Presented at the Detroit
Physiological Society, 6CVNP
December 17, 1959

The Physical Basis of Intelligence

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The physical processes which produce thoughts, abstractions and activities, both of the normal and abnormal variety are misunderstood and neglected, and yet a field most pregnant with promise. Despite this, there have been few conceptual theories which attempt to provide a physiological basis for intelligence. The sort of knowledge required for analysis of this problem cuts across many of the scientific disciplines, and yet those who work in the field of intelligence seem to feel that words such as information theory, communication, black boxes, nerve impulses, etc. are concepts with a self-evident aura but few, if any, can speak from this axiomatic base confidently; for there is really no clear conception of how or why changes in metabolism, drug administration, hormonal imbalances, or the reaction of chemistry on tissue can cause thought, ordered or disordered.

There is no need for mysticism. The problem is not self-limiting. Although behavior is usually considered the exclusive domain of psychologists and psychiatrists, 2 hopeful attempts are being made to correlate behavior with the biophysical sciences, and it is the unification of the physiological with other physical sciences that holds promise in this area. Communication engineering, such as Wiener's cybernetics, has been a partial attempt to accomplish this, but information theories so far suggested treat with the "traffic problems of the nervous system" without indicating how the information is first created. Unfortunately the few speculations offered have no basis in actual physiologic structures.

Information theories put the cart before the horse. They usually treat only with the results due to quantitative interactions of physical units. A general theory, on the other hand, must approach this problem differently. Before we concern ourselves with the transmission of intelligence information, or the signal (as we shall refer to it), we must first determine how the content of the signal is formed. The method ~~in which~~

these signals are transmitted is perhaps the simplest part of the problem. How are they shaped to be useful information? How is it possible for cells to form intelligence in the first place? How are meaningful signals created? In order to illustrate some of the concepts presented here we will demonstrate models of some of the mechanisms. So, to make our talk pertinent to practical problems we will pose the following questions - and you the audience should be able to find some answers to them.

1. Why does fever affect mentation and behavior?
2. Why does a one atom change to LSD produce a non psychotomimetic substance?
3. Why can chlorpromazine affect mentation?
4. Why does electric shock affect mentation?
5. Why does sleep deprivation affect mentation?
6. Why do environment and lack of sensory stimuli affect mentation?
7. Why can senility affect mentation?
8. Why can mechanical irritation such as tumors affect mentation?
9. Why can Schizophrenia and other mental ills be considered physiological disturbances with psychological consequences?

You in the audience ponder for a moment. Do you know these answers?

To answer these questions with all their implications by a basic theoretical approach and also show models in the time allotted me would be impossible. However, I will lay the basic framework tonite, and if you feel that the talk tonite was worthwhile I will come back again for Part II of this paper entitled "The Physiological Utilization of Intelligence".

We must define intelligence. Unfortunately it is usually defined in such a broad way as to lose its meaning. So we shall try to build up block by block a definition of intelligence from its most basic concepts till by the time the talk is done we will be able to assemble a generalization that will be understood.

The first basic statement then is that intelligence starts with a repeatable change of state of a unit in response to a stimulus. What is a stimulus? A stimulus is a small amount of energy capable of transforming or transferring a larger amount of energy into a more organized form. The mechanism for changing the state of a unit - that is, its transferring vehicle-is the electron. This is true whether we are expressing intelligence in its most basic unit the atom or in complex molecules.

Nothing is more misleading than comparing nerves to switches or brains to computers. A switch in a computer is a step function device whose actions depend on an electrical current wired in from another switch. It does not depend on its structure or it its environment for the manufacturing of the signal. A physiological signal starts on a basic level of atomic configuration and through a series of multi-steps ends with allowing a non linear reaction. The meaning of the signal unlike its synthetic counterpart depends on its environment - pH, temperature, electrical field charges and even flowing fluids to arrive at a point where like its synthetic counterpart it can be switched. In other words there are a whole series of switching events inside the switch before the switch itself performs its functions. Therefore, the superficial approach of utilizing an electronic device which operates on electronic conduction - is inapplicable. The neuron is an electrochemical switch where many factors and complex events transpire through ionic conduction before the final non linearty occurs. Therefore our prime purpose this evening is to understand the factors that occur before final switching of a cell takes place - for it is precisely in these events that intelligence is created physiologically and it is precisely because computers do not have these events that it is not possible to discuss the physiological base of intelligence in terms of computers. Only in the subsequent paper on intelligence utilization can computers be considered with profit. By the way, if a computer had to use its switchery means to compute all of the physiological interaction for its own control, it would become an unwieldy process. The beauty of a neuron is that it has numerous switching processes and reference levels

built in while its alleged snythetic counterpart - the computersdoes not. Therefore, the extra levels of information available to a neuron which mean its multiplicity of choices allow interactions expanding its area of competence presently unapproachable in synethic computation. For a computer computes based on reference levels we provide it. We being the analogues to the sub-events of a final discharge, - that is humans, who are electrochemical devices, act to provide the physiological basis for computer intelligence.

The basic foundation of intelligence is the understanding of what a signal is. A signal is any stimulus which can alter the state of a cell or group of cells from one energy level to another. The cell must have a stable reference point of activity to which it can revert upon the cessation of stimulus. It will then react again to the same stimulus, all things being equal, in the same manner.

What is a reference point? A reference point is a physical reflection of a cell's intrinsic metabolic state. This is signified by a threshold point wherein its membrane becomes permeable to certain ions and in doing so alters the potential difference between the inside of the cell and the outside, resulting in a logitudinal change in the electrical resistivity of the membrane. When this energy difference has expended itself, the cell draws from its environment the necessary materials to re-establish stability. If in any way these materials are not available to the cell, it will not be able to retain its original threshold reference point and intelligence will be altered.

To have communicative value, a cell must be able to repetitively change its state from stability to unstability. The change of state of the cell which is considered to be a discrete phenomenon in actuality depends on the state of many other factors. Therefore, the first rule in physiological communication is that a signal must be shaped, this is done by the interaection in time of a group of occurrences. This group will be enumerated. Intelligence is expressed through a cell which has a double value function. That is a repeatable cyclical hysteresis pattern wherein the resting state of the cell can be changed to an active state and then in a set time resume its resting state.

The hysteresis factor is the cell's internal knowledge or memory which relates the variable of the present state to its past values. By altering a cells rate of stimulus and its ability to respond, information is transmitted to areas wherein the number and rate of pulsations form an analogue mosaic image in the area reflecting the stimuli. In other words the stimulus energy in time is transformed into an analogue representation of that stimulus in certain cells wherein precepts and concepts are the symbols of this ordered transformation.

The above is absolutely meaningless unless it is understood that the individual cell forming the mosaic is not merely a step function unit but instead must be technically classified as a multivariable non linear element that relates to three or more variables while at least two variables are held constant. Therefore, to understand physiological intelligence, we are interested in the factors that shape the threshold response which then allows for the descrete signal. What we are saying is that the frequency response is the final image builder and in fact frequency can be considered a code response. To understand intelligence physiologically we must "break" the code and determine how the content of the signal - that is how its intelligence-is created.

We will start with the atomic structure to illustrate how the build up of changes of state finally results in membrane permeability. Too often it is forgotten that atoms must be described in terms of their electrical and magnetic components and that the very basis of chemistry instead of being antithetical to any electrical theory is in fact only a reflection of the basis of all electricity which is the activity of electrons. Electron movement will be the thread that will connect all of the following discussions.

It has been in vogue for many years to juxtapose electrical theory of nerve transmission against the chemical theory. Since we will show that in a physiological system the integrity of one depends upon the other. This debate I hope will be relegated in the future to the position of other sterile arguments with which medical history is replete.

This paper is an earnest attempt to this end.

First a fundamental review:

In chemical, as well as electrical actions, it is usually only the outermost electrons of the atoms which are participants. This is due to the fact that the electrons in the innermost shells are the most strongly bound to the nucleus. The energy levels available at which physiological activity takes place are not sufficient to overcome the strong attraction which these electrons have to the nucleus. An atom with a completed shell is chemically inert. An atom must have its outer shell incompletely filled with electrons, that is a valence electron structure, to participate in chemical or electrical reactions. Whatever therefore acts as a stimulus to donate, accept, or exchange electrons, is a communicative signal. In an organism this means that a coordinate approach that is the intersection in time of various factors to be described, must be utilized. This is where classic theory is least helpful. We must appreciate that a change in any one part of the coordinate structure would alter the entire system of communication, but it is the understanding of these factors which the black box theorists do not grapple with or indeed recognize. The following are the factors which can intersect to create a measurable signal.

1. Temperature - Thermal activity can alter outer shell electron mobility.
2. pH (which is allied with temperature)-Since we are discussing physiological phenomena wherein electrolytes have importance, our line of reasoning is aided if we consider that an acid can be defined as an electron pair acceptor and a base as an electron pair donor.
3. Electric Fields by their nature can orient and direct electrons. An electric field creates forces acting on electrons, and exerts forces on a charged particle. Since an ion is a charged particle, much information is created by this mechanism. Electrostatic fields are the mechanism for building

up chemical binding since it is in the charges created by the transferring of outershell electrons that opposite attractions are set up for many binding functions to take place. Here we see now an electrical phenomenon is both the precursor and product of chemical action. Intelligence signal shaping in a cell therefore is affected by electric fields nearby - statically or in movement. We add in movement because in an electrolyte as in the cells themselves, there are ions in movement. These ions are known to affect nerve conduction.

4. The potentials which develop between materials, that is, their electromotive force.--This area of consideration is important because concentration, polarization, & the non-linear osmotic forces affecting cell permeability are factors which can control the firing rate and the threshold level of the cell. The concentration potential is both a product of electric field orientation and a means itself of forming new chemical structures.

Physiological membranes must be viewed as electrodes and electrode potentials are important as a selective means of organizing a series of events culminating in a final signal. (The Double Layer Effect). Not only the collection of charges at the electrode or membrane but also the charges which are represented by materials in the electrolyte now have a reference point, for they can be selectively energized by certain electrode potentials and the possibilities of oxidation and reduction are set up. For oxidation and reduction potentials are one of the most significant means of forming our signal. It must be recalled that in the organism electrical actions, i.e. electron exchange, is carried out by ions, and the giving up of electrons from an ion at an interface while another ion pick up electrons at another is the basis for localized electrical currents to flow. This flow is concurrent with a chemical change.

We will show in our models how electrical activity initiates chemical change with resulting electrical change. We turn now from the atomic scale of events to the molecular.

The cell requires energy to create internal order which means activity of large numbers of atoms cooperating in a statistical manner to overcome binding forces of the environment. This requires a cell which is always energized by the internal movements of its atoms and molecules seeking to sustain order in a surrounding of disorder, which is one reason that the cell develops considerable heat in its activities. Accepting this we now have a factor (heat) which can help determine a standard reference for signal formation.

The cell's response to its environment increases or decreases its energized state with an electrical expression in the form of a spontaneous beat reflecting its internal reaction to its external environment.

Information that has been around a long time is very pertinent to our discussion of the construction and modification of intelligence signals in an organism.

1. We know "that changes in the chemical composition of the fluid surrounding a nerve may drastically alter certain of its properties".
2. The action of inorganic ions affects nerve conduction greatly, since relatively small changes of their concentration (especially calcium and potassium) result in "Profound changes in the nerve".
3. Spontaneous activity, which we consider of very great importance in the problem of establishing reference points correlated to behavior and psychosis, is also associated with increased pH levels.
4. The fluids that bathe nerves are also extremely noteworthy. As Curtis states, "conditions of the ionic balance of the blood may produce profound changes in the nervous system".

Roeder notes that "there is only a difference of degree between a nerve cell that is normally spontaneously active and a nerve cell that is normally inactive unless stimulated".

Granit in considering the role of spontaneous activity, discusses the impulses which "remained in the abortive states as prepotentials incapable of maturing into a discharged spike". He also suggests that spontaneous activity is more significant than the random noise that it was considered.

Discussing brain electrical activity, we first of all note that on the cortical level we measure and record large groups of neurons, which are engaged in varied activities. These activities are modified in a patterned manner by environmental changes reflected to the cells by chemical changes and electric field influences. This results in particular voltage levels and frequency responses which are construed as meaningful information.

We can postulate, then, that from their evolutionary beginning, cells were randomly in movement and through their established polar electrical activity, predicated on chemical and field relationships, statistically met situations which imposed specialized responses on those susceptible to such stimuli. No doubt some cells had different excitability factors than others, and the stimuli randomly impinging on many cells fired responses in those whose threshold would receive the particular voltage-current-frequency values of the stimuli. Thus, some cells automatically differentiated themselves by their response to various stimuli. Roeder states that "analysis of spontaneous activity shows that each neuron may discharge quite regularly at its own frequency".

The original threshold of cells could have been set by their own physical configuration and environmental pecularities. Pathways evolved (and this is possibly still one of the mechanisms for neural activity) that were susceptible to certain

electrical values regardless of the difference in input stimuli. Auditory, chemical, visual, or mechanical forces were translated into electrical values of a definite order to which certain cells were receptive. Varied inputs, therefore, might create similar signals which would lead to an equivalent final action. Part of Kluver's theory of equivalence may be explained in this manner. The same situation was enlarged as more and more cells and organs were added. Specialization through neurons accelerated these tendencies. Cells were given characteristic activity by their particular responses to stimuli, which established their reference state for certain thoughts or actions. The many interactions occurring at one time of chemical, electrical or mechanical stimuli provided the needed stimulus values for the cells to alter their activities and join with other groups. In a particular sequence, cells could receive and stimulate others so that an imprinted reference point was established. This reference could then only be altered by some chemical, mechanical, or electrical change sufficient to establish a different threshold of response.

It is our opinion that there can be no arbitrary division between the metabolic function and the reaction of the cell to its environment. The environment always affects the metabolic function from which the signal-forming elements are drawn. If at a point an outside disturbance or a qualitative internal change takes place, the cell reflects it by a change in signal which may be of value in stimulating adjoining cells that would be sensitive to that particular specific change in potential. Nervous activity can be modified and altered by changes in the neuronal processes of changing threshold values. Biochemical change (or drugs) can vary certain threshold levels.

The cerebral cortex gradually evolved as the central specific area for coordinated neuronal action, because its neurons were best adapted to communication interchange. The unmyelinated fibers are pressed together and cross each other

in manners that suggest that there is a communicative value through the actions of the intertwining fibers.

In summation of the above, we may say that as part of the information integrating process, a volley is fired which seeks all paths indiscriminately but only discharges across those which are responsive to the particular voltage and current pulse conditions triggered by the initial volley and this is dependent upon the aforementioned chemical forces in the area.

Mechanical Groupings

In order to contain stored energy and direct it in the manner we have discussed, it is necessary that certain mechanical groupings perform specialized operations. Since the anatomical, mechanical containers utilize portions of themselves as energy sources, it is readily appreciated that mechanical damage to a specialized area must of necessity mean chemical and electrical changes.

If damage is done to a cell or group of cells, the mechanical surface is ruptured and as is well known, the injury potential is signaled by its chemical and electrical changes. A mechanical lesion, if in an area which subserves a specific function, will result in a change of information to the organism by the creation of spurious signals, the mechanical lesion therefore produces secondary chemical and electrical changes and the many similarities between brain-injured subjects and neurotic and psychotic individuals indicate that localized brain area irritation, regardless of how initiated, affects the process of mentation.

Electrical Activity Interrelationships

Electrical potential, whose substratum is chemical action, is the means of intelligence-signal formation and communication. It must therefore be underlined that any substratum chemical change results in altered electrical activity. This indicates the chief error in comparing a computing machine with the brain. Probably

the semantics involved have been misleading, as neurons, unlike switches, must act on their own stored energy and create their energy along the line of signal travel by interaction with their environment. Computers operate without direct analogy of synapses, even though in some cases delay lines give some similarities. Chemical changes in a synapse alter the formation of a signal and this can be related to psychotomimetic drug action. We assume from our experiments to be shown this evening that the electric field action in the synapse is instrumental in directing the chemical changes that others have postulated. The chemical composition of fluids, including the particles, can affect the electric field in many ways. Ionization, dielectric constants, and electrical resistances all alter messages in their vicinity of action, even though these messages are presumed to be firing in a discrete manner.

The time has come to lay to rest the fiction that the nerve impulse can be accurately classified as merely an all-or-none phenomenon found in most textbooks. I recommend a study of Bishop's classic paper in this area. The nerve impulse is an all-or-none action only to the extent that when it does fire through its axon, there is a discrete pattern. In unmedullated axons, however, there is a possibility that interacting fields may affect the impulse, and the resultant contamination of signals may help explain some psychic effects.

The complexities of actions on cell bodies is apparent when one considers the multitude of factors involved in enzymatic actions performing work at cell sites. Enzymatic activity involves electrons and the nature of the free radical electron reaction is of importance to our general theory but too lengthy to be gone into here. Dendrites, because of their dimensions and configurations, are preferred modes of acting on the cell body, since fluctuating fields affect their electrical activity. An understanding of dendritic activity in communicative signal formation is emphasized by Purpura's work, which showed that the activities of cortical dendrites are markedly affected by LSD.

The geometry of the cell, the type of chemical environment and the influence of adjoining fields help shape signals. There are many electric fields operating in any one area which are a composite of various charges and potentials. The body fluids and blood are sources of metabolic material and act as electrolytic fluids. Charged particles inhabit these fluids and act upon them as well as being acted upon. Altering the blood and oxygen supply changes metabolic activities which soon reflect themselves in psychic reactions.

The Rules of Communication

Whether biological or physical, the laws of communication are not violated but honored by their application in the nervous system.

1. A moving charge (which is treated as a conductor) generates voltages and currents in conductors as it passes by them.
2. The charge is in turn affected by electrical activities which operate in the conductors.
3. The charge is created by an inherent chemical process which forms potentials.
4. The charge affects the development of the electric field which it inhabits. It can also impress charges on other materials nearby. Therefore any change in the energy system affecting charges would change the basic reference point and be reflected in altered thresholds.
5. The diameter, composition, and configuration of conductors and non-conductors imbue the field with certain electrical value.
6. The content of the fluid in which the conductors reside acts to modulate the activity of the conductors.
7. There is a specific electrical value, which is a unification in a coordinate system, of chemical, mechanical and electrical values which represent certain specific meaningful information to the organism - in other

words, a determined value for every thought and action.

8. These values are references for defined information, and if changed, no longer give the same information that the standards represent.

We assume that reflex or automatic reference signals are phylogenetically established. In an instinctual or automatic response system, certain specific areas respond due to their chemical makeup and certain fields and impulses are created within an electrolytic solution which follow certain pathways and further stimulate areas, resulting in specific actions or activities. This is the morphological base of the organism's signal formation.

Cell Activity and Psychosis

In the foregoing we developed how individual cellular systems might have their baseline activity determined phylogenetically in groupings within organisms. Two other points should be developed. First, the development of the brain could only evolve from the complex physiologic functions of the organism that it must subserve. Secondly, various specialized areas of the body developed their own chemical environment; for example, portions of the gut have a pH different from parts of the liver, which resulted in different constructs of signals representing specific needs. Signals would have to be propagated in more than one manner for a complex organism to function. Humoral secretions could act selectively on certain types of cells, as well as specific areas of individual cells within widely diversified regions of the organism. Specific nerve cell discharges would not be (due to the problems of interacting circuitry) the most efficient manner of integration. Evolutionary specization does not mean that the most logical circuits were formed.

There are many pathways which are not efficiently connected in the human organs. Nerve pathways, due to their selective stimuli to a particular cell, energize humoral substances which flow past other areas that are polar-sensitive to these substances, reconstituting in analogue form a message to another area.

Therefore, this would be the method of carrying analogue information, and in effect, a means of storing phylogenetic information.

Reference information can be contained in humoral secretions as well as in electric potential levels. In fact, it would be difficult to change one without affecting the other. Are there any physiologic indications of reference levels which signify to the organism a balance with its environment? One such mechanism immediately indicated is fever. It is no accident that highly developed intelligence systems need a homeostatically (thermostatically) controlled warm-blooded animal, for reference points once established cannot be allowed to shift. In any physical system, increased thermal activity results in many ionic changes and the effects of heat on chemical reactions are too well-known to be amplified. Every species has its phylogenetically determined temperature reference points, as many uncontrolled chemical and electrical actions take place through rising thermal activities. False signals are created and consciousness altered by temperature changes. Although objective reality may not be budged a bit, subjective perceptive factors can be altered considerably.

It would seem that the embattled psychiatrists in the field of model-psychosis should have been delighted with the accusation that their schizophrenic models are forms of intoxication or similar to fevers, for chemical action can take place in a hot as well as in a cold "delirium". The organism by defective metabolic activity can cause altered molecular forms, just as can alcohol, fever, drugs. It can therebe appreciated that to have reference levels undeviating enough to form signals, a narrow overall pH and temperature level must be adhered to.

Now to complete the framework that we have attempted to erect here this evening. We will answer the various questions that we have posed.

Since altered metabolism alters thresholds and therefore changes intelligence, we can appreciate that senility changes mentation.

It also can be seen from this that sleep deprivation and sensory deprivation would affect both metabolism and threshold setting.

Chlorpromazine has been shown by Karreman et al, to be a powerful electron donor.

Electric shock affects electrical field and stimulates chemical reactions which temporarily alter thresholds.

As for Schizophrenia. I refer you to my previous papers on the subject.

We have attempted to show that electron activity is the basis for setting thresholds and therefore for altering thresholds and therefore the physiological base of intelligence resides in the understanding of these various processes which we have indicated in this paper and which we will now demonstrate through models.