SCIENTIFIC TRACTS.

NUMBER V.

ANIMAL MECHANISM.

THE EYE.

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A VARIETY of professional works are already before the public on the anatomy of the eye, but it is questionable whether any of them are sufficiently divested of technical language, to be of utility to that class of readers who are only interested in the beauties of science.

Without making pretensions to originality, the writer of the following pages will endeavor to simplify a subject, too generally considered abstruse, that it may be understood by those who have neither patience, time, nor inclination to pursue it under the guidance of a public instructer.

Well acquainted, as anatomists are, with the minute organization of the eye, no one has been able to explain *how* or *why* we see. Although the visual organs are constructed with such exact reference to the laws of light, that telescopes and microscopes, made upon truly philosophical principles, are but imitations or modifications of the apparatus of the human eye,—there is still a difference between the animate and inanimate, the most wonderful and astonishing. The first is a *perceiving* instrument; the second, a *receiving*.

The eye can only perform its destined functions, in connexion with a living system, regulated by an existing harmony of all its complex machinery, consisting of nerves, blood vessels and brain. However perfect in its several tunics the eye may be, or transparent in its fluids, if the sensorium become disordered by disease, it no longer recognises the images or impressions transmitted to it through the visual nerve. Thus it will be understood, that the eye may labor, receive, and transmit a miniature picture of all it perceives to the soul; but, if there is a derangement of that mass of mysteriously constructed matter, filling the whole skull, which all experience demonstrates to be the seat of thought, no idea is excited. On the other hand, when individuals suddenly lose their sight, without materially injuring the optic nerve, they sometimes dream of seeing. In this case, imagination excites the nerve in such a peculiar and inexplicable manner, as to call up the idea of vision. This nerve being formed with exclusive reference to that function, in the economy of animal life, any impression upon it will excite a corresponding impression in the brain, and no other.

All creatures, from man downward, living on land, have their eyes very similar in structure. The same quantity of light that enables a man to see distinctly, will also answer for a horse, an ox, and, indeed, most of the domestic and graminivorous animals. A natural inference would be, then, were it not otherwise known by dissection, that all the parts entering into the composition of their eyes, in order to produce the same effect as in man, were of the same materials.

In carnivorous animals, the original principle of vision is preserved, but most curiously modified, according to their habits and characters. Those that feed on herbage, are commonly of social dispositions, feeding in companies through the day, and quietly ruminating or sleeping through the night.

Those, on the contrary, that live by violence, preying on those they have slain, are generally solitary: they lie in ambush, alone, watching for their victim; and it is so ordered, by the immutable laws of nature, that they slay such as are more timid and helpless than themselves. In order to accomplish this, with the greatest certainty, carnivorous animals have the power of seeing in the dark.

Fishes, by a further modification of the original apparatus, common to all others, probably see with peculiar distinctness, in the darkest night, at unfathomable depths of the ocean.

With another alteration, not unlike changing the distances between the lenses of a spy-glass, another family of animals, as seals, &c, see alternately in two elements. Still further, on the descending scale of creation, insects are provided with motionless eyes, — giving them the faculty of seeing in every possible direction. And, lastly, in snails and some kinds of worms, the eyes are fixed at the extremity of a moveable feeler, adapting them to different focal distances, — or they can be drawn entirely within the head, for safe keeping, when not in use, precisely on the same principle of care that we draw out the slides of an opera glass, and close them up again, when no longer needed.

Were we desirous of describing the nice variations in the mechanism of the eyes of the several species of animals adverted to in this preliminary, however interesting it might be to some, would, perhaps, appear tedious to others. Confining ourselves, now, to the exclusive consideration of the human eye, we shall proceed with an orderly description of its several parts, — hoping that the few scientific terms which must necessarily be retained, will not prove to be a serious embarrassment.

THE SOCKET IN WHICH THE EYE ROLLS.

Several thin pieces of bone assist in the formation of the orbit, which, in a dry skull, is shaped much like a pear, with its large end turned outward. The upper plate of bone is arched, slightly resembling an arch of a bridge, having the brain resting on it above, and the eye ball moving under it below. Externally, the eyes are at considerable distance, but the inner termination of the conical orbits, answering to the small end of the fruit, are quite near together. At their points, is a ragged hole, in each, through which the nerve of vision enters the brain. A large quantity of fat is deposited in this socket, between the bones and eye-ball, that the latter may always move with perfect freedom, and without friction, in all directions. After a long sickness, this cushion of fat is absorbed, with that deposited in the bones, to sustain the system, which accounts for the sinking in of the eye: as the person recovers, the stomach resumes the task of taking care of the body, the fat is deposited again, and the eye becomes prominent as before.

GLOBE OF THE EYE.

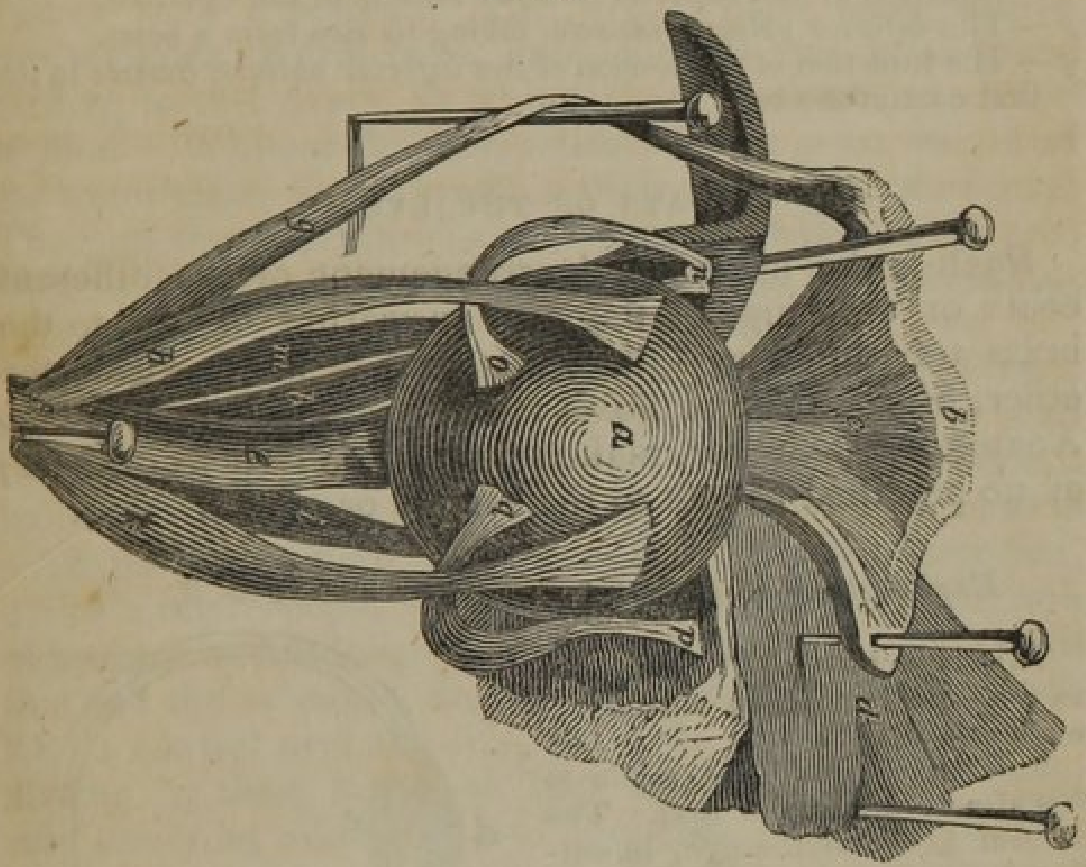
When detached from the surrounding parts, the eye-ball does not appear exactly round: it is, in outline, more than two thirds of a large sphere, with a portion of a lesser glcbe laid upon it.

The use of this arrangement is obvious. If the ball had been actually round, the compass of vision would have been very limited: as it is, the smaller portion, by its short curve, protrudes so far beyond the socket, where the globe is lodged for safety, that the sphere of vision is very much enlarged.

MUSCLES OF THE EYE.

To move the ball, cords, called *muscles*, were necessary; otherwise, animals would have been obliged to turn their bodies as often as an object was to be seen. Of these, four are straight, going from the sides of the ball, to be fastened near the hole, at the termination of the bony cavity: their office is to hold the eye firmly, in a fixed position, as in steadily contemplating a painting. Two others are given, making six in the whole, to express, principally, the passions of the mind: they are denominated the *oblique*, in consequence of their oblique movement of the eye. One rolls it downward and outward, as in viewing the shoulder; the other, going through a loop, which is so purely mechanical, that it has been the theme of admiration with philosophers in all ages, carries it upward and inward. The last action can be shown by looking at a button, held on a line with the nose, midway of the forehead. Although these oblique muscles exist in monkeys and nearly all tribes of quadrupeds, they are imperfectly developed; showing most conclusively that they were designed for expressing the feelings and passions of man—an ineffable language, which all the brute creation have the sagacity to understand. When one of the four straight muscles is shorter than its fellow on the opposite side, it produces the *cross-eye*, or squinting.

FIG. 1.



Explanation of Figure 1.

This plan, from a careful dissection of the right eye, exhibits the muscles, viewed obliquely from its upper and outer side.

a—The eye-ball.
b—Part of the upper eye-lid.
c—*Tunica* Conjunctiva, or inclination of the common skin of the forehead, which turns over the edges of the lids, and is finally carried over the front of the globe, but is perfectly transparent at this point.
d—The integuments of the right side of the nose.
e e—The optic nerve.
f—The four *straight muscles*, with the *levator*, or *raising muscle* of the upper eye-lid, together with the *superior oblique muscle*, embracing the optic nerve where it enters the orbit.
g—The levator of the lid drawn aside.

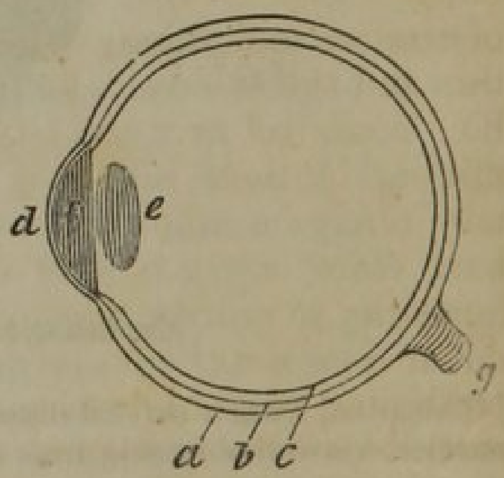
h—*Levator occuli*, or superior straight muscle,—to roll the ball upward.
i—*Abductor occuli*, rolls the ball outward.
k—*Adductor occuli*, rolls it towards the nose.
l—*Depressor occuli*, rolls the ball downward, towards the cheek.
m—The *superior oblique* muscle, passing through a loop at *n*.
n—Called the *trochlea*, or pully, but, in fact, a simple loop.
o—Insertion of the *superior oblique muscle* in the eye-ball.
p—The *inferior oblique muscle*, taking its rise from a bone.
q—The insertion of the tendon of the *inferior oblique muscle* in the first coat of the ball.

COATS OF THE EYE.

Such is the mechanical arrangement of the different coats or coverings of the eye, answering in use, to the brass tubes of a spy-glass, that one is fitted within the other, like a nest of boxes: they are three in number. Anatomists, however, make minute subdivisions of these, of no practical benefit to themselves or others.

Explanation of Figure 2.

FIG. 2.



This is a plan of the coats, or as they are termed in anatomical works, *tunics*.

Reference should be made to this after reading the text. The natural figure of the eye, in outline, is preserved.

a—The *Sclerotic*, or first hard tunic.
b—The *Choroid*, or fleecy tunic.
c—The *Retina*, or third and inmost tunic, which is an expansion of the optic nerve *g*—the certain seat of vision.
d—The *Cornea*, or prominent, transparent circle, over which the lids close, in winking,—hereafter to be described.
e—The *Crystalline lens*, or little magnifying glass of the eye, about a quarter of an inch in diameter.
f—Is the space filled by one of the fluids of the eye, and called the *anterior chamber*.
g—The stump of the optic nerve, which is prolonged into the substance of the brain.

1st. The first is the *Sclerotic** coat, thick, firm and possessing but little sensibility. Its hardness gives security to the delicate membranes beyond; affords attachment for the muscles; and by its elasticity, equally distends the ball, that none of the humors may suffer from pressure. Happily the hard coat is very rarely diseased. Fishes have a sclerotic coat strictly hard, being either cartilaginous or firm bone, graduated in this respect according to the depth to which they descend in search of food. Without this compensation, the great weight of the water above would crush in their eyes instantaneously. Through this coat, in what is called the white of the eye, the occulist plunges a needle to cure some kinds of blindness.

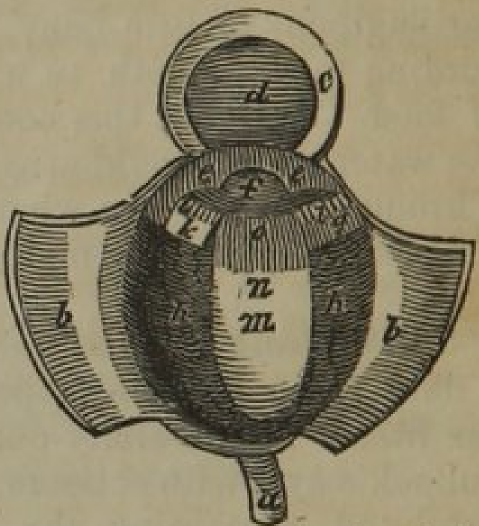
2d. *Choroid*† is the name of the second coat, having a dark red color, and apparently slightly connected with the first. By carefully cutting off the sclerotic from a bullock's eye, with scissors, the choroid will be beautifully exhibited, sustaining the humors. Minute dissection, under a microscope, shows this tunic is a complete web of arteries and veins; — hence its reddish hue. Between this and the sclerotic, fine silvery threads are seen, which hold a control over the *iris*, yet to be described, — determining by their influence how much or how little light may safely be admitted into the eye. Fungous tumors have their origin in this coat, growing so rapidly as to burst the sclerotica, pushing their way out of their orbit down upon the cheek, incorporating the whole ball in one prodigious mass of disease. The inside of this membrane resembles closely woven wailed cloth, having a fleecy nap, similar to velvet, called *tapetum*.‡ This tapetum is particularly interesting in a philosophical point of view, as on its shade of color, in a great measure, as will be more fully explained in the sequel, depends the power of seeing in the dark.

3d. *Retina*,§ so called from its resemblance to a net, completes the number, being the innermost and last. Its

* *Sclerotic*, from a Greek word meaning hard.
† *Choroides*, — like a lamb-skin, fleecy.
‡ *Tapetum* — resembling cloth, called tapestry.
§ *Retina* — a net.

color is that of gum arabic, or ground glass: nothing can be more delicate, being too tender to bear its own weight. In fact, it is the expansion of the optic nerve, the immediate seat of vision. To see it well, an eye should be taken to pieces in a tumbler of water.

FIG. 3.



Explanation of Figure 3,

from dissection of a human eye, the organ being represented of the proper size.

a — The *optic nerve.*
b b — The *Sclerotic coat* cut and turned outward.
c — A circular portion of the *Sclerotica,* being a rim of the *white* of the eye, cut, and turned upward, having in its embrace the *cornea.*
d — The *cornea.*
e e — One half the *iris,* in its place, the other half being removed.
f — The *Pupil,* soon to be described, with the *crystalline lens* in its place.
g — The *Ciliary circle,* or second vertical partition, within the eye, behind the iris.
h h — *Choroid* coat.
i — The *Ciliary processes,* or ruffle like plaits of the ciliary circle, yet to be explained. A small portion of the iris is cut away to show them
k — A portion of the *iris* cut and turned back.
l — The floating points of the *ciliary processes,* also turned back.
m — The middle smooth part of the *retina,* seen by cutting a hole through the choroid coat.
n — The roots of the ciliary *processes,* to which the black paint, secreted by the tapetum or inner surface of the *choroides,* adheres.
o — The *ciliary processes* inserted into the *capsule* or sack which contains the *crystalline lens.*

THE CORNEA.

Anteriorly, that clear, shining wall, resembling a watch crystal, which finishes the membranous box, is called the *cornea.* Simple as this thin crystal appears, it is infinitely curious in structure. It is made of thin, pellucid plates, one over another, held together by a spongy elastic substance. By maceration in water, a few hours, the sponge will absorb it, to such a degree, that the plates may be distinctly felt to slide upon each other, between the thumb and finger.

Little glands, like bags of oil, only to be seen by the most powerful microscope, are lodged under the first plate, which are continually oozing out their contents upon the surface, which gives the sparkling brilliancy to this part of the eye. As death approaches, this fluid forms a pellicle, like a dark cloud, over the lower portion of the cornea. This formation is taken to be a sure indication of approaching dissolution. Many diseases are peculiar to the cornea; such, for example, as a milky colored effusion of matter under the external plate, preventing a free transmission of light to the interior. See fig. 2, letter *d*, and fig. 3, letters *c* and *d*, for representations of the *cornea*.

IRIS.

By looking into a person's eye, there seems to be a vertical partition, either black, blue, or hazle, as the case may be, which prevents us from looking into the concealed regions beyond, — having a round hole in its centre. Scientifically, this partition is called the *iris*, while its central orifice is denominated the *pupil*. How the diameter of this hole is enlarged or diminished, anatomists have never been fortunate enough to explain, satisfactorily, the apparatus is so minute, that they cannot decide upon its true character. One fact, however, is certain, that the pupil is large or small, according to the quantity of light that may be necessary to the formation of a distinct picture of the object seen, — and this change is effected without our being conscious of the action. Resembling other delicate membranes, in many respects, we are unwilling to confuse the subject with a description that would distract the mind of a new beginner.

From the reflection of such rays as are not admitted through the pupil, or central hole, we account for much of the lively brilliancy of the iris. On its back side it is rather fleecy, like the tapetum, but dissimilar in other respects. Over this is spread a black, blue, hazle, or tea-colored paint, which gives a permanent color to the eye It has been often remarked, that the eyes and hair ordinarily correspond in color. Whenever the iris acts, as for instance, it does, in going from a dark, into a light room, the pupil is made smaller, — acting uniformly in its fibres, to keep it circular. On returning to the dark apartment, the pupil enlarges again. A knowledge of this fact, will explain the reason of a painful sensation in the eye, caused by a strong and sudden light. As soon as the iris has had time to diminish the size of its pupil, we can endure the same luminous object with perfect comfort. When we leave a well lighted room, on first going into a dark street, everything appears lurid and indistinct. The iris soon begins to enlarge the pupil, to admit more light, and when that has been accomplished, although in comparative darkness, we recognise objects without an effort. Acting independently of the will, its duties are like those of a faithful sentinel, always consulting the safety of the splendid optical instrument confided to its care, with reference to its subserviency to the being for whose use it was exclusively constructed. Were it otherwise, — were it left to our own care, how often it would be neglected, and indeed, totally ruined, solely for the want of undivided attention. All that complex system of machinery, on which life and existence are constantly depending, (the vital organs,) are wisely placed beyond the reach of the laws of volition. If the pulsation of the heart, the function of the lungs, or the circulation of blood in the brain, depended upon our attention, — our recollection of the fact, that they must be kept in motion, or we could not live, we should be in great danger of forgetting it, and therefore die in our first slumber!

Parrots have a voluntary control over the pupil, opening and closing it at pleasure. How this is done, or why, in the constitution of that bird, it is necessary, we cannot determine. Cats, also, appear to have a similar power of moderating or graduating the quantity of light, admitted into their eyes, as it suits their own convenience.

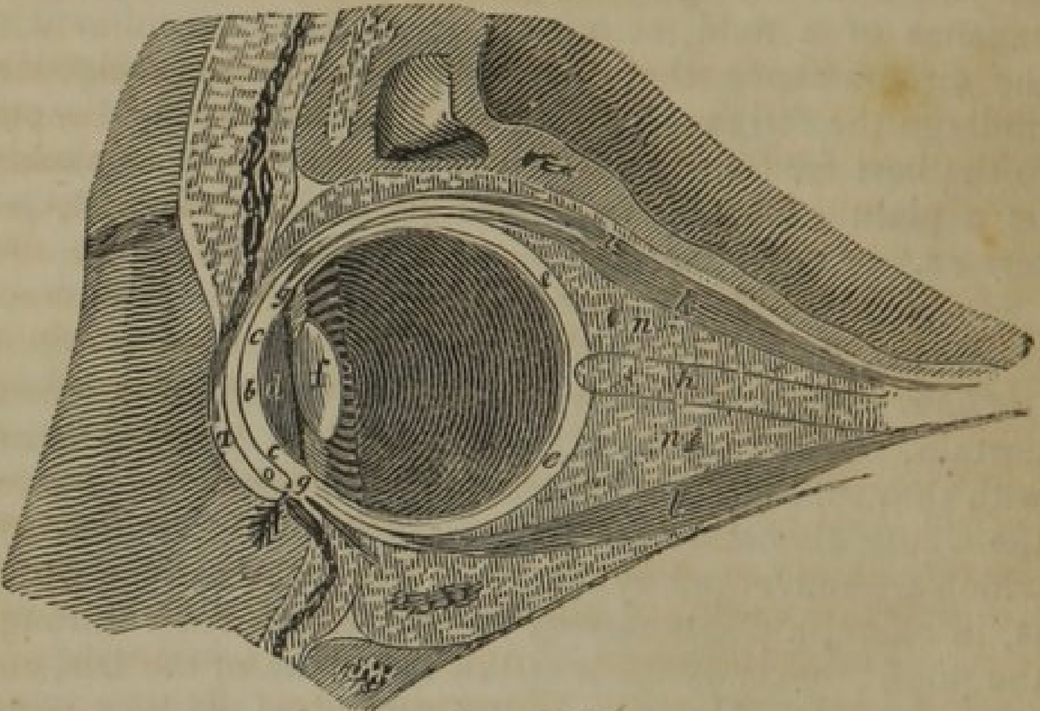
In carnivorous quadrupeds, the pupil is commonly oval, and oblique, permitting them to look from the bottom to the top of a tree, without much elevation of their heads. Graminivorous quadrupeds have an oblong pupil, placed horizontally, with respect to the natural position of the body. This form gives them the faculty of surveying the expanse of a field, at once. Farmers are familiar with the circumstance that the ox, without being obliged to undergo the fatigue of circuitous marches, walks directly to the best feed in the whole lot, provided the enclosure be a plain. See fig. 3, letters *e e*, and *k*. Fig. 4, letters *c c*.

CILIARY PROCESSES.

Ciliary Processes. Directly behind the iris, is a second curtain, having a central hole through it, corresponding with that through the first curtain, but nearly as large as the whole diameter of the lens. All the luminous rays which are converged by the convexity of the cornea, which is, in effect, a plane convex lense, cannot enter through the pupil ; many of them strike the plane of the iris, and are reflected back, as on a looking-glass, without penetrating its substance. If any rays were to get through, by such an irregular process, it would produce great confusion, by destroying the outline and vividness of the image previously made on the visual nerve, through the natural opening. To prevent such mishaps, the paint on the back of the iris is to absorb such rays as are not reflected, and have a tendency therefore to pass onward. Nature, as though fearful that circumstances might so alter the condition of the pigment,* as that some light, notwithstanding this precaution, might penetrate, has interposed this second veil,— solely it is supposed to stop all wandering rays. This ciliary curtain presents three thicknesses, and lastly has a thick coat of black paint on its back. In order to give it treble security, as it regards thickness, it is plaited like the folds of a ruffle. There are seventy folds in the human eye, of equal width, nicely laid, one over the other. A part so highly important, cannot be overlooked in studying the philosophy of vision.

* Pigment—*paint*.

FIG. 4.



Explanation of Figure 4.

This plan presents a longitudinal section of the left eye and bony orbit.

a — The upper eye-lid, shut.

b — The *cornea.*

cc — The cut edges of the *iris.*

d — The *pupil* or round hole through the centre of the *iris*, which, in the living eye, resembles a black, highly polished dot.

ee — The cut edges of the *sclerotic* and *choroid* tunics, with the *retina*, before exhibited in the preceding drawings.

f — *The crystalline lens*, as it is lodged, with reference to other parts.

gg — The *Ciliary processes* continued from the *choroid coat.* The plaits are here distinctly seen. In other designs accompanying this article, they will be noticed in a front view.

h — The *optic nerve* running from the brain, through the bones, to the globe of the eye, apparently closely embraced by the *recti*, or straight muscles.

i — The *levator*, or muscle that raises the upper eye-lid.

k — The upper straight muscle of the eye, called *levator occuli.*

l — Inferior straight muscles, its antagonist, on the under side of the ball, called *depressor occuli.*

m — A section of the inferior oblique muscle, called *obliquus inferior*, used in rolling the eye upward and inward, as in looking at a button laid above the root of the nose. The *superior oblique*, passing through a loop, carries the eye downward and outward, as in looking at the top of the shoulder. These two *muscles*, by old writers, were termed *rotatores* and *amatores*, in allusion to their office of rolling the ball and expressing passions.

nn — A section of the blood vessels and nerves, with a large quantity of fat, surrounding the *optic nerve.* This fat lies between the muscles and betwixt the socket and globe.

HUMORS OF THE EYE.

By humors, medical writers mean the fluids which distend the eye-ball. They are three in number, — possessing different densities, and varying much in quality, quantity and use. Beside fulfilling the first intention, — viz., distension, they are so purely transparent, as to offer no obstruction to the free passage of light. Too much care cannot be bestowed on the anatomy of these fluids by surgeons, as they are the seats of many remarkable diseases. Those only interested in this description, as general philosophers, by close examination, will have a perfect idea of them, and will consequently understand the real nature of some of the many causes that weaken the power of vision, or ultimately produce a total blindness. The gratification afforded by the examination of a bullock's eye, — tracing the several parts by this paper, will be an ample compensation for the labor, because it will forever fix on the mind interesting discoveries, and lead the reader, insensibly, to a course of reflections, productive of much intellectual enjoyment.

AQUEOUS HUMOR.*

The aqueous humor is the first in the order of demonstration, lying directly back of the cornea, — so clear, that one unacquainted with the existence of it, would not suspect a fluid there. In volume, it is far less than the others: it keeps the cornea prominent, always at the same distance from the iris, in the early periods of life. The space occupied by the aqueous humor, is called the *anterior chamber* of the eye. (See fig. 2, letter *f*.) Passing freely through the pupil, it also fills an exceedingly thin apartment, the circumference of the iris, called the *posterior chamber*. Thus it will be comprehended, that the iris, or in familiar language, first curtain, is actually suspended and floating in a liquor. Were it not for such a contrivance, the iris would soon become dry and shrivelled, by the intensity of the sun, and therefore rendered totally unfit to perform its appropriate office of opening

* Aqueous — *like water.*

and closing the pupil. An opinion is current, founded undoubtedly in truth, that the aqueous humor is never suffered to remain long at a time, but, on the contrary, is constantly poured in and again drawn off by an infinite number of invisible ducts. By being stationary, it would become speedily turbid, and finally lose its transparency. A knowledge of the rapidity of the secretion, has been the means of encouraging occulists to undertake novel methods of extracting cataracts, a kind of dark mote, through the cornea, as the most certain mode of restoring sight. Twentyfour hours after drawing off the aqueous humor, by a puncture, the anterior chamber will be full again.

Old age, characterized by a gradual decay in the vigor of all the individual organs, shows also its insidious approach in the eye. Vessels that have toiled with untiring diligence to the meridian of life, begin to show a loss of energy. Those which have carried the new, pure liquid, forward a less quantity in a given time than formerly, — while those whose task it was to convey away the old stock, are dilatory in the performance of their work. Hence, from being kept too long in the reservoir, in consequence of a tendency to become more turbid, does not allow the light to pass with former facility to the nerve : elderly persons, therefore, have indistinct vision from this cause, similar to looking through a smoky atmosphere. The writer has a favorite Newfoundland dog, whose eyesight is impaired in this way. Fishes have no aqueous humor at all, as it could be of no service in the element in which they swim : — the water surrounding them is the aqueous humor to their organs. Kept, as the humor is, in its own capsule, gives other advantages to the apparatus of vision : it is a concavo-convex glass, absolutely and indispensably requisite in an instrument that will produce an image by the same laws that govern the human eye. A sensible diminution in the quantity of this fluid, is very apparent in people advanced in years : the cornea becomes flatter ; the segment of the transparent cornea is so altered, that rays of light are no longer converged as in younger days. This, together with corresponding derangements within the globe, constitutes the long-sightedness of old age, — mechanically overcome by wearing convex spectacles. So gradually are the changes wrought by age, that glasses of different focal distances are sought from time to time, to keep pace with the progress of decay.

The ingenuity of man is nowhere more curiously displayed, than in thus availing himself of his discovery of the laws of refraction, in producing artificial lenses to gratify his eye, a never failing source of enjoyment, long after nature has begun to draw the blind that will ultimately close between him and the world forever.

CRYSTALLINE LENS.*

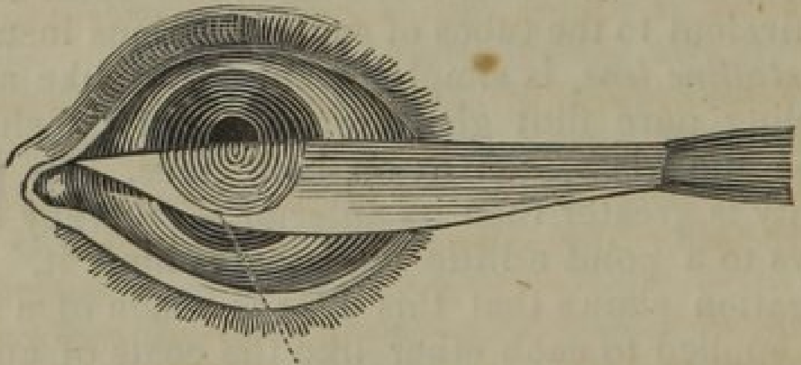
As magnifying glasses of different refractive powers give perfection to optical apparatus, so it is with respect to the lenses within the ball. The coats of the eye are equivalent to the tubes of such ingenious instruments. By *crystalline lens*, is simply meant a body like a button, resembling pure flint glass, somewhat of the shape of a common sun glass, convex on both sides. Its posterior convexity is greater than its anterior, — thereby bringing the rays to a point a little distance behind it. Careful investigation shows that this lens is made of a series of plates, applied to each other like the coats of an onion: the centre is firmer than the edges or space between the nucleus and margin.

As a whole, it possesses a highly refractive property, but in different degrees, according to the thickness of the lens, — receding from the centre to the circumference. Over the whole, to keep it from sliding in any direction, that the centre may not get without the axis of vision, is an envelope, having connexion with all the coats, where they are united on the borders of the cornea, and where it joins the white part of the eye. Being equally transparent with the lens itself, it cannot be conveniently exhibited. One of its properties is elasticity, though not to the extent we should at first view be led to imagine from the following remarks.

Cataracts, the most frequent cause of blindness, origi-

* *Crystalline lens*, — resembling crystal or glass.

nate in the lens; sometimes half way between the centre and margin, but ordinarily in the centre. They are either a peculiar deposition of opaque or milky matter, entirely preventing the ingress of light, or an opacity of some of the internal layers of plates, equally destructive to vision. Nothing short of the actual introduction of the couching needle within the globe, or a knife, promises any hope of recovery. Many children are born with this affection; at all ages, they are liable to form: perhaps the habit of gazing habitually on a strongly reflecting surface, may have a tendency to generate the disease. To remove cataracts by extraction, the operator slides a sharp, thin knife, resembling a lancet, through the cornea, from one side to the other, cutting one half from its natural attachment —leaving it, when the knife comes out, in the form of a flap, thus: FIG. 5.



Explanation of Figure 5.

This plan represents an eye, surrounded by its natural appendages with a knife passing through the anterior chamber of the eye. A dotted line indicates the lower edge of the flap, made by cutting off just one half the cornea from its attachment with the sclerotica, in order to allow the crystalline lens to escape, whenever the knife is withdrawn.

As a matter of course, the aqueous humor escapes in a twinkling, at the same moment, the capsule of the lens, previously ruptured, designedly, by the point of the knife, as it slides along, spasmodically acts upon the lens by spontaneous contraction, and protrudes it through the wound. Undoubtedly, the grasp which the straight muscles have on the ball, accelerates its escape.

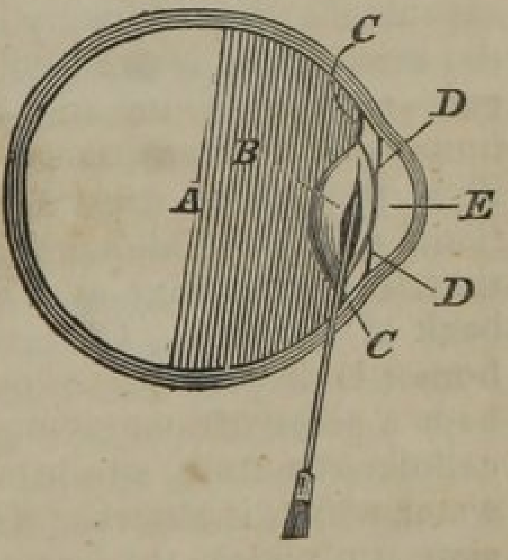
Thus, in taking away the obstruction to sight, the whole lens is extracted. Perhaps the question may arise

— how the eye is to answer its original design with the loss of one of its important glasses?

To *couch*, an operation often mentioned, and often performed, is to thrust a delicate needle through the white of the eye, just on its border, till the point reaches the lens, which is then depressed into the lower part of the eye, below the optic axis, so that light may, by entering the pupil, arrive at the nerve. In this last operation, fears are always entertained, that the lens may rise again to its former position, rendering a repetition of the operation indispensable. *Secondary cataracts* sometimes form, after couching or extraction, and arise in consequence of a thickening and opacity of the capsule, which is left behind. Such cases are more alarming in their progress than a disease of the lens, as no surgeon is warranted in promising even a partial relief. If he attempted to tear away the membrane, he might also rend every other within the globe.

A few facts of this kind which have a practical bearing, more or less interesting to every person, may lead to correct views, in relation to some of the diseases which are common to this curious, wonder-working organ.

FIG. 6.



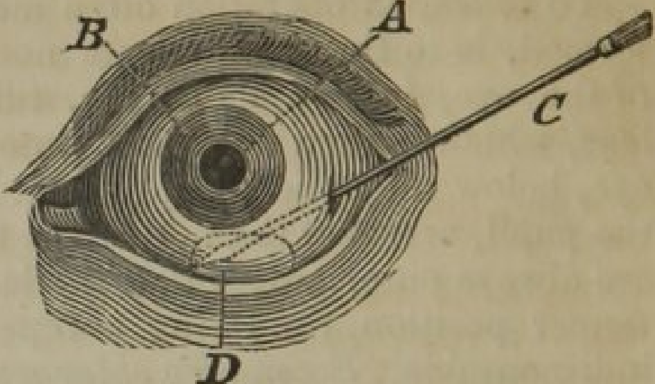
Explanation of Figure 6.

This is a scheme showing how a bad operator, by introducing the couching needle too near the cornea, may rupture the ciliary processes, and actually divide the lens in two pieces, without moving it from the optic axis.

A — The *vitreous humor*.
B — The *lens*.
CC — *Ciliary processes*, torn by the lower part of the needle, thereby doing great violence and a permanent injury to the organ.
DD — The *iris*.
E — The anterior chamber of the aqueous humor.

Explanation of Figure 7.

FIG. 7.



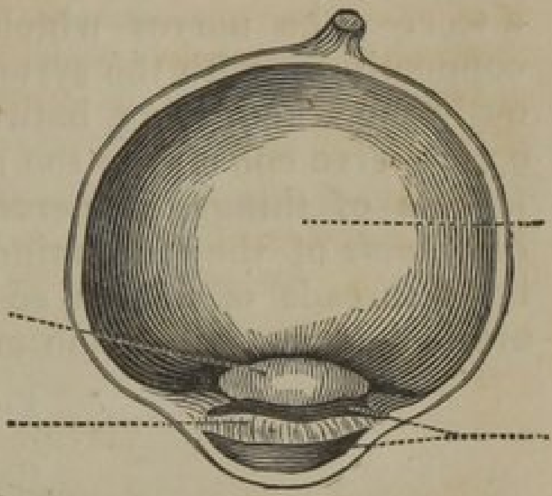
This figure represents the mode, and, in fact, the place into which the couching needle is introduced, in the operation of couching.

A — The pupil is seen through the transparent cornea.
B — The *iris*.
C — The needle, with the handle elevated so as to depress the point.
D — The lens and point of the needle in outline: this precisely represents the position of the lens after couching. To complete the operation, it must be carried a little back before withdrawing the needle.

VITREOUS HUMOR.

Beyond the two humors we have been describing, is the third, differing essentially from either of them. In the first place, in volume it far exceeds the others, — occupying more than two thirds of the whole interior and posterior of the ball. Its consistence is that of the white of an egg, but kept in its place by its own appropriate capsule; it presents many interesting phenomena. When the sack is punctured with a pin, it flows out slowly, in consequence of its adhesiveness. Like the preceding humors, it is transparent, allowing the free passage of light through its substance, and also possesses the additional quality of allowing the rays to separate again, as they leave the point at which they were converged, just back of the lens. Observation proves that the vitreous humor is kept in place by being lodged in cells. Perhaps a piece of sponge might give a tolerable idea of the cellular structure, admitting it to be as transparent as the water which it absorbs. On its fore part, it has a depression, in which the posterior convexity of the lens is lodged, — as represented in this diagram. Concave, therefore, in front, and convex behind, gives another kind of optical glass, known as the *meniscus*, — the crescent, faintly resembling the first quarter of the new moon. If by accident, or a want of skill, the operator suffer this humor to escape, in any of his operations, the globe at once diminishes in size, and all hope of the restoration of a diseased eye is lost. The small mistake of pricking the sack containing the vitreous humor, will decide whether the patient is to live in never ending night.

FIG. 8.



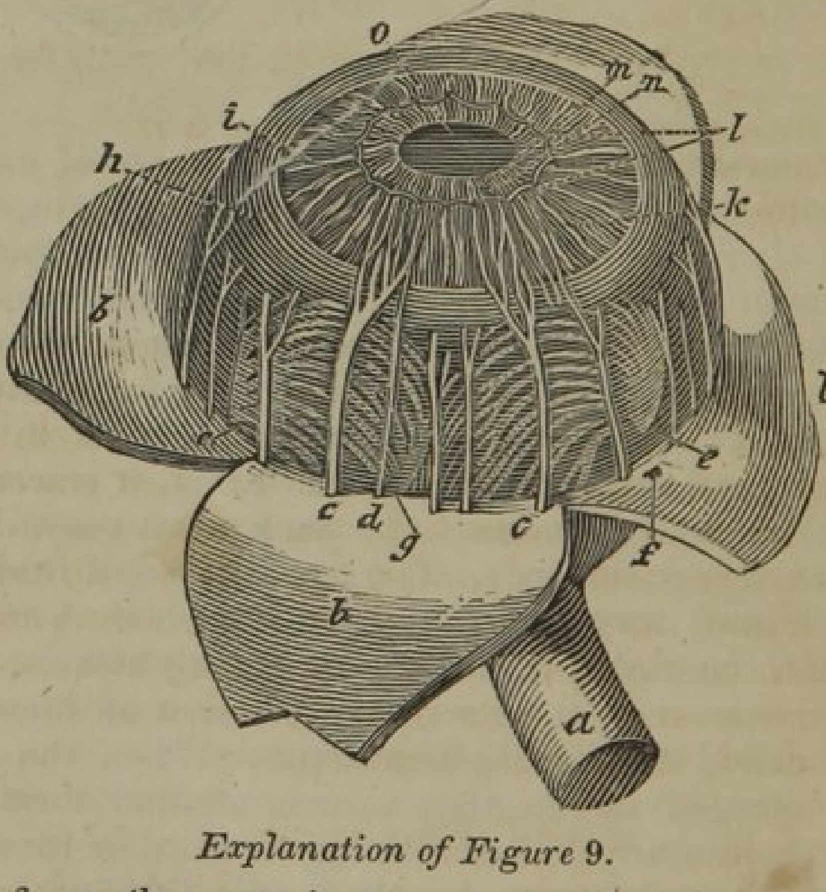
Explanation of Figure 8.

One dotted line, indicates, in this diagram, the aqueous humor; another the iris, and a third the lens, and the fourth the vitreous humor. Let it be remembered that all the space between the back side of the lens and optic nerve, is filled completely, with the glairy, vitreous humor, the third fluid, and inmost of the eye.

OPTIC NERVE.

Any person possessing an ordinary share of curiosity, can examine the *optic nerve*, or nerve of sight, at leisure, in slaughter houses, fish markets, and in fowls. In the human eye, — perhaps, to be clearly understood, outside the eye, as it extends to meet the brain, it is like a cotton cord, larger than a wheat straw, of a mealy whiteness, not far from three quarters of an inch in length. Arising from the substance of the brain, it traverses the bony canal till it reaches the back of the eye-ball; as soon as it arrives in contact, as it were, it is suddenly divided into innumerable filaments, which wend their way into the globe, through very minute holes. From a fanciful resemblance to a sieve, this spot on the sclerotica, is called the *cribriform* plate. When the threads have emerged within, they assume another form, by expanding into a web, constituting a third or inmost box. Some believe the nerve is spread on a thin, *unseen* membrane, in the form of a highly organized nervous paste. Here, on this pulp, having considerable range of surface, is the sole seat of vision. A vulgar opinion presupposes some exceedingly acute nervous point, — the exquisite point of vision. Nothing, however, is more absurd; vision includes considerable surface. In the centre of the substance of the nerve, an artery penetrates the eye, accompanying the *filaments*, to nourish the humors. When the cornea has been cut away, and the iris detached, this vessel may be distinguished, of a bright scarlet, spreading its hair-like branches about, like the limbs of a tree. The nerves which give sensation to the eye, connecting it with the system, may be noticed, as previously remarked, lying between the two first coats. The optic nerve conveys to the mind the sensation of the existence of things, as perceived by the eye, while the *commands* of the same mind are conveyed to it by these little threads of nerves, so insignificant, as to be often overlooked in a dissection made purposely for them.

FIG. 9.



Explanation of Figure 9.

In this figure, the *cornea* is cut away, and the *sclerotic* dissected back. This is a beautiful and easily accomplished dissection. In a bullock's eye all these delicate nerves can be readily displayed. A pair of sharp pointed scissors and a few pins, to hold parts to a board, are the proper instruments. Even in schools, ladies could exhibit most of this beautiful optical apparatus.

a—The *optic nerve.*
b—The *sclerotic coat* turned back, so as to show the vessels of the *choroid* coat.
cc—The *ciliary nerves*, seen piercing the *sclerotic coat*, and passing forward to be distributed to the *iris*. The *iris*, so highly organized, is not supplied by any nervous influence from the *optic*, but by the hair-like nerves, here displayed, creeping to its margin between the two exterior coats.
d—A small nerve passing from the same source to the same termination, but giving off no visible branches.
ee—Two *venæ vorticosæ*, or whirling *veins*, so denominated, because they seem to fall into shapes, resembling falling jets of water; these return the blood from the eye, sent in by its central and other arteries.
f—A point of the *sclerotic*, through which the trunk of one of the veins has passed.
g—A lesser vein.
h—The point, or circular point of union, where all the coats of the eye, together with the cornea and iris, seem to be glued firmly together.
i—The *iris*.
k—The *straight fibres of the iris.*
l—A circle of fibres or vessels, which divide the iris into the larger circle *k*—and the lesser one *m*.
m—This letter points to the lesser circle of the *iris*.
n—The fibres of the lesser circle.
o—The pupil.

PIGMENTUM NIGRUM.*

Lastly, to complete the internal structure, and fit it for the performance of its destined office, the inside surface of the second coat, *choroides*, is thoroughly painted black. In the order of explanation, this paint is just behind the retina. When the humors have been taken out the pigment is readily examined. The use of it is very obvious; viz., to absorb any aberrating or unnecessary rays of light, which confuse the vision; or destroy the intensity of the impression on the nervous expansion of the retina,—and indeed, to *suffocate* them entirely.

JUNICA CONJUNCTIVA.

Posteriorly, the eye, by its long cord of optic nerve, seems to rest on one extremity of an axle;—the opposite in front, being the skin, passing over the eye, as it comes

*Pigmentum Nigrum—*black paint*

down from the forehead, to join the cheek. To comprehend, clearly, the manner in which the eye is fastened, before, — observe how the skin turns over the edge of the lid, going about three quarters of an inch back, striking the ball to which it is made fast, then folded back upon itself, adhering to the whole anterior surface of the cornea, — dipping down and finally mounting over the margin of the lower lid, and ultimately losing itself on the face. As we cannot recognise this, on a living eye, it will at once lead one to suppose it is as clear as glass, which is the case. Streaks of blood, when the eye is inflamed, lie covered over by the tunica conjunctiva. Now if particles of sand, or other irritating substances get under either eye-lid, they cannot possibly enter but little way, before reaching the duplication of this transparent skin ; there is no danger, therefore ; the offending matter cannot get so far between the socket and ball, backward, as to abridge the free motion of the organ, or do a permanent injury to the parts. This partition, or doubling over of the conjunctiva, is a curious provision, as we are thereby enabled to reach the source of irritation. The principle of introducing eye-stones, to extract foreign matter, is this, and not owing, as vulgarly supposed, to the crawling about of a smooth piece of sulphate of lime, on some forty or fifty feet. The stone is so much larger than the extraneous body, already there, that it excites a proportionably larger quantity of tears, to wash it away : in essence, therefore, we submit to a greater temporary evil, to get rid of a lesser one. Precisely on this principle, a person chewing tobacco, is constantly spitting : the vile weed is so offensive to the nerves about the region of the throat and tongue, — a stimulant so unnatural and uncongenial to the constitution of the body, that the saliva is poured out, with increasing copiousness, to wash it from the mouth.

Serpents annually shed their skins, which, unaccountable as it at first appears, are whole over the holes where the eyes were. That thin sheet, so very clear and fine in texture, is the conjunctiva, showing its origin, —hence a similar origin may safely be inferred over other eyes.

Every species of animal with which naturalists are conversant, possess this defensive transparent membrane.

MEMBRANA NICTITANS.

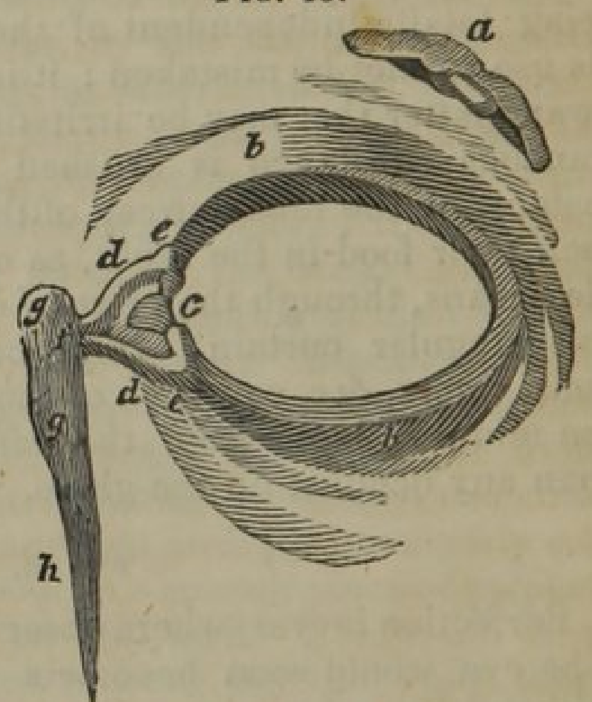
A third eye-lid is given such animals as are destitute of hands, or are incapacitated, by the arrangement of their limbs, from reaching their eyes. This is called membrana nictitans, — and a more striking piece of mechanism, there is not in existence. It slides from one angle of the eye to the opposite one, under the first pair of lids, — and that, too, whether the others are open or shut, being totally independent of them in muscular action. Its use cannot be mistaken : it is on purpose for clearing away matter that may be irritating to the eye. Any extraneous substance is brushed from the cornea in an instant, by the broad sweep of the night lid. Birds that seek their food in the night, as owls, defend their irritable organs, through the glare of daylight, by drawing over this singular curtain. Dogs, cats, foxes, wolves, bears, lions, tigers, &c, can each of them, by this brush, remove the minutest mote from the cornea, more expeditiously than any occulist on the globe.

TEARS.

Perfection is everywhere observed in animal mechanics. The eye would soon become a useless instrument, notwithstanding the nice adjustment of its several parts, were it not for the external apparatus of eye-lids, glands and tears, whose combined action keeps it always in a condition to be useful. Were not the cornea frequently moistened, it would become dry and shrivelled. To obviate this, a sack of fluid is fixed just under the edge of the orbit, above the eye-ball, which is continually pouring out its contents by the pressure and rolling of the eye. Flowing through numberless apertures, it washes the crystal, and finally passing into grooves, on the inner margin of both eye-lids, runs to their terminations in a small pin-like orifice, at the inner angles. To keep them open, a hoop is set in the mouth of this lachrymal duct. This, too, can be shown by turning the lid outward by the finger. Finally, the tears are conveyed into the nose through a bony tube, answering the double purpose of softening and keeping moist the living membrane, on which the sense of smell depends. On both eye-lids, at the roots of the eye-lashes, are in each, a row of glands, equivalent to bags, smaller than pin heads, which ooze out an oily secretion, to prevent the adhesion of them together, as is sometimes the case when the eyes are much inflamed. Surely such manifest provision for contingencies, and for the preservation of this one piece of mechanism, indicates Super-human contrivance.

Explanation of Figure 10.

FIG. 10.



This plan exhibits the natural size of the passages of the tears.

a — Is the lacrymal gland, or in other words, the organ that secretes the tears; showing its natural situation, with respect to the eye-lids.

bb — The eye-lids, widely opened.

c — The situation of the *puncta lacrymalia*, or the holes, at the inner angles of the lids, through which the tears flow, to get into the tube which finally conveys the fluid to the nose.

dd — The ducts continued from the *puncta lacrymalia.*

ee — The angles which the ducts form after leaving the puncta.

f — The termination of the lacrymal ducts in *gg*.

gg — The lacrymal sac.

h — The nasal duct, continued from the lacrymal sac.

ON SEEING AT A DISTANCE.

When we speak of the distance to which vision extends, we can understand either the sphere of distinct vision, or of seeing in general. The latter has a much larger semi-diameter than the former; and the series for the one is in animals different from that of the other. The extent of distinct vision, is pretty nearly in relation with the distance of the lens from the retina in the axis of the eye. But the power of seeing at a distance, depends, in general, in land animals, on the absolute magnitude of the semi-diameter of the external surface of the cornea. The larger this is, the greater is the number of rays that reach from distant objects through the cornea to the interior of the eye, and the more easily are such objects rendered visible. But this applies to land animals only. The cornea has no such value in aquatic animals, in arresting the rays of light, as that the limits of vision can be determined by it. If we arrange land animals and birds according to the measure of their power of seeing in the distance, we obtain the following series:

Horse - - - - -	73	Rough-legged Falon -	32
Ox - - - - -	66	Buzzard - - - -	28
Asiatic Elephant - -	65	Night-Heron - - -	27
Antelope Rupicapra	64	Short-eared Owl -	27
Lynx - - - - -	55	Psittacus Aracanga -	25
Kangaroo - - - -	50	Turkey - - - -	25
Wolf - - - - -	45	Tame Swan - - -	23
Fox - - - - -	38	Ardea stellaris - -	22
Man - - - - - -	34	Carrion Crow - -	22
Simia Inuus - -	30	Tarrock - - -	20
Hystrix cristata - -	30	Green Woodpecker -	19
Marmot - - -	28	Corvus glandarius -	17
Brown Bear - - -	27	Yellow Oriole - - -	15
Otter - - - - -	26	Psittacus rufirostris	11
Ursus Lotor - - -	25	Virginian Opossum -	20
Simia Capucina -	24	Common Squirrel -	19
Beaver - - - - -	23	Badger - - - - -	19
Polecat - - -	23	Cavia Cobaya - -	18
Horned Owl - - -	56	Water Rat - - -	14
Ostrich - - -	50	Hamster - - -	12
Golden Eagle - -	40	Long-eared Bat - -	4
Stork - - - -	33	Crossbill - - -	9

In this table the larger animals, in general, are those that see farthest. But there are exceptions to this rule. It is worthy of remark, that birds which, in the distinct vision of a point, precede quadrupeds of similar magnitude, are inferior to them in distant vision, and that man agrees with birds in this respect. Thus the great owl, *(Striæ Bubo,)* ostrich, and golden eagle, excel in the first point; in the latter are inferior to the ox, elephant, &c. The chamoi and the Lynx, and many other animals, have a wider power of vision than man, in which the radius of the sphere of distinct vision is much smaller than in him.

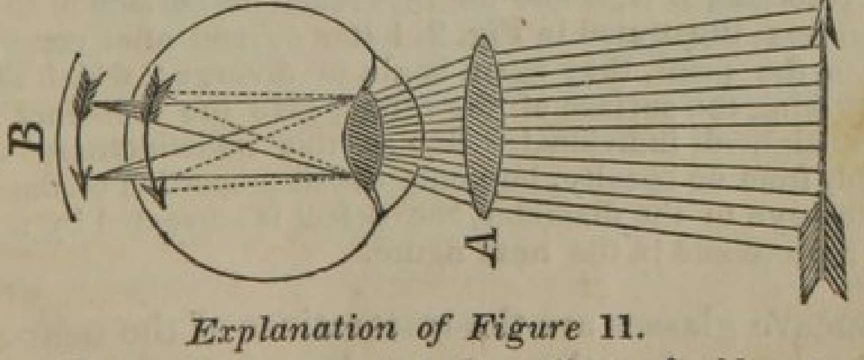
This conclusion is contrary to the generally received opinion on the subject. Birds, and particularly rapacious birds, are considered as having a much greater power of distant vision than most quadrupeds; and many will be disposed to challenge the fact, that the ox possesses this power in an equally high, or even higher degree. But when we consider fairly the experience on this subject, we shall find that it is not in opposition to what has just been stated. Mayer found in his experiments on the acuteness of vision, that, in seeing, it depends not only on the illumination of the object, and its distance from the eye, but also on the relation of the object and the eye to the neighborhood. But it is quite otherwise with birds which look from above, downwards, or with quadrupeds, whose vision is directed upwards or forwards. No one has measured the great distance at which a far-seeing bird perceives its prey; and indeed it will always be difficult to do this with accuracy. But Treviranus remarks, 'I doubt not, if we possessed certain observation on this point, that the greatest distance would not exceed that of a far-seeing man.

When, for example, Faber, in proof of the sharpness of the sight of birds, remarks, 'the high flying eagle or the kite perceive the motions of small animals on the ground; the solan sees a very small fish from a considerable height; and gulls, terns, rapacious gulls, *(Lestri,)* and petrels, fly from all sides to a particular point, where an object is seen floating on water; he presents us with data which are far from being satisfactory. When, on the contrary, Ross affirms, in his voyage to Baffin's Bay, that he obtained certain data, proving that the power of vision of man over the surface of the sea extended to 150 English miles, it is conceivable that the farthest seeing bird could not exceed this. But experience would seem to show, that birds, although in general their power of distant vision is not very great, that they possess a very *sharp sight* in a greater distance than most quadrupeds. There are many curious observations illustrative of what we have just said. He says, he threw, at a considerable distance from a throstle or mavis *(Turdus musicus)* a few small beetles, of a pale gray color, which the unassisted human eye could not discover, yet the throstle observed them immediately, and devoured them. The long tail titmouse *(Parus Cordatus)* flits with great quickness among the branches of trees, and finds on the very smooth bark its particular food. When we examine the spots where it stops for food, nothing is perceived by the naked eye, although minute insects are visible by means of the magnifying glass. A very tame redbreast *(Sylvia rebecula)* discovered from the height of the branch where it usually sat, at the distance of eighteen feet, small crumbs of bread spread out on the ground, the instant they were thrown down; and this, by bending its head to one side, and therefore using only one eye. A quail, at the same distance, discovered, by the use of only one eye, some poppy seeds.

A REASON WHY PERSONS IN ADVANCED LIFE, REQUIRE CONVEX GLASSES.

Age gradually relaxes the tension of the whole system; the eye, therefore, suffers in a corresponding ratio. The cornea becomes less prominent:—the convexity of the lens is also diminished, and the rays of light are consequently less convergent than formerly. The picture of the object is faint, because the rays have a tendency, by their divergency, to impinge at a supposable plane, beyond the retina.

FIG. 11.



Explanation of Figure 11.

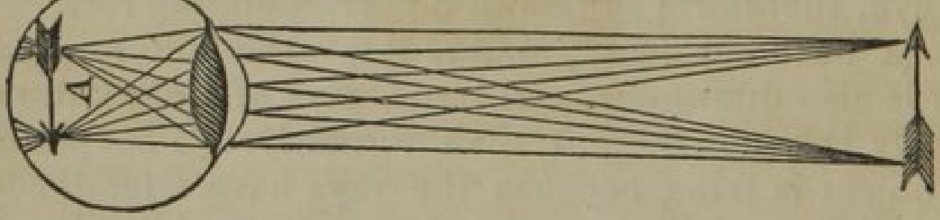
In this figure is represented the effect of old age on the humors: without the intervention of the glass A, the rays have a direction which would form the image at some distance beyond the *retina*, as at B. But, by the convex glass A, which, for example, is the spectacle worn by aged people, the *direction* of the rays of light is so corrected, that the image falls accurately on the bottom of the eye, or *retina*.

When the convex lens is interposed between the eye and object, as represented in the above diagram, the rays are made more converging, — so that the picture strikes exactly and distinctly on the nerve. People slide their spectacles on the nose unconsciously till the true focus is procured.

A REASON WHY NEAR-SIGHTED PERSONS SEE INDISTINCTLY.

Either the crystalline lens, but more generally the cornea, is too prominent — converging the light too suddenly; — that is, converging the luminous rays at an unnatural place within the vitreous humor. An indistinct outline of the object is the effect of their great divergency, after decussating — before they arrive at the retina. The following diagrams will illustrate the subject far better than a whole volume of written explanations.

FIG. 12.

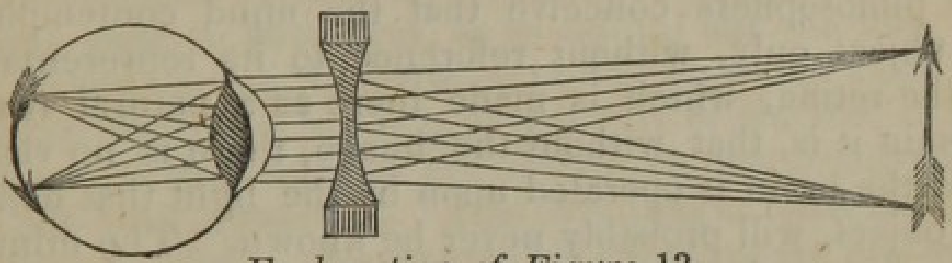


Explanation of Figure 12.

In this figure, the convexity of the cornea, or the focal powers of the lens, being too great for the length of the axis of the eye, the image is formed at A, before the rays reach the surface of the *retina*, or inner box, illustrated in Fig. 2, letter *c*; and after coming accurately to the point, they again begin to diverge; which diverging rays, striking the surface of the retina, give the indistinct vision of the near-sighted individual. But as this indistinctness of vision proceeds from no opacity, but only the disproportion of the convexity of the eye to the diameter, the defect is corrected by a concave glass, represented in the next figure.

Concave glasses are the restoratives of the near-sighted eye, by separating the rays, and carrying the image so far back as to place it on the retina. Old age, the destruction of the first eye, eventually restores the near-sighted, by the gradual flattening of the cornea, till at threescore and ten, such persons can see clearly and distinctly without artificial aid. Many near-sighted people totally ruin the organ by prematurely wearing glasses, as a focus is established which neither glasses can keep pace with in age, nor age thoroughly overcome.

FIG. 13



Explanation of Figure 13.

The effect of this glass being exactly the reverse of the convex, it causes the rays to fall upon the surface of the eye, so far diverging from the perpendicular line, as to correct the too great convergence, caused by the convexity of the humors. When a near-sighted person has brought the object near enough to the eye to see it distinctly, he sees more minutely and consequently more clearly; because he sees the object, says Mr Bell, larger, and as a person with a common eye does, when assisted with a magnifying glass. A near-sighted person sees distânt objects indistinctly, and, as the eye, in consequence, rests, says the same observing writer, with less accuracy upon surrounding objects, the piercing look of the eye is very much diminished; and it has, moreover, a dulness and heaviness of aspect. Again, the near-sighted person knits his eye-brows, and half closes the eye-lids; this he does unconsciously, to change the direction of the rays, and to correct the inaccuracy of the image. Near-sighted people have but little expression; the countenance loses all its majesty, by habitually wearing glasses.

THE IMAGE OF AN OBJECT IN THE EYE, IS INVERTED.

Rays of light going from the upper and lower points of an object, are refracted towards the perpendicular; that is, bent out of the course which they have a tendency to run, by the crystalline lens behind, where they unite in a point, — and, then crossing, diverge again. Here then, the image is bottom upward, as will be noticed in the preceding diagrams by the arrow, and its image on the retina. Decussation is indispensable to the vision of things. An object could not be represented on a point;

there must be surface to create an image on, and by the laws of optics, the representation of the object, without an additional glass within the eye, must necessarily be as it is.

HOW THE OBJECT APPEARS IN ITS TRUE POSITION, THE IMAGE BEING INVERTED.

Habit is supposed to be the cause of seeing objects as they really exist, in relation to surrounding bodies.* A few philosophers conceive that the mind contemplates the object only, without reference to its representative on the retina, which is made there as a natural result. Certain it is, that without the image, there is no vision. How the brain is operated upon by the light that defines the object, will probably never be known. The minuteness of the miniature traced on the retina, precisely like the object in every minute particular, is truly astonishing. By cutting off the coats of a bullock's eye, and holding a clean white paper near, this beautiful exhibition can be leisurely observed. If a sheet of white cotton cloth, six feet square, is elevated 24,000 feet in the air, the eye being supposed one inch in diameter, the miniature of the sail on the retina will be only one eight thousandth part of an inch square; which is equivalent to the 666th part of a line, — being only the 66th part of the width of a common hair! Leaving this point to philosophers, we proceed to such facts as are susceptible of positive demonstration.

HOW, WITH BOTH EYES, ONLY ONE OBJECT IS SEEN.

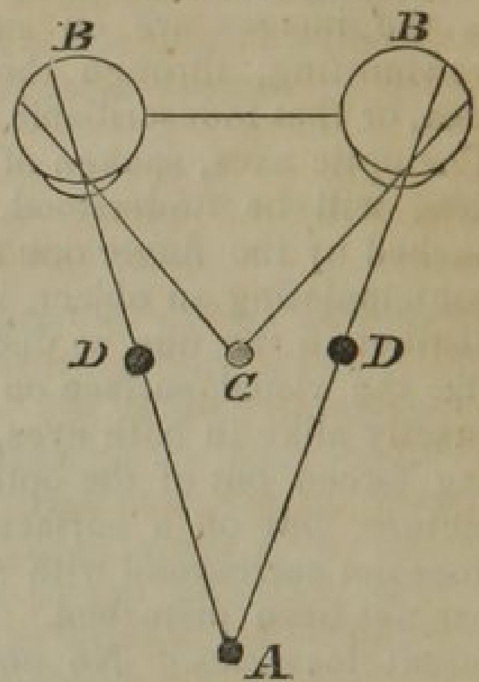
At one side of the centre of each eye, there is a surface more susceptible of visual impressions than any other. These points correspond in both eyes — being precisely on the two retinas alike. An impression therefore on one, provided the light strikes them equally, produces precisely the same effect on both. This, instead

* A Dr Reed, of Cork, has recently attempted to demonstrate that the *cornea* is the true seat of vision, and that we see by means of erect and reflected, and not by refracted and inverted images.

of making vexation, gives strength or greater vividness, as the images are on surfaces of the same structure, transmitting, through the two optic nerves, the same idea, or that indescribable something that creates an idea. The optic axes, spoken of in the books, by this explanation, will be understood. If one eye is distorted,—pushed by the finger one side, when we are in the act of contemplating an object, it will appear double, but less distinct in the one so distorted. The rationale is this; viz. the visual surface on which the image is made, so exactly alike in both eyes, as to call up but one idea, being forced out of the optic axis, the rays still make the picture, but on a surface, less highly organized,—that does not correspond with the surface on that retina which has not been disturbed. The two images have now different localities. No course of experiments are more within the reach of those who have the desire to experiment, than these.*

* Generally the eyes of insects are of two kinds; viz. simple and compound, having the appearance of two crescents, making the largest part of the head, and containing an infinite number of little hexagonal protuberances, convex, and placed in lines. The number of lenses in one eye, vary in different insects. Hooke computed those in the eye of the *tabanus* or horse-fly, to amount to nearly 7000. Loewenhoek found in that of the *libellula*, (dragon-fly) 12,544; and 17,325 have been counted in a common butterfly; the picture of an object, impinged on their retinas, must be millions and millions of times smaller than in the human eye. Some insects have a still more curious apparatus of vision; three small spherical protuberances rise from the top of the head, and are eyes, in addition to the ordinary ones on the side of the head. They are solely for seeing distant objects; the first, for near ones. Loewenhoek looked through the eye of a dragon-fly with a microscope, as a telescope, and viewed the steeple of a church, which was 299 feet high and 750 feet distant. He plainly saw the steeple, though it did not appear larger than the point of a very fine needle. He also viewed a house and could distinguish the front, discern the doors and windows, and moreover, perceive whether they were open or shut. The writer has recently seen the light strongly reflected from the eye of the bee-moth, which precisely resembled the ground faces of a stone in a watch seal. This, therefore, was a multiplying eye. Several insects present the same structure, but nature's object is not understood by entomologists.

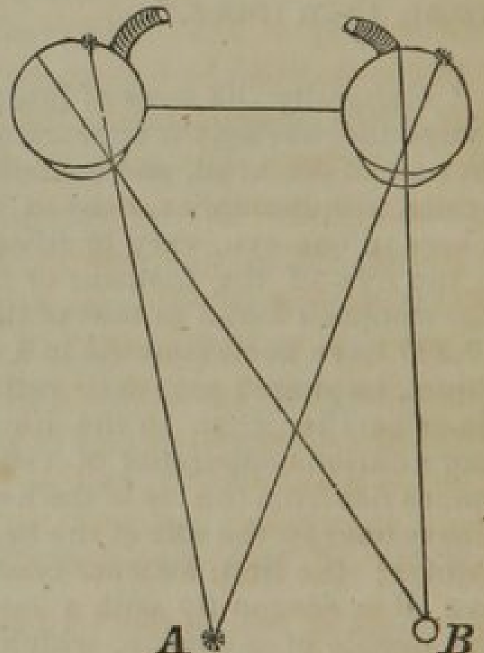
FIG. 14.



Explanation of Figure 14.

In this figure, B, B, the eyes, having their axes directed to A, will see the object C, double, somewhere near the outline D, D. Because the line of the direction of the rays from C, do not strike the retina in the same relation to the axis A, B, in both eyes. If a candle is placed at the distance of ten feet, and I hold my finger at arm's length, between the eye and the candle, when I look at the candle, my finger appears double, and when I look at the finger, the candle is double.

FIG. 15.



Explanation of Figure 15.

A is exactly in the centre of the axes of both eyes; consequently it is distinctly seen, and it also appears single, because the form of it strikes upon the points of the retina, opposite to the pupils in both eyes. Those points, as before remarked, have a correspondence, and the object, instead of appear ing double, is only strengthened in the liveliness of the image. Again, the object B will be seen fainter, but single and correct. It will appear fainter, because there is only one spot in each eye, which possesses the degree of sensibility necessary to perfect vision: thus, it will be understood, the object will appear single, as the rays of light proceeding from it have exactly the same relation to the centre of the retinæ, in both eyes.

THE REASONS WHY CROSS-EYED PERSONS SEE ONLY WITH ONE EYE.

With such as have a permanent squint, (cross-eye,) only one eye is attended to, though they may not be apprehensive of the fact. From continued neglect, the distorted organ wanders farther and farther from the axis of vision, till it finally becomes totally useless: hence one is doubtful, at times, which way the cross-eyed person is looking, from a want of parallelism in the motions of the eyes. When the wandering eye is exclusively attended to, the vision appears unimpaired. The image is well painted in the natural one, but weak in the other, solely because the place of the image does not correspond with the place of the image in the first. The mind, instinctively, therefore, is devoted to the eye that gives the liveliest impression, to the entire neglect of its aberrating fellow.

THE REASON WHY THE PUPILS OF AN ALBINO'S EYES ARE RED.

If a person is born without the *pigmentum nigrum*, — heretofore defined to be a paint to suffocate all unnecessary light, as it goes through the retina, after the image is formed, — the blood vessels of which the *tunica choroides* or second coat is made, are not hidden. Consequently, they show through the transparent humors, like a sparkling red gem, the size of the diameter of the pupil. If a delicate brush could be inserted to give it a black coat of paint, the eye would appear as others do. Such persons can see better in a weak light than in broad day, because the brightness of the sun's light dazzles, and produces a tremulous motion in the whole organ. As an evidence that this redness is caused by the blood in the vessels, after death, when it coagulates, the redness, in a great measure, disappears. White rabbits, white mice, brought in cages from China, besides a vast variety of birds, have no pigment on the *choroides*, and are therefore distinguished for red pupils. The existence of the pigmentum nigrum, is a concomitant of a day-seeing eye. In man, the want of it, constituting the albino, is an anomaly.

A morbid action of the absorbents sometimes removes the paint, and the pupil, to the surprise of observers, becomes scarlet. A partial absorption of it is often the cause of a diminution of the original powers of vision: under such circumstances, the pupil assumes a bronze hue, accompanied by a debility and tremor of the globe under the influence of a moderate degree of light.

The writer remembers an accomplished female albino, who publicly exhibited herself in Boston, several years since. An exact wax figure of the lady with the 'red eyes,' belongs to a group, now in exhibition at the New England Museum. About the same period, the writer also recollects of seeing a white negress, who was an albino. Her father and mother were of the jet black color, though she had a pale, deadly white complexion. The hair of both these albinos was silky and milk white.

THE REASON WHY MANY ANIMALS SEE IN THE DARK.

Owls, fishes, cats, bats, &c, instead of the pigmentum nigrum, have a silvery paint of a metallic lustre, where others have the black paint, which operates like a mirror, in reflecting the light from point to point, within the eye, illuminating it till its concentration excites the retina to perceive. When viewing a cat's eyes in the remote part of a dark room, there are certain positions, in which they are seen by the observer, by the reflected light within themselves, as though they were phosphorescent: their brilliancy is very peculiar. Upon the principle of a looking-glass behind the retina, all the night-prowling animals are qualified for seeing with those few rays of light, which the constitution of their eyes is formed for collecting in the dark. By daylight, they perceive objects, as man does in the dark, viz. indistinctly. Nature is remarkably economical in the use of matter which enters into the composition of animal bodies. If a man be kept a long time in a perfectly dark room, the pigmentum nigrum is taken away; but a compensation is given him, for he can then see as perfectly in the dark, as he could before in the light. On the other hand, the paint is deposited again when he is restored to the light of day. This point has been decided in the persons of state prisoners kept in the dungeons of European despots.

Is there any arrangement in the eye, and what is it, by which animals that see in the dark are enabled to make up for the want of external light? When we consider the metallic lustre of the tapetum, which in many animals occupies a great part of the choroid coat, or even its whole surface; farther, its resemblance to a concave mirror, and its relation to the light that penetrates into the interior of the eye, we cannot help considering it as the means employed for this purpose, by its collecting the light and illuminating, by its reflection, objects lying in the axis of the eye. Prevost objects to this explanation, that there are many animals whose eyes have no tapetum, although they conduct themselves as if they saw in the dark. This is actually the case. The tapetum occurs in carnivora, ruminantia, pachydermata, cetacea, owls, crocodiles, snakes, rays and sharks: it is wanting in apes, glires, chiroptera, hedgehogs and moles; in birds, with the exception of owls, and in osseous fishes. But the gnawers or glires, bats, the hedgehog and mole, are animals that obtain their food more by night than during the day; and many of them conduct themselves in the deepest darkness, as if they were directed by the sense of sight. But this objection may be obviated, by remarking, that it is probably some other sense than that of vision, which procures for many of these animals sensations of external objects in the dark. We have in favor of this opinion, not only the experiments of Spallanzani on bats, from which it appears that, after these creatures were deprived of the use of their eyes, they conducted themselves as if they still possessed the power of vision, but also the examples of species of that family, in which the eyes are so imperfectly developed, or lie so much concealed behind the outer skin, that they are of little or no use to the animal. The genera that see in the dark, have undoubtedly so irritable a retina, that they can only see during a very feeble light; whereas in those animals whose eyes are organized equally for daylight and nocturnal darkness, the retina possesses less irritability. Hence, although these are without a tapetum, it does not follow that this organic part does not afford a mean for seeing during a feeble light.

The tapetum is either spread over the whole choroid, or only over the upper half of it. The first is the case with the cetacea, owls, and with those amphibia and fishes which are provided with this shining envelope; the second occurs in carnivorous and ruminating animals. It is more extended in the ruminating than in the carnivorous tribes. But it always extends so far as to encompass the posterior extremity of the internal occular axis. All the rays of light from external objects which reach it, are united on it, through the transparent part of the eye, and it again reflects back the whole united rays towards the lens. This latter unites them into a single cone, which has the occular axis as its axis, and its point is directed outwards. The very convergent rays of this cone become more divergent by their passage from the lens into the aqueous fluid, and from this into air or water. Finally, the apex of this cone falls into the point of most distinct vision; for in this point is situated the focus of all the rays that reach from the interior of the eye to the posterior surface of the lens. The cone is complete when the tapetum is spread over the whole of the choroid; but the upper half of it is wanting, when it occupies only the upper hemisphere of the coat. The tapetum is confined to the upper half of the choroid in all animals, whose residence and manner of life are of such a nature, that the under half of the retina is immediately struck by bright daylight, and for this simple reason, because the animal must have been dazzled by the reflection of the bright light from the under half of the latter. It covers the whole posterior portion of the internal eye in the cetacea and owls, many amphibia, rays, and sharks, because these animals live constantly in the water, or in a feebly luminous medium, or have their place of residence in dark corners, or go in quest of food during the night. The experiments and observations of Prevost and Esser, detailed in 1826 and 1827, show that the reflection of light from the tapetum is the cause of the luminousness of the eyes, observed under certain circumstances in the twilight, in cats, dogs, sheep, and in general in all the animals having a tapetum. But whether or not a phosphoric light sometimes proceeds from the retina or choroid, has not as yet been fully ascertained. There are many examples of a luminousness in the dark having been observed in the human eye.

THE REASON WHY FISHES CANNOT SEE IN AIR AS WELL AS IN WATER.

When the rays of light pass from a rarer to a denser medium, as from air into the aqueous humor of the eye, they are refracted towards the perpendicular. Now the fish has but a drop, as it were, of aqueous humor, and, moreover, the light arrives at its eyes through the whole body of water above. The light is refracted only in a small degree in entering its eye, because the humor is of the same density of the fluid through which the light is transmitted. The cornea is quite flat; if it were prominent, like the human eye, the sphere of vision would be too circumscribed; — but by giving a prominence to the whole, and placing the crystalline lens in the fore part of the eye, they have a long diameter, — and with the provision of a large pupil, are completely fitted to see in the element in which they are destined to live. With an eye of this description, they must necessarily see in air, as other animals see in water.

Those animals whose eyes are organized for seeing in water, see but indifferently in air. Hence, in those cases where the habits of the animal require it to see in both *media*, it is provided with two sets of eyes, or with eyes accommodated for seeing in each element. Thus the Gyrinus natator, an insect which generally swims on the surface of water, but half submerged, is provided on each side with two eyes, one pair situated on the crown of the head, for seeing in the air, and another pair under the head, for seeing in the water. It is also probable that the fish named Cobitis anableps, which has in each eye an upper and under cornea of different curvatures, and for each cornea a particular anterior surface of the lens, is capable of seeing in water with the one half of the eye, and in air with the other half. Thus Sœmmering found in this fish, the semi-diameter of the upper cornea — 1,0; the under 1,2; the two curvatures of the upper part of the lens — 0,5; and the two curvatures of the under part of it — 0,2 Paris lines. It cannot be denied, that, in general, land animals can see under water, and aquatic animals in air; even man sees under water, although the contrary has been maintained. It is not, however, possible, that the same eye is ever so organized as to see equally well in both elements. Land animals always see indifferently in water, and aquatic animals imperfectly in air. The one is long-sighted in water, and the other short-sighted in air. An animal in which the eye is adapted for seeing equally well in air and water, can have but imperfect vision in either. These conclusions are in conformity with what is known of the power of vision in those animals that live partly on the land and partly in the water. The seal (phoca) is one of those animals that live in both elements. But the seal has but imperfect vision in the air. Rosenthal in his memoir on the organs of the senses of seals, says, 'we have convinced ourselves by careful observation with living seals, of the species Phoca Grypus of Faber, that the animal is always short-sighted in the air; for when we held before it fish and other bodies, as pieces of wood or stones, it did not distinguish them accurately, until they were brought so near, that the organ of smell could be called into activity. I have the most satisfactory evidence of the short-sightedness of seals, from a series of experiments and observations, made in Boston harbor. My duties requiring me to be floating in a boat, from vessel to vessel, many months of the year, I have been so often accompanied by seals, alongside and astern, as to establish the fact, that they can see but a few yards in the air, and then very obscurely. Scoresby remarks, 'Whales are observed to discover one another, in clear water, when under the surface, at an amazing distance. When at the surface, however, they do not see far.' *Scoresby's Arctic Regions*, vol. i. p. 456. Faber, in his very interesting work on the habits and manners of birds that inhabit high northern latitudes, remarks that Divers (Colymbus) do not see so well above water as Grebes (Podiceps,) but better under water, because it is there they obtain their food.

It also appears, that birds which see well in one element, do not see so well in the other. Faber proposes the question, 'Is it the case that divers, when under water, draw their nictitating membrane over the eye, as they do when looking towards the sun, in order to prevent the contact of the water?' It would appear, from the observations of Treviranus, from whose excellent work, the observations on vision we are now detailing are principally extracted, that, by drawing the nictitating membrane over the eye, divers, and all other land animals which seek their food under water, are enabled, not only to prevent the immediate action of the water on the eye, but also to discover their prey. But as the light loses more of its power on passing through water, than in passing through air, and is still more weakened in its progress through the nictitating membrane, it follows that owing to this membrane, vision must be less distinct under the water than in the air.

THE REASON WHY MAN CANNOT SEE UNDER WATER.

A man under water, sees objects as a very aged person sees through a concave glass, placed close to the eye. The fish is long-sighted under water and man is short-sighted. If he uses spectacles, whose convexity is just double the convexity — or equal in convexity on both sides to the cornea of his own eye, he will see under water. The necessity of this is obvious; the aqueous humor is of the same density with the water, and there cannot, therefore, be any refraction of the rays in passing from the water into the land-seeing eye.

Euclid and other distinguished ancients, contended, and, indeed, supposed that vision was occasioned by the emission of rays from the eye to the object. He thought it more natural to suppose that an animate substance gave an emination, than that the inanimate body did. In 1560, the opinion that the rays entered the eye, was established. Kepler, in 1600, showed, geometrically, how the rays were refracted through all the humors, so as to form a distinct picture on the retina; and he also demonstrated the effect of glasses on the eyes.

IN WHAT MANNER DOES THE EYE ADAPT ITSELF TO THE DISTANCE OF OBJECTS?

No one has satisfactorily answered this question. One philosopher supposes the eye is at rest, when we examine a distant object, as a mountain, the spire of a church, or a landscape, but, that in the act of seeing near objects, there is an effort. It has been supposed that this effort is the action of the straight or *recti muscles*, exhibited in the first plan of the cordage of the eye, compressing the globe, so equally, as to elongate the eye, and lengthen the axis, so much, as to favor the union of the pencils of

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rays on the sensible retina. This could not take place in many aquatic anmials, in whose eyes the sclerotica is perfect bone. Another opinion is, that the eye is at rest in looking at near objects, and laboring, when viewing things at a distance. One writer is of the opinion that the iris contracts, and so draws the circular margin of the cornea, towards the pupil, as to make it more or less convex, according to circumstances. A great variety of experiments have been instituted, to determine, accurately, whether there really is any change made in the length of the axis of the eyeball or not, but none of them can be certainly relied upon. A favorite theory has had its advocates, that the crystalline lens has an inherent power of altering its degree of convexity, and thus accommodates the eye to all distances. Of all the absurd hypotheses on the subject under consideration, this is decidedly the most objectionable, in the estimation of an anatomist. The truth is, an action takes place in the eye, in adapting itself to near and distant objects, which depends on that vital property of a living system which no theory can reach, and which the deductions of human philosophy can never with certainty explain.

Having now completed this very brief and imperfect sketch, of the mechanism and philosophy of the eye, condensed from manuscript observations, which from the peculiar nature of my studies, have been continually accumulating, I leave it with regret, conscious of its defects,—although a hope is entertained that it will serve to excite an additional interest in this department of science, and thus accomplish one of the principal designs of the series to which it belongs.

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