god of physicists of the nineteenth century. This analogy between God and ether as a logical concept is very deep indeed. The development of the ether theory followed precisely the same lines as the development of the idea of divinity. In primitive physics ordinary crude substances forming "ponderable bodies" were distinguished from certain divine bodies, imponderable substances like the caloric, electric and magnetic fluids and finally the ether, which were responsible for all the other properties outside gravity, just as in primitive religion the ordinary mortal beings were opposed to divine or immortal beings. Then in physics we had a gradual fusion of various divine imponderable substances to one divine substance, which was the ether, just as in religion we had a fusion of small deities into one big deity, whose properties are defined in the above ode. In physics the process did not stop here but continued (as by the way it is being continued in religion). It did not stop with the electron theory of Lorentz, where the ether was actually stripped of all its physical properties and reduced to the rôle of Newton's "absolute space remaining at rest." This idea of the ether corresponds to the idea of the perfectly neutral God in modern "deistic" religions.

Finally Einstein threw the ether overboard, and through this "atheistic" act opened the way to the discovery of his relativity theory. In his revolutionary step Einstein was helped very much by Michelson's experiment. In trying to measure the velocity with which light was propagated with respect to the ether, which was supposed to fill all space and which in Lorentz's theory was supposed to be at rest, Michelson found that this velocity remains the same in all directions, irrespective of the alleged motion of the earth through the ether, and this result was the starting-point of Einstein's researches that led to getting physics freed from the ether.

We must not be overthankful to the ether, and keep it in spite of the fact that it is no longer useful. It is rather a nuisance, for it interfered with the development of the true theory. Those who were used to think of physical phenomena in terms of the ether theory, *i.e.*, of the theory that physical actions were propagated through ether, were confronted with extremely difficult problems which could not be solved.

From the point of view of the ether theory, astronomical phenomena pointed to the fact that the earth was moving with respect to the ether while terrestrial experiments pointed to the opposite fact that the ether was dragged along by the earth and physicists were at a loss how to reconcile this contradiction. This problem was, however, a purely fictitious one, like many problems discussed by medieval scholars; for instance, those referring to the properties and behavior of the devil. Some said the devil had a tail, others that he did not. Then there was the issue: if he had a tail he must show it, whereas according to the protagonists of the anti-tail theory it has never been seen. But the representatives of the other point of view retorted that the devil concealed his tail so well that it could not be seen. Exactly in the same way argued the protagonists of the ether.

If Michelson failed to discover motion of the earth through the ether, *i.e.*, the drift of the ether with respect to the earth, then said these people, this meant that the ether produced such a longitudinal contraction in the earth and all the terrestrial bodies that its drift could not be observed.

Einstein was the first to recognize that all these difficulties were fictitious, because the ether, like the devil, was not a real object but a product of human imagination which was helpful for some time in the development of physics but detrimental for further progress of science, and he accordingly threw it overboard.

PHYSIOLOGICAL TIME

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PHYSICAL time, which is measured by a clock, obviously differs from the time which we live. Time is as much a constituent of ourselves as space. Body and consciousness are a history. Existence is identical with duration. This inherent time can not be reduced to psychological time, which consists of the succession of our states of consciousness as consecutive instants. According to the Bergsonian view, these states of consciousness are only instantaneous pictures which stand out against a continuously streaming background. But our duration is certainly much more than the flux of our inner life. It comprehends the whole organism. Mind and body are two aspects of a single thing. We are composed of structural and functional, as well as of psychological changes. The time which we live includes both physiological and psychological times. It is measured in hours, days and years, and assumed to flow evenly, inexorably and at the rate of solar time. Such a supposition is convenient, but its truth should be questioned. Even at a superficial glance, physiological time does not seem to pass at a constant rate through

the frame of physical time. It is a matter of common knowledge that real age differs from chronological age. The value of a year is not identical for short-lived and long-lived animals. Moreover, within a single individual such value seems to vary. Time is said to flow more quickly in old age than in youth. Our duration, then, appears to be independent of physical time. It differs from that measured by a clock, because its substratum is physiological and not physical. If the motion of the sidereal bodies and of the clocks of the earth were simultaneously retarded or accelerated, physiological time would not vary. Each human being constitutes a relatively independent world in a state of continuous transformation. It is the rate of this transformation which can be assumed to characterize our specific duration.

The living organism undergoes two classes of changes: rhythmical and reversible, or progressive and irreversible. These changes are as indispensable a part of the body as the tissues and organs described by the anatomists. Anatomy, to use a definition of Woodger, studies the organism in timeless space. Such a study is imposed by methodological necessity. Its object is not the concrete body, but only an artefact. An organism deprived of duration is just as unthinkable as if deprived of spatial extension. Dead organs and histological sections are nothing but useful abstractions. The body really consists of a flux of structural and functional processes, that is, of an uninterrupted modification of tissues, humors and consciousness. Such is physiological duration. The process of aging starts simultaneously with embryonic life. It is expressed by irreversible changes progressing during the entire span of our existence. The decrease in the rate of growth during infancy and youth, the occurrence of puberty and menopause, the lowering of basal metabolism and the modifications of the skin and hair, etc., appear as the stamp of time on the organism. Most of these phenomena either occupy a relatively short period of our duration or are not susceptible of sufficiently precise measurement. Fortunately, other physiological and chemical processes taking place in tissues or in blood plasma have been found to be measurable during a considerable part of the life span. When small fragments of tissue are removed from an animal and placed in a medium practically deprived of nutrient substances, they manifest some activity and for a few days increase in size. The length of the period of growth and the velocity of the process can easily be ascertained. They express the residual growth energy of the tissues. In an embryo, this residual energy is greater than in a new-born animal. It continues to decrease during youth. But the aging of the organism can not be traced during the whole life by this method because the differences in the growth energy of the tissues of adult and old animals are too small to be accurately detected. Moreover, each type of tissue appears to record time in its own way. A more definite effect of time on living structures is observed when one studies the variations of the rate of healing of a wound in function of the age of the patient. As is well known, the progress of the cicatrization of a wound kept in a sterile condition can be calculated by du Noüy's equation. This equation contains a constant which depends on the size of the wound and on age. After the size of a wound and the constant of cicatrization have been experimentally determined, the age of the patient is easily found. A table established by du Noüy shows the corresponding age for a given size of the wound and a given index of cicatrization. The human beings used as standards belonged to the same race, were in excellent health and lived under identical conditions. Thus, it became possible to ascertain whether an individual is older or younger than his age. This method has given us, for the first time, a means of measuring the passing of physiological time. Unfortunately, it is not practical because it requires the presence of a wound. Moreover, during middle and old age, the differences in the rate of cicatrization become too small to be accurately recorded.

These changes in the growth energy of tissues in function of age are obviously related to simultaneous changes of the humors. The tissues and organs of the body and the interstitial fluids and blood plasma in which they are immersed constitute a relatively closed world. No part of it can undergo any modification without affecting the other parts. While the growth energy and the regenerating capacity of tissues decrease, the functional state and the chemical composition of blood plasma show parallel variations. These variations are irreversible, progress during the entire life and are measurable. Blood serum has been found to possess the property of restraining, under certain conditions, the growth of pure cultures of fibroblasts. The ratio of the area of a colony living in serum to that of a similar colony living in saline solution is called the growth index of the serum. The smaller the index, the greater the inhibiting effect of serum. The serum of a dog a few days old has no inhibiting effect. Its growth index is equal to unity. Soon, it begins to restrain cell multiplication. The growth index decreases very rapidly during the first months of life, more slowly during youth and generally reaches a very small value during maturity. In old age, the variations from year to year are hardly measurable. Although such procedure is only roughly approximate, it has brought to light an important phenomenon: the existence of an irreversible change

in blood plasma which develops from the beginning to the end of life. It has also rendered possible the expression of duration in units of physiological time, and the measurement of the rate of aging of a given animal during practically its whole existence. Should an attempt be made to rejuvenate such an animal, the result of the treatment could be ascertained by the value of the growth index.

The inhibiting effect of serum on cell multiplication is due to the presence of proteins and of lipoids. The serum proteins of a new-born animal do not restrain the growth of colonies of fibroblasts. But their concentration increases as age advances and their nature becomes modified. They rapidly acquire their growth-restraining power. But it is chiefly to lipoids that the inhibiting property of serum must be attributed. These substances increase in quantity and change in quality during life. In old age, they are responsible for the toxic effect on tissue cells which serum manifests *in vitro*. These alterations in the chemical composition of blood plasma can be considered as causing not only the decrease in the value of the growth index, but probably also that of the index of cicatrization in du Noüy's formula.

It is a striking fact that both the index of cicatrization and the growth index of blood serum undergo at the beginning of life a rapid decrease which later becomes slower. The curves representing these indexes slope downward very sharply during youth. At the end of adult life, they are almost horizontal. Therefore, old age may extend over a very long period, when premature senility of some essential organ does not occur. Evidently, the physiological processes responsible for the phenomenon of aging do not advance at an even rate during the whole life. They are far more rapid in infancy than in senescence.

Such processes are the substratum of duration. Their characteristics are those of a stream of organic states which ceaselessly blend with one another in the same manner as the states of consciousness constitute our psychological duration. Physiological time is part of the body, while physical time is foreign to it. The present of a living organism does not pass into nothingness. It never ceases to be, because it remains in the memory and is entered in the tissues. Bergson has clearly shown how the past persists in the present. The body is obviously made up of the past. While the present glides into the past, it seems to assume a spatial form. During development, an animal extends simultaneously in time and in space. Temporal extension is absolutely indispensable to spatial extension. Growth is unthinkable except along one temporal and three spatial axes. In this manner, time is given a spatial representation and considered as a fourth dimension. But such a convenient assumption is probably not accurate. In fact, each spatial dimension also contains temporal elements. At every point of the living things created in space by time, space and time are indissolubly united. Biologists should have conceived long before Einstein and Minkowsky that space and time are not separate entities but constituent elements of a four-dimensional continuum. However, while the organism is evidently located in space time, consciousness can not be completely described within these particular four dimensions.

Physical time flows at a uniform rate. When referred to it, physiological time differs in value from individual to individual, and also from one period to another of the life of a single individual. A unit of physical time may contain larger or smaller amounts of physiological time. It is far richer in organic and neurological events during infancy and youth than during adult and old age. Our duration does not flow at an even rate.

The passage of physical time is inexorable and irreversible. No one can think of controlling it. Physiological time also moves irresistibly. But, owing to the nature of its substratum, it possesses the relative imprecision and variability which characterize biological processes. In recording time, the living organism is far less accurate than an astronomical clock. The rate of its duration may fluctuate. If pathogenic factors happen to modify some of the organs and alter the chemical composition and the physical conditions of the humors, aging becomes accelerated. Physiological time has been found to be not quite inexorable. In lower organisms, its rate can be artificially modified. By drying a rotifer, one may temporarily stop the stream of its duration. On the contrary, when Loeb increased the temperature of the environment of *Drosophila melanogaster*, these flies aged more rapidly. As the organism of the warm-blooded animals is comparatively independent of the outside world, an artificial modification of the processes on which aging depends is a difficult undertaking. However, it would certainly be possible to discover what physiological and psychological disciplines should be offered to human beings in order to increase the span of their life. On the contrary, the problem of rejuvenation, if this word is taken with its full significance, appears to be insoluble. The reversion of physiological time would require a method capable of replacing tissues and humors in the structural and functional state of an earlier life period. Such a method has still to be discovered. It goes without saying that no senescent organism has ever been rejuvenated by the procedures of Steinach and Voronoff. So far, the process of aging remains irreversible.

Physiological duration depends entirely on the presence in the universe of organized living matter. It appears as soon as a portion of space containing metabolizing things becomes relatively isolated from the surrounding world. At all levels of organization, in the body of a minute cell as well as in that of an elephant, the cause of duration seems to consist of the modification of their medium produced by living structures, and of the secondary changes undergone by these structures under the influence of the modified medium. Time is recorded by a cell community only when the metabolic products are allowed to remain around the tissue. The simplest artificial system which shows the phenomenon of aging consists of a colony of tissue or blood cells living in a medium limited in quantity. In such a system, the medium is progressively altered by the products of cell activity and, in its turn, reacts on the cells. Then aging and death take place. The rate of aging of a given colony depends on its size and metabolic activity, and on the volume and composition of the medium. The fate of a tissue differs profoundly according to whether it lives in a small drop of plasma in the limited atmosphere of a hollow slide, or in a flask containing a large quantity of plasma and gases. It is the accumulation of metabolites in the medium which determines the duration of the system cells-environment. If these metabolites are removed at short intervals and the composition of the medium is kept constant, the cell colonies remain indefinitely in a same state of activity. They do not record time qualitatively. In fact, they are immortal. In the simple systems which we have so far considered, the existence of the process of aging must be attributed to the capacity of the environment to be permanently altered by tissue metabolism.

The relations of the tissues and organs to their environment are infinitely more complex in the higher animals than in these artificial systems. Although lymph and blood plasma which constitute the *milieu intérieur,* to use an expression of Claude Bernard, are continuously modified by metabolic products, they maintain a nearly constant composition, owing to the work of the lungs, kidneys, liver, intestines, etc. However, in spite of such an elaborate regulatory mechanism, slow changes, as stated above, take place in the composition of plasma and, under the influence of these changes, the tissues themselves become modified. Such phenomena are bound to a certain constitution of the organism. The fact of duration necessarily depends on the nature and mode of association of the metabolizing elements of the body and of the *milieu intérieur.*

We may conclude that physiological time is a succession of irreversible changes of the system cells-medium; that it can be measured by the rate of these changes and expressed in special units; and that the fundamental constituents of duration are structural and physiological processes bound to a certain type of organization, and specific of each species, of each individual and of the age of each individual. As living organisms are immersed in the physical universe, their duration must either be placed in the frame of physical time or be used as a frame for physical time. In fact, physical time is referred to physiological duration. Then, an important phenomenon takes place: physical time loses its constant value. It extends during infancy, and contracts during old age. Let us suppose two trains starting with the same speed and running on parallel tracks. The first train represents physical time and moves at a constant speed. The second train, on which we travel, represents physiological time and moves at a decreasing speed. At the beginning, the first train remains immobile, because we run as fast as it does. Later, as we advance less rapidly, its speed increases. Finally, when in maturity and old age we slow down, the train symbolizing physical time acquires great velocity and flies away. In the same manner, one year is far longer for a child than for his parents. Young and old people, although spatially united, live in separate universes where the value of physical time profoundly differs. It does not appear that educators and psychologists have as yet realized the importance of the unequal temporal value of the successive periods of life. Although these inequalities are clearly shown only by the measurement of physiological duration, it is certain that they are also a datum of consciousness. During youth, one year seems to be very long, and in old age, very short. Both psychological and physiological times flow in the same direction. But their reciprocal relations remain as mysterious as those of consciousness and cerebrum. Physiological time has the advantage over psychological time of being measurable. Hence, a more complete knowledge of its nature can easily be acquired. Such a knowledge is indispensable to a real understanding of the constitution of the body, which is composed not only of organs, bones, lymph and blood, but also of duration.

OBITUARY

MEMORIALS

THE *Journal* of the American Medical Association reports that a medical and surgical building was completed at the Johns Hopkins Hospital, on November 6, giving the institution a capacity of about 1,000 beds. Half of the building, the Osler Clinic, was com-