

most persistent advocate of tonsillar invasion is Aufrecht, who has held that the nasopharynx is the point of entrance, going from thence into the blood vessels. It is an interesting question whether the bacillus can pass through a healthy tonsil or a diseased (not ulcerated) tonsil, without leaving behind any trace of its passage. There seems to be good evidence that it can do so. The question to be worked out is: Can the bacillus pass through the tonsil, through the chain of cervical glands, and enter the circulation without leaving this trace? Dr. Wood's work is a contribution in this line. The solution of this problem may change all our ideas regarding the point of entrance of tuberculosis. We have been believing for years that the bacillus is inhaled directly into the alveoli; this has seemed absolutely conclusive from Cornet down. Now we have evidence that the infection is by ingestion. The question is an exceedingly complex one, and experimental work is extremely difficult. There are many things to be considered before final conclusions can be reached, but it is evident that there are various methods by which the bacillus can reach the pulmonary area.

DR. GEORGE B. WOOD—I can not agree with Dr. Swain that the faucial and the pharyngeal tonsils are not the most active source of infection of the cervical lymph glands, and I do not believe that the solitary lymph follicles show a less resistance to bacterial invasion nor that they absorb infectious material any more than their comparative size would lead us to suppose. Invading bacteria are killed unless they can overcome the vital resistance of the surrounding tissues, but if they live they must by the very act of their living produce toxins which, in the case of pathogenic organisms, give rise to specific tissue reaction. Pathogenic germs can not, therefore, pass through normal tissue without some sign of their presence being manifested. The experiments of Ravenel, however, proved that tubercle bacilli could pass through the normal intestine within four hours after being placed in the gastrointestinal tract. Absorption through the intestinal wall is a different question from the passage of bacteria through lymphoid tissue. It is well known that all lymphoid tissue acts as a filter for micro-organisms, and until the resistance of the tissue is overcome this filtration is active. Hence it would seem that some lesion must exist in the tonsil before infection of the cervical lymph nodes is possible. So far as the possibility of a general infection from a tuberculous tonsil is concerned, I scarcely believe I would have my tonsil taken out because of a tuberculous lesion, any more than I would have my finger amputated if I contracted a tuberculous deposit from making an autopsy. At present I am inclined to believe that in the great majority of cases infection of the lungs takes place through the air and not through the blood. Tubercle bacilli gaining access to the lungs through the blood produce a miliary tuberculosis, whereas the ordinary tuberculous pulmonary lesion begins as a single focus in the apex, which, gradually spreading, involves the rest of the lung.

THE ETIOLOGY OF EYE STRAIN.

FROM A PHYLOGENETIC AND ONTOGENETIC STANDPOINT.

AUGUSTUS GROTE POHLMAN, M.D.

Assistant Professor of Anatomy, Indiana University.
BLOOMINGTON, IND.

Eye strain may be divided into two general classes—that due to irregularities in refraction and that due to muscular imbalance. To the average physician the irregularities in refraction constitute the sum total of what may be termed normal variations, in contradistinction to pathologic disorders. The consideration of the muscular insufficiencies is limited more exclusively to the specialist who justly recognizes their importance, and, to judge from the recent literature on heterophoria, the subject is still open for investigation. As an anatomist, however, I have only to deal with the anatomic facts bearing on the causes of variations and will confine myself to this side of the subject, which has hitherto

been dealt with sparingly. To understand why an organ is degenerating or subject to troubles unknown to the lower forms, it is necessary to study its comparative anatomy. I purpose to call attention to facts which in their sequence form themselves into a hypothesis that may aid in the explanation not only of the muscular difficulties but of the refraction errors as well. Strange as it may seem, muscular insufficiency is phylogenetically older than refraction error but both are intimately connected because the muscular apparatus is merely an accessory to the sense of sight. The comparative anatomy, therefore, must be followed from the lower vertebrates to the highest in the hope that the findings in some stages may throw light on the question, and a comparison must be made between the phylogeny and the ontogeny in the animal most concerned—the human being.

It may be well to state in advance how it comes that I interest myself in the province of the ophthalmologist, a field so far removed from my present line of research. I suffer from an exophoria of from 4 to 8 degrees, and while at Freiburg in Baden I consulted Professor Axenfeld. Here I learned that the insufficiency is most marked when the eyes are raised, and I was advised to hold the head well back and look down a little even when doing distance work.

About that time, an exhaustive article by G. Lindsay Johnson¹ appeared on "The Comparative Anatomy of the Mammalian Eye." It is replete with beautiful illustrations of the ophthalmoscopic appearance of the retina of practically all the mammals in the London Zoological Gardens. A chapter is also devoted to the influence of domestication and a part to the position of the eyes. Several interesting ideas developed in my study of this paper, and these, together with some grosser facts in comparative anatomy. I submitted to Professor Titchener of Cornell University, to whom I express my thanks for valuable suggestions and criticism.

I hardly deem myself qualified to discuss the practical outcome of the hypothesis I present. There may or may not be a grain of truth in the deductions from the facts, which I hope to give clearly and concisely, in this paper. A larger and more exhaustive treatise is needed to bring out all the points in detail and a greater amount of material and more thorough investigation are required than I can offer at this date. At the conclusion of the discussion on the comparative anatomy, I will review briefly the grounds for assuming that the human eye is subject to abnormality because of the domestication of civilized man from an aboriginal form—an idea which may not meet with unanimous approval. Civilized man, to my mind, is undoubtedly a domesticated aborigine and therefore is subject to the same changes from unnatural environment to which any domesticated animal is subject.

In the lower forms the eyes are placed on the sides of the head and the animal is, more or less strictly speaking, monocular in its vision. In the fish, for example, the eyes, although intrinsically different from the mammal's are moved by the same muscles, which possess relatively the same origin in the orbit and the same insertion into the eyeball. I will only consider the internal and external recti because they are the most affected in the changes in position of the eyeball.

In the pilot fish the optical axis of one eye passes through that of the other—a full 90 degree divergence

1. Transactions of the Royal Society of London.

for each eye. The eyes look out (lateral) and are capable of little movement, probably because the range of vision in the fish is necessarily small. The movement of the eyeball is practically confined to a forward one. The eye fits snugly into the rounded orbit, and the two recti, internal and external, take their origin well back on the posterior (caudal) wall. The insertion of these two muscles is about the same in the human being—equidistant from the corneal margin into the sclerotic.* The line passing through these insertions falls within the plane of muscular attachment, and is at right angles to the apparent optical axis—the direction in which the eye looks. The origins of the internal and external recti are about the same, but the internal is longer and swings around the back of the eyeball to the anterior (cephalic) insertion, while the external is short and direct. The arrangement shows clearly that the internal rectus is more powerfully placed and has the greater range of action—anatomically, leaving the check ligaments out of the question, the direct opposite of the human. The animal tends to see what is in front of it rather than what is behind, probably relying on the special development of the nervous system for protection from that quarter.

In birds, the owl family excepted, the arrangement is similar to that in the fish, except that the anatomy of the eye is intrinsically different and that the range of motion, because of the larger orbits, is necessarily greater. The bird, like the fish, is monocular in vision. The orbits are perhaps a trifle less divergent and comparative measurements must be made to determine this point. The internal and external recti have the same relation to the orbit and eyeball as in the fish and reptile.

Passing from bird to mammal and through a series of the mammals from types with the most divergent eyes to the highest forms with sustained binocular vision, I note, according to Johnson, the divergence in each eye, for the hare, 85 degrees; for the giraffe, 72 degrees; for the skunk, 45 degrees; for the pig, 33 degrees; for the dog, 20 degrees; for the cat, 10 degrees; for the lemur, about 5 degrees, and for the monkeys and apes, as in man, no degrees. As the animal advances in the scale, the eyes become more ventrally placed, the exceptions being found in the monotremata and the bats, where the position of the eyes is probably a special development dependent on the habits and environment of the animals.

The hare, with eyes each 85 degrees divergent, enjoys a visual field of 190 degrees for each eye. The fields cross in front as well as in back and the animal sees the whole horizon without moving the eyes or the head, a feature necessary to the protective motionless position and unimpeded flight. This animal, according to Johnson, is probably capable of receiving sharp impressions, even to the periphery of the visual field, and for this reason there must be some binocular vision for objects directly in front and in back. Probably no mammal is strictly monocular, although that is the usual mode of vision.

As we pass from the lower forms to the higher, the visual field becomes more and more contracted and the animal moves the head and the eyes, preferably the former, to make up for the deficiency. Up to the *Simia* the eye movements are not co-ordinated and are merely

accessory to the head movements. In the dog, for example, the head movement is well developed and a decided preference for monocular vision is displayed. This is also manifested in the cow—the animal always turns the head and is content with monocular vision. In the cat the divergence is not so marked—first, because it is a higher form than the dog, although not nearly so well domesticated, and second, because its prey is small and usually directly in front of it.

In the next highest family, the *Prosimia*, we find the nearest approach to the monkey. These small nocturnal animals (lemur, tarsius, etc.) have a divergence of about 5 degrees for each eye. In the monkeys, apes and man, the divergence is entirely overcome and the eyes are placed with parallel axes. The plane of muscular attachment remains the same at right angles to the apparent optical axis in all mammals, but the eyeball in man is rotated through 85 degrees on comparison with the hare. All mammals with eyes of less than 25 degrees divergence each are twilight animals, with the exception of the *Simia*.

In the advance from the *Prosimia* to the *Simia* several marked differences appeared. The *Simia* were probably developed from a twilight form into a daylight type and a portion of the retina lying directly in the visual axis was specialized for acute daylight perception. With the sustained parallel axes, the co-ordination of the eye movements was developed. The macula lutea, sustained binocular vision and co-ordinate eye movements are therefore confined to monkey, ape and man.

During the rotation of the eyeball to the front, the orbits also became less divergent. While in the fish the eye fits the orbit, in mammals the orbits become relatively larger and more pyramidal as the form advances. The primitive origin of the internal and external recti, however, is maintained. Both muscles elongate progressively, particularly the external rectus. The orbits approach each other until the two inner walls are parallel and in relation with the nasal fossæ, as in man. The outer wall is directed at an angle of 40 degrees to the inner, giving an orbital axis in the human being of 20 degrees divergence from the middle line.

If a human eye were to be placed in an orbit of 20 degrees divergence and if the recti were of equal strength, the optical axis would correspond with the orbital axis, the plane of muscular attachment would be at right angles to both axes, the recti would be of equal length and the eye would be 20 degrees divergent, as in the dog, and muscularly balanced. The 20 degrees divergence is overcome by a rotation of the eyeball and, undoubtedly, is phylogenetically due to muscular pull. As the muscles rotated the eyeball, however, they obtained ligamentous support from the walls of the orbits—the check ligaments—which “took in the slack,” as it were, and limited the amount of return to the former state. In every mammal there is a tendency toward a reversion to a lower form and the apparent optical axis is less divergent during life than after death or during a state of perfect muscular relaxation—sleep or anesthesia. The ligamentous support limits the amount of divergence and theoretically no mammal should revert to a greater degree of divergence than the next lowest form. In man, for example, the latent squint normally should not be more than the position of the eyes in the *Prosimia*, or 5 degrees divergence for each eye—exophoria in contradistinction to divergent strabismus. In dogs, as in monkey and man, the eyes roll out during sleep and anesthesia, or after death.

* The equi-distant insertion of the recti muscles from the corneal margin is granted to avoid complicated angles. The spiral line of insertion is too well known to need any mention.

In the development of the human embryo we find a similar picture to that described for the ascending scale of mammals. The eyes develop on the sides of the head, as in the fish—a relic of our ancestry. Gradually, with the formation of the face, they are brought around to their permanent ventral position and are in place about the end of the second month. In this the ontogeny agrees with the phylogeny and the rotation as described in the mammals is also to be found in the developing embryo.

With the upright position a second displacement of the eyeball was necessary. The eyes in the lower mammals are directed on a plane with the horizontal vertebral column or above this plane. With the assumption of the upright position, the head was not tilted forward to an angle of 90 degrees to the animal head, and the eyes were depressed to maintain the horizontal plane. This naturally involves a strain on the inferior rectus. In the relaxation occurring during anesthesia the eyes of the monkey, as of the man, roll up and out—the position of perfect muscular rest and ligamentous support. In the horizontal position, the eye is held by the internal and inferior recti, but when the eyes are raised the strain, otherwise shared by the inferior rectus, is thrown entirely on the internal rectus and for this reason the latent divergence is more marked when looking up. The latent squint is therefore indirectly affected by the upright position because of the poorly balanced and heavy head tending to drop forward, which tendency is made up in an elevation of the eyes.

The reversion of the eyes to a former position is not entirely confined to the amniota. In the flat fish family (*Pleuronectidae*) during the earlier periods in the development, the fish is like any other fish. When it reaches a certain stage it lies down on one side on the bottom. The eye that is directed down is then pulled to the top side of the head, mostly through muscular effort, and in the adult living flounder the eyes are side by side and are parallel or even convergent. On the death of the fish they become widely divergent, illustrating the tendency to assume the original position and acting similarly to the divergence in the eyes of dogs, monkeys and man.

The stimulus to the animal to see what is directly in front of it attains its highest development in the Simiæ who use both eyes. Man, however, carries the matter still farther and develops an inco-ordination of the eye muscles to enable him to see things which are close by with both eyes. The monkey can only maintain a limited convergence for a short time and man, as Johnson says, is the only animal with sustained convergence. As man advanced, the near work became more and more essential and convergence was correspondingly more developed until at the present day the eye has practically become a contact organ, as well as one of distance perception. (Emmetropia.)

Convergence is ontogenetically a trained effort and, like any trained effort, is best developed when begun early. The training of convergence ought, therefore, to be marked in the precocious myopic child who prefers to read rather than to play, and, because such children begin the near work at a very early age, the latent insufficiency should theoretically be less pronounced than in the hyperopic individual whose refraction interferes with this exercise. Whether the distortion of the eyeball has anything to do with the matter is still to be determined. The matter is still hypothetical as far as I am concerned. I shall endeavor to measure volunteer

students for the grosser errors of refraction and for the amount of latent squint in each case and shall present my findings in a future paper.

Sightseer's headache, therefore, is not due to the strain on the elevator muscle, as suggested by Snell, but to the greater strain on internal rectus to overcome the more marked divergence in the raised position of the eye. Convergence when looking up is an appreciable effort and, granting that there is always a muscular pull necessary to hold the parallel axes, this slight exertion is also increased.

There is a tendency toward a divergence in all mammals. In the highest form the muscular effort is increased because the orbits are not capable of any less than 20 degree divergence and a rotation of the eyeball is necessary. The check ligaments are probably the means of limiting the divergence in muscular relaxation. The latent squint is overcome in man mostly through an early training of the adducting muscles for convergence and, finally, exophoria has a phylogenetic origin which is substantiated in the ontogeny and is an inheritance from a lower form.

The explanation of the refraction errors is not so simple. Are they, as Johnson suggested for animals, a result of domestication? What is domestication but an adaptation to unnatural and false surroundings with more or less complete interference with the laws of natural selection. The survival of the fittest, as far as the eyes are concerned, is undoubtedly interfered with in the present civilized state. Rabbits, dogs and horses are subject to myopia and astigmatism—a difficulty unknown in the wild state. All wild animals, with few exceptions, and those to be found mainly in the semi-aquatic forms, are hyperopic and anastigmatic, including savage man. With domestication the same eye errors arise in the animals that occur in educated man, and it appears that the individual with degenerate eyes is better fitted to survive than his far-sighted brother.

Emmetropia is an adaptation of a far-sighted eye to near work, through development of the muscle of accommodation. Is this any different from the arrangement found in the seal, where a slit pupil and highly developed accommodative apparatus overcomes the enormous astigmatism? The normal eye was not made for near work and must be considered a mildly hyperopic eye with a limited degree of latent lateral squint. The adaptation of the eye as a contact organ seems to be inevitable. This is the age of the short-sighted with the large amount of necessary reading, the instruments of precision and the arts involving the near work. The oculist may step down the hyperopic eye with the + spherical, but the muscular insufficiency always remains the unsurmountable obstacle. As age advances the eye loses accommodative power and near work is made still more difficult in the approach to the animal normal. It appears that the more perfect our eyes are the less they are adapted to the present conditions.

It leaves the problem in a very interesting situation. Are we voluntarily to become a race of myopics or are we going to hold to the animal normal? The answer is obvious, and to achieve this result two things must be accomplished—as far as possible the eye must be fitted for the present conditions, and a reasonable method must be found of doing a large part of the near work in the distance. The errors in refraction may be corrected, but distance work decreases the strain on the already poorly placed internal rectus muscle.

The subject is not without its pedagogic side, but this

must be deferred until later, when all the inferences shall have been verified or disproved. For further investigation of the comparative anatomy, I have two fishes with normal eyes and the complete series of the flounder, including all the changes in position from the beginning to the completion of the wandering. In birds, I have also two species with normal eyes, and the owl as the aberrant type. In mammals, I have the hare, skunk, pig, dog, cat, lemur and man—of the latter embryo and adult specimens. This material will be supplemented by investigations on normal individuals in order to obtain the grosser refraction errors and the muscle status.

I shall be grateful for any criticisms or suggestion regarding the ideas advanced in this article or in the methods to be followed, and I shall take pleasure in replying to and in acknowledging such communications.

SOME ASPECTS OF SCIENCE AND FALLACY AS THEY RELATE TO MEDICINE.*

F. J. RUNYON, M.D.
CLARKSVILLE, TENN.

"Faith, fanatic Faith, once wedded fast
To some dear falsehood, hugs it to the last."

In the preparation of this paper I have had in view several motives. First, to emphasize the fact that the practice of medicine consists simply in the intelligent application of common-sense principles and forces. It has nothing of the mysterious and supernatural about it. The further one gets from common sense the further he gets from scientific medicine.

Second, to call general attention to the value and to the dangers of that force which we call "suggestion." For, while the forces of nature intelligently employed may result in great good, wrongly employed they are equally as potent for harm. Take whatever force or power you will and reason out the principle; see if these powers wrongly used are not equally as dangerous as they are beneficent when rightly used. Merely for illustration, I will mention fire, water, powder, dynamite, steam and electricity. Anything incapable of doing harm is also incapable of doing good. To argue, then, that anything may do good should suggest that it may do harm. Yet many people seem to think (and it is because they are ignorant of the forces) that they can try with impunity any quack remedy. We see the results often when it would not be humane to the victim to relate the consequences.

Third, I wish to call attention to the danger of drawing deductions from imperfect knowledge or when unfitted by education or training to discriminate. As the same end is at times obtained by widely different means, the question is suggested, what, then, is the force or what are the forces giving rise to the results? These are usually the curative power of nature; in some, nature plus suggestion, etc. On the other hand, in many instances, there is self-deception. Just as in consumption the sufferer often fancies he is improving, so thousands of certificates of cure have been obtained from the diseased whose troubles were never delayed and who never received the slightest benefit from the treatment. They are like "Sir William Edward Peary and his party, who were going straight towards the pole in one of their Arctic expeditions, traveling at the rate of 10

miles a day, while the ice over which they were traveling was drifting straight to the equator at the rate of 12 miles a day, and yet no man among them would have known that he was traveling 2 miles a day backward unless he had lifted his eyes from the track in which he was plodding."¹

"The science of medicine had its birth in necessity."² It has materially lengthened the average duration of human life, and rendered worth living the lives of countless thousands. It has reached a point in its development where its claims as a science are generally acknowledged. Yet, as from primeval times to the present, fallacies have so often been exploited as infallible cures, I think an analysis of some of them may prove interesting. With each changing cycle some new error is born, to be in turn clasped to the bosom of those "who follow the lead of their emotions" rather than the dictates of common sense and, as Gould states, "the emotions are good incentives, but poor guides."

Four hundred years before the birth of Christ, Hippocrates wrote: "Life is short and the art long; the occasion fleeting; experience fallacious and judgment difficult." Though the truth of this aphorism, which has come down to us through the centuries, is fully appreciated by the thoughtful physician and is as true now as when written, it is really wonderful to note, even in this advanced age, the ease with which so many people succumb to "fallacy" and, finding a sprig of truth, at once mistake it for the whole tree, trunk, roots and branches, and attempt thus to make the part greater than the whole. The scientific physician is neither the slave of custom nor the victim of circumstance. In the pursuit of his calling, he brings to his aid many forces the logical application of which tends to alleviate human suffering and to dissipate disease. Wedded to no creed, handicapped by no narrow dogmas, above the plane of blinding prejudice, he toils on, bringing to bear on the case in hand whatever force or forces reason and wisdom have shown to be of value. Even with this, "it takes half a lifetime to learn how not to make useless mistakes." (Gould.)

In regard to the many panaceas that have at times claimed the attention of the public (besides the curative power of nature, which many seem never to have considered), one dominant force pervades them all. A force which has been used and utilized from the days of Hippocrates to the present time. A force which has been used ignorantly by the untrained, who never appreciated its character, its source, its powers or its limitations. It runs like a thread through every method of treatment, wise or otherwise. It is this force and nature which give a life-history to every new form of treatment, however absurd it may be. I refer to the power of "suggestion," now vulgarly known as the "mind cure." Its use is as old as history, but it is a force hardly yet fully appreciated by some and by others employed to a degree beyond the warrant of reason. "The earliest practitioners of medicine concerning whom we have any authentic information were the *Æsclepidæ*, or priest-physicians, who endeavored to cure the sick partly by superstitious modes of working on the imagination" (mind cure), "and partly by more rational means, suggested by observation and a patient study of the phenomena of disease."² That "suggestion" is a power for good in suitable cases every physician knows; that it is also a power for evil the many wrecks of Christian

* President's address, read before the Middle Tennessee Medical Association, 1904.

1. Holmes: "Currents and Counter Currents."

2. Adams: "Life of Hippocrates."