plasmolyzed to a moderate degree[8] recovered in about twenty-four hours. The *Spirogyra* lives and maintains its normal permeability indefinitely in such dilute sea water.

When placed in a solution of pure NaCl .4 M the vitality of the cell is rapidly impaired and it dies in the course of two or three hours.[9] If such a cell be plasmolyzed by .4 M NaCl to a moderate degree[8] it recovers in the course of half an hour. Since the permeability is inversely proportional to the time of recovery, it is evident that the NaCl impairs the vitality of the cell and at the same time increases its permeability.[10] The two processes go hand in hand. The permeability continues to increase until death occurs, when the cell becomes completely permeable.

These experiments were repeated with a variety of reagents and were afterward confirmed in every detail by the method of determining electrical resistance.

As the result of these and other experiments we may say that the permeability is greatly affected by changes in the composition of the salt solution in which the cell is placed. Normal permeability is best preserved in solutions in which the proportions of salts are approximately the same as in sea water and normal vitality is also maintained longest in these solutions. In general we find that vitality and permeability are affected in exactly the same way by various kinds of electrolytes.

This principle may be applied much more generally. The writer finds that all substances (whether organic or inorganic) and all agents (such as excessive light, heat, electric shock, mechanical shock, partial drying, lack of oxygen, etc.) which alter the normal permeability of the protoplasm shorten the life of the organism. This is equally true whether the alteration consists in an increase of permeability, or in a decrease of permeability (followed by an increase) as is the case when certain reagents (such as $CaCl_2$) are applied.[1] This is a very striking fact and its significance in the present connection seems to be clear and unmistakable. It shows in the most convincing manner that permeability is a delicate and accurate indicator of vitality.

We are unable to say why there is such an intimate connection between vitality and permeability. It is evident that permeability may control metabolism by regulating the osmosis of various substances, and conversely that metabolism may affect permeability. What is needed is not more speculation in this direction, but a careful analysis of the factors which control permeability. If we are successful in determining what these factors are we may hope to arrive at a more satisfactory formulation, in physico-chemical terms, of our conception of vitality as well as of that of injury.

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SOIL ACIDITY AND METHODS FOR ITS DETECTION

The so-called "acid" soils are peculiar in that a solution obtained by shaking such soils with water will be found, except in rare cases, to be absolutely neutral toward litmus paper. However, if the test paper be brought into direct contact with the soil particles themselves, a very sharp acid reaction will be obtained. These acid soils possess another peculiar property in that if shaken with a solution of some neutral salt such as sodium chloride, an appreciable amount of a soluble acid will be found to be set free.

Two theories have been advanced to explain these properties. The older and perhaps still the most generally accepted theory is the humic acid theory. This theory assumes that there are present in the acid soils, as the result of the decomposition of animal and vegetable matter, some very insoluble organic acids called humic acids. These are supposed to be definite

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[8] This degree is a definite one. It was usually chosen as the condition in which the protoplast just touched the end walls.

[9] This applies only to the species of *Spirogyra* used in these experiments: some species may be more resistant while others are much more sensitive and are killed in less than ten minutes.

[10] In other solutions in which vitality is more rapidly impaired the recovery from plasmolysis is also more rapid and we must conclude that the permeability is proportionately increased.

compounds which react with litmus when the test paper is brought into direct contact with the solid particles and which enter into double decomposition with any salt with which they come in contact liberating the corresponding soluble acid. This latter assumption is rather absurd in the light of our modern ideas of chemistry. The law of mass action is probably one of the most generally accepted laws of chemistry and if we are to accept this law, it is hard to conceive of any acids, as insoluble as these humic acids must be, entering into a double decomposition with a neutral salt such as sodium chloride and setting free such a strong acid as hydrochloric acid. Much experimental work has been done on these humic acids, most of this work consisting of attempts to isolate the acids in a pure form. Experimenters claim to have done this and have even gone so far as to assign definite chemical formulæ to some half dozen of these acids. However, no two experimenters seem able to agree on these formulæ.

Since Van Bemmelen's work on colloids and adsorption, a newer and certainly far more reasonable theory has been put forward to explain the action of acid soils. It is well known that the coagulation of a colloid by a solution of a neutral salt is accompanied by the adsorption of one or other of the ions. If the colloid be electro-negative, it will adsorb the positively charged ion of the salt setting free a corresponding amount of acid. If it is electro-positive, it will adsorb the negatively charged ion setting free a corresponding amount of the base. In the case of the soils, there is present much negatively charged colloidal matter. If deficient in basic material, this colloidal matter is present in a deflocculated condition and is capable of adsorbing the base from any neutral salt with which it comes in contact. Thus if the soil particles are brought into contact with blue litmus, it adsorbs the base of the blue litmus salt leaving the red acid dye on the paper. When shaken with a solution of a neutral salt, the basic portion of the salt is adsorbed leaving a corresponding amount of acid in solution. If the salt used be sodium chloride, the sodium hydroxide is adsorbed and hydrochloric acid liberated.

The acid soils may be divided into two types: first, those found in sandy upland regions, and second, those found in peat or muck lands. The first type has been thoroughly investigated by the writer[1] in the chemical laboratory of the Michigan Agricultural Experiment Station, and he has been able to show that not only is the peculiar behavior of these soils not due to the presence of any true organic acids, but that it is not due to organic matter at all. It was found that soils in which all the organic matter had been destroyed, still retained their acid properties, these properties being due to the presence of colloidal substances, probably hydrated silicates of iron and aluminum. The second type of soils have been investigated by Baumann and Gully[2] who have shown that in the peat soils the acid properties are due to the colloidal matter of the cell covering of the hyalin sphagnum cells.

The remedy for soil acidity is well known. If a soil be treated with lime (either calcium carbonate or calcium hydroxide), the acid properties are destroyed and the soil restored to its former condition of fertility. Many methods have been devised for the determination of the degree of acidity of the soil or, as it is often called, the "lime requirement" of the soil. Most of these methods are based on the old humic acid theory in spite of the fact that this theory has been so thoroughly discredited of late. Such a method was recently described by E. Trugg.[3] The method consists of treating the soil with calcium chloride, zinc sulphide and water. The soil, if acid, reacts with the zinc sulphide liberating hydrogen sulphide which can be detected by means of lead acetate paper. As to the use of the calcium chloride, we will quote from the article:

> The calcium chloride is added to make the test more sensitive. It reacts with the comparatively insoluble soil acids and forms a small amount of

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[1] *Jour. of Phys. Chem.*, 18, 355 (1914).

[2] *Mitteilung der K. Boyr. Moorkulturanstalt*, 1910, 31–156.

[3] Science, 50, 246 (1914).

hydrochloric acid which readily liberates hydrogen sulphide from zinc sulphide.

This statement brings out very clearly the absurdity of the position of those who accept the humic acid theory. These humic acids are supposed to be strong enough and soluble enough to liberate hydrochloric acid from calcium chloride, but not strong enough or soluble enough to liberate hydrogen sulphide from zinc sulphide. It is also suggested that this method be made the basis for a quantitative determination of the lime requirement of the soil. The writer does not believe this possible because he has shown[4] that acid soils do not adsorb equivalent amounts of different ions. A determination of the amount of zinc adsorbed by the soil will not tell us the amount of lime to be applied to the soil. Furthermore it is not possible to use a factor to determine the amount of lime to be used from the quantity of hydrogen sulphide given off, because it has been found that the ratio of the amounts of two different ions adsorbed will vary with the character of the soil used. The ratio of the amount of zinc adsorbed to that of calcium will vary with each different sample of soil depending upon the kind of colloidal matter present. The only sure way to determine the lime requirement of an acid soil is to use the same material in the test as is used in the field for correcting the acidity. This is done in the methods of Veitch and Süchting.

As to the qualitative methods for the detection of soil acidity, it has been found that all kinds of litmus paper are not suitable. In fact, in the chemical laboratory of the Michigan Agricultural Experiment Station, Kahlbaum's litmus paper has been found to be the only one not so thoroughly saturated with alkali as to make it unsuitable for this purpose. This litmus paper is so sensitive that it is necessary to leave it in contact with the soil particles only for a moment or two. In this way it has been found that soils only very slightly acid give a distinct test.

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A SUGGESTION IN CONNECTION WITH THE STARK-ELECTRIC EFFECT

THE discovery last year of the separation of certain spectrum lines when emitted in an electric field has been followed by a remarkably thorough investigation of the phenomenon by Stark and his co-workers.[1] Hydrogen, helium, lithium, calcium, sodium, magnesium, aluminium, thallium and mercury lines have been examined; but only the diffuse, subordinate series lines of hydrogen, helium and lithium show a separation as great as an angstrom for a field intensity of 10,000 volts per cm. The Stark-electric effect differs from the Zeeman effect in that the various lines of the same series are not equally affected, but, for the same field, the separation increases with the number of the term. Stark emphasizes the complexity of the effect, and gives no law for the relative separation of various lines of the same series, though he suggests that a relation should be sought between the relative change of frequency of the various lines and their term numbers.[2]

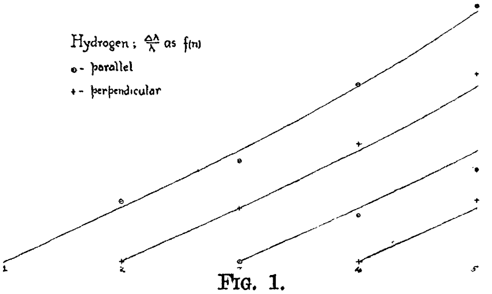

FIG. 1.

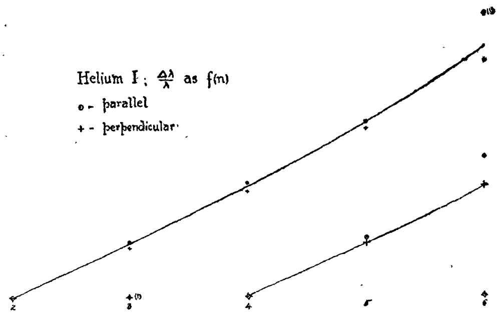

FIG. 2.

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[4] *Loc. cit.*

[1] *Annalen der Physik,* 43, 965–1047, 1914.

[2] *L. c.,* p. 1033.