transitions of the "second kind." On page 159 there is an unqualified statement that a neutral atmosphere does not influence the vapor pressure. It is true that the effect is very small, but it is definite and may be deduced by thermodynamic methods, as in Lewis and Randall, page 183, first edition, for example. The treatment of work function and potential differences in the chapter on the electron and ion clouds I think is very confusing and in need of radical clarification. On page 267 it is made to appear that the potential used in the analysis is the classical electrostatic potential; in a footnote on page 274 it is explained that it is not the classical potential, but is derived from the force on the electron *under the actual conditions* (that is, it includes the image force) and then on page 275 the Volta contact potential difference is found by subtracting two of these, whereas the Volta difference by definition is the difference of the classical potentials. Later, on page 367, the same confusion leads to a completely unjustified relation between Volta difference and Peltier heat.

One can excuse these various defects, some of them copied from the literature, in view of the fact that the author has put into the book a number of results of his own independent investigations. His little investigation of the historical background of the first law and why it was first formulated by men outside physics will be found illuminating. There is a chapter on the le Chatelier principle which is much more carefully done than usual, and recognizes that really two different principles are involved. There is a final chapter on the limitations of thermodynamics reproduced from the author's contribution to the "Commentary on the Writings of Gibbs" recently issued by the Yale University Press. All in all, a most useful career may be anticipated for this book.

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HIGHER ALGEBRA

Modern Higher Algebra. By ADRIAN ALBERT. Chicago University Press, xiv + 319 pages, $4.00.

THE title of Professor Albert's "Modern Higher Algebra" is very apt. The book is "modern" in its organization of algebraic theory around such central abstract concepts as those of a group, a ring, an integral domain and a field. This organization was perhaps inspired by van der Waerden's now classic "Moderne Algebra," but has never before been done in an English or American text.

The book is also a "higher algebra," in that it deals with such relatively advanced topics as the classification of fields and matrices, the abstract extension of fields by adjunction of roots of polynomial equations, Galois theory, Galois fields and valued fields ("bewertete Korper"). The study of matrices goes beyond anything in van der Waerden, but ideal theory is not studied.

The exposition of these subjects is extremely clear in detail throughout. On the other hand, the abstract point of view will not easily be assimilated by the average college undergraduate, who will also be hampered by the absence of any treatment of such "elementary" things as complex numbers and determinants. The dabbler, too, will find it hard to detach morsels of intellectual nourishment from a complex and highly coherent mass of ratiocination.

But the serious student of mathematics will find Professor Albert's book stimulating and packed with ideas. It is in a class quite apart from the mediocre and nearly identical "college algebras" which American commercial publishers seem to prefer. The University of Chicago is to be congratulated for publishing an indispensable book, which every specialist in algebra should own.

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SPECIAL ARTICLES

DEVELOPMENT UNDER STERILE CONDITIONS OF THE SHEEP STOMACH WORM HAEMONCHUS CONTORTUS (NEMATODA)

IN a paper now in press we report the cultivation of bacteria-free larvae of *H. contortus,* in a suitable medium, up to the infective stage, *i.e.,* through the two larval free-living stages. The larvae obtained from such cultures differed from those grown under natural conditions in that they were slightly smaller, although the size ranges overlapped. These *Haemonchus* larvae produced in a susceptible lamb normal adult forms.

We wish here to report progress in the cultivation of the parasitic stages. At first we used for the inoculum the bacteria-free larvae from the cultures of the free-living stages. It was, however, difficult to secure enough larvae from the initial medium and we therefore used larvae that had reached the end of their free-living stage in sheep feces. These larvae were isolated in a Baermann funnel.

Since bacterial sterility appears to be an absolute requirement for further progress, the infective larvae were washed by sedimentation many times in sterile water in long glass tubes. To expedite the sterilization and also to unsheath the infective filariform larvae, Labarraque's solution, diluted one to twenty parts with distilled water, was also used. Unsheathing takes only about fifteen minutes, but the entire procedure including the washings consumes about two and one half days. This not only removes the microorganisms adhering to the cuticle of the larvae but gives time for those within the larval intestine to be excreted and eliminated. The final washing is always made in Ringer's solution, after which the nematodes are transferred to a special medium. Being unsheathed infective forms, they are now in the stage in which they would normally continue development in the abomasum of the sheep.

The medium consisted of a 0.5 per cent. agar in Ringer's solution containing sheep liver extract, heat-killed ground yeast, sheep blood and sheep kidney, the last either in small pieces or as an extract. The reaction was adjusted to pH 3.0. Two or three drops of defibrinated sheep blood were added to the surface of the semi-solid medium prior to inoculation with several drops of the nematodes suspended in Ringer's solution. The cotton-plugged tubes after inoculation were sealed with sealing wax and incubated at a temperature of 39.5° C.

In numerous tubes examined at intervals during three weeks of incubation, definite development into the parasitic phase has been demonstrable. The presence of new sheaths enclosing the larvae, which were introduced unsheathed into the culture, is an early sign. There is little or no growth during this period, which ends with the ecdysis of the third larval (first parasitic) stage, shown by the presence of cast sheaths and live fourth larval (second parasitic) stages. With subsequent growth and differentiation, these fourth stage larvae have commonly reached a size of 1–2 mm; and some exceeding 3 mm in length have been found. The larger specimens show a well-defined provisional buccal capsule; esophagus 0.3–0.4 mm long; markedly elongated genital primordium, exceeding 200 μ, whose termini can not be easily determined; and clear-cut differentiation into males and females by characteristic configuration of the posterior ends. By comparison with the figures and descriptions of Veglia,[1] these larger forms are advancing into the last third of the fourth larval stage, and by his chronology are comparable to the sixth day of parasitic life in the abomasum. They are about five times the length of the unsheathed larvae with which the culture tubes were inoculated.

We have not seen adult worms in our cultures, but feel confident that these will be obtained with some further slight modifications of the nutritional environment. From the work to date, we do not believe, as has been occasionally concluded by other investigators, that a serious obstacle exists in culturing parasitic stages of the helminths of mammals. The successful *in vitro* culture of the parasitic worms should lead to a more adequate understanding of their physiology and to further elucidation of the mechanism of immunity developed against helminths by their hosts.

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[1] Frank Veglia, 3rd and 4th Reports Dir. Vet. Res. Onderstepoort, pp. 349–500, 1916.

EVIDENCE OF A ROTATIONAL GROWTH FACTOR IN BACILLUS MYCOIDES

IN recent years the question of spirality in animal and plant cells has received wide-spread attention. Little progress has been realized in obtaining an explanation of the phenomenon, but in general it would seem that spirality may arise from the cell itself and is due to the resolution of two growth factors, one longitudinal and one rotational. According to Smith[1] spontaneous growth movements have been said to be due to a wide variety of conditions such as osmotic currents, the action of cilia, peristaltic contractions, protoplasmic streaming and the secretion of gelatinous materials.

Rotation of cells on their long axis is not unknown among the *Thallophyta.* Smith mentions that many of the *Oscillatoria* exhibit such rotations, and Pringsheim and Langer[2] call attention to the well-known twisting in certain of the *Begiotta.*

Hastings[3] has suggested that the characteristic spirality of colonies of *Bacillus mycoids* may be comparable to the spirality in other single-celled organisms, in higher plants and animals. The efforts of numerous bacteriologists to explain the cause of colonial spirality constantly exhibited by *B. mycoides* have failed to produce a convincing explanation. Recently, while studying growing cultures, it was possible to confirm the observations of Pringsheim and Langer concerning the occurrence of spirally twisted filaments of *B. mycoides* (see figure). Evidence obtained from studies on such spiral twists indicates that *B. mycoides* possesses a rotational growth factor which may be responsible for the typical colonial spirality on solid culture media.

A possible explanation for the formation of the rarely occurring spiral twists was sought. Two explanations seemed possible: Either (1) in its normal forward growth the filament of cells moved through the proper planes to eventually form the spiral figure, or (2) the twisted spirals resulted from tension produced by rotation of the cells on their long axes when at some point the filament was so firmly attached that the only relief was to twist or break.

Two methods of establishing conditions under which spiral twists form in great numbers have been successful. In both methods the conditions produced were

[1] G. M. Smith, "The Fresh Water Algae of the United States," McGraw-Hill Book Co., New York, 1933.

[2] E. T. Pringsheim and J. Langer, *Centbl. Bakt.* (etc.), II Ab., 61: 225, 1924.

[3] E. G. Hastings, SCIENCE, 75: 16, 1932.