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THE VELOCITY OF LIGHT.

A POPULAR SCIENTIFIC LECTURE.[1]

BY PROF. ERNST MACH.

When a criminal judge has a right crafty knave before him, one well versed in the arts of prevarication, his main object is to wring a confession from the culprit by a few skilful questions. In almost a similar position the natural philosopher seems to be placed with respect to nature. True, his functions here are more those of the spy than the judge; but his object remains pretty much the same. Her hidden motives and laws of action is what nature must be made to confess. Whether a confession will be extracted depends upon the shrewdness of the inquirer. Not without reason, therefore, did Lord Bacon call the experimental method a questioning of nature. The art consists in so putting our questions that they may not remain unanswered without a breach of etiquette.

Look, too, at the countless tools, engines, and instruments of torture with which man conducts his inquisitions of nature, and which mock the poet's words:

> "Mysterious even in open day,
> Nature retains her veil, despite our clamors:
> That which she doth not willingly display
> Cannot be wrenched from her with levers, screws, and hammers."

Look at these instruments and you will see that the comparison with torture also is admissible.

This view of nature, as of something designedly concealed from man, that can be unveiled only by force or dishonesty, chimed in better with the conceptions of the ancients than with modern notions. A Grecian philosopher once said, in offering his opinion of the natural science of his time, that it could only be displeasing to the gods to see men endeavoring to spy out what the gods were not minded to reveal to them.[2] Of course all the contemporaries of the speaker were not of his opinion.

Traces of this view may still be found to-day, but upon the whole we are now not so narrow-minded. We believe no longer that nature designedly hides herself. We know now from the history of science that our questions are sometimes meaningless, and that, therefore, no answer can be forthcoming. Soon we shall see how man, with all his thoughts and quests, is only a fragment of nature's life.

Picture, then, as your fancy dictates, the tools of the physicist as instruments of torture or as engines of endearment, at all events a chapter from the history of those implements will be of interest to you, and it will not be unpleasant to learn what were the peculiar difficulties that led to the invention of such strange apparatus.

Galileo (born at Pisa in 1564, died at Arcetri in 1642) was the first who asked what was the velocity of light, that is, what time it would take for a light struck at one place to become visible at another, a certain distance away.[1]

The method which Galileo devised was as simple as it was natural. Two practised observers, with muffled lanterns, were to take up positions in a dark night at a considerable distance from each other, one at A and one at B. At a moment previously fixed upon, A was instructed to unmask his lantern; while as soon as B saw the light of A's lantern he was to unmask his. Now it is clear that the time which A counted from the uncovering of his lantern until he caught sight of the light of B's would be the time which it would take light to travel from A to B and from B back to A.

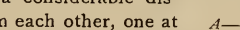

Fig. 1.

The experiment was not executed, nor could it, in the nature of the case, have been a success. As we now know, light travels too rapidly to be thus noted. The time elapsing between the arrival of the light at B and its perception by the observer, with that between the decision to uncover and the uncovering of the lantern, is, as we now know, incomparably greater than the time which it takes light to travel the greatest earthly distances. The great velocity of light will be made apparent, if we reflect that a flash of lightning in the night illuminates instantaneously a very extensive region, whilst the single reflected claps of thunder arrive at the observer's ear very gradually and in appreciable succession.

[1] Graz, 1867. Translated by μκρκ.

[2] Xenophon, Memorabilia iv, 7, puts into the mouth of Socrates these words: οὔτε γὰρ εὑρετὰ ἀνθρώποις αὐτὰ ἐνόμιζεν εἶναι, οὔτε χαρίζεσθαι θεοῖς ἂν ἡγεῖτο τὸν ζητοῦντα ἃ ἐκεῖνοι σαφηνισαι οὐκ ἐβουλήθησαν.

[1] Galilei, *Discorsi e dimostrazione matematiche*. Leyden, 1638. *Dialogo Primo*.

During his life, then, the efforts of Galileo to determine the velocity of light remained uncrowned with success. But the subsequent history of the measurement of the velocity of light is intimately associated with his name, for with the telescope which he constructed he discovered the four satellites of Jupiter, and these furnished the next occasion for the determination of the velocity of light.

The terrestrial spaces were too small for Galileo's experiment. The measurement was first executed when the spaces of the planetary system were employed. Olaf Römer, (born at Aarhuus in 1644, died at Copenhagen in 1710) accomplished the feat (1675–1676), while watching with Cassini at the observatory of Paris the revolutions of Jupiter's moons.

Let AB (Fig. 2) be Jupiter's orbit. Let S stand for the sun, E for the earth, J for Jupiter, and T for Jupiter's first satellite. When the earth is at E_1 we

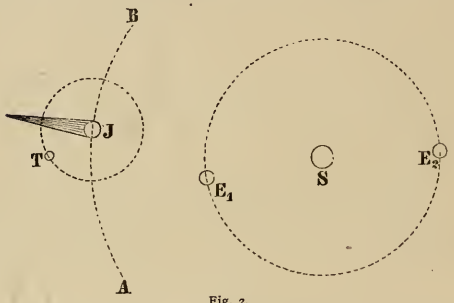

Fig. 2.

see the satellite enter regularly into Jupiter's shadow, and by watching the time between two successive eclipses, can calculate its time of revolution. The time which Römer noted was forty-two hours, twenty-eight minutes, and thirty-five seconds. Now, as the earth passes along in its orbit towards E_2, the revolutions of the satellite grow apparently longer and longer: the eclipses take place later and later. The greatest retardation of the eclipse, which occurs when the earth is at E_2, amounts to sixteen minutes and twenty-six seconds. As the earth passes back again to E_1, the revolutions grow apparently shorter, and they occur in exactly the time that they first did when the earth arrives at E_1. It is to be remarked that Jupiter changes only very slightly its position during one revolution of the earth. Römer guessed at once that these periodical changes of the time of revolution of Jupiter's satellite were not actual, but apparent changes, which were in some way connected with the velocity of light.

Let us make this matter clear to ourselves by a simile. We receive regularly by the post, news of the political status at our capital. However far away we may be from the capital, we hear the news of every event, later it is true, but of all equally late. The events reach us in the same succession of time as that in which they took place. But if we are travelling away from the capital, every successive post will have a greater distance to pass over, and the events will reach us more slowly than they took place. The reverse will be the case if we are approaching the capital.

At rest, we hear a piece of music played in the same *tempo* at all distances. But the *tempo* seems to be accelerated if we are carried rapidly towards the band, or to be retarded if we are carried swiftly away from it.[1]

Picture to yourself a cross, say the sails of a windmill (Fig. 3), in uniform rotation about its centre. Clearly, the rotation of the cross will appear to you more slowly executed if you are carried very rapidly away from it. For the post which in this case conveys to you the light and brings to you the news of the successive positions of the cross will have to travel in each successive instant over a longer path.

Fig. 3.

Now this must also be the case with the rotation (the revolution) of the satellite of Jupiter. The greatest retardation of the eclipse (16½ minutes), due to the passage of the earth from E_1 to E_2, or to its removal from Jupiter by a distance equal to the diameter of the orbit of the earth, plainly corresponds to the time which light requires to travel a distance equal to the diameter of the earth's orbit. The velocity of light, that is, the distance described by light in a second, as determined by this calculation, is 311,000 kilometres, or 193,000 miles. A subsequent correction of the diameter of the earth's orbit, gives, by the same method, the velocity of light as approximately 186,000 miles a second.

The method is exactly that of Galileo; only better conditions are selected. Instead of a short terrestrial distance we have the diameter of the earth's orbit, three hundred and seven million kilometres; in place of the uncovered and covered lanterns we have the satellite of Jupiter, which alternately appears and disappears. Galileo, therefore, although he could not himself make his proposed measurement, found the lantern by which it was ultimately executed.

Physicists did not long remain satisfied with this beautiful discovery. They sought after easier methods of measuring the velocity of light, which might be performed on the earth. This was possible after the difficulties of the problem were clearly exhibited. A measurement of the kind referred to was executed in 1849 by Fizeau (born at Paris in 1819).

[1] In the same way, the pitch of a locomotive whistle seems to rise as a rapidly moving train approaches a railway station, and to fall as the train passes away from it.—*Trans.*

I shall endeavor to make the principle of Fizeau's apparatus clear to you. Let s (Fig. 4) be a disk free to rotate about its centre, and perforated at its rim with a series of holes. Let l be a luminous point

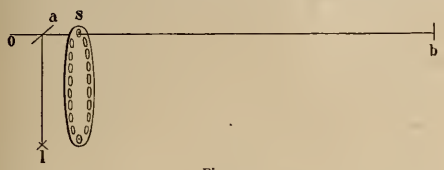

Fig. 4.

casting its light on an unsilvered glass, a, inclined at an angle of forty-five degrees to the axis of the disk. The ray of light, reflected at this point, passes through one of the holes of the disk and falls at right angles upon a mirror b, erected at a point about five miles distant. From the mirror b the light is again reflected, passes once more through the hole in s, and, penetrating the glass plate, finally strikes the eye, o, of the observer. The eye, o, thus sees the image of the luminous point l through the glass plate and the hole of the disk in the mirror b.

If, now, the disk be set in rotation, the unpierced spaces between the apertures will alternately take the place of the apertures, and the eye o will now see the image of the luminous point in b only at interrupted intervals. On increasing the rapidity of the rotation, however, the interruptions for the eye again become unnoticeable, and the eye sees the mirror b uniformly illuminated.

But all this holds true only for relatively small velocities of the disk, when the light sent through an aperture in s to b on its return strikes the aperture at almost the same place and passes through it a second time. Conceive, now, the velocity of the disk so increased that the light on its return finds before it an unpierced space instead of an aperture, it will then no longer be able to reach the eye. We then see the mirror b only when no light is emitted from it, but only when light is sent to it; it is covered when light comes from it. In this case, accordingly, the mirror will always appear dark.

If the velocity of rotation at this point were still further increased, the light sent through one aperture could not, of course, on its return pass through the same aperture but might strike the next and reach the eye by that. Hence, by constantly increasing the velocity of the rotation, the mirror b may be made to appear alternately bright and dark. Plainly, now, if we know the number of apertures of the disk, the number of rotations per second, and the distance sb, we can calculate the velocity of light. The result agrees with that obtained by Römer.

The experiment is not quite as simple as my exposition might lead you to believe. Care must be taken that the light shall travel back and forth over the miles of distance sb and bs undispersed. This difficulty is obviated by means of telescopes.

If we examine Fizeau's apparatus closely, we shall recognise in it an old acquaintance: the arrangement of Galileo's experiment. The luminous point l is the lantern A, while the rotation of the perforated disk performs mechanically the uncovering and covering of the lantern. Instead of the unskilful observer B we have the mirror b, which is unfailingly illuminated the instant the light arrives from s. The disk s, by alternately transmitting and intercepting the reflected light, assists the observer o. Galileo's experiment is here executed, so to speak, countless times in a second, while the total result admits of actual observation. If I might be pardoned the use of a phrase of Darwin's in this field, I should say that Fizeau's apparatus was the descendant of Galileo's lantern.

A still more refined and delicate method for the measurement of the velocity of light was employed by Foucault, but a description of it here would lead us too far.

The measurement of the velocity of sound is easily executed by the method of Galileo. It was unnecessary, therefore, for physicists to rack their brains further about the matter; but the idea which with light grew out of necessity was applied also in this field. Koenig of Paris constructs an apparatus for the measurement of the velocity of sound which is closely allied to the method of Fizeau.

The apparatus is very simple. It consists of two electrical clock-works which strike simultaneously, with perfect precision, tenths of seconds. If we place the two clock-works directly side by side, we hear their strokes simultaneously, wherever we stand. But if we take our stand by the side of one of the works and place the other at some distance from us, in general a coincidence of the strokes will now not be heard. The companion strokes of the remote clock-work arrive, as sound, later. The first stroke of the remote work is heard, for example, immediately after the first of the adjacent work, and so on. But by increasing the distance we may produce again a coincidence of the strokes. For example, the first stroke of the remote work coincides with the second of the near work, the second of the remote work with the third of the near work, and so on. If, now, the works strike tenths of seconds and the distance between them is increased until the first coincidence is noted, plainly that distance is travelled over by the sound in a tenth of a second.

We meet frequently the phenomenon here presented, that a thought which centuries of slow and painful endeavor are necessary to produce, when once

developed, fairly thrives. It spreads and runs everywhere, even entering minds in which it could never have arisen. It simply can not be eradicated.

The determination of the velocity of light is not the only case in which the direct perception of the senses is too slow and clumsy for use. The usual method of studying events too fleet for direct observation consists in putting into reciprocal action with them other events already known, the velocities of all of which are capable of comparison. The result is usually unmistakable, and susceptible of direct inference respecting the character of the event which is unknown. The velocity of electricity cannot be determined by direct observation. But it was ascertained by Wheatstone, simply by the expedient of watching an electric spark in a mirror rotating with tremendous known velocity.

If we wave a staff irregularly hither and thither, simple observation cannot determine how quickly it moves at each point of its course. But let us look at the staff through holes in the rim of a rapidly rotating disk. We shall then see the moving staff only in certain positions, namely, when a hole passes in front of the eye. The single pictures of the staff remain for a time impressed upon the eye; we think we see several staffs, having some such disposition as that represented in Fig. 6. If, now, the holes of the disk are equally far apart, and the disk is rotated with uniform velocity, we see clearly that the staff has moved slowly from *a* to *b*, more quickly from *b* to *c*, still more quickly from *c* to *d*, and with its greatest velocity from *d* to *e*.

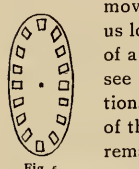

Fig. 5.

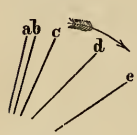

Fig. 6.

A jet of water flowing from an orifice in the bottom of a vessel has the appearance of perfect quiet and uniformity, but if we illuminate it for a second, in a dark room, by means of an electric flash we shall see that the jet is composed of separate drops. By their quick descent the images of the drops are obliterated and the jet appears uniform. Let us look at the jet through the rotating disk. The disk is supposed to be rotated so rapidly that while the second aperture passes into the place of the first, drop 1 falls into the place of 2, 2 into the place of 3, and so on. We see drops then always in the same places. The jet appears to be at rest. If we turn the disk a trifle more slowly, then while the second aperture passes into the place of the first, drop 1 will have fallen somewhat lower than 2, 2 somewhat lower than 3, etc. Through every successive aperture we shall see drops in successively lower positions. The jet will appear to be flowing slowly downwards.

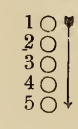

Fig. 7.

Now let us turn the disk more rapidly. Then while the second aperture is passing into the place of the first, drop 1 will not quite have reached the place of 2, but will be found slightly above 2, 2 slightly above 3, etc. Through the successive apertures we shall see the drops at successively higher places. It will now look as if the jet were flowing upwards, as if the drops were rising from the lower vessel into the higher.

You see, physics grows gradually more and more terrible. The physicist will soon have it in his power to play the part of the famous lobster chained to the bottom of the Lake of Mohrin, whose direful mission, if ever liberated, the poet Kopisch humorously describes as that of a reversal of all the events of the world; the rafters of houses become trees again, cows calves, honey flowers, chickens eggs, and the poet's own poem flows back into his inkstand.

* * *

You will now allow me the privilege of a few general remarks. You have seen that the same principle often lies at the basis of whole classes of apparatus designed for different purposes. Frequently it is some very unobtrusive idea which is productive of so much fruit and of such extensive transformations in physical technics. It is not different here than in practical life.

The wheel of a waggon appears to us a very simple and insignificant creation. But its inventor was certainly a man of genius. The round trunk of a tree perhaps first accidentally led to the observation of the ease with which a load can be moved on a roller. Now, the step from a simple supporting roller to a fixed roller, or wheel, appears a very easy one. At least it appears very easy to us who are accustomed from childhood up to the action of the wheel. But if we put ourselves vividly into the position of a man who never saw a wheel, but had to invent one, we shall begin to have some idea of its difficulties. Indeed, it is even doubtful whether a single man could have accomplished this feat, whether perhaps centuries were not necessary to form the first wheel from the primitive roller.[1]

History does not name the progressive spirits who constructed the first wheel; their time lies far back of the historic period. No scientific academy crowned their efforts, no society of engineers elected them honorary members. They still live only in the stupendous results which they called forth. Take from us the wheel, and little will remain of the arts and industries of modern life. All disappears. From the spinning-wheel to the spinning-mill, from the turning-

[1] Observe, also, the respect in which the wheel is held in India, Japan, and other Buddhistic countries, as the emblem of power, order, and law, and of the superiority of mind over matter. The consciousness of the importance of the wheel seems to have lingered long in the minds of these nations.—*Trans*.

lathe to the rolling-mill, from the wheelbarrow to the railway train, all vanishes.

In science the wheel is equally important. Whirling machines, as the simplest means of obtaining quick motions with inconsiderable changes of place, play a part in all branches of physics. You know Wheatstone's rotating mirror, Fizeau's wheel, Plateau's perforated rotating disks, etc. Almost the same principle lies at the basis of all these apparatus. They differ from one another no more than the pen-knife differs, in the purposes it serves, from the knife of the anatomist or the knife of the vine-dresser. Almost the same might be said of the screw.

It will now perhaps be clear to you that new thoughts do not spring up suddenly. Thoughts need their time to ripen, grow, and develop in, like every natural product; for man, with his thoughts, is also a part of nature.

Slowly, gradually, and laboriously one thought is transformed into a different thought, as in all likelihood one animal species is gradually transformed into new species. Many ideas arise simultaneously. They fight the battle for existence not differently than do the Ichthyosaurus, the Brahman, and the horse.

A few remain to spread rapidly over all fields of knowledge, to be redeveloped, to be again split up, to begin again the struggle from the start. As many animal species long since conquered, the relicts of ages past, still live in remote regions where their enemies cannot reach them, so also we find conquered ideas still living on in the minds of many men. Whoever will look carefully into his own soul will acknowledge that thoughts battle as obstinately for existence as animals. Who will gainsay that many vanquished modes of thought still haunt obscure crannies of his brain, too faint-hearted to step out into the clear light of reason? What inquirer does not know that the hardest battle, in the transformation of his ideas, is fought with himself.

Similar phenomena meet the natural inquirer in all paths and in the most trifling matters. The true inquirer seeks the truth everywhere, in his country-walks and on the streets of the great city. If he is not too learned, he will observe that certain things, like ladies' hats, are constantly subject to change. I have not pursued special studies on this subject, but as long as I can remember, one form has always gradually changed into another. First, they wore hats with long projecting rims, within which, scarcely accessible with a telescope, lay concealed the face of the beautiful wearer. The rim grew smaller and smaller; the bonnet shrank to the irony of a hat. Now a tremendous superstructure is beginning to grow up in its place, and the gods only know what its limits will be. It is not different with ladies' hats than with butterflies, whose multiplicity of form often simply comes from a slight excrescence on the wing of one species developing in a cognate species to a tremendous fold. Nature, too, has its fashions, but they last thousands of years. I could elucidate this idea by many additional examples; for instance, by the history of the evolution of the coat, if I were not fearful that my gossip might prove irksome to you.

* * *

We have now wandered through an odd corner of the history of science. What have we learned? The solution of a small, I might almost say insignificant, problem—the measurement of the velocity of light. And more than two centuries have worked at its solution! Three of the most eminent natural philosophers, Galileo, an Italian, Römer, a Dane, and Fizeau, a Frenchman, have nobly shared its labors. And so it is with countless other questions. When we contemplate thus the many blossoms of thought that must wither and fall before one shall bloom, then shall we first truly appreciate Christ's weighty but little consolatory words: "Many be called but few are chosen."

Such is the testimony of every page of history. But is history right? Are really only those chosen whom she names? Have those lived and battled in vain, who have won no prize?

I doubt it. And so will every one who has felt the pangs of sleepless nights spent in thought, at first fruitless, but in the end successful. No thought in such struggles was thought in vain; each one, even the most insignificant, nay, even the erroneous thought, that which apparently was the least productive, served to prepare the way for those that afterwards bore fruit. And as in the thought of the individual naught is in vain, so, also, it is in that of humanity.

Galileo wished to measure the velocity of light. He had to close his eyes before his wish was realised. But he at least found the lantern by which his successor could accomplish the task.

And so I may maintain that we all, so far as inclination goes, are working at the civilisation of the future. If only we all strive for the right, then are we *all* called and *all* chosen!

CHAPTERS FROM THE NEW APOCRYPHA.

BY HUDOR GENONE.

PAUL'S EPISTLE TO THE DAMASCENES.

Dearly beloved, this epistle write I unto you, for as much as it hath been told me how ye receive not with meekness the truth as it is in Christ Jesus:

But are puffed up with your own conceits, relying upon your traditions, saying one to another and to him whom I sent unto you, that a priest must be of the sons of Levi.

Know ye not that ye all are a royal priesthood,—a peculiar people?

Verily I say unto you in Christ Jesus is neither priesthood nor tradition, neither tithes nor burnt-offerings, neither temples nor altars, neither circumcision nor uncircumcision;

But ye are all free, made free with the freedom with which Christ hath made you free.

For now hath light come into the world that ye need walk no longer in darkness, neither stumble any more, nor seek any more, nor doubt any more.

Was it not said of old, even by David, King of Israel, Thou art a priest forever after the order of Melchizedek.

And this Melchizedek was a type of Him who should come, even the very Truth, who was first pure, being King of Righteousness, then peaceable, being King of Peace.

And the same was without father or mother, having neither beginning of days nor end of life; but was truly like unto the Son of God, abiding a priest continually.

Who is made, not after the law of a carnal commandment, but after the power of an endless life.

Behold it came to pass that this same Melchizedek preached unto your fathers this doctrine;

But their hearts were hardened against him, and they understood him not, but reviled him,

For Melchizedek came unto your city. And beheld standing in the market-place thereof images of gold of the gods of the people,

Of the Canaanites and the Moabites and the Midianites, aye and of the Israelites also, whose seed ye are.

Behold there he saw and beheld an image of Baal, even a golden image, and an image of Ashteroth, even a golden image,

And an image of Jahweh also, even a golden image.

And they all fell down before the images and did worship them.

Then Melchizedek called with a loud voice and saith, O ye children of Israel, why are ye gone after a strange god?

Then saith the Israelites, Behold the image that we have set up is not the likeness of Baal nor of Ashteroth.

For the gods of the Canaanites and the Moabites and the Midianites be false gods.

But He, whose image we have made, is the true God, even Jahweh, who brought us out of the land of Egypt, even Him do we worship.

Look now upon the image of Baal and the image of Ashteroth. Is not the image, even the golden image that we have set up, comlier of form than they?

Then was Melchizedek wroth and saith unto the Israelites:

Behold God, even the God of Moses, is not a god made with hands like unto the image that ye have set up.

Neither is He made in the likeness of anything that is on the face of the earth;

For God, even the true God, hath no form nor comeliness, that ye should desire his likeness.

And Melchizedek took the image, even the golden image that the Israelites set up, and cast it into the fiery furnace.

And there were of the children of Israel in number about ten thousand.

And Melchizedek turned the golden image into money, even into ten thousand pieces of gold, and every piece of gold was in the form of a lamb.

And he gave unto the Israelites the pieces of gold, even the golden lambs; to every man his piece; to every one of the children of Israel one lamb.

And the image was made an end of, but the gold remained.

Behold now I say unto you, O men of Damascus, that as it was in the days of old it is now.

And this same Jesus, whose gospel I have preached unto you, is now become your great High Priest.

The priest forever after the order of Melchizedek,

Who hath made a new covenant with his people in a greater and more perfect tabernacle, saying,

I will put my laws in their mind and write them upon their hearts.

For the law is a shadow of good things to come and not the image of the things.

Behold the lamb of God which taketh away the sins of the world.

KIDD'S "SOCIAL EVOLUTION."

BY DR. LEWIS G. JANES.

Though over-rated by some critics, Mr. Benjamin Kidd's recently published work on "Social Evolution" has one supreme merit—that of venturing boldly upon the frontier-line of thought concerning the grave problems pertaining to the relations of the individual to society. It is probable that the author, himself, would hardly claim that he had furnished the solution of these problems. The general impression produced by his book, indeed, is that in the opinion of the author there is no rational solution. Social adjustments must be made in the future, as they have been in the past, according to his understanding of the philosophy of societary progress, by the complete subordination of the rational nature to the super-rational sanctions of what he sometimes calls the "ethical" and sometimes the "religious" motive. This conception constitutes the key-note of Mr. Kidd's doctrine of social evolution.

The conclusions of the author are largely vitiated by the dependence of his argument on certain underlying and undemonstrated assumptions, as well as by annoying vagueness and inaccuracy in the use of terms. He apparently uses the words "rational" and "intellectual," for example, implying egoistic hedon-

ism as the supreme motive of human action. The admitted altruistic tendency in our modern civilisation is traced to the conception of human equality, which is assumed to be the product of the "super-rational" teachings of Christianity. Religion and morality, apparently regarded as identical in their origin and character, and as antithetical to the rational nature, are traced to this super-rational source.

These erroneous assumptions doubtless arise from insufficient acquaintance with the natural history of the evolution of the religious and moral sentiments, and in part from a common misconception of the essential character of the early Christian doctrine. To the student of human origins, nothing can be clearer than the fact that religion and morality were distinct in their origin and earlier evolution, and have only become united in our thought by a gradual process of mental association. The earlier stages of human progress were characterised by the dominance of the religious sentiment, and by great feebleness of the ethical impulse. Most savage tribes are still dominated by super-rational or super-natural motives to a degree almost inconceivable by the modern rational thinker. The progress of civilisation, indeed, has been marked by the gradual supplanting of supernatural or religious by ethical and rational motives in the government of conduct. This substitution has unquestionably been the result, mainly, of intellectual progress in the race.

This is no less true of the progress of Christianity itself than it is in those lands where Christianity has supplanted earlier and cruder manifestations of the religious sentiment. That which differentiates Christianity from the religions which preceded it is not the supernatural substratum which it holds in common with Judaism, Buddhism, Zoroastrianism, and the polytheistic cults of Greece and Rome, but certain ethical and intellectual conceptions which are readily traceable to their historical antecedents in intellectual speculation. To say nothing of the teachings of Paul and the Alexandrian school, dominant in the earlier as well as the prevailing schools of Christian theology, largely based on Greek philosophical ideas, there is an intellectual element, too little recognised, in the teachings of Jesus himself. The very "repentance" (*metanoia*), which lies at the foundation of his ethical teaching, was not a mere emotional "change of heart" as taught by Protestant divines; still less was it the "doing of penance" (*agite pœnitentiam*) of the Romish creed; it was a purely intellectual act of thinking through to the results of one's action, and thus initiating a rational change of motive.

Nor is it less evident that the movement of modern thought beginning with the Italian Renaissance and the Protestant Reformation, was essentially intellectual—a revival in its deeper motives of Greek and pagan ideas; though Mr. Kidd boldly assumes the contrary. He interprets the Reformation as a return to the primitive "super-rational" religion of the Gospels. But every theologian is aware that the Pauline and Alexandrian, as well as the later Augustinian elements in Christian doctrine were never more strongly emphasised than in the theologies which marked the period of the Protestant revival. The Christian doctrine of the Brotherhood of Man which Mr. Kidd refers to the super-rational teachings of Christianity, has in reality been of slow growth in the Christian consciousness, and has blossomed into deed *pari passu* with man's intellectual enfranchisement. The Gospel teaching, backed by no explicit condemnation of slavery by the founder of Christianity, and hindered by the countenance given to the "peculiar institution" by Paul and the almost universal custom of Christian peoples for fourteen centuries, failed to break the bonds of the heavy laden. In our own country economic conditions first rid the Northern States of the curse of slavery; climatic influences built up an opposing civilisation, and pagan powder and shell rather than Christian ethics did the rest.

We cannot think that Mr. Kidd is doing a real service to the world by asserting that the true interests of the "power-holding classes" are antagonistic to those of the people. In so far as popular rights have been secured with the consent of the "power-holding classes," it is because the latter have been intellectually convinced that their own true interests are favored by the liberation, education, and improvement of the masses.

The economic lever is to-day the potent instrument by which the standard of living is being raised and the condition of the poor and oppressed is being ameliorated; and its fulcrum is in the growing intelligence of the people—capitalists and wage-laborers alike. To this power we must look for the peaceful correction of existing social inequities, not to sentimental declamation concerning the brotherhood of man; still less to an alleged super-rational sanction for this humane sentiment.

Mr. Kidd's identification of morality and religion with "super-rationalism" must give joy both to the rigid orthodox defenders of Christianity and to the crude "liberal" dogmatist who holds that the world has no further use for religion. If this assertion were well founded, the effort to establish religion on a scientific basis would be preordained to failure, and for rational minds the logical conclusion must be the entire rejection of religion. If, however, religion be understood as the reverent recognition of man's dependence upon the Supreme Reality, it may have a scientific and rational as readily as a "super-rational" sanction.

Mr. Kidd argues with much force and reason, in opposition to Mr. Herbert Spencer, that a condition of "social equilibrium," such as Mr. Spencer's ethical system contemplates, could only exist as a prelude to social degeneration. Differences in function and capacity, the competitive struggle for existence, are essential conditions to selection and must permanently prevail amongst every form of life which is not actually retrograding. This consideration should constitute a corrective of all extreme socialistic experimentation, which aims, as Mr. Kidd truly affirms, to create artificially the conditions for such a state of social equilibrium.

Though not devoid of serious faults, Mr. Kidd's work, on the whole, is a wholesome stimulus to thought and merits the perusal of all who are interested in the serious problems of our modern civilisation.

SCIENCE AND REFORM.

REGICIDE REMEDIES.

On the Plain of Prayer, south of Mecca, the traveller Burton saw an isolated rock, known as the Harrat el Sheytan, or "Devil's Head," on account of a bowlder which the enemy of mankind is supposed to have placed on the summit of the crag. Pious pilgrims endeavor to enhance the merit of their journey by flinging stones at that top-rock, and Bedouins often use it as a target to try the range of their long muskets. When the Emir of El Obid was offered the throne of the Caliph, he raised his hands in horror and then pointed to the fear-haunted rock. "Friends and brethren," said he, "I have always welcomed an opportunity to serve you, but, as for your present request, I would really as soon camp on top of the Harrat." The successors of the Prophet had, indeed, special reasons to consider a common turban preferable to a crown, but Jeremy Bentham's remark holds good that the establishment of social authority always implies the retrenchment of other rights, and that it is impossible to assert that authority in practice without incurring the open or secret enmity of malcontents. And though tyrannicide may be the last resource of the oppressed, it is equally true that under certain circumstances a mania for visiting a nation's sins upon its rulers may take the form of a moral epidemic. "Build an almshouse and save the expenses of your bodyguard," was the advice of Sultan Bajazet's vizier; but Henri Quatre's liberality could not placate the rancor of fanaticism, and President Carnot's generous confidence in the affection of his

countrymen did not save him from the dagger of conspirators who hated him as the representative of authority, with absolute indifference to his qualities as a man. The attempt to extirpate such mutineers against the principle of law and order has overtaxed even the resources of the Russian autocrat, but it would be less impossible to improve the present plan for preventing the peculiar methods of their propaganda. "The garotting epidemic of the English metropolis," said Deputy Bergeaud, "was suppressed in a month by treating brutal offenders of that sort to a dose of the whipping post, and the mania of our political amuck-runners could undoubtedly be cured by a similar prescription. The prospect of the guillotine has no terror for those wretches, a large plurality of our butcher-knife assassins and dynamitards are men at war with themselves, as well as with society in general,—desperadoes who engage in murderous enterprises with the deliberate resolution of risking the consequences of their crimes. Their recklessness is, in fact, a modified form of suicide; they are weary of life, but dread direct modes of self-destruction, and enjoy the idea of preparing the finale of their life's tragedy with a few weeks of excitement: notoriety, the gratitude of newsmongers and the applause of their fellow fanatics. The last act of expiation, they know, will be swift and almost painless; they are insensible to shame, and exult in the thought that society is unable to hurt their feelings. It would be a good plan to dispel that illusion."

THE NEMESIS OF REFORM.

It is true that reformers are specially apt to step on the sore toes of some contemporary dreading invasion of his hereditary prerogatives, and that every change of political institutions tends to provoke the vendetta of conservative bigots. But that circumstance only emphasises the necessity of forestalling the risk of assassin epidemics, f[illegible] no doubt that the history of the next twenty decades [illegible] an age of reform. The world does not [illegible] of a superstition-disturbing truth:

[illegible] rav, vergehens tüchtig,
[illegible], man will sogar dich nichtig,"

but it is enough that the leaders of emancipation have to fight the harpy-brood of envy, bigotry, and stupidity, without unchaining the furies of nihilistic fanaticism—that hatred of social order directs its blind rage against *aristocracy* even in the sublime original sense of the word—the Rule of the Best.

SAM JONES'S PRECURSORS.

There is nothing new under the sun, even in the way of burlesque pulpit orations, and several hundred years ago the Vienna court chaplain, Abraham de Santa Clara, moved his hearers by turns to tears and paroxysms of laughter. Most of his jokes were pointed by his talent of mimicry, exerted at the expense of small and great transgressors; but some of his sermons are wholly untranslatable and would nowadays be apt to scatter even a congregation of South Carolina darkeys. Dr. Luther and his chief opponents, Eck and Hochstraten, vied in the use of grotesque invectives, and various extravaganzas of English slang have been traced to the sermons of Bishop Latimer, who, e. g., used the phrase "Going to pot," in the sense of being on the road to Dante's picnic-grounds.

THE AMERICAN SCAPEGOAT.

Four hundred years ago every public calamity was blamed on the Jews. In America the prowling tramp has taken the place of the mediæval back-alley bugbear. Unaccountable fires, murders, and dam-breaks are all booked to his credit, and even during the recent strike some fifteen different railway disasters evolved the theory that malicious vagrants must have tampered with the switches and air-brakes.

AN ANCIENT INSTITUTION.

Two hundred years ago the English Puritans would have mobbed a man for hinting that the world could possibly be more than eight thousand years old. Now Sir Archibald Gerkie demonstrates that certain rock formations of our planet indicate an age of at least 85,000,000 years. The length of what zoölogists call the mammalian era is another question, but there are reasons to believe that in the valleys of the French Jura, men, or manlike apes, existed 15,000 years ago.

A KNOUT MANUAL.

The Grand Duke Constantine is going to publish a treatise on the "Principles of Education." The work will be distributed in the Russian normal schools, and is almost sure to prove a hit, as the distinguished author is known to have a bias in favor of striking arguments. FELIX L. OSWALD.

NOTES.

A misprint occurs on pape 4147 of *The Open Court* at the close of the article "In Memoriam of Gen. M. M. Trumbull. The phrase "the supernatural God of science," should read "superpersonal God of science."

With reference to the article "The Latest Development of an Old Disease," a reader gives us the information that the name of the disease is *Debs*omania, but we are not informed whether Mr. Keeley is able to cure it.

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