The Science of Behavior and the Internal Universe

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SCIENCE AND THE INTERNAL UNIVERSE

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I.

Introduction

At the fourscore year mark my curiosity about the universe having increased rather than diminished, I have the advantage of using the perspective of many years in the background to look forward.

Science began with unity, e.g., Aristotle was not only one of the three great Greek philosophers who dominated thinking down to the Middle Ages, but he was as well an astronomer, a physicist, an anatomist and a biologist.

The Middle Ages saw the foundation of a science with a new outlook, a perspective based upon the experimental method and observation combined with an elaboration of concepts. This foundation was laid especially by Galileo and Newton, with an emphasis on the conceptual side by Francis Bacon and Descartes.

Our interest, however, is centered around John Locke, born 1732, on account of his emphasis on the relation of the individual to the external environment, his tabula rasa upon which experience writes. From him has developed the materialistic point of view in behavior. Hence began the emphasis upon the data brought to us by the sense organs, later greatly amplified by instrumentation. What occurred in the body was likened to what was seen with machines, e.g., the pumping of the blood by the heart and the discovery of the circulation by Harvey to hydrodynamics. Thus, it was apparent that many of the functions of the body obeyed the laws of mechanics.

Behaviorism as we know it today obtained a great stimulus from the discovery of sensory and motor nerves by Bell and Majendie, about the beginning of the 19th century. The Russian physiologist Sechenov in 1863 wrote his "Reflexes of the Brain." This was a bold step to include thinking and mind on a purely reflex basis, denying the reality of a separate subjective life. This was emphasized by Thomas Huxley in his statement, "No psychosis without neurosis," meaning that all thinking was underlayed by detectable neural processes. Thus the 19th century began to think of mind as equivalent to complex physical and chemical changes in matter.

The study of the nervous system as a vehicle for total behavior was founded around the turn of the 20th century. This development diverged along two paths, the study of gross movement, and the quantitative measurement of secretions to a food stimulus, the former being developed by Bekhterev, Thorndike, Watson, and Skinner, the latter by Pavlov. On this divergence there have been built up two schools called the Operant and the latter the Classical-Pavlovian. Operant conditioning has been greatly expanded in America; its emphasis is chiefly on how the external behavior can be "shaped" according to the wishes of the experimenter. This at first made use only of the skeletal movements, but later has included the autonomic nervous system.

An entirely different elaboration was centered around Pavlov, who had received the Nobel Prize in 1903 for his work on the physiology of digestion. His contributions involved chiefly the use of the dog over its life span, viz., the chronic experiment, the use of quantitative measures (units of saliva), the emphasis on the individual rather than on statistical surveys and the recognition of individual differences by his four "temperaments".

The evaluation of the Pavlovian school, including that of his successors, such as Skinner, the electrophysiologists, and others, fluctuates from the extreme optimism that "the behaviorists are the people who have got to save the world; they may win the race with total destruction" to the more cautious statement of Grey Walter: "At the present time there is still not one single principle of mental physiology that can claim the status of a natural law, in the sense that it receives universal acceptance and permits deductive prediction or extrapolation."

Though they may espouse monism, most scientists will recognize that for the subjective phenomena of our life there are no objective representations.

A simple test is to try to communicate to anyone the sensation of the color "blue." No matter what you say about its wave length or other measurable physical properties, these do not even approach the subjective feeling. They are of a different order--and never the twain shall meet.

Pavlov said science must be satisfied with its practical achievements--its ability to give us the measurable relationships in physical, objective items. Perhaps the monist should heed the counsel of Planck, not to ask of science questions it cannot answer.

Finally, Pavlov, as well as every student of the nervous system, owes much to Descartes' concept of reflex. Pavlov and Sherrington adhered to this concept either implicitly or explicitly in their epochal researches. The difference between them is that whereas Sherrington did not think that his laboratory methods could give him the ultimate answers to the riddle of our mental life, Pavlov had the adolescent hope that at some future time "the omnipotent scientific method will deliver man from his present gloom, and will purge him from his contemporary shame in the sphere of interhuman relations."

II.

Many other responses and reactions in the organism have been brought within the conditional reflex (CR) methodology since Pavlov. In the Pavlovian Laboratories, we have extended this field to include vestibular reactions of equilibration, respiratory and cardiovascular responses including heart rate and blood pressure as well as responses to stimuli placed within the central nervous system (interoceptors). In the human being we have added to these the psychogalvanic.

To epitomize, four decades of work from my laboratory on the cardiac reactions: (the cardiac component of the CRs are in general parallel to the secretory and motor) there is a quantitative relationship to the intensity of the excitatory CR, a marked difference between the cardiac component of the excitatory and inhibitory CRs, a precise cardiac time reflex, etc. The inhibitory CR is characterized by a slight rise in HR with a marked subsequent decrease below normal. Here we have in the cardiac response a measure of inhibition which gives an explanation to the quiescent phase and sleep which Pavlov found resulting from inhibitions.

George Burch and some others in the USA have contributed to this field through a study of vasomotor responses. Burch in the course of his detailed and painstaking research on the heart and vascular reactions, has shown that the latter are definitely modified through experiences of the individual, i.e., they are capable of being conditional reflexes.

III.

The preceding description of the ability of many systems to form CRs involves many stimuli from the external environment. The relative role of the periphery and the center, the external sense organs and the central nervous system, concerned us. To solve this, we considered the elements of the reflex arc, both the conditional reflex arc and the unconditional reflex arc. We successively eliminated the different parts of the conditional reflex arc--the external sense organs, the peripheral nerves, the spinal pathways to the motor area of the brain, finally the executor organ, viz., the motor movement or the salivary secretion with the result that the only essential part for conditional reflex function is the central nervous system.

This then puts the importance of the adaptation <u>within</u> the central nervous system, diminishing the function of the external environment in the healthy subject. This, of course, does not negate the influence of the external environment in such items as nutrition, etc. It means that many adaptations can be found within the central nervous system.

In directing our attention to the inner universe, we must acknowledge the debt we owe to Claude Bernard for his study of the inner world through which study he was led to the realization of the fact that the body maintains a constant chemical composition for its life within. This idea was taken up later by Cannon and made the principle of his "homeostasis". Thus arose an over-emphasis of the ability of the organism--beyond its powers--to regulate its economy and to maintain its equilibrium in an unfavorable environment. In psychiatry it took the form of believing that whatever the individual tended to do represented a healthy, balancing action. The counterpart of this idea was expressed by Pavlov, viz., that the CR was a means of preserving an equilibrium between the individual and its environment. This idea of equilibrium will be discussed later.

In the formation of the conditional reflex we can eliminate the external sense organs (eye, ear, skin) by placing electrodes within the nerves to produce the conditional stimulus. To supplant the unconditional stimulus an electrode may be placed 1) on the posterior nerve root, 2) on the posterior columns of the spinal cord, 3) within the cerebellum, 4) in the motor area of the cortex. In all these regions the movement produced and be conditioned as easily as if the stimulus were applied to the skin receptors. Also for the conditional stimulus may be substituted an electric stimulus in the silent areas of the cortex. In these instances the unconditional stimulus or the conditional stimulus or both are entirely within the central nervous system. Also the efferent end may be eliminated by crushing of the anterior nerve roots within the spinal canal to a limb, training the animal during the period of paralysis and testing him after recovery; the motor reflex appears on the first trial after several months interval required for regeneration of the nerve.

Thus the conditional reflex can be formed and can exist internally without involvement of the external environment! If the nervous system can form conditional reflexes from a stimulus applied within, albeit an artificial one, it is reasonable to assume that it can elaborate conditional reflexes from stimuli arising from origins peculiar to itself.

IV.

From the consideration of many approaches to the adaptability of the organism during its life experiences we see that its various functions do not make parallel adaptations; some functions readily become CRs, others are absolutely unconditionable. From this we arrive at the law of <u>fractional conditioning</u>. Besides this absolute difference, there are differences of degree relative to the speed of formation of a CR and the durability once formed. To this marked difference, first seen with the cardiac conditional reflex, we get the name of schizokinesis.

In the study of the cardiac components of the conditional reflex to food or to pain we saw that the cardiac conditional reflex formed rapidly, usually before the motor or the salivary and often after one reinforcement by the unconditional stimulus. Not only did it form first, as a rule, but it generally was much more resistant to extinction. Often the cardiac conditional reflex might continue for several years after the motor or the salivary component had been extinguished by active efforts for extinction. The respiratory conditional reflex behaves in this respect more like the cardiac conditional reflex than like the specific salivary or motor components.

The fact that the cardiac conditional reflex may continue while the other components are absent led to the concept of schizokinesis, a split between the more general functions as the respiratory and the cardiovascular and the specific ones. Such a split--a persistence of one activity in the absence of the other--would seem to represent a maladaptation, a kind of built-in lack of integration of the physiological systems.

The existence of the conditional reflex may at times seem to be a liability and a lack of equilibrium with the environment, and even the opposite, viz., dysfunction. Thus, as shown by Bykov, more oxygen is consumed in performing a given task when the performance is preceded by a conditional stimulus, i.e., the oxygen consumed by the conditional reflex plus the amount consumed by the unconditional reflex alone not preceded by the conditional stimulus. We have shown a similar thing for the salivary secretion; more saliva is required for the same amount of food when the eating of the food is preceded by the conditional stimulus. The organism must pay in efficiency, i.e., in the amount of energy required, for its function of being ready for emergencies.

The fact that conditional reflexes are so often difficult to eradicate once formed makes the individual a museum of antiquities as he grows older, as I have pointed out previously. He is encumbered with many reactions no longer useful or even those detrimental life. This is especially true for the cardiovascular function, and it is these conditional reflexes that are the most enduring. A person may be reacting to some old injury or situation with his cardiovascular system which no longer exists, and he is usually unconscious of what it is that is causing an increase in heart rate or blood pressure. The result may be chronic hypertension. This may be the explanation of many cardiac deaths.

The persistence of the cardiac conditional reflex and of other general components in the absence of the more specific parts, e.g., the salivation and the movement, should lead to a revision of the idea of inhibition. Formerly we considered that the dog was in a state of complete inhibition in regard to a specific stimulus when he no longer gave the salivary secretion and the motor component, but now we see that inhibition can be and probably is, partial, incomplete fractional. The animal may be quiet externally but violently agitated internally. This seems to me a usual and therefore normal occurrence instead of an exceptional and abnormal one.

Autokinesis

By means of the chronic experiment, studying the subjective for a long period of its life, we can see important changes within the organism, changes which indicate that interactions among foci of excitations stored in the central nervous system. To this function we give the name of autokinesis.

A familiar example is acquired immunity to disease. Having once had certain diseases--measles, mumps, chicken pox, whooping cough, typhoid fever--the person does not contract them a second time. But what remains? Certainly not the antigen, certainly not the same antibodies. It is the pattern of activity that is present, the ability to react when the stimulus has long since passed. There is some trace left in the living tissue somewhere. There are many other examples, occurring in biology or as a result of individual experience. One is the spontaneous restoration of the conditional reflex. Pavlov, as well as I and others, showed that generally a conditional reflex could be extinguished in one day but that it would reappear the next day, and that sometimes many separate days of repetitions were necessary for complete extinction. As he did not measure all components, this view would have to be modified somewhat at present in the light of the cardiac responses, but essentially the fact of spontaneous restoration remains.

I have noted that sometimes one injection of a drug will permanently, or at least for a long time, change the level of reactivity of the dog, the size of his conditional reflexes, though the drug is not repeated. Wiener, recognizing the development of pathologic reactions to formerly innocuous stimuli, explained it by saying that the level of feedback had been altered.

Every physician knows that a patient may steadily improve after one visit and consultation, and we all know how one experience in life may change our whole future. When the development is in the direction of making better adaptations this I call positive autokinesis, when the direction is downward, negative autokinesis.

There is growing anatomical evidence that new connections can be made in the nervous system through emerging nervous processes or perhaps even through the origin of new nerve cells. Thus Jerzy Rose has shown that if one of the cortical layers are destroyed by radiation, the axons of the two layers adjacent, on either side of the destroyed layer will grow through the degenerate layer to make new connections with each other. At the XXIII Physiological Congress in Tokyo in 1965, Drs. M. Adal, D. Barker, and M. C. Ip, University of Durham, England, reported the growth of entirely new motor endings of nerves to muscles.

Organ System Responsibility

For the last few years we have been concerned with the comparative study of the renal and cardiac functions in the dog. It had been previously reported that the kidney was susceptible to conditioning to the same extent that the gastrointestinal functions were. However, after a number of years of trying to form renal CRs in the dog we have not found it possible.

When we begin to analyze renal function we come to an explanation of why this difficulty in forming a diuretic CR. The usual way of considering conditioning was a stereotyped one: you select an inborn type of reactivity, an unconditional reflex, you give the adequate stimulus to produce this UR, and then you precede this stimulation with any signal, the conditional stimulus, and _ipso facto_ you get a CR. This has been the usual method for obtaining all CRs. There has been little question that the application of this stereotyped method will produce a stereotyped result, viz., the CR.

Recently I have looked for an explanation of why the kidney did not respond the way the salivary and the gastric secretions do, the way the motor system does. The function of the motor system is to adjust in a useful way to the coming events in the external environment, and the cardiovascular and respiratory systems prepare the organism for this action. In a like manner the salivary secretion, the gastric secretions prepare for the ingestion of food. When the signal for one reason or another does not signalize the events that it once did for the CR to occur is no great loss except a slight loss in physical energy. This is because the secretions, salivary and gastric, etc., are poured into the gastrointestinal canal and promptly reabsorbed; there is no loss of either fluids or solutes. Several gallons of saliva, gastric, pancreatic and intestinal secretions and bile are poured into the gut, reabsorbed and reused. It is as if a city continually reused all its sewage, for this happens with the aqueous solutions of the body, except those lost through the skin, lungs and kidney, and a small portion through the feces.

However, if the kidney were to function according to the same stereotyped paradigm, there would occur in the conditioning process a discharge of water and electrolytes which are unrecoverable. This would mean that a thirsty animal responding to the signals for water and also for foods could be depleting itself of these very essential items, leading to the death of the individual. For what the kidney discharges into its pelvis and into the bladder cannot be reabsorbed into the body system and it is therefore lost irrevocably.

The principle of organ responsibility means that the formation of a conditioral reflex in greater or lesser degree is in relation to the phsyiologic function of the system upon which it is operating; a conditional reflex appears impossible to form if it would violate radically the function performed by this system in the body economy, thus opposing the principle of homeostasis.

Organ-system responsibility and the principle of teleology do not mean that we can always made a prediction according to logic, according to teleology; we do not know precisely the teleology of the organ or of the individual. We only know a little about it. So we cannot, as the great physicists--Einstein and Planck have done--sit down with a few figures and, without performing an experiment, make predictions and come out with great laws. You cannot do that with a biological organism because of the tremendous number of factors which are at work. So you have to go to the dog and do the experiment to find out what happens; you cannot bypass the experiment simply by the principle of organ-system responsibility. This leads me to the conclusion, however, that I, as well as other people, can be very wrong by adhering to a stereotyped paradigm without looking at the underlying function of the physiology of that system with which you are working. And although it seems very popular and very alluring to say that everything can become conditioned, that you can cure heart disease, and that you can regulate every autonomic function of the body by the simple bell-and-food paradigm, I think that we have to exercise wisdom, look more at the physiology, and understand what are the organs doing--what are they for--and, thus, get rid of stereotyped thinking.

V.

Pragmatism, the production of Charles Peirce, was developed and applied by William James and John Dewey. It is not reality that we are concerned with (and cannot know) but with only the part accessible to us can we interact.

The laws of the external universe result in pragmatic control. We assume that the external sense organs record accurately the phenomena of the external world, and we work pragmatically with these laws.

Nerves from the internal universe give us a vague sense of the degree of well-being. Furthermore, we know when we are conscious, but these states are not recognizable in any scientific quantitative measurements. For the whole internal universe, we are unaware what goes on, except under pathological conditions.

The significance of the part of the information brought by the nerves of pain is subjective. The electrical impulses conducted over the nerves are of no significance to us, unless they are represented by the subjective feelings of pain.

The content of the states of consciousness cannot be communicated--first, these states are not quantitatively recordable, in the terms of which they are significant. Secondly, they are not communicable in their essence. There are objective correlates--e.g., heart rate, motor movements.

In regard to communication, who knows what a baby is thinking when he looks at red?

Therefore, the science that we have and use for the internal universe is a foreign science built on external data.

We are lacking a science for what goes on inside.

In all of this, an important, if not the central role is played by the information brought to the brain by the external sense organs, viz., the visual, auditory, olfactory, gustatory, tactile, temperature functions. All these organs turn outward. They register what goes on in the external universe. Normally they cannot sense even their own existence--the eye does not see itself, the ear hear itself, the tongue taste itself, the olfactory organ smell itself, the skin feel itself. We are concerned here with the conscious experiences, not what may be conveyed to the subconscious, nor with the electrical potentials or chemical perceptions since it is the conscious perceptions that are the basis of our science. What the external sense organs bring into consciousness, as far as is obvious and demonstrable, is the *sine qua non* of the science that we know.

Thus our science is constructed from the building blocks of the external sense organs arranged and cemented into place by the inner master architect, the brain.

Furthermore, science is a human product and practically all of this science depends on (involves?) the function of vision. The eye is not only the sense organ at the basis of our human science, but it is the most sensitive instrument that we know, either in nature or man-made. This is true both as regards the amount of energy it can detect--viz., several quanta, nearly at the theoretical physical limit of energy--but the simplicity of its construction to perform its function. And as Sherrington points out, it is constructed mainly from water plus a little of the substance of egg white, entirely in darkness.

Although we do not know of a science devoid of the facts and involvement of vision, it is conceivable that, given our human brain, we could build a rudimentary science from other external sense organ data. Thus Helen Keller without the sense of vision could understand visual science, because the facts were supplied by other eyes which could see for her. If we had the auditory and tactile sense organs of a bat, or the olfactory sense organs of a dog, or of some worms, we could construct a certain kind of science, but it would include only things which could be heard or smelled and very circumscribed as to distance. Space would have to be estimated as with a bat by resonance of reflected sound waves emitted from the vibration of its own voice, or by the muscular sense of spanning the distance with arms or legs. We would know of the existence of the sun but not of the moon or stars, nor anything of its distance.

Because some animals are guided by delicate sense perceptors, e.g., insects to their goals perhaps by heat radiations, salmon, eels, seals, etc., into streams by a chemical or pressure sense, this is a long way from a science.

So far we have discussed the science that has been erected on the sense organ data of the external universe. But there is an internal universe bounded by our skin plus a few small areas of sensitive mucous membrane and modified visual epithelium, the boundary that prevents any unscheduled interchange of substance between the two universes. This internal universe of which we are a part is immeasurably more complex, infinitely less comprehensible than the exte universe of which we are not a part. By the standards of external science it is mainly an unstable aqueous solution comprising at any one instant vitriolic and toxic substances, perhaps many thousands of compounds and to exact proportions, immersed together in a common medium, often strictly limited to one small area (e.g., HCl) or everywhere abundant (hemoglobin), confined rigidly to certain places, but under great pressure, by a watery membrane not visible to the naked eye and thinner than the finest tissue paper, yet strong enough to withstand a constant fluid pressure greater than that of the most powerful suction pump (the epithelial cells of the renal tubules). Without any known centrally and uniquely controlled mechanism, this living organism of thousands of simultaneous reactions, compositions, functions, structures, infinitely varied and separate, yet with a common goal, maintains itself and contributes its prescribed allotment for the survival of the whole.

But what of the science for this complex internal universe? How does it compare with the science of the infinite external universe, relatively speaking? Have we evolved such an adequate science?

Let us compare the science for the external universe and that for the internal universe. As pointed out, the science of the external universe has been constructed on the data brought to the integrating organism, the brain, by the external sense organs. It has been a science which, though it may reveal only a very minute part of the external universe, of reality, it provides us a pragmatic basis for working with that part of the external universe to which the external sense organs are sensitive.

Now if science for the external universe is dependent upon what the sense organs tell us of this external universe, how can we escape the conclusion that an adequate science of the internal universe must depend upon sense organ data from that internal universe.

But what are the sense organs for this internal universe? Sense organ data for the basis of science must bring information from the universe with which it deals, even though we admit the data is of a relatively small part of the whole. For example, the ear records only vibrations within the range of 16 to perhaps 30,000, the eye between the wave lengths of red and blue, one octave.

The sense organ data from the internal universe that reach consciousness, and these are the only ones that science so far can deal with, are nil under normal conditions. All these myriad interactions work silently and to our sight, blindly. None of us are conscious of the function of the liver, kidney, spleen, adrenals, stomach, vestibular apparatus. We have a proprioceptive sense, but it is doubtful to what degree it normally enters consciousness.

It is true that under conditions of malfunctioning, or pathology, we sometimes feel discomfort or pain, but even this sense is not always present. Thus one can be dying of cancer, silent tumors, unconscious of their presence or location. The surgeon Blalock was not conscious of the cancer of the liver from which he died until it had spread throughout his body. Such facts are too commonplace in medicine to require elaboration.

Even when one has information from the internal universe it is usually vague and imprecise, comparable to what it would be to view an object through a ground glass window, a heavily smoked glass, or to listen for a specific sound in the roar of Niagara. We do often have a sense of well-being or the opposite, but it would be very difficult to measure or to record euphoria objectively.

VI.

On the same basis as we assess the science of the external universe, we have no adequate science for the internal universe.

But as we well know the science that we have evoked for the external universe has produced remarkable results in biology. We have the cure for many diseases, e.g., diabetes, pellagra, scurvy, to say nothing of the drugs for combatting infections, the analgesics, anesthetics, stimulants, etc.

But this science of the external universe applied to the internal universe, though it is useful and often alters profoundly biological processes, we are still lacking in a science that adequately explains life. The science that we have is foreign to life, borrowed from the science of the dead universe.

Even our language when applied to the subjective, the most conscious part of the internal universe, is descriptive of spatial, auditory, visual relations. The terms for this idea, as well as the idea itself come from conversation with my friend John Lamb, who said:

> Our language is replete with words brought from objective descriptions of the external universe. For example: we turn now to the subconscious from which ideas come to the surface in the form of mental images during a flash of insight. The rate at which this happens is taken to be a function of a person's psychic energy. Deeply felt emotions, though, are likely to color our ideas and becloud our thinking. Those who are deemed the sharpest thinkers seem to be the most adept at circumventing these distractions in order to penetrate to the core of a tangled mass of abstractions.

It is perhaps for this inadequate science of the internal universe corresponding to our science of the external universe that we have practically no science of the most important part of the life as we estimate it for ourselves, viz., our subjective life. This we cannot even record scientifically, as we do the elements of the external universe. When we record the change in heart rate, blood pressure, respiration, muscular contraction in pain, we have an objective correlate, but a correlate of a zero function except when we experience it in ourselves. What we record is something of another category, the existence of which is known to ourselves but only inferred in others, animal or human. The science of the external universe does not touch this subjective.

Furthermore some subjective processes--thinking, feeling, perception, etc.--may be below quantum level and therefore theoretically never recordable by any instrument other than mind. This view is especially reenforced by the purest scientists, the modern physicists, Planck and Schroedinger, but also by the philosopher-physiologist Sherrington. Planck states that science cannot deal with our subjective life.

"Science thus fixes for itself its own inviolable boundaries. But man, with his unlimited impulses, cannot be satisfied with this limitation. He must over step it, since he needs an answer to the most important, and constantly-repeated question of his life: What am I to do? -And a complete answer to this question is no furnished by determinism, not by causality, especially not by pure science, but only by his moral sense, by his character, by his outlook on the world."

And Schroedinger says that our psychical life does not involve energy.

"One can say in a few words why our perceiving and thinking self is nowhe to be found within the world picture, because it itself is this world picture

And Sherrington:

"Mind, for anything perception can compass, ... remains without sensual confirmation, and remains without it forever."

The failure by Kety to measure any increased blood supply to the brain during consciousness or thinking, though still not conclusive, may be relevant.

Is it because of the lack of a specific science for the internal universe and the probable inadequacy of the science of the external universe when applied to the internal universe, that there is so much unknown about biology and life? Here the imponderables remain as stubbornly incomprehensible as they were in the dawn of recorded human history. Most of the eminent scientists sense the existence of mind, love: Individual free will, a world with a beginning or a world without a beginning, limited or unlimited space, time, God, are equally difficult. Even with our advanced and advancing science of the external universe, for each one of us what we value most highly are the emotions and the subjective. The objective science of the external universe has no meaning of its own--only as it can affect our subjective. This becomes apparent when we look at how the human values the idea of an after-life; it is not the body that he aspires to preserve, but the spirit, i.e., the subjective part. When there is the lack of interest in an after-life it is not because of the uncertainty of the objective body, but because of the doubt of such a subjective persistence. Thus:

> Why if the soul can fling the dust aside,
> And naked on the air in Heaven ride,
> Were it not a shame, were't not a shame
> In this clay house imprisoned to abide.

The situation then is that when a science of the world of the subjective and perhaps of life is not only woefully behind the science of the external universe, but perhaps theoretically it will always remain inadequate.

We could erect a similar though very limited science to the one we have now by using auditory sense data or a system of radar as used by bats. Thus we could form a science of music--pitch and the length of strings--but such a science would be limited only to what could be transmitted through actual matter, or perhaps through the thermal sense and heat rays.

But let us reverse the process of applying the science of the external sense organs to the internal universe, viz., using the internal sense organ data applied to the science of the external universe. The most definite and continually acting internal sense organs are proprioceptive, vestibular, which are mainly below consciousness and therefore, because they are below consciousness, inadequate by the criteria (sense organ data reaching consciousness) for our science of the externa universe. The sense organ which preeminently brings us data from within and enters consciousness is the pain sense.

To reverse the process, to found a science of the external universe on the sense organ data from the internal universe: the science, the relationships developec from the perception of pain would be applied to the scientific understanding of the external universe. This would be a poet's world of images rather than a scientific world; the external universe would be explained by subjective terms such as groaning, suffering, etc. Such an idea is evidently preposterous, but I raise the question whether it is not equally absurd to look for an adequate science of the subjective world and of the whole internal universe from the sense organs which bring data from the external universe.

Without doubt it is true that we can produce certain results by studying the living organism as if it were a part of the dead external universe.

When we measure the effect of meditation and other mental states in objective physiological terms--heart rate, blood pressure, oxygen metabolism, etc.--we are doing no more than Pavlov did seventy-five years ago when he converted the state of hunger to a quantitative record, drops of saliva.

What is to be done?

Given the structure of the nervous system and the lack of a basis for a science of the internal universe comparable to the science of the external universe, it is hardly likely that we can ever develop such a science. We then must make what pragmatic use we can of the science that we have.

But if one chief goal of science is to comprehend the nature of the biology of our subjective life we should understand the differences in the study of the external universe compared with the internal universe. Such a point of view will not blind us to the pragmatic value of science, of the wonders revealed by science, of the adventures ahead into the Unknown, of what is knowable and what is unknowable.

In conclusion, we must assess the inadequacy of our present science of the external universe for the complete study of the internal universe, of consciousness and our various subjective states. And despite our misgivings, we shall face all the universe, the external and the internal, with an open mind and the spirit not of despair but of adventure.