The New England
Journal of Medicine

VOLUME 198 JUNE 14, 1928 NUMBER 17

The Massachusetts Medical Society

THE MECHANISM OF EMOTIONAL DISTURBANCE OF BODILY FUNCTIONS*

BY W. B. CANNON, M.D.†

IN 1896, when I was a first-year medical student, Professor Henry P. Bowditch, whose memory his former students delight to recall, invited me to make use of the then newly discovered Röentgen rays in a study of the activities of the alimentary canal. In December of that year we demonstrated to the members of the American Physiological Society the passage down the esophagus of a swallowed mass made opaque to the rays by adding subnitrate of bismuth. After that beginning we studied the mechanical functions of the stomach and intestines, and the various conditions affecting the rate of passage of food through the digestive tract. Almost from the start of these investigations an outstanding fact appeared. The smooth-running recurrent waves of peristalsis coursing over the stomach, and the rapidly shifting segmentation of the food masses in the small intestine were promptly abolished whenever the subject showed signs of anxiety, distress or rage. It was evident that these alimentary functions were extremely sensitive to emotional disturbances. My interest in effects of excitement, which was thus initiated, led to studies of the services of the sympathetic nervous system, by itself and in coöperation with glands of internal secretion, and that in turn to an examination of the parts of the central nervous system which govern these fundamental reactions of the organism. You will pardon these references to personal experience, I trust, for they account for the selection of the title of this discourse. Since you have asked a physiologist to address you, you will permit him, I feel sure, to come and bring his contribution to medical thought and counsel. It has seemed to me, therefore, that we might profitably consider together the ways in which strong emotional states may endanger bodily welfare.

I think that we must admit that, although physicians have not infrequent occasions to observe instances of functional disturbance due to emotional excitement, there is an inclination to minimize or to slight that influence, or even to deny that it is part of a physician's service to his patient to concern himself with such troubles. Let the patient go to the clergyman for comfort and consolation and for the resolution of his deep anxieties. A too common unwillingness among physicians to regard seriously the emotional elements in disease seems to me to be due perhaps to the subtle influence of two extreme attitudes and disciplines. On the one hand is the powerful impress of morphological pathology. So triumphantly and so generally has it demonstrated under the microscope the structural alterations which accompany altered functions that any state which has no distinct "pathology" appears to be unreal or of minor significance. Fears, worries and states of rage and resentment leave no clear traces in the brain. What, then, have we physicians to do with them? On the other hand, these mysterious and dominant feelings which surge up within us from unknown sources—are they not pure perturbations of the "psyche"? In that case, what, again, have we physicians to do with them? If we show this indifference, however, is it surprising that men and women, beset by emotional stresses, turn from us and go for help to faith healers, to Christian Scientists and to others who recognize the reality of these disturbing states?

An escape from the insistent demands of the pathologist for morphological evidence of disease, and also from the vagueness and mysticism of the psychological healers, can be found, I am convinced, in an understanding of the physiological processes which accompany profound emotional experience. As a physiologist I have the reasonable right to consider what goes on in the nerve paths of the brain as not associated with any demonstrable structural change. Indeed, very pronounced and disastrous consequences may result in the organism because of habit reactions, which may be regarded as not different in quality from any of our ordinary ways of behaving. Also as a physiologist I have the reasonable right to regard suddenly altered functions of organs innervated from the central nervous system as occurring in consequence of nerve impulses discharged from that system.

*The Annual Discourse delivered before the Massachusetts Medical Society, at Worcester, June 6, 1928.

†For record and address of author see "This Week's Issue," page 920.

Using the physiological point of view, therefore, I propose to consider emotions in terms of nerve impulses, much as I might consider the nerve impulses from the "motor area" of the cerebral cortex as they govern the movements of skeletal muscles. Although I shall use words with psychological implications, such as "fear," "rage," "feelings," and others, let me state at the outset that I use them solely as convenient short terms for complex activities in the brain. I shall be discussing, throughout, the *physiological* aspects of emotional excitement—the nervous mechanisms which are operating.

First, what is an emotion? From the physiological point of view it is a typical reaction pattern. Let us consider rage as an example. In its extreme form the signs of rage include the crouching body, the moist or frowning brow, the firm lips, the clenched or grinding teeth, the growled threats or imprecations, and the tightened fists or the seized weapon ready for attack. This is a complex attitude which we do not have to learn—its occurrence is a part of our native inheritance. It occurs promptly when the stimulus is appropriate. It is a constant and uniform type of behavior, having features which are common in widely scattered races of men and even in lower animals, so that the nature of the attitude is at once understood without the necessity of words. It is a permanent mode of reaction; throughout an individual's life the characteristic display of the rage response may be suddenly evoked in all its elaborateness and, whether in childhood or old age, it differs only in minor details. Further, it is a response to a fairly definite stimulus—any hampering or checking of activity, or opposition to one or another primary impulse brings it out. Threaten the free motion of a dog or a man and the teeth will be uncovered. Again, the rage response may be interpreted as being useful. Elsewhere[1] I have called attention to the wide range of bodily adjustments which occur when one is enraged—the more rapid heart-beat, the redistribution of the blood, the increase of red blood corpuscles in the circulation, the larger ventilation of the lungs, the dilatation of the bronchioles, the liberation of sugar from the liver, the secretion of adrenin with its favorable action on fatigued muscles—all of which may properly be regarded as rendering the organism more efficient in struggle, in such struggle as may be required to overwhelm the opposition and to allow the natural impulse to prevail. As we survey the characteristics of the outburst of rage as a typical emotion—the inborn, prompt, constant, uniform, permanent and useful nature of the response to a definite kind of stimulus—we note that these are the characteristics of a simple reflex, such as sneezing or coughing. They differ not in quality but in complexity.

Man is superior to the lower animals mainly because of the extensive development of the cerebral hemispheres. Comparative anatomy shows that these structures have been superposed on a brain stem which differs relatively little in the higher vertebrates. And physiological investigation has proved that whereas the reactions which involve the cerebral cortex may be delayed, unpredictable, short-lived, and readily modifiable, those which involve the lower levels of the brain and spinal cord are prompt, uniform and stereotyped. Hence the difference between the complex behavior of the normal human being and the relatively simple behavior of the idiot. It is of interest, therefore, to learn where the nervous mechanisms lie which operate the various emotional displays. Do these mechanisms have their seat in the newly developed cerebral cortex or in the more ancient parts of the brain?

In the brain stem are centers which, in the lower vertebrates, lacking a cerebral cortex, carry on the primitive functions of maintaining existence, such as seizing their prey and escaping from their enemies. These are activities which in man are associated with attack or with flight from danger and are attended by the emotions of rage or fear. In higher forms the centers for these functions, though normally held in check by the dominant cortex, are capable of energetic response when conditions require urgent and insistent action. It seemed reasonable to expect that the centers in the brain-stem would manifest their typical activity if the cerebral cortex was removed. Removal of the cortex would destroy the possibility of sensation and, therefore, a depressing or disturbing anesthetic could be dispensed with. Accordingly Britton and I[2], using cats as subjects, undertook an investigation of some of the immediate effects of a decortication which left intact almost all of the gray masses at the base of the brain. As soon as recovery from anesthesia was complete a remarkable group of activities appeared, such as are usually seen in an enfuriated animal—a sort of sham rage. These quasi-emotional phenomena, which appeared to result from the restraint, included lashing of the tail, arching of the trunk, thrusting and jerking of the restrained limbs, display of the claws and clawing motions, snarling and attempts to bite. These were all actions due to skeletal muscles. Besides these, and more typical and more permanent, were effects on the viscera, produced by impulses discharged over the sympathetic nerve fibres. They included erection of the tail hairs, sweating of the toe pads, dilatation of the pupils, micturition, a high blood pressure, a very rapid heart beat, an abundant outpouring of adrenin, and an increase of blood sugar up to five times the normal concentration[3]. This display of a "pseudaffective" state or sham rage might continue for two or three hours.

As stated above, Britton and I left untouched almost all of the basal gray matter of the anterior brain-stem. Where among these basal ganglia does the neurone pattern for the rage

response reside? The answer to this question was obtained by Bard[4] who, after removing under ether the cerebral cortex and various amounts of the brain-stem, studied the behavior of the preparation. He found that typical sham rage, accompanied by vigorous discharge of sympathetic impulses, occurs when both hemispheres, the corpora striata and the anterior half of the diencephalon have been completely isolated (i. e., the crosshatched parts in figure 1).

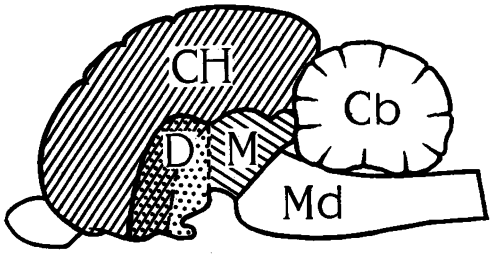

FIGURE 1. Median section of the brain. CH, cerebral hemispheres; D, diencephalon (indicated by dots); M, mesencephalon; Cb, cerebellum; Md, medulla. The crosshatching, from right downward to left, marks the portion of the brain which can be removed without interfering with the emotional expression of rage.

The additional extirpation of the posterior half of the diencephalon promptly abolishes the spontaneous activity. Further tests proved that the center lies in a small brain mass in the ventral part of this region, i.e., in the subthalamus.

Here is a fundamental fact which I wish to emphasize—that the nervous organization for the display of rage, both in bodily attitudes and in visceral changes, is located in an ancient portion of the brain, the optic thalamus which is a part of the diencephalon. This region is not like the cerebral cortex where new adjustments with the outer world are constantly being made or modified. Instead, it is like the spinal cord, a place where the simpler mechanism for orderly motions reside and where stimulation evokes fixed and uniform reflex responses. The typical postures and visceral changes which result from action of the thalamus are more complicated than the knee jerk or other spinal reflexes, but they are not essentially different.

I have laid stress on the locus of the physiological mechanism for the reflex figure of rage because it may serve as a model for other primitive emotional responses. The expressions of fear, joy and grief are similar to it in character. In their essential features they are not learned (i. e., they are inborn) and they are prompt, constant, uniform and permanently established patterns of reaction to appropriate stimuli. In other words they are like the simple reflexes and not like the complicated adjustments managed by the cortex. There is good evidence that the central control for the expression of these emotions, like that for rage, lies in the thalamic region. For example, Bechterev[5] has reported that in an animal freshly deprived of its cerebral hemispheres, petting may call forth signs of pleasure, e. g., purring in the cat and tail wagging in the dog.

The evidence which I have adduced to show that the neural arrangement for emotional display is near the optic thalamus has been based wholly on experiments on lower animals. That evidence, however, is consistent with indications that in man also emotional expression is managed by parts of the brain below the cortex and specifically by centers in or near the optic thalamus. Thus when in human beings the cortical processes are abolished by anesthesia, emotional display may be most remarkable. During the excitement stage of anesthesia, for example, the patient may sob as in grief, or laugh as in joy, or make the energetic aggressive actions of rage. While the patient is struggling, shouting and muttering the surgeon may open the chest or perform other operations of equal gravity; a few minutes later, when conscious, the patient will testify that he has been wholly unaware of what has happened. It is when "laughing gas" or alcohol has set aside the cortical functions (i. e., has functionally decorticated the individual), that he laughs or weeps. In all these conditions the drug acts first as a depressant on the highly sensitive cells of the cortex and thus lessens or temporarily destroys their control of lower centers; then the lower centers, released from the dominance of the cortex as in surgically decorticated animals, show forth their functions in free play.

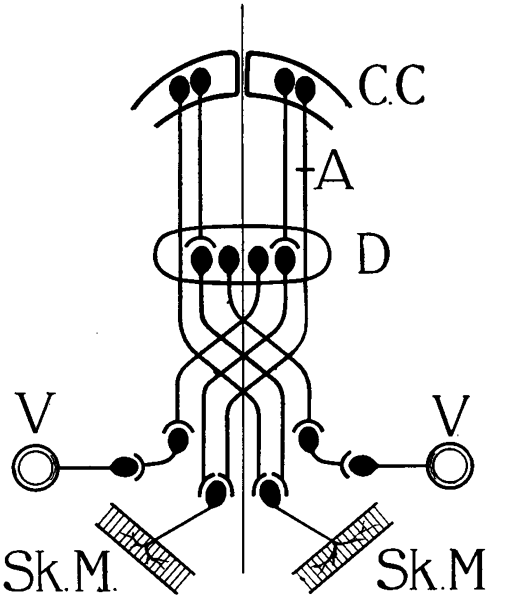

FIGURE 2. Diagram of possible relations of the nerve cells of the cerebral cortex (C.C.) and of the thalamic portion of the diencephalon (D.) to the viscera (V.) and to skeletal muscles (Sk.M.). The cortico-thalamic fibre is regarded as inhibitory. Sensory fibres are not represented. Damage to the cortico-spinal tract at A interrupts cortical control of certain skeletal muscles on one side, but it does not prevent control of these muscles on both sides by the centers in the diencephalon. Unilateral injury of centers in the diencephalon may leave bilateral control from the cortex.

In harmony with the experimental evidence from lower animals and the just described pharmacological evidence from man is that derived from pathological studies of human cases. In certain forms of hemiplegia patients are in-

capable of moving the face on the paralyzed side; but if an emotional (i. e., a sorrowful or joyous) situation develops, the muscles which were unresponsive to voluntary (i. e., cortical) control flash into action and give *both* sides of the face the expression of sadness or gaiety[6]. These are cases of subcortical interruption of the motor tract (e. g., at A. figure 2), and presence of an intact optic thalamus. The converse of this condition is seen in unilateral injury of the thalamic neurones (figure 2); then the patient moves symmetrically both sides of the face at will, but when he laughs or weeps the emotional expression is unilateral. Cases of pseudo-bulbar palsy also bring interesting testimony. In this disease there is usually a bilateral facial paralysis, with one side somewhat more involved than the other. Voluntary pursing of the lips as in whistling, or wrinkling of the forehead, or making a grimace, may be impossible. And yet the apparently paralyzed muscles function quite normally in laughing or crying, scowling or frowning. Indeed patients may have prolonged and uncontrollable fits of laughing or weeping. According to Brissaud[7] the pathological condition in this disease is a lesion of a part of the cortico-thalamic tract which frees a portion of the thalamus from the cortical check. All these observations, experimental and clinical, consistently point to the optic thalamus as the region in which resides the neural organization for the different emotional expressions.

The thalamic region is not only the seat of the neural patterns for the various emotional displays. It appears to be also the source of the peculiar feelings which contribute glow and color to otherwise drab sensations. The evidence for this inference is mainly clinical. Head[8] has cited numerous cases of unilateral lesions in the thalamic region in which stimuli which evoke feelings have an excessive effect—pin pricks, painful pressure, pronounced heat or cold all produce much more distress on the damaged side than on the normal side of the body. Agreeable stimuli likewise are felt keenly on the damaged side; a warm test tube, for example, may give rise to intense pleasure, attended by signs of enjoyment on the face and by exclamations of delight. Again, the playing of music and the singing of hymns may arouse such increased emotional feeling, which is referred by the patient to the damaged side, that they may be intolerable. Imagined or remembered situations associated with past emotional experiences have an influence on the damaged side similar to the disturbing stimuli from the sense organs. This excessive influence of affective stimuli, whether from the body surface or from the cortex, Head attributed to the release of the thalamus from cortical control. When freed from check it overacts. And since in these cases the feelings are magnified on the damaged side, Head has concluded that the thalamus is occupied with the emotional aspect of sensation and that the unilateral overaction there is the cause of the unilateral magnification of feeling.

We have reviewed the evidence that the neurones of the thalamic region discharge outward and downward to muscles and viscera to produce the typical bodily changes of emotional excitement, and that they discharge upward to the cortex to add richness and warmth to the simple sensations. Two other important points I wish now to emphasize.

The first of these is concerned with the relations of the cortical and the thalamic control of bodily processes. It is clear that *skeletal muscles are governed at both levels, cortical and thalamic* (see figure 2); for example, we may laugh spontaneously because of a ludicrous situation (thalamic laughter) or we may laugh as a voluntary act (cortical laughter). It is quite as clear that the *viscera,* on the other hand, *are only under thalamic government;* we cannot by direct act of will increase the blood sugar, accelerate the heart, or stop digestion. When there is double control the cortical neurones, to be sure, are ordinarily dominant and may not release the excited neurones of the thalamus (though we sometimes cry or laugh "in spite of ourselves"). Then there is conflict between the higher and lower controls of the bodily functions—there are opposing influences with accompanying confusion. The cortex, however, can check only those bodily functions which are normally under voluntary control. That point I would emphasize. Just as the cortex cannot cause, so likewise it cannot prevent those stormy processes of the thalamus that increase the blood sugar, accelerate the heart, stop digestion, or produce the other disturbances characteristic of great excitement. When an emotion is repressed, therefore, it is repressed only in its external manifestations. There is evidence, to be sure, that when the external manifestations are maximal, the internal turmoil is also maximal[2]; and it is probable that cortical control of the outward display of excitement results in less internal disturbance than would accompany free expression. Nevertheless in a conflict between the cortical government and the activities of the thalamic centers the ungovernable internal manifestations might be intense.

The second point is related to evidence that states of consciousness are associated only with the cortical neurones. Certainly we are unaware of the numerous and complicated reflexes which determine bodily posture or the size of the pupil, for example, although these reflexes are regulated in the brain-stem. It follows that the neural mechanisms for the primitive emotions, active in the basal ganglia, are likewise probably not directly associated with consciousness. This consideration explains, I conceive, some of the most characteristic features of emotional experience. The disturbance in extra-conscious parts boils up into the realm of the conscious. Therefore, we have emotional "sei-

zures"; we may laugh, weep or rage "uncontrollably"; we feel as if "possessed"; what we do in the stress of excitement is "surprising" or "shocking"—something "surges up within us" and our actions seem no longer our own. These common bywords are explicable in terms of a sudden and powerful dominance of the bodily forces by subcortical neurones, i. e., neurones whose activity is not immediately attended by conscious states. Under favoring circumstances, with only a momentary lifting of the normal inhibitory check, these lower neurones capture the machinery of action and drive it violently into one or another of its variegated patterns.

I have now reviewed the evidence that the thalamic region, when freed from cortical control, is capable of elaborate independent activity of a stereotyped character; that when it acts it produces the typical reaction patterns in posture, expression and visceral responses that characterize various strong emotions; and that the activity of the thalamus occasions the feelings of excitement or depression which we experience during an emotional disturbance. Now the question arises, how are these considerations related to practical affairs? How do the processes going on deep down in the old part of the brain affect the workings of the body? To show how events in the thalamus can profoundly disarrange the nice adjustments of the normal organism, I shall cite some illustrative cases. I am sure that they will not seem unusual or improbable to many of you.

First, with regard to digestive functions. As stated earlier, my interest in the effects of emotions in the organism began with observations on the abolition of gastric peristalsis during excitement. Elsewhere[9] I have described instances of total stoppage not only of the mechanical action of the canal, but also of the work of the digestive glands, in consequence of emotional stresses. An evening's meal may remain undigested all night in the stomach if there is persistent worry during the period. The saliva, the gastric and the pancreatic juices all may be stopped by fear. The whole digestive process, which is subject to check by the sympathetic system, may be profoundly disarranged by anxiety and distress—the minor aspects of fear. McLester[10] has estimated that one-third of the patients with disorders of the alimentary tract are suffering because of lack of emotional balance. Alvarez[11] cites a case of persistent vomiting which started when an income tax collector threatened punishment if a discrepancy in the tax statement was not explained, and which ceased as soon as Alvarez himself went to the collector, as a therapeutic measure, and straightened out the difficulty. The natural processes of the alimentary canal are fundamental to all other functions of the body. Any disturbance of normal peristalsis, segmentation, and secretion of the digestive fluids may have widespread ill effects in the organism. Cabot[12] has recorded an instance of fracture of the leg which failed to unite. Investigation showed that the patient was fearful lest his family was suffering while he was absent at the hospital, i. e., the anxiety resulted in loss of desire for food (absence of hunger contractions of the stomach), that resulted in impaired nutrition, and that in turn led to such impairment of the reparative processes that the bone fragments were not welded together. Assurance that his family was well and happy, and being cared for, quickly altered the patient's condition; he ceased worrying, thereupon began to eat heartily and gain in nutrition, and then his broken bones began to knit.

The cardiovascular system, like the digestive system, is under the influence of the sympathetic nerves, but instead of being depressed or inhibited, it is stimulated by them. The excitement which stops gastric digestion makes the heart beat more rapidly and raises blood pressure by contracting the blood vessels. During the War there appeared not infrequently cases of "disorderly action of the heart" or, as it was sometimes called, "soldier's heart." The slightest excitement or perturbation would send the pulse bounding at a high rate (130 to 150 beats per minute). The general physical and nervous condition of the victims of this disturbance—their anxious faces, their troubled eyes, the drawn lines about the mouth, their trembling—was such as to make reasonable the view that the stresses of the war had become intolerable and had resulted in such sensitizing of the sympathetic control of the heart that even mild stimulation produced extreme effects[13]. The mechanism by which emotion may bring about such sensitizing is illustrated in a case reported by Foster[14]:—

> A wife, who was free from any cardiac disorder, saw her husband walking arm in arm with a strange woman and acting in such a way as to rouse jealousy and suspicion. Profoundly stirred by the incident the wife hastened home and remained there several days. She then began to fear going out lest she might meet her husband with her rival. After days of wretchedness she was persuaded by a friend to venture forth, "probably in a state of abject terror," as Foster remarks, but she had not gone far when she ran back to her home. Then she noted that her heart was thumping hard, that she had a sense of oppression in her chest and a choking sensation. Later attempts to go outdoors produced the same alarming symptoms. She began to feel that she might die on the street if she went out. There was no organic disease of the heart, and yet slight effort as she moved from her home brought on acute distress.

The influence of excitement on arterial blood pressure may also be noted. The pressure is produced by the energy of the inflow of blood into the arteries and the resistance to the outflow from them. The sympathetic impulses, by speeding the heart rate and constricting the arterioles, raise the pressure by affecting positively both factors. Gallavardin and Haour[15]

have reported after a study of 100 cases that the first time the blood pressure is taken, and the subjects are, therefore, excited, the systolic level may be 25 to 35 millimeters higher than it is later. And Schrumpf[16] relates an instance in which fear of a serious diagnosis raised the pressure 33 per cent., with prompt return to normal when reassurance was given. In extreme cases of pleasure, anger or fright a rise of 90 millimeters of mercury may occur. It is clear that patients suffering from hypertension and senile impairment of the circulatory system should avoid conditions and obligations which are likely to cause excitement.

Another effect readily produced by sympathetic impulses is the increase of blood sugar. The influence of emotional disturbance in bringing about a hyperglycemia in men subjected to the intense stresses of competitive sports or critical examinations I have pointed out elsewhere[1]. The same phenomenon has been observed in diabetic patients, probably because the sugar excretion is watched more closely in such persons. Woodyatt[17] cites the following from among many similar experiences in his practice:—

A man of 65 years, a diabetic, was in the hospital on a quantitative diet and with a small dose of insulin daily was passing a sugar-free urine. Suddenly one day, without any change in regimen, he secreted 43 grams of sugar. And on another day he secreted 76 grams and developed a mild acidosis; the glycosuria, therefore, could not have been due merely to the taking of extra food. A careful checking of all the circumstances and tests proved that there was no error of technique; nor did examination reveal any evidence of intercurrent physical disease. It was found, however, that the patient had received news which led him to fear that the corporation in which he had been an officer for more than 20 years had taken steps to retire him. That was the occasion for his disturbed sugar metabolism.

As Woodyatt remarks, "It is interesting to be able to measure the power of emotion in terms so tangible as ounces of sugar. *The power of emotions to produce physical alterations of the body* does not seem unreal under these conditions."

There is evidence that violent emotional disturbance can produce profound effects on the organism through influences on the thyroid gland. Marañon[18] has collected an extensive series of cases of hyperthyroidism brought on by stressful experiences during the Great War. Recently Emerson[19] has reported some striking instances of hyperthyroidism which followed intensely affective scenes in the lives of the patients.

One was a married woman who had had two illegitimate children and whose husband committed suicide in her presence as a rebuke to her manner of living. Thereupon she dropped to the floor and exhausted herself in shrieking. At once she had a sense of constriction of her throat and was troubled with difficulty in swallowing; the thyroid gland enlarged and six weeks after the incident she had a metabolism 65 per cent. above normal. Later troubles of an exacting character were associated with the development of high blood sugar and a high arterial pressure.

Another case. A man of twenty years had a quarrel with his fiancée. She, pretending to commit suicide, had in his presence swallowed some pills and fallen down screaming. The man departed hastily. Within a week he was suffering from swelling of the neck and nervousness. When he appeared at the hospital four months later he had lost weight, he presented a large goitre over which a definite thrill could be felt, and his basal metabolism was up 24 per cent. above the normal level.

A third case was that of a married woman who had seen her husband kill his two brothers. The husband bitterly reproached her for not coming to his defense at the trial. A week after the trial a goitre became evident and reached a large size in seven days. When she came to the hospital a few months later, the goitre was huge, it pulsated visibly, had a palpable thrill and was causing an oppressive sense of suffocation. There was pronounced exophthalmus with marked tremor and restlessness. The basal metabolism varied from +40 to +117 per cent.

There are other emotional effects on bodily functions which might be mentioned, such as disorders of menstruation[20], emptying of the bladder[21], secretion of milk[22], discharge of adrenin[23], altered coagulability of the blood[24], increase in the number of red corpuscles[25], and others. Enough instances have been given, however, to show that there are effects wrought on the organs innervated by the sympathetic nervous system—glands both of external and internal secretion and parts supplied with smooth muscle—that are just as real as the effects which are produced when the biceps is used to lift a weight. A remarkable difference lies in the level of the nervous control of these two effects. Whereas the biceps is usually managed from the cortex, the viscera are managed from the diencephalon. Whereas the biceps is under "voluntary" control, the viscera are not under that control, but are influenced favorably or unfavorably by processes associated with feelings and emotions. Although the neural center for emotional expression is subcortical indeed, is low in the brain-stem—yet cortical processes are involved in the total reaction to a situation which evokes strong feelings. We might be frightened by a real bear, but not by a stuffed bear. The discrimination between the two is made by the cortex. How may this relation between cortex and thalamus be interpreted in physiological terms?

Earlier I have pointed out that an emotional reaction has many of the characteristics of a reflex response. To evoke a reflex an appropriate stimulus must be applied; an irritant in the larynx produces coughing, food in the mouth calls forth a flow of saliva. Similarly with the emotional expressions. Watson[26] has studied new-born babies and has found that from the beginning loud sounds and also indications of loss of support are the natural stimuli for the

reaction of fear. Limitation or hampering of the freedom of bodily movement is from the beginning the natural stimulus for rage.

Agents other than the natural stimuli, however, can easily be made to set a reflex in action if only they are closely associated with the natural stimuli. Thus if a red light is flashed repeatedly at the same time that food is placed in the mouth, the red light will itself, alone, become as effective as the food in causing a salivary discharge. The indifferent stimulus, the red light, is then called the conditioned stimulus and the reflex salivary secretion, under the circumstances, a conditioned reflex. All sorts of ordinarily indifferent external agents—not only a light, but a sound, a shape, a contact, an odor, indeed *anything* that will influence a sense organ—may be made into an effective stimulus by close association in time with the normally effective stimulus. Thus objects and events in the world about us are constantly acquiring new significance for our reactions. All the processes of conditioning are carried on in the cerebral cortex. These facts, which have been studied in great detail and most instructively by the Russian physiologist, Pavlov[27], have pertinence for the explanation of emotional behavior.

Our emotional reflexes, like the salivary reflex, become complicated by the conditioning of indifferent stimuli. A white rat shown to a baby causes the baby to reach for it and to play with it; there is no fear. Then the rat is presented repeatedly but at the same time a loud sound is made by striking a steel bar. The rat thus becomes a conditioned stimulus for the fear reaction produced by the loud sound, and thereafter, when the rat is shown, the baby cries and turns away. He is now afraid of the rat not because it is a rat but because it has become the signal and symbol of something fearful—the loud sound. In such ways as this the indifferent circumstances of an emotional disturbance become conditioned stimuli or signals for renewal of the disturbance. The wife who saw her husband paying attention to a strange woman on the street had an intense emotional experience which was renewed, not by seeing again the errant husband and his distressing companion, but by going into the street! Thus by extended associations emotional responses become subjected to more and more involved conditioned stimuli, until great complexity and intricacy of affective behavior result.

In the foregoing discussion I have purposely emphasized the physiological mechanisms of emotional disturbances, and for two main reasons. First, I wished to show that these remarkable perturbations could be described in terms of neurone processes. And again, I wished to persuade you that these interesting phenomena should not be set aside as mystical events occurring in the realm of the "psyche," but rather should be regarded as movements and inhibitions and disturbances in the body which properly fall within the province of the physician.

Probably a physiologist is venturing too far if he attempts to suggest practical modes of treatment. And yet in what I have presented to you there are physiological implications which have practical bearings on the care of patients who have been or are being profoundly disturbed by emotional experience.

First, there is the importance of early treatment. We are all acquainted with the readiness with which habits are established in the nervous system by frequently repeating an act. Every time the nerve impulses traverse a given course they make easier the passage of later impulses. Thus habitual emotional expressions, both in the facies and in the viscera, may become fixed and deep-set in the neural organization, just as the complicated adjustments of swimming, skating or bicycle riding become inwrought during our later years by repeated practice. It is clear that so far as possible emotional habit-reactions should be prevented by prompt treatment.

As we have seen, the cortex has no direct control over the functions of the viscera. It is useless, therefore, to try to check a racing heart or to lower a high blood pressure, or to renew the activities of an inhibited digestive system by a coldly reasoned demand for different behavior. The man whose broken bone failed to knit because he was fearful about his family's welfare could not be *argued* out of his fear; the fear left him when he learned that his family was actually comfortable. The cortex, which is concerned with analysis of the outer world, should not, therefore, be the sole means by which treatment is attempted; the *occasion* for worries, anxieties, conflicts, hatreds, resentments, and other forms of fear and anger, which affect the thalamic centers, must be removed. In short, the factors in the whole situation which are the source of strong feeling must be discovered and either explained away or eliminated.

Although the cortex has no direct control over the viscera, it has indirect control—we can walk into danger and have a thrill, though we cannot have a thrill by merely resolving to have one. Similarly we can often avoid the circumstances which rouse fear or rage or disgust and their attendant visceral turmoil—we need not go near the agitating spot.

Again, when the reason for the perturbation is not clear, it can sometimes be found by careful enquiry or analysis. It is an interesting fact that a full explanation of the way in which the trouble has been caused will not infrequently suffice to remove the trouble, promptly and completely.

Finally, a word of warning may not be out of place. If an objective cause for a patient's

complaint is not found, nothing is easier than to attribute the difficulty to nervous factors. There is danger, when one emphasizes the importance of nervous factors as disturbers of the bodily peace, that one may be understood as minimizing the need of search for a gross pathology. Nothing could be farther from my intention. The assumption that emotional agencies are causing mischief in the organism should be a last resort—an explanation which is offered only after every effort has been made to find another explanation. And even when the cause is ascribed to fear or rage or some other strong feeling, proof for that conclusion should be carefully sought both at the source of the trouble and in the effect of appropriate therapy. Nor should the possibility be overlooked that along with profound emotional disturbance there will be discovered a demonstrable lesion. The two conditions, the altered structure of some organ and the altered function of the nervous system, may be causally related, and may have to be treated as a single disorder. Certain it is that only when they are both regarded as the perturbations of a single unity, the organism, will they be properly conceived and effectively treated.

I have tried to indicate the ways in which the functions of the body may be upset by the neural processes which are associated with emotions. I hope that I have convinced you that interest in this realm of medicine should not be relegated to cults, mental healers and the clergy. The doctor is properly concerned with the workings of the body and their disturbances, and he should have, therefore, a natural interest in the effects of emotional stress and in the modes of relieving it. The field has not been well cultivated. Much work still needs to be done in it. It offers to all kinds of medical practitioners many opportunities for useful studies. There is no more fascinating realm of medicine in which to conduct investigation. I heartily commend it to you.

BIBLIOGRAPHY

1 Cannon: Bodily Changes in Pain, Hunger, Fear and Rage, New York, 1915.
2 Cannon and Britton: Am. Journ. Physiol., 1925, lxxii, 283.
3 Bulatao and Cannon: Ibid., 295.
4 Bard: Ibid., 1928, lxxxiv, 490.
5 Bechterev: Virchow's Arch., 1887, cx, 345.
6 Roussy: La Couche Optique, Paris, 1907, p. 31.
7 Brissaud: Leçons cliniques, 1894.
8 Head: Studies in Neurology, London, 1920, ii, 620.
9 Cannon: The Mechanical Factors of Digestion, London, 1911.
10 McLester: Journ. Am. Med. Assn., 1927, lxxxix, 1019.
11 Alvarez: Personal communication.
12 Cabot: Harvard Alumni Bulletin, 1925, xxviii, 384.
13 Cohn: Am. Journ. Med. Sci., 1919, clviii, 453.
14 Foster: Journ. Am. Med. Assn., 1927, lxxxix, 1018.
15 Gallavardin and Haour: Arch. de Mal du Coeur, 1912, v, 81.
16 Schrumpf: Deutsch. med. Wochenschr., 1910, xxxvi, 2385.
17 Woodyatt: Journ. Am. Med. Assn., 1927, lxxxix, 1013.
18 Maranon: Annal. de Med., 1921, ix, 81.
19 Emerson: Trans. Assn. Am. Phys., 1927, xlii, 346.
20 Mayer: Schwarz's Psychogenese und Psychotherapie körperlicher Symptome, Vienna, 1925, p. 298.
21 Schwarz: Ibid., p. 273.
22 Greving: Müller's Die Lebensnerven, Berlin, 1924, p. 226.
23 Cannon, Britton, Lewis and Groeneveld: Am. Journ. Physiol., 1927, lxxix, 433.
24 Cannon and Mendenhall: Ibid., 1914, xxxiv, 251.
25 Izquierdo and Cannon: Ibid., 1928, lxxxiv, 545.
26 Watson: Lectures on Behaviorism, New York, 1925, 114.
27 Pavlov: Conditioned Reflexes, Oxford, 1927.