A Model of the Central Nervous System

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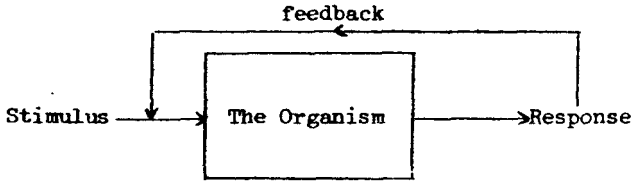
A model of a complicated system is of use in understanding the activity of the system, in that confusing detail can be eliminated yet permit of valid generalizations. There can be several models of the same system depending upon the activities that are to be examined. Dr. Osmond's work on "Models of Medicine; Models of Madness" is an example of the value of various models in elucidating confused thinking on one system.

In this model of the Central Nervous System I am focusing upon the activity of decision making, that is, on the procedure through which response arises out of stimulus, and from this I hope to demonstrate the evolution of the CNS, hence a model of its structure. By this means I may (and I repeat "may") be able to explain some obscure concepts - and their verbal symbols - in psychology and psychiatry and also to explain some of the phenomena that result from dysfunction of the system. The model is neither anatomical nor neurophysiological, it is behavioral. Some of the statements to be made in this context I shall assume to be axiomatic because nothing in the literature, which I have examined extensively, appears to contradict them.

The first proposition is that a living organism is a system of interrelated parts, the interrelation depending upon the teleological nature of the system. It is "living" because it shows those characteristics regarded by biologists as distinctive of life - ingestion, processing, action on and with the environment, support regeneration, and reproduction.

The second proposition is the basis of behavioral psychology; a living organism, if stimulated, responds in some way or another.

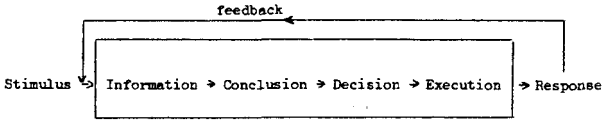
Figure 1



The response, as affecting the environment, may be fed back as a stimulus itself, leading to a second response that may be similar to or differ from the first. This is the basis of adaptation - and of the subject cybernetics.

What is more important for my purpose is what goes on inside the organism, the procedure of converting stimulus to response, the decision-making procedure**.** Since it is more easy to observe our own decision procedures than the procedures of other organisms, we can state the process in words that describe what we do.

Figure 2



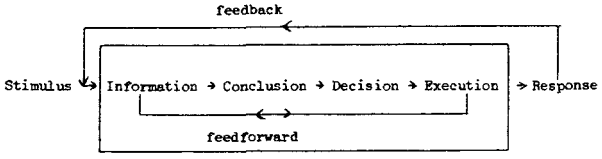
The procedure takes the following course which I express, in rough outline, as four distinct stages:-I **Information** - categorization of data incoming through the sensory system, rejection of data irrelevant to the objectives of the organism (teleology), recognition of a problem, a threshold value which must be reached before a decision is required, then what can, should, or ought to be done. C **Conclusion** - assessment of the data presented by the I-stage, leading to a set of alternatives for action (of what must be done), presented in a range of bad, good, better, best.

D **Decision** - examination of these alternatives, **choice** of one, the decision, sensu stricto, a commitment to achievement of a particular end or objective, that is in terms of right or wrong, what will be achieved.

E **Execution** - choice of ways of achieving the objective, i.e., decision on the **means,** the right or correct means that must be used to achieve the end.

But, in an organism, the l-stage must include data on feasibility. It is illogical, irrational, and unreasonable to reach alternatives (for choice of objectives and action) which include alternatives that cannot be executed. Therefore there is communication between the I- and E-stages, internal feedforward as distinct from external feedback.

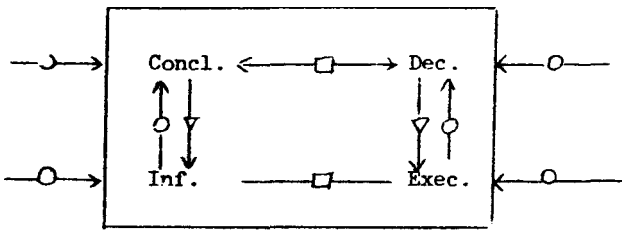
Figure 3



The internal intercommunication between the stages is reciprocal, two-way. (The communication of external feedback is one-way.) Of necessity, that is, in terms of the ultimate objectives of the decision-making system, the Conclusion stage must be able to require of the Information stage, and inquire about data relevant to conclusion-assessment. The Decision stage not only receives alternatives from the Conclusion stage, it requires and can ask for alternatives. The Execution stage cannot act unless it receives an objective (there can be no means without ends) and so can ask for objectives. Similarly the Execution stage can inform the Information stage what can and cannot be done when asked by the Information stage.

The procedure can be represented, therefore, by a nonlinear, circular, decision complex:

Figure 4



This is an **open system** as distinct from the closed systems of inorganic nature. The openness is indicated by the arrows at each stage entering from the external environment. The signal system between each stage (and, in more than elementary cellular organisms, each stage becomes a unitary organism itself, a unit) is expressed by symbol-marked lines, the

symbols indicating whether the signal leads to near all-or-none response (v), a limited range of responses (D), or a wide range (O). There is a fourth (A), not represented here, which leads to a one-only response. (To make a slight excursion into the realms of physics and metaphysics - there are four energy levels.)

It is not without interest to call attention to J.Z. Young's discussion of the complexes of four kinds of cell in the brain to which he has given the titles "sensory," "memory," "command," and "motor."

To return to the necessity for internal feedforward: If there were no such feedforward, situations can arise when the Execution (E) unit could not make the choice of action. In such a case there are two alternatives:

(a) There could be no response and the system would come to a halt, a condition of **stasis.** (Note that since there is no action there could be no external feedback in order to change the stimulus.)

(b) The system would go into internal **oscillation.** The reciprocity between the E and D units would lead to recycling of the signals between them, requiring recycling of the signals between the D and C units and between the latter and the I unit. The last, receiving the same external stimulus, could not act other than by repeating the previously passed-on signal.

At the monocellular level the decision system is not so clear. The reactions to stimuli (withdrawal, attack, compromise) can be observed, but the detailed decision procedure cannot, as yet, be even simply stated. What can be stated is of a generalized nature: (a) According to the stimulus the chemical structure changes. A chemical stimulant will produce a response different to that of a physical; and we know that these "irritants" must be above a threshold value before a response ensues. (This resistance to change is closely related to the Principle of Le Chatelier.)

(b) These changes in the chemical structure are "communicated" electro-chemically to other parts of the cell. The equilibrium is disturbed, and a new equilibrium is established - homeostasis.

(c) The new equilibrium is dependent upon the "choice" of reaction to the stimulus, i.e., to its form and the degrees of freedom of reaction in terms of energy levels.

The organism, whether mono- or multicellular, reacts to environmental changes by reason of the freedom of choice in decision making. (At the monocellular level this can be regarded as an expansion of the Principle of Indeterminism.) Because adaptation can be stated in this fashion, there is no need to argue the case for or against Darwinism and Lamarckism.

The system being open, there is the possibility of negative entropy and hence growth. Of necessity (the end being survival) there has to be coordination of the parts of the growing system. This is achieved by invagination and mitosis of C and D units which are concerned with setting alternatives and so objectives, i.e., coordination of the parts. These units, becoming internal, are no longer sensory and motor in contact with the external environment, but they become and remain decision systems in themselves (units) reacting to stimuli from the internal environment. Hence they too can go into stasis or oscillation if the internal communication system becomes dysfunctional and reduces feedforward. Such a disturbance at the cellular level is chemical, or electrochemical, if we take into consideration the neurone communication system of more advanced multicellular systems.

(This progressive invagination can be observed in the ontogenetic development of the vertebrate brain, from a hollow tube the ventral wall of which is sensory [the alar plate], the ventral wall [the basal plate] being concerned with motor, i.e., E-functions. The importance of the l-functions appears in the way in which the tel- and diencephalon develop from the sensory material alone, thence

to the neocortex. Between the two developing sensory and motor parts there develops intercalary material which acts as an adjustive, coordinative mechanism. The time-lag between stimulus and response is generated in this intercalary mass, as pointed out by Sherrington; if this were not present there would be immediate motor response to stimulus, that is to say, without reference to ends).

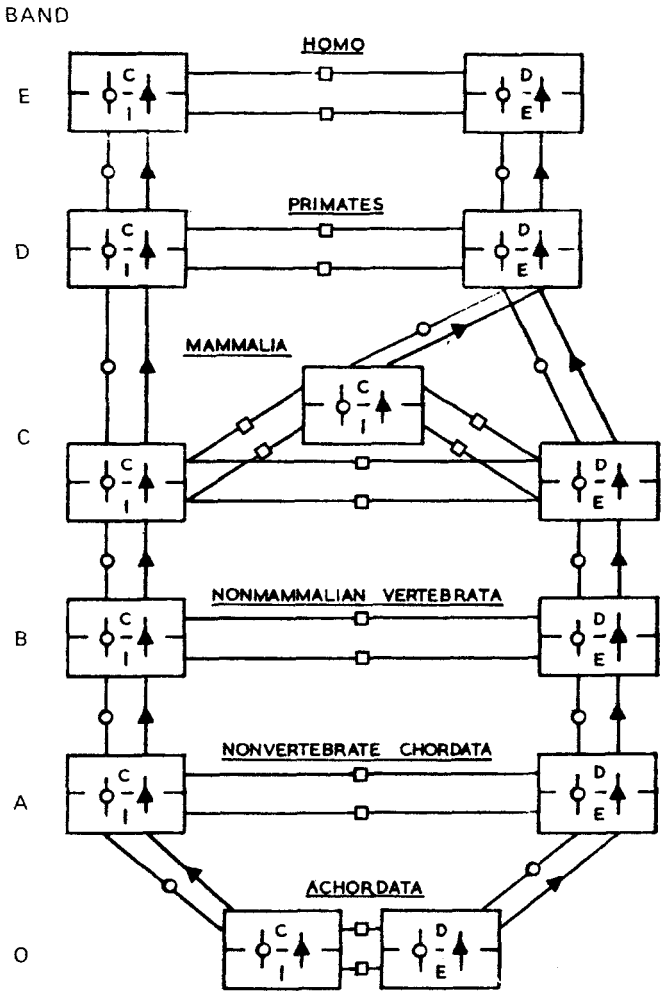
The phylogenesis of the Central Nervous System can be summarized as in Figure 5.

this figure should be in three dimensions to illustrate the interrelations of the various basic, biological functions. There is no clear-cut break between these various stages, only a gradual organizational development, each "sliding" into the other, but for ease in communication
I have called these stages Bands and distinguished them by the letters O, A, B, C, D, and E as indicated.

It is impossible to cover the immense range of such a phylogenetic evolution of the CNS in terms of decision making. The evolution towards and including the non-mammalian vertebrates is fairly clear. And there is much evidence on behavior patterns from such psychologist-biologists as Skinner and Lorentz, the latter a student of von Uexkull who early recognized that the organisms in these various Bands apprehended the environment in different fashions. For our purpose I enlarge somewhat on Bands C, D, and E.

Band C (Mammalian development). Increase in mobility of the

Figure 5



non-mammalian vertebrates in the Palaeozoic led to an extension of environment and variety of stimuli and so a need for "storage" of stimuli and feedback of response. (This was achieved through progressive invagination of the sensory material in the tel-and diencephalon as already mentioned.) From this arose the possibility of comparison of previous reactions (that is of patterned responses) with new stimuli, and so to prediction, as if there were a quadratic equation for solving the set of variables presented by the new stimulus. This led to the reduction of the need for trial-and-error adaptive decision making. If there is a stimulus X, the organism can not only react as Y but can forecast Y and its result and hence can go straight to Y1. This, it seems to me, is why the primitive mammalia could survive the holocaust of the end of the Mesozoic but the dominant reptilia could not. From the decision-making point of view, it was expansion of the feedforward system.

Moreover, and interrelated with this, came distinction between ends and means. The mammal adapts by "intelligent" or seemingly "intelligent" action that, in the non-mammalia, depended upon chance; hence the mammal could distinguish itself, the "doer," from the environment. Maclean has called this the distinction "between I and non-l."

(This stage is represented in ontogenesis by the temporal lobe, sometimes called the limbic system or, better still, again to use Maclean's term, the "visceral brain." This complex integrates the past and the present and the internal and external environments of the CNS. As Kubie says, "it is through the temporal lobe and its connections that the 'gut' component of memory enters into our psychological processes," and, again to quote Maclean, this "was an animalistic and illiterate brain.")2

Band D (Primate development). Again by progressive invagination and mitosis it became possible for "storage" of those quadratic equations, solving problems of

2 MacLean, P.D.; Psychosomatic disease and the visceral brain. Psychosom. Med., 11, pp. 338 - 353, 1949.

reaction to new stimuli as a set of equations in themselves. That is to say, not only were ends recognizable, but a set of ends that were coordinative was established. End-deciding became possible. Here is the differentiation of the "person" from the "doer" as well as from the environment, the decider of ends from the doer of means; a self-deciding organism emerged.

(This is reflected ontogenetically in the development of the neocortex. Whereas in the premammalia the diencephalon acts as integrator, in the mammalia information goes through the visceral brain; and in the neocortex of the primates the information from the basic brain is coordinated in an infinitely detailed fashion. Organized planning -hence judgement in terms of purpose - becomes possible The whole "doer," the body, comes under the end-deciding control of the neocortex.)

Band E (The development of Man). This is intimately associated with the development of speech and the use of symbols. This can be expressed as abstraction or conception of ends as distinct from perception, i.e., the emergence of a value system, of a "unit"

that can ask "why" and so can conceive of creation of its own environment. Man can simultaneously live in the past, the present, and the future. He can decide to do something in the here and now in the light of a remembered past, for achievement of a future objective which he can evaluate in terms of the values of Tightness (i.e., what is proper and appropriate to his value system) and of goodness (i.e., what is betteringness of his value system). Because of this Man has been called a "time-bender." This is the basis of Dr. Osmond's experiential typology.

Again the emergence of symbolism can be simply illustrated: The eye receives light and, at Band C, this can be recognized, interpreted as a stimulus from an external environment. At Band D it is recognized, as white light (say) as distinct from red or green. At Band E the

abstraction "whiteness" is possible, an association of remembered stimuli/responses of white. Or, a strong stimulus on some nerve endings can be integrated at the limbic centre, Band C, in producing avoidance motor activity. At Band D this stimulus could be recognized as hurtful. At Band E, an association of such remembered hurts becomes symbolized as "pain." We can actually think and conceive of pain without being hurt or "pained." The essence of the distinction is between **"feeling," "knowing,"** and **"thinking."**

Since there is evidence that, on the whole, ontogenetic development recapitulates the phylogenetic, we can draw the decision-making system (a model of the CNS) in a similar fashion (Figure 6).

To Bands C,D, and E, I have applied the words "awareness," "consciousness," and "mind," for these are already in use and, in much of the literature, are applied to these Bands of behavior. But they are also as frequently confused in their application. What is unconscious and subconscious? Is the body aware, as in sleep, yet unconscious? What is instinct? Are we referring to somatic activity at Bands O and A, sometimes B? The difference between Bands C, D, and E can be illu'strated very crudely in Table 1.

Figure 6

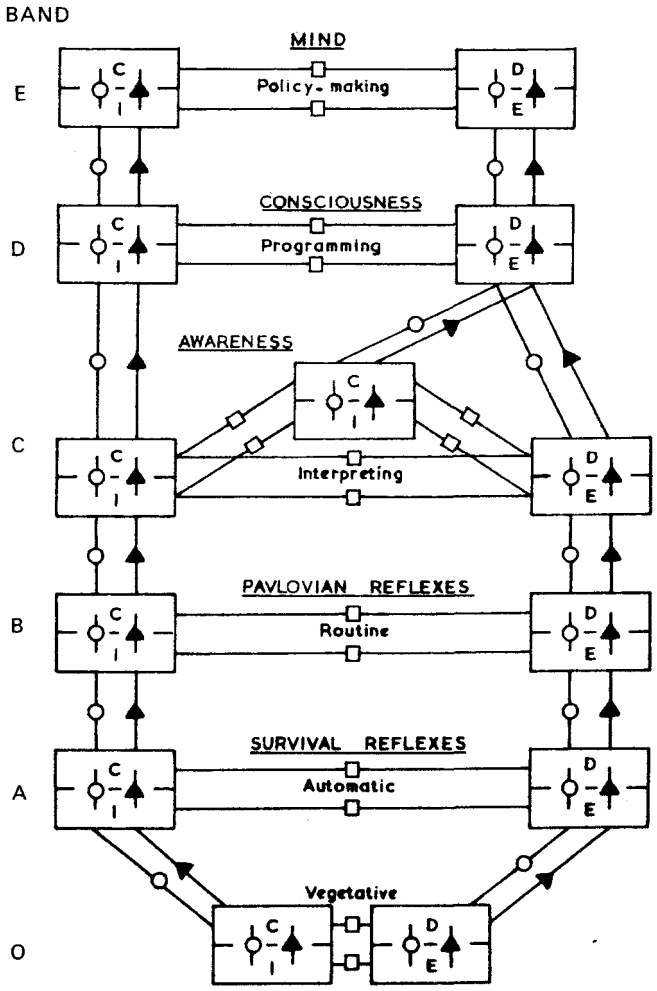


Table 1	EMind-	thinking	pain	self	l-image
	D Consciousness -	knowing	hurtful	person	Me-image
	C Awareness-	feeling	strong stimulus	doer	Body-image

One could add to these the Freudian concepts of Id, Ego, and Superego, the latter two being "the conscious mind."

The total model is a reflection, not only of these three Bands, but of those "below." The self has no existence without the person, the "doer" and the other Bands. They are inextricably interrelated by the CNS (and, through the visceral brain, the sympathetic and parasympathetic systems). A change in the internal environment of the lower Bands must stimulate the upper Bands, just as ingestion of chemicals causing dysfunction of the lower Bands can cause dysfunction of decision making at Band E. Similarly a disturbing stimulus at Band E, say a challenge to an accepted set of values and so difficulty in decision making, can cause dysfunctioning in the lower Bands.

It is to be remembered in what follows that the model is of a decision-making system. Its applicability can be supported by a quotation from Bishop.[3]

"Nothing could be more conservative than the persistence of the general plan of the chordates to the extent that Herrick could outline in the larva of Amblystoma precursors of the main structures of the primate. The success of the vertebrate nervous system seems due not so much to the virtues of this fundamental plan, however virtuous, as to the capacity it has shown for almost infinite elaboration of its details. But in this flexibility of differentiation little has been discarded and the higher vertebrate still performs some of his 'lower' functions with machinery quite as primitive as that of his ancestors. Even the cortical neurone, except for some elaboration of its processes and connections, probably still functions in its various parts quite like the neurone of

3 Bishop, G.H.: Natural history of the nerve impulse. Physiol. Rev., 46, p.395, 1956.

the lowly vertebrate before a cortex had been invented. The cortex still operates largely by means of connections characteristic of the primitive neuropil." The "fundamental plan" is the decision complex of Figure 4 with its basic units and "connections."

Dr. Hoffer has quoted a definition of psychosis, "diseases of perception and inability to judge that these changes are real." In terms of the model "diseases of perception" implies dysfunction of the sensory l-unit and its connections with the others. "Inability to judge" implies that assessment of the information and judgement (G- and D-units of the decision-complex) are dysfunctional. With such dysfunctions the organism, in this case Man, cannot act (E-unit) "normally," i.e., cannot make appropriate, rightful decisions and, therefore, is "abnormal" in behavior. Here "normality" does not mean behavior as believed by others to be rightful - or even good -but rightful in terms of the person's own set of values (of which more later).

If the conceptual "centers" at Band E are disturbed, the "I" cannot make moral judgements on appropriate ends and so cannot decide how to act - if no ends, no means. We can see here an explanation of the McNaghten Rules - if a person is unable to judge the right and wrong he cannot be held responsible for what he does; action which may stem from decisions at Band D or, more frequently, at Band C, the visceral brain, the "emotional center." His decisions are not reasoned or reasonable, they are called "emotional." As I have already pointed out, inability to decide ends will lead to stasis (in the extreme case catatonia), or oscillation, which expresses itself in cyclic behavior of a variety of kinds.

If the Band E "centers" can decide on the right and the good in terms of ends, the Band D"centers" may be unable to decide on means. The "I" knows what it wants, the "Me" cannot decide how to

achieve them. This, broadly speaking, is neurosis. Again we may see stasis, an inability to "do something about it," or oscillation, repetition of action "leading nowhere," a depressive or a compulsive neurotic. Anxiety may be the result of the clash between "I" and "Me." The latter, unable to act, begins to question the ends for which it can find no means; the "Me" begins to doubt the "I," the very essence of self. And self being thus questioned, a state of danger or imminent danger ensues.

If the Band C "centers" are unable to decide, that is, if the somatic functions are unable to cope with the objectives set by Bands E and D, then we have the phenomena of psychosomatic disturbances, for the visceral brain is "heavily responsible for psychosomatic disorders."

The source of dysfunctions would seem to lie mainly in the communication complex of the various decision systems. We know that the neurone transmission is affected by changes in K and Na ion balance. In the same way chromium and zinc deficiency may affect behavior by inhibiting or catalyzing communications between the units of the decision complexes at various Bands. Do the "natural" chemicals, such as the vitamins, have their effect upon behavior in the same way?

We do not know if this is how they produce the effects they do, but it seems to me that there are possibilities of categorizing the function of chemicals (and so foods) not only in terms of their results (i.e., by response) but by their activities in affecting the various communication systems. For example, is sleep the result of hormonal dulling of the communication between Bands D and C, between consciousness and awareness? And anaesthesia the breaking of communications between Bands C and B? Similarly there appears to be a possibility of categorizing neurophysio-logical disorders (as shown in comparative behavior patterns) in terms of dysfunctions of communication systems in and between the decision complexes of the various Bands.

We can apply the model to psychotherapy. The philosophical discourse that leads to the result "I think therefore I am" can be reworded as: "I can evaluate my decision making in terms of Tightness and goodness and therefore I have self." Or, "I am a moral animal and therefore I have self." (Self here refers to the l-image). The circular thinking between "I" and "Me" can be explained by way of the complex of the two Bands D and E.

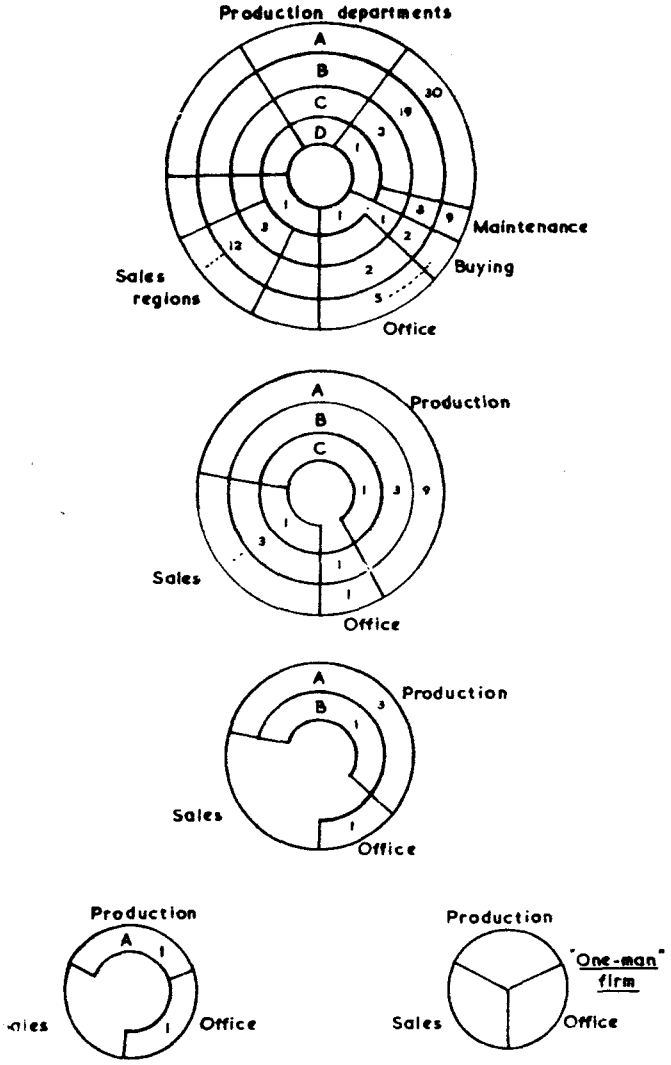
As often remarked, the psychotic is "searching for self."

In our Greek-based culture the two concepts of Tightness and goodness are symbolized by the male and female respectively. Freudian analysis is fundamentally a process of helping the psychotic find "self" by solving problems of the right and good. In "treating" (so-called) the neuroses, the Freudians are attempting to help the patient find a new value system by which he can establish new ends and so means. Freudian analysis is essentially a technique of using symbols for symbols, surely difficult and unnecessarily so since the trouble may lie in neurophysiological (communication) dysfunctions which can be truly treated. How else can we justify the use of psychotropic drugs?

Nevertheless "straight" psychotherapy, as the psychologist would use it, is of use. It can "strengthen" units in the complex at Band E, and so the signal system is changed since the "strengthening" will affect "potential" differences and so affect strength of signal: Psychotherapy can assist Orthomolecular psychiatry - it is very doubtful if it can replace it.

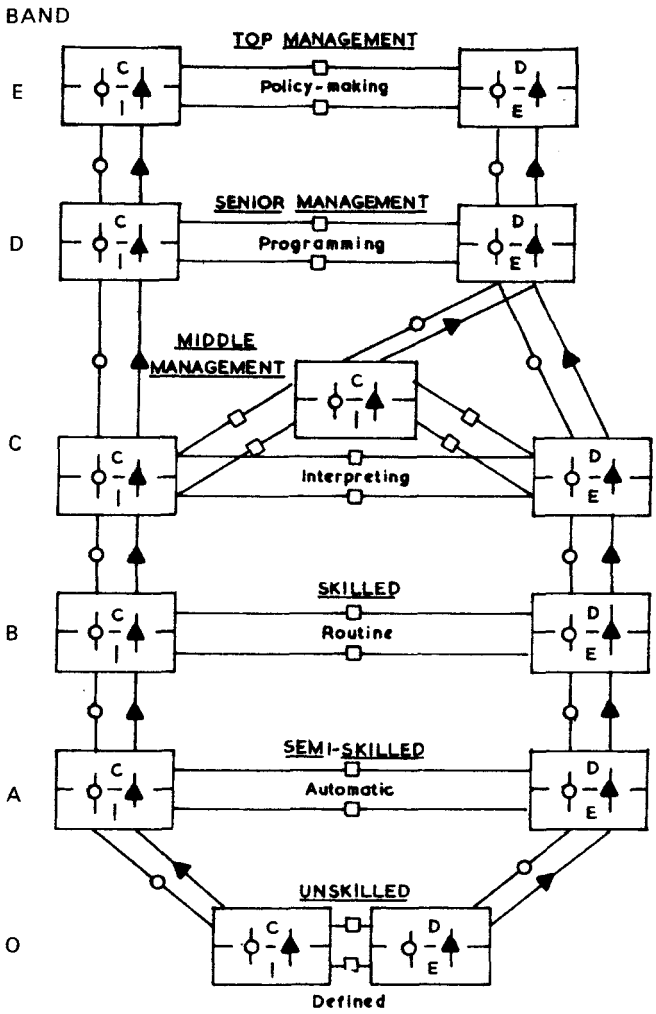
Here I propose to extend the model to the **social system.** I shall not survey the literature on the hive, the shoal, the flock, the herd, the pack, and the tribe, but show (again a matter of ontogenetic recapitulation of the phytogeny) that a modern social system, in this case an industrial firm, grows out of a one-man firm by a process parallel to that of invagination of the C and D units.

Figure 7



The one-man, making all decisions, gets help to make decisions of Bands O and A (the numbers represent, as an example, numbers of people) in one or two of the basic functions of a firm -which are parallel to the basic biological functions - purchasing, production, marketing, finance (support), and personnel (regeneration). As the firm grows, he delegates more of the lower-level decisions (Bands) and so on, until finally he heads up the Board, the body or "center" that makes decisions on the ultimate objectives of the organism, the firm.

The communication system can be expressed in a model parallel to that of the CNS and, like that, should be in three dimensions.



The kinds of decision, the Bands, appear in all firms and need not be described here. But the recognition of these kinds is to be seen in names that are commonly given to the Bands. Moreover, the subconscious appreciation of these differences appears in the pay given for jobs whose contents reflect the different Bands. In every firm, and this is, statistically speaking, universal, the differentials between pay for Bands is constant. This is what is called "fair" and is always "felt" to be so (subconscious). The model can be applied to a community or even a larger social group.

As the model parallels that of the CNS, so it is possible to talk of "social pathology," "social psychosis," and "social neurosis." In all cases the dysfunctions indicated by such terms are failures in communications. (How often do we hear this remark today!)

The individual is immersed in this kind of social matrix and, because of this, some psychiatrists see the psychotic and neurotic individual as suffering from the dysfunctions of the matrix, believing that their psychotic and neurotic behavior is caused by the disorders of society. But many more individuals who are neither psychotic nor neurotic, that is, who are capable of making decisions, live in the same societies. And psychotics and neurotics can be found in societies that are wholesome and on-going, "normal." The dysfunctions that lead to psychoses and neuroses are internal to the individual; they are Orthomolecular dysfunctions and not social. Undoubtedly a group that is not functioning well presents problems requiring difficult decisions; but the non-psychotic and non-neurotic make decisions, reasoned and reasonable decisions in these

circumstances.

It is the function of the social psychologist to study the behavior of "normal" individuals in their decision making as influenced by the "abnormal" society, and so to diagnose the dysfunctions of the society and hence "treat" it. It is not his function to study the "abnormal" individual who, because of his difficulty in decision making, cannot adapt to the "abnormal" society.

Hence those who see psychoses and neuroses in terms of a social model are making a profound mistake. These disorders are properly the field of the psychiatrist focussing on the individual, in terms of a clinical or, more accurately, an Orthomolecular model. Those like Szasz and Laing who, as psychiatrists, use the social model are entering the field of the social psychologist and leaving the field of psychiatry proper. They are moving still farther from their field when they use the moral model -which is the field of the anthropologist. They should keep out of fields that are beyond the scope of their profession, and "stick to their last."

Their field is psychiatry, the diagnosis and treatment of dysfunctions of the individual decision-making system, more particularly of the communications; that is to say, Orthomolecular psychiatry. In terms of this particular model of the CNS, Orthomolecular psychiatry is the only true psychiatry.

It is my belief that at this Conference you have been concerned, rightly so, with a modus vivendi. This model may have provided you with a raison d'etre.