

**AN EXPERIMENTAL  
STUDY OF  
SLEEP. [1909]**

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# AN EXPERIMENTAL STUDY OF SLEEP

(From the Physiological Laboratory of the  
Harvard Medical School and from Sidis' Laboratory)

BY

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## CHAPTER I

### *Introductory Remarks*

WRITERS on sleep complain that little attention has been paid to the subject, that it is sufficient to open a text-book on physiology to be convinced of the fact that the physiology of sleep is almost entirely neglected, inasmuch as the school-physiologist usually dismisses the subject with a few phrases, often quite general and devoid of meaning. It is quite true that while one cannot as a rule be satisfied with the imperfect state of textbook-physiology which usually lingers in the hind ranks of the battle-ground of science, still one cannot blame the text-books for avoiding such a delicate subject, the nature of which is so uncertain and so highly problematic.

In addition to the uncertainty of the subject of which the more conservative of school-physiologists fight shy, there seems to be an ill defined feeling which is not without some good foundation, namely, that sleep is not entirely a physiological subject, that sleep presents some very important aspects that need be taken into consideration which the

physiologist is unable to deal with by his usual methods and from his standpoint alone.

Moreover there may be another reason for the indifference of school-physiology to a subject which is otherwise of such a vital importance in the whole domain of animal life. Man is more interested in active than in passive states. It is therefore natural that the physiologist should devote his attention more to waking life than to sleeping states. Besides, physiology dealing essentially with activities and functions tends to ignore states which are usually regarded as the very acme of inactivity. With the advance however of biological, physiological and psychological sciences even states of passivity can no longer be ignored, — their conditions, causation and nature must be studied and closely investigated, especially if those states are found present throughout the ascending line of animal life. The conditions for the study of sleep become all the more favorable as we reach man. We find that sleep-states in man's life are no longer instable and taken by snatches, because the watchfulness requisite in wild-life under the constant strain of the struggle for existence no longer obtains. In man's life sleep-states become more or less organized, systematized and are no longer disturbed, — they alternate rhythmically with waking states. More than one-third of man's life is passed in sleep, — it seems that this fact alone should indicate the importance of sleep-states in man's cycle of biological and physiological processes and should arouse the interest of the scientific investigator. As a matter of fact some scientific thinkers have given the subject of sleep a good deal of their attention. Although text-book physiology passes over the subject with a few meaningless phrases, the literature of sleep is really very extensive. It may be well before we proceed with the exposition of our own observations and experiments on sleep to give first a brief review of the chief theories on sleep.

## CHAPTER II

### *Theories of Sleep*

FROM the very earliest times man wondered about sleep and attempted some explanation of it. It was supposed that in sleep the soul wanders away from the body and leaves it in a lifeless condition. Many of the savage tribes are on that account afraid to waken people lest the soul may be frightened away and not return at all to the body. That is why even at present we often hear the saying that sleep is the companion of death. On the other hand death is often described as sleep. On the same basis dreams were explained by the primitive mind,—the soul in sleep leaves the body and wanders away; on its wanderings the soul meets with all kinds of adventures and it is such experience that gives rise to dreams. In sleep the wandering soul, not encumbered by the gross body, can visit great distances in a short time and can even communicate with heavenly powers,—with angels and gods.

The impassive soul reluctant flies,  
Like a vain dream, to these infernal skies.

Modern spiritualists adopt this ancient belief in full or express it as "the release of human personality from the subliminal."

The scientific theories of sleep are numerous, but they can be reduced to a few main types. This reduction will help the reader to become oriented in the vast literature that has gathered about the subject. The theories of sleep may be classified as follows:

- 1) The Physiological theories, which may be subdivided into:
  - a) Mechanical  
and
  - b) Chemical
- 2) Pathological
- 3) Histological
- 4) Psychological
- 5) Biological



The mechanical theories are of the circulatory variety and are usually much favored by physicians,— they attempt to explain sleep by changes in the blood circulation of the cerebrum. As far back as the eighteenth century the theory of sleep greatly in vogue among the physiologists was— congestion of the brain favored by the position of the head. This view was entertained by Haller, J. Müller, Hartley and others. Cappie has somewhat enlarged on it, inasmuch as he ascribes sleep to the venous congestion of the brain. This congestion of blood was supposed to bring about pressure on the brain with the result of depression of all the cerebral functions. The great psychologist Hartley summarises the physiological theories of his time thus: "It appears then that during sleep the blood is accumulated in the veins and particularly in the venal sinuses which surround the brain and spinal marrow. . . . And it is agreeable to this that in most dissections after lethargies, apoplexies, etc., the venal sinuses of the brain and consequently those of the spinal marrow which communicate freely with them are particularly full. . . . It follows therefore that the brain and spinal marrow will be particularly compressed during sleep, since the blood then takes up more space, is particularly accumulated within the cavities of the skull and vertebrae, and the hardness of these bones will not suffer them to yield or make more room. . . . In short this compression will result in sleep." These generalizations were favored by observations on the famous case of the Parisian beggar whose injured skull gave the opportunity to observe the rise and fall of the exposed cerebrum in the waking or sleeping state. Recently Mosso claimed the same causation of sleep and on similar observations. As to the circulatory changes proper, two opposing views have been taken. Some, such as Durham, Cl. Bernard, Kussmaul Howell, Lehman, de Fleury ascribe sleep to cerebral anemia. Others again, such as Brown, Czerny, Broadman maintain that sleep is due to cerebral hyperemia. Claperede in reviewing the circulatory theories of sleep quotes Richer's apt criticism: "Sleep and waking states bring about all kinds of changes in cerebral circulation depending but little on the position of the head. Birds whose hemispheres have

been removed still present the same changes of sleep and waking. Biologically regarded, sleep is a far more general phenomenon than that of the presence of a brain irrigated by a blood circulation. Finally the activity of a tissue is not entirely dependent on the amount of blood circulating in it." There are however still more cogent objections to such theories of sleep, objections which clearly show the incongruence of the circulatory theories. We shall point them out further in our present study.

We may turn now to the chemical theories which are far more favored by the conservative physiologist, inasmuch as they fall in with what the physiologist regards as more scientific. With the experiments of Pettenkofer and Voit on the respiratory quotient new life was injected into sleep theories. Those two investigators have found the respiratory quotient  $\frac{CO_2}{O_2}$  is diminished during sleep. The tissues absorb relatively more oxygen during the day than during the night. This fact of the using up and impoverishment of blood of intermolecular oxygen started new life in the theories of sleep. Pflüger, Sömmer and others attempted to work out a scientific theory of sleep based on research of the bio-chemistry of the cell and the intermolecular activity of the oxygen-molecule or atom. Pflüger's authority lent vitality to this view so that even Heubel whose theory of sleep is really psychological in character tries to shelter it under Pflüger's physiological wings.<sup>1</sup>

With the chemical theories we pass by degrees into the pathological theories of sleep. Already in the early part of the nineteenth century Marshall Hall proposed the view that sleep was a kind of epilepsy. This view however met with little favor, because of lack of facts to support it. With the advance of chemistry and of its application to physiological research, and especially with the rise of the modern views of the rôle of autointoxication and toxins in diseases, the pathological theories of sleep were resuscitated under the new guise of autointoxication. Obersteiner and Preyer launched the theory that sleep was an autointoxication of the system by toxic matters accumulating in the blood, due to the

<sup>1</sup> We may possibly refer to Loeb's work on heliotropism and sleep of butterflies as an example of a purely bio-chemical view of sleep. See *Dec. Public Univ., Chicago, V. I.*

activity of the various tissues. Lactic acid was supposed to be the particular substance in question. Others such as Dubois ascribed the same state to the accumulation of carbonic acid. These were followed by a host of writers such as Binz, Errero, Bouchard, Breisacker and others. The toxic and autotoxic theories of sleep enjoy quite a wide popularity, because they fall in with the scientific notions of the age. Those theories would make of sleep a pathological state, but the facts are against such a view.

By the middle of the nineteenth century, when physiological experiments on nerve-conduction were at their height, Purkinje proposed the theory that sleep might be due to the interruption of neural conductivity between the cortical matter and the rest of the cerebrum. This view was further developed by Mautner, Warlomont, Oppenheimer and others. As a further modification of the same theory, but based on more fundamental physiological processes may be mentioned Verworn's theory which refers sleep and waking-states to processes of assimilation and dissimilation going on in the organism. At the same time with Verworn, Van Gieson and Sidis worked out their theory of sleep, basing it on similar processes, namely on anabolism and catabolism and developing the interrelation of waking and sleeping states with the symptom complexes of nervous and mental diseases. The theory of Van Gieson and Sidis is based on the variability of different levels of neuron energy. We may dismiss this latter theory in a few words as we shall discuss it in our study. We can only say here that the theory is essentially based on the concept of neuron-energy.

This brings us close to the famous theories of retractility of neuron-elements which have been of late utilized by many writers for various purposes. The development of the histology of the nervous system and especially of neuropathology have brought new life to the solution of the problem of sleep. The biological investigations of the cell by Kölliker, Remak, Nageli, Hoffmeister, Virchow, Max Schultze, Hertwig, Fol, Van Beneden, Strassburger, Heidenhein, Boveri and many others opened up new horizons for theories of cellular activities. Naturally the sleep theories