ART. VI.—*Sleep : Normal and Abnormal.*^a By E. H. C. ALLEN, B.A., Corresponding Secretary of the Dublin University Biological Association.

Introduction—Some of the greatest intellects of ancient and modern times from Aristotle downwards have been exercised by the problems of sleep, but such knowledge as we possess is of recent origin and is the fruit of the labours of a comparatively small number of workers. It is remarkable, in view of the fact that one-third of our lives is passed in sleep, that this condition did not claim more thorough investigation. From one point of view only did sleep notably attract the attention and interest of men; in dreams some anthropologists find the chief impulse to man's conception of his personality and to that of a general doctrine of spirits. The primitive man in his dreams finds himself engaged in activities similar to those of his waking life. He hunts, fishes and feasts, fights battles and braves dangers, and these visionary occurrences are to him just as real as the everyday occurrences which they faintly or vividly resemble. He learns from others that while these dream-adventures have been taking place his actual body has been lying motionless. He is thus led to a belief in a wandering double or other-self, which is temporarily absent in sleep and takes a final departure at death. Dreams of dead relatives and friends are interpreted as actual visitations of the ghosts of the departed and from this springs his idea of an after life. This dream-world is absolved from all limitations of space and time, and the secrets of the future may be revealed by good or evil spirits to him that can interpret his dreams aright. Throughout classic and mediæval literature we find a record of prophetic dreams, and that these tendencies have persisted to the present day among the more ignorant is evidenced by the circulation of numerous books on dream-interpretation. Lecky re-

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marked that the religion of one age becomes the poetry of the next, and certainly, whatever part sleep and its dreams played in moulding early religious ideas, it subsequently formed the theme round which poetic fancy was wont to roam untrammelled. Now, however, the poet must reckon with the physiologist and his plethysmograph. "Sleep, the twin-brother of Death," sings the poet; "the comparison, though picturesque cannot be justified," replies the physiologist, "for death implies the complete arrest of all the psychic and organic functions of the body, whereas in sleep the latter are operative and only a few of the psychic functions are suspended, the rest continuing to act with more or less modification." While the true nature of sleep cannot be determined until we have a more rational conception of what constitutes the actual physical basis of consciousness yet many instructive facts have come to light. The object of this paper is to deal, as briefly as possible, first with the physiology, and then with the pathology of sleep, referring in conclusion to some points in connection with its hygiene. The treatment of the psychological aspect of the subject is left, from consideration of space and personal ignorance, to some more capable pen.

PHYSIOLOGY.—"Sleep," wrote Schopenhauer, "is to a man what winding-up is to a clock." It is a period of anabolism, repair, and growth, during which the organism fits itself for renewed activity.

Onset—The state of sleep is one to which there is a periodical tendency, and in man and most animals the night, from its darkness and silence, is the natural period of repose. A feeling of fatigue or exhaustion is usually experienced when the waking activity has continued during a considerable portion of the 24 hours—a feeling that the brain requires rest. The attention wanders; yawning occurs; the eyelids become heavy and the sight blurred; the muscles relax and the head tends to fall forwards on the breast. The sense of sight is lost first, that of hearing last. The onset of sleep is sometimes

quite sudden, the individual passing at once into a state of torpor, but usually the transition is gradual and the mind remains for a variable period in a sort of "No man's land" between sleeping and waking.

Changes in the organism—What changes in the organism are associated with sleep? The eyelids are lowered, and the eyeballs turned upwards and inwards, the pupils being contracted. Voluntary muscles are relaxed, except the sphincters. There is a general diminution in the body metabolism as shown by the reduced output of CO_2 . The character of the respirations alters; they become slower and shallower. The respiratory exchange is diminished. The inspiratory phase is more prolonged than in the waking state, and the thoracic type of breathing predominates over the abdominal.

Vascular system—The changes in the vascular system are of particular interest. Dr. Leonard Hill wrote:—"The vaso-motor centre is the hub round which turns the wheel of a man's active mental life." During sleep the heart beats more slowly and less forcibly, the peripheral vessels dilate, and the blood pressure diminishes. Sleep, however, is not a permanent or invariable state, but is subject to modifications by many factors, *e.g.* its duration, the time of the night, the character of the dreams, and the state of the organism generally. Variations occur in the volume of the thorax, abdomen, and limbs. Mosso's plethysmographic experiments demonstrated the enlargement of the limbs. More recently Howell has determined variations in the volume of the arm, observing that, from the moment the subject of the experiment closed his eyes and endeavoured to go to sleep, an increase in the volume of the arm within the plethysmograph was registered. With the onset of sleep the volume increased continuously and fairly regularly for $1-1\frac{1}{2}$ hours, when it reached its maximum extent. This level was maintained for an hour or two, with certain rhythmic variations, and then the volume of the arm gradually diminished until about half an hour before final

conscious waking, when its rate of diminution became much accelerated. These phenomena are due to a diminution in the tone of the vessels of the arm leading to vaso-dilation, mainly of the cutaneous vessels. Similar changes occur in the peripheral vessels elsewhere over the general cutaneous surface of the body with the result that the arterial blood pressure falls. Since the amount of blood supplied to the brain is generally stated to be proportional to the velocity of the cerebral circulation, which in turn depends almost entirely on the general arterial pressure obtaining in the body, it follows that a fall in the blood pressure must entail a corresponding diminution of the cerebral blood supply. If this be so, Howell's observations must be interpreted to mean that during the period preparatory to sleep the blood-flow through the brain begins to diminish in quantity, and continues to do so for an hour or more after the onset of sleep; that after reaching its minimum the cerebral circulation, with temporary variations, remains nearly constant for one or two hours, perhaps longer, and then the amount of blood flowing through the brain increases in proportion to the rise in blood-pressure produced by the gradual recovery of tone in the peripheral vessels; and that this process becomes much more rapid just before waking, when the condition approximates closely to that prevailing before the onset of sleep. The association of cerebral anæmia with sleep is directly opposed to the older idea that during sleep the brain is in a condition of congestion and that the pressure of the blood by some means induces a state of repose. There is, however, further evidence to show that the older theory is erroneous. At a meeting of the British Association at Oxford in 1860, Durham gave an account of some instructive experiments carried out at Guy's Hospital. Among other things he said:—"A dog having been chloroformed, a portion of bone, about as large as a sixpence, was removed from the parietal region of the skull by means of the trephine; the subjacent dura mater was cut away and the surface of the brain exposed. As long as the animal continued under

the influence of chloroform, the smaller vessels of the pia mater were turgid with dark-coloured blood, and the larger veins were considerably distended. No difference in colour between the arteries and veins could be recognised. The exposed portion of the brain manifested a tendency to rise into the opening through the skull. By-and-by the immediate effects of the chloroform passed off, and the animal sank into a comparatively natural and healthy sleep. A very marked change in the appearance of the brain accompanied this change in the state of the animal. As sleep supervened, the vessels gradually emptied themselves; the veins ceased to attract notice by their distension; the exposed surface of the brain sank down to, or below, the level of the opening, and became pale in colour. In the course of a short time the animal was roused and irritated. A blush seemed to start on the surface of the brain; the vessels of the pia mater became fuller and fuller, and of a bright arterial hue. The contrast between the appearance of the brain during this state of functional excitement and the previous state of quiescence was most striking. The more the animal was excited, the fuller of blood did its brain appear to become, and the higher did the exposed portion rise above the general level. When the animal was allowed to return to its state of repose, the brain again sank down, and resumed its pale aspect." Further observations on this point made on subjects whose brains had been exposed by injury go to show that cerebral anæmia is a concomitant of sleep, and that the brain assumes a rosy hue and rises in the wound at the moment of waking. Mosso took graphic records of such cases, observing that the volume of the brain diminished during sleep, but that every stimulus, such as a sudden noise or light, though insufficient to awaken the sleeper, disturbed his repose and occasioned an increase in the volume of the brain. The same investigator placed a subject horizontally on a delicately poised balance, and found that on the appearance of sleep, the subject's head began to rise and his feet to sink, indicating that blood

must have left the head. The inclination of the body seemed to be proportional to the depth of sleep. Hooker states that in sleep the veins exhibit a pulse of peripheral origin, which lends very strong additional support to the experimental observation that the peripheral arteries of the skin are dilated. Brush and Fayerweather found that the blood-pressure in the wrist arteries falls during the first two hours of sleep, and then gradually rises up to the time of waking, and that the maximum intensity of sleep corresponds with the minimum blood-pressure. Shephard, on the other hand, contends that the volume, not only of the peripheral parts, but also of the brain, increases during sleep and decreases on waking. He says there is sometimes a temporary fall of the brain volume preceding the more marked rise which ushers in deeper sleep; that stimuli which disturb, but do not awaken, the subject cause a fall of volume of the brain and peripheral parts; and that changes in brain and periphery are always parallel or very nearly so. According to this observer the cerebral blood-supply does not vary passively with changes in the general blood-pressure, but there is actual constriction and expansion of the cerebral vessels themselves. Thus, while the evidence for the existence of peripheral hyperæmia in sleep is conclusive, some authorities, though a very small minority, refuse to admit that this condition is accompanied by cerebral anæmia.

Internal organs—The internal organs share in the general slowing-down of the body-metabolism, and it is probable they are more or less anæmic on account of the peripheral vaso-dilatation. The degree of activity of the stomach, intestines, and kidneys during sleep bears an obvious relation to the subject's habits. Food-assimilation does not necessarily modify sleep and it may even have a soporific effect. The boa-constrictor manages to sleep well during the arduous process of digestion. The general tendency is for the kidneys to secrete less actively, though this condition is by no means invariable. Secretions in general are diminished in amount, with the exception of sweat, which is more actively secreted during

sleep on account, possibly of the cutaneous hyperæmia. The greater functional activity of the sweat-glands reduces the amount of work to be done by the kidneys.

Temperature—Less heat is produced during sleep, on account of the passivity of the voluntary muscles and the diminished glandular activity, while heat loss is increased by sweat evaporation and the distribution of the blood near the body surface, consequently the temperature may fall from 0.5° to 1.0° F.

Nervous system—Sleep, then, does not entail arrested, nor necessarily even enfeebled, activity on the part of those internal organs already considered, but what is the state of the nervous system, central and peripheral? Preparatory to sleep men and animals attempt to avoid all peripheral stimulation by seeking quiet and seclusion. The impulses which reach the higher centres must be reduced to a minimum, hence light and noise act as disturbing factors. Lombard found that sleep exercised a depressing effect on the knee-jerk, and observed that a dream of active movement was associated with a very violent knee-jerk, a fact which points to a certain amount of cerebral activity making itself felt throughout the body even during sleep. Noyes caused the ligamentum patellæ of a demented patient to be tapped every 5 seconds, and a graphic record showed that during quiet sleep no response was elicited, but that the application of any stimulus, though insufficient to awaken the sleeper, led to the production of a series of kicks. Experiments by Rosenbach in 1881 showed that reflex-excitability is weakened during the initial period of light sleep, while in deeper slumber the abdominal, cremasteric, and tendon reflexes are abolished, though the tickling of sensitive areas of the skin causes response even in the most profound stage. He held that the active contraction of the sphincters during sleep is due to direct cerebral influence, because if sleep were a cerebral paralysis, the spinal reflexes, instead of being weakened, would be increased as in decerebrated animals. Tarchanoff investigated the state of the cerebral cortex, the afferent nerves, and the spinal cord in

sleeping puppies. His results show that the cerebral cortex ceases to react readily to electrical stimulation, which in the waking condition was sufficiently powerful to excite pronounced muscular reactions. Moreover, when the animals were subjected to auditory, luminous, or tactile stimulation flushing of the brain and increase in its volume were observed, clearly indicating the persisting activity of the afferent nerves, even though the impulses conveyed by them were not registered in consciousness. It can be shown, also, that the efferent nerves are able to transmit impulses during sleep. A sleeper may be observed to brush away an irritating fly or to assume a more comfortable position; he may talk and even answer questions. The somnambulist leaves his bed and engages in the most various occupations. Börner tried the experiment of placing a heavy coverlet over the faces of persons in deep sleep; without awaking the sleeper always removed the impediment. Soldiers have frequently been observed to sleep during forced marches, a well-known instance of this occurring during the retreat of Sir John Moore to Corunna. It is evident, therefore, that sleep is not incompatible with activity of the voluntary muscles and their associated nerves, and one must assume, also, that the portion of the brain, whence the motor impulses proceed, functionates when deliberate movements are executed. Tarchanoff divided the spinal cord above the lumbar region in puppies, and, after they had recovered from the operation, compared the effect of electrical stimulation of the hind- and fore-paws during sleep. He found that the reflex movements of the hind-paws, innervated by the portion of the cord caudal to the point of section, were the same as during the waking state, but that the response of the front-paws in nervous connection with the cephalic part of the cord and the brain, was decidedly less, from which he argued that the brain during sleep exerts an inhibitory action on reflex movements. Moreover, the occurrence of dreams can be explained only by the continued activity of those cerebral centres concerned with the reception and storage

of impressions derived from the sensorium. Partial cerebral activity, then, is not incompatible with sleep. The brain is affected by impulses from the special sense organs, although the sleeper is not fully conscious of them and does not awake; in cases where it is exposed through cranial injury its volume is seen to increase during dreams and it may even rise above the level of the edges of the wound. It has been stated that it is the attention and will that sleep; but, if so, how is it possible to explain the ability to awake at a fixed hour, or at some given signal which would otherwise be inadequate to arouse us? Surely this must imply some exercise of attention and will! The activity of consciousness is dependent on a constant stream of sensory and mental impressions, which must attain a certain intensity in order to be registered in consciousness. It seems as if what might be termed the "threshold value of consciousness" were raised during sleep, so that stimuli to be adequate must considerably exceed in strength those which would be effective in the waking condition. Sleep is the resting-time of consciousness, but there are obviously many states of unconsciousness which are not normal sleep—even though some of them are associated with cerebral anæmia; hæmorrhage, extreme cold, anæsthetics, hypnotic suggestion, compression of the carotids, or a blow on the head may produce loss of consciousness, but in so far as this condition is unaccompanied by recuperative changes in the central nervous system it differs from normal sleep.

Intensity of sleep—The measurement of the depth of sleep depends upon the persisting activity of the nerve-paths and their corresponding cerebral centres. The principle of all the methods employed is the determination of the intensity of the stimulation required to arouse the sleeper at different periods during normal sleep. The dropping of a metallic substance on a metal plate from varying heights has been frequently employed for this purpose. The results obtained show that the depth of normal sleep increases during the first and second hours,

and then gradually decreases with more or less regular fluctuations. Moreover, each awakening is followed by an increased intensity of sleep, an effect observed also after a definite weakening of sleep, which stops short of complete awakening. Using an induction coil Howell recorded his own curve of sleep-intensity by measuring the strength of the current necessary to arouse him, and found that the maximum was reached in the first hour or so.

Theories of sleep—Special organ theories—In the endeavour to explain the phenomenon of sleep many and various theories have been propounded from time to time. Some authors have assigned localised causes. It was suggested that the thyroid gland was the organ of sleep on the ground that it acted as a vascular “shunt” for the cerebral circulation, and that it was congested and enlarged during sleep. Osborne credited the arachnoid plexus with being the sleep organ, and stated that during sleep it secreted cerebro-spinal fluid sufficient to produce considerable distension of the ventricles of the brain. Purkinje supposed that cerebral congestion compressed the nerve-bundles, thus interrupting communication between brain and periphery. Increase of knowledge has shown that these theories are untenable. The vaso-motor theory found greater favour for it rested on a more solid basis.

Vaso-motor—Reference has already been made to some of the evidence for the association of cerebral anæmia with sleep, but many additional observations lend confirmation. The scalp covering the anterior fontanelle in young infants is depressed during sleep and elevated during wakefulness. Weir-Mitchell and Hammond, working independently, found that cerebral anæmia precedes sleep, a fact which seems to indicate that it is at least a factor in its causation. It is a common observation that the escape of cerebro-spinal fluid from the ears in cases of fracture of the base of the skull is much greater in the waking hours than during sleep, and such a condition is irreconcilable with the theory of venous

stasis in the brain. Moreover, somnolence is produced by any circumstances which diminish the cerebral blood-supply, *e.g.* the action of heat, excessive hæmorrhage, or the process of digestion. Reference has already been made to Howell's views. He holds that the factors which lead to normal sleep are:—Diminution of irritability, caused by fatigue, of large portions of the cortical area; voluntary withdrawal of sensory and mental stimuli; and cerebral anæmia due to relaxation of tone of the vaso-motor centre and fall of blood pressure. Hill, another supporter of the vaso-motor theory, believes that the regulation of the cerebral blood-flow is effected through the control of the splanchnic, not the peripheral, area.

Chemical theories—Some investigators favoured a chemical explanation of the causation of sleep. The cerebral-asphyxia theory supposes that sleep is due to oxygen deficiency in the brain following on exhaustion of the reserve oxygen of the body, and rests mainly on the fact that oxygen absorption is greater by night than by day. Since less oxygen is required during sleep owing to decreased metabolism it would seem as if some of it were accumulated for utilisation during a more active phase. Preyer holds that sleep is due to the accumulation of fatigue products in the blood, and that these, being easily oxidisable substances, absorb the oxygen required by the brain for its continued activity. He found that the injection of lactic acid, a normal fatigue-product, caused sleep. Pflüger suggested that the formation of CO_2 produced a series of violent oscillations in the surrounding atoms and that these vibrations are necessary for the maintenance of the tissue activity, sleep being the result of a diminution of CO_2 formation in the brain. Professor Errera of Brussels defines sleep as “a physiological intoxication” due to the accumulation of leucomaines or poisonous alkaloids in the tissues. He says that work necessarily involves chemical breaking-down, and that the products, including leucomaines, are carried by the blood to the brain, where they at length produce sleep. During activity more leucomaines are formed by the breaking-

down than oxidation can destroy, but during sleep they are destroyed and carried away. This theory was opposed on the ground that over-fatigue prevents sleep, but Errera urged that the effects of toxic substances vary according to the dose, and while in small doses they can produce sleep, in larger quantities they sometimes cause excitement.

Histological theories.—Some histologists have attributed sleep to the interruption of communication between neighbouring neurons caused by the retraction of their nerve-processes, while others suppose its explanation to be found in the establishment of more extensive mutual relations between the arborisations of the various neurons, with the result that impulses are, as one might say, lost in a labyrinth of nerve-paths and never succeed in reaching the higher centres at all. Ramon y Cajal endowed the neuroglia with amoeboid characters in virtue of which it can extend pseudopodia between the nerve elements and interrupt or impede the transmission of impulses.

Consideration of these theories.—None of these theories is satisfactory. With regard to the vaso-motor theory one might quote Crichton Browne's remark that "the blood vessels were made for the brain, not the brain for the blood vessels." The advocates of the fatigue-product theory do not explain why sleep can be produced by mere boredom or monotony in the absence of all fatigue; while until the histologists compose some of their own more obvious differences they cannot expect to make many converts.

Loss of sleep.—Deprivation of sleep entails far more serious consequences to the organism than does deprivation of food. This was recognised in China, where it was employed as a form of torture and even as a method of capital punishment, and it is difficult to understand how Girondeau in 1886 characterised sleep as "a useless, foolish, and even hurtful habit"! Direct experiments on animals, which have been deprived of food for 20 days and have lost half their weight, show that they may

recover when treated with suitable precautions; while puppies, provided with adequate nourishment, but prevented from sleeping for 4-5 days, died in spite of every care. The puppy deprived of sleep for 3-4 days was in far worse case than one that had passed 10-15 days without food. In starvation the brain and nervous system are the last parts of the organism to suffer, while deprivation of sleep seems to act primarily on the cerebral centres, in which it provokes pathological changes. Patrick and Gilbert in America experimented on three University teachers, who were kept awake continuously for a period of 90 hours. One of the subjects suffered much from sleepiness during the second night, but not nearly so much the third night. He experienced particularly hallucinations of sight, the air seeming full of dancing particles, coloured red, purple, and black, which he tried to catch. He had never had hallucinations before and they disappeared completely on the conclusion of the experiment. All the subjects exhibited an increase in weight, followed by a decrease after sleep. The dynamometer indicated a steady decrease in muscular strength; the reflexes, except in one case, became slower. It is remarkable that the sense of sight grew more acute in all three, but fell below normal after sleep. Memory was very defective and the power of attention exceedingly feeble. Complete restoration was effected by making up about 35 per cent. of the sleep lost, which is possibly accounted for by the greater depth of the resulting slumber.

PATHOLOGY.—Pathological changes affecting any organ in the body are associated with either defective or exaggerated functional activity. Insomnia and excessive sleep are the outward and visible signs of inward and pathological conditions.

Insomnia.—Cases of complete insomnia, unless relieved quickly, terminate in death. Patients who assert that they are entirely without sleep are usually suffering merely from insufficient sleep, not absolute insomnia. Sleeplessness results from any cause producing cerebral hyperæmia,

e.g. excessive intellectual labour, anxiety, and various emotional conditions. Undue physical exertion, also, may act in the same way, and is possibly accounted for by the more forcible action of the heart. On the other hand there is experimental evidence to show that extreme cerebral anæmia and great diminution in blood pressure lead to insomnia. Sleep is the resting-time of consciousness and it is interesting to note that the most intractable form of sleeplessness is found in mental disorders characterised by a doubling or division of consciousness. The general fatigue of consciousness is in these cases nearly impossible for it only grows weary and sleeps in part. The insomnia of neurasthenia may possibly arise from a certain lack of unity of consciousness in the victims of this disorder, whose opinions and convictions, sympathies and antipathies, are liable to undergo sudden and frequent changes. Discomfort and physical pain render sleep impossible, for consciousness, played upon by a continuous stream of painful stimuli, cannot rest.

Rational treatment of insomnia—It is doubtful how far artificially induced sleep is really conducive to the restoration of exhausted tissues. A certain antagonism would seem to exist between the action of soporific drugs and of sleep, for otherwise it is hard to explain why the habitual use of such drugs should lead to the loss of the power of normal sleep. In the treatment of mental, just as in that of bodily pain, rest must be obtained, if not by natural then by artificial means. In dealing with persistent insomnia, rational treatment should first be employed, and only when this fails may recourse be had to drugs. Good results frequently follow proper attention to hygienic conditions, baths, cold compresses to the head, electricity and massage to the head, neck and spine, and any modification in diet that may be indicated. Since normal sleep demands cerebral anæmia the patient should avoid all source of excitement during the evening. A light supper may be useful in producing hyperæmia of the digestive organs, but an overburdened stomach tends to produce nightmare. Broadbent recommends the

placing of a hot bottle under the neck and the use of aperients even if the bowels are free. The influence of constipation on the general health, and particularly on the nervous system, has long been common knowledge. Voltaire advised that before asking a favour of a minister "we should adroitly ascertain whether his bowels are acting freely." The influence of monotonous sensations in inducing sleep are referred to by Southey in "The Doctor." "I listened," he says, "to the river and the ticking of my watch: I thought of all the sleepy sounds and of all the soporific things—the flow of water, the humming of bees, the motion of a boat, the waving of a field of corn, the nodding of a mandarin's head on the chimney-piece, a horse in a mill, the opera, Mr. Humdrum's conversations, Mr. Proser's poems, Mr. Laxative's speeches, Mr. Lengthy's sermons. I tried the device of my childhood and fancied that the bed rushed with me round and round. At length Morpheus reminded me of Dr. Torpedo's Divinity Lectures, where the voice, the manner, the matter even the very atmosphere and the streaming candle-light were all alike soporific; when he, who by a strong effort, lifted up his head and forced open the reluctant eyes, never failed to see all around him asleep. Lettuces, cowslip wine, poppy syrup, mandragora, hop pillows, spider's web pills, and the whole tribe of narcotics, up to bang and the black drop, would have failed—but this was irresistible; and thus, 20 years after date, I found benefit from having attended the course."

Excessive sleep.—A feebly developed consciousness is easily and quickly fatigued, hence those in whom it is found require a great amount of sleep. Children, savages, cretins, and people of inferior intelligence fall asleep as soon as they have no occupation. A similar tendency is observed in some diseases, *e.g.* anæmia and myxœdema. Again diminution of sensibility to exteroceptive impulses entails necessarily some enfeeblement of consciousness. A case is quoted by Strümpell of a youth of 16, blind of one eye and deaf of one ear, who suddenly developed

complete cutaneous anæsthesia. By closing the sound eye and stopping the healthy ear no impressions from without could reach his brain, nor could he furnish sufficient images or ideas from within to maintain consciousness in a state of activity, with the result that he fell into a deep sleep. The tendency to sleep seems to be increased whenever there is a more or less pronounced enfeeblement of consciousness, whether this weakening depends upon abnormal substances circulating in the blood, the cutting off of exteroceptive impulses, or general exhaustion of the organism following disease or malnutrition.

Hibernation—The hibernation of certain animals such as bats, marmots, and hedgehogs presents many features of interest. These animals fall asleep with the advent of cold weather and remain so until the following spring. Their metabolism diminishes greatly, the respiratory exchange and quotient being lowered. The heart's action becomes slower and feebler, and Cheyne-Stokes' breathing frequently occurs. The muscles assume a condition of semi-rigidity; the temperature falls, but always remains higher than that of the surrounding air. At the beginning of hibernation the animal's "fat depôts" are full, for during the winter-sleep it must be self-supporting and live on its own tissues; on awakening it is emaciated and voracious. If the animal be protected from fall of temperature hibernation does not occur. The overpowering and irresistible desire to sleep that afflicts polar explorers and others who are exposed to extreme degrees of cold is notorious. Hibernation, however, is a self-protective mechanism which enables an animal to live through a season when food might be unprocurable with the minimal amount of tissue-waste, while the man who yields to the desire for sleep induced by extreme cold wakes no more. There appears, then, to be nothing in common between the two cases except that cold is the exciting cause. Instances of prolonged sleep in human beings, however, are not uncommon, and develop sometimes in consequence of considerable hæmorrhage,

painful emotions, or excessive fatigue, and sometimes without any discoverable cause. Sleep of this kind may last for days, weeks, or even months without intermission. The patient, as a rule, cannot be roused, and if he is awakened he soon relapses into slumber.

Narcolepsy.—During this condition of narcolepsy metabolism is decreased just as in hibernating animals, for the patient can subsist on little or no food or drink, though liquids introduced into the mouth are easily swallowed. Furthermore, a more or less pronounced cataleptic condition is generally associated with narcolepsy, producing a certain degree of muscular rigidity, and increasing the resemblance to the winter-sleep of animals. Blanchet, a French physician, has recorded the case of a lady, aged 24, who slept for 40 days when she was 18 years of age, and 50 days when she was 20, and at length had a sleep of nearly a year, *viz.* from Easter Sunday, 1862, to March, 1863. During this period a front tooth was removed in order to feed her with milk and soup, her only food. She was motionless and insensible. The pulse was low, the breathing scarcely perceptible, there were no evacuations, and she showed no emaciation, her complexion remaining florid and healthy throughout. A state such as this is not a prolongation of healthy natural sleep, but one of hysterical coma, and the victims of the disorder are nearly always of low intellectual development and feeble consciousness, or members of families possessing a history of nervous or mental disease. In another case of narcolepsy a man of 43 died after a sleep of 465 days. This individual slept $4\frac{1}{2}$ years during the last 8 years of his life. He belonged to a family with an hereditary predisposition to mental disease and the autopsy revealed a centre of necrosis in the brain. Massage and electrical treatment are said to have proved beneficial in cases of narcolepsy.

Prolonged sleep may follow very violent emotion. It is recorded that Napoleon after the battle of Aspern, his first defeat after seventeen victories, was overpowered by sleep, and slept 36 hours without waking, a circumstance

which caused his attendants to fear for his life, as he usually slept very little, seldom exceeding 4-5 hours. His powerful consciousness must have been temporarily overcome by the emotion arising from the loss of this battle. Let us hope that an even more prolonged slumber has been enjoyed by the *ex-All-Highest* of Germany! !

Paroxysmal sleep—Besides prolonged pathological sleep briefer lapses of consciousness may occur, known as paroxysmal sleep, and generally considered to be of an epileptic character. This condition ranges in severity from simple drowsiness or actual sleep to various degrees of mental automatism. The subject of this disorder, if talking, may stop short in the middle of a word or sentence for the duration of the attack, and then complete what he was about to say without being aware of any unusual occurrence. This epileptic form of sleep usually lasts for a few minutes, sometimes half an hour or more. It resembles in many respects normal sleep, the extremities being relaxed, pulse and respiration slowed, and sensibility so lowered that no stimulation will arouse the subject. The pupils, however, are usually dilated, not contracted as in normal sleep.

Hypnosis—Hypnosis is a condition produced through an artificial enfeeblement of consciousness by means of monotonous or uniform sensations. Psychologists have shown how speedily monotonous work produces fatigue and it is a common experience that concentrating the attention upon some monotonous sound or uniform sensation tends to induce sleep. Many and various are the devices that have been employed for this purpose. Russian nobles had a habit of soothing themselves to sleep by having their servants scratch their heels. Savage-Landor records that in Korea mothers scrape their infants gently on the abdomen for a similar reason. Rabelais tells a story of some monks who, oppressed with wakefulness, resolutely addressed themselves to prayer, and before they had concluded half a dozen aves or paternosters they all fell asleep. There are people who count in order to send themselves to sleep; others sample

the fatiguing qualities of a Greek verb; children are crooned to sleep by means of monotonous lullabies. The fundamental principle of all these various methods is to fatigue consciousness by monotony. Normal and natural sleep is the outcome of all such procedures as these, for if any hypnotic element is present at the commencement it is only transitory. Prolonged hypnotic sleep is induced also by means of monotonous or uniform sensations, but it differs manifestly from natural sleep, and hence may be considered here as a form of abnormal sleep. Walden in America investigated the condition of the vascular system during hypnosis, and points out that the pronounced and increasing vaso-constriction of the arm, which is shown in plethysmographic records, is the reverse, in general, of the condition observed in natural sleep, which is associated with peripheral dilatation. He draws one general conclusion from his experiments: "Assuming," he says, "as there is good reason for doing, that lessening of mental activity is accompanied by a peripheral dilatation of the blood vessels, particularly perhaps in the skin, and that increased psychical activity is accompanied by the reverse condition of a peripheral constriction, then the remarkable general tendency to a peripheral constriction during hypnotic sleep, except for a variable initial period, would point to a steadily acting mental stimulation during the time that the suggestion is effective."

Somnambulism—Somnambulism is a condition commonest in childhood and youth. In cases of extreme fatigue consciousness may be arrested while muscular action is continued, as *e.g.* the sleeping of soldiers during forced marches. This, however, is merely the continued performance of those actions which were being carried out by the sleeper prior to the onset of sleep, whereas the somnambulist retires to rest, and during sleep arises and executes automatically all sorts of muscular acts without awakening, *i.e.* without consciousness. In this condition the eyes are frequently open and the pupils dilated, so that objects can be perceived with very little light; the sense of touch is usually more acute, though

there may be analgesia; while reaction to auditory stimulation is sometimes observed. Remarkable intellectual feats have been performed by somnambulists, and cases of murder and suicide are on record. There is usually little or no power of recalling events that have occurred in this state, and if anything is remembered it is only as a dream. The phenomenon of double personality has been held by some to be really a manifestation of somnambulism in which all the senses and faculties are active.

HYGIENE.—Finally a few points about the hygiene of sleep claim consideration. How much time should be devoted to sleep? Usually the amount required is in inverse proportion to the strength and development of consciousness. Infants require a great deal of sleep, because a brief period of waking suffices to fatigue their feeble consciousness. With increase of years less sleep becomes necessary until middle age is reached when consciousness is at the zenith of its development. In old age the amount required depends upon the state of preservation of the intellectual powers and varies much in individual cases. The period devoted to sleep by healthy adults is usually 8 hours, but some have been satisfied with much less. Jeremy Taylor is said to have allowed himself only 3 hours out of the 24. Persons of very marked personality and highly developed consciousness seem to require less sleep, their consciousness not being readily fatigued. Napoleon rarely slept more than 4-5 hours. On the other hand Dr. Johnston complained of his tendency to somnolency. Kant, who regarded bed as the nest of diseases, risked the consequences for 7 hours. If consciousness becomes much enfeebled in old age the need for sleep is the same as in young children, but if the intellectual faculties are well preserved there may be a tendency to insomnia, for the aged have a somewhat detached and unimpassioned point of view, and consequently the world, the flesh, and the devil have a diminished power of fatiguing their consciousness.

Excessive sleep—Excessive sleep is injurious at all

ages. Hippocrates stated that it prevents the aliment from being digested and generates crude humours. The vegetative life of the organism tends to be over-developed to the detriment of the central nervous system. Exercise of consciousness is a condition necessary for its development, and enfeeblement must follow unduly prolonged inactivity, just as atrophy is the fate of an unused muscle. Moreover, since excessive sleep entails more or less inactivity of many of the chief organs and tissues of the body, these also will tend to undergo weakening. Therefore an undue tendency to sleep must be combated. Any means of producing a copious flow of blood towards the brain may be employed, *e.g.* pleasant society and amusements, stimulating drinks—like tea and coffee. What a useful institution is the tea which prefaces the proceedings of this Society! Erasmus Darwin records the habit of a friend of his who used to resist overpowering somnolence successfully by dwelling on some grievance, and his righteous anger being roused caused the desired cerebral hyperæmia. It is not improbable, that this gentleman's friends would have preferred him to go to sleep, for he cannot have been a pleasant companion at these times! One writer says of those afflicted with this somnolent tendency:—"We must therefore procure them occupations, in no serious sense of the word, but such as to correspond to the general level of their psychic development. There are persons who find a serious and interesting occupation in observing whether all the clocks strike simultaneously or in a certain order; others occupy themselves with table-turning, playing at Patience, and so on. Such occupations, proportional to the intelligence of each, are necessary to overcome the exaggerated and harmful tendency to sleep."

Position in sleep—The sleeper should lie as nearly horizontal as possible, and he should accustom himself to sleep with equal ease on either side or in the supine position. Dr. Osborne in the Dublin Quarterly Journal of Medical Science in 1859 stated that children up to the age of 14 sleep equally well in any of these positions, but between 14

and 20 a preference is exhibited for the right side. Change of position prevents venous congestion and advantage should be taken of every awakening to vary the attitude, and indeed this is generally done almost unconsciously. Macnish in his "Philosophy of Sleep" quotes a statement by a Dr. Hunter to the effect that women who love their husbands generally lie on the right side, adding "this interesting point I have no means of ascertaining, although, doubtless, the ladies are qualified to speak decidedly on the subject."

Hours of retiring and rising—As regards the hours of retiring and rising, it would probably be beneficial to conform more closely to natural conditions than is habitual among civilised peoples. It is doubtless healthful, provided the hour of retirement be not too late, to rise early in the summer, and it confers a pleasant sense of moral superiority over one's lie-a-bed neighbours, but the "early-to-rise" enthusiasts are not convincing when they acclaim the virtues of the extreme psychic depression consequent on a winter morning's toilet made by the light of a spluttering candle.

ART. VII.—*A Direct Reading Localiser for X-ray Work.*^a

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X-RAYS being propagated in straight lines, the position of a shadow thrown by an opaque body must depend on the relative positions of the source of rays, the opaque body, and the receiving surface. If the source of rays is moved the position of the shadow alters according to simple geometrical principles. If by actual measurement we know two positions of the x-ray tube in relation to the fluorescent screen or photographic plate and know the two corresponding positions of the shadow cast by an opaque body, it is a simple geometrical problem to determine the position of the opaque body.

With the exception of such methods as the use of visual

^a A Thesis read for the Degree of Doctor of Medicine in the University of Dublin on July 3, 1919.