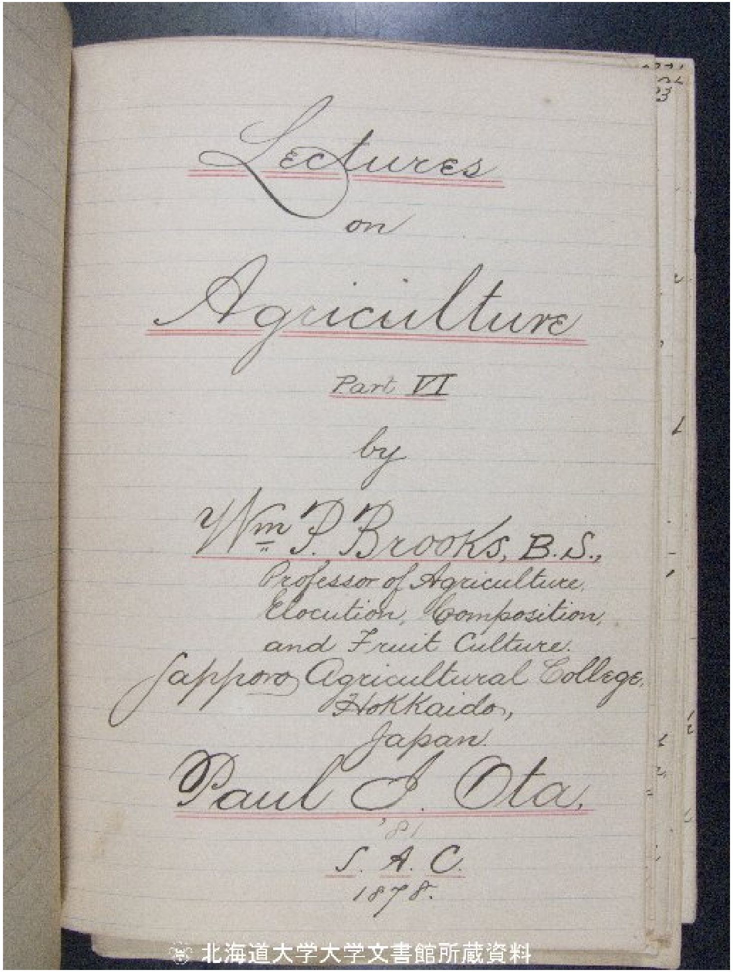

Lectures

on

Agriculture

Part VI.

By

Wm P Brooks, B. S.,

Professor of Agriculture

Elocution, Composition,

and Fruit Culture.

Sapporo Agricultural College,

Hokkaido,

Japan

Paul I. Ota,

’81

S. A. C.

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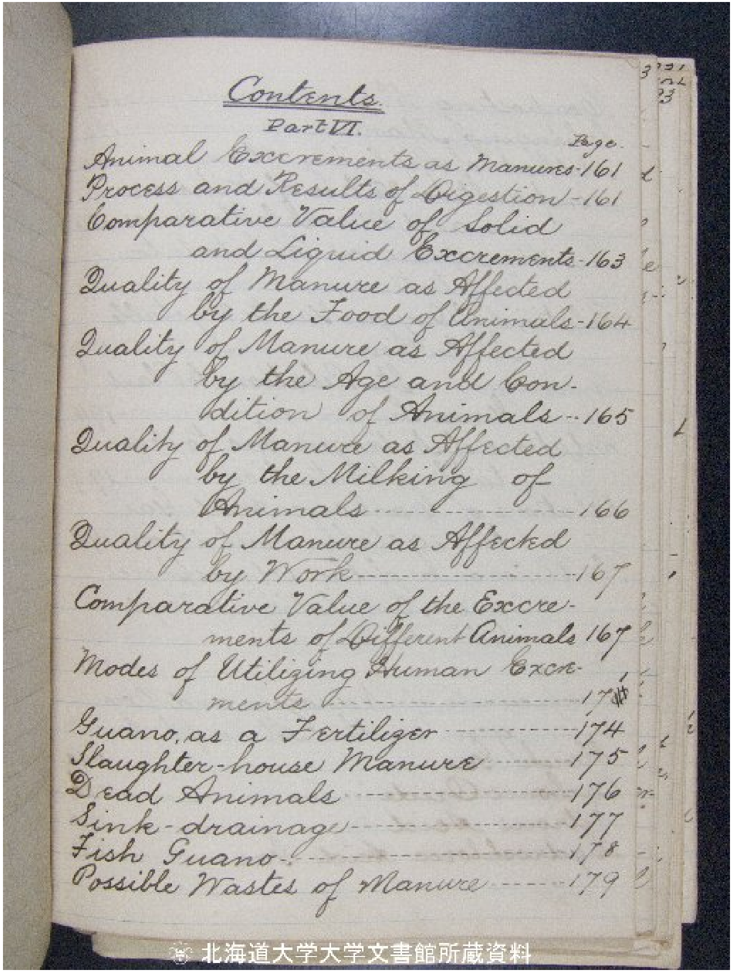
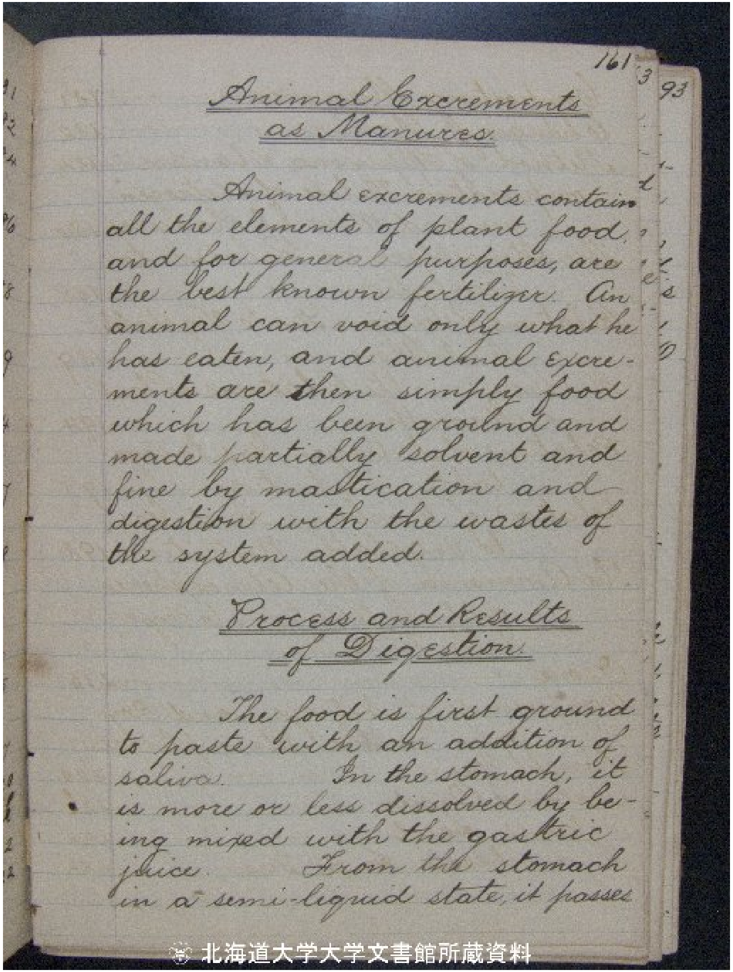


<u>Contents</u>

(Part VI)


161

Animal Excrements
as Manures.

Animal excrements contain
all the elements of plant food
and for general purposes, are
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ments are then simply food
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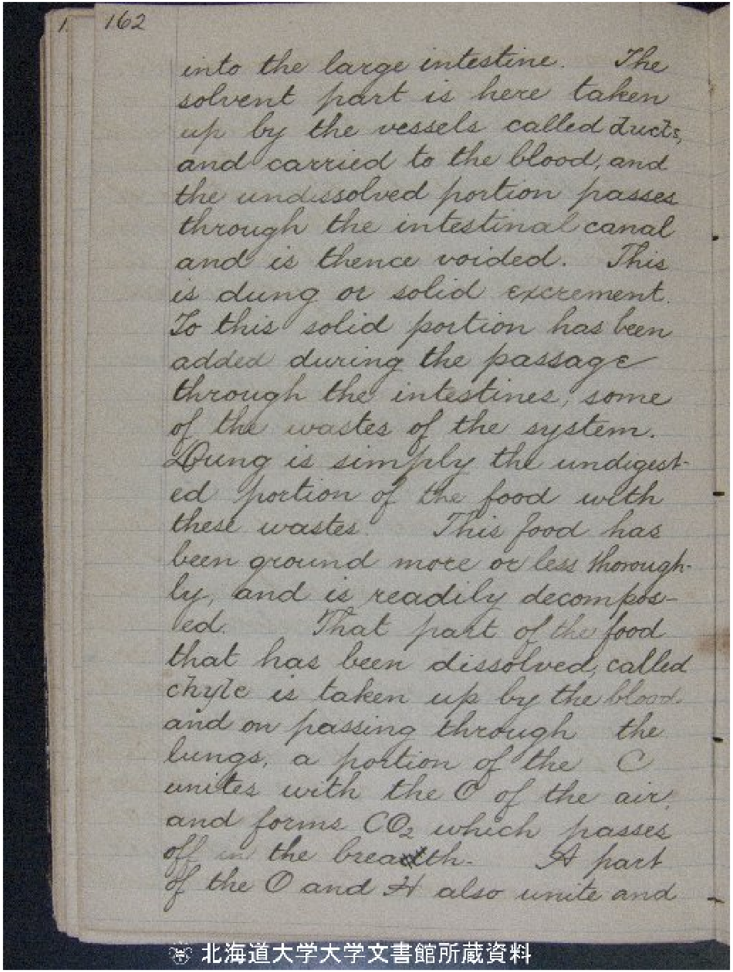

162

into the large intestine. The solvent part is here taken up by the vessels called ducts, and carried to the blood, and the undissolved portion passes through the intestinal canal and is thence voided. This is dung or solid excrement. To this solid portion has been added during the passage through the intestines, some of the wastes of the system. Dung is simply the undigested portion of the food with these wastes. This food has been ground more or less thoroughly, and is readily decomposed. That part of the food that has been dissolved, called chyle is taken up by the blood and on passing through the lungs, a portion of the C unites with the O of the air, and forms CO_2 which passes off in the breath. A part of the O and H also unite and

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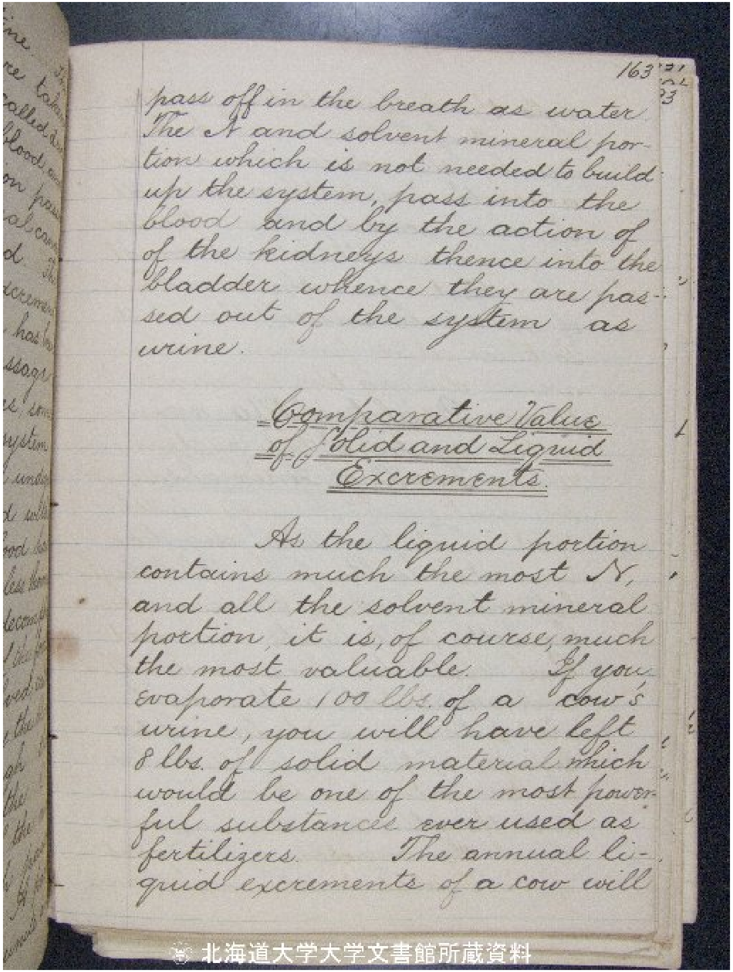

163

pass off in the breath as water
The N and solvent mineral por-
tion which is not needed to build
up the system, pass into the
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Comparative Value
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As the liquid portion
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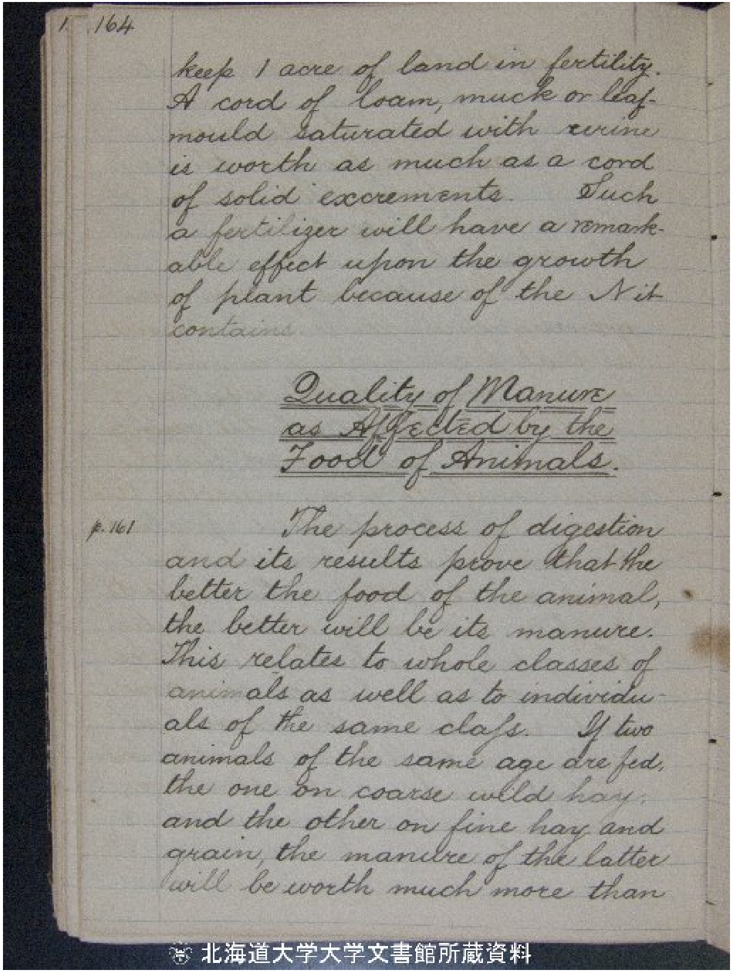
164

keep 1 acre of land in fertility. A cord of loam, muck or leaf-mould saturated with urine is worth as much as a cord of solid excrements. Such a fertilizer will have a remarkable effect upon the growth of plant because of the N it contains.

Quality of Manure as Affected by the Food of Animals.

p.161 The process of digestion and its results prove that the better the food of the animal, the better will be its manure. This relates to whole classes of animals as well as to individuals of the same class. If two animals of the same age are fed, the one on coarse wild hay, and the other on fine hay and grain, the manure of the latter will be worth much more than

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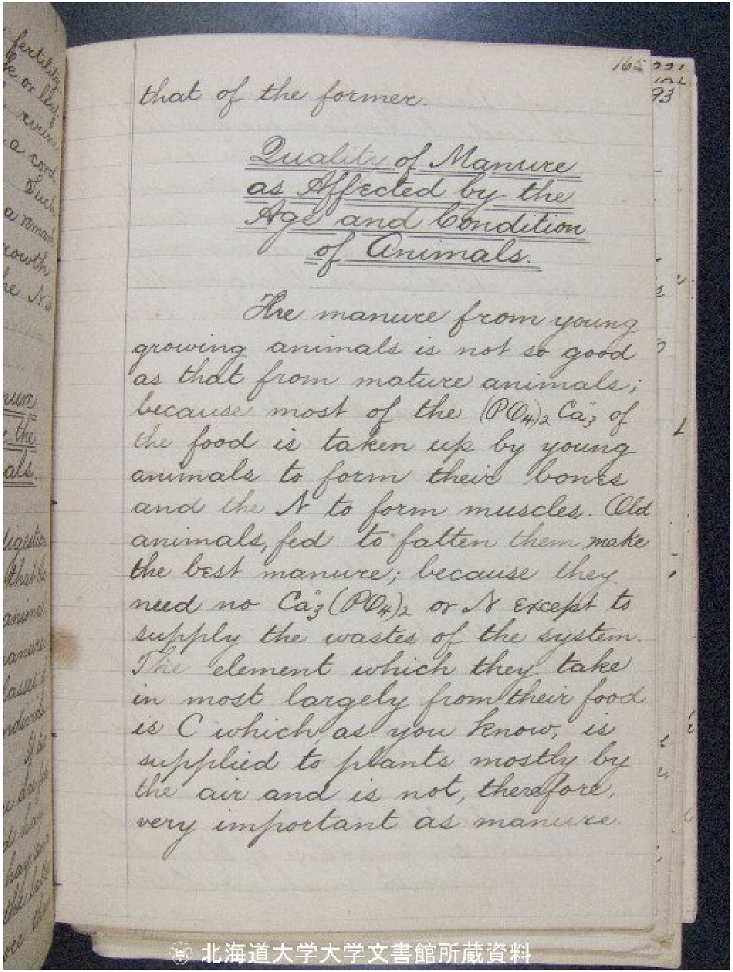
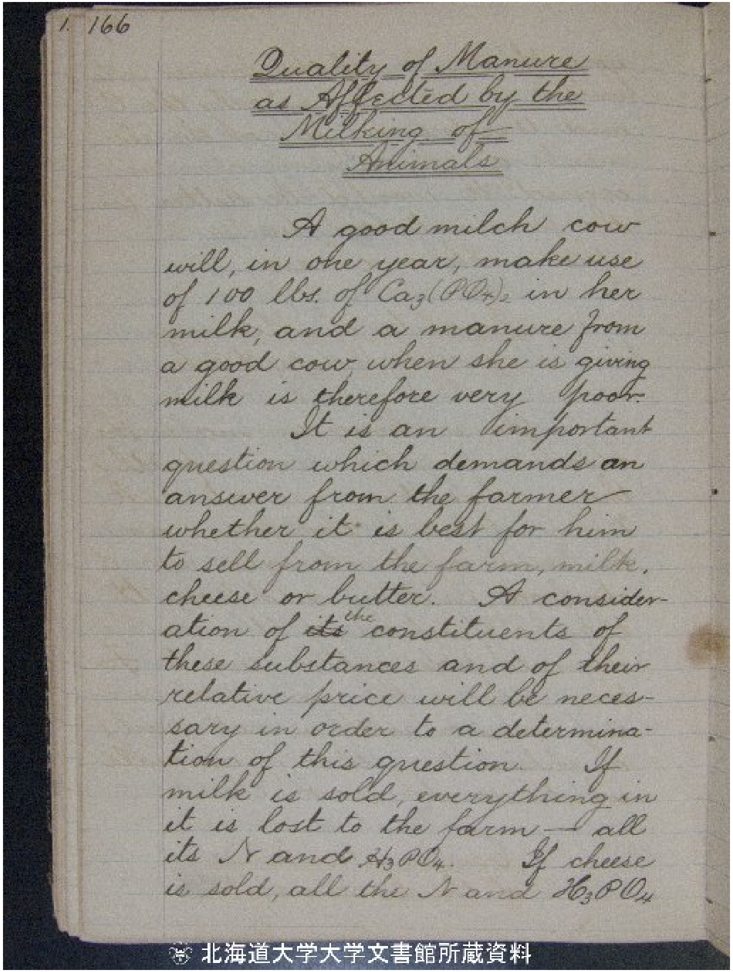


that of the former.

<u>Quality of Manure</u>
<u>as Affected by the</u>
<u>Age and Condition</u>
<u>of Animals.</u>

The manure from young growing animals is not so good as that from mature animals; because most of the $(PO_4)_2Ca''_3$ of the food is taken up by young animals to form their bones and the N to form muscles. Old animals, fed to fatten them, make the best manure; because they need no $Ca''_3(PO_4)_2$ or N except to supply the wastes of the system. The element which they take in most largely from their food in C which, as you know, is supplied to plants mostly by the air and is not, therefore, very important as manure.



1. 166

Quality of Manure as Affected by the Milking of Animals

A good milch cow will, in one year, make use of 100 lbs. of $Ca_3(PO_4)_2$ in her milk, and a manure from a good cow when she is giving milk is therefore very poor.

It is an important question which demands an answer from the farmer whether it is best for him to sell from the farm, milk, cheese or butter. A consideration of ~~its~~ the constituents of these substances and of their relative price will be necessary in order to a determination of this question. If milk is sold, everything in it is lost to the farm — all its N and H_3PO_4. If cheese is sold, all the N and H_3PO_4

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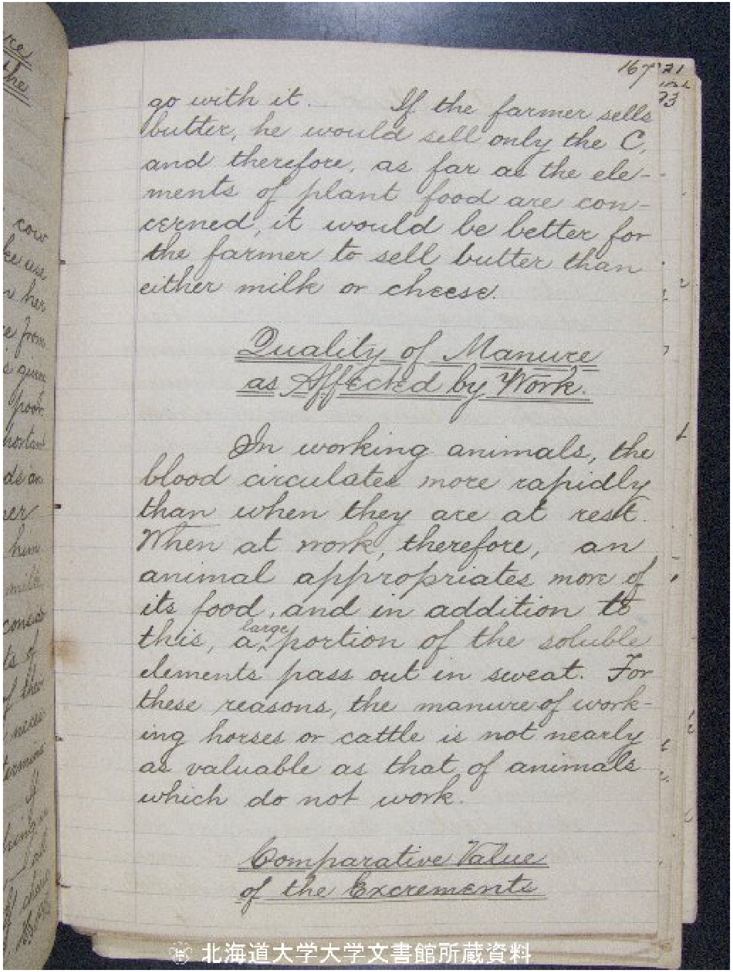
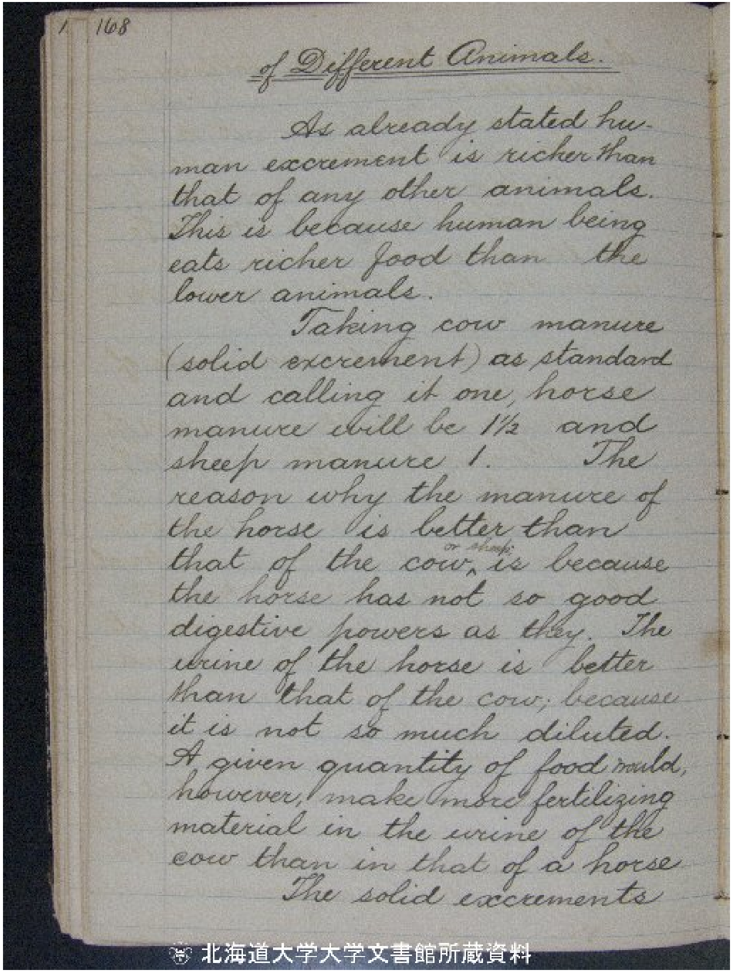


go with it. If the farmer sells butter, he would sell only the C, and therefore, as far as the elements of plant food are concerned, it would be better for the farmer to sell butter than either milk or cheese.

<u>Quality of Manure as Affected by Work.</u>

In working animals, the blood circulates more rapidly than when they are at rest. When at work, therefore, an animal appropriates more of its food, and in addition to this a large portion of the soluble elements pass out in sweat. For these reasons, the manure of working horses or cattle is not nearly as valuable as that of animals which do not work.

<u>Comparative Value of the Excrements</u>


168

of Different Animals.

As already stated human excrement is richer than that of any other animals. This is because human being eats richer food than the lower animals.

Taking cow manure (solid excrement) as standard and calling it one, horse manure will be 1½ and sheep manure 1. The reason why the manure of the horse is better than that of the cow or sheep is because the horse has not so good digestive powers as they. The urine of the horse is better than that of the cow; because it is not so much diluted. A given quantity of food mould, however, make more fertilizing material in the urine of the cow than in that of a horse

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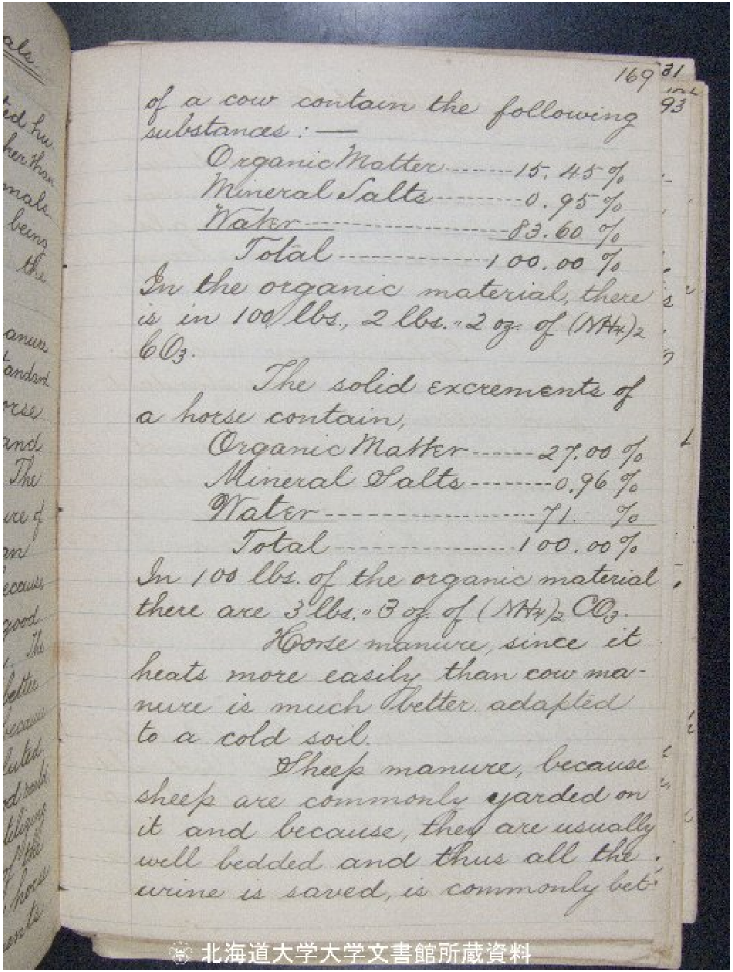


of a cow contain the following substances: ——

Organic Matter …… 15.45%

Mineral Salts …… 0.95%

<u>Water …… 83.60%</u>

Total …… 100.00%

In the organic material, there is in 100 lbs., 2 lbs. 〃 2 oz. of $(NH_4)_2CO_3$.

The solid excrements of a horse contain.

Organic Matter …… 27.00%

Mineral Salts …… 0.96%

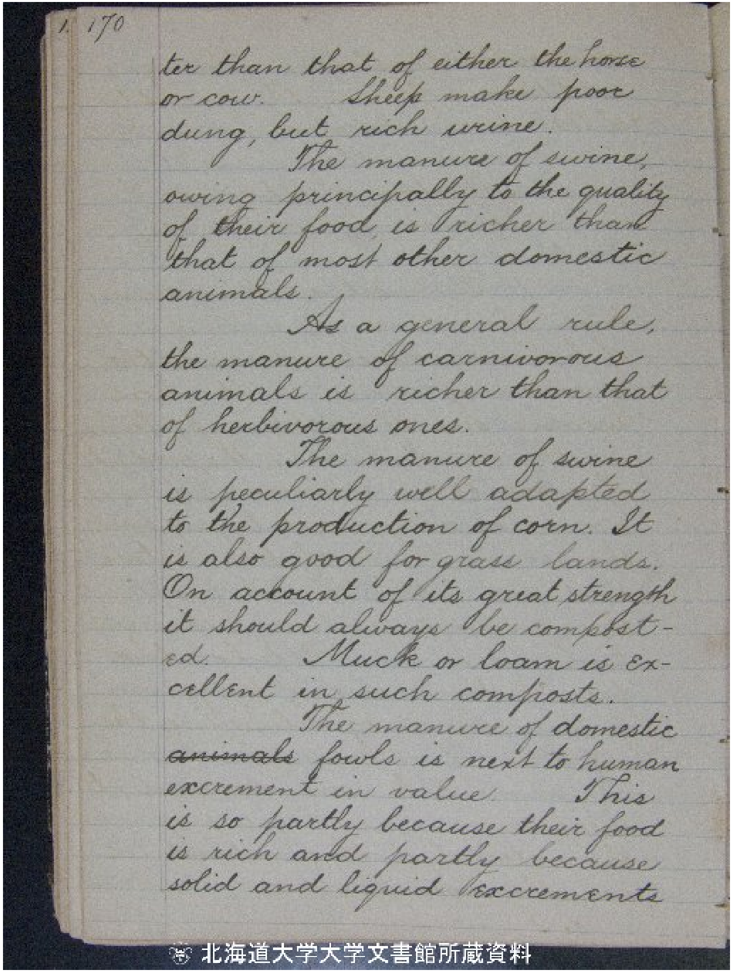
<u>Water …… 71.%</u>

Total …… 100.00%

In 100 lbs. of the organic material there are 3 lbs. 〃 3 oz. of $(NH_4)_2CO_3$.

Hose manure, since it heats more easily than cow manure is much better adapted to a cold soil.

Sheep manure, Because sheep are commonly yarded on it and because, they are usually well bedded and thus all the wine is saved, is commonly better



1. 170

ter than that of either the horse or cow. Sheep make poor dung, but rich urine.

The manure of swine, owing principally to the quality of their food is richer than that of most other domestic animals.

As a general rule, the manure of carnivorous animals is richer than that of herbivorous ones.

The manure of swine is peculiarly well adapted to the production of corn. It is also good for grass lands. On account of its great strength it should always be compost-ed. Muck or loam is ex-cellent in such composts.

The manure of domestic ~~animals~~ fowls is next to human excrement in value. This is so partly because their food is rich and partly because solid and liquid excrements

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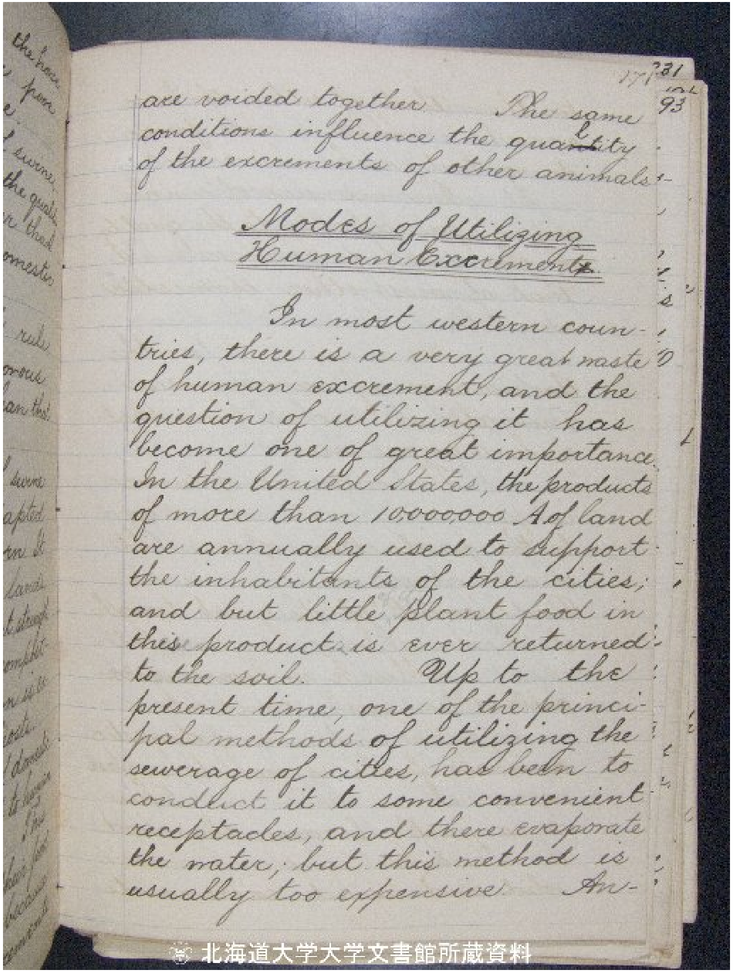

171 231 93

are voided together. The same conditions influence the quantity of the excrements of other animals.

Modes of Utilizing Human Excrements.

In most western countries, there is a very great waste of human excrement, and the question of utilizing it has become one of great importance. In the United States, the products of more than 10,000,000 A of land are annually used to support the inhabitants of the cities; and but little plant food in this product is ever returned to the soil. Up to the present time, one of the principal methods of utilizing the sewerage of cities, has been to conduct it to some convenient receptacles, and there evaporate the water; but this method is usually too expensive. An-

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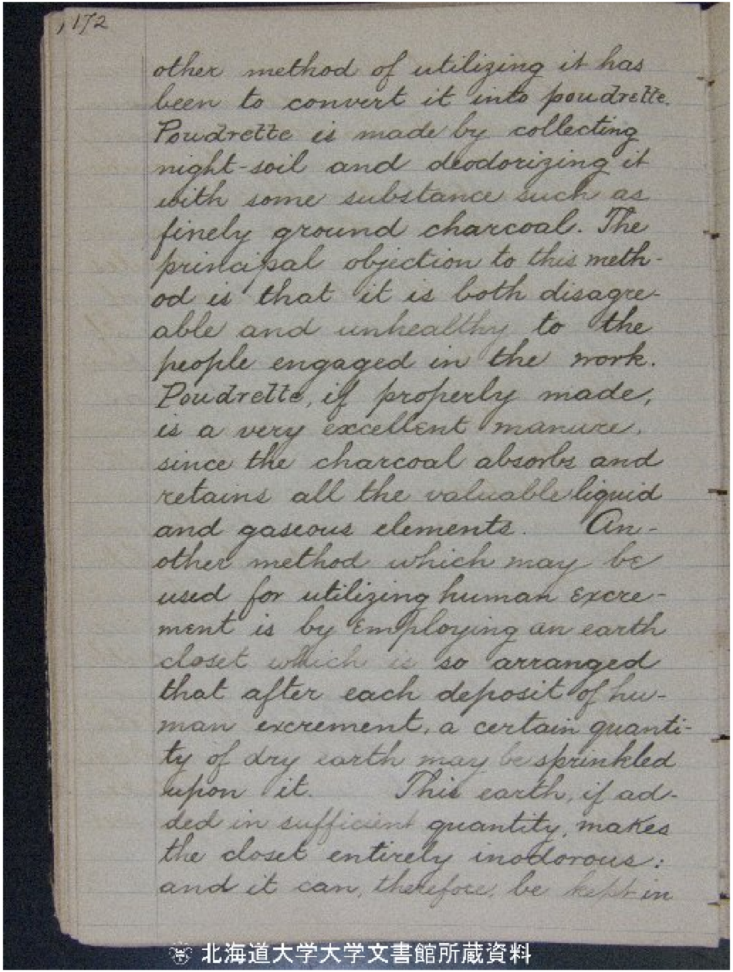

172

other method of utilizing it has been to convert it into poudrette. Poudrette is made by collecting night-soil and deodorizing it with some substance such as finely ground charcoal. The principal objection to this method is that it is both disagreable and unhealthy to the people engaged in the work. Poudrette, if properly made, is a very excellent manure, since the charcoal absorbs and retains all the valuable liquid and gaseous elements. Another method which may be used for utilizing human excrement is by employing an earth closet which is so arranged that after each deposit of human excrement, a certain quantity of dry earth may be sprinkled upon it. This earth, if added in sufficient quantity, makes the closet entirely inodorous: and it can, therefore, be kept in

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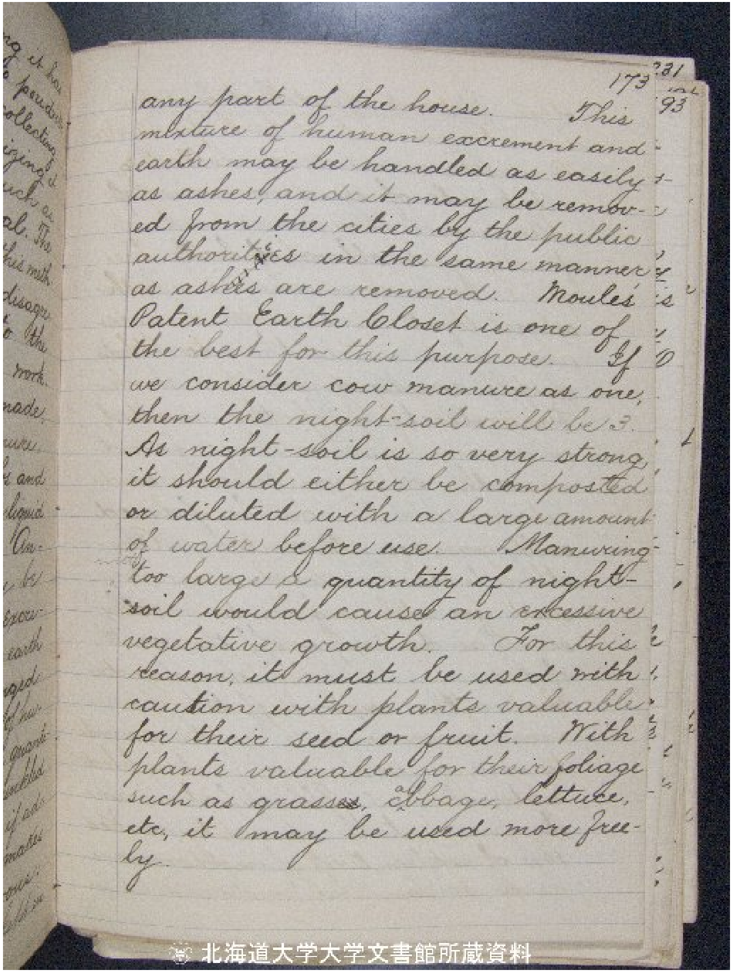
173

any part of the house. This mixture of human excrement and earth may be handled as easily as ashes, and it may be removed from the cities by the public authorities in the same manner as ashes are removed. Moules' Patent Earth Closet is one of the best for this purpose. If we consider cow manure as one, then the night-soil will be 3. As night-soil is so very strong, it should either be composted or diluted with a large amount of water before use. Manuring too large a quantity of night-soil would cause an excessive vegetative growth. For this reason, it must be used with caution with plants valuable for their seed or fruit. With plants valuable for their foliage such as grasses, cabbage, lettuce, etc, it may be used more freely.

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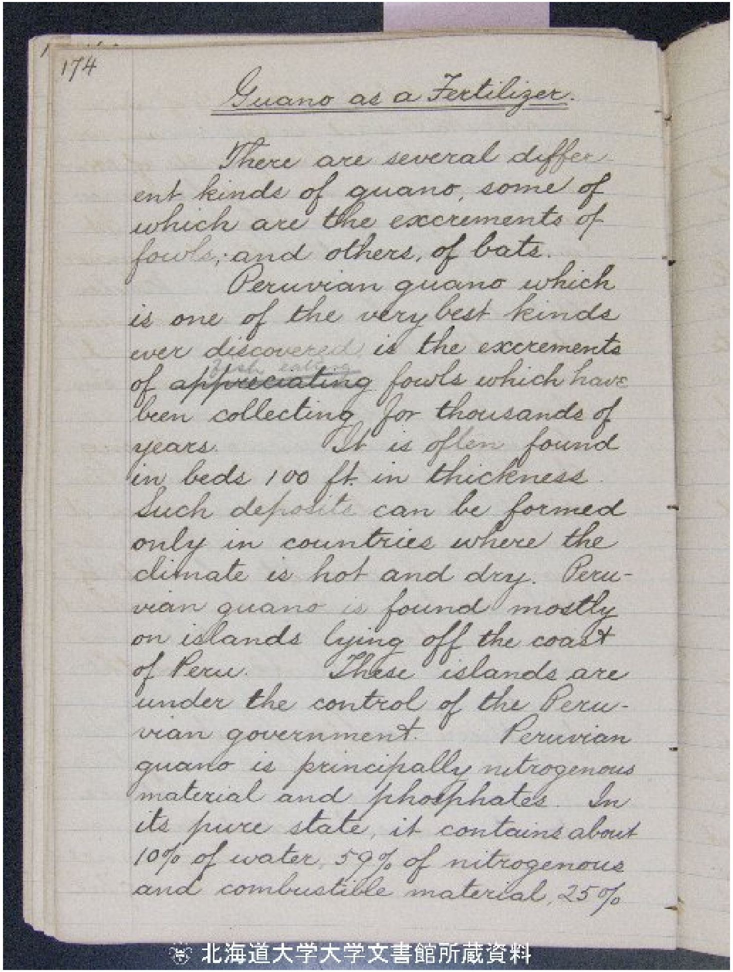

174

Guano as a Fertilizer.

There are several different kinds of guano, some of which are the excrements of fowls; and others, of bats.

Peruvian guano which is one of the very best kinds ever discovered is the excrements of ~~appreciating~~ fish eating fowls which have been collecting for thousands of years. It is often found in beds 100 ft. in thickness. Such deposits can be formed only in countries where the climate is hot and dry. Peruvian guano is found mostly on islands lying off the coast of Peru. These islands are under the control of the Peruvian government. Peruvian guano is principally nitrogenous material and phosphates. In its pure state, it contains about 10% of water, 59% of nitrogenous and combustible material, 25%

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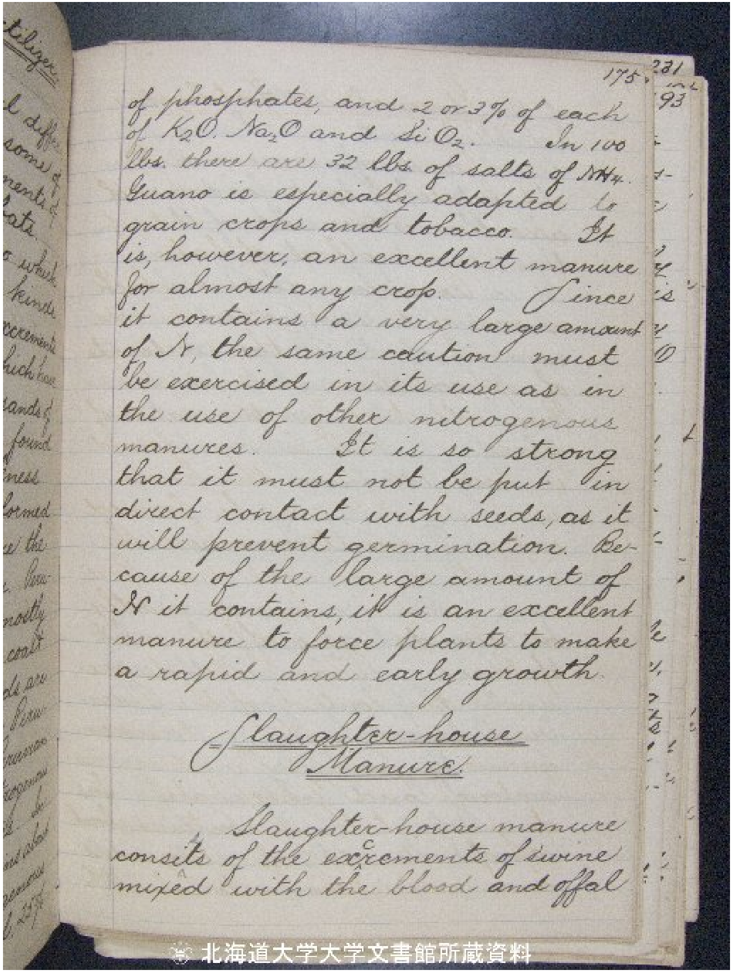
175

of phosphates, and 2 or 3% of each of K_2O, Na_2O and SiO_2. In 100 lbs. there are 32 lbs. of salts of NH_4. Guano is especially adapted to grain crops and tobacco. It is, however, an excellent manure for almost any crop. Since it contains a very large amount of N, the same caution must be exercised in its use as in the use of other nitrogenous manures. It is so strong that it must not be put in direct contact with seeds, as it will prevent germination. Because of the large amount of N it contains, it is an excellent manure to force plants to make a rapid and early growth.

Slaughter-house Manure.

Slaughter-house manure consits of the excrements of swine mixed with the blood and offal

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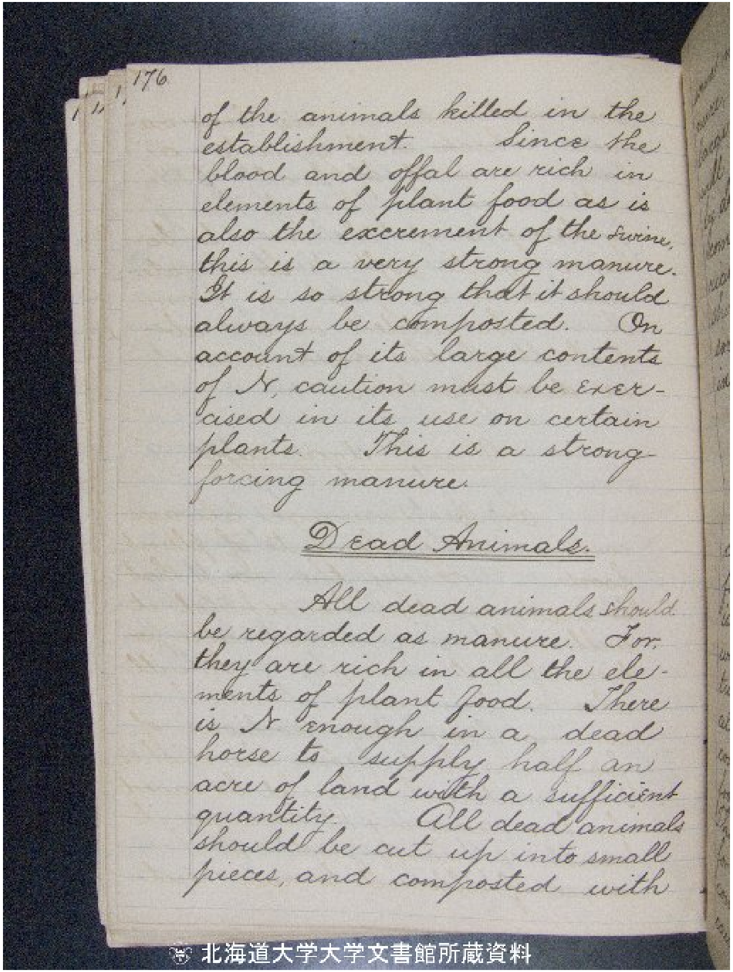
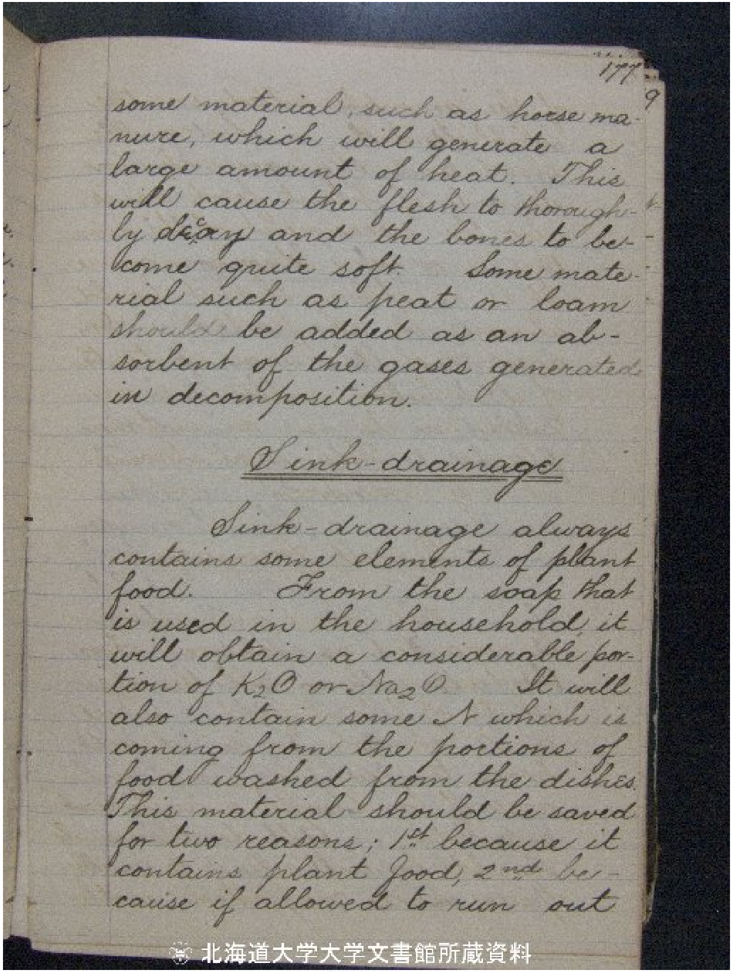


of the animals killed in the establishment. Since the blood and offal are rich in elements of plant food as is also the excrement of the swine, this is a very strong manure. It is so strong that it should always be composted. On account of its large contents of N, caution must be exercised in its use on certain plants. This is a strong forcing manure.

<u>Dead Animals.</u>

All dead animals should be regarded as manure. For, they are rich in all the elements of plant food. There is N enough in a dead horse to supply half an acre of land with a sufficient quantity. All dead animals should be cut up into small pieces, and composted with



177
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some material, such as horse manure, which will generate a large amount of heat. This will cause the flesh to thoroughly decay and the bones to become quite soft. Some material such as peat or loam should be added as an absorbent of the gases generated in decomposition.

Sink-drainage

Sink-drainage always contains some elements of plant food. From the soap that is used in the household, it will obtain a considerable portion of K_2O or Na_2O. It will also contain some N which is coming from the portions of food washed from the dishes. This material should be saved for two reasons; 1st because it contains plant food, 2nd because if allowed to run out

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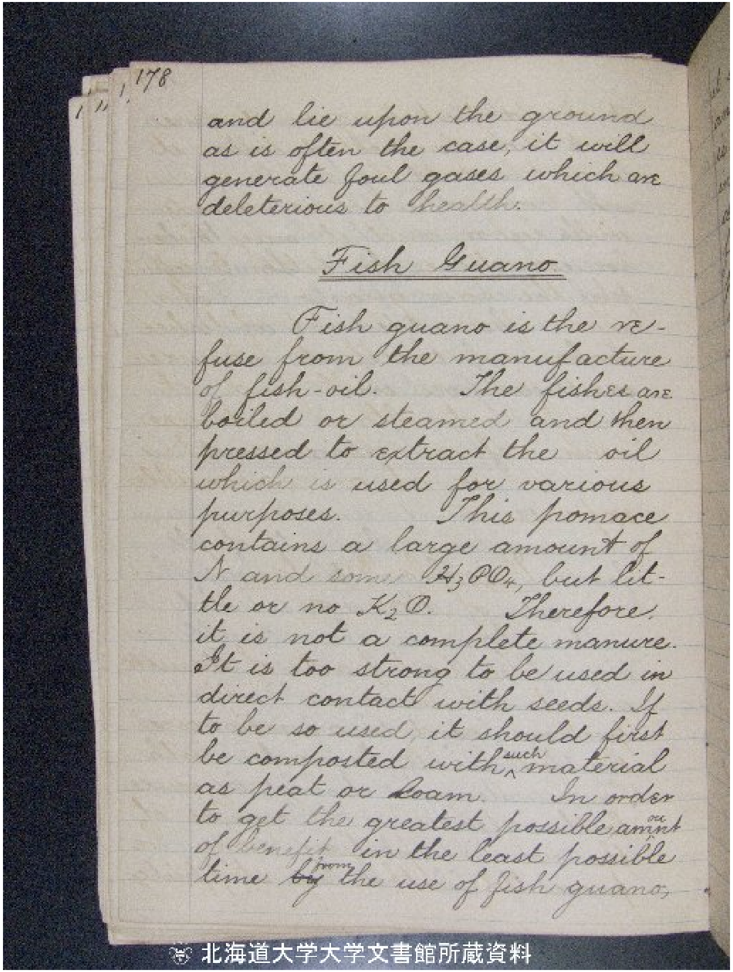

178

and lie upon the ground as is often the case, it will generate foul gases which are deleterious to health.

Fish Guano

Fish guano is the refuse from the manufacture of fish-oil. The fishes are boiled or steamed and then pressed to extract the oil which is used for various purposes. This pomace contains a large amount of N and some H_3PO_4, but little or no K_2O. Therefore it is not a complete manure. It is too strong to be used in direct contact with seeds. If to be so used, it should first be composted with such material as peat or loam. In order to get the greatest possible amount of benefit in the least possible time ~~by~~ from the use of fish guano,

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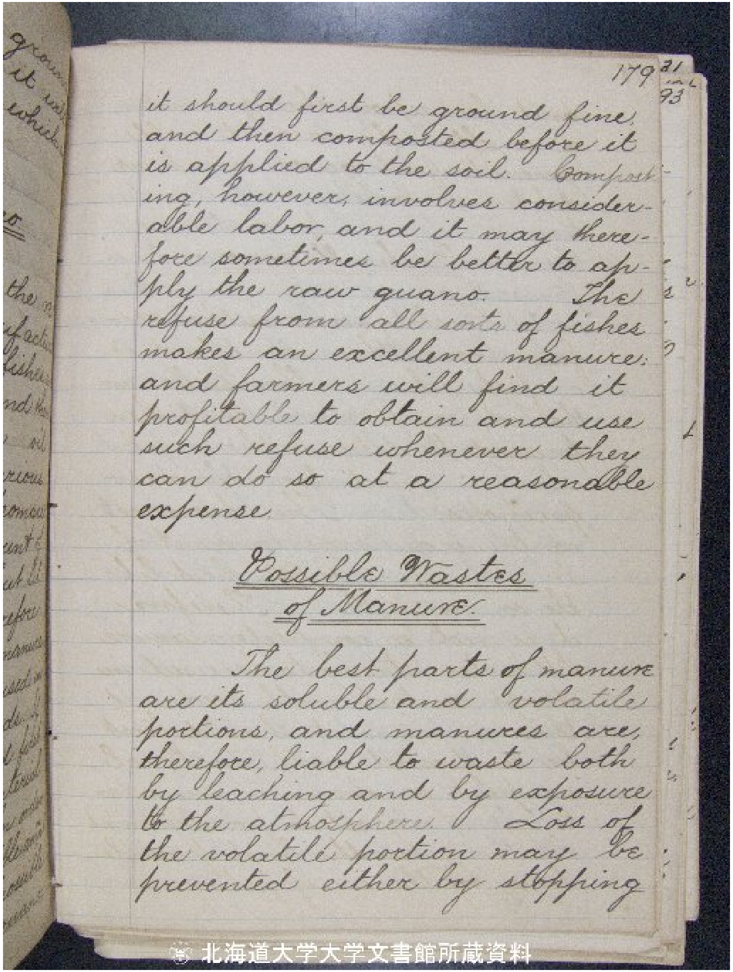
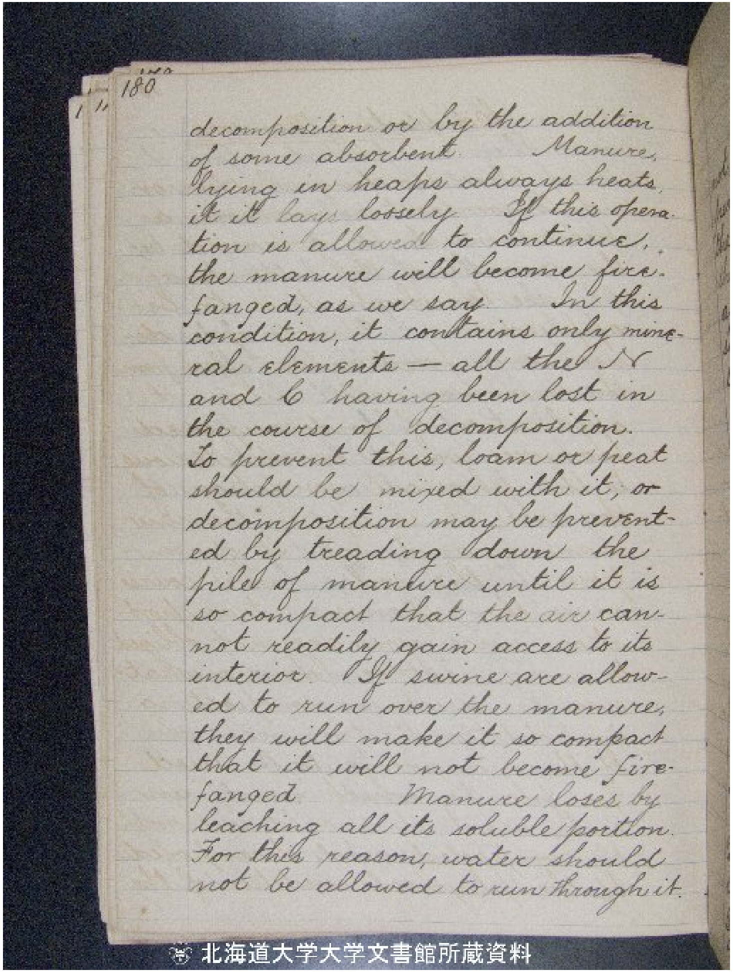


it should first be ground fine and then composted before it is applied to the soil. Composting, however, involves considerable labor, and it may therefore sometimes be better to apply the raw guano. The refuse from all sots of fishes makes an excellent manure: and farmers will find it profitable to obtain and use such refuse whenever they can do so at a reasonable expense.

<u>Possible Wastes</u>

<u>of Manure.</u>

The best parts of manure are its soluble and volatile portions, and manures are therefore, liable to waste both by leaching and by exposure to the atmosphere. Loss of the volatile portion may be prevented either by stopping


180

decomposition or by the addition of some absorbent. Manure, lying in heaps always heats, it it lays loosely. If this operation is allowed to continue, the manure will become fire-fanged, as we say. In this condition, it contains only mineral elements — all the N and C having been lost in the course of decomposition. To prevent this, loam or peat should be mixed with it, or decomposition may be prevented by treading down the pile of manure until it is so compact that the air cannot readily gain access to its interior. If swine are allowed to run over the manure, they will make it so compact that it will not become fire-fanged. Manure loses by leaching all its soluble portion. For this reason, water should not be allowed to run through it.

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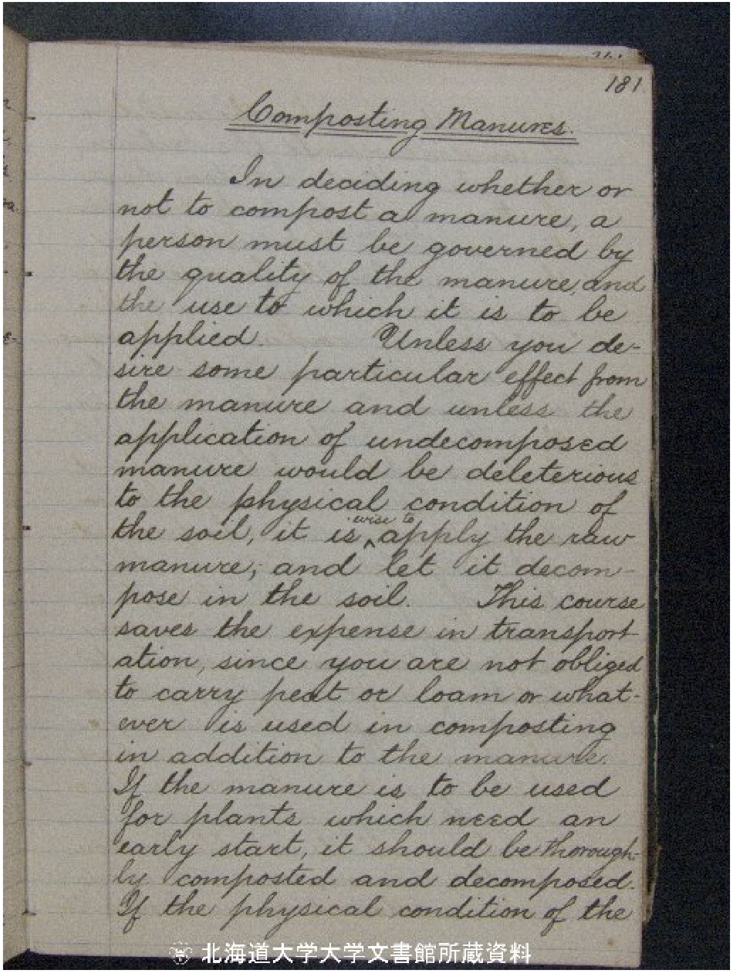

Composting Manures.

In deciding whether or not to compost a manure, a person must be governed by the quality of the manure, and the use to which it is to be applied. Unless you desire some particular effect from the manure and unless the application of undecomposed manure would be deleterious to the physical condition of the soil, it is wise to apply the raw manure; and let it decompose in the soil. This course saves the expense in transportation, since you are not obliged to carry peat or loam or whatever is used in composting in addition to the manure. If the manure is to be used for plants which need an early start, it should be thoroughly composted and decomposed. If the physical condition of the

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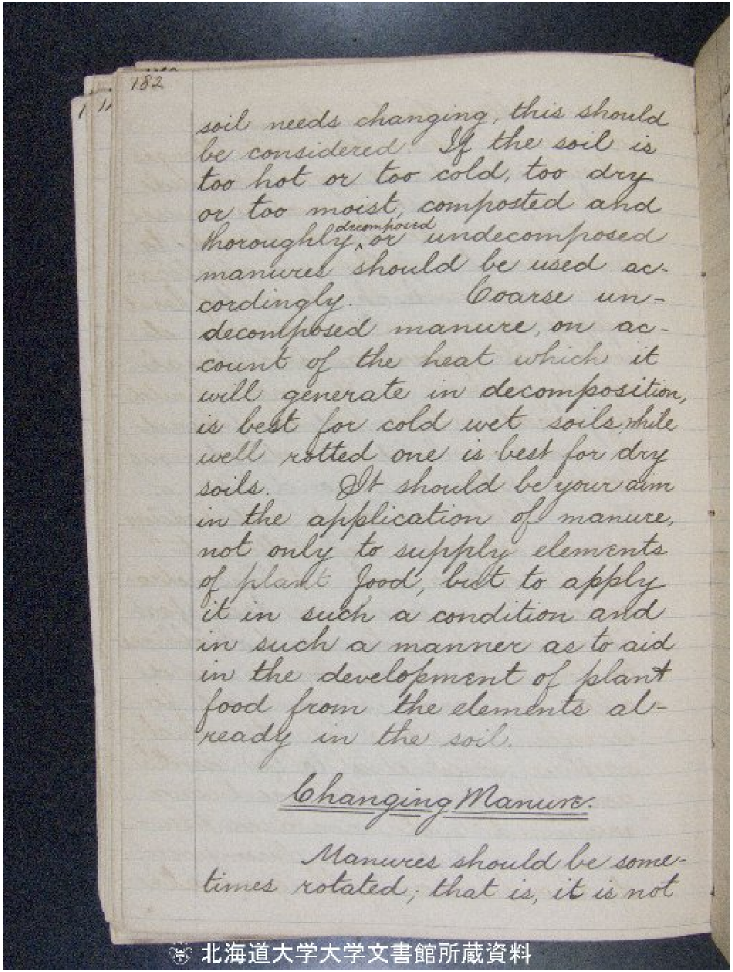
182

soil needs changing, this should be considered. If the soil is too hot or too cold, too dry or too moist, composted and thoroughly decomposed or undecomposed manures should be used accordingly. Coarse undecomposed manure, on account of the heat which it will generate in decomposition, is best for cold wet soils, while well rotted one is best for dry soils. It should be your aim in the application of manure, not only to supply elements of plant food, but to apply it in such a condition and in such a manner as to aid in the development of plant food from the elements already in the soil.

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Manures should be sometimes rotated; that is, it is not

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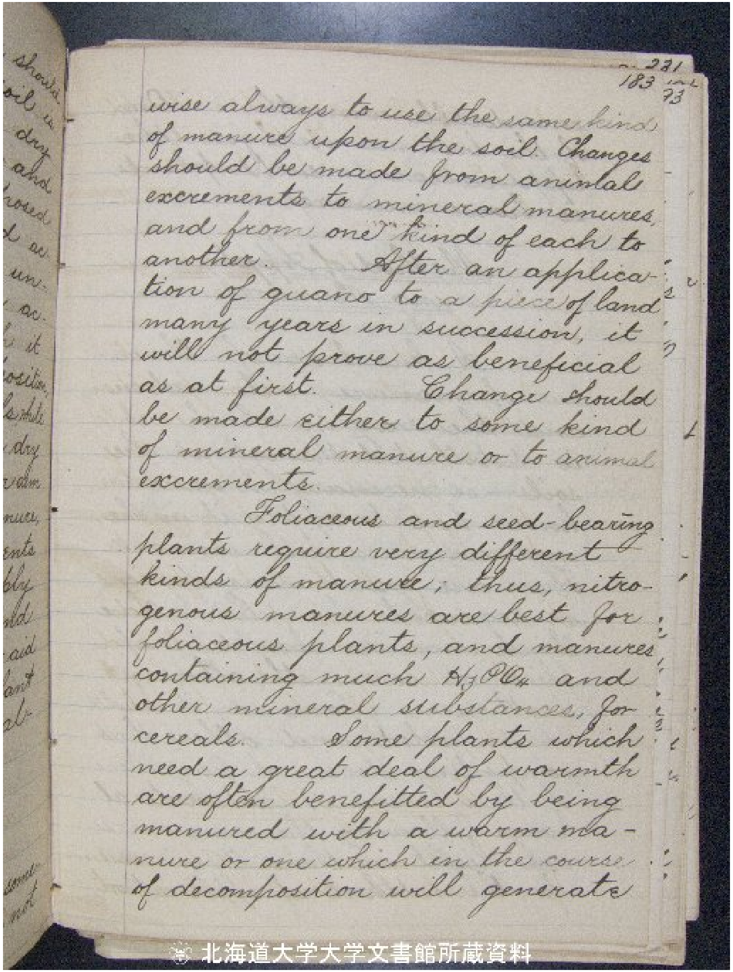

wise always to use the same kind of manure upon the soil. Changes should be made from animal excrements to mineral manures, and from one kind of each to another. After an application of guano to a piece of land many years in succession, it will not prove as beneficial as at first. Change should be made either to some kind of mineral manure or to animal excrements.

Foliaceous and seed-bearing plants require very different kinds of manure; thus, nitrogenous manures are best for foliaceous plants, and manures containing much H_3PO_4 and other mineral substances, for cereals. Some plants which need a great deal of warmth are often benefitted by being manured with a warm manure or one which in the course of decomposition will generate

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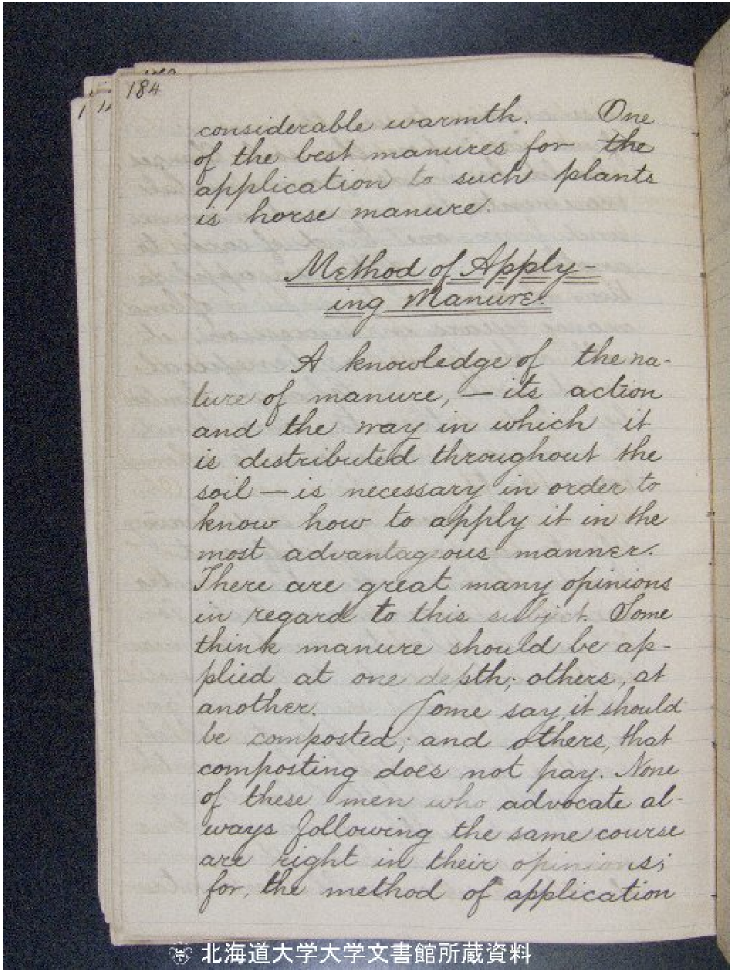

184

considerable warmth. One of the best manures for the application to such plants is horse manure.

Method of Apply-ing Manure.

A knowledge of the nature of manure, — its action and the way in which it is distributed throughout the soil — is necessary in order to know how to apply it in the most advantageous manner. There are great many opinions in regard to this subject. Some think manure should be applied at one depth; others, at another. Some say it should be composted; and others, that composting does not pay. None of these men who advocate always following the same course are right in their opinions; for, the method of application

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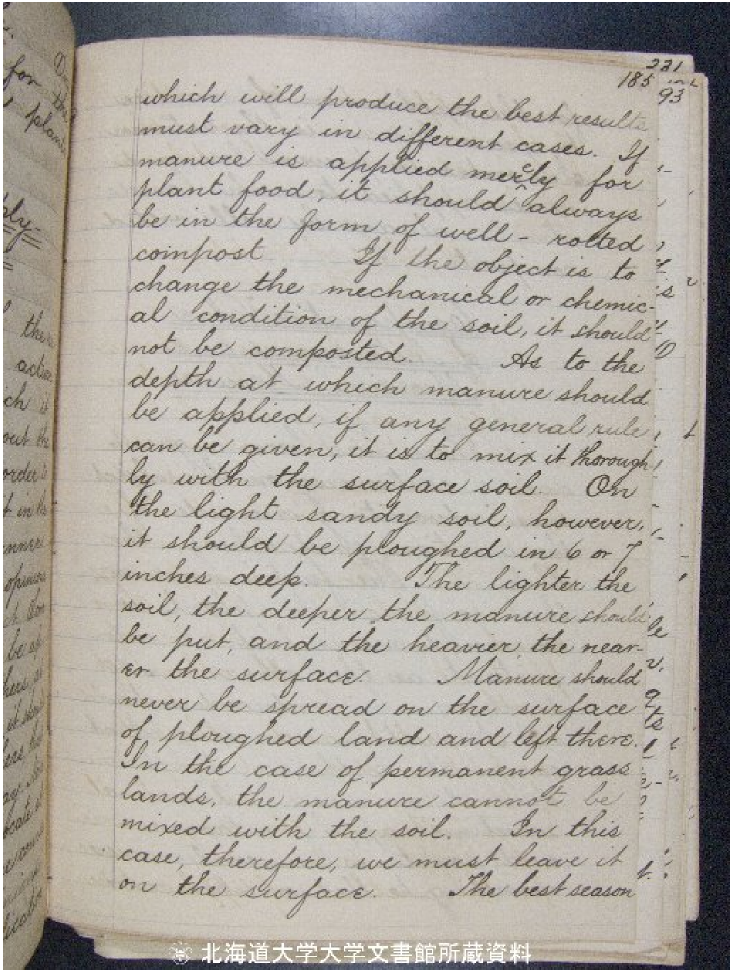

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which will produce the best results
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manure is applied merely for
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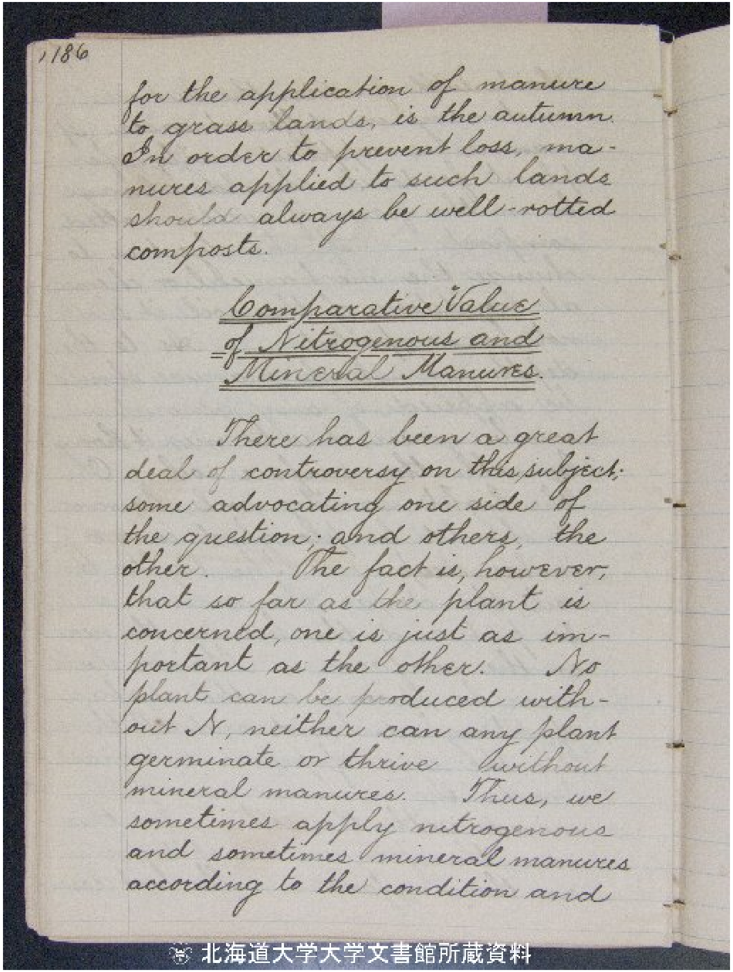

186

for the application of manure to grass lands, is the autumn. In order to prevent loss, manures applied to such lands should always be well-rotted composts.

Comparative Value of Nitrogenous and Mineral Manures.

There has been a great deal of controversy on this subject; some advocating one side of the question; and others, the other. The fact is, however, that so far as the plant is concerned, one is just as important as the other. No plant can be produced without N, neither can any plant germinate or thrive without mineral manures. Thus, we sometimes apply nitrogenous and sometimes mineral manures according to the condition and

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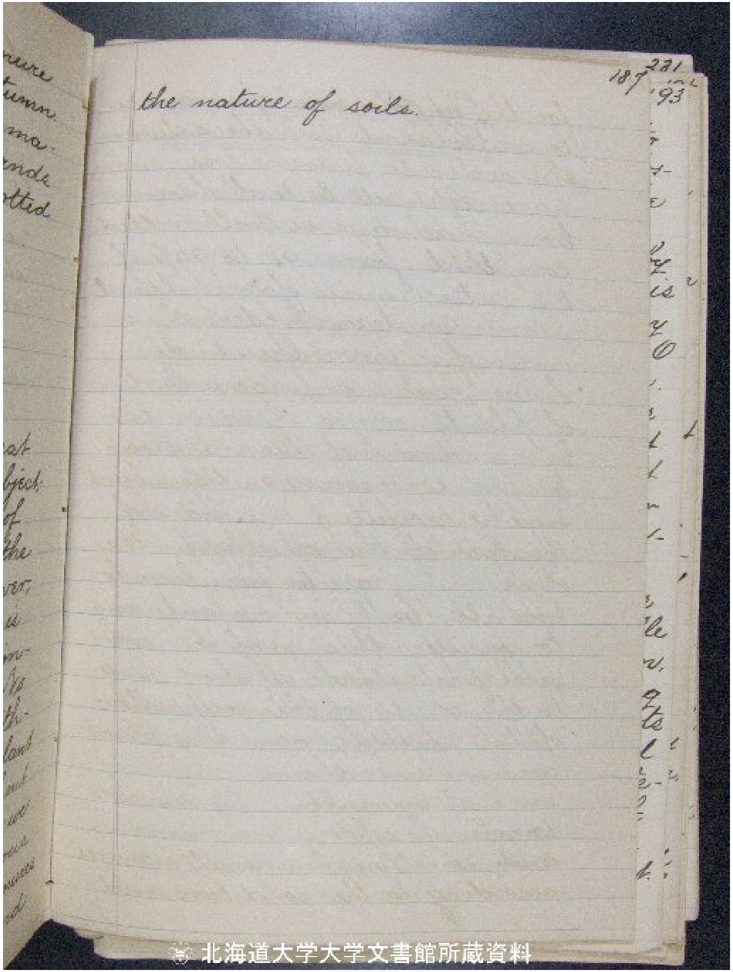

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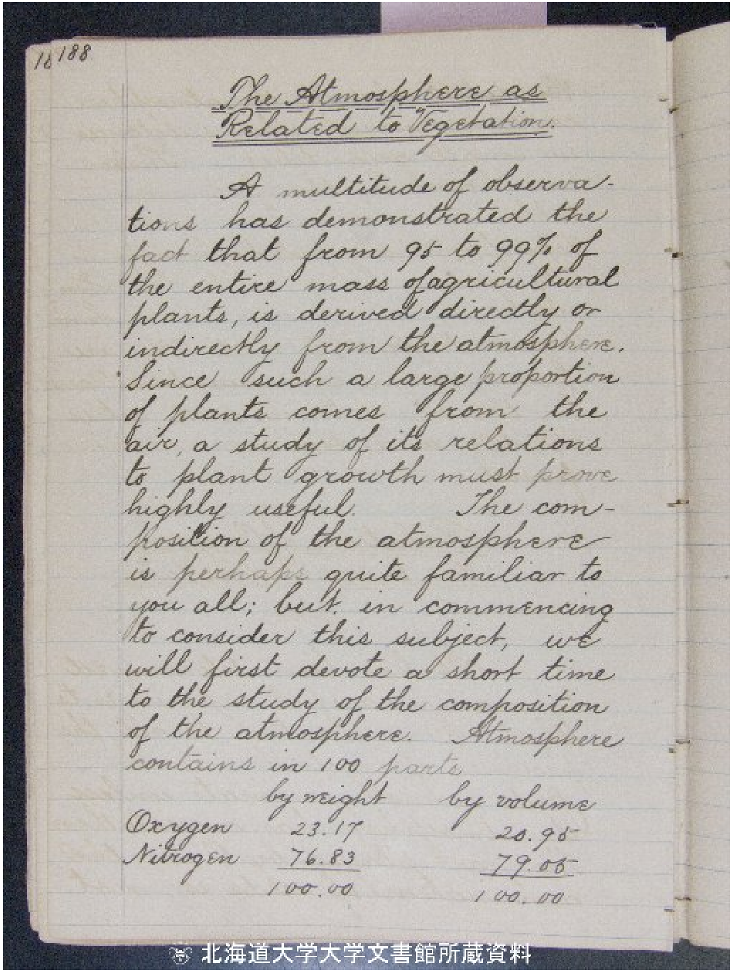
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The Atmosphere as
Related to Vegetation.

A multitude of observations has demonstrated the fact that from 95 to 99% of the entire mass of agricultural plants, is derived directly or indirectly from the atmosphere. Since such a large proportion of plants comes from the air, a study of its relations to plant growth must prove highly useful. The composition of the atmosphere is perhaps quite familiar to you all; but in commencing to consider this subject, we will first devote a short time to the study of the composition of the atmosphere. Atmosphere contains in 100 parts

	by weight	by volume
Oxygen	23.17	20.95
Nitrogen	76.83	79.05
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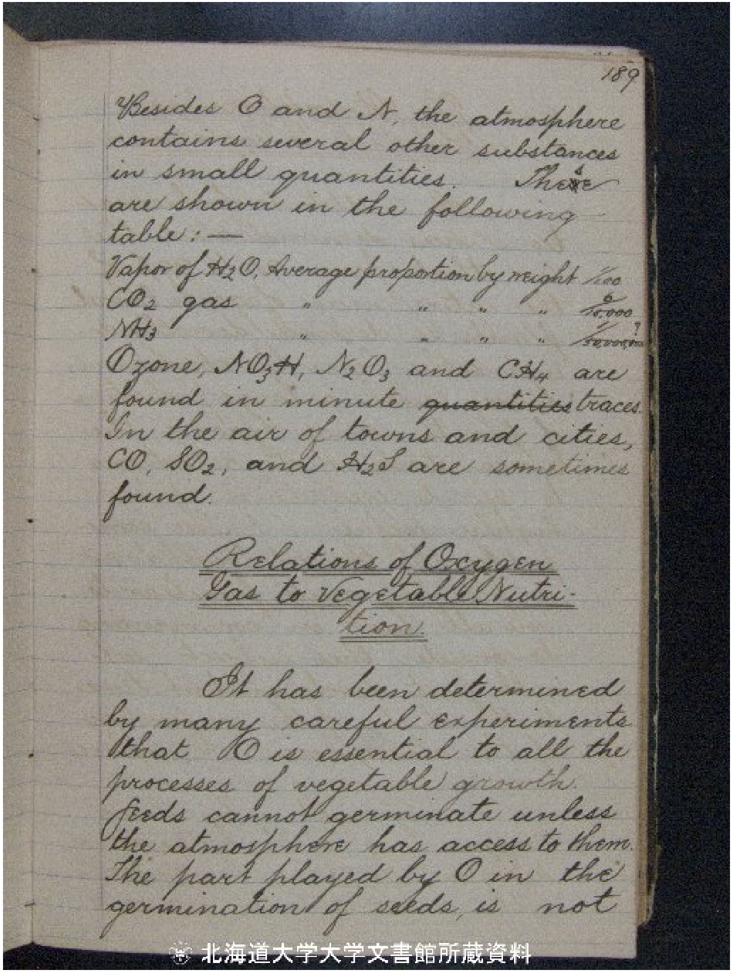

Besides O and N, the atmosphere contains several other substances in small quantities. These are shown in the following table:—

Vapor of H_2O,	Average proportion by weight	1/100
CO_2 gas	" " "	6/10,000
NH_3	" " " "	1/50,000,000 ?

Ozone, NO_3H, N_2O_3 and CH_4 are found in minute ~~quantities~~ traces. In the air of towns and cities, CO, SO_2, and H_2S are sometimes found.

Relations of Oxygen Gas to Vegetable Nutrition.

It has been determined by many careful experiments that O is essential to all the processes of vegetable growth. Seeds cannot germinate unless the atmosphere has access to them. The part played by O in the germination of seeds, is not

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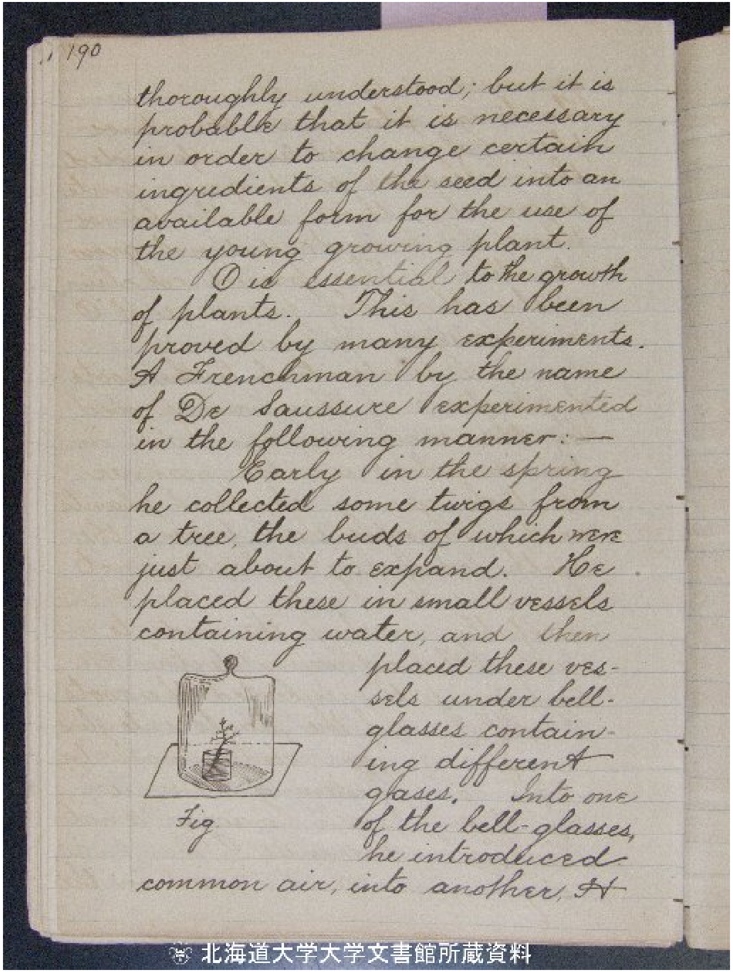

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Early in the spring he collected some twigs from a tree, the buds of which were just about to expand. He placed these in small vessels containing water, and then placed these vessels under bell-glasses containing different glases. Into one of the bell-glasses, he introduced common air, into another, H

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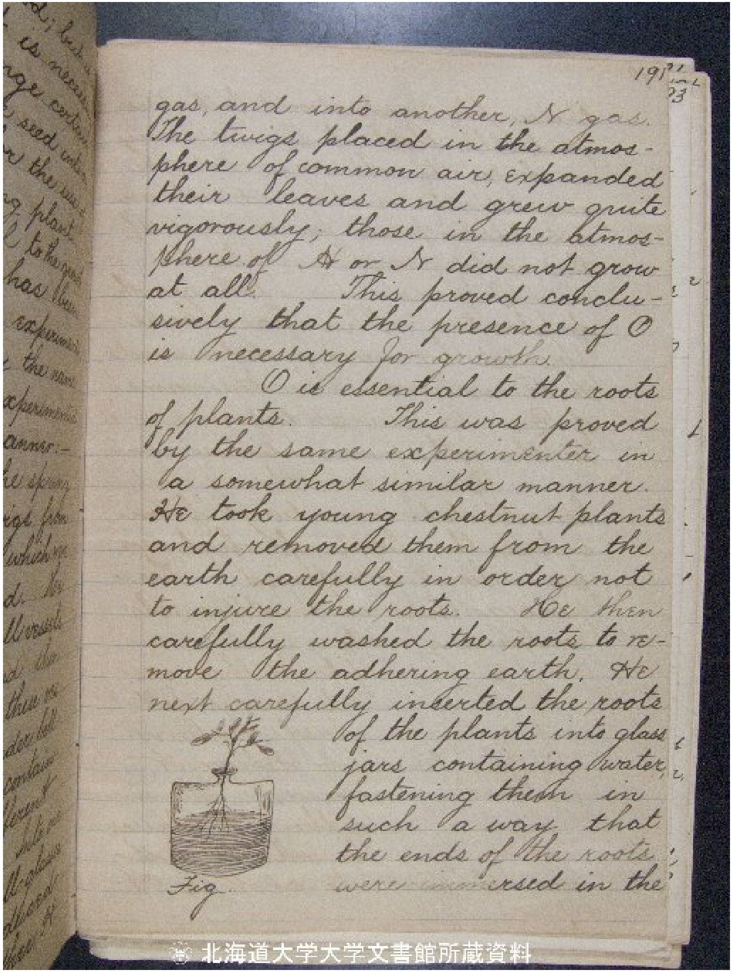
191

gas, and into another, N gas. The twigs placed in the atmosphere of common air, expanded their leaves and grew quite vigorously; those in the atmosphere of H or N did not grow at all. This proved conclusively that the presence of O is necessary for growth.

O is essential to the roots of plants. This was proved by the same experimenter in a somewhat similar manner. He took young chestnut plants and removed them from the earth carefully in order not to injure the roots. He then carefully washed the roots to remove the adhering earth. He next carefully inserted the roots of the plants into glass jars containing water, fastening them in such a way that the ends of the roots were immersed in the

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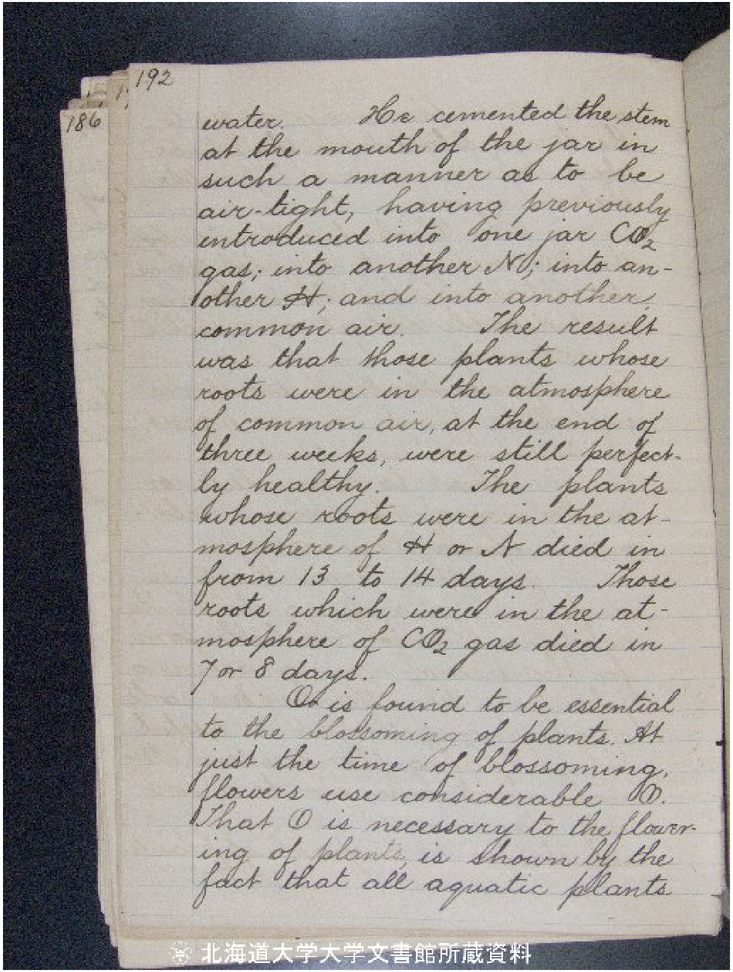
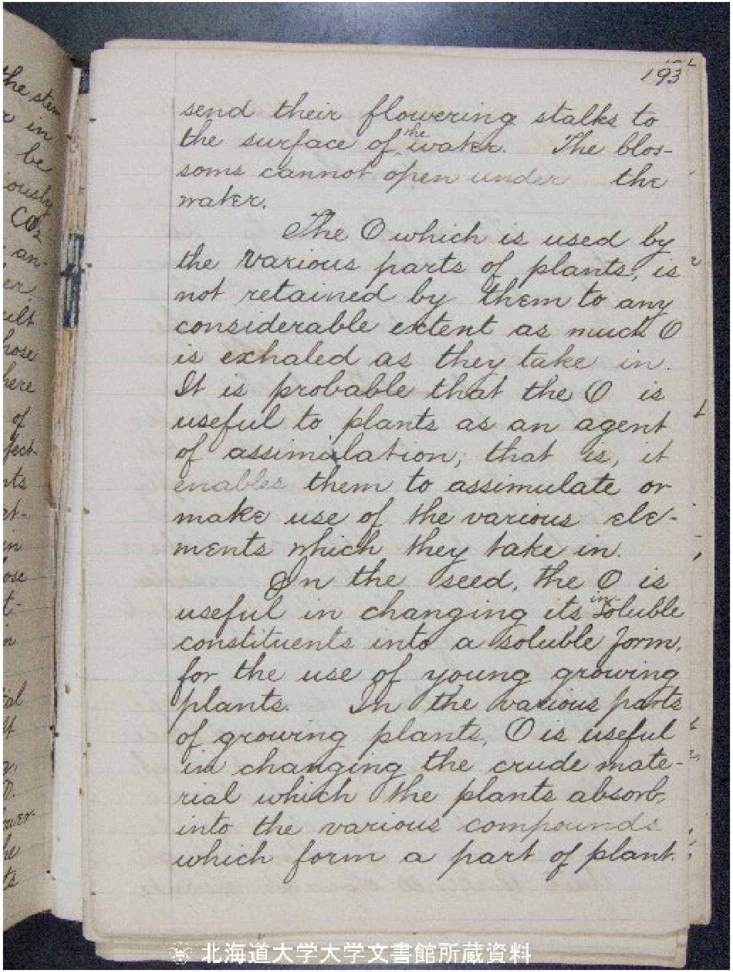


water. He cemented the stem at the mouth of the jar in such a manner as to be air-tight, having previously introduced into one jar CO_2 gas; into another N; into another H; and into another common air. The result was that those plants whose roots were in the atmosphere of common air, at the end of three weeks, were still perfectly healthy. The plants whose roots were in the atmosphere of H or N died in from 13 to 14 days. Those roots which were in the atmosphere of Co_2 gas died in 7 or 8 days.

O is found to be essential to the blossoming of plants. At just the time of blossoming, plowers use considerable O. that O is necessary to the flowering of plants is shown by the fact that all aquatic plants



193

send their flowering stalks to the surface of the water. The blossoms cannot open under the water.

The O which is used by the various parts of plants, is not retained by them to any considerable extent as much O is exhaled as they take in. It is probable that the O is useful to plants as an agent of assimilation; that is, it enables them to assimulate or make use of the various elements which they take in.

In the seed, the O is useful in changing its insoluble constituents into a soluble form, for the use of young growing plants. In the various parts of growing plants, O is useful in changing the crude material which the plants absorb, into the various compounds which form a part of plant.

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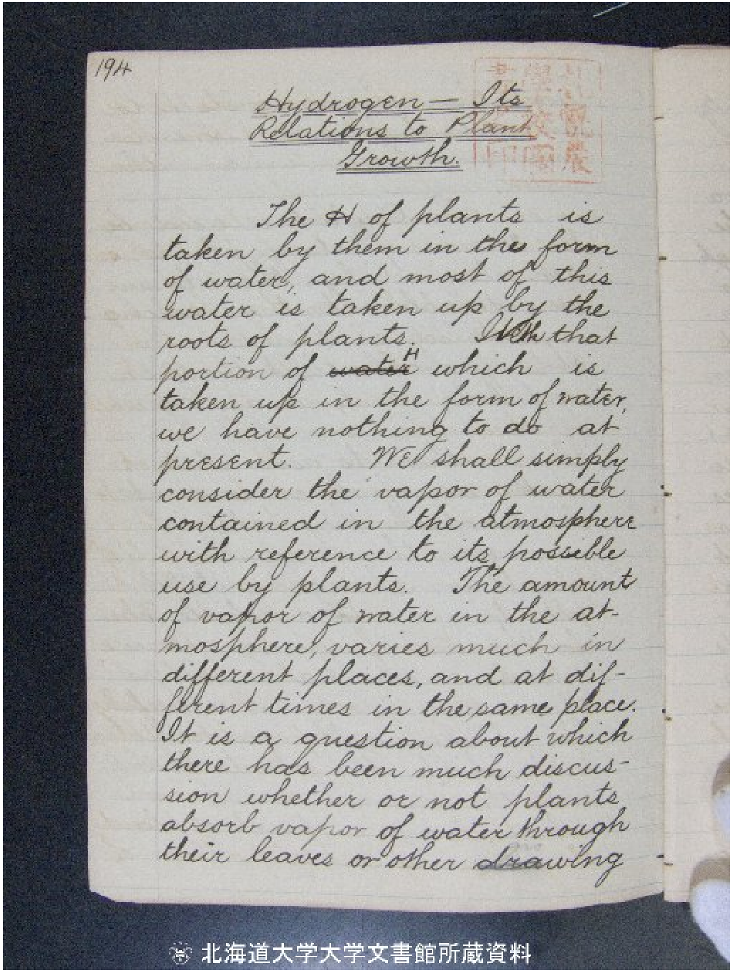
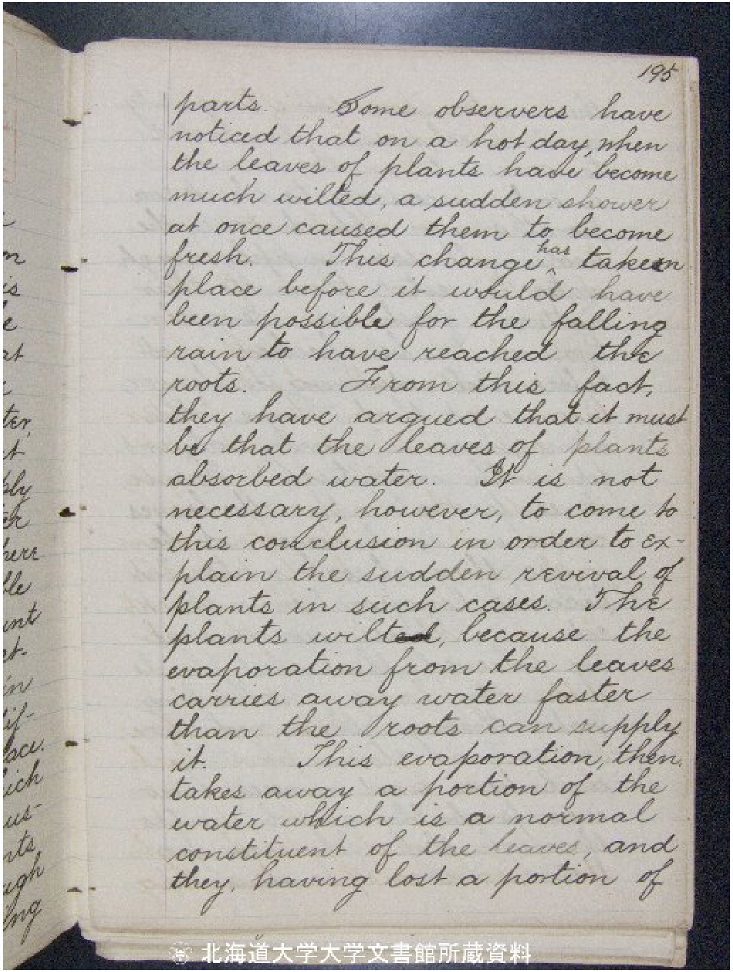


Hydrogen-Its Relations to Plant Growth.

The H of plants is taken by them in the form of water, and most of this water is taken up by the roots of plants. With that portion of H which is taken up in the form of water, we have nothing to do at present. We shall simply consider the vapor of water contained in the atmosphere with reference to its possible use by plants. The amount of vapor of mater in the atmosphere, varies much in different places, and at different times in the same place. It is a question about which there has been much discussion whether or not plants absorb vapor of water through their leaves or other drawing



195

parts. Some observers have noticed that on a hot day, when the leaves of plants have become much wilted, a sudden shower at once caused them to become fresh. This change has taken place before it would have been possible for the falling rain to have reached the roots. From this fact, they have argued that it must be that the leaves of plants absorbed water. It is not necessary, however, to come to this conclusion in order to explain the sudden revival of plants in such cases. The plants wilt~~ed~~, because the evaporation from the leaves carries away water faster than the roots can supply it. This evaporation, then, takes away a portion of the water which is a normal constituent of the leaves, and they, having lost a portion of

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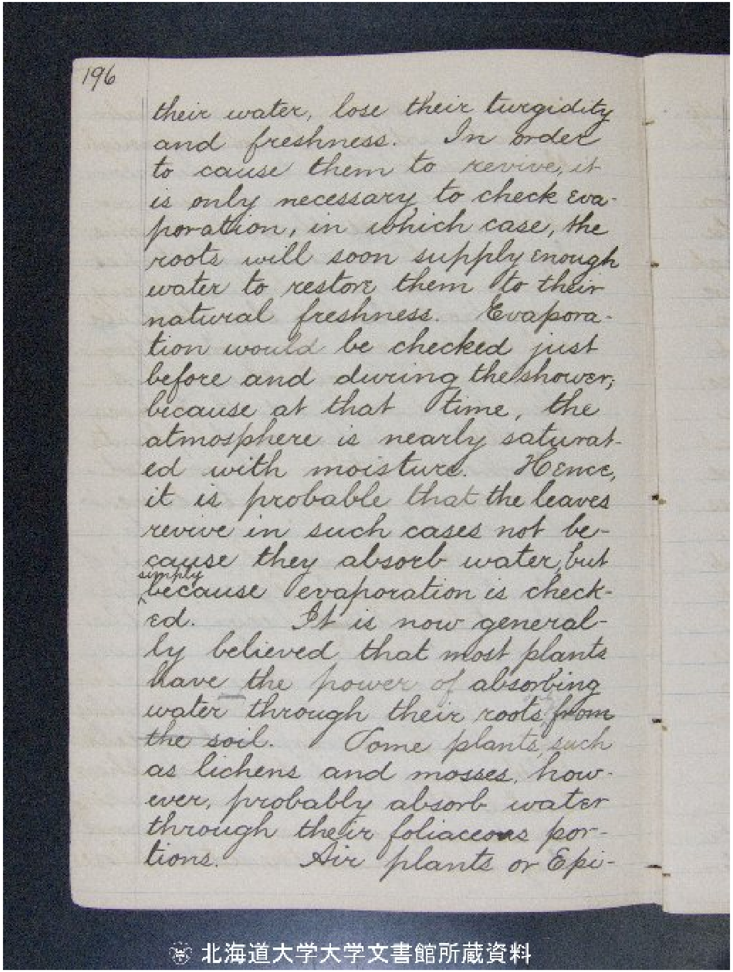

196

their water, lose their turgidity and freshness. In order to cause them to revive, it is only necessary to check evaporation, in which case, the roots will soon supply enough water to restore them to their natural freshness. Evaporation would be checked just before and during the shower; because at that time, the atmosphere is nearly saturated with moisture. Hence, it is probable that the leaves revive in such cases not because they absorb water, but simply because evaporation is checked. It is now generally believed that most plants have the power of absorbing water through their roots from the soil. Some plants, such as lichens and mosses, however, probably absorb water through their foliaceous portions. Air plants or Epi-

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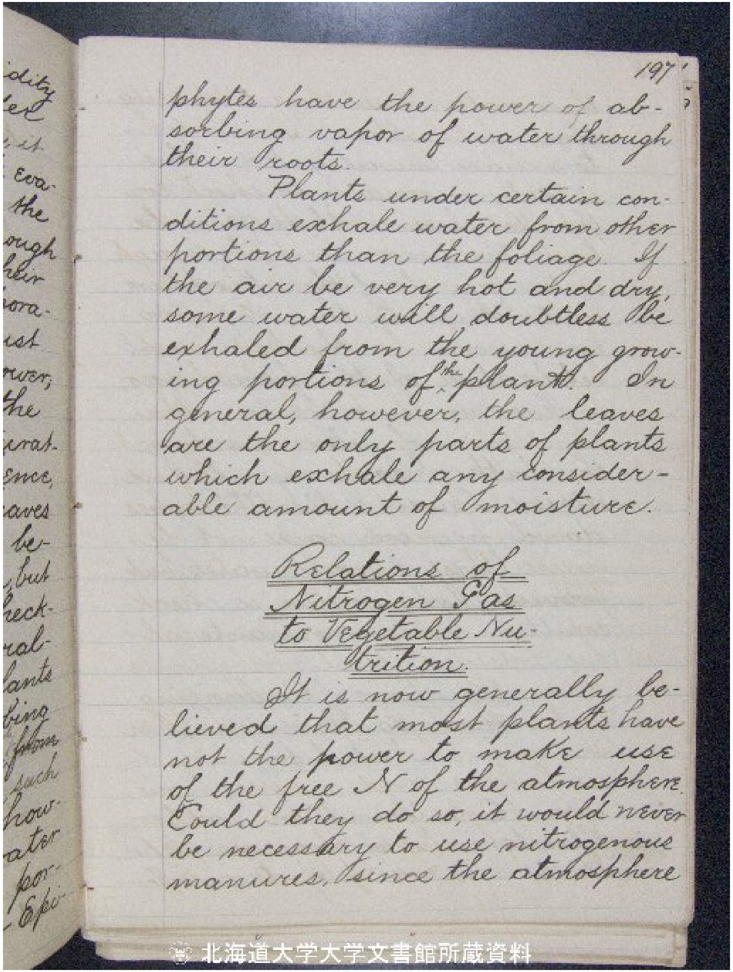
197

phytes have the power of absorbing vapor of water through their roots.

Plants under certain conditions exhale water from other portions than the foliage. If the air be very hot and dry, some water will doubtless be exhaled from the young growing portions of the plant. In general, however, the leaves are the only parts of plants which exhale any considerable amount of moisture.

Relations of Nitrogen Gas to Vegetable Nutrition.

It is now generally believed that most plants have not the power to make use of the free N of the atmosphere. Could they do so, it would never be necessary to use nitrogenous manures, since the atmosphere

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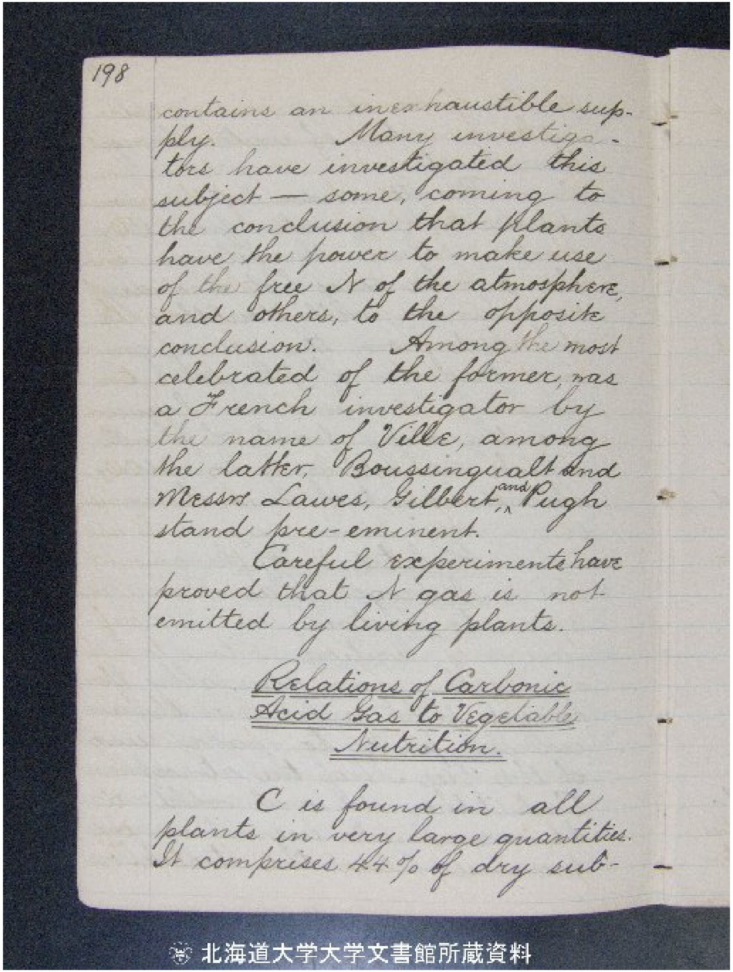
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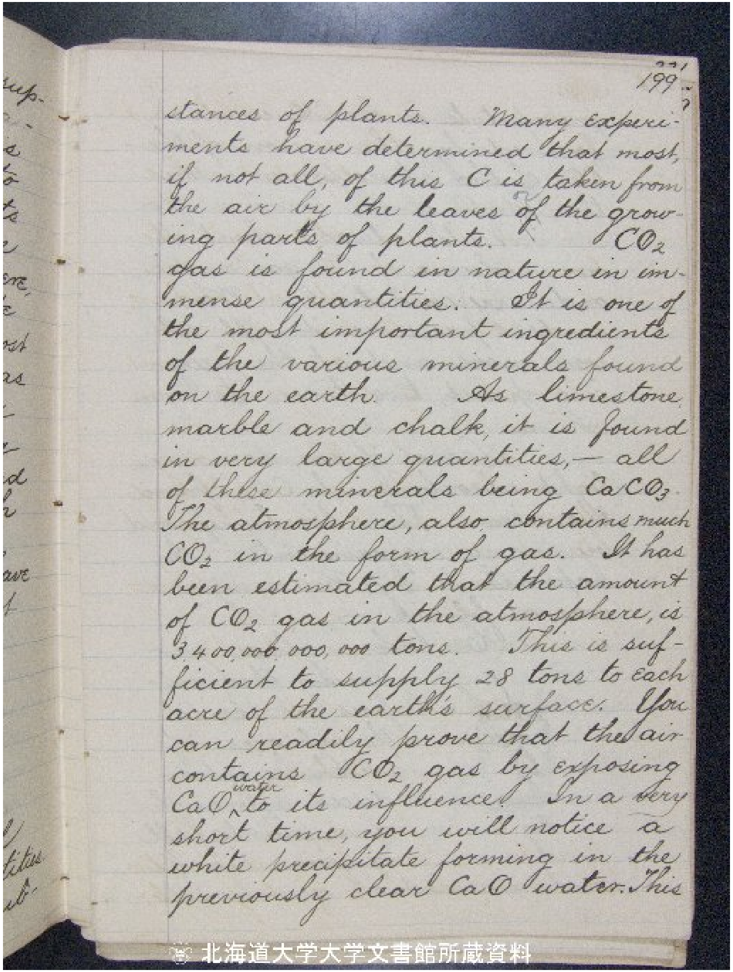

stances of plants. Many experiments have determined that most, if not all, of this C is taken from the air by the leaves of the growing parts of plants. CO_2 gas is found in nature in immense quantities. It is one of the most important ingredients of the various minerals found on the earth. As limestone marble and chalk, it is found in very large quantities,— all of these minerals being $CaCO_3$ The atmosphere, also contains much CO_2 in the form of gas. It has been estimated that the amount of CO_2 gas in the atmosphere, is 3400,000 000,000 tons. This is sufficient to supply 28 tons to each acre of the earth's surface. You can readily prove that the air contains CO_2 gas by exposing CaO water to its influence. In a very short time, you will notice a white precipitate forming in the previously clear CaO water. This

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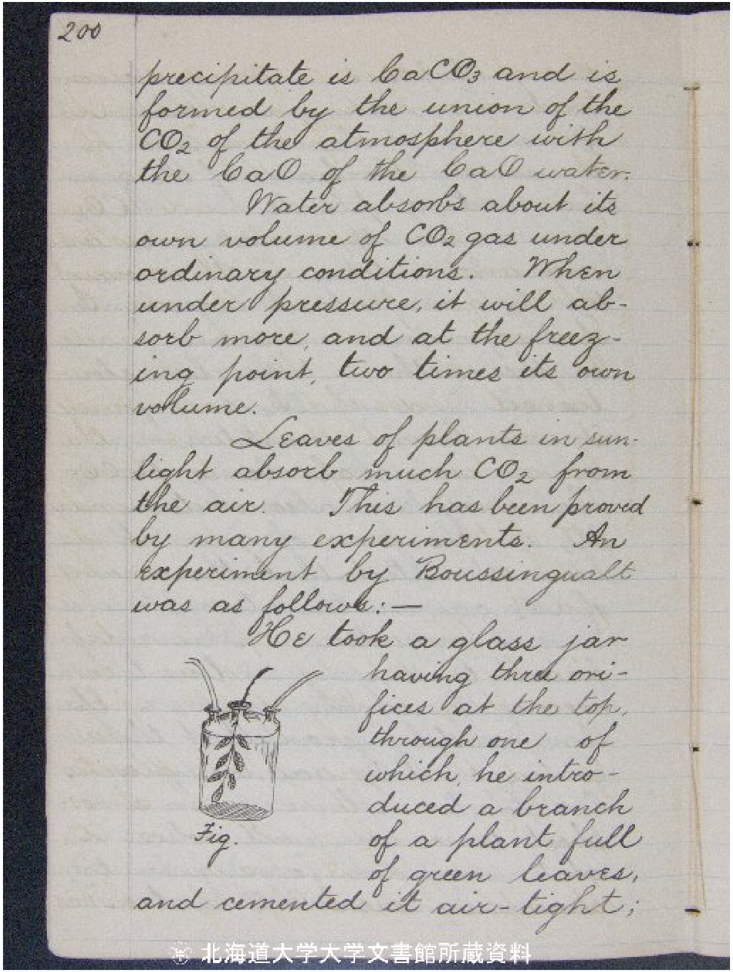
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precipitate is $CaCO_3$ and is formed by the union of the CO_2 of the atmosphere with the CaO of the CaO water.

Water absorbs about its own volume of CO_2 gas under ordinary conditions. When under pressure, it will absorb more, and at the freezing point, two times its own volume.

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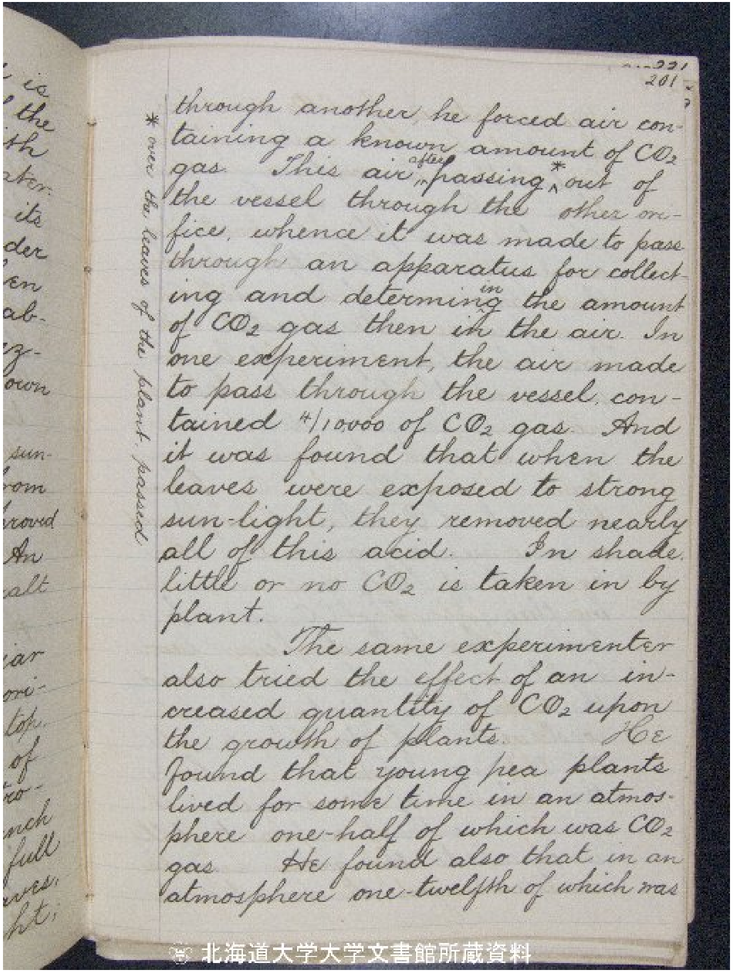
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through another, he forced air containing a known amount of CO_2 gas. This air after passing * out of the vessel through the other orifice, whence it was made to pass through an apparatus for collecting and determing in the amount of CO_2 gas then in the air. In one experiment, the air made to pass through the vessel, contained 4/10000 of CO_2 gas. And it was found that when the leaves were exposed to strong sun-light, they removed nearly all of this acid. In shade little or no CO_2 is taken in by plant.

The same experimenter also tried the effect of an increased quantity of CO_2 upon the growth of plants. He found that young pea plants lived for some time in an atmosphere one-half of which was CO_2 gas. He found also that in an atmosphere one-twelfth of which was

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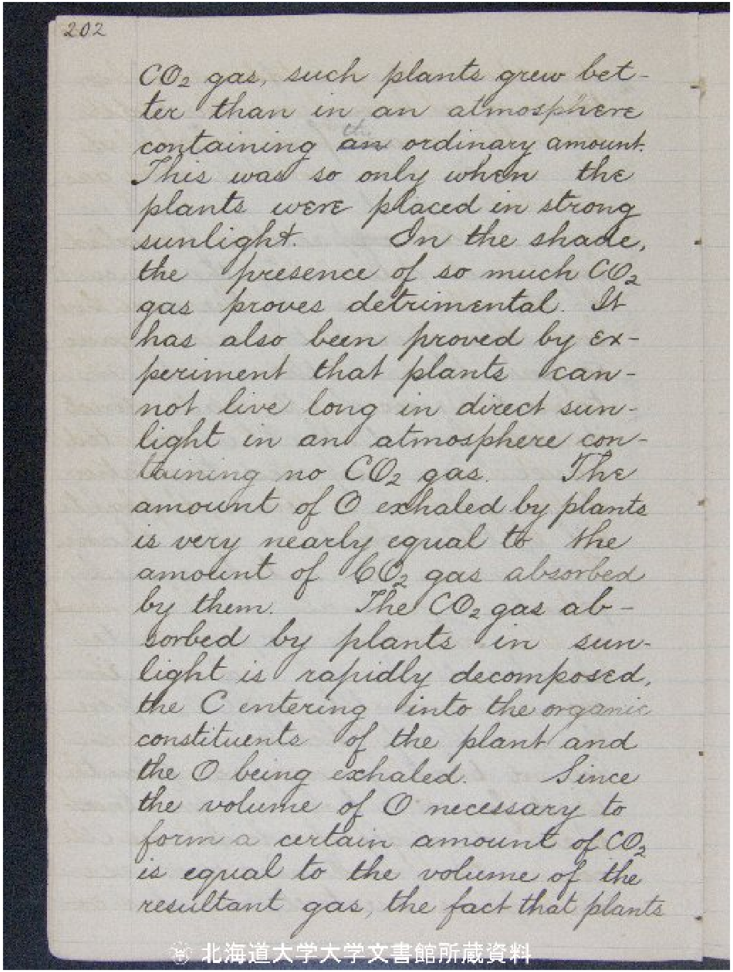

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CO_2 gas, such plants grew better than in an atmosphere containing ~~an~~ the ordinary amount. This was so only when the plants were placed in strong sunlight. In the shade, the presence of so much CO_2 gas proves detrimental. It has also been proved by experiment that plants cannot live long in direct sunlight in an atmosphere containing no CO_2 gas. The amount of O exhaled by plants is very nearly equal to the amount of CO_2 gas absorbed by them. The CO_2 gas absorbed by plants in sunlight is rapidly decomposed, the C entering into the organic constituents of the plant and the O being exhaled. Since the volume of O necessary to form a certain amount of CO_2 is equal to the volume of the resultant gas, the fact that plants

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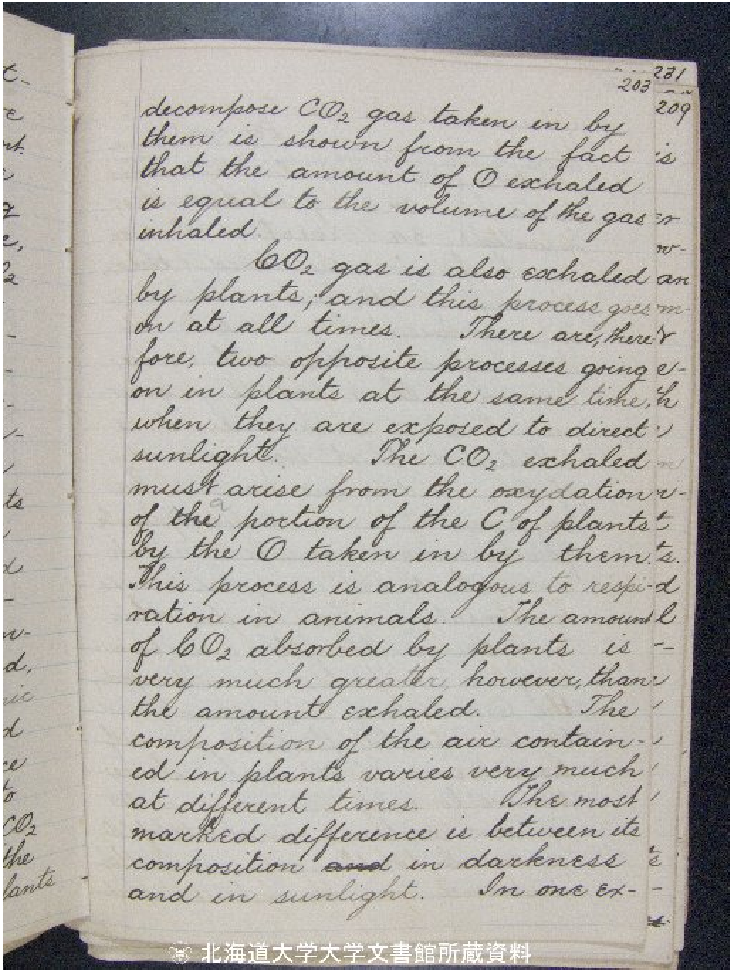

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decompose CO_2 gas taken in by them is shown from the fact that the amount of O exhaled is equal to the volume of the gas inhaled.

CO_2 gas is also exhaled by plants; and this process goes on at all times. There are, therefore, two opposite processes going on in plants at the same time, when they are exposed to direct sunlight. The CO_2 exhaled must arise from the oxydation of the a portion of the C of plants by the O taken in by them. This process is analogous to respiration in animals. The amount of CO_2 absorbed by plants is very much greater, however, than the amount exhaled. The composition of the air contained in plants varies very much at different times. The most marked difference is between its composition ~~and~~ in darkness and in sunlight. In one ex-

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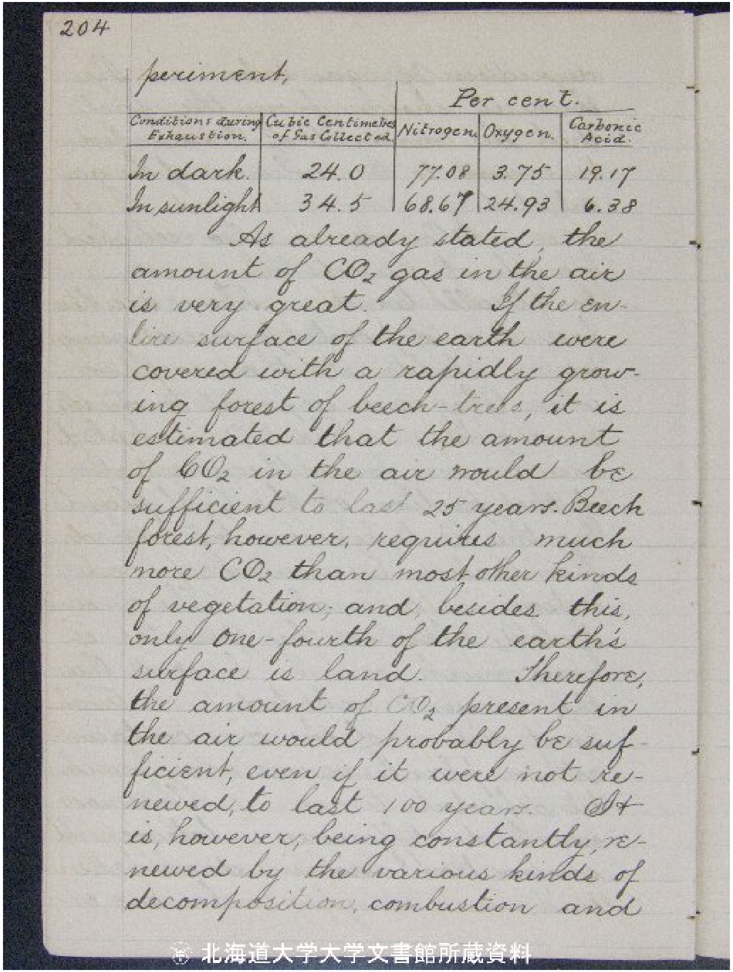

204

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Conditions during Exhaustion.	Cubic Centimetres of Gas Collected.	Per cent. Nitrogen.	Oxygen.	Carbonic Acid.
In dark.	24.0	77.08	3.75	19.17
In sunlight	34.5	68.67	24.93	6.38

As already stated, the amount of CO_2 gas in the air is very great. If the entire surface of the earth were covered with a rapidly growing forest of beech-trees, it is estimated that the amount of CO_2 in the air would be sufficient to last 25 years. Beech forest, however, requires much more CO_2 than most other kinds of vegetation; and besides this, only one-fourth of the earth's surface is land. Therefore, the amount of CO_2 present in the air would probably be sufficient, even if it were not renewed, to last 100 years. It is, however, being constantly renewed by the various kinds of decomposition, combustion and

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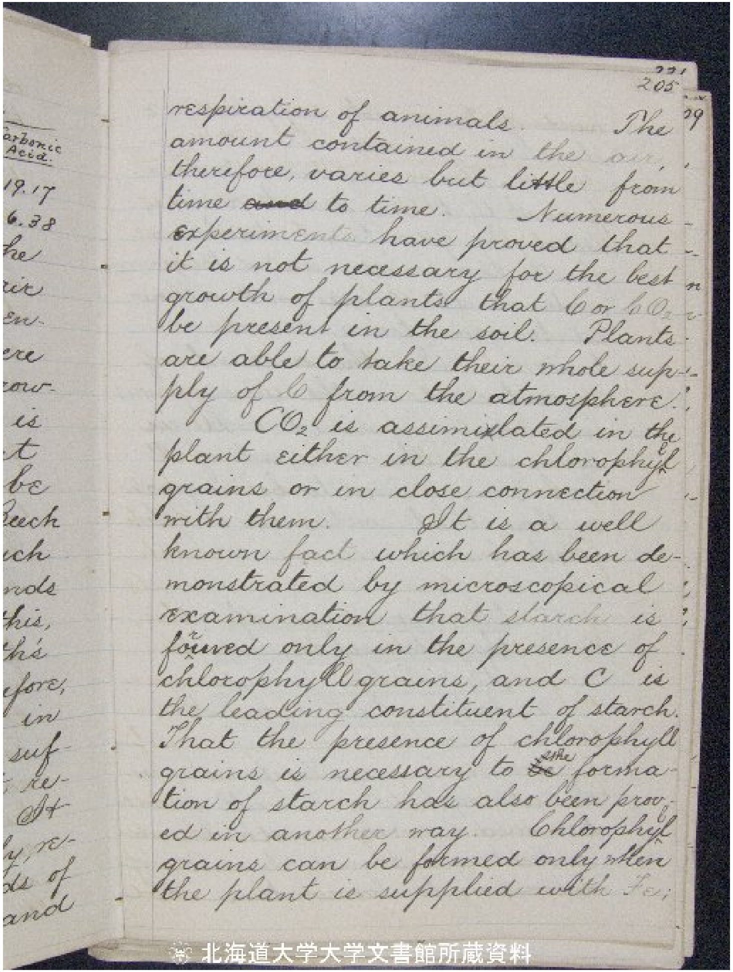
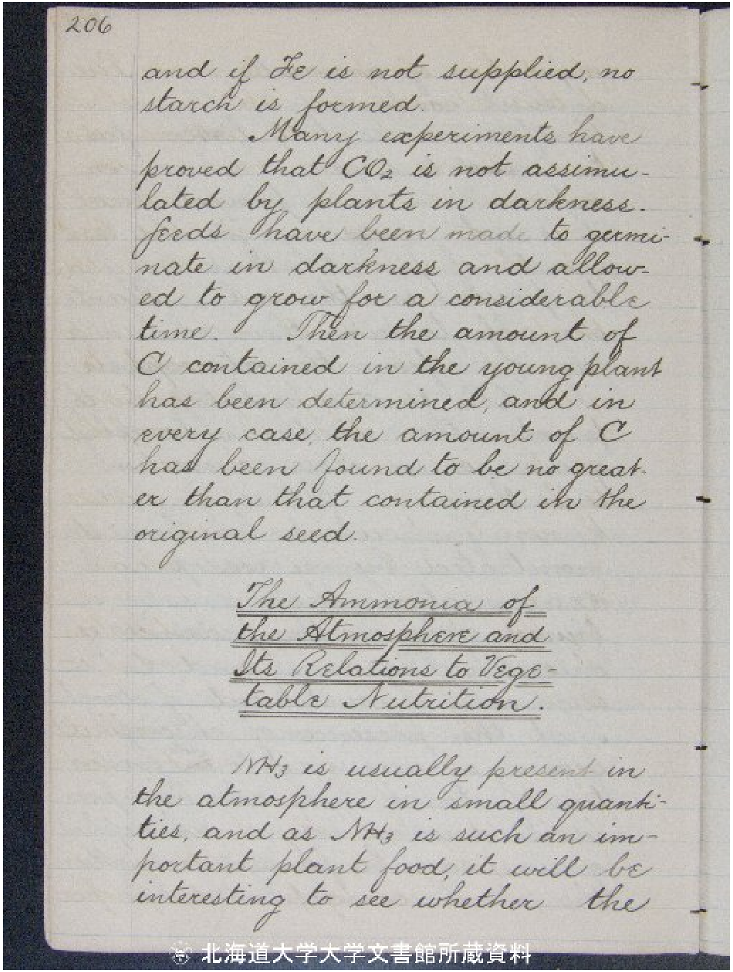


respiration of animals. The amount contained in the air, therefore, varies but little from time to time. Numerous experiments have proved that it is not necessary for the best growth of plants that C or CO_2 be present in the soil. Plants are able to take their whole supply of C from the atmosphere.

CO_2 is assimilated in the plant either in the chlorophyll grains or in close connection with them. It is a well known fact which has been demonstrated by microscopical examination that starch is formed only in the presence of chlorophyll grains, and C is the leading constituent of starch. That the presence of chlorophyll grains is necessary to the formation of starch has also been proved in another way. Chlorophyll grains can be formed only when the plant is supplied with Fe;


206

and if Fe is not supplied, no starch is formed.

Many experiments have proved that CO_2 is not assimulated by plants in darkness. feeds have been made to germinate in darkness and allowed to grow for a considerable time. Then the amount of C contained in the young plant has been determined, and in every case, the amount of C has been found to be no greater than that contained in the original seed.

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NH_3 is usually present in the atmosphere in small quantities, and as NH_3 is such an important plant food, it will be interesting to see whether the

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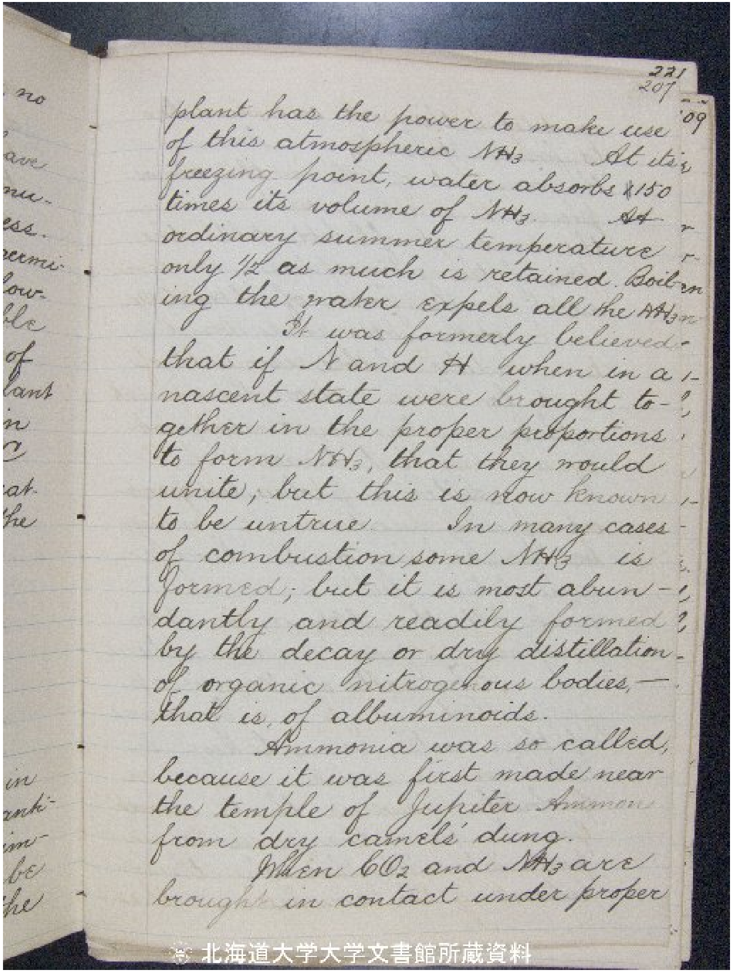

plant has the power to make use of this atmospheric NH_3. At its freezing point, water absorbs 150 times its volume of NH_3. At ordinary summer temperature only 1/2 as much is retained. Boiling the mater expels all the NH_3.

It was formerly believed that if N and H when in a nascent state were brought together in the proper proportions to form NH_3, that they would unite; but this is now known to be untrue. In many cases of combustion some NH_3 is formed; but it is most abundantly and readily formed by the decay or dry distillation of organic nitrogenous bodies, ── that is, of albuminoids.

Ammonia was so called, because it was first made near the temple of jupiter Ammon from dry camels' dung.

When CO_2 and NH_3 are brought in contact under proper

208

conditions, they at once unite to form $(NH_4)_2CO_3$. Now, since the amount of CO_2 in the atmosphere is much greater than the amount of NH_3, all the NH_4 of the atmosphere must exist in the form of $(NH_4)_2CO_3$.

Both NH_3 and $(NH_4)_2CO_3$ are readily soluble in water and for this reason, the amount of these substances varies greatly at different times.

After a protracted period of dry weather, they may be present in quite large quantities; but a rain will wash all the NH_3 and NH_4 compounds from the atmosphere.

The salts of NH_3 are appropriated by plants by means of their roots, being taken in solution in water. It is probable, however, that some plants have the power to appropriate NH_3 through their leaves. To how great a

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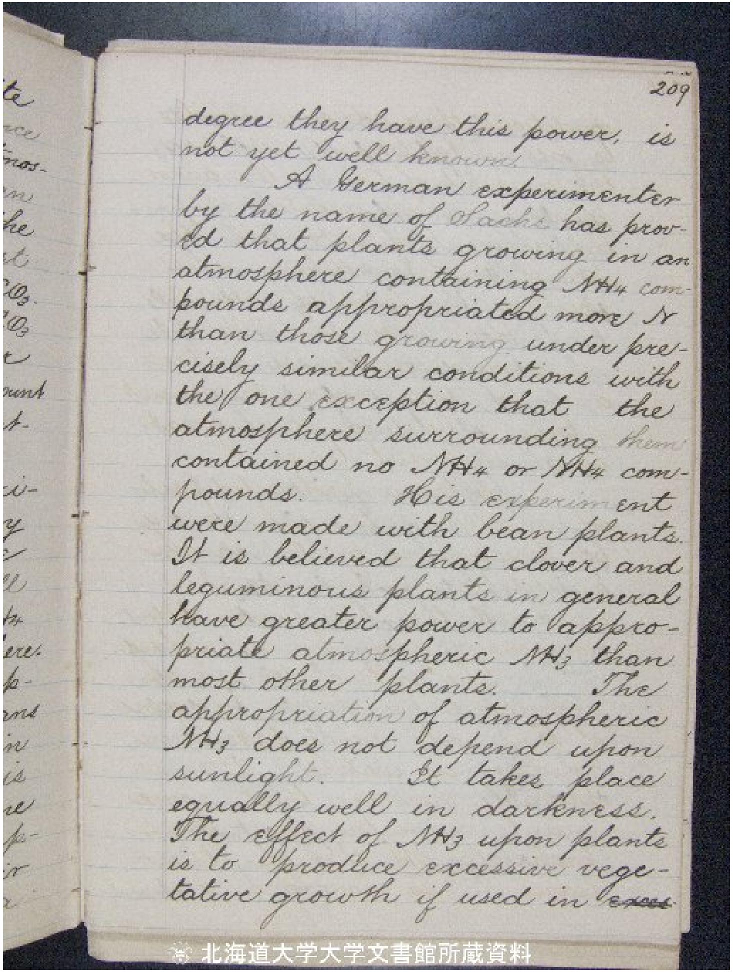

209

degree they have this power, is not yet well known.
A German experimenter by the name of Sachs has proved that plants growing in an atmosphere containing NH_4 compounds appropriated more N than those growing under precisely similar conditions with the one exception that the atmosphere surrounding them contained no NH_4 or NH_4 compounds. His experiment were made with bean plants. It is believed that clover and leguminous plants in general have greater power to appropriate atmospheric NH_3 than most other plants. The appropriation of atmospheric NH_3 does not depend upon sunlight. It takes place equally well in darkness. The effect of NH_3 upon plants is to produce excessive vegetative growth if used in ~~excess~~

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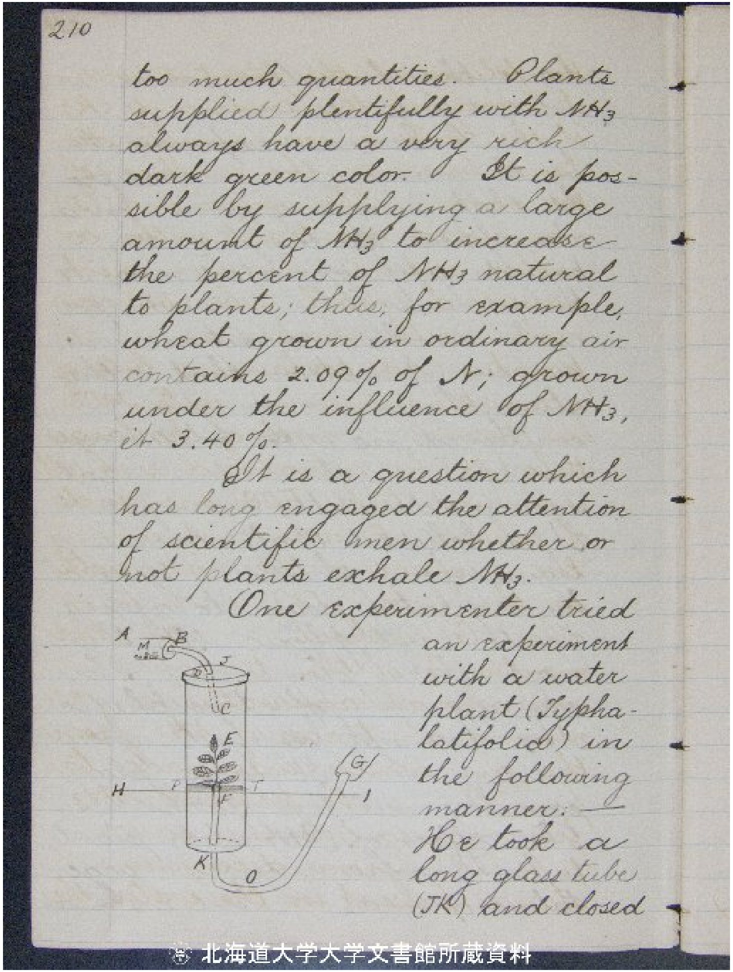

210

too much quantities. Plants supplied plentifully with NH_3 always have a very rich dark green color. It is possible by supplying a large amount of NH_3 to increase the percent of NH_3 natural to plants; thus, for example, wheat grown in ordinary air contains 2.09% of N; grown under the influence of NH_3, it 3.40%.

It is a question which has long engaged the attention of scientific men whether or not plants exhale NH_3.

One experimenter tried an experiment with a water plant (Typha-latifolia) in the following manner: — He took a long glass tube (JK) and closed

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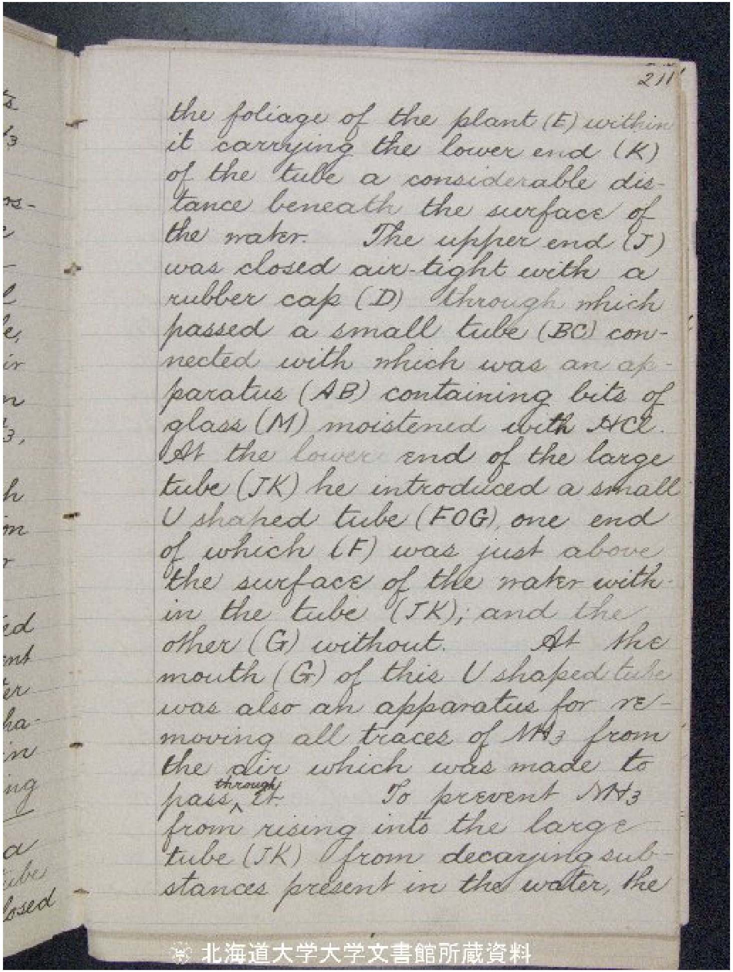

the foliage of the plant (E) within it carrying the lower end (K) of the tube a considerable distance beneath the surface of the water. The upper end (J) was closed air-tight with a rubber cap (D) through which passed a small tube (BC) connected with which was an apparatus (AB) containing bits of glass (M) moistened with HCl. At the lower end of the large tube (JK) he introduced a small U shaped tube (FOG) one end of which (F) was just above the surface of the water with in the tube (JK); and the other (G) without. At the mouth (G) of this U shaped tube was also an apparatus for removing all traces of NH_3 from the air which was made to pass through it. To prevent NH_3 from rising into the large tube (JK) from decaying substances present in the water, the

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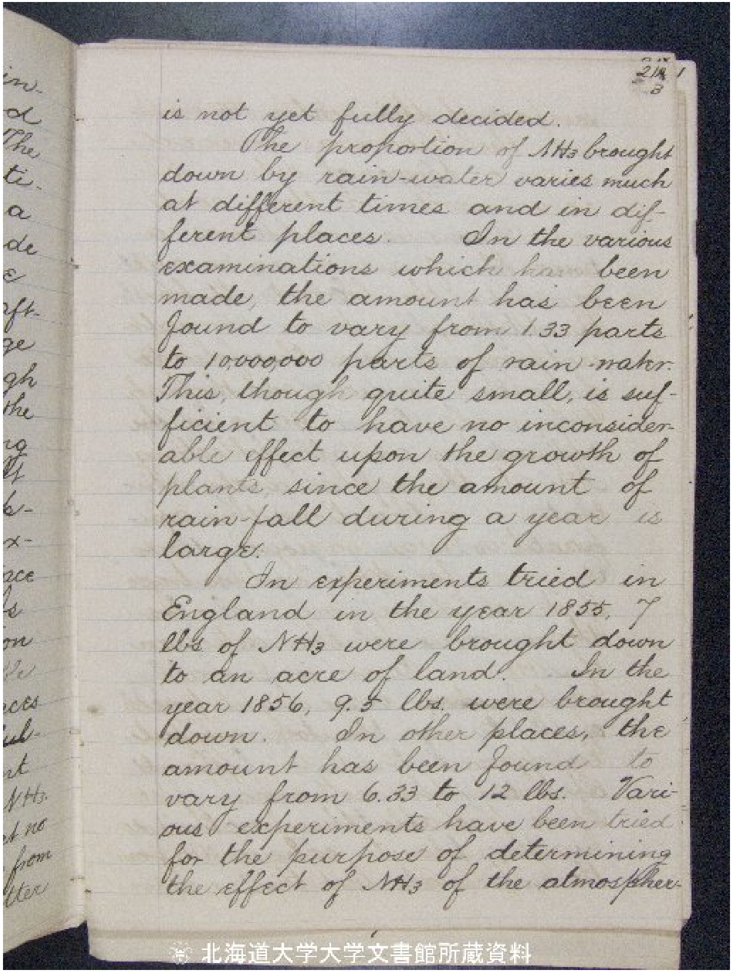
212

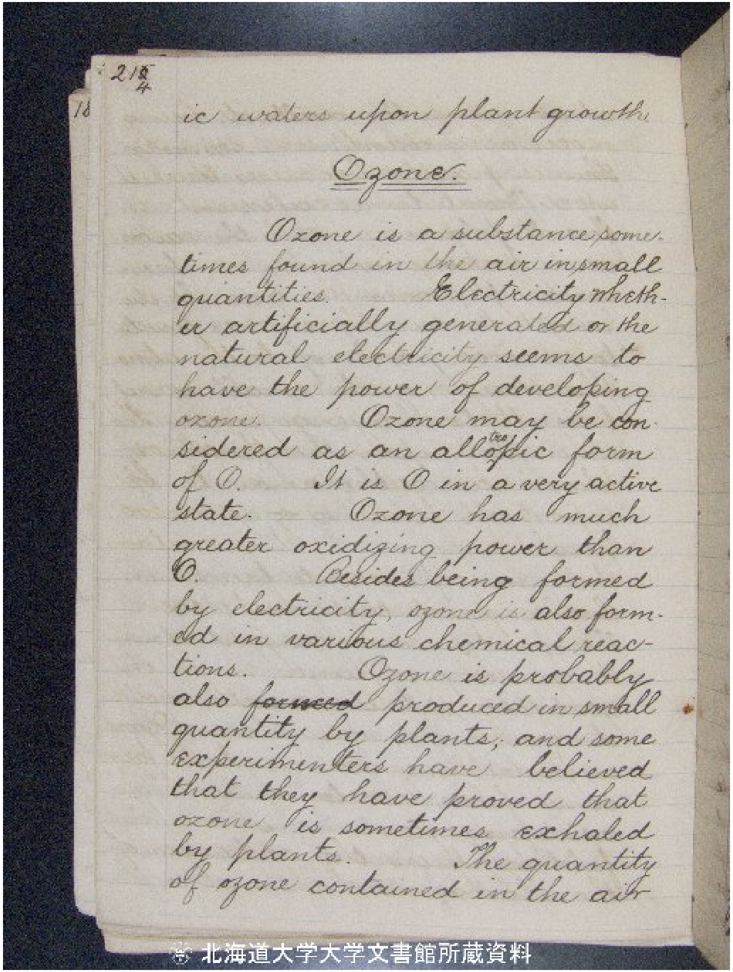
surface of the water (PT) inside the tube was covered with a layer of oil. The experiment was then continued for about 48 hours, a current of air being made to enter the large tube through the U shaped tube and after passing over the foliage of plant to pass out through the small tube (BC) and the apparatus (AB) for collecting NH_3 at the upper end. At the end of this time this apparatus was carefully examined for NH_3; but no trace of it could be found. As the means for the detection of NH_3 are such as to enable us to notice very slight traces of it, it was, therefore, clearly proved that this plant at least did not exhale NH_3. It is probable, therefore, that no healthy plants exhale NH_3 from their foliage; but this matter



is not yet fully decided.

The proportion of NH_3 brought down by rain-water varies much at different times and in different places. In the various examinations which have been made, the amount has been found to vary from 1.33 parts to 10,000,000 parts of rain-water. This though quite small, is sufficient to have no inconsiderable effect upon the growth of plants, since the amount of rain-fall during a year is large.

In experiments tried in tried in England in the year 1855, 7 lbs. of NH_3 were brought down to an acre of land. In the year 1856, 9.5 lbs. were brought down. In other places, the amount has been found to vary from 6.33 to 12 lbs. Various experiments have been tried for the purpose of determining the effect of NH_3 of the atmospheric


215/4

ic waters upon plant growth.

Ozone.

Ozone is a substance sometimes found in the air in small quantities. Electricity whether artificially generated or the natural electricity seems to have the power of developing ozone. Ozone may be considered as an allotropic form of O. It is O in a very active state. Ozone has much greater oxidizing power than O. Besides being formed by electricity, ozone is also formed in various chemical reactions. Ozone is probably also ~~formed~~ produced in small quantity by plants, and some experimenters have believed that they have proved that ozone is sometimes exhaled by plants. The quantity of ozone contained in the air

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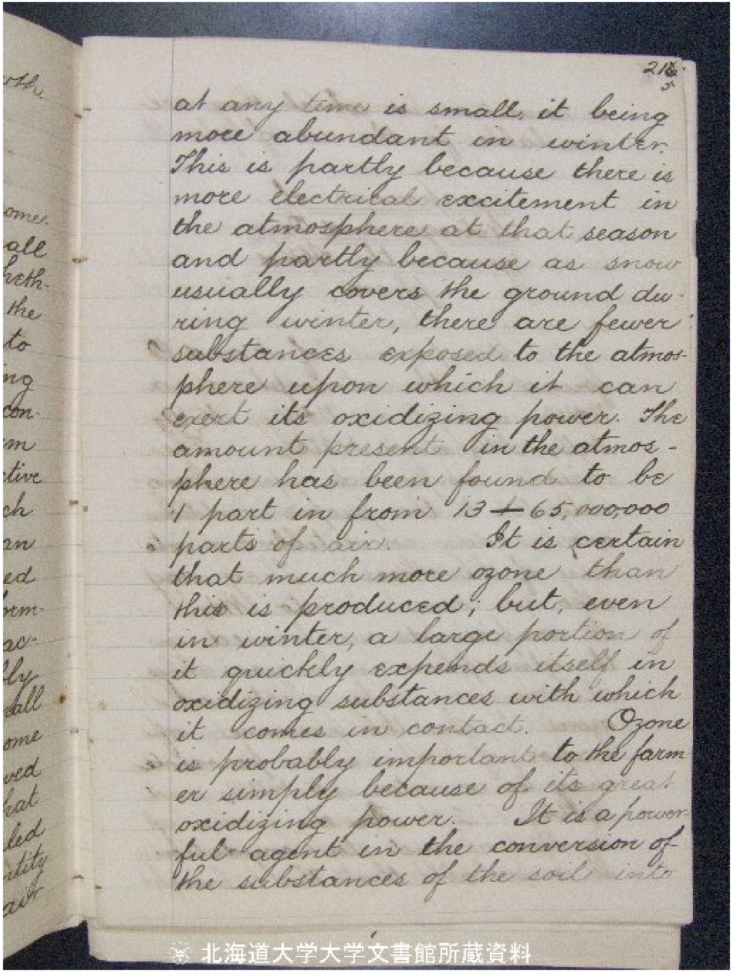
216
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at any time is small, it being
more abundant in winter.
This is partly because there is
more electrical excitement in
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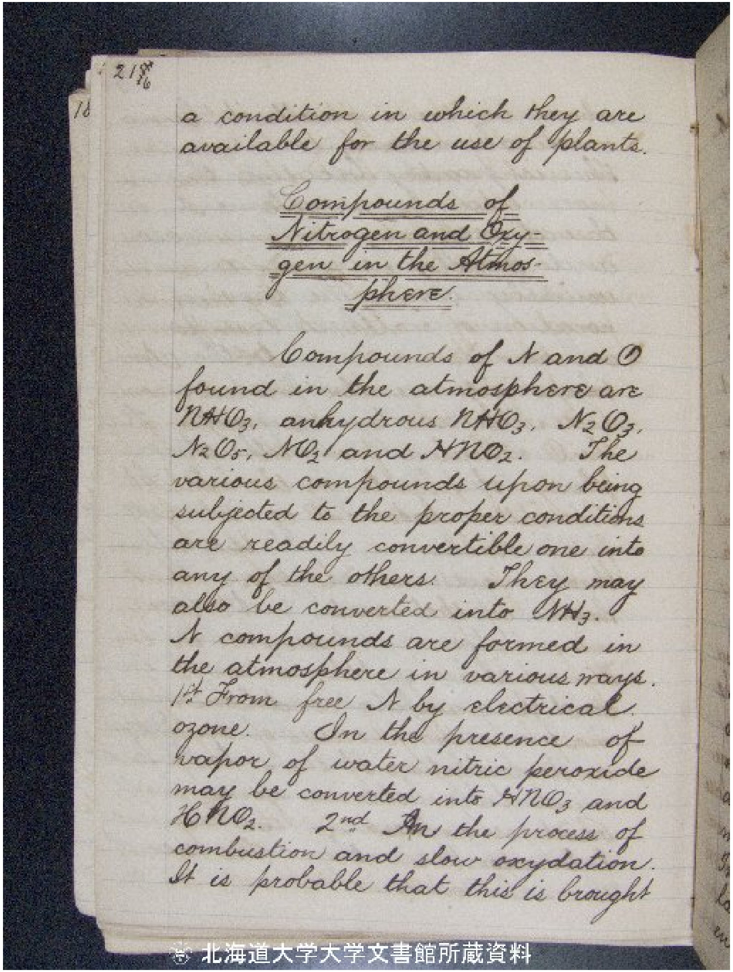

218/6

a condition in which they are available for the use of plants.

Compounds of Nitrogen and Oxy-gen in the Atmos-phere.

Compounds of N and O found in the atmosphere are NHO_3, anhydrous NHO_3, N_2O_3, N_2O_5, NO_2 and HNO_2. The various compounds upon being subjected to the proper conditions are readily convertible one into any of the others. They may also be converted into NH_3. N compounds are formed in the atmosphere in various ways. 1st From free N by electrical ozone. In the presence of vapor of water nitric peroxide may be converted into HNO_3 and HNO_2. 2nd In the process of combustion and slow oxydation. It is probable that this is brought

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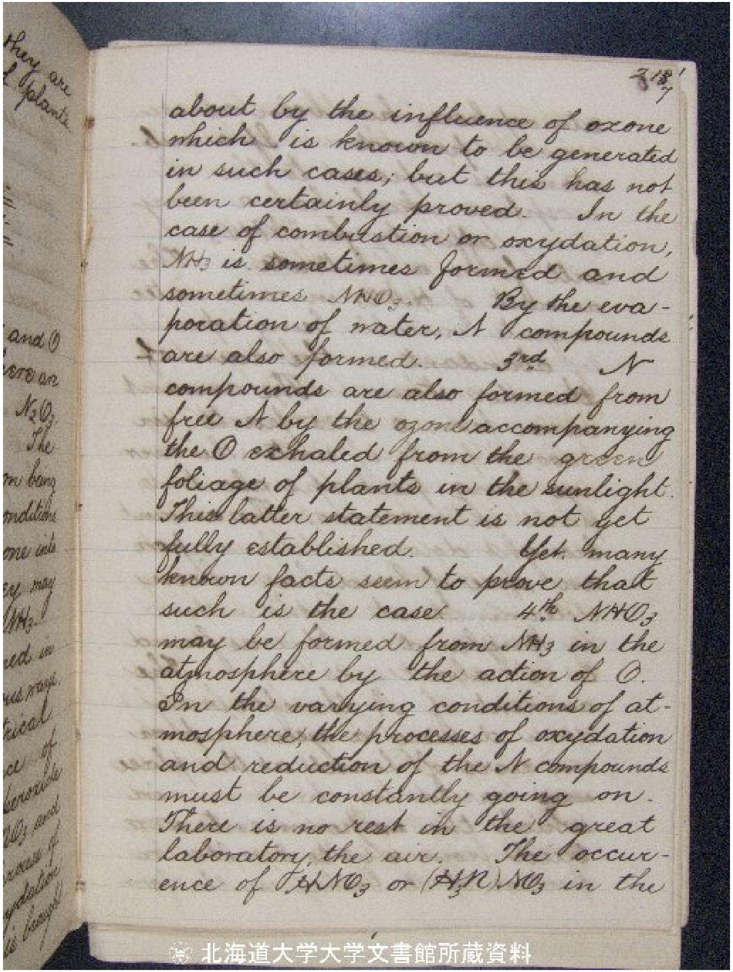

about by the influence of oxone which is known to be generated in such cases; but this has not been certainly proved. In the case of combustion or oxydation, NH_3 is sometimes formed and sometimes NHO_3. By the evaporation of mater, N compounds are also formed. 3^{rd} N compounds are also formed from free N by the ozone accompanying the O exhaled from the green foliage of plants in the sunlight. This latte statement is not yet fully established. Yet. many known facts seem to prove that such is the case. 4^{th} NHO_3 may be formed from NH_3 in the atmosphere by the action of O. In the varying conditions of atmosphere, the processes of oxydation and reduction of the N compounds must be constantly going on. There is no rest in the great laboratory, the air. The occurence of HNO_3 or $(H_3N)NO_3$ in the

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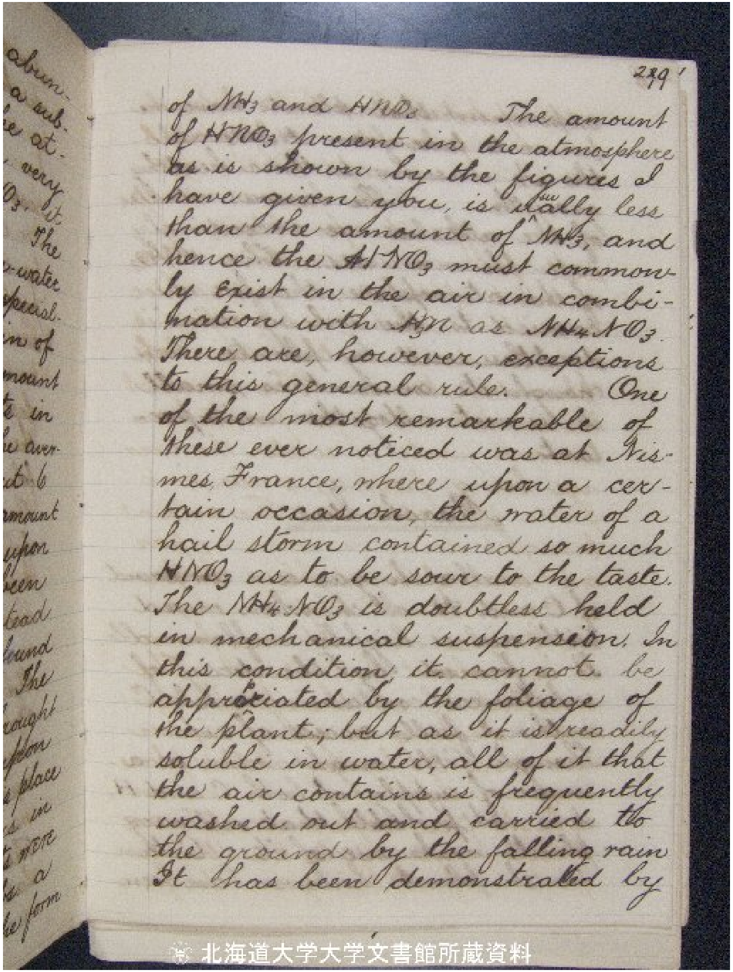

249

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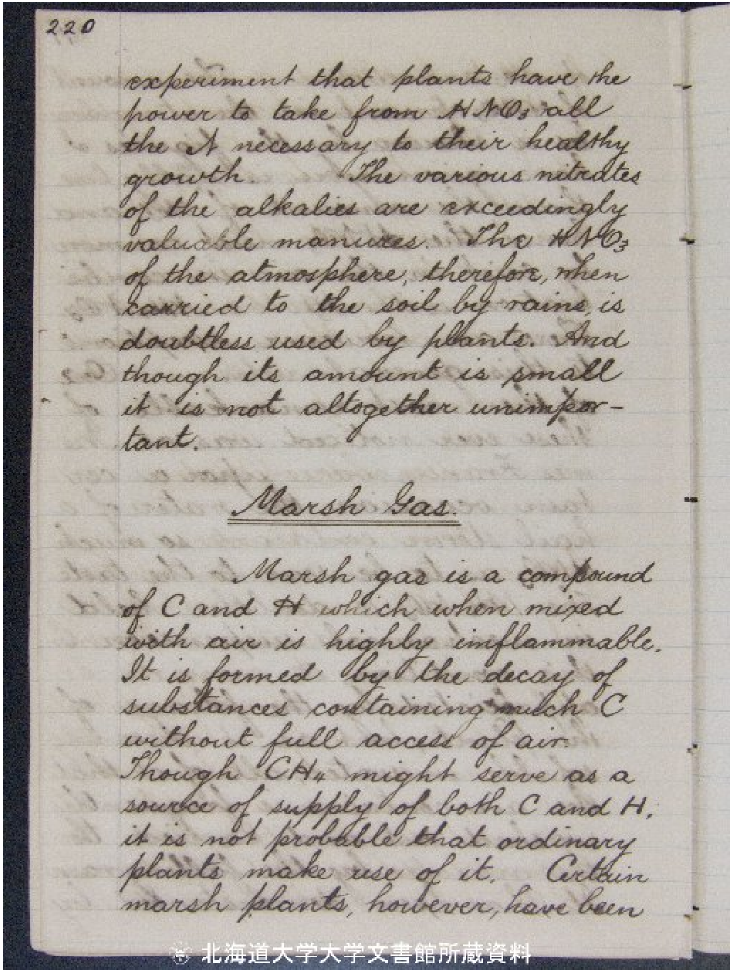
of NH_3 and HNO_3. The amount of HNO_3 present in the atmosphere as is shown by the figures I have given you, is usually less than the amount of NH_3, and hence the $AlNO_3$ must commonly exist in the air in combination with H_3N as NH_4NO_3. There are, however, exceptions to this general rule. One of the most remarkable of these ever noticed was at Nismes, France, where upon a certain occasion, the water of a hail storm contained so much HNO_3 as to be sour to the taste. The NH_4NO_3 is doubtless held in mechanical suspension. In this condition, it cannot be appropriated by the foliage of the plant; but as it is readily soluble in water, all of it that the air contains is frequently washed out and carried to the ground by the falling rain. It has been demonstrated by



220

experiment that plants have the power to take from HNO_3 all the N necessary to their healthy growth. The various nitrates of the alkalies are exceedingly valuable manures. The HNO_3 of the atmosphere, therefore, when carried to the soil by rains, is doubtless used by plants. And though its amount is small it is not altogether unimportant.

Marsh Gas.

Marsh gas is a compound of C and H which when mixed with air is highly inflammable. It is formed by the decay of substances containing much C without full access of air. Though CH_4 might serve as a source of supply of both C and H, it is not probable that ordinary plants make use of it. Certain marsh plants, however, have been

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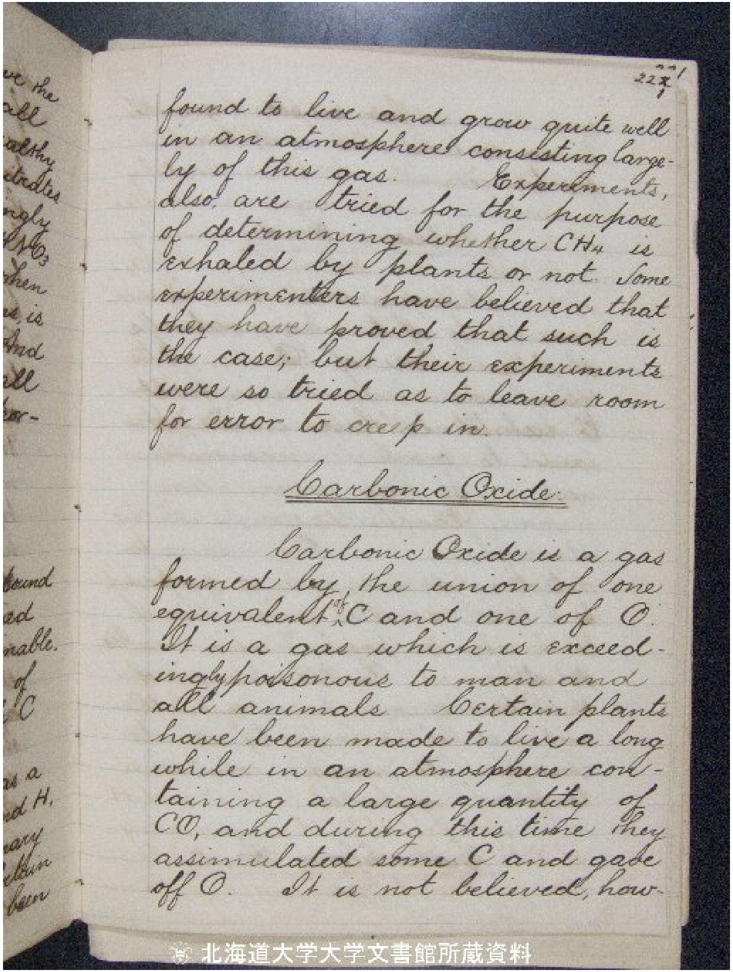

227

found to live and grow quite well in an atmosphere consisting large-ly of this gas. Experiments, also, are tried for the purpose of determining whether CH_4 is exhaled by plants or not. Some experimenters have believed that they have proved that such is the case; but their experiments were so tried as to leave room for error to creep in.

Carbonic Oxide.

Carbonic Oxide is a gas formed by the union of one equivalent of C and one of O. It is a gas which is exceedingly poisonous to man and all animals. Certain plants have been made to live a long while in an atmosphere containing a large quantity of CO, and during this time they assimulated some C and gave off O. It is not believed, how-

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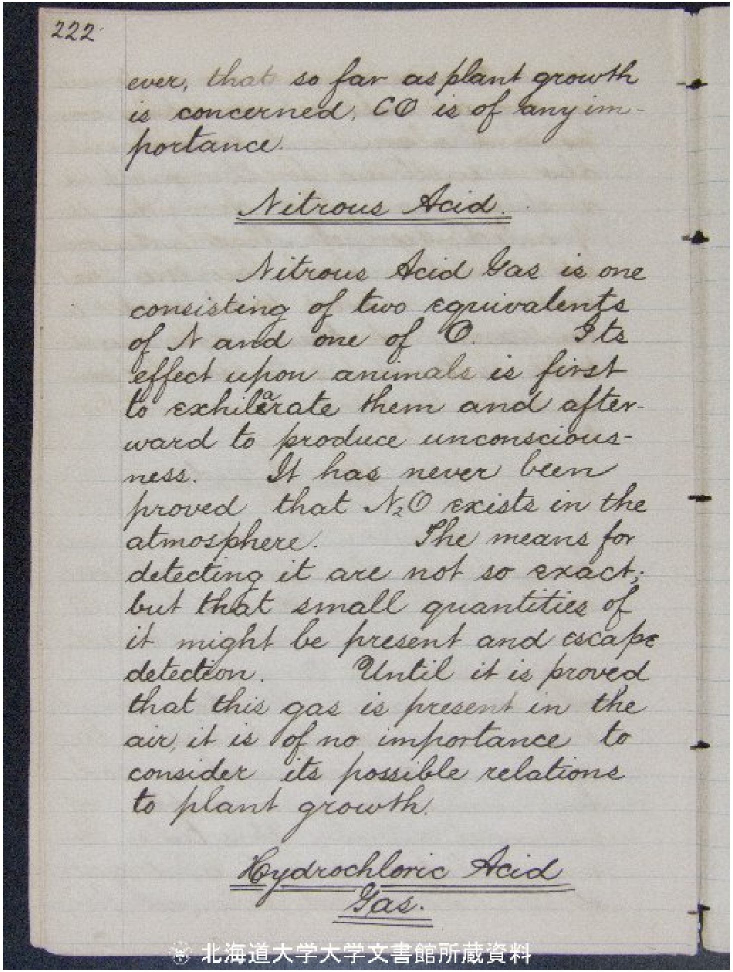
222

ever, that so far as plant growth is concerned, CO is of any importance.

Nitrous Acid.

Nitrous Acid Gas is one consisting of two equivalents of N and one of O. Its effect upon animals is first to exhilarate them and afterward to produce unconsciousness. It has never been proved that N_2O exists in the atmosphere. The means for detecting it are not so exact, but that small quantities of it might be present and escape detection. Until it is proved that this gas is present in the air, it is of no importance to consider its possible relations to plant growth.

Hydrochloric Acid Gas.

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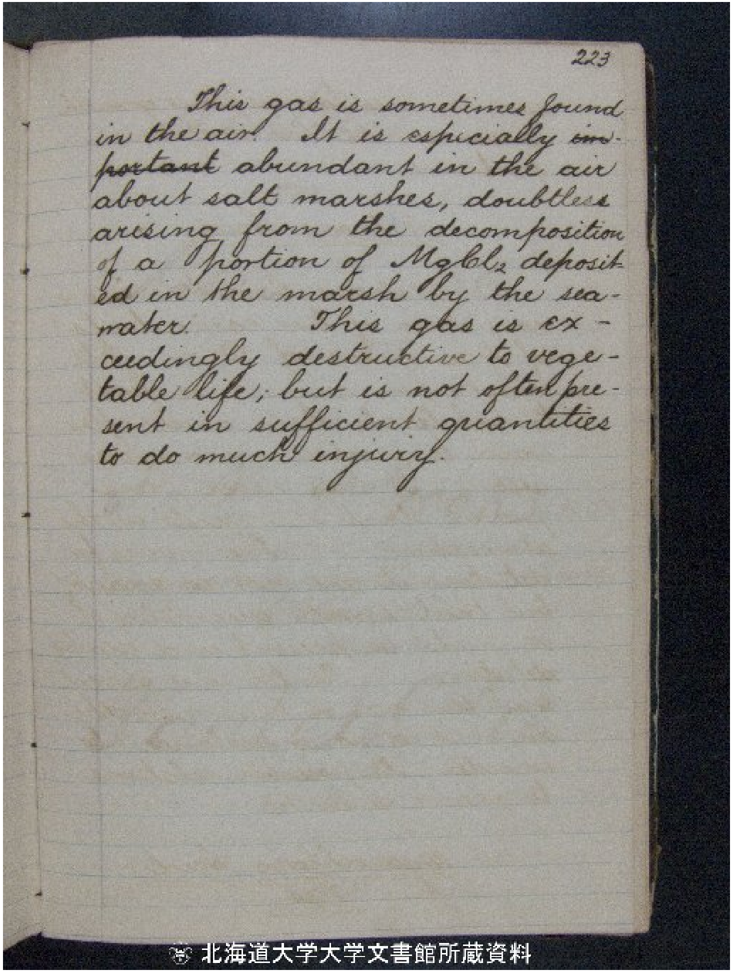

This gas is sometimes found in the air. It is especially ~~important~~ abundant in the air about salt marshes, doubtless arising from the decomposition of a portion of $MgCl_2$ deposited in the marsh by the sea-water. This gas is exceedingly destructive to vegetable life; but is not often present in sufficient quantities to do much injury.

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