Neurology and Education

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Welcome.[1] I'd like to begin by reading a quote from an article in the *New York Review of Books* by the renowned Oliver Sacks, the neurologist. It is wonderful little article called "Neurology and the Soul."[2] He begins by quoting from one of his mentors, Wilder Penfield, who was a neurosurgeon:

> Wilder Penfield, a neurosurgeon, who devoted his entire career to studying seizures, arrived at the end of his life at a view that memory, imagery, sensation, and experience are "engraved in the brain." The active faculties of will or judgment are not in the brain, are not represented physiologically, but are transcendent functions.
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> For Penfield, there was a biological stream and a supra-biological stream that watches and directs the biological stream. In the patient, decision comes from the mind and engages the neurology. All brain action is automatic and computational, and yet humans are clearly not automatons. The mind in Penfield's view lacks memory or even a need for memory. It can open the memory files of the brain in a flash, but in reality it needs none of the physicality of the brain. However, the mind does need energy, and that is normally supplied by contact with a living brain.
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> And yet the mind may have a way of surviving even bodily death. Penfield believes that it may do this by establishing an energy flow or energy relationship to the living or with the mind of God in the cosmos. Penfield concludes that the time may come when scientists will be able to make a valid approach to the study of nature of a spirit other than the spirit of a human being.

I use this quote as a beginning of my lecture because here is someone in the public eye, in the public domain, saying exactly the same thing that we find in Spiritual Science. This points to the idea that maybe it's time for anthroposophy to bring to the sciences a cosmology that some scientists seem to be seeking, a cosmology that is currently lacking. The dexterity of scientific experimenters and the rigor of the experiments has yielded a treasure trove of data and information that are in urgent need for people with an education in the spiritual language to address. In speaking with my colleagues at the conference here, they find a need for cosmological insight in their work with their clients and in the medical profession in general. There is a need in the world to bring cosmology of the creation into the scientific dialogue to provide something that is felt to be missing. To be sure, cosmology is not for everyone, but there are colleagues out there who would very much love to hear the spiritual implications of research science. So, this work of finding a cosmic reality in data-driven science is what I feel I can bring to you as a question and, I could even say, as a challenge: to find in the work that you do in science or in education a way to somehow bring insights from the language of the spirit.

It's time for anthroposophy to bring to the sciences insights from the language of the spirit.

I'd like to begin by giving you a very curious picture. In the work of Thomas Aquinas, there is a concept called *adequatio*. *Adequatio* means

the equation of the thing and the mind. In the work of Thomas Aquinas, it was seen to be a kind of spiritual imperative that humans learn how to equate the things in the world that are produced by the action of spiritual hierarchies with the activity of their own minds. If you want to trace that back from Aquinas, the idea of equation of the spiritual reality and the mind of a human goes back into alchemical thinking from the 7th and 8th centuries. Equating of the thing and the mind in the ancient world was given in the formula: *as above so below, as below so above,* by the alchemical adept Hermes Tresmegistus.

But in Thomas Aquinas there was actually a call for a practice, a spiritual practice, wherein the practitioner would learn to assess the degree of equation between the mind and the inspiring being. That's what he called *adequatio.* He was addressing, fundamentally, the varieties of religious experience, as for instance William James: how do I know that it's God talking to me and not me telling myself that God thinks I'm really important?

How do I work that out? Because maybe God's telling me I'm really important, but not for the reasons I think. So the question of *adequatio*, of equating the mind and the being that's inspiring was taken up by a teacher at the university in Vienna in the late 1800s. His name was Franz Brentano.

Franz Brentano was what today we would call a "Don." He was a real *il professore.* He had many students and all the trappings of academia around him, but he was a bit of a rebel. He was also a bit of a recluse, and he brought this strange, almost metaphysical idea from Thomas Aquinas—*adequatio*—into his teachings of the theory of knowledge: how do we know that we know? That's called *epistemology.* And, in line with Thomas Aquinas, what Brentano felt was that there was a force in the soul called *intentionality* or *intention.* And intention was a vectoring force in the soul that allowed the person who had intention to understand that it was his mind that was connecting to the inspiring thing, whether it was an inspiring being or a tree stump. Intention was the key. Brentano was describing a very high level of will that had lost its intentional or motive force of like and dislike as the force behind desire. In pure intent desire simply becomes the urge to know, the urge to know that which is inspiring. It could manifest in the mind as a dialogue with a spiritual being or insight into the spirituality of the archtype of the tree that produced the stump, as the will activity of a spiritual being.

Now, the dilemma for Brentano was that the sense world and all of the environment of learning around him in the late 1800s in the university system in Vienna was going hell-bent-for-leather towards the physical realm, and the whole realm of epistemology and knowledge was veering in the direction of describing the minutia of how the eye operates and things like that. The intent was to pin down the elements of perception and cognition. The focus of the developing sense of psychology was moving towards detailed descriptions of the physical aspects of the perceptive apparatus. Into this environment Brentano brought the idea from Thomas Aquinas that in the soul intent exists as a kind of a force that allows a person to connect to an idea.

At the end of his life, Brentano eventually made a complete reversal on his original experience of the transcendent aspect of Aquinas and went into the nuts and bolts of perception. He evolved towards the position that there is nothing *but* the sense world. Think about it: if you're on the line—publish or perish—and you're making your money teaching at the university, and everybody is worried about the minutia of everything, if that's the general focus of scientific consciousness, and you're talking about mystical union with the spirit—that's a little strange.

But in his teaching life at the university Brentano was very popular. And he had a very illustrious student, Edmund Husserl.

Husserl is the granddaddy of phenomenology as an academic and philosophical concern. Husserl inherited Brentano's penchant for this searching for how the mind interacts with that which is coming towards it. Husserl devised the two philosophical categories of what he called *époque*, which means bracketing. This concept can be traced back to Goethe. To "bracket" my thinking I need to get rid of any previous implications or thought patterns, or imagery, or feelings, or any kind of representation, if I really want to honor the phenomenon. We owe that work to Edmund Husserl, who took the impulse of what Goethe called "higher beholding" and formed it into a very, very complex and profound philosophy. It is a philosophy that is at the root of psychology. In his later work Husserl reacted against Brentano's insistence on the primacy of the sense object and went completely in the other direction. Where Brentano monitored the activity of his mind while engaged with a sense object, Husserl focused on the activity of the mind while engaging archetypal consciousness. He went completely away from the sense world. This is an interesting polarity.

Now there was another very illustrious student of Franz Brentano at the university in Vienna and that was Sigmund Freud. Freud inherited from Brentano the concept of intent, and this became his categories of id, ego, super ego, libido—all characterizations of what makes a mind work while it is engaging phenomena that are coming to it. You can hear Brentano speaking there. Again, intent was the springboard for a prolific researcher in the phenomenology of mind.

There was yet one other very illustrious student of Franz Brentano: Rudolf Steiner. Yes, Steiner was a student of Franz Brentano, and if you want to read about his work with Brentano, read *Riddles of the Soul*. Brentano taught Rudolf Steiner about percept, concept, duality, epistemology, and what today would be called theory of mind.

Theory of mind is the common language today for people who are researching the autistic spectrum. The issue in the theory of mind is called "mentalizing." Mentalizing is: one, I know I have a mind (that's the first symptom of mentalizing), and two, because I know I have a mind, I can recognize mind in others. This is cutting edge stuff for the study of what's known as the autistic spectrum. Where is the mind? What is the mind? That's why I read the Oliver Sacks quote in the beginning. If any of you has seen *Awakenings* with Robin Williams, this film tells the true story of British neurologist Oliver Sacks, who, in 1969, discovered beneficial effects of the then-new drug L-Dopa. He administered it to catatonic patients who had survived the 1917–1928 epidemic of encephalitis lethargica. It was believed at that time that people who were in catatonia had no mind. Why? Because the theory of mind says you have to recognize mind, and if you're catatonic, there's no way to find out whether you recognize mind or not, because you show no symptoms of mind, which is also an aspect of very low-functioning autism. Is there a mind there in this person?

In *Awakenings*, the Dr. Sacks character gives dopamine injections to these catatonic patients, and they begin to awaken and describe the fact that they had still been in their mind even though they were catatonic. But when they come back, their mind is in the place that it was when they got their encephalitis. And then he finds that it is a temporary measure; he has to keep giving them more and more dopamine in order for them to stay awake, and he reaches a certain toxic level of dopamine where he becomes kind of like Faust: if I give them more I kill them, but I also heal them.

In the movie there was a kind of conclusion —I don't want to give the whole thing away, but there was a segment dealing with a woman who, when she starts to come back from this catatonic state, she's in a wheelchair, and every day at a certain time, she stands up and walks towards what the hospital staff thinks

is the water fountain. She's been catatonic for years. But as she is awakening every day, she walks towards the water fountain, and each time she stops in her walking at a certain place. Eventually the whole staff watched this happen and wondered what was going on. And then Sacks made a discovery: every day they parked her wheelchair in such a way that when she stood up, she would walk along the black tiles that were arranged in a line to get halfway across the room. And at halfway across the room, the black and white tiles stopped and a monochrome-colored floor began. Dr. Sacks noticed that she stopped where the line of tiles stopped. Then overnight the staff completed the pattern on the floor of the black and white tiles and formed a line all the way to the water cooler. And the next morning she got up and walked, and when she reached the spot where the separation had been, she stopped. And then she continued and walked towards the water cooler, and walked past the cooler, and looked out of the window.

What Sacks concluded from that was that these people receive their will from the outside. They receive their will from what comes *to* them. They're present in their mind, but they have no will of their own. They can't mentalize. But they do perceive and they are in their mind, but have lost this capacity for initiating will. This is an amazing picture.

So, in order to try to understand these issues, I've spent the past two years reading books about autism and Asperger's syndrome, trying to form pictures of what's happening. My contact with Aonghus Gordon in the UK over the years has helped me in this work. I've seen the work that they do in the UK engaging students in the crafts and the healing that happens in these processes. It is impressive work, but I keep searching for a bigger picture. How can we understand these learning difficulties from an esoteric perspective? I have this question because I keep having the feeling that something in anthroposophy is very vital to understanding this. So please look at your handout.[2]

I'd like to use this diagram to give you a picture of the insights that are possible today due to the development of functional magnetic resonance imaging (fMRI). This is really quite remarkable. With this technology, we can watch how this super-sensible being that lives around the brain enters into the brain in very specific circumstances. And we can do that by watching the metabolic oxygen-assimilating blood flow in the various parts of the brain while a person is engaged in some sort of cognitive task. The therapist will give a task and then watch where the blood flows in the brain: the blood, the carrier of enthusiasm and warmth of the ego, moves into the dead instrument of the brain and animates it. And we can film these movements. Quite remarkable! It used to be that if you wanted to study the brain, you had to chop a dog's cerebrum off and then watch it walk around. That's true! Or, you had to do autopsies or frontal lobotomies. But today we can actually watch the "eurythmy of the soul" —we can say—as it engages the architecture that has fallen out of its cosmic intent. That is the neuro-architecture of the brain. So the creative movements revealed in fMRI have resulted in a temple, a building that the spirits can inhabit sometimes and then pull away, then come in, and pull away. And the structures that have been created are imaginations in the minds of the hierarchies that created them. They're pictures. And, what I'd like to do is use "mythos" as a way to describe these functions for you, so that you can experience them at a whole other level.

The [brain] structures that have been created are imaginations in the minds of the hierarchies that created them.

The first one I'd like to share with you is a process called encephalization. It means "to get a head" or "to create a head." Encephalization

is the process of how neurology develops through the phyla, starting with the ganglia of a worm, going up and up and up, until we get to the neurology of a human being where a head with a brain has been created. So on your chart there is a process of encephalization. Look down here at the brain stem. That brain stem is the result of a momentous event that happens about the fourth week in the embryo. And if you'd like to see a depiction of that, that's in figure 1.[3]

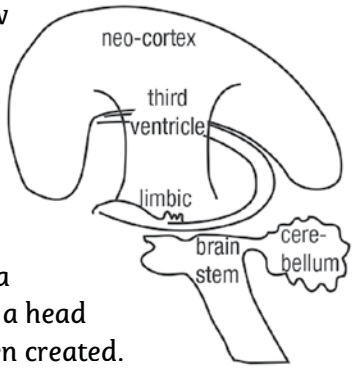

Figure 1

And that's the beginning of encephalization. The embryo starts out as a three-layered disk. At about the second week, there's a groove that is formed in the disk. And this groove is actually like a hole that gets punched down into the middle layer, the mesoderm, and travels from the tail end up to the head end. And this groove that gets punched in eventually becomes what's known as the notochord.

Now, I did some surfing around on that word "groove," and in Greek, the word is *psorat.* That means "a groove." So, there is an engraving into creation in the second week. And that kind of irritation gets engraved in there. Out of that irritation comes, then, in the fourth week, a kind of inflammatory reaction. As that grooving of that notochord goes into that little disk, just after that happens, the heart actually starts out outside the embryonic disk as a hollow. And as soon as that groove happens, the heart begins to move into that place; it's called a stomodeum: the mouth or "hole" of God. The heart that starts outside of the head goes in through the mouth of God and then travels down through the body and rotates.

But simultaneous to the heart going in and rotating down is a movement in the neurology (a kind of inflammation of the neurology) that expands and goes up and rotates. At that time the brain stem explodes upward and starts curling in on itself as the heart moves in and down and starts curling in on itself. Those two movements are simultaneous in the fourth week. The heart comes in and meets resistance in the tissues of the body, then curls in on itself in a kind of folding gesture similar to the meander of a river meeting the resistance of the banks.

One gesture is a force coming in and then suddenly there is a curling in on itself, creating an inner kind of space. We could call the forming of an inner space like this the process of astralization. In the embryo one force coming from the outside and forming a hollow within is the essential gesture of organ formation. In the form of the heart in the fourth week, this gesture of coming back on itself as a meandering stream is mirrored by a hollowing that takes place on the surface of the brain. As the cortex grows, the surface of the limbic brain beneath it maintains itself in position on the lateral portions of the embryonic brain. This gesture of holding onto its space eventually creates a groove in the sides of the brain as the cortex and related organs expand beyond the groove on both sides. Eventually the groove is submerged in brain tissue and is folded in on itself as the cortex expands around it. At term this submerged spiral groove is called the hippocampus, the site of our long-term memory. It is significant that both the hippocampus and the heart are astralized at the same time. That's a very significant coincidence that links the heart to memory and makes it possible for human beings to eventually experience their True Self or "I" Being.

We could call the forming of an inner space like this the process of astralization. That (process) links the heart to memory and makes it possible for human beings to eventually experience their True Self or "I" Being.

When the heart comes in and starts pushing down, there is an organ already there in the back of the brain area in the place where the cerebellum will eventually arise. That organ is the pronephros or primal kidney. The kidneys get pushed down, out of paradise to be recovered late and slow. Adam and Eve get pushed out of the higher realms and fall to the bottom of the pelvis. They make a short upward comeback to settle just above the diaphragm but at the level of the digestive organs. And forever and a day they are wishing to be back in Paradise again. So, that first gesture of the grooving and then the hollowing of the organs at the top of the brain stem creates neurological organs that then receive sensory impulses from the metabolic regions.

The brain itself begins out of that upward surge and inward roll. In it, there is a whole series of lobes that are formed out of that hollowing or rolling-inward gesture. One early lobe that forms out of that hollowing gesture is a little model of what the big brain is going to be, that's the cerebellum. So on your diagram it's the one on the right that says cerebellum; it's in the sensory motor pole.

These organs are in the back of your head. The function of the cerebellum and its core, the vermis, is known as sensory-motor. Sensory-motor impulses arise when we are engaged in finding our limbs in space. These impulses are automatic when we're engaged in movements related to sense experiences. The sensory-motor areas in the brain allow the human soul to rely on the genius of the body as we're moving a limb. The automatic functioning of these lobes allows us to know where a limb is in space without having to bring that position into focus. If you look at a picture of the brain, the sensory motor cerebellum is like a little brain, but it's wedged under the back of the posterior cortex. In that position the cerebellum receives direct impulses from the body via the brain stem. These are impulses from the metabolic areas that stream upwards towards the head. Now there is a curious picture here in this encephalization, because the formation of the cerebellum and the hippocampus (see figure 2) is just the first kind of astralization or in-rolling wave that comes off the brain stem as the embryo matures. The upward moving wave of in-rolling neural tissues creates the limbic structures linked to feelings, and finally the neo-cortex linked to higher cognitive functions. The development of these waves of encephalization is a bottom-to-top process that I like to call *Jacob's ladder.*

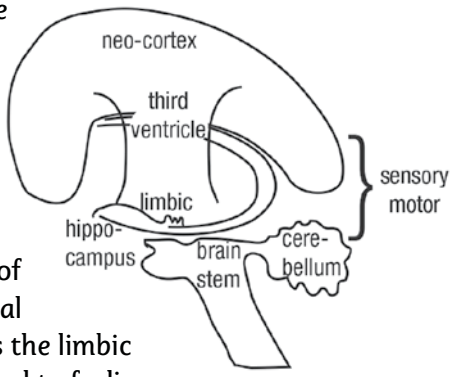

Figure 2

If you look on your diagram here, you have the cerebellum in the back, and then we go up to the middle where there is the hippocampus of the limbic structure. What happens is that the cerebellum forms off of the fourth ventricle and at the same time the limbic structure forms in the floor of the third ventricle.

The limbic structure is a whole ensemble of organs that are brought to a very fine resolution in mammals. And it's in the limbic structure of the brain where the soul life activates feelings, emotions, memory, and learning. So, in the Jacob's ladder imagination we start out with the brain stem down below, then we go up to the cerebellum. Here the organism can have its senses and its motor responses connected to each other; then we move up to the limbic structure where there are feelings integrated into the sensory-motor responses. From the limbic structures we then move up into the neo-cortex, or new brain. The structure of the new brain is not included in figure 3 except for the frontal lobe of the cortex, known as the prefrontal cortex (see the left side of the diagram). This area is an important link to the limbic structures.

Actually the human brain is like a donut. The center of the brain is hollow. And that

hollow is known as a ventricle. In Rudolf Steiner's work with physiology, the ventricles are very important because they don't have anything in them in terms of tissue. He felt that the ventricles were the actual places where human beings form inner images. This is interesting because in the ancient world the third ventricle was known as the "womb of the immaculate conception." We'll take a look at that in a moment.

The ventricles are formed as the cortex goes up and mushrooms in a form similar to the mushrooming or in-rolling of the other lobes. There's a continual unfolding of larger and larger layers that just keep mushrooming up out of the brainstem and in-rolling to form a donut shape. As I mentioned earlier, as the heart starts to move down and to send out blood vessels, the same type of blossoming and flowering is happening up above in the neurology. So finally we have the ventricles arising as the cortex forms, and the last part of the cortex that forms is called prefrontal cortex. That is the area right behind your forehead.

So in the ladder we have brain stem, cerebellum, limbic structure, ventricles as the cortex is formed, and then the last part of the cortex is the prefrontal cortex. Rudolf Steiner gives an interesting picture that the prefrontal cortex is actually an evolution of the olfactory bulb, and if you check that out in physiology, you'll see that it's true. The prefrontal cortex is a metamorphosis in a human of the olfactory bulb, your smell organ in the brain. He says that morality is a fragrance. That opens the door to things like aromatherapy.

A lot of the inner life of lower mammals is designated for smell: for identification and all kinds of stimulus response patterns, and for finding out who is the top dog and, you know, the social order is based on smells. Even in humans the role of smell is very powerful. So here in your diagram, this little bulb on the left under the prefrontal cortex—that's the olfactory bulb in a human brain. In a possum brain two thirds of the cortex is devoted to processing smells and the prefrontal cortex is not present. In humans the prefrontal cortex is this large outgrowth that has come out of the olfactory sense. The actual olfaction in a human has been reduced, but in its place the expanded prefrontal cortex is active when humans are engaged in making moral decisions. To make a moral decision a human must exert what are known as executive forces. A human making an executive decision activates the prefrontal cortex.

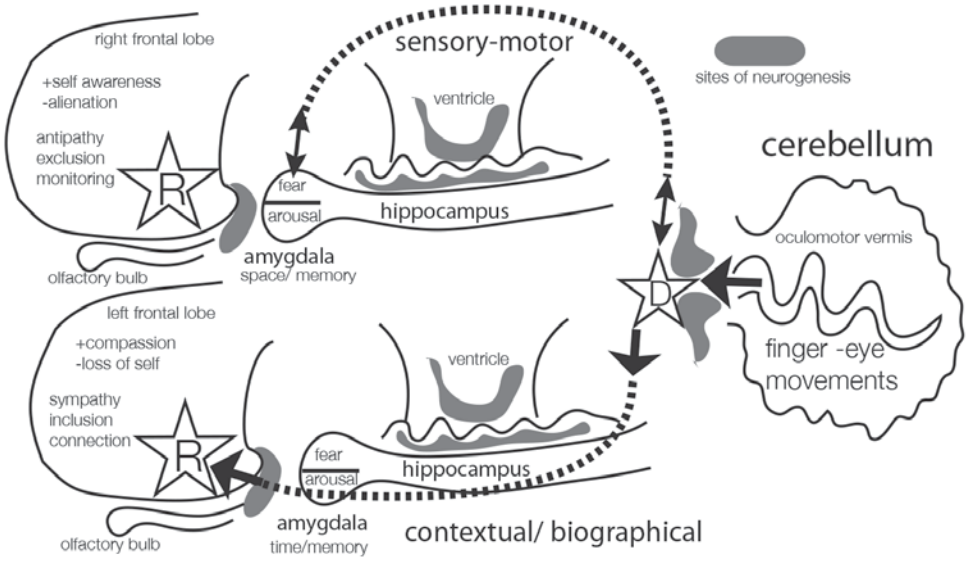

Figure 3

Executive decisions that lead to moral actions require reasoning, and that's the issue. Reasoning is a unique blend of memory and creativity and has to do with mentalizing. Mentalizing means that I ask myself if I have a mind, that is: can I recognize mind? First I need to remember that I have a mind and then I spend the rest of my time looking for it. That's the search for meaning: looking for mind. Because that's who I am as a human being. We could say that "looking for my mind" is the job description of the archetypal human. If I recognize mind in me, I can recognize mind in you. And this is just what is challenged in the minds of people who are on the autistic spectrum. To be clear, research has shown that people who are on the autistic spectrum are in contact with their own mind. The challenge for them is to recognize the activity of mind in the words, gestures, and thoughts of others. In psychology studying the ability to recognize these qualities in another person is known as theory of mind.

Looking for my mind is the job description of the archetypal human.

So this is encephalization, what I am calling Jacob's ladder. We start down here in the basement, and we come up, and we build and we build, and finally, we end with this organ that can tell "right" from "wrong," good from bad. Then we get into this: is it a thought that allows me to be moral or is it a feeling? Or is it a will impulse?

Today there is an epidemic of people who are challenged in theory of mind. People who are challenged in this way are said to be on the autistic spectrum. And I've heard that one in a hundred persons is challenged in this way, and recently I've heard one in thirty are on the spectrum in some countries. One in a hundred is a clinical, low-functioning autistic person who needs care and support in order to stay alive. One in thirty is somewhere on the spectrum from low functioning to high functioning people who are challenged with theory of mind. And the question is: what is the spectrum? Is it PTSD or ADD or ADHD or any other acronym? When we go into this little diagram, I hope you will see why it's a mix-and-match, neurologically speaking. Any scrambled linkages in these delicate lobes lead to one or another set of symptoms. This is why the healers who work with these people have constructed a spectrum of dysfunctions. What they're finding today is that brain function is not a single activity. It's the action of neurological ensembles that is critical. It's chamber music. And I have to understand which instruments are playing to be able to do that, and that's where fMRI methodology comes in because with it we can pinpoint a particular organ linkage that's not really working. When a person makes a particular decision, that requires him to activate a functional linkage, an emotional linkage, a reasoning linkage, an abstract linkage, a spatial orientation, a contextual orientation, a sensory deprivation thing, or a sensory motor pattern, et cetera, et cetera. Much research is devoted to pinpointing these specific linkages and the neurotransmitters that activate them. But if we look at these linkages as a whole, there are other pictures that emerge. And that's where I want to go.

So Jacob's ladder is the first neurological myth I want to present to you. The key to Jacob's ladder, if you remember the story from the Bible, is that the angels don't just go up, they also come down. And Jacob has his dream by putting his head on a stone. There's a picture here of what a therapeutic approach can be. In order to heal, I have to come back down the ladder out of the cortex and find out why I have a couple of rungs that are cut out. If I just keep going up, I get up to right hemisphere, left hemisphere, prefrontal cortex, and there's nothing left, because we've reached the end of our biological development for that organ. Why? Because we're now in the apocalypse. We're in it. So no new neurological

lobe will spring up in your head that can give you some other unrecognized capacity such as we find in the developmental stages of the brain. In order to develop new capacity we must use the organ that has reached perfection (the brain) in a different way.

There is a great secret in this process called neurogenesis. Ten years ago, twelve years ago, it was commonly believed that adults no longer made new neurons. They could mess around with synapses, but not neurons. But since science has been able to do this very delicate fMRI research, it has been discovered that there are three areas where new neurons develop in the adult brain.

Brain function is not one organ; it's the action of neurological ensembles that is critical. It's chamber music.

So, on your chart, we're going to do a little drama of how the immaculate conception works. In the center is the third ventricle. In the development of encephalization, the hollow of the third ventricle is the fountain-like area whence all the new neurons for further development come in the embryo. It's the fountain of who you can become. The neurons come out as amoebic forms and they migrate to other places. So, indeed, the third ventricle is a womb for neurons. The gray areas in the diagram show the sites in the brain where adult neurogenesis takes place.

In the lower part of the diagram there is a dashed arrow from the dopamine center (star D) through the hippocampus at the bottom of the third ventricle towards the olfactory bulb. Because the olfactory bulb, as we've just heard, is functionally linked to our prefrontal cortex in which is the dopamine-utilizing area of the reward center. The area around the olfactory bulb is one of the areas in the brain that even in adulthood retains the ability to make new neurons. And the reason is that in embryological time there is a huge migration of neurons from the third ventricle into that area. Why do we need new neurons? The sites of neurogenesis are functionally linked to the production of memory and learning. In the diagram there are two dashed arrows. One comes from the top of the amygdala that is linked to fearful memories. This can be seen in the upper part of the diagram. The arrow goes from there to the fear center in the amygdala and back to the dopamine center (star D) in the back of the brain. This circuit of dopamine is connected to short-term rewards for activities that allow me to soothe fear. That is why the arrows go from the fear center to the dopamine center and back again. This circuit is the basis for unconscious, habitual, and sometimes addictive behaviors.

The other dashed arrow goes from the hippocampus through the lower, arousal portion of the amygdala to the reward center in the executive portion of the prefrontal cortex. This circuit involves dopamine and reward, but the impulses have to pass through the hippocampus where short-term, unconscious reward strategies, based on fear, are transformed into long-term memories of my self as a person who has learned things about controlling fear instead of just looking for an instant reward. This circuit builds new memories that can replace the old memories based on fear and reward seeking. The new neurons are generated to change old memories. As an adult I can actually do things to create new neural passageways: exercises, activities, and art (all things that stimulate novelty) create new neuronal patterns so I can learn and re-plasticize my old patterns of behaviors. This is incredible. Incredibly hopeful!

So an unconscious pathway is based on short-term unconscious risk/reward memory patterns in the upper amygdala that are linked to sensory motor responses near the cerebellum that result in the production of dopamine. Together they constitute a habitual, non-contextual source of what is known as procedural memory. That is memory that

happens automatically on the basis of past stimulus/response patterns based on fear and reward reactions.

But in the embryo the largest group of neurons migrates to the bottom of the third ventricle to make the basis of what will later be the limbic structure or the sub-ventricular zone. And it's in that sub-ventricular zone here that we find the picture of the womb of the immaculate conception. In the embryo the sub-ventricular, hippocampal, lower amygdala areas are the sites of new neurons that allow us to learn and grow.

As an adult I can create new neuronal patterns and re-plasticize my old patterns of behaviors.

These areas of the brain are currently the focus of intense research since many of the most widespread neurological challenges for humans come out of these relationships.

To be clear, this diagram is really a strange juxtaposition of parts of the brain that exist side by side. I just put one over the other to be able to illustrate them clearly. They are symmetrical and located in the center of your brain. The upper part is the right side of your brain and the lower part is the left side of your brain. These organs are symmetrically split to right and left. You have a right amygdala, and a right hippocampus, and a right prefrontal cortex; and you have a left of all of those. But you have one cerebellum that kind of brings it all together in the back.

That area is the base of emotional life for a human; feelings are the focus of the limbic structure. The right side of the limbic structure has to do with orientation in space and unconscious inner imaging of the body. All the experiments show that spatial memory is more connected to the right side of the limbic area, while memory of events in time is more connected to the left side. The more unconscious memories of both space and time flow back from the amygdala to the back of the brain on the upper side of the limbic structure. These sensory motor impulses are active when a person is doing actions like running where he or she does not need to consciously give commands to parts of the body. In contrast to this sensory-motor pathway, the contextual pathway is through the hippocampus in the lower side of the limbic structures. This flow is from the back towards the front of the brain.

The hippocampus is the center for contextual memory, and in that area, the dentate-gyrus (wrinkled section above the hippocampus) is a continual fountain of new neurons for neurogenesis. Complex cellular reactions govern the shift of neuronal structures between the dentate gyrus and the hippocampus. The new neurons allow for memories to be changed. The flow of impulses from the hippocampus then moves to the lower portion of the amygdala and on into the prefrontal cortex which becomes active when a person is making decisions based on conscious or focused memories. This circuit changes the nature of the will in the human from the automatic reward-centered will of the sensory-motor circuits to the more benevolent, conscious will based on biographical experiences.

Rudolf Steiner says that the will of the physical body is geared to maximize pleasure. So the upper pathway, through the sensory-motor circuits, is focused on the dopamine center and is part of a feedback dopamine looping called the nigro-striatal linkage. This just means that the unconscious gets a dopamine reward when actions are repeated. In the lower circuit the hippocampus links to the lower portion of the amygdala that then activates the reward center that utilizes dopamine when good choices are made or feelings of compassion are generated in the soul. This circuit then links to the prefrontal cortex, a site of higher cognitive functioning. The result is that dopamine is administered in both circuits. The upper circuit fires when impulses are being played out below the level of consciousness. This leads to impulse control issues and repetitive habitual impulses when

the limbic connections for the lower circuits are not secure. The consciousness is dominated by impulsive behaviors. Passage through the hippocampus allows impulses in the lower contextual circuit to utilize conscious or biographical memories to control impulses.

In the literature the learning strategy for the upper circuit is called "risk/reward." If I do this, will I get the reward? How much am I going to get back from this? Risk/reward is the primary learning mode of the child up to eighteen months of age. The irony is that this very effective learning mode is based on fear impulses that form the developing neurology around survival traits. In the diagram you can see that the upper portion of the amygdala is designated as a fear-driven impulse. Early sensory input in the infant lacks contextual memories and is primarily a fear-based learning that is just organized around getting rewards. Later learning is capable of modifying early fear-based learning of sense-motor experiences. The adult must bring the fears to awareness and place them into context with biographical or declarative memory experiences. However, for many reasons it is possible that the linkages that allow for these modifications are not present in the life of the infant and young child. This then leads to learning difficulties. Researchers have found that, in the autistic child, the amygdalas have a huge development in the first two years and then stop. The child is very good at fear-based learning but is challenged with contextual or biographical learning modalities. In autism, as the rest of the neurology grows around this impacted hippocampus / amygdala linkage, the amygdala gets compromised. Meaning that when that soul comes into that brain to use that amygdala to say, "Is this okay, is this not okay?" the only language available is the more literal sensory driven risk/reward language of the upper circuit. The more subtle, contextual memory patterns of the lower circuit are challenged in this soul, making it difficult for the lower portions of the amygdala to get rewards that lead to cognition based on social exchanges (biography). When this happens, the person has difficulty reading subtle body-language cues from others. Subtle facial gestures that inform the listener about inner states of others are overwhelmed by the literal immediacy of sensory inputs. As a result the inferences or metaphorical aspects of communication are out of reach. This then is the challenge of theory of mind. The person is in touch with the activity of his/her own mind, but the sensory universe that he inhabits with his own form of communication is challenged by the nuanced inner life of another human.

So, on the right side, that experience in the amygdala is a kind of "fear of space." And this includes: alienation, not getting what I want, unease in the body due to too much sensory stimulation. This can lead to the feeling that "maybe I should just shut down here, because it's too much stimulus to the spatial feelings of my body." That's the right side.

The fear impulse on the left side is not space, but time or context. People challenged with time issues can obsess over time commitments, such as being responsible for planning to pay bills, or being surprised by unexpected events that disrupt the schedule, or issues around leave-taking and reentering relationships, or even obsessive daily rituals. When the hippocampus links to the amygdala, the lower portion of that organ fires off and the consciousness of the person can experience a tempering of fear by becoming aware of thresholds of arousal. The lower circuit puts the brakes on the obsessive or compulsive impulse control issues in the soul. Conscious memories make it possible to monitor the onset of fear states and modify them into states of heightened awareness. That kind of influence then links to the dopamine-utilizing function of the reward center in the prefrontal cortex. The result is impulse control that is directed by the conscious soul life of the person. This is the source of moral impulses of compassion and self-awareness.

Harry T. Reis, psychologist at the University of Rochester, speaks about three vital functions for harmonious human relationships: the need for autonomy, the need for connectedness, and the need for feeling competent.[4] So in the right prefrontal cortex, I express my autonomy by monitoring. This is very good if I have problems with impulse. I need to have that right cortex go, "I don't think you should do this." It allows me to hold back on an impulse that is based on fear of space or body integrity in my right amygdala. If my amygdala says, "Attack this or run away," I need to have a prefrontal cortex monitor this so that I can say, "What have I learned about this in the past?"

In reality this activity in the front goes into the back also. And in the center of the cerebellum is an organ known as the vermis. *Vermis* means "worm" and the vermis is that worm-like part of the cerebellum on the right. The vermis is the white matter inside the grey matter of the cerebellum, and the term that's sometimes used is the ocular-motor vermis. Ocular-motor refers to the the muscles that move the eyes. So in the center of your cerebellum you have a very deep nucleus that is connected to the movements that your eyes make when you're going through the world. We could call it "eye eurythmy." As your eyes move in the act of looking at forms in the world, the forms that you perceive create maps in space in your neurology. That's the function of the right side of the brain, to create spatial maps so you can say, "This person is too close to me; that person is at the right distance from me." That's a sense-motor memory. Spatial mapping and fear about space activate the right side of the brain. When that impulse gets sent to the cerebellum, the neurons in the vermis are active and my pupils expand and contract and my eyes start tracking the changes in the forms and shapes of the things around me in space. The vermis is active when I'm monitoring the space. This comes into play as you are driving and watching whether or not you'll be able to pass the slow RV on the mountain road before the lumber truck coming at you from the opposite direction becomes too close. Basically you're triangulating that space as it's changing, and that's your right side doing that.

In the same situation the left side is also active. I have a left prefrontal cortex, a left amygdala, and a left hippocampus. On the left the fear in the amygdala is not triggered by space but by relationships of time. Time in the soul manifests as the experience of context. Shape recognition gives humans hints as to how events are unfolding. This is a subtle realm, but it has to do with the shapes that make up the faces of other people as well as the cues given by a series of eye movements accompanying speech. These seemingly unrelated tasks can be gathered together under the rubric *pattern recognition*. Patterns display figure/ground relationships to humans. Distinguishing a figure against a ground is a fundamental pattern- or context-recognition faculty. The left amygdala is the place where people who have issues with pattern recognition or contextual recognition often have neurological complications. This can result in such complaints as schizophrenia or high functioning Asperger's syndrome.

Shape recognition in the soul creates context. So, if I take this paper and I rotate it in front of you, you're seeing a shape that is changing, but in time you can see that it is the same paper that is turning. Context. The context is: "He's turning the paper" instead of "That's a different paper than the one you had before." If it were otherwise, welcome to the world of neurological challenges: "That's a different paper than the one before."

There's a thing called the Dick and Jane test. Dick and Jane are sitting at a table, and there's a box on the table. And in the box Dick puts a donut. And then the phone rings, and Dick gets up and goes out to answer the phone. Jane opens the box, eats the donut, and puts a pen in there and closes the box. Dick comes back. The question is: what does Dick think is in the box? If you're autistic you say "a pen."

Because that's literally the last thing that happened. That's called not having the context to form a theory of mind about what Dick might be thinking.

We're talking about a deep soul dilemma. When I can only experience the fear gesture in the left amygdala, dorsal striato-nigral pathway, I can't bring biographical or contextual memories forward to put together events in time. Everything is a snapshot. All my inner pictures are like snapshots, and I have to struggle to make a movie out of them. And that happens in this area of the hippocampus where I have to take the short-term snapshot memory and collate it into long-term contextual memories; it's difficult for me to do that when I have a problem in the left side.

An activity like knitting in the Waldorf school sets the stage for eventual connections to a moral imagination.

When I can exert impulse control on the left, I can sense that I am being aroused. So on the left-hand side, this contextual side, I read situations where I begin to sense stimuli that will arouse me, and that quality of arousal can actually start to flow into this dopamine-utilizing area where I begin to be able to monitor habituated arousal. Then I'm in the realm of trying to deal with an addiction. It's an inability in the emotional life to make a distinction between a short-term and a long-term memory that essentially creates both the challenge and the method of healing for learning difficulties. Working through the lower circuit I can consciously get access to the prefrontal cortex. In that area I can find the great gifts of compassion and the ability to monitor my own consciousness.

The people who work with the idea of neurogenesis as a healing modality understand that the mapping of space, the creating of context, the overcoming of fear, the ability to limit arousal symptoms, control them, and integrate them into creative activity all require the integration of ensembles of neurological organs, rather than a drug that targets a specific organ. You can take a drug that targets a specific organ, that allows that organ to kick in with the secretion it needs, the neurotransmitter it needs, but you're only just putting a band-aid on that link. What research is understanding now is that it's possible to stimulate new neurological structures to actually rebuild the lobes that are either lesioned or compromised in some way. This happens when I have to do an activity where the finer motor controls of my eye and hand have to engage an idea that I am trying to work out, and that includes, then, input from my feelings. I need to have the fine motor control connected especially to my sensory input. I have to get the sensory motor inputs of the upper unconscious pathway to link consciously through subtle eye/hand relationships to the vermis. So, an activity like knitting in the Waldorf school sets the stage for eventual connections to a moral imagination. That then has to be worked through by my feelings. We could put that requirement in a nutshell and say "aesthetic experience." So, I'm bringing very fine motor control linked to my feelings when I'm working with a paintbrush or when I manipulate a chisel so that I can make that curve in the wood just so. I'm exercising all of these areas to have a flow; go back and forth and stimulate neurogenesis in all of them.

So artistic or aesthetic experiences engage not only the finer motor controls of the cerebellum. They engage the ocular-motor and auditory centers in the back, but also my feeling life based on biographical or contextual memories in the hippocampus. This is now in the realm of skill development or, in the professional language today, praxis. (Praxis means I do something that is skilled.) So here I have praxis when I bring sensory motor impulses linked to feelings that I then control through evaluative functions of the prefrontal

cortex. These impulses are generated when I evaluate: is this good? is this not good? But then I have to include my feelings about this, about the way the form goes, and how does this color fit that, is this the right color for that space, is this the right word for that poem? This creates what is known in psychology as a lateral integration.

As an exercise we can create a collage, for which we spend three days ripping pages out of *National Geographic* and putting them in an envelope. And then we take a piece of cardboard about the shape of a face, and each one has to take scissors and cut out pictures of dolphins and bears and volcanoes and other things and make a face out of those pictures. And then we have a dialogue with that face: "What are you telling me?" We do this as a symbolic activity in which my feelings begin to enter into the image of a face that is made of symbols of other things in the world. This is a kind of visual alchemy. Yesterday, someone told me that this kind of activity is an exercise that's given to autistic children to help them come out. This symbolic activity stimulates neurogenesis.

So, neurogenesis is this great force that humans have that allows them to actually restructure their own neurology. And it's better than a drug. It's better than surgery. It's actually a resurrection of the neurology, a reforming of the pictures that have been there. And my question now, that I put to you, is: what is the cosmic soul significance that one in a hundred children is coming back with this kind of neurological structure? What does that mean for society that their souls don't have access to the full aspect of their architecture? What does that mean, and what is it saying about computer use? What is it saying about menu consciousness, where I can only use my executive function if somebody has already figured out the menu that I need to choose from? Which is where we're going.

There is an article in *Wired* magazine[5] in which Steve Silberman speaks about the epidemic of autism in Silicon Valley. People are wondering: what's going on? The largest concentration of autistic people in the general population is in Silicon Valley and in Redmond, WA, home of Microsoft. Well, these clusters occur in centers where people can spend their lives in cubicles, doing very complex thought patterns without having to relate to other people emotionally. And that's rewarded in our society by earning them $150K because they can write code for twenty hours a day. These situations raise very deep questions about human consciousness and the children and adults who will be coming to us for education in the future.

I want to read a quote from Goethe, just to finish. "The ancients said that the animals are taught through their organs. Let me add this, so are men. But men have the advantage of teaching their organs in return."

Endnotes:

1. This article was originally given as a lecture at Rudolf Steiner College, CA in 2011 to a conference on Psychosophy and Psychology.
2. *New York Review of Books*, Vol. 37 No. 18, Nov. 22, 1990.
3. All illustrations in this article are by the author.
4. For more on Reis: http://reis.socialpsychology.org.
5. *Wired Magazine*, Vol. 9 No. 12, Dec. 2001.

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