Sutherland relation (Einstein, *Zeits. Elektrochem.*, 14: 235, 1908) $D = \frac{RT}{6\pi\eta rN}$ (η is the viscosity of the solvent and r is the radius of the solute molecules), whereas in the gas phase the two coefficients are proportional to each other, being related by the equation $D = \frac{\eta}{\rho}$ (Loeb, "Kinetic Theory of Gases," p. 224, McGraw-Hill Book Co., 1923). The former relation assumes the validity of Stoke's law, which is valid for large spheres but for small molecules could not be justified on a kinetic conception of viscosity analogous to that for gases. This should at once suggest that new kinetic factors prevail in the liquid phase. It is apparent that the micro-crystals which augment viscosity in proportion to the fraction of the volume which they occupy will hinder diffusion to a corresponding degree, and thus account for the reciprocal relation. The concept of micro-crystals should shed its light upon other properties of liquids. Thus their resolution into single molecules with increasing temperature would add a term to the specific heat expression for a liquid. The measured compressibility of a liquid is a composite of the compressibility of the liquid and microcrystalline portions. The micro-crystals in liquid surfaces offer centers for catalytic action which would not have been suspected without them. These questions have not been developed sufficiently for presentation.

ROBERT E. BURK
WESTERN RESERVE UNIVERSITY

THE ETIOLOGY OF EPIDEMIC COLDS IN CHICKENS*

DEBLIECK[1] was the first scientist to report on the cause of colds in the chicken. This investigator discovered a hemophilic bacterium which appeared to be involved in the disease in Holland. The first American investigator to report on a similar disease was Nelson.[2] This worker found a Gram negative bacterium which appeared to be responsible for the outbreaks investigated. The chickens affected with this disease did not appear sick, and there was no mortality. Production was seriously affected; and some of the birds showed a bilateral discharge, while distinct gurgling sounds were heard in the trachea. At necropsy considerable exudate was found in the nasal passages, the infraorbital sinuses and the trachea. The disease was transmitted to healthy birds by fresh tracheal exudate from diseased birds and by a hemophilic bacterium isolated from the exudate on culture media.

Delaplane and Stewart,[3] working independently and at the same time as DeBlieck and Nelson, found a Gram negative hemophilic bacterium which they considered to be the cause of a serious outbreak in Rhode Island. The symptoms were those of an exudative rhinitis and sinusitis with little involvement of the larynx, trachea or bronchial tubes. The eyes, turbinates and infraorbital sinuses showed various degrees of inflammation. The mortality in the Rhode Island outbreaks was comparatively high.

Lewis and Mueller[4] report a series of experiments which lead them to believe that the agent of the "common cold" in chickens is not a filtrable virus, and further work by Eliot and Lewis[5] indicates that a pleomorphic, hemophilic, Gram negative bacterium is the responsible agent. They suggest the name *Hemophilus gallinarum* for the microorganism. In their filtration experiments Lewis and Mueller used Berkefeld, Mandler, Chamberland and Seitz filters with negative results.

Six widely separated outbreaks of coryza or colds in chickens have been studied in Massachusetts, using both bacteriological and filtrable virus methods. Five of these outbreaks presented symptoms similar to those described by Nelson, and one in a flock of game birds was like that described by Delaplane and Stewart. A hemophilic streptococcus was isolated from one,[6] a hemophilic bacterium from three[7] and no pathogenic microorganisms could be found by cultural methods in two of these outbreaks. Filtrable agents were not demonstrated in any of these cases when Berkefeld, Coors and Seitz filters were used. These findings are in agreement with those of DeBlieck, Nelson, Delaplane and Stewart, in that Gram negative, hemophilic microorganisms may be present in colds of chickens and aggravate the symptoms and lesions of the diseases, as well as taking some part in immunity.

Tracheal exudates from the two outbreaks in which hemophilic microorganisms could not be isolated were studied by means of a series of graded acetic-cellodion filters prepared according to the directions of Cox and Hyde.[8] The causative agent passed successfully through these filters, and was transmitted directly to healthy chickens by intranasal and intratracheal inoculation of bacterial free filtrates. The outbreaks from which the hemophilic microorganisms were isolated occurred before the series of graded acetic-cellodion filters were used in this laboratory and were not tested by this method.

Since there is no satisfactory standard for measuring the size of the pores in the filters used in this

* Contribution No. 214, Massachusetts Agricultural Experiment Station, Amherst, Mass.

1 L. DeBlieck, *Vet. Jour.*, 88: 9, 13, 1932.

2 J. B. Nelson, *Jour. Exp. Med.*, 58: 289, 304, 1933.

3 J. P. Delaplane and H. O. Stewart, *R. I. State Coll. Bul.*, 29: 92, 94, 1934.

4 M. R. Lewis and E. Mueller, *Jour. Am. Vet. Med. Assn.*, 37: 759, 769, 1934.

5 C. P. Eliot and M. R. Lewis, *Jour. Am. Vet. Med. Assn.*, 37: 878, 888, 1934.

6 C. S. Gibbs, *Poultry Sci.*, 12: 46, 48, 1933.

7 C. S. Gibbs, *Mass. Agr. Exp. Sta. Bul.*, 311: 15, 1934.

8 H. R. Cox and R. R. Hyde, *Am. Jour. Hyg.*, 16: 667, 728, 1932.

experiment, the size of the coryza virus particles can only be compared with particles of known dimensions which were treated in a duplicate series of filters at the same time and under the same conditions as the tracheal exudates from the chickens. This experiment indicates that the coryza virus particle is smaller than *S. marcescens,* 0.5 by 1.0 μ, Bergey,[9] and larger than the carbon monoxide hemoglobin molecule which has been determined by Northrop and Anson[10] and Svedberg[11] to be about 5 m μ in diameter. Svedberg also found the ovalbumin molecule to possess a diameter of 4.34 m μ. Using these values in connection with Poiseuille's law for determining the radius of the pores in permeable membranes, it has been found that the coryza virus particles pass through acetic-cellodion filters with pores of an estimated diameter of 120 m μ, and are retained by those possessing a calculated pore size of 80 m μ. Therefore, the diameter of the coryza virus particles must be between 80 and 120 m μ. In general this finding is in line with the observations of Bauer and Hughes[11] and Elford,[12] who state that a relatively large group of virus particles has an end-point within these limits.

CHARLES S. GIBBS

[9] D. H. Bergey, Textbook, 3rd ed. 116, 117, 1930.

[10] J. H. Northrop and L. M. Anson, *Jour. Gen. Physiol.,* 12: 543, 554, 1929.

[11] T. Svedberg, Kolloid-2, 51: 10, 1930, quoted by J. H. Bauer and T. P. Hughes, *Jour. of Gen. Physiol.,* 18: 161, 162, 1934.

[12] W. J. Elford, *Proc. Roy. Soc. London.* Series B, 109, 360, 1931.

THE HEART RATE IN HEAVY WATER

HEAVY water should afford a new method of controlling the rate of physiological processes. We have found that the frequency of pulsation of the excised heart of the frog can be slowed down in 20 per cent. D_2O.

The heart of a winter frog was carefully excised, including the *sinus venosus,* and the base tied to a small glass rod. A fine wire hook was inserted in the apex and attached to a heart lever writing on a kymograph. The heart was immersed in a 2 cc of Ringer's fluid containing approximately 20 per cent. heavy water in a small shell vial. The room temperature was 18–20° C.

The first heart tested was slit in the ventricle to facilitate diffusion, but this treatment rendered the beat rather feeble. After 15 minutes in ordinary Ringer the time for ten beats was 11.3 secs. The vial of D_2O Ringer was then substituted for the control, and the time for ten beats became 16.9 secs. after 5 minutes. The second heart tested was not slit and beat more vigorously. After 6 minutes in H_2O Ringer the time for ten beats was 11.5 secs. It was then immersed in the D_2O Ringer and after 10 minutes the time for ten beats was 27.8 secs. It was then transferred to ordinary Ringer and the time for ten beats was reduced to 20 secs. The third heart tested was placed immediately in the Ringer containing heavy water and after 5 minutes it was beating vigorously once a minute. Seven minutes after immersion the beat was constant at a rate of once every 5 secs. After transfer to H_2O Ringer the heart gave a regular beat every 2 secs. After 10 minutes of this constant rate the heart was replaced in D_2O Ringer in which the pulsations occurred every 3 secs. for 1 minute and then stopped. However, the heart partially recovered when replaced in H_2O Ringer after 7 mins., the rate being once every 2.5 secs. in regular sequence, except for a regular pause every 6 to 8 beats.

Although the scarcity of the heavy water precludes extensive tests at the present time, the slowing down was twice reversed in the third heart, indicating the influence of the heavy hydrogen isotope.

A similar effect has been observed by Mr. H. Z. Gaw[1] in the rate of contraction of the vacuole in a race of *Paramecium caudatum* in 30 per cent. D_2O, in which the vacuole empties every 19 secs. compared to every 11.3 secs. in controls (Temp. 18.8° C.). The slowing of the vacuole is completely reversible after return to ordinary water and it is probable that complete recovery of the heart would occur under conditions of normal circulation. In each case the heavy water has an effect similar to that produced by lowering the temperature. The biological effects of heavy water are what one would expect from the lower energy content[2] of chemical systems involving deuterium.

T. CUNLIFFE BARNES
J. WARREN
OSBORN ZOOLOGICAL LABORATORY,
YALE UNIVERSITY

[1] T. C. Barnes and H. Z. Gaw, *Jour. Am. Chem. Soc.* (in press).

[2] H. Urey and G. K. Teal, *Rev. Modern Physics,* 7: 34, 1935.

BOOKS RECEIVED

BLACK, NEWTON H. *An Introductory Course in College Physics.* Pp. viii + 714. 645 figures. Macmillan. $3.50.

GLENNIE, AGNES E. and GWEN DAVIES. *Index to the Literature of Food Investigation.* Vol. 6, No. 1, March, 1934. Pp. 309. His Majesty's Stationery Office, London. 5s.

PARSONS, G. L. *Scientific Papers and Addresses of the Hon. Sir Charles A. Parsons.* Pp. xxviii + 260. 8 plates. Cambridge University Press, Macmillan. $4.50.

PEATTIE, DONALD C. *An Almanac for Moderns.* Pp. 396. Illustrated by Lynd Ward. Putnam. $3.00.

RICHMOND, DONALD E. *The Dilemma of Modern Physics.* Pp: xiii + 120. 15 figures, 2 plates. Putnam. $2.00.

SNYDER, LAURENCE H. *The Principles of Heredity.* Pp. xiii + 385. 152 figures. Heath. $3.00.