in detecting immediately any lots of flour that are unenriched in respect to niacin as well as in segregating for more precise testing those lots in which the enrichment is of doubtful adequacy.

The rapid niacin test can also be used in a similar manner to distinguish enriched from unenriched white bread.

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DISCUSSION

ROTATING ACTION ON MATTER IN A BEAM OF LIGHT[1]

REFERRING to the paper read by me on January 19, 1945, at the New York meeting of the American Physical Society, G. F. Hull has clearly understood that my claims are new, as he says "that he (Ehrenhaft) had claimed to prove that a beam of natural (unpolarized) light produces a rotating action on matter," while, as Hull states later on according to his text-book, "the rotating action in a beam of circularly polarized light is exceedingly small, and in a beam of natural light nothing whatever."

When Lebedew[2] and Nichols and Hull[3] worked, forces only down to 10^{-5} or 10^{-6} dyne could be measured.[4] In 1909 I developed a method of measurement of forces exerted on single microscopic or submicroscopic bodies which enable the measurement of forces as small as 10^{-10} dyne and applied it for the determination of the size and the electric charge of single spherical particles of well-known density.[5] This method was next used by K. Przibram[6] in the measurement of the electric charge on single droplets of mist and later by others on oil drops. This method, 10^4 times more sensitive than former methods, has resulted in the detection of phenomena concerning the interaction between radiation and matter which I termed "Photophoresis."[7] In a concentrated beam of natural light, test bodies of the same size and with the same physical properties move simultaneously with the direction of propagation of the radiation (light positive) and against this direction (light negative). Radiometer forces of the Crookes type or similar effects can not be accountable for the observed facts.[8, 9]

The above movements can be influenced by the superposition of homogeneous magnetic or electric fields (magnetophotophoresis, electrophotophoresis). Particles irradiated by light do move in the homogeneous magnetic field and reverse their direction of movement with the reversal of the field as often as desired. It must be concluded that they carry an excess of north or south magnetic charge. Many of the test bodies exhibiting a magnetic charge in the light retain this charge in the dark and continue their movement in the dark.[10] Thus, expanding the terminology of Faraday, there exists a magnetic ion in general and consequently a magnetic current. The electric action of magnetic currents, the counterpart of the magnetic action of electric currents has been demonstrated.[11] This means that the single electric charge (pole) rotates around the magnetic current and that the single magnetic charge (pole) rotates around the electric current (Oersted-Ampere).

In my recent measurements of single magnetic charges on microscopic particles, I separated the influence of light from the influence of the magnetic field by measuring these charges in the dark.[12] I further investigated again the ponderomotive force of light upon matter. If one introduces and allows to fall into a vertically projected beam particles of, for instance, Cr, Fe, Mn, Cu_2O, those of a size of about the wave-length of light and smaller fall vertically, while those of more than wave-length of light in size describe in falling distinct helical paths in the beam of light, as already observed by me and my school in Vienna and Whytlaw-Gray (Leeds)[8] in the horizontal beam. Whytlaw-Gray has repeated my experiments and obtained identical results.

1 Comment on Gordon Ferrie Hull's article "The Torque or Rotating Action in a Beam of Light," SCIENCE, 101: 220, 1945.

2 P. Lebedew, *Astr. Ges. St. Petersbourg*, 37: 220, 1902.

3 E. F. Nichols and G. F. Hull, *Ann. der Phys.*, 12: 223, 1903; F. Ehrenhaft, *Ann. der Phys.*, 56: 103, 1918; *Ann. de Phys.*, 13: 171, 1940.

4 D. K. Konstantinowsky, *Physik. Ztschr.*, 21: 698, 1920.

5 F. Ehrenhaft, *Wiener Akad. Anz.* VII, March 4, 1909; X, April 21, 1910; *Wiener Berichte*, 119: 815, 1910; *Physik. Ztschr.*, 11: 619, 1910, etc., *Physik. Ztschr.*, 39: 673, 1938; *Philosophy of Science*, N.Y.C., 8: July 3, 1941. "The Microcoulomb Experiment, Charges smaller than the Electronic Charge."

6 K. Przibram, *Physik. Ztschr.*, 11: 630, 1910.

7 F. Ehrenhaft, *Ann. der Physik.*, 56: 81, 1918; Comp. Rend., 190: 263, 1930; see literature about photophoresis: *Ann. de Physique*, 13: 151, 1940; *Jour. Frank. Inst.*, 233: 235, 1942.

8 R. Whytlaw-Gray and H. S. Patterson; "Smoke, a Study of Aerial Disperse Systems." London: Edward Arnold and Company, 1932. P. 126; *Leeds Phil. Lit. Science*, Sect. 1, 70, 1926.

9 F. Ehrenhaft, *Jour. Frank. Inst.*, 233: 239, 1942.

10 F. Ehrenhaft and Leo Banet, SCIENCE, 96: 228, 1942.

11 F. Ehrenhaft, *Nature*, 154: 426, 1944; *Phys. Rev.*, 65: 287, 1944.

12 F. Ehrenhaft, *Bull. Am. Phys. Soc.* (New York Meeting) 6; 1945. See H. S. Renne, *Radio Electronic Engineering (Radio News)*, 4: 22, 1945.

In my recent experiments made with Richard Whitall it was determined that often the bodies made five to ten revolutions per second around the axis of the helix, and the radius of this helical path is exceedingly large compared with the radius of the body. These facts can be easily understood. Optically active substances rotate the plane of polarization of light, and Faraday (1845), despite the scepticism of his contemporaries, succeeded in rotating the plane of polarization by applying a magnetic field parallel to the beam.

The helical paths have been observed with linear polarized light as well as with natural light, with and without parallel external magnetic field. This is to be expected, since the light scattered by a spherical body is for the most part linear polarized, and since our magnetophotophoresis experiments demonstrate that in the direction of the light beam there exists a static longitudinal magnetic field analogous to the electrostatic field therein predicted by Woldemar Voigt.[13] These fields can explain in some respect electro- and magnetophotophoresis with the movement of electrically charged bodies in the longitudinal electric field or magnetically charged bodies in the longitudinal magnetic field of the beam of light. Concerning the helical movement in the beam of light, the electric charge rotates around the longitudinal magnetic field and *vice versa*.

The helical movement of particles observed by me and Whytlaw-Gray can not be explained by the formulation of Maxwell-Poynting, on which point of view G. F. Hull has based his work on light pressure.

It has been found that light rotates matter, if matter is free to move with three degrees of freedom. The well-known principles of conservation of linear and angular momentum of electrodynamics (Poincare, Max Abraham) do not cover the experimental facts that light can exert forces of attraction, repulsion and torsion. Regarding the general theoretical conclusions it is evident that we have to add to the electrodynamic equations the expression for the true single magnetic charge and therefore the term for the magnetic current.[14] The formulations have to be broadened in such a way as to include the three actions listed above.

These observed actions require a modification of the relation $E = m c^2$, pronounced for the first time by Hasenoehrl (1904) for the radiation of black bodies,[15] generalized later on, as well as a revision of the more modern concepts which have been derived from the enunciation of A. Soldner (1801), entitled "About the Deflection of a Beam of Light from its Rectilinear Movement through the Attraction of a Celestial Body Near Which the Beam Passes."[16] In considering astrophysical questions it is clear that one must take into account not only the repulsive force of radiation but also the attractive and rotational forces.

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[13] Woldemar Voigt, Festschrift fuer Heinrich Weber, 1912.

[14] Oliver Heaviside, "Electromagnetic Theory," 1, 25, 1893.

[15] F. Hasenoehrl, *Ann. der Physik.*, 15: 344, 1904; 16: 589, 1905.

[16] A. Soldner, Bode's Astronom. Jahrbuch, 161–172, 1804.

COLCHICINE AS A GROWTH STIMULATOR[1]

IN a recent paper, Loo and Tang[2] reported that colchicine in relatively low concentrations (10^{-5} M to 10^{-6} M) accelerated the germination of seeds of mungo bean, maize, cabbage, rice and wheat, but the treating of seeds for twelve hours at these concentrations was deleterious to subsequent early growth. Patton and Nebel[3] had previously observed that colchicine in a concentration of 10^{-4} M seemed to stimulate respiration slightly.

That colchicine or any toxic substance should act as a metabolic stimulant in very dilute concentrations is not surprising, but our observations on the results of the use of colchicine on seedling trees indicate that colchicine in effective concentrations short of that necessary for the production of polyploid cells does stimulate growth in some plants.

In the spring of 1944, more than twenty species and hybrids of tree seedlings were treated with a 0.4 per cent. solution of colchicine emulsion which included a wetting agent. The trees were treated by pipetting one drop per day on each apical meristem for four to, in some instances, twenty days. The usual cessation of apical growth and subsequent hypertrophy with some killing occurred, but in sixteen seedlings of four species of *Quercus,* two species and one hybrid of *Castanea* and three hybrids of *Corylus,* there followed marked increase of the rate and total length of apical growth. The order of increase was slightly more than double the best growth of the untreated controls. Allowing for differences in genetic and possibly environmental factors, the evidence seems to indicate that the increase in rate and total length of growth was due to the action of colchicine.

Whether the increase in growth was due to the direct stimulation of cellular metabolism or produced

[1] This work was part of a program in forest genetics supported by a grant from the General Education Board.

[2] T. Loo and Y. Tang, *Am. Jour. Bot.*, 32: 106–114, 1945.

[3] R. L. Patton and B. R. Nebel, *Am. Jour. Bot.*, 27: 609–613, 1940.