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SOIL FERMENTS IMPORTANT IN AGRICULTURE.*

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Introductory.—Soil ferments important in agriculture are those which help to make the soil from original rocks and those which are active in preparing the food of plants for absorption and assimilation. The old idea that the soil is an inert mass of mineral matter has given way to the new conception of the soil as a living organism. The parts of the soil which are not endowed with life at the present time have their highest significance as the environment of the living organisms which they contain, and which they may help to nourish. The plant which forms the growing crop receives its nourishment through the media of the air and soil, but this nourishment must undergo a process of digestion, similar to that suffered by the food which nourishes animals, before it becomes available as plant food. Indeed, the purely mineral, inorganic foods of plants are probably not always absorbed as such, and must undergo a decomposition before they are assimilated. A striking instance of this is shown in the case of silica, an important plant food and a type of inert mineral matter. Silica is highly insoluble and apparently the least suited of the mineral constituents of the earth to enter the vital organism of the plant. Yet not only do we find it in the tissues of the mature plant, but also, strange to say, in the greatest abundance in those parts of the plant organism—viz.: the leaves—most remote from the sources of supply. It is evident from this that the highly insoluble silica of the soil must undergo a

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complete solution in order to be carried by the juices of the plant through the network of cellular tissues, to be finally redeposited in the leaf.

The part which soil ferments have played in the formation of arable soil from the original rocks is not thoroughly appreciated. The naked rocks of high mountains comprise mineralogical types of the most varied nature, viz.: granite, porphyry, gneiss, mica schist, volcanic rocks and limestones of all varieties, and all these have been found to be covered with a nitrifying ferment which is doubtless extremely active in producing incipient decay. At the high altitudes in which these observations have been made, the activity of bacteria is necessarily limited by the low temperature to which they are subjected during the greater part of the year. During the winter season their life is suspended, but is not extinguished, since they have been found living and ready to resume all their activity after an indefinite sleep, perhaps of thousands of years, on the ice of the glaciers, where the temperature never rises above the freezing point. When the activity of these ferments in the most unfavorable conditions is recognized, it is easily seen how much more active they become when brought down to lower levels, where they are nourished by the favoring conditions which exist, especially during the summer, in cultivated soils. In fact, the importance of the action of these bodies on the mineral particles of which the soil is largely composed has never been fully recognized, and there is no doubt whatever of the great significance of their decomposing action in the liberation of plant food locked up in undecomposed mineral structures. In this case the activity of the bacteria is not limited to the surface of rock masses, but permeates every particle of soil and thus becomes effective over a vastly extended surface.

When the extreme minuteness of these organisms and of the phenomena which they produce is considered, there may be a tendency to despise their importance; but by reason of the fact that their activity is never ceasing and of the widest application, it must be placed among the geologic causes to which the crust of the earth owes a part of

its actual physiognomy, and to which the formation of the deposits of the comminuted elements constituting arable soil is due.

But the action of these ferments has not stopped with the aid they have given to soil formation. It is highly probable that they assist in a most marked manner in the final dissolution of the soil particles, and the setting free of the plant foods which they contain. It is quite certain that in the primary decay of bare rocks, especially at high altitudes, the nitrifying organism plays a highly important part, preparing the surface of the rock for the first growth of lichens and other low vegetable organisms, from which the first traces of humus are formed. The discovery that the nitrifying organism can subsist upon a purely mineral food is one of the chief supports of the idea that they were especially active in the very beginning of soil formation. It has been shown that these bacteria can be developed by absorbing from the ambient atmosphere traces of ammonia and other bodies which may be present in the air. There is thus discovered in the very first products of the attrition of rocks the characteristic element of vegetable soil, viz.: humus, the proportion of which increases rapidly with the processes of disintegration, until finally the decaying mass is capable of sustaining chlorophyll-containing plants. Not only upon the surface of exposed rocks have these organisms been discovered, but they are found to extend also to a considerable distance in the interior. They not only play an important part by direct action upon the mineral matters which the rocks contain, but later on, through the production of nitric acid, greatly favor the final solution of the soil particles.

Kinds of Organisms in the Soil.—The nitrifying organisms in the soil exist in common with hundreds of others, many of which are doubtless active upon the soil particles. The organisms to which particular attention is called in this address, in addition to those which help to dissolve the soil particles already mentioned, are those which are active in preparing organic foods for absorption and assimilation by

plants, and those which act upon free atmospheric nitrogen, and bring it into a shape suited to plant nutrition.

In general these are called the nitrifying ferments, and their action is uniformly favorable to vegetable growth. Attention should also be given to another class of organisms found in the soil, whose activity is inimical to plant growth or hurtful in some other way. This class comprises the denitrifying organisms, and those of a pathogenic nature which may exist in the soil, and by their activity cause disease in man and beast.

The Nitrifying Ferments.—The micro-organisms of most importance to agriculture, and those to which attention is particularly called in this article, are the bacteria which act upon nitrogenous matters and oxidize them to nitric acid, or which exert a reducing effect on nitric acid, bringing it to lower forms of oxidation, or even to free nitrogen. These organisms belong to many different species, and act in very many different ways. The general group to which they belong is known as nitro-bacteria. The classification of these organisms by genera and species would prove of little interest to the readers of this article. In general it may be said that there are three distinct genera, comprising, in the first place, those organisms which form ammonia or carbonate of ammonia from organic nitrogenous compounds, such as albumin; in the second place, the organisms which transform carbonate of ammonia into nitrous acid; and, in the third place, those which transform nitrous into nitric acid. Each genus is necessary in the complete transformation of proteid matter into nitric acid, in which latter form alone nitrogen is chiefly available for plant food.

Production of Ammonia.—The bacteria which are especially active in the formation of ammonia are found constantly in surface soils and in the air and rainwaters. By the activity of these organisms in the decomposition of proteid matter, large quantities of ammonium carbonate are produced. The organic carbon which is present in a compound is acted upon during the oxidation of the proteid, and carbon dioxide and certain organic acids are formed.

The organic sulphur which is present is converted into sulphuric acid, and the hydrogen partly into water and partly into ammonia. This oxidation is accomplished by bacteria, and, to a less extent, by moulds and yeasts. The table shown on the screen contains the names of the common soil bacteria, which ammonize proteid matters. The column headed "per cent." shows the amount of proteid matter changed into ammonia by the several organisms in twenty days at a temperature of 30°. Of all the bacteria which have been studied, the species *mycoides* has the highest ammonizing power, being capable of changing nearly half of the proteid into ammoniacal nitrogen in the time named. In soils where the environment does not permit of the development of the nitrifying ferments, the change stops with ammonia. Such conditions are found in the vegetable soils of swamps, which are extremely acid. In such soils ammonia is quite freely produced, while the nitrous and nitric organisms are absent.

In the analysis of a swamp soil, which had been shown by a bacterial culture to contain no nitrifying ferments, 0.03698 per cent. of nitrogen was found as ammonia and only a trace as nitric acid. In another vegetable soil, which contained nitrifying organisms, 0.0336 per cent. of ammoniacal and 0.0474 per cent. nitric nitrogen were present. Of the moulds, several have been found capable of producing considerable quantities of ammonia. Among these '*Cephalothecium roseum*' converted over 30 per cent. of proteid into ammoniacal nitrogen in five days, and *Aspergillus terricola* was only a little less active.

The yeasts are still less active, but a large number of them produces ammonia in small quantities.

In general, it may be said that in cultivated soils, which have a neutral or alkaline reaction, bacteria are almost the sole ammonia makers, while in vegetable soils of a marked acid reaction, as in swamps and forests, the moulds are the chief producers of ammonia.

In the oxidation of albumin by the *Bacillus mycoides* the carbon is oxidized to carbon dioxide, the sulphur to sulphuric acid and the hydrogen to water and to ammonia.

The reaction may be expressed by the formula

The *Bacillus mycoides*, under certain conditions, can form ammonia also from nitrates. In the absence of oxygen it reduces nitrates to ammonia in presence of an organic substance like sugar. In this action it is anærobic, while in the ordinary process of converting proteid matter into ammonia the action takes place in the absence of oxygen. This is a curious instance of a reverse action produced by the same organism in a different environment, showing, as it does, an oxidizing action in the presence of oxygen, and a reducing action in its absence. Some idea of the character of the *Bacillus mycoides* and the methods of its culture can be gained by a study of the photographs which will now be projected upon the screen.

Production of Nitrous Acid.—The next step in the process of nitrification is the conversion of ammonia or its compounds into nitrous acid. With a moderate store of ammonia the oxidation into nitrous acid takes place, as a rule, without any of the nitrogen being lost in a free state or being volatilized as ammonia compounds. When, however, there is a large excess of ammonium carbonate, a considerable loss of nitrogen may take place. The practical deduction to be drawn from this fact is apparent. Nitrogenous fertilizers should be applied only in moderate quantities, so as not to increase the stock of material beyond the power of the active ferments to handle it.

The nitrous ferment is by far the largest and most vigorous of the nitrifying organisms. It is from three to four times as large as the nitric ferment, and under a high power of the microscope appears as minute globules, slightly oblate. These globules are multiplied by fission and the divided parts develop rapidly to perfect organisms of full size. In most cases the organisms appear as distinct globules, but many are congregated into masses where the distinctive cell structure seems to be lost. A photograph of the nitrous organism is shown upon the screen.

Conversion of Nitrous into Nitric Acid.—The last step in the process of nitrification consists in the oxidation of nitrous to nitric acid. As a rule, plants absorb nitrogenous food only as nitric acid, but it cannot be said that the nitrogen may not be used by the plant in other forms. Some experiments seem to show that ammonia and its compounds and humus may be directly absorbed by plants, but if this be true it must be only in very limited quantities. The final step, therefore, in nitrification is necessary to secure this valuable food in its most highly available state. The nitrifying organisms are much smaller than their nitrous cousins, and of the same general shape, but more globular.

It must not be supposed that these steps in the preparation of a nitrogenous food are performed with entire distinctness. The impression might be obtained that the ammoniacal ferment exerted its activity, converting the whole of the nitrogenous supply into ammonia, and that in this state only the nitrous ferment would become active and convert the whole product into nitrous acid, which finally, under the influence of the nitric ferment, would form nitric acid. In point of fact, however, in arable soils and under favorable conditions, the steps of nitrification may be almost synchronous. In the case of a growing crop, a chemical examination or repeated chemical examinations might find only traces of ammonia and nitrous and nitric acids. As each particle of ammonia is formed, it is converted without delay into nitrous acid, and then at once into nitric acid. The nitric acid formed is absorbed by the growing plant, and thus it might seem that the activity of the ferments present in the soil had been reduced to a minimum, when in point of fact they were exercising their functions with maximum vigor. The separate stages of nitrification mentioned above can only be secured in the laboratory by a skilled bacteriologist patiently working to separate the different genera of nitrifying organisms until he procures them in an absolutely pure form. As may be supposed, this is very difficult to accomplish.

(A photograph of the nitric organism was shown upon the screen.)

Ferments Oxidizing Free Nitrogen.—In the preceding paragraphs the attention of the reader has been briefly called to the action of those species of ferments which attack nitrogen in some of its forms of combination. Since nitrogenous food is the most expensive form of nutriment which the plant consumes, it is a matter of grave importance to agriculture to know the full extent of the supply of this costly substance. It is evident that the continued action of nitrifying ferments finally tends to exhaust the stores of this substance which have been provided in the soil. The quantities of oxidized nitrogen produced by electric discharges in the air and by other meteorological phenomena, and which are brought to the soil in rain waters, are of considerable magnitude, but lack much of supplying the ordinary wastage to which the stores of soil nitrogen are subjected. Even with the happiest combination of circumstances, it is not difficult to see in what way the available stores of nitrogen could be diminished to a point threatening the proper sustenance of plants, and thus diminishing the necessary supplies of human food. The examination of the drainage waters which come from a fertile field in full cultivation, is sufficient to convince the most skeptical of the fact that the growing crop does not by any means absorb all of the products of the activity of the nitrifying ferments. Nitric acid and its compounds, the nitrates, are exceedingly soluble in water, and for this reason any unappropriated stores of them in the soil are easily removed by heavy downpours of rain. Happily the living vegetable organism has the property of withholding nitric acid from solution, either by some property of its tissues or more probably by some preliminary combination which the nitric acid undergoes in the plant itself. This is easily shown by a simple experiment. If fresh and still living plants be subjected to the solvent action of water, very little nitric acid will be found to pass into solution. If, however, the plants be killed before the experiment is made, by being exposed for some time in an atmosphere of chloroform, the nitric acid which they contain is easily extracted by water.

The losses, therefore, which an arable soil sustains in its

content of nitrogenous matter must be supplied either by the addition of nitrogenous fertilizers or by some action of the soil whereby the nitrogen which pervades it may be oxidized and fixed in a form suited to the nourishment of plants. The discussion in regard to the possibility of fixing nitrogen in the soil has been carried on with great vigor during the last two decades. The proof, however, is now overwhelming that such fixation does take place. It would not be proper here to enter into a discussion of the processes by which this fixation is determined, and, in fact, they are not definitely known. One thing, however, is certain, viz.: that it is accomplished by means of micro-organisms or ferments similar, perhaps, in their nature to those already mentioned, but capable of absorbing, assimilating and oxidizing free nitrogen.

Methods of Oxidizing Free Nitrogen.—At the present time, it is sufficiently well known that this operation takes place in two ways. In the first place, there are found to exist on the rootlets of certain plants, chiefly of the leguminous family, colonies of bacteria whose function is known by the effects which they produce. In such plants in a state of maturity, as was mentioned above, are found larger quantities of organic nitrogen than could possibly have been derived from the soil in which they were grown or from the fertilizers with which they were supplied. Cultural experiments in sterilized soils, with careful exclusion of all sources of organic nitrogen, have proved beyond question that this gain in nitrogen is found only in such plants as are infected by the organism mentioned. The logical conclusion is therefore inevitable that these organisms, in their symbiotic development with the plant rootlets, assimilate and oxidize the free nitrogen of the air and present it to the plant in a form suited to absorption. Attempts have been made to inoculate the rootlets of other families of plants with these organisms, but so far without any pronounced success. There are, however, certain orders of low vegetable life, such as cryptogams, for instance, which seem to share to a certain degree the faculty of the leguminous plants in acting as a host for the nitrifying organisms men-

tioned. The observation above recorded becomes a sufficient explanation of the fact that the fertility of fields is increased by the cultivation of leguminous plants, which would not be possible except they possess some such property as that which has already been described.

Another order of organisms has also been discovered which is capable of oxidizing free nitrogen when cultivated in an environment from which organic nitrogen is rigidly excluded. It seems probable, therefore, even in soils which bear crops not capable of developing nitrifying organisms on their rootlets, that the actual stores of available nitrogen may be increased. This fact explains the observation which has frequently been made that in fields which are not cultivated, but which remain in grass, there may be found an actual increase in the total amount of nitrogen which is available for plant growth. As will be seen further along, the soil is also infested with an organism which is capable of destroying nitric acid and returning the nitrogen which it contains to the air in a free state. It seems almost certain that in every complete decomposition of a nitrogenous organism a part of the nitrogen which it contains escapes in the free state. Were it not, therefore, for the fact that this free nitrogen can be again oxidized and made available for plant growth, the total stores of organic nitrogen in existence would be gradually diminished, and the time would ultimately come when their total amount would not be sufficient to sustain a plant life abundant enough to supply the food of the animal kingdom. Thus the earth itself, even without becoming too cold for the existence of the life which is now found upon it, might reach a state when plant and animal life would become practically impossible by reason of the deficit of nitrogenous foods.

Much less is known concerning the character and activity of the organisms that oxidize free nitrogen than of those which feed upon organic nitrogen. It cannot be doubted, however, that these scarcely known ferments are of the greatest importance to agriculture, and the further study of their nature and the proper methods of increasing their

activity cannot fail to result in the greatest advantage to the practical farmer. (Photographs showing the occurrence of the nitrifying tubercles of leguminous and other plants were shown upon the screen.)

Fertilizing Ferments.—Two years ago I used the following words in a report published by the Department of Agriculture:

“When a soil is practically free from albuminoid bodies and contains but little humus, the attempt to develop a more vigorous nitrifying ferment would be of little utility. Even in a soil containing a considerable degree of humus, it may be found that its nitrogen content has been so far reduced as to leave nothing practically available for the activity of nitrification. In such cases the only rational method of procedure is in the application of fertilizers containing nitrogen. In other cases where the lack of fertility is due to the extinction or attenuation of the nitrifying ferment, remunerative results may be obtained by some process of seeding similar to that described above. It is entirely within the range of possibility that there may be developed in the laboratory species of nitrifying organisms which are particularly adapted for action on different nitrogenous bodies. For instance, the organism which is found most effective in the oxidation of albuminoid matter may not be well suited to convert amides or the inert nitrogen of humus into nitric acid. We have already seen the day when the butter-maker sends to a laboratory for a ferment best suited to the ripening of his cream. It may not be long until the farmer may apply to his laboratory for particular nitrifying ferments to be applied to such special purposes as are mentioned above. Because of the extreme minuteness of these organisms, the too practical agronomist may laugh at the idea of producing fertility thereby, and this idea, indeed, would be of no value were it not for the wonderful facility of propagation which an organism of this kind has when exposed to a favorable environment. It is true that the pure cultures which the laboratory would afford would be of little avail if limited to their own activity, and it is only in the possibility of their almost illimitable development that their fertilizing effects may be secured.”

It is of interest in this connection to recall the fact that a few months ago the realization of the prophecy above made was accomplished. There is now made, and offered for sale to farmers, a nitrifying ferment called nitragin, which is prepared from the tubercules of certain leguminous plants. It is found that this material is of use only when applied to crops similar to those from which it is made, while it does not act upon other crops, especially those of a non-leguminous nature. For instance, if the farmer wish to fertilize his clover field with a nitrifying ferment prepared in this way, he must get one which is prepared from clover. If it be a field of peas or beans, on the other hand, he must secure a ferment prepared from these vegetables. This process may seem ridiculous to those who do not carefully consider all of its aspects, but in a little phial, no bigger than a goose-quill, can be easily contained the seeds of ferments, which, by proper multiplication, will produce an active nitrification over a large area. In the preparation of the ferment it is best to mix it with fine, moderately moist soil. After thorough mixing, this soil is then sowed over the land as one would sow wheat or oats. By the process of fission the organisms which are thus introduced into the soil rapidly multiply, and if they find the rootlets of plants suitable to their environment they at once attach themselves thereto, where new tubercules similar to the ones you saw upon the screen, are formed. It is too early yet to speak of the commercial success which will attend this method of fertilization, but there is no doubt of the fact that when a field which contains an abundance of nitrogenous matter becomes practically sterilized, this matter may be rendered more available by the introduction of proper nitrifying organisms, and it is also certain that when those crops, such as the leguminosæ, which are suited to the development of the colonies of tubercules upon the rootlets, are seeded with the proper organisms, the number of tubercules is increased, their activity favored, and the assimilation of atmospheric nitrogen hastened.*

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* Photographs were exhibited upon the screen to show the influence of inoculating different plants with different ferments developed on radical tubercules.

Ferments Inimical to Agriculture.—It has been noticed by many observers that when nitric acid is subjected to certain fermentative processes it becomes decomposed and gradually disappears. In studying the causes which lead to this decomposition, it is found that it is due to the action of a micro-organism or ferment, which, by reason of the result of its functional activity, is called a denitrifying organism. While it is true that in numbers and activity this denitrifying organism does not equal its nitrifying relation, yet it is a matter of no inconsiderable importance to know fully the laws which govern its existence. As in the case of the bacteria which are found in ripening cream, where some produce evil and some good effects, so it is with those in the soil. The favoring organisms, whose functional activity prepares nitrogen in a form suited for plant food, are accompanied by others, doubtless nearly related to them, whose functional activity tends to destroy the work which the first have accomplished. It thus happens that in the fermentation of nitrogenous bodies there is danger of losing, as has already been said, a part of the nitrogen, which may either escape as gaseous oxides unsuited for the sustenance of plants, or even as free nitrogen. The object, at least the practical object, of the investigation of these denitrifying organisms, should be to discover some process by which their multiplication could be prevented and their activity diminished. At the present time all that is known is that in ordinary circumstances these organisms are not developed in sufficient numbers to prove very destructive. It has already been mentioned, however, that in case of a very great excess of organic nitrogenous matter a considerable quantity of the nitrogen therein contained may, through the action of these organisms, be lost. The practical lesson taught here is to apply nitrogenous foods in a moderate manner and avoid every unnecessary excess.

In the case of nitrifying ferments, it has been seen that nitric acid and carbon dioxide are some of the final products of bacterial activity. In the denitrifying process, on the other hand, free hydrogen and free nitrogen are the results of the final activity of the micro-organisms. In these tubes

which I show you, which are partly filled with gas, the evolution of the gaseous material has been secured by introducing into the sterilized solution containing a nitrate, a denitrifying ferment obtained from a soil taken in proximity to a stable. Experience has shown that stable manures of all kinds contain these denitrifying ferments, and that these are capable of causing considerable waste of nitrogen, unless care is taken in their use. The results of such experiments as these show conclusively that it would be a useless extravagance to use a fertilizer containing nitric acid, such as Chili saltpetre, in connection with stable manures.

Pathogenic Ferments.—There are also other forms of ferments in the soil of an objectionable nature which are not related to the nitrifying organisms. It has been observed in France that, in localities where animals are interred which have died of charbon, the germs of this infectious malady persist in the soils for many years, and that, especially when cereal crops are cultivated upon such soils, there is great danger of contaminating healthy cattle with the same disease. In one case it was observed that many sheep which were pastured in a field in which, two years before, a single animal which had died of charbon was buried, were infected with the disease and died. In like manner, it is entirely probable that the germs of hog cholera may be preserved in the soil for many years, to finally again be brought into an activity which may prove most disastrous for the owners of swine. Every effort should be made by agronomists to avoid infecting the soil by carcasses which are dead from any zymotic disease. Cremation is the only safe method of disposing of such infected carcasses. The investigations of scientists have shown that there are many diseases of an infectious nature due to these germs, and that these germs may preserve their vitality in the soil. Among others may be mentioned yellow fever and tetanus, and the microbe producing the bubonic plague, which retains its vitality in the soil and thus escapes entire eradication.

Use of Sewage as Fertilizer.—For the reasons given above, the agronomist, who also has at heart the health and wel-

fare of man and beast, can hardly look with favor upon any of the plans which have been proposed for the use of sewage from large cities for irrigation purposes. There is scarcely a time in any large city when some infectious disease, due to the activity of germs, does not exist, and the sewage is liable at all times to be contaminated therewith. In view of the fact that the vitality of the germs mentioned above may be continued for a long time in the soil, it is fair to conclude that it is of the utmost importance to avoid the contamination of the soil, where it is to be used for agricultural purposes, with any of the dejecta which may come from those infected with any zymotic disease whatever.

Supplying Lost Nitrogen.—It is evident that if no process of supplying the loss of nitrogen existed, the soil would soon lose its power of furnishing food and raiment for man. The philosopher who studies the system of nature sees in the far future the advent of a time when the environment of man on the earth will be too harsh for his present organization. The slow cooling of the sun, and, consequently, of the earth, is the principal cause of this misfortune. But added to this must be considered the gradual disappearance of carbon dioxide and organic nitrogen, two of the essential components of the environment which makes plant life possible. Diminishing heat and light, disappearing carbon dioxide and organic nitrogen are little by little making the struggle for existence harder.

Nitrogen is lost not only by the action of the denitrifying organisms, but also by the solution of nitrates and their loss in drainage waters. From the sea this loss is restored in part by fish and sea-weeds. This is a practical illustration of the text: "Cast thy bread upon the waters, and it shall return after many days." The organisms that oxidize atmospheric nitrogen supply another part.

Fortunately, living organisms adapt themselves to changes in their environment, and life, therefore, will still be possible when the present conditions of existence shall have disappeared.

A careful study of the causes which produce a waste of nitrogen and those which restore the loss, gives the pleas-

ing assurance that the present kind of man will not die of nitrogen hunger. Some of the best producers of proteids flourish at high latitudes.

When the last man of the present race, with a stature diminished by long ages of hopeless labor, and with features pinched from hunger and cold, shall have been driven to the equator by the advancing armies of ice, his last look will be at the mocking disc of the sun, denying him warmth, and his last mouthful of food will contain the proteids of oat-meal.

[The lecture was fully illustrated with experimental cultures of soil microbes and by means of lantern slides.]

CHARLES HENRY BANES.

It is fitting, on the death of a public man, that some record should be made of the services he has rendered his fellows. For this reason, the Franklin Institute has appointed a committee to prepare, for permanent record, a brief account of the eminent services the late Charles Henry Banes has rendered it. In presenting this record of the life of their late fellow-member, the committee recognizes that any mere recital of the varied abilities of the man will but inadequately express the extent and value of his public work. In preparing the record the committee has thought it best not to limit the recital to the work he performed in connection with the Institute, but to include therein some reference to his labors and public services in other fields.

Charles Henry Banes was born in the city of Philadelphia, October 24, 1831. He received a public school education, and was graduated from the Central High School of Philadelphia in 1847. At the close of his school life he became interested in mercantile pursuits, in which he continued to be engaged until the breaking out of the war of the rebellion in 1861, when he entered the United States service as Captain of Company E, of the 72d Regiment of