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GEORGE DRAPER

SOME THOUGHTS ABOUT THOUGHT

The Invisible Horse

We members of the Athenaeum Society find ourselves banded together essentially because we share a mutual keen appreciation for the delights of intellectual inquiry. It has been said that one might classify intellectual levels by the subjects discussed, with the three ascending levels being people, things, and ideas. Because of my respect for the Society's intellectual level, I have selected this subject, which is mind, or thought, in the hope that some ideas and findings in this area might prove stimulating to you.

Man is extremely presumptious; he has the effrontery to use his organ of thinking to try and understand his organ which thinks; or, in different terms; he attempts in his human and feeble manner to understand his power to reason by applying to the problem his own reasoning power.

The problem is an intriguing one. Upon engaging in conversation, and stating an idea, we express the idea in words which come to mind as though the words themselves are the idea, and of course they are not, for they are the superficial and audible (or visible, if written) manifestations of the idea itself which detaches itself in communicable form from the somewhat mysterious regions of the central nervous system. We ask the question, "What happens either before, or as, the words are spoken, the thought is expressed?" This is the attempt to penetrate to the very essence of human reality, of which the brain appears to be

the principal repository, pure thought.

A discussion of thought, mind, and brain could easily be framed as a purely physiological discussion. Time limits preclude more than a cursory outline, and a sketch of findings.

In my investigation, some attention to anatomy is important. Aristotle argued that the mind was farther down inside the body, in the beating heart. Religious literature refers to a man "thinking in his own heart." In a way, this was acute observation, for thinking without exception stopped when the heart stopped beating. We know better, of course. We observe, set down our findings. We have the new tool of electricity, and varied devices which employ it in testing. Accidental injuries to the brain, through their localization and resultant malfunctions, have added to our store of knowledge, and shortly some of these will be examined.

But let us not lose sight of the avowed goal of the researchers. It is to show that mind or consciousness is purely a physiological phenomenon, a self-contained chemical or electrical process. For example, Walter B. Cannon, in The Way of an Investigator, states "...to me as a physiologist....the evidence seems to be strong that mind or consciousness is associated with a limited but shifting area of integrated activity in the cortex of the brain."

It is important to notice the hedging of the statement. He does not say "it is," he says rather that "the evidence appears to be strong that it is."

Thus the ancient question of "What is mind? What is

soul?" might, from a sophomoric standpoint, be answered, "This is simply an illusion. Man is simply an animal with a bigger and somewhat different brain, a bit beyond the apes, perhaps not too far beyond the dolphins, since these animals approach man in terms of brain weight related to body weight."

At first inspection this Darwinian view may appear a neatly packaged statement, until we remember that our subject of discussion is qualitative rather than quantitative, so this answer is no answer at all.

Is there a pure physical basis to mind? This is quite possibly one of the oldest philosophical questions in the world.

Professor Gilbert Ryle, of Oxford, told a little story which neatly sums up the materialists position. The story is about a peasant who had never seen a steam locomotive. Someone explained carefully to him how a steam engine works. "Yes," the peasant answered, "I quite understand. But there really is a horse inside, isn't there?" So the peasant was asked to examine the engine and peep into every crevice of it. When he couldn't find any horse inside, he still had an answer. "I know," he said, "It's an invisible horse."

Professor Ryle then extracted the meaning of the story. This, he said, is the attitude of people who insist there must be an invisible thing called mind inside the body. Let's stop looking for the horse, he suggested, and find out all we can about the engine.

Whether or not we agree that there can be useful or

ultimate answers, certainly we can agree that this is an intriguing field of study. Sir John Eccles, a pioneer in neurobiology, at a conference on the future of the brain sciences held in New York in 1968, stated:

"Brain research is the ultimate problem facing man. Ever since the realization of his existence, man has been trying to understand what he is and the meaning of his life. But for man's brain, no problem would exist: the whole drama of the cosmos would be played out before empty stalls. Nothing would be known to exist because there would be no knowing. A better understanding of the brain is certain to lead man to a richer comprehension both of himself, of his fellow man, and of society, and in fact of the whole world with its problems. It is the greatest adventure undertaken by man."

It is also an adventure that does not fit into a neat single box for examination. Our presumption to understand must embrace as well the fourth dimensional factor, for both structure and function cannot be understood solely as a static mechanism. The brain develops embryologically, and continues its development with the growth of the child, both physically and functionally, reaching ultimately full adult development . Furthermore it in no way exists independently, for it must be bathed and nourished continually to maintain its functioning.

Thus, total understanding of brain function would automatically embrace the full understanding of purposeful embryological development, and before that the mystery of

reproduction. For the brain might be compared to the petals of a plant. How can we possibly understand the petals apart from the plant and its means of propagation? For the petal is a fractional manifestation of purposeful and on-going life.

Nevertheless, fractional findings, fractional concepts, a tiny glimpse at a single constellation in the vast universe of whirling galaxies, may be in itself intellectually and scientifically rewarding.

Knowledge of the brain and its specific functions has come about piecemeal. Looking back, we find that Vesalius published his Fabrica and Epitome both in 1543, and at that time did accurately recognize the brain as the center of human faculty.

Others contributed in a less measured, unwitting sort of way.

As an example, Phineas Gage was a laborer involved in the construction of the Rutland and Burlington Railroad in the year 1848. He was highly intelligent, of splendid character, and extremely well liked.

One day, in 1848, Phineas placed in a drill hole a liberal amount of explosive together with a fuse, and started to tamp this with a tamping iron, which was 3 feet 7 inches long, 1-1/4 inches in diameter. Something went wrong. The iron rocketed upward into Phineas's face, on through the orbit of his left eye, into his skull, sped through the frontal lobes of his brain, emerged from the middle of the top of his head, and landed a considerable distance away,

bloody and greasy.

Strangely enough, Phineas was not dead, although he was stunned. He was driven in an oxcart nearly a mile, walked up a long flight of steps to his hotel room, remained in full possession of his senses, with a pulse of sixty, expressed the hope that he was "not hurt much," was examined by a doctor, and survived twelve years.

The tamping iron amputated the forward part of the frontal lobes on both sides, as was found in the post-mortem. This was the world's very first documented prefrontal lobotomy.

Phineas's character was altered. He used profanity, was obstinate, lost the ability to plan ahead. He did, according to the record, retain his passions. A doctor had this comment to make about the new Phineas, "The equilibrium of balance, so to speak, between his intellectual facilities and his animal propensities seemed to have been destroyed....A child in his intellectual capacities but with the general passions of a strong man." The tamping iron and skull can be examined by anyone who has the curiosity, in the Warren Museum, at Harvard.

Nearly a hundred years later, in 1935, the Portugese neurologist Egas Moniz, in a refinement of Phineas's terrifying operation, injected alcohol into the front lobes of an asylum patient. The alcohol completely destroyed as it spread, forever damaging the tissue beyond ability to function. Later the procedure became one of completely severing the white fiber tracts joining frontal lobes to

thalmus, on both sides of the brain, thus the lobes were varyingly disconnected from the rest of the nervous system.

Predictably, frontal lobe surgery produced thousands of Phineases.

Among the case histories of patients who have undergone this surgery, we find this remark made by a wife of her husband, "His soul appears to be destroyed." This same remark has been repeated many times by those who treat the mentally ill.

Question, therefore. Where does the soul reside--in the frontal lobes? In the thalmus? In both? I hasten to state, David Conley, Dr. Lowery, and Dr. Crane, that my question is largely facetious.

In the year 1691 a young man suffered a skull fracture that would link for us brain damage with body movement. A fragment of splintered bone pressed down on his brain, on what we now know as the motor control area. Robert Boyle, the natural philosopher, reported the case, said the young man suffered a dead palsy of arm and leg, and that when the splinter was lifted, the palsy was simultaneously lifted. It was a miracle of sorts. More than this, it was enlightenment, for from such experiences, at first accidents, later controlled experiments, we have, in at least a superficial way, learned the functional geography of the brain.

One more example of an early finding may be of interest, that of Mary Rafferty. When Mary was a baby, in Ireland, she had fallen into the fire and burned off her hair. Later she

wore a wig which was secured in place by a whalebone. Constant pressure eventually eroded her skull, produced an ulcer, and at the bottom of the ulcer Mary's pulsing brain was visible.

Mary sought medical help at Good Samaritan Hospital, in Cincinnati, Ohio, in the year 1874. Her Doctor, a Dr. Bartholow, had read of electrical experiments on dogs, and boldly proceeded to experiment on Mary. Bartholow wrote that movements were observed on the opposite side of Mary's body: "Very soon the left hand was extended, as if in the act of taking hold of some object in front of her. There were sudden single movements. A leg shot forward. An arm was thrown. The head was deflected." Unfortunately, following another stimulation Mary had a convulsion, with varied adverse effects, and the experiment was abandoned. It was clear, though, that specific areas of control existed in the brain, and actions could be stimulated electrically. Poor Mary died shortly afterwards, possibly of the experiment, possibly of septic meningitis.

Bartholow's experiments could not have been made without the basic work in the 18th century of Luigi Galvani, an Italian anatomist who discovered electricity, and found that electrical impulses could be conducted to the legs of frogs which invariably twitched. Actually it was Galvani's wife who noticed this first. This led to the idea that animal motion ("animation") was in its deepest sense caused by electricity. This was not wholly true, but contained elements of truth.

One man who has done the most in exploring the mind's engine is Dr. Wilder Penfield, Professor of Neurology and Neurosurgery at McGill University in Montreal. In addition to performing many hundreds of operations on tumors and other brain diseases, he took the surgeon's opportunity of exposed brains to assemble information.

He applied a wire with very weak electric current to various areas of the brain and thereby made his patients, as the stimulus was repeatedly applied, move their arms of legs, utter sounds, hear noises, or see shapes and colors. His patients, under local anesthesia, did these things without willing them, simply as a result of electrical stimulation of the appropriate brain cells.

Dr. Penfield established, beyond doubt, that the brain has two parallel halves and that most of the important brain centers exist in duplicate, one right and one left. The connecting nerves cross from one side of the body to the other. Dr. Penfield's conclusion was that "most of us who are right-handed are left-brained and speak, listen and think with the left side of our brains only."

Solid proof that human reality lies in the confines of the brain came from Dr. Penfield's amazing ability to tap peoples memories with his electrical stimulation. He discovered that memory of right handed people is located in the left temporal lobe of the brain, behind the temple and above the ear. Stated more carefully, the memory is located in the whole brain but activated from that particular area.

An example or two of what happened--one fourteen-year-

old girl screamed in fear "Oh, I can see something coming at me! My Mother and my brothers are yelling at me for doing something wrong! Stop them!" Another patient was a fourteen-year old boy. When the wire was applied to his memory nerves, he cried, "I see a man fighting!," and when another spot was touched, " I see two men in an armchair."

Experiences are relived in their entirety, complete with all the sights, sounds, smells. The electrical stimulation directly brings to consciousness the memory which is some way, chemical or electrical, has been stored.

Unquestionably electricity is involved in brain function.

Even from the outside of the head electrical rhythms may be detected. In 1875 Richard Caton spoke of the "feeble currents of the brain," but actual recording from outside the skull did not begin until 1929. Hans Berger did the first recordings, and summarized them by saying that there were two principal rhythms, one when the mind was attentive, the other when inattentive, but there were still other rhythms, which changed with changing states of consciousness.

Later research established that, even before birth, electrical rhythms can be picked up from the forward part of the fetal skull (It may have been there earlier, but masked.). The rate is slow. Gradually the rate increases. By the time the child is thirteen, the characteristic rhythm is established.

Many experts believe that these electrical rhythms give us the best chance of creeping in upon the obscure relations

of brain to mind. Does the brain code electrically?

Certainly it possesses an enormously complex neural system. The human brain, i. e., the two cerebral hemispheres (leaving aside the cerebellum, for the moment) contains about ten billion switching elements called neurons, or about one hundred million per cubic inch. These hemispheres are recognized, with the present state of the neurologists and neurobiologists art, as the flesh involved in human cognitive functions. Back to the cerebellum, at the back of the head; it also contains about ten billion neurons. Current travels along pathways, or networks of neurons. We know that purposeful, or directional, flow of electricity can set up magnetic fields. Such things can be detected with sensitive instruments.

In 1949, Dr. John L. Kennedy, of Tufts College, Massachusetts, came upon something new. It was a new and different kind of brain wave. He decided to call these "kappa" waves. These waves appeared on the recording machines when students were given problems in arithmetic, or geometrical puzzles. One day he hitched his instrument to an electrical oscillator so that the kappa waves would produce a noise instead of moving a pen. Then he asked a test student to "keep adding twenty-sevens orally." The result was a record on which the brain whistled while it worked. It sounded like this "Twenty-seven (Pause) Tweet! Fifty-four (Longer pause) Tweet! Eighty-one."

Dr. Kennedy's conclusion was that the kappa waves are connected with the effort to remember--with the conscious

electrical operation of the memory. They are a sign of the groping of the mind--"sand in the gears."

By now you can guess from what part of the brain Dr. Kennedy picked up his kappa waves. Right! Behind the temple, on the left side--at the same place where Dr. Penfield had been able to turn on memories with outside stimulation.

Most of the neurobiologists believe that the neurons are the active elements in brain function, although there is evidence that some specific memories and other cognitive functions may be contained in particular molecules in the brain, such as RNA or small proteins. An average neuron in the brain has between 1,000 and 10,000 synapses or links with adjacent neurons. The brain has been likened to a computer, which functions on a strictly yes-or-no basis at its switching elements. Assuming this power for each synapse contained in the cerebral hemispheres, we can immediately determine that the brain, on this yes-no answer basis, could contain 10 trillion bits on the low estimate, or 100 trillion if we use the upper number of 10,000 synapses per neuron.

Our old friend two to the nth power now comes into play, for it is easily seen that the number of states of the human brain is 2 to the nth power with the exponent on the modest lower estimate 10 trillion, or in shorthand 10 to the thirteenth power. This is an incomprehensively huge number, surpassing in its order the number of protons and electrons in the entire universe, which is only 2 raised to the power 10 to the third (or two to the thousandth power)>

If we have not already found within ourselves an awe and "reverence for life," as Albert Schweitzer expressed it, knowledge of the phenomenal complexity of the human brain should bring us to a state of amazement and respect. There are an enormous number of mental configurations which have never been framed in mans mental architecture in all of history. Should other frontiers be closed, there is a limitless frontier pulsing within our skulls. From this perspective every human being is truly rare and different and the sanctity of individual human lives becomes a plausible ethical consequence.

As if this were not enough in recent years it has become clear that there are electrical microcircuits in the brain. In these microcircuits the constituent neurons are capable of a much wider range of responses than the "yes" or "no" of computer elements. The microcircuits are extremely small in size (typical dimensions are about 1/10,000 of a centimeter). Perhaps the real refinement of mind lies here. These tiny microcircuits respond to about 1/100th of the voltage necessary to stimulate neurons, thus they are capable of far finer and subtler responses. It has been observed that such microcircuits seem to increase in abundance in a manner consistent with animal complexity, and are far more prolific in human cortex. They develop late in human embryology.

Consequently, percentage relation of brain to body mass is not the sole index of intelligence: the abundance of highly specialized switching elements must be considered. Remember that we did not include in the previous calculation

the microcircuits, consequently the number of mental states is raised again by exponents in the trillions. Our brains are unquestionably unique.

Neuroscientists continue in their search to understand the structure of the brain, at every level from the anatomical down through the cellular to the molecular. At the level of individual neurons, axons, and synapses, the last few years have seen a great increase in understanding the way that information is transmitted. For example, once a neuron has been "fired" the progression of an electrical nerve impulse down the axon to the synapse is now understood in some detail, at least at the physiological level. More exciting advances have been made from the studies of the synapses themselves. It is now clear that communication between cells is chemical rather than electrical. The arrival of an electrical impulse at the synapse triggers the release into the junction of a transmitter chemical, which either tells the receiving neuron to fire or prevents it from firing.

This is anything but guesswork. The knowledge came from two basic techniques: ultracentrifugation, by which process synapses can be cleanly separated from the rest of the brain tissue; and microelectrode techniques by which electrical impulses can be administered and recorded from neurons and tiny amounts of suspected transmitter substances can be administered, to test their effects.

If sense is to be made of any of this, the emphasis on the nervous system must be on the word system. The patterns

formed by the connections gives the brain its functional ability. In computer terms, one might designate this as "software." This is what really counts.

What about memory? The brain continually sifts its sensory data and stores what it considers important. Exactly what is memory---what restructuring of the brain constitutes it? Brain researchers feel that the answer lies in the nature of the contacts formed between neurons.

What is there within nerve cells which "tells" them what connections to form? The only reasonable answer is that it is some kind of molecule. And this is what a vast quantity of experimental evidence which has been gathered over the last decade points toward, a molecular basis of memory.

The search for knowledge continues, at many angles and in the guise of many disciplines: neurochemistry, behavioral science, experimental psychology, physiological psychology, neuropharmacology, electrophysiology, neuroanatomy. The molecular biologists would like to make their mark in the field, but the higher nervous system presents a problem in which reasonable molecular mechanisms cannot so much as be imagined at the present time.

Gustav Eckstein asks the question: "Does any of this help us to understand the mind, that rests like a filmier film on the film of life that hugs the planet?"

Perhaps not. But, since God gave us brains, and an insatiable intellectual drive to understand the nature of our surroundings and the nature of our own reasoning selves, we feel compelled to plunge ahead in the quest to unravel man's

greatest mystery, the mechanism of his own awareness, his own rationality.

R. Buckminster Fuller, in one of his lectures, called attention to an important fact when he said, "I'm quite confident that one thing about you and (me) is unique. What's going on in this room between us is absolutely weightless, purely metaphysical.

"All the meaning of life, all our awareness, is completely abstract."

What appears to us reality, these familiar sensory stimuli, the mechanisms of memory, learning, thinking, and creating; all seem so very solid, so totally grounded in reality itself. But the reality truly exists for us in the cerebral cortex, in waves of electricity, chemical stimulation and repulsion, a mysterious coding as yet familiar and functional only at the important cellular level.

Again, what about the soul? A Swedish doctor claims to have found through sensitive before and after deathbed measurements, that the soul weighs exactly three-quarters of an ounce. I leave comment on this to our resident divines, and swiftly conclude with another quotation from R. Buckminster Fuller.

"It has been customarily said by the public journals, assumedly bespeaking public opinion, that scientists "wrest order out of chaos." But the scientists who have made the great discoveries have been trying their best to tell the public that, as scientists, they have never found chaos to be anything other than the superficial confusion of innately a

priori human ignorance at birth---an ignorance that is often burdened by the biases of others to remain gropingly unenlightened throughout its life. What the scientists have always found by physical experiment was an a priori orderliness of nature, or Universe operating at an elegance level that makes the discovering scientist's working hypothesis seem crude by comparison. The discovered reality made the scientist's exploratory work seem relatively disorderly."

And that is exactly where we are today in groping in a disorganized way toward some useful, imaginative construct or hypothesis to conceive even faintly for ourselves the marvel which resides in our skulls.

It is fortunate for us that we do not need to understand ourselves to duplicate ourselves. The sperm and egg know, though. They know how to make another human, and they know how to grow his brain. How marvelous, how beautiful, how elegant!