Dr Mott
with the Author's Respects

WONDERS OF VISION,

A

TREATISE ON THE EYE;

CONTAINING

DISCOVERIES OF THE CAUSES OF NEAR AND FAR SIGHTEDNESS, AND OF THE AFFECTIONS OF THE RETINA, WITH REMARKS ON THE USE OF MEDICINES AS SUBSTITUTES FOR SPECTACLES.

WITH FIFTY-FIVE ENGRAVINGS.

BY WILLIAM CLAY WALLACE,
OCULIST.

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1841.

TO

WILLIAM MACKENZIE, ESQ.

Lecturer on the Diseases of the Eye in the University of Glasgow.

MY DEAR SIR,

WHEN I was Surgeon's Assistant at the Glasgow Eye Infirmary, under you and the late Dr. Monteath, I had many proofs of your friendship; as a small acknowledgment of which, and of your attention since, I dedicate this to you.

Gratefully and Respectfully, yours,

W. C. WALLACE.

90 *Chambers st. New York,*
1*st January,* 1841.

PREFACE.

On a subject on which so much has been written, and which has been so often investigated, it might be thought that nothing new could be advanced; yet the philosophical enquirer will perceive that I have not only availed myself of what has been already written, but that I have added many new facts which explain much of what was formerly obscure, in the physiology of vision.

90 Chambers Street, New York.

July 4th, 1839.

LIST OF CUTS.

RECOMMENDATORY NOTICES.

From Sir John F. W. Herschel.

"Highly curious and interesting, as well as in many respects new."

From Professor Knight, of Yale College.

"He has made interesting discoveries, which throw much light, on hitherto obscure points in the physiology of vision."

From the Report in the London Athenæum, of the eighth meeting of the British Association for the Advancement of Science.

"Sir David Brewster laid before the section, a series of beautiful preparations of the eye, made by Mr. Wallace, an able oculist in New York, calculated to establish some important points in the theory of vision. He stated, 'that one of the most important results of Mr. Wallace's dissections, was the discovery of fibres in the retina. Sir John Herschel had supposed such fibres to be requisite in the explanation of the theory of vision, and it is therefore doubly interesting, to find that they have been actually discovered.'"

From Professor Silliman.

"I have been very favourably impressed by his various communications on the eye, and topics relating to that organ."

From the London British and Foreign Medical Review.

"This is an ingenious and well written paper."

STRUCTURE OF THE EYE.

No person of ordinary intelligence would on the inspection of a steam-engine, acknowledge that the parts of a machine of such power, and indicating so much thought and design, could, by natural causes alone, assume their form and be placed in situations proper for the purpose for which they were intended. It is clear that without the smelter the ore might have remained in the mine for ever, and that without the mechanic the metal, when formed, would never have been a steam-engine.

It is proved by geologists that the earth we inhabit was at one time a melted mass, of such a temperature, that no living thing, as at present organised, could then exist; there was consequently, a period when the machinery of animated beings was formed and put together, and when all the contrivances we witness were planned and executed. There were no gradual advances to perfection; every organised being was at once adapted to the element in which it was destined to live. From the examination of the remains of animals, we find that their organs were as perfect thousands of years ago as they are now, whereas the master-pieces of human contrivance are daily undergoing improvement. In the construction of living creatures there is no room for improvement — there is no science nor art of which advantage is not taken; for when we discover a new principle, or application of a principle, we find on an appeal to nature, that it has been known and acted upon long before. As an example; — the eye of the halibut is directed upward, and the animal could only see in that direction if there were not a provision for turning it forward. Below the eye-socket, and communicating with it by an opening,

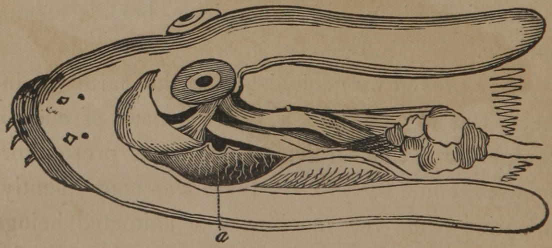
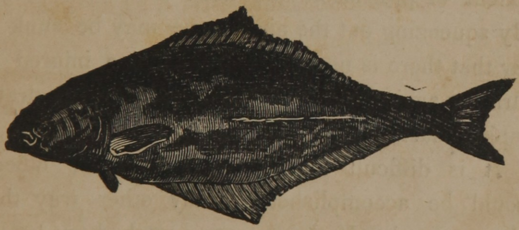


Fig. 1.—EYE OF HALIBUT.

a Aperture between the Eye-Socket and the Cavity beneath it.

there is a cavity containing water which may be forced into the socket, and be squeezed back again when required. The skin is firmly fixed before, while it is loose behind, and permits the organ to be turned round and elevated, so that the animal can see straight forward when the water is forced into the socket. To protect the nerve of vision from injury arising from the changes of temperature thus produced, a thick coating of jelly, a bad conductor of heat, is placed between the fluid and the nerve. (See Fig. 41. *b.*) The want of mobility in the neck is thus supplied by means quite as efficient, and which man, with all his ingenuity, did not discover or apply to a practical purpose for more than five thousand years.



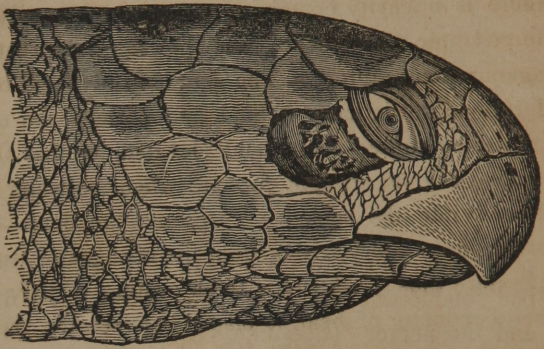


Fig. 3.—EYE OF TURTLE.

a Air Cavities in Eye-socket of Turtle.

The socket of the turtle contains cavities into which air may be forced and the eye be blown out, while numerous intersecting bands limit the extent of protrusion and keep it from bursting By squeezing out the air the eye may be sunk so far that there is no danger of its being injured by striking against the shell, when the head is drawn rapidly back.

It is difficult to perceive how these objects could be accomplished in any other way than above stated. If the eye were pushed out by the direct application of muscular power, the muscles for the purpose would occupy so much of the socket that there would be no room for those which move the eye in different directions. Although deservedly vaunted as a modern discovery, the principle of the hydrostatic press was understood and practically applied long before the time of Bramah.

"A striking evidence of design in the position of the eyes is this, that they are so placed as to look in the direction in which the legs move and the hands work. It might have happened very differently if left to chance. There were at least three quarters of the compass out of four to have erred in. Any considerable alteration in the position of the eye or the figure of the joints, would have disturbed the line and destroyed the alliance between the sense and the limbs."*

Another evidence of design exists in the direction of the eyes of carnivorous animals and of those on which they feed. The eyes of the former are directed forward that they may observe their prey, while those of the latter are directed backward, that they may escape pursuit.

To protect an organ so essential to existence, it is placed in a socket of bone which defends it on every side, and projects above like a roof, having its edge furnished with the eyebrow, which is so shaped, that it conducts the sweat of the forehead, or the rain that may fall on it away from the eye. The eyelids are lined by a soft moist skin, which when they are moved, passes over the transparent window, and keeps it clean and polished. This skin is turned from the eyelids to cover the white

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* Paley.

of the eye, and thus forms a fold, which prevents motes from getting behind the eyeball, and destroying the organ, by producing inflammation. (Fig. 19, *i.*) The nerve which animates the lachrymal gland is spread out on this skin, and there is such a sympathy between them that the moment a particle of dust irritates the sensible lining, there is a gush of tears to wash it away.

On the inside of the eyelids there are a number of little glands, (Fig. 13, *c*,) which prepare an oily fluid which passes through holes (*d*) at the edge, for the purpose of keeping them from sticking together, and preventing the tears from running on the cheek, just as water does not pass readily over a vessel, the edge of which is smeared with oil. The eyelashes, which are placed in irregular rows on the outer edges of the eyelids, serve as a palisade to exclude dust and unnecessary light. When applied to each other they form an interlacement which keeps the opening secure.

Muscles of Eyelids.—The upper eyelid is opened by a muscle which rises at the bottom of the socket and is fixed into the gristle of the eyelid. It resembles the other muscles of the body in being occasionally palsied, and then the sufferer is unable to open the eye. "With much compassion," says a religious philosopher, "as well as

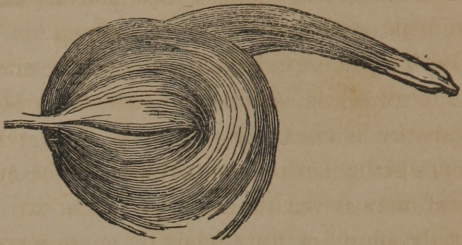


Fig. 6.—MUSCLES OF EYELIDS.

astonishment at the goodness of our loving Creator, have I considered the sad state of a gentleman, who, as to the rest, was in pretty good health, but only wanted the use of these two little muscles that serve to lift up the eyelids, and so had almost lost the use of his sight, being forced, so long as the defect lasted, to lift up his eyelids with his own hands."

The eyelids are shut by a muscle that surrounds them, the fibres of which draw them together without wrinkling, because they are kept firm by the gristle of the eyelid. When we close the eyelids the pupil is turned upward: if we place a finger over one eye, and wink with the other, the eye will be felt to roll on each motion of the lid. In a person who cannot shut the eye in consequence of palsy of the muscle, or the contraction produced by a burn, we can see the transparent window raised beneath the upper eyelid, and its surface wiped clear at the usual time of winking.

The velocity with which the eyelids move at the appearance of danger is, indeed, wonderful. Gunpowder is often exploded in the face, without the eyes being in the least affected. The eyelids present themselves to the danger, and are often seriously injured while attempting to preserve this important organ.

The eyelids of the chameleon are drawn to a small aperture opposite the pupil, and they move with the eyeball, so that its glistening is not exposed. Without eyelids to correspond with its habits of concealment, its colour changing with surrounding objects, and its slow and cautious motion would pass for nothing, if the insects upon which it feeds perceived the brightness of its eye; but like the leaves around it, without even the eye exposed, it approaches its prey with so little appearance of life or motion, that the insect is not aware of the presence of an enemy before it is secured.

Third Eyelid.—The eyes of birds are much exposed during their rapid movements among the branches of trees. To suit their necessities they have a third eyelid, which, when drawn over the eye, is an effectual protection to the organ by its toughness, and owing to its partial transparency vision is not altogether obscured. It is moved by

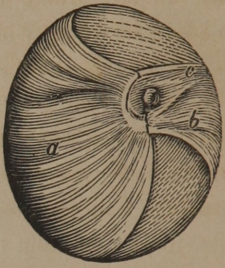


Fig. 7.

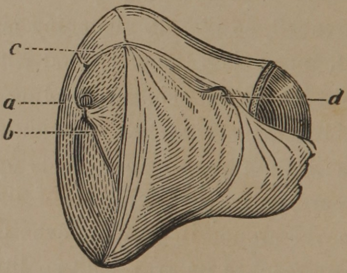


Fig. 8.

Figs. 7 and 8.—MUSCLES OF THIRD EYELID OF OWL.

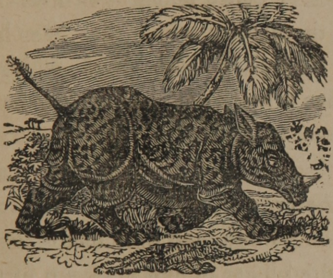
a The Square Muscle through the edge of which the Tendon *c*, of the Pyramidal Muscle *b*, passes and plays over the pulley *d*.

two flat muscles, which having no room elsewhere, are closely applied to the back of the eyeball. One of the edges of the broader muscle resembles a string case, through which passes the tendon or cord of the other muscle, which is fixed to the membrane. In some birds there is a hook at the side of the eye. When the muscles act they pull the cord over this hook, and draw the membrane across the eye, as we would hoist the sail of a ship. No other contrivance in the same space could cover so much surface with the same rapidity.

Fig. 10.—EYE OF RHINOCEROS.

As the eyes of quadrupeds are not defended by a projecting brow like that of man, they have a third eyelid called the *haw*, which in some respects resembles the corresponding membrane in birds. A gland on the internal surface prepares a gummy fluid, which the animal sweeps across the eye to entangle the dust that falls upon it, and to keep the window moist and transparent.

In the rhinoceros this gland is of enormous size when compared with that in other animals. When ploughing the ground with its horn, and throwing earth and dust on its enemies by way of defence; the eye is much exposed and requires unusual protection.



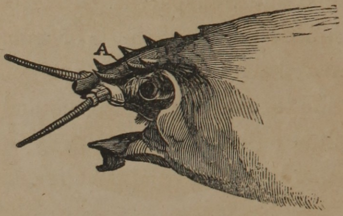


Fig. 12.--EYE OF LOBSTER.

a Brush.

The eyes of fishes being bathed and kept transparent by the fluid in which they live, have no occasion for eyelids, yet the shark, which is obliged to fight, has a scaly covering which he can draw over the eye to protect it when injury is threatened.

The lobster and the crab, which are usually found at the bottom, and thus liable to have their eyes obscured by sand and mud, are furnished with a brush with which they can sweep away the impediments to vision.

The gland for preparing the tears is about the size of an almond, and sunk into a hollow of the bone at the upper part of the socket, to be out of the way of the motions of the eye. The fluid which it prepares passes to the inside of the upper eyelid by seven pipes, so small that they will not admit a hair; it is prevented from running

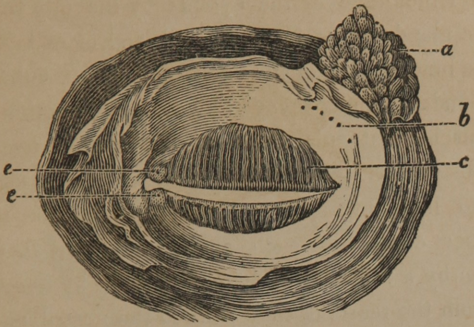


Fig. 13.

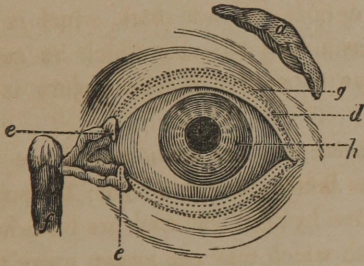


Fig. 14.

Figs. 13. and 14.--APPARATUS FOR THE TEARS.

a The Gland that prepares the Tears: *b* The Passages by which they are poured out on the inside of the Eyelid; *c* The Meibomian Glands, which prepare the fluid for preventing their running over on the cheek; *d* The openings of the Meibomian Glands; *e* The Points which take up the Tears; *f* The Channel through which they pass to the Nose; *g* The Roots of the Eyelashes; *h* The Iris.

over the edge of the eyelids by the oily fluid of the glands formerly mentioned, and is collected at the inner corner of the eye, from which, unless too abundant, it is conveyed away by the action of a muscle that enlarges the size of the tear-bag, and pumps into it the collected tears through two little pipes, the openings of which, at the inner corner of each eyelid, are kept in situation by a red substance, made elastic by fine hairs. From the tear-bag they pass to the nostril, and are evaporated by the current of air which is always passing over it during the process of breathing. "Can any pipe or outlet," says Dr. Paley, "be more mechanical than this is. It is easily perceived that the eye must want moisture, but could the want of the eye generate the gland that produces the tear, or bore the hole by which it is dis charged. A hole through a bone!"

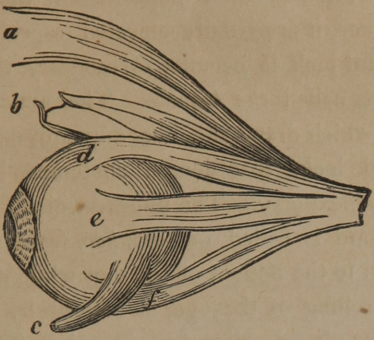


Fig. 16.—MUSCLES OF EYEBALL.

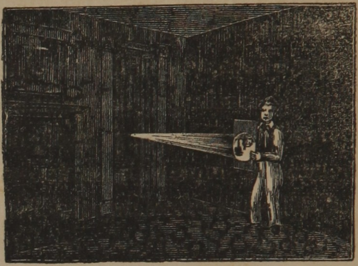
a Muscle which lifts the upper Eyelid; *b* Upper oblique Muscle passing through its pulley; *c* Lower oblique; *d* Upper straight Muscle; *f* Lower straight Muscle; *e* Outer straight Muscle, parallel to the inner straight Muscle on the other side.

The motions of the eye are effected by six muscles, which rise from the bone at the bottom of the socket, and are fixed to the eyeball. Four of these are placed opposite to each other, and are called the *straight muscles,* one of which turns the eye upward and another downward; another turns it toward the nose, and the remaining one toward the temple. These muscles are named according to their actions. "The upward turning of the eye" being expressive of devotion, the upper muscle is sometimes called *the pious,* from producing this effect: it is also called *the proud,* because, with a peculiar disposition of the muscles of the face, it is partially elevated in pride. As a downward look is peculiar to modesty, the lower muscle is called *the humble.* The action of the muscle which draws the eye outward, causes the sideward looks that denote contempt, hence its name — *the angry.* The muscle which draws the eye inward is called *the drinker,* from directing the pupil to the bottom of the cup while drinking.

The rolling of the eye is caused by muscles which are placed obliquely to its axis. The lower oblique commences near the nose, and passes under the eye to the outer part of the case, where it is fixed. The upper oblique rises from the bottom of the socket, and ends in a cord, which passes through a ring, and then turns back to be fixed to the outside of the eyeball. The passing of the tendon through the ring resembles the placing of a rope over a pulley to move an object in the required direction, while an additional contrivance for keeping it moist, makes it move easily like machinery which is oiled. "By its six muscles," observes Dr. Barclay, "the eye, like the needle of the mariner's compass, pointing to the pole, preserves the same relative position with regard to its object, whether the object be in motion or at rest; and hence it is, that instead of the eye moving in its socket we sometimes see the socket moving round the eye, and the eye quite still, performing its functions."

"Each of these muscles is provided with an adversary. They act like two sawyers in a pit, by an opposite pull, and nothing surely can more strongly indicate design and attention to an end than their being thus stationed, and this collocation."*

* Paley.



When a magnifying glass is fitted into a hole in the window-shutter of a dark room, und the light which is admitted is received upon a sheet of white paper held at a certain distance, a beautiful but inverted picture of everything before the glass is formed on the paper. The representation of the scene without is so true to nature, that artists sometimes avail themselves of this method to make a correct landscape. The things essential to this experiment, are: 1. A convex glass, to collect and concentrate the light from surrounding objects. 2. An opaque or semi-opaque substance placed at the focus to intercept the light and make the image visible; and 3. A covering to keep the parts in situation. The eye is just such an instrument, consisting of all these parts, besides others which cannot even be imitated, and it is constructed with such exquisite workmanship, that even the microscope cannot exhibit the minuteness of its structure.

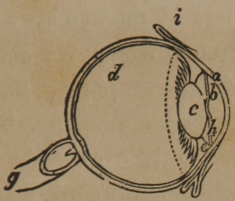


Fig. 19.—SECTION OF THE HUMAN EYE, NATURAL SIZE.

a Cornea or Window; *b* Aqueous Humour; *c* Crystalline Lens or Principal Magnifier; *d* Vitreous Humour; *e* Adjusters; *g* Optic Nerve; *h* Iris; *i* Fold of Conjunctiva.

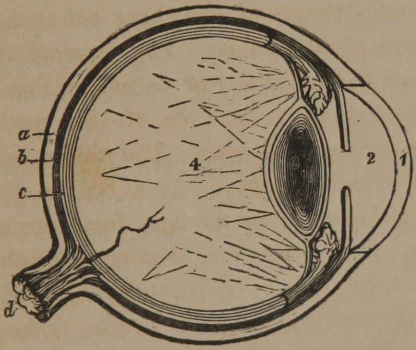


Fig. 20.—PLAN.

1 First Magnifier or Cornea; 2 Aqueous Humour; 3 Principal Magnifier; 4 Vitreous Humour; *a* Outer Case; *b* Second Case; *c* Retina.

The magnifiers of the eye are: 1. the transparent window through which we see the coloured circle surrounding the pupil; 2. a quantity of water which becomes a magnifier by the shape of the skin in which it is contained; 3. the crystalline lens which is the principal magnifier; and 4. another portion of water, intersected by so many skins that it has the appearance of jelly.

1. The first magnifier, which is the window of the eye, is called the cornea, and resembles a small watch-glass, fitted to the outer case or white of the eye, like the glass to the watch-case.

2. The water behind the window is of the purest transparency, and is called the aqueous humour: as it is not intersected by skins, the enlargement or diminution of the pupil is not interrupted.

3. The crystalline lens or principal magnifier, consists of a series of coats placed under each other like the liths of an onion, and these again consist of fibres which are more compactly arranged as they approach the centre. In animals which live in air, this magnifier resembles a common burning-glass, for the most part convex on both sides, but occasionally a plano-convex. In fish it is either round like a pea, (a sphere,) a pea slightly flattened, (an oblate spheroid,) or a pea elongated, (a prolate spheroid.) This magnifier

CASE
- *a* Cornea or Window
- *b* White or Sclerotic

REGULATORS
- *c* Curtain
- *d* Ad: Muscles
- *f* Ad: Leaves

MAGNIFIERS
- *g* Principal Magnifier
- Vitreous Humour

RETINA
Four Layers
- 1 Vascular Membrane
- 2 Fibres
- 3 Globules
- 4 Jacob's Coat

LINING
Four Layers of which the 2 and 3 are only represented.
- 1 Fold of Jacob's Coat
- 2 Mondini's
- 3 Venous
- 4 Vascular

CASE
- Sclerotic

is contained in a transparent case, the edge of which passes in front of the next magnifier, leaving an unattached part between them, called the canal of Petit, for the purpose of allowing it to be moved backward and forward for proper adjustment. With all the light of modern knowledge, no artist can manufacture a magnifier as perfect as that possessed by the meanest animal. Its structure has been imitated by making use of glasses of different degrees of density, with the result, that optical instruments have been much improved, although the imitation is far from perfect. "Could this be in the eye, without purpose, that suggested to the optician the only means of attaining that purpose?"

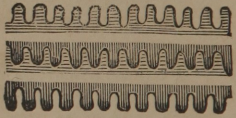


Fig. 22.—FIBRES OF MAGNIFIER.

Some idea of the extreme minuteness of the workmanship may be acquired from the fact, that Sir David Brewster has lately ascertained, that the fibres of the magnifier of the cod are locked together by a kind of teeth resembling those of rack-work. He found the number of teeth in each fibre to be twelve thousand five hundred. As the magnifier contains about five million fibres, the number of these minute teeth will amount to sixty-two billion, five hundred million.

The material of which the principal magnifier is composed, resembles that of the globules of the blood deprived of colouring matter. As more matter is required for the formation of a perfect sphere than for a part of one, we find that the eyes of animals with spherical magnifiers have an apparatus, apparently for the purpose of supplying the additional demand. At the back of the eye, there is a kind of gland or strainer which may be easily separated into two portions: in one, the bloodvessels divide into numerous branches terminating in open mouths, close to the mouths of the vessels of the other. The prepared material given out by one set of vessels is probably taken up by the other and carried on to the magnifier.

Fig. 23.—STRAINER OF HALIBUT.

Like other portions of the body, the principal magnifier is supplied with bloodvessels and nerves. A preparation which I presented to Dr. Knight of Yale College, demonstrated vessels passing from the case to the body of the magnifier, very clearly.

4. About three fourths of the hollow globe of the eye is filled with water contained in transparent cells, which prevent the contents of the eye from running out when wounded. The fluid of of the opened cells only, then escapes, and the form of the eye is preserved. On a principle somewhat similar ships are constructed, divided into various compartments, one of which only, fills when a plank is started, while the buoyancy of the vessel is preserved by the rest. From the intersections of the membranes forming the cells, the fourth magnifier resembles a gelatinous mass, which, from a fancied similarity to melted glass, has been called the vitreous humour. In the structure of these cells, and the sources whence they derive their nourishment, care is taken to avoid the retina, for though they are close to each other, not a single vessel passes from the one to the other throughout the whole extent of the latter, with the exception of a solitary vessel that proceeds from the entrance of the optic nerve, a spot which is blind, and which does not therefore require the precautions requisite for vision. After there is no

risk of interfering with the retina, the membranes forming the cells pass backward in the form of a star.

The magnifiers just described collect the light in such a manner that an image is formed on the inner layer of the retina, which consists of extremely minute blood-vessels branching out like the veins in a leaf, after the soft part has been eaten away by insects. From the network appearance of these vessels, the whole nervous expansion has received the name of the retina. As the light proceeding from a magic lantern or through the mag nifier into a dark room, would not form an image unless there was a sheet of paper or other opaque or semi-opaque substance to intercept it, so the light passing through the magnifiers of the eye must fall on a similar substance before it can form an image. This network, then, may be called the screen on which the image is received.*

An image of the coarser vessels of the network resembling a withered tree exhibited on a screen will soon appear, if when the eye is directed steadily forward, we move a lighted candle up and down on one side of the line of vision. The vessels appear much magnified on account of the proportion of the nervous expansion they cover when compar-

* For the appearance of the vessels, globules, &c., see Fig. 21.

ed with that of an ordinary image. This representation may be owing to pressure on the vessels by a swelling of the nervous fibres, produced by a violent and irregular play of light upon them; or it may be the effect of violent exercise of the coloured circle round the pupil, and consequent accumulation in the neighbouring vessels.

The strings of the expanded nerve are spread over the network, and on these again there is a layer of minute globules retained in their place by a fine skin which is called the coat of Jacob.

The rays of light being collected by the magnifiers, and intercepted by the network or screen, cause a vibration of the nervous fibres on the globules behind them, and these vibrations being communicated along the nerve, which after joining its fellow of the opposite side proceeds to the brain, vision is the consequence.

That both surfaces of the retina are not equally sensible to light may be illustrated by an experiment related by Sir Charles Bell: "Close the eyelids and cover them with a piece of black cloth or paper that has a small hole in it, and place this hole, not opposite to the pupil, but to the white of the eye; direct a beam of light upon the hole: a person will see this light in its true direction." In this experiment the light falls upon two parts of the retina; the same or a greater impulse is given to the fibres first struck, but we see only one circle of light. When the light passes through the retina in the first instance, it forces the fibres against the vascular membrane without producing an impression, but when it strikes upon their concave surface, and impels them against the globules, the light is seen in the true direction.

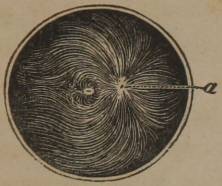


Fig. 24.—FIBRES OF RETINA.

a. Entrance of Optic Nerve.

There is an opening with a yellow margin in the centre of the retina in man, round which the ends of some of the nervous fibres meet. The probable use of this arrangement is to enable him to see very minute objects, for as sensation is most acute at the extremities of nerves, the impression from a minute object received on the ends of the fibres thus collected, will be more powerful than elsewhere, just as a stroke on the end of a wire causes a greater vibration than on the middle. In order to give nourishment to these fibres, as well as to form the meshes of the network above described, a bloodvessel enters with the optic nerve, and in its course it avoids, by passing round it, this yellow spot, which is the most sensible part of the eye. The care which has been taken to keep the trunk at a distance is also extended to the branches, for no coarse vessel is permitted to approach this delicate structure and thus interfere with vision.

Fig. 25.—BLOODVESSELS OF RETINA.

We sometimes see a portion of the network, of the fibres, or of the globules, floating before the eyes when they have been for some time exposed to a very bright light, as after riding, when the ground is covered with snow. The cause of the apparent motion seems to be this: As other nerves become erected so the nervous fibres or strings become erect or tuned like a musical instrument, in order to be placed in a proper condition for distinct vision. Should there be any unusual fulness of the reticulated vessels or any displacement or deficient energy of the strings or of the globules —

the strings will not be free to vibrate by the light, but will convey false impressions, when, during their erection or tension, they come in contact with bloodvessels, nervous fibres, or globules, out of their natural order.

As the image of a grain of a sand, or a still smaller object must be very minute, when represented on the retina, a very slight tension of the strings would make the bodies, to which we refer seem to pass over a great space.

One of the greatest discoveries in modern physiology, is that of Sir Charles Bell, who ascertained that there are two sets of nervous fibres — one for sensation and one for motion. By the one the impressions from external objects are communicated to the brain, while the mandates of the will are conveyed from the brain by the other. Each of the organs of the senses is supplied with different nervous fibres, one set for sensation and another for adjusting the apparatus by means of which the sensation is effected. Magendie, an eminent French physiologist, found that when the adjusting nerve of the eye was cut across, the animal became as blind as when the optic nerve itself was divided.

That objects are inverted on the retina may be easily shown by cutting off the posterior coverings of the eye of one of the lower animals. The demonstration may also be made by an apparatus which I have invented.

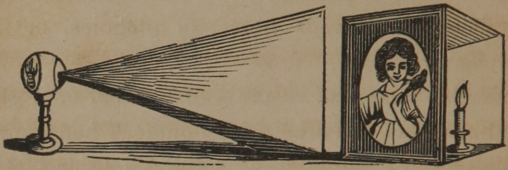


Fig. 26.

a is a square box on the side of which is a transparent painting; *b*, is a pyramidal box to the small end of which is adapted an artificial eye *c*. When a light is placed behind the transparency, and the boxes closely applied, a beautiful inverted representation of the transparency may be seen on the artificial retina, when the room is darkened.

The reason why we see objects erect, although the image is inverted is a subject upon which a great deal has been written. The explanation is simply this — the fibres of the retina when struck on one side of the nervous expansion, convey to the brain an opposite impression.

If I shut my eyes and press the retina of one of them on the outside, the circle of light which is thus produced will appear as if proceeding from the inside. If I press above, the circle will seem below, and if I carry the finger completely round the eye, the light will always be opposite to the finger. If with this disposition of the nerve, the picture were not inverted, everything would appear upside down.

From the inverted picture on the retina, and from the facts that children miss the object at which they grasp, and that a person who had been born blind, after restoration to sight by an operation, could not at first see correctly, it was inferred that everything really appears upside down, but that the error was corrected by the sense of touch. Although it is obvious that the eyes of children are not perfect for a considerable time after birth, and that eyes which have been couched are deprived of the use of the principal magnifier, it is remarkable that the opinion that we do not see correctly unless we learn to do so by experience, is still maintained by most authors on the subject. A chicken, as soon as it is hatched, without any education of the sense of sight, can pick up a seed with unerring certainty, and the sparrow and the bee fly in correct directions at the very first attempt. Although we are convinced by the sense of touch, that an oar may be straight, yet when partially immersed in water, it will seem crooked; and when we look at a long row of trees of equal height, the one which is most distant will appear the shortest, notwithstanding our experience to the contrary. The Divine Architect has formed every sense perfect in itself, and independent of any other.

The extreme minuteness of the inverted picture is far beyond our comprehension. "A whole printed sheet of newspaper," says Dr. Arnott, "may be represented on the retina on less surface than that of a finger-nail, and yet not only shall every word and letter be separately perceivable, but even any imperfection of a single letter; or, more wonderful still, when at night an eye is turned up to the blue vault of heaven, there is portrayed on the little concave of the retina, the boundless concave of the sky, with every object in its just proportions. There a moon in beautiful miniature may be sailing among her white-edged clouds, and surrounded by a thousand twinkling stars, so that to an animalcule, supposed to be within and near the pupil, the retina might appear another starry firmament with all its glory. If the images in the human eye be thus minute, what must they be in the little eye of a canary bird, or of another animal smaller still!"

The optic nerve does not enter the eye at the centre, but at a little toward the inner side. (Fig. 24, *a*, and Fig. 25.) Had it entered at the focus of the lenses, vision would have been indistinct, for it is insensible at the part where it expands to form the retina. In order to be convinced of this, place two wafers on a wall about a foot apart, and with the right eye directed to the one on the left, shut the other. When the observer is near, both objects are seen, but by withdrawing three or four feet, one of them becomes invisible, because the light from it strikes upon the entrance of the nerve, a spot where the fibres are bound together, and where no vibration can be effected; just as the stroke on the end of a bunch of wires would not cause them to vibrate, if it fall in the direction of the wires. By withdrawing further, the light from the wafer falls on another part of the retina, and the object again appears.*

As the nerve where it enters each eye is absolutely blind, we should expect to see two dark spots on every landscape: but as has been observed by Sir David Brewster, "the Divine Artificer has not left his work thus imperfect. Though the base of the optic nerve is insensible to light that falls directly upon it, yet it has been made susceptible of receiving luminous impressions from the parts which surround it, and the consequence of this is, that when the wafer disappears, the spot which it occupied, in place of being black, has always the same colour as the ground upon which the wafer is laid."

* Mariotte.

The vibrations of the strings of the retina continue for about the sixth of a second. When a stick burning at one end is turned rapidly round, the whole of the circle through which it passes becomes luminous. At every change of place, the vibrations caused by the light from the burning wood are renewed before the previous vibration ceases, and the appearance of a continued circle is thus produced. If the impression of light did not remain for some time, the sight would not be steady, for objects would disappear while winking.

The duration of the impressions has been studied in the construction of various toys. The wonder-turner of Dr. Paris consists of a card, on one side of which is painted a part of the objects intended to be represented, and on the other side the remaining part. When the card is turned rapidly round by means of twisted strings, at each side the objects appear together. For example, if a man be painted on one side of the card, and a horse upon the other; or if a bird be painted on one side, and on the other a cage: when the card is turned round the man will appear on horseback, or the bird will seem imprisoned in the cage.

The phantasmascope consists of a circular card, on which are painted figures gradually changing from one attitude to another. The margin is painted of a dark colour, and perforated with numerous apertures. If, when the card is turned round, we look through the apertures before a mirror, the figures will appear in active motion, because the impression from those at one extreme of attitude is gradually lost before the card is turned round to the other extreme. The dark space between the apertures removes the figure for a moment, but the impression remains; another figure is then presented, the attitude of which is so slightly changed that the eye cannot perceive the difference: the figures in the other attitudes are successively removed, a new one being presented before the previous impression ceases. The eye becomes deceived by the mixture of impressions, and the appearance of objects in motion is produced. In this way a smith will seem to strike his anvil, a harlequin to dance, or a horse to run a race.

The anorthoscope is made by fixing to an axis two circular papers—the one dark and opaque, and perforated by four slits; and the other having a transparent distorted figure painted on it. When placed before a candle and revolved in opposite directions, the distorted figures are reduced to correct proportions, and their number is increased according to the perforations. The impressions from the different portions of the distorted objects come so rapidly before the perforation that they are all blended together, and the size of the figure is regulated by the size of the aperture in the opaque paper.

The eyes of those fishes which are furnished with a hydrostatic apparatus for forcing out the eye, are protected by a thick layer of fat or jelly, of all animal substances free from air, the worst conductors of heat. The animal heat is thus preserved, and the retina kept in a proper condition for receiving impressions. (See Figs. 36, 37, 41.)

Immediately behind the window of the eye, and immersed in the water which lies before the principal magnifier, is the circle called the iris, which gives colour to the eye, and which, by becoming larger or smaller, regulates the admission of light. The pupil is merely a hole in the centre of this circle, and it is dark, owing to the lining of the eye.

The retina is unable to bear a sudden or too strong light, for we know that persons have become blind by sudden exposure to the direct rays of the sun. It is said of Dionysius, the tyrant of Syracuse, that he used to bring his prisoners from the dark dungeons in which they were confined, into a white, well lighted room, and that the sudden transition from darkness to light, immediately blinded the unfortunate victims of his cruelty. Northern travellers are obliged to protect their eyes, by wearing spectacles which admit only a very small portion of light through a hole in the centre. To guard the retina, therefore, and to regulate the admission of light, the *iris* is placed as a watchful sentinel. When the light is strong, the diameter of the pupil is contracted, to prevent the admission of too great a quantity, and when feeble, it is expanded, to admit what may be necessary.

This coloured circle round the pupil, or curtain of the eye, is full of blood-vessels, the fluid in which is controlled by a series of muscular fibres, placed at the circumference. By the contraction of these fibres, the blood is collected in the vessels, which thus become lengthened, and the size of the pupil diminished, while it is increased by the relaxation of the fibres, permitting the passage of the blood, and allowing the vessels to become smaller

The eyes of those animals that obtain their food at night, are furnished with a bright reflector, which prevents the total loss of light by absorption, and by reflecting it again, produces sufficient agitation of the fibres of the retina, when the light is feeble. In a strong light, a retina, accompanied by a reflector, would be more violently exercised than without such an accompaniment. Accordingly we find, that to exclude unnecessary light, the iris in nocturnal animals is capable of great contraction. Of the fishes I have examined, the skate is the only one furnished with a reflector: to protect the retina, which is in consequence unusually sensible, there is a curtain at the upper part of the pupil, having the appearance of a hand, the fingers of which may be so expanded, that the light may be altogether excluded or admitted, only through very small chinks.

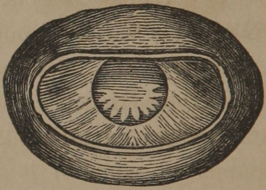


Fig. 25.--EYE OF SKATE.

During sleep the pupil is contracted and turned upward, and the eyelid drawn down; three provisions are thus adopted to exclude the light, and allow the nervous fibres repose.*

The form of the pupil varies in different animals. In some it is circular; in the sheep and the ox, it is oblong and horizontal, that they may

* Bell.

see a large portion of the meadows on which they graze ; while in the cat it is perpendicular, that it may see better up and down.*

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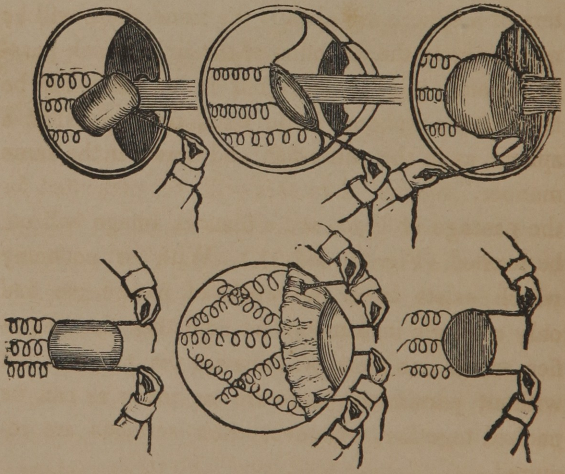
* Porterfield.

THE APPARATUS BY WHICH THE EYE IS ADJUSTED TO DISTANCES IN DIFFERENT ANIMALS.

As the magnifier or screen in the dark chamber, requires to be shifted according to the distance of the object, so a change must be effected in the eye when looking at near or at distant objects, in order that a perfect image may be formed on the retina. In the eye, as there is no provision for moving the screen, the effect is produced by changing the position of the magnifier.

In the shifting of an ordinary magnifier, we must be careful to keep every part of the edge at



Figs. 30, 31, 32, 33, 34, 35.--PLANS.

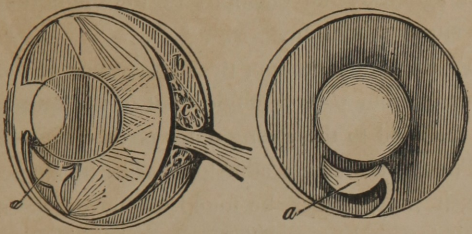
an equal distance from the space it formerly occupied, or it will be turned away from the object; we cannot, therefore, adjust it by traction at a single point, (Fig. 31.) What happens in this respect to a magnifier, which is less than a sphere, will also happen to one which is greater, (Fig. 30,) but with a perfect sphere, it is immaterial whether the traction be made at a single point, or at a number, (Fig. 32.) This may be illustrated by the preceding sketches.

If we attach a thread to one point of a magnifier, which is a perfect sphere, and draw it forward, the latter will be turned on its axis, and as the diameters of a sphere are always the same, there will be no change in the direction of the light which passes through it, (Fig. 32;) but if the magnifier be less than a sphere, as in man, or larger than a sphere, as in the cuttle-fish, and drawn in the same manner, unequal diameters will be presented for the passage of light, and a distinct image will not be formed, (Fig. 30 and 31.) With that economy which exists in all the works of nature, we find only a single instrument for adjusting the magnifier, when one alone will answer the purpose, but without parsimony there are as many as can be packed together, whenever their services are required.

In a large perch found on the American coast,

Figs. 36, 37, 38, 39, 40.—STRIPED BASS.

called the striped bass, there is a triangular muscle attached to the sheath of a nerve which enters at the back of the eye and runs along a division at the the lower part of the retina. One of the angles of the muscle is fixed to the magnifier, and another after passing through a loop at the back of the coloured circle round the pupil, is inserted into the membranes of the vitreous humour. When the muscle contracts, the magnifier is drawn forward and adjusted to near objects, while it is drawn back again or regulated to distant objects, by the elasticity or spring of the membranes of the vitreous humour.



Figs. 41, 42.—EYE OF HALIBUT.

a. Adjuster, *b* Gelatinous Fluid, *c* Choroid Gland or Strainer.

In the halibut, the muscle which is of a different shape, and larger than in striped bass, does not pass through a loop, but lies diagonally across the

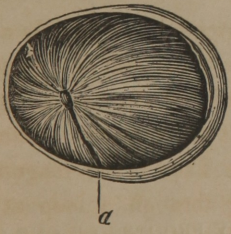


Fig. 43.—RETINA OF HALIBUT

a. Division in the Retina.

eye, having one attachment to the magnifier, and another to the coloured circle round the pupil The magnifier is drawn forward when the muscle acts and when the power is removed, it is drawn back again, by the elasticity of the membranes of the vitreous humour.

To aid the retraction, the membranes of the vitreous humour pass through a slit in the retina, and are fastened to the strong outer coats, (Fig. 43.)

Though the single adjuster varies in shape and size, it may always be found whenever the magnifier is a sphere. When the magnifier is less than a sphere, as in animals which live in air, and some inhabitants of the water as the shark, the porpoise, &c., and whenever it is greater, as in the cuttle-fish, there are numerous adjusters closely arranged round the circumference.

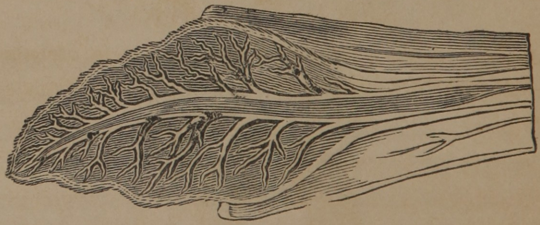


Fig. 44.—CILIARY PROCESS, OR ONE OF THE ADJUSTING LEAVES OF THE OX, MAGNIFIED.

Immediately behind the coloured circle round the pupil, and attached to the extended margin of the case of the magnifier, there are about seventy or eighty vascular membranes, resembling leaves, and called the ciliary processes, which are placed round the magnifier, like the petals of a flower. When the magnifiers are separated from the cases, these leaves adhere so firmly that the separation can only be effected by tearing them asun-

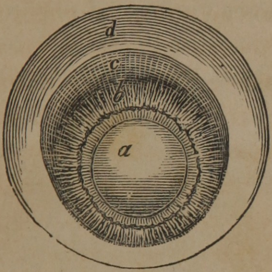


Fig. 45.—EYE OF SHEEP.

a Principal Magnifier, *b* Portion of Adjusting Leaves, *c* Impressions from Upper Adjusting Muscle, *d* Vitreous Humour.

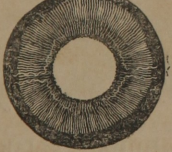


Fig. 46.—FRONT VIEW OF ADJUSTING MUSCLES IN MAN.

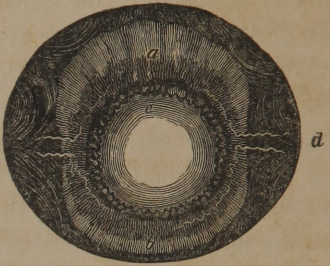


Fig. 47.—FRONT VIEW OF ADJUSTING MUSCLES IN OX.

a Upper, *b* Lower Muscle, *c* Magnifier, *d* Bloodvessels.

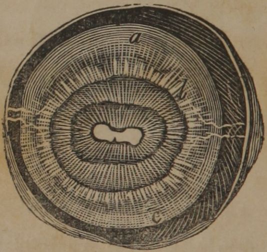


Fig. 48.—BACK VIEW OF ADJUSTING MUSCLES IN SHEEP.

Fig. 49.—HUMAN CILIARY VEINS.

a Natural Size, *b* Iris, *c* Adjusting Leaves, *d*, *e* The Veins returning from them.

der. The portion which remains forms a kind of circle, (Fig. 45, *b.*)

At the roots of the adjusting leaves there are muscles with radiating fibres, which are covered by a white ligamentous substance, and a thin dark skin which lines the eye, and keeps them from being readily observed. The vessels which supply the adjusting leaves, pass at the junction of the muscle — a spot where they are not affected by pressure, (Fig. 47, *d*,) while the returning veins are so situated that the progress of the blood as it passes through them, may be arrested, (Fig. 49, *c*, *d*.)

When the muscles contract, an additional quantity of blood, is collected in the adjusting leaves, which being consequently elongated, draw forward the margin of the case to which they are attached, and of course the magnifier which it envelopes, in this manner adjusting the organ to the vision of near objects, while it is drawn back or adjusted to those which are distant, by the elasticity or spring of the membranes of the vitreous humour which radiate from the magnifier.

The plan of the adjustment of the eye, may be familiarly illustrated in the following manner:—

Cut out of an apple a piece resembling a magnifying-glass, which may represent the principal magnifier the remainder of the apple representing the vitreous humour. Cover this magnifier with cloth to represent the case, and put a ruffle round the edge for its margin. For ciliary processes, fix to the ruffle, by their tops and sides, pieces of cloth or paper, resembling leaves, with their sides pressed together, and folded down at the top, as in the cut. Attach the magnifier to its socket by a few threads of India-rubber, and fix the edge of the ruffle to the vitreous humour at the dotted line. Unfold the leaves, and the ruffle with the lens attached to it will be drawn forward; close them again and it will be drawn back.

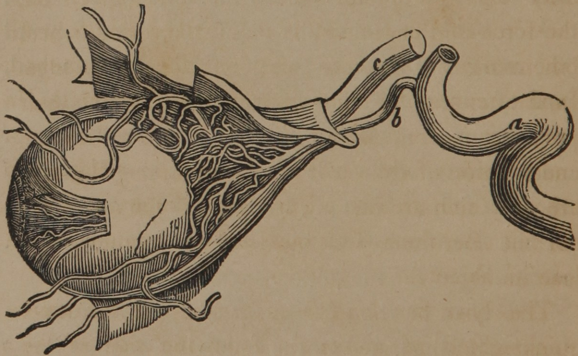


Fig. 51.—BLOOD-VESSELS OF THE EYE.

a Carotid artery: *b* Ophthalmic artery; *c* Optic nerve.

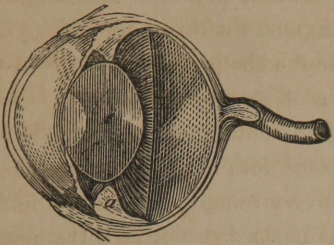


Fig. 52.—EYE OF LYNX.

a Ciliary Processes or Adjusters.

To prevent the adjustment being disturbed by the beats of the heart, there are bendings in the blood-vessel from which the eye is supplied; and after the appropriate stream has been given off, the force of the current is still further diminished, by numerous divisions and additional bendings. In the cat and the dog—animals which watch their prey for a long time—the division, subdivision, and reunion of the vessels before entering the eye, are very remarkable. The beats of the heart are not felt after these divisions, and the eye does not lose its object.

The lynx has long been considered the most quicksighted of animals. From the size of the adjusters, it should possess a great range of vision.

By the eighty processes arranged round its circumference, the crystalline lens is drawn backward and forward, and even a little obliquely, like a magnifying-glass with eighty strings at its edge, pulling it and adjusting it to fit the distance and the direction of the object.

The experiments of Audubon show that the turkey-buzzard does not discover carrion by smell; yet, though very remote, it will find its prey when a carcass is exposed. The observations of others on birds, prove that they see at a great distance. Their adjusting apparatus is of great breadth, and made stiff by plates of bone wedged into each other. A strong fixture is thus afforded the adjusters, when they require unusual exertion, and their effect may be increased by the marsupium.

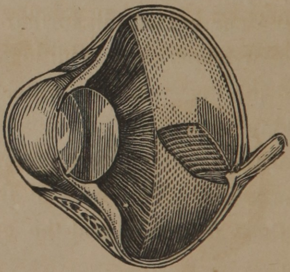


Fig. 53.—EYE OF EAGLE.

a Marsupium.

In birds, a skin called the *marsupium*, which resembles a fan, arises at the back of the eye, where it passes through a division in the retina, and is inserted into the vitreous humour, not far from the foremost or inner edge of the magnifier, out of the way of direct vision. The eyes of birds are directed to each side to afford the wide field of vision which their necessities require; yet when this membrane contracts, it will alter the position of the magnifier, by drawing back the inner edge, and thus enable the bird to look straight forward. From numerous dissections, I believe it to be established, that the marsupium becomes smaller, in proportion as the direction of the eyes become parallel. By drawing back the magnifier, this membrane will assist in accommodating the eyes of birds to distances; but as the direction of the light would be then changed, the organs cannot be regularly adjusted in this manner.

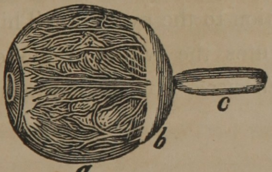


Fig. 54.—LINING.

a Choroid or lining; *b* Sclerotica; c Optic Nerve:

Attached to the adjusting apparatus, and enveloping the semi-transparent retina, there is a vascular membrane called the *choroid*, which prepares the globules of dark paint that line the eye, for the purpose of absorbing unnecessary light, and making a more distinct image. The vessels of which it consists, spread out like the branches of a weeping willow, and in their passage through the strong outer case, or white of the eye, they are kept at a distance from the aperture which admits the optic nerve. If they passed through the same aperture, partial or total blindness would occur at every violent exertion, from the pressure of the blood against the nervous fibres.

The anterior fifth of the outer case, is formed by the cornea or window of the eye, which has been already described; while the remaining four fifths is formed by a strong tough membrane, which, by its firmness, keeps the parts in situation, and receives the attachments of all the muscles that give motion to the eyeball. This strong covering constitutes the white of the eye, which is called the *sclerotica*, from its hardness.

In the eye, we find an instrument made perfect for the purpose, with the utmost economy of material. As tears would be of no use to the inhabitants of the deep, no organs are provided for them; but where they are required, there is a gland for preparing them, and a channel for carrying them away. When the crystalline lens may be adjusted by the pulling of a single string, a single string is all that we find; but when action at only one point would alter the direction of the light, the requisite strings are liberally supplied. According to the danger to which the organ is exposed there are suitable provisions for defence, but in no instance are they found where they are not absolutely required. Wisdom, power, and goodness, are manifest in the whole structure. The bountiful Creator has provided an organ suited to the wants of His creatures, and with consummate knowledge He has varied it according to the demand.

When the most exquisite work of man is examined with a microscope, the artist is ashamed of the coarseness of his production; but no microscope is sufficiently powerful to exhibit the minute structure of the eye of an elephant or a rhinoceros, far less of a wren or an animalcule.

In the eye of man there is marked care. It is protected by a projecting brow, and placed in such a situation that he can see before him, beneath him, around him, and above him. Its expressions add much to social intercourse, and enable him to explain by a look the thoughts of his heart. But it is by the reason with which he is endowed that his organs excel those of every other creature. When all around is dark, he can make artificial light. By the aid of instruments which he has formed, his sight surpasses that of the lynx or the eagle, and when it is dimmed by age, he can restore its distinctness. By the telescope he discovers that there are no bounds to the vastness of the creation, while the microscope exhibits that its minuteness is unlimited.

The more we pry into the works of the Almighty, the more do we witness the design of an intelligent contriver. We see with what exactness one organ alone is made to correspond with the little, we know, of the laws of optics, chemistry, and mechanics. A Creator there must be, who is perfect in every science, and in every art.

What is the composition of this masterpiece of design and fine workmanship? The eye is made of the commonest materials, water, a little charcoal, some air, and a few salts — all ingredients of the dust of the ground.

What is nature? Is it chance? Could chance put a rope over a pulley and place it where required? Could chance make a telescope with glasses to correspond, or fit them into a case in which they could be regulated according to the distance? Above all, could chance make the eye? Could chance prepare its magnifiers, so clear, and transparent, from substances, the solid part of which is almost altogether charcoal? Could chance, from the same brittle, porous material, make the fibres of the case so tough that the fingers cannot pull it asunder, or weave them so closely together as to contain water? Could chance spin the fibres of the nerve so fine, that their minuteness has not been ascertained by the microscope, or spread them out at the proper distance behind the magnifiers? Could chance make the crystalline lens of a fish suited to the element in which it lives, or prepare an apparatus to regulate it? Could chance make the iris a measurer of light? Could chance give the eye so many muscles to direct it, or make the string of the upper oblique to pass through a pulley, and then to go back, and be fixed at the part of the case proper for rolling the eye in the direction which is wanted? Could chance lodge the gland which prepares the tears in a hollow of the bone, to be out of the way of the motions of the eye, or make the little holes which pour out the matter that keeps them from running on the cheek, or prepare the passages which convey them away? The answer must be — No.

Of all the creation, man alone has been permitted to witness the magnitude, the minuteness, and the design which the Creator has been pleased to exhibit. Surely it is not in vain that he has been endowed with knowledge to recognise Him in His works.

MEDICINES AS SUBSTITUTES FOR SPECTACLES.

From the generally received opinion that the eye is adjusted to different distances by the pressure of the external muscles, it is almost universally stated that nearsightedness is owing to unusual convexity, and that more remote vision, as age advances, is occasioned by increasing flatness of the anterior surface.

Though unusual convexity of the anterior surface, is an occasional cause of nearsightedness, it cannot be observed in a majority of instances. As far as my observation extends, the eye is seldom flattened by age, but on the contrary, it is often of unusual convexity, in consequence of the contraction of a portion of the circumference which forms a semi-opaque ring, well known to oculists under the name of *arcus senilis*; yet the persons thus affected are obliged to wear convex spectacles.

The true method by which the eye is adjusted, is clearly proved, not only by the structure of the organ in man, and the lower animals, but also by physiological observation. As the apparatus by which the change is effected, becomes stiff with age, the magnifier cannot be brought sufficiently far forward, to adapt the eye to the vision of near objects, and the person is obliged to remedy the defect by using glasses. Grief, or any other cause that debilitates the body, also affects the sight. There are some, who though obliged to wear glasses at their business, can easily see to read without them, after leaving town for a few days, and enjoyiug the invigorating air of the country. On the other hand, when the strength is renewed by nourishing food, by wine or exhilarating company, the sight becomes improved. Dr. Tully, the distinguished professor of Yale college, has ascertained that when aged persons are under the influence of strychnine, they can read without their spectacles. On the other hand, it has been long known, that there are medicines called stramonium, deadly nightshade, and henbane, the effect of which is to relax the adjusting apparatus, and thus accommodate the eye to the vision of distant objects.

The use of spectacles should be delayed as long as possible, as when once commenced, it is difficult to see clearly without them, and permanent injury to the eyes is often caused by magnifiers of a high power. The use of spectacles might be postponed, by exerting the organs as little as possible, during the evening by candlelight, and to give them immediate repose when they become hot and fatigued.

The eyes may be strengthened by the application of cologne-water, or camphorated spirits, to the brow or temple, three or four times a day, after bathing the eyes with cold water. If no effect is produced by these applications to the brow and temple, they may be changed for a solution of strychnine, in equal quantities of alcohol and vinegar in the proportion of two or three grains to an ounce of the mixed liquid. The medicine may be also taken internally, in very small doses, but it should only be used under the direction of a skilful practitioner, as it is as dangerous in an over-dose, as morphine, iodine, or other powerful remedies, which are perfectly harmless, when the quantity is properly regulated.

When glasses are indispensible, the weakest only should be first selected, as other magnifiers will be afterward required.

Dr. Kitchiner has constructed the following table of the focal lengths of the convex or magnifying-glasses commonly required at various ages.

Years of Age.	Focal Lengths in inches.
40	36
45	30
50	24
55	20
58	18
60	16
65	14
70	12
75	10
80	9
85	8
90	7
100	6

Shortsightedness is far more common among the higher, than among the lower classes of society, and most frequently occurs about the time of puberty—a period when there is often a morbid excitement of all the erectile tissues. As a portion of the adjusting apparatus of the eye belongs to this class, it partakes of the general erethism of the system, and occasions the complaint by drawing the principal magnifier too far forward.

By the imprudent commencement of the use of spectacles, the magnifier is kept in a wrong position, and the efforts of nature to relieve the complaint are prevented. The adjusting apparatus loses its power, just as other portions of the body become weak from want of exercise.

Between the ages of fourteen and eighteen, when the nearsightedness is owing to fulness of the system, every effort should be made to invigorate the health, by exercise in the open air, cold bathing, the shower-bath, agreeable company, proper wholesome food, and if necessary, mild aperient medicine. All stimulating food and drinks should be avoided. Novel-reading is weakening by the confinement it occasions, as well as by undue exertion of the sight, extremely injurious. Shortsightedness is seldom seen in a country-girl, while it is frequently witnessed among the females of a crowded city.

Four or six leeches may be applied to each temple every week, or every two weeks, and the brow and temples bathed with bay rum, night and morning. The adjusting apparatus may be relaxed, by rubbing over the eyebrows, at bed-time, a very small portion of the extracts of belladonna, stramonium, or hyosciamus; retaining it on the forehead by a bandage, and washing it off in the morn ing. Small quantities of the most suitable of these remedies, (hyosciamus,) may also be taken inwardly, but they should never be pushed so far as to cause much dilatation of the pupil.

Like strychnine, these medicines are unsafe in the hands of those unacquainted with the practice of medicine; besides as usually sold, they are often from age, or improper preparation, totally inert.

THE PROXIMATE CAUSE

OF

AFFECTIONS OF THE RETINA.

Read before the New York Medical and Surgical Society, October 21, 1837.

The spots which, witnout external existence, appear before the eycs, are either fixed or floating, and from the descriptions of patients, they assume a great variety of forms. To some, they appear as an insect's wing, a spider with long projecting legs, a network, a branch, or an angular or straight line. By others, they are represented as twisted or undulating hairs, a string of beads, a shower of opaque or transparent globules separate or united; or as tufts of black cotton, or the black particles which are produced from smoke and float in the atmosphere. They are more distinctly observed when the eyes are exposed to intense light, as looking long at white objects well illuminated, at flame, or at a clear sky.

Various opinions have been entertained about the nature of *muscæ volitantes*. Morgagni supposed them to arise from thickened lachrymal humour, formed on the cornea. On account of their motion, Delahire thought they arose from substances floating in the aqueous humour, and to support his opinion, made the following experiment: He received upon white paper, the rays of the sun through a pane of glass, in which there were vesicles and filaments and the imperfections in the glass appeared upon the paper, as the bodies in question upon the retina.*

To ascertain if Delahire's opinion was correct, Demours opened the cornea and evacuated the aqueous humour, as had been proposed by Le Roy, without the least diminution of the appearances. He consequently concluded that the seat of the disease, was the humour of Morgagni, some small portions of which, without loss of transparency, had acquired a greater density and refrangibility.

As it is obvious that the light refracted by the lenses of the eye and received upon the retina cannot be compared to the passage of light through a pane of glass, I modified Delahire's experiment by using a double convex lens which contained a number of *striæ*. I found that the shadows of these *striæ* were visible upon a screen at a certain

* Demours.

distance from the glass, but at situations far beyond its focus. When the screen was moved towards the focus, the inverted picture was not in the least interrupted nor were shadows produced on the picture by placing small bodies before or immediately behind the glass. Hence we may conclude that spots or filaments in the crystalline lens, or anterior, or immediately posterior to it, cannot be represented on the retina.

Most people in ophthalmic practice, have seen small fragments of capsule remaining in the pupil after the operation for cataract, and have found on enquiry that vision was not disturbed by a fixed or flying musca, nor are these symptoms produced by small ulcers on the cornea. A case occurred to Mr. Ware, in which after the removal of a cataract, a white opaque particle, about the size oi the head of a small pin, moved continually upward and downward near the centre of the pupil. Though very perceptible to observers, it was wholly unperceived by the patient, and neither interfered with vision nor occasioned the slightest appearance of a *musca volitans*. I have myself operated for the removal of a fragment of capsule, which floated in the pupil, and though previous to the last operation, the vision was partially cloudy and wavering, still there was no appearance that might be compared to those under consideration.

Guided in his opinion by the principles of optics, Pitcairn thought the disease arose from congestion or varicosity of some of the bloodvessels of the retina.* By Willis it was attributed to insensibility of certain filaments of the optic nerve.

"The fixed musca," says Mr. Travers, "is generally an organic affection, probably a deposite or extravasation between the choroid and retina, compressing to a certain space the papillæ of the retina, to which the musca corresponds in figure. In other instances it is independent of deranged structure and may be presumed to be an insensible spot of the retina."

In his memoir upon the subject, published in the fifth volume of the Medico-Chirurgical Transactions, Mr. Ware states that "it is not easy to ascertain the proximate cause of these moats, but from the constancy in their figure, and their frequently long continuance, it seems probable that they depend upon a steady pressure on one or more minute points of the retina, which are situated near the axis of vision, but not exactly in it. The pressure must be near this axis, because the moats always appear near the objects that are looked at; but it cannot be in the axis, because the moats do not injure or impair their natural appear-

* Demours.

ance. As the pressure is not in the axis, the outlines of the moats is always somewhat obscure, and the exertion that is made to bring the moats into the axis, by moving the eye gives them an apparent motion, which is sometimes upward and downward, and sometimes from side to side. That the tunica retina is liable to be affected by this partial pressure, may be fairly inferred from an examination of the structure of this tunic in connection with the parts that are contiguous to it."

"The concave surface of the choroides, when well injected, has been said by Tina, to have a villous appearance, produced by innumerable short flocculi which are exquisitely minute, and, indeed, they are perceptible to the naked eye. They are covered by a black mucous substance, called the pigmentum nigrum, which is so equally spread over the retina, that when the person is in health, it only serves to render the retina duly susceptible of the impressions made upon it by the light transmitted from external objects. When, however, a morbid sensibility is excited, like that which general debility, or much anxiety, is apt to occasion, the retina (which has a larger quantity of nervous medulla spread over it in proportion to its dimensions, than any other part of the body) becomes morbidly impressed by any little points or projections that happen to be in contact with it. This morbid impression may be occasioned either by the pressure of small portions of lymph, diffused irregularly between the choroid coat and retina; by some minute particle of the pigmentum nigrum larger or more uneven than the rest, or by one or more of the minute *villi* of the choroides itself; and such a pressure, however it be occasioned, is sufficient in my apprehension, to produce the image of an object, similar in every respect, to that of a real object so situated that light proceeding from it would have produced a similar impression upon the retina. The imaginary object is seen in a right line, continued from the point where the impression is made on the retina, through the centre of the eye, conformably to a known law in optics; and the distance at which it is seen from the eye is that at which objects of a similar size are in general most distinctly perceived. The difference between the structure of the retina and choroides, when capable of producing these morbid sensations, and that of these parts when in perfect health, is, however, exquisitely minute; and the morbid impressions made on the retina, are so much out of the line of the axis of the eye, that the imaginary moats they occasion, do not interfere with the sight of external objects, these moats being in general so faint and undefined, that they can only be perceived when the light is strong, and the attention is directed particularly to them."

As it is only by a knowledge of structure that we can acquire a philosophical view of disease, we shall examine the descriptions of the retina, by the authors most frequently perused.

Mr. Ware, in the paper just quoted, says, "the retina in a recent human eye, has the appearance of a plain, uniform, transparent, pulpy membrane, which surrounds the vitreous humour, but is unconnected with it. On a close examination it is discovered to be composed of two substances. One of these is an exquisitely thin membrane, on the inner side of which, in the fœtal subject, many bloodvessels may be traced, and on the outer a medulla is spread, which lies in contact with the inner concave surface of the *tunica choroides*."

Sir Charles Bell, in his Bridgewater Treatise, which is his latest publication, says, that "there is no fibrous texture in the matter of the nerve," (meaning the retina,) and again when combating Herschel's hypothesis of vision, "It appears to me natural to suppose that, if these fibres of the nerve (*which, be it remembered, are also imaginary*) were moved like the cords of a musical instrument, they would be most easily continued in motion by undulations in the same time," &c.

The most modern work on the structure of the eye, which I have seen, is that of Dalrymple, published in 1834. His account of the retina is as follows :—

" Several of the older anatomists, among whom we find the names of Ruysch and Briggs, assert that the retina is composed of minute fibres, evidently derived from the fibrous appearance of the optic nerve, and thence radiating in the form of a star. Haller denies this, and attributes the appearance in question, to certain plicæ or folds, into which the retina probably falls, by the evaporation or dispersion of the fluid of the vitreous body after death. *It has assuredly never happened to me to observe any fibres, or any appearance that could be mistaken for fibres in a recent human eye.*"

Let us now appeal to nature for the correctness of these assertions.

When the inner surface of the choroid is examined with a microscope, in place of the *villi* of Tina and Ware, we find the membrane of Mondini, upon which is deposited the globules of the *pigmentum nigrum*.

When the convex surface of the retina is exposed under water, and scratched with a scalpel, a membrane of great delicacy may be separated and turned over in folds, with the assistance of a camel's-hair pencil. This is the coat of Jacob.

When the same preparation is allowed to putrefy, and the nervous matter washed away with a camel's-hair pencil, the vascular membrane may be exhibited. The ramifications of the blood-vessels on this membrane, resemble that of the veins in a leaf, after the soft part has been eaten away by insects, and by their intertexture, they form a semi-opaque screen, on which is received the image of external objects, just as the ground of a camera-obscura, or the screen of a magic-lantern.

The nervous matter may be divided into two layers. By allowing an eye to macerate in alcohol, for the purpose of preventing the retina from collapsing, when the anterior half of the eye is cut off, and pouring upon the retina thus exposed, a watery solution of corrosive sublimate, the fibres may be seen lying beneath the vascular membrane, when they are separated by a camel's-hair pencil. In young animals, the fibres are more easily exhibited than in those that are old, and in the human eye they converge round the central foramen. By pouring upon an eye, exposed in the same manner, an alcoholic solution of corrosive sublimate and muriate of ammonia, the fibrous coat becomes so compact and hard, that it may be easily torn off with forceps, and a layer of globules will be brought into view. These globules are kept in place by the coat of Jacob, which is reflected over the choroid, as may be easily seen by opening an eye under alcohol.

The retina then consists of four layers, a vascular, a fibrous, a globular, and a serous.

By this exposition of the retina, we may account for the various appearances of *muscæ volitantes*. I have occasionally, when entering an ordinarily lighted room, after a full meal, and exposure to a bright light, witnessed glimmerings like a network, which from its resemblance to the vascular coat, left no doubt in my mind, that the blood-vessels of the retina were visible: at other times in the same circumstances, there was a twisted tube, or a chain of beads, as if there had been an error loci of one of the curved fibres of the retina; or there was a cloud of globules sometimes packed together, but more frequently separated, and floating in all directions. Each globule was visible for a considerable time, and repeatedly reoccupied the same space. When clustered together, they had a great resemblance to the globules of the retina.

From the similarity of the drawing of the floating network, in Case No. 1, to the vascular coat of the retina, I am persuaded that any person who has seen both, will have no hesitation in locating the disease; and if the net-work, curved filaments, and globules, appear to others as they do to me, the various *muscæ* will be ascribed to affections of the structure which they resemble.

Beer observed in some cases, that the vessels of the vascular membrane had become varicose. Dr. Wardrop, in his "Morbid Anatomy of the Eye," states that "it was observed by Sauvages, that the pulsations of the optic artery might be perceived, by looking intently at a white wall, well illuminated. A kind of network, darker than the other parts of the wall, appears and vanishes at every pulsation. This change of color in the wall, he ascribed to the compression of the retina, by the diastole of the artery. Richter mentions the case of a plethoric person, who, when he held his breath, and looked at a white wall, perceived a kind of network, which alternately appeared and disappeared with the diastole and systole of the arteries. Mr. George Young, saw a cadet at Woolwich, who, from being obliged to wear a very tight neckcloth and collar, had his sight very much impaired; the pupils were dilated, and he had the appearance of flies floating constantly before his eyes; and Richter relates the case of a man, who became suddenly blind, by carrying a heavy load up stairs."

If when the eye is directed forward at a distance, we move a lighted candle up and down on one side of the line of vision, a representation of the vessels of the vascular membrane shortly appears, as if displayed upon a screen. The vessels are greatly magnified, on account of the portion of the retina which they occupy, compared with that of an ordinary image. We may hence infer, that a very minute congestion, may cause a large musca.

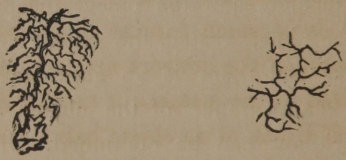
It is stated by Demours, that the diameter of muscæ appears to increase in proportion as we recede from the plain in which they are examined. Such a filament as appears one sixth of a line in diameter, and one inch long, when seen on a leaf of very white paper, at the usual focal distance, appears two lines in diameter, and more than a foot long, when we examine it by looking at a white wall, at the distance of twenty or thirty feet, and in the only case in which he mentions the subject, Mr. Ware says, that the magnitude of the moats, depended much on the distance at which they were observed, being larger when seen far off, and smaller when near the eyes. Can the diminution arise from the less degree of pressure as the lens approaches the cornea, when adjusted to near objects ?

As the papillæ of other nerves, become erected when excited, it would seem that the fifth, which is a compound nerve, enables the expanded fibres of the optic nerve, to be placed in a proper condition for conveying a distinct impression to the sensorium. Should there be any unusual turgescence of the vascular membrane, or any *error loci*, of the globules, or of the sentient fibres, or diminished supply of motive power to the latter, or should there be effusion of lymph or varicosity of the choroid, the fibres will not be free to the action of light, but will convey false impressions, and there will be an appearance of motion, when during their erection or tension, the fibres come in con tact with diseased vessels, filaments, or globules.

It is difficult to keep the eye on one object for a long time, but when it is accomplished, the retina soon becomes fatigued, the fibres lose their tone or tension, and the object disappears. As soon as they have rested, the object comes again into view, and there is an alternate disappearance and reappearance of the object, as long as the experiment can be continued. If when the light is very obscure, we look intently at a feebly illuminated object, the fibres, in endeavouring to adapt themselves to the degree of light, soon become painfully affected, and the object is no longer visible.

The connection between the second and the fifth pair of nerves, may explain why there is a halo round luminous objects during *catarrhal ophthalmia*, when the distended vessels press upon the filaments of the latter, which are so abundantly spread upon the conjunctive ; and why in *strumous ophthalmia*, there is such intolerance of light, when the nerves are irritated by exposure in consequence of ulceration of the anterior membrane.

Case 1.—A highly intelligent gentleman from Newark, N. J., consulted me some time ago, about a network which appeared before his eyes, and impeded vision. While describing his complaint he drew a representation of part of the vascular coat of the retina, as perfectly as if he had a preparation of the membrane before him for a copy. I took an unusual interest in the case from the drawing, and obtained the following account of it.



The appearances before my eyes are drawn as correctly as I am able ; they do not appear stationary, for when I suddenly throw my eyes up, they will also go up, and appear to rise above the object upon which I fix my sight ; they then move slowly downward and sink below the sight, sometimes a little on one side and at other times exactly in the way, so as to cover a letter or figure at which I may happen to look, I can still see the object, though imperfectly, as if through thin gauze or something of the kind, which dims the sight a little. When they get on one side of the sight, and I attempt to turn my eyes to get a more complete view of them, turning my eyes appears to turn them also, and they keep at about the same distance. When my eyes are open they do not appear so large, nor so plainly as they do when I partly close my eyes. When I fix my sight upon an object and look at it for a moment or two without moving my eyes, they will disappear, but the least motion of the eyes will bring them back again as plainly as ever. I have two or three different times, noticed a kind of motion as if caused by hundreds of small insects in strong daylight. The distance of the network appearances seems to be regulated by the distance of the objects at which I look. If I look at an object half a mile off they seem considerably farther from me, than they do when I look at an object which is only two or three feet distant. The appearances are worse after a hearty dinner, or loss of sleep, and they trouble me least when I feel otherwise well.

As there appeared considerably bilious derangement, I prescribed an emetic and alterative doses of calomel. I also recommended regular cupping every two weeks, cold applications to the brow and temple, a loose neckcloth, and to avoid whatever might occasion straining. He is now much im proved, though the network is occasionally visible

Case 2.—The studies of a young gentleman at Princeton College, were interrupted by a network which was without motion, and which was always present and impeded vision. The regular application of leeches was recommended but they were not applied. Cold applications and aperients had no effect. Mercury and Iodine were tried without benefit. The loss of blood was again urged, and the patient was immediately relieved after the application of cupping-glasses to the temple. By weekly repetition of the cupping he soon became quite well.

Case 3.—A theological student from Schenectady, consulted me about hundreds of moving globular specks which without any other morbid symptom, were constantly floating before his eyes, and caused much inconvenience and anxiety. He was not at all improved, after having made use of various remedies.

Case 4.—A gentleman was for upward of a year, annoyed by a floating musca similar to a portion of the soot produced by burning turpentine, and which flies in the air. After having had occasion to undergo a course of mercury for another com plaint he was entirely cured.

NEW THEORY OF VISION.

From the experiments of Morichini, of Rome, and Mrs. Somerville, of London, we learn that violet and green light possess the property of rendering steel magnetic, while no effect is produced by yellow or red. If we consider the former colors positive and the latter negative, and if, as Sir John Herschel supposes, there are a number of minute fibres placed at right angles to the coarser fibres of the retina, as the pile of velvet rises from the coarser texture of the woven silk—an opinion which he expressed not long ago in a letter to me—we may easily conceive that the impressions on the retina may be conveyed through the bundles of the optic nerve to the sensorium, on the principle of the electro-magnetic telegraph.

This theory derives plausibility from the fact, that the spectrum, which remains after looking at a bright object, is always of an opposite color; and from some ingenious experiments made by Mr. Newberry, a scientific teacher of drawing, in this city. When light is admitted through blue glass and received upon a sheet of white paper, the shadow of the object held before the paper is yellow. When it is admitted through yellow glass the shadow is blue; when the glass is red the shadow is green; and when green the shadow is red. The shadows of a landscape have a purple hue during a summer's sunset when the sky is yellow.

The brain itself is an electro-magnetic instrument, consisting of a brown and a white plate convoluted in such a manner that with a great extent of surface they are packed in a very narrow compass. From the white plate proceed numerous conductors twisted round the base, not at all dissimilar to the arrangement of Henry's magnets. See Tiedemann's and Spurzheim's plates.

As motion can be effected by transmitting galvanic currents along the nerves which proceed from the brain, there is reason to believe that sensation is produced by similar currents passing to the brain, and that these currents are always changing with the nature of the impression. If the minute fibres of the retina are made positive by blue light, a positive effect will be immediately made at their termination in the brain. If yellow light be then presented, the fibres being negatively affected will assume a different position and thus alter their terminations. All the other colors may produce similar effects, and may be conveyed by their own peculiar fibre contained in the bundles of which the nerve is composed.