glass, fertilizers, etc.—ought to be treated in such courses, and crude drugs, essential and fixed oils, and petroleum, are products closely allied commercially to chemicals about which the student should know something. A series of lectures on the chemical markets—how chemicals are sold, containers, insurance, fire risks, sales contracts, etc.—might well be delivered by some sales manager or broker familiar through daily, practical experience with this subject. Supplementary courses in applied economics, such as given in many of the larger universities on banking and finance, commercial law, traffic and transportation, business administration, advertising, and even actual salesmanship, might to advantage be offered to the students of commercial chemistry.

A definite and very real need for men with technical training in chemistry as applied to commerce exists and, as yet, there has been no systematic, serious effort on the part of our colleges and universities to supply this demand. Young men equipped with this training would find places in the most highly paid branch of industry open to them, and institutions giving this training would increase the scope of their chemistry departments. Moreover, to supply the American chemical industry with technically trained merchandizing experts will strengthen a "key industry," necessary to national prosperity and, in event of war, essential to national preservation.

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SCIENTIFIC BOOKS

The Physical Chemistry of the Metals. By Rudolph Schenck, Professor of Physical Chemistry in the Technischen Hochschule in Aachen. Translated by Reginald Scott Dean, Research Metallurgist, American Zinc, Lead and Smelting Company. New York. John Wiley and Sons, Inc. 1919. VIII + 239 pages.

It is surprising that this book published in Germany in 1908 should have escaped the eye of the translator until now. It is, however, most encouraging to the future of American industry to find the translator connected with one of the large metallurgical plants. Usually texts which deal largely with theoretical subjects are translated by college men for use in their classes and find their way into the practical field only indirectly. It is, therefore, doubly welcome to see a translation emanating from an industrial plant.

The book deals very largely with principles, but is eminently practical for the metallurgist. The chapter headings: I. Properties of Metals; II. Metallic Solutions and Alloys; III. Alloys of Metals with Carbides, Oxides and Sulphides, Iron and Steel, Mattes, Phase Rule; IV. Metallurgical Reactions, Oxidation and Reduction; V. Decomposition of Carbon Monoxide, Blast Furnace Process; VI. The Reactions of Sulphides give a good idea of the subject matter contained in the book. All of this material is essential to the well-trained metallurgist, but particularly that in the last four chapters. Each subject is treated briefly, but clearly and special emphasis is laid upon equilibrium phenomena and the factors which influence equilibrium. The reactions between carbon and oxygen and metallic oxides receive the full attention they deserve.

With the many merits which the book has it is surprising that it has some simple faults which might easily have been corrected. As examples might be mentioned the following: the omission of the eutectic lines in the diagram on page 51; the form of curves 1, 2, and 4 in diagram on p. 50; the inadequacy of the treatment of Crystal Growth on p. 20; the synonymous use of the terms martensite and austenite; the use of the term sorbitic as applied to chilled cast iron. These are, however, unimportant and it is hoped and believed that the book will be a distinct help to American metallurgists.

H. F.

SPECIAL ARTICLES

THE DEVELOPMENTAL ORIGIN OF THE NOTOCHORD

The notochord is so constant, fundamental and distinctive a structure in the Chordate

group that its interpretation—as is of course thoroughly known—has received great attention, and it plays a part in many of the theories of "the origin of vertebrates." Despite the great theoretical importance attaching to the origin of the chorda dorsalis or notochord, we find in the current text-books statements of its origin most conflicting—and as it seems to me unnecessarily so. Of five standard text-books of human anatomy in the English language, two give the notochord as entodermal, three as derived from the primitive streak. Of five text-books of histology, two describe the notochord as entodermal, one as ectodermal, while two make no statement; two standard comparative anatomies give the notochord as entodermal; of seven embryology texts, five state that it is of entodermal origin, although three of these qualify it as an apparent origin only, one gives the notochord as mesodermal, while one states that it may in different vertebrate groups be ectodermal, mesodermal, or entodermal. Three standard text-books of pathology state that the notochord is an endodermal structure. Most text-books of zoology will probably be found to adhere to the entodermal origin of the notochord. The preponderant statement is thus that the notochord is an entodermal structure, and since this is the origin in the latest human anatomy and in the latest vertebrate embryology, it is clear that this interpretation is not an old obsolete one held over from edition to edition.

In the attempt to reconcile the apparent differences of origin of the notochord or the different interpretations, we have two attitudes illustrated: (1) Kellicott in his "General Embryology" confessedly accepts an origin from any one of the three germ-layers when he says (p. 358): The "notochord may with equal correctness be described as entodermal, mesodermal or even ectodermal, in various forms." Kingsley, in his "Comparative Anatomy of Vertebrates," who accepts the entodermal origin says, however (p. 13, footnote): "The statement is made that in some groups the notochord arises from another germ layer than the entoderm, but these statements apparently rest on erroneous observations or interpretations. Different origins in different vertebrates would tend to show that what are called notochord are not homologous." It requires but brief review of the early development of the chick (for example) to recognize that the notochord is here developed from the primitive streak and hence not entodermal. Furthermore, the fundamental plan of the vertebrate body is so constant and the occurrence, position, extent and relations of the notochord so uniform that any suggestion that the notochord is not homologous in the different vertebrate classes must be rejected at once as without evidence. Finally, it would be improbable that such a structure as the notochord should have fundamentally different origins in different forms as Kellicott felt forced to asume.

When the facts of vertebrate development are fully examined, it becomes at once apparent that it is unnecessary to assume lack of homology, error in interpretation or real diversity in origin, but that in all vertebrates whose development has been traced—from *Amphioxus* up to man—the notochord is formed from the dorsal lip of the blastopore or (in higher forms) its equivalent the primitive streak. For the preponderance of the view that the notochord is an entodermal structure perhaps three things are mainly responsible: (*a*) the prevailing tendency to interpret development as seen in the convenient transverse plane, with (*b*) neglect of the concomitant changes in the long axis and without an appreciation of the dorsal lip of the blastopore as the center of differential growth which lays down, along with other structures, the notochord. (*c*) The preponderant work done upon the development of the lower vertebrates, particularly *Amphioxus* and the *Amphibia*, where, as followed in transection without an accompanying consideration of the growth in the longitudinal planes, it would be unhesitatingly stated that the notochord was folded off from the entoderm. But even in these forms, it would be only the first, more cephalic, portion, of the notochord that could be under any interpretation termed ento-

dermic, since as soon as the so-called "tail-bud" has formed by growth-transformation of the blastoporic lip, differential growth in that region continues to form notochord that has no association with the entoderm whatever. Cerfontaine,[1] it may be pointed out, in his classical paper on the early development of *Amphioxus,* has critically studied the development of the notochord from the dorsal blastoporic lip, and accordingly ranks it as an ectodermal structure.

It is unnecessary to take up here in detail the evidence of the formation of the notochord from the blastoporic lip. There is no reason to consider the development of the chick as exceptional among birds. In mammals, the evidence as it accumulates shows the same mode of origin (from the primitive streak), as exemplified by the recent careful description of Huber[2] for the guinea pig.

The acceptance of the origin of the notochord from the dorsal lip of the blastopore (resp. primitive streak) throughout the vertebrate group (including *Amphioxus*) leads naturally to the statement that the notochord is to be regarded as ectodermal in origin. For many years it has seemed to the writer that the conception of a germ-layer should include nore than topographical relation. It is therefore advantageous to consider the blastoporic lip, primitive streak and so-called "tail bud," undifferentiated material rather than definitive ectoderm, and having within it the "potentialities" of the several structures developed out of it. Its cells would be "totipotent" or at least "pluripotent," if we wish to use these terms. Particularly from the pathological viewpoint, in the interpretation of teratomata from the persistence of undifferentiated cells of primitive streak or tail-bud origin would this be helpful.

The notochord throughout the vertebrate class shows the marked association with the entoderm, which is of course directly responsible for the prevailing view that the notochord is an entodermal structure. While in the phylogenetic interpretation of the origin of the notochord this fact must ultimately be taken full account of, ontogenetically, the entoderm is the only one of the three germ-layers which can not be considered as the source of its cells—the one to which it may be referred. Many, as indicated above, from the fact of the superficial location of the formative centers in the blastoporic lip will regard the notochord as ectodermic. One may, as Keibel clearly does,[3] consider it unnecessary to refer the notochord to any germ-layer. However, if we must group the notochord in with one of the three fundamental germ-layers, it has seemed to the writer that the notochord must be included among the mesodermal structures, for the following reasons: (1) The mesoderm—or, to make due allowance for other possible sources of mesoderm—that portion of the mesoderm with which the notochord is associated is developed from the blastoporic lip (resp. primitive streak, tail-bud), and is similarly "handled" in development. When, as in *Amphioxus* the notochord is at first associated with the entoderm, forming temporarily part of the roof of the archenteron, the mesoderm is similarly associated. (2) It attains like the mesoderm an interior (intermediate) position. (3) It is endoskeletal in its physiologic significance. (4) The notochord in amphibia and reptilia at least gives rise to hyalin cartilage, a tissue of recognized mesodermal characteristic. This seems to be clearly shown by a number of investigators.[4] Considerations similar to the above led Triepel[5] to pronounce the notochord a mesodermal structure.

Were the pathologists to accept the notochord as a mesodermal structure rather than entodermal, it may be suggested that the close resemblance of chordomata to myxomata, myxo-chondromata and chondromata, which I

[1] Cerfontaine, P. *Arch. de Biol.*, Vol. 22, 1906.

[2] Huber, G. Karl, 1918, *Anat. Record,* Vol. 14.

[3] Keibel, Franz, 1900, *Anat. Hefte,* Vol. X.; Keibel, Fr., 1910; Keibel and Mall, Vol. I., Ch. V.

[4] Bruni, A., 1912, *Anat. Hefte,* Vol. 45. Krauss, Fr., 1909, *Arch. f. mikr. Anat.,* Vol. 73. Pusanow, I., 1913, *Anat. Anzeiger,* Vol. 44. Schauinsland, H., 1906, in Hertwig's *Handbuch d. vergel. Entw. ges.,* Vol. III., Pt. 2.

[5] Triepel, H., 1914, *Anat. Hefte,* Vol. 50.

understand so frequently makes diagnosis difficult, might have added significance.

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THE CONFERENCE AT CLEVELAND ON THE HISTORY OF SCIENCE

READERS of Science may be interested in some account of what was probably both the most novel and significant conference of all those held by the various learned associations at their recent holiday meetings, namely, the conference devoted to the History of Science at the Annual Meeting of the American Historical Association in Cleveland. Of even more value than the papers read and the public discussion, although these were marked by an unusual degree of originality, interest, and enthusiasm, and were heard by an audience of very gratifying numbers, most of whom remained throughout the unusually long session, was the opportunity offered—in many instances for the first time—to those engaged in research in this promising field to become personally acquainted, and to talk over matters of common interest informally and face to face.

The chairman of the conference, George L. Burr, librarian, and Andrew D. White professor of history at Cornell University, and a former president of the American Historical Association, presided with something even more than his characteristic charm and felicity. In his opening remarks he noted the fact that while isolated papers bearing on the history of science had been presented at some previous meetings of the American Historical Association, this was the first time in the history of that organization that a conference had been especially devoted to that subject. He also emphasized the rapid strides that research in this subject had made in recent years. Of the papers which followed it will be possible to give only a very brief and, I fear, otherwise imperfect summary here; it is to be hoped that they may be published in full at an early date.

T. Wingate Todd, professor of anatomy in the medical school of Western Reserve University, in an illustrated address on Egyptian medicine showed the predominance of ritual and superstition in that field and the employment of similar postures and paraphernalia by the natives of modern Africa. He questioned whether the priest-physicians of the Nile Valley advanced far beyond the stage of primitive practise in dentistry, general surgery, and therapeutics; and was also skeptical as to their contributions to pharmacology. Before the Eighteenth Dynasty abscesses were incised and fatty tumors removed, but surgery of the extremities is doubtful. During the Fifth Dynasty splints were used with the idea of supporting the injured limb rather than of controlling the fragments.

The paper on "Peter of Abano: A Medieval Scientist," 1250–1316(?), by the present writer discussed the sources for and chief events of his life, showing that he perhaps lived beyond 1316 and taught at Treviso and Montpellier as well as at Paris and Padua, that the evidence for his being protected and employed by popes is better than that for his supposed trial by the inquisition, and that he was a commentator on Aristotle, a critical translator especially from the Greek, and an experimental astronomer, as well as a keen student of medicine and natural science. He was far, however, from being free from the superstition of his age.

Louis C. Karpinski, professor of mathematics in the University of Michigan, spoke concerning "The history of algebra." After touching briefly upon the contribution to mathematical speculation made by the Egyptians, he illustrated the relations of Greek geometry, especially in such a problem as that of the construction of a regular pentagon, to the development of algebraic thinking. He concluded with a summary of the contributions made by several Arabian mathematicians to the growth of algebra.

Henry Crew, professor of physics in Northwestern University, discussing "The problem of the history of science in the college curriculum," pled for a more human treatment