behavioral ones, as pointed out by several investigators (442, 444, 445, 1321, 4207); to complicate matters, in man atropine causes drowsiness and other behavioral effects consistent with the EEG changes (3066, 3895). Atropine has been shown to neutralize the alerting action of methedrine, closely related to benzedrine and an adrenergic agent (868). In the decerebrated cat, after an injection of epinephrine, single neurones in the BSRF showed "an increase in their discharge rate, a decrease, or were unaffected by the drug" (449). In the same preparation acetylcholine also produced facilitation, inhibition, or a mixed response in a single neurone. Thus, there may be cholinergic and adrenergic mechanisms in the BSRF, synergistic or antagonistic, depending on conditions (449, 1134).

Bradley (441), Verdeaux and Marty (4046), and Himwich (1774) prepared tables showing the comparative behavioral and EEG effects of a number of psychopharmacological agents, as well as the sites of their action in the CNS. Considering the multiplicity of species of animals, and the variety of preparations (intact, anesthetized or not, curarized or not, EI, decerebrated, CI) tested, and that injected epinephrine does not duplicate its neurohumoral role in the organism, the lack of consistency in the findings reported is not surprising. The operation of a single adrenergic or cholinergic mechanism, or a combination of the two, as related to the possible functioning of a single wakefulness or sleep center, or sleep-wakefulness regulating system, is discussed in the last part of this book.

Chapter 30

The Hygiene of Sleep and Wakefulness

How much sleep does one need? What can one do to improve the quality of sleep? How can one get the greatest benefit from a certain amount of sleep? Is it harmful to one's health to cut down on the time allotted to sleep? Can one sleep too much? Is "tossing and turning" during sleep beneficial or harmful? Is it desirable to eat or drink shortly before going to bed? These and dozens of similar questions concerning beds, bedding, bedroom conditions, reading in bed, use of an alarm clock, going to bed early or late, are constantly being asked, and very few of them can be answered adequately at the present time. There are many and diverse opinions on the topic but not many established facts.

The disparity between the number of hours of sleep infants "should" have (89, 1004) and the number of hours they actually sleep was already dwelt upon (p. 114). Still some authors (3002, 4247) maintain that infants do not get enough sleep. Although there are circumstances that interfere with the sleep of infants (621, 975, 1793, 2665, 3064, 3867, 3928, 3929, 3988), under equal environmental conditions, individual infants have a tremendous range in the hours of sleep, as shown in Table 13.1 (p. 116) Sarylowa (3525) stressed habit-training, or a conditioning process, as an aid to proper sleep in infants and children, but in the 1890's Manacéine (2643) condemned "all methods of putting infants to sleep artificially by . . . lullabies and the rocking of infants in cradles." What has been said about body weight or the time of eruption of the first tooth also applies to tables of sleep hours for infants based upon means, modes, or medians obtained on groups.

The same considerations hold for the hours of sleep of older children. Although Kotsovsky (2252) found a relation between sleep and the rate of growth in puppies, Anderson (60) admitted that there was "no evidence to show a direct relation between hours of rest in bed and the general nutrition of children." Burn (577) noted that "a large number of children do not readily show signs of fatigue, even when the amount of sleep is markedly inadequate." Reynolds and Mallay (3327) observed that, in spite of large daily fluctuations

in the amount of sleep taken by individual children, over long periods each child seemed to find its own norm for the duration of sleep. Bowers (430) considered that sleep has the same value whenever taken and that it does not make any difference at what hour a child goes to bed. Manacéine (2643) stated that "the wish of grown-up persons to arrange their evenings as freely and quietly as possible has led to the widespread custom of sending children to bed at a very early hour." Reese (3291) found that daylight-saving time had no effect on the duration of sleep in young children who lived in an institution where the mode of existence was strictly routinized. For the "underrested" child Ramsay (3264) suggested, in addition to correction of dietary and hygienic faults, a rest cure in bed, involving a 2-hour rest in the afternoon and a 15-hour (7:00 P.M.–10:00 A.M.) stay in bed at night, followed by breakfast in bed. It is doubtful if any but a sick child would submit to such a routine. The cure may be worse than the disease of "underresting." Despert (924) suggested that parental attitude toward children's sleep should not be rigid, as many sleeping problems are initiated by undue stress on the need for obtaining an arbitrary number of hours of sleep.

The problem (for such it is sometimes) of the daytime nap for older children has been discussed (p. 117). As there is no general rule about the total duration of sleep per 24 hours for the individual child, there can be none for the afternoon nap. Aron (136) recommended 1 to 2 hours for pre-adolescent children. It will be recalled, however, that children take or give up their naps on an all-or-none basis rather than by a gradual shortening, as they might be expected to do. Sherman (3678) observed no connection between the duration of the afternoon nap and the activity, as well as the behavior, of preschool children. Staples and Anderson (3785) could not detect any relation between the length of the afternoon nap and the time it took preschool children to fall asleep in the evening, although for some children, particularly older ones, such a relationship may exist. A safe rule with respect to afternoon naps may be that they should be encouraged, unless (and until) they can be seen to delay the onset of sleep in the evening. Anything that causes a child to remain awake after going to bed is undesirable, as it may lead the child to play while in bed, and thus destroy the conditioning process of associating bedtime with sleep time. Usually, dispensing with the afternoon nap meets with the enthusiastic approval of the child, who may be easily induced, by way of compensation, to go to bed a little earlier, should he show signs of sleepiness before his customary bedtime.

According to Boynton and Goodenough (437), children who usually assume definite positions on going to bed fall asleep more readily. As pointed out (p. 11), the position of the child may influence the jaws and the teeth system, but there is no agreement on the seriousness of these influences, nor on the means of avoiding them (2653, 3626, 3771).

Heavy evening meals have a disturbing effect on the sleep of children, as judged by increased motility (1433, 1434, 2344). Karger (2081) found mental work and exciting games in the evening, and Renshaw and co-workers (3320) certain types of moving pictures, disturbing to the subsequent sleep. Giddings (1435) noted no change in the sleep motility of children after an hour of study or of outdoor exercises, but emotional states (fear, worry, disappointment, or pleasant anticipation) increased the number of movements during sleep (1435, 1437). In general, emphasis is placed on the proper distribution of work, play, and rest, and the development of habits that are conducive to regularity in eating and in bedtime hours as means of "improving" children's sleep (286, 323, 372, 577, 612, 674, 924, 1210, 1253, 1324, 1457, 1528, 1529, 1687, 1691, 1692, 1800, 1801, 2188, 2738, 2961, 3371, 3653, 3741, 3773, 3774, 4078, 4137, 4189, 4277).

What constitutes the proper duration of sleep has no more been decided for adults than for children (3236). Several authors (2070, 2161, 2226) came to the conclusion that not only do different individuals require varying amounts of sleep, but that certain persons may get enough sleep and think that they do not. Camp (615) maintained that many people sleep too long and that oversleeping is just as reprehensible as overeating. Although it is said that it is not the duration of sleep but its quality that counts, there is no agreement on what constitutes good quality of sleep.

The daytime nap for adults was condemned because it destroys the depth of the night sleep (2226) or because one's mood is worse on awakening (1718). It was held to be desirable, and refreshing out of proportion to its duration, as a "pick-me-up" (3175, 3796).

The timing of sleep was crucial, according to Stöckmann (3830–34), who presented evidence that a shortening of sleeping time could best be accomplished by changing the hours of going to bed to about 7:00 P.M. One could then get up at 11:00 P.M. or midnight and feel more refreshed and be more efficient than one was previously on 8 to 10 hours of sleep during the conventional hours. Stöckmann (3832) attempted to rationalize his "discovery" by pointing out that the earth is governed by the rising and setting of the sun, through which life is alternately stimulated and depressed. Sunset is the best time for going to bed, as it insures a quick recovery sleep. These views were criticized by Laudenheimer (2378), mainly because Stöckmann was not a physician but only a teacher and, as such, had no business to meddle with the sleep problem.

In actual practice the time of going to bed is often related to an individual's occupation, and, if the latter is not restrictive, to one's personal 24-hour rhythm. Wuth (4283) distinguished two types of sleepers: one type is tired in the evening, quickly falls asleep, soon reaches the greatest depth of sleep, and wakes up refreshed and well rested; the other type is alert in the evening, does not fall asleep easily, achieves the greatest depth of sleep toward the morning, and

wakes up feeling tired. Schultz (3604) also acknowledged the existence of two types, but he based his division on different grounds. One type he designated as a monocyclic sleeper, who sleeps well through the entire night and needs no daytime nap. He called the other type of sleeper dicyclic—such people have two periods of deep sleep; they are ready to get up after 4 to 5 hours of sleep; but, if they do not, they have a second period of deep sleep; if they cannot get a second period of sleep during the night, they need an afternoon or twilight (6:00 P.M.–8:00 P.M.) nap. This dicyclic type is close to the young child, with its daytime nap, and Schultz designated such persons' sleep pattern as "sleep infantilism."

Léopold-Lévi (2435), as mentioned (p. 161), divided mankind into four types, related to propensities for going to bed early or late, and for rising early or late. The "to-bed-late, rise-early" type needs little sleep and has overactive endocrine and sympathetic nervous systems. The "to-bed-early, rise-late" type suffers from an endocrine-sympathetic asthenia, is obese, always tired, and can sleep 10 to 14 hours. The "to-bed-early, rise-early" or "morning" type conforms to the "law of nature," follows the sun, like "animals and peasants." The "to-bed-late, rise-late" or "evening" type needs no excessive sleep, but is unhappy because he does not conform to the social habits of the majority of the population. He seeks night work. If he is an intellectual, he does his best work in the evening or at night. Sheldon (3676) worked out only three extreme body-build and temperament combinations (p. 120), lacking the "to-bed-early, rise-early" type of Léopold-Lévi. Of course, both classifications apply to extreme types and by Sheldon's scheme nearly everyone has viscerotonic, somatotonic, and cerebrotonic components in varying proportions in his temperamental makeup. Bingel (347) noted that schizophrenics are often of the morning type, whereas cyclothymics and manic-depressives are likely to be of the evening type. Volkind (4083) found that the time of onset, the duration, and the depth of sleep of dogs were also related to the types of nervous system they possessed. Geyer (1414) reported that identical twins, in addition to the presence or absence of a positive Babinski sign (p. 17), showed several other sleep characteristics in common and even awakened in the same manner. As everyone is born with certain hereditary bodily and temperamental characteristics, there may be a limit to the degree of modification that can be accomplished by training and experience.

Much has been written on the setting that is conducive to good sleep. After a day of sustained activity, the motility of the sleeper may be greater than normal (2004). Evening activity may also have a deleterious effect on sleep (2963), because the individual cannot properly prepare himself for sleep. Our subjects (2200), likewise, did not sleep well when their usual evening routine was upset. Cultivation of regularity and avoidance of excitement are undoubtedly beneficial for those who are temperamentally inclined to a "vegetative"

existence and enjoy their evenings at home, reading a book or listening to music.

The matter of evening meals was stressed by some writers, who ascribed restlessness during sleep and bad dreams not so much to eating as to unwise eating or overeating (3332); or stated that more restful sleep can be obtained if nothing is eaten just before going to bed (3782); or found that a light snack at bedtime decreased the motility of their subjects (by 6 per cent), compared to control nights when nothing was taken (2344). It is probably true that one person will sleep better if he eats or drinks something before going to bed, whereas another will do better if he takes nothing at that time.

The alleged benefits of the proper bedspring and mattress have been emphasized, mainly by the makers of such equipment. Instead of offering the consumer a well-made article which can be expected to last for a number of years, the advertiser attempts to make the buyer good-sleep-conscious by extolling the "sleep-improving" properties of one or another type of bedding equipment. Bowers (431) traced the evolution of the bed from a pile of leaves, skins of beasts, framework interlaced with thongs, through the ornate beds of Cleopatra and of the Roman emperors, the couch, the bedstead, the twelfth-century high-post canopy-top beds, down to the iron beds of the eighteenth century and the modern folding cot.

The substitution of the vertical coil spring and mattress for the horizontal coil (hammock-type) spring and plain felt mattress has been considered a tremendous improvement, as it prevents the weight of the body from producing a sagging in the middle of the bed. Diagrams have been prepared to show how curvature of the spine is prevented by the individual vertical coils giving way only in certain places and conforming the contour of the bed surface to that of the body. Aside from the fact that the spine has a couple of natural curves, there is no evidence that a change in curvature is produced in the cat, which sleeps curled up; in the Japanese, who sleep on the ground, which usually does not conform to the curves of the body; or in sailors, who often sleep in bona fide hammocks, with a considerable sag in the middle. The sagging of the mattress and bedspring may discourage frequent changes in position in some people, but that is an individual matter. Likewise, some persons prefer a softer mattress than do others. It is all a matter of individual likes and dislikes and, except through suggestion, the type of mattress used has little, if any, influence on the "quality" of sleep. Indeed, Suckling and associates (3863), who compared the effects of hard, medium, and soft mattresses on sleep and found that hard surfaces tended to increase motility and decrease the depth of sleep, as well as the subjective estimates of the quality of sleep, concluded that "the differences in these variables were not large and were not always statistically significant."

Even the placing of the bed in a certain way, usually with its head in the

direction of north, had been advocated and practiced by Charles Dickens, according to Sarton (3524). Stopes (3838) not only insisted on this orientation, but could "feel" or "magnatate" the north and claimed to be able to detect a deviation of only 4° off the true north-south meridian.

The matter of bedcovers is also one for the individual to decide. With the rooms at the same temperature some people will sleep without covers, while others feel that they must have something, if only a sheet, over their bodies. In cold weather, also, there are great differences in the number of blankets one would consider just enough to make one comfortable. In this connection, Hellmuth and De Veer (1695), it may be recalled (p. 87), recorded the skin (thigh) and bed temperatures, as well as the movements of the sleeper, in 90 experiments on several women, and found the level of the skin temperature to have little influence on motility, provided the difference between the bed and skin temperatures was not too small. This difference usually amounted to 4°–5° C., but, if it got to be 1°, or smaller, the motility was increased. On the other hand, too great a difference between these two temperatures prevented the onset of sleep. A low bed temperature also discourages changes in position, as in the wintertime, because the sleeper finds that any movement beyond the confines of the area warmed by his body brings him into an "arctic" zone; he therefore immediately retreats into the previously occupied warmed part of the bed. The sleep paralysis, described by Stockmann (3828) as occurring on awakening, and evidently due to lying too long in one position, is much more frequent in the winter than in the summer. A way to make conditions favorable for motility is either to keep the room warm or else to use an electric blanket to keep the bed warm. Prewarming the bed on a cold night also makes it more pleasant to get into and thus contributes to the removal of a possible source of annoyance that may interfere with the onset of sleep. On the other hand, some of our subjects reported that, on getting into an ice-cold bed, they were constrained to lie still, and thus fell asleep quickly. Evidently, it is again a matter of individual preference, and it makes little difference what one does about the temperature of the bedding.

The position in which one is to sleep and the use of pillows have come in for their share in the discussion of the hygiene of sleep. Earlier writers weighed all the arguments for and against lying on one's back or abdomen, in left- and right-side position, but as early as in 1834 Macnish (2610) knew that the sleeper changes his position during the night. In 1897 Manacéine (2643) observed that "to maintain the regular nutrition of all the tissues and organs of the body it is important to change the position of the body as often as possible during sleep, and to take advantage of each awakening during the night to sleep in turn on the right side, the left side, and the back." But it was Szymanski (3897) who gave an impetus to the study of the motility of sleepers, and through the work of Johnson and associates (2003) there is not only a better knowledge

of the frequency with which one changes positions during sleep but also photographic evidence of the multiplicity of positions a particular sleeper may assume during a single night's sleep. Later observations only confirmed the universality of sleep motility, and subsequent evaluations of beds and bedding have been largely based on whether this or that construction encourages or discourages changes in position during sleep. Our results differed from those of Johnson and co-workers on the question of the distribution of the movements through the night. All our normal subjects showed a gradually increasing frequency of movement—certainly a greater motility during the second half of the night than during the first. Remaining too long in one position, as happens after a large dose of alcohol (p. 61), is likely to produce a feeling of discomfort and stiffness in the musculature, or may lead to temporary paralysis. Too much motility, on the other hand, denotes disturbed sleep. The difficult question to answer is how much one should move and what the normal range is for motility figures. In this connection, from our data on seasonal variation in motility it can be seen that our subjects moved 50 per cent more in the autumn than they did in the spring (2200), and yet, until they were told about it, they themselves did not know it. It is therefore fair to conclude that the permissible (and the naturally occurring) variation in motility is rather large and the night-to-night variability in the motility of a partcular subject is even greater than the mean seasonal variation for the group as a whole.

Ventilation of the sleeping quarters is advocated by some and condemned by others; likewise, the sharing of a bed by two sleepers, or even the presence of more than one sleeper in the same bedroom; and the taking of exercise before going to bed. The undesirability of setting a certain hour for awakening as a disturbing influence on sleep was mentioned by Omwake and Loranz (3056). Boigey (395) condemned early-morning exercises as a menace to health, or even life, particularly in elderly persons. He saw danger in quickly getting out of bed on awakening, as practiced by "energetic" people.

Among the conditions required to insure a good night's sleep, darkness and quiet have been stressed by Vorwahl (4085), but Johnson (1998) considered light and noises inconsequential, and Craig (771) found that his subjects fell asleep sooner under the influence of disturbing sounds than in perfect quiet. Production of monotonous sounds, as a soporific agent, is, of course, an ancient procedure.

In addition to all the other measures, or in their default, various suggestions that can best be characterized by the term "rituals" have been offered for improving the quality of sleep. They involve doing certain things which, the prospective sleeper must believe, will make him fall asleep and sleep well. Drinking or eating or taking a warm bath—anything that could be called a conditioning process—may solve the problem. If not, progressive relaxation (1936, 4276) or passive relaxation by means of Rosett's apparatus (3416) is said

to be of help. Iselin (1920) has proposed that a subject lie on his back, hold his head free in a lateral position (to diminish the arterial blood supply to the head) and direct his eyes inward and upward, inhaling and exhaling deeply—then he will fall asleep. Evans (1114) recommended taking two deep breaths before an open window, or some rhythmical physical exercise, and Kennedy (2138) suggested a combination of muscular relaxation and rolling the eyes into the upward position they are supposed to assume in sleep as the best procedure for inducing sleep. "Psychological" rituals have also been proposed. Binns (348) referred to a story told by Rabelais concerning "some monks, who, oppressed with wakefulness, resolutely addressed themselves to prayer, and before they had concluded half a dozen aves, or pater-nosters, we forget which, they all fell asleep." Evans (1114) also suggested prayer as an alternate ritual for breathing exercises, declaring: "This ritual at its best involves body, mind and soul in its performance. It is for this reason that prayer has satisfied human nature for centuries of time." Farrow (1140) offered a psychoanalytical method of going to sleep: all one has to do is to paint large imaginary figure 3's extremely slowly on a large imaginary black wall by means of an imaginary brush and a tin of white paint. Anyone who painted three of these 3's in this very slow manner would find it quite impossible to remain awake. Tichenor (3938) recommended turning one's thoughts to trivial things such as naming objects of different categories following the alphabet (example: ape, bear, cat, dog, elephant, fox, goat). The autosuggestion of Coué could probably also be placed in the ritual classification.

Additional information and advice on the hygiene of sleep have been offered by many authors (45, 47, 127, 152, 348, 578, 627, 693, 728, 789, 1042, 1214, 1267, 1516, 1604, 1649, 1938, 2332, 2337, 2338, 2341, 2343, 2564, 2607, 2610, 2643, 2947, 2984, 2985, 3026, 3119, 3182, 3200, 3489, 3521, 3561, 3651, 3694, 3742, 3795, 3841, 3936, 3963, 4078, 4218, 4297).

In our subjects (2200) we studied six characteristics which, we thought, might collectively determine the quality of sleep: (*a*) the ease of going to sleep; (*b*) motility during sleep; (*c*) sleeping continuously; (*d*) incidence and character of dreaming; (*e*) the duration of sleep; and (*f*) the subjective feeling of being well rested on awakening. The most striking feature of the results obtained on 36 subjects, with a mean number of 179 nights per subject, was that, with respect to every sleep characteristic, there was a considerable variation from subject to subject, and in the same individual from night to night.

Having obtained a control pattern of our subjects' sleep, we then studied its modification by various external and internal conditions, such as: (*a*) environmental conditions not under the control of the individual; (*b*) daytime and evening activities, entirely or partly under his control; (*c*) feelings, moods, attitudes, state of health, perhaps partly dependent upon the individual's actions but not under his control; and (*d*) imposed or prescribed conditions, when the individual was instructed to eat, drink, or swallow certain materials. From an analysis of the results we concluded that "none of the foregoing influences on the several sleep characteristics affected all our subjects in the same way, or a particular subject to the same extent on different nights. They represent shifts in the general tendencies which determine the quality of sleep characteristics of the group studied." Concerning the significance of the changes produced in the sleep of the group as a whole, some were definitely without significance, and others could be considered significant.

Another sleep variable is the "quantity" of sleep, as the product of its depth and duration (1081, 3346), based on the assumed correctness of the depth-of-sleep curve drawn by Kohlschütter (2228). On this premise, the amount of sleep obtained during the first 2 hours exceeded that furnished by the remaining 6 hours. Therefore, ran the argument, by sleeping for 2 hours, then staying awake for 4 and sleeping for 2 hours once more, one could obtain as much sleep in 4 hours as one usually gets from continuous sleep of 8 hours' duration. Many people have tried this scheme at one time or another and have given it up as unworkable. Husband (1876, 1877) studied his own performance during a month on a normal sleeping routine of 8 continuous hours, and then during a second month, when he slept from 11:00 P.M. to 2:00 A.M. and from 5:00 A.M. to 8:00 A.M., a total of 6 hours. He felt well, and his health was unimpaired. Physiological measures, such as blood counts and BMR, showed no deviation from the normal. His performance suffered some slight deterioration in tests pertaining to hand steadiness (tremor), body steadiness (ataxia), and speed of tapping. In spite of the absence of untoward symptoms, Husband did not adopt divided sleep as a permanent routine.

We had two subjects, O and T, follow the divided sleep routine for about a month. They slept for two 2.5-hour periods, separated by a 4-hour interval of wakefulness. They compared their motility during the two portions of divided sleep with that prevailing during a normal night's sleep of 7 to 8 hours' duration, as well as with the incidence of movements during a sleep period of only 5 hours per night, or the sum of the two periods of divided sleep. Both subjects had a somewhat greater motility during the second 2.5-hour period of sleep than during the first, suggesting a lack of equivalence between the two. But for both sleep periods the motility figures were within the normal range and did not differ much from the corresponding figures for the 7- to 8-hour or the curtailed 5-hour sleep. Subjectively, both individuals reported a very low capacity for work during the 4-hour interval separating the two "sleeps." They happened to be of the type who feels tired on getting up in the morning, and getting up twice did not improve matters. The routine definitely did not appeal to them as a time-saving proposition.

A hygiene of wakefulness is even more requisite than a hygiene of sleep. Much as one should like to insure the euphoria said to follow a "good" night's sleep (427, 428), it is capacity for performance during the hours of wakefulness that one seeks to achieve by the proper kind of sleep. Rowe (3458) found no relation between the length of his sleep and the amount of daily work he performed. Viaud (4056, 4057), noting that performance immediately upon getting up in the morning was often poorer than it was just before retiring the night before, chose afternoon hours for testing five subjects, whose sleep hours varied widely. For a sleep duration of 1 to 6 hours, afternoon performance improved almost linearly with the length of sleep. Beyond a duration of 6 hours

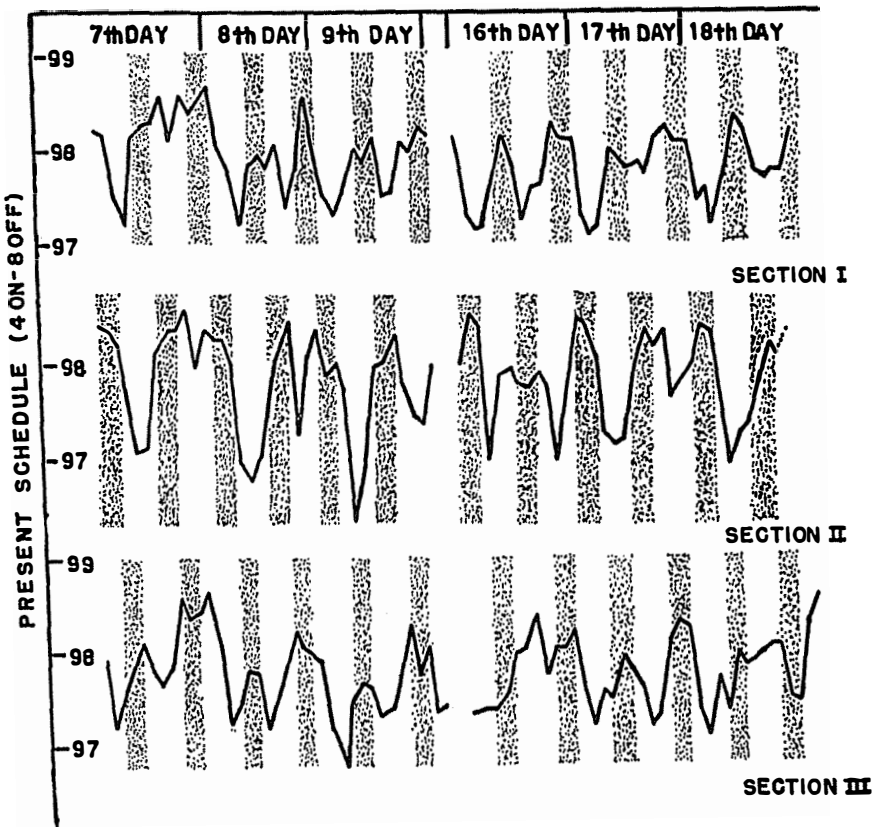

FIG. 30.1—Samples of group mean 24-hour body-temperature curves of three sections (10, 11, and 8 men, respectively) of a submarine crew during a 19-day simulated wartime patrol, reported by Utterback and Ludwig (4028). Watch-standing time of 8 hours out of 24 consisted of two 4-hour watches (shaded bands), separated by two 8-hour "off" duty periods (white spaces between bands)—a 12-hour routine of activity and rest. The 24-hour body-temperature curves of each of the three sections were irregularly bimodal.

of sleep, improvement was less marked, and it was completely absent when sleep was lengthened from 8 to 10 hours.

Efficiency of performance during the 15 to 17 hours of daily wakefulness follows the 24-hour rhythm, with an initial ascent, a terminal descent, and a crest or plateau in the middle (p. 151). Driving late at night (1165, 2752, 3944), or a rapid transfer by air into a distant time zone (3253, 3855, 3856), as well

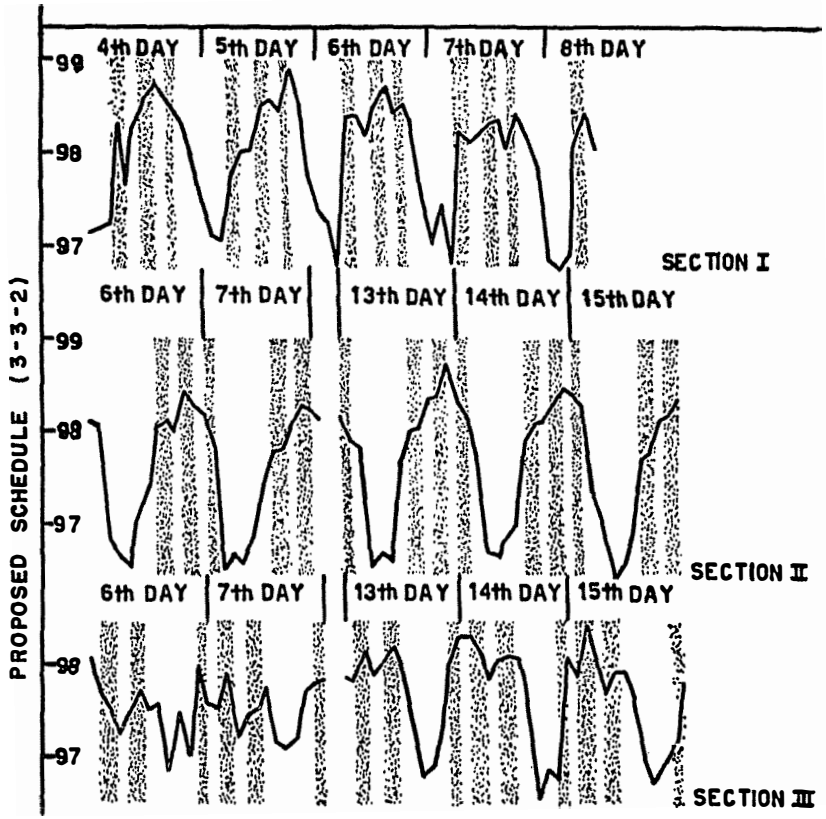

FIG. 30.2—Samples of group mean 24-hour body-temperature curves of three sections (8, 10, and 10 men, respectively) of a submarine crew during a 21-day simulated wartime patrol, reported by Utterback and Ludwig (4028). Watch-standing time of 8 hours out of 24 was divided into three 2 to 3 hour fractions (shaded bands), close together, thus allowing for a 12-hour period of freedom from duty daily. Distinct 24-hour body-temperature curves were in evidence in the fourth and sixth 24 hours in Sections I and II, but were also established later in Section III whose watch-standing hours were at night, necessitating an inversion of the customary 24-hour shore routine of living. The adjustment of the members of the crew to three different "time zones" is shown in the 8-hour shifts in maxima and minima of the body-temperature curves of the three sections, the maxima corresponding to the hours of duty, and the minima to the duty-free intervals.

as working during the night without adjusting the 24-hour rhythm (2563, 2903, 3778) may result in a greater number of errors (361, 362, 541) and accidents (2773, 2775, 4285). The round-the-clock operations of certain industries, public utilities, transportation and communication companies, police and fire departments, hospitals and military services necessitate the employment of multiple shifts with a dislocation from the customary acquired 24-hour rhythm of wakefulness and sleep. Night workers often get less sleep than day workers (2773, 3778) and complain of fatigue (501, 2903, 3183) and a variety of ailments, particularly digestive ones. Reports of a greater incidence of gastric ulcers among night and shift workers (1449, 2381, 3890), however, have been denied (3922, 3923). The timing of the shifts is unfortunate. When a second shift is required, in addition to the usual day shift, hours of 8:00 A.M. to 4:00 P.M. and 4:00 P.M. to midnight are logical, as both shifts then allow for sleep at night. However, that leaves only the hours from midnight to 8:00 A.M. for a third shift, which necessitates daytime sleep and working during the part of the 24-hour rhythm when temperature is lowest and sleepiness greatest (p. 157). A more physiological timing would provide for shift hours of 4:00 A.M. to noon, noon to 8:00 P.M., and 8:00 P.M. to 4:00 A.M. (2184), doing away with the "graveyard" shift entirely.

Work-rest alternation of 4 hours on and 4 hours off (3801) and 4 hours on and 2 hours off (13) has been tried experimentally, but the most common division, as practiced on U.S. submarines, is the "4 on, 8 off" schedule of watch-standing which is essentially an operation on an artificial 12-hour cycle. It may be recalled that it is practically impossible to establish such a rhythm in man (p. 175). A study of members of a submarine crew, with three watch-standing sections (2187) revealed that meals, recreation, and sleep were all skewed to correspond, as much as possible, to the regular "shore" routine of living. The body-temperature curves of members of the three sections were shown by Utterback and Ludwig (4028) to be unequally bimodal, but somewhat closer to the ordinary 24-hour body-temperature curve in the section whose hours of duty were 8:00 A.M. to noon and 4:00 P.M. to 8:00 P.M. (Fig. 30.1). A "close" watch schedule, with the 8 hours of duty divided into three parts and a free period of at least 12 hours for each section, led to the establishment of three distinct 24-hour rhythms, as shown by the body-temperature curves of members of the three sections operating on this schedule (Fig. 30.2). The "close" watch system was acceptable to the crews of several submarines, but has not been adopted by the U.S. Navy, even for the Polaris-type submarines which travel submerged for many weeks. It should be added that "unphysiological" as the "4 on, 8 off" system of watch-standing may be, it is much superior to the daily rotation of the "dogged" watches as practiced on large U.S. Navy surface vessels (p. 157). Daily rotation was a necessity when members of the crew slept in hammocks, strung in the large mess area, and daytime sleep was

impossible. Now that separate sleeping quarters allow for a fixed system of watches, there is every reason for instituting a "close" watch-standing schedule which would give each man 12 hours free of duty daily.

Another solution to the multiple-shift problem, when fixed or permanent hours of work are not practicable, is to rotate the shifts as infrequently as possible (99, 362, 380, 1449, 2184, 2562, 2903, 4048).

The maintenance of a stable sleep-wakefulness rhythm, as indicated by a superimposable 24-hour body-temperature curve, serves a double purpose: (*a*) it makes for alertness and efficiency during working hours, and (*b*) it insures an easy onset of sleep and a "good" night's sleep, when they coincide with the drop in body temperature at certain hours of the evening and a low temperature during the night. The rhythm can be disrupted by irregularity and fortified by regularity in one's schedule of work, meals, recreation, and sleep. Children in particular can be more easily induced to follow a repetitive routine of living (4078).

It must be conceded that some persons are temperamentally more suited to a regular mode of living than are others. Morning persons have an advantage over evening ones, as the "early-to-bed, early-to-rise" system, upon which the working hours of society are largely based, fits in with their natural inclination. Certain individuals are capable of incurring a "sleep debt" by going to bed much later than usual for several nights in succession, but getting up at the customary hour. Such persons develop a feeling of lassitude and manifest a decreased alertness during their regular period of wakefulness. Those who are capable of accumulating a sleep deficit of several hours liquidate the debt by allowing themselves to sleep longer during the weekend. The ability to remain asleep much beyond one's customary getting-up time indicates a failure to establish and maintain a sleep-wakefulness rhythm.

The 24-hour routine of sleep and wakefulness, linked to living on the surface of the earth, may not be the optimal routine under conditions of isolation where day-night alternations are absent. In studies of non-24-hour schedules (p. 177), it was shown that the longer the sleep-wakefulness cycle the greater the body-temperature range. This finding suggests that, by operating on a longer than 24-hour routine, one may expect to reach a higher degree of alertness and level of performance, on the one hand, and a more complete muscular relaxation, perhaps better sleep, on the other.

Whatever one's temperament and disposition may be, it should be remembered that the 24-hour rhythm is an individually acquired, learned process, depending upon the presence and functional participation of the cerebral cortex. Physiology can contribute to hygiene by rationalizing the development of regular habits with respect to sleep and wakefulness.