lar tissues. Mental capacity and vigor may depend upon an upsetting of the physiological balance and the aggrandizement of the central nervous system at the expense of these other processes. Great prosperity in the vegetative functions—which we call physical health—would thus be inimical to the highest intellectual enterprise, and the case of *D* would be made characteristic instead of anomalous. It is at least suggestive that the eupeptic maximum in adults is found in connection with the first stages of general paralysis.

The gist of the figures contained in the table, theorizing apart, is sufficiently indicative of the importance of physical vigor as a condition of mental activity to make the matter worthy of consideration in future study.

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THE ELECTRON THEORY.

PROFESSOR J. J. THOMSON in the March number of the *Philosophical Magazine* discusses the theory of the stability of systems of electrons. His conclusion is that a number of electrons constitute a stable system when they are grouped in a series of concentric circular rings, very similar to Saturn's rings, which rotate about a common axis. Stability depends upon two conditions, namely, (*a*) upon a certain minimum angular velocity of rotation of a ring, and (*b*) upon the presence of at least $f(n)$ electrons at or near the center of a ring containing n electrons. Stability increases when the angular velocity increases above the critical value and when the number of internal particles is greater than $f(n)$; $f(n)$ being a definite function of n.

The first part of Professor Thomson's paper is devoted to the establishment of the two conditions of stability (*a*) and (*b*) and the second part of the paper is devoted to the application of these results to the theory of the constitution of the atom. The features of the second part are:

1. A brief discussion of the types of oscillation of systems of electrons and the application of these results to the rationalization of spectra. Professor Thomson goes no farther than to show in a general way that the spectral lines of a given element may be grouped in a number of series of related lines, and that the different chemical elements of a group or family, such as the alkali metals, may have closely related series of lines. This same idea has been advanced by H. Nagaoka, of Tokyo, who promises soon to publish a paper devoted to this method of classifying spectra.

2. A full discussion of the relations between stable systems containing greater and greater numbers of electrons, and the application of these results to the rationalization of Mendeléef's periodic law. In this section of the paper Professor Thomson shows that a system of electrons furnishes a dynamic model which, with increasing numbers of electrons, exhibits properties closely analogous to those remarkable periodic variations of valency of the chemical elements with increasing atomic weight. This constitutes the first suggestion of anything worthy to be called a rational basis of Mendeléef's law, and its importance can scarcely be overestimated. It is, perhaps, the greatest contribution to theoretical physics during a decade. In this section of his paper Professor Thomson discusses the process of chemical combination in terms of his theory and he suggests an explanation of the catalytic action of water and of a metal such as platinum.

3. An application of the fact that the stability of a system of electrons depends upon a certain minimum angular velocity of the electron rings, to the explanation of radioactivity.

It is the purpose of this note merely to call attention to Professor Thomson's paper, which should be carefully read by every student of chemistry, and to give to the reader a sufficiently clear idea of the electron to enable him to fully appreciate Professor Thomson's theory of the structure of the atom.

It is not to be expected, of course, that a new hypothesis should lead at once to anything approaching a completely consistent theory and it may be helpful to readers of Professor Thomson's article to point out the weak points of his theory.

The electron itself, although it has some very definite claims to objective existence, is not an entirely clear idea. The electric stress which radiates from an electron can, indeed, be thought of in mechanical terms, and the manner in which these lines of stress sweep through space when the electron moves, and the way in which they build up a magnetic field by their motion, can be thought of in a precise way, but no one has at present any definite idea of the nucleus of an electron nor of the way in which the nucleus moves. The mechanical analogue outlined below is misleading in this respect in being free from some of the essential difficulties which arise in the electrical case.

Professor Thomson's explanation of zero valency (which is exhibited by such elements as helium, neon, argon, etc.) does not appear quite satisfactory. He represents zero valency as an extremely evanescent and unstable case of monovalency.

I fail to see how, in Professor Thomson's theory, to explain the rise of valency of a given element by twos, for example the rise of valency of nitrogen from 1 to 3 to 5. This mode of rise of valency has suggested to chemists the idea of the neutralization of valency bonds by each other in pairs. However, this difficulty may be met, perhaps, by using the notion of subsidiary groups of electrons.

On the other hand, Professor Thomson's hypothesis, that the atom consists of a number of extremely minute negative electrons moving about in a small spherical region containing uniformly distributed positive charge, meets a fundamental difficulty, namely, that experiment has hitherto failed to give any evidence of the existence of concentrated positive charges corresponding to the excessively concentrated negative charges which constitute cathode rays. In conformity with this hypothesis as to the structure of the atom, the mass of an atom is to be taken as proportional to the number of negative electrons the atom contains, regardless of the extent and value of the distributed positive charge. This is explained later in mechanical terms.

A clear idea of the behavior of a system of electrons depends upon an understanding of the dynamics of a single electron, and the dynamics of an electron is very different from the dynamics of a material particle.

The dynamics of an electron depend primarily upon the fact that kinetic energy is associated with a moving electric charge independently of the 'material' mass of the body upon which the charge resides. That is to say, electric charge has inertia or mass. This association of kinetic energy with an electric charge is a phenomenon of the electric field, not of the charge itself and the mode of association is precisely (not necessarily accurately) understood. Stated in terms of a mechanical analogue, it is as follows: Imagine a great lake of jelly with a mass-less cylinder pressed down upon its surface. Underneath the cylinder the jelly will be under stress and strain and this stress and strain will represent energy, corresponding to the purely electrical energy associated with the electrical stress surrounding a charged body. If this mass-less cylinder be rolled along over the jelly surface the strain figure underneath the cylinder will travel with the cylinder, and each successive portion of the jelly will move as it is twisted into conformity with the approaching strain figure and as it is again twisted into its unstrained condition after the strain figure is passed. *This motion represents kinetic energy corresponding to the magnetic energy of a moving electron, and the strain figure, therefore, has inertia.*

If the cylinder is small in diameter the strain which is associated with it is greatly concentrated and for a given integral amount of stress or strain (given force pushing the cylinder down) a much greater amount of kinetic energy would be associated with a given velocity of the rolling cylinder, inasmuch as the successive portions of the jelly would move with increased velocity as they are twisted into conformity with the approaching strain figure, and as they are again twisted into an unstrained condition after the strain figure has passed. Therefore, a strain figure having a given integral amount of strain has greater and greater inertia the more the strain figure is concentrated. At velocities which are low as compared with the velocity of wave propagation on the jelly surface the kinetic energy of the moving strain-figure is proportional to the square of its velocity and, therefore, its inertia or mass value is constant. Where the velocity of the strain figure is not very small then the inertia reaction of the moving particles of jelly as they are twisted into and out of the moving strain figure *helps to sustain or hold the strain of the moving figure.* Thus at full wave velocity a strain figure is held wholly by this inertia reaction and no cylinder need be pressed upon the jelly to maintain a strain figure. On the other hand, when the cylinder is pushed down with given force the integral stress increases more and more with increasing velocity, a portion of the stress being sustained by the cylinder and a portion being sustained by the inertia reactions above mentioned. Therefore, with given force on the cylinder the integral stress approaches infinity as the velocity of the cylinder approaches the wave velocity, and corresponding to this increase of integral stress due to given force on cylinder the inertia or mass value of the strain figure increases indefinitely as its velocity approaches the wave velocity.

The inertia or mass value of a given electrical charge (integral value of electric strain) increases as the charge is more and more concentrated, and the inertia or mass value increases with velocity, approaching infinity at the velocity of light. In case of the moving electric charge, however, the increase of mass value due to magnetic reaction (corresponding to inertia reaction in the jelly) does not affect the integral value of the electric strain, but merely concentrates the electric strain more and more into a plane perpendicular to the direction of motion.

A clear picture in two dimensions of an electron may be obtained by imagining massless points to rest with a certain force against a horizontal stretched sheet of rubber, each point producing a deep funnel-like depression. The mass value of each depression for given force pushing the point down is greater and greater the smaller the point.

This picture is, however, incomplete in several respects, notably in that two depressions (two negative charges) attract each other while a depression and an elevation (a positive and a negative charge) repel. This is due to the essential differences between electric stress and any kind of mechanical stress.

A clear picture in two dimensions of a system of negative electrons moving about in a region of distributed positive charge—Professor Thomson's hypothetical atom—may be obtained by imagining a wide and shallow saucer-like depression in a rubber sheet in which a number of point depressions are moving about and held together as a system by the gradient of the saucer-like depression.

Such a system moving as a whole would owe its mass value chiefly to the concentrated point-like depressions, inasmuch as the broad and shallow saucer-like depression would have a negligible mass value, as explained above.

Some striking features of the dynamics of an electron are the following (see paper by M. Abraham, *Ann. der Physik,* January, 1903). These features depend partly upon the above-described increase of mass value of an electron with increasing velocity partly upon the slight delay between a given assumed change of velocity of the electron and the consequent rearrangement of the surrounding electromagnetic field, and partly upon the fact that an *accelerated* electron radiates energy in the form of waves like a steadily moving boat.

The mass value of an electron moving at given velocity as measured by the acceleration produced by a given impressed force varies with the direction of the force, being greatest in the direction of the motion (longitudinal mass) and least at right angles to the direction of the motion (transverse mass). Furthermore, the acceleration is in general not in the direction of the accelerating force; the relation between force and acceleration being represented by the relation between the diameter of a circle (sphere) and the corresponding radii vectores of an ellipse (ellipsoid) in the drawing which is ordinarily made by students to show the projection of a circle into an ellipse (a relation known as the linear-vector-function).

An electron moving uniformly in a circular orbit has acceleration and radiates energy so that its motion dies away. The dying away of the motion of a circular row or ring of electrons in this way is excessively slow if the number of electrons in the ring is great and if the velocity is small as compared with the velocity of light (see J. J. Thomson, *Phil. Mag.*, December, 1903). In fact, the time required for the angular velocity to fall from a value slightly above the critical value required for stability to the critical value might easily be a matter of millions of years under certain conditions.

It is interesting to note, although perhaps useless, considering the widespread confusion of the fundamental ideas of thermodynamics, that this electron theory, pointing as it does to finite systems which apparently never can settle to thermal equilibrium, suggests a class of phenomena, sensible and *steady* phenomena too, which are on the wrong side of thermodynamics, that is, on the side opposite to mechanics; phenomena which are to be treated by developing a systematic theory of atoms as isolated systems and the subsequent merging of this systematic theory of single atoms into a statistical treatment of aggregates of atoms; but this is another story. W. S. F.

A HEAVY JAPANESE BRAIN.

THROUGH the kindness of my friend, Mrs. Helen H. Gardener, now in Tokio, I am able to publish the following extract from the post-mortem examination of Professor K. Taguchi, the celebrated anatomist, of the College of Medicine in the Tokio Imperial University. His death took place in Yumi-cho, Hongo, on February 4 of this year, and, in accordance with the terms of his will, his body was dissected by his colleagues at the college. Professor Taguchi is perhaps the first of his race to bequeath his body in this manner. His work on the brain-weight of the Japanese has been referred to by the writer in SCIENCE (September 18, 1903). His own brain is the heaviest on record among the Japanese, and in the list of eminent men throughout the world, whose brains have been weighed (107 in number) it occupies second place. Taguchi's brain-weight (1,920 grams or 67.7 oz. avoir.) exceeds the highest recorded Japanese brain-weight by 130 grams (or 4.5 oz.).

"Extract from report of the post-mortem examination of Professor K. Taguchi on February 5, 1904, in the Pathological Institute, Tokio, by Professor Dr. K. Yamagiwa:

"Age, 66 years.

"Body-weight, 49,000 grams.

"Brain-weight, 1,920 grams.

"Clinical diagnosis: Cirrhosis of the kidney.

"Anatomical diagnosis: Hypertrophy with dilatation of the left ventricle of the heart; endocarditis valvularis chronica fibrosa adhæsiva aortica; endocarditis valvularis chronica fibrosa mitralis; œdema pulmonum; hypostatic pneumonia of lower lobe of left lung; nephritis chronica interstitialis; cystic degeneration of the kidney; atheroma in the aorta." EDW. ANTHONY SPITZKA.

PROFESSOR RUTHERFORD ON RADIUM.

PROFESSOR E. RUTHERFORD, of McGill University, lectured before the Royal Institution on May 20, on 'Radiation and Emanation of Radium.' According to the London *Times*, the lecturer first showed the power of radium to excite phosphorescence and to discharge a charged electroscope, and then described the properties of the three kinds of rays which it had been found to give off. In addition it gave off an emanation which behaved like a gas and could be condensed by cold; it could also be secluded in the radium itself, and was liberated when the salt was dissolved in water. This emanation, though exceedingly minute in quantity, possessed three-quarters of the characteristic powers of radium and all its properties. If we could collect a cubic inch of the emanation, the tube that contained it would probably melt, while a few pounds would supply enough energy to drive a ship across the Atlantic, though each of those pounds would require 70 tons of radium to supply it. In regard to the process going on in the emission of the emanation, he advanced the theory that radium was continuously producing it, but that when produced, instead of remaining constant, it was continuously being changed into something else. He supposed that some atoms of the radium in some conditions be-