film were not present. The film disappears at higher salt concentrations because the charge (ζ-potential) becomes less (or λ becomes comparable to Δr), and thus the capillary rise h_s decreases and produces an apparent decrease in surface tension.

If we measure the capillary rise in a tube of radius r whose walls are covered by a water film of thickness Δr the surface tension of the water should be calculated by

$$\gamma = \tfrac{1}{2}\rho g h (r - \Delta r). \qquad (15)$$

Jones and Ray, however, calculated their surface tension by the equation

$$\gamma_{JR} = \tfrac{1}{2}\rho g h r. \qquad (16)$$

The value of Δr can be calculated by Eq. (14) by inserting $\gamma / r = \rho g h / 2$, so that we have

$$\Delta r = (kT/2e)(\pi D/\rho g h)^{1/2} = 2.16 \times 10^{-5}/h^{1/2} \qquad (17)$$

According to this interpretation the values of γ_{JR} at low concentrations are higher than the true surface tension of water by an amount:

$$\gamma_{JR} - \gamma = (kT/4e)(\pi D \rho g h)^{1/2} = 0.0107 h^{1/2} \qquad (18)$$

Jones and Ray in all their experiments used a single capillary of radius $r = 0.01361$ cm, and the capillary rise was $h = 10.8$ cm. According to Eq. (18) the increment $\gamma_{JR} - \gamma$ should have been 0.035 dyne cm^{-1}. This is of the same order of magnitude as the apparent decrease in surface tension of 0.015 dyne cm^{-1} which they observed at concentrations below 10^{-3} M.

The values of Δr and $\Delta\gamma$ given by Eqs. (17) and (18) have been based on the assumptions that $\Delta r << \lambda$ and $\eta_1 >> \eta_M >> 1$. When these conditions are not fulfilled, Δr and $\Delta\gamma$ will have lower values.

In the following table the values of λ are given for various assumed concentrations between 10^{-3} and 10^{-5} M as calculated from Eq. (4). The next column contains values of $\Delta\gamma$ from a curve plotted from data of Jones and Ray for KCl. From these we can calculate values of Δr which would account for these values of $\Delta\gamma$. The last column gives η_M as calculated from Eq. (8) by inserting $p = \rho g h/2 = 5300$ dynes cm^{-2}. The values of λ decrease far below the maximum value of Δr (280 Å), but Δr decreases too, so that in all cases the condition $\Delta r << \lambda$ is approximately fulfilled. The reason that Δr never rises as high as 650 Å, which is given by Eq. (17), is that the condition $\eta_1 >> \eta_M$ is not fulfilled at the lowest concentrations.

TABLE I

CALCULATIONS BASED ON THE SURFACE TENSION DATA OF JONES AND RAY FOR KCl

Molar concentration	λ	$\gamma_{JR} - \gamma$ dyne cm^{-1}	Δr obs	η_M
0.0010	97 Å	0.000	..	0.46
.0005	137	.0014	26 Å	0.65
.0003	178	.0065	122	0.82
.0002	217	.009	174	1.01
.0001	307	.012	230	1.36
10^{-5}	970	.015	280	3.15

The ζ-potentials determined by the electric mobility of particles of glass and quartz[3] are negative and are of the order of 50 to 100 millivolts at concentrations of about 10^{-5} to 10^{-6} M and decrease rapidly as the concentration rises from 10^{-4} to 10^{-3} M. The highest values of η_1 calculated by Eq. (2) from these potentials thus range from 2 to 4. The marked decrease in η_M to low values shown in Table I as the concentration increases is probably the cause of the decreases in Δr and $\Delta\gamma$ at higher concentrations.

These rough calculations show that the Jones-Ray effect can be adequately explained on the basis of a water film held on the surface of the capillary tube by electric charges bound by the quartz.

The present paper is merely preliminary. It has been possible to obtain a complete integration of Eq. (5) in terms of elliptic functions. Some calculations have shown that by applying these exact expressions to the experimental data of Jones and Ray it is possible to calculate the potential of the quartz surface at each concentration. These potentials are reasonable and vary with the concentration in the manner shown by mobility experiments.

Further experiments should make it possible to check this suggested theory. For example, we see by Eq. (18) that $\Delta\gamma$, which does not represent a true change in surface tension, should vary in proportion to $h^{1/2}$ or $r^{-1/2}$. The addition of thorium nitrate in concentration of 10^{-6} M brings the ζ-potential of glass to about zero.[3] This should eliminate the Jones-Ray effect. If solutions of proteins are passed through the capillary and this is then carefully washed, the ζ-potential can be made to vary through wide ranges, depending on the choice of protein, and the pH of the solution. This should cause marked variations in the Jones-Ray effect.

IRVING LANGMUIR

GENERAL ELECTRIC COMPANY,
SCHENECTADY, N. Y.

THE EFFECTS OF AGE AND ESTROGEN ON THE STROMA OF VAGINA, CERVIX AND UTERUS IN THE MOUSE[1]

UNDER normal conditions an increase in the amount of collagen in the stroma of vagina, cervix and uterus of mice begins in the first few weeks of life and from then on progresses more definitely in older mice, especially after cessation of the sexually active period. However, on the whole the differences found at different age periods are relatively not great as compared with those experimentally produced through the ad-

[3] H. A. Abramson, "Electrokinetic Phenomena," Chemical Catalog Company, New York, 1934. See pp. 203–8.

[1] These investigations were carried out with the aid of grants from the International Cancer Research Foundation and from the Committee on Research in Endocrinology of the National Research Council.

ministration of estrogen. Injections of estrogen extending over long periods increases the amount of fibrous-hyaline material which is deposited in the stroma; this increase is the greater, the larger the amounts of estrogen injected at each period and the longer it is continued. If very large doses of estrogen (100 or more rat units in oil) are injected weekly, large amounts of a hyaline substance are deposited, which act as foreign bodies and cause the formation of epithelioid and giant cells and an ingrowth of connective tissue. Thus an organization of this substance is attempted, which is interrupted, however, by renewed deposition of this hyaline material. In certain places solution processes seem to be associated with the hyalinization of the connective tissue and non-striated muscle layers. No definite statement can be made at present as to the chemical nature of this substance and its possible relation to a plasma constituent, except that it is not amyloid.

A hormone, estrogen, may affect therefore the stroma of various organs in two opposite directions: By inducing growth processes in the epithelial structures and perhaps also by definite changes in the circulation it may cause an activation of the stroma and a diminution in the amount of fibrous-hyaline material in various tissues; this seems to occur also in uterus and vagina under certain conditions. But if very large doses of this hormone are administered over long periods of time, the opposite effect may be obtained, namely, a very intense fibrosis and hyalinization of the stroma which may induce abnormal reactions in the surrounding tissue. In this way it seems to be possible to accelerate and intensify very much some of the old age changes in certain organs.

LEO LOEB
V. SUNTZEFF
E. L. BURNS

LABORATORY OF RESEARCH PATHOLOGY,
OSCAR JOHNSON INSTITUTE,
WASHINGTON UNIVERSITY
SCHOOL OF MEDICINE,
ST. LOUIS

THE EFFECTS OF AGE AND HORMONES ON THE STROMA OF THYROID AND MAMMARY GLAND IN THE GUINEA PIG[1]

IT is assumed that one of the changes characteristic of old age in higher organisms consists in an increase and condensation of the collagen in the stroma of various organs and that such changes may reduce the metabolic activities of sensitive tissues. We have begun, therefore, a study of the changes which take place in the stroma at different age periods, as well as of the effect of various hormones on this tissue.

(1) In the thyroid gland of guinea pigs at about the time of birth the amount and density of the stroma are relatively slight. From then on a constant increase in the amount of fibrous tissue takes place, especially around the arteries, but less about the veins and least around the lymph vessels. This increase is already considerable in young, sexually immature female guinea pigs weighing about 180 grams; it increases still more in older guinea pigs, although in individual cases certain variations occur in this respect. Growth and functional stimulation of the thyroid gland by the stimulating hormone of the anterior pituitary gland causes a partial loosening of the stroma, owing to increased transudation from the blood vessels. However this does not, as a rule, cause a noticeable loosening of the dense fibrous tissue directly surrounding the arteries.

(2) In the mammary gland and in the surrounding fat tissue changes occur similar to those observed in the thyroid gland of young and adult guinea pigs; but here much dense fibrous tissue develops, not only around the blood vessels, but also around the larger ducts. There is less fibrous tissue around the end ducts and acini, which function and grow actively; however, a complete parallelism between the amount and density of the stroma in thyroid and mammary gland does not exist because of the differences in functional and growth changes and other more accidental factors in these organs.

In the mammary gland a transformation of the dense fibrous-hyaline into loose fibroblastic, fibrillar stroma can be readily accomplished under the influence of hormones which stimulate the growth of the mammary gland tissue. Implantations of pieces of cattle anterior pituitary gland previously treated with formalin or with urea and glycerin are very efficient for this purpose; they cause maturation of ovarian follicles and the discharge of oestrogen into the circulation. Accompanying the growth processes in the epithelium of the mammary gland a marked stimulation of the surrounding stroma occurs, leading to mitotic proliferation and amoeboid movement of fibroblasts. They readily change the dense fibrous tissue around the ducts into a loose and much more permeable fibrillar, cellular stroma. These effects begin around the glandular structures, but they may extend from there with gradually diminishing intensity also to the adjoining fibrous-hyaline material around arteries and to the fibrous-hyaline bands in the fat tissue. This condition suggests the action of hormone-like contact substances which are given off by the active gland structures and which then diffuse for a certain distance into the neighboring stroma. Such a conception would agree with our earlier conclusion that contact substances might be responsible for growth and move-

[1] These investigations were carried out with the aid of grants from the International Cancer Research Foundation and from the Committee on Research in Endocrinology of the National Research Council.