size of the moon, for example, because, although we receive a clear image which subtends a certain angle, we receive no accompanying sense experience which might enable us to judge the distance of the object. (Astronomically determined distances are not, of course, perceived directly.) Elementary observations in optics show that whenever a real image is formed by a lens, as in the case of images formed on the retina by the lens of the eye, the size of the image decreases as the distance between lens and object increases. We learn in infancy to interpret this relationship between image size and distance of object. The following paragraphs describe a simple experiment which is, in a sense, the converse of our common experience with retinal images.

It is well known that exposure of the eye to bright light produces retinal fatigue and that after one has gazed intently for several seconds at a bright source, there may appear an after-image of the source soon after the eyes are shifted to some less brightly illuminated area. This after-image is commonly seen in a color complementary to that of the source, a fact which has heretofore played a part in hypotheses of color-vision, but which is, for the present, of secondary importance. It is the *size* of the after-image rather than its color to which the writer wishes to direct attention; for this persistent image may be used to produce the illusion of an external object whose apparent distance from the eye may be varied at will, with the result that the illusory "object" changes size, and its apparent size depends entirely upon the observer's judgment of its distance from the eye.

Let the observer, with one eye closed, look with the other eye steadily for ten seconds upon the bright filament of an unfrosted 60-watt lamp situated, say, two feet from the eye. If the gaze is then shifted to some less bright region, there soon appears a pronounced after-image of the lamp filament which may persist clearly for a minute or two because of the fatigue of that portion of the retina which has been so strongly exposed to light. If the observer has difficulty in discovering the after-image, it may be "developed" or made more apparent by blinking the exposed eye occasionally or by exposing it indirectly to intermittent flashing of a low-power lamp (15 or 25 watt). Once the image is seen, it may be followed from spot to spot about the room as the observer shifts his gaze; it may appear as a large object on a distant wall or as a small object on a piece of paper held close at hand. The change in apparent size of the illusory object is immediately evident; it is amusing, for example, to "fix" the object on a finger tip held not far from the eye and to observe the increase in its apparent size as the finger is moved farther away. By observing the after-image on a scale and by recording its apparent size as a function of the observer's distance from the scale, it is possible to check with reasonable accuracy that this apparent size of object is directly proportional to the distance between the eye and the scale on which the after-image appears to be situated.

Because of the well-known phenomenon of irradiation and because of involuntary movements of the eye during exposure to the light, the after-image on the retina is somewhat extended and looks larger than the lamp filament. However, the horseshoe-shaped filament of a 60-watt lamp gives an image which is readily recognized and is sufficiently definite in outline to serve for measurement. A frosted lamp may be used if it is obscured from view except for a small aperture of sharp outline and characteristic shape. The color of the after-image is not always the same but appears to depend upon length of exposure and upon external illumination. It may, at first, be dark blue (roughly complementary to the bright yellow of the source); but in many cases, especially under periodically changing illumination, it may change from dark blue to bright yellow, and by this reversal of color the after-image may be easily detected. In many cases it appears as a bright yellow object like the lamp filament, but with a blue border. When this experiment was tried with a group of twenty students at once, it was found that nearly all of them observed the effects described herein. The experiment may serve to demonstrate to students of physics and psychology certain fundamental facts of vision by the simple expedient of using a strong retinal after-image for purposes of measurement and observation. It is recognized that there may be danger to the eye in prolonged exposure to an intense source of light, but the writer has personally repeated the experiment a great many times without any observed harmful effects.

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## THE OCCURRENCE OF THE TWO RARE GENERA, PROTOHYDRA AND PROTODRILUS, ON THE EAST COAST OF NORTH AMERICA

THESE two genera, so far as can be ascertained, have never before been reported from the North American continent. The first form, *Protohydra leuckarti,* probably represents the most primitive coelenterate of the class Hydrozoa. It was found in a small brackish water creek formed at low tide on the mud flats in New Haven harbor together with numerous Protozoa, rotifers and Turbellaria. Only one specimen was found which after several hours' isolation divided by transverse fission. The two individuals thus formed lived for several weeks in the laboratory, when for some unaccountable reason they disintegrated over night. The animals, which lack tentacles, feed on small

crustacea, rotifers and protozoa, which they capture by means of the expanded spoon-shaped peristome. Although discovered by Greeff in 1870 in Europe, the animal has been collected only occasionally since that time and consequently practically no experimental work has been done upon it. Recently, chiefly through the work of Westblad,[1] the sexual reproduction has been studied, and the extremely interesting observation made that the sex cells are of endodermal origin with the ovaries and testes projecting into the enteric cavity. Only two species are known, *P. leuckarti* Greeff and *P. caulleryi* Dawydoff.

The second animal, *Protodrilus leuckarti* Hatcheck, was collected by Mr. D. J. Zinn, of the Osborn Zoological Laboratory, from intertidae sand near Branford, Conn. Although some eleven species of this archiannelid genus have been reported from Europe, thus far none has been found in North America, chiefly, it is believed, because of failure to collect from its habitat. As is the case with *Protohydra,* little experimental work has been performed upon this form because of its comparative rarity. Very likely large numbers of European invertebrate genera are present here and will be discovered when our coasts are studied more intensively.

Both *Protohydra* and *Protodrilus,* it is believed, offer excellent possibilities for experimental work if they can be collected in more abundance and maintained in culture.

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# SCIENTIFIC BOOKS

## THE TEACHERS OF PHYSICS

WE have probably all listened to a teacher explain in glowing colors his way of teaching physics and have had the feeling that we should rush home and introduce his system into our classrooms. Closer thought, however, shows us that we have been listening to a happy, competent, enthusiastic teacher who has successfully fitted his teaching to his school, his students and his own personality. This same system forced on an overworked, less competent and unsympathetic teacher or a group of students of different training and point of view might well fail even worse than the system now being used. It seems that the same reasoning must be applied to text-books.

Probably most teachers are a bit dissatisfied with the text they are using. If only we could inject into the first-year student some of the enthusiasm of many graduate students, then our work would be made more easy. The advanced student is out on the front of new advances and new discoveries. Then should not these same "newest" ideas be made the theme of elementary texts? Some writers of text-books think so.

Smyth and Ufford (S & U)[1] is a text with this theme of "newness." The whole treatment is novel and new. The writers have not omitted the fundamental laws but rather have caused them to be brightened by the light of the advances of recent years. They are among the first writers of general texts to introduce and use the long recommended K.M.S. system of units with the Newton ($=10^7$ dynes) as the unit of force. This factor alone will doubtless influence some teachers in favor and some against this text. It would hardly be possible for the teacher to cling to the C.G.S. system and use this text.

In the hands of an experienced teacher who can keep in mind that good foundations are still necessary for safe construction and who nevertheless is willing to follow the spirit of the book S & U should be a real experience to the beginning college student. On the other hand, the inexperienced teacher who permits enthusiasm for the new to cause him to forget the necessary fundamentals or the teacher who puts this text into the hands of his student and then tries to teach in the conventional manner will produce neither good physicists nor clear thinkers.

Housman and Slack (H & S)[2] have avoided some of these dangers by writing a more conventional text with the material arranged as we are accustomed to find it, and yet they have included nearly every bit of new physics that S & U have used and some besides. A text which includes the "fission of uranium" and "non-reflecting glass," as does the H & S text, can hardly be called old-fashioned, yet these authors have kept their emphasis on teaching the fundamentals to the beginning student, to whom all physics is new. In their greater emphasis on fundamentals they have taken particular care to get the subject of units clear and straight in the student's minds. Also they have been careful to keep fundamental statements and definitions from becoming lost within long paragraphs of explanation.

There was some criticism on the part of teachers using H & S that the first edition showed a lack of care in the latter chapters compared to the earlier ones, as if the authors had been hurried to finish their task. This defect seems to have been eliminated completely in this second edition.

Both of these texts recognize that too many college students are poorly prepared in the art of working

[1] E. Westblad, *Arkiv för Zoologi,* 21A, No. 23.

[1] Smyth and Ufford, "Matter, Motion and Electricity." McGraw-Hill Book Co. $3.75.

[2] Housman and Slack, "Physics." Second edition. D. Van Nostrand Co. $4.00.