rill Ricketts, 'The Dermal Coverings of Animals and Plants;' Jan. 27, Joseph F. James, 'The Great Deserts of the Earth;' Feb. 3, Amos R. Wells, 'Volcanoes;' Feb. 10, D. S. Young, 'Some Characteristics of Fishes;' Feb. 17, Charles Dury, 'Reason and Instinct in Animals;' Feb. 24, Walter S. Christopher, 'Bacteria and Fermentation;' March 2, F. W. Langdon, 'Races of Man;' March 9, A. B. Thrasher, 'The Voices of Animals.'

— The Council of the American Economic Association held its annual meeting in Hamilton Hall, Columbia College, at 10.30 A.M., Friday, Dec. 30.

— The *Political Science Quarterly* for December contains several articles that are worth reading, though none of special importance. Two of them are on the subject of profits and wages, — a subject that is sure to attract readers, but on which we cannot say that much light is shed. Professor Clark recognizes the fact, which most economists overlook, that a large portion of the employer's profits is of a mercantile character, arising from buying and selling to good advantage rather than from special skill in production; but, strangely enough, he thinks that this profit is due to causes beyond the employer's control, and "comes to him as rain from the clouds;" whereas it is due in great measure to his skill in taking advantage of the markets so as to buy at a low price and sell at a high one. The opening article of the number is a vigorous attack on the oleomargarine law, and will be read with interest by all opponents of government interference. The article on local government in England is of interest just now, when new and extensive changes in that branch of the English Government are in contemplation. There is also an article of considerable historical interest, on the Constitution in reconstruction, giving an account of the contest between Congress and President Johnson in regard to the recognition of the Southern States and the guaranties to be required of them before such recognition was granted. The closing essay is on India's unadjusted trade balance, and the usual complement of book-reviews fills up the number. This review, together with the *Journal of Economics* issued at Harvard, and the various publications of the Johns Hopkins University, are an addition to our periodical literature; for they furnish a kind of reading that we should otherwise hardly get.

LETTERS TO THE EDITOR.

*** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

Twenty copies of the number containing his communication will be furnished free to any correspondent on request.

The editor will be glad to publish any queries consonant with the character of the journal.

The Flight of Birds.

IN your issue of last week, my friend, Dr. Elliott Coues, takes part in the current discussion of the flight of birds with his usual boldness and independence, but not with his usual care and accuracy. He practically begins his letter with the following *ex cathedra* condemnation of Professor Trowbridge's theory, and denial of his facts: "With regard to the alleged locking of the primaries: 1. It does not take place; 2. Did it take place, flight would be impossible."

As Professer Trowbridge is abundantly able to defend himself, I leave the answer to the above extraordinary statements to him, and will simply remark, in passing, that I know from my own observation that the locking of the primaries can and does occur, either by accident or design, and that when it takes place it does not render flight impossible, as it affects only the extremities of the feathers. It is evident that Dr. Coues has not taken pains to inform himself in regard to the facts brought forward by Professor Trowbridge, otherwise he would not have uttered such dogmatic assertions.

Further on, Dr. Coues decapitates me much in the same way he does Professor Trowbridge; for he says, "The fixing of the wing of a mortally wounded bird in the manner described by Professor Newberry does not bear on the case. It is simply a muscular rigidity due to nervous shock, and of a part with the convulsive muscular action, which, under similar circumstances, results in the well-known 'towering' of hard-hit birds."

We have here other proof that Dr. Coues has not read all that has been said in this discussion: if he had done so, he would have seen that I did not claim that the automatic rigidity of the arm and fore-arm, the 'setting' of the wing, first described by Professor Wyman, had any thing whatever to do with the locking of the primaries. As was said in the discussion of Professor Trowbridge's paper before the Academy of Sciences, and reported in my former letter to *Science*, the spreading and folding, and, according to Professor Trowbridge, the locking of the primaries, are functions of the *manus*, and have nothing to do with the flexion and extension of the arm. The spread of the wings of the turkey-buzzard maintained after death, reported by me in my 'Notes on the Birds of Northern California and Oregon' (*Pacific Railroad Reports*, vol. vi. Zoölogy, p. 74), was certainly not a case of muscular spasm. My report of it will be found at the place cited, and is as follows: —

"For the purpose of examining this bird in California, to determine for myself its identity, or otherwise, with the turkey-buzzard of the East, I took occasion to shoot one which was flying over us in the upper part of the Sacramento valley. He made no motion indicating that he had been struck by my shot, but sailed on with widely expanded and motionless wings, as before. Gradually, however, he began to descend in wide and regular circles, till finally, without a wing-flap, he settled as lightly as a feather on the prairie, and remained motionless. I went to him, and found him resting in the grass, his wings still widely and evenly expanded, but the head drooping and life extinct. It was a male, large, in fine plumage, and apparently identical with ours; then, too late, I regretted that I had been the cause of a death so calm and dignified."

I have been shooting now for a great many years, have killed many thousands of birds, and ought to know what their behavior is when mortally wounded; yet I do not hesitate to say that the extension of the wings in this case and those reported by Dr. Storer was not due to muscular spasm, but to a locking of the wing-bones. Nor had the death of the turkey-buzzard, cited above, any thing whatever in common with the phenomena of 'towering,' as asserted by Dr. Coues. Towering is exhibited only by birds which are wounded in the head, and which, with confused intellects, fly up and up, perhaps till lost to view. I have reported one such case in my notes which is typical, and I here repeat my account of it to show that it was totally distinct from all wing-setting, spasmodic or articular.

"Once when collecting water-birds on San Pablo Bay, California, I shot a gull (*Larus Hermanni*), which fell, apparently dead, upon some rocks near me. When I stooped to pick it up, however, it flew swiftly away, and mounted in circles higher and higher until it disappeared."

The article by Bergmann in Müller's *Archiv für Anatomie und Physiologie* (1839) has no bearing upon the statements made by Professor Trowbridge or myself. It is true that Bergmann describes the sliding of the radius on the ulna, and in the discovery of this anatomical feature he antedates Wyman; but he makes no reference to the 'setting' of birds' wings, which was the special subject of Professor Wyman's note. All Bergmann says about the function of the anatomical peculiarity which he pointed out is, "that it is desirable that observations should be made (for which he had no opportunity) to determine whether it might not have efficiency in the soaring of rapacious birds or in the flight of those which must quickly change the direction of their flight."

In conclusion I will venture to suggest that neither Professor Trowbridge nor myself are such tyros in science as to warrant the didactic tone which Dr. Coues assumes. Professor Trowbridge needs no indorsement from me, but I venture to say that he is one of the most eminent engineers in the country, and that he has occupied himself for many years in the study of the mechanics of animal locomotion, upon which subject he is as well informed as any one living. As for myself, I was for many years as enthusiastic an ornithologist as Dr. Coues himself, and have shot over as much ground, and have perhaps killed as many birds. I was also educated as a physician, and, at the time I made the observations cited above, I was serving as naturalist and medical officer to a detachment of troops.

I would also call attention to the fact, that, for all the interesting information we now have in regard to the structure and functions of the wings of birds, we are indebted, not to ornithologists, but to

comparative anatomists: it is therefore quite possible that even Dr. Coues may learn something from one outside his profession.

J. S. NEWBERRY.

New York, Jan. 3.

THE communication of Mr. Elliott Coues in the last number of *Science*, on the mechanism of the flight of birds, renders a response from me, in the interest of science, indispensable. This is the more necessary on account of the unavoidable delay which has occurred in the publication of a paper sent by my son to the *Ornithologist and Oölogist*, and which will appear in the next number of that periodical, and also the delay in the publication of the paper read by me before the National Academy of Sciences, and which has given rise to comment and discussion, and is referred to in Mr. Coues's communication.

During the last autumn my son, C. C. Trowbridge, who is now a pupil in the Hopkins Grammar School at New Haven, Conn., and who has for several years devoted much of his leisure time to the collection and study of birds, brought to me a hawk which he had shot while it was soaring, and called my attention to the fact that the four outer primaries in each wing were interlocked; that part of each primary along which the lower margin was cut away lapping over or behind the succeeding primary, which was cut along its anterior or upper margin to permit of this interlocking and crossing of these feathers. This was the condition of the wings when he picked up the bird. The general appearances of the wings were so little altered from their ordinary aspects that the interlocking would ordinarily escape notice. My son suggested that this interlocking has the effect of relieving the muscular action required for the extension of the primaries during long flights, especially in soaring birds, and, further, that it might aid the bird in steering its way while soaring.

This discovery seemed to me of much interest; and after having assured myself by inquiries, and the examination of works on ornithology, that it had not been made by others, I concluded to bring the subject to the notice of the New York Academy of Sciences, and shortly afterwards read a paper in relation to the same before the National Academy of Sciences.

I supposed that all lovers of true science would welcome so interesting a discovery, even though it was made by a boy. Such, indeed, was the reception of the paper by all the naturalists present; Professor Marsh, Professor Newberry, and Professor Cope commending the paper, and Dr. Gill, who was not present, but to whom I had exhibited drawings of a wing, and explained the matter, giving encouraging assent to the novelty and importance of the discovery. I mention the names of these gentlemen, because I do not think they will ever have reason or cause to regret their favorable comments, nor to retract their opinions.

During many years' study of animal mechanics I have found no facts which exhibit more wonderfully and beautifully than those I have described, the mechanical adjustment of the organs of motion to the medium in which motion takes place, and to the conditions for which provision is made.

I have in my possession the wings of two large hawks (*Buteo lineatus* and *Buteo borealis*) in which the effects of the habitual interlocking of the four outer primaries has been to wear deep notches, and to produce permanent wrinkles, in the feathers at the point of crossing or overlapping. These I have shown to many scientific men without hearing a doubt expressed of the object or uses of the emarginate cuttings. These long primaries present a serious resistance, with a long leverage, when a bird is soaring, which would overtax the extensor muscles in long-continued soaring flights, if not relieved by the process of interlocking. That this interlocking does not impede flight, but in a wonderful and peculiar way aids the evolutions of the bird, is evident from the fact that by this interlocking a curvature is given to the anterior edge of the wing, which produces a warped surface, thus enabling the bird to have easy control of the wing with the least possible exertion. A perfectly flat, thin disk, in moving through air, is liable to be violently inverted, or turned broadside to the motion, by the slightest change of angle with the plane of motion. Every one has noticed this when a playing-card is seen to fall through the air. The edgewise position is one of extremely unstable equilibrium. This would be the condition of the outer part of the wing in soaring, were it not for the warped-surface form which, in the wings I have examined, is almost wholly maintained by the interlocking of the primaries, justifying my son's remark that this interlocking is an aid to steering, in soaring flight.

Mr. Coues, in his communication to *Science*, disposes of all this matter by a sententious dictum, which, from his extensive knowledge of ornithology, must be regarded as an extra-judicial opinion, pronounced with much regret, but with the severe force which science and truth demand, in the following words:—

"Much as I regret my absence on those occasions [the meetings at which the papers were read and discussed], I am still more sorry to be obliged to dissent without qualification from the position taken, . . . which is, to my knowledge, quite untenable. . . . With regard to the alleged locking of the primaries: 1. It does not take place; 2. Did it take place, flight would be impossible." And further, "It is fortunate that the mechanism of the wing does not permit the primaries to lock in the manner that has been supposed, for, if it did so, birds could not fly."

I am necessarily provoked, by these unexplained judgments, to test Mr. Coues's knowledge of the mechanism of the wing which "does not permit the primaries to be locked." I have found, by dissecting the wings of the hawks which I have referred to, that in these birds ten muscles are concerned in the movements of that part of the wing which corresponds to the human hand. Among these are three muscles, with their tendons, which have for their object solely the extension and flexion of the four or five outer primaries. The extensor muscles lie between the radius and ulna of the fore-arm, but the tendons run through the wrist-joint and along the hand to the joints of what corresponds in the human hand to the fore-finger, acting solely to extend the four or five primaries beyond any extension which they could otherwise have.

The flexor muscle lies in the hand,—a very small muscle,—with its tendon so attached that its only use is to flex the four or five primaries through the small angle by which they are extended by the opposing muscles just described. These muscles are not referred to, nor described, in Mr. Coues's admirable and voluminous work on ornithology, and I beg that he will inform the readers of *Science* where specific descriptions of these particular muscles, and their uses, can be found.

There are two other muscles whose tendons are so attached to the joints of the wrist, in the specimens I have, that when the wrist is extended or flexed by the larger extensors and flexors, a partial rotatory motion outwards and inwards may be given to the whole hand. May I ask Mr. Coues where I can find specific descriptions of these muscles, and their uses? These several muscles are principally concerned in the mechanism which does permit of the locking of the primaries.

Mr. Coues discusses another matter in his communication which has only a very general bearing on this question of the primaries. It is the automatic or concomitant extension and flexure of the wrist in birds when the elbow is extended or flexed. In the specimens which I have examined, I have found an inelastic tendon, without a muscle attached, fastened at one end to the humerus at the elbow, and at the other to the hand at the wrist, which is an essential feature in this purely kinematic combination. Moreover, this tendon, or string, plays another important part in acting as a string to the bow of the ulna, and taking the strain which might break the ulna, when the bird strikes the air strongly, but for this remarkable support. This is not referred to in Mr. Coues's work, and I would ask him where I may find its description.

Finally, will Mr. Coues explain *why* birds cannot fly when a few inches in length of the outer primaries lap over and behind others? Mechanically this makes a very strong wing, admirably adapted to soaring flight, for which it is evidently intended; and in one instance, at least, which I have given, the bird did apparently fly very well and very naturally with its primaries thus interlocked.

Moreover, from my own experiments with wings, both before dissection and after the muscles and tendons have been exposed, so that they might be operated by hand, I am convinced that the interlocking of the primaries is a simple and easy operation, entirely under control of the bird, and with many birds is habitual.

W. P. TROWBRIDGE.

New York, Jan. 3.