THE ROOTS OF FUNCTIONAL INTEGRATION

PART III: The Shift In Thinking

by Carl Ginsburg

Feldenkrais wrote in his book, *Higher Judo,*

> "In a perfectly matured body which has grown without great emotional disturbances, movements tend gradually to conform to the mechanical requirements of the surrounding world. The nervous system has evolved under the influence of these laws and is fitted to them. However, in our society we do, by the promise of great reward or intense punishment, so distort the even development of the system, that many acts become excluded or restricted. The result is that we have to provide special conditions for furthering adult maturation of many arrested functions. The majority of people have to be taught not only the special movements of our repertoire, but also to reform patterns of motions and attitudes that should never have been excluded or neglected."

It is one thing to learn a repertoire. It is quite another thing to "reform patterns of motions and attitudes." One has to know something of how our most basic functions such as walking or sitting are learned and organized. This topic has virtually been ignored in twentieth century psychology with its emphasis first on learning repertoires, and then on programs and algorithms of formal thinking processes. These studies, useful as they are, are not relevant to the problem of learning in terms of organizing the system for functioning.

Feldenkrais had what seems a monumental task, with little in the way of a theory to go on. He did have at his disposal his background in judo, his understanding of basic physics, and an understanding of systems from his contact with the burgeoning science of cybernetics. Above all, he had his ability to explore on his own with an extraordinary open-mindedness, as well as his attention to detail that led to discoveries of great uniqueness. We have already explored some of the characteristics of this learning process in parts I and II of this essay. In this third part we will attempt a synthesis, bringing the disparate elements of the process into a more cohesive understanding. We need, however, a bigger picture, a biological view that shifts the ground of our thinking.

The work that Feldenkrais developed is practical and immediate. As he developed his work, however, Feldenkrais evolved his thinking process in the direction of this larger picture. In many ways he anticipated a revolution in thinking about life and living beings that is only being articulated in recent years. This shift in thinking is incorporated directly in Functional Integration work. Much of it has already been discussed in the first two parts of this essay. But it has not been articulated directly and set apart in distinction to the usual way we think in our culture.

Thinking in a Lesson

Let us begin with a practical example of this thinking. A young man came for a few lessons with me at the urging of a student in a Feldenkrais Training. He had injured his right elbow two years before. Now his elbow was stiff; he could not bend it fully and could not touch his right shoulder with his right hand. He also had pain with certain movements which interfered with one of his great loves, playing tennis. Serving the ball was a quite painful action. He had had one surgery to attempt to relieve the elbow. X-rays now showed a calcium deposit near the original site of injury. It was the cause of the pain, he was told and should be removed. The young man was not so sure that he wanted to undergo another surgery.

I began the lesson with this young man by gently moving the ribs and the shoulder together and then apart on the left side. Only later did I repeat similar movements on the right. This allowed him to feel how he restricted these movements on the right as compared with his uninjured left side. He wondered at first why I wasn't interested in his elbow. But then he commented, as he began to allow more movement, on how much he restricted himself and actually held the right shoulder higher than the other. Now that he felt something of the participation of the ribs, spine, and pelvis, he recognized that he could comfortably move much more than he allowed himself. His father, who had accompanied him, sat and watched with fascination. "And you can use this in tennis," I said. The father nodded in agreement at my remark. An engineer, he apparently understood that a tennis serve required more than just an arm in the action.

After this first lesson his shoulder, neck, and upper back felt much easier. So too did his elbow, although we never mentioned it at the end of the lesson. In the second lesson I held his forearm so that it was stable, and slowly moved his upper arm and body to indirectly close the elbow joint. As the ability to use the joint improved, I directed him to think of moving the elbow away from himself rather than to try to bend the elbow. His father said that this was also clever engineering. In the end he could touch the shoulder with his hand without pain or discomfort, and he could play tennis.

A lesson sequence like this is so much of what many of us do in Feldenkrais work that I tend not to find it remarkable. I forget how great a shift in thinking is required. What I know is this: given that some freedom of choice and action is created, the human system will organize itself in a more optimal way. If I had focused my thinking on the elbow and the corresponding "cause" of the pain, namely the calcium deposit, the young man would still have his problem. I shifted my thinking away from looking for a mechanical or physical cause of the "problem," toward thinking about the whole way this young man organized himself in his action to protect his elbow, and about how I could give him support and alternatives that would allow him to find a better organization for his purposes. He now had a new way of thinking.

A New Biological Thinking

In the last twenty years a new thinking has been emerging in scientific fields such as chaos theory, fractal mathematics, and systems biology that no longer sees each event in the phenomenal world as a separate entity. The older thinking can propose mechanisms. It has a devilishly hard time showing how order arises in complex systems. Theoretical biologist Franciso Varela has contrasted the two approaches in biology in the following way:

> "Current biology: Heteronomous units operating by a logic of correspondence. New biology: Autonomous units operating by a logic of coherence." (Varela, 1986)

We need to explain this further, as the language here is unfamiliar. Varela's shorthand way of putting it describes two very different modalities of understanding. Let us begin with what is familiar, although described in an unfamiliar way: heteronomous units and logic of correspondence.

The term heteronomous units refers to a way of seeing living organisms as if they were a collection of parts, where each part contributes to the overall functioning. The parts, however, are independent of each other. Here the emphasis is on understanding the components.

The logic of correspondence is what we already understand as what we mean by logic. For example, we see an organism behaving in a certain way. We then search for a mechanism that may be external, or internal, to the organism which will correspond to and explain the behavior. Basic to such a logic is the notion of cause and effect. We notice that an organism exhibits a certain response. We look for an environmental stimulus or some stimulus from within the organism to connect to the production of the response. As another example, a person reports that he or she has a pain. We search for some pathology or structural anomaly that we can relate as a cause of the problem. We assume that finding a cause will lead to a solution to the problem, a solution which works by eliminating or neutralizing the cause. This is so taken for granted in most disciplines that it is rarely if ever questioned.

Correspondence also leads us to the notion of how systems relate to the outside environment. We see that an organism connects with this environment, and postulate that the organism must contain some sort of internal representation that corresponds to the environment. This view dominates cognitive science and the field of artificial intelligence, where it is assumed that a system that shows some degree of intelligence, i.e. which can act in a way that appears sensible in its environment, has some design that allows it to respond to the environment. It has an internal perception of what is outside itself so that its behavior corresponds to the needs of the environment.

Let us look now at Varela's alternative. We must begin with the word autonomous. Autonomy is one of those problem concepts that many scientists would rather ignore than try to grapple with. Yet it is understood generally in an intuitive way, and when we see it, we tend to think that whatever thing shows this characteristic is alive. Varela (1984) describes a situation where he sees a dog walking on the street and the dog changes direction and walks toward him. In this situation, Varela describes how he is tempted to impute the idea that the dog intends to greet him. What is important to Varela in this is that "the dog's behavior is difficult to account for unless I observe that the dog confronts its environment not as if it were receiving instructions from the environment for particular outcomes, but rather as if these instructions were mere disturbances that the dog interprets and constructs according to its sense of regulation and balance. This is again that peculiar quality we call autonomy."

Thus an autonomous unit, or organism, will act in its environmental medium according to its own internal structures. If such a system does so with what appears to be intelligence, we are mystified, however. We want to know how it is designed to do this. Varela speaks of a "subtle but powerful twist." And that is to emphasize the system's coherence. This is a far more radical notion than first meets the eye.

Coherence emphasizes the interconnectedness, internal consistency, and unity of a living system. Coherence arises because living systems, from the very outset, are systems that have a certain kind of organization. The very survivability of the system implies that this organization is a necessary condition and is maintained as long as the life of the system continues[1]. A living system then acts in such a way that it maintains its organization, its set of internal relationships. The system knows nothing of inside or outside, but adjusts to every disturbance in order to maintain itself. These adjustments then become a kind of history of its interactions that makes it more likely that the same behavior will be reproduced in similar circumstances.

How can we have two points of view, one looking at mechanisms, and the other looking at the unity and interconnectedness of the system? Both must be useful. What then are the advantages of shifting our thinking to the systemic perspective? A perusal of the scientific literature written from the perspective of correspondence and design reveals that such an approach generally leads to very complex models that often only partially solve a problem. Researchers often develop conflicting theories without finding a definitive way to decide among them[2]. The coherence perspective, on the other hand, leads to a kind of economy and simplicity in thinking and acting without needing to elucidate mechanisms. It takes into account the whole. It avoids the pitfalls of tinkering with parts to the detriment of the complete situation. Further, as Varela suggests, it is vital for leading us toward increasing our chance

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1. This insight about living systems was first articulated by systems biologist Humberto Maturana, and then expanded upon by his student, Francisco Varela. Because these authors use certain common terms in a special way, we need to be careful to be clear as to their special use. Organization refers specifically to the organization of processes of production and destruction that maintain a living being in its form, unity, and ongoing life. Note that in terms of its materiality and energy, a living system is in constant exchange with the environment. Therefore, it has no identity in terms of its material makeup. What we can observe is that the structures of such a system are "plastic" and can compensate for the way it interacts and couples with its environment. Structures here refer to the actual components of a system which carry out the organization. The system thus has a history, or if you will, a memory of its compensations, and the ability to update its structures. (Varela, 1979, Maturana and Varela, 1987).

2. For an example of the difficulties of understanding human movement from an engineering and analytical perspective, see *Multiple Muscle Systems*, edited by Jack Winters and Savio Woo. The many papers in this volume detail attempts to mathematically analyze movement and the underlying skeletal structure. Most of the papers are speculative and only attempt a solution to very limited and restrictively simple problems (Winters and Woo, 1990).

for survival on the planet. For him it is a radical shift in epistemology as well as a "new mind."

I believe that Feldenkrais developed his thinking in this same direction. Without articulating it in the same way, I also believe that he developed Functional Integration using a logic of coherence and not a logic of correspondence. It enabled him, as it enables us, who practice his method, to act directly with another person through a coupling of two systems. Such a coupling depends upon this characteristic of coherence.

Coherence and Control

Here is Feldenkrais describing how a person orients himself or herself to a sound. "Now with the ears, we have exactly the same thing. If someone talks to my right, really on my right, then the sound will reach my right ear first and it will be delayed by the time necessary for the sound to travel around my head to reach the other ear, and until I hear with both ears, I don't know where the sound is coming from. So if someone makes a noise at my side, my head will turn around so that the noise reaches my ears at the same time. *And this is reflective of a lot of the working of the nervous system* [emphasis mine]. This is how it organizes to make sure that both ears receive the same intensity, and when I've done that, my eyes are directed at the source of the sound." (Feldenkrais, 1987)

This is a kind of universal way of describing movement in a concrete context in which the complex activity can be made sensible in terms of a simple parameter; that is, both ears receive the same intensity. That "my eyes are directed at the source of the sound" indicates a basic coherence about action and its relation to a world. Feldenkrais's description is related to his understanding of cybernetics and predates the work of Varela[3]. The thinking is in the same direction.

Maturana and Varela (1987, p.147) describe how a simple single-cell animal such as an amoeba can move. The amoeba comes in contact with a protozoan. What is seen behaviorally is that the amoeba engulfs the protozoan. What is seen up close is that substances from the protozoan interact with the amoeba membrane; this, in turn, changes the

3. The cybernetic approach models a self-regulating, or control, system. The key in cybernetics is that the system matches the present condition against a desired condition and detects the difference or error between the two conditions. This error signal is called feedback. The move towards correction is simple in that it reduces the error signal. Such a system doesn't have to compute a great deal of mathematical data.

Feedback is essential to control and learning for human beings, as was amply demonstrated by the research efforts of K. U. Smith at his laboratory at the University of Wisconsin back in the nineteen fifties and sixties. In a number of Smith's experiments an experimental subject was given a task to track a target. Smith observed both the learning and performance of the task by measuring the accuracy of the tracking as a function of time. He then delayed the feedback time and measured the degradation of both learning and performance. A delay of seconds will result in difficulty for the experimental subject. Note that feedback in Smith's experiments occurs in the real time of the task. This is not the same as either reinforcement or what psychologists call *knowledge of results*, both of which are usually given to the subject at a time after the performance (Smith and Smith, 1988).

For those readers wishing more details about the cybernetic approach, I highly recommend Larry Goldfarb's recently published thesis explaining cybernetics and describing Feldenkrais work in cybernetic terms (Goldfarb, 1990).

consistency of the protoplasm so that it flows and forms what is called a pseudopod. The pseudopod in turn changes the position of the amoeba, thus changing how the membrane contacts the substances in the environment. "This cycle is repeated, and the sequence of movements of the amoeba is therefore produced through the maintenance of an *internal correlation* between the degree of change of its membrane and those protoplasmic changes we see as pseudopods." Thus there is matching of what is happening at a sensory surface of a cell with a motor surface in such a way as to maintain an internal set of relations.

This is also a cybernetic description. It follows directly, however, from understanding "autonomous units operating by a logic of coherence." It avoids the entire pitfall of thinking that movements are represented somehow inside the living system, or as in higher species, that they are represented inside the nervous system.

Feldenkrais and Physics

We can see now how the development of coherent movement of oneself involves an implicit physics. As we quoted Feldenkrais before, ". . movements tend gradually to conform to the mechanical requirements of the surrounding world." (op. cit.) We use this basic physics all the time whether we are teaching Awareness Through Movement or we are making contact, giving support and so forth in a Functional Integration lesson. We do not need to articulate what we know, given that we have a tacit understanding directly in what we sense in ourselves, and with others, in terms of knowing what organization of the self works to provide ease and comfort in action. This is the condition we seek and we can match the actuality of our action against some very simple parameters such as reversibility of action, smoothness and ease in moving, etc. It is very fortunate because the engineering problem, as I pointed out before, is formidable.

Feldenkrais's initial discoveries in this realm were made before he developed his method. His source was judo. Moshe's judo teacher, G. Koizumi, pointed out in his introduction to *Higher Judo* that Feldenkrais had "studied and analyzed judo as a scientist in the light of the laws of physics, physiology and psychology. . ." (Koizumi, 1962). Judo, which requires great skill in finding the most efficient use of oneself, can be a guide to the conditions of efficient action. In judo, for example, Feldenkrais discerned through his knowledge of physics that it was the action of the pelvis that allowed a person to easily throw another. Even a person considerably smaller than the person thrown could be capable of doing this. From this observation, he established that easy action required that the larger, stronger musculature of the trunk and pelvis be used for actions requiring strength. One major reform of patterns of motion thereby involves learning to move with the center of the body for such action. Conversely, delicate and refined action needed the musculature of the periphery, the arms and hands, for example. One can find numerous examples in Awareness Through Movement lessons of this and other applications of the basic physics of conforming to the requirements of the world.

Cybernetics and Learning

K.U. Smith, as cited in note 3, showed that distortions in feedback resulted in degradation of learning. Feldenkrais went about corroborating the importance of feedback for learning from the other side. He noted that loss or lack of smoothness and coordination in human movement related to some sort of loss of sensory feedback for the person. This might be due to over-contracted musculature from which feedback is limited by the noise of over-contraction. Or it might be due to lack of sensation and awareness of some part of the self necessary to the movement. He then explored ways to recover or create increased sensitivity, finding that allowing movement in itself reduced over-contraction and that imagining the body in itself increased sensitivity. Such processes are abundant in Awareness Through Movement lessons and in Functional Integration. With increased sensitivity, one feels differences that were not apparent before. For an outside observer, the same effects can be seen in improved coordination and smoothness in a person's action.

A second corroboration of a cybernetic effect occurs with the use of Feldenkrais's Functional Integration strategy of taking the person more in the direction of the pattern of contraction in the musculature. The observed effect of this strategy is that the over-contracted muscles become reduced in tonus. This is counterintuitive to the idea of directly correcting a fault. Nevertheless, this is exactly how we would expect a system with a feedback loop to behave. Here one supports the system and the system self-corrects. Understanding the cybernetic point of view already involves a shift in thinking, and it involves a shift away from the logic of correspondence.

Movement and Organization

Feldenkrais has been quoted as saying, "Movement is the key to life." Let us go back for a moment to the formulation of Francisco Varela and Humberto Maturana. We need now to look at how movement of the organism, in the space of the environment, evolved. We will see something startling. Simple organisms that do not have a nervous system actually behave by cybernetic processes similar to those of complex organisms. The example of the amoeba has already been cited. Movement, thereby, comes before the nervous system, but as Maturana and Varela note (1987, p. 145), "from the standpoint of the nervous system's appearance and transformation, the possibility of movement is essential."

The Nervous System

Feldenkrais often asked, "What is the function of the nervous system?" His students would provide answers ranging from ideas such as, to make the limbs move, to perceive the world outside, to saying that the nervous system controls and regulates the body. He always had a different unexpected answer, and would frown and ask for the next explanation, shaking his head in disappointment. Eventually everyone in the room wanted to know his answer to his question. "Aha," he would say, "you haven't yet got the idea. The function of the nervous system is to create order out of chaos." Life itself involves order forming out of chaos. How can such order come about given that the tendency of systems left alone is to move toward an equilibrium and increased disorder? Ilya Prigogine has shown that the answer lies in noticing that the conditions of systems on the earth are far from equilibrium and that there is a constant influx of energy from the sun (Prigogine, 1984). Here we have irreversibility. Under certain conditions in processes taking place in these conditions, order will spontaneously appear. One characteristic that seems vitally important is that there is a kind of feedback in that what the system produced is enfolded back into the process. This is called iteration or recursion.[4] Are there similar iterative processes in the nervous system? Let us see what is known.

The sensory nerves and their connections into the central nervous system comprise only a tiny fraction of what is in the nervous system. What is very interesting is that one finds nerve pathways that indicate that the central nervous system feeds back onto every sensory surface. This includes the retina of the eye, the spindles in the muscles that detect lengthening and shortening, etc. Thus there is no such thing as pure sensory data unmodulated by the central nervous system. The many loops in the nervous system therefore allow for the iterative or recursive processes to take place. Recursion, i.e. repetitive cycling, may be the most essential process available to the nervous system in the creation of invariances, perceptions, actions, etc. (Pribram, 1971; Maturana and Varela, 1987).

The nervous system responds to change and not to static or constant irritation. For the eye to see, for example, the eye must move if nothing else is moving. A static image on the retina will disappear as the cells on the retina habituate. So too with every other sensory system (Pribram, 1973). Equivalently, the nervous system does not respond to absolutes, but to relationships. For example, there is no direct correlation between the color one sees and a given frequency of light. The color one sees can frequently depend upon relationships to the surroundings. Changes in lighting will be compensated for so that things seen in red light will still appear colored as they were in white light even though the wavelengths of light hitting the retina are now different. Another example is that a tune is recognized as such even though the absolute pitches in which it is played are different. Here are some more instances: an object is recognized even though it may be at different distances and produce images of widely varying size and shape on the retina; one's handwriting is the same whether one writes on a blackboard or on a sheet of paper on a desk. Thus we can say that the nervous system creates invariances, which include such things as tunes, objects, handwriting, etc., that allow for the distinction of "things" as separate from background, as well as distinct actions. What is invariant is the relation of the parts and not the measure (Maturana and Varela, 1987).

Despite the belief of many researchers of human movement that "...the simple tasks studied constitute building blocks of more complex tasks,"(Huer et al., 1985). Feldenkrais demonstrated that a whole func-

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4. John Briggs and F. David-Peat provide an excellent introduction to chaos theory in their book, *Turbulent Mirror* (Briggs & Peat, 1989). They show how iteration is generative in both mathematical and real systems.

tional movement is learned more quickly and easily (Ginsburg, 1988, p. 13). Feldenkrais work also shows that differentiating parts of the self within the self-image leads immediately to improved performance of action.

The nervous system doesn't see what it doesn't see. The blindspot in the retina is never noticed unless one does an experiment to reveal its presence. Damage to the nervous system, such as the loss of part of the field of vision, is also not noticed and the missing part of the field is sometimes experienced as filled in.

The nervous system creates a stable background or world, which is an ordering necessary to be able to get around easily in the world. If you move your eyeball with your finger, you can notice that the world jumps as the image on the retina jumps. Move your eye and the world stays still, even though the image on the retina jumps as much. This shows that the system compensates for the movement of the eye as detected by the kinesthetic feedback from the eye muscles. The ordering takes place in the context of movement. As we indicated before, no sensory system can operate without movement. Thus there is always a circularity between action and experience. In the words of Humberto Maturana and Francisco Varela, "*All doing is knowing, and all knowing is doing.*" (Maturana & Varela, 1987)

So-called nerve impulses, i.e. polarized waves that jump across synapses, may comprise only a small part of the activity of the nervous system. There are neuroelectrical processes, that do not involve propagated impulses, going on continuously in the nervous system (Pribram, 1971). We could conclude that there are probably inductive effects in the nervous system so that electrical activity in one part induces activity somewhere else. From this we might speculate that the nervous system can be modeled better if it is understood as operating in a non-localized distributive fashion rather than as a collection of individual functioning units.

The details of the actual organization of the nervous system in structure and function is still undisclosed, and there are still a lot of unsolved problems. Gerald M. Edelman notes that modern neuroscience is actually in a crisis since it is unable "... to explain how, prior to conventional learning, neural structure and function can result in pattern recognition or perceptual categorization with generalization." (Edelman, 1987, p.25). The crisis, Edelman believes, is masked by "... interpretations that evade or obscure a number of critical difficulties, contradictions, and lacunae in neuroscience." We have moved away from the telephone switchboard metaphor for the nervous system, and are well on the way toward eliminating the digital computer metaphor. Some radically new ideas are leading in different directions.

Nervous System and Body

Let's begin with an already organized network of nerve cells as might exist in an infant. This network has a structure already as a result of evolution, although for a human being very little about it is fixed at birth. The pathways of its organized processes need to be formed. Feldenkrais saw that the initial action of the infant is global. Learning then involves a shift from global undifferentiated movement to action of the self which is differentiated and organized to carry out intention and function. The only way this can happen is through movement and experience. "So we come to an extraordinary conclusion—that our brain and our body are one thing and they grow together, only through the perfection of the body movements." And, "You find that the body is necessary to train the brain, otherwise differentiation cannot be performed... the brain has no contact with the surroundings." (Feldenkrais, 1987). Some other observations from this lecture included that if one is deaf, one is also dumb, that once a person has learned to write, you can cut off the hand and the person can write with the other hand. What we have is an extraordinary system that gives both stability and the flexibility to adapt to new circumstances.

What kind of system can do what we have described so far? Note that one cannot teach a person how to organize movement or how to perceive. These activities can only be learned. In other words, we need a system that organizes itself as it experiences. It is a system that has both stability and an extraordinary plasticity to shift with changing circumstances. It is a system that is exceedingly difficult to model[5].

Autopoiesis and Organization Closure

Generally speaking, neuroscientists, biologists, and others interested in the problems we have addressed have worked from the bottom up. That is, the belief has been that if we can understand the process at the lowest level—the level of the cell, the neuron, and the synapse—we can develop an understanding of the system. Much of what we discussed so far we have looked at more from the top down. Here, we can observe the way a system works as a whole, as Feldenkrais did, and evolve strategies based on the coherence of living beings. We can go a step further and ask a new, and very different, question: What kind of organization of a system is necessary for a system to show that it has a unity as a system? What kind of organization of a system is necessary for a system to show that it operates by autonomy, coherence, and self-maintenance (i.e. can reproduce and rebuild itself)? Organization here refers to the processes that underlie biological existence. More generally, organization indicates what relations are necessary for something to exist. For a living being to stay alive, its organization in this sense must be con-

5. Allman, 1989, reviews advances made in modeling intelligent systems with so-called neural networks. A more biological model has been developed by Edelman, 1987, called a neuronal selection theory. Edleman charts out a process of brain organization that can take into account many features of the nervous system that are not accounted for in other models to date. In this theory, neurons are already organized into groups and, through the experience of the organism in motor behavior, the signals from the environment dynamically induce a selection process in which certain functional groups of neurons are selected out and reinforced through changes in electrical and biochemical activity. Structures in the nervous system are not thereby determined by information from the environment. The capacities are already there. Nevertheless, Edelman has eliminated the question of design and paralleled the workings of the nervous system to the process of evolution. This is a good step. It was anticipated by Bateson when he showed that evolution and learning are both stochastic processes (Bateson, 1979). It is also a feature of Maturana and Varela's radical reworking of biological theory. Edelman's idea also fits very well with Feldenkrais's idea of differentiation being the central element in learning. And in a true biologist's fashion, Edelman shows that movement is essential for the organization of perception, and that the organization of both movement and perception are adaptive to survival of the organism.

tinued. A break in organization results in death. This is a different use of the word organization from our common use in the Feldenkrais work to refer to the organization of an action.

The question is radical in the true sense of that word. For Maturana and Varela, it is a question that also asks: What is it that characterizes a living system and makes it different from any other kind of system? We return now to their formulation[6]. Maturana and Varela note a very obvious thing: living systems are organized in such a way "that their only product is themselves with no separation between producer and product." In a living system, such as a cell, there is a continuous inflow and outflow of materials and energy. On the other hand, the organization of the processes by which the cell constructs itself from the materials is not changed, and it must be maintained as we stated. This organization needs also to be stable and unchangeable. It must therefore be a series of processes that at each end connect together to form a loop. The organization is thus closed to the outside.

But what if some outside agent perturbs the cell, or the outside environment itself creates a perturbation? This could endanger the organization. In order to maintain itself, a cell must effectively make some change so that the organization will persist. There is a change in structure. Structure here also has a special sense and refers to the way the physical components of the system are put together. One of the most important structures that the cell creates is the membrane that the cell uses to separate itself from the environment. The cell membrane both contains the unity of what is inside and allows for flows of energy and materials to and from the outside.

Maturana and Varela have named this kind of organization autopoiesis (Maturana and Varela, 1987). Maturana has further stated the idea as a general law of biology. He calls it the law of conservation of organization. A living system is alive as long as its organization of processes is maintained. The implication of all this is that a living system, while open to flows of material and energy, is closed to information.

Now we can notice another unexpected feature. We noted that when a system is perturbed, it adapts itself structurally in such a way as to maintain its organization. Because of this, each living system has a history. The structural changes become a record of how the system was perturbed over its life. This relation to the environment can be described as a structural coupling. "We speak of structural coupling whenever there is a history of recurrent interactions leading to the structural congruence between two (or more) systems." (Maturana and Varela, 1987). As living systems can interact with each other, coupling can lead to larger unities than single cells. We can have multicellular organisms, as well as coupling at a still higher level between organisms.

We can now make a radical thesis about the nervous system. As with the basic organization of the cell, the nervous system is organizationally closed. By this, we mean that looking from the point of view of the system and its internal relationships, there is no information transferred from the environment, no-input-output, no representation of the out-

6. The best introduction to this work is Maturana and Varela's popularization of their ideas in *The Tree of Knowledge* (Maturana and Varela, 1987). Varela's *Principles of Biological Autonomy* provides a very closely argued technical presentation of the thesis (Varela, 1979).

side world inside the nervous system. As with our description of the cell, the nervous system shifts structurally to maintain its organization when perturbed by the environment. And, as with the cell, the record of these structural changes becomes a history, or what we commonly call a memory. Learning occurs because the nervous system has developed to be extremely flexible and structurally plastic so as to maintain its own internal relations. Stability arises as invariances are created within the internal relations.

Lastly, I will just hint at the possibilities when we consider the results of those interactions between living beings that result in structural coupling. Interactions can lead to a much larger domain. For example, the creation of a culture through social interaction. Or the evoking of learning in a person through interactions with a world and with other people.

From our point of view, we now have a parallel to the Feldenkrais shift in thinking. We can look at a lesson from this perspective and say that there is no information passed in a Functional Integration lesson. A lesson is a coupling between practitioner and pupil in which the adaptive processes are elicited and in which it is the internal processes of the pupil that make the difference.

A Functional Integration

I am working with Brenda who suffered a cerebral accident when she was in her twenties, some twelve years ago. She has pursued many avenues toward recovery of use of her paralyzed left hand, this hand which contracts into a snarl of confused twisting along with her wrist and arm when she tries to use it. When she ignores the arm and hand, it hangs with the elbow partially bent. We have worked together for four sessions and have already discovered a number of new things not available before. First, and foremost, Brenda found it easier to progress when she shifted focus away from the hand and the details of the action. And there was her discovery that her loss of mobility and function is not limited to her hand.

I began my first lesson with Brenda by touching the ribs and spine on each side, revealing to myself that the affected left side was quite immovable as compared to the right. When I passively moved her left arm, the ribs stayed glued to the table; this was in contrast to the right side, where lifting her arm led to the entire rib cage following and facilitating the movement. As I continued the lesson, I spent a good bit of time with the "good" right side. I explored how pressing her foot moved the ribs on this side and the spine, and I continued with the movements of the arm in conjunction with the trunk and pelvis. Only then did I approach the left side again, and, in so doing, I also brought Brenda's awareness to the differences. As I sensed improvement—such as feeling that her ribs and spine began to respond when I pressed her left foot—I checked with Brenda to find out whether she felt the differences. She did and indicated that she really appreciated sensing the movement. Moving her arm, head, and shoulder together, I was able to slowly, passively, move her hand to touch her shoulder and then her neck and finally her face. At no time did I attempt to move her past any resistance that I sensed in her.

Now, in the fifth session, I feel that when I move her arm, the ribs follow. I ask Brenda to take my hand and move it through space. This she does by catching my hand in her still spastically contracted fingers. But her arm and shoulder are no longer behaving in a spastic pattern of fixed contractions. I ask her to move me wherever she wishes. This she does by lifting my arm, pushing it forward, and pulling it back. Suddenly, she realizes that she can move me, and, therefore, herself, to places that were unreachable when we started together. It is as if this functioning came out of nowhere. Later, Brenda tells me that she has caught herself spontaneously using her left side in situations where, previously, she would never have considered it.

We work more with her hand. I have her touch and feel my hand, touch and stroke herself. In previous sessions, when I moved her passively to bring her hand to herself, I arranged her fingers, as they diminished in spasticity, to touch her neck or her face. We work with her sensation and perception: how she feels and identifies each finger and how she feels where they are in space and in movement. It turns out that her senses of space and movement are not reliable, whereas her sense of touch is. As she uses her hand in the small ways that are possible, in touching and feeling, her sensation becomes more accurate.

What is different about our work together? There are elements here of communication and contact; there is my ability to sense at all times what is going on with Brenda and to stop when it is too much, or when she begins to resist. There is the support I am able to give her, so that she trusts that my touch is safe, that I will respect her space and her being. There are aspects of my skill that allow me to be intentional without being invasive, that allow me to guide without ever needing to be forceful. I am constantly reminding her that there is no need to succeed, that success will follow our engaging in this process. I evoke a coupling that allows Brenda to find a new possibility. I do not give her any information, but out of our coupling, out of the dance we do together, she senses differences and, in effect, creates new information. This is the importance of the idea of organizational closure: we avoid the arrogance of thinking that we are responsible for what happens in the lesson.

And then there is this further shift in thinking that I have been presenting here. A shift from focusing on the parts to dealing with the movement in a whole context. There is no isolation of fingers or hands or whatever, as something separate from what Brenda needs to do in life. From the beginning, what I do is connected with action and function. Function isn't something complex. It is mundane things like touching and feeling, basic things to the use of the hand.

Now we can articulate a little better about the process. Varela and Maturana's work helps us to describe the biological basis of this essential (biological) process that we have labeled functional integration. When I see it happening right before me, I am still awe-struck by the power of our nature as human beings.

I would like to conclude with the passage from *The Elusive Obvious* that I quoted in the first part of this essay. Now you can see that

Feldenkrais had a complete grasp of the understanding articulated by Maturana and Varela. Feldenkrais wrote:

> "Through touch two persons, the toucher and the touched, can become a new ensemble: two bodies when connected by two arms and hands are a new entity. These hands sense at the same time as they direct. Both the touched and toucher feel what they sense through connecting hands even if they do not know what is being done. The touched person becomes aware of what the touching person feels and, without understanding, alters his configuration to conform to what he senses is wanted from him. When touching I seek nothing from the person I touch; I only feel what the touched needs whether he knows or not, and what I can do at that moment to make the person feel better."

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