Of the special senses of fishes, in relation to the art of angling. No. 1. Vision : a paper read before The Gresham Angling Society / by John Brunton ; J. Theodore Cash in the chair.

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No. 1.—VISION.

(6)

A PAPER

READ BEFORE

The Gresham Angling Society,

BY

JOHN BRUNTON, M.A., M.D.

J. THEODORE CASH, ESQ., M.D., IN THE CHAIR.

"THE EYE SEES WHAT IT BRINGS ITS POWER TO SEE."—*Carlyle.*

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Mr. Chairman and Gentlemen,

In introducing this subject to you, it seemed to me desirable to select a paragraph from some writer which would serve the purpose of a text.

I chanced to find one which I think is suitable in the writings of a "Father" who was cotemporaneous with our dear old Father Walton. Both are revered, respected, remembered and honoured, and though it may be out of place here to say it, I think it will be admitted that, as contemplative men, their writings are, have been, and I trust always will be, a great moral power for good.

At the very time when dear old Walton was enjoying

"his walks abroad" and, rod in hand, either rambling by the lovely meadows of the then silvery Lea or meditating by the rocky valley of the winding Dove, forgot not his innate pleasure of angling, nor thought "his idle time idly spent," because he found

> "Tongues in trees, books in the running brooks,
> Sermons in stones, and good in everything."

While thus "providing his store" of observations, facts, and fancies, which make his "Compleat Angler" so very interesting, amusing, and good,—John Bunyan, the author of my text, was cooped up in prison meditating also. Although deprived of the associations of those external worldly beauties which enliven man's mind and cheer his soul, his thoughts came from his inner consciousness fully charged with its memories of the past. Though not writing for the recreation so much as the good of his fellow creatures, his books have been the pleasure and pastime, as well as for the advantage, of many a youth.

In his "Holy War," which was published about the time Charles Cotton produced his treatise on "Fly Fishing," you will find the following passage, which I have chosen as my text:—

> "The famous town of *Mansoul* had *five gates* in at which to come and out at which to go, and these were made likewise answerable to the walls—to wit, impregnable, and such as could never be opened or forced but by the will of those within. The names of the gates were these: Eye-gate, Ear-gate, Mouth-gate, Nose-gate, and Feel-gate."

To deal with these five gateways to knowledge in the special manner as relating to fish and the angler's art is a much more formidable undertaking than I at first contemplated, and as I desire to do the matter justice, and in such a way as is consonant with one's duty to a learned society like our own, I find that I can only take up one gateway at the present time, and that one for this evening is *Eye-gate*. In discussing this subject, Eye-gate, it is obviously necessary to consider (1) the eye-gate of the fisher, and (2) the eye-gate of the fish, for relatively fisher and fish become subject and object.

After the able manner in which Mr. Bentley* dealt with the general feeling in fishes, and the descriptions he gave, with illustrations of the brains and larger nerves, it is quite unnecessary for me to open up this subject again. I may, however, say that "it seems probable that all animals which possess a definite nervous system have a greater or less degree of consciousness of the impressions made upon it, whether by external objects or by changes taking place in their own organism, and to this consciousness we give the name of sensibility." Fish have a definite nervous system, and pointedly come under the category of sensible animals.

In the brain of fishes the optic lobe is very large

* See paper by Mr. B. on "Sense of Pain in Fishes."

in proportion to the other parts. Such development evidently points to a definite intention—a means to an end—and intimates to us that of all the senses that of *vision* is of most importance to the fish.

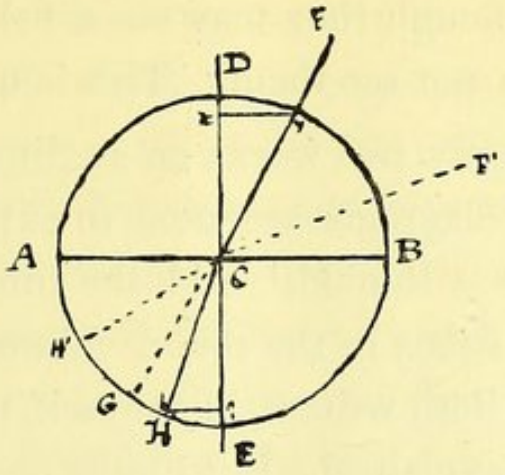
Vision, the most important and delicate of the special senses, involves not only impressions conveyed by the optic nerve to the brain, but the action of accessory parts, the structure of which is exceedingly complex.

For my purpose it will be quite sufficient to give you as simple descriptions as possible; there is no need to weary you with details which belong rather to the province of anatomy and physiology as applied to medical science.

Before proceeding further, I think it will much facilitate to make a few brief remarks regarding the properties of light, and their application to the theory of vision.

Light is the physical agent by which the external world is rendered manifest to the sense of sight. When light travels through the same medium, it travels in straight lines; when it passes into a denser medium, such as from air into water, the ray of light on entrance is refracted or broken back. For the sake of illustration I have drawn this diagram.

Water always finds its own level, so the line A B represents the surface of water which is here represented as *perfectly still*. Let us draw a perpendicular,

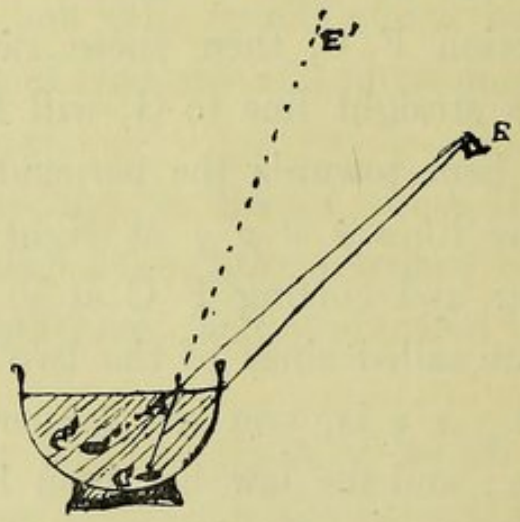


D E, through A B, cutting A B at C, and from centre C describe a circle, A B D E. Now, if we suppose a pencil of light—a bundle of rays—to pass in the direction F C, then these rays, instead of passing in a straight line to G, will be refracted at C to H, *i.e.*, bent towards the perpendicular ; and if we draw the lines *x y p q* at right angles to the perpendicular, and cutting F C at *y*, and C H at *q*, these lines are called sines of the two angles, F C D and H C E. *x y* is, you see, longer than *p q* by four to three ; and the law has been laid down that the sine of the angle of incidence bears to the sine of the angle of refraction a constant ratio for each refracting medium. So that if the ray is bent towards the perpendicular on passing from air into water, the reverse takes place when the ray passes from water into air. Still the sine is in the same ratio.

This power of refraction has induced many to

believe that though they may see a fish in the water the fish does not see them. This is quite a mistake.

There are only two works on angling that I know of in which diagrams are used to explain the vision of fish. One is Ronalds', and the other a paper on the vision of fishes in the recent volume of "Anglers' Evenings." Both writers, like myself, make use of the diagram just explained. But I must now call attention to this one representing the experiment of the *invisible* coin, made visible by the refractive power of water. A line C E, drawn from the coin lying at the bottom



of the basin when there is no water in it to the angler's eye at E, must necessarily pass through the edge of the basin; but that being non-transparent the ray from the coin is intercepted and does not reach the eye—the coin is out of sight. By pouring water into the basin, another ray, C A E^1, is refracted at A—it is bent in the direction of the eye, A E. Now, whenever a luminous pencil passes in a straight line from a body

to our eye, we see that body exactly as it is; but if in consequence of refraction, the pencil of light is deviated in its route—if it ceases to come to us in a straight line—we no longer see the body in its proper place, but in the direction of the luminous pencil (as C^1 E) at the moment it enters the eye. Now, here we have the pencil C A E^1, bent at the surface and travelling in the direction of the eye and entering it; thus the eye reads the coin to be at C^1 and in the direction C^1 E.

In other words there is nothing changed in the position of eye or coin; but rays from the coin have changed direction—those intercepted by the side of the vessel are still so intercepted, and the rays which before the entrance of water passed above the observer's head, are directed towards the eye, being refracted in passing from the water into air, and thus the coin appearing in the line of vision, is seen at C^1. Refraction produces various curious phenomena, the effect of which is to deceive the eye by making us see objects in other than their true position. We do not see fish in the place they actually occupy, but nearer the surface by about a fourth, and they appear considerably smaller; and it follows conversely, when a fish sees the angler he appears further off than he really is. You must therefore understand, that whatever may be the power of refraction, both spectator and object bear to one another the same relation. Were it not for the

water, the coin—or, if it were a fish—would not be visible, and conversely the angler's eye would not be beheld by the fish ; so if the angler under ordinary circumstances can see the fish, the fish can see him.

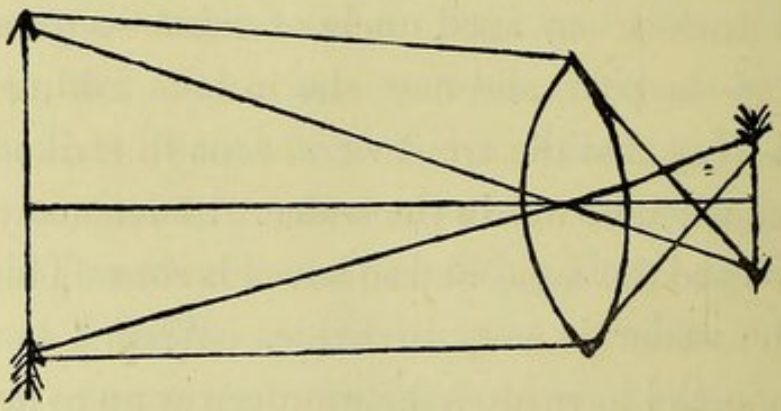
Following the principles of the refraction of light, Mr. Ronalds has given an illustration in his "Fly-fisher's Entomology" of a fisherman on the bank and another wading, and what both angler and the fish see, or are supposed to see. These illustrations are, to my mind, somewhat exaggerated. That of the angler on the bank just proves that if he can see a fish the fish can see him. The fish to the angler's eye appears much shallower, and the angler to the fish's view is high up in the air. Of course a portion of the bank ought to have been carried up also, and then the fish would see the angler in a rational position on *terra firma*, and not like a kite aloft in mid air. In short, the fish sees the bank as it always has been accustomed, and the angler or other human being that may chance to be there is but an accident of the locality. There can be no separation 'twixt angler and the bank.

The second illustration, representing the angler as wading, is of greater purport. It is necessary for me to explain that there is a limit to the passage of light rays from a denser to a thinner medium. This can be explained by trigonometrical principles, which it does not become me to introduce any further than I can help.

This limit is explained by the fact that rays of light passing from water to air at a greater angle than 48.28° are totally reflected, and if the water's surface be perfectly still the bottom of the pool is reflected on the under surface, so as to make *this under surface* as difficult to see through as the silent pool's *upper* surface is to the angler when trees, bank, hill, or dappled cloud are there to him mirrored. This under surface, with its picture of the bottom painted upon it, becomes a screen to hide the angler's body as he wades, but his legs are visible to the fish by direct rays through the water. Possibly the fish may take these legs, encased in wading stockings, as tree stumps, or something whose nature does not produce terror. I used to hear an aged uncle of mine—a great trout fisher of the past, and one who in lake fishing always waded—say that the trout were wont to strike him on the legs when he was in the water. I have many a time experienced the same, and so have his sons. This shows that the wader is very invisible. When I have been wading—as I have often done as deep as up to my watch pocket—fish have risen within a yard of me. Is it that the divided body of Ronalds is no longer a scare? If so, that may be a reason why the angler on his knees—to a certain extent well out of sight—becomes a kind of half body, and is less an object of terror than the man of perfect stature. It is obvious that a little man has a marked advantage over a tall one.

This is explained by the fact that obliquity of entrance into a denser medium has a marked influence upon the visibility of rays. The greater the obliquity —the greater the refraction—the less capable are the rays of discernment; for the distinctness with which the object is seen decreases in an inverse ratio. Thus the angler who stands on a low bank or wades even to a little depth is less likely to be visible than he who is higher up.

There are different refractive powers for different media. While air into water is as 4 to 3, air into glass is 3 to 2. Every one of you knows how advantage has been taken of this power of refraction to construct lenses. Without these we would possess but few



optical instruments. The human eye is one of the most perfect of these instruments, and the commonest and most popular optical apparatus of the present day, and which most nearly resembles the arrangements of the human eye, is the photographer's camera, an instrument with which everyone is familiar.

You have the lenses for concentrating, the screw

adjustment for focussing, the various stops for regulating the admission of rays, and the ground glass screen—or more correctly the sensitized plate on which is registered the optical image, as on the retina of the eye.

In the human eye, as seen by diagram, we have

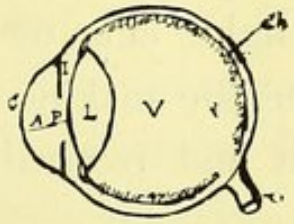


Diagram of Human Eye

beautiful examples of refractions, and their adaptation to the purposes desired and intended.

In front there is C the cornea and A aqueous cavity, then the iris I, behind it the lens L, and last V the vitreous or glassy humour. Through these we have successive refractions wonderfully adapted for producing at the base of the eye a perfect image of the thing looked upon.

At the base there is a R thin transparent network of nerve, spread out like a net to catch the image, and immediately behind this is a layer of dark pigment, Ch., called choroid, which absorbs the rays when they are no longer useful to the retina.

The part which gives beauty and expression to the eye is the iris, or curtain, in whose centre is the pupil, P. In warm-blooded animals this iris is muscular and

contractile, dilating when the light is weak, and contracting in proportion to the stimulus of its rays. The eye of a cat is a good example; witness in daylight how the pupil is but a slit, but when evening comes with its diminished light the eye appears as if it were all pupil. The pupil is to the eye what the stop is to the photographer's camera—it modifies the admission of light, cuts off the excessive and divergent rays, thereby making the image on the retina more perfect and receivable without pain or discomfort.

Now what are the conditions required for perfect vision ?

1st. A perfectly adjusted and sound eye.

2nd. A condition of light or illumination of the object which will put no strain upon the eye. Everyone from his experience knows what strain there is upon the organ in excessive as well as in defective light.

"Within our eyes at every instant a picture of the outer world is painted by the pencil of the sun upon the white curtain at the back of the eye, and when it has impressed it for a moment the black curtain absorbs and blots out the picture, and the sun paints a new one, which, in its turn, is blotted out, and so the process goes on all day long." While the eye of man observes the external world with all its beauties of nature and art, it is difficult to say what fish see, if

they do admire anything in the depths, except their mates, neighbours, enemies, and food. A writer has thus put it: "To his eyes the sea is thronged with inhabitants, and look where he will he is always moving in a crowd. Whether he rises or sinks, he finds the waters populous with multitudes of diverse creatures, and every one of them is interesting to him, for those he cannot eat, eat him."

By far the most interesting part of this optical arrangement is that for adjusting the eye to see near or far-away objects as well as objects at any intermediate distance. This is accomplished by the action of a muscle attached to the capsule of the lens, which, by its contraction or relaxation as the case may be, enables the anterior surface of the lens to become flatter or rounder according to circumstances, and so alter the focus for near, medium, or distant vision; this action is also aided by the iris or stop. The accommodation, as it is called, is known to everyone who uses an opera glass; but though there is a similarity in effect the action is quite different. In the human eye the *curvature* of the lens is changed, in the opera glass or camera —by means of the rack screw the *position* of the lens is altered—and both in the eye and opera glass, at and by the *will* of the possessor, for the same end, viz., accurate vision.

Let us examine now the eye of a fish—I have taken the eyes of the cod *(Gadus Morrhua)* for dissection

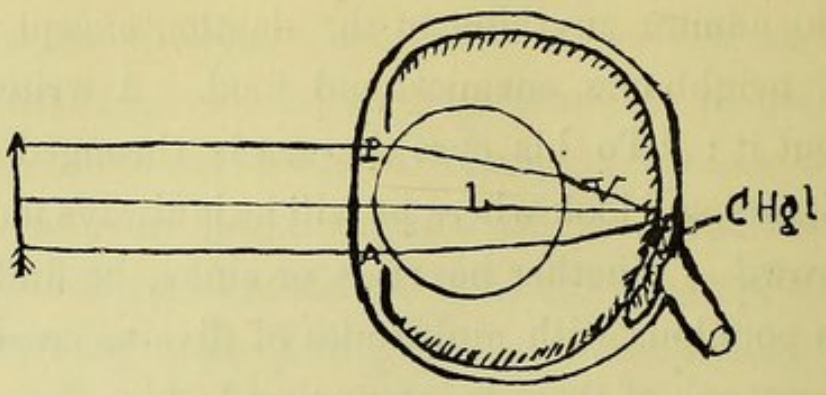


Diagram of Cods Eye

and illustration, because they are large and easily procurable. You will observe that the outline of a vertical section through the middle is markedly different from that of the human eye. The human eye is very nearly spherical—the fish eye something like *two-thirds sphere*, very much flattened anteriorly ; posteriorly slightly. "Fishes in general, compared with other vertebrata, have large eyes. Sometimes these organs are enormously enlarged, their great size indicating that the fish is either nocturnal or lives at a depth to which only a part of the sun's rays penetrate."

The general skin in all fishes passes over the eye, but it is transparent at the orbit. There are neither eyelids nor tear-glands. There are many peculiarities in form, position, and size. I must refer you to works on ichthyology for the study of these curiosities. The eye of the cod will serve my purpose at present.

The eyes of fish, such as we usually angle for in fresh water and the sea are situated on the side and

anterior half of the head, and the outer covering is very much harder than that of man—mostly cartilaginous, and in some cases bony. Stewart and Stoddart, however, say that fish have their eyes with a set backward, which enables them to see behind to a moderate degree.

The anterior chamber and cornea are flattened—this is a provision of nature to protect it from injury and friction, for there are no eyelids ; there is very little aqueous fluid, just sufficient to float the free border of the iris.

The iris is merely a continuation of the choroid ; it is non-muscular, and as a rule incapable of contraction or expansion. The pupil, or stop-hole, is usually round ; sometimes it is diamond-shaped, pear-shaped, horizontally or vertically elliptical.

The lens is nearly spherical, and in this way makes compensation in refractive power for the diminished quantity of fluid in the anterior chamber. It is denser in the middle, is firm, and lies in the hollow of the vitreous humour.

The vitreous fills the posterior cavity of the eyeball, and is of greater consistency than in man ; and behind is the retina and choroid, with its dark pigment and vascular layer. The optic nerve emerges much as it does in man, and the muscles attached to the fish's eyeball are the same in number and similar in arrangement for its movement. There is this

difference, however, that they do not seem to act so quickly and with the same kind of expression which is an attribute of the human eye. Did anyone ever see a fish squint? Of course they cannot wink, for they have no eyelids, nor can they shed a tear.

You will notice this important fact, that to all appearance there is no arrangement of accommodation. I said to all appearance, but, were there not, fish would only be able to discern objects at very near distances. Now, how does this accommodation obtain? You observe (*vide* diagram) that I have drawn the outline of *a body*, C H *g l*, situate behind the choroid and round the root of the optic nerve. This is called the choroid *gland* or muscle. It is supposed that the fish at will can fill this gland with blood, and by its distension push *forward* the retina and choroid to a limited extent, and thus focus the eye.

There is a very interesting anatomical fact in connection with this vascular gland. In Teleosteans (Pseudobranchiœ)—such as we fish for—there are remains of an anterior gill which had respiratory functions during embryonic life. A change in the circulation has caused these gills to lose their function in adult fish, but the vessels remain, and carry highly oxygenated blood to the head and eye,—in Teleosteans to the eye only. Professor Jacob, however, considers this extra blood supply to the choroid gland to be only for nourishing the fundus of the eye. It is

also supposed that the fish can pull back the ball by the action of the muscles, and as the posterior portion of its wall is thin and flexible, alteration in shape is effected, and so the retina is pushed forward and the focus shortened—just as some photographers do. With a fixed camera they focus by moving the ground glass screen nearer or farther away, according to circumstances. This power in the fish's eye is a matter of supposition ; there is an amount of reasonableness in it nevertheless ; but I think, from the optical arrangements as a whole, the power of accommodation is limited, and those of you who are familiar with optics can easily understand how the sphericity of the lens is a bar to much alteration of focus, and consequent power of vision at long and unlimited ranges.

Now, what about practical and experimental facts ? In the fish's eye the pupil is fixed, and the rays of light are admitted just as they come, be they strong or weak.

Do fish see better on a medium or on a bright day? What says analogy ? If the pupil of the eye of man be artificially dilated (and this can easily be done by the judicious use of atropine), in ordinary daylight his sight, *i.e.*, his power of discerning is rendered very defective, distance and definition being seriously interfered with, in spite of the accommodating power of the organ, and vision becomes actually painful. In bright sunlight he can scarcely see at all. How about fish ?

We know that they can see remarkably well in twilight, and even in what is to us comparative darkness. When we can no longer see our fly the fish go on rising freely. Is their sight better or worse on days when nature is brilliantly lit up by the all-powerful rays of the sun ? When one says it is too bright a day for fishing, is it always because the fisher, rod, and lures are thereby too visible to the fish's eye? or is not that the brightness drives the fish down into the depths and into shades ? The brilliance is too much for their sight ; the power of discerning food is minimised, and as man does not care to eat in the dark, because he cannot see what he is eating, or about to eat, so with fish, excess of light is worse to them than very little. Hence the reason why morning and evening fishing are nearly always the best, and the cloudy day, with its diffuse and modified light, is the angler's as well as the fish's desire.

No better example of the fact that fish are dazed by sunlight could have occurred than to-day (Nov. 30, 1882). I began fly-fishing for grayling at 10.30 a.m., and by 11 took six. Then the sun burst forth and all the morning clouds were dissipated. From eleven till one there was not a cloud, but a clear blue sky and a brightly shining sun. Genial warmth brought plenty of cock-winged duns on the water, and though the fish rose freely before sunshine, not one would show except at an odd place under a shady bank or tree so long as the sun shone brightly. By and by clouds

came up from the north and west and veiled the sun. No sooner was the brilliance dimmed—or more properly speaking the light made diffuse—than the fish rose freely and continued to rise, till a rift in the cloud let the sun out again, and all was as instantly quiet. The condition of the river's surface was smooth and slowly running; the water as clear as if it had been filtered. Contrast the effect of too much light with a deficient supply. Does not the angler shake his head and say "Bother that sun," when he has to fish with his face to it, and his flies float along on the water's surface invisible to him by reason of the too brilliant glare? Or in the twilight, when he desires to make his last cast or two over a rising fish, watch how he opens his eyelids and stares to catch each "lessening ray."

The light, then, that is best for full vision is a diffuse one—such light as exists on a day with thinly clouded sun, when the angler says, This is a good day for my sport—in other words the more diffused light a body sends to us, the more precisely can we distinguish it. Thus, the photographer seeking diffuse light arranges his operating room that it may either have a northern exposure away from the sun's direct rays, or clouds over his studio's glass roof with suitable blinds or semi-transparent paint. I take it, then, that the condition of light which make the power of vision in fish most perfect in their own element, are also the best for angling.

The range of the human eye is limited by extremes of nearness and distance, as well as by similar extremes of light. Its wonderfully accommodating power is proof of this. Conversely, the fish's eye is limited in range, but is quick at short and very short distances ; it is not tolerant of brilliant light, but, catlike, can see in darkness that to man's eye is felt.

The effect of direct bright piercing light upon fish is sometimes very peculiar. Fish are paralysed by bright unnatural lights, as in leistering, etc., or, terrified, jump out of the way (*vide* Franck, "Northern Memoirs," p. 151 : 1821), or they "go at" the light much as a bull does at a red rag. It is well known that flying fish may be caught in quantity during the night, and the plan adopted is to hang a bright lamp over the ship's side. The fish spring in the direction of the light, and are either taken by a judiciously arranged net or fall on board the vessel. I am quite certain that these fish do not see where they are going—there is no diffuse light ; they rush at the light—beyond is darkness. Were the conditions otherwise I am sure they would be scared, and not leave their own element to meet death on deck, land, or in the pot. Is this not a kind of fascination like that of a moth as it flutters round the candle light?

A great portion of what I have said to you so far is all very well in theory, and when looked at from a diagrammatic point of view may be very pretty.

These illustrations are drawn to show the effects of light and vision in perfectly still and pure water. It is not difficult to understand or comprehend by contrast what takes place when the water surface is ruffled by wind, blurred by rain, or broken by fall or stickle. Alas! by this breaking of the surface all my fine straight lines then become distorted, my pencils of rays have gone off like bursting crackers, and the beautiful image of the angler, painted in the still lake on the pretty fishes' little eye, has become, by the influence of this gentle zephyr's ripple, as blurred and distorted, nay, as invisible, as your face or mine would be when looked at through this sheet of corrugated glass.* Just as the angler, with his gifted optical apparatus for keen sight, finds it impossible to discern a fish when the water's surface is broken, so as certainly is it impossible for the fish to discern its angling enemy. Though one cannot see any distance, perhaps beyond an inch, through corrugated glass, there is no difficulty in seeing objects in immediate contact with it, *e.g.*, compare this fly on the glass with a fly on the surface of roughened water. Perhaps the reason why trout so often spring into the air when tempted by a drifting fly is that the blurring effect on the surface interferes with their measurement of distance. One knows how trout, grayling, dace, roach, and chub suck in, with

* This was illustrated by the use of a sheet of roughened glass.

gentlest purl, the flies which drift along a glassy surface, having dropped from the overhanging boughs or waving grass and flowers adorning the water's bank, or may be lighted, life-like, from the angler's line. There is no rush or dash. Contrast this with the flying leaps that trout make when one is fishing on a lee shore, and casting among the breakers, and ask the question, Why is it so? My answer is, the power of judging distance is marred, and the trout is deceived. Were it possible for trout to see—to recognise a boat with its contained enemy drifting along a lake surface roughened by a gentle breeze, they would be scared and off long before the angler's fly could lure them. What is one's experience? Is it not quite the contrary? Is it not that, of successful methods of catching trout in a lake, this is the most successful? Nevertheless, the angler is up in a boat—more often standing and as much exposed as on a high bank—and yet it is a matter of every-day experience to find fish come up and take the artificial fly e'en at the vessel's side. So in stream fishing, if there is a good ripple on the surface the fish will just as soon take the angler for a tree as for a man, *i.e.*, if the fish can discern any object out of the roughened water that is distant more than one inch.

I need not say how my argument, if correct—and I have no doubt about it myself—*modifies* the much-vaunted doctrines of up-stream fishing. I do not

mean to say that it is not an advantageous method in certain circumstances, such as in fishing sluggish streams, say chalk streams, where the water is clear as gin and there is little disturbance of the surface; but when up-stream fishing is cast into one's face as *the only* method, then I must say I wholly differ.

Now, as regards the effect of the angler's shadow on the water, and his rod glistening with highest varnish or grand French polish, it wholly depends on the condition of the surface. You will observe that the *worst* condition for fishing is absolutely still clear water, coupled with brilliant sunshine. It is needless almost to say in such conditions what shadow or rod, or moving rod alone would do,—surely scare every fish away that is within twenty yards.

While the sun may be in its full power and brilliance to the angler, it is very much modified and diffused to the fish, by the action of an uneven and a roughened surface. The straight-piercing, all-searching rays are refracted, diverged, dispersed, and interfered with in a manner similar to the loss of power which discordant undulations of sound undergo as they either modify the power or tend to destroy one another. One knows how the sunlight becomes diffused and toned down by passage through roughened glass, and that the sun can be gazed at through it, while it is impossible to do so through clear, smooth plate.

Many a time I have had a good fishing when, standing up in a white-painted boat, I have drifted along with the sun at my back and my flashing rod hard at work; but there was a good ripple on the water, and thus neither boat, nor fisher, nor rod—each with their shadows—proved obnoxious, for all were *practically invisible* to the trout; and yet the light was diffused enough by the dispersing power of the wavy surface to tempt the fish from their places of shade and refuge to come forth and feed.

Now, as to muddy water and the power for fish to see in it, I can only remark—as I said to a friend the other day when I was spinning for jack in the river Lea—" I might as well expect a jack to take my bait in such water, as for a London ' bobby ' to catch a thief in a London fog." Of course, if the thief were to run into the policeman's arms, or the bait to rub itself against the jack's nose, there might be a catch !

How far can a fish see ? To most people this is simply a matter of conjecture. Perhaps one of the best tests is one that depends on a most important part of the law of self-preservation—I mean fear of enemies. I have made a good many observations on this point, and notably in the circumstances when shy fish have been quietly resting and waiting for the luscious flies to drop down stream within reach, so that the smallest possible effort might be called forth in their capture, the water at the same time being

clear as crystal, slowly flowing, smooth of surface, and about two feet deep. As I have walked down the bank I have found the fish start off at 18 yards distance at the farthest, some at a much less distance. In one special case I saw a fish quietly swimming in three feet of water,—it was plainly visible; it seemed not to see me, or if it did it was not afraid. I dropt my fly over it and hooked it on first trial; this fish was not above six yards off. When walking up bank I have seen the fish go off at about eight yards length from me at farthest; in many cases I was almost upon the fish before they started.

Some fishes can see (like a hare) in a backward direction, but as a rule our common fishes, if you go towards them directly from behind, can be approached very close. On one occasion, fishing up stream, wading in rough broken water, I dropped a worm-baited hook about a foot in front of my legs, and took a trout.

A very interesting part of my subject is the perception, discernment, and, if I may use a classical expression, the diagnosis-power possessed by fish in distinguishing colours. I need not enter here into the details of different flies, having different colors, or of how one fly takes better in one place than another, and so on—how bright flies, with lots of silver or gold in their structure and brilliant body hues, are very attractive on Highland lakes and rivers, while

more sombre flies fill the same *rôle* in southern streams. Most anglers are acquainted with the flies for different streams, and well know when and how to use them. But certain I am of this, that trout and grayling have a predilection for certain colours, and these are green and red. Of the red the late Rev. Chas. Kingsley says that they "like something that has an appearance of flesh."

Of the preference trout have for one colour over another, I cannot do better in the way of illustration than relate a little experience of my own. There is a fly which is one of the favourites in the north, in almost every lake, and is generally held in the acceptance of north-country anglers as one of the most killing. It is not an elaborate fly; it consists of a black hackle with a red tag, and is known as the Black Watch or Zulu. Now, one day, a few years ago, my brother-in-law and I were fishing from a boat on Loch Shin, in Sutherlandshire, and a steady breeze blew from the south-west. We fished with marked success the lee side, or that on which the waves were breaking, but as such fishing is rather uncomfortable for the occupant of the boat's bow when there is a bit of a sea on, by reason of the sundry bruises and scrapings his shins are subjected to, in addition to the insecure foothold and ever-ready tendency thereby produced to topple overboard when a wave interferes with the equilibrium of boat and angler, I gave

directions that we should pull across and fish the weather shore.

The Black Watch had done good duty—done duty so well that on arrival I found that my brother-in-law's fly had been picked to pieces, and he naturally asked me for another to replace the one worn out. I searched my book, expressed my regret I had not one left, when the boatman said, quietly, "There is a gentleman comes here to fish, and gets a great many; he fishes with fly of the same kind with a *white* tag." No sooner said than I dropped down into the boat's bow, out of the wind, and "fashioned a fly"—black hackle with white tag—handed it over to my friend, who, adjusting it, began to fish. At first cast he took a trout, then another and another, and so on, I fishing all the while with the Zulu (black and red;) not a fish could I take so long as the black and white was on the water. Our casts were so closely made that there could be no excuse for saying we were fishing different water. Finding myself so beaten, for I could not get a fish, I again sat down in the bow and made a white tag for myself—began, and we got fish about for a time; then, unfortunately—or rather, fortunately for me, a fish took off my fly, and my little game was ended only to be begun again more fiercely. Examining my book, I found that some years before I had made some black hackles with *yellow* tag, but had never ventured to try one; in present circum-

stances I put one on, and under all the same conditions ; so soon as my fly with the yellow tag touched the water I had a fish. So attractive was it that I spoilt my friend's fishing ; he could not after that get a fish, while every one that was going fell to me. Since that day I have used red tag and yellow tag at one and the same time, and found the yellow preferred.

As regards selection of colour, the following anecdote will perhaps interest you and illustrate :—My friend, Dr. R—— related to me that twenty years ago he often used to fish the Wandle. He took with him a friend one day, whose success was almost exasperating; nearly every fish he saw rising he was able to take. Dr. R. asked, " How did you do so well, and what fly did you use ? " His friend said, "I have flies made like your own, but they have a particular body; that body is raw China silk, yellow when dry, but on being wetted it assumes a pale green colour. Now, with this fly," he said, " trout could be taken when they were refusing everything else." Dr. R. managed to get some of the silk and had flies made, with which he captured trout in any water. Everywhere he went trout yielded to this yellow-turning-green body. By mischance my friend lost his silk, and though he has tried the various silk merchants of this great city he has never been able to get the same kind of material. He thinks its efficiency was due to some peculiar method of preparation done in China, which has been given up or changed. Only

the other day he said to me, "If I could but get that silk I could catch trout anywhere. I have tried sample after sample, till I have a drawer full, but none of it will do."

Doubtless there are some things I have overlooked, but the most important I trust I have put before you. Before concluding I would just like to say a few words regarding the discernment of the angler's hook or hooks by fish; I need not say much. Hitherto I spoke of the discernment of colour and flies. But the angler's fly carries a hook—sometimes two. It takes very little common sense to comprehend that if the fish was such a discerner of hooks and hook-points as is so strongly put in books of instructions on bottom fishing—I don't care what kind—there would be an end to all fly-fishing, spinning, snapping, &c. What does a fish know of a hook till it is pricked or fixed? —nothing. It then recognises something as having stung it. A fish knows infinitely less of what a hook is than a human being, alike ignorant of fish and fishing, who has had a hook presented to him for the first time. Man may reason out a use for the hook—a fish cannot. If I may speak from experience, and I think from what I have done in trout, perch, roach, dace, and gudgeon fishing with worms, as well as in sea-fishing, and I have had a fair share of practice during the past forty years, I say, emphatically, that throughout all this time I have invariably fished with

the point and barb of the hook exposed. Such baiting may not look so pretty, but it is more effectual. Doubtless many will differ with me on this matter, but how are we to get over the exposure of the hook in all flies. In a rapid stream or broken water the hook certainly is not so visible ; but in fishing with a dry fly in smooth water, there floats the fly with its neck, bend, barb, and point of hook exposed. If you have the right fly no hook or part of it will deter the voracious fish.

Then if we take an extreme case, is it not the experience of the vast majority of fly fishers to have, at some time or other, the favourite fly of the day picked to pieces, the wings torn off, the hackle plucked out by the root, body and hook being only left, and yet this denuded fly has continued to be the most acceptable to the fish of any going? If one says, "Oh, you have feathers to cover your hook!" Then how about the covering and concealment in this case? The truth of the matter is as I have said before, the fish knows not what a hook is. Nevertheless I do not deny the necessity and advantage as occasions arise of *fine*-fishing as it is called. Having alluded to the fearlessness of fish towards such an enemy as our barbed hooks, it is quiet a different matter when humanity shows his face and is observed. Instinctive dread enters just as if the fish were aware that man came to desolate more than replenish the earth. "For

a cow might come and look into the water and put her yellow lips down, a kingfisher, like a blue arrow, might shoot through the dark alleys over the channel, or sit on a dipping withy bough with his beak sunk into his breast-feathers ; even an otter might float down-stream, likening himself to a log of wood, with his flat head flush with the water-top, and his oily eyes peering quietly ; and yet no panic would seize other life as it does when a sample of man comes."—*Lorna Doone.*

As a sort of *resumé*—

1. The eyes of fishes are much inferior optical instruments to those of man.

2. Though the range of sight is limited, it has one advantage over man's—that it can be used with a much more diminished quantity of light, but is defective in opposite conditions.

3. The eye of the fish is a means of self-preservation—quick to see food, and more quick to see an enemy—in his own element and out of it.

4. When the angler can see the fish, it is a rule that the fish can see the angler.

5. The best light for fishing is a diffuse light—such as when the sun is clouded over—for then the fish come out to feed, can see their food, and search for it without pain or discomfort. And conversely—

6. The worst fishing light is brilliant sunshine ; not that the fish can see the lures more easily, but because the fish are dazed, and seek shelter.

7. A ruffled surface, by dispersion of rays, utterly obliterates the fish's view of anything out of water beyond an inch or so from the surface. A running water does the same, but to a less extent.

8. Fish have a power of selection of colours, for food.

9. The colour of anglers' clothes is not of so much importance as keeping out of sight—dim or green garb is best—but it is the angler's eye and face that frighten most.

10. Fish no doubt sleep, though they have no eyelids to shut out the light.

11. Till a fish has been pricked or hooked it is quite ignorant of the existence of such a thing as a hook; and were it possible for it to be recognised by the fish, voracity would overcome fear.

12. It is the angler's duty to keep himself as much as possible out of sight.

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