yet failed to find any one who can readily detect the seven primary colors. It is said of Dalton, from whom color-blindness was once named, that he could distinguish only the colors of blue and yellow in the solar spectrum. Dr. Mitchell tells of an officer who chose a blue coat and a red waistcoat, believing them to be of the same color; of a tailor who mended a black garment with a crimson patch, and put a red collar on a blue coat. Such mistakes seem quite as ridiculous to me as to others. Yellow and black I have never confounded with other colors.

There is such a diversity in color-blindness, that it seems impossible to determine the cause. I am convinced that it is a physical defect. The eye, as a mechanical instrument, has not been found at fault. The cause is undoubtedly due to some peculiarity of cerebral formation. Like the cause of left-handedness, which is due to unusual development of the right brain, color-blindness is due to a freak of nature.

The education of the color-sense among the children of the primary schools has proved of great value in removing that uncertainty in distinguishing colors which of course may be found among most ignorant people, old or young. This has its parallel in the education of the ear to the appreciation of all the variations of the musical scale. But for one who is really color-blind, education can be of little avail in correcting the defect. W. B. HARLOW.

Syracuse, N.Y., Jan. 27.

A New Text-Book on Zoology.

THERE can be no better evidence of the growing interest on the part of certain reading-classes of all ages, and the importance that is being daily attached to biological studies by school authorities and educators, than the ever-increasing demand for good text-books in zoölogy, and the frequency with which such volumes put in an appearance. We now have before us a thoroughly revised edition of Steele's 'Fourteen Weeks in Zoölogy' (New York, Barnes), — a little work that held its place with great popularity for ten years, and which has now been almost entirely rewritten by Prof. J. W. P. Jenks of Brown University, who is quite responsible for its present form.

From the author of the work I learn that the volume in scope is principally designed for beginners in our high schools and academies at the average age of fifteen to eighteen years, in which schools they have no special means for illustration. Moreover, to be efficient as a text-book, it is intended to be used only by a class of teachers who presumably possess quite a thorough knowledge of general zoölogy, drawing, dissecting, zoölogical aids and appliances, and kindred subjects. Taken as a whole, were this volume placed in the hands of such a teacher, and its chief aim to be to impart a notion of general zoölogy to a class of students of the average age mentioned, after faithfully following out its chapters for three or four months, we must believe that no better work has yet appeared having a higher claim to such an end. Its pages are crowded with beautiful cuts of the forms used in illustration of its text, which cuts and illustrations have been for the most part admirably chosen; and, notwithstanding its unavoidable brevity, the subject-matter, as a rule, is presented in a manner calculated to interest and instruct the student at every step. It seems to me, however, that even in a work of this character its author should add a page to his preface, and explicitly state in words and figures and acknowledge to whom he is indebted for his illustrations. We find here numerous drawings of birds taken from Audubon and Wilson, and many others, without a word of such acknowledgment, and the oversight occurs throughout the work. We must believe that even young academical students should be taught that this is not the proper custom; but where an author meets with such material assistance, it should be duly noted. An excellent feature of the work consists in properly dividing and accenting the technical names to assist in their pronunciation; while, on the other hand, a serious defect is evidenced in the absence of a 'glossary of terms' at the end of the volume.

In the main, the classification adopted shows the impress of recent views in the premises; but here, as much as anywhere else, it needs the explanation of a skilled teacher, as the student would gain but a very erroneous idea of the subject from this work alone, as no family nor generic lines are drawn. Take, for example, the order *Passeres*, where lyre-birds, birds-of-paradise, finches, crows, and larks, follow each other in the order I have given them, without a single word of explanation as to their affinities. Then again we find the author at total variance with the leading authorities in placing the bats in the order *Insectivora*, without a word as to why such a step should be taken. Nor will he meet with full support in his order *Bimana*, containing only "one genus and a single species," and that species having "the rank of a being who is alone declared to have been created in the image of God" (p. 277). We have no scientific proof for this latter view. Beneath about half the figures we find given in parentheses each one's proportionate size as compared with the living subject: we regret that this excellent idea was not carried out through the entire work, and it will be well for future text-books in zoölogy to adopt this plan. Written, as the author of this work declares it is, for a class of students as late as eighteen years of age, to my mind it exhibits another thoroughly fatal omission, for it has not a word to say of that great universal law pervading all nature and the world, which explains the very origin of organic forms and the relations of the living ones to those now extinct. Should a young man of eighteen years of age complete the course pointed out by this work, and yet be ignorant of the law of evolution, I hold his zoölogical studies have been but poorly grounded. A companion work to the one under consideration on physics would be in the same case, had it omitted the law of gravitation.

The object of a text-book in zoölogy for a class of students from fifteen to eighteen years of age should not have as its aim the endeavor to teach the greatest number of names of animate objects, for at the present day that is a hopeless task, even were it a desirable end. It should, on the other hand, undertake to make clear the general principles of biological classification; it should by a careful, detailed study of a few types, both vertebrate and invertebrate, clearly point out the universality of morphological laws, then these two lessons should be combined; next, it should be clearly shown the relation between living and extinct types, and finally, by a few clear examples, show the origin of certain forms, as the birds from reptiles, and the ancestry of the horse, and so on; all of which is far more comprehensible than a jumble of isolated facts unconnected by any known law. Such a course, properly expanded and illustrated by a competent teacher, will give a student at once a more intelligent appreciation of life and living forms; make him a better observer; create in his mind a more healthy interest in the subject; and finally send him forth with a kind of stimulation and systematized knowledge which fits him to further pursue biological research, should it happen in any given case to be imparted to the mind of a student cast in the biological mould.

R. W. SHUFELDT.

Fort Wingate, N. Mex., Jan. 9.

The Flight of Birds.

IT is with great diffidence that I take part in a discussion participated in by such eminent authorities as Professor Newberry and Professor Trowbridge, and it is with still more hesitation that I venture to disagree with any opinions brought forward by either of these gentlemen. Nevertheless, I can but feel that undue stress has been laid upon certain facts, while others of equal importance have been overlooked or incorrectly stated.

To a great extent the discussion hinges on the assumption that birds need some mechanical device to relieve the muscles of strain while soaring, — an assumption whose truth seems open to question, as many of the lower animals are capable of automatic muscular movements of very long duration.

Among mammals the cetaceans are almost constantly on the move both by day and by night, while others rest in positions that seem to entail considerable muscular strain. Thus horses very frequently sleep in a standing posture, and the skunk and baboon have been observed to seek repose lying flat upon their backs, with all four legs stiffly extended in the air; a very good example of unrelieved muscular strain may be seen in the tail of the spider-monkey, whose prehensile power is sufficient to sustain the animal after life is extinct; some birds, during their migrations, fly or swim for immense distances without stopping for rest, and there is very good reason for believing that many of the petrels keep on the

wing for days and nights together without intermission; many fishes require perpetual motion in order to preserve their equilibrium, while other pelagic forms appear to be on the move for long periods of time without flagging, — all these cases necessitating oft-repeated movements, which call for far more serious strain on the muscles than the mere extension of the wings during the act of soaring.

The strain on the extensor muscles at such a time can be but trifling, compared to the strain on the levators and depressors of such a bird as the albatross, whose weight of nine to fifteen pounds is supported by two levers of the third class, five to seven feet in length; and yet no bird makes longer flights than this wanderer of the southern seas, who has no special device to keep his wings outstretched.

These instances are brought forward, not to disprove the fact that a device to ease the muscles in soaring may not exist, but to show that there is apparently not the slightest need for it.

In regard to the interlocking of the primaries, which unquestionably takes place, is not this the result of their emargination, and consequent failure to glide smoothly over one another, rather than the end to be accomplished by this cutting-away of the feather toward the extremity?

This view of the case is borne out by the fact that the longer, more flexible ulnar border of the primary naturally gives at each stroke of the wing, thus catching in the radial portion of the feather immediately behind it, whether the bird wishes it or not.

Moreover, during the act of soaring, the wing is expanded to its utmost, and the tips of the primaries widely separated, while in a fresh specimen of *Buteo borealis* no locking is possible until the wing is partially closed. This would seem to be conclusive as regards the importance of the locking of the primaries as an aid in soaring; although there remain the facts that some birds who soar to perfection — such, for example, as gulls, cranes, storks, and the frigate-bird — do not possess emarginate primaries, while others, like some owls and flycatchers, have emarginate primaries but do not soar.

Professor Trowbridge's comparison of the wing to a flat card is hardly felicitous, and his statement that it would be in a state of unstable equilibrium but for the locking of the primaries would seem open to serious doubt.

One absolute requisite of a wing is that the anterior margin should be rigid, and the posterior border flexible, — a requirement which is met toward the extremity of a bird's wing by bringing the quill close to the radial margin of the feather, leaving a posterior pliable edge.

Now, if the primaries are interlocked, a rigidity is created toward the ulnar border of the wing, which would thus become more card-like and unserviceable than if the primaries did not lock.

A pertinent question that might be asked of Professor Trowbridge, is, Why, if the "long primaries present a serious resistance . . . when a bird is soaring," do all birds that soar or sail possess just such primaries, while the corresponding feathers in birds which do not soar are short?

One feature in the wings of birds pre-eminent for soaring abilities, e.g., the *Vulturidæ* and *Falconidæ*, has not been touched upon in this discussion, so far as I am aware; and this is the fact that when the wing is extended to its utmost, as it invariably is during soaring, the metacarpus and phalanges are not in line with the ulna, but are bent forward of it. By this arrangement some of the muscles and tendons that ordinarily act in flexing the wing are brought upon the dorsal surface of the bones, and thus have their power of flexion weakened, or possibly even made to aid in the automatic extension of the wing. If, now, a bird with wings thus spread be so killed that there is no perceptible shock or nervous start, the bird may remain with outstretched pinions and sail gradually downward, — exactly such a case as Professor Newberry describes.

In conclusion, I can but regret that I have no facts to adduce that will throw any light on the problem of flight, as it is far easier to find fault with any theory than to suggest a better, and purely adverse criticism must always seem more or less ungracious.

FREDERIC A. LUCAS.

Washington, D.C., Jan. 16.

Binocular Combinations upon Disparate Retinal Points.

EVERY one is familiar with the fact that Wheatstone and many subsequent investigators have explained the binocular perception of solidity by the theory of the 'fusion of images upon disparate points,' as they are called, in the retina. They have generally denied the original possibility of a monocular perception of solidity and distance; and hence, when certain plane figures were stereoscopically combined, the apparent solidity of the resulting single figure suggested its explanation in accordance with what had previously been supposed of the mathematical relation between combination and convergence. Thus Wheatstone's view may be illustrated by the following figure. It is well known that the stereoscopic combination of these figures, although making a plane image only upon the retina and representing only a plane surface externally, nevertheless produces the appearance of a solid body. Previous theories of vision had maintained that single vision took place upon corre-

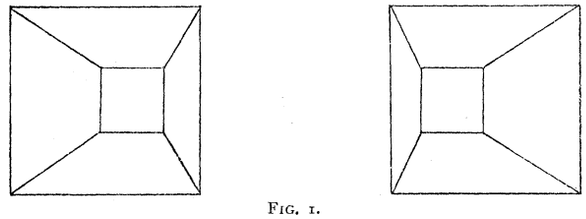

FIG. 1.

sponding points of the retina, and double vision upon disparate points. Now, as the mathematical construction of the case would not allow the inner figures and lines to fall upon exactly corresponding points, the apparently single character of the image in stereoscopic combination was most naturally explained by saying that fusion took place upon disparate points; and hence when the perception of solidity, or relatively different distances between the larger and smaller figures, uniformly accompanied this kind of fusion, it was naturally ascribed to that process as its cause. Whether such a fusion really takes place or not, has been hotly contested, and we wish here to present a few new considerations to show that it does not occur, notwithstanding the strongest apparent evidence of our actual perception of it.

To make the argument clear, a few words will be necessary upon what is meant by 'corresponding' and 'disparate' points. As indicated, they denote the points upon which respectively single and double vision takes place. But the second term has two very distinct applications, — one binocular, and the other monocular. It is

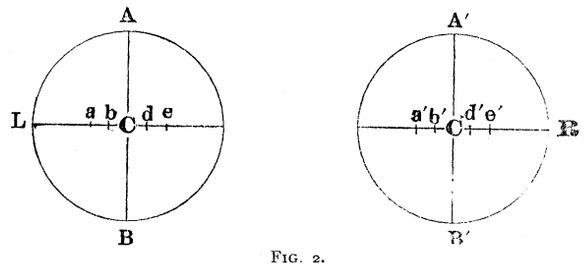

FIG. 2.

this last fact and its implications which most investigators, and among them Wheatstone, seem to have ignored. But the importance of taking it into account will be evident from the following considerations. Take the circles R and L to represent the retinal surfaces of the two eyes. Divide each retina into halves by the vertical meridians AB and $A'B'$. Draw also the horizontal meridians in which lie the points a, b, c, d, e, and a', b', c', d', e'; c and c', at the intersection of the vertical and horizontal meridians, represent the *fovea centralis* of each eye. Now, the vertical meridian divides each eye into halves, that correspond to the opposite halves of the other eye. Thus we have what are called the nasal or inner, and the temporal or outer halves of the eyes. The nasal halves of each eye are said to 'correspond' to the temporal halves of the other eye. How this will appear can be seen by superimposing one circle upon the other; and the points a and b in the temporal half of the left eye, L, will coincide with a' and b' in the nasal half of the right eye, R; and d and e in the nasal half of the left will coincide with d' and e' in the temporal half of the right eye. By