4

The Remarkable Human Blueprint

"The body has its own way of fighting illness, readjusting itself to harmony. We all want to survive and be well and will find infinite ways to serve our needs. There are no obstacles to this tremendous urge to live. The body will always strive to overcome the difficulties impeding its existence. To live is one of the greatest miracles."[1]

Vanda Scaravelli

Yoga is about the process of unifying form and the union of all our aspects. This includes the mind, the being and the form of the body through which we express ourselves, in action and in stillness; both are performances of a sort. Embryology is about the process of forming from original unity (one unicellular being) as much as it is about the formation of all aspects of us into one whole multi-cellular being, aspiring to unity. Yoga and embryology are intimately related. Perhaps all we ever needed to know about yoga but were too afraid to ask is there, in the embryo.

It is interesting to consider that we all began as embryos. Like the acorn that somehow "knows" how to become an oak tree, we know what is required to become all that the remarkable human blueprint promises. The embryo essentially self-assembles, motivated by the miraculous ability to animate the codes and patterns it inherits, through the matter of its own architecture – literally and symbolically. Embryology is the study of how we achieve this. In a medical context, this is described as the progressive stages of developmental growth on a somewhat linear and horizontal timeline. In the advanced practices of yoga, it becomes a metaphor for the symbolic growth of our emerging consciousness, in anything but linear patterns. The fundamental question remains: how exactly does the embryo differentiate, in time, to emerge as us?

Whichever lens we look through to explore our origins, embryology is the story of an evolving work in progress. The process could be described as an evolution, a convolution and a revolution, in the sense of its volume, its spiral motion sequences and its incorporation of every performance to form the next "volution" if there is such a word to describe the voluntary nature of that self-directed assembly. It is very complex; however, it describes only one particular period in our development, which is a progression of changes on a continuum throughout our lives. Each of us goes physically from a uni-cellular conceptus to a multi-cellular embryo, from fetus to neonate, newborn to baby, toddler and child. We all undertake a journey to whichever point we reach, through a process of adolescence to arrive at adulthood, and eventually elderhood. We continue to express this in a body that presents "time" or "sensitivity-dependent periodicity[2]" at each cyclical stage to which it has developed, in an invariably unique way.

Embryogenesis: the word "embryo" comes from the Greek meaning "young one" and came to mean "fruit of the womb" (literally "that which grows", from *en* "in" + *bryein* "to swell, be full"). "Genesis" means beginning. At the earliest stage, one name for the fertilised egg is the "conceptus", from the Latin "a collecting, gathering, conceiving"; the term can also be used at the metaphysical level to describe the conception of a new idea.

Yoga is interested in developing our awareness of that process and becoming ever more present to it. The yogic Yantra speaks of a "sacred journey", which might describe the developmental weeks of embryonic forming or the developmental years of a whole life. They are seen in these terms as a microcosm of the macrocosm. The question of scale differentiates them. At this early stage of embryogenesis, yoga views the energetic body as part of the forming process. Medical textbooks, in contrast, identify process in terms confined to physical developments and the genetic codes that authorise them, usually compressed into as linear a timeline as it is possible to reduce them to. It is a difficult task, because every single stroke of embryonic development takes place in the round and impacts the entirety of the form it is in the performance of forming. It is invariably a multi-dimensional metamorphosis, as is the case for the rest of the ensuing life cycle(s), perhaps predicted by that which precedes and predicting what proceeds this transformation-in-progress, we each perform.

Research into the role of the connective tissue offers some interesting invitations that seem to help bridge between these linear and non-linear ideas. Given its unifying nature, the fascia is, perhaps unsurprisingly, evoking a new curiosity around classical explanations of our original formation.

Sensing into Form

When we practise the yoga poses, by exploring the shapes of new forms we develop our physical bodies as well as our mind and being; our inner and outer sensory awareness. We practise to become more articulate, developing our inner sense as we perform the poses while, with our outward attention, we listen to where we are in space, seeking congruency between them, in all the variety of shapes, directions and ways in which we can balance and respond to and from the ground (see Ch. 5). We move in the gravitational field and although we are no longer wrapped in the fluid chambers of our original forming (morphogenesis), we might say we are wrapped in gravity, matched and perfectly balanced by ground reaction force (see Ch. 6). We are managing and exploring the subtle, invisible forces within and around us, all the time.

Much like the forming embryo, we interact with biodynamic forces, rates of change and relationships between the forms. We experiment with the forces in which we are growing and moving, as a whole body, all the time: from the outside in, the inside out, side to side, rotation to counter-rotation, and so on. On the mat, we consciously explore the ways the forms and forces interact as we effectively change them, by moving. That might be very similar to what the embryo does. The earliest cells grow and organise the forms by moving and changing biodynamic forces[3] and genetic patterns; they consequently change each other. Yoga could be said to do the same, since we all express its forms and practices uniquely.

"If you think the adaptability and range of possibilities and complicated interactions in the body of an adult is a beautiful achievement, you can multiply that by a million in the embryo. It appears as a kind of chaos, if you can say that of something that contains and emerges into such exquisite and various order."[4]

Chemistry or Geometry?

The scientific and medical books on embryology tend to take a point of view based mostly around genetics. However, that view is changing. Advanced technology in instrumentation and the new questions arising from research in connective tissue biology are affecting every field of knowledge; the study of the embryonic process seems to include them all. From maths, physics and chemistry to biology and music we can find rhythmical patterns and correlates in the embryonic forming process. Authors such as Richard Grossinger, in a work rich in metaphor,[5] take a phenomenological approach, comparing the embryo to the galaxy, the difference being one of scale. Emeritus associate professor of Anatomy and Embryology, Dr Jaap van der Wal (see Ch. 3) presents the embryo as a sentient being, highlighting the primary role of the fascial matrix and the subtle exchanges that take place as it self-develops, through the medium of that maternal context. Proprioception is presented as our original *sensing* of form and van der Wal[6] describes human beings as multisensory and aware, unified from the beginning. The suggestion is that we learn from the embryo, as distinct from thinking we might explain entirely how it functions from the anatomy of the parts (as if we ever get to tell it how, before it self-assembles!). Understanding living tensegrity extends the point of view further, unifying the science and the symbolism in the geometry that is fundamental to both.

Yoga's most ancient history is richly woven with symbolic geometry (see Ch. 12). It is no coincidence that the earliest pre-embryonic forms can be shown geometrically to present many aspects of Sacred Geometry (see Chs 2 & 12) and the principles of Divine Proportion and the Golden Ratio. More contemporary studies of geodesic geometry[7] are also providing new lenses through which to view embryological forming. The symbolism is rich and rewarding on every level and, depending on what we are looking for, embryology resonates with many people in different ways. The same patterns are original to the yogic Yantra's, so we are constantly learning how the newest science of Body Architecture re-iterates the ancient wisdom that precedes us.

The Scientific Questions

The potential role of the fascia in our bodies is gaining in significance in many fields. Embryological research carried out by Evans (a developmental tissue biologist and anatomist) and colleagues in 2006 refers to the fascia as "the forgotten player".[8] It suggests that connective tissue may be more primary than muscle tissue, essential for the **creation** of the "musculoskeletal unit". Evans' research is endorsed by Sharkey[9] and Levin[10] and van der Wal.[11] As we learn that the fascial matrix cannot be logically excluded from understanding the musculoskeletal system or any of our movements, new ways of examining embryogenesis are emerging.

This point of view suggests the continuity seen in Jean-Claude Guimberteau's films of the living (adult) matrix (see Ch. 3). Guimberteau places great emphasis on the way the connective tissue matrix is organised and omnipresent. It has multiple functions, as is suggested here. The paradigm shift from thinking in terms of muscle and bone units to thinking in terms of continuity of form throughout the tissues *in their variety of texture and density* is highlighted by such research questions as these.

"Connective tissue: the forgotten player? … Skeletal muscle is invested and anchored to a number of specialised connective tissue layers organised as the endo-, peri- and epi-mysium [see Ch. 3]. These layers not only act as a conduit for blood vessels and nerves but because they become continuous with the connective tissues of the tendons and other muscle attachments, they are essential in transmitting the motive force of the muscle to the attached structure (e.g. bone) as appropriate."[12]

What if muscle protein arises from *within* the fibrous net of the ubiquitous fascial matrix; if fascia is the primary placeholder of our potential form (and all the forms within it)? It would make sense that the integration of growth functions and their forces animate the appropriate changes that bring about the different structures. What we call (variously) tendon, ligament, muscle, bone and cartilage (visceral wrapping and neuro-vascular vessels) are all woven together in an intimately organised morphology. Could bony calcification (that comes so much later in the process) be the result of cartilaginous placeholders in the blank folds of the origami canvas? As we fold, enfold and unfold into forms, could they be a densification response, when *we* are strong enough to balance strong forces moving through the denser connective tissues? In other words, can we pose the question that the fascial matrix *is the primary* structural "*materia biologica*" of embryogenesis, through and with which we feel our way into form? Van der Wal[13] suggests it is the biological fabric, and his formal writings on the subject are eagerly awaited.

The Embryonic Period

At the earliest stage of our development, the moment of conception, the embryo is whole and complete, so let us start from that beginning.

How the embryo essentially forms itself is a complex and exquisitely detailed series of events that take place over a period of just five weeks (from approximately week 3 to week 8 after fertilisation). In that short space of time, a tiny ball of water* just visible to the naked eye becomes a recognisable, if barely, developing baby human, about the size of an acorn. It still has a long way to go to become a newborn; however, the plan (the whole anlage, or rudimentary basis of a particular organ or part) is in place. It has an immature heart and primitive, but nevertheless distinct and functioning, organs: head,

*Water is a term of convenience used loosely here, referring to a transparent droplet that is really the "embryonic soup" of mesenchyme that will become the embryo. It describes the major component of this "soup", rather than implying that it is much like the water running in a stream or from a tap/faucet, since it is, essentially, *bound* water. Think egg white, in terms of the more viscous, or gel-like properties of this (mostly water) embryonic medium. It will become important in later chapters in Part A. As an example, the jello or jelly you make for a "jelly and ice-cream" party, is about 98% water, with gelatin or other protein, acting as a binding agent. Squishing that jello/jelly between a child's fingers doesn't leak any water as such – as it expresses the properties of "bound water" (see Ch. 7).

spine, body wall and limbs; pulsing lungs, moving fingers, and toes, eyes, ears and nose. They are all ready to grow and develop into the precise features we embody and enjoy exploring on the yoga mat.

The Journey

The embryonic journey is mostly described in books as a number of *quantitative* events, one following after the other in sequence. In fact, many of the events happen at the same time, in one co-creative, *qualitative* process of development; in 360 degrees. Each one relies on the other and the whole is something indefinably and unpredictably greater than the sum of the parts. It is not like building a robot or making a soft toy, with the right amounts of each ingredient. Nothing in the embryo is bolted on or added afterwards or part of a linear time sequence. The entire biomotional orchestration is a symphony of emergent properties (see Ch. 6) expressing an interdependent (and interrelated) global and local performance.

For the yoga practitioner, it is fascinating to discover that the heart descends according to the (reverse) order of the yogic chakras, from the crown, ultimately down to the coccyx (see Ch. 12). The first, pre-embryonic heart cells syncopate the rhythmic growth of the embryo, brain first. They are pushed downward by the growing brain, over the crown, placing the heart opposite the spine. The face folds then unfolds upwardly from there, as the spine grows down the back at the same time; so chakras 5, 6 and 7 (in a very metaphorical sense) grow back up from the heart. The heart is eventually incorporated with the "septum transversum" (which becomes the diaphragm) as the thoracic cavity is formed. The third chakra descends from the fourth (heart) and as the spine grows down towards the tail, the second and first chakra positions arise later in the sequence, completing the base of the torso at the root chakra (Mulhadara) (see Ch. 12). From this point of view our subtle body is formed originally in our physical form, from the crown towards the tail, in the multi-dimensional patterning process of a mobius strip (see margin note).

If that is the case, i.e. that a mobius-strip-shaped sequence takes place, then in full 3D, the embryo forms by folding through itself and around itself. It is a sequence called "invagination" that means the embryo "turns itself inside out to form". The mobius, in the round (or 4D), would be a Klein bottle pattern that can move through itself and takes us into the realm of Hyperbolic Geometry (see Note 7, Graham Scarr: in his book *Biotensegrity: The Structural Basis of Life*, Ch. 10 Complex Patterns in Biology, p. 118 onwards, Second Edition). There is an illustrated example of how a Klein bottle pattern may be fundamental to the organisation of human form and forms within the whole. This 4D matriarchal (*meaning of the mother and of the matrix – which comes from mater – Latin for mother*) organisation gradually makes sense once we realise that the entire embryonic structure begins and ends with two spheres meeting and folding (within another one that enfolds them), enfolding and unfolding into form, from within those spheres. That is almost impossible to imagine (and much harder to write about). Suffice to say here, it is anything but linear!!

We could say it is more like folding an exquisitely elaborate origami sculpture, in that the innate geometry of form has a sequence but the whole arises from the folds and interrelating creases and invaginations of the original "*single piece of paper*". (Which in our case is an *original sphere – which is beyond our standard visualisation ability to interpret.)* All folds come together at the end, they all rely upon each other, and if one fold is inaccurately pleated, it affects the whole finished form. So too with our embryonic developmental folds; uniting to create our basic morphology, or human shape.

Every fold, every enfoldment, every pattern and pulsing rhythm of the embryonic progression happens inside continuously connected pockets. The pockets form within pockets in this multi-dimensional, fluid, biodynamic origami continuum. The folds form tubes and bags, as these are volumes rather than flat paper pleats. Our "one piece of paper" has no edges; it is formed in the round; it is in the round, i.e. tubular. The pockets and apparent spaces are formed such that the folding consequences bring us and all our organs into the shape of an embryonic miniature human being. Each phase takes those sacs with it, as it itself folds, and, in less than two months from conception, the emergent creature incorporates all of them, on every scale. It then grows and expands into the fluid sacs (*amniotic and chorionic*) from within which it formed. We discover that the enfoldings and organisations are all from the same original "piece of paper". That is, the single, tiny ball of fluid (somewhat like a dew drop) enclosed in a membrane that is the fertilised egg (wrapped in its adjacent and surrounding soft-tissue containers).

The Embryonic Parts are Whole

In the embryo section of many books on the subject, each tiny enfoldment stage and position has been reduced to a two-dimensional icon, annotated and given a name (which is considerably longer in the writing than the length of the formed embryo), in order that the sequence of metamorphosis can be followed, albeit reduced to a somewhat linear progression, for convenience. In textbooks the embryological sequence is usually presented visually as a series of graphic icons, cut out of the spherical sacs in and around which the actual embryo folds itself. The placenta, which is part of the embryonic self-assembly, is often assigned the status of a separate item, despite the umbilical cord being the result of the enfoldment of the original yolk sac. The embryo self-assembles its own body and that of the placental supply system. At the earliest stages, the placenta holds the functions that the embryo must acquire and incorporate. They must progress together, in a manner that unifies the nutrient supply with the nurturing/nurtured architecture.

The word "yoga" means unifying. The primary, connected chamber of our origin holds our entire remarkable human blueprint in potential as one unified form; the size of that original water* droplet. It multiplies into folds within folds, part of this original uni-cellular being residing in the nucleus of every other cell, each one a "mini-me" (see margin note) capable of all that the others can do, albeit with their own specialisations. Every part of us arises from the one whole unit of us, from which we emerge. It is somewhat like an Escher painting or a Rumi poem. "The embryo is the architect of the architecture that forms the embryo. Indeed, it forms the architecture to express the architect". The reasoning mind comes a considerable time after.

The term "mini-me" comes from John Sharkey, Clinical Anatomist, who describes every cell in the human body as a "mini-me" of the person who effectively self-assembled it.

Depending upon which text you are reading, development can be a literal and prosaic description of stages or a poetic story of transformation. Either way, many people (even those who have studied the basics of embryology as part of a medical degree) can learn the facts without necessarily realising that in three dimensions, the embryo forms from the actual meeting of two tiny water* bags, both inside another surrounding one (Fig. 4.1).

The embryo takes these sacs with it during every fold of the journey to formation. It only sheds them at birth, having structuralised its own outermost layer (skin) inside what becomes the surrounding amniotic sac. The skin itself is formed from the lower continuity of the amniotic membrane. They are not separate entities. This is almost impossible to represent as multi-dimensional form in two-dimensional media, even visually. It is entirely impossible in words, as they are simply an inappropriate medium. The essence of that continuity (and its sentience) is exactly why fascia is raising so many questions

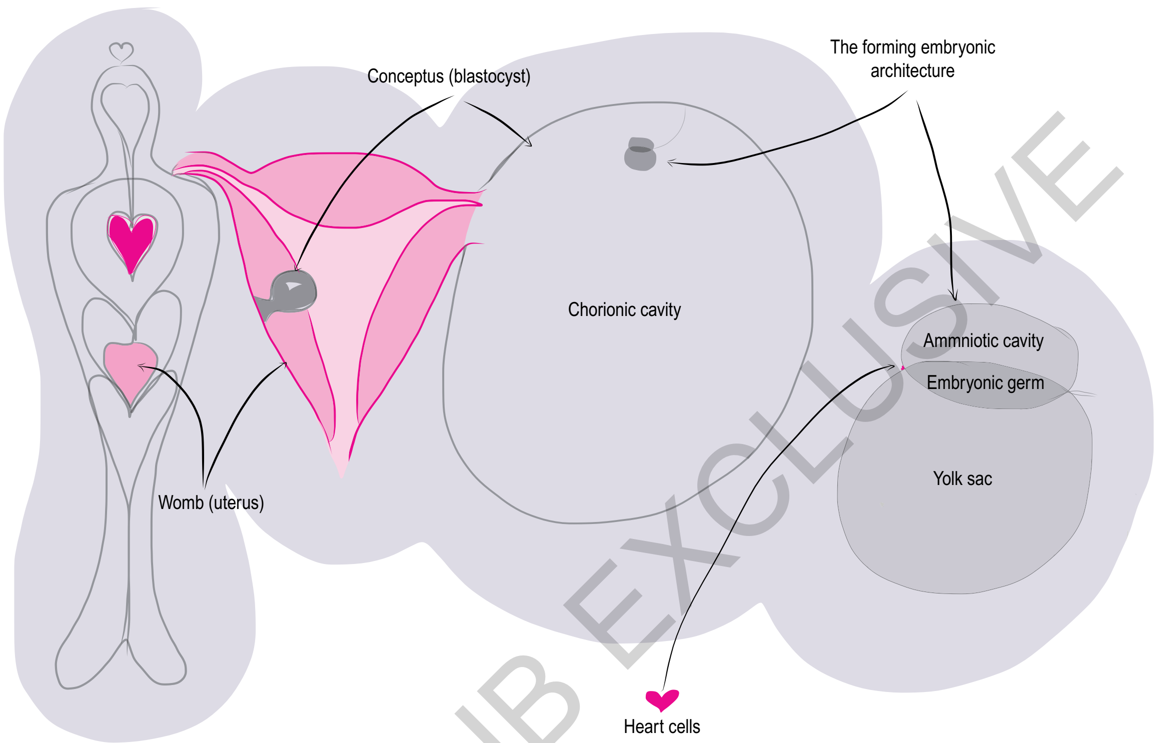


Figure 4.1

The embryo forms at the meeting place of the upper (future amniotic) sac and the lower (yolk) sac. The heart begins just beyond where they join, above what will become the crown. It is not a seed or a germ between the sacs. It is the sacs.

and inviting different perspectives to account for our anatomy, physiology and biomechanics, at all stages of our development. Fascia seems to play an essential role in every aspect of our formation; perhaps that is how it earns the title "organ of organisation" as it clearly organises and seems to unify the embryological forming processes. It is quite literally mind-blowing and beyond reason, so fitting it into words is at best a reductionist attempt to point to the moon. Even visually, we are reduced to 2D images that, like the cross-section of the orange in Chapter 3, don't tell you much about the morphology or the wholeness.

Heart-felt Beginnings

In Figure 4.1 we see that the inner chambers touch each other, forming the upper and lower sentient membranes that will become the embryo; the future heart starts "above the crown" before the growing brain folds over it. We will also learn that the fluid of these chambers (the "embryonic soup") is the basis of all the building materials[14] and connective tissues from which we form ourselves. The rhythmical beat of the heart begins very early in the process, syncopating the motion of blood to the rapidly growing brain, as we will see in a little more detail below.

Spacialisation

From dot to disc:

Anatomist and embryologist Jaap van der Wal (see Ch. 3) celebrates embryology from a more humanist view of being and becoming. He points out that, at the initial stage of fertilisation, the egg (ovum) is (approximately) 90% cytoplasm and 10% nucleus; it is the largest single cell in the human body, visible (just) without a microscope. When sperm reach the outermost membrane of nutritive cells of the ovum (called the corona radiata; "encircling radiance"), they first rest there and the egg begins to spin within its "radiant crown".

The sperm is the smallest human cell and is made up of (approximately) 90% nucleus and 10% cytoplasm, in other words, the opposite of the egg. These essentially polarised cells enter what van der Wal describes as a "conversation" or subtle exchange. If they merge, the sperm completes the nucleus of the ovum and the ovum completes the cytoplasm of the sperm, and vice versa. Thus, together, they form one whole and complete original unicellular organism; the conceptus, from (and within) which all subsequent multiplications occur. Van der Wal describes the process of spinning as "*a very subtle mutual process of encounter and exchange of signals and substances, which lasts for several hours*".[10] He elevates it from genetic coding reactions to a wondrous process of recreation at the mutual agreement of the feminine and masculine polarities. A third being, the child, arises when the egg is fertilised and the outer membrane of the egg (zona pellucida; "transparent membrane") shields the conceptus from the outside environment and other sperm.

The entire embryonic process is one of specialisation and *spacialisation,* in that the embryo must form the cavities, tubes, fabrics and membranes, which fold and enfold the organic origami pattern. They all remain connected and continuous, although distinct and differentiated, throughout what Jaap van der Wal calls the "embryonic performance".

Interesting research at Tufts University,[15] in 2011, involved filming the development of a frog embryo using a method that could capture light. The clip shows that what is called "bioelectric signalling" made a holographic light-print in the embryonic tissues. The clip clearly shows a midline and the sensory features of the head, in a moment of illumination. The researchers discovered that if this light-print was interrupted, the tadpole developed abnormally (two heads or two tails, for example). This indicates that the signals interrelate with membrane voltage and pH levels, influencing the forming process of the embryo. Their research suggests this illumination might precede the genetics. Clearly, many questions remain unanswered.

Some geneticists believe this differentiation into form is attributed only to a genetic coding programme, the chemistry of the DNA. Other researchers (epigeneticists) believe that the movements of forces in the forming and growing process create the tension and compression or dynamic fields that participate in shaping the embryo into form. They argue that it is the "movement fields" (kinetic morphology) that initiate which genetic coding patterns get switched on. In other words, what can DNA do without the appropriate cell in which to express itself? Which comes first?

Perhaps we could simplify a little and imagine the genetic codes as "pattern potentials". Since movement is a sign of life, then each vital movement can produce a pattern. Like the colours in a kaleidoscope, there is a limited number of individual, coloured pieces. However, with reflections and shifts of the structure and motion of the kaleidoscope, infinite variety of patterns occur down the viewfinder. Could we imagine that the colours are the genes and the movement of growing presents them in unique patterns, within the blueprint? Perhaps that is a way of seeing how order arises from many different aspects of the apparent chaos of the embryonic forming. We are all unique presentations of our species, which, paradoxically, makes us all the same.

The Sequence of Events

Table 4.1 highlights the key events in the sequence of embryological forming and provides a basic chronological reference for the rate at which changes take place. What is harder to appreciate is that the forming process occurs in 360 degrees and, in fact, many of the processes happen simultaneously. They do not wait for one event to be followed by another in a horizontal timeline. In many of the drawings and schematics of the forming process, the focus is mainly on the actual embryonic germ changing shape (it has to be) within the chambers from which it forms; as it is in continuity with them. What we have to remember is that this is similar to cutting muscles out of their original habitat and placing them separately on the drawing board. Muscles do not function on their own, out of the context of the connecting tissues and fluids they contain and reside in, and nor does the embryo.

"Life makes shapes. These shapes are part of an organising process that embodies emotions, thoughts and experiences into a structure. This structure, in turn, orders the events of existence. Shapes manifest the process of protoplasmic history finding a personal human shape – conception, embryological development and the structures of childhood, adolescence, and adulthood. Molecules, cells, organisms, clusters and colonies are the beginning shapes of life's movement. Later on, a person's shape will be moulded by the internal and external experiences of birth, growth, differentiation, relationships, mating, reproducing, working, problem solving and death. Throughout this process, shape is imprinted by the challenges and stresses of existence. Human shape is marked by love and disappointment."[16]

The Basic Process

The three fundamental principles of the embryonic period are:

- for the cells to flow into the right positions (the first three weeks)
- for the forms to fold and grow the emergent architecture into being (weeks four to eight)
- to orchestrate the organisation of the foundational pattern of the remarkable human blueprint once that form has emerged, from which the development of the neonate can grow and emerge. (It is a continuous process, in continuity.)

Bearing in mind that the wholeness of each stage gives rise to the parts (not the other way around) let us consider each of the eight weeks from conception, including the pre-embryonic period.

Week 1

Fertilisation (forming the original unicellular being) takes place in the fallopian tube. The fertilised egg travels to the uterus, as it multiplies within itself, contained by the zona pellucida, into daughter cells (Fig. 4.2).

Cleavage (from uni-cellular to multi-cellular). On the way to the uterus (Fig. 4.2), the uni-cellular chamber (conceptus or zygote) begins to rapidly multiply (from conception) into two identical daughter cells. They will then repeat this process (cleavage) to form eight daughter cells. Each one is whole and complete in itself, with nucleus and cytoplasm, smaller than the cell it multiplied from within (see Ch. 13).

On the fourth multiplication, to sixteen cells, the conceptus forms a ball of cells and is called a blastocyst. The surrounding membrane (zona pellucida) has not expanded in size but encloses the increasing number of smaller and smaller daughter cells (blastomeres). By the seventh or eighth multiplication there are over 100 of these. The blastocyst is called a morula at this stage, meaning "mulberry" shape, although it is in fact still enclosed by the zona pellucida (Fig. 4.3).

Table 4.1
Table of embryonic process showing main features of embryonic development in days

Pre-embryonic Period							
Week 1	*Day 1*	*Day 2*	*Day 3*	*Day 4*	*Day 5*	*Day 6–7*	
Fertilisation	Fertilised egg; the single-celled conceptus in fallopian tube enclosed by membrane (Zona Pellucida)	1st multiplication into 2 identical cells after (30 hours). More dividing into smaller cells	A ball of over 100 cells in the Zona Pellucida carried along the fallopian tube	A ball made of cells with an outer layer and an inner cell mass (the blastocyst)	Beginning of implantation. The blastocyst must snuggle into the uterine lining	The pre-embryonic journey of the fertilised egg, down the fallopian tube, takes about a week. The cells are dividing within the delicate membrane of the Zona Pellucida until they form into the blastocyst (a ball made of cells), losing the membrane and beginning to implant into the lining of the uterus	
Week 2	*Day 8*	*Day 9*	*Day 10*	*Day 11–12*		*Day 13*	*Day 14*
Implantation (the week of twos)	Embedding in uterine lining. This is essential or there is no pregnancy. The outer part of the blastocyst has to establish this direct nourishment to grow	Forming the outer chamber and the cavities that will form the inner chambers	Forming layers and linings of the inner chambers that become the amniotic and primitive yolk sac	Forming connection with the mother through implantation, the blastocyst must send out a tiny root into the uterine lining that will eventually become the placenta. This continues to grow from the structures of the outermost chamber		Chambers within chambers form growing spaces of the amniotic sac that meets the yolk sac, forming inside the outermost chamber	A two-layered disc forms where the upper (amniotic) sac meets the lower (yolk) sac. This interface, where they touch, forms the pre-embryonic disc
Embryonic Period							
Week 3	*Day 15*	*Day 16*	*Day 17*	*Day 18*	*Day 19*	*Day 20*	*Day 21*
Orientation Neurulation, Gastrulation; (the week of threes)	Polarity and orientation arise: head end, tail end and laterality. The primitive streak and node predict the Notochordal axis	Early notochord, predicting future spine, axis for formation and support of the entire embryonic forming process	Growth rates pull the upper and lower layers of the pre-embryonic disc apart. Cells pour into the gap from the upper layer	The upper (ectoderm), the middle (mesoderm) and lower layer (endoderm) form 3-layered embryonic disc and notochord	Central Nervous System is induced where spinal cord will grow	Neural tube formation and the somites begin to form. They are organs of the body wall: 360° forming vertebral organisation and the axial body	The heart starts above the crown of the embryonic disc: so-called at this point for the tri-laminar disc that is formed

Week 4	*Day 22*	*Day 23*	*Day 17–28*		*Day 26*	*Day 27*	*Day 28*
	Neural tube closure begins. Number of somites increasing from head towards tail	Heart pumps the rapidly growing brain, intimately relating the circulatory and neural growth functions	The Folds; Head Fold, Tail Fold and Lateral Fold shape the form and inner cavities of the head and torso. Meanwhile the outer (chorionic) sac grows and the placenta develops		Pharyngeal arches appear and lung buds begin inside the anlage of the thorax	Somites, important transient features of segmentation, grow the embryo. (Number of pairs denotes age)	Neural tube complete. Primitive anlage of ear and eye structures appear
Week 5	*Day 29*	*Day 30*	*Day 31*	*Day 32*	*Day 33*	*Day 34*	*Day 35*
2nd Month 5–8 mm	Arm buds and (about 2 days later) leg buds forming from body. Lung buds forming inside	Developing gut tube from membrane to membrane that will form the mouth and anus at either end	Embryo in flexion as it expands into growing chambers	Umbilical ring forms. Body stalk grows	The heart grows and body begins to form more recognisable proportions	The eyes appear in the cranial formation, initially oriented more laterally.	The lungs develop further as the anlage of the pleural cavity and bronchial apparatus. Thorax forms a primitive breathing pattern
Week 6	*Day 36*	*Day 37*	*Day 38*	*Day 39*	*Day 40*	*Day 41*	*Day 42*
10–14 mm	Umbilicus forms	Face develops more detail and organisation	Myofascial development (according to the somitic segments) and differentiation	Visceral development and differentiation: e.g. liver filters blood to heart	Ear structures develop for balance and hearing	Differentiation of the heart. Atrial septum formed	Differentiation of the hand digits then the foot. They begin as paddles and transform via four interspacings
Week 7	*Day 43*	*Day 44*	*Day 45*	*Day 46*	*Day 47*	*Day 48*	*Day 49*
17–22 mm	Limb differentiation and digital rays of the fingers and toes, more detail	Development of the face and cranial formation	Detail of the heart more developed	Expansion of placenta, as chorionic cavity grows	External genitalia appear	Facial prominences fused	Hands, fingers, feet and toes present, eyelids forming, upper lip forming
Week 8	*Day 50–56*						
28–30 mm	Limbs lengthen proportionately and fold at knees and elbows. Fingers and toes are free and face becomes more clearly organised and proportioned as recognisably human. Tail disappears and umbilicus forms						
Fetal Period (from 9th week onwards)							

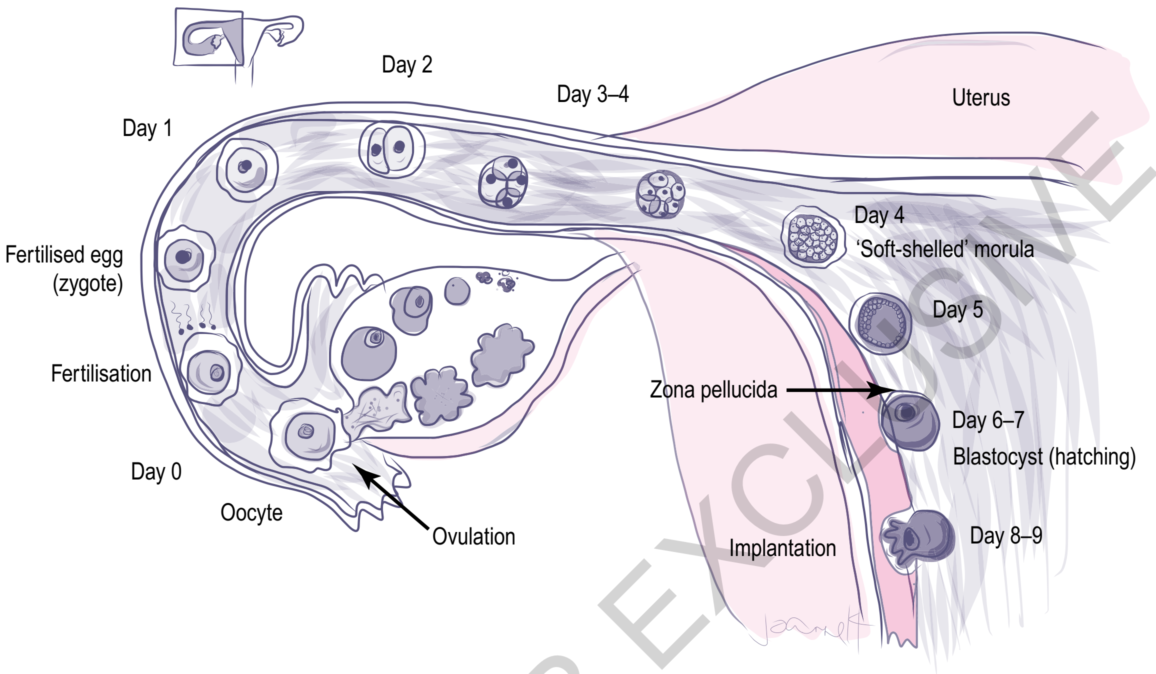


Figure 4.2

The journey of the conceptus (zygote) from fertilisation to implantation (Days 1–9 approximately).

The fact that this is called a morula may be one of the fundamental reasons that embryogenesis is so variously described and confusing in the literature. A morula is a mulberry – an open design, like a raspberry or such fruit, with no surrounding membrane. The surrounding membrane (the zona pellucida) means this structure is not a morula at all. It is a pocket of cells, inside a connective tissue membrane, within which are contained (bound) fluids. That containment creates the "in between stuff" (mesenchyme) of the embryo and is actually the precursor of the circulatory system. Without the membrane, we have no containment for the proliferation of daughter cells to begin the blueprint. For a beautiful presentation of this sequence, albeit in another species, Jan van Ijken[17] has made a film in time-lapse photography of a salamander or

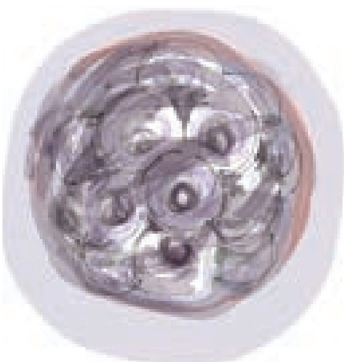


Figure 4.3

The blastocyst, a ball of cells, is still wrapped in its containing membrane (the zona pellucida), a significant aspect of the primitive circulatory processes of fluids between the cells.

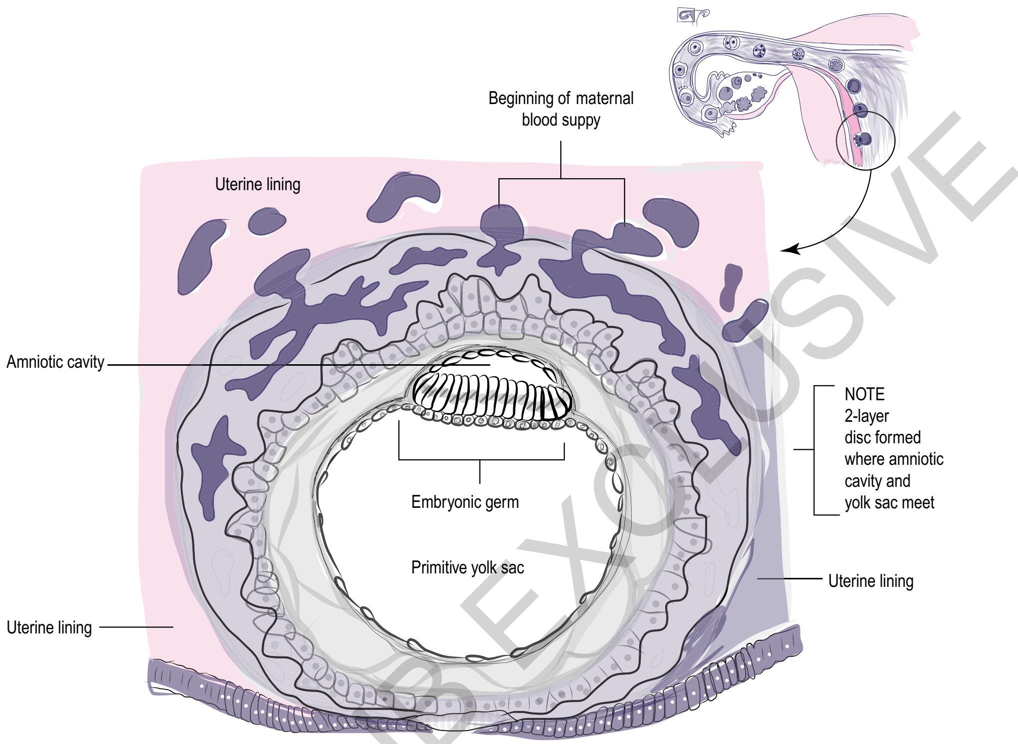


Figure 4.4

In this sketch the tiny outermost chamber implants within which the sacs of the innermost chambers are forming.

Week 2

newt embryo forming. This will give you a wonderful sense of the massive proliferation of cells, within transparent membranes. It also begins to iterate the rapid, simultaneous multi-dimensional processes of development. Watch and see how impossible this is to describe!

The fertilised egg must snuggle into the uterine lining and literally implant itself. Mother and future embryo respond to each other chemically, kinaesthetically and proprioceptively in multiple subtle exchanges. They form specialised circulations to provide nourishment (including nutrients and oxygen) at the rate the embryo will be able to receive it and send out its own circulatory by-products of metabolism (waste and carbon dioxide).

Implantation. The ball of cells then changes itself into a ball formed of cells with a distinct "outerness" and an inner cell mass around a cavity. It must reach and implant itself in the uterine lining (Fig. 4.4), where it has to suckle its way in to becoming impregnated.

Post-implantation. Implantation confirms the pregnancy. Described as the "week of twos", in this second week the biodynamic origami begins, and folds form into pockets inside the earlier ball, made of cells. An upper cavity forms that will become the amniotic sac and the lower cavity will become the yolk sac, inside the surrounding (chorionic) chamber. This statement grossly over-simplifies a complex sequence in which the embryo forms its own "living accommodation" within (and from) which to grow.

As mentioned earlier, the fascinating aspect of this that is hard to appreciate from two-dimensional schema is that the embryonic germ itself forms from the interface where these two main inner sacs (amnios and yolk) meet. The initial germinating pre-embryo is the in-between – the meeting place where these two "soft bubbles" touch. The embryonic disc actually derives its upper and lower laminae from where the outer membranes (of the amniotic and yolk sacs) contact each other (Fig. 4.5).

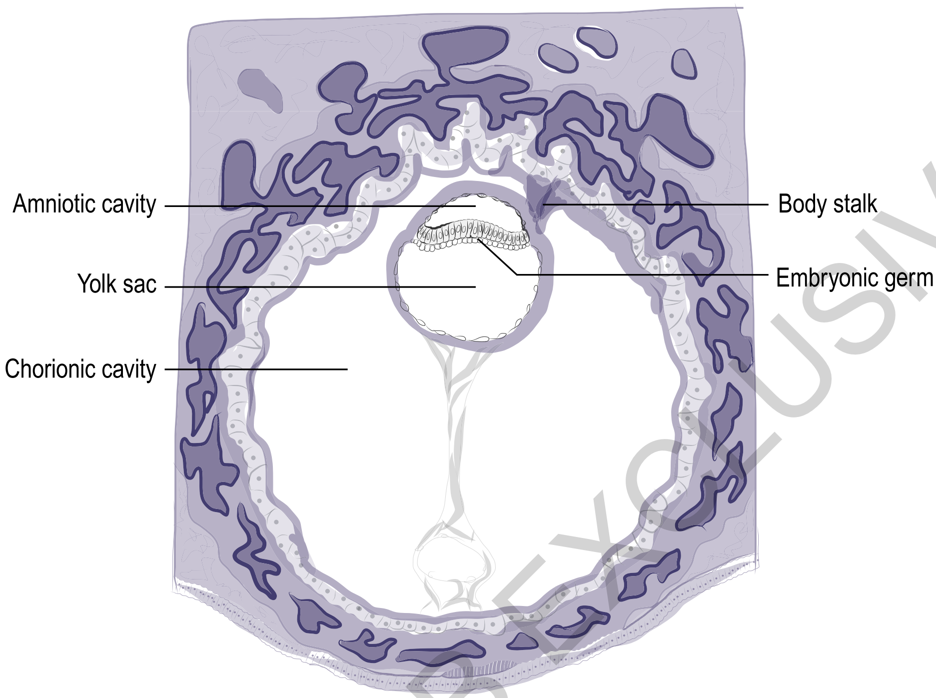


Figure 4.5

Pockets within pockets. The embryo itself is formed where the two main inner sacs meet. It is not a separate seed or a germ between their layers. It is their layers.

Image modified after T.W. Sadler, *Langman's Medical Embryology* (see note 23).

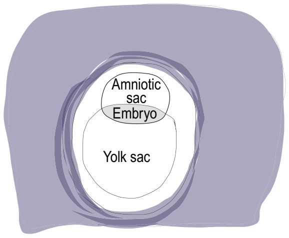
Always in the round: the "embryonic disc" is named in advance of its clarified form. It is not a disc that ends at its edges; it appears two-laminaed where these two sacs touch each other. They remain whole. The embryonic "disc-shape" remains the lower aspect of the upper sphere (amniotic sac) and the upper aspect of the lower sphere (yolk sac) in continuity with each, throughout its growth. They acquire different textures and densities to the amniotic and yolk membrane, incorporating one and being incorporated by the other through the process we will now attempt to describe – however, they never separate from them until birth; they remain in complete continuity.

Membranes will form to "join" them, that will eventually become the mouth and anus at either end of the gut tube, when it has formed in the folding sequences. Once the embryo has grown and folded laterally and longitudinally into tubes within tubes to form the body, it will begin to resemble a developing fetus. At this stage before the folding begins it is *apparently* a two-laminaed disc. When the embryo folds (week 4), it will take these chambers with it, remaining part of them. It folds around the lower one as it is enfolded by the upper one. Thus, it is formed from the continuity of its own architectural continuum. It is self-assembled and self-animated.

Before this embryonic folding sequence can happen, the pre-embryonic disc has to become a volume, by creating a middle. (We might say it "spacialises" into outermost, innermost and in between.) First, however, it has to gather coordinates from which to orientate, in order to organise.

Week 3

(a) Orientation, (b) gastrulation and (c) neurulation. Three key processes happen in this third week. The so-called disc also develops orientation with a head end, a tail end and sides (laterality). This predicts an axis, around which the subsequent



In fact, the different growth rates, mean the outer membrane (from the attached end where the food is closest) grows faster and rounds out over the inner membrane, as they move apart. Between them, an inner "spacialisation" forms, creating a volumetric whole tubular (soft-tissue) architecture. Van der Wal[18] calls this the "innerness" or the "meso" and refutes the term "layer" or "derm" as a misleading way of describing something that isn't layered. In fact, it is more toroidal (donut shaped), the outside and the inside being in continuous continuity; the "meso" describes the volume within the toroidal shape, or morphology.

developmental progress will evolve. It is generally referred to as a "two-laminaed disc becomes a three-laminaed (trilaminar) disc" of the true embryo.

This process is called *gastrulation*. The third process in week three is neurulation, which refers to the formation of the brain and spinal cord.

From a biodynamic point of view, this "enclosure" within a containing membrane is an important distinction because it influences the motion of the internal fluids and shape changes between the cells, in the tension–compression, close packing matrix of the micro-network. It might correlate to a very primitive form of the micro-vacuoles seen in *Interior Architectures*, by Jean-Claude Guimberteau.[19]

Let us consider these stages one at a time:

(a) Orientation. Perhaps we are drawn to the spine in yoga because it is one of our primal and primary features of orientation, present even before the pre-embryonic stage of development is complete. A midline (called the primitive streak) forms in the uppermost membrane of the bilaminar disc identifying axes: a left and a right side, a head and a tail end. (At this time the embryo is about 0.23 mm in length.) We might consider this original organisation as our "null point" (Fig. 4.6)[20]. It remains our movement reference throughout our lives. It is something we consciously explore in yoga practice and recognise in positions of the chakras along the spine (see Ch. 12).

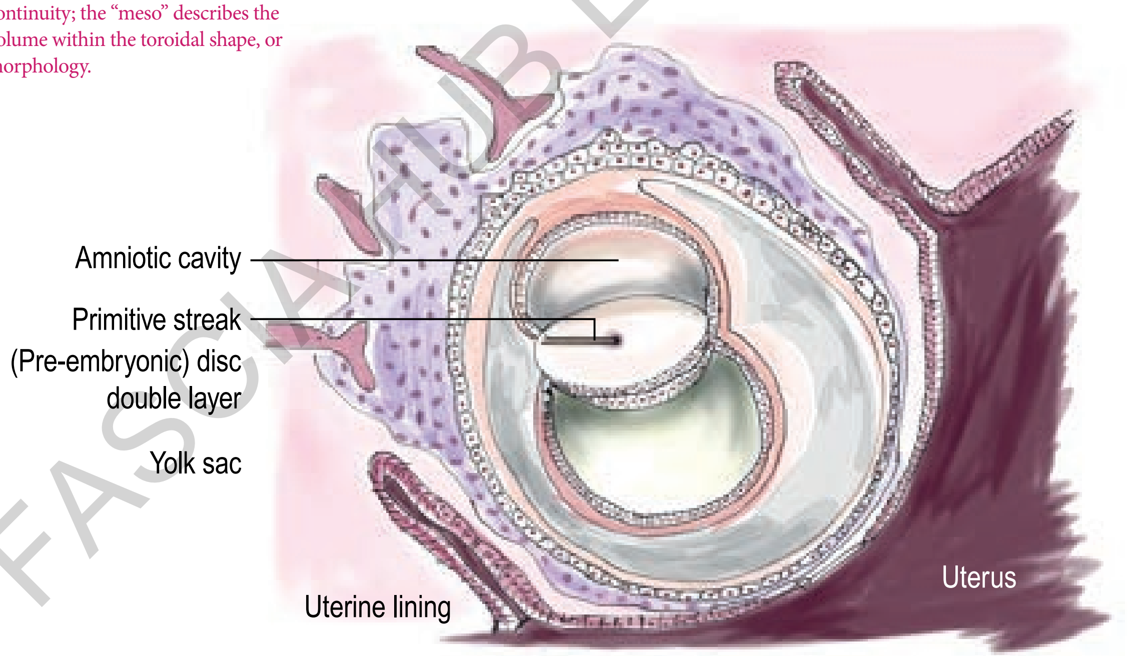


Figure 4.6

The flat embryonic two-layered (bilaminar) disc within its growing chamber. As Blechschmidt describes in The Ontogenetic Basis of Human Anatomy (see note 3): "the apex of the axial process can be considered as the centre or, better, the null point of the developmental movements of the whole [bi-laminar] disc. The apex of the axial process provides a natural reference for interpreting all subsequent biomechanical movements and the action of biodynamic forces."

Modified after images available from the following website, where an excellent chronological visual presentation can be found: www.bionalogy.com/human_embryology.htm

Imagine a blue water* balloon placed on top of a yellow water* balloon. Where the blue balloon touches the yellow balloon, there will be a green-coloured disc, the soft ovoid shape where the two layers come together. Where they meet is going to become the upper and lower membrane of the pre-embryonic disc. Its upper lamina is the lowest part of the blue balloon. Its lower lamina is the upper part of the yellow one; they remain in continuity with the original balloon (amniotic and yolk sacs) throughout the pregnancy.

This delicate structure will eventually include the formation of the placenta, the "other end" of the umbilical cord, where food and oxygen will be supplied for the duration of the pregnancy.

(b) Gastrulation. The upper membrane (lowest "bowl-shape" of the amniotic sac) of the tiny germ grows the most rapidly. It is nearest the source of nourishment. The lower membrane (which in 2D is the upper curve of the yolk sac, in 3D the uppermost "cap-shape") grows more slowly. It is furthest away from the food supply. These differing growth-rates animate cause the formation of volume, as they grow apart from each other and the "middle" or *meso* forms between them:

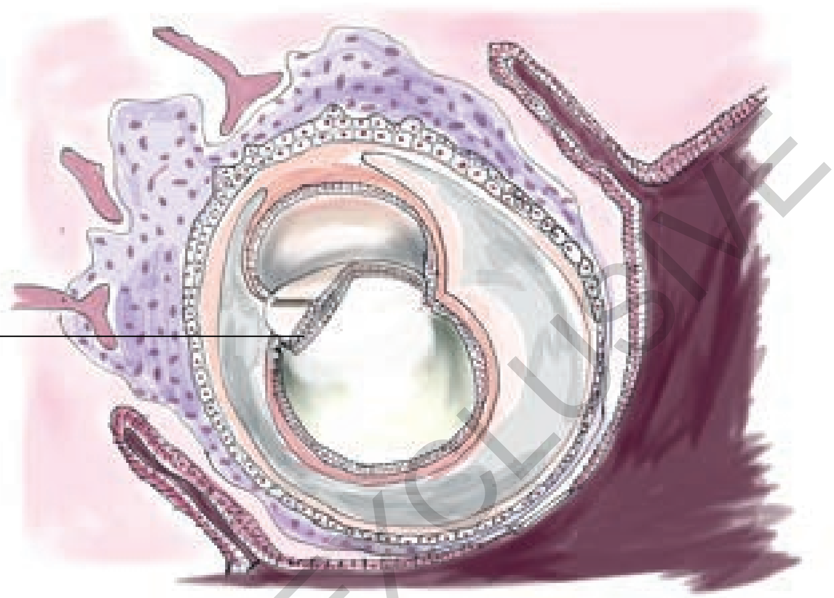
"as a consequence of rapid differential growth, the ectoblast [upper] glides away from the hypoblast [lower] and an intermediate lamina of loose tissue forms between them. Thus from a biomechanical point of view, the tissue at this depth is strained under tension in a circular and radial direction as the conceptus enlarges. As far as the cells of this intermediate lamina are concerned, they become flatter and this leads to a loss of their intracellular fluid. This fluid collects together in the interstices as intercellular substance. In this way the tissue becomes reticulated or honeycombed. The network is the middle blastocyst form."[21]

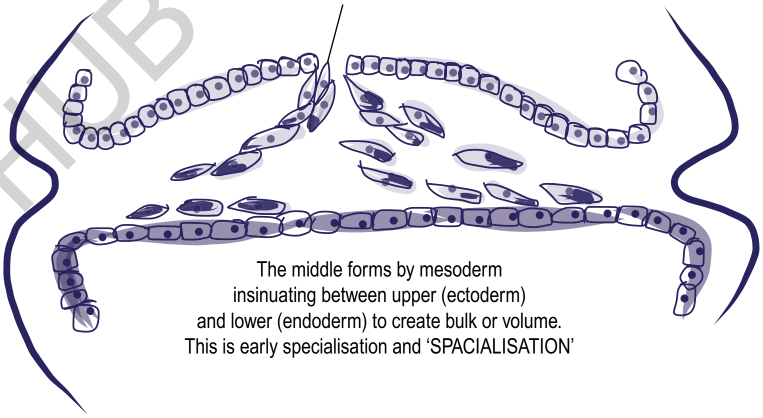
It is noteworthy when we consider the self-assembly of the embryonic form that, as van der Wal points out, the embryonic version of us must also assemble the placenta. There is a quality of awareness that must focus outwardly to the primitive "kinesphere" and animate the formation of the placenta *to a point*, where it must return and focus attentively upon the "innersphere" to grow its own architecture. In radial terms we might say *these qualities of* attention move centrifugally and centripetally. These are keys to understanding movement and breath *in the round* that we will explore later; however, they are important *turning points* in our original developmental process. The placenta, initially, does the functioning that the embryo must gradually *incorporate* through the process of self-assembly. According to van der Wal, attention must *approximate* full expansion (outward focus) and then turn towards a counter-balancing inward focus at the appropriate time. If this fails, the issue corresponds to the timing points of miscarriage at 6 and 12 weeks.

The cells from the upper (*ectodermal*) lamina subsequently lose some of their close-packed organisation or structure (de-epithelialise) as that membrane opens out radially (thus *spacialising them)* and cells pour into the space created between the two laminae, through the primitive streak (Figs 4.7 and 4.8). The first to arrive form the *true endoderm* by restructuring their close organisation. Thereafter, they fill the space between the lower membrane (endoderm) and the upper membrane, thus becoming the middle. The upper membrane becomes the definitive ectoderm, while the middle layer is called the mesoderm – which is misleading, because it is never a layer; it is an intermediating volume, essentially, *between* layers; that van der Wal calls "inner-ness".

(c) Neurulation (Fig. 4.9) is the transformation of the neural plate into the neural tube. In concert with the central part of the middle-ness or *meso* (paraxial), the upper (ectodermal) lamina has to fold back on itself along the midline and form the neural tube; a distinct tube, within the longitudinal shape of the forming torso. It does this by invaginating and joining the fold edges (like a zip) along its length. It eventually encloses and forms what will become the spinal cord, longitudinally. The somites, formed from within the paraxial mesoderm, line either side of the neural tube and will form from the base of the cranium position, growing towards the tail, in pairs, dividing the spine into segments. The number of pairs of somites gives rise to the age of the embryo, predicting and incorporating the length and structures of the torso, or (*axial*) body.

This sequence confirms the formation of what are called the "three germ layers" but in fact, in biodynamic terms, the middle part of the embryo represents many aspects of entering three dimensions. The transformation of the two-layered (bilaminar) germ disc into a what is called a "three-layered (trilaminar) disc" is the transition from the pre-embryonic stages to the true





Figures 4.7 and 4.8

Cells from the upper (epiblast) membrane pour through the primitive streak into the space forming between the upper and lower membranes.

Modified after images available from the following website, where an excellent chronological visual presentation can be found: www.bionalogy.com/human_embryology.htm

There is total dependency upon the mother for nourishment and oxygen. From a structural point of view, there is also a need for containment, with the biodynamic forces of invaginating containers and limiting tissues. The womb, the soft tissue of the abdominal wall and the framework of the pelvis will play a containing role for the growing fetus similar (though on a different scale) to the zona pellucida for the blastocyst. Thus, the balance of forces is maintained in a living tensegrity pattern as the growth function expands and the limiting tissues constrain the growth, offering a reciprocal force transmission, *in the round.* The growth tensions the constraining tissues, while the tissues offer compression (to provide the resistance forces) needed to feed back the biological pattern process. It is relentless, as it will be after the birth, albeit in a different amplitude of forces. *In utero* the embryo is in a fluid, gravity free environment – however the forces of tension and compression are working together to provide the *force transmission pattern* that the embryonic matter (or biomaterial) must learn to incorporate. After birth, the neonate will effectively be "wrapped in gravity".

embryo. The three main classifications for what the membranes will become are as follows:

- The upper membrane (ECTODERM) becomes the brain, spinal cord, nervous system and skin.

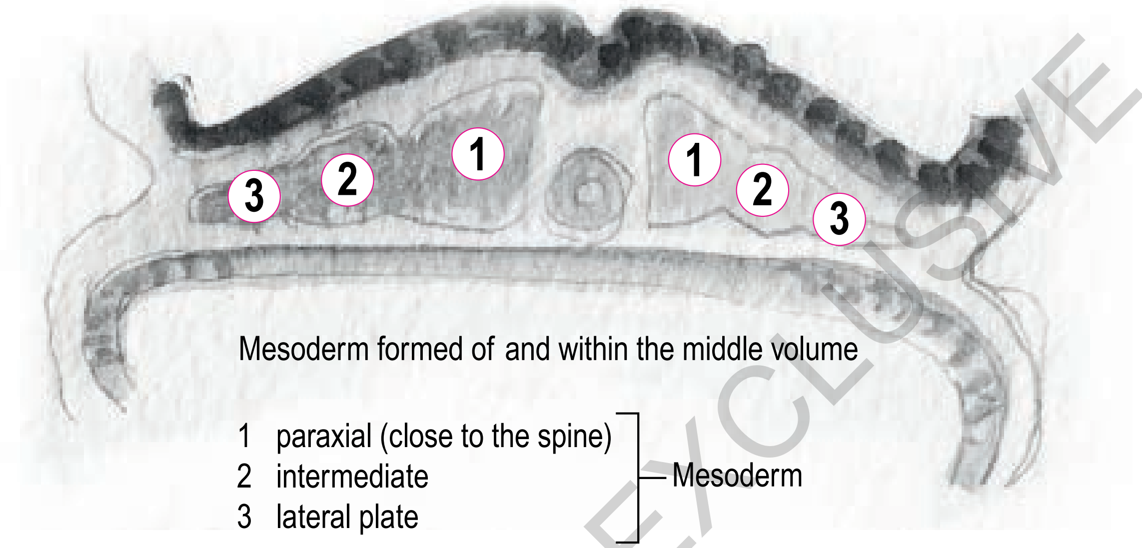


Figure 4.9

The neural tube forms from the ectodermal membrane folding back upon itself, along its length (C shows how this begins in cross-section). See Fig. 4.15 for a longitudinal view.

The mesoderm. This middle layer (mesoderm) does not form a "derm" (layer) quite like the other two layers, above and below it. The network that the middle layer forms is a loose aggregate (of unstructured, *de-epithelialised* cells) called mesenchyme. It could be thought of as a "mesenchymal milieu" of potential building materials. These include blood cells and other connective tissue and fascia. The cells, such as those producing fascia, muscle, cartilage and bone and "biomaterial" of all the organs and vessels, are contained in and integrated with the connective tissues. They respond to the shapes and forces of the containing forms. These are the architectural components of the forms within and around the forming body walls and cavities. Mesenchymal cells can migrate and move around, serving and mediating the process of formation. This *meso* contains these undifferentiated "forming potentials" that respond kinetically and genetically to various signals, forces of growth and metabolic movement; i.e. responding to the

- The middle aspect (MESODERM) becomes the body wall, cavities, muscles, bones, connective tissues and blood, including the spine and limbs later.
- The lower membrane (ENDODERM) becomes the gut tube, from mouth to anus.

In the process of forming, the embryo can create structure and release it. This means it can close-pack cells together to form a membrane or lining (epithelialise) or release them into a looser aggregate of cells (de-epithelialise). In this way, tissue can respond to changes in genetic chemistry, signals, forces, growth patterns and position by structuralising and destructuralising appropriately. Blechschmidt[22] identifies "metabolic growth fields" that significantly influence our shape-changing movements (kinetic morphology). Fluids and membranes are formed into primitive precursors of networks, systems and structures where some tissues are pulled apart and others are pushed together, folding and expanding, tensioning and compressing, thickening and spiraling, at different rates, but always connected. It is an organic, living tensegrity volume, self-organising its way into form.

The mesoderm subdivides spatially, through its bioorganic origami process of folding (remember nothing separates from the wholeness) either side of the forming central axis into: (1) *paraxial mesoderm* (closest to the central axis), which becomes segmented into somites, predicting the vertebrae (see later); (2) intermediate mesoderm, which will give rise to parts of the shape-changes. This is the pattern of our species, that comes to be uniquely expressed by each one of us in the matter of our fabric; the architecture of our architect self-assembling.

Mesenchyme is defined as "any loosely organised tissue composed of fibroblast-like cells and extracellular matrix regardless of the origin of the cells".[23] It is thought to represent the primitive extracellular matrix of the future adult form. (It is inclusive of the cells in the embryo.) This *meso*, containing the mesenchyme, forms the "connectedness" that holds the

urogenital system; (3) lateral plate mesoderm (outermost), which becomes divided into two parts, mainly due to the excessive growth of the embryo. One membrane becomes associated with the uppermost, ectoderm (*somatic mesoderm*) and the other gets tensioned away from the somatic mesoderm to form in association with the endoderm (*splanchnic mesoderm*). Some lateral plate mesoderm also invades the developing limb buds. These membranes specifically form the shapes, spaces and characteristics of our head, body, viscera and limbs; once the folds are in place the tubes can spiral their way into form, according to the genetic and kinetic patterns of self-assembly.

Within the mesoderm. The mesoderm also divides itself spatially, into three further aspects, either side of the central axis, out to the lateral edges (Fig. 4.10). As it forms, specialised cells move towards the head and form the

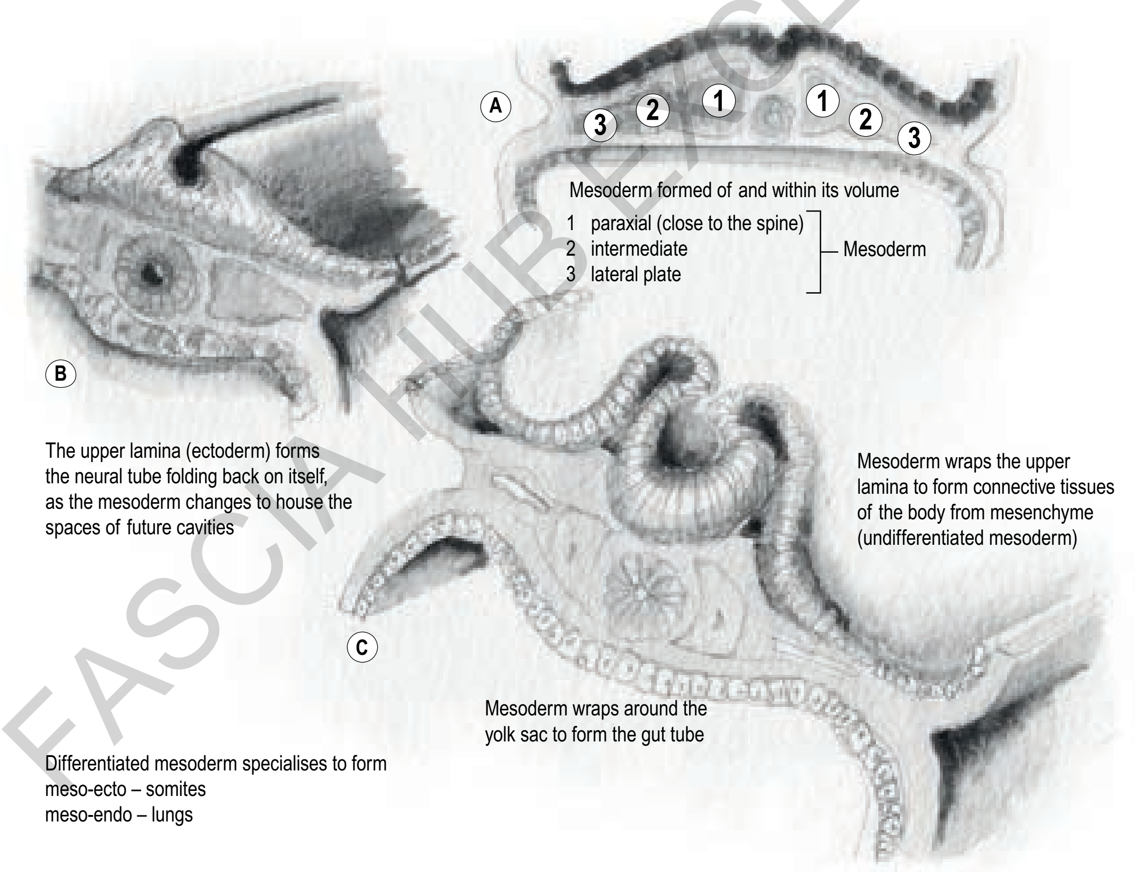


Figure 4.10

The other mesoderm cells, which form from the primitive streak, move out from the central axis and form inner (paraxial), in-between (intermediate) and more lateral mesoderm (lateral plate mesoderm).

other two membranes together, forms pockets within them and at the same time keeps them apart. They are not so much separate entities as structuralisations (membranes) around a middle aspect that plays a role in the structure of all our forms.

prechordal plate, which is important in forebrain development, and the notochord. This predicts the spine and acts as a longitudinal support for the early embryo as well as a signalling centre for certain molecules. These play a part in activating and instructing cells in what to do and which specific tissues to form, according to the genetic blueprint. The next stage concerns bringing the basic human form into being, predicting the placement of the human anatomy and physiology.

Week 4

"The primary connective tissue of the body is the embryonic mesoderm. The mesoderm represents the matrix and environment within which the organs and structures of the body have been differentiated and, in fact, are 'embedded' … in harmony with the view that the principal function of mesoderm as 'inner tissue' is 'mediating' in the sense of 'connecting' (binding) and 'disconnecting' (shaping space and enabling movement)."[24]

This week includes the formation of the somites – transient features of the embryo that play a fundamental role in the structure of the spine. It is also the week of folding into form and developing the placenta.

The tiny heart awakens in concert with the somites (Fig. 4.11), orchestrating growth of the spinal structures and body walls, folding and forming in 360 degrees. This in turn causes the whole embryonic disc to fold laterally and longitudinally, growing omnidirectionally from the central axis, wrapping the body form around the heart.

The ectoderm will form the tissues relating to our response to the outside world, that is, our outer skin and our innermost spinal cord, and the nervous system. It is evident that it does not do this separately in layers. Indeed, since all the cells forming the true endoderm and the meso arise from the ectoderm, the embryo invites us to consider that they would all be sensory in nature and provide our inner sense of the outer world. (Perhaps also our outer expression of our inner world?) They may form into specific structures, but the forming materials and processes all arise from the same original membranes, indeed, the one unicellular organism.

With the forming potentials in place as three aspects (so-called *derms*) and three aspects of orientation (on either side of centre in the middle volume), the embryo creates its length (from head to tail), its depth (from back to front) and its roundness of volumetric form by buckling (folding), taking the (upper membrane) amniotic sac with it whilst enfolding the (lower membrane) yolk sac.

The midline of the developing notochord, neural tube and somites stiffen the back orientation (dorsal axis) supporting the embryo as a more densely textured feature of its architecture, still in complete continuity as it is self-assembled from a fold in the ectoderm (lower part of the amnios). The head end, the tail end and the lateral margins all grow around and fold to become the front and sides of the embryonic body. (They bring the whole amniotic sac they are contained within with them, so that the embryo grows inside it, surrounded by it and expanding into it.)

There are three named folds: *head*, *tail* and *lateral*. These attempt to explain this biodynamic origami so that it can be understood in all its three-dimensional (360 degrees) shape-changing patterns.

Embryonic Folding

The **head fold** is first (Fig. 4.12). The embryo grows forwards and gradually buckles underneath, bringing the heart from beyond the crown to the front

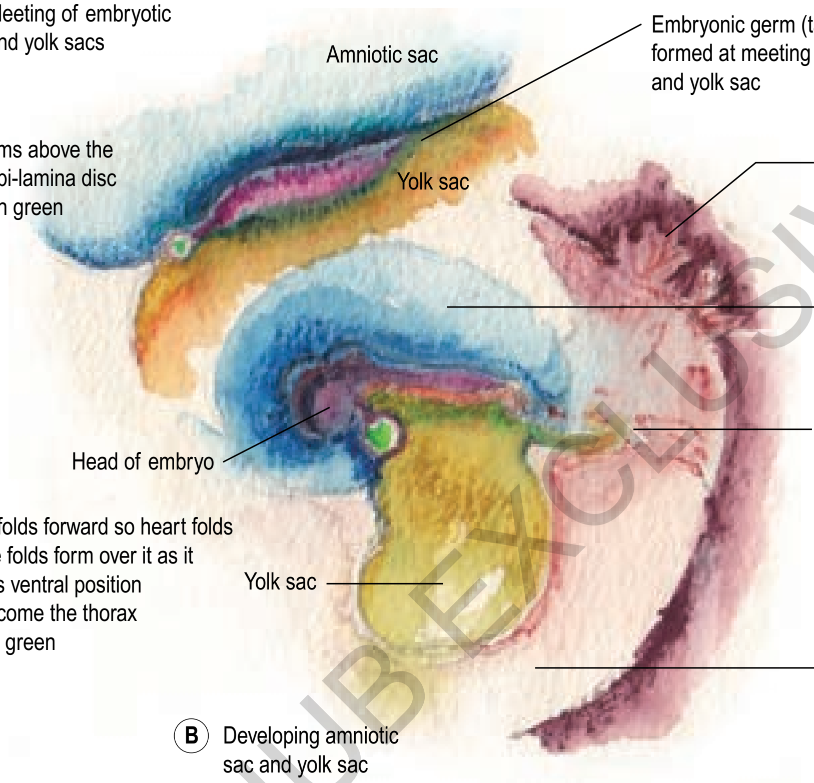


Figure 4.11

The heart starts above the crown. These two paintings illustrate where the amniotic sac meets the yolk sac, which become the developing embryo.

of the body (ventral); the body walls will form around it. A small portion of the yolk sac becomes enclosed with this fold, incorporating the future foregut (*pharynx*).

Lateral fold. The folding of the lateral sides of the embryo (along its length, making it a lateral fold) comes around the front towards the midline, creating a more cylindrical embryo (Fig. 4.13). As the abdominal wall forms, part of the yolk sac becomes enclosed and incorporated into the embryo as the mid gut (the anlage of the small intestine) and the beginnings of the abdominal (peritoneal) cavity. Mesenchyme and somites form the developing torso segmentally.

Tail fold. The tail region of the embryo is last to fold (Fig. 4.14). It grows backwards, lengthening the axial body and effectively drawing the back of the diaphragm down with it as the somites grow towards the tail. It also buckles under the rest of the embryo, bringing the body stalk onto the ventral surface of the embryo and incorporating the hind gut.

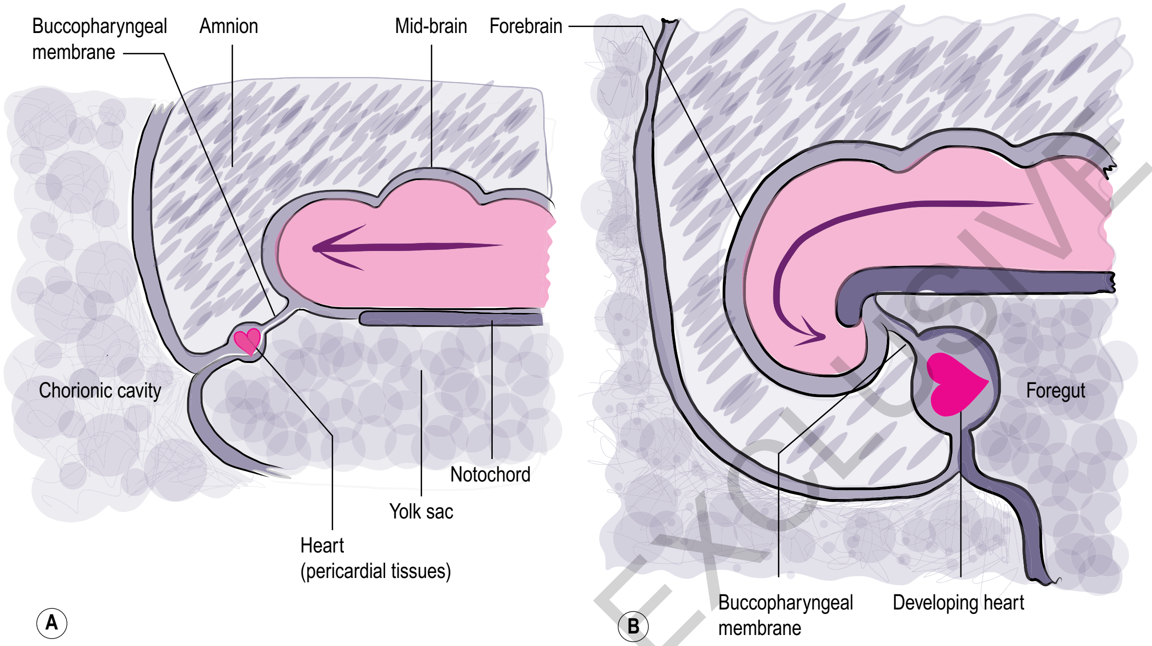


Figure 4.12

The head fold brings the heart to the front of the body.

Folding Consequences

The consequences of this process of folding are that the ectoderm, which was the outer or upper membrane of the embryo, now covers the entire embryo except for the body stalk (Fig. 4.15). The heart and the body stalk are located at the front of the embryonic body because of the head and tail fold. The body stalk will form the umbilicus. Finally during this folding process, parts of the yolk sac become incorporated into the embryo. These gradually form into the gut regions, in concert with the meso (*mesoderm*), the *volume* of the forming torso and future limb buds.

Somites: The Spinal "Spacing"

The growth of the brain, spinal cord and central nervous system is critical for somite development, differentiation and specification (Fig. 4.16). The somites are related to the timing and spacing of how the body walls form (genetically and kinetically) and how the internal spaces, or volumes are enclosed and segmented. They also play a role in limb formation.

Week 5

This developmental week marks the appearance of the limb buds on the outside and growth of the lung buds on the inside.

The lung buds first appear as an outgrowth from the front wall of the foregut, at which stage the anlage of the respiratory organs, the liver bud and the stomach is closely situated around the heart. Remember, they all remain in

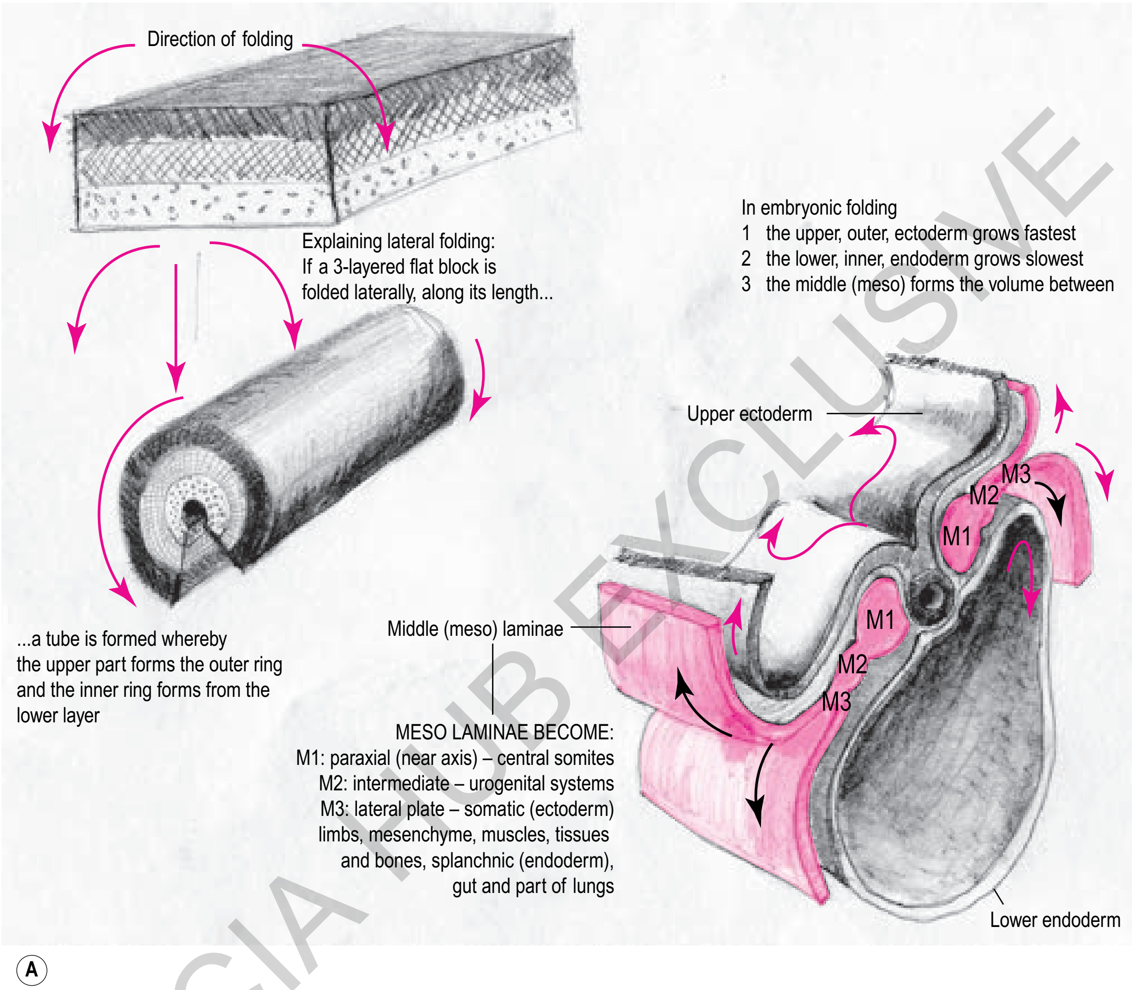


Figure 4.13 (A)

Explaining the lateral fold.

complete continuity. At no point does anything in this process separate from the original membranous continuum. The cartilage, myofascial and connective tissue components of the lungs are derived from the so-called *mesodermal layer* (see note under *Lateral fold*; margin Fig. 4.13B) – as a continuity of the fabric forming the volume of the torso.

Biodynamic growing forces (tension and compression) are also considered to contribute to the formation of the lungs, *suctioned* outwards into the growing space around the heart that was formed in the folding described. Originating from the endodermal tissues, continuous with them, the meso forms the sacs of the pleural cavities (from mesenchyme) and the lung buds grow

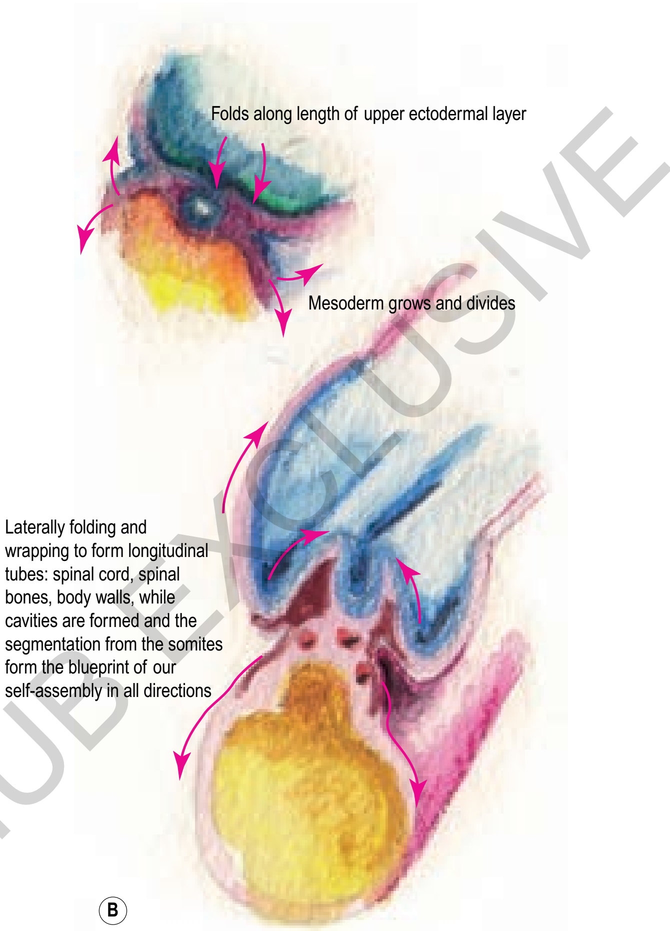


Figure 4.13 (B)

The lateral fold.

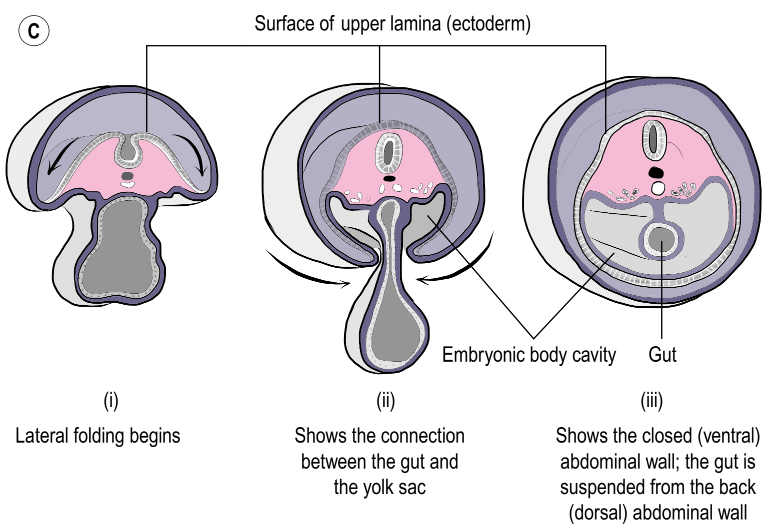


Figure 4.13 (C)

Image modified after T.W. Sadler, *Langman's Medical Embryology* (see note 23).

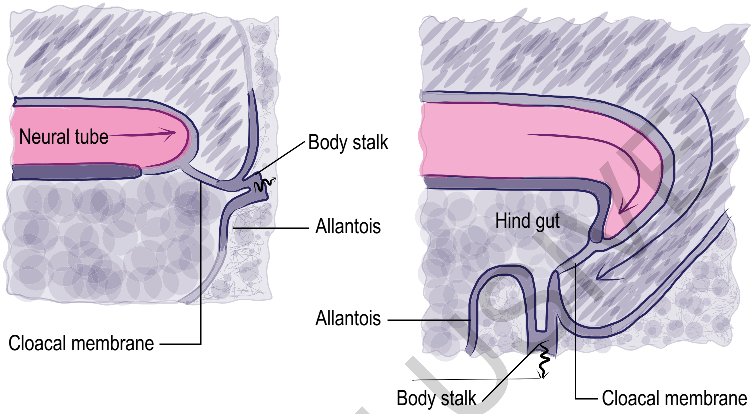


Figure 4.14

The tail fold.

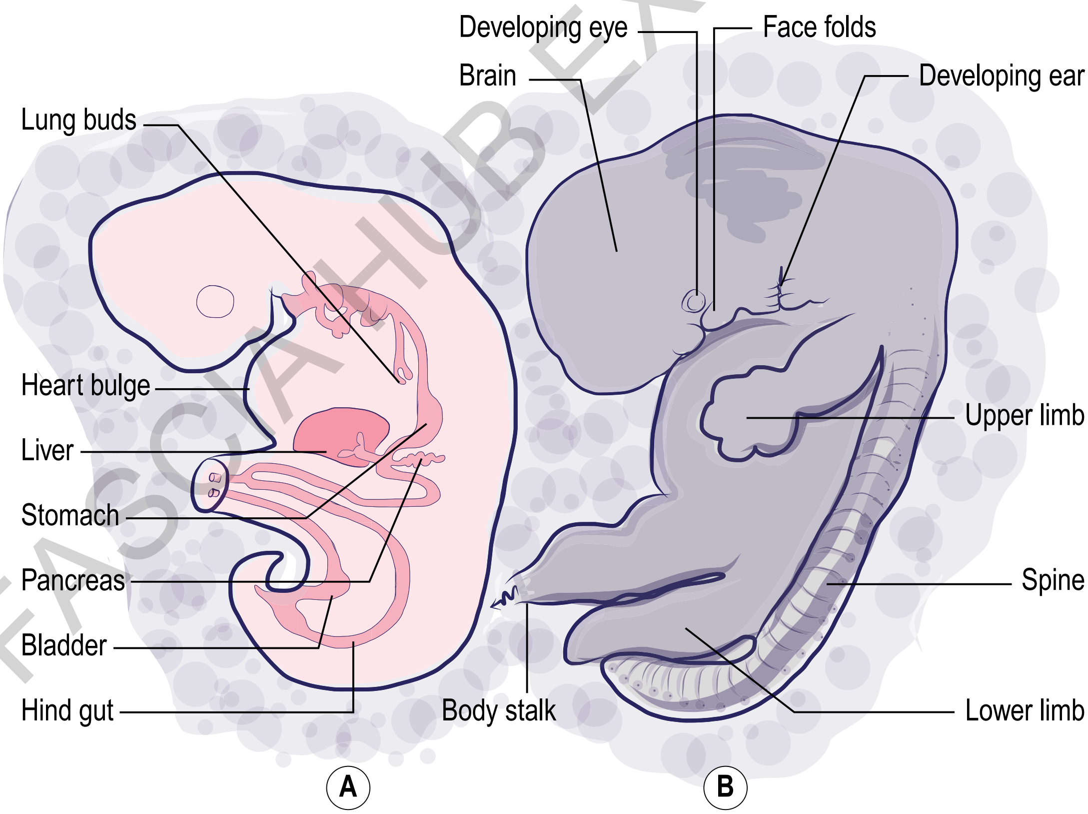


Figure 4.15

The folded embryo showing (A) some of the gut development at approximately Day 31 and (B) the formation of the face folds; developing ear and eye (approximately Day 36). The hand and upper limb are forming before the foot and lower limb.

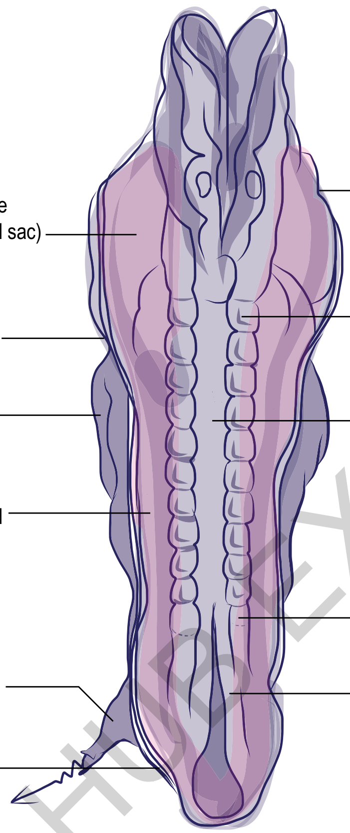


Figure 4.16

The somites grow from the cranial base towards the tail. Each pair predicts the upper and lower half of subjacent vertebrae, prescribing the spaces between them in the spine. They also grow and form the body wall; tubes within tubes and pockets within pockets. They play a primary role in designating the formation of what we might think of as our "growth rings" as well as their segmental arrangement. It is in 360 degrees.

with the tracheal lining inside their own compartment, or fold or pocket in the fabric. Organised in part by the growing heart, nourished by it, and reciprocally enclosed by the pericardial sac, they will grow to fill the thoracic cavity together, nourished by the blood supply that is also formed from the same living matrix. (It is almost too miraculous to imagine.)

During this folding sequence, there is a "gap" (there are no empty spaces in this process; remember it is a virtual gap or a "preparing pocket") that forms in the outermost part of the middle volume (*lateral plate mesoderm*), within which it subdivides into two more membranes or pockets. This location in the 360-degree volume of continuous membrane becomes an *internal cavity*. This internal cavity then divides again into the primitive heart (*pericardial cavity,* *to pericardial sac*) and the abdominal (*peritoneal cavity, to peritoneal sac*). They become distinct, although connected to each other by two channels, into which the primitive lung buds form another pocket (*pleural cavity to pleural sac*). Folds form within these biodynamic origamis. They wrap the heart and form between the lung buds and developing mid gut. At the same time they join with a thick membrane (a condensation of meso material) called the septum transversum (meaning "separating across"). This septum transversum will become the respiratory diaphragm through the intricate growth patterns that ensue. *It remains continuous with the abdominal visceral pockets, that form the pockets we name for the viscera.* Thus, what began as a continuous tube-like structure differentiates into three distinct pockets, although they remain continuously connected. They are called cavities as if they are separate from each other, but they never separate – nothing does. The pleural and pericardial cavities become differentiated and divided from the future peritoneal cavity by the textures of the forms, thickenings and densifications, between them. They become the main containers of the upper and lower body cavities. The changing, growing kinetic and genetic signals cause myofascial cells to infiltrate these tissues and the "crossing divider" (the septum transversum) becomes the future diaphragm, forming the roof of the abdominal cavity and the base of the thoracic cavity. They are distinct pockets; the intestines will form in the lower peritoneal pocket, remaining always integrated with the heart and lungs above it, in *their* respective pockets. The diaphragm is then tensioned downward (caudally) at the back by the growth direction of the somites, as they predict the formation of the spine, growing towards the tail, folding under the body as they lengthen. Where this septum transversum is attached to the front of the spine will become the legs (crura) of the diaphragm. In yoga practice we seek to unite breath and motion: the waves of the breath and the movement of the spine. The embryo guides us to recognise that their structures emerge from their original unity and remain continuously organised as such.

"The very development of the respiratory tract and the lung is therefore a remarkably differentiated beginning of the subsequent activity we call breathing. Strictly speaking it is incorrect to talk of the 'first' inspiration after birth. Breathing movements, by which air is sucked in and expelled from the lungs, are late consequences of the most complicated processes that were established and regulated long before birth."[25]

Somites are considered to be transient features of the embryo (they come and go during the embryonic period). They initiate tremendous change and transformation in that time. They form in pairs from the base of the cranium towards the tail, in concert with the mesenchymal meso, into regions. These regions will become the parts of the outermost skin (dermatomes), the inner bones of the spine (sclerotomes) and the muscles and connective tissues between them (myotomes). Between them, there is now research suggesting, they are fasciatomes.[26] Some of the somitic cells also migrate to enter the developing limbs.

Somites are particularly significant for our understanding of the spine. It is a common misunderstanding that a pair of somites gives rise to either side of a single vertebra. They certainly contribute to the length and depth of the spine in sequenced intervals; however, they do not simply predict bony blocks. They prescribe the spaces between the vertebrae, where nerves exit and linking facets form. Each pair of somites represents what will become the lower half of one vertebra and the upper half of the subjacent vertebra.[27] They create the feature of vertebral segmentation, predicting placement of ribs, discs and organising tissues of the body wall. They are "spacialisers" for future forms, rather than structures.

The limbs. As the embryo develops roundness, there is an ectodermal ring all around the outside, like a kind of "side seam" of the embryonic body. As cavities form inside, limb buds appear at the upper and lower points of the torso. At first, they grow as undifferentiated mesenchymal buds, eventually growing away from the torso and forming flat, paddle-like structures (the pre-plan of the hands and feet).

In this fifth week there is further differentiation of the eyes and detail of the beginnings of the mouth and jaw formation.

If you imagine putting your hand into a thick, strong surgical glove while someone holds it, pushing your fingers into the glove-skin, as it is held back (pretend it is attached over your shoulder to the breast bone and spine) – push hard and you will effectively be using your arm and hand as "bones" and the glove as "skin". It will feel something like a trampoline, all around your upper limb. You can readily imagine, then, how the piston-like growth of the "inner tube" of the limb (cartilage that is yet to be compressed into bone) tensions the fabric of the "outer tube" tissues (myofascia and skin), which keeps the inner tube compressed in a reciprocal dance (of a living tensegrity pattern). This also keeps the limbs restrained in a semi-folded *pre-tensioned* architecture. That is the basis of what anatomy refers to as a *pre-stiffened* form. Baby is born in this naturally folded expression that predicts where the cartilage will densify into bone–joint–bone continuity, deep within the limbs and torso, when forces guide it accordingly – it will condense into a variety of textures, all made from the fascial foundation. (See Chapter 6, where we consider these different manifestations of fascial fabrics.)

Week 6

By this time, there is more detailed formation of the ear and development of the torso myofascial architecture.

As the young limb buds appear they are fed from the heart, vascularised by circulatory vessels in the tissues (all of which grow from the same original tissue, so it is quite a remarkable orchestration of movement and organisation that the heart rhythm syncopates and accompanies). The anlage of the bone (which is mostly cartilage until suitable forces are put through it, *ex utero*) grows in a piston-like manner outward, while the softer-textured tissue is limited or constrained and tethered by the growth of the blood vessels (from the heart) on the medial side. Blechschmidt[28] suggests that this contributes to the chirality of the limbs; the natural growth pattern of a medially rotated lower arm. Essentially, between them, these forces provide the tension and compression field of natural, spiral patterning of close-packed systems in volume.

Also, at this time in the embryonic sequence, the heart becomes more differentiated; also thought to spiral into formation from one "cardio-myo-fascial" tube, into the complex, four-chambered vessel it becomes. The limbs grow (under tension) and grooves in the hand and foot paddles appear. In the following week, these will become spaces between the digits. (We might call this further differentiation in the process of spacialisation.)

Week 7

The rays of the fingers and toes become apparent (Fig. 4.17), and the eyelids begin to form. The eye primordium is completely embedded in mesenchyme, while fibres of the neural retina converge towards the optic nerve. The face begins to change, as the facial prominences fuse (the meeting of the lateral

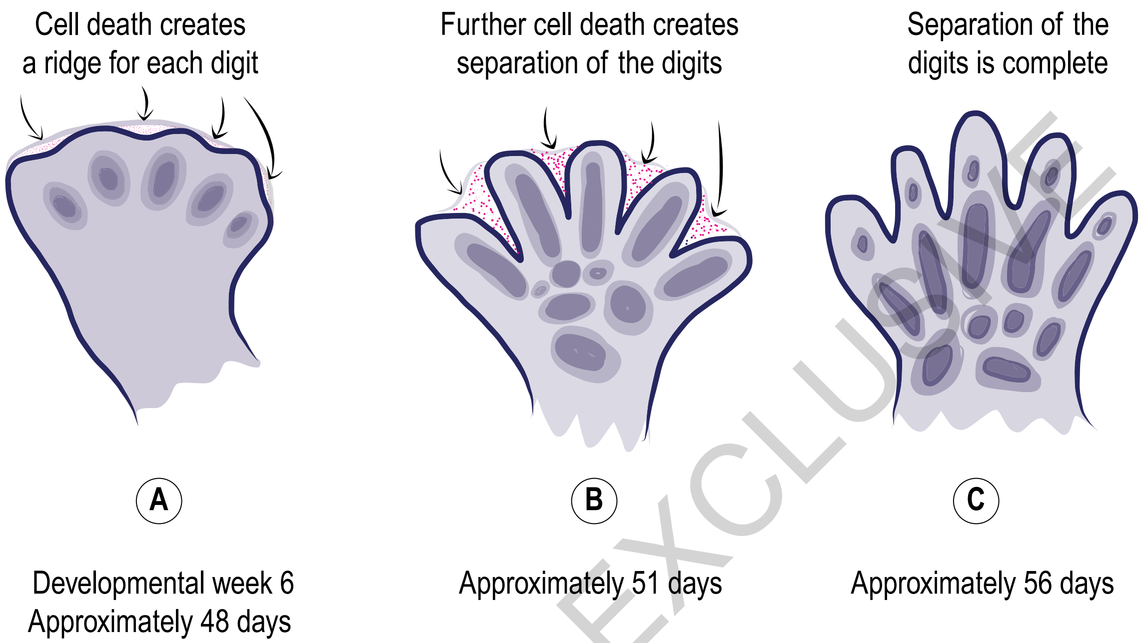


Figure 4.17

From a paddle shape, the hand begins to develop as spaces are formed between digits.

folds) and the jaw and nasal swellings form the upper lip. Once again, it is worth noting that nothing has been added or taken away. All this from the original amniotic and yolk sacs, meeting and folding in genetic and kinetic patterns of 360 degrees of roundness.

Week 8

The limbs become longer and bent at the elbows and knees, with fingers and toes free to move individually (Fig. 4.18). In van der Wal's way of seeing, they form the "disjoints" in the continuity of the soft tissue limb growth, in order that movement can be facilitated. This image shows how the anlage of the bones is first formed in cartilage, like a placeholder. However, this style of presentation focuses upon the bone growth, when in fact the soft tissues including the fascia all play a role in the biodynamic kinetics (as well as the chemical genetics) from which the architecture forms itself. It is *all* from the original meeting place of the amniotic sac and yolk sac. It never ceases to present emergent properties from the surrounding context of the mesenchymal milieu in which it resides (see Ch. 6). As such, Figure 4.19 presents it slightly differently from standard text[29] to include the surrounding tissues and growth directions of the whole form.

"Muscles, tendons, ligaments and bones take on identity in concert with arteries, veins, nerves and the organs and life plans they serve. The overall musculoskeletal signature of a bear or walrus is different from that of a mole

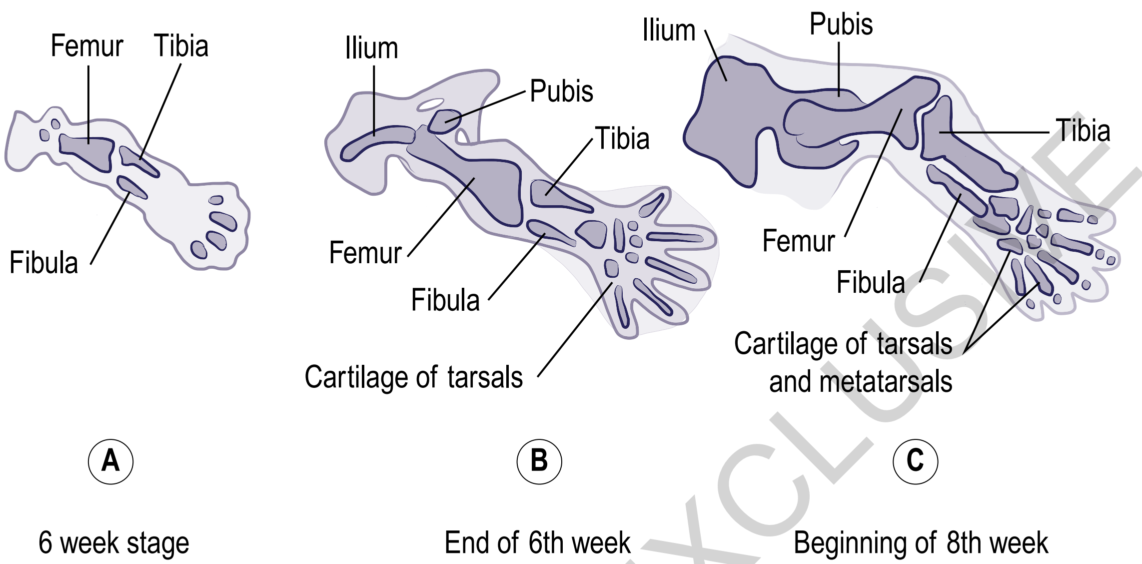


Figure 4.18

Detail of growing limb buds in their metabolic fields, surrounded by the amniotic sac, from which the embryo originally formed in part. The entire development of the embryonic tissues appears as a continuum, which is lost to the limitations of two-dimensional schematic diagrams.

or owl, and that difference is established by small, accumulating embryonic strokes that proceed in waves from the neural tube and somites."[30]

Blechschmidt suggests that all muscles grow into part of a myofascial sling:

"Seen from the perspective of developmental dynamics, muscles cross joints because the muscles develop in segments of various large [connective tissue] sling systems and joint spaces arise within the compass of the same slings. … the tissue at the periphery of the space becomes stretched forming the joint capsule. Those parts of the joint capsule that are particularly well stretched are called ligaments."[31]

This is the basis upon which van der Wal considered the tissue-sparing dissection we referred to in Chapter 3. He revealed the continuity of the fascial slings that the muscle cells originally rely upon (see Evans et al.[32]). Indeed, the muscle fibres are made of the essential material in continuity with all that forms. With the muscle element removed, the tissue continuity around the entire joint was clearly revealed. This emphasises the significance of fascial continuity as an essential part of our structure and our original motion. Could it be a kind of soft woven scaffolding in the formation process, a pattern recapitulated on every scale (from organelle to organism) at finer and finer textures (see Ch. 7)? It also endorses ideas of myofascial continuity throughout our form, as proposed in the work of Tittel[33] and Myers,[34] among others: "Fundamentally there

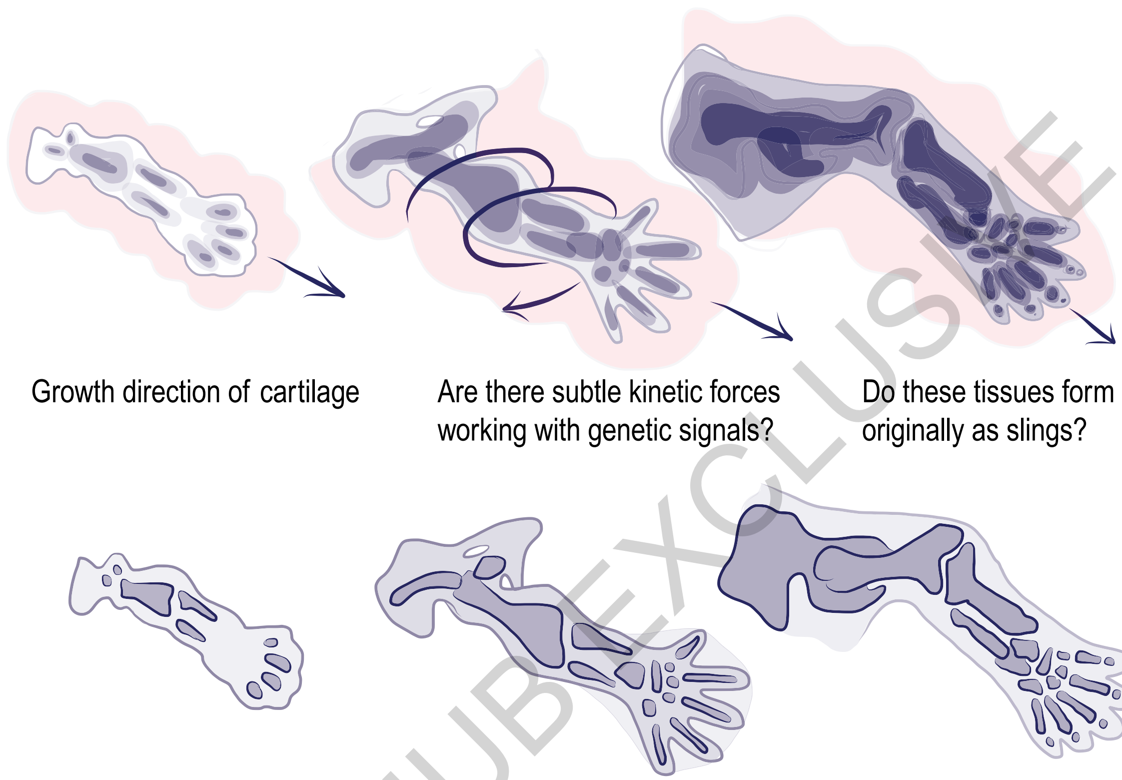


Figure 4.19

Earlier in this chapter we noted the question about connective tissue, "the forgotten player" (see note 8), and its primary role in providing the motive force for myofascia and osseofascial (bone) formation. If it is indeed such a "keynote speaker" in the story of how our architectural self-assembly finds its way into form, how can the surrounding tissues be presented so that they do not appear to have a role in the scheme of things?

are no differences between the organs of movement in the head, the trunk and the limbs" (Blechschmidt[35]).

Laying down the rest of the remarkable human blueprint. At this point the embryonic period is considered to be complete (Fig. 4.20). There is a great deal more to grow and form; however, the primary purpose of (a) flowing the cells to the right positions, and (b) folding the basic human form into being, so the foundational pattern predicts appropriate placement of the human anatomy and physiology, has been orchestrated. From this point, the embryo becomes a fetus and (c) continues to develop the rest of the pattern of the remarkable human blueprint, once that form *has* emerged, from which the neonate can grow *and* emerge. It doesn't end in the sense that the baby might be said to continue to develop upon these themes, through all the stages from child to elder.

Figure 4.20

The folded embryo at Week 8: approximately Day 49. It is about the size of an acorn (30 mm). The eyelids are forming, the limbs and digits are present. It is still bathed in the fluids of the surrounding amniotic sac, from which it formed and emerged originally, the architect of its own architecture.

Yoga Genesis

In yoga we seek to move and explore being alive in the body's own language, with a quiet mind. We prepare the body for stillness and meditation, another stage rich with embryological symbolism. The meditative practice is designed to heighten our awareness, the involution of our self-sensing senses. Yet it also allows us to absorb and reflect, cocooned in contemplation and conscious of being relatively motionless. We can emerge, nourished and new, reborn after a period of restoration that is part of the cycle of renewal that *Samsara* (meaning "continuous flow") speaks of in yoga. However we describe it, we continue as part of a continuum, stage after stage of ongoing development. Perhaps that is, in itself, the miracle of life.

Notes

1. "The miracle of life", in Part 1 of Vanda Scaravelli, *Awakening the Spine*, 2nd edition, Pinter and Martin, London, 2011.
2. James Gleick, *Theory of Chaos*, The Butterfly Effect, p. 23, regarding the weather, prediction of which is a wonderful example of how tiny changes become exponentially vast shifts in weather patterns. This book is a fabulous read to shed light on cyclical, sensitive processes of emergent properties – something that symbolises the development of the human embryo (or any other developmental story of a non-linear, biological creature). Also: Wikipedia: https://en.wikipedia.org/wiki/Chaos_theory: Sensitivity to initial conditions. Main article: Butterfly Effect.
3. Erich Blechschmidt, *The Ontogenetic Basis of Human Anatomy: A Biodynamic Approach to Development from Conception to Adulthood*, edited and translated by Brian Freeman, North Atlantic Books, Berkeley, CA, 2004. Morphogenetic Metabolic Fields.
4. Darrel J.R. Evans, Vice-Provost (Learning and Teaching), Monash University, Melbourne, Australia.
5. Richard Grossinger, *Embryos, Galaxies and Sentient Beings: How the Universe Makes Life*, North Atlantic Books, Berkeley, CA, 2003.
6. Jaap van der Wal: see www.embryo.nl for papers and courses in which these views are extended and further explained.
7. Graham Scarr, www.tensegrityinbiology.co.uk, article: "Geodesic". See also: *Biotensegrity: The Structural Basis of Life,* Handspring Publishing Ltd., Pencaitland, 2018, 2nd Edition.
8. D.J. Evans, P. Valasek, C. Schmidt and K. Patel (2006) Skeletal muscle translocation in vertebrates. *Anatomy and Embryology (Berlin)* 211 (Suppl 1):43–50.
9. J. Sharkey (2019) Regarding: Update on fascial nomenclature-an additional proposal by John Sharkey MSc, Clinical Anatomist. *Journal of Bodywork & Movement Therapies* 23(1):6–8.
10. Article by Stephen M. Levin - 2018/08/21, SP , Bone is Fascia - published on ResearchGate and as a special contribution within the Introduction of Susan C. Lowell de Solórzano's *Everything Moves: How Biotensegrity Informs Human Movement*. Handspring Publishing Ltd, Pencaitland, 2020.
11. Jaap van der Wal MD PhD, Emeritus Associate Professor Anatomy and Embryology, Maastricht University, The Netherlands.
12. Ibid.
13. Ibid.
14. Deane Juhan, *Job's Body: A Handbook for Bodywork*, Station Hill Press, Barrytown, NY, 1987.
15. Tufts University, 2011 [YouTube: *Morphogenetic fields in the developing frog embryo*]. Video can be seen at: <http://phys.org/news/2011-07-frog-time-lapse-video-reveals-never-before-seen.html>
16. Stanley Keleman, *Emotional Anatomy*; originally published in 1985 by Center Press. Keleman has been the director of Berkeley's Center for Energetic Studies since 1971. He has sought to show "the geometry of somatic consciousness" based on the idea that emotional and psychological reality is expressed in physical human shape. Vincent Perez (anatomist and illustrator) depicts Keleman's concepts of somatic function in strong black.
17. Jan van Ijken; https://www.janvanijken.com/film-projects/becoming/ from his website: *Becoming* is a short time-lapse film about the miraculous genesis of animal life. In great microscopic detail, we see the "making of' a salamander in its transparent egg from fertilization to hatching". https://vimeo.com/316043706
18. Jaap van der Wal: see www.embryo.nl for papers and courses in which these views are extended and further explained.
19. See Dr Guimberteau's work. Jean-Claude Guimberteau, MD (www.endovivo.com/en/dvds.php). His DVD, *Interior Architectures*, is available on the same site. See also *The Architecture of Living Fascia: The Extracellular Matrix and Cells Revealed Through Endoscopy*, Handspring Publishing Ltd., Pencaitland, 2014.
20. Erich Blechschmidt, *The Ontogenetic Basis of Human Anatomy: The Biodynamic Approach to Development from Conception to Adulthood*, edited and translated by Brian Freeman, North Atlantic Books, Berkeley, CA, 2004.
21. Ibid.
22. Ibid.
23. Thomas W. Sadler, *Langman's Medical Embryology*, 11th edition, Lippincott Williams and Wilkins, Baltimore, 2010.
24. Jaap van der Wal, "Proprioception", Ch. 2.2 in Robert Schleip, Thomas W. Findley, Leon Chaitow and Peter A. Huijing, *Fascia: The Tensional Network of the Human Body*, Churchill Livingstone/Elsevier, Edinburgh, 2012.
25. Erich Blechschmidt, *The Ontogenetic Basis of Human Anatomy: The Biodynamic Approach to Development from Conception to Adulthood*, edited and translated by Brian Freeman, North Atlantic Books, Berkeley, CA, 2004.
26. Research re Fasciatomes: Carla Stecco, Carmelo Pirri, Caterina Fede, Chenglei Fan, Federico Giordani, Luigi Stecco, Clogero Foti, Raffaele D Caro (2019) Dermatome and fasciatome. *Clinical Anatomy – Special Issue on Fascia* 32(7):896–902. https://doi.org/10.1002/ca.23408
27. Darrel J.R. Evans (2003) Contribution of somatic cells to the avian ribs. *Developmental Biology* 256:114–126.
28. Erich Blechschmidt, *The Ontogenetic Basis of Human Anatomy: The Biodynamic Approach to Development from Conception to Adulthood*, edited and translated by Brian Freeman, North Atlantic Books, Berkeley, CA, 2004.
29. Thomas W. Sadler, *Langman's Medical Embryology*, 11th edition, Lippincott Williams and Wilkins, Baltimore, 2010.
30. Richard Grossinger, *Embryos, Galaxies and Sentient Beings: How the Universe Makes Life*, North Atlantic Books, Berkeley, CA, 2003.
31. Ibid
32. D.J. Evans, P. Valasek, C. Schmidt and K. Patel (2006) Skeletal muscle translocation in vertebrates. *Anatomy and Embryology (Berlin)* 211 (Suppl 1):43.
33. Kurt Tittel, *Beschreibende und Funktionelle Anatomie des Menschen*, Urban and Fischer, Munich, 1956.
34. Thomas W. Myers, *Anatomy Trains: Myofascial Meridians for Manual and Movement Therapists*, 2nd edition, Churchill Livingstone, Edinburgh, 2009.
35. Erich Blechschmidt, *The Ontogenetic Basis of Human Anatomy: The Biodynamic Approach to Development from Conception to Adulthood*, edited and translated by Brian Freeman, North Atlantic Books, Berkeley, CA, 2004.