BEGOT IN THE VENTRICLES OF MEMORY

BY

ARTHUR E. LYONS, M.D.

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SHAKESPEARE'S BRAIN

This is gift that I have, simple, simple; a foolish extravagant spirit, full of forms, figures, shapes objects, ideas, apprehensions, motions, revolutions: these are begot in the ventricles of memory, nourished in the womb of pia mater, and delivered upon the mellowing of occasion.

From ; *Love's Labour's Lost* Act IV, ii, 60

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God evening.

In contrast to previous speakers at these meetings who spoke about things they are familiar with, tonight I am going to talk about something I know too little about. I am going to talk about the brain. This might seem peculiar coming from someone who has spent his professional life as I have, devoted to the brain and nervous system, but often with more questions than answers. The function of the brain I will be dealing with tonight is something that no one thinks too much about unless he has lost it. It will be that of memory and

incidentally time: memory, which is not unique to man, and the concept of time which is.

I shall begin with a story with a San Francisco connection. The story begins not in California but in Vermont at a time when railroads were altering the American landscape. A new right of way of the Burlington and Rutland Railroad was being prepared in the fall of 1848. A 25-year-old man, Phineas Gage was employed as a foreman. In order to create the road bed and laying the track, he was responsible for carrying out blasting granite for which the state is famous. In the days before the invention of the safer dynamite which made Alfred Nobel's fortune, blasting required the appropriate placement of charges of highly volatile black gunpowder. The procedure required boring a hole or a series of holes in the rock, tamping

the charge gently into place and then filling the hole with sand before igniting a fuse. The tamping was done with an iron bar with a tapered end some three feet long, 1¼" in diameter. In September of that year as Gage was doing his normal job, as he was tamping a gunpowder charge in place, there was a premature explosion. The 13-pound tamping bar blew out of the hole and penetrated Gage's left cheek angling upward. It entered his skull behind his eye and blew out through the top of his head. Instead of killing him, it just thoroughly destroyed the left frontal lobe of his brain. The bar, covered with gore landed 25 feet away while Gage was thrown backwards on to the ground, stunned but unaccountably remaining conscious. And strange as it seems, unlike the present day football player suffering a stunning head injury, Gage had perfect recall of the event and seemed not at all confused. He was moving about,

speaking normally and was able to get into a nearby wagon with help and was taken to the nearest town to a doctor. After a very stormy course during which his survival was often in doubt, amazingly, Gage ultimately recovered. After a time his wounds had healed. In two months he was able to get about, and completely care for himself and he seemed to be normal to his doctors. However, he was not the old dependable responsible Gage who had gone to work on the Burlington and Rutland Railroad. He was different. His personality had completely changed. Before the accident he was thoughtful, reliable and sober with normal intelligence. Afterward, although bright enough with a good memory and speech, he was impulsive, fitful, profane and obstinate. He was unable to formulate future plans and often acted childlike and irresponsibly. As the result, Gage was unable to return to his

normal job and was frequently seen as a derelict in Boston begging on the street. He was always accompanied by his tamping iron that he readily acknowledged had blown through his head. His unusual case was well publicized, being the subject of at least three medical papers. Gage was also seen by several well-known doctors in Boston on the faculty at Harvard. Gage's story after his immediate recovery by contrast, is rather poorly documented. He slowly faded from view. His physician lost track of him. His life was not followed in any consistent manner. We do know that subsequently, Gage was reported to have held various odd laboring and stable jobs in New England and had shown himself for a time in Barnum's Museum in New York. He never married. He eventually took a ship to Valparaiso, Chile where he worked for several years as a wagon driver. His mother and married sister had in the meantime moved to San

Francisco in the Gold Rush, and there, Phineas Gage moved in 1859.

In San Francisco Gage was observed to be drinking heavily and subject to periodic epileptic convulsions. He unfortunately died during a convulsive attack here in 1860. Regretfully, no autopsy was performed and his brain was not examined. He was interred in the Laurel Hill Cemetery with his tamping iron at his side. He had survived his severe brain injury eleven and a half years, dying at age 36. Eight years later in 1868 at the request of his original treating physician in Vermont, Dr. Harlow, Gage's body was exhumed. His skull accompanied by the tamping iron was sent to Boston over the newly completed transcontinental railroad.

Besides being a test of my memory perhaps, what has the case of Phineas Gage have to do with my subject of memory?

Although short-term memory can reasonably localized to the medial temporal lobes of the brain we have not yet been able to adequately localize memory of other types. Normal long term and short-term memory function and the ability to learn were spared by Gage's tamping iron in spite of his massive injury. What Gage had learned prior to his injury remained intact, its connections forming his memory of time and place developed in infancy, his language learned in childhood and skills learned as an adult remained untouched. Similarly, Gage's ability to learn and absorb new information remained unaffected. Is there any wonder that in the days before modern psychological testing, Gage was considered normal by many of his examining doctors? Were his personality changes merely the result of his surviving a life threatening injury, i.e. post-traumatic stress. Those convinced that the brain itself was of

minor importance remained convinced. Others saw in his injury evidence that the brain determined one's personality and governed his moral behavior and his relations with others. What were not affected in spite of his brain damage was Gage's memory and his sense of time, Gage's functionality though defective, was preserved. As a result of these apparent contradictions, the case of Pheneas Gage has remained controversial.

I believe time is intimately connected with memory.

Let's address time. Time is something that we experience, know all know about and measure but find it difficult to define. There is the old story of the immigrant who spoke limited accented English who not having a watch, approached a man and asked:

"What is time?"

The man answered; "I don't know; for that, you had better ask a philosopher. I am just a physicist"

We can measure time easily enough with a clock with the repeated winding and unwinding of a hairspring or the electrically induced vibration of a crystal or by the slow revolution of our galaxy. But, what is time, really? A definition is hard to come by.

We also know that thanks to Einstein, time is relative and is the fourth dimension of space. Space-time slows up directly with one's speed. Sending a man into space at close to the speed of light will age him much less than his twin brother who remains behind, for so many earth years. I won't attempt to explain this except to say that Einstein determined that time is dimension of space.

What has memory to do with time? Memory is the ability of the mind to recall a real or imagined past event and to somehow react to it. Time can be segregated into the past, the present and the future. However, from a purely relative standpoint, without memory there is no past, present or future, and thus, no time. Time does not truly exist without memory. What we think of as the present is merely a construct. Why do I say that? Let's address the future. It is also a construct. It is a construct of the mind in anticipation, projection and speculation, all based on the conscious and unconscious memory and interpretation of past events. The future is constantly moving into, and becoming the past. The past is also the recall and interpretation of past events based on memory. We cannot go into the future any more than we can return to the past, as they do not exist. It is only a memory

function that separates the future from the past. That separation or gap creates that instant that we call the present. Paradoxically, we exist in that gap. We exist only in that instant and series of instances, in that construct which we call the present. This, I suggest is our only reality. Therefore it is our memory that places us in time. It establishes the present and our existence in time. Although, I have not defined time, and this is my argument, time and memory are inseparable.

We are all too familiar with memory problems. As we age, I am afraid our wives never let us forget our own. Basically there are two major types of memory with many variations: short-term memory and long-term memory. Short-term memory can change into long-term memory depending on many factors often beyond our control, but our entire education system is

based on the conversion of short-term memory into long-term. Both types may be lost with particular traumatic events involving the brain. We all know of football players following a head injury in particularly hard scrimmage may have no recollection of subsequent events for minutes or hours though they appear and act normally. After being stunned he might have no recollection of the event or the events leading up to it. He may be confused or disoriented in time place. This type of post-traumatic amnesia: retrograde or antegrade, the result of brain trauma can also be seen in strokes or failure of brain circulation, or be the result of certain drug ingestion and in certain emotional states. All these things can significantly affect the brain's normal memory function.

Occasionally our memory for unaccountable reasons become spontaneously but fortunately only mildly confused. We have

all experienced déjà-vue, when things appear familiar when they are not, in fact. This is a non-disturbing trick of exaggeration of memory is usually quite transient. There is the reverse phenomenon as well: jamais-vue. The latter is a loss of immediate and orienting memory. This is called temporary partial amnesia. Fortunately it is also usually transient and benign. It is however, particularly disconcerting. There is an extreme feeling of being lost; of feeling of isolation in time and space. I recall a patient who suffered an idiosyncratic reaction to a powerful tranquilizer with complete loss of immediate memory. The resulting panic and depression required psychiatric hospitalization with suicide watch for a few days until the effect of the drug wore off. Though it is not generally recognized I believe one of the brain's primary unconscious function is to utilize memory to orient us in time and place to

keep us in contact with the environment, the people around us and space we occupy. Without it, the sense of reality of time and space is lost. Along the loss of reality, the individual is lost. Although serious memory loss is not funny, minor loss can be humorous. I am reminded of the joke about a man who had a terrible memory. His memory was so bad he could not even remember his wife's or his children's names. He drove his friends and family to distraction. In desperation his relatives got money together and enrolled him in a memory course, which he attended conscientiously. Later, proudly walking home with his diploma under his arm, a man approached:

"Jake, do you remember me?"

"Let me think. It was 1976. No, 1977, Monday, April 14th. I had just mailed my income tax for $3658.79 at the post office

at 1:30 just in time for the 2 o'clock pickup when you stopped me on the street to ask the time. How's that?"

" Fool, I'm your brother, Irving!"

What is the anatomic basis of memory? If memory is somewhere located in the brain as it most surely is, there must be an organic mechanism, anatomic or chemical or both that subserves it, the brain is a bodily organ after all. How the brain creates and integrates what we perceive and remember, what we call memory has long been a subject of intense interest. We know a great deal more now than we used to but all the answers continue elusive.

Memory in some form or other seems to exist in all animate creatures. From the lowest amoeba to man there is a certain form of memory that is intrinsic; a memory trait that is

necessary for survival. It enables food seeking, ingestion, excretion and reproduction. It accounts for a certain awareness of self; an awareness that allows for the continued existence of the individual or the species. Recent work with living organisms with the simplest of nervous systems has shown that even a sea snail has the capacity to learn and remember. Pavlov called this a conditioned reflex. He demonstrated that involuntary gastric secretion could be turned on by the sound of a bell in dogs appropriately trained. What he showed was that the dog's unconscious brain has a memory for things learned. But, of course there are all sorts of memory from the simplest reflex to the recall of the most complicated formulas in physics. There is also the unconscious immediate memory for time and space and resulting self-awareness that we have been talking about. It keeps us in contact with what is going on around us.

There is also the old memory of the burn we got when touching a hot stove for the first time. There is the recent memory of something just heard or read. There is the memory for the multiplication table drummed into us in the second grade. There is the memory of the pleasure we got from our first girl friend when something somehow brings her to mind. There is the recall only after several seconds or so of the name or the face of a long lost friend or acquaintance. We can all think of many different examples. Memory in all its forms and learning upon which it depends, are all stored in the hundred billion neurons and thousands of miles of nerve fibers which make up the brain. Just where and how memories are stored and released are questions that are now slowly being worked out. Working with individuals whose brains have been damaged has shown that newly acquired knowledge is stored in the grey

matter of the inner temporal lobes on each side above and deep to the ear. However long established memory seems more diffuse. However with weak electric currents long past events can be recalled in the awake patient when these currents are applied experimentally to the temporal lobe surface. On the cellular level, memory of perceived stimuli seems to correspond with changes in the tangle of DNA of genes in particular nerve cells. This results in production of protein molecules, actual nerve growth and new permanent nerve connections which supports to Freud's conviction that nothing is ever completely forgotten. However, where in the brain are these memory functions located; these connections that store memory and memories that make each of us unique? Just as important: how do we forget? To determine this and other questions the mapping of the human brain begun seriously in the 1800's

contnues with ever more sophisticated instrumentation. The knowledge of brain function remains however, in its infancy.

In the nineteen thirties and forties before the advent of psychotropic drugs, in a desperate attempt to help the suffering of incurable psychotics and to help relieve severe overcrowding in state mental hospitals, planned frontal lobotomy of the brain, that is surgical separation of the frontal lobe of the brain became a standard treatment in the United States. The psychiatrist most responsible for its popularity was a distinguished looking, tall bald man with a small goatee from Palo Alto. Trained as a psychiatrist, Walter Freeman was practicing locally here in the 1950's and 60's. After noticing the calming effect of this surgery in experiments on vicious animals, lobotomy had been adopted with great hope and

optimism. Freeman was famous for carrying out the procedure on a production-like scale using a sort of ice pick under minimal anesthesia, often at the patient's bedside. However, after a few years of initial enthusiasm and widespread use on hundreds of patients, the procedure was given up. Freeman faded into obscurity. Lobotomy was abandoned precisely because of the unacceptable of side effects. These side effects were those identical to those which disabled the unfortunate Phineas Gage one hundred years earlier. His was an object lesson which went unheeded.

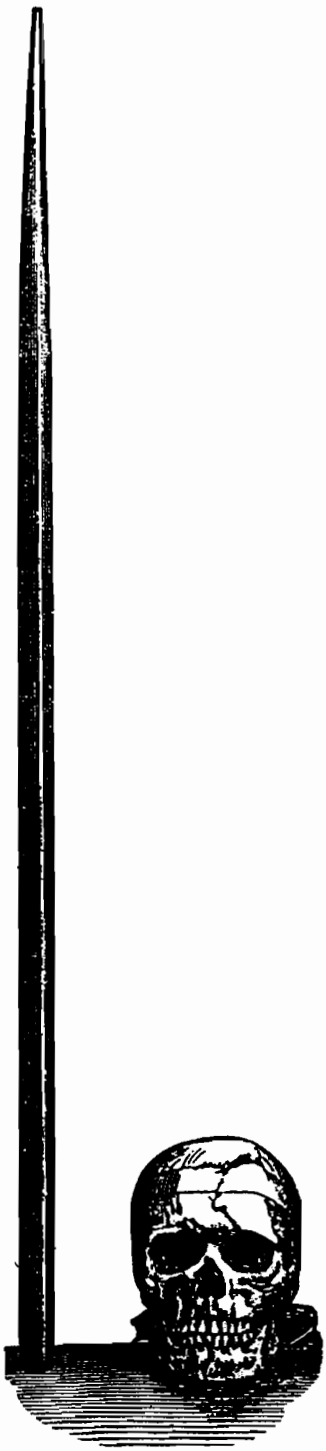
We know now through accident and design that normal intellectual, physical and emotional life depends on an intact brain. Defects in brain function spontaneous or accidental may be profound or subtle but are never truly silent. As long as we retain the "ventricles of memory", we retain whatever it is that

makes us who we are. This may be the real soul that DesCartes thought he found in the back the 17th Century.

Brain function remains a challenge at many levels and much remains to be learned.

Recently I was in Boston and saw what remains of Phineas Gage in a glass case. Gage's grinning skull seemed to me a mocking reminder of brain's mystery as I also use my memory to recall his unfortunate life.

Fig. 1.



View of the tamping iron, and front view of the cranium, showing their *comparative* size.

Fig. 2.

Front and lateral view of the cranium, representing the direction in which the iron traversed its cavity; the present appearance of the line of fracture, and also the large anterior fragment of the frontal bone, which was entirely detached, replaced, and partially re-united.

Fig. 3.

View of the base of the skull from within; the orifice caused by the passage of the iron having been partially closed by the deposit of new bone.