course requires to be substantiated by a more detailed study and I am making a cytological investigation of the embryo sac development and fertilization in *O. lata* with the hope of obtaining more conclusive evidence of the presence of some form of apogamy in this mutant.

R. R. Gates

Missouri Botanical Garden,
September 29, 1909

Membrane Formation and Pigment Migration in Sea Urchin Eggs as Bearing on the Problem of Artificial Parthenogenesis

In a recent number of Science McClendon[1] has summarized his work on artificial parthenogenesis in *Arbacia* and discussed it with reference to changes in permeability of the surface layer of the egg. With the same point in view, during June and July at Tortugas and the latter part of August, 1909, at Woods Hole, I have been studying the earliest changes taking place in developing sea urchin eggs, especially the formation of the fertilization membrane.

Ever since the paper of Delage appeared, on electric parthenogenesis, I have been impressed with the great similarity in the means of stimulating eggs to develop and the means of stimulating muscles and sensitive plants. Morgan expressed the situation clearly when he compared the means of causing development to a stimulus. A considerable mass of evidence now exists, especially emphasized in recent papers of Ralph Lillie, that stimulation of muscles is effected by a momentary increase in permeability of the muscle membrane to CO_2, allowing its more ready escape during contraction. CO_2 is the chief end product of the energy-yielding reaction on which contraction depends and its removal from the cells allows the reaction to proceed (during contraction) to a new equilibrium (of rest), when checked by a second accumulation of CO_2. The increase of permeability on stimulation removes the condition which is preventing the contraction. The movements of sensitive plants can best be explained as due to an increase in permeability of the cell membranes relative to the turgor-maintaining substances. The important point is that processes in general brought about by stimulation are connected with changes in permeability. This holds good for secretion, and the fact that the first visible change in many eggs is a secretion is certainly significant.

Several authors have recorded instances of development without membranes, perhaps the best known case being parthenogenesis by hypertonic sea water. I have repeated this experiment and find that there is without doubt a surface change in the egg, visible on slightly high focus, which I take to be a membrane very close to the egg surface. Similar membranes are produced in *Hippanoë* eggs by treatment with CH_3COOH. They are hardly noticeable even with the high power. Very close fitting membranes and membranes which surround each blastomere when the egg divides may be produced in other ways. It seems as if development without membranes was rather a case of development without pushing out of the membrane.

This pushing out appears to be due to the formation of some substance exerting an osmotic pressure between it and the cell surface, which absorbs the surrounding sea-water. It would be impossible for the fluid between fertilization membrane and egg to have come from the egg without a greater diminution in volume than is observed in eggs immediately after fertilization. Loeb[2] has discussed the above view and designated a proteid or lipoid as the substance in question. A very small concentration of some substance formed just behind the fertilization membrane would account for its pushing out, provided the membrane were impermeable to the substance and freely permeable to the salts of sea-water. For the latter there is ample evidence.

The membrane itself is a secretion comparable to the cellulose layers formed on plant cells after division. It is composed of some substance of a highly resistant nature

[1] N. S., XXX., p. 454, October 1, 1909.

[2] *Arch. Entw. Mech.*, XXVI., 1908, p. 82.

as is shown both by its insolubility in concentrated mineral acids, including sulphuric, and also on short boiling in molecular solutions of caustic alkalis. On prolonged boiling it either dissolves or becomes so broken up as to be unrecognizable. The egg itself dissolves entirely in concentrated H_2SO_4 and in NaOH except for a few granules. Unfertilized eggs dissolve entirely in concentrated H_2SO_4, showing that the membrane is not present before fertilization. It is also left undigested by pepsin HCl.

Regarding the membrane as a secretion, its formation is strong evidence that an increase of permeability, of which it is the direct result, is brought about by the various membrane-forming substances. Its removal from the sphere of reacting substances (in the egg) must upset any chemical equilibrium which has been attained, this equilibrium meaning a condition of rest and non-development of the egg.

The second visible change occurring in some sea-urchin eggs, *e. g., Arbacia,* is the migration of the red pigment granules, which, until after formation of the fertilization membrane are distributed throughout the cytoplasm, to the periphery of the egg, as mentioned by McClendon. This migration can be explained on the assumption that the change of permeability associated with membrane formation is connected with ionic interchange between exterior and interior of the cell giving rise to potential differences such as are seen in the functioning of glands, muscles, nerves and sensitive plants. Lillie[3] has discussed this, theoretically, in a paper in which an increase in permeability is also taken to be the change bringing about development. "With the appearance of an increased permeability . . ., the peripheral regions of the protoplasm must become, for a time at least, until the potentials are equalized, *positive* relative to the interior." Most small particles suspended in a fluid become negatively charged and migrate in an electric field. The fact that these bodies are repelled by the asters is further evidence for regarding them as negative, for Lillie has suggested several reasons which point to the asters as regions of negative charge. It is on account of the prominent asters present at this stage that the micromeres are free of pigment. Even when cut off from the pigmented area of centrifuged eggs these cells are relatively free from pigment granules.

Such small electro-negative particles, in equilibrium under conditions of rest in the cell, would, on an increase of permeability, migrate toward the now positive cell surface. A calculation (by Lillie) of the potential difference which might arise, based on the observed changes in muscle cells, gives a value of 14 volts per cm., which would be ample to account for the changes observed in *Arbacia.* This same movement occurs in eggs treated with hypertonic sea-water and CH_3COOH.

This change in potential must be accompanied by an increase in surface tension (see Lillie) and it is quite generally true that the surface tension increases immediately after fertilization, as indicated by the rounding up of eggs which were previously oval or elongated in shape.

The facts which indicate an increase in permeability of the surface membrane as the first change taking place in the development of an egg may be summarized as follows:

1. The general similarity in the means of stimulating eggs to divide and the means of stimulating muscles and sensitive plants. These may be broadly classified as chemical, mechanical, electrical, thermal and osmotic.

2. The fact that the chemical substances which start parthenogenesis cause in other cells an increase in permeability (hæmolysis of red blood corpuscles and loss of pigment in pigment-bearing cells).

3. Evidence that stronger concentrations of development-starting substances cause loss of pigment in pigmented eggs.

4. That a secretion is the first visible change occurring in many eggs.

5. That a migration of pigment-containing granules to the cell surface in *Arbacia* eggs is caused by a region of positive charge at the surface resulting from ionic interchange ac-

[3] *Biol. Bull.,* XVII., p. 207, 1909.

companying increased permeability after membrane formation.

6. That an increase of surface tension, which must accompany a change of potential at the surface, is quite general in naked eggs after fertilization, as indicated by their rounding up when previously they had been irregular in outline.

A logical explanation is afforded why such a change as increased permeability should cause development, namely—the removal of some reaction product whose accumulation has brought the cycle of reactions occurring during the growth period to a standstill. This does not exclude the possibility that in time another change may take place which leads to those disintegrative changes, especially emphasized by Loeb.

E. Newton Harvey

Columbia University,
October 7, 1909

Societies and Academies

The Philosophical Society of Washington

The 668th meeting was held on October 9, 1909, Acting President Wead presiding. The following papers were read:

Reversion of Power Series: C. E. Van Orstrand, of the Carnegie Institution of Washington.

The equation which Professors Harkness and Morley developed for the reversion of a power series was extended so as to obtain a general term for the reverse series similar to the one obtained by Professor McMahon. The complete expansion for the first thirteen coefficients was given, and some comment was made in regard to the application of the reverse series to inverse functions including solutions of polynomials of the n-th degree.

The Vibration Galvanometer: Frank Wenner, of the Bureau of Standards.

The vibration galvanometer is an instrument for the detection or comparison of small alternating currents and electromotive forces. It differs from other instruments for the same purpose mainly in having the moving system tuned to the frequency of the current or electromotive force to be investigated.

The general theory of the instrument was developed, and equations derived which show how the amplitude of the vibration depends upon the various constants of the instrument and the conditions under which it is used. An auxiliary set of equations gives all the constants in terms of quantities easily measured. This makes it possible, with but few simple measurements on any particular instrument, to predict its behavior under almost any set of conditions, or to calculate the effect of any contemplated change in the design.

It has been observed that some instruments resonate to two different frequencies. The cause of this double period of the moving system was explained. For those instruments which develop a relatively large back electromotive force the effect of putting a large inductance in the circuit is shown and the advantage of using a step-up transformer is pointed out.

The experimental part of the work has to do mainly with the verification of the more important relations shown by the equations. The constants of the different instruments used were obtained, using the theory developed. Some of the constants are also determined by an independent method and thus serve as checks on the theory. A method of tuning was given which is more sensitive than the method generally used and which is applicable in other cases where the vibration is forced.

W. P. White, of the Carnegie Institution of Washington, spoke informally on the zero shift in moving-coil galvanometers, discussing briefly its cause and how it may be lessened.

R. L. Faris,
Secretary

The Chemical Society of Washington

The 192d meeting of the Washington Section of the American Chemical Society was held at the George Washington University Lecture Hall on October 14, 1909. President Walker presided, the attendance being 94. Dr. H. W. Wiley gave a report of the seventh International Congress of Applied Chemistry, held in London in May and June of this year, including a history of the development of the society. He described the entertainments furnished by the British members, told of the more important papers presented at the meeting and of the personnel in attendance, and the part taken by some of the prominent American chemists. Twenty-one new names were added to the list of members and twelve names removed.

J. A. LeClerc,
Secretary