Homo Fasciaticus Globalis

For over 20 years I have attempted to demonstrate the organisation and behavior of the matter of which human beings are made. This differs from previous research because it was carried out inside living people during surgical procedures. This exploration of living matter was made possible by the emergence of new technology such as high definition cameras, digital imaging and editing software. It can be easily carried out by any surgeon as well as being accessible to any observer, and therefore easily verifiable.

In seven films and three books, we have tried to show that human anatomy is actually more complex than we imagine it to be. Outdated traditional explanations need to be reassessed in the light of recent technological progress and new theories that have emerged in the fields of physics and mathematics.

This new film introduces the actors behind the scene in an attempt to look a things from a different perspective and offer new ground for thought.

First of all, we must remember the physical factors that reside within us. They are often dismissed because they are deemed to be trivial, but they cannot be ignored. The permanent, powerful endogenous force exerted by bloood pressure is a good example. When we observe the edges of skin draw away from an incision, or the separation of the incised edges of an aponeurosis, the permanent tension within the prestressed tissues is obvious. Less visible forces include osmotic pressure, Van Der Waals forces and ph gradients. They all determinine a set of specifications necessary for biological life. These basic, essential forces were identified by D 'Arcy Thomson, an 18th century Scottish biologist and mathematician, but his work was submerged by the wave of evolutionary thinking.

What does the observation of living matter by intratissular endoscopy and the study of our micronatomy have to offer that is uniquely different from traditional anatomical research?

The first major observation is the continuity of structures. The fibrillar architecture forms a continuous framework that *structures* the *entire* body from the surface of the skin to the cell interior, from macroscopic to microscopic down to the molecular level, and atomic structures. Simple, contiguous physical spatial relationships can be defined within living matter. They determine a structured, continuous form that can be represented, drawn and schematized. This ties in with the concept of a bodywide matrix.There is total physical continuity within living tissue, and this renders the concepts of virtual spaces, separate planes and other artificial divisions within living tissue obsolete.

We are looking at a continuum of living matter.

But this continuous mesh of interwoven fibers traditionally called connective tissue can no longer be neglected or ignored. Simple logic points towards to an essential conclusion: This irregular fibrillar network is found in all types of tissue, including muscle, bone, periosteum, tendon and fat, and is continuous with the cytoskeleton, as demonstrated by the American biologist Donald Ingber.

This fibrillar network is our interior architecture.

We believe that it is a continuous, fibrillar, *constitutive* architecture .

Is the role of connective tissue simply to connect and separate organs and specific anatomical structures, or is it *constitutive*, providing a global, three dimensional architecture in which different types of cells can perform their specific roles?

This represents a fundamental paradigm shift. From now on, anatomy can be perceived only in terms of globality and continuity. There can be no more layers, strata, separate planes, but instead, a single, common fibrillar network inhabited by cells with different densities that gather together to perform specific functions. Our anatomy manuals still describe highly stratified layers of tissue, a model first described by Vesalius in the sixteenth century. This anatomy described by Vesalius and our elders must now be reconsidered in the light of current scientific thinking that integrates life sciences with modern physics and new mathematics.

The transition from the concept of discontinuous to continuous living matter would be as fundamental as the transition from classical Newtonian physics (where physical volumes behave in a continuous manner), to quantum physics (where physical volumes at the atomic level behave in a discontinuous manner). Descriptive Anatomy would therefore undergo a profound renewal.

What is really disturbing is that this framework of *constitutive* fibers with its wide variety of shapes and forms displays ***no symmetry or regularity***. We cannot find any known Euclidean forms. There are no vertical, horizontal or parallel fibers, no lozenges or circles. Instead, we find a tangled mesh of fibers, a mishmash of complete chaos. There is no discernible beginning or end to this irregular, global network. This optimally coherent fibrillar architecture at first appears to be a confusing entanglement of continuous fibrillar chaos. However, it explains the tormented and sometimes astonishing paths of microvessels that are shaped by the fibrillar framework. This continuity is accompanied by the uniqueness of all its elements such as the polyhedrons of the skin, the fatty lobules and the structures of the fibrillar network, as well as the cells. Everything seems similar but not identical.

Some observers find this irregularity of the structures difficult to accept. For others the visual evidence is incontrovertible, and any model not integrating it cannot be exact.
We must try to understand this irregularity rather than simply denying or neglecting it.

Why is everything around us irregular and asymmetrical? Irregularity is the rule. Why is this tangled mesh of fibres and movements so difficult to replicate by even the most powerful computers?

Why do we never see perfect symmetry, and why is it always approximate? There *appears* to be left-right symmetry in the body. But this is a false impression. The heart is on the left, the liver on the right. People can be left-handed or right handed. However, even when you think that the symmetry is perfect, it's always approximate. Why does the unidirectional force of gravity create such superb physical irregularity? Moreover, the polarity of the earth's magma is already a factor of asymmetry.

This brings us to the notion of *rupture of symmetry* developed by Nobel Prize winners Kobayashi and Maskawa in 2008. They explained that at the moment of the Big Bang, the universe was symmetrical and without structure. As it cools, the universe ruptures one symmetry after another, thus allowing the appearance of an increasingly differentiated structure by separation of matter and antimatter. This allows for the appearance of matter and light in the quantum vacuum, producing the germ of the wide variety of structures currently present in the universe.

Life, like all biological processes, is also a rupture of symmetry. Symmetry reigns only in an immobile, non evolutive world with no past and no future.

This optimally coherent, irregular continuity is disturbing because it is not what we were taught. This could explain the apparent lack of interest by our forbears because traditional anatomical teaching prepares us to discover a well oiled, organized, rational human machine governed by the principles of classical Newtonian physics. To accept that the architecture of the sliding system, to which we owe the harmonious movement of the body, is apparently completely irregular and chaotic, questions the basic principles of linear causality.

The fibrillar movements within the multifibrillar network clearly have a functional finality, which is mobility. But how?
In the film « Interior Architectures » we see fibers that stretch, slide and divide, and behave coherently in 3 dimensions.

We realize that the fibrillar mechanism is full of surprises on a purely mechanical level. We've seen that the fibrillar system is able to absorb an applied force by diffusing it across the network, thus permitting both interdependence of separate anatomical structures, and optimal transmission of the force.

But if we look more closely at this set of movements. We observe a mechanical system in constant search of equilibrium. It provides an immediate solution to any constraint. This is a completely new, previously unobserved mechanism. It is never ending. It is also flexible, adaptable and interactive. There is no tearing or sectioning of fibers. The system comes up with unexpected solutions. It is energy efficient and seemingly inexhaustible.

Could this be an example of an irreversible dissipative structure described by Ilya Prigogine, who was awarded the Nobel prize for chemistry in 1977? That is to say, a structure that functions contrary to the second principle of thermodynamics, which states that loss of energy in an isolated system is inexorable, and increases over time. This is called entropy and in traditional physics entropy is associated with disorder and the loss of information.

But Prigogine goes further. He suggests that an open system that is not in a state of equilibrium does not necessarily evolve towards maximal entropy, but on the contrary is capable of transforming lost energy produced by any disturbance. This energy is "dissipated" and utilised for the creation of a new organised project that is more complex, and enables the structure to adapt to its function. He stated that the particularity of life is to *reverse the process of entropy* with a subsequent increase in complexity that opens up a world of possibilities.

While I was looking for a coherent explanation by using mechanical principles worthy of a steam engine, the explanation provided by Prigogine's work enabled me to think that the apparent fibrillar chaos I was seeing could not only be efficient, but in the most beautiful way. Thus reassured, I could now understand all the spatial movements made by the human body in 3 dimensions with minimal loss of energy, and reduced entropy.

At the same time, Prigogine expressed the notion of the irreversibility of time – characterised by time flowing only in one direction. This concept of the irreversibility of time appealed to me because I had noticed that the fibers did not all function in the same way and at the same time. Some were fixed, stable, and therefore determined to behave in a predictable way. Others seemingly less so, but unidirectional, as in the case of the lengthening of this fiber with rings made of elastin and collagen.

Look at the movement of these fibers. They move up and down, divide and then stick together again. We cannot anticipate any of the movements. Their behavior is unpredictable, but prepared to deal instantly with all internal or external mechanical constraint. These are clear examples of unpredictability of the movement and trajectory of the fibers, but also of non-determinism and non-reversibility within this chaos of fibers. Of course I found these observations puzzling to say the least!

This amazing behaviour at the molecular level is mind boggling! How can all these collagen molecules peel away from each other and then stick back together again in an instant, smoothly and without rupture? If we think about it, the combination of these movements at a specific time and place will never be repeated.

I will let you watch a few of these movements so that you can understand the non-determinist nature of this fibrillar behaviour. The association of all these individual movements represents incalculable combinations that cannot be resolved mathematically, and ensures that each movement we make is not reproducible in space and time. Each movement is therefore unique, in a creative non-deterministic universe that allows for the possibility of multiple solutions.

The observation of all this uncertainty inevitably led me to quantum physics, especially since we are talking about microscopic scales of about a micron that can be influenced either by Newtonian or quantum physics, or both. Confronted with the observation of apparent disorder resulting in efficiency, and the mixture of quantum and Newtonian physics with a dose of thermodynamic physics, it was obvious that I needed to change my way of thinking.

I had to leave my traditional academic world and begin to study the science of complexity, and of chaotic, non-linear systems.

Chaos Theory refers to chaos as described by modern physics. Many disciplines such as sociology, cosmology, computer science, engineering, economics, philosophy, and of course biology had already sought to find solutions to this problem. The study of complex non-linear systems such as ecosystems allow us to address complex natural phenomena that are unstable and cannot be accounted for by classical mathematics and physics. Ecosystems do not express themselves with the forms of classical geometry such as straight lines, planes, circles, spheres, triangles and cones.

Euclidian measurements such as length, width and height cannot account for irregular forms like clouds, waves, turbulence in a torrent of water or the distribution of the branches in a tree. These are the forms and patterns of life. Clouds are not spheres, mountains are not cone shaped, and lightning doesn't move in straight lines. Natural geometry is interlaced, entangled and twisted.

The classical linear model of Platonic harmony turns out to be inadequate, and it cannot help us to understand complexity because it favours order and stability.

Chaos theory is a recent discovery.
In 1795, Laplace, the master of determinism declared in his book "A Philosophical Essay on Probability" that order is the result of random events. This in turn leads to unpredictability and instability.
Henri Poincarré, a mathematician, physicist and philosopher of the late 19th century was the precursor of the Chaos theory. He asserted that the laws of nature do not deal with certainties, but possibilities. The future is not given, it is in the making.

The Meteorologist and mathematician Edward Lorenz who won the Crafoord Prize in 1983, established the legitimacy of the Chaos theory through the discovery of the notion of strange attractors..

In 1963, Lorenz succeeded in reducing meteorology to its simplest expression by modeling the movements of air and water using simple computer assisted equations based on fluid mechanics. To his great surprise he discovered that two meteorological models calculated from almost identical initial conditions give rise to two divergent curves as time passes. Lorenz thus highlights the chaotic nature of meteorology. It was he who famously declared that a butterfly flapping its wings in the Amazon forest could cause a hurricane in Washington. In other words, the effect is not proportional to the cause. This is non-linearity.

He noted that in the long term, all the trajectories occupied by the molecules of the atmosphere evolve irreversibly, in the absence of disturbance, towards a so-called Strange Attractor, of fractal dimensions. This concords with the Theory of Information described by Claude Shannon, whose work led to the production of computer memory bits, that we use every day.

Shannon asserted that complex systems generate information that is stored within their structure, and that the appearance of the chaotic phase coincides with the transfer of information from small molecular scales towards larger scales. This occurs through the Strange Attractor, the creator of unpredictability, entropy, and an apparent orderly disorder that is both deterministic and structured. Information is thus passed from one scale to the next.

For me, a rational thinking surgeon, this was a period of neuronal turmoil and an upheaval of my way of thinking. At the time I felt that everything that I had learned was perhaps not wrong, but certainly incomplete. Everything needed to be reappraised from this new perspective of nonlinear chaotic systems. The combination of determinism and chaos confers certain advantages, and this is disturbing to a rational, cartesian mind. Deterministic chaotic behaviour broadens the scope of possible solutions, allows for more efficient exploration of these solutions, and permits greater complexity. It is one of the potential dynamic capabilities of nature. This apparent disorder is governed by an underlying dynamic order. This provides an explanation for previously incomprehensible natural phenomena and the behaviour of ecosytems.

I studied the fibers first because I was looking for a rational explanation for the sliding of tendons, and the fibers seemed to be central to this mechanism. They were also easy to observe. But it was also necessary to explore fluids and volumes in the body. Fluids such as blood, bile, urine, cerebrospinal fluid and intra –

articular fluid are omnipresent during surgery. All tissues are humidified at all times. But when the surgeon makes an incision in the skin, water doesn't flow freely from the incision. We notice a little liquid known as lymph along the edges of the incision, but that is all. So the fluids that represent 85% of our body weight do not escape through the incision. Their distribution appears to be organised, but how?

As shown in the film « Interior Architectures », intratissular endoscopy reveals areas that resemble bright mirrors. They reflect the light of the endoscope, and they are the result of the intercrossing of fibres in three dimensions. This irreguarity is not the result of chance or accident. These forms are not imperfections. They are irregular for a reason, because a degree of irregularity enables them to occupy space more efficiently compared with Euclidian forms.

These microvolumes are irregular polyhedral forms that are all different – the same forms we find at the surface of the skin. Their seemingly chaotic disposition, their variable forms, and their non-systematized contiguity are not the result of chance or accident. They reveal an underlying order. These forms are not imperfections. They are irregular for a reason which could be that a degree of irregularity enables them to occupy space more efficiently compared with Euclidian forms.

These microvolumes are known as microvacuoles. It took us a while to understand that the colloidal gels they contain are in a state of emulsion induced by atmospheric pressure that enters the body through the incision made by the surgeon's scalpel. They appear a few minutes after incision and eventually evaporate.

This observation provides us with essential information. The subdivision of living matter into microvolumes allows us to tackle the thorny problem of the distribution of fluids within living matter, and the adaptability of this living matter to external physical forces. When I compress the skin, the internal pressure of the microvolumes varies simply because the fibres, consisting mainly of collagen, move and then return to their original spatial configuration due to the pre-existing stress of the fibres. This is also possible because the microvacuoles are not hermetic, thanks to the tensio-active properties of their membranes. However, the overall volume of the microvacuoles remains constant. Their form is thus maintained.

Inside the constantly changing polyhedral framework of the microvacuoles are fluids, but there are no rivers or underground lakes. Living matter is soaked in fluid, rather like the juice inside the pulp of an orange.
Colloidal states are an "ultra-divided" state of matter consisting of various proteins, mineral salts, water and various other contents. Their presence is permanent, but in varying concentrations.
They have the capacity to disperse that generates an excellent exchange surface which increases considerably at the interface. For example, the surface area of foam is much greater than the surface area of a bubble. Their ultra-light masses are animated by Brownian movement, and so they seem to escape the force of gravity, as well as the Van Der Waals forces. Michael Feigenhaum, Albert Lichaber and Leo Kadanoff were awarded the Wolf Prize for physics for pointing out that minute modifications in these systems can lead to significant changes in their overall behaviour, at all scales.

This is called *turbulence* and the final result is « phase transition » which In the terminology of the physics of complex chaotic systems, is this capacity of a dynamic state to rapidly swing in one direction or another.

These *phase transitions* that occur across all scales, obey non-linear mathematics, and so predictions of their future state are said to be random. This is the physics of Soft Matter. Pierre-Gilles De Gennes, who is known as the founding father of Soft matter, received the Nobel Prize for physics in 1991.
All this research is relevant to our daily work as therapists.
Local pathologies such as oedema or inflammation can be considered as areas of turbulence with the capacity to recover.

In old hematomas, and olecranon bursitis, we first observe an oedematous reaction, with enlarged microvacuoles and fibres.The microvolumes are drawn or pushed apart, and the fibres separate, forming a space filled with glycoaminoglycans and free of fibres.
. We also note the presence of numerous bubbles within the fibres. We know that this phenomenon was observed during the phase prior to the rupture of fibres in experiments .

In these cases, a transition phase is a *functional adaptation* with a change in physical and metabolic behaviour.
The multifibrillar, microvcuolar system is progressively transformed into a *Megavacuole.*

On the other hand, this notion of changes in state that is observed in living human beings is very useful when attempting to interpret anatomical situations hitherto poorly explained.

For example, the carpal tunnel in the wrist is the primary area of external mechanical constraint during flexion. The flexor tendons are subjected to this constraint as they pass below the annular ligament. We also see the same mechanical constraints acting on the digital pulleys of the fingers. The multifibrillar sliding system adapts to repetitive mechanical pressure during flexion of the wrist and fingers by forming what appear to be carpal and digital canals, but are actually *megavacuolar morphological variations*.

This conclusion is very important because it also provides an explanation for certain anatomical spaces in the body such as the spaces surrounding the heart - the pericardium, around the lungs - the pleura, and even the peritoneum. These spaces all have one thing in common. Inside these spaces, there is permanent, repetitive movement.
We could hypothesise that during phylogenisis, a more effective formula has been developed to meet the specific mechanical transformations.

A strong impression of total coherence emerges from these observations.
All these changes are structurally coherent with the multifibrillar architectural organisation of the entire human body. The same fibrillar system is found everywhere.

It is this structural coherence that is fundamental, because it is then possible for us to describe a body that is structured by the same architectural framework, with two essential components:

-First a *mobile component* either with or without functional adaptations brought about by phase transition. These are the sliding areas, composed essentially of fibers and fluids and containing few cells. These areas play a *shock absorbing role*. They deal with endogenous or external constraint by absorbing and spreading the load.
- Second an *operative or productive component* of the same multifibrillar system but essentially filled with cells and few fluids. Examples are fatty lobules, the thyroid gland, the kidneys and the adrenal glands, each with specific functional roles.

But exploration under the skin reveals further surprises!

Within these more homogenous concentrations of cells, endoscopic observation has revealed rather unexpected relationships between the fibres and the cells as shown in the recent film « Of Cells, Fibers and the Human Living Body ». Firstly, one cannot dissociate the cell from the fibrillar mesh. The cells are embedded in the fibrillar network, and they are in total continuity with this network. The fibrillar network and the cytoskeleton together form a structural continuum.

Secondly, some cells appear to migrate along certain fibers.

The third conclusion is that cells do not occupy all the space in the body. Some areas of the body contain very few cells, particularly those subject to mechanical stress.
Cells alone are therefore not responsible for the form and volume of the body.

Moreover, there is another observation that is unavoidable in endoscopic exploration, This is the observation of fractalization. We now know that some fibres in the multifibrillar network are able to divide into sub-fibrils. In this way, force is dispersed throughout the structure right down to the molecular level. The force of gravity is also diminished in this way, at all scales, from macroscopic to microscopic.

From the outset we observed this phenomenon of fractalization at the surface of the skin. But we now know that it also occurs in the fibers and subfibrils and down to the molecular level.
Fractalization, or scale invariance theory, was first described by Benoit Mandelbrot, French and American mathematician. He coined the word 'fractal', and is recognised for his contribution to the field of fractal geometry. A fractal structure looks similar no matter what distance we view it from. Whatever the scale under which it is examined, each part posesses the same structure as

the whole. This property is called self-similarity. Fractal structures display regularity within their irregularity, and this adds another dimension to the chaotic aspect of living matter.

Fractalisation is a widespread phenomenon in anatomy. In this way, a large surface can be contained within a small volume, thus providing a larger surface area for exchange. This is the case with the alveoli in the lungs but also the intestinal villi. Each vilus is divided into smaller, comparable formations. We find similar arrangements in tendons. Fascicles contain fibers, fibrils and microfibrils and collagen molecules. This solution has been retained by nature because it increases metabolic efficiency and maximises the exploitation of space. Unlike Mandelbrot's drawings, nature offers us irregular fractalisation which is not inert, it is dynamic. We have seen that it enables adaptation to movement, prevents the rupture of collagen molecules, preserves the integrity of the microvacuoles, and thus helps to maintain the shape and form of the body.

But while fractalisation helps to understand mobility and adaptability, it has other important roles and provides explanations for key questions.
The following question is fundamental: How is this volume of colloidal living matter, containing at least 75% of fluids able to overcome gravity, the strongest fundamental force in our universe?

The answer to this question has already been addressed in the film "Interior Architectures", that explored the concept of tensegrity. This concept was developed by Buckminster Fuller, an American Architect, and demonstrated by the sculptor Kenneth Snelson.

Stephen Levin coined the term biotensegrity when he applied this concept to living organisms. It represents a major advance in our understanding of the organization of anatomical structures, and helps us to understand how the multifibrillar network is able to grow, and withstand the force of gravity.
It is the only concept capable of explaining the perfect balance between the constituent structures of the body.

This capacity to resist gravity is fundamental because it throws new light on the processes of morphogenesis and organogenesis. Of course, the discovery of homeobox genes that regulate the expression of other genes provide essential answers regarding the localisation of the blueprint, but provide no explanation of spatial organisation and contiguity.
Yet again, this continuous fibrillar organization can provide answers.

Self assembly is made possible by the fractalisation of fibres in the multifibrillar network, and this enables the transition from one stable form to another when sufficient energy is available. Under the influence of growth hormones, the network multiplies, develops, and grows without rupture. Cells develop within this fibrillar framework. The fundamentals of mechanical behaviour are respected at all times.
The ability of the fibrils to reproduce the basic polyhedral forms, combined with the phenomenon of dynamic fractalisation, helps us to better undestand how all the forms we observe in the human body can be created. Standard 3D design software is a very efficient tool to illustrate this. For example, if we take a set of lines with irregular intersections as previously described, all we need to do is impose a longitudinal force to obtain cylindrical structures.Tendons are examples of longitudinal structures. The intermuscular septa and some articular ligaments are also

longitudinal structures, but the spatial arrangement of their fibres is different. The formation of hollow tubular structures like blood vessels, the bronchial tree, the intestines and excretory ducts occurs spontaneously. The formation of a canal is simply the continuation of an imposed constraint in the same structure.

This is also the case with more complex forms such as this spiral that is seen in vessels, the renal glomeruli and the middle ear. Bone is simply a reinforcement of the fibrillar system with hydroxyapatite. The respiratory system can be considered to be the result of the penetration of air into the fibrillar system. It is the same process for joints.The thyroid is the result of that area of the fibrillar system being inhabited by cells that group together to perform specific physiological functions. The vascular, nervous, lymphatic and muscular systems are completely integrated into this network, as explained in the film "Interior Architectures".

There is global coherence at all levels of organisation within the fibrillar network.

This organizational model is comparable to that of a tree, which is a perfect example of the fractalisation of life. This occurs across all scales from the trunk to the main and secondary branches, stems and then the framework of the leaf and down to the plant cells themselves.

As we approach the conclusion, two avenues of reflexion can be considered.

One is of a more general nature. Confronted with this polyhedral human architectural framework, it is difficult to ignore the fact that it is found in all other living species, animal, vegetable and even minerals. From the skin to the pulp of an orange and volcanic rock, the list is long. This encourages us to think, or even affirm that all biological systems employ the same universal mechanisms for evolution and complexification.

The second touches on our work as therapists. It is now possible to explain and define pathologies such as oedema – swelling of the microvacuoles without lasting alterations to the multifibrillar, microvacuolar system. Inflammation is a dilatation of the microvacuoles and the vessels, and an alteration of fluids.

We now better understand, as we have shown in the film "Skin, Scars and Stiffness", why a scar can have multiple consequences because of the loss of fibrillar harmony that is replaced by stiffness. We have clear mental images of obesity, an overloading of the microvacuoles by adipocytes. The microvacuoles become so heavy that they can no longer resist gravity. Finally, we understand the programmed aging of all the components that is the revenge of gravity, and leads inexorably to the sagging of our contours. There is so much more left to discover about the human body.

Conclusion

We have now arrived at the end of this journey.It is complicated and still imperfect, but even though there is still much scientific knowledge to acquire, it is no longer possible to consider human anatomy as it has been taught since Vesalius.

New techological advances have allowed us to lift a corner of Nature's veil, and we have been able to observe the ocean of apparent disorder that generates the order of life.

From now on, it will be difficult to ignore this extracellular "interior architecture", that forms a symbiosis with the cytoskeleton. Could this be (identified and) defined using the term "fascia"?

Its organization is continuous, irregular, mobile, adaptive, fractal, chaotic and nonlinear, from the surface of the skin to the smallest constituents of our structure, vector of that most beautiful of optimal efficiencies, life.