help us if we assume a greater vigor of the white germ cells, so that unions do not take place in hap-hazard fashion, but two germ cells bearing black are less apt to get together than two bearing white, pure black zygotes being produced in less than one fourth of the cases.

We may conclude, then, that while the third criterion of recessiveness is imperfectly met this does not militate against the recessiveness of black in the Mendelian sense, but indicates the presence of a second, disturbing, factor.

The fourth criterion is the least critical because of the impossibility of judging whether a dominant is homogametous or not, except by its performance; if the hybrids are not dominants we conclude that the parent is not a pure dominant. The existence, however, of white individuals which always throw whites when mated with blacks is significant in relation to this criterion. Three white parents, descended, so far as known, from white ancestors, produced, when crossed with black sheep, 13 offspring, all white.

A special case deserves particular mention. No. 907 is a white male both of whose parents, 606 and 810, are also white, but both of whose grandfathers are black. Consequently, 606 and 810 are heterogametous but, until tested, we have no means of knowing whether their son, 907, is heterogametous or has only white germ cells. When No. 907 was crossed with heterogametous, white females all offspring were white. This would indicate that No. 907 is homogametous. When No. 907 was, however, crossed with pure recessives (blacks) one out of five offspring was black, and when crossed with 'extracted' recessives (having one heterogametous white parent) it produced two black offspring out of 18. In relation to these three offspring out of 23, assuming the record to be correct, No. 907 acts as if heterogametous. The occasional appearance of black offspring from a homogametous and a heterogametous parent may be explained as an occasional prepotency of black over the dominant white,—a phenomenon described by Castle[2] (1905, p. 58 et folg.).

[2] Castle, W. E., 1905, 'Heredity of Coat Characters in Guinea-Pigs and Rabbits.' Papers of Station for Experimental Evolution at Cold Spring Harbor, New York, No. 2.

It may be concluded that the fourth criterion also speaks for the recessiveness of black, the only exceptional case being explained on special grounds.

The conclusion of the whole matter is that black wool color in sheep behaves like a Mendelian recessive characteristic.

C. B. DAVENPORT.
DEPARTMENT OF EXPERIMENTAL BIOLOGY,
CARNEGIE INSTITUTION,
STATION FOR EXPERIMENTAL EVOLUTION,
COLD SPRING HARBOR, N. Y.

PHOTOTROPISM IN THE LARVAL AND EARLY ADOLESCENT STAGES OF HOMARUS AMERICANUS.

IN view of the interest which, by the recent excellent work of Keeble and Gamble on the color physiology of higher crustacea, has been renewed in the study of the effects of light upon many forms of littoral crustacea, the following results obtained during the past summer, in a series of experiments upon the effect of light on the larval and early adolescent stages of the American lobster, may be appreciated by some who are engaged in investigation of a similar nature upon other forms. The records of the following experiments cover but a small part of the field of inquiry into the effect of light upon these forms, in so much as they do not take up the subject of the influence of light upon chromatophore activity or pigment movement, but merely attempt to describe the reactions of the first five stages of *Homarus americanus* to light, upon backgrounds of black and white.

The apparatus used for the experiments consisted of an oblong wooden box whose inside dimensions were 6 x 18 x 4 inches (deep). The box was black inside and fitted with a light-tight cover, through one end of which protruded, to a length of 6 inches, a cardboard tube, 1½ inches in diameter, the function of this tube being to admit none but nearly parallel rays of light into one end of the box, thus distinctly localizing the light area. In cases wherein a white background was required, the black interior of the box was merely covered with white paper, as was the inside of the light-tight cover.[1]

[1] The design of the box is based upon that of Keeble and Gamble.

The method of conducting a single experiment was essentially as follows: The box was filled with salt water to a depth of 2 inches or thereabouts, and placed in a quiet and level position. The desired number of lobsters, together with sufficient salt water to make the total depth about 3 inches were added. When the water had quieted and the young lobsters had arranged themselves more or less uniformly in the water area, the cover was placed in position. At intervals, varying from 5 to 15 minutes, the cover was removed and the position of the young lobsters was observed. After some of the observations the cover would be reversed in position, so that the illuminated area in the water would be changed to the opposite end of the box. After other observations, however, the cover would be left as in the first instance, or removed entirely until another uniform distribution in the position of the young lobsters had been obtained. Whether the position of the cover was changed or not, the results, with few exceptions, agreed with great uniformity.

The light intensity was regulated by the time of day at which the observations were made—either at noon, mid-afternoon or nearly evening. In this way, without using artificial means, it was possible to regulate the degree of light intensity with a very fair degree of precision. In the case of studying monochromatic lights (red and blue) sheets of glass were used, the plate being placed over the entrance of the tube. Without doubt, liquid filters would have been an advantage; but the experiments which were made with glass plates gave such marked and definite reactions that they were judged satisfactory for preliminary work.

The counts were made by dividing the field into three areas, namely, the illuminated, the mid-area and the dark. Owing to the fact, however, that the illumination in the mid-area must have been almost imperceptible, for practical results it might have been quite safe to include the mid-area counts with those of the dark area, but for sake of surety they have been considered as a separate area. In the greater number of cases it was an easy matter to count the number of individuals in each of the three areas before a change in position took place. The number of twenty individuals was, in most cases, used for experimentation, for so small a number distributed over three areas could be taken in at a glance, and furthermore twenty seemed a sufficient number to give representative results. In the following account are recorded experiments carried on with the first five stages (*Homarus*. All the conditions of light and backgrounds were not brought to bear upon all five stages, and only a sufficient number of experimentation reports are here recorded to show the general drift of the results.

EXPERIMENT I.

Conditions: black background; sunlight dull; 20 first stage larvæ.

Test.	Lt. End.	Mid-area.	Dk. End.	Cover.
1	2	6	12	
2	3	4	13	Reversed.
3	1	5	14	
4	3	4	13	Reversed.

Similar results were obtained when a greater intensity of light was used.

EXPERIMENT II.

Conditions: white background; sunlight dull; 20 individuals used, first stage.

Test.	Lt. End.	Mid-area.	Dk. End.	Cover.
1	2	5	13	
2	2	2	16	Reversed.
3	2	3	15	Reversed.
4	1	5	14	

EXPERIMENT III.

Conditions: white background; sunlight bright; 30 individuals used, first stage.

Test.	Lt. End.	Mid-area.	Dk. End.	Cover.
1	22	4	4	
2	18	7	5	Reversed.
3	20	7	3	

These results seem to show that the first larval stage of *Homarus* is negatively phototropic on a black background, with both dull and bright light; but that while on white backgrounds he is, under low intensity, negatively phototropic, if the intensity of light becomes greater he becomes positively phototropic. Similar results were obtained with second and third stage larvæ under similar conditions of light and background.

EXPERIMENT IV.

Conditions: white background; red monochromatic light; 20 first stage larvæ.

Test.	Lt. End.	Mid-area.	Dk. End.	Cover.
1	2	1	17	
2	2	3	15	
3	3	4	13	Reversed.
4	6	2	12	

EXPERIMENT V.

Conditions: white background; blue monochromatic light; 20 first stage larvæ.

Test.	Lt. End.	Mid-area.	Dk. End.	Cover.
1	12	4	4	
2	11	3	6	Reversed.
3	13	2	5	

These two experiments indicate that in the case of a white background and red monochromatic light, the first stage lobsters are negatively phototropic, while in the case of a white background and a blue monochromatic light the same lobsters are positively phototropic. This was naturally somewhat unexpected, but in all the experiments involving similar conditions of light and background, the second and third stage lobsters respond in a similar manner. In case, however, a black background is used with lobsters of the first three stages, numerous experiments demonstrate a negative phototropism under the conditions of both red and blue light.

EXPERIMENT VI.

Conditions: black background; 20 early fourth stage lobsters; sunlight bright.

Test.	Lt. End.	Mid-area.	Dk. End.	Cover.
1	13	3	4	
2	15	3	2	Reversed.
3	12	4	4	
4	15	4	1	

When experiments were tried with the fourth stage, however, a different reaction was found to occur. On black backgrounds and with lights of any intensity or color, the fourth stage lobsters appeared, contrary to the first three stages, positively phototropic, as the following table demonstrates. The degree of light intensity made no further change in the results, save that in instances where the light was the least intense the reaction was least marked; and when the light was most intense, as obtained by reflecting rays of light by means of a mirror into the tube, the definiteness of reaction was most evident.

When white backgrounds were used in connection with the fourth stage lobsters, it was found that in every case except with the monochromatic red light, a positive phototropic reaction resulted. The latter, which was also contrary to expectations, may be outlined as follows:

EXPERIMENT VII.

Conditions: white background; monochromatic red light; 20 early fourth stage lobsters.

Test.	Lt. End.	Mid-area.	Dk. End.	Cover.
1	8	5	6	
2	1	6	13	Reversed.
3	1	10	9	Reversed.
4	4	5	11	

These resulting reactions in the case of the early fourth stage lobster may offer an explanation for the fact that this stage is so frequently caught in tow-nets drawn over the surface of any of our shore waters, while it has been a very unusual occurrence to secure in this manner either the earlier or the later stages. The same causes may also have worth for the reported facts that certain stages of the free-swimming larvæ of other forms of crustacea are found more frequently at the surface than are other larval stages of the same species.

It was a noteworthy fact, however, that old fourth stage lobsters would never manifest positive phototropic reactions with the same degree of certainty as that demonstrated in the case of younger fourth stage lobsters. Indeed, in a number of instances, fourth stage individuals which were due to molt within a period of one or two days, manifested on black backgrounds a definite tendency towards a negative phototropic reaction. This response was assumed without exception after the lobsters had molted into the fifth stage, and this reaction was manifested with any combination of light intensity, color or background. The following tables show the reactions in the case of the late fourth and the fifth stage lobsters.

EXPERIMENT VIII.

Conditions: black background (similar results were seldom obtained on a white background); sunlight bright; 20 late fourth stage lobsters.

Test.	Lt. End.	Mid-area.	Dk. End.	Cover.
1	9	4	7	
2	11	5	4	Reversed.
3	7	6	7	
4	9	3	8	

EXPERIMENT IX.

Conditions: black background; medium sunlight; 12 fifth stage lobsters.

Test.	Lt. End.	Mid-area.	Dk. End.	Cover.
1	2	4	6	
2	2	3	7	
3	2	2	8	Reversed.
4	1	3	8	

The results of these experiments may also explain, to a certain degree, the facts which appear through the observation of large numbers of the larval stages of *Homarus* when confined and exposed to different light conditions, as they may also interpret to some extent the behavior observed in the larval and early adolescent stages of lobsters under natural conditions of environment. The first three larval stages, when confined in the large twelve-foot white canvas bags in which they were observed, manifested at all times a marked tendency to sink toward the bottom—except perchance at night, when more active swimming is observed in all the stages. This tendency during the daytime could not be controlled in any way. At night, however, it was possible to evoke a seemingly positive phototropic reaction from any of the thousands of young larvæ in the large canvas bags. This was accomplished by means of an acetylene light so directed against a certain area of the white field of canvas that large numbers would at once group themselves thickly about the illuminated area, manifesting, in the case of the third and fourth stages, such an effort to come into the light area that they would often throw themselves partially out of water, causing thereby numerous surface ripples. Since, however, similar results could be obtained when a black background was employed with the acetylene rays, and since the results were not so definite when the incident rays struck the water perpendicularly as when they were thrown at an angle, it was assumed that these reactions were not true phototropisms, but were largely due to the effort on the part of the young lobsters to move in the direction of the incident light rays. This phenomenon was better observable in the fourth stage of *Homarus*, when the very definite rheotropic proclivity, first clearly observable in this stage, could be entirely broken up by introducing the incident rays either at right-angles to or in opposition to the direction of the current. The fourth stage lobsters, however, even under the natural conditions of light, swim actively at the surface. It is not until the fifth stage that the bottom-seeking and 'hiding-habit' is fully established.

PHILIP B. HADLEY.

ANATOMICAL LABORATORY,
BROWN UNIVERSITY,
October 10, 1905.

AN ILLUSTRATION OF THE USE OF THE WIRE-BASKET METHOD FOR SOIL TESTING.[1]

THE method of cultures in paraffined wire baskets, for determining the relative agricultural values of soils and for investigating the effects of various fertilizers, which was described in Bulletin No. 23 of this bureau, consists in growing wheat seedlings in the soils to be tested for from two to three weeks, determination being made of the water lost by transpiration and of the green and dry weights of the plants at the end of the period. Where differences between the various treatments are developed it is found that the transpiration varies with the weight, being, therefore, a fair measure of growth.[2] This method, which virtually furnishes a pot the walls of which are composed of soil cemented with paraffin, causes a uniform distribution of roots in the soil and exhibits the effects of

[1] By permission of the Secretary of Agriculture.

[2] See in this regard a paper on the relation of transpiration to growth in wheat, about to appear in the *Botanical Gazette*.