to the state legislature, drew up a bill to control the destruction, aroused public support and secured the establishment of the first game warden system in any southern state along lines at once so sane and so successful that the plan was followed for many years in other states as well.

Out of such achievements grew naturally the National Association of Audubon Societies in 1905, in which he was first its secretary and then president, but always at the front of the fight for the conservation of wild life. His tact, his resourcefulness and his persuasive power served to carry through successfully measures in many states, north and south, for game protection, despite powerful opposition. Probably the best known as also the greatest of these battles was that in New York state and later in Congress to put an end to the traffic in bird plumage sold for millinery. This carried his work beyond the limits of the United States and resulted in similar movements in many other countries and in the organization of the important International Committee for Bird Preservation in which he still retains an influential position. The origin and growth of these and numerous other valuable scientific movements are sketched by Dr. Pearson in accurate and unassuming fashion.

The quaint style of the author, the vein of quiet humor which runs through the book, the frank attack upon excesses wherever manifested and the tolerant spirit which has characterized his attitude throughout all the controversies in which he has been engaged are responsible in large measure for the remarkable success which has attended his efforts. This feature stands out clearly in his book. It is a veritable mine of information concerning men and movements in conservation. It covers well the history of the movement during the last fifty years, and the material is presented with a frankness and fairness that is unusual and that makes this record of permanent value.

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DIESEL ENGINEERING

Elements of Diesel Engineering. By ORVILLE ADAMS. Pp. xvi + 478. 250 figures, New York, Henley, 1936. $4.00.

THE book presents the elements of the subject in a clear and concise manner—from the earliest design to the most modern development. The operating principles of the various forms of Diesel construction are presented with a minimum of mathematics and irrelevant detail, consistent with a clear presentation of the subject. Topics of such major importance as fuel injection, fuel pump design, injection nozzles, combustion chamber designs, etc., are treated in such a way as to give a new man in the field an understanding of many of the fine points as well as the basic principles and the present status of development.

The many and varied problems that have been encountered in the development of the Diesel are outlined, and their solutions—or the progress that has been made toward these solutions, with particular emphasis upon the development of the high-speed Diesel—are discussed at length. Such topics as selection, installation, inspection, operation and maintenance of the automotive Diesel engine occupy a relatively large space, which is in keeping with the importance of this phase of the subject, particularly to those persons looking to this field as a means of livelihood.

One gets from studying the book a very good picture of the entire field and the great development that has been made in the Diesel engine, without getting the impression that all the problems have been solved. It is a record of the important background and present state of an industry which, although still in its infancy, has already developed to a place of great importance.

The subject-matter is particularly well selected and organized to serve as a text in a classroom or for individual use in obtaining a thorough picture of the elements of Diesel engineering.

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SPECIAL ARTICLES

THE ORIGIN OF THE AFTER-FEATHER[1] IN FOWL: A PROCESS OF TWINNING

IN 1932[2] we emphasized the origin of the barbs of the definitive feather from a single center situated at or near the mid-ventral line of the formative ring of cells ("collar") surrounding the base of the feather germ and enclosing the neck of the pulp. From this results the invariable seriation of barbs both as to time of origin and apico-basal order in the definitive feather. Though Hosker[3] has questioned this conclusion, farther study has served only to confirm it. We shall designate the place of origin of barbs as the *ventral locus;* it has a central position in the "ventral triangle" of our former paper. The other postulates of our pre-

[1] We use Studer's term "after-feather" (Afterfeder) for the small fluffy feather emerging from the superior umbilicus of the contour feathers of most carinate birds. The commonly accepted designation of this feather as aftershaft or hyporhachis is confusing, because the after-feather is a complete feather with its own shaft, barbs and barbules, though of course without a separate calamus of its own. (For current terminology of the feather see Asa C. Chandler, *Univ. of Calif. Publ. in Zool.,* 13: 243–446, 1916.)

[2] Frank R. Lillie and Mary Juhn, *Physiol. Zool.,* 5: 124–184, 1932.

[3] Anne Hosker, *Philos. Trans. of the Roy. Soc. of London,* Sec. B, 226: 143–188, 1936.

vious paper, such as a gradient of activity from mid-ventral to mid-dorsal positions in the collar, and the concrescence theory do not enter into the present considerations.

At the ventral locus, prior to origin of the after-feather, barb primordia are constantly being initiated on both sides of the formative center located here. This bilateral activity is a fundamental feature of the formative center. When, in the fowl, regenerating feathers of the breast or saddle have reached a length of about 5.5 cm, which occurs after about 33 to 35 days of regeneration in the breast, and after about 40 days in the saddle, barbs begin to arise in the center of the ventral triangle instead of at the sides. These have a strictly vertical arrangement instead of an inclination parallel to the sides of the ventral triangle characteristic of their predecessors. When about six to eight of these have formed it is seen that there are now two ventral triangles, one at each side of the vertical barbs. It is inferred that division of the formative center at the ventral locus has taken place. It is then observed that, as each of the daughter formative centers has the same bilateral type of activity as the parent one, they are gradually forced farther and farther apart by the two series of barbs formed between them. At the meeting point of the two series of barbs between the daughter centers a new feather shaft (the hyporhachis) arises. The barbs formed on the opposite sides of the respective formative centers belong to the main feather. Seriation of barbs is identical in the after-feather and the corresponding part of the main feather.

As developing feathers have their ventral surfaces apposed to the pulp, these surfaces of the main feather and its appurtenant after-feather are also apposed to one another when regeneration is completed. They are thus mirror images of one another. In most breeds of fowl, and very generally in birds, the fluffy part of the feather, to the lower part of which the after-feather corresponds, is without pigment pattern; but in the barred rock fowl the barring is continued to the base of the feather and corresponds in the main and after-feather. In the hybrids between barred rock and brown leghorn, pigment pattern is usually absent in the fluffy part, but is occasionally represented by incomplete bars, or asymmetrical spots of black, on a white background. When this happens the asymmetries in the main and the after-feather are mirror images, occurring in quite exact correspondence on the right side of the one and the left side of the other. This test of twinning also thus holds for the after-feather.

Miss Hosker[3] deserves credit for the first records of stages of development of the after-feather; but the incompleteness of her material did not enable her to reach correct conclusions. Total preparations are indispensable for the study of this subject; these are prepared by splitting the cylinder of epidermal cells surrounding the pulp, as described in our former paper, spreading it out flat and fixing it under pressure between two glass slides. Our preparations show every stage in the formation of the after-feather from the origin of its first barbs to its completion. Sections made in different planes furnish valuable supplementary evidence.

The division of the formative center and the mirrored correspondence of patterns between the main feather and the after-feather demonstrate that this phenomenon belongs in the category of twinning. As a corollary, the formation of two feathers after division of the formative center demonstrates that the latter has properties with reference to the formation of the feather comparable to those of the primitive streak or blastopore with reference to the formation of the axis of the embryo. These conclusions are limited for the present to the material actually investigated.

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THE INFLUENCE OF ELECTROLYTES ON THE OXYGEN DISSOCIATION OF HEMOGLOBIN[1]

NUMEROUS have been the attempts to interpret the equilibrium between oxygen and hemoglobin since Hüffner's first contribution 36 years ago. Adair's intermediate compound hypothesis,[2] a theory which led to an equation with four constants, successfully expressed his own data; Ferry and Green,[3] however, were forced to change the values of these four constants, in order to adapt the equation to their results. In view of this lack of agreement, it was clear that the fundamental assumptions had to be reconsidered.

When blood ferri hemin, dissolved in phosphate and borate buffers of identical pH value, was titrated potentiometrically with a reductant, the E'_0 values in phosphate buffer were 38 millivolts more positive than those of hemin in borate buffer. Hemin, on combining with phosphate and borate, formed complex compounds possessing different free energies (Fig. 1). Hemoglobin, like hemin, combined with a number of anions (chloride, sulfate, citrate, phosphate, bicarbonate) giving complex compounds possessing different dissociation constants for the reaction Hb + anion $\rightleftarrows$ Hb anion and the reaction Hb anion + $O_2 \rightleftarrows$ Hb anion O_2. This is clearly demonstrated in the experiments plotted in Fig. 2, where the per cent. of HbO_2

[1] From the Lasker Foundation for Medical Research, Department of Medicine, and the George Herbert Jones Chemical Laboratory, the University of Chicago.

[2] G. S. Adair, *Jour. Biol. Chem.*, 63: 529, 1925.

[3] R. M. Ferry and A. A. Green, *Jour. Biol. Chem.*, 81: 175, 1929.