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# PHYLOGENETIC ASSOCIATION IN RELATION TO THE EMOTIONS.

By GEORGE W. CRILE, M.D.

(Plates I-VIII.)

(*Read April 22, 1911.*)

To the surgeon every variety of the human emotions in the various stations of life, from infancy to senility, in health and in disease is presented. Not only does the surgeon come in intimate contact with emotions displayed by the victims of disease and accidents but he also observes those manifested by the remainder of the family circle and friends. Then, too, he is unhappily forced to notice the effects upon himself when he is waging an unequal battle against death—the strain and worry at a crisis when a life is in the balance and a single false move may be fatal is an experience unknown to others as it is to the operating surgeon.

My personal experience as a surgeon and an experimental research of my associates, Dr. H. G. Sloan, Dr. J. S. Austin, and Dr. M. L. Menten, and myself furnish data for this paper.

On this occasion I shall limit my discussion mainly to the strongest emotion, viz., *fear*. I believe that it can be shown that the emotion of fear can be elicited only in animals that utilize a motor mechanism in defense against danger or in escape from it. For example: the defense of the skunk is a diabolic odor which repels its enemies. The skunk has no adequate equipment for defence or escape by muscular exertion. The skunk has little or no fear. Again certain species of snakes are protected by venom. They possess no other means of defense nor adequate motor mechanism for escape. They show no fear. Other animals because of their prowess have but few fears. The lion, the grizzly bear, and the elephant are examples. Animals having armored protection, as the turtle, have little fear. It is therefore obvious that fear is not universal. The emotion of fear is felt only in those animals whose

self-preservation is dependent upon an uncertain adequacy of their power of muscular exertion either in defense or in flight.

What are the principal phenomena of fear? They are palpitation of the heart, acceleration of the rate and alteration of the rhythm of the respiration, cold sweat, rise in body temperature, tremor, pallor, erection of the hair, suspension of the principal functions of digestion, muscular relaxation and staring of the eyes. The function of the brain is wholly suspended except that which

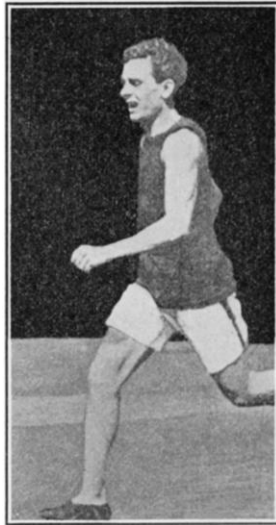


FIG. 1. The expression in this picture, copied from "Outing," shows the participation of the facial muscles in physical action—perhaps it may indicate the origin of the activity of the facial muscles in ancient fighting with teeth.

relates to the self-protective response to the object feared. Neither the brain nor any other organ of the body can respond to any other lesser stimulus during the dominance of fear.

From the foregoing it would appear that under the influence of fear, most, perhaps all of the organs of the body, are divided sharply into two classes: first, those that are stimulated, and second, those that are inhibited. Those that are stimulated are the entire muscular system, vasomotor and locomotor systems, the senses of per-

ception, the respiration, the mechanism for erecting the hair, the sweat glands, the thyroid gland, the adrenal gland (Cannon), and the special senses. On the other hand the entire digestive and procreative functions are inhibited. What is the significance of this grouping? So far as we know the organs stimulated increase the efficiency of the animal for fight or for flight. It is through skeletal muscles that the physical attack or escape is affected; these muscles alone energize the claws, the teeth, the hoofs, and the means for flight. The increased action of muscles of the heart and the blood vessels increases the efficiency of the circulation; the secretion of the adrenal gland causes a rise in the blood pressure; the increased action of the thyroid gland causes an increased metabolic activity; there is evidence that glycogen is actively called out, it being the most immediately available substance for the production of energy; the increased activity of the respiration is needed to supply the greater requirements of oxygen and the elimination of the increased amount of waste products; the dilation of the nostrils affords a freer intake of air; the increased activity of the sweat glands is needed to regulate the rising temperature of the body from the increased metabolism. The activity of all of the organs of perception—sight, hearing, smell—are heightened for the purpose of more accurately perceiving the danger. It can not be a mere coincidence that the organs and the tissues that are stimulated in the emotion of fear are precisely those that are actually utilized in the perception of danger in a physical struggle for self-preservation.

Are there any other organs stimulated by fear except those that can or that do assist in making a defensive struggle? I know of none. On the other hand, if an animal could dispense with his bulky digestive organs, whose functions are suspended by fear, if he could, so to speak, clear his decks for battle, it would be advantageous. Although the marvelous versatility of natural selection apparently could devise no means of affording this advantage, it shut off the nervous current and saved the vital force these non-combatants ordinarily consume in the performance of their functions. Whatever the origin of fear is, its phenomena are due to a stimulation of all of the organs and tissues that add to the efficiency

of the physical struggle for self-preservation through the motor mechanism and an inhibition of the function of the leading organs that do not participate—the non-combatants, so to speak. Fear arose from injury, and is one of the oldest and surely the strongest emotion. By the slow process of vast empyricism nature evolved the wonderful defensive motor mechanism of many animals and of man. Now the stimulation of this mechanism leading to a physical struggle is action, and the stimulation of this mechanism without action is emotion.

We may say that fear is a *phylogenetic fight or flight*. On this hypothesis all the organs and parts of the entire animal are integrated, connected up or correlated, for self-preservation by activity of its motor mechanism. We fear not in our hearts alone, not in our brain alone, not in our viscera alone; fear influences every organ and tissue—each organ or tissue is stimulated or inhibited according to its use or hindrance in the physical struggle for existence. In thus concentrating all or most of the nerve force on the nerve muscular mechanism for defense alone, a greater physical power is developed. Hence, it is that animals under the stimulus of fear are able to perform preternatural feats of strength. Then, too, for the same reason the exhaustion following fear will be the greater, as the powerful stimulus of fear drains the cup of nervous energy, though no visible action may result. An animal under the stimulus of fear may be likened to an automobile with the clutch thrown out but whose engine is racing at top speed. The gasoline is being consumed, the machinery is being worn, but the machine as a whole does not move, though the power of its engine may cause it to tremble.

Applying this conception to human beings of today certain mysterious phenomena are at once elucidated. It must be borne in mind that man has not been presented with any new organs to meet the requirements of his present state of civilization—indeed not only does he possess the same type of organs as his savage fellows but also the same type of organs possessed by even the lower animals. In fact the present status of civilization of man is now operated with the primary equipment of brutish organs. Perhaps the most

striking difference is the greater control man has gained over his primitive instinctive reactions. Contrasted with the entire duration of organic evolution, man has come down from his arboreal abode and assumed his new rôle of increased domination over the physical world but a moment ago. And now, though sitting at his



FIG. 2. Note the resemblance between the facial expression in the great efforts of the athlete and the expression of the strong emotions. The relation of motion and emotion becomes more obvious as strong motor and emotional acts are compared. From "Outing."

desk in command of a complicated machinery of civilization, when he fears a business catastrophe it is in the terms of his ancestral physical battle in the struggle for existence. He cannot fear intellectually, he cannot fear dispassionately, he fears with all of his

organs, and the same organs are stimulated and the same organs are inhibited as if instead of its being a battle of credit, of position or of honor, it were a physical battle with teeth and claws. Whether the cause of acute fear is moral, financial, social, or stage fright, the heart beats wildly, the respirations are accelerated, perspiration is increased, there is a pallor, trembling, indigestion, dry mouth, etc. The phenomena are those of physical exertion in self defense or escape. There is not one group of phenomena for the acute fear of the president of a bank in a financial crash and another for the hitherto trusted official who suddenly and unexpectedly faces the naked probability of the penitentiary; or one for a patient who unexpectedly finds he has a cancer and another for the hunter when he shoots his first big game. Nature has but one means of response and whatever the cause the phenomena are always the same—always physical.

The stimulus of fear if repeated from day to day, whether it be a mother anxious on account of the illness of a child; a business man struggling against failure; a politician under contest for appointment; a broker in the daily hazard of his fortune; litigants in legal battle, or a jealous lover who fears a rival,—the countless real as well as baseless fears in daily life—all forms of fear as it seems to me, express themselves in similar terms of ancestral physical contest and on this law dominate the various organs and parts of the body. Anger and fear express opposite states. Fear expresses the evidence of a strong desire to escape from danger; anger, a strong desire to attack physically and vanquish opposition. This hypothesis is strongly supported by the outward expression of fear and anger. When the business man is conducting a struggle for existence against his rivals and when the contest is at its height, he may clench his fists, pound the table, perhaps show his teeth and he may exhibit every expression of physical combat. Fixing the jaw and showing the teeth in anger merely emphasizes the remarkable tenacity of phylogeny. Although the development of the wonderful efficiency of the hands has led to a modification of the once powerful canines of our progenitors, the ancestral use of the teeth for attack and defense is attested in the display of anger. In all sta-

tions of life differences of opinion may lead to argument and argument to physical combats, even to the point of killing. Physical violence of the savage and the brute still lies surprisingly near the surface.

There have now been presented some of the reasons based largely on gross animal behavior why fear is to be regarded as a



FIG. 3. The attitude and the facial expression represent anger, and the integration of the entire body for a strong aggressive action shows the extent to which the body of man has been evolved as a motor mechanism. From "Outing."

response to phylogenetic association of physical danger. I shall now present some additional evidence in support of this hypothesis from the clinical and the experimental side. Although there is not convincing proof yet there is evidence that the effect of the stimulus of fear upon the body without physical activity is more injurious than actual physical contest which results only in fatigue without gross physical injury. It is well known that the soldier lying under



fire waiting in vain for orders to charge suffers more than the soldier that flings himself into the fray; that a wild animal in an open chase against capture suffers less than when cowering in captivity. An unexpressed slumbering emotion is measurably relieved by action. It is probable that the various energizing substances needful in physical combat such as the secretion of the thyroid, the adrenals, etc., but which are not consumed in action may, if frequently repeated, cause physical injury to the body. That the brain is definitely influenced, even damaged by fear has been proved by the following experiments:

Rabbits were frightened by a dog but not injured, and not chased. After various periods of time the animals were killed and their brain cells compared with the normal. Widespread changes were seen. The principal clinical phenomena expressed by the rabbit were rapid heart, accelerated respiration, prostration, tremors, and a rise in temperature.

The dog showed similar phenomena—excepting instead of muscular relaxation as in the rabbit the dog showed aggressive muscular action. Both the dog and the rabbit were exhausted and although the dog exerted himself actively and the rabbit remained physically passive, the rabbit was much more exhausted.

Further observations were made upon the brain of a fox chased for two hours by members of a hunt club, then finally overtaken by the hounds and killed. The brain cells of this fox as compared with those of a normal fox showed extensive physical changes in most of the cells.

The next line of evidence is offered with some reservation but it has seemed to me to be more than mere idle speculation. It relates to the phenomena of one of the most interesting diseases in the entire category of human ailments—I refer to exophthalmic goiter or Graves' Disease—a disease primarily involving the emotions. This disease is frequently the direct sequence of severe mental shocks or a long and intensely worrying strain. The following case is typical. A broker was in his usual health up to the panic of 1907. During this panic his fortune and that of others was for almost a year in jeopardy, failure finally occurring. During this

heavy strain he became increasingly more nervous, and imperceptibly there appeared a pulsating enlargement of the thyroid gland, an increased prominence of the eyes, marked increase in perspiration, even profuse sweating, palpitation of the heart, increased respiration with frequent sighing, increase in blood pressure; there was tremor of many muscles, rapid loss of weight and strength, frequent gastro-intestinal disturbances, loss of normal control of his emotions, and marked impairment of his mental faculties. He was as completely broken in health as in fortune. These phenomena

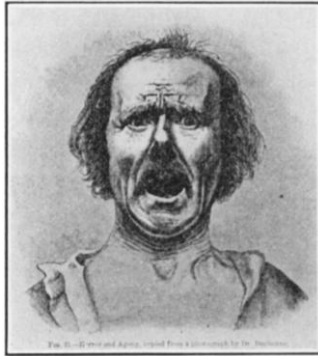


FIG. 4. This picture is taken from Darwin's "Expression of the Emotions in Man and Animals" and expresses horror and agony.

resembled closely those of fear and followed in the wake of strain due to fear.

In young women exophthalmic goiter often follows in the wake of a disappointment in love; in women, too, it frequently follows in the wake of an illness of a child or parent in which the double strain of worry and of constant care is present. Since such strains usually fall heaviest upon woman, they are the most frequent victims. Now, whatever the exciting cause of exophthalmic goiter, whether unusual business worry, disappointment in love, a tragedy, or the illness of a loved one, the symptoms are alike and closely resemble the phenomena of one of the great primitive emotions. How could disappointment in love play a rôle in the causation of Graves' Disease? If the hypothesis presented for the explana-

tion of the genesis and the phenomena of fear is correct then it would hold for the emotion of love. If fear is a phylogenetic physical defense or escape but without resulting in muscular action then love is a phylogenetic conjugation without physical action. The quickened pulse, the leaping heart, the accelerated respiration, the sighing, the glowing eye, the crimson cheek, and many other phenomena are merely phylogenetic recapitulations of ancestral acts.

The thyroid gland is believed to participate in such physical activities. Hence, it could well follow that the disappointed maiden who is intensely integrated for a youth will at every thought of him be subjected by phylogenetic association to a specific stimulation analogous to that which attended the ancestral consummation. Moreover, a happy marriage has many times been followed by a cure of the exophthalmic goiter which appeared in the wake of such an experience. The victims of Graves' Disease present a counterpart of emotional exhaustion. The emotions in Graves' Disease are abnormally acute as illustrated by personal observation of death of a subject of this disease from fear alone. Whatever the exciting cause of this disease the symptoms of Graves' Disease are the same; just as in fear the phenomena are the same whatever the exciting cause. In Graves' Disease as illustrated by the photographs the resemblance is close to that of fear. The following phenomena fear and Graves' Disease have in common: increased heart beat, increased respiration, rising temperature, muscular tremors, protruding eyes, loss in weight; Cannon has found an increased amount of adrenalin in the blood in fear and Frankel in Graves' Disease; increased blood pressure; muscular weakness; digestive disturbances; impaired nervous control; hypersusceptibility to stimuli; in protracted intense fear the brain cells show marked physical changes; in Graves' Disease analogous changes are seen. In Graves' Disease there seems to be a composite picture of an intense expression of the great primitive emotions. If Graves' Disease is a disease of the great primitive emotions or rather of the whole motor mechanism how is the constant flow of stimulation of this complicated mechanism supplied? It would seem that at some period

there must be secreted in excessive amount some substance that activates the motor mechanism; then too the nervous system in Graves' Disease is hypersusceptible to stimuli and to thyroid extract. It might follow that even a normal amount of thyroid secretion



FIG. 5. This photograph of fear closely resembles the expression of patients afflicted with Graves' disease or exophthalmic goiter.

would lead to excessive stimulation of the hypersusceptible motor mechanism.

This condition of excessive motor activity and hyperexcitability may endure for years. What is the source of this pathologic excitation?

The following facts may give a clue, viz., in suitable cases of Graves' Disease if the thyroid secretion is sufficiently diminished by a removal of a part of the gland or by interruption of the nerve and the blood supply, the phenomena of the disease are immediately diminished, and in favorable cases the patient is restored to approximately the normal condition. The heart slows, the respiration falls, the restlessness diminishes, digestive disturbances disappear,

tremors decrease, there is a rapid increase in the body weight, and the patient gradually resumes his normal state. On the other hand, if to a *normal* individual extract of the thyroid gland is administered in excessive dosage over a period of time, there will develop nervousness, palpitation of the heart, sweating, loss of weight, slight protrusion of the eyes, indigestion; in short there will be produced, artificially, most of the phenomena of Graves' Disease and of the strong emotions. On discontinuing the administration of the thyroid extract these phenomena may disappear. On the other hand, when there is too little or no thyroid gland the individual becomes dull and stupid and emotionless, though he may be irritable; but if a sufficient amount of thyroid extract is given such a patient he may be brought up to the normal again.

Hence, we see that the phenomena of the emotions may be, within certain limits, increased, or may be diminished, or abolished by increasing, diminishing, or totally excluding the secretion of the thyroid gland.

Graves' Disease may be increased by giving thyroid extract, and by fear. It may be diminished by removing a part of the gland, or by tying the blood and nerve supply, or by complete rest. Finally in Graves' Disease there is at some stage an increase in the size and in the number of the secreting cells. These facts relating to the normal and the pathological supply of thyroid secretion point to this gland as one of the sources of the energizing substance or substances for the execution of the motor phenomena of animals as well as the expression of their emotions.

Anger is, of course, of similar origin and is an integration and stimulation of the motor mechanism and its accessories. Animals having no natural weapons for attack experience no emotion or anger, and the animals that have weapons for attack express anger principally by energizing the muscles used in attack. Although the efficiency of the hands of man has largely supplanted the use of the teeth, he still shows his teeth in anger and so gives support to the remote ancestral origin of this emotion and the great persistence of phylogenetic association. On this conception we can understand why it is that a patient consumed by worry—which to me signifies

the state of alternation between hope and fear—interrupted stimulation, suffers so many bodily impairments and even diseases. It explains the slow dying away of animals in captivity. It explains the grave digestive and metabolic disturbance under any nerve strain—especially under the strain of fear, and the great benefits of confidence and hope; it explains the nervousness, loss of weight, indigestion—in short the comprehensive physical changes that are



FIG. 6. This is a typical picture of exophthalmic goiter, and illustrates well its resemblance to the expression of the emotion of fear. From American Practice of Surgery.

wrought by fear and sexual love and hate, On this hypothesis we can understand the physical influence of one individual over the body and personality of another; and of the infinite factors in environment that play a rôle in the functions of many of our organs all through phylogeny and association. It is because we were evolved as motor beings on the uncompromising law of survival of the fittest, hence it is that we are not in possession of any organs or faculties which have not served our progenitors in their survival in the relentless struggle of organic forms with each other. We are now as we were then essentially motor beings and our only way of responding to the dangers in our environment is by a motor response. Such a motor response implies the integration of our entire being for action and the activity of certain glands such as the adrenals, the thyroid, the liver, etc., resulting in the throwing into the blood stream substances which help to form energy, but which if no muscular action ensues are harmful elements in the blood.

While this motor preparation is going on the entire digestive tract is inhibited. It is then clear that an emotion is more harmful than action.

If the agency that inspires sufficiently the faith—whether the agency be mystical, human, or divine—whatever dispels worry will at once stop the body-wide stimulations and inhibitions which cause lesions as truly physical as a fracture. The striking benefits of good luck, success and happiness; of the change of scenes; of hunting or fishing; of optimistic and helpful friends, are at once explained by this hypothesis. One can also understand the difference between the broken body and spirits of an animal in captivity and its buoyant return to normal condition when freed; but time will not permit following this tempting lead which has been introduced for another purpose, which I may say, is one of the principal objects sought in this paper, viz., a proposed remedy.

Worries either are or are not groundless. Of those that have a basis many are exaggerated. It has occurred to me to utilize as an antidote an appeal to the same great law that originally excites the instinctive involuntary reaction known as fear, viz., the law of self-preservation.

I have found that if an intelligent patient suffering from fear is made to see so plainly as to amount to a firm conviction that his brain, his various organs, indeed his whole being could be physically damaged by fear, this same instinct of self-preservation will to the extent of his conviction, banish fear. It is hurling threatened active militant danger, whose imperious influences are both certain and known, against an uncertain, perhaps a fancied one, or in other words fear itself is an injury which when recognized is instinctively avoided. In precisely a similar manner anger may be softened or banished by an appeal to the stronger self-preserving instinct of the fear of physical damage,—such as the physical injury of brain cells. This playing of one primitive instinct against another is comparable to the effect upon two men quarrelling when a more powerful enemy of both comes threateningly on the scene.

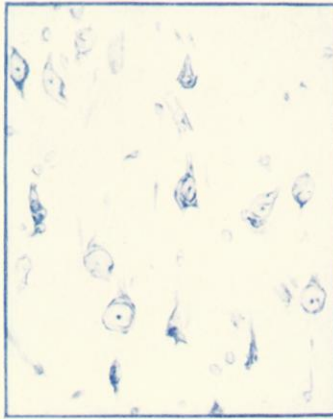
The acute fears of surgical operations may be banished by the use of certain drugs that depress the associational power of the brain and minimize the evidence that usually inspires fear. If in

addition the entire field of operation is blocked by local anesthesia so that the associational centres are not awakened, the patient passes through the operation unscathed.

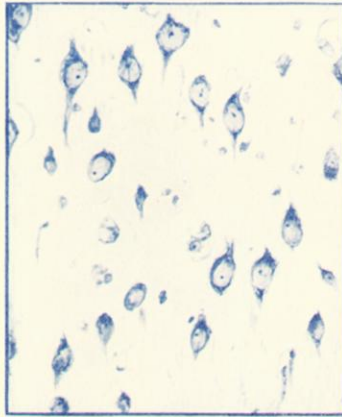
The phylogenetic origin of fear is injury, hence injury and fear cause the same phenomena—psychic shock is the same in quality and in its phenomena as traumatic shock. The perception of danger by the special senses as the sound of the opening gun of a battle, the sight of a venomous snake, cause the same effects upon the entire body and are phylogenetically the same as operations under anesthesia or a physical combat in that they all drive the motor mechanism. The use of local anesthetics in the operative field prevents the injury currents from reaching the brain and there integrating the entire body for a self-defensive struggle, though a part of the brain is asleep and the muscles paralyzed, is the same as the interception of the terrifying sound of the gun, or the sight of the dangerous reptile, because it prevents the stimulation of the motor mechanism. From both the negative and positive side we find abundant evidence which forces us to believe that the emotions are primitive instinctive reactions representing ancestral acts which utilize the complicated motor mechanism which has arisen through the forces of evolution in establishing beings best suited for their adaptation to their environment and for procreation.

The mechanism by which the motor acts are performed, and the mechanism by which the emotions are expressed are one and the same. These acts in their infinite complexity are performed by association, *i. e.*, phylogenetic association. When our progenitors came in contact with excitation in their environment, action ensued then and there. There was much action—little restraint or emotion. Civilized man is really in auto-captivity. He is subjected to innumerable stimulations, but custom and convention frequently prevent physical action. When these stimulations are sufficiently strong but no action ensues, the reaction constitutes an emotion. A phylogenetic fight is anger; a phylogenetic flight is fear; a phylogenetic copulation is sexual love, and so one finds in this conception an underlying principle which may be the key to an understanding of the emotions and of certain diseases.

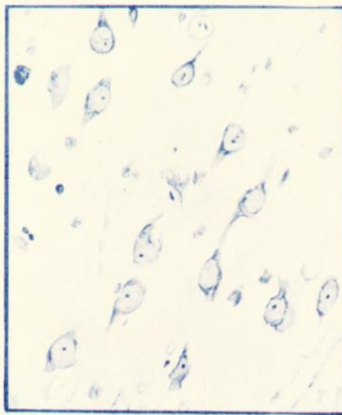




Normal Rabbit : Cerebrum.



Frightened Rabbit : Cerebrum. The rabbit was frightened once and *immediately killed*. Note the hyperchromatism.

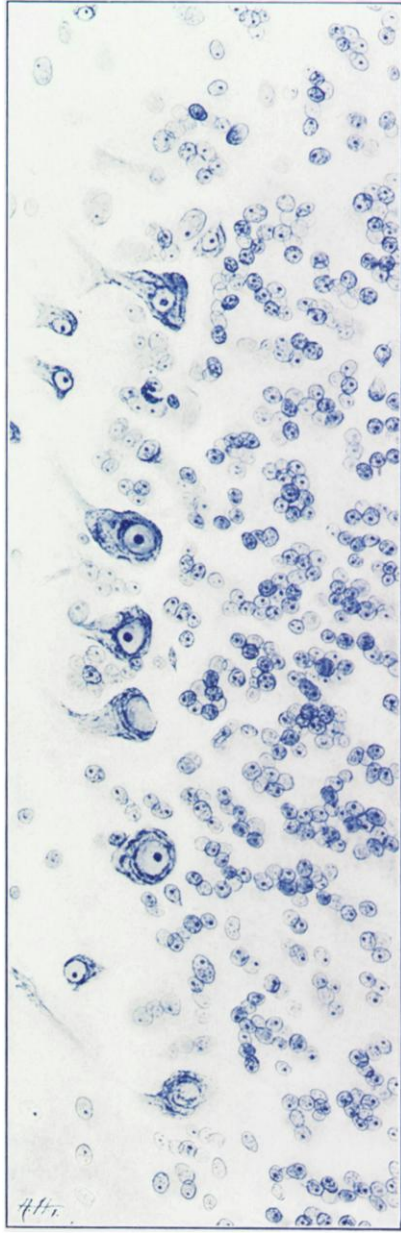


Frightened Rabbit : Cerebrum. The rabbit was frightened once and killed at the end of six hours. The cells are more swollen than in the normal.

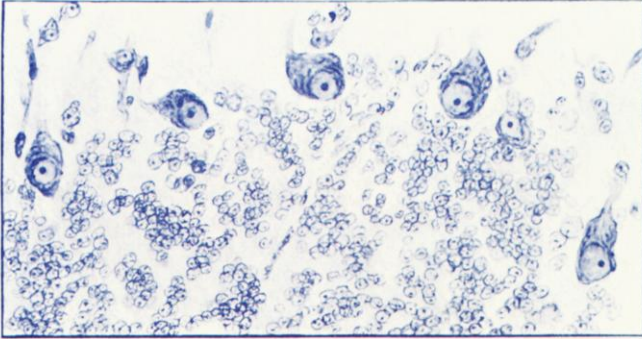
FEAR IN RABBITS.

These and the following cuts are intended to show that fear and exophthalmic goitre cause demonstrable morphologic changes in the nerve cells of different parts of the brain which vary in degree [rather than in specificity] according to the part of the brain.

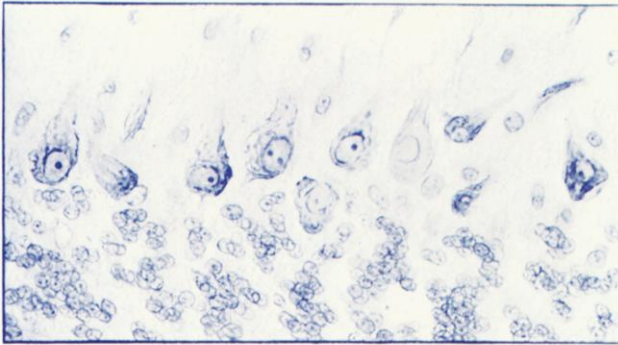
The rabbits used in the fear experiments were frightened by dogs *without being injured* or without making muscular efforts of any consequence.



Normal rabbit: Cerebellum. The average of ten differential Purkinje cell counts from ten rabbits was : Active cells, 64.8 per cent. ; fatigued cells, 34.5 per cent. ; exhausted cells, 0.7 per cent. [For comparison with cuts on Plate III.]



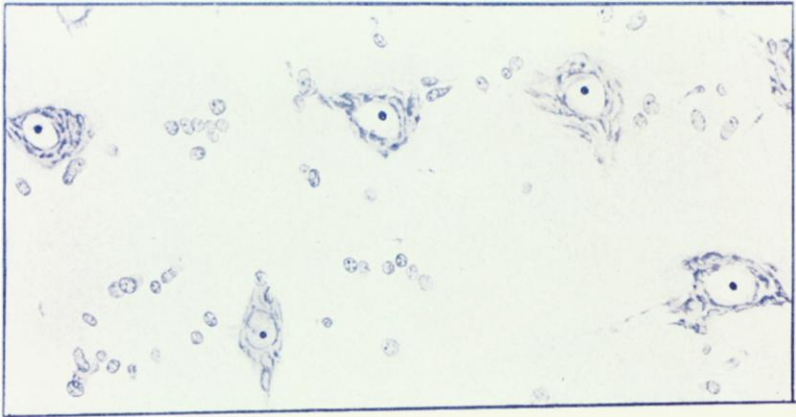
Frightened rabbit: Cerebellum. The rabbit was frightened once and *killed immediately*. The average of ten differential Purkinje cell counts from ten such experiments was: Active cells, 83.4 per cent.; fatigued cells 15.7 per cent.; exhausted cells, 0.9 per cent.



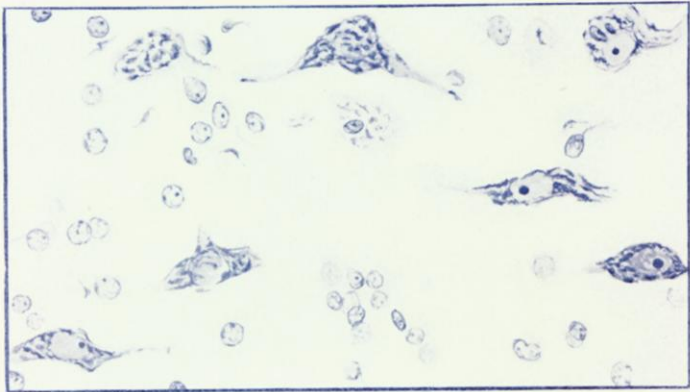
Frightened rabbit: Cerebellum. The rabbit was frightened once and *killed at the end of two and one half hours*. The average of five differential Purkinje cell counts from five such experiments was: Active cells, 55.6 per cent.; fatigued cells, 35.4 per cent.; exhausted cells, 9.0 per cent.

#### FEAR IN RABBITS.

These cuts and the cell counts as given above illustrate several important points, viz., that cerebral stimulation by fear causes, first, demonstrable morphologic changes in brain cells, second, a marked early increase in the number of active [and hence also hyperchromatic] cells, and, third, that this stimulation is followed by later and more serious morphologic changes in the cells which do not attain a maximum until from 2½ to 6 hours have elapsed after the period of fright.

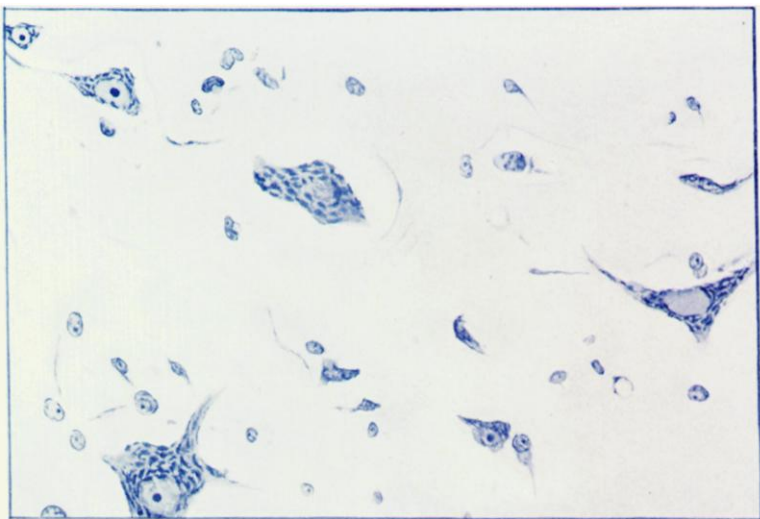


Normal rabbit : Medulla.

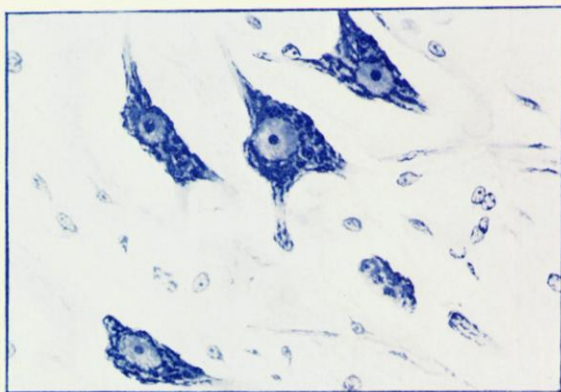


Frightened rabbit : Medulla. The rabbit was frightened once *and immediately killed.*

**FEAR IN RABBITS.**



Normal rabbit : Cervical cord, anterior horn.



Frightened rabbit : Cervical cord, anterior horn. The rabbit was frightened once and *immediately killed*. Note the marked hyperchromatism.

**FEAR IN RABBITS.**

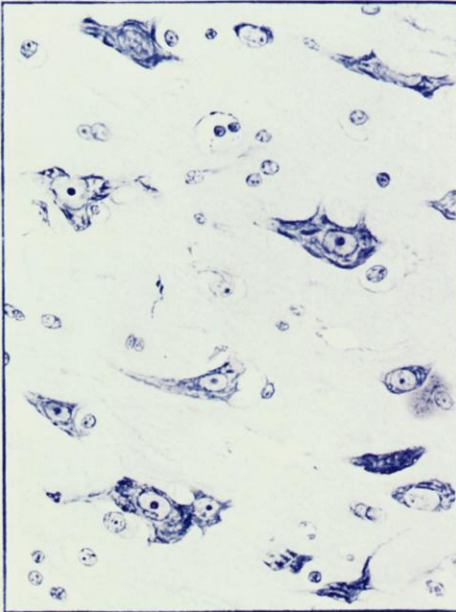


FIG. 1. "Normal" Human Cerebrum.

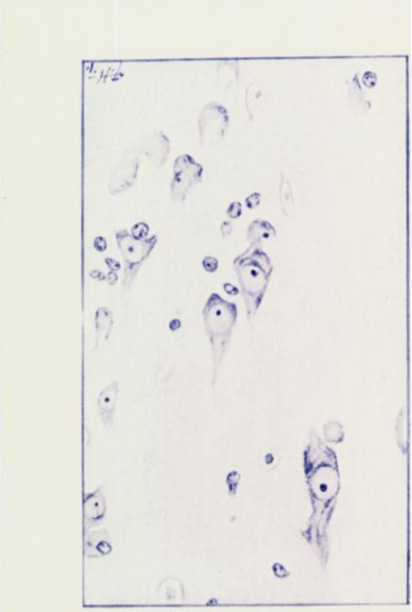


FIG. 2. Exophthalmic Goitre Cerebrum

Exophthalmic Goitre. The contrast between the normal and exophthalmic goitre cerebrum sections is more marked than between the medulla sections. As a rough general rule it may be said that the lower the portion of the central nervous system affected the slighter the degree of injury.



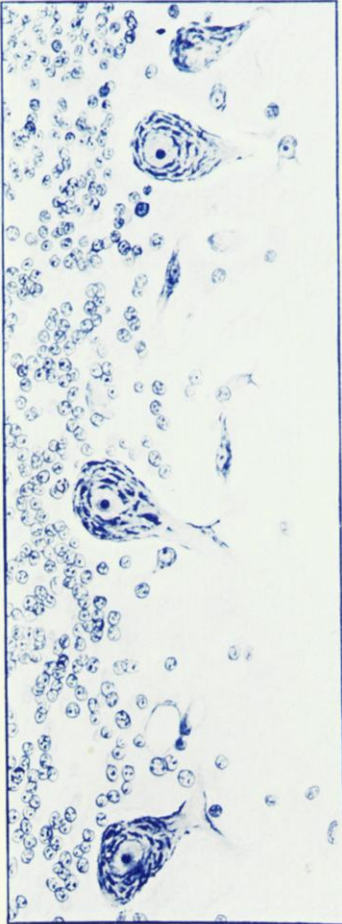


FIG. 1. "Normal" Human Cerebellum.

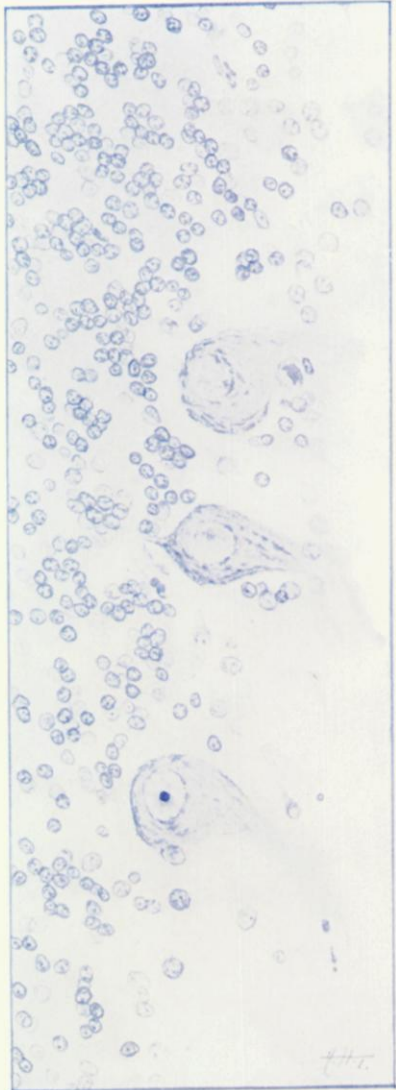


FIG. 2. Exophthalmic Goitre Cerebellum.

Exophthalmic Goitre. Note the marked injury of the Purkinje cells, and the striking contrast between the general appearance of the two cuts. The average differential Purkinje cell count from five cases of exophthalmic goitre was: Active cells, 34.2 per cent.; fatigued cells, 37.6 per cent.; exhausted cells, 28.2 per cent.

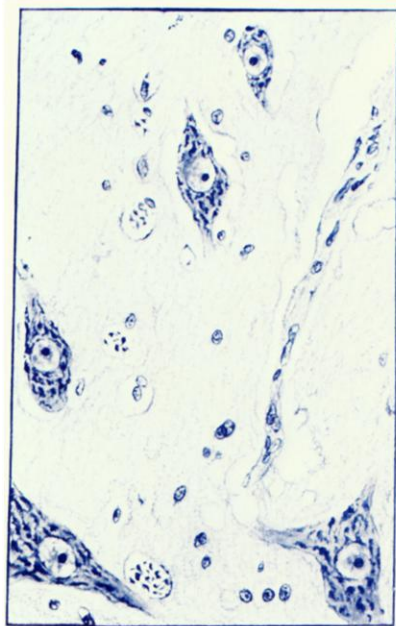


FIG. 1. "Normal" Human Medulla.

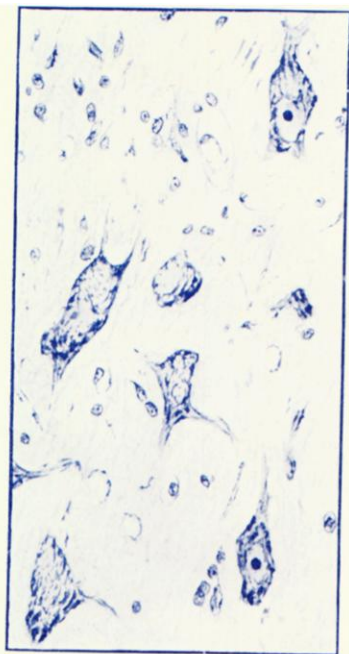


FIG. 2. Exophthalmic Goitre Medulla.

EXOPHTHALMIC GOITRE.