related to the atomic numbers in a definite manner is brought out by the curve which Harkins[32] has worked out and in a more striking fashion the curve given by Dushman[33] relating the logarithms of the susceptibilities of the elements to the atomic numbers. The curves showing these relations indicate a very definite tie between them and yet there seems to be no other properties associated with atomic numbers which are definitely related to the susceptibilities of the elements. May not this fact also emphasize the importance of placing some of the magnetic properties of the elements in the nuclei?

To come back to the field of magnetostriction it would appear from its teaching that in addition to electronic orbits, to explain magnetic susceptibility, *there must be given to the positive nucleus of the atom a property of induction just as Ewing had in his elementary magnets, and, for ferromagnetic substances at least, these nuclei ought to have different dimensions in different directions, capable of being rotated by means of an external field.*

Helmholtz once said,

> The disgrace of the nineteenth century is our ignorance concerning magnetism.

What shall we say of the twentieth century?

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FUNDAMENTAL PRINCIPLES ESTABLISHED BY RECENT SOIL INVESTIGATIONS

INTRODUCTION

The following is a brief review of the fundamental principles established by modern methods of soil investigation in the Bureau of Soils in the past twenty or thirty years:

TEXTURE OF SOIL

The first step taken established the fact of the general influence of the texture of the soil and its water-holding capacity on the distribution of the great classes of crops; that is, the general relation between the sand, fine sand, silt and clay soils and the general distribution of areas devoted to the production of truck crops, corn, wheat, hay and other heavy farm crops. This together with field studies of origin, mode of formation, and observable physical differences led to the mapping of soils, or the soil survey, which has been extended over a considerable part of the United States.

With the wide field experience it became evident that differences existed between different soil types or in the same soil type that were not to be explained by differences in texture or in water-holding capacity, but that yields vary with the practise of the farmer or from other causes, as was fully known and commented upon by the early Roman writers, that would need to be explained before the practise of agriculture, the application of fertilizers, and the handling of soils could be put upon a truly scientific basis.

ORGANIC CHEMISTRY OF SOILS

The study of some notably infertile soils and of very productive soils of the same type which had been held under what we call "better systems of farming" revealed the presence of certain toxic organic compounds in the one which were not present in the other. This led to a study of the organic chemistry of the soils. Finally we succeeded in separating from soils some 35 definite organic compounds, some of which were beneficial to certain crops and some of which were toxic to certain crops and nontoxic to others. It was also found that soils under a certain condition of aeration would yield certain organic products and under other conditions of aeration other organic products. It was found that the compounds separated from the soil were of the same nature as the compounds in the digestive system and in the blood of man and animal and it was finally realized that the soil has a digestive system as it were and breaks down organic materials such as the proteins, carbohydrates, and fats much

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[32] Harkins and Hall, *Journ. Amer. Chem. Soc.*, 38, 210, 1916.

[33] Dushman, *l. c.*

as they are broken down in the digestive system of animals. The soil has the same kind of bacterial, enzymatic and oxidation processes as are common to the animals. It is evident that soil through these digestive agencies will take care of the excreta of plants and the organic matter that accumulates in the soil from various causes, reducing the organic matter to lower and lower forms of oxygenated bodies until they approach the hydrocarbon type of compounds in our humus, which are stable, innocuous and form the sewage disposal of the soil.

In the animal under abnormal functional conditions the too great accumulation of products of metabolism causes a fatigue of the muscles or if the system can not eliminate them the death of the animal. So under abnormal conditions in the soil brought about by adverse methods of cropping, of tillage, of the selection of crops, or improper methods of crop rotation the soil, as the French put it. becomes fatigued and the plant is unable to function.

The second stage of soil investigations therefore has developed the fact that the soil has a digestive system and is liable to fatigue or exhaustion as regards its power to produce crops and is dependent for its efficiency upon normal conditions, much as the animal is dependent upon normal functional activities to maintain life energy. This is a great field opened up for the organic and physiological chemist and bacteriologist. It may be stated more concisely that the chemistry of the soil is running parallel to the chemistry of the animal.

Some of the organic compounds isolated from soils and identified are as follows:

Acrylic acid,
Adenine,
Agroceric acid,
Agrosterol,
Arginine,
Creatinine,
Cytosine,
Dihydroxystearic acid,
Glycerides, liquid,
Guanine,
Hentriacontane,
Histidine,
Hypoxanthine,
Lignoceric acid,
Lysine,
Mannite,
Monohydroxystearic acid,
Nucleic acid,
Oxalic acid,
Paraffinic acid,
Pentosan,
Pentose,
Phytosterol,
Picoline carboxylic acid,
Resin,
Resin acids,
Resin esters,
Rhamnose,
Saccharic acid,
Salicylic aldehyde,
Succinic acid,
Sulphur,
Trimethylamine,
Trithiobenzaldehyde,
Xanthine.

MINERAL CHEMISTRY OF THE SOIL SOLUTION

The mineral particles that make up the structure of the soil are bathed with a solution containing both inorganic salts and organic compounds. The circulation of this solution is similar in purpose to the circulation of the blood and it is upon this nutrient solution that the plant depends for its nourishment. It is particularly desirable, therefore, that the constitution of this nutrient solution be understood. By handling large quantities of soil in our laboratories it has been possible to obtain large quantities of this soil solution in dilute form. This solution, if allowed to evaporate quietly at ordinary temperatures yields successive crops of crystals which are found to be analogous to the salts found in the Stassfurt deposits of Germany and to the inland lake and sea deposits throughout the world. Silvite, kainite, and carnalite, the three important potash salts of Stassfurt, are commonly present in the nutritive solution of our soils, and, when we come to think of it, it appears to be the simplest thing in the world to understand that the salts that we value so highly in our mines are formed in our soils, transported through the oceans, and crystallized out again when the waters evaporate.

Our chemists have been expressing the results of their analyses in simple conventional terms of single salts. This work shows that the soil solution is most complex and that there are besides single salts, double salts and triple salts. In a complex salt solution changes of temperature or additions of material have a profound effect upon the character of the double or triple salts especially. No correlation has yet been made between these different complexes and the production of crops, or between these different complexes and the effect of soluble fertilizer materials, or between these different complexes in different soil types, but the way has been opened for chemists now to study the soluble mineral compounds in the nutritive solution of the soil as never before.

The following list of salts has been identified in soils, or obtained from soils through the quiet evaporation of the dilute extracts until crystals appear.

Aphthitalite,
Aragonite,
Blodite,
Borax,
Calcite,
Carnallite,
Dolomite,
Epsomite,
Gaylussite,
Gypsum,
Halite,
Hanksite,
Kainite,
Kieserite,
Langbeinite,
Leonite,
Loweite,
Magnesite,
Mirabilite,
Natrolite,
Northupite,
Picromerite,
Soda niter,
Sodium carbonate,
Sulphohalite,
Sylvite,
Thenardite,
Thermonatrite,
Tri-sodium phosphate,
Trona,
Vanthoffite.

COLLOIDAL CHEMISTRY—THE ULTRA CLAY

This brings us down to the fourth great fundamental line of research which completes the outline of the problems to consider in future soil investigations and the most difficult of all to understand.

Always in our study of the texture of the soil, we have realized that there was something which modified the texture, something that bound the grains of soil together making certain soils very plastic when wet and very hard compact when dry and making other soils more friable and even incoherent when dry. It took us a long while to determine the cause of this plasticity. It was something that went obviously into solution but did not have the properties of a true solution. Finally we were able to separate it and found that it was a colloidal solution. From this we have prepared and collected the colloid itself, to which we have given the name ultra clay. The examination of this material leads us into the realm of colloidal chemistry which is a most difficult field to investigate because of the extremely inert nature of all materials in a colloidal state.

This ultra clay when dry will absorb as much as 200 times its volume of ammonia gas, from 20 to 40 per cent. of its weight of water vapor in a closed space over free water at 30° C. and in a wet state will absorb from 10 to 30 per cent. of its weight of certain dyes. By heating the ultra clay or an ordinary soil to 900 to 1000° C. this absorptive power is practically completely killed. By measuring the absorption of water vapor, of ammonia, and of certain dyes in the original soil, in the killed soil, and in the ultra clay separated from the soil, we have been able to estimate the amount of ultra clay in soils.

This ultra clay is as strong in its power to cement sand grains as is Portland cement, but when a dry briquette cemented by ultra clay is put into water it goes to pieces while a similar briquette of Portland cement holds its shape and crushing strength. When soil is heated to 900 or 1000° C. it loses almost completely its binding power when formed into a briquette, but if the amount of colloid estimated to be present by the methods already referred to is added to the killed soil the original plasticity is restored and the crushing strength of the dry briquette is about the same as in the original soil.

This colloidal material is disseminated through the soil as a film over the mineral grains, giving plasticity to the soil when wet, and hardness to the soil when dry, and is the medium for the absorption of gases, of organic, and of mineral matters. Physically it is analogous to the muscles and tendons of the animal body, which permits the articulation and motion of the skeleton and its fleshy covering in the animal; chemically it is analogous to the lining of the stomach and other digestive and respiratory organs of the animal and of the protoplasmic content of the vegetable cell. It appears to be essentially a silicate of aluminum and iron. We have not as yet been able to determine whether the small amount of lime, magnesia, potash, and soda present are a part of its constitution or whether they are held there in colloidal form. The material is so inert in its chemical affinities that we have not yet been able to kill it or to control it in any material way except by heating. This is a matter of the greatest importance in the cultivation of the soil and is a matter of profound importance in road building as it appears to be the main cause of the deterioration and the breaking down of the modern road surfaces.

MILTON WHITNEY

BUREAU OF SOILS,
U. S. DEPARTMENT OF AGRICULTURE

SCIENTIFIC EVENTS

THE COUNCIL MEETING OF THE AMERICAN CHEMICAL SOCIETY

FROM the report in the *Journal of Industrial and Engineering Chemistry* we learn that Rumford Hall, Chemists' Club, was the gathering place on September 6, of the largest Council Meeting in the history of the society. President Edgar F. Smith was in the chair, and one hundred and sixteen councilors were present in person or by proxy. The business of the day consisted in large part of matters concerning the internal policies of the society, a complete report of which will appear in the proceedings in the October issue of the *Journal of the American Chemical Society.*

Two matters of national policy were discussed at length. The society's committee on patents and related legislation submitted a report on the Stanley Bill, now before the congress. The following resolution was unanimously passed:

> While the council is disposed to accept the views of its committee on patents, nevertheless it is felt that a constructive suggestion should be made by the committee as to legislation which would prevent the utilization of our Patent Office by foreigners for the suppression of the development of industries such as was so clearly apparent in the organic chemical industry upon our entrance into the war in 1917. The committee is therefore urged to consider this problem immediately and to report to the committee on national policies.

President Smith outlined the present legislative situation with regard to the organic chemical industry, whereupon it was moved that resolutions urging the passage of a limited embargo on synthetic organic chemicals be prepared for presentation to the general meeting on the following day.

It was decided to hold the annual meeting in September, 1922, at Pittsburgh, Pa. It will be remembered that this section relinquished its lien upon the September, 1921, date to permit the international gathering to be held in New York City. The spring meeting will be held in Birmingham, Ala., early in April, 1922.

The secretary presented an ad interim report of the finance committee and gave statistics regarding the paid and unpaid membership. It is estimated by the directors that the actual expenditures for the year 1921 will exceed the receipts by approximately $10,000.

The president of the Chemists' Club, John E. Teeple, presented a suggestion that the society take over the Bureau of Employment now run by the club, or establish a bureau to replace this organization. In accordance with the Council vote, the President appointed a committee consisting of H. P. Talbot, Edward Bartow, and A. C. Fieldner, to consider this question and report at the spring meeting.

Dr. Smith told of the work of the Priestley Memorial Committee, describing the Priestley portrait, and outlining the plans of the committee to establish a Priestley Medal fund. Plans are also under way for the restoration of the Priestley home at Northumberland, Pa., and President Smith spoke of his wish that the society might celebrate its fiftieth anniversary with a meeting at Northumberland in 1925.

THE OPTICAL SOCIETY OF AMERICA

THE fourth annual meeting of the Optical Society of America will be held in Rochester, New York, on October 24, 25, and 26. A large number of important papers dealing with all branches of optics will be presented. Several of the papers on the program will deal with the various phases of physiological optics. At this meeting a section on vision