explaining the reason of a threshold, around 55° C., and the proportionality to temperature of the phenomena: as long as the kinetic energy of the water molecules does not reach a certain value, the forces binding the external groups of the protein together will not let them in. When the critical temperature is reached, it simply means that the kinetic energy of the water molecules is of the same order of magnitude, and that they can force their way through. From that moment on, the amount of molecules which will penetrate is directly proportional to their energy, that is to say, to the temperature. The volume of the protein molecules will then increase until they occupy the whole volume of the solution: the sol becomes a gel. As the concentration of proteins in horse serum, for instance, is high (about 7 per cent.), and as the volume occupied by these molecules, expressed in per cent. of the total volume, is roughly equal to 11, it means that if the molecules of protein increase their volume nine times, they will be in contact with no free solvent between them; in this case, their mean diameter is only increased about twofold. Such an amount of hydration (900 per cent.) is not at all in contradiction with what is known concerning the capacity of hydration of proteins. Marinesco[3] has found for egg-albumin values as high as 1.300 per cent.

A detailed paper will appear shortly and bring forth a few more facts in favor of this hypothesis.

P. LECOMTE DU NOÜY
INSTITUT PASTEUR, PARIS

ELECTROMAGNETIC RADIATION AND THE PROPERTIES OF THE ELECTRON

THERE is weighty evidence, I have shown,[1] that the link between electromagnetic radiation and the electron, which engages the attention of physicists very much at present, is represented by certain properties of the electron. I would like to point out here additional evidence. Consider an electron gas kept at constant temperature, through which two beams of *continuous* electromagnetic radiation of equal intensities parallel to each other are passed in opposite directions. Suppose that the electrons consist of perfectly reflecting particles. On account of their motion the radiation will exert a pressure tending to decrease their velocities continually. But on the average this can not happen. The electrons therefore regain their velocities during the collisions, which can happen only through an increase of their fields during the process; and hence their fields decrease during the intervals between collisions. The increase in electric potential energy during the collisions can be derived only from the internal energy of the electrons, which can be replenished only through an absorption of radiation, into which the kinetic energy lost was initially converted. The electrons thus absorb radiant energy during their motion which is stored up as internal energy and which is attended by a decrease in their electrical fields.

Now suppose that the intensities of the two beams are varied in such a manner that the velocity of a selected electron of the gas is not influenced through the change of the distribution of the pressure of the beams and surrounding radiation acting upon the electron. If further we suppose that the absorption of radiation takes place in such a manner that no force is exerted upon the electron, it would proceed indefinitely with a constant velocity while absorbing radiation, whose total amount may become infinitely large. But this is impossible. Hence the absorption of radiation takes place asymmetrically and in such a way that a force is introduced acting contrary to the motion of the electron, and in a degree that when the motion is reduced to zero the absorption ceases. Hence if v_0 denote the velocity of the electron at the beginning and v that at the end of a free path, the change in momentum under these conditions is given by

$$m\,(v_0 - v) = k_1 h \Sigma\ k_2 \nu / c$$

where m denotes the mass of the electron, h Planck's constant, c the velocity of light, ν the frequency of radiation, and k_1 and k_2 denote constants. The amount of internal energy converted during the collision at the end of the path into kinetic energy and radiation by acceleration will be less than twice the change in kinetic energy, since the acceleration is produced by a recovery of the field. The difference

$$k_3 h \Sigma k_2 \nu - m \cdot (v_0^2 - v^2)$$

is therefore the minimum amount of internal energy that at some part of the path (probably where collision occurs) is reconverted *directly* into radiation, where $k_3\ h\ \Sigma\ k_2\ \nu$ denotes the energy absorbed over the path, k_3 being a constant equal to or greater than k_1. This expression may be written

$$\left(k_3 c - k_1 (v_0 + v)\right) \frac{h \Sigma k_2 \nu}{c}$$

by means of the above equation. It is evidently a positive quantity, and electronic internal energy is thus converted *directly* into radiant energy under these conditions. They will, no doubt, occasionally be satisfied by the radiation surrounding an electron without any external assistance. Internal energy will also obviously be directly converted into radiation

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[3] N. Marinesco, *C. R. ac. Sc.*, 189: 1274, 1929; 187: 718, 1929.

[1] *Phil. Mag.*, 7: 493, 1929; SCIENCE, 70: 478, 1929; 61: 340, 1930; *Nature*, 124: 728, 1929.

whenever the radiation absorbed by an electron in passing over a free path is greater than the increase in kinetic energy and energy radiated through acceleration during collision.

If the electron consists of a packet of radiation, as de Broglie and Schrödinger suppose, it is all the more likely to possess the above properties.

R. D. Kleeman

Schenectady, New York

INTERPRETATIONS OF THE CURVE OF NORMAL GROWTH

Although there seems to be a striking similarity between the course of growth in animals and plants and the courses followed by the autocatalytic curves as described by Robertson[1] and Crozier,[2] it seems doubtful whether such a complicated process as growth would follow so simple a chemical reaction. A growth equation embodying a general biological rather than a chemical interpretation of the growth process may be derived in the following manner. Minot[3] showed for a number of animals that the percentage increments in body weight $\frac{W_2 - W_1}{W_1}$ tend to decrease constantly from birth to maturity. Child[4] explains this decrease in the percentage increments as due to the ever-increasing mass of inactive protoplasm in the body cells accompanying growth and differentiation. As the mass of inactive protoplasm increases, the mass of active protoplasm decreases and hence the relative rate of metabolism decreases, which in turn brings about a decrease in the reproductive or growth power of the cells. These percentage increments may be looked upon as measuring the average growth power of the body cells, if growth power may be defined as the percentage rate of increase in growth. Wright[5] suggested briefly that the hypothesis that growth power falls off at a constant percentage rate leading to the curve

$$\log \log \frac{c}{W} = a - kt \qquad (1)$$

might often give a good fit to growth data. This equation may also be expressed in the forms

$$\log W = A - be^{-kt} \qquad (2)$$

and

$$L = Be^{-Ce^{-kt}} \qquad (3)$$

Dr. Wright found that equation (1) gave a very good fit to growth in weight W of rabbits. Equation (2) was found by Davidson[6] to give a good fit to growth in weight W of dairy cattle. Equation (3) was applied by Weymouth[7] with excellent success to growth in length L of the razor clam.

The derivation of equation (2) is as follows: $\frac{dW}{Wdt} = P$ where W equals body weight at any time t, and P equals the growth power of the body cells. Since growth power is assumed to fall off at a constant percentage rate, $\frac{dP}{Pdt} = -k$. By integration $\log P = -kt + C$, or $P = e^{C-kt} = \frac{dW}{Wdt}$. By integration again, $\log W = -\frac{1}{k}e^{C-kt} + A$, or $\log W = A - be^{-kt}$. In the last equation A is the logarithm of the weight of the animal at maturity; 100k is the constant percentage rate of decrease in growth power according to the above interpretation, and b locates the curve in time; W is the weight at any time t. The equation of the curve for weight W is $W = e^{A - be^{-kt}} = Be^{-be^{-kt}}$ where $e^A = B$. This equation is similar to equation (3) for length L and is S-shaped with the point of inflection at approximately 37 per cent. of the final weight. It differs from the growth curves of Robertson and Crozier in that it embodies a general biological rather than a chemical interpretation of the growth process and at the same time requires the utilization of fewer velocity constants.

Frederick A. Davidson

U. S. Bureau of Fisheries,
Stanford University

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