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DISCUSSION AND CORRESPONDENCE.

HOW TO AVOID THE DANGERS OF FORMALIN.

TO THE EDITOR OF SCIENCE: In the issue of SCIENCE for October 22d I note a letter by Dr. Dall, of the United States National Museum, in which the use of formalin for the preservation of zoological objects for dissection is declared to be dangerous to the cuticle, to the digital neural terminals and to the eyes of the dissector.

When working with formalin my eyes and nasal passages have been affected and it seemed to me that its use might be fraught with some danger. But the effect of the gas arising from specimens and of the solutions has never given in my case such serious trouble as seems to have been given the person of whom Dr. Dall speaks. To be contrasted with the effects of the reagent in this case is the fact that formalin and formaldehyde have come to be regarded as very important germicidal disinfectants to be used in inhabited rooms, where, we are told by members of the medical profession to which Dr. Dall appeals, that their use need not endanger in any way the inhabitants. Special lamps are on the market for generating formaldehyde from wood alcohol, and to be used in just such rooms. There may also be noted an experiment performed upon a calf, in which the animal was exposed for five hours to an atmosphere containing about 2% of formaldehyde. The only noticeable effect was a slight cough and a slight watering of the eyes, both of which disappeared upon bringing the animal into fresh air. What might have happened had the animal been subjected to such an exposure daily for several weeks is a question that remains to be solved. In view of the fact that formalin seems destined to be used to a very great extent in laboratories and museums, and also in view of its having been recommended as a disinfectant to be used as noted above, experiments to determine how great an exposure eyes, cuticular organs and mucous membranes can stand without injury can have nothing less than a very great importance.

But even though the use of the reagent is as dangerous as the case of the slug dissector mentioned by Dr. Dall would lead one to think, such dangers may be obviated by taking advantage of the strong affinity formaldehyde and ammonia have for one another. In rooms where formaldehyde is used dishes of ammoniated water may be placed, and specimens preserved in formalin may be washed in ammoniated water before dissection, with the result of completely neutralizing the effects of the disinfectant or preservative.

F. C. KENYON.

WASHINGTON, D. C.

PROFESSOR CATTELL'S REVIEW OF 'SIGHT.'

I RARELY ever reply to any criticism of a work of mine. I never do so unless to explain something misunderstood. But in the case of Professor Cattell's review of 'Sight' in SCIENCE for September 24th, I feel the less hesitancy because of his generous estimate of its value. There are three points on which I wish to explain myself more fully.

1. Professor Cattell objects to my view that "the central spot is necessary to the development of the higher faculties of the mind," and asks in rejoinder: "May not the mental faculties of the born-blind be developed?" And well might he object if I implied anything so absurd. But he has entirely mistaken my meaning. Perhaps I am partly responsible for a possible ambiguity, and, therefore, thank him for drawing my attention to it. I did not mean development of the higher faculties in the *ontogeny*, but in the *phylogeny*, of man; not in the education of the *individual*, but in the origin of the *race*. Perhaps, however, I ought to have used the word *evolution* instead of development. I shall make the correction.

2. Again Professor Cattell objects to my saying: "We see things double except under certain conditions." He says: "This is bad psychology. We *learn* to see them double." Of course, we learn to consciously see them double. But if we see only what we consciously see, we see comparatively little. The phenomena of double vision lie so near the surface of consciousness that the least attention recalls them. They may be called subconscious, but we base our judgments on them all the time. Surely it is the business of psychology to bring

into clear consciousness phenomena which underlie so much of our daily conduct.

3. The last point which I wish to touch is again the much discussed question of *upright vision*. I feel like apologizing for bringing up this question again; but I am convinced that much of the difference of view is the result of misunderstanding. For example, I explain upright vision by the *law of direction*. Now, surely, Professor Cattell must misunderstand the explanation when he talks of standing on one's head and still seeing things upright as controverting that law. The law of direction explains uprightness equally well, whatever be the position of the observer. I am sure the question has been obscured and the mystery intensified by that wonderful inverted retinal image. But seeing things upright is not necessarily connected with an inverted image. It is easy to imagine an eye so constructed that the retinal image shall be upright, and yet by the law of direction the object shall also be seen upright. We probably have something like this realized in the case of insects. The compound eye of insects is so constructed of slender tubes lined with pigment that only the central rays of each radiant pencil can reach and impress the retina, all others being quenched by striking on the sides. This, as shown by the figure, would make an upright

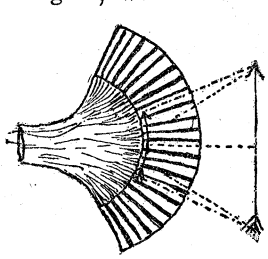

FIG. 1. Diagram showing the upright image in the eye of an insect.

image, and yet by the law of direction the object would be seen upright also. Our retina is *concave* instead of convex. It is so because the image is inverted, and, therefore, must be reinverted in the act of outward reference.

The marvellousness of the inverted image has diverted attention from the real question, which is, the seeing things in their true places. A child only a few days old will turn the eyes toward a bright light. Is there anything so mysterious in this? But why *toward*, unless it saw the light in its true direction? Now, upright vision is only a case under this more general fact; for objects are made up of an infinite number of lights or radiants and each is seen in its true direction, and, therefore, the object in its true position.

Professor Cattell refers to the recent experiments of Dr. Stratton* as controverting the law of direction, although he thinks a much easier way of doing so 'is to stand on one's head.' I am glad to have the opportunity to express my admiration of these experiments of Dr. Stratton, and my high estimate of their value; and I cannot think that the simpler mode suggested by Professor Cattell would be at all an adequate substitute. In brief, the experiment consists in the wearing of inverting glasses continually for eight days. The experimenter for that length of time never saw things except reversed. The ground was above and the sky below, things on the right were seen on the left, and *vice versa*. And yet by the end of the experiment all the movements of the body were so adjusted to the new conditions that he could walk the streets with comparative comfort.

This seems very extraordinary, and it is possible that we may have to reconstruct some of our fundamental conceptions of space; but evidently it does not controvert the law of direction. If we only think a moment, we shall see that we already have phenomena approaching in various degrees the extreme conditions of this experiment, but they are so familiar that they do not strike us with wonder. In looking in a mirror one image is *partly* inverted, *i. e.*, it is turned about a vertical axis—it is inverted from side to side, but not up and down. And yet, we easily adjust our movements to the changed conditions. We make complex movements, such as tying a cravat, with ease and accuracy.

Again, in looking through a microscope the image of the object is *completely* inverted, *i. e.*, it is turned about the visual axis 180°; and, yet, with a little practice, we adjust our movements to the new conditions. We slide the object in all directions accurately and even

* Psych. Rev. for July and September.

automatically, although to do so we must move it in a direction exactly contrary to what the image seems to require.

Now, Dr. Stratton's experiment goes one step farther. In this, not only an object, but the *whole external world*, including the visible parts of the body, are inverted. Not only some, but *all* our movements must be readjusted. The results are certainly surprising and may possibly require some reconstruction of fundamental conceptions of space—how much I am not prepared to say, but they certainly do not affect the law of direction properly understood.

The law of direction gives nothing but *the direction of the impressing force*, and this it gives always. Under *normal* conditions, *i. e.*, when the light comes straight, and without deviation from the object to the eye, it gives the true places of objects and radiants, and therefore upright vision; but not under *abnormal* conditions of deviation of the light. For example, we look at an object in a mirror inclined 45° to the line of sight. The apparent object is seen far away, 90°, from its true place; but this does not violate the law of direction, but confirms it. We see in the direction of the impressing force, which in this case—in all cases—is the *last direction of the light.* Again, in gazing at an object through a microscope, we see it inverted, *i. e.*, the radiants are seen in wrong places. But this does not violate the law of direction. We still see every radiant in the direction of the impressing force, but that direction has been changed so as to give wrong places.

So in Dr. Stratton's experiment. At first, at least, we see things in wrong places, *i. e.*, wrong as judged by the deliverances of other senses, but yet in strict accordance with the law of direction, *i. e.*, in the direction of the impressing force. As to the final result of an indefinite continuance of these experiments and whether complete accord in the deliverances of all the senses would ever be reached, so that things would again seem natural as they do now, this seems to me a question of philosophy rather than science, or, perhaps, I should say of psychology rather than physiology. I am not now concerned with it.

But it must be clearly understood that the law of direction is purely a *formal* law, *i. e.*, a law which groups consistently all the facts concerning the relative places and positions of objects in the external world *as we know it.* This is all that it pretends to do. The discovery and announcement of such general formulæ is the main function of science. As to what the external world is, and what space and direction are, that is another matter. These more ambitious questions belong to philosophy, not to science.

In conclusion, I have said that the law of direction is inherited, not acquired. By this I do not mean that in the last analysis it is not due to experience. It does, indeed, come from experience, but not mainly from *individual* experience. It is the result of *ancestral* experience, inherited all along the line of evolution ever since eyes were formed, and finally embodied in brain structure.

JOSEPH LE CONTE.

BERKELEY, October 11, 1897.

WHEN an author replies to a reviewer it is but courteous for the latter to try to show that he has not been careless in his statements.

1. Professor Le Conte's statement (page 78), "I believe that the existence of the central spot is necessary to fixed, *thoughtful attention*, and this again in its turn is necessary for the development of the higher faculties of the mind," I understood to refer both to individual development and to race evolution. The limited field of distinct vision and the associated eye-movements seem to me factors or correlates in the evolution of attention, but by no means 'necessary.' That is a dangerous word to apply to nature, which works in many ways. Most men may be 'visuals', but some of us are 'motiles'; the horse is an 'audile,' the dog an 'olefactor'. As a matter of fact, Professor Le Conte makes a mistake in stating that the 'central spot * * * exists only in man and in the higher monkeys' with a foot-note to the effect that in different forms it is found in some birds. Knox in 1823 described the central spot and fovea in lizards and they have been found in fishes by Carrière, Krause and others. A central spot, *i. e.*, an area of acute vision, has been described in nearly all mammals, though the fovea is probably only present in the pri-

mates. * Professor Le Conte maintains not only that "the fovea is necessary to the concentration of the attention on the thing looked at," but also (p. 302) that "the existence" of the fovea is determined by "the habits of the animal, especially in looking attentively."

2. I regard it as either bad psychology or bad terminology to say: "We do, indeed, see all objects double except under certain conditions." We do not hear each of the overtones of a tone because most people can learn to distinguish them, nor do we know the motives of our actions because we believe that motives exist.

3. I am glad that Professor Le Conte here calls attention to the real psychological problems involved in localization in the field of vision and in the coordination of visual and motor perceptions. The section in his book which I criticised is, however, headed 'Erect Vision,' and he writes: "How, then, with inverted retinal images, do we see objects in their right position, *i. e., erect?* This question has puzzled thinkers for many centuries," etc. The question seems to me analogous to that of the child who asks how people in China with their heads down can hang on by their toes. It may be a popular paradox, but I do not admit that it is a question deserving serious scientific discussion.

J. McKeen Cattell.

A SIMPLE METHOD OF COMBINING THE COLORS.

The following very simple method of illustrating the recomposition of the spectral colors into white light has some obvious advantages in the way of ease of apprehension on the part of the beginning student. It also possesses an additional and not inconsiderable advantage in that it is striking.

A rectangular refraction tank with glass ends is set up in front of the lantern, both being preferably upon a rotating stand. From a horizontal slit a beam is projected and the prism interposed in such a manner that there is sent down into the water the rays of the spectrum, their order from red to violet running lengthwise of the tank. A few drops of milk are mixed with the water, and with care a mixture may be obtained which in a side view shows the separated rays clearly, while at the same time if viewed from the end of the tank it looks quite white. On cutting off either the violet or red end of the spectrum the end view becomes colored.

If a strong beam is available it is better to turn it back toward the lantern by a reflector before sending it through the prism. This brings the violet rays which are least intense nearest the end, where they have to traverse a thinner stratum of the mixture.

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* For the most recent work on the subject *cf* the thesis by Dr. Slonaker in the *Journal of Morphology* XIII., 3. Professor Le Conte himself in a later chapter refers to a more highly organized central area in the lower mammals.

SCIENTIFIC LITERATURE.

Report of Explorations in the Labrador Peninsula along the East Main, Koksoak, Hamilton, Manicuagan and the Portions of Other Rivers in 1892–93–94–95. By A. P. Low, B. Ap. Sc. Annual Report of Progress, Geological Survey of Canada, Vol. VIII., pp. 385.

One of the most interesting and valuable reports which has been issued by the Geological Survey of Canada in recent years has just appeared on the peninsula of Labrador, by Mr. A. P. Low.

The report embodies the results of four years' exploration, during which time Mr. Low has traversed Labrador from north to south and from east to west, and it presents in readable form a summary of our knowledge, not only of the geography and geology, but also of the climatology, botany, zoology and natural resources of this remotest part of the Dominion, the interior of which, prior to Mr. Low's exploration, was practically unknown. Mr. Low's work, the results of portions of which have been previously published in preliminary reports to the Geological Survey, and in papers presented to various scientific societies, has attracted much attention and has recently been accorded an especial recognition by the Royal Geographical Society of England. The report is accompanied by a fine map of Labrador, in four sheets, on a scale of 25 miles to the inch, which is colored geologically along the lines