

Scientific American.

ESTABLISHED 1845.

MUNN & CO., Editors and Proprietors.

PUBLISHED WEEKLY AT
NO. 37 PARK ROW, NEW YORK.

A. D. MUNN. A. E. BEACH.

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VOL. XXXVI., No. 26. [NEW SERIES.] Thirty-second Year.

NEW YORK, SATURDAY, JUNE 30, 1877.

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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 $\frac{1}{100}$ 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 $\frac{1}{100}$ 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 $\frac{1}{125}$ 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 $\frac{1}{100}$ 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 $\frac{1}{300}$ inch in diameter and a line about $\frac{1}{100}$ inch in breadth. The same authority has found from several measures that a line $\frac{1}{100}$ 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 Moestlin, 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 δ 30' known as α in Capricornus. When the sky is very clear, he has resolved ν 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