules composed of carbon, hydrogen, oxygen and other atoms obtained from the environment. The next step is mineralization of the organic matrix with hydroxyapatite crystals (an aggregation of previously absorbed calcium and phosphorous atoms) which occurs in two phases: vesicular transport and then rupture (the fibrillar phase) allowing hydroxyapatite crystals to spread to the matrix.[3] Healthy bone is formed once the hydroxyapatite crystals have bonded to the collagen matrix and the bone hardens. Osteoclasts dissolve the bone's organic matrix thus releasing calcium and phosphorous from bone into circulation.[4] When functioning appropriately, the homeostatic processes involved in bone formation and dissolution

result in "bone health" typified by normally structured bone. When all of the homeostatic processes that form and maintain material structures within the body are fully operational, all structures within the body are aggregated into their normal, functional structure; in other words, the life form is considered to be "healthy."

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CHAPTER 5 – Morbidity Results from Structural Entropy

AT Still wrote, "Any variation from perfect health marks a degree of functional derangement in the physiologic department of man."[1] Homeostatic processes are either operating normally to aggregate normal structures in the body, or they are not. As an example, no force other than gravity is known to keep the Moon in orbit around the Earth. The orbit of the Moon around Earth would become entropic if either the force of gravity holding the Moon in orbit around the Earth was somehow interrupted, or if an external force (i.e., if a large asteroid struck the Moon) changed the Moon's orbit. In either instance, the Moon's orbit would become entropic until either gravity was restored or the effect of the outside force resolved and a new orbit was established.

Similarly, morbidity occurs when the matter aggregating a life form becomes structurally entropic either due to an inhibited homeostatic process or the effect of an external force. Morbidity results from entropy, but does not create a new homeostatic system or a new structure in the organism. From this perspective, pathology is the science and art of linking patterns of entropy, of disorder, within the formerly structured matter constituting an organism with dysfunction of the organism. All current diagnostic modalities ranging from the stethoscope to imaging techniques to lab work to EKG's ultimately evaluate the structure of the matter aggregating the body.

To continue with the example of calcium and bones, bone health is heavily dependent on access to necessary environmental matter for the aggregation of bone, including calcium. A lack of access to appropriate environmental matter such as food, water, and oxygen results in bone disease or morbidity which can be shown in increased entropy within the bone's structure. Chronic starvation is known to significantly increase the risks of bone fracture, reduce bone density, and

decrease cortical strength.[2] Chronic dehydration is known to cause, "…structural changes (i.e. shrinkage) which can themselves significantly alter the mechanical properties, particularly in cancellous bone."[3] Chronic hypoxia, or low oxygen levels, may effect bone health by increasing endothelial dysfunction, resulting in the release of vasoactive factors that, "… have direct effects on both osteoblasts and osteoclasts, and may influence interstitial fluid flow within osteocyte lacuna and canniculi."[4] Rickets, often due to Vitamin D deficiency, results in impaired bone formation including: "… flared wrists, lower limb bowing, rachitic or rickety rosary, poor growth, delayed dental eruption and enamel defects, bone pain, myopathy, and motor development delay."[5] Infections, such as osteomyelitis, result when an infectious life form competes for matter and disrupts homeostasis within the host life form. In chronic osteomyelitis, bones become structurally abnormal and dysfunctional due to the development of sequestrum and involucrum, and "…marked cortical destruction, a disorganized trabecular pattern and ill-defined bony lucencies, best demonstrated with CT."[6] Note that the terms such as "lower limb bowing" and "involucrum" are terms used in pathology that actually describe patterns of entropy, a loss of normal structure.

Age-related osteoporosis is another example of structural entropy within the formerly structured matter aggregating bones that is typified by a decrease in bone density and changes in bone mechanical competence and bone geometry, secondary to structural changes within the bone.[7] In part, age related osteoporosis is due to increased osteoclast activity secondary to decreased estrogen levels, which normally inhibits osteoclast activity. Additional factors that may lead to osteoporosis also influence preexisting homeostatic systems and include excess glucocorticoid which, in part, inhibits osteoblast activity, antiepileptic drugs which reduce Vitamin D levels, loop diuretics that decrease calcium resorption in the kidney, and proton pump inhibitors which affect calcium resorption and osteoclast precursor stimulation.[8]

As weight-bearing activity triggers changes in bone to increase bone density as described by Wolff's law, inactivity may also be a risk factor for decreased bone density. "Wolff's law states that bones will adapt to the degree of mechanical loading, such that an increase in loading will cause the architecture of the internal spongy bone to strengthen, followed by the strengthening of the cortical layer."[9] This process is thought to occur through the transduction of mechanical stress signals into biologic activity by osteocytes.[10] The homeostatic processes that aggregate bone are inhibited by a lack of activity that would normally cause stress signals in the bone to activate osteocytes.

Chronic emotional stress is thought to negatively affect bone structure by reducing its density. This occurs through the effect of tyrosine hydroxylase (an enzyme involved in catecholamine biosynthesis), increased stress hormone signaling, and increased systemic inflammation, which has been shown to promote osteoclast differentiation and apoptosis of osteoblast populations. Chronic stress has been associated with multiple conditions beyond osteoporosis, including obesity, atherosclerosis, lung pathologies and diabetes.[11]

The structure and function of bones can also be affected by acute, traumatic environmental forces, such as a fall. The force generated by a fall through the effect of gravity results in an area of entropy within the formerly organized atoms forming the bone, a fracture. "Fracture" is a term referring to a lack of organization, or entropy, within the bone that also results in a loss of function. Whether diagnosed as comminuted, complex, greenstick, simple, or spiral, the fracture does not create anything new in the body; rather the fracture is classified based on recognizable patterns of entropy within the bone. Recognizing the pattern of entropy is critical in helping to determine the course of patient care as a greenstick fracture is managed differently than a complex fracture.

Aging is another form of entropy in the body, a gradual loss of maintained structure in the aggregated matter forming the body. As all matter that aggregates life forms is billions of years old, aging is not a process where the atoms that form the body become "old." Rather aging reflects continuously increasing entropy in the molecular structure and aggregation of matter within the organism. The atoms forming both a newborn and a ninety-year-old are as old as the Earth, however the newborn's molecular structure is newer and less entropic than a ninety-year old's molecular structure.

As shown by these examples, morbidity stems from an entropic loss of structure within life forms due to either inhibition of a life form's homeostatic processes or disruption of a life form's organized material structure by an outside force. Morbidity does not create a new homeostatic process within the life form; rather pathology describes the pattern of entropy, the pattern of loss of normal structure due to impaired homeostatic processes and/or an external force.

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CHAPTER 6 – Healing Results from the Return of Normal Structure

As written by AT Still, "When all parts of the human body are in line we have health. When they are not the effect is disease. When the parts are readjusted disease gives place to health. The work of the osteopath is to adjust the body from the abnormal to the normal, then the abnormal conditions give place to the normal and health is the result of the normal condition."[1] Healing results when normal structure, and thus function, is restored to the matter aggregating a life form, either directly through restoring structure within the organism (i.e., surgery) or indirectly by influencing preexisting homeostatic systems (i.e., medication or restoring a Vitamin D deficiency). When an injured or diseased life form is healed, the original (or close to original) aggregated structure of the organism has been restored.

No current form of healing creates a new homeostatic system in the body to restore the original structure of the body, whether pharmaceutical, surgical, manipulative, dietary, exercise or other. Any form of healing that creates a new homeostatic system in the body would be similar to a functional genetic mutation in the process of evolution that results in the aggregation of a new structure (i.e., a new protein) that would have a new function. One example of this process is a genetic mutation in cod fish that led to the production of a new aggregated structure, an "antifreeze protein," that provided the cod fish with a new function, the ability to thrive in icy water.[2] Prior to this genetic mutation, antifreeze proteins did not exist, and cod fish was unable to survive in icy waters. Evolution describes the ongoing development of new aggregations of matter with new functions within life forms.

To continue with the example of bones, exercise is considered a low-cost and safe treatment strategy for decreased bone density that relies on the activation of preexisting homeostatic systems to restore normal bone structure. Weight-bearing exercise can increase bone density, thus treating

osteoporosis, likely in part due to Wolff's law and osteocyte activation.[3] Regarding the effect of emotional stress on bone health, a multitude of options exist for managing stress, and each could potentially result in an improvement in bone structure by influencing the inhibitory effect of stress on osteoblast function.

Medications also affect changes in bone density by influencing existing homeostatic processes, either activating or inhibiting them. As an example, bisphosphonates are a class of medication used to treat osteopenia and osteoporosis. When absorbed by osteoclasts within the bone, bisphosphonates inhibit osteoclast activity thus reducing bone resorption.[4] Without the presence of osteoclasts, a component of a preexisting homeostatic system, bisphosphonates would not affect bone homeostasis.

Another class of medications that affects bone density are HMG-CoA reductase inhibitors, commonly known as statins, which are primarily used for lipid and cholesterol management. Statins have been found to enhance new bone formation *in vitro* and in rodents. "This effect was associated with the increased expression of the bone morphogenetic protein-2 (BMP-2) gene in bone cells," after the ingestion of statins.[5] BMP-2 is a glycoprotein that, "has pleiotropic functions that range from extraskeletal and skeletal organogenesis to bone generation and regeneration."[6] In other words, the statin does not create a new homeostatic system to increase bone density, rather the statin influences another pre-existing homeostatic system: BMP-2.

Managing osteoporosis from a holistic perspective also involves influencing preexisting homeostatic processes. Primarily through lifestyle and dietary (ie nutrient) changes, overall treatment goals are to normalize homeostasis by reducing inflammation and emotional stress, maintaining appropriate nutritional intake for an ideal acid/base balance, and maintaining appropriate levels of dietary nutrients, including calcium, vitamin D, vitamin C, and magnesium.[7]

Bony fractures result when an external force disrupts the aggregated structure of bone, introducing an area of entropy into the bone. Long bones heal from a fracture through the same endochondral ossification process that embryologically formed the long bones. After a fracture, an initial hematoma is formed on days 1 through 5, then the formation of a fibrocartilaginous callus on days 5 to 11 and a bony callus formation on days 11 to 28. This is followed by bone remodeling from day 18 onwards, a process that can last for years.[8] Homeostatic processes involved in bone healing can be assisted by Vitamin D supplementation, bisphosphonate use, or other intervention such as an electrical current, however no new homeostatic process is created.

Healing of bony fractures can be influenced by restoring normal structure to the bone as shown by use of immobilization (i.e., a cast) or by orthopedic surgery thus helping to restore the function of preexisting homeostatic processes. Surgical treatment of a bony fracture with implantation of rods or other prosthetics restores the original structure to the bone to support the original embryological endochondral ossification process that heal the bone. Following surgery, bleeding initially introduces platelets to the implant surface while other cells, neutrophils and macrophages, create a hematoma via inflammation. Contact osteogenesis describes bone formation on the surface of the implant, as osteoblasts begin to lay down new bone. Distance osteogenesis occurs when existing bone grows toward the implanted prosthesis, again via preexisting homeostatic processess.[9]

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CHAPTER 7 – The End of Homeostasis: Death

Death is defined as, "a permanent cessation of all vital function, the end of life."[1] Death reinforces the notion that life's homeostatic processes exert a force on environmental matter to aggregate a body. When a life form dies, homeostatic functions no longer influence the matter which aggregates the body eventually leading to complete structural entropy. The process of decomposition after death involves the complete loss of an organism's aggregated structure and the return of the matter of which the body was aggregated to the environment.

The process of decomposition following death occurs at different rates depending on the involved form of matter, environmental conditions, and other factors. In plant decomposition, the type of plant, the amount of precipitation, and environmental temperature and humidity levels were found to influence the return of matter (especially water soluble minerals such as potassium, phosphorous, and nitrogen) to the environment.[2]

In animal bodies, the process of decomposition is also affected by many factors including soil moisture levels and acidity. Most animal body decomposition occurs in the first 60 days following death. Experimentally, the elements most rapidly dispersed into the environment following an animal's death are water-soluble minerals such as potassium, sodium, and nitrogen. Minerals within bones were released to the environment more slowly with minimal phosphorous, calcium, and magnesium dispersed within the first 60 days.[3] However, animal activity helps to speed the return of minerals within bones to the environment. Hyenas were found to play a significant role in recycling calcium and phosphorous within terrestrial landscapes by chewing animal bones and returning these minerals to the soil through their feces.[4]

Regardless of the involved process, after death any calcium that had been aggregated as bones within a life form returns to the environment as inert matter, perhaps to be absorbed for use

by another life form. While the forces expressed by life are rather temporary, the matter of which an organism is aggregated will likely continue to exist unchanged for billions of years.

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CHAPTER 8 – Conclusion

Clearly defining Osteopathic philosophy, the roots of the Osteopathic profession, in evidence-based terms will accomplish several purposes, most notably creating a distinct identity for DO's within the American medical system. An evidence-based Osteopathic understanding of broad subjects such as life, health, morbidity, and healing (LHMH) can also spark a much-needed sense of wonder and awe when practicing medicine and create enthusiasm to better understand the mysteries of life. AT Still's insight was based on the general observation of nature and accurately applies to even the most microscopic understanding of organisms.

An evidence-based translation of historic Osteopathic philosophy suggests that:

- life expresses a force to aggregate environmental matter into specific structures to form a body,
- health is the normal operation of life's homeostatic processes resulting in the normal structure and function of the organism,
- morbidity results from an entropic loss of aggregated structure within the body, and
- healing results from restoring normal aggregated structure within the body.

In a clinical environment, Osteopathic philosophy is practical and utilitarian. Understanding that all morbidity results from structural entropy in the body, even in instances where a clear diagnosis is not available, and that all healing restores structure in the body, allows for a clearer vision in managing disease. This understanding also unites all DO's regardless of specialty or whether they use Osteopathic manipulative treatment. The mechanism of action of Osteopathic manipulative treatment is the same as all other forms of healing, to restore the structure of the aggregated matter making up a body either directly by applying a force that

normalizes structure or indirectly by restoring the function of impaired homeostatic processes leading to improved structure.

The scope of Osteopathic philosophy is wide enough to suggest future possibilities that are consistent with current evidence and provide a goal for future study. The aggregation of matter into specific molecular structures that form a body is the effect of something other than the involved inert atoms. As a metaphor, the construction of a toy house is the effect of a child at play. The parts and pieces that compose a toy house cannot assemble on their own; they are put in place by forces expressed by the child at play. The child who is moving toy pieces to assemble the toy house is distinct from the toy pieces. If our senses were limited to the toy pieces of which the toy house was made, the child would not be seen, and the toy house would seem to assemble itself. Through the advancement of technology, humans have developed the ability to identify energies that are not directly appreciable by the senses, such as infrared light, magnetic fields, and radio waves. Potentially, future technological advancements will identify currently unidentified energies involved in homeostatic processes within life forms that cannot be directly sensed by humans. Such breakthroughs may lead to a more complete understanding of self-organization within embryos. At a minimum, if the mass of the embryonic structures and the direction and speed of their motion could be determined, the forces involved could be measured and predicted similar to how astronomers measure the influence of gravity by plotting the course of celestial bodies.

When organized inductively within Osteopathic philosophy, current evidence leads to a new paradigm of science dedicated to describing the child, to describing that which is moving the toy pieces. Without a wider framework with which to explore the concepts of LHMH, such as that provided by Osteopathic philosophy, current scientific theories that limit the origin of life to matter

are like an ancient Hindu myth where it was said the Earth is supported on the back of a turtle. When asked what the turtle is standing on, the traditional answer is that there is another turtle beneath the first one, and so on, that there are, "turtles all the way down." Down to where? To the place where a turtle is standing on something that isn't a turtle? At some point there can't be another turtle, at some point something other than matter must come into play to keep the Earth where it is. Science eventually discovered gravity, a non-material force, to explain what keeps the Earth in place.

In the words of WG Sutherland, "You know what Dr. A.T. Still said the letters, 'D.O' stood for, don't you? Well, just keep Digging on."[1] Whether a chain reaction in matter or matter put in motion by an undiscovered force, life is distinct from the atoms that make up a life form. The desire to explore this phenomenon called life is a central component of the DO identity that will guide the future of Osteopathic medical education and research.

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APPENDIX – Translation of Historic to Evidence-Based Osteopathic Philosophy

	Historic Osteopathic Philosophy (*AT Still Quotes*)	**Evidence-Based Osteopathy Philosophy**
Life	*The human body is a machine run by the unseen force called life…* *…life is matter in motion.* *…motion is the first and only evidence of life….*	Life is the sum of homeostatic processes within a life form Life expresses a force that does work upon inert environmental matter (like CO2 or H2O) to aggregate a life form, an organism All organisms/life forms are aggregations of inert matter in motion An organism's function is related to the structure of the matter aggregating its body
Health	*When all parts of the human body are in line we have health*	Health results from the normal operation of life that aggregates normal functional material structures within the organism
Morbidity	*When they are not the effect is disease*	Morbidity results from increased entropy (or loss of organization) within aggregated structures thus reducing their function Morbidity can stem from external forces or from interruption of homeostatic processes within the organism
Healing	*When the parts are readjusted disease gives place to health*	Healing results from a return to normal (or more normal) structure of the organism either directly by changing the organism's structure or indirectly by restoring normal homeostatic function.
Death		Death results from the complete loss of homeostasis resulting in complete entropy within the formerly organized material structures of the body.

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