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THE BRAIN, THE BEAUTY OF SCIENCE AND LEARNING

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The human brain, which weighs about three pounds, is probably the most complex structure in the universe. Your brain contains roughly 10 billion nerve cells connected and interconnected with such complexity as to make the most sophisticated man-made computer look like a child's toy by comparison. A cubic inch of brain tissue may contain 100 million cells with connections to 50 thousand other cells.

The superior part of the brain, known as the cerebral cortex, consists of two hemispheres sometimes referred to as the right and left sides of the brain, or more simply as the right brain and the left brain. The two sides of the brain are joined laterally by a large fiber tract of nerve cells called the corpus callosum. Additional fiber tracts connect each hemisphere to the body. Tracing the fiber tracts that go to the body reveals that the right brain controls the motor and sensory aspects of the left side of the body. The right brain also receives sensory input from the left half of each eye. The left brain controls the motor and sensory aspects of the right side of the body and receives sensory input from the right half of each eye.

If you focus on a point centered in front of your eyes, the visual field to the left of this point is transmitted to your right brain while the visual field to the right of the point is transmitted to your left brain. This phenomenon is explained on the basis of the fifty percent crossover of nerves serving each eye. Damage to the right brain may cause impairment of vision in the left visual field and vise versa.

Through experiments on cats, during the early 1950's Meyers and Sperry found that learning achieved through visual input from one eye to one side of the brain is not transferred to the other side of the brain when the optic chiasm and the corpus callosum are sectioned (10). Sperry (10) reported similar observations on callosum sectioned monkeys where he found that learning with one eye had to be relearned when the animal was exposed to the same learning situation but had to use the other eye.

Sperry (10) further observed that animals in which the corpus callosum is cut behave in essentially the same way as normal animals. The severing of the callosum did not produce mental conflict. When the corpus callosum is cut, each side of the brain functions as a separate complete brain and each is capable of perceiving, learning, and carrying on other mental processes independent of the other side. Apparently at any given instant, one half of the brain gains control and the lower centers respond fully. The next instant, the other half of the brain may assume full control of the lower centers. Each half of the brain is essentially a whole brain with an entire set of integrating centers, and each half is capable of taking over full control of the body (10).

In 1962 Bogen and Vogel, at the White Memorial Medical Center in Los Angeles, surgically separated the two halves of the brain in a human subject. The experimental surgery was performed in anticipation that severing the corpus callosum would relieve the patient of uncontrollable epilepsy. The surgery was successful in alleviating seizures. Since 1962 a number of patients with severe seizures have had the same operation with similar success in alleviating seizures (6).

Gazzaniga and Sperry have conducted continuing observations on these human patients with severed callosums. The patients provided an opportunity to test for unique functions in the left and right brain (5). By controlling input to one hemisphere at a time they observed specialization of functions in each half of the brain. For example, when patients viewed objects flashed in the left visual field, they could find the object with the left hand, but could not describe the object verbally. Pictures of objects flashed in the right visual field could be described verbally but could not be found with the left hand. Also, when an object was placed in a patient's right hand he could describe the object verbally and in writing, but when the same object was placed in the left hand the person could not give a verbal or written description.

You will recall that visual information seen in the left visual field goes to the right brain while visual information seen in the right visual field goes to the left brain. And, that sensory information from the left hand goes to the right brain while sensory information from the right hand goes to the left brain. Testing of the callosum sectioned patients led Gazzaniga and Sperry (6) to the conclusion that sensory information going to the left brain can be described through speech or writing, whereas information received by or generated by the right brain had to be communicated through non-verbal responses. They further discovered that the right brain was incapable of carrying out even the simplest of mathematical problems. However, the right brain was capable of forming complex ideas and of dealing with abstractions, associations, spatial relationships, and generalizations (6).

The work of Gazzaniga and Sperry has added a significant dimension to our understanding of brain functioning in humans. Their work supports the idea that the left and the right halves of the brain are essentially complete brains with comparable sensory and motor centers. However, they also found that each half of the brain specializes in a separate group of higher order mental activities.

The left brain specializes in linear, sequential thought. It attacks problems logically and analytically. It works like a digital computer and moves step by step through problems to come up with answers based upon reason. The left brain houses the linguistic centers and is the site for processing speech, reading, writing, and arithmetic (9). It is in the left brain that ordinary conscious experience is perceived, and it is in this half of the brain that willed action orginates (3).

In contrast, the right cerebral hemisphere is the center for imagination and holistic perception. It treats input intuitively and works like an analog computer jumping from one idea to another in an effort to synthesize concepts and establish patterns (9). The right side of the brain provides our moments of insight. It is also the right brain which perceives meaning in metaphore, in art and in music. And, it is the center for feelings, appreciations, and visuospatial thought. Unlike the left brain which dominates the verbal activities of our lives, the right brain is essentially non-verbal. It sees pictures and conjures images and is the seat for imagination.

During the first four years of a child's life both sides of the brain appear to be able to process all types of input with equal facility. At about age four, however, something happens which initiates specialization (4). As an individual matures, one side of the brain appears to gain dominance over the other side. We have all encountered people who would be classified as left brain dominant individuals. Such people pride themselves on intellectual prowess or the ability to verbalize about historical, literary and scientific information. We also have encountered people who could be classified as right brain dominant individuals. Such people pride themselves on artistic prowess such as their ability to communicate impressionistic or symbolic messages through music, art and metaphore.

The values which Western civilization imposes on both children and adults are values which are largely attained through left brain activities. Our educational system is dedicated to the development of verbal and mathematical skills (7). We have come to believe that problems in the humanities as well as in the sciences can be solved by logical, and sequential analytical approaches. Our emphasis on left brain thinking has obviously paid big dividends, particularly in the fields of business and technology.

In the sciences, as well as most other disciplines, we recognize the necessity for educating the left brain. However, the mental capacities that we prize the most—that elusive something we call creativity, and that fleeting moment we allude to as insight—these are abilities which require right brain development. The scientist admittedly spends much time in making observations, checking variables, collecting and crunching data, and testing predictions. These logic-oriented left brain operations provide only the background for discovery. The imaginative/intuitive right brain is required to do something worthwhile with the accumulated information (1).

The split-brain theory of the human brain provides us with a very useful model for working with educational problems. If we assume that different higher level, mental activities are housed in each side of the brain, we can use the model to analyse our teaching and hopefully gain insights into how we can provide better instruction to both sides of the brain.

When we examine our teaching in light of the model, we recognize immediately that most of our conscious efforts are directed to the left brain—to the mastery of facts and concepts. We also recognize that our highly polished lectures, computer assisted programs, and reading assignments—our teaching methods—are organized in logical, sequential left brain formats. To evaluate student progress we usually require written playback of input—another left brain activity. We pursue each topic within our courses in great detail then systematically move to the next topic. If we are to cover the material in a respectable manner very little time can be allowed to ponder the greater meanings, or to consider applications, or to investigate possible associations which may exist among the ideas from different disciplines. The amount of knowledge in science is so vast that we can not take the time to pursue these frills. Or can we? Should we?

Using the model again, let us examine the input we are providing to the other fifty percent of our student's cerebral endowment. Whether we are aware of the fact or not, we communicate with the right side of the brain constantly. We do so by the sincerity in our tone of voice, by facial expressions and other forms of body language, by emphasis on words and ideas, by transmitting the feeling of excitement one derives from discovery, by showing the passion we have for scholarship, by displaying open jubilation for success and compassion for failure, by alluding to the satisfactions of knowing, by dealing with the values and importance of our subject matter, and by bringing alive the fascination and intrigue of science. To me, this right brain input can be synthesized into a simple phrase—"the beauty of science."

The attitude which a person developes toward a field of study probably has a greater impact on long term learning than any other single factor. And, the likelihood that a student will put his left brain knowledge to use is heavily influenced by his right brain concern for the subject matter. When you analyse the traits of good teachers, I think you will agree that they have at least two traits in common. One trait is that they have full knowledge of their disciplines. The other is that they inspire students to learn. They know what to teach, and they also know how to transmit excitement, fascination, concern, and feeling for their subject matter. A good teacher consciously or unconsciously provides quality input to both sides of the brain of his students.

Unfortunately, we sometimes communicate relatively ineffective messages to the right brain of our students. For example, we may inadvertantly give students the impression that the objective for mastery of subject matter is to pass tests. Or, because of the pressure of time we may discourage the exploration of ideas and channel student responses into the simple recall of information. Or, if things have not gone well in a faculty meeting, we may even demean or berate our students. Also, I am sure that all teachers have, at one time or another, cut students short with such statements as, "We do not have time to discuss that issue," or "The reason you need to know this is that it is a prerequisite for the next course." Even teachers suffer the frailities of being human and we can not expect them to be capable of providing positive input to the right brain at all times. A significant thing to remember, however, is that when we thwart or subvert the right brain, about the only type of learning that we can expect is short-term learning.

Teachers have learned how to extend and enhance vocal communication through technology. Books represented the first major technological advance in educational communication. And, of course, in more recent years motion pictures, slide projectors, cassette recorders and computers have greatly expanded the teacher's power to communicate. Regardless of the technological device used, the teacher programs the message which is received by students.

Just as with face to face communication, right brain input as well as left brain input is perceived by students who are the recipients of mediated instruction. And, it is the right brain input that largely determines the success of mediated instruction. We note, for example, that the most successful audiotutorial programs transmit the true enthusiasm of the narrator, and the most successful computer programs incorporate techniques which require the learner to interact with the subject matter rather than to deal passively with left brain storage.

The power of multimedia programs to stimulate right brain functions has been demonstrated by several approaches. Two examples of such research applied to science teaching are illustrated by the investigations of Chapdelaine (2) and Ketcham (8). Chapdelaine used a variation of the Osgood Sematic Differential to measure attitudes about biological concepts before and after students participated in multimedia programs that had been designed to develop positive attitudes toward biological concepts. He found that significant attitude changes can be accomplished in relatively short twenty minute programs (2). Ketcham's approach was to measure galvanic skin response of students as they participated in the same multimedia programs. By this technique she was able to determine particular events and combinations of events which caused emotional arousal (8). Research of this type points to some of the teaching techniques which we can use effectively in communicating with the right brain.

Useful long term learning is dependent upon conceptualization of meaning by the learner. This activity requires processing of information by both sides of the brain. The so called affective components are just as important as the strictly cognitive components. The corpus callosum, which physically connects the two sides of the brain, provides the channels through which integration of higher level mental activity takes place. Transmission of neural activity through the corpus callosum is an extremely important part of mental activity (11). During productive thinking, data stored in linear format in the left brain is sampled for pattern fit by the right brain. The synergy of the two brains acting though the corpus callosum produces conscious mental activity.

We need to see the world as we study its' parts. This is the way the mind is designed to function. As new bits of information are supplied to the left brain, the right brain must be enticed to test the new bits of information within holistic settings. The richness of the data bank in the left brain plus the stage of imaginative/intuitive development in the right brain determines the quality of insightful thinking of an individual. We should remember that the right brain is essentially non-verbal. It deals with imagery, feeling, and generalization. It may see, but its' perceptions must be translated into words by the left brain before they can be communicated. This is a difficult task and requires much effort. How do you describe the beauty of a mountain, the roar of the ocean, the howl of the wolf? How do you explain your appreciation of biology or chemistry or physics? How do you compress the significance of what you know into a few concise statements? Difficult, yes, but these simple examples illustrate our most challenging task as teachers. The task of forcing the left brain and the right brain to work together.

Most truly significant accomplishments are developed in stages over long periods of time. And, most great discoveries are the products of individuals who make unlikely connections through flashes of insight. I contend that our commitment to values, to the formation of positive attitudes, and to the development of creative thought processes should equal our commitment to teaching the subject matter of our respective disciplines.

At this point I need to reiterate that I have been using the model of the split-brain to direct attention to two very significant and different modes of mental activity. Although substantial evidence exists to support the concept that each of these modes is centered in a different half of the human brain, much additional work remains to be accomplished before we can determine with certainty that these centers of activity are situated in the same location in all people. A model is useful when it helps us think through a problem, and this is the value which I place on the split-brain model. The model enables us to extend the principle of isolated functions within the higher centers of the brain, and at the same time the model provides us with a conceptual basis for understanding how these isolated functions are integrated.

The "Brain" is a fantastic structure. We need to nourish it with the "Beauty of Science"—with the fascination of our disciplines, with feeling, compassion, and dedication, and especially with continuing challege to fit new information into ever changing patterns of the whole. It is the "Beauty of Science" which provides the catalyst for meaning, for discovery, and for creative thought. These are the truly valued outcomes of "Learning."

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