outcome of the physical structure and the ceaseless change of the earth's mass. Eventually "the earth itself will have ceased to breathe. And the mind of Man, which alone comprehends it, will have become part of the forgotten past."

We congratulate the author on his inspired and inspiring work, and conclude with the advice that no geologist can afford not to make this book a part of his theoretic and basal knowledge.

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SPECIAL ARTICLES

THE DIFFERENTIATION OF HERPETOMONADS AND LEISHMANIAS BY BIOLOGICAL TESTS

THE question of possible insect or plant hosts of the leishmanias is one of considerable practical importance in the study of the mode of infection in kala-azar, espundia and oriental sore. The identification of leishmanias among the very large number of flagellates of the herpetomonad type which live in insects and plants is, however, difficult of accomplishment by the methods hitherto employed. A new method of attacking the problem, which promises to give more reliable results, is the comparison of the serological and carbohydrate-fermenting properties of cultures of these organisms. This method has been employed with interesting results in connection with a group of herpetomonads isolated in pure culture by the writer and Miss Tilden[1] from flies, mosquitoes, milkweeds and milkweed-feeding insects. Twelve strains were cultivated, as follows:

From latex-feeding insects:	*Oncopeltus fasciatus*	1 strain
	Lygaeus kalmii	2 strains
	Oncopeltus sp.? (Peru)[2]	1 strain
From milkweeds:	*Asclepias syriaca*	2 strains
	Asclepias nivea[3]	1 strain
From mosquitoes:	*Culex pipiens*	1 strain
	Anopheles quadrimaculatus[4]	1 strain
From flies:	*Musca domestica*	1 strain
	Calliphora sp.?	2 strains

Once obtained in culture, all the strains grew well on the semisolid "leptospira" medium, yielding within 72 hours at 26° C. a layer of heavy growth 1 cm. deep. Rabbits were immunized by repeated injections of flagellates, the layer of maximum growth being pipetted off and utilized for this purpose. The results brought out by testing the effect of the various immune sera on the individual strains were of considerable interest. Among the seven strains of flagellates of milkweeds and milkweed-feeding insects, two immunologically different species were distinguished. The two mosquito strains were serologically identical, while each of the fly strains was serologically distinct. The cultures were also compared in their effect on a number of different carbohydrates, and in these tests the same relationships and differences manifested themselves which had been demonstrated by the serological reactions.

Morphologically it was impossible to differentiate the milkweed flagellates from one another, either in the plant latices or in culture, except perhaps for slight differences in size, nor could the flagellates of the different latex-feeding bugs be separated morphologically. On the other hand, it was extremely difficult to identify the characteristic twisted, ribbon-like flagellates of the plant latex with the slenderer, more actively motile insect herpetomonads with their enormously long flagella. By means of agglutination and complement fixation tests, however, it was possible to identify as a single species strains cultivated from three insects (*Oncopeltus fasciatus, Oncopeltus sp.?* (from Peru), and *Lygaeus kalmii*), and from two plants (*Asclepias syriaca* and *A. nivea*). This organism has been named *Herpetomonas oncopelti.* By the same method this flagellate species was differentiated from another which had been isolated from a second plant of the species *Asclepias syriaca* and from another individual of the species *Lygaeus kalmii;* to the latter strain the name *H. lygaeorum* has been given. *H. oncopelti* ferments 13 carbohydrates, *H. lygaeorum* ferments only 3.

The three strains of fly flagellates showed some morphological differences, but their species entity was clearly brought out by serological and fermentation tests. The house fly strain (*H. muscidarum n. sp.*) ferments 14 carbohydrates, one Calliphora strain (*H. media n. sp.*) ferments 7, the other (*H. parva n. sp.*) ferments 6.

The herpetomonads from *Anopheles quadrimaculatus* (adult) and *Culex pipiens* (larva) were found to represent a single species. This flagellate (*H. culicidarum n. sp.*) fermented most of the 17 carbohydrates tested, including amygdalin, which was not attacked by any of the others. Serologically this organism has no relation to any other strain isolated.

Cultures of *Herpetomonas ctenocephali* and *Trypanosoma rotatorium,* which were obtained through the courtesy of Dr. E. E. Tyzzer, of Harvard University Medical School, were found to be serologically different from all the other flagellates and from the

[1] In press.

[2] Obtained through the courtesy of Dr. T. S. Battistini, of Lima, Peru.

[3] Plant presented by Dr. F. O. Holmes, of the Boyce Thompson Institute for Plant Research, who had infected it by allowing infected specimens of *Oncopeltus fasciatus* to feed on the seed pods.

[4] Material obtained through the kindness of Dr. M. F. Boyd, of Leesburg, Ga.

leishmanias. They did not attack any of the carbohydrates of the series.

Leishmania tropica, L. brasiliensis, L. infantum, and *L. donovani* resemble one another in morphological features, but in serological reactions *L. infantum* and *L. donovani* proved to be very closely related. In fermentation tests the leishmanias resembled most nearly the strains isolated from blue bottle flies. No immune serum prepared with other strains had any effect on the leishmanias, nor did the leishmania immune sera have any action on the insect or plant strains.

The foregoing observations indicate unmistakably the value of serological and fermentation tests as a means of identifying the strains of flagellates; by the application of these methods it may be possible to determine the presence or absence of leishmanias in invertebrate hosts suspected of harboring them.

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GYROMAGNETIC ELECTRONS AND A CLASSICAL THEORY OF ATOMIC STRUCTURE AND RADIATION

A CHARGED sphere in rotation was shown by Maxwell as long ago as 1870 to give a uniform internal field, and an external field equivalent to that of a magnetic doublet. The writer has considered the problem of determining the fields due to a spinning electron moving with uniform velocity v making any direction with the axis of spin, taking into account the deformation or contraction of the electron boundary into an ellipsoid of axes a and $a(1-v^2/c^2)^{1/2}$, the short axis being in the direction of motion. Regarding this as a real, physical deformation, the energy of the electrostatic and magnetic fields, internal and external, separates into two terms, one translational, the other due to components of spin $(\omega_1\omega_2\omega_3)$. The final result is

$$T = mc^2 + 1/2(A\omega_1{}^2 + B\omega_2{}^2 + C\omega_3{}^2) + constant \quad \text{.........(1)}$$

In the first term, $m = m_0/(1-v^2/c^2)^{1/2}$ where $m_0 = \frac{2}{3}e^2/a$ and account is taken of the boundary stresses (probably magnetic in origin) which keep the electron in equilibrium. The electrodynamic moments of inertia may be rigorously evaluated for the simple type of spinning electron considered, and in general may be expressed in powers of $\beta^2 = v^2/c^2$ in the form

$$A = I(1 + a_1\beta^2 + a_2\beta^4 + \ldots),$$
$$B = C = I(1 + c_1\beta^2 + c_2\beta^4 + \ldots) \quad \text{.........(2)}$$

where $I = \frac{2}{9}m_0a^2$ is the moment of inertia of the spinning electron at rest. Applying Lagrange's equations to the rotations expressed by T as kinetic energy, the precessional motion of the electron is determined by Euler's equations,

$$A_1\dot{\omega} = L_1 \qquad C\dot{\omega}_2 - (C-A)\omega_1\omega_3 = L_2 - Ck\omega_2$$
$$\text{.........(3)}$$
$$C\dot{\omega}_3 + (C-A)\omega_1\omega_2 = L_3 - Ck\omega_3$$

$(L_1L_2L_3)$ being couples from nuclei in atomic systems, or due to the magnetic forces of the radiation field. The precessing electron has magnetic moments proportional to $(\omega_1\omega_2\omega_3)$ whose periodic variations thus give rise to electromagnetic radiation of the same frequency. The constant k is a simple type of damping factor due to the loss of rotational energy by radiation. Under no forces the stable configuration of the electron is easily seen from (3) to be with the axis of spin along the direction of motion. When disturbed the frequency of precessional motion and of emitted radiation is seen to be, if Ω_1 is the intrinsic spin,

$$2\pi\nu = \Omega_1(C-A)/C = \Omega_1(c_1 - a_1)$$
$$\beta^2(1 + b_1\beta^2 + b_2\beta^4 + \ldots) \quad \text{.........(4)}$$

If we denote

$$h\Omega_1 = \pi c^2 m_0/(c_1 - a_1), \quad \text{.........(5)}$$

where $(c_1 - a_1)$ is a numerical constant equal to $\frac{2}{5}$ for the simple model considered, we have to a first approximation a relation between *precessional electron radiation* and *velocity* in the form

$$h\nu = \tfrac{1}{2}m_0v^2, \quad \text{.........(6)}$$

the well-known photo-electric equation, while *Planck's constant h becomes a fundamental characteristic of a rotating electron expressed in terms of spin by equation* (5).

This purely classical interpretation appears to be the key to radiation problems generally. With similar hypotheses as to spinning protons as constituents of atomic nuclei, the theory of slightly perturbed, simple orbits under an inverse-square law of electrostatic attration from the nucleus, with the fundamental relations (6), leads to the series formula for hydrogen and helium spectra and in more complex cases to the S,P,D and F series, with the correct value for the Rydberg constant. Perturbations of orbits due to variation of mass with velocity, external electric and magnetic fields, with in some cases slightly different interpretations, lead to formulae the correct type for fine structure, Zeeman (normal and anomalous) and Stark effects. The fundamental formula (6), used in conjunction with a Maxwellian distribution of electron velocities, also leads with reasonable hypotheses as to electron orbits in a space lattice to Planck's formula for black-body radiation and the associated formulae for specific heats.

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