Scientific American.

ESTABLISHED 1845.

MUNN & CO.. Editors and Proprietors.

PUBLISHED WEEKLY AT

No. 361 BROADWAY, NEW YORK.

O. D. MUNN. A. E. BEACH.

TERMS FOR THE SCIENTIFIC AMERICAN.

One copy, one year, for the U. S., Canada or Mexico.................$3 00
One copy. six months, for the U. S., Canada or Mexico.................1 50
One copy, one year, to any foreign country belonging to Postal Union. 4 00

Remit by postal or express money order, or by bank draft or check.
MUNN & CO., 361 Broadway, corner of Franklin Street, New York.

The Scientific American Supplement

is a distinct paper from the SCIENTIFIC AMERICAN. THE SUPPLEMENT is issued weekly. Every number contains 16 octavo pages, uniform in size with SCIENTIFIC AMERICAN. Terms of subscription for SUPPLEMENT, $5.00 a year, for the U. S., Canada or Mexico. $6.00 a year to foreign countries belonging to the Postal Union. Single copies 10 cents. Sold by all newsdealers throughout the country. See prospectus, last page.

Combined Rates.—The SCIENTIFIC AMERICAN and SUPPLEMENT will be sent for one year, to one address in U. S., Canada or Mexico, on receipt of *seven dollars*. To foreign countries within Postal Union *eight dollars and fifty cents a year.*

Building Edition of Scientific American.

THE BUILDING EDITION OF THE SCIENTIFIC AMERICAN is a large and splendid illustrated periodical, issued monthly, containing floor plans and perspective views pertaining to modern architecture. Each number is illustrated with beautiful plates, showing desirable dwellings, public buildings and architectural work in great variety. To builders and all who contemplate building this work is invaluable. Has the largest circulation of any architectural publication in the world.

Single copies 25 cents. By mail, to any part of the United States, Canada or Mexico, $2.50 a year. To foreign Postal Union countries, $3.00 a year. Combined rate for BUILDING EDITION with SCIENTIFIC AMERICAN, to one address, $5.00 a year. To foreign Postal Union countries, $6.50 a year. Combined rate for BUILDING EDITION, SCIENTIFIC AMERICAN and SUPPLEMENT, $9.00 a year. To foreign Postal Union countries, $11.00 a year.

Export Edition of the Scientific American.

with which is incorporated "LA AMERICA CIENTIFICA E INDUSTRIAL," or Spanish edition of the SCIENTIFIC AMERICAN, published monthly, uniform in size and typography with the SCIENTIFIC AMERICAN. Every number contains about 50 pages, profusely illustrated. It is the finest scientific, industrial export paper published. It circulates throughout Cuba, the West Indies, Mexico, Central and South America, Spain and Spanish possessions—wherever the Spanish language is spoken. THE SCIENTIFIC AMERICAN EXPORT EDITION has a large guaranteed circulation in all commercial places throughout the world. $3.00 a year, post paid to any part of the world. Single copies 25 cents.

☞ Manufacturers and others who desire to secure foreign trade, may have large and handsomely displayed announcements published in this edition at a very moderate cost. MUNN & CO., Publishers,
361 Broadway, New York.

☞ The safest way to remit is by postal order, express money order, draft or bank check. Make all remittances payable to order of MUNN & CO.

☞ Readers are specially requested to notify the publishers in case of any failure, delay, or irregularity in receipt of papers.

NEW YORK. SATURDAY, JULY 6, 1895.

Contents.

(Illustrated articles are marked with an asterisk.)

TABLE OF CONTENTS OF

SCIENTIFIC AMERICAN SUPPLEMENT

No. 1018.

For the Week Ending July 6, 1895.

Price 10 cents. For sale by all newsdealers.

RECENT PROGRESS IN SOIL ANALYSIS.

The usefulness of the chemical analyses of soils in practical agriculture has long been a theme of contention among agronomists. On the one hand the advocates of chemical analysis have contended that the agricultural value of a soil could be easily deduced from the data afforded by analysis. On the other hand, it has been affirmed with equal persistence that the data of a chemical examination afforded no just criterion of the availability of plant foods found in the sample. It is not the intention here to review these discussions, but it will be sufficient to say that there is a certain relationship between the quantities of plant food revealed by chemical analysis and the productiveness of the soil.

It is so evident, however, that this relationship is not constant that it is not necessary to cite any proof. The physical state of a soil, the climatic condition prevailing, the character of the cultivation and the nature of the crop have all to be considered and all have their influence. It has long been known that the supply of water which is furnished to the plant has more influence upon the amount of product than the fertility of the soil itself. A given field which will in one season produce a maximum crop will with practically the same amounts of plant food available in the soil in the very next season give a minimum yield. It is therefore evident that, without taking into consideration all the conditions above mentioned, no safe prognostication of yield can be based upon chemical data alone.

The principles of chemical analysis of a soil have been firmly established and especially in this country chiefly through the researches of Hilgard and Peter. While the methods of examination may vary in unimportant particulars, the general principles of procedure have remained the same for many decades. It is not believed that there can be any very important amendment of a useful nature made to the methods already in use.

The digestion of a soil of a given degree of fineness for a given length of time in hydrochloric acid of such a density as to be practically preserved at a given point of saturation throughout the whole course of solution leaves little to be desired in the way of scientific accuracy in securing the soluble constituents of a soil. On the other hand the processes of bulk analysis are based upon the well known principles of examination of minerals which have been so well established as to have suffered little change during the past few decades, nor is it likely they will suffer any great change in the future.

We must look, therefore, for progress in the line of soil analysis in some other direction than in that which has been so thoroughly investigated in the past.

Among the prominent features of recent investigation may be mentioned two which are of prime importance. In the first place attention is invited to the attempts to imitate in the chemical laboratory more nearly the solvent action of bio-chemical activity upon the plant foods present in the soil.

Every chemist has been struck with the fact that the achievements of bio-chemical activity are far more wonderful in their nature than the most brilliant achievements of the chemical laboratory. We find passing into solution in the juices which circulate through plants substances which are obtained only with the greatest difficulty and at the highest temperatures in the laboratory. We find everywhere in the vegetable world striking instances of metabolism which any chemist, even the most distinguished, would be glad to imitate. We find silicates of the most refractory nature dissolved and in this state passing to form new combinations in various parts of the plant, especially in the bark and the leaves. We find in the same juices the alkalies which only a short time before were united in the most stable chemical compounds in the mineral fragments of the earth's crust. We find compounds of mineral acids broken up, the mineral acids driven out by organic acids which ordinarily would not affect them at all and the bases with which they were combined passing in organic forms into the vegetable organism.

Evidently, therefore, in attempting to imitate in the laboratory these complicated chemical phenomena we should not lose sight of the fact that it is not possible for us to measure by our ordinary methods the power of vegetable metabolism. Nevertheless we are justified in assuming that as a rule boiling concentrated hydrochloric acid will attack mineral fragments in a way different from the organic acids which are brought in contact with them by the rootlets of the plants. Acting on this idea, it has been suggested, especially by Dyer, to substitute organic acids or their salts for mineral acids in determining the available quantities of potash and phosphoric acid in soil samples. With this idea in view the chemists belonging to the Association of Official Agricultural Chemists have been during the past year engaged in co-operative work, with a view to testing the merits of these methods of determining solubility.

It is evident, however, that no method of arbitrarily determining the solubility of plant food in soils can prove of actual value unless it be tested against the actual capabilities of plants acting upon soil of the same description. It is with this end in view that the Department of Agriculture organized a system of soil analysis in which the chemical results obtained in the laboratory are checked against the actual results obtained by experimental growth in pots. These experiments have now been under way for two years, chiefly, however, with the idea of testing the proper processes to be employed. This having been, with a certain degree of success, accomplished, the work is now considerably extended. A vegetation house has been built capable of accommodating 200 pots. These pots are kept on trucks running on rails. During the day they are run out into the open air and sunshine; during the night and in time of storms they are kept in the vegetation house, which is covered with glass. The soil which is contained in each of the pots is subjected to chemical examination in various ways and with various solvents. In this way it is believed that the actual available plant food which a soil contains, as shown by the character of the crop grown, will be by some of the methods employed indicated with a considerable accuracy by the chemical analysis.

Another most important step forward in the examination of soils consists in the methods which are now employed for determining the number and vitality of the nitrifying organisms which they contain. As is well known, the nitrogen which plants use as food can only be assimilated after it has been oxidized by passing through a vegetable organism of a lower nature. The process of changing organic nitrogen, which plants cannot assimilate, into nitric acid, which is a food suited to their needs, is called nitrification.

The process of nitrification consists of three distinct steps. In the first place, organic nitrogen is changed into ammonia. This change is produced by a number of organisms existing in the soil, the most active of which is the bacillus mycoides. The ammonia thus formed is next converted into nitrous acid by the action of a genus of organisms—nitrosomonas. The nitrous acid produced as above described is oxidized to nitric acid by another organism, the nitrobacter. But it is not our purpose here to discuss the processes of nitrification, but rather the methods which are to be employed in examining soils for these organisms. It will not be long before a chemical analysis of a soil will not be considered to be complete until the sample has been examined for the number and vitality of the nitrifying organisms which it contains. In order to make such an examination of practical value, the samples of soil must all be taken under such precautions as to exclude any contamination, and the cultures for developing the micro-organisms must all be conducted under the same conditions. In order to secure this uniformity, the Department of Agriculture has developed a method of taking the samples in sterilized tubes, under precautions which render contamination impossible, if the directions are carefully followed. The samples of soil thus obtained are used for seeding culture solutions, and the number and vitality of the nitrifying organisms in each sample can be determined by noting the time at which nitrification begins in each of the solutions, and by the seeding of sub-cultures from the original cultures employed. This work is now going on in our laboratory on samples of typical soils and subsoils taken at the agricultural experiment stations of different States, and representing the same samples that are employed in the pot cultures and for chemical analysis. By proceeding in this way, it is seen that a uniform method of chemical and bacterial examinations of the soil is secured, and the data of these examinations are checked directly against the products of vegetation secured in the experimental pots.

Further progress has already been recently made, especially in this country, in the physical analyses of soils, chiefly through the researches of Whitney and King. The separation of a sample of soil into silt particles of different degrees of fineness will give data of great value in respect of the capabilities of a soil for holding moisture and delivering it to the roots of growing plants. All the physical data obtained from the examination are of value in the final judgment, and should be considered in connection with the chemical and bacterial data obtained as above described.

The Seasoning of Stone.

Stone, like lumber, requires seasoning. Stone is often spoken of as the synonym of solidity—"as solid as a rock," we say, but, as a matter of fact, stone is very far from being solid. A cubic foot of the most compact granite, for instance, weighs about 164 pounds, while a cubic foot of iron weighs 464 pounds. This plainly shows that in between the atoms which compose the mass of the most enduring stone there exists much space for air, moisture, etc. This seasoning of stone prior to use for building purposes has been well understood by the architects of all ages, but in the modern rush of nineteenth century building too little attention has been paid to it. Now it enters into the calculations of every good architect.