of the "Rz" cells as derivatives of the fused polar bodies and with the new light thrown on the spermatogenesis of the honey bee, the reviewer has been fully, if tacitly, converted to the interpretation of the origin of the sex-glands from the visceral wall of the mesodermal tubes as promulgated by Wheeler and Heymons and accepted by Nelson. Of especial interest are the chapters on segmentation and nervous system. It is rather unfortunate that instead of giving a diagram of his own, representing segmentation in insects, Nelson reproduces in Fig. 36 a diagram from Snodgrass, which can not be considered correct. Nelson himself is aware of this, as may be seen from his footnote on page 106. It is important to mention that Nelson describes and figures the evanescent appendages of the tritocerebral or intercalary segment in *in toto* views of the egg (VIII*a*, 3Br). Although the truth of his statement can not be doubted, this as well as the following figures are not conclusive and we regret that no figure is given of a transverse section through the region of the tritocerebrum as described on page 106. Another point of interest is the absence of a segment between the mandibles and the maxillæ as described by Folsom for *Anurida*. The reviewer has never been able to accept Folsom's interpretation and finds in Nelson's description a new proof against the existence of such a segment. On the other hand, the rudiments of the second maxillæ (the future lower lip) in the honey bee appear well represented in Figs. X.–XIII. The rudimentary appendages representing the future thoracic legs disappear before the larva is hatched. The statement that the abdomen consists of 12 segments must be accepted as correct, but a drawing of the sagittal section showing all segments is wanting. A feature of great importance, especially for future investigators, is the table showing the rate of development. The data accumulated by Nelson for this are much more correct and detailed than those obtained by any of his predecessors. The drawings are well executed and for the most part original. Some of them are especially welcome, as for instance Figs. 1 and 2 showing the external structure of the egg, Fig. 39 showing the cephalic portion of the nervous system of a newly hatched larva, Figs. 63 and 64 showing the tracheal system and the figures reproduced in the plates.

Many readers will probably regret that no account is given of oogenesis, of spermatogenesis or of fertilization. To be sure, the inclusion of these chapters would have increased the size of the book as well as required careful sifting of data and a great deal of original, tedious reinvestigation. At the same time it would be difficult to find a more appropriate place for these chapters than in a monograph on embryology. But it is scarcely fair to criticize the author for omitting to deal with a subject which does not necessarily come within the scope of his work. Dr. Nelson's is the first comprehensive monograph which has ever been printed on the embryology of the honey bee. It will be of great value both to the investigator and the student and we should be truly grateful to its author for having presented us with a work of such high standard.

ALEXANDER PETRUNKEVITCH

SCIENTIFIC JOURNALS AND ARTICLES

THE March number (Vol. 22, No. 6) of the *Bulletin of the American Mathematical Society* contains: Report of the twenty-second annual meeting of the society, by F. N. Cole; Report of the winter meeting of the society at Columbus, by H. E. Slaught; "On Pierpont's definition of integrals," by M. Fréchet; "Reply to Professor Fréchet's article," by J. Pierpont; Review of Carmichael's Theory of Numbers and Diophantine Analysis, by L. E. Dickson; "Notes"; and "New Publications."

THE April number of the *Bulletin* contains: "Some remarks on the historical development and the future prospects of the differential geometry of plane curves," by E. J. Wilczynski; "A certain system of linear partial differential equations," by H. Bateman; "Changing surface to volume integrals," by E. B. Wilson; "A new method of finding the equation of a rational plane curve from its parametric equations," by J. E. Rowe; "The physicist J. B. Porta as a geometer," by G.

Loria; Review of Pierpont's Functions of a Complex Variable, by H. P. Manning; "Shorter Notices": Snyder and Sisam's Analytic Geometry of Space, by R. M. Winger; Slichter's Elementary Mathematical Analysis, by L. C. Karpinski; Ford's Automorphic Functions, by A. Emch; Gibb's Interpolation and Numerical Integration and Carse and Shearer's Fourier's Analysis and Periodogram Analysis, by M. Bôcher; Herglotz's Analytische Fortsetzung des Potentials ins Innere der anziehenden Massen, by W. R. Longley; Lange's Das Schachspiel, by L. C. Karpinski; Ince's Descriptive Geometry and Photogrammetry, by V. Snyder; "Notes"; and "New Publications."

SPECIAL ARTICLES

THE PRESSURE OF SOUND WAVES

In his "Wärmestrahlung"[1] Planck, after proving from electromagnetic theory that the pressure of radiation equals the volume density of radiant energy, shows that the corpuscular theory of light would give a pressure twice as great. From this he infers that the Maxwell radiation pressure can not be deduced from energy considerations, but is peculiar to the electromagnetic theory and is a confirmation of that theory. The implied conclusion is that mechanical waves would not exert a pressure of this magnitude. It may be well to recall, therefore, that Lord Rayleigh has shown, from energy consideration,[2] that transverse waves in a cord exert a pressure equal to the linear energy density, and that sound waves in air must cause a pressure equal to the volume density of energy in the vibrating medium. Altberg[3] has made the conclusions of Rayleigh the basis of a method of determining the intensity of sounds.

As the pressure due to sound waves in a gas must be ultimately the result of molecular impacts, it would seem probable that the magnitude of this pressure may be determined from the elementary kinetic theory, and this proves to be the case. Consider an extended wave incident normally on a unit surface. According to the kinetic theory, the molecules which strike this surface are reflected with the same velocity that they had just before impact. As the surface is small in comparison with the extent of the wave front, we need not follow the history of these reflected molecules, which will immediately become dispersed in the passing wave in all directions. In other words, under these conditions no stationary waves will be formed by reflection, and we may confine our attention to the effect of the incident wave. Of course there will also be increased pressure on the rear surface due to the diffracted waves, but this will not affect the pressure on the front surface. At the instant that the wave front strikes the surface imagine the whole wave length divided into thin strips parallel to the surface, s in number and each of thickness x, so that sx is equal to one wavelength. The velocities of displacement due to the wave are mass effects, but it seems proper to add them to the different individual velocities of the gas molecules which move *en masse*. Let the velocities of wave displacement in the successive strips be $u_1, u_2, \ldots u_s$. The component velocities of translation of the gas molecules normal to the surface are U_1, $U_2, \ldots U_n$. The two other components contribute nothing to the pressure on the surface. The resultant velocity of the molecules having a velocity of translation U_1 in the first strip will be $U_1 + u_1$. As they are reflected with the same velocity, the change of momentum of each molecule is

$$2m(U_1 + u_1) = f.dt,$$

where m is the mass of each molecule and $f.dt$ the impulse of the force during collision. If N_1 is the number of molecules per unit volume having the velocity U_1, the number in the strip of thickness x is N_1x and if t_1 is the time required for the strip to move a distance x,

$$N_1x = N_1(U_1 + u_1)t_1.$$

Taking account of the fact that half the molecules of this class will be moving away from the surface, the total change of momen-

[1] "Wärmestrahlung," 2d ed., p. 58.

[2] *Phil. Mag.*, 3, 338, 1902.

[3] *Ann. der Phys.*, 11, 405, 1903.