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THE LIMITS AND POWERS OF VISION.

Delicacy of vision is due to two causes: sensitiveness of the retina, which allows of the perception of minute differences of light, or, in other words, of the clear definition of objects illuminated very slightly more or less than the background against which they appear; and the perfection of the different portions of the eye itself, which admits of the perception of very small objects, or of separating those nearly approximated without the images becoming confused through irradiation. Dr. Carpenter states that the smallest particle of a white substance distinguishable by the naked eye upon a black ground, or of a black substance upon a white ground, is about $\frac{1}{400}$ inch square. "It is possible by the closest attention," he continues, "and by the most favorable direction of light, to recognize particles that are only $\frac{1}{840}$ inch square, but without sharpness and certainty. But particles which strongly reflect light may be distinctly seen when not half the size of the least of the foregoing. Thus, gold dust of the fineness of $\frac{1}{1125}$ inch may be discerned with the naked eye in common daylight. When particles that cannot be distinguished by themselves with the naked eye are placed in a row, they become visible, and hence the delicacy of vision is greater for lines than for single particles. Thus, opaque threads of more than $\frac{1}{4800}$ inch across, or about half the diameter of the silkworm's fiber, may be discerned by the naked eye when they are held towards the light."

Professor Mayer, in the first of his admirable papers on the "Minute Measurements of Modern Science," now appearing in the SCIENTIFIC AMERICAN SUPPLEMENT, states that by actual experiment he has determined the limit of visibility of the minute to be exemplified by a disk $\frac{1}{800}$ inch in diameter and a line about $\frac{1}{2000}$ inch in breadth. The same authority has found from several measures that a line $\frac{1}{1000}$ inch in breadth is obtained by drawing the finest line possible on Bristol board with a sharply pointed H H H pencil.

In general, in order to distinguish clearly a dark object on a light ground, or the reverse, it is necessary that the object subtend an angle of at least one minute. But this again is dependent upon accidental and often personal conditions. Gassendi, the astronomer, was unable to perceive with the naked eye (protected only by smoked glass) solar spots subtending angles of 80 seconds; while other astronomers have, by practice, acquired the power of distinguishing spots of 50 seconds in diameter.

On a clear moonless night, every one possessing average powers of sight is capable of discerning stars of the sixth magnitude. There are, therefore, at any time two thousand stars visible above the horizon, or about four thousand over the entire heavens. But under very favorable circumstances and in the absence of all other light (reflection of terrestrial lights, zodiacal light, twilight, etc.), when the atmosphere, cleansed by recent rain, is very moist and the stars seem exceptionally brilliant, heavenly bodies between the sixth and seventh magnitude are also discernible by the naked eye. The contrast due to the apparent extinction and apparition of the smallest stars, a phenomenon due to their twinkling, allows of their being momentarily perceived, especially by the parts of the retina a little to one side of the direct point of formation of the image, as these parts are usually more sensitive on account of their not being normally used for visual purposes. Under these conditions, persons whose sight has become acute through repeated observations are able to see, in the entire heavens, some eleven thousand stars, this aggregate having been determined by the astronomers Heis, at Munster, and Gould, at Cordova.

It is ordinarily possible to see six stars in the Pleiades; some people can distinguish seven. Heis has counted ten, Denning at Bristol saw thirteen, and Maestlin, Kepler's preceptor, saw fourteen. Mr. Heis possesses both the qualities of delicate vision above noted in a remarkable degree. In full sunlight he has perceived Venus, Jupiter, and Mercury; and at night, when the moon was absent, he saw Vesta and Uranus, with the unassisted eye. So clear is his sight that he is at all times able to separate the two neighboring stars of η of the Great Bear, and also those relatively distant 6′ 30″ known as α in Capricornus. When the sky is very clear, he has resolved w of the Scorpion, δ of the Lyre, and ε of the same constellation, of which the stars are distant but 3′ 27″.

There are, however, well known cases of even more wonderful feats of vision. The difficulty of perceiving the satellites of Jupiter is enormous because of the great brilliancy of the planet and the nearness of the satellites. The first of the latter is distant but two and a quarter minutes, and the fourth nine minutes and three quarters. They vary in brilliancy from seventh magnitude downward, so that in any event they are radically invisible to the average naked eye. The third satellite is the largest and brightest, and hence this one is most frequently seen, although Heis, with all his wonderful powers, has never accomplished its perception. Jacob, however, saw it at Madras, and Buffham and Mason in England. Boyd saw both the second and third satellites separate and distinct in 1860, and Denning perceived the third and fourth, in 1874, by masking the bright face of the planet. Schoen, a tailor of Breslau, perceived the first and third satellites at the time of their greatest elongation. These are the most difficult to separate, owing to their proximity to Jupiter.

Probably the most difficult feat of all recorded done by human sight is the perceiving of the crescent of Venus. This has been done but three times, once by Stoddard, a missionary on the high table lands of Persia, once by Theodore Parker when a child in Chili, and once by Abbé André, in 1868, in France. The Abbé saw the crescent when it subtended an angle of but fifty seconds.

TRANCE.

Whether his particular theories and opinions do or do not hold strictly correct when gauged by more extended future investigation, Dr. George M. Beard, of this city, is doing capital work in directing the light of purely scientific inquiry upon that host of psychological delusions, which occupy a vaguely defined suppositious borderland of science. It is hard nowadays for any thinking person to view with equanimity the miserable deceptions which are imposed, not upon the obviously ignorant, but apparently upon the most enlightened portion of the community. College professors, to whom we look for the careful training of young minds, have lent themselves to the serious consideration of the absurd performances of a self-styled mind reader. A person of morbid intellect was recently enabled in this city to inflict a room full of sensible people with a lecture replete with the profoundest nonsense, through the wholesale publication of an invitation apparently signed by some of our foremost citizens. Blue glass panes, dotting the windows of scores of the finest mansions, attest the fact that a popular delusion is by no means confined to the presumably educated. "The outcome of two thousand years of human learning since the foundation of the science of logic by Aristotle," says Dr. Beard, "is that the *Encyclopædia Britannica*, in its latest edition, regards it as an open question whether ghosts appear." In short, even if the majority of people do not absolutely acquiesce in a modern form of superstition or delusion, they declare with Emerson that all these claims are mysteries of which a wise man would prefer to be ignorant. Credulity, then, on one hand, ignorance on the other, whether self-imposed or not: these are the mental states, which generate a third, wherein a reasoning being bids farewell to his reason, wherein a logical mind becomes illogical, and doubt, surmise, and deception reign unchecked.

Dr. Beard has made an especial study of the symptoms connected with the nervous system, whereon are based the superstitions known as mesmerism, animal magnetism, hypnotism, etc. As the result of his investigations, he propounds the theory that "trance is a functional disease of the nervous system, in which the cerebral activity is concentrated in some limited region of the brain, with suspension of the activity of the rest of the brain and consequent loss of volition." From this hypothesis, he deduces explanations of all the various phenomena which have been ascribed to the causes above detailed. For the sake of convenience, trance is divided into four varieties: the spontaneous, the self-induced, the emotional, and the intellectual trance. A typical form of the first is natural somnambulism or sleep-walking, in which, "the cerebral equilibrium being spontaneously disturbed through the subjective action of dreams, the subject, under the dominion of a restricted region of the brain, the activity of the rest of the brain being suspended, runs and walks about like an automaton. Under self-induced trance are comprised those cases where the subject can bring himself into this state at will, either suddenly or gradually. This can be accomplished by low living, approaching nearly to starvation. Emotional trance, which includes by far the larger number of cases, may be induced by fear, reverence, wonder, or expectation, exerted to such a degree that the activity of the brain is suspended, while these emotions are abnormally active, and consequently the will loses control and the subject acts automatically in response to external or internal suggestion, doing the very things he wishes to avoid doing, and being unable to do what he desires. It is of no consequence in what manner this trance is produced; it is purely subjective, and depends wholly upon the emotions of the subject. The mesmeric operator or medium has really nothing to do with the physical effect produced; it is only necessary that the subject believe in him. To intellectual trance belong the extreme cases of absent-mindedness. A large portion of the brain is active, and, until aroused, is insensible to surroundings and responds automatically to external suggestions or influences.

We cannot here follow Dr. Beard in detail through all the phenomena of trance to which he shows that his theory can be fitted. Some of his explanations are exceedingly ingenious, and merit study; and the simple simile, which he offers to realize his distinction between sleep, trance, death, and normal waking state, is quite happy. "When all the burners of a chandelier are fully lighted," he says, "that is the normal waking state; when all of the burners are turned down low but not turned out entirely, that is ordinary sleep; if I turn out entirely all the burners except one, and that one, as often happens, flames all the more brightly from increased pressure, that is trance; if all the burners are turned out entirely and permanently, that is death."

The application of the hypothesis to the singular phenomenon of double life—cases of which we have repeatedly noted—is perhaps the most interesting. In trance there is probably always consciousness at the time; but it is not always or usually remembered consciousness. On awaking, the dreams fade; but on resuming the trance state, the exalted functional activity of the region of the brain in which the cerebral force is concentrated is able to bring back these impressions of the previous attack of trance, forgotten during the intervening normal state. Thus the subject carries on an independent trance life. On returning to the normal state, the cerebral force, being again diffused, is insufficient to enable the subject to recall trance experience, but quite

sufficient to enable him to recollect his normal feelings. Thus he leads two independent lives.

The direct consequence of Dr. Beard's theory is that it tends to reduce all such delusions as clairvoyance, spiritualism, etc., to one common basis of scientific hypothesis; but the indirect consequence seems to us to be fraught with much graver interest to society. The only deduction to be drawn is that there is more evidence of the irresponsibility of humanity, further proof of another state when man may be but an automaton. Last week we brought forward competent medical evidence to prove that a drunken man is as irresponsible as a lunatic. Here again is expert testimony to the effect that, under a host of other conditions, a person may become unaware of his own acts. If fear and excitement are powerful exciting causes for trance, and the person in the trance or near the trance state receives erroneous impressions, wherein is the value of evidences by eye-witnesses of crimes committed under circumstances of great fear or excitement? Testimony as to sudden accidents might be similarly viewed with doubt; yet on the other hand, if we admit irresponsibility in the entranced person, how are we to guard ourselves against deception? for, as Dr. Beard says, "nothing is easier to counterfeit, after slight practice, than the early physical symptoms of trance." We cannot but agree with our author in the view that the day for the examination of this subject by the average individual has gone by, and that the only reliable informant is the medical expert. We do not send committees of lawyers and clergymen to examine peculiarities in construction of buildings; how much less logical is it to ask them to comprehend the hidden phenomena of brain construction? We need something more than a report of what trustworthy men think they see; and that something is the testimony of experts who look to causes and not to mere visible effects.

THE BANIAN TREE.

Of the remarkable phases of vegetable growth, that of the banian tree is certainly the most astonishing. We have more than one running plant, which, like the wild strawberry, spreads around a central stem by dipping into earth its distant branches, and thus establishing subsidiary centers; and in the mangrove of our southern shores we may see a tree, of considerable height, dropping from elevated limbs a number of whip-like roots which penetrate the ground, often through a foot or more of water; then, reversing their circulation, they become true stems, capable of maintaining themselves when separated from the parent stock. But, even with these illustrations before us, it is hard to realize the appearance and life conditions of a wide-spreading communal forest, the connected outgrowth of a single tree.

The anomalous physiology of a mangrove or banian root stem we have never seen described. How is it that its character is so completely reversed? At first its growth is downward, by a true root-like increase of cell structure at its free end. It remains perfectly cylindrical throughout, without the slightest variation in diameter, until it branches in the ground. Up to this point its circulation is downward from the parent stem: but now all is changed. It ceases to be a root, and becomes a stem, growing and supplying its branches with sap like a tree trunk of ordinary growth.

The banian adds another strange peculiarity, namely, that it rarely sprouts from the ground, the crown of a palm being usually its starting place. The banian seed is dropped by some bird into the frond, or upper cluster of leaves of the palm, and, sprouting there takes root within the palm: this commonly when the palm is in its infancy. The palm grows upward, an unbranching column. The banian spreads outward and begins to send its root stalks downward from its branches; not diverted twigs, but special growths, true aerial roots. With this exception, Milton only describes without exaggeration, when he writes of this tree as

> "Branches so broad along that in the ground
> The bending twigs take root, and daughters grow
> About the mother tree, a pillared shade
> High over-arched, with echoing walks between."

Meantime the palm is pushing upward, embraced by the descending banian shoots, which become so interlaced in course of time that the trunk of the palm is wholly concealed. At this stage appearance flatly contradicts reality; the palm seems to be growing from the heart of the banian, as though a date seed had taken root in the banian top. Possibly the curious Hindoo custom of marrying trees of different species had its origin in, or was suggested by, these natural unions.

The banian (*ficus Indica*) is one of the great natural family the *urticaceæ*, to which our familiar stinging nettle also belongs. It bears a small red fig or berry, which in times of famine has afforded food for thousands. An instance of the vast extent of country which may be covered by a single-tree banian grove is furnished by the island of Nerbudda, which is entirely covered by one tree. A considerable portion of the island and the grove growing upon it has been washed away by river floods during recent years; but enough remains to make one of the noblest groves in the world. The natives boast that it once afforded shelter for a troop of 10,000 horses. Another extensive banian forest—all parts of one tree—occurs in the district of Beerbhoom, in Bengal. It covers "an immense extent of country," and overshadows more than four hundred temples.

The bride of the banian, in the ceremony above alluded to, usually the sacred *peepul*, or bo-tree (*ficus religiosa*). It is one of the latter that inspires such widespread reverence among Thibetian and other Buddhists, from the circumstance that its leaves bear well marked characters in their sacred language. That these characters are not the work of the priests who have charge of the tree seems to be well established. A couple of French missionaries who were permitted to examine the tree report their inability to discover the least sign of art in these mysterious—and to the Buddhists miraculous—markings. "We examined," they write, "everything with the closest attention, in order to detect some trace of trickery, but we could discern nothing of the sort; and the perspiration absolutely trickled down our faces under the influence of the sensations which this most amazing spectacle created."

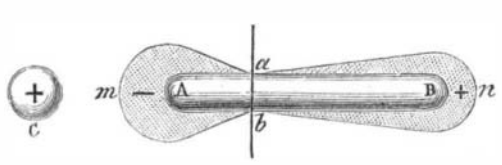
The mental attitude of these perspiring missionaries, when brought face to face with an alleged miracle that bore no evidence of trickery, is instructive. That the markings could be natural seems not to have occurred to them. Dr. Hooker, from his familiarity with Nature in India, was able to explain the miracle offhand with the single word "insects!"

VOLPICELLI'S NEW THEORY OF ELECTRO-STATIC INDUCTION.

An insulated conductor charged with either kind of electricity acts on bodies in a natural state placed near it in a manner analogous to that of the action of a magnet on soft iron, that is, it decomposes the neutral fluid, attracting the opposite and repelling the like kind of electricity. The action thus exerted is said to take place by influence or induction. The usual apparatus for demonstrating this hypothesis is a brass cylinder placed on an insulated support and provided at its extremities, or at various points along its length, with pith balls suspended by linen threads. If this arrangement be placed near an insulated conductor charged with either kind of electricity, the natural fluid of the cylinder is supposed to be decomposed, and free electricity is developed at each end, when both pith balls there located will diverge. The electricity of opposite character to that of the conductor goes to the end of the cylinder nearest that conductor, while electricity of the same kind as the conductor seeks the further extremity. There is a point on the cylinder where no divergence of the pith balls occurs, and this is termed the neutral point.

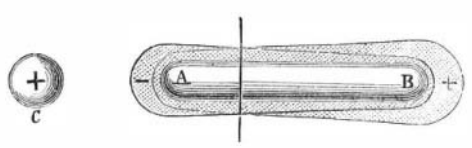
This hypothesis was, some thirty years ago, attacked by Melloni, who asserted that the imaginary electric fluid was not separated into its positive and negative components, but that both of the latter existed all over the cylinder, although, in point of quantity, there was more negative fluid on the end nearest the positive conductor and more positive fluid on the opposite extremity. The difference between Melloni's theory and that first noted will be clear from the annexed engravings. If the inducing source, *c*, Fig. 1, is positively electri-

Fig. 1.



fied, all the negative fluid of the cylinder, A B, according to the old hypothesis, goes to *a m b*, and all the positive fluid to *a n b*, *a b* being the neutral point. Melloni's idea is exemplified in Fig. 2, where both kinds of electricity exist in some degree over the entire cylinder. Melloni had scarcely more than reached a definite conclusion on this subject when

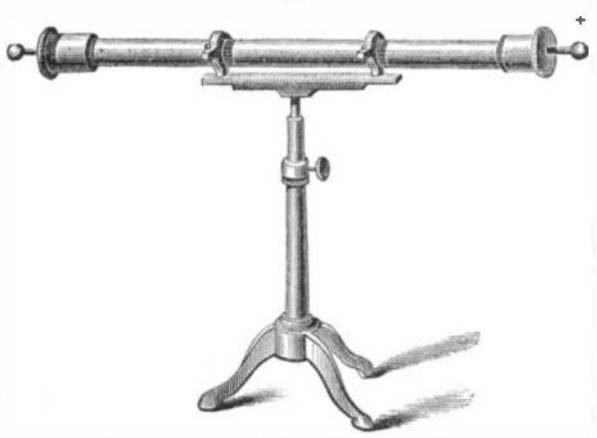
Fig. 2.



he died; but his work was taken up by M. Volpicelli, who for some twenty years has pursued the necessary investigations, and has recently announced conclusions confirming those of their original enunciator.

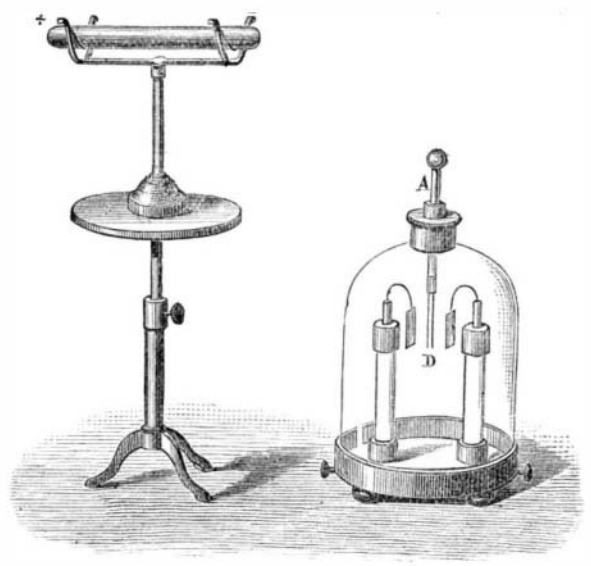
M. Volpicelli's apparatus consists of a large glass tube, 70 inches long, terminated by metallic armatures, and contain-

Fig. 3



ing a dry pile composed of 24,000 disks closely packed together and covered with a layer of copper on one face and of peroxide of manganese on the other (Fig. 3). This battery works uniformly for several months, and is a constant source of electricity. The body on which the induced electricity is developed is an ordinary glass cylinder, perfectly isolated by threads of raw silk, by which it is suspended in the crotches of a support (Fig. 4). The electricity rendered free by induction is taken on the cylinder by means of a little proof plane, which merits a special description; for the success of the experiments is largely dependent upon the excellence of the instruments used and the care with which all possible causes of error are avoided. The plane is composed of two small disks of copper, 0·35 inch in diameter, separated by a thin layer of insulating varnish. One of these disks is in communication with the soil by means of a metallic rod which is held in the hand. The other disk is fixed to a metallic rod terminating in an ivory ball, which slides freely in an opening situated in the middle of the first disk and in an eyelet carried by an annexed arm. In order to use the device, the two disks are brought into contact, and the movable disk is placed on the cylinder. The free electricity on the surface of the latter condenses on the disk, and may be transported to a distance, as, for example, upon the exterior armature of an electroscope, situated far enough away from the dry pile not to be influenced by it. M. Volpicelli also uses a proof plane consisting simply of a pin head. A portion of the end of the pin is cut off, and the rest inserted in a knob of sealing wax at the end of a metal handle. A Böhnenberger electroscope, containing improvements devised by M. Volpicelli, is also used. The two plates, towards which the gold leaves, D, are attracted when the exterior armature, A, is electrified, are supported by two glass columns containing dry piles analagous to those of the large inducing cylinder (Fig. 5). This electroscope has

Fig. 4. Fig. 5.



great sensibility. It might be termed a kind of electrical microscope.

In order to make the experiments, the insulated cylinder is properly placed in view by the electric source. It becomes electrified by induction. The free electricity on the cylinder is collected by the proof plane; and with the charge plane the electroscope is touched. The following phenomena then appear:

1. The free electricity found on the portion of the cylinder nearest the electric source is of the same character as that of the latter. This is diametrically opposite, of course, to the assertion of the old theory. The experiment may be repeated five or six times successively.

2. If the cylinder be placed in communication with the soil, so that the free electricity is allowed to escape, and the experiment with the proof plane be again tried, no sign of electricity is manifest.

3. If the cylinder be moved away from the electric source, so that the influence of the latter is diminished, and the proof plane be applied, the electroscope to which the latter is touched indicates an electricity of opposite character to that of the inducing body.

M. Volpicelli sums up the result of his investigations as follows: "Upon an insulated conductor submitted to the influence of an electrified body, electricity of opposite name possesses no potential. It is found in greatest quantity at the end of the conductor nearest the electrified body, and diminishes towards the opposite end. Electricity of the same name as that of the electrified body is found at all points on the insulated conductor, the end nearest the electrified source not excepted. It increases as it approaches the other extremity, and is always free." We extract our engravings from *La Nature*.

A New Projectile.

Mr. W. H. Lewis, a Welsh gentleman, of Hafod, near Swansea, has invented a new engine of warfare, which will be likely to attract considerable attention. It consists of a cannon, so arranged as to discharge a sharp sword-blade crosswise in the direction of the enemy, the knife or cutter being so poised in its career through the air as to cover the whole space in a longitudinal direction described by the blade itself. An 8-inch ball would carry a sword 14 feet in length 600 yards, literally mowing down every human obstacle in its path.