The papers to which reference was made above are unanimous in agreeing that the Department of Marine Biology should be continued, but there is divergence of opinion as to the desirability of continued operation of the laboratory at Tortugas, the alternative suggestion being the establishment of a *permanent* laboratory of the type of Wood's Hole, Plymouth or Naples and located somewhere in the tropics or the subtropics or in Bermuda or southern California. It is with reference to the latter suggestion that I wish to contribute the following observations to the discussion.

As a general proposition, biologists would probably be almost unanimous in welcoming the establishment of a permanent laboratory in another faunal and floral region than the one Wood's Hole now draws upon; there is no doubt that its facilities could and would be used to advantage. But since it seems only a remote possibility at best that such a station will be established at present because of the great expense involved, it seems to me to be far more in the interest of biology to urge instead the retention of a station already in effective operation. It may be added that because of the more or less temporary nature of the laboratory at Tortugas, it could be moved to another locality without great expense, and its transformation into a permanent station at Panama or Jamaica or any of the localities named above, could be effected at any time in the future at no greater expense than would attach to such change now. It may be presumed that as soon as a considerable body of biologists strongly feel the necessity of a permanent station in our southern waters the Carnegie Institution or some other agency of research will take the matter under serious consideration.

In weighing the desirability of continuing the operation of the Tortugas station the following seem to me to be among its outstanding qualities and should receive careful consideration:

1. For American biologists, Tortugas is the best equipped and most accessible tropical marine station.

2. It has been in effective operation for eighteen years and the large amount of published results emanating from it are generally admitted to be of high order.

3. The work carried on there could not for the most part have been done satisfactorily at any other station. It does not compete with but complements the work of other stations.

4. There is evident demand for a station like Tortugas. During the past eighteen years 68 different investigators studied there, each investigator spending on the average three seasons at the laboratory.

5. The living and working conditions are entirely satisfactory.

This point needs a word of explanation. In the earlier years of the laboratory the living conditions were undoubtedly "trying" to a few of the investigators. In recent years, however, a new laboratory has been built and the old one remodeled and the cuisine has been greatly improved, so that the living and working conditions are now in fact considered almost ideal by most of the investigators. One can work ten hours a day every day through the entire season of eight or ten weeks and remain in perfect physical condition. It is not unusual indeed for one to gain in weight while working at this rate.

Altogether the Tortugas laboratory seems too effective an instrumentality for furthering biological science to allow it to lapse with nothing definite in view to take its place.

A. A. SCHAEFFER

HISTORICAL NOTE ON THE PROBLEM OF LIGHT DEFLECTION IN THE SUN'S GRAVITATIONAL FIELD

A SERIES of articles recently published by Professor T. J. J. See, U. S. Navy,[1] gives a quite incorrect impression of the relation of J. Soldner's and of Einstein's work in connection with the deflection of light in the sun's gravitational field. It therefore seems desirable to make a short statement of the history of this problem.

In 1801 Soldner[2] calculated the deflection of light according to (1) The corpuscular theory of light (light consisting of material particles which are subject to gravitation), and (2) Newton's law of gravitation. The problem was simply that of determining the hyperbolic orbit of a small mass traveling with the speed of light under the influence of the gravitation of a celestial body. Considering a ray of light just touching the surface of the attracting body, Soldner worked out the well-known solution of the problem of two bodies. In setting up the differential equations for the motion of the particle he erroneously used for the gravitational force the expression

$$2gr^{-2}$$

where g = acceleration at the surface of the attracting body, and
r = distance from the center of the attracting body (adopting the radius of this body as unit distance).

The factor 2 has no justification and should be omitted.

Designating by ω the angular deflection of light from a star at infinity until it reaches the surface of

[1] San Francisco *Journal*, May 13, 20, 27; 1923.

[2] Bode, "Astronomisches Jahrbuch für das Jahr 1804," Berlin, 1801, p. 161.

the attracting body Soldner derived the formula

$$(1) \qquad \text{tang}\,\omega = \frac{2g}{v\sqrt{v^2 - 4g}} \quad (v = \text{speed of light})$$

which he applied to the earth and the sun. On account of the mistake mentioned his result for the sun

$$\text{(half deflection)}\ \omega = 0''.84$$

is twice too large. Correcting Soldner's formula and using modern constants a ray of light just grazing the sun's surface is deviated from infinity to infinity by the angle

$$\alpha = 0''.87$$

if the corpuscular theory of light and Newton's law of gravitation are adopted.

Soldner did not have in mind any test of the theory of light, his sole purpose being to find out whether the gravitational light deflection need be taken into account in astronomical measures of star positions. He was chiefly interested in the effect of the earth's gravitation upon a stellar ray, and he gave the application to the moon and the sun only a short mention at the end of his paper.

Before establishing the generalized theory of relativity, Einstein touched the subject of light deflection in 1908[3] and developed it more fully in 1911.[4] In the second paper Einstein states his principle of the equivalence of a uniform gravitational field with an accelerated system of reference. This principle leads to the necessary conclusion that energy of radiation (light) has inertia or mass, and that this mass must be subject to gravitation. From this conclusion the deflection of light could be calculated by using Soldner's method. Einstein, however, follows an entirely different course. For the time measure of an observer, according to the principle of equivalence, the speed of light in a gravitational field changes from place to place. The path of a light ray is then found by using the Huyghens principle, which leads to the formula

$$(2) \qquad \alpha = \frac{2kM}{c^2\Delta}$$

where α = full deflection of light ray from infinity to infinity
k = constant of gravitation
M = mass of attracting body
Δ = distance of light ray from attracting body
c = speed of light in vacuum.

For the sun Einstein finds $\alpha = 0''.83$, but with more accurate data the value $\alpha = 0''.87$ is obtained. This formula (which is based on the principles (1) Light is subject to gravitation, (2) Gravitation follows Newton's law) is equivalent to Soldner's formula, but is more general.

[3] "Jahrbuch der Radioaktivität und Elektronik," 4, 411, 1908.

[4] "Annalen der Physik," 35, 898, 1911.

In 1916[5] Einstein published his "Generalized Theory of Relativity," in which a new law of gravitation is given, differing from Newton's law by small terms, which, however, become sensible close to the sun, as for example, for the planet Mercury and for light rays passing near the sun. The light deflection required by this generalized theory is twice the amount given by formula (2); Einstein gives 1".7 at the sun's limb, but more accurate calculation gives 1".75. The increase of this value over that in Einstein's 1911 paper is not due to any mistake in calculation in the earlier paper but is an effect of the difference between Einstein's and Newton's law of gravitation, as the 1916 deflection is essentially based on the principles:

(1) Light is subject to gravitation.

(2) Gravitation follows Einstein's law instead of Newton's.

The observations of the 1919 and 1922 eclipses confirm the amount of light deflection predicted by the generalized theory of relativity of 1916 and they should therefore be considered as supporting the two last named principles. There is at present no other theory which satisfactorily explains the observed light deflections as to their numerical values.

The relation of Soldner's work to Einstein's results is characterized by the following points:

(1) It is through a mistake made by him in his work that Soldner obtains an amount of light deflection at the sun's limb which is in agreement with the recent eclipse observations; his theory, correctly developed, can only furnish a basis for half of the observed deflection. Einstein's generalized theory of 1916, on the other hand, necessarily leads to the full deflection observed.

(2) The fundamental assumptions on which Soldner's work is based are equivalent, as far as the present problem is concerned, to those of Einstein's 1911 paper, and Einstein's 1911 results must be and are in agreement with those of Soldner (after correcting Soldner's mistake).

(3) Soldner treats only the case of a light ray grazing the surface of the attracting body; Einstein considers the more general problem of any light ray passing through a gravitational field, and his formula (2) not only gives the light deflection at the sun's edge but also states that for other light rays the deflections are inversely proportional to the distance from the sun's center, a law which is not even touched by Soldner.

(4) The two authors derive their formulae by entirely different methods.

(5) Einstein's result differs from Soldner's formula not only in notation but also in terms of higher

[5] "Annalen der Physik," 49, 769, 1916.

order, and Einstein does *not* repeat Soldner's mistake.

(6) Soldner does not mention the application of this problem for testing the theory of light which is the principal purpose of Einstein.

This comparison sufficiently shows the independence of Einstein's work even if he knew about Soldner's paper, which is not likely, as Soldner's result had fallen into oblivion following the rejection of the corpuscular theory of light on which it is based. Professor See, accusing Einstein of plagiarism, clearly has not read Soldner's original paper and has been misled by a fragmentary reprint[6] of it published in 1921 together with comments by a German physicist, P. Lenard.[7] In these comments (page 603) Lenard transforms Soldner's formula into a notation and form similar to that employed by Einstein. Professor See mistakes Lenard's transformed formula for Soldner's and bases his unfounded accusation upon its similarity to Einstein's result.

ROBERT TRUMPLER

LICK OBSERVATORY

A RECESSIVE BLACK VARIETY OF ROOF RAT

THE pelage color of most wild mammals is characterized by a rhythmical deposition of dark and light pigments in the hair, giving rise to what is termed an agouti pattern. One of the common variations occurring in agouti animals is the disappearance of the bands of yellowish pigment, which results in a totally black coloration, provided no other variations are present simultaneously. It is known that mammals may be black genetically, for one or other of the following reasons: (1) Because they possess a dominant or incompletely dominant extension factor, which extends the dark pigments into the regions ordinarily occupied by the lighter ones only, as in "steel gray" rabbits;[1] (2) because they possess a recessive non-agouti factor which precludes the formation of light pigments in the hair with the dark ones. Most black varieties of domesticated animals belong to the latter class.

The natural color of the black rat, *Mus rattus,* is a uniform black, which has been found to be dominant over the agouti of the closely allied roof rat, *Mus alexandrinus.*[2] This case obviously falls into the first of the above-named categories. Black individuals obtained from a stock received from Mr. H. C. Brooke of Taunton, England, were at first supposed to be specimens of the dominant black derived from *M. rattus.* These blacks were produced in matings between grays and yellows, and it was assumed at first that black would be found to be dominant over gray as in Morgan's experiments. The incorrectness of this assumption was apparent when gray mated to gray produced litters containing black animals; six black rats produced in this way have been recorded. Matings of such black males to wild gray *M. alexandrinus* females have resulted in the production of seventeen offspring, all of which are gray.

This evidence indicates very clearly that we have in this black variety a color factor which is different from the one characterizing the black rat, *Mus rattus;* one which is recessive to gray or agouti, and which is probably the homologue of the factor producing the black variety in the Norway rat, the house mouse, the guinea-pig and the rabbit.

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QUOTATIONS

A "ROSS INSTITUTE"

THE approaching twenty-fifth anniversary of Sir Ronald Ross's epoch-making discovery that malaria is transmitted to man by the mosquito has led a number of influential persons, including leaders of the profession in this country, Mr. H. H. Asquith (ex-prime minister), Dr. Roux, director of the Pasteur Institute, Paris; Dr. R. M. Strong, of Harvard University; Dr. William H. Welch, of Johns Hopkins, and Sir Charles Sherrington, president of the Royal Society, to make an appeal to the public. They point out that the discovery has revolutionized medical science and living conditions throughout the tropics and, among other great things, enabled the Panama Canal to be constructed. It is impossible to exaggerate the services Ross has rendered. He must be ranked among the great investigators whose labors, like those of Pasteur, Lister, Jenner and Golgi, have conferred inestimable and lasting benefits on mankind. All the world has shared in these benefits, but Great Britain, which has vaster tropical areas than have ever been ruled by a single power, has profited most abundantly, and she owes a very special debt of gratitude to the son who has rendered this service. There is in

6 "Annalen der Physik," 65, 593, 1921.

7 Lenard, it should be said, recognizes the error in Soldner's work to which attention is called in this paper and gives correctly the value for the deflection to which Soldner's theory leads. It may further be stated that Soldner's result for the light deflection by the Earth $\omega = 0''.001$ is also in error and should be $\omega = 0''.00014$ (in addition to the erroneous factor 2 in the formula a mistake was made in calculating the value of the acceleration for the peculiar units used).

1 Punnett, R. C., 1912, *Jour. Genet.,* 2, 1915; *ibid.,* 5.

2 Morgan, T. H., 1909, *Am. Nat.,* 43.