

possible disturbing influence of fear and novel surroundings in certain convenient and, if legitimate, illuminating experiments.

[NOTE.—On page 268 Professor Mills has put ‘to the laws of nature’ instead of ‘to the laws of its nature,’ which means something rather different.]

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## NOTES ON AFTER-IMAGES.

### LOCATION OF AFTER-IMAGE.

The following *Experiment 1* was made while I studied at Princeton, January 26, 1895. With an ordinary students’ stand-lamp, I closed the left eye, shaded it with the hand, and gazed steadily at the flame until an exceedingly strong image was secured. Then, closing this eye and likewise covering it with the hand, I secured a strong image with the left eye.

Then, with a large piece of cardboard the eyes were shaded from the lamp-light and the after-image of the right eye was projected upon the wall, which was of a light shade. While this image was complementing from green to red, and at just the time the red was well produced, that eye was closed and the image of the left eye was thrown upon the wall, which image was found to be green at the instant that of the right was red. In like manner, when the image of the left eye was complemented into red, and the image of the right eye was at that time found to be green. Opening and closing the eyes alternately, it was found that each eye had its own independent after-image.

*Experiment 2.*—Proceeding as before in securing the after-images opposite in color for the eyes, the left eye was closed and the image of the right eye was projected on the wall. When this after-image had changed to red I projected the after-image of the left eye upon that of the right, that of the left at that instant being green. The combined image appeared green. Upon closing the left eye, or upon shifting its image to the left so as to make two separate images, it was found that the image of the right continued to be red while that of the left was green. The reverse was likewise accomplished. With sufficiently strong images this shifting of images into and away from each other proved an exceedingly interesting and beautiful process.

The above experiments, if taken alone, seem to indicate quite decisively that the after-image pertains to the retina of the eye. Mr. McCurdy, who frequently studied in my room, upon being informed of this experiment, tried it and obtained the same result, and likewise felt satisfied with the evidence of retinal location.

#### AFTER-IMAGE AND TEMPERATURE.

The following describes what was rather an experience than an experiment, since it conducted itself, and that so impressively that I was enabled to chronicle it in detail after going to my room.

It is necessary to explain that, while studying in Chicago, I was accustomed to public speaking each Sunday evening, and finding that a double bath—that is, a hot bath succeeded by a cold one—proved beneficial toward reducing nervous excitement following on the effort of speaking, and conducive to sleep, it was habitually practised.

On an evening in March, 1898, while lying in a bath as hot as I could well endure, my eyes being closed, I noticed a very lively after-image. I presume it had been caused by looking at the gas light in the bath room, although unconsciously. Its peculiar shape and brilliancy attracted my notice so much that I became interested in its life history. Its shape was that of a heart and its color that of the gas flame recently lighted. Besides its peculiar form, another novelty was the trimming of green globules which embroidered the image. While attending this feature I became aware that the image, instead of diminishing in intensity, as becomes the normal after-image, was growing more intense and brilliant. At the time I had become so warm that perspiration stood out on my face and forehead. As I watched, the globular fringe began to shift around to one side—the left side—and to thicken there into a kind of knob. At about the same time another small after-image of exactly the same color and shape as the former image began to form in the right center of the latter. It must be noticed here that the old image persisted in remaining the same color and refused to complement itself. The second image grew rapidly; and now a strange thing took place, namely, the small image moved closer outside to the right of the older and larger, and increased to about the same size. Then both images changed position, rolled over, as it were, upon their sides, with their niches toward each other. The green fringe of globules now concentrated in each image at the niche and the two images began to coalesce. First, the marginal perimeters remained distinct between them, then merged into one separatrix, but eventually disappeared, leaving but one after-

image, with a core, as it were, in the center. At this point the image was much larger than the first image had been, and more intense than any I had ever previously observed. And, strange to say, the color persisted without complementing. That is, in general, for the color had gradually shaded into a beautiful pink, while the center was a sort of apple green. In fact, the appearance of the image at its zenith resembled a large pink candy apple with its green center toward the eye. At this time I was suffering from the heat. Turning on the cold water, the bath began gradually to cool. With the decrease of temperature the size and intensity of the after-image reduced. By the time the bath was reduced in temperature so as to feel decidedly chilly, it had entirely disappeared. The last glimpse I got as it was fast paling—there was an orange colored daub across the left center. When the water was really cold I not only could not get a return of the image, but could get but a very poor after-image by repeatedly gazing at the gas flame.

I judge from this experience that the high temperature of the bath caused a rush of blood to the periphery of the body and so to the end organs of the optic nerves, stimulating the retina, so that feeble impressions were wrought up to remarkable intensity.

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