

As already announced by Prof. Rowland, it appears that the anode is as important in the matter as the cathode. We have a number of tubes which give results, but none better than the one mentioned, while a tube just received, of American manufacture, promises to equal the imported ones.

The success so far obtained with the arm and chest encourages us to think that still thicker portions of the human body may be studied advantageously, and experiments will be immediately undertaken in this direction.

DAYTON C. MILLER.

CASE SCHOOL OF APPLIED SCIENCE,

March 25, 1896.

[The photographs referred to by Prof. Miller, like all others of a similar character, are difficult of adequate reproduction by photogravure. The bones of the wrist and the large bones of the forearm are splendidly shown and the aluminum medal shows detail nearly as well as an ordinary direct photograph. T. C. M.]

THE INVERTED IMAGE ON THE RETINA.

I CANNOT justly take to myself the severe remarks which Prof. Brooks makes, in the last number of *SCIENCE*, concerning those who have understood him to mean that there is something peculiarly inconceivable in the *inversion* of the image on the retina; I did not myself take this view, because I happened to know, before writing my letter, that he disavowed this interpretation of his words. I even fail to understand by what rule of logic he drew the conclusion that he was the distinguished scientist to whom I alluded when I used these words: "Prof. Brooks can hardly hope that there should be any consensus among scientific men in regard to * * * * *consciousness*, if there are still distinguished scientists who think that there is anything which needs explanation in the fact that the image on the retina is inverted." (I add the italics now.) This view of the matter is not uncommon, as the following instances, in addition to the discussion which has been going on for more than six months in *SCIENCE*, and which Prof. Brooks has found so wearisome, will indicate. A physician who had been travelling among the Esquimaux recently reported

before a medical society in Philadelphia that those people are in the habit of holding a picture upside down when it is given them to look at; he accounted for this curious fact by supposing that they were in such a low state of development that they had not yet learned to reinvert the image on the retina, and this hypothesis was seriously discussed by this body of physicians, without having its absurdity pointed out by a single member. As another instance, I mention that a prominent Baltimore physician, in writing on the sensations of infants, lately said that they see everything upside down at first, and only learn afterwards to correct this impression.

Since Prof. Brooks has included me among those who have failed to take his meaning as he intended it, he cannot complain if I come to their defence in a single word. He had said: "We all believe many things that are inconceivable, such as the truth that the image in the retina is upside down;" and again, "I illustrated, by the inversion of the retinal image, the fact that evidence may furnish conclusive proof of truths that are inconceivable." Now, while it is true that "if, for purposes of illustration, I declare my conviction that the moon is not made of green cheese," no one has a right to infer that I think the moon is made of cheese of any kind, this supposititious assertion offers no analogy to the case in hand. If a person said that he could not believe that *the cheese of which the moon is made is green*, and also that he was not able to believe in the *greenness of the cheese of which the moon is made*, he would be using expressions precisely analogous to those made use of by Prof. Brooks in the case of the retinal image. Would anyone be expected to use language like this, unless it was the greenness only that troubled him?

C. L. F.

NECESSARY AND SUFFICIENT TESTS OF TRUTH.

EDITOR OF *SCIENCE*: When Prof. Brooks says that it is a 'great law of logic that the test of truth is evidence and not conceivability,' he uses the phrase 'test of truth' in a loose way which (while it is not uncommon), in the interests of logic, I must protest against.

To the mathematician it has long been a

thing which he has at his finger's end to make the distinction between the *necessary* and the *sufficient* condition for the truth of a statement, and there is no reason why other scientists should not speak with the same precision. One thing is the *necessary* condition for the truth of another, if the latter cannot be true in its absence; it is the *sufficient* condition, if it must be true in its presence. It may be matter of question whether 'test of truth' should be used in the sense of necessary or of sufficient condition of truth, but it certainly should not be used in both senses in the same sentence. 'Evidence' is the *sufficient* condition for the truth of a statement, but it is not in every instance *necessary*. I need no evidence to convince me that I am conscious. Now those who regard conceivability in the way that Prof. Brooks objects to, do not for a moment consider it to be a *sufficient* condition of the truth of any statement, but they do consider it to be the *necessary* condition of the truth of every statement. The inconceivability of a statement is for them the sufficient test of its falsity, and its conceivability is the necessary test of its truth. Instead of saying, therefore, with Prof. Brooks, that *the test of truth is evidence and not conceivability* (a statement which gives me a slight feeling of dizziness), it would be better to say that *the test of truth is evidence, and inconceivability is no criterion* (or test) *of falsity*, provided the exact terms, necessary and sufficient, should be considered too pedantic.

I have used the terms *necessary* and *sufficient* because they have been consecrated to this purpose by the mathematician, but I believe that *essential* and *sufficient*, or perhaps *requisite* and *sufficient*, would convey the meaning much better for ordinary language. We should then say, *evidence is a sufficient test* and conceivability is not a requisite test of truth*. The sentence "conceivability is not a necessary test of truth" is somewhat ambiguous; it might mean 'is not a test such that the truth necessarily follows from it,' instead of 'is not a test which it is necessary to have fulfilled if the truth is to hold.' But 'requisite test of truth' is not open to any ambiguity.

* That, for nearly all truths, evidence is also a requisite test, is true, but is denied by no one.

I am convinced that if the terms requisite and sufficient (or something equivalent to them) were to come into common use as defining the *kind* of ground, reason, argument, condition or test that the writer has in view, it would conduce very much to facility of comprehension on the part of the reader. M. M.

THE TEMPERATURE OF THE EARTH'S CRUST.

MR. SERENO E. BISHOP, in his letter in SCIENCE, March 13th, remarks that it would be interesting to ascertain what are the rates of increase of temperature now under regions where the subsoil is permanently frozen, as in the tundras of Siberia and Alaska.

Attention may here be called to the Report made to the British Association in 1886, by the committee appointed to organize a systematic investigation of the depth of the permanently frozen soil in the polar regions. Of some twenty-two localities mentioned in that Report, Jakutsk, Siberia, lat. 62°, is perhaps the most noteworthy, the limit of the frozen soil being 620 feet and the temperature rate 1° for 28 feet.

The transcendental formula employed by Lord Kelvin in his well-known chapter on the 'Cooling of the Earth' furnishes results in marked harmony with the temperature rate as determined by many observations. (Prestwich, Proceedings of the Royal Society, 1886.) It does not logically follow, of course, that Lord Kelvin's premises are necessarily correct. However, whether we accept the argument in the 'Cooling of the Earth' or rely on observations alone, we must for the present regard 1° F. per 50 feet (approximately) as expressing the law of the rate of increase of the temperature of the earth's crust near the surface; some local factor should be looked for as the cause of such an exceptionally low rate of increase as that found in the Calumet mine, or such a high rate as that in the Jakutsk mine. In any case it is scarcely safe to assume, as Professor Agassiz seems to do, that the rate observed to the bottom of the Calumet mine holds to the depth of 19 miles and beyond, and thence to conclude that the earth's crust has a thickness of 80 miles. The crust of the Lake Superior region may have counterbalancing abnormal features, so that the low temperature rate for the first mile is amply