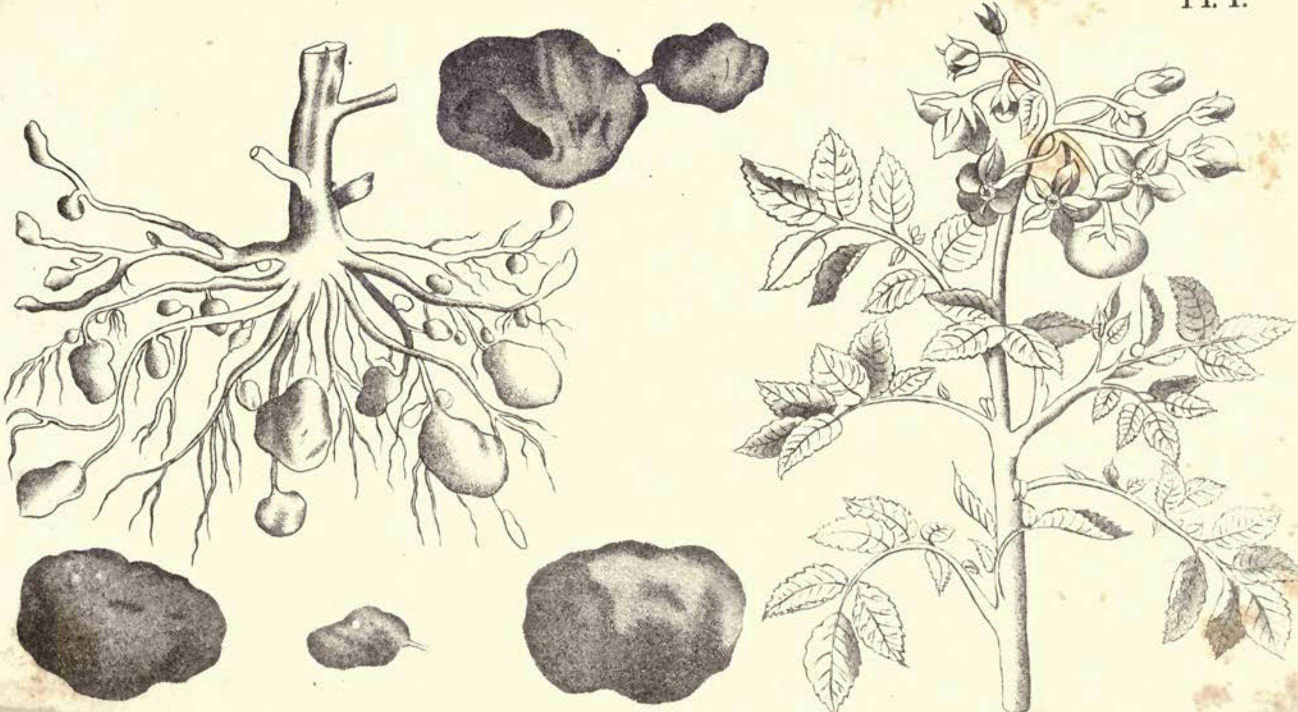
Pl. 1.



On Stone by Gratacap, 31 City Hall Place, N. York.

THE

POTATOE PLANT,

ITS USES AND PROPERTIES:

TOGETHER WITH

THE CAUSE OF THE PRESENT MALADY.

THE EXTENSION OF THAT DISEASE TO OTHER PLANTS, THE QUESTION OF FAMINE ARISING THEREFROM, AND THE BEST MEANS OF AVERTING THAT CALAMITY,

BY ALFRED SMEE, F.R.S.

SURGEON TO THE BANK OF ENGLAND; TO THE ROYAL GENERAL DISPENSARY; TO THE CENTRAL LONDON OPHTHALMIC INSTITUTION; AND LECTURER ON SURGERY AT THE ALDERSGATE SCHOOL OF MEDICINE.

ILLUSTRATED WITH TEN LITHOGRAPHS.

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TO

HIS ROYAL HIGHNESS

THE PRINCE ALBERT, K.G., F.R.S.

Sir,

I feel most deeply the honor which your ROYAL HIGHNESS has conferred upon me in condescending to allow another Treatise to be dedicated to your ROYAL HIGHNESS.

In submitting the result of my labors to your ROYAL HIGHNESS, I rejoice in the belief that the discovery of the cause of the present Scarcity will lead the nation to employ the best means of averting the progress of the calamity.

I have the honor to be,

Sir,

Your Royal Highness's

Most dutiful Servant,

ALFRED SMEE.

PREFACE.

WHEN a great Calamity, arising from some unknown cause, comes over the human race, every individual feels the deepest interest in ascertaining the agent which has given rise to the mischief. Hence I was led to inquire into the present potatoe malady, but had no idea, in the first instance, that a volume would have been written to record my observations.

The result of my inquiries might have been conveyed in a few words, had there been no other observations published upon the subject. I have now, however, been compelled to consider all the assumed causes of this malady, which have been already promulgated by scientific men.

It is to be regretted that some of our most respected philosophers should have committed themselves early in this matter. For now, I fear, in some cases, they will not like to reconsider their opinion; and should this be the case, they must necessarily act as opponents to all other rationalia of this lamented malady.

I have to apologize to Entomologists for having violated an established rule, by changing the name of an insect; I found, however, that such confusion would attend my adoption of their name, "Rapæ," or turnip, for the destroying Aphis, that I at once determined, for the sake of perspicuity, to call it in my work the "Vastator."

This work has required some labor in its preparation; at times I have frequently had to traverse many miles, in order to determine a single fact. For the purpose of ascertaining the existence of the disease in any plant, it was not sufficient merely to examine it in one locality; it might not have been attacked at that spot; the insect might have left the plant, or the plant might not grow in the place which I visited.

This work also required a knowledge of Botany, Entomology, Chemistry, and Agriculture. I cannot be expected to be conversant with all these matters, for each, alone, would take a long lifetime to acquire. I am therefore fully aware of the great imperfection of the work in these particulars; but I trust that the development of the Cause of the disease in the potatoe, and the discovery that it attacks other plants, will prove useful to mankind.

As soon as I perceived that it would be necessary to write a small Treatise on the subject, I pressed numerous friends into my service, and I obtained valuable assistance in numerous quarters. To all these friends my best thanks are due. I am, however, more especially bound to return my grateful acknowledgments to Mr. INGALL, Deputy Principal of one of the Stock offices of the Bank of England. This gentleman, although his labors at the Bank are sufficiently arduous, has yet found time to make one of the finest private collections of insects in this country, and is, besides, an ardent cultivator of the sciences of Natural History and Botany.

The service which he has rendered to me in this work is of such value, that the Volume could hardly have been produced, in its present form, without his aid; for he made all the Drawings, which I have been enabled to lay before my readers, and arranged the plates for the artist.

I have also to thank my pupils, Mr. LATHAM and Mr. GREATREX, for procuring me various information.

To Mr. THOMPSON, the indefatigable and learned Librarian of the London Institution, I have to tender my grateful acknowledgments for the aid which he afforded me in referring to works and in copying plates.

To my old and kind friend Mr. JOHN BEADNELL, Jun., I have, as on former occasions, to render my best thanks, for revising the entire proof sheets of this work. And my excellent friend Dr. FERGUS I have also to thank for the compilation of the Analytical Index.

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EXPLANATION OF THE PLATES.

PLATE I.

Fac-simile of the wood-engraving printed in Gerard's "Herbal," which is the first figure of this plant, and shows the general characteristic of the plant at its introduction.

PLATE II.

Fig. 1. Diagram of the potatoe plant, to show its mode of growth, particularly with respect to the formation of the tubers.

a Original set. *b* Stem. *c* Collar. *d* Above ground stem.
e Fruit. *f* Leaf. *h* Axil of the leaf. *j* Flower.

k Under-ground, or tuber-bearing stem. These stems are given off chiefly in two places, the upper one of which arises after the plant is earthed up, and shows the utility of the process.

l Tuber.

m Tuber growing from a former. This second tuber takes the starch from the first (*s*), and renders it useless; and this continues to grow, taking the starch from the further part of its own tuber, so that one end is good, the other worthless.

n Above-ground stem growing from a tuber-bearing stem.

o Tuber with roots, which is an unusual occurrence.

r True roots of the plant.

2. *Botrytis infestans*, after Berkeley, showing the manner in which it ramifies amongst the cellular tissue of the leaf. This figure is highly magnified.

PLATE III.

Fungi (*Smee*).

All these are highly magnified.

Fig. 1. Fungi found on rotten potatoes, either on cut sections or in cavities arising from the shrivelling of potatoes, or thrusting up the cuticle, and thus appearing in great masses.

a Young top. *b* In a more mature state.
c Showing its appearance when it is quite ripe, and throwing the spirals.

2. Black fungus (probably *Protomyces*), in a stalk, slightly magnified.

3. One patch alone, more strongly magnified. This is found in the tuber, as well as the haulms.

4. A fungus probably allied to fig. 1.

5. A fungus with small heads, which resembles the Medusa's head under a powerful micoscrope.

6. A fungus (probably *Botrytis*), from the edge of the leaf. The lithographer has rather sacrificed the distinctness of the mode of fructification.

7. A fungoid growth upon the *Aphis vastator*, much resembling that found in the scald-head of man.

PLATE IV.

Fungi (*Smee*).

All these are highly magnified.

Fig. 1. The leg of the *Aphis vastator*, showing a parasitic fungus.

2 and 3. Delicate fungus often growing upon diseased tubers.

4. A singular fungus, resembling a rush. I do not know whether it is in a persistent state, and I have only observed one example of it.

5. A very beautiful and abundant fungus, often to be found on the exterior of decaying tubers, or on a cut section. It is apparently of a brown color, like oxide of iron, but under the microscope shows this beautiful and distinct form. One of the drawings is more highly magnified than the rest.

6. A fungus (probably *Botrytis*), from under-ground stem. This appeared somewhat similar to the *Botrytis* of Berkeley, except that the top was more globular.

7 and 8. Fungi from under-ground stem.

9. Fungi from diseased tubers.

PLATE V.

VARIOUS SUBJECTS.

All the figures but fig. 4 are magnified.

1. Empty cell, after Martius.

a Light yellow grains of Protomyces.
b Fungous fibre commencing.

2. Beautiful fungus found on under-ground stem. (*Smee.*)

3. *Botrytis*, after Berkeley.

4. Leaf, showing the manner in which it evinces the gangrene and blotches.

5. Starch granules, after Pereira, showing their external appearance.

a Normal starch particles.
b Irregular.
c, *d* Particles, each having two hila.
e, *g* Particles broken by pressure and water, the internal matter remains solid.

6. *Thrips munitissima*, after a drawing from the "Gardener's Chronicle."

7. *Eupteryx solani*, after a drawing from the "Gardener's Chronicle."

8. *Acarus farinæ*, which is found abundantly on diseased potatoes.

9. Red Acarus, which preys upon Aphides.

10. A species of Aphis which was noticed upon a potatoe plant.

PLATE VI.

FUNGI AND DISEASED STRUCTURE, AFTER MARTIUS.

All the figures are highly magnified.

FIG. 1. A part of the epidermis of a white potatoe separated by a horizontal cut. (Plate III., fig. 17.)

2. Vertical section through the epidermis of a white potatoe to the cells.

a Cells of the epidermis. *b* Cells under them pressed together.
c Common cellular tissue. At * is seen a small forked fibre, and four small bodies, the presumed commencement of the fungus. (Plate III., fig. 18.)

3. Horizontal section of the cellular tissue, in which the cells are partly torn. (Plate III., fig. 19.)

4. Section of a fungoid excrescence from top to bottom.

a Healthy. *b* Diseased cell. *c* Epidermis.
d Exhausted cellular tissue, which serves as a matrix for the fungoid growth.
e The fungus surrounded and entangled by cellular tissue raised at *f*. (Plate III., fig. 22.)

5. A very young fungus, growth intersected by grains of Protomyces strongly magnified. (Plate III., fig. 23.)

6. Vertical section of an excrescence of which the fungus is fully developed.

b Decayed cellular tissue under the epidermis.
c, *d* Empty cellular tissue, serving as the foundation for the fungus.
e Part of the cellular tissue.
f A dense mass of upright flakes of *Fusisporium solani*. (Plate III., fig. 25.)

7. Separate portions of fungus highly magnified. (Plate III., fig. 26.)

8 and 9. *Fusisporium solani* at a more advanced stage with seed grains fully developed. (Plate III., figs. 27, 28.)

10. A ripe seed grain more strongly magnified. (Plate III., fig. 29.)

11. A single fungous fibre with its seed grain, showing its changes after being moistened with vitriolic acid. (Plate III., fig. 30.)

PLATE VII.

FIG. 1. Section of a diseased carrot, showing the manner in which it rots in consequence of the disease. (Natural size.)

2. Section of diseased turnip in the first stage of the disease, showing that the malady evinces itself principally between the spiral vessels and bark. (Natural size.)

3. Section of a potatoe in the first stage of gangrene, showing

that the disease in the first instance is most prone to attack the tuber between the cuticle and spiral vessels.

4. Section of a potatoe affected with dry gangrene, with a cavity in its interior of the form of an irregular X. The mass left in this case is principally starch. (Natural size.)

5. Section of parsnip in the first stage of the disease. (Natural size.)

6. Mangel wurtzel. In this case the whole structure appeared killed, and the malady is seen to progress from the spiral vessels. (Natural size.)

7. Cells of diseased potatoe empty of starch. (Magnified.)

8. A section of healthy wild potatoe, showing the cells filled with starch. (Magnified.)

9. Starch with cellular tissue disorganized, and fungoid fibre substituted. (Magnified.)

10. Little aggregations of starch, which are to be seen occasionally in diseased potates in little isolated masses. (Magnified.)

PLATE VIII.

APHIS VASTATOR.

All the figures are magnified.

Fig. 1. The ovum immediately after exclusion, showing the two eyes through the membrane.

2. Young Aphis.

3. Full-grown larva, with the antennæ in the position it carries them when on the march.

4. *Aphis vastator* in the pupa state. In this figure the antennæ are reflexed over the back, a position which the insect always takes when feeding.

5. Claw of the Aphis.

6. Abdominal tubercle.

7. Rostrum.

a Setæ withdrawn. *b* the setæ projecting.

c Setæ separated into three parts, the outer of which correspond to the jaws of insects, the middle one to the tongue. It is by this apparatus the insect pierces the cells of the plant, which enables it to suck the juices.

PLATE IX.

APHIS VASTATOR.

All the figures are magnified except the leaflet.

Fig. 1. *Aphis vastator* in the winged state.

2. Under side with rostrum in situ.

3. One of the antennæ carefully drawn with the camera lucida.

4. Perfect insect, showing the manner in which it carries its wings in a state of repose.

5. *Aphis vastator* in which an ichneumon had deposited its eggs, and from which the perfect parasite has escaped through the aperture shown in the dorsum.

6. Leaflet (natural size), showing its appearance when covered by the vastator. For perspicuity the antennæ are all shown projecting in front, whilst in reality they are reflexed when the insect is feeding.

PLATE X.

DESTROYERS OF APHIDES.

Fig. 1. Psen equestris.

2. Diodontis gracilis.

3. Cynips.

4. Aphidius rapæ.

5. Larva of Chrysopa perla.

6. Chrysopa perla.

7. Larva of Scæva pyrastri.

8. Pupa of Scæva pyrastri.

9. Scæva pyrastri.

10. Larva of a Coccinella.

11. Coccinella punctata.
12. Coccinella instabilis.
13. Pemphredon unicolor.
14. Colax dispar.
15. Tropoxylon clavicerum.

The genera, Nos. 1, 2, 13, and 15, deposit the Aphides in the cells with their eggs, to feed their larvæ when they are hatched.

It is probable that many more of the fossorial Hymenoptera furnish their cells with Aphides, as food for their young; and the insects figured are rather to illustrate the genera that prey upon Aphides, than the species that specially destroy the vastator.

Nos. 3 and 4 deposit their eggs in the Aphides.

Nos. 5, 7, 10, 11, and 12, feed upon the Aphides.

No. 15 is parasitic upon some of the parasites of Aphides.

INTRODUCTION.

A VERY bad disease now exists in the potatoe plant, but it is by no means certain at what period the malady first appeared. The first description, of any importance, of the present epidemic, is (as far as I can learn) to be found in a treatise by Von Martius, who conceives that the disease is attributable to vegetable fungi.

Martius states that the disease has existed in Germany since the year 1830, and that, in November of the year 1841, Dr. Zuchcariani wrote a paper upon the disease, which was read in the Royal Bavarian Academy of Arts. In 1840 the malady spread rapidly through the Bavarian Palatinate, which caused inquiry. On the 27th February, 1842, the Government issued an order for the Academy to inquire into the malady, and transmitted to them various samples of the diseased tuber. At that time Zuchcariani was indisposed, and on this account Von Martius undertook the investigation.

In this country, Dr. Bell Salter, on August 16th, 1845, first communicated to the "Gardener's Chronicle" the startling intelligence, that a blight of an universal character had appeared in the potatoe plant; which intelligence was speedily confirmed by other observers. When the fact was announced, several communications were sent, to the effect that the disease had existed to a large extent the previous season; but, strangely enough, although the fact is undoubted, no person had chronicled the important circumstance.

Every circumstance worthy of note upon this all-interesting topic is to be found in the daily and weekly newspapers; and now, scientific intelligence is so rapidly promulgated in these great organs of knowledge, that an invention of one day is in active operation over the country the next. This extraordinary and rapid diffusion of knowledge is certainly not without its disadvantage; for though it be communicated with great rapidity, yet the subsequent reference to it is the less easy, as the mass of newspapers is so great, that it is almost impossible to hunt over by-gone periodicals for particular essays.

The "Gardener's Chronicle," under the able editorship of Dr. Lindley, has always freely discussed the subject since the 16th of August, 1845. In the "Illustrated London News" there is also an excellent article, illustrated by wood cuts, which, if we can believe common report, was also written under the superintendence of the same distinguished botanist.

If we turn to the proceedings of the great learned societies, we shall perceive that they have not done much for the inquiry. The Royal Society contains a large number of the most distinguished and active men in their private capacity in Europe; yet, collectively, they are inactive, and a century behind the spirit of the age. Their Transactions are published but twice a year, whilst a discovery in these days has its run, and is supplanted by another discovery, in half that time.*

All the minor societies, also, which have split from the great parent institution, for the advancement of natural knowledge, partake of its inactive character, and have made scarcely any attempt to elucidate the nature of the present malady.

In the year 1845 Commissioners were appointed by Government to inquire into the present malady existing in the potatoe plant; and three able men, Kane, Lindley, and Playfair, were selected to perform these duties. As far as their investigations went, their recommendations were practical and generally valuable. Their attention, however, at that time, was properly concentrated on the best mode of preserving the tuber, instead of ascertaining the cause of the malady.

The investigation into the nature of an universal disease among organic bodies belongs especially to the practical surgeon. He is investigating disease in every hour of the day, and every day of his life. He

* This year forms an exception to the general rule, as four parts have been published at a cost exceeding 1000*l.*; but no doubt a more frequent and cheaper means of publication might be employed.

is accustomed to weigh the various difficulties which arise in the investigation of a complex organic body; and on that account he is peculiarly suited for the discovery of the cause of an universal malady. The disease in the plant is a death of the vegetable tissue, and the questions of life and death especially pertain to the business of a surgeon.

The death of a vegetable is referable to causes precisely similar to those which occasion the death of an animal; and although the embarrassing circumstances are less numerous in the vegetable than in the animal, yet they are of the same nature, and are to be investigated upon similar principles. It is for this reason that I attempted the inquiry, and I applied a mode of investigation into the cause of the potatoe disease, similar to that which I should have employed in an investigation of the causes of death in the human being, and the result has been the elucidation of the mystery.

Man is influenced by temperature, light, electricity, barometric pressure, hygrometric state of atmosphere; by the action of new material as food, morbid poisons, air for respiration; by anything which draws nourishment from the body; by vegetable parasites, as in the case of scald-head; by animal parasites, as in the case of tape-worm, pediculi, &c.; and, last of all, he is influenced by moral impressions, as fear, hope, joy, &c. The vegetable is influenced in a similar manner by temperature, light, electricity, barometric pressure, hygrometric state of atmosphere; by the action of new matter, such as manures, the carbonic acid in the atmosphere, poisonous agents; by any circumstance which draws matter from its texture; by vegetable parasites, and animal parasites. In all these respects the pathology of the vegetable is like the pathology of the animal, except that it is less complex, and presents fewer difficulties to investigation.

The business of a surgeon is essentially locomotive, and his duties are practised over an extensive space. It frequently happens that I have to traverse London in two or even more directions in a single day, which circumstance has given me abundant opportunities of making my observations in different localities.

Moreover, during the summer months, I was living at Springfield, Upper Clapton, where I had the advantage of a large garden, wherein were several plots of potatoes, which I was in the habit of observing the first thing in the morning, again on my return from London, and frequently the last thing at night. In the neighborhood, moreover, were larger potatoe grounds, where I used to enjoy the air, and study the disease in the evening; and it has curiously happened, that I have made my observations on the potatoe plant in the same garden in which I conducted the experiments for my former work, on "Electro-Metallurgy."

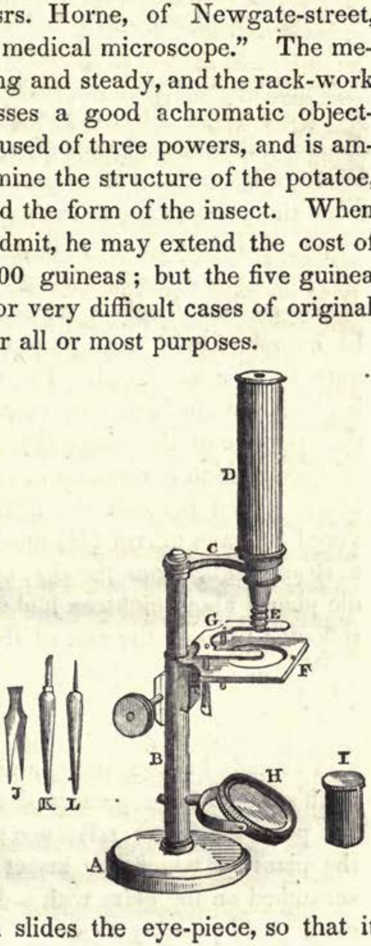
I must caution my readers against supposing that they will be able to find in a single day all the evidence which I have collected. They will have to traverse, as I have done, many miles to procure it, especially with relation to its existence in the rarer plants. It is only where the insect excessively abounds that many of the plants are affected; and so numerous are the creatures sometimes, that I have taken a lid of a pill-box, and scooped up half a box full of the winged creatures from a single leaf of the beet plant. Their number in some cases has exceeded all description; and there was a little field in the Old Kent Road, surrounded by houses, which presented a wonderful living mass of these creatures.

The migratory habits of the insect will sometimes perplex the investigator; for, upon searching over a tract of land, he may find none of these creatures; yet, upon a more careful scrutiny, the ichneumoned remains which are still to be seen adhering to the leaf, will bear sufficient testimony of the previous existence of the destroyer.

The examination of the plants for the Vastator may be performed with the naked eye, though the more minute investigation of the insect itself doubtless requires a glass. The agriculturist should procure a small pocket glass, with lenses of three focal distances, which he can procure for five shillings.

He should also possess a microscope of higher power, to examine more minutely the parts of insects. These can be bought for twenty-five shillings, but I should certainly recommend him not to give less than five guineas for an instrument. I have carefully examined a microscope which is manufactured at that price by Messrs. Horne, of Newgate-street, which he calls the "medical microscope." The mechanical part is strong and steady, and the rack-work excellent. It possesses a good achromatic object-glass, which can be used of three powers, and is amply sufficient to examine the structure of the potatoe, the various fungi, and the form of the insect. When circumstances will admit, he may extend the cost of the apparatus to 100 guineas; but the five guinea instrument, except for very difficult cases of original research, will answer all or most purposes.

This instrument is represented in the engraving set up ready for use; and consists of a firm brass foot (A), into which is screwed the pillar (B), having at the upper part a fine rack-work for adjusting the focus. At the top of the pillar is a brass arm (C), holding the body of the microscope (D), consisting of a brass tube, in the upper part of which slides the eye-piece, so that it



may occasionally be withdrawn for the purpose of cleaning the glasses, which is best done with a piece of soft wash-leather; the lower end of the body (D) has a screw, to which is attached the achromatic object-glass (E). The object-glass consists of three distinct achromatic lenses of equal foci, mounted in brass cells, so that one or more can be used at the same time, according to the power required: for example, if the whole of a large object is required to be seen at one view, a single achromatic must be employed, but if only a particular part is desired to be examined with a high power, then two or three must be used combined. The object to be examined is placed on the concave piece of glass, which fits the aperture of the stage (F), or else on a flat strip of glass, which is retained in its proper position by being placed beneath the brass fork (G). The silvered concave mirror (H) must be so arranged that a strong light from the sky, or from a lamp or candle placed about eighteen inches from the mirror, is reflected through the axis of the microscope.

Whenever I found a plant infested by an Aphis which appeared to be the vastator, I secured specimens of it in a pill-box, and in the evening placed it in Canada balsam, and examined it more carefully. In this way I have preserved all my evidences upon this point for future reference; and as the name of the plant on which the insect fed was immediately scratched on the glass with a diamond, no source of error could possibly arise.

The mode of fixing the insect in Canada balsam is very simple: a slip of glass is warmed over a candle, and a drop of the balsam is then placed upon it; the insect, whilst yet alive, is placed on the balsam, and the glass is then again very gently warmed, in order to kill the insect; another piece of the glass is then heated over a candle, and placed on the insect, when the creature will be hermetically sealed up for ever. It is necessary that the insect should be dry when it is mounted, and we must take especial care not to apply too much heat, which will corrugate the antennæ, and destroy the form of the insect.

The strips of thick, and pieces of thin glass, I always procured of Mr. Topping, No. 1, Penton-place, Pentonville-hill, who is moderate in his charges and exceedingly obliging.

I strongly recommend to all entomologists this mode of preserving small insects, and having once properly secured them, they will last for an indefinite period, and can be handled without the slightest risk of injury.

It is admitted on all hands that the disease in the potatoe plant itself is a local or general death. Now the death of a plant may arise from ten thousand causes, independently of the present cause, which is effecting the total destruction of the potatoe plant. Under these circumstances, in conducting our investigations, we must isolate solitary causes of death, and confine our attention to the particular agent which so universally affects the potatoe plant. A plant may die from heat, from cold, from light, from darkness, from electricity, from moisture, from dryness, from improper soils. We isolate all these causes by finding, that, under all variations of their influence, the disease more or less appears; we isolate the effects of vegetable fungi, by showing that they do not appear till the plant is damaged.

With regard to animal parasites, we discover one particular Aphis which comes before any part of the plant exhibits the malady. But here, again, in the potatoe plant, we have other sources of error. A diseased plant propagates its disease; hence we must prove previous health before we can show that the insect comes before the disease.

We then look about other plants, and find that they are also attacked by the same Aphis; and that when they are so attacked, the same effects are manifested. The mode of death is also precisely similar in these plants to that in the potatoe; for, in all cases, the collar of the plant becomes swollen with watery matter and dies; and thus the root is separated from the leaf, and the entire plant perishes.

In all these cases the vastator is the antecedent, and the death of the plant the consequent, of the malady. We desire naturally to inquire whether this injurious action is confined to one species of Aphis; and we find large trees destroyed, and other useful crops annihilated by other species.

Here we have our argument strengthened by analogical cases; but we are naturally led to inquire why this creature should do this mischief particularly at the present time ; and the answer at once is, that there is a preternatural abundance of these creatures. If we search historical records, we find that insects are very prone to assume these periodic multitudinous appearances ; and what is most strange is, that they almost totally disappear between the times of their occurrence.

All these facts I have fully described, and have thus proved unquestionably and beyond a doubt that the vastator is the cause of the present disease in the potatoe plant ; that it is also the cause of the present disease amongst various other plants ; that it is like all other Aphides in its destructive character ; and, lastly, that the preternatural appearance of insects is, and has been, a common and universally known fact from the earliest ages.

Pl. 2.

Fig. 1.

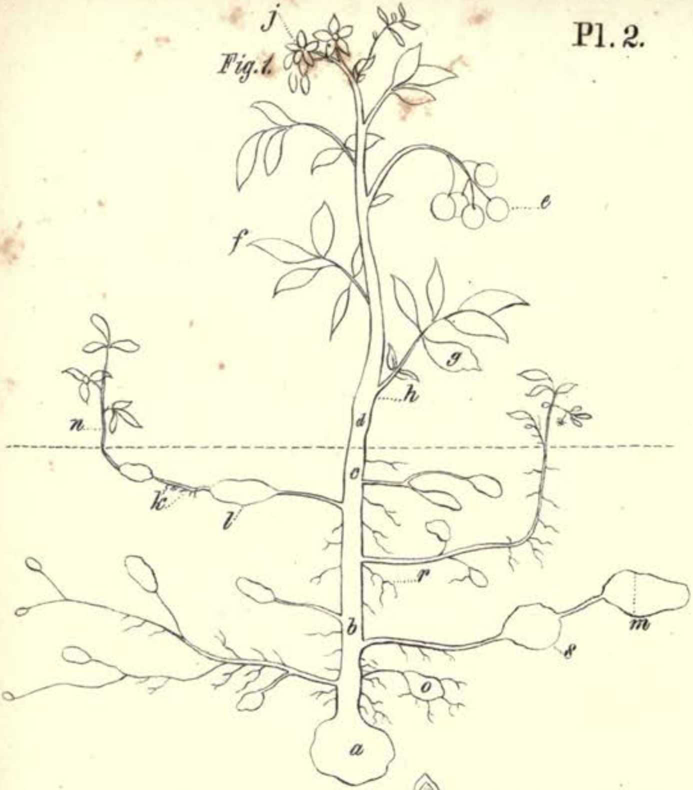
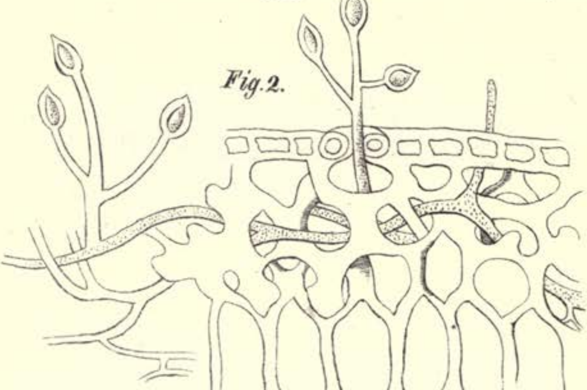


Fig. 2.



GRATACAR DE

THE POTATOE,

ITS USES AND PROPERTIES.

CHAPTER I.

ON THE POTATOE PLANT.

Parts of Potatoe plant (1); set (2); stalk (3).—Under-ground stem and tuber (5–7); roots (8); haulm (9); flowers and fruit (10).—Essential parts of plants (11, 12).—Ultimate parts of potatoes (13–16).—Origin of starch (17).—Origin of nitrogen (18).—Motion of sap (19, 20).—Experiments on Endosmosis (21).—Quantity of water imbibed by roots (22).—Resumé (23).

(1.) The perfect potatoe plant (plate II., fig. 1) consists of a set, or original potatoe, under-ground stem, tubers, roots, above-ground stem, leaves, flowers, and fruit.

(2.) The set, or original potatoe plant, from whence the rest of the plant proceeds, is derived from a former plant, this from one antecedent, and in this manner we might trace it up to the first potatoe which existed on the earth's surface. There is no occasion to suppose that a potatoe plant has had in all cases such an extensive existence, for we may trace the set to a former plant, and that former plant may have been derived from the potatoe-seed, which I shall hereafter more fully describe.

(3.) From this set, or original potatoe, a stalk or stem proceeds, which takes its course towards the light, and becomes the haulm or stalk of the plant. The stalk proceeds from that part of the set called the eye, which is to the potatoe what a bud is to a tree. From a potatoe three or more large stalks will grow; and, if these are successively removed and separately planted, the number of plants which one potatoe will produce is almost incredible.

(4.) In consequence of the set being usually below the ground, and the shoots having a tendency to grow towards the light, part must be below the earth's surface, whilst the other part extends upwards and expands its foliage to the atmosphere.

(5.) From that part below the earth's surface other stems proceed, which are termed under-ground stems, though perhaps they should rather be called the tuberose stems, because it is upon these that the tubers or potatoes are found.

(6.) These tuber-bearing stems, starting from the main stem, become dilated at certain intervals, which dilatation is the potatoe. This has, at certain parts, eyes or buds, from whence the new plant grows.

(7.) From the potatoe the stem extends itself, and creeping upwards through the ground, at last becomes a stalk or above-ground stem, sending off in its turn other tuber-bearing stems below the surface of the ground, and having on its upper part foliage, as in the case of the primary stem.

(8.) The original stem, together with the primary and secondary tuber-bearing stems, has fine filaments running from it in the ground, which are the true roots of the plant, performing the same functions as the roots of other plants, and which are totally distinct from the underground stem.

(9.) The stalk or haulm divides into branches, and to these the leaves are attached. The leaves themselves consist of a series of leaflets, each leaflet being attached by a fine stalk to the main stalk of the leaf; and at the axil of each leaf is a bud, from whence the potatoe plant may be propagated as well as from the eye of a tuber. Sometimes a potatoe or tuber is developed at the axil of the leaf.

(10.) Besides these various parts, the plant sends forth flowers which in time produce fruit, and this fruit is termed the potatoe apple. The potatoe apple consists of a pulpy envelope containing small seeds, from which also plants may be raised.

(11.) Such are the parts of which the potatoe plant is made up in reality. However, we might consider the plant in a more simple manner, for its only essential parts are the leaves and roots, with the intervening stems. The tubers are mere dilatations of the stem, and the flowers and fruit are the result of certain conditions of the plant, and are destined to perform the offices of reproduction.

(12.) Regarding a plant in this point of view, we have an organic body with certain parts bearing definite relation to each other. The root takes up moisture and earthy salts from the ground; the leaves separate carbon, and send back woody fibre to the root.

(13.) The potatoe plant, like all organic bodies, consists of a solid and a fluid portion. The solid portion gives form, tenacity, and firmness to the plant, and is composed of matter arranged in the form of cells, and is hence called cellular tissue.

(14.) These cells contain the fluid, or sap, which, when influenced by the external agency of heat, light, and electricity, undergoes various changes essential to the vitality of the plant.

(15.) These changes can only take place when the sap is in proper relation to the cellular tissue, and both are acted upon in a proper manner by heat and light. Upon these changes depends the life of the plant; and the moment these changes, from any cause, cease, other changes, those of putrefaction, ensue; the plant loses its organic existence, and is obedient to the laws which govern inorganic bodies.

(16.) Perhaps one of the most curious facts connected with vegetable physiology is, that a whole plant must not be subjected equally to these external forces—one part must be subjected to the light more than another; and this singular circumstance gives us the idea of a root and leaf, the one creeping into dark and moist recesses, and the other seeking the all-important influence of the sun's rays.

(17.) The starch deposited in the dilated stem or tuber, is, doubtless, produced by the leaves, and acts as a source or store-house of nutrition, from which future fibre may be formed. It is not itself to be regarded as a perfect material, but as a temporary substance deposited for the future exigences of the plant.

(18.) The mode in which plants procure their nitrogenized substance, or albumen, does not appear quite clear. It is possible that the nitrogen may become fixed from the air, or it is possible that it may be derived from the earth in which the plant grows.

(19.) The mechanism whereby the fluid rises and the solid part descends, is not certainly ascertained; eventually, probably, we shall find that it is due to some very simple law. The phenomena of endosmosis may explain many of the facts which we observe.

(20.) Various theories have been propounded with respect to the cause of the motion of the sap, but a very simple experiment will show how water may be taken from the earth, and how the solid material may be sent back to the root through the same vessel, and in fact how both operations may proceed at one time.

(21.) To explain this phenomenon, take a tube having a rim at one end, and tie a piece of goldbeater's skin over the rim. Into this tube put a solution of chloride of calcium, sugar, or indeed of almost any body which will add to the specific gravity of the fluid, and then immerse the tube in a glass of pure water. After a short time the water will pass into the tube, and at last run over like the bleeding haulm. The leaf may be imitated by a piece of blotting paper; and it is possible exactly to regulate the amount of attraction to the evaporation. The descent of the salt or sugar, like that of the solid material descending from the leaf, may be proved by examining the glass of water, when it will be found that the solid matter has descended, in spite of the powerful ascending current which is opposed to the force of gravitation.

(22.) To show the extent to which the potatoe draws water from the earth, Marshall states, that, "on observing the place where the haulm was cut, he found wet places covered with vegetable blood, and that the stems bled profusely. On examining it more accurately he noticed that each stem exhaled seven hundred and twenty drops in twenty-four hours, and continued for about seven days, giving off in drops two pints and a half of liquid in that time. Upon this, calculating the number of stems in one acre of land, he concluded that five tons of liquid were exhaled daily, and that in a week they carried into the atmosphere a sheet of water equal to their own superficies, and one-third of an inch in thickness.

(23.) Avoiding theories, I desire to impress upon my readers in this chapter, that a root and a leaf are required for the perfect potatoe plant, and that these two parts bear important relation to each other, for the continuance of the vital action between the sap and cells.

CHAPTER II.

INDIVIDUALITY OF THE POTATOE PLANT.

Individuality of the potatoe plant (24).—Plurality of individuals (25).—Individuals are seedlings (26—29).—Duration of individuals (30).—Potatoe botanically considered (31).—Gerard's description (32—34).—Introduction of potatoe (35, 36).—Wild potatoes (37).—Humboldt's account (38, 39).—Meyer's account (41).—Don Jose Pavon (42).—Caldcleugh (43—46),—Chelsea wild root (47—49).—Uhde (50).—Origin of our varieties (51).—Number of (52).—Propagation of (53).—Selection of (54).—Analogies of varieties (55, 56).—Sweet potatoe (57—59).—Origin of name (60).—Resumé of the chapter (61).

(24.) The potatoe plant which I have described is an individual, propagating its individuality or peculiarity from potatoe to potatoe, and which peculiarity cannot be materially affected by external agents. If we propagate one kind of potatoe for several years, it still remains the same kind; and although millions of potatoes have been raised from the original parent plant, yet the millionth potatoe is but an extension of the first plant of that peculiar kind.

(25.) We have, however, many kinds of potatoes, and, therefore, many individuals which we have preserved and propagated, because their individual peculiarities have been found to be most serviceable to the wants of man.

(26.) These kinds of potatoes are seedlings, and each seedling is a distinct individual, which, although it may follow the general law of the transmission of peculiarities from parent to offspring, is yet always liable, after a few generations, to revert to the original type, whence all the varieties came.

(27.) When persons are desirous of raising new kinds of potatoes, they sow seed and collect the produce. If any one plant is particularly good in quality, they specially preserve it; and so long as this plant is propagated by the tubers, the distinctness or the excellence of the kind is preserved.

(28.) When you are desirous to raise potatoes from seed, collect the apples in autumn when they will fall spontaneously; preserve them in sand till spring; sow in fine garden mould; transplant, as soon as the young plants are strong enough, into other mould, and keep clear from weeds. The tubers of the first year are as big as a nut or walnut; those of the second year attain a middle size; and in the third or fourth full-sized tubers are produced.

(29.) This mode of raising choice potatoes is similar to that of raising all other vegetable varieties; for the delicious Ribston pippin is but a seedling variety of the common crab ; and the large strawberries now supplied to the London market are but seedlings of the little Alpine.

(30.) The duration of the life of an individual potatoe is altogether unknown, for it is uncertain whether a single plant is capable of being indefinitely propagated, or whether after a certain time it becomes feeble, and ceases to live from mere old age. There is a strong feeling generally in favor of this latter hypothesis with gardeners and farmers.

(31.) The potatoe plant belongs to the nightshades, or genus *Solanum*, and is called botanically the *Solanum tuberosum*. It is grouped in the same natural family with very many poisonous plant's, such as the tobacco, belladonna, stramonium, henbane ; aad the plant itself contains a poisonous ingredient, which I shall hereafter describe.

(32.) The first figure of a potatoe is to be found in Gerard, Herbal (1597). He there calls it *Batata Virginiana*. He states that "the root is thick, fat, tuberous, not much differing in shape, color, and taste from the common potatoe, saving that the roots hereof are not so great nor long ; some of them are as a ball, some oval or egg-fashion, some larger, some shorter, the which knobby roots are fastened into the stalks with an infinite number of thready strings. (Plate 1.)

(33.) "It groweth naturally in America, where it was first discovered, as report says, by Columbus, since which time I have received roots hereof from Virginia, otherwise called Nurenbega, which grow and prosper in my garden as in their own country.

(34.) " The Indians do call this plant ' pappas,' meaning the roots, by which name also the common potatoes are called in those Indian countries. We have the name proper to it mentioned in the title, because it hath not only the shape and proportion of potatoes, but also the pleasant taste and virtues of the same: we may call it in English, 'potatoes of America or Virginia.'"

(35.) In 1693 Sir Robert Southwell informed the Fellows of the Royal Society that his grandfather introduced potatoes into Ireland, and that he first had them from Sir W. Raleigh. He probably, however, only had that statement by tradition, and therefore I attribute very little value to the fact, further than to show that about the time of its introduction it was commonly supposed to have come from Virginia. In confirmation of this statement, we must not forget that Sir Walter Raleigh gave the name to Virginia.

(36.) It is said that the potatoe was also imported into Italy about the same period from South America, and Clusius mentions that he received it therefrom. In all probability, the Papists, who early had a strong footing in that quarter of the globe, transmitted the root to the Pope. In those times the potatoe was esteemed as a provocative to lust.

(37.) The potatoe plant, however, does not grow wild in Virginia, nor in any part of North America; but in its natural state is only to be found on the western side of South America.

(38.) Humboldt states that "the plants which are cultivated in the highest and coldest part of the Andes and Mexican Cordilleras are the potatoes, the *Tropæolum esculentum* (page 448).

(39.) Humboldt also states (page 441) that "the potatoe is not indigenous in Peru, and that it is nowhere to be found wild in the part of the Cordilleras situated under the tropics. M. Bompland and myself herborized in the back and in the declivity of the Andes, from the 5° north to the 12° south, and informed ourselves from persons who have examined this chain of colossal mountains as far as the Le Pan and Oruro, and we ascertained that in this vast extent of ground no species of solanum with nutritive roots vegetates spontaneously. It is true that there are places not very accessible, and very cold, which the natives call 'Parana de las Papas.'"

(40.) Passing further southward beyond the tropics, we find that, according to Molina, in the fields of Chili, the natives distinguish the wild potatoe, of which the tubers are small and somewhat bitter, from that which has been cultivated for a long series of years.

(41.) Meyer observes, that "if the potatoe had migrated from Chili to Peru, it would probably have retained its Chilian name; but this conjecture is no longer necessary, for it grows wild in both countries. I myself have found it in two different places on the Cordilleras of these countries." Jenin and Pavon mention the mountain of Chancay as a station where the potatoe is to be found wild.

(42.) "Don Jose Pavon, in a letter to M. Lambert, says that *Solanum tuberosum* grows wild in the environs of Lima, and fourteen leagues from Lima on the coast; and I myself have found it in the kingdom of of Chili. And M. Lambert adds, 'I have lately received from M. Pavon very fine wild specimens of *Solanum tuberosum* collected by himself in Peru. In Chili it is generally found in steep rocky places, where it could never have been cultivated, and where its introduction must have been almost impossible. It is very common about Valparaiso, and Cruickshank has noticed it along the coast for fifteen leagues to the northward of that port; how much further it may extend north or south, he knows not.' "*

(43.) Caldcleugh, who had been some time resident at Rio Janeiro, holding the office of secretary to the British minister, brought with him two tubers of the wild potatoe, which he sent to the secretary of the Horticultural Society of London, with the following letter, which is to be found at p. 249 in the fifth volume of the Transactions of the Society.

(44.) " 'It is with no small degree of pleasure that I am enabled to send you some specimens of the *Solanum tuberosum*, or native wild potatoe of South America. It is found growing in considerable quantities in ravines in the immediate neighborhood of Valparaiso, on the western side of South America, in lat. $34\frac{1}{2}°$ south. The leaves and flowers of the plant are similar in every respect to those cultivated in England and elsewhere. It begins to flower in the month of October, the spring of that climate, and is not very prolific. The roots are small, and of a bitterish taste, some with red, and others with yellowish skins. I am inclined to think that this plant grows on a large extent of the coast, for in the south of Chili it is found, and is called by the natives *maglia*, but I cannot discover that it is employed to any purpose. I am indebted for these specimens to an officer of his Majesty's ship Owen Glendower, who left the country some time after me.'

(45.) "The two tubers were exhibited to the Society, and a drawing made of them before they were planted (plate ix., fig. 2, Hort. Trans., vol. 5). Had there been a third, I should have been tempted to have satisfied my-

* Hooker's Botanical Miscellany, as quoted in the Journal of the Royal Institution, 1831.

self as to the real flavor which Mr. Caldcleugh, as well as Molina, describes as bitter. They were planted separately in small pots, and speedily vegetated; they grew rapidly, and were subsequently turned out into a border at about two feet distance from each other, when they became very strong and luxuriant. The blossoms at first were but sparingly produced, but as the plants were earthed up they increased in vigor, and then bore flowers abundantly; but these were not succeeded by fruit. A drawing of a branch was made by Miss Cotton, which has been engraved (plate xii., Hort. Trans., vol. 5). The flower was white, and differed in no respect from those varieties of the common potatoe which have white blossoms. The leaves were compared with specimens of several varieties of the cultivated potatoe, which generally were rather more of a rugose and uneven surface above, and with the veins stronger and more conspicuous below, but in other respects there was no difference between them. The pinnulæ, which grew on the sides of the petiole, between the pinnæ of the leaves, were few, not near so numerous as in some varieties of the cultivated potatoe; but in specimens of other varieties that were examined, their leaves were destitute of pinnulæ, so that the existence of these appendages does not appear to be so essential a characteristic as has been supposed, and as is stated in the supplement to the 'Encyclopædia.'

"The plants have been recently taken up, and all doubt respecting them is now removed; they are unquestionably the *Solanum tuberosum*. The principal stems, when extended, measured more than seven feet in length. The produce was most abundant; above six hundred tubers were gathered from the two plants. They are of various sizes, a few as large or larger than a pigeon's egg, others as small as the original ones, rather angular, but more globular than oblong; some are white, others marked with blotches of pale red or white; two of these were selected to be drawn, and are represented (plate ix., fig. 3, Hort. Trans., vol. 5). The flavor of them when boiled was exactly that of a young potatoe.

"The compost used in moulding up the plants was very much saturated with manure, and to this circumstance I attribute the excessive luxuriance of the growth of the stems. Had common garden mould been applied, they would not probably have grown so strong; and I suppose, that whilst the plants were thus rapidly making stems and leaves, the formation of the tubers was delayed, for the production of these has been the work of the latter part of the season. They cannot be called fully ripe, nor have they attained the size which they probably might have done if they had been formed earlier."

(46.) I am informed by Mr. Thompson that this wild potatoe was lost from the Horticultural Gardens many years ago.

(47.) There is, at the Botanical Gardens, Chelsea, a fine plant, said to be of the wild potatoe, which Mr. Anderson informs me he obtained from Mr. Renegal, who procured it, together with some nasturtiums, from Santa Fe.

(48.) This plant has been in the garden about ten years, and bears tubers of a medium size, of a mottled white and red color. When cooked they have a high flavor, and are perhaps a little bitter: in other respects they somewhat resemble the new tubers of ordinary potatoes. When the plant was removed from the ground, its total length from the top of the stem to the end of the root was about eight feet. In this instance the amount of tubers was very small relatively to the size of the leaf, when compared with plants of other varieties.

(49.) This plant was characterized not only by this abundance of leaves, but was peculiar also, in having a great tendency to send forth numerous lateral shoots at the surface of the ground, which, spreading in all directions, become other above-ground stems.

(50.) Another wild plant has been received by the Horticultural Society from E. H. Uhde, Esq., from Michuacca and valley of Tolucco. It has the same tendency as that in the Chelsea Gardens to throw out lateral shoots from the collar, but it is not now above three feet high. The tubers from whence it was raised were about the size of a small walnut. They were planted in July, and were in flower in the middle of October; but up to that time no tubers were formed.

(51.) All our garden varieties which exist at the present time have probably sprung from Gerard's specimen (plate I.), or some of the same period; but it is very uncertain how the plant got to Virginia.

(52.) Miller gives forty-four species of potatoes. A potatoe grower enumerates one hundred and fifty-eight kinds, with their respective flavor, height of the stem, &c. At the Horticultural Gardens, Mr. Thompson informs me that they cultivate two hundred kinds, though perhaps not more than twenty varieties are commonly sent to the London market.

(53.) The peculiar kind of potatoe is maintained by an extension of the same individual from a bud. This bud may be either the whole tuber with its eyes, the eye of the potatoe alone with a small piece of tuber attached, a shoot from that eye, or a bud from the haulm, which will grow either by layering or from a cutting.

(54.) In the cultivation of the potatoe, man has especially in view the selection of those varieties the tubers of which are most developed. The tuber is the part employed for the purposes of man, and therefore he selects those varieties which will give the largest produce, and which are richest in starch.

(55.) These individual peculiarities which attach to the kinds or varieties of potatoes, are to the plant what idiosyncrasy is to the human being. Every man has certain constitutional peculiarities: some persons even die from the bleeding following trifling operations, others are poisoned by minute doses of mercury; some are short, others are tall, and in fact every one has something sufficient to distinguish him from his neighbors.

(56.) Every kind of plant evinces these peculiarities where every seedling is an individual. If we walk along a country road in spring, we find every thorn putting forth its buds at a different time; and the varieties are so marked in the horse-chestnut tree, that some individual plant will be many days in leaf before its neighbor has expanded its buds.

(57.) Our present potatoe must not be confounded with the potatoe in use before 1600. The potatoe then spoken of is the *Convolvulus batata*, or sweet potatoe, a convolvulaceous plant now in use in the West Indies.

(58.) It is this potatoe to which allusion is made in Shakspeare ("Let the sky rain potatoes") in the "Merry Wives of Windsor," act v., Scene 5; the word "potatoe" also occurs in "Troilus and Cressida," act v., Scene 2.

(59.) About the year 1600, and for some time after, the convolvulus potatoe is spoken of as the common potatoe, and our present potatoe is noticed as the new potatoe of Virginia. Now the tables are completely turned; the sweet potatoe is become the scarce one, being worth ninepence a pound, and frequently not to be procured, whilst the other is in every-day use.

An attempt is being made by Dr. Stewart to naturalize the sweet potatoe in this country. He planted his specimens too late this year, and therefore no tubers are formed, but it is not improbable that the early kinds may thrive here. Gerard grew them in his garden 250 years ago.

(60.) Our potatoe received its name from Gerard, in consequence of its general resemblance to the sweet tuber. This plant is also well figured by the same author.

(61.) In this chapter I wish particularly to enforce the fact that we are not using the wild plant, but an abnormal deviation from it; in fact, we are employing plants peculiar from the exaggerated quantity in which they produce tubers, and in which, notwithstanding the increase of tuber, the quantity of leaf is very materially diminished.

CHAPTER III.

CHEMISTRY AND USES OF THE POTATOE.

Ingredients of potatoe (62).—Analyses of potatoe (63, 64).—Solanine (65).—Starch (66).—Albumen (67).—Ultimate analyses of potatoe (68).—Gerard's description of (69).—Evelyn's (70).—Use of the potatoe (71, 72).—Relative value of potatoe (73).—Quantity required for food (74).—Phosphorus in potatoe (76, 77).—Aphrodisiac properties (78) —Iron in potatoe (79).—Modes of cooking (81).—Use of potatoe for bread (82).—Potatoe in wheaten bread (83).—Potatoe a medicine (84).—Extraction of starch (85—87). —Uses of starch (88—90).—Conversion of starch into dextrine (91); into sugar (92).—Potatoes used for the manufacture of spirit (93, 94).—Frosted potatoes used for spirit (95); for wine (96).—Potatoes for feeding cattle (97); sheep and swine (98).—Potatoe apples for salad (99).—Preserved potatoes (100).—Resumé (101).

(62.) The potatoe plant in a state of health contains several ingredients, the most important of which are starch, albumen, and solanine. These, however, do not exist in a concentrated form, but are united with a large quantity of water.

(63.) I have extracted from Dr. Ure's "Dictionary of Chemistry" the following table of

ANALYSES OF THE PLANT.

	Fibrin.	Starch.	Veg.Album.	Gum.	Acids and Salts.	Water.	Analyst.
Red potatoes	7·0	15·0	1·4	4·1	5·1	75·0	Einhof.
Id. germinated	6·8	15·2	1·3	3·7	—	73·0	,,
Potatoe sprouts	2·8	0·4	0·4	3·3	—	93·0	,,
Kidney potatoe	8·8	9·1	0·8	—	—	81·3	,,
Large red do.	6·0	12·9	0·7	—	—	78·0	,,

	Fibrin.	Starch.	Veg. Album.	Gum.	Acids and Salts.	Water.	Analyst.
Sweet potatoe	8·2	15·1	0·8	—	—	74·3	Einhof.
Potatoe of Peru	5·2	15·0	1 9	1·9		76·0	Lampart
" England	6·8	12·9	1·1	1·7		77·5	,,
Onion potatoe	8·4	18·7	0 9	1·7		70·3	,,
" Voigtland	7·1	15·4	1 2	2·0		74·3	,,
" cultivated in the environs of Paris.	6·79	13·3	0.92	3·3	1·4	73·12	Henry.

(64.) Pereira, in his valuable work on "Food and Diet," gives a full analysis of the potatoe by Michalles.

PROXIMATE COMPOSITION OF THE POTATOE.

Water	66 875
Starch and amiglaceous fibre	30·469
Albumen	0·503
Gluten	0·055
Fat	0·056
Gum	0·020
Asparagin	0·063
Extractive	0·921
Chloride of Potassium	0·176
Silicate, phosphate, and citrate of iron, manganese, alumina, soda, potash, and lime (of these potash and citric acid are the prevailing ingredients)	0·815
Free citric acid	0·047
	100 000

(65.) The solanine exists principally in the leaves and stem, and perhaps in the root to a very small extent. It is composed, according to Blanchet, of

Carbon.	Hydrogen.	Nitrogen.	Oxygen.
62·11	8·92	1·64	27·33

(66.) Starch exists in the plant in the form of rounded, elliptical, or polyhædral granules, each of which has a little spot called the hylum, by which it is supposed to be attached to the cell of the plant. (Plate v., fig. 5, Plate vii., fig. 8.) The starch granules consist of concentric rings or rugæ, similar to those which starch cells present on their surface. Potatoe starch consists of carbon 44·25, water 55·75. The quantity of starch differs in different months, and the size of the granules varies from the $\frac{1}{4000}$ to the $\frac{1}{300}$ of an inch.

	lbs.		lbs.
In August, about . .	10	In March	17
In September . . .	14½	In April . . .	13¾
In October . . .	14¾	In May	10
In November . . .	17		

(67.) I am not aware that any good analysis of potatoe albumen has been published; but from analogy we may suppose that it consists of carbon, hydrogen, nitrogen, and oxygen. It exists in the potatoe plant in a state of solution, and separates spontaneously by coagulation from the expressed juice.

(68.) Regarding the potatoe in a more chemical manner, we find that, according to Boussingault and Bæchmann, it is composed of the following ultimate elements:—

	Boussingault.	Bæchmann.
Carbon . .	44·1 . .	43·944
Hydrogen .	5·8 . .	6·222
Nitrogen—Oxygen .	45·1 . .	44·919
Ashes . .	5·0 . .	4·915
	100·0	100·000

(69.) Gerard says "that the temperature and vertues be referred unto the common potatoe (meaning thereby the sweet potatoe, the only root known before this period), being likewise a food as also a meat for pleasure, equal in goodness and wholesomeness unto the same being either roasted in the embers or boyled and eaten with oyle, vinegar, and pepper, and dressed in any other ways by the hand of one cunning in cookeries;" so that at first it was used as a luxury, and not as an article of food.

(70.) Evelyn states, "the root being roasted under the embers or otherwise roasted, with a knife the pulp is buttered, in the skin of which it will take up a good quantity, and is seasoned with a little salt and pepper. It is also stewed and cooked in pyes."

(71.) The potatoe is valuable to man as an article of food, from the starch and albumen which it contains, as these two principles can effectually nourish the human being. The one acts by combining with oxygen in his lungs to give him warmth; the other nourishes his muscular system and fits him for labor.

(72.) Neither principle alone would suffice, for man would starve upon either one; it is the combination then which is valuable, and we find that this combination cannot be produced at so cheap a rate from any other source.

(73.) The nitrogenized portion is the most costly to buy, and we find that the relative value of the potatoe, in point of weight with other substances, is as follows:—

Wheat flour	100	Maize, or Indian corn	138
Barley	130	Peas	67
Oats	117	Potatoes	613
Rye	111	,, dried at 212°	126
Rice	177	Jerusalem artichokes	539
Buck wheat	108	Turnips	1338

These are termed nutritive equivalents, 613 parts of potatoe being equal to 100 wheat flour, &c.

Taking female milk as the standard, and making it 100, MM. Schlossberger and Kempt have given the following scale of the nitrogen contained in different varieties of food, which will show the relative value of the potatoe for this purpose :

Female milk 100

VEGETABLE FOOD.

Rice	81	Black bread	166
Potatoes	84	Bread from Glasgow	134
Turnips	106	Beans	320
Rye	106	Peas	233
Maize	100—125	Pulse	276
Oats	138	French beans	283
Barley	125	Three species of agaricus respectively	289
Wheat	119—144		264
Wheat bread	142		

ANIMAL SUBSTANCES.

Cow's milk	237	Veal	873
Cheese	231—447	Veal boiled	911
Yolk of egg	305	Beef	880
Oysters	305	Beef boiled	942
Eels	434	Pure protein	1006
Salmon	776	Pure albumen	996
White of egg	843	Pure fibrin	999
Flesh of pigeon	756	Pure casein	1003
Flesh of lamb	833	Pure gelatin	1028
Flesh of sheep	773	Pure chondrin	910
Flesh of sheep boiled	952		

(74.) From certain experiments made at Glasgow, it was found that six pounds of potatoes alone were amply sufficient for the food of a man per diem ; now this costs 1¾*d.*, which is probably the least possible cost at which a man could be fed in ordinary times. An Irishman in health and activity is said to eat from ten to twelve pounds of potatoes per diem.

(75.) I have been for some months past trying experiments with fowls upon the value of various foods for nutrition, but in the instance of the potatoe could obtain no result. The fowls ate the boiled potatoes ravenously for a few days, and then absolutely refused them. 10 lb. of potatoes appeared to go as far as one quart of wheat.

(76.) Potatoes also contain a large quantity of phosphorus, which is supposed to act as a stimulus to the nervous system. The following table from Pereira shows the relative quantities contained by the potatoe and some other substances:—

Potatoe	2·5		
Wheat	0·792	to	1·98
Barley	0·22	to	1·32
Oats	0·352	to	1·32
Rice	0·286	to	0·88

(77.) Burnet mentions that the potatoe is remarkable for becoming phosphorescent during putrefaction, affording even light sufficient to read by. An instance in point is mentioned in the "Edinburgh Philosophical Journal," in which it is related, that an officer on guard at Strasburg thought the barracks were on fire, so great was the light emitted from a cellar filled with potatoes which were in an incipient state of decomposition.

(78.) It appears that Clusius had the potatoe from the Pope's garden, the Pope having received it from South America. In those times it had a great reputation for its aphrodisiac properties, and therefore it is especially to be avoided by monks, nuns, popish priests, and others who think fit to make vows of celibacy.

(79.) Iron also is contained in the potatoe, and adds materially to its value as an article of food, that metal being always required as a constituent of the blood.

(80.) We thus perceive that as an article of diet the potatoe is invaluable, as it contains hydrogen, carbon, nitrogen, phosphorus, sulphur, iron, and lime; all elements required for nutrition.

(81.) Potatoes can be cooked either by boiling, steaming, baking, or frying, the only point requiring attention being the application of the heat, which should be managed in such a manner that all parts may be cooked equally, and not one part overdone before the other is warm.

(82.) Potatoes may be made into bread according to Parmentier. He first boils them and reduces them to a very fine tough paste by a rolling-pin, and then mixes with this an equal weight of potatoe starch. He states that this mixture makes a very white, well raised, pleasant bread.

(83.) Wheaten bread in London generally contains potatoes, and I am informed that they are used in the following manner:—The potatoes are generally placed in cold water and boiled for one hour; they are then taken out and well mashed; a quantity of warm water is then added with the yeast, and this is allowed to stand four or five hours. The mixture is then strained through a fine sieve, and half the flour is added, and worked up to form a sponge. This sponge is allowed to stand about six hours, after which it is made into bread. Donovan states that 4 cwt. of flour will bear 5 stone of potatoes. Potatoes are also used for boiled and baked puddings, cakes, &c.

(84.) Not only for food, but also as a medicine, is the potatoe valuable. It is found of great efficacy when used for scurvy; and Dr. Baillie has lately discovered, at the Penitentiary, that its efficacy is not impaired by boiling.

(85.) The starch of the potatoe is used in the arts for various purposes. "To extract it the potatoe should be grated fine (a piece of iron pierced with holes makes a good grater), and on a first attempt I found that 10 lb. weight will be grated by a boy in twenty-five minutes. A crushing machine would be preferable where large quantities have to be treated. The pulp should be thoroughly washed in water, and the whole strained through a very fine sieve several times, when the starch and soluble matters will pass through; and after standing a short time, the starch, by its superior weight, falls to the bottom. The separated liquor should be poured off, and the starch mixed successively with several quantities of water till the water becomes quite tasteless. The starch should then be dried in a warm room, and thus prepared will keep for a long period."

(86.) Various machines have been contrived for performing the operation of rasping potatoes with rapidity, one of which, invented by St. Etienne, is said to be capable of preparing eighteen cwt. per hour.

(87.) The starch is much used in the preparation of calicoes, but every judicious housewife will buy that unstarched. To detect starch in calico, apply a drop of solution of iodine in iodide of potassium; this shows the presence of starch by striking a deep blue color.

(88.) Potatoe starch is often sold under the name of English arrow-root, and is probably often sold for the true arrow-root, being applicable to the same purposes. According to Christison it is more apt to cause acidity. It is used by the cook in the preparation of *soufflés*, and sometimes as a substitute for wheat flour in thickening sauces, &c., on account of its being both cheap and tasteless.

(89.) The refuse of potatoe from starch making is employed, according to Loudon, for cleansing woollen clothes without injuring their color; and the liquor decanted from the starch is excellent for cleaning silk without doing the smallest injury to the color.

(90.) Potatoe starch may be converted into dextrine, or British gum, by merely heating it. This substance is now largely used as a substitute for gum-arabic, and a familiar example of this is furnished by the postage-stamps, which are said to be gummed with potatoe dextrine. Dextrine is composed, according to Marcet, of carbon 35·7, hydrogen 6·2, oxygen 58·1.

(91.) Potatoe starch is converted into sugar by means of acid. To effect this, a pound of starch may be digested in six or eight parts of distilled water, rendered slightly acid by two or three drachms of sulphuric acid. The mixture should be simmered for a few days, fresh portions of water being occasionally added to compensate for the loss by evaporation. After this process the acid is to be saturated with a proper proportion of chalk, and the mixture filtered and evaporated to the consistence of syrup: its taste is sweet, and by purification in the usual way it affords granular sugar.

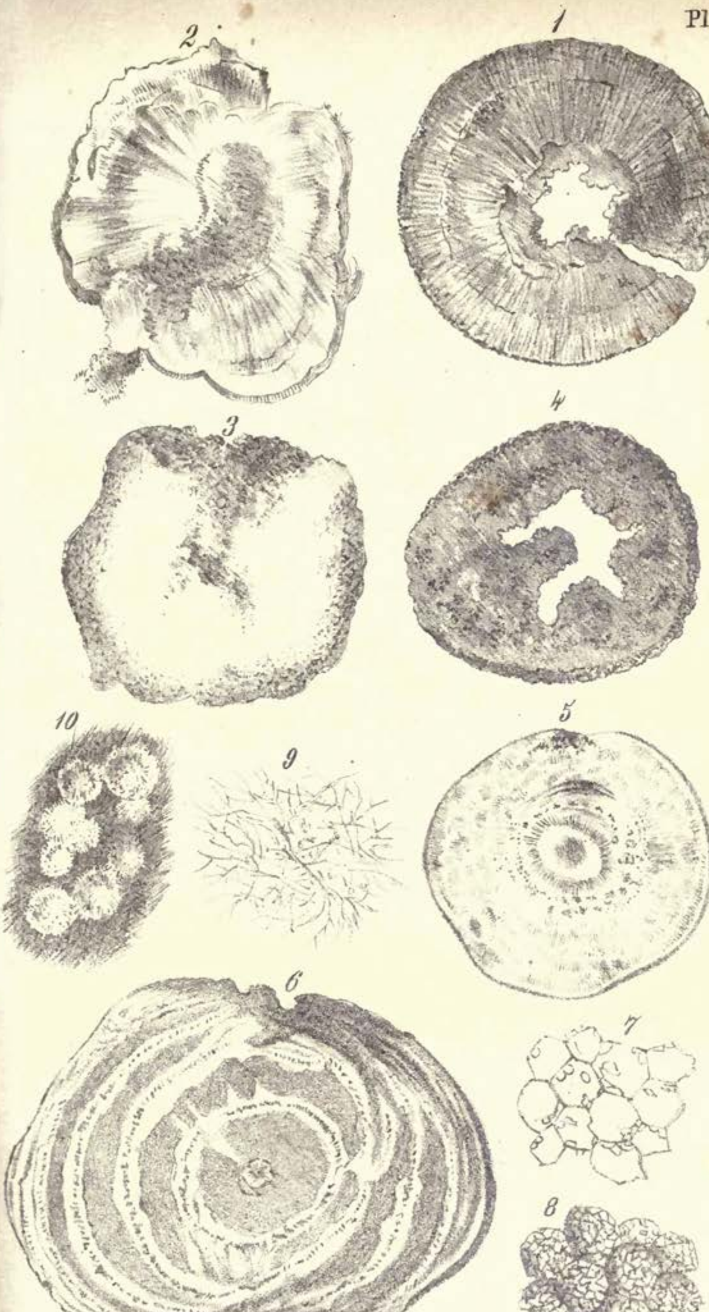
(92.) This sugar is manufactured at Bow, but it contains sulphate of lime, which gives it an offensive bitter taste. It is employed to adulterate the sugars sold by grocers at a very cheap rate.

(93.) Potatoes may be employed for the preparation of alcohol, and Donovan states that there are large manufactures for that purpose in France; and Cadet states that 100 lbs. of potatoes will afford 30 lbs. of spirit. The alcohol may be obtained either by fermenting the potatoes without any previous preparation, or from sugar previously made from starch.

(94.) The process is not followed by any distiller at present in the United Kingdom, for several reasons; first, because it would cause an outlay of several thousand pounds for extra utensils and machinery to carry on the process; secondly, because the spirit produced from potatoes is not so good as that produced from corn; and, lastly, because our revenue laws compel us to produce as much spirit from wash made from potatoes as from wash made from sugar, or 25 per cent. more than from wash made from corn. Thus, 100 gallons of wash at 50° of gravity is charged from attenuation at the rate of ten gallons of spirit to be produced; and for any quantity above that made or produced the duty is charged on the additional quantity of spirit; but from 100 gallons of wash at 50° of gravity, made from *any other* material than corn, twelve and a half gallons of spirit are charged, whether that quantity be produced or not. Thus, if we were working from potatoes on an extensive scale, we might have to pay thousands of pounds of duty annually for spirit which we could not produce. There was a potatoe distillery erected near Vauxhall turnpike about fifteen or twenty years ago by a company of Frenchmen; but they only worked about two months, when they became insolvent, in consequence of being charged by the excise with much more spirits than they could possibly make from potatoe wash.

(95.) Even frosted potatoes may be employed for the production of ardent spirits; and it is said that three bushels and a half of potatoes afford the same quantity of spirit as one of malt.

(96.) It is said that good wine may be made from frosted



On Stone by Gratacap.

Printed by H. B. Robinson.

potatoes, but I should think that the drinkers could be no great epicures. The action of frost, no doubt, generates sugar in the decaying tuber.

(97.) Potatoes, especially the coarser kinds, are employed for feeding cattle. Milch cows, however, when thus fed, are supposed to give large quantities of milk, but of an inferior quality.

(98.) They are also employed raw for feeding sheep; for swine, however, they are more generally steamed or boiled. In some places poultry are fed with them, and very commonly with the addition of butter-milk.

(99.) A very curious use of the potatoe plant is given by John Evelyn, which now doubtless has become obsolete. "The small green fruit, when about the size of the wild cherry, being pickled, is an agreeable sallet."

(100.) The Mexicans, like the Peruvians, can preserve potatoes for whole years by exposing them to the frost and drying them in the sun. The root, when hardened and deprived of water, is called *chama*.

(101.) Such are the various purposes for which the potatoe is employed, and so valuable to man are its uses, that the plant has had an extraordinarily extensive range of cultivation. Humboldt states that it is found from the southern extremity of Africa to Labrador, Iceland, and Lapland.

CHAPTER IV.

ON THE GANGRENE OF THE POTATOE, OR PRESENT DISEASE IN THE PLANT.

Disease of potatoe (102).—Mortification (103).—Commencement of and propagation in leaves, stalks (104—107); in under-ground stem (108); in collar (109).—Modes of proceeding (110—113); in tubers (114); in seeds (120).—Odor in (121).—Dryness of leaf in (122).—Diseased plants (123).—Plants not injured (124); afterwards die (125).—Primary effect (126).—Entire plant diseased (128).—Top of haulm left (129—132).—Continuity of disease in future plants (132).—Period of growth when affected by disease (134—136).—Diseased potatoes bad (136).—Structure impaired (137).—Decomposed (138—141).—Irregular cavity (142, 143).—Shrivelling of (143.)—General character of alteration (144).

(102.) THE potatoe plant has lately become the subject of a peculiar disease, by the operation of which a larger or smaller part of the plant loses its proper characters and dies.

(103.) This disease is mortification, or gangrene, in the truest sense of the term, and presents itself for our consideration under two varieties, as *gangrena sicca*, or dry gangrene, where the part shrivels up and becomes quite hard and desiccated, and *gangrena humida*, or moist gangrene, by which the potatoe becomes disorganized by rotting, and is wet and offensive.

(104.) Upon examination we find that this gangrene may commence in various parts of the plant, and produces consequences important to the vitality of the plant, commencing at the spot which it first attacks. It may attack a part of a single leaflet, which may dry and become dead. It may even commence at any portion of the leaflet —in the centre forming a little dry circle, which may become a simple hole; or it may commence on one side, or round the edge of the leaflet. (Plate v., fig. 4.)

(105.) In some cases the gangrene is propagated down the leaf-stalk, thus cutting off nourishment from the other leaflets, which then die from secondary causes, being thus as completely isolated as if they had been removed from the plant by the gardener's knife.

(106.) From the leaf it may be propagated down the stalk, and in this way cut off the supply from other entire leaves, or even from whole stems, which, from their having no nourishment, must perish.

(107.) At other times the malady attacks the base of the leaflets in the first instance, and thus cuts off the leaf from further nourishment. It may in the same way attack any part of the stalk, and cause the death of the part above it.

(108.) Very frequently it is first found in the underground stem of the plant, or those parts of the principal stem which are situated below the earth's surface. In this instance the supply of nourishment is entirely cut off from the upper part of the plant; and the top will frequently die from this cause, as rapidly as if it had been mown down with a scythe.

(109.) It is from this cause that potatoe plants in a green succulent state seem at certain times prematurely to wither up in a few hours. The stems, separated from the root by the action of the disease, are sometimes filled with water by a little rain or heavy dew, which renders them fresh and beautiful to the sight. They are sometimes exposed to a sultry sun, when they will wither and die. In this case I have observed a most striking difference between the plants in the morning and evening, and in two or three days I have seen the whole crop die down and rot away.

(110.) Previously, however, to the collar of the plant actually exhibiting the gangrene, it swells, and is much distended with water, and if scratched with a nail at this time the preternatural wetness is more apparent. This fact is of very general occurrence; and it is not only shown in the potatoe, but in all other plants affected by this disease, which I shall hereafter have to describe.

(111.) I am not quite certain whether the over-distended cells burst, or whether they die in consequence of the excess of the aqueous material; but I am confident that this distension is speedily followed by the destruction of the part.

(112.) When, however, the malady does attack the plant in this vital situation, it is not necessarily so destructive, for a portion only of the under-ground stem may perish. In this case the effect upon the leaves and above-ground stems is more limited, and the leaves will partially die.

We have thus seen that the disease has two general modes of proceeding; in one of which the disease proceeds from above downwards, in the other the plant is affected from below upwards.

(113.) In either case the tube-bearing stems eventually take on the gangrene, and the tubers become isolated from the roots, the leaves, and other parts of the plant.

(114.) The tubers themselves at last become more or less diseased, and sometimes the disease may be seen extending from the tuberose stem to the tuber. In some cases I have noticed the disease to commence in the new tuber itself, where the potatoe has formed new tubers without roots, stems, or leaves.

(115.) When the tuber is affected, parts here and there become soft, discolored, and rotten. Under certain circumstances this altered material becomes dry, passing into a state of dry gangrene; in other cases it remains soft, or in the state of moist gangrene.

(116.) The disease does not always commence at the external surface of the tuber, for it is frequently seen a short distance inwards, forming an irregular circle of disease. This fact was so well known, that I observed that potatoe salesmen in the low districts were accustomed last winter to exhibit a cut potatoe, to show to the buyer its general condition.

(117.) The part decidedly most liable to disease is that which lies between the bark and an irregular circle, which a section of a potatoe always presents. This circle is formed by a layer of spiral vessels, which contain air having seven or eight per cent. more oxygen than atmospheric air. (Plate VII., fig. 3.)

(118.) At times the ravages of the gangrene are not confined to this incipient spot, but the entire potatoe suffers and becomes disorganized as the disease continues to advance.

(119.) Occasionally, moreover, after the lapse of a longer period, we find that the internal portion of the potatoe has shrivelled into irregular masses, leaving a great cavity in the centre, having somewhat the form of an X. (Plate VII., fig 4.)

(120.) Besides the general effects of the disease which I have now enumerated, there are some others consequent on the premature decay of the plant. In the first place, the plant perishes before the tuber is properly ripened, and thus the tuber will be injured; in the second, the fruit may perish before it has arrived at its perfect state, and hence the seeds may be incapable of renewing the species.

(121.) In the progress of the malady the potatoe plant is observed to give off a most offensive odor. This is frequently an early symptom of the existence of the malady, and it will continue till the haulms of the entire field be destroyed.

(122.) Before the stalk perishes, if the plant be attentively observed at the dawn of day, the under side of the leaf will be found to be perfectly dry: this is an undoubted symptom of the diminished vitality of the plant. In the healthy vigorous plant the under surface of the leaves will be covered with a copious dew, doubtless the exhalation of the plant.

(123.) In observing a large field we find that it is not every plant which perishes; but that one here and there is damaged, but not destroyed, and that this plant continues its vigorous growth for some time longer.

(124.) Upon examining these vigorous plants they will generally be found to possess two sets of under-ground stems. Above the lower set the stalk may be found to be dead, and a separation to be thus effected between them and the leaf; but above the upper and younger set, which have grown at a later period, after the plant has been earthed up, the stalk may still be sound, and thus a continuity preserved between the leaf and the root.

(125.) It does not, however, preserve its integrity long; the stem, hitherto apparently sound, generally becomes affected, the leaves become dry, and the whole plant dies.

In this case the destruction of the plant is not referable to a new infection, but to the previous existence of disease in the plant; and thus we find that a diseased portion of a plant is very apt to cause the disease in all future growths emanating therefrom.

(126.) On account of this continuous propagation of the disorder, it requires much care at the present time to determine the spot at which the first action of the disease takes place; or, in other words, to ascertain whether the plant be primarily affected at the leaves or at the tuberose stems. From the results of all my experience, I believe that the primary effect is more generally first noticed at the upper stem, but that a diseased tuber tends greatly to the destruction of a plant by the changes occurring in the stem below the surface.

(127.) Notwithstanding innumerable investigations upon this point, I wish to speak with great caution; and, in fact, it is but of little consequence whether the effect of the disease is shown at the upper or lower parts of the plant in the first instance, as there can be no doubt that the malady severely injures the entire plant, in whatever part it may originate.

(128.) The mere local changes in the plant, or dead portions which we perceive, are the results of the malady: the disease itself attacks the entire plant, and, therefore, the mere local changes are really of no great importance. The disease cannot be said to reside in the blotch in the leaf, the dead part of the stem, or in the rotten potatoe: it is a far more recondite affair, having its residence in the vital elements of the plant; and, therefore, we may infer that it is a disease connected with the sap and cellular tissue, and thereby influencing the vital actions which occur between these necessary constituents of the organic body.

(129.) Sometimes the potatoe tops lose their leaves with the exception of a few at the extreme top, which will remain and help to nourish the plant; at other times they totally rot, and the mere remains are to be seen in the field. In the first case, the plant has been more mature when the disease appeared; in the second, the stem has been more succulent. The potatoes or tubers of a plant are not all necessarily destroyed: some will be immature and will not keep, others will be thoroughly rotten, and some will be but slightly injured; and, as a general rule, tubers in all states are found on every diseased plant.

(130.) The tuber suffers less, or, I may state generally, all the plant suffers less, the older it is before it manifests the disease, because the death of any part of the plant necessarily cuts off nourishment from the rest.

(131.) It is remarkable that even those tubers of diseased plants which appear sound in the first instance, are very apt to become diseased upon keeping; and whole cargoes of potatoes, which, when shipped, are to all appearance perfectly good, prove only fit for manure when they reach their destination.

(132.) Thus we may infer that every part of a diseased plant is diseased. As a consequence of the individuality of a plant being preserved and propagated from parent to offspring, a plant originally diseased will continue its disease in any new growth which originates from it. And thus it is impossible to tell for how long the disease may continue to show itself in the progeny of a plant once infected. The probability is, that in time, if the original cause should not continue to act, the malady would be gradually annihilated.

(133.) I have had abundant opportunity, nevertheless, of observing, on the other hand, that potatoe plants which are the offspring of formerly infected tubers manifest the disease without the intervention of the cause which first produced it, and which I shall hereafter point out.

(134.) The disease affects plants at all periods of their age, from the newest seedling to the oldest variety. There is, however, a difference in different kinds in this respect; and in a field where many kinds of potatoes are planted, a considerable variety is observable in the mode in which the plant is attacked.

(135.) It affects plants also in all periods of their growth. I have seen it in a plant where tubers have been formed without haulm; I have seen it where the stem has not exceeded three inches in height; and I have seen it in more mature plants.

(136.) The examination of the diseased tuber presents very interesting matter. In the first place, we observe the potatoe in some instances to have an undue hardness to the feel; in this case, where a thin section is examined under the microscope, the cells will show but a small quantity of starch, the granules will be but few, and in some cases merely rudimentary. (Plate VII., fig. 7.)

(137.) At a later stage we may observe these cells breaking up into a brownish material, and losing their perfect cellular character. We perceive, also, fine lines crossing the cellular tissue here and there, phenomena to which I shall hereafter more particularly draw attention.

(138.) When the decomposition is more advanced, and the plant takes on a more fluid condition, we find starch globules floating about in a fluid among broken down cells and spiral vessels.

(139.) Such is the course which the disease takes in gangrena humida; but the appearances in gangrena sicca are somewhat different. In this form of disease, the potatoe, when entirely affected, may retain its outward form; and yet, on being cut open, there will be found a large irregular cavity in its centre, which cavity often takes the form of an imperfect X. (Plate VII., fig. 4.)

(140.) To form this cavity, the mass of the potatoe has shrivelled up, and presents either a white or brown appearance. If this matter be examined microscopically, it will be found to consist of starch globules, with perhaps some fine lines which have replaced the structure of the plant, and the entire cellular tissue will have vanished. Under certain circumstances in this case, the tuber becomes as hard and as dry as a bit of wood, and will even in some cases bear polishing. Sometimes a potatoe is found to be partially affected with dry gangrene, in which case it will fall in or contract on one side, showing a pit on its outer surface.

(141.) A potatoe occasionally shows a cavity in its interior, which presents little rounded masses, which, under the microscope, show masses of globules of starch, with fungoid growths. (Plate VII., fig. 10.)

(142.) When the disease attacks the plant and cuts down the haulm, the crop of tubers is rendered deficient according to the period of growth of the haulm when it dies. This is consonant with facts previously known, for Marshall found that after the haulm was cut he observed the same result. He "took up two rows of equal length, the haulm of one of which had been previously cut, that of the other uncut. The produce of the uncut ones was obviously the better. The number of tubers is, no doubt, the same, but the quantity is nearly double: the tubers of these large and fine, of those small; and probably they have not increased in size since the haulm was cut, but they do not appear shrivelled."

(143.) If we examine the diseased potatoe, we find that the structure of the plant is eventually destroyed; the cells which held the fluid and contained the starch granules no longer exist; and, in more advanced stages of the disease, we observe that there is left either a mere shell containing starch, or a shell containing a fluid holding starch and broken-down cells in suspension.

(144.) The disease manifests itself in a disorganization of the framework of the plant. The cellular tissue, which gives the form and consistence necessary for the organization of the plant, is destroyed, the vital actions no longer take place, and the plant dies.

CHAPTER V.

CHEMISTRY OF DISEASE.

Diseased tuber different in quality (145).—Mode of analysis (147).—Value of analyses (148).—Analyses (149) —Deficiency of fibre (150).—Starch in excess (151).—Albumen destroyed (152).—Solly's analysis (153).—Diseased potatoes partially destroyed (154).—Sugar in diseased potatoes (157).—Butyric acid (158); liable to fermentation (159, 160).—Difference between the sound and diseased potatoes (161).

(145.) The diseased tuber possesses different qualities from the sound one, and although not absolutely destroyed for the purposes of man, it is frequently very much impaired.

(146.) In examining potatoes chemically, we must bear in mind that different potatoes vary much in composition, and even the same potatoe at different periods of time.

(147.) The rough analysis of the potatoe is very easily performed, when we desire merely to know the relative constituents most useful to man. A given weight of the tubers should be rasped to a fine powder, these raspings should be placed in cold water and thoroughly washed, to separate the starch from the fibre: the liquid should be strained through a fine sieve several times, and allowed to stand to deposit the starch. The fibre remaining in the sieve should be placed in a piece of linen, and the water pressed from it; and, upon being dried in a water-bath, it will give the full amount of starch. This may be placed in a crucible over a clear fire, and thus the quantity of ash may be learnt. After the starch has settled, the water should be very carefully poured off and evaporated to dryness at a moderate heat, when the quantity of albumen, mucus, &c., will be indicated. The starch should then have more water poured upon it, and be allowed to settle, after which the water should be poured away from the sediment; this process should be repeated with fresh portions of water until the supernatant liquid remains quite colorless. The water may then be finally poured off, when the starch must be very carefully dried in a dry room before the fire, and its weight ascertained. The amount of water would at last of all be inferred from the loss.

(148.) Analyses of rotten potatoes are really of very little use, because, in every state of rottenness, great differences will be observed. In some cases of gangrena sicca, an analysis would show that the potatoe was almost converted into starch. In other cases, when the potatoe is fresh and simply hard, it would show a great deficiency of starch; but, if we took the produce of an acre, I have no doubt that the total quantity of starch in the whole space would be found to be enormously deficient.

(149.) The following are the results of two analyses of diseased tubers, which were so thoroughly rotten that the mass was only held together by the skin. They were so soft that they required no grating, and smashed under slight pressure.

	I.	II.
Fibre . . .	4·4	4·6
" Ash . . .	2	·2
Starch . . .	21·4	21·6
"	·2	
Albumen, gum, &c. .	1·5	1·8
" Ash .	·3	
Water . . .	72·0	71·8
	100·0	100·0

(150.) In this case the fibre was not the cellular tissue, or fibre of the potatoe proper, but that of the peel. We thus find that that important element of the plant was materially diminished. In this way the chemical examination of the diseased root tallies with the anatomical. When the tubers were only partially diseased, I found as much as seven per cent. of fibre.

(151.) The quantity of starch in relation to the entire mass was above the average even of good potatoes, which I attribute to three causes: first, to the evaporation which the fluid matter of the potatoe had suffered; secondly, to the starch being all absolutely extracted, and scarcely a single grain left with the amylaceous fibre, which would never be the case with sound potatoes; and, thirdly, to minute portions of fibre passing through the finest sieve. In other analyses of partially diseased potatoes I obtained 23·7 per cent. and 23·4 per cent. of solid material in the entire mass.

(152.) With regard to the albumen and gluten, they are in a diseased state, in fact in a state of putrefaction, and consequently unfit for all human purposes. It is Liebig's opinion that the vegetable albumen is converted into vegetable caseine, which is more prone to decomposition.

(153.) Solly gives the following comparison between the analysis of the bread-fruit potatoe for 1845 and other years:—

	1842.	1843.	1845.
Starch	1074	1383	1004
Fibre	652	685	482
Gum and Resin	504	284	266
Soluble azotised matter—Albumen	87	80	86
Insoluble azotised matter—Gluten	103	121	100
Water	7610	7447	8063
	10000	10000	10000

(154.) An interesting fact appears in my two analyses quoted above, which, though not connected with the disease, I think it worth while to mention. It is there evident that the earthy material exists in combination with the three great component parts of the potatoe, the fibre, the starch, and the solution of gluten, so that it is divided between them. The ash of fibre and starch is white, while that of albumen is of a reddish tint—from the presence of iron.

(155.) Diseased potatoes are not, then, thoroughly destroyed. They may indeed not contain all the elements of food, and, therefore, are not fit for perfect nutrition; yet the starch may be turned to account for all the various purposes for which that substance is employed.

(156.) A great deal has been said about the extraction of this principle, viz. starch, and ridicule has been attempted to be thrown over the process; yet, for the purposes of fattening animals, and of conversion into dextrine and sugar, its separation may be advantageously performed.

(157.) Dr. Ure has pointed out that sugar is to be found in the diseased potatoes. This is an interesting fact, as it explains the reason why diseased potatoes have so great a tendency to sprout. The sugar may be determined by fermentation or other suitable means.

(158.) Mr. Rogers found butyric acid in rotten potatoes which had been buried for three years one or two feet deep, but it does not appear that it is found in the diseased substance now under consideration.

(159.) Diseased potatoes are especially liable to fermentation: two or three placed in a bottle, and tied over with a bladder, will give off gas to such an extent as to distend the membrane and finally burst it.

(160.) So prone are they to putrefaction, that I find that when they are hermetically sealed with balsam of canada, still they evince the property of fermentation and evolve gas.

(161.) The diseased potatoe differs from the sound potatoe in its various ingredients. The only material left in any degree of integrity is the starch, whilst we find the gluten in a state of utter decomposition, the amylaceous fibre disorganized, a little sugar formed, and a new substance generated, which I shall hereafter describe.

(162.) Looking at the malady with a political eye, we have seen in the diseased potatoes some useful matter mixed with abundance of putrid useless substance.

CHAPTER VI.

RELATION OF THE DISEASE TO INTERNAL CAUSES.

Gangrene from old age (164).—Kinds not equally affected (165).—Progress of disease in Chelsea wild plant (166); in Uhde's plant (167); in various varieties (168); in plants requiring much leaf (170).—Horticultural Society's plant (172).—Greatrex's account (175).—Storr's account (176).—Latham's account (177).—Early varieties less liable to disease (179).

(163.) It is difficult to imagine how any organic body should produce within itself means for its own destruction; yet we perceive in our own bodies that man gets old, his organs no longer perform their functions, he ceases to live, and is gathered to his fathers.

(164.) A theory has been started, that the potatoe, being but a variety, has had its career; that the plant has become old, and is now dying. Facts, however, do not bear out this assertion, for I have see this year's seedlings as much diseased as the oldest variety. The malady has paid no respect to youth or to age, but has cut down potatoe plants in all periods of their existence.

(165.) Every particular kind of potatoe, however, is not equally prone to disease, or rather, I may say, to carry its individuality or peculiarity into its diseased condition. The supposed original Chelsea potatoe seems to resist the action of this malady nobly, the disease only attacking it from leaf to leaf, and not affecting so materially the underground stems.

(166.) I have carefully examined this specimen, in order to observe how it would be attacked, and I found that the large leaves were all destroyed, and that the disease progressed from the large leaves to those somewhat smaller, and so crept on till it progressed to the top. In consequence of this mode of attack, the main shoot and all the lateral shoots were green, healthy, and vigorous, and the plant appeared to a casual observer to be quite healthy; and the large leaves, or those out of sight, being alone destroyed up to October the 16th, the plant was still growing vigorously.

(167.) At the Horticultural Society's Garden, on my first visit, Uhde's wild potatoes showed the disease only on the leaflet, and on a subsequent occasion there was also one other leaf curled. In both cases I removed the diseased leaf, and found that they were inhabited by a parasite, which I shall hereafter describe.

(168.) No two kinds of potatoes show the effects of the disease equally; and it is generally supposed that that potatoe which ripens in the early period of the year, manifests the malady less than those which ripen later, so that the early Shaws are tolerably free from it.

(169.) On examining a field in which many varieties are cultivated, every sort will be found to exhibit the malady in its own way; some varieties will be more diseased than others, and some will die down earlier than others.

(170.) Some potatoes require more leaf than others, and I have no doubt that those which require an extensive crop of leaves are more prone to be influenced by the disease than others.

(171.) There is one kind of potatoe which has been lately raised, which is called by the gardener a "go-before," which arrives at maturity earlier in the open border than any kind before known, and which has a top only eight or nine inches high. The haulm is said to be ripe by June, and thus does not exhibit the disease.

(172.) At the Horticultural Society's potatoe-ground, many kinds were found to have the tubers quite healthy, while others were much diseased. The white-eyed red was of the former class; the Sourris Jaune of the latter. I dare say that it will be found that the more nearly the tuber reverts back to Gerard's old type, the more capable it will be of resisting the disease. The white-eyed red was in some respects similar to the old species in the Chelsea Garden.

(173.) I applied at the Horticultural Society's Gardens for a return of the relative number of good potatoes to bad ones in each sort cultivated by them, but was unable to obtain it, as a similar return was ordered to be printed in their own Transactions.

(174.) However, after I had examined their potatoe-ground, I found that I incurred no great loss by being debarred from obtaining the above-mentioned return, for I found that the disease had visited them with a comparatively lenient hand this year, and that it did not exhibit itself in its most destructive form.

(175.) Mr. Greatrex has favored me with the following statement, which is valuable, because the disease attacked his neighborhood very severely. "The crop is less than that of last year, not yielding in some situations more than one bushel per rood (good and bad), and these unusually small; but it is believed that the tubers which have come to maturity keep better than those of last year. In this district a large common was inclosed three years back (light soil). This land bore a good crop last year, and has this year escaped better than any other land in the neighborhood: it is situated about 100 feet above a large meer of forty-seven acres, which may perhaps be considered to have arrested the blight. Light soils have answered best.

"Previous to August all the early kinds were sound and productive.

"Several gentlemen have had foreign seed, and have not half the average crop of good and bad."

	Quantity.	Bad.
Bread-fruit	1 Bush. per rood	—
Farmer's Glory	do.	—
Red and White do.	do.	—
Willow-leaf	2 bush.	—
Keen's Seedling	good early	—
London Olives	2 bush.	$\frac{1}{3}$
Irish Tabs	do.	$\frac{1}{5}$
Irish (pink)	do.	—
Sir Watkins	do.	
Knapsacks	do.	$\frac{1}{2}$
2d Kidneys	do.	
Blue Ruffs	2 bush.	—
Buckshin Kidney	very bad	—
Lancashire	do.	—

.	Quantity.	Bad.
Mangel Worzel .	2 bush.	—
Early Kidney . .	good crop	—

Average in good year, 4 bushels per rood.

(176.) Mr. Storr states that the "potatoe crop has failed in the neighborhood of Howder, Yorkshire, very seriously. The Scotch reds are much the worst. I planted twenty tubs of them last spring, and have not more than ten tubs fit for use from them, and this is the case all through Marshland. The white ones are much better, say about thirty tubs per acre fit for food; but they are very small, the haulm having been prematurely killed by the disease."

(177.) Mr. Latham, one of the great potatoe growers in Yorkshire, says, that "Many expedients were resorted to during the last winter, such as early planting and deep planting; and in some cases the crop of 1845 was suffered to remain in the ground, and the winter proving mild, no serious consequences from frost took place. So far as my observation extends, the early planted potatoes are the freest from disease, the largest in size, and the best crop, but certainly not less than one-third was bad even in these. On some of the best potatoe soils the crop, in many instances, is a total failure. The quantity per acre will vary from 40 bushels to 100, but there are very few instances of the latter quantity being obtained. It is perhaps worthy of remark, that red potatoes were those most severely affected in 1845, and white ones in the present year."

(178.) From these facts we discover, that, although a potatoe plant might become old and might die, death from old age is not the cause of the present epidemic, and that old and young, according to their deviation from the state of nature, become more or less affected with the malady, and die either locally or generally.

(179.) The above statements also show that early kinds, which are ripe before August, are generally less affected by the disease.

CHAPTER VII.

RELATION OF THE DISEASE TO EXTERNAL CAUSES, TEMPERATURE, LIGHT, ELECTRICITY, ETC.

Gangrene not the result of any internal cause (180).—Effect of temperature upon plants generally (181).—Potatoe thrives in various climates (182).—Cold (184).—Influence of temperature (185); upon the decay of tubers (187).—Effect of light upon plants (190).—Effects of light upon tubers (193).—Influence of electricity (194).—Influence of atmospheric moisture on plants (195).—Excessive moisture a cause of disease (196); its influence on the disease (197); effect on the tubers (199); other atmospheric agents (200).—Effect of winds (201).

(180.) As we cannot explain the gangrene by the supposition of its origin from internal causes, and as, on the contrary, facts forbid us to assign any such causes for the malady, we are led in the next place to inquire into the effects of external agents upon the plant.

(181.) Every plant requires a certain temperature, or rather a certain range of temperature, which is indispensable to its existence. The plant of the frigid region soon grows itself to death in the torrid region, and the plants of the torrid regions soon cease to grow in the arctic.

(182.) The potatoe plant has a wide distribution, and lives under varied circumstances better than most other plants, as I have before observed.

(183.) If the life and death of a plant depend upon the variations of temperature, it is fair to suppose that lesser alterations of temperature will influence the health of the plant, and, in some cases, tend to disease.

(184.) Cold has been assumed as the cause of the present potatoe disease; but if we look to the average of three years, during which the disease has been known to be prevalent, we find that it cannot be from that cause. In fact, the spring and summer of 1846 have been remarkable for their extreme heat, so much so that the out-door grapes have attained extraordinary perfection, and the larger kinds of Indian corn have completely ripened in the open air.

(185.) Temperature does not cause the disease, although it has an important influence upon it. In the first place, when the disease cuts off the supply of the sap from the leaflet, the leaf and the stalk, or the entire haulm, it frequently happens that a very hot day will affect a large plot of potatoe haulms at once, and dry them up.

(186.) I watched the potatoes the first thing in the morning before I went to business, the moment I returned, and the last thing at night; and there were hot days when the change produced from this cause exceeded all belief.

(187.) Temperature has an important influence upon the decay of the tuber; and it has so happened that in ships' cargoes, where the potatoes were sound when put on board, yet when they were in the ship's hold they became heated, and not one sound one remained. In fact, I have been informed that many tons were in such a bad state last year when they arrived at London, that they were only applicable for manure.

(188.) To preserve potatoes, especially when they are suspected to have a predisposition to the gangrene, it is almost essential that they should be kept in a cold place.

(189.) An improper temperature may then cause death in the potatoe, though it is not to be assumed that it has produced the present malady. Excessive heat, under certain circumstances, materially influences the progress of the disease, and hastens the death of the plant and its consequent putrefaction.

LIGHT.

(190.) Every plant requires a certain amount of light; many plants are killed by a strong light, and others will die in the shade.

(191.) Absence of light has been assumed as a cause of the disease, but the examination of the last three years shows that it cannot be assigned either to a deficiency or superabundance of this agent.

(192.) The action of light upon the tubers is supposed to mature them, and to render them especially fit for planting. Potatoes when exposed to the sun's light become green; in fact, they become above-ground, instead of under-ground stems.

(193.) Potatoes required for keeping should be protected from the influence of light, being thus less prone to grow or sprout, as it is termed. In fact, light favors all changes. Absence of light may cause the death of the potatoe, but it cannot be said to have produced the present epidemic.

ELECTRICITY.

(194.) Nothing is known of the influence of electricity upon the growth of plants. The world was startled a year or two ago by the notion that electricity was to serve the purposes of manure; there is no doubt, however, that the author of this idea was mistaken. The influence of artificial electricity upon plants is unknown; and, in fact, the artificial application of electricity has not been proved to exert any influence whatever. To conduct experiments on this subject would entail much labor and expense upon the experimenter, but I believe they would be well worth trying in a manner different from former experiments.

HYGROMETRIC CONDITION OF THE ATMOSPHERE.

(195.) Every plant requires a certain hygrometric condition of atmosphere. Hence some plants, as ferns, require a moist atmosphere; other plants, the flowering plants for instance, require an atmosphere which is dryer.

(196.) Too much moisture prevents the woody fibre from being perfectly ripened; and the wet season of last year has been assumed as a cause of the potatoe disease. This year, however, has been especially the reverse, and yet the disease continues or even increases.

(197.) Moisture is not the cause of the disease, although it may influence it. When the under-ground stems are cut off by gangrene, a moist atmosphere will fill and swell out the haulm with water, when a hot day subsequently acting upon it will totally destroy it and cause it to rot.

(198.) Potatoe tubers kept in a wet atmosphere I have found prone to rot: it is, therefore, advisable to keep them in a place which is both cold and dry.

(199.) Moisture, then, is sufficient to cause local or general death of the potatoe plant. It has not, however, produced the present epidemic, though in solitary cases it may have influenced the progress of the malady.

OTHER QUALITIES OF THE ATMOSPHERE.—WINDS.

(200.) There are evidently other qualities of the atmosphere, besides heat, light, moisture, and electricity. Many persons can tell in bed when the east wind blows; and such a deleterious influence is exerted by this wind, that every angler knows that he fishes in vain under its pestiferous blast.

(201.) The apparent influence of the east wind upon vegetation is to stunt it, and to arrest the progress of its growth. In this way it may favor the disease to a certain extent: there is not, however, the slightest reason to believe that it actually produces it. The motion or stagnation of the air also influences vegetation: some plants, like fungi, like a close confined atmosphere, others like a more exposed situation. It is also apparent that as the atmosphere contains carbonic acid, the chief food of plants, the health of the plant might be influenced by a proper proportion of that gas. No evidence has, however, been afforded that any variation in amount has existed to cause the present malady.

(202.) Various hurtful agencies appear to exist which are not referable to any of the above causes; for instance, the cholera morbus in man seems to arise from some such unknown agent. The cause of the potatoe disease does not appear at all analogous to any agent of this kind.

(203.) Upon the whole it is probable that certain abnormal qualities of the atmosphere have influenced to a very slight extent the present universal epidemic.

CHAPTER VIII.

RELATION OF DISEASE TO SOILS AND MANURES.

Soil which suits the potatoe (205).—Diseased in all soils (206).—Statement of Mr. Latham (207); of Mr. Greatrex (209).—Influence of wet soils on the disease (211).—Guano and Animal Salts (214).—Influence of manures on the disease (216).

(204.) Every plant requires a peculiar soil in which to vegetate; thus, ferns like a peaty soil, wheat a rich loamy soil; other plants thrive only in a sandy soil, and in fact every plant has a peculiar soil in which it grows best.

(205.) The potatoe plant succeeds best in a rich alluvial soil; and in Yorkshire, where potatoes are grown for the London market, it is a common practice to allow water to deposit a sediment over land, till two or three feet of rich mould are deposited.

(206.) It might be thought that a wrong soil has caused this epidemic, but the disease is to be found in every kind of earth whatever. It is found round London in the light alluvial soils left by the rivers Thames and Lea; and it is found in the stiff London clay, and in light gravel.

(207.) It is found in wet soils, and also in the dry sandy soils round London ; and, in fact, there is no kind of earth which will protect the plant from the malady. Mr. Latham, a large potatoe grower at Wressall Castle, Yorkshire, states, in a letter to me, " that fresh land, poor land, sand land, clay land, and good warp land, are all equally susceptible of its influence, and at about the same time."

(208.) Mr. Greatrex informs me " that all newly tilled land has answered best, and in some situations near here there may be two bushels of potatoes per rood, good and bad, which is less by more than one-half than the average crop. In land well limed and another well sooted, although seed was used from Bedfordshire, where no disease appeared, the crop was equally bad."

(209.) I have also seen the disease in one case where a potatoe tuber had fallen accidentally under some old planks, and in this situation was completely sheltered from all moisture; in fact, the bank was so dry, that it was wonderful how any plant could live at all.

(210.) Perhaps the most curious case is that of an old potatoe throwing out diseased tubers, when it had never been in any soil, or even out of the house. In this instance it was no doubt the propagation of the disease from a formerly damaged tuber, a phenomenon which I shall hereafter more fully explain.

(211.) There is, then, no reason for believing that the disease has been produced by the influence of peculiar and inappropriate soils, but, on the contrary, there is every reason to suppose that it has not had its origin from this cause. Although, however, it has not been produced by soils, it is nevertheless the concomitant testimony of all observers, that a heavy wet clayey soil greatly favors the mischief.

(212.) It has been observed by many persons, that in sand or peat the disease has not shown itself to its full extent; but in quoting a general opinion, I have no precise facts to warrant my making any assertion. Mr. Stone states, that, "in his opinion, a light soil without manure is less subject to disease than a better soil well cultivated."

(213.) Some persons have imagined that our mode of treatment is injurious, and that the process of ridging up is deleterious. This, however, deserves no credit, for I have seen the disease in hundreds of plants which have never been banked up, and even in tubers half of which were quite green from exposure to the light and air.

(214.) Next to soils, manures have attracted attention, and the guano from Ichaboe has been blamed. Now, the redundancy of animal salts is calculated to materially injure plants. I placed some crocuses in a solution of that character, which grew and flourished, and became intensely green. Instead of flowering, however, the roots began after a time to die, and finally the entire plants were destroyed. No doubt, guano in excess may act highly injuriously, but no evidence can be adduced that it ever caused the potatoe disease. Mr. Stone states that he did not use any manure except on one piece, where he applied some pigeon's dung, and there he found most of the potatoes good for nothing.

(215.) I am informed that London returns its manures to Yorkshire, from whence the metropolis derives its supplies of potatoes; and in various parts of the country every kind of manure is used to further the growth of the potatoe plant.

Gratacap. del. N.Y.

(216.) Manures, from their stimulating character, have doubtless an influence on the disease; and, as far as I can learn, those plants are freest from disease which grow on soil which has been left quite unmanured. The only manner, however, in which manures do injury, is by causing the plant to assume a very succulent and cellular character.

CHAPTER IX.

RELATION OF DISEASE TO FUNGI.

Berkeley's opinion (217).—Fungi common to decaying matter (219).—Fungi on decaying tubers (221).—Botrytis infestans (223). —Fungus in the inside of tubers (226).—Different fungi growing in rotten tubers (227—230)—Black fungus on stem (231).—Other species of fungi (232, 233) —Singular appearance of motion in fungi (234).—Fungi influence the disease (237).—Fungi fulfil important functions in nature (238—240).—Gangrena sicca and humida (241).—Tubers infected with fungi perhaps injurious as food (241).

(217.) MR. BERKELEY states, that "to his own apprehension it appears clear that the cause of the premature decay and putrefaction of the haulm is to be found in the parasitic fungus, in consequence of whose attacks the tubers are unripe, and in a bad state for preservation."

(218.) His article upon this subject is well worth perusing, and the figures with which it is illustrated are ex·

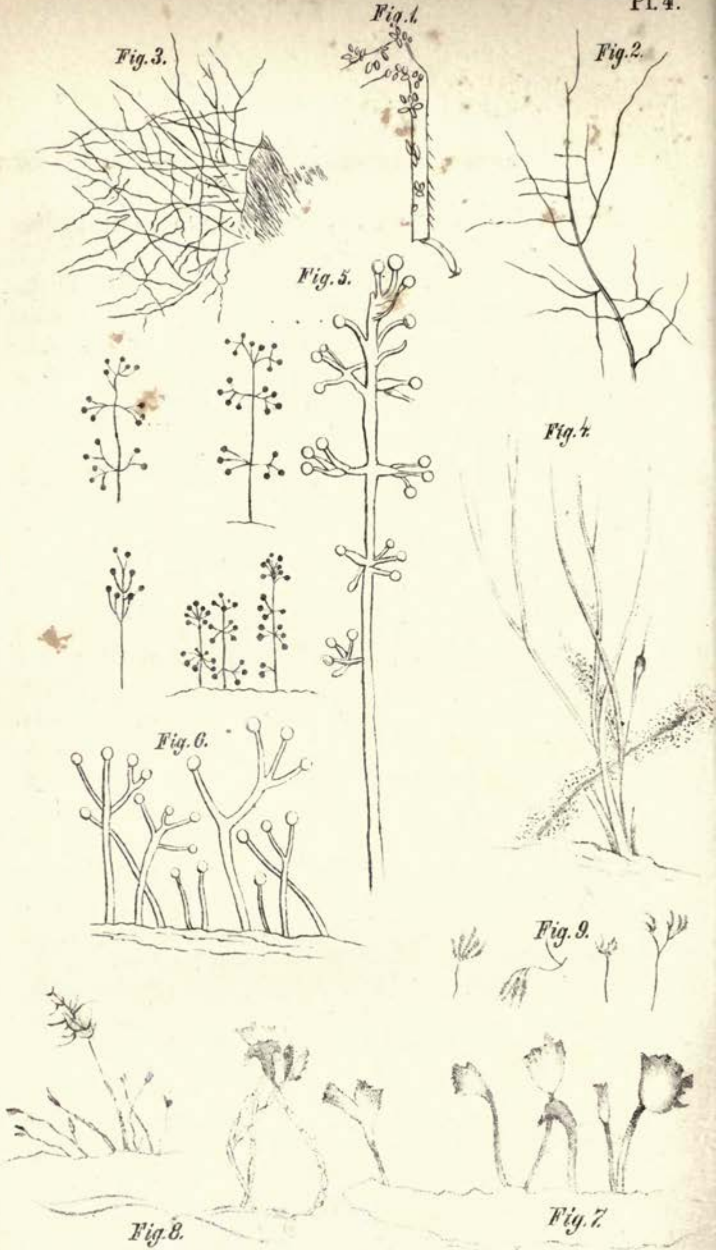
cellent; nevertheless, his facts do not bear him out in the opinion which he has promulgated.

(219.) All decaying matter becomes rapidly covered with fungi; and if we examine rotten potatoes, we find that they form no exception to the rule.

(220.) The question of the origin of these fungi is one of great importance and intricacy, involving as it does the whole question of equivocal generation: certain it is, however, that they frequently make their appearance in cases where, to our senses, the possibility of their existence would almost be precluded.

(221.) If we watch potatoes affected with the disease, we shall observe in some cases that the potatoe is attacked with dissimilar fungi. One of the most beautiful with which I am acquainted may often be found in the inner cavities of the diseased tuber; it is one of the most beautiful microscopic objects which can possibly be conceived. It has long slender threads running about upon the surface of the decayed matter, and sends up stems with a large round ball at the top, which when mature becomes covered with sporules for its reproduction.

(222.) This beautiful fungus is frequently to be found in the shrivelled cavities of diseased tubers. Sometimes a cut surface will be covered with it, giving the appearance of a most beautiful miniature forest; and I am now writing with a specimen before me, having thousands of these seed-vessels rising upwards in every stage of growth. In their early stage they are white, later they are brown, and finally they are quite black, and covered with myriads of seeds. This fungus sometimes sends forth these growths through the cuticle of the potatoe, bursting its way outwards, and presenting its numerous heads to our view.



Gratacap, del.

(Plate III., fig 1.) I have seen the same or a very similar fungus on glue and in other situations.

(223.) Another species is also said to be found on the decaying leaves, and likewise on the tubers. It has been called the Botrytis infestans; and this is the specific fungus which Berkeley believes to cause the disease. There cannot, however, be any question that the fungus is a consequence, and not a cause of the malady.

(224.) Berkeley says that this fungus is to be found in the first instance in the cells, before it bursts through. The Botrytis is not always of the species described by Berkeley, for Martius has figured a different one, to which he assigns the cause of the malady, and has beautifully and correctly figured the manner in which this kind of fungus pushes forwards through the cuticle into the atmosphere.

(225.) I am very uncertain about the species of fungus figured by Berkeley. I have figured one something like it, growing on the edge of a leaf, and another variety which was growing upon an under-ground stem, and which I take to be either the same or an allied species. (Plate III., fig. 6; Plate IV., fig. 6.)

(226.) A fungus is to be found frequently in the interior of the tuber, amongst the grains of starch; and in this case the microscope shows nothing but starch and fungoid fibre. The mass appears to the naked eye like a piece of boiled potatoe. This is probably analogous to mushroom spawn; but to what species it may be assigned, I do not with certainty know. (Plate VII., fig. 9.)

(227.) A fourth species presents a reddish aspect, and forms one great mass in the interior of the tuber. Examined with the microscope, the edges are one mass of fine lines, but the red part appears opaque. What it is, I do not know.

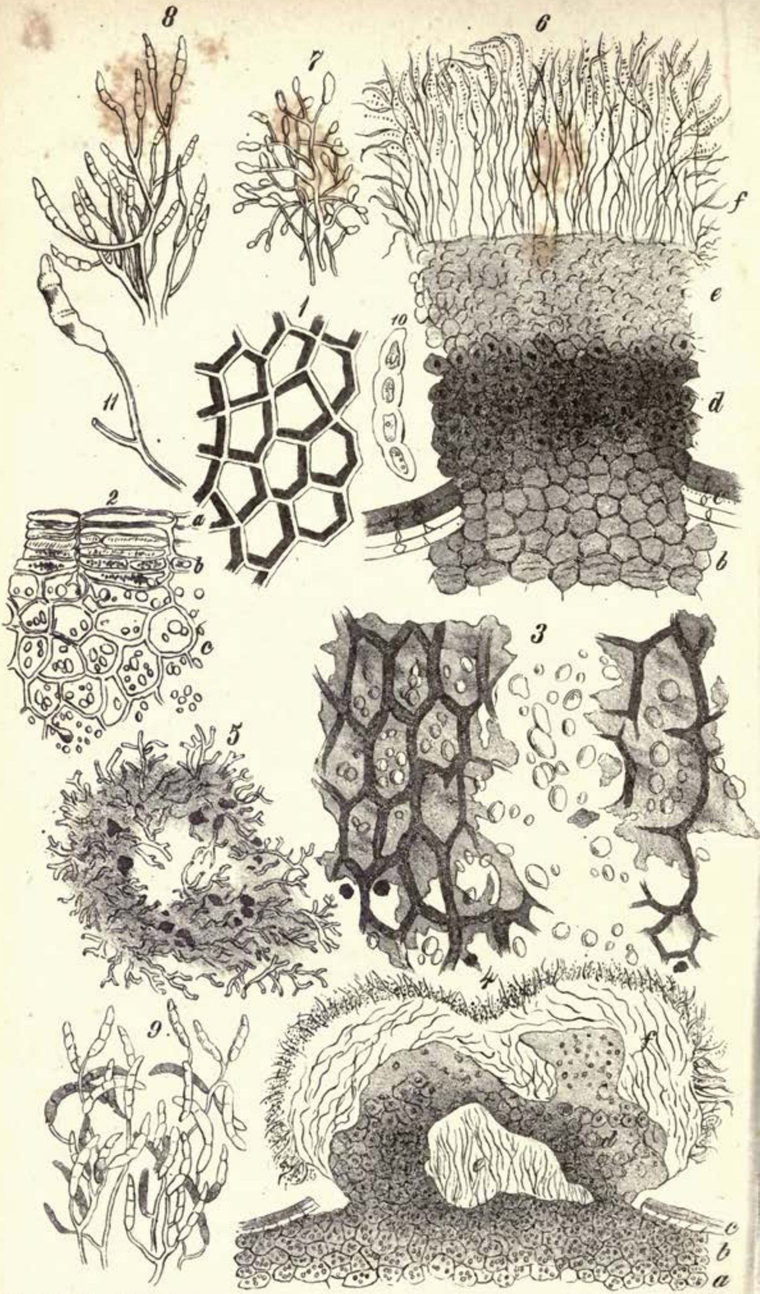
(228.) Sometimes in a rotten potatoe we find that there is a sort of growth of a brilliant carmine color, but I have not detected any very definite structure in it. The color is so deep, that it is as intense as carmine, and will bear an equal magnifying power before the color is lost. Under the highest power of the microscope I can only make out minute cells. Its intensity of color is the prominent feature.

(229.) There is a magnificent fungus of a brown color, resembling in fact oxide of iron to the naked eye, which fungus may often be seen in the interior of a diseased potatoe, when its cavity has been exposed to the air. Under the microscope it is found to be a perfect forest, with branches resembling in some degree the regularity of a pine-tree, with a seed-vessel at top of each. It is really and truly a most delightful object for a good microscope. (Plate IV., fig. 5.)

(230.) There is also a little fungus which appears to have a small top, which a microscope breaks up into a Medusa's head. I think it is the same as that to which the name is assigned; but I must refer my reader to the faithful drawing of my artist. (Plate III., fig. 5.)

(231.) Almost every stem has a black fungus growing from it, which to the naked eye gives a dotted appearance to it. Under the microscope fine stems are seen to emanate from it. I think it is the same as the Protomyces. I have not thought it therefore worth while to figure Martius's drawing, but have given a figure from one of my own specimens. This fungus is also frequently to be found in the tuber. (Plate III., figs. 2, 3.)

Pl. 6.



On Stone by Geo. G. Gratacap.

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(232.) One very delicate fungus is frequently to be seen, but I do not know its mode of fructification. (Plate IV., figs. 2, 3.)

(233.) There is a fungus with a great number of seed-vessels at the top, which is sometimes to be met with, growing from the tubers and under-ground stems, which I have figured. (Plate IV., fig. 9.)

(234.) Many of these fungi move about when placed under the microscope, an effect which probably arises from evaporation. And this, I am inclined to believe, must have been the appearance which misled some one, who stated in a newspaper article that he imagined these fungi to be of animal origin.

(235.) One of the last fungi which attracted my attention I found on an under-ground stem. It presented a lovely beaded form (Plate V., fig. 2). And I have also noticed a fungus resembling that existing in the scald head of human beings growing from dead Aphides. (Plate III., fig. 7; Plate IV., fig. 1.)

(236.) Potatoes in a diseased condition are the prey of many other fungi; but I think it quite needless to trouble the reader with further description. In Plates III. and IV. I have figured what I have found; in Plate VI. I have copied the figures of Martius, and in Plate II., fig. 2, and Plate V., fig. 3, Berkeley's figures.

(237.) Doubtless the fungi exercise an important influence upon the progress of the disease, although they most assuredly have not the power of producing it. In fact, they never make their appearance until the potatoe plant has been previously damaged, and until some portion of it is already dead. I have tried several experiments on the inoculation of sound potatoes with fungi, but the result has been a comparative failure; and sound potatoes would remain amongst others abounding in numerous fungi, without being injured.

(238.) When the plant is damaged then these vegetable parasites appear, and the function which they are destined to perform is highly interesting, and, in fact, a wonderful example of natural economy; for whilst man is careless, and allows decomposing bodies to send forth their putrid exhalations, and even buries the dead in the midst of the houses of the living, and allows the existence of open drains and untrapped sewers, Nature, when not interfered with, amply provides against the occurrence of such unhealthy and offensive conditions, by taking effectual means to remove the dead material.

(239.) The carrion crow, the vulture, and the jackall may do much,—the maggot, the beetle, and the wasp may do much,—towards the removal of dead animal matter; yet to the vegetable parasite is left the duty of annihilating the exhalations of putrefying vegetables.

(240.) No sooner does death occur than fungi grow: these eat up, as it were, the soft decaying parts as fast as they rot; and thus is inorganic matter converted into organic,—thus is death converted into life.

(241.) The difference between gangrena sicca and humida frequently depends, to a great extent, or even entirely, upon these parasites. When the parasites appear they dry up the potatoe, absorb the decomposed cells, and leave the starch. When they do not appear the tuber is far more prone to become putrid, and evince the properties of moist gangrene.

(242.) We all know that many fungi are poisonous; and I ask, what surgeon can say that some of these fungi may not also be highly deleterious, either to all persons, or to some, as the result of idiosyncrasy. In my opinion, it would be a prudent course to reject potatoes which are much affected with fungi, either for the use of man or beast.

(243.) I have viewed with great interest the relation of the fungi to the diseased potatoe; I have seen these exquisitely beautiful parasites proceeding from that which would otherwise have been offensive and disgusting; and thus, when the diseased tuber becomes unfit to nourish the body, the parasite that emanates from its decay may furnish to the mind matter for observation and study replete with interest.

CHAPTER X.

RELATION OF GANGRENE TO ANIMAL PARASITES.

Numerous species of insects on potatoe plant (244) —Acarus (245). Coccinella, ichneumons, flies (247).—Aphis (248).

(244.) The relation of this gangrene of the potatoe to animal parasites must also be carefully examined. Flies will sometimes lay their eggs in rotten potatoes, various infusorial animalcules may very probably be produced in them, and if the potatoe plant be carefully examined, numerous insects may be discovered upon it.

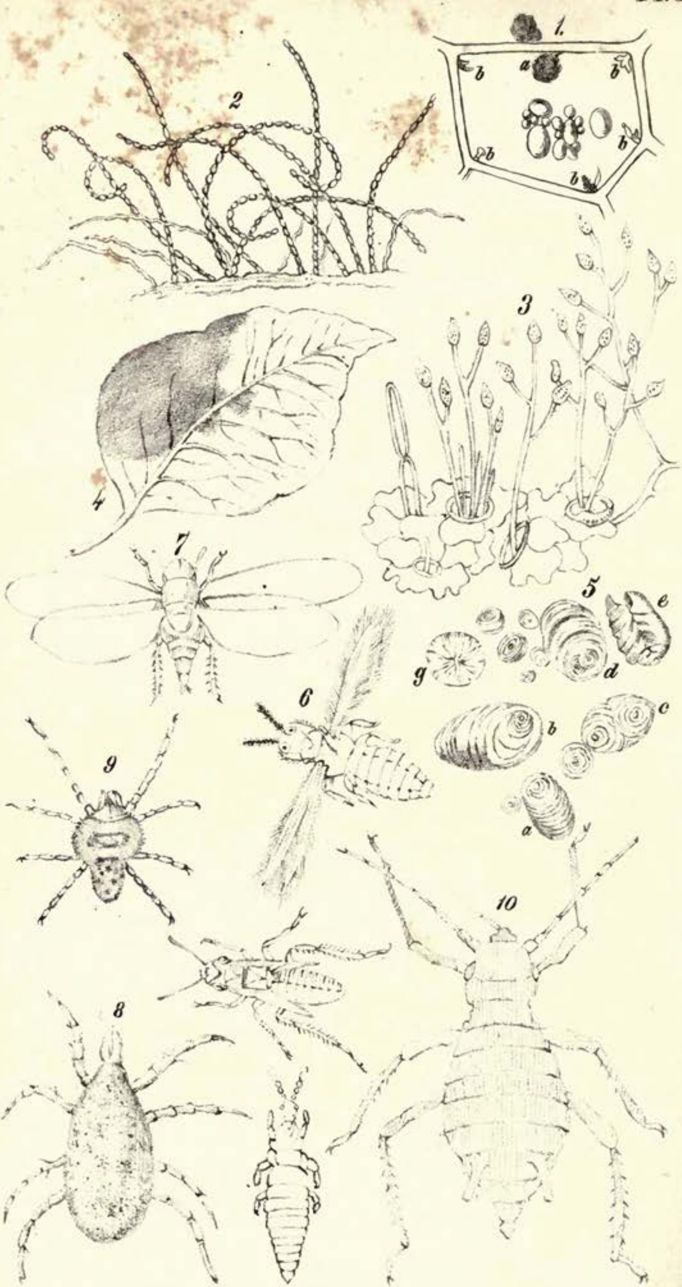
(245.) A very common insect, which is constantly to be seen upon tubers, is a small Acarus, which runs about the potatoe very nimbly. Martius has figured it, but I have given an illustration from one which I captured myself. There is no reason whatever for believing that it causes the malady. Mr. Ingall, who was so kind as to make the drawing, remarks that this little fellow, when viewed under the microscope travelling among the dense growth of the fungi, put him in mind of a great rhinoceros trotting about in the jungles. He certainly does present a very extraordinary appearance. (Plate VII.)

(246.) There is a little yellow insect which is common upon all potatoes, but I do not know its name. It appears, however, to me to be quite innocuous, for I have found it upon other vegetables which have been quite healthy and uninjured. In the "Gardener's Chronicle" two insects are figured which have been supposed to have an influence on the disease—the potatoe thrip and the *Eupteryx solani;* but I see no evidence to suppose that they cause the malady.

(247.) Lady-birds of different species are to be met with in great profusion on the potatoe and other plants, but they are animal feeders, and can therefore do no harm. Various ichneumons also in great numbers are to be found, together with many dipterous insects, to neither of which can any hurtful quality be assigned.

(248.) If, however, we carefully examine the potatoe at different times, we find another insect, an Aphis, in great abundance; which Aphis exerts so important an influence, that I must devote to it an entire chapter, in order to separate it from other animal parasites, and treat it with that respect which its formidable powers unfortunately entitle it to. On one occasion I found a second Aphis, of a black color, on the plant, different from the one just mentioned,

Pl. 5.



On Stone by Gratacap. Printed by H. R. Robinson but this, from its rare occurrence, cannot produce the present universal epidemic.

CHAPTER XI.

APHIS VASTATOR.

Insect on the potatoe plant (249—250); its color (252); dimensions (256—259).—Suctorial apparatus (260); head and eyes (261); abdomen and tubercles (262); pupa (263); imago, or perfect insect (264); named "vastator," and why (265).—Curtis' description (266).—Astonishing fecundity (267—269).—Continuance of the species (270—273).—Mode of attack on the plant (274, 275).—Restlessness of the insect (276—278).—Flight of the insects (281, 282).—Progress of the mischief (283—285).—Action on different varieties (286, 287).—Effect of moisture after attack (288, 289).—Attack at different ages of the plant (290, 291).—Relation of the disease to this insect (292—294).

(249.) Upon a minute examination of the leaves and stalk of a potatoe plant, a small insect will be found, feeding either alone or in company with others, and principally on the under surface of the leaf.

(250.) This insect is generally seen perfectly stationary, and might easily elude observation, from being in the early stage of its growth of a color not widely differing from that of the leaf. If attentively examined with a magnifying-glass, it will be seen to be adhering to the plant, and remaining in a state of repose, with its antennæ reflexed over its back, and a sort of proboscis applied to the leaf. (Plates VIII. and IX.)

(251.) If the insect be touched, it will be found that it adheres pretty firmly to the leaf by its suctorial apparatus, and that it requires one or two seconds to disengage itself from its position.

(252.) The color of this little insect is various: in very early life its body is nearly transparent; later it is of an olive color; at other times it is grass green, and at a later period it may be found to be of a reddish color.

(253.) We have in this little insect a parasite which derives its nourishment from the plant by sucking the juices, which operation it effects by means of the very curious apparatus which I shall hereafter describe.

(254.) This insect is found in three stages of existence,—the larva, the pupa, and the imago, or perfect winged insect; in all of which states, like its congeners, it feeds, remains active, and probably multiplies.

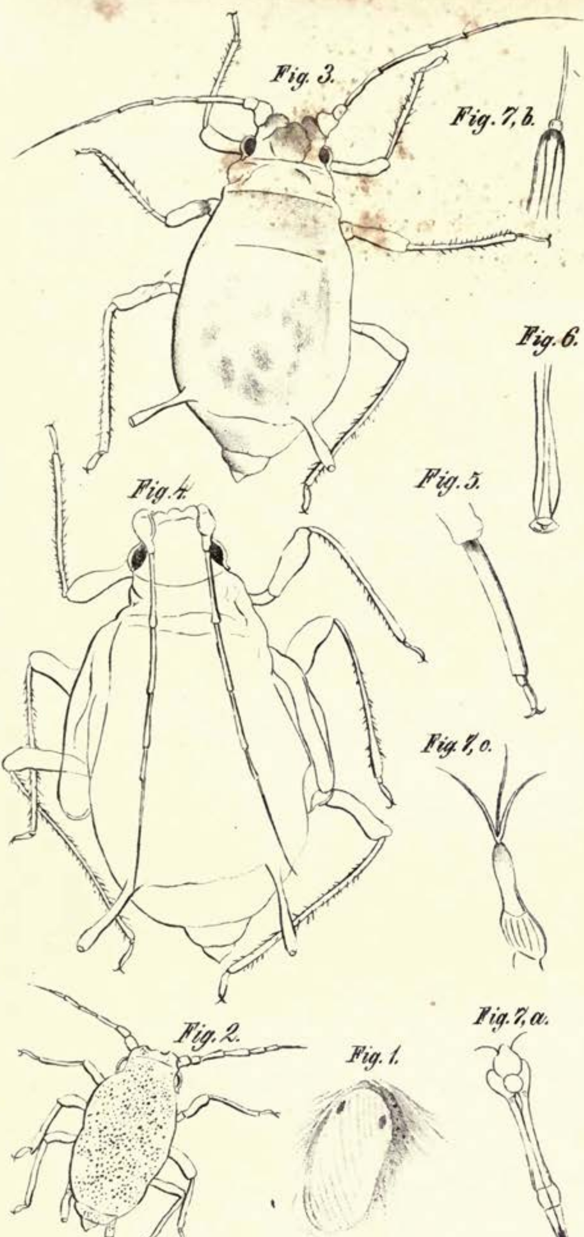
(255.) From an examination of its different states, we know that it not only belongs to the family of *Aphidæ*, but must be classed under the genus *Aphis*.

(256.) The *Aphis vastator* when full grown is about the tenth of an inch long, and, as I have before mentioned, the color is white, olive green, brown, or inclined to red.

(257.) The Antennæ are seven-jointed; they are nearly as long as the body, and sometimes even longer. The subjoined measurement of a specimen, which I take to be an adult apterous female, shows the dimensions of the various parts of the insect in 1000ths of an inch:—

Length of body from base of antennæ to apex of abdomen	106
Greatest breadth of body - - - -	55
Breadth of head between the eyes - - -	12
Anterior femur - - - - -	22
" tibia - - - - -	36

Pl. 8.



On Stone by Gratacap, 31 City Hall Place. N.Y.

Anterior tarsus	5
Posterior tibia	55
Abdominal spines	24
Length of rostrum	26
Antennæ, 1st articulation	4
" 2d "	3
" 3d "	20
" 4th "	16½
" 5th "	14
" 6th "	5
" 7th "	19
In a winged specimen the wing measured about	128

(258.) Considerable variation is observed in the total length of the antennæ in different specimens, the reason for which I do not know. In all cases, however, they are long in this species, and the relative length of the different joints forms an important characteristic.

The following measurements give the comparative lengths of the articulations of the antennæ in different specimens of this insect:—

1.	2.	3.	4.	5.	6.	7.	TOTAL
4	3	18	15	12	6	20	78
3	2½	9	7	9	4	13	47½
2½	3	16	13½	10½	5	19	69½
4	3	20	16	14	5	19	81

(259.) When the creature is at rest and feeding quietly, the antennæ lie reflexed over his back; and this posture is well shown in the diagram. (Plate VIII., fig. 4.) When, however, he is roving about, he carries them extended before him, apparently to feel or smell by their assistance.

(260.) The rostrum is about one fourth as long as the body, and contains a fine apparatus for piercing the leaf and walls of the cells. This instrument when open presents three diverging delicate piercers, one of which answers to the tongue and the other to the jaws of insects. (Plate IX., fig. 2; Plate VIII., fig. 7, *a*, *b*, *c*.)

(261.) The head is very distinct in its form, and has fine spines upon it. The eyes are red or black, and so strongly colored that they may be seen through the membrane which envelopes the insect before it is born.

(262.) The abdomen is very angular when the creature is walking about, and is furnished towards its extremity with tubercles, which extend posteriorly as far as the apex of the abdomen. These tubercles are hollow, and contain a peculiar matter in the interior.

(263.) In the pupa state it has rudimentary wings, which grow for a certain time, when the creature casts its skin, and comes out a winged specimen.* (Plate VIII., fig. 4.)

(264.) The winged insect has four wings, which are carried in the same posture as they are by all other Aphides. With these wings it is cabable of flying to great distances, but it is generally, except when on flight, a lazy creature in its final or perfect state, and not very prone to fly away for slight causes. (Plate IX., figs. 1 and 4.)

(265.) After a careful comparison of this insect with all the other Aphides of which descriptions have been publish-

* I do not know exactly how many times the insect casts its skin, but I am inclined to think that this operation is performed at least three or four times.

Pl. 9.

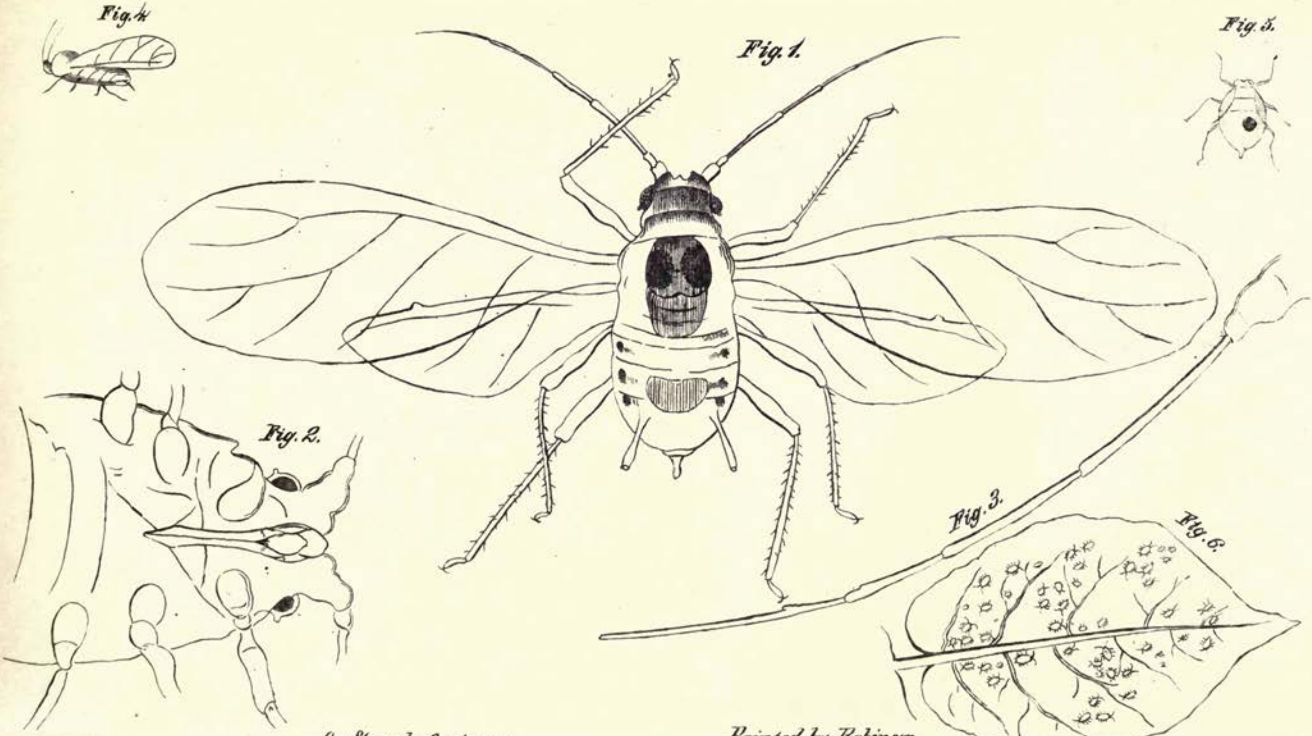


Fig. 4
Fig. 1.
Fig. 5.
Fig. 2.
Fig. 3.
Fig. 6.
On Stone by Grutacap.
Printed by Robinson.

ed, I found that it was identical with one known heretofore to infest the turnip, and which is called by Curtis the *Aphis rapæ*. I found, however, that the use of this name was so embarrassing, and led to such confusion, from the insect feeding upon the turnip in common with other Aphides, itself too attacking twenty or thirty different plants, that I decided to meet the difficulty by describing it under a new title; and having discovered that this pest is a great destroyer of human food, a waster of our best provisions, I have therefore termed it the *vastator*, or destroyer.

(266.) Having determined that the vastator is the same insect as the Aphis rapæ of Curtis, I make no apology for transcribing his description of the animal, which is as follows:—

"Male ochraceous: horns moderately long, setaceous, fuscous, two first joints black, third ochraceous at the base; head blackish; collar ochraceous and brown; disc of thorax shining black; abdomen greenish; the spiracles or breathing pores brown; tubes long, slender, ochraceous at the tip; the apical process of the body ochraceous also; wings iridescent, the nervures light brown; stigmatic spot long and yellowish; apical cell somewhat oval; furcate cells elongate, trigonate; terminal very short; tips of thighs, shanks, feet, and claws black. Female light green, shagreened: horns fuscous, except at the base; eyes, tips of shanks and feet black."

I do not know whether this Aphis has ever been named before the time of Curtis, and in fact the description of Aphides by the older writers is so imperfect that even their figures would answer for any insect of the same genus.

(267.) The Aphis vastator comes upon the potatoe plant in the winged state, and there brings forth its young alive. These generally prefer at first a large and rather debilitated leaf. After a short time the insect brings forth other young, which young themselves reproduce without any connexion with individuals of the other sex; and thus from a single specimen a plant may speedily become covered with the insects.

(268.) It has been proved by Reamur, that in five generations one Aphis may be the progenitor of 5,904,900,000 descendants; and it is supposed that in one year there may be twenty generations. I know no reason why the vastator should be less prolific than its congeners; and the rapid rate at which I have seen them produced would in some degree justify the conclusion that they are not at all behind-hand in this respect.

(269.) I have repeatedly seen both winged and apterous specimens produce their young alive, though up to the present time I believe that I am conversant only with females. I do not certainly know the males of the vastator. It is stated, however, that the males of all Aphides may be either winged or apterous, and that the females may produce young for nine generations without any union with the males.

(270.) As far as my own observations are concerned the vastator always appears as a viviparous creature; but I do not as yet know how it is propagated throughout the year.

(271.) Entomologists state that in autumn the females lay eggs, instead of bringing forth their young alive; but this I have not yet myself had an opportunity of observing. It is, however, a very important circumstance, and I hope eventually to make myself conversant with the fact, as it has a bearing upon the future course of the potatoe disease.

(272.) I have found eggs apparently of other Aphides upon the couch-grass. I have also given a figure of the young Aphis enveloped in a membrane, and in a state just ready to come into the world. This therefore shows me what sort of an egg we may expect to find, if the creature ever lays one. (Plate VIII., fig. 1.)

(273.) The desired information probably will resolve itself into three questions: Does the vastator lay eggs which hatch in spring? Does it hybernate, and come out again in the spring? Does it continue to propagate notwithstanding cold, frost, and rain? Up to November 4th, I have found the creature bringing forth its young alive.

(274.) The vastator begins at the larger leaves of the potatoe plant, which, after a short time, becoming injured by the abstraction of the sap, die either partially or entirely. In this case the insect follows up the leaves till only a few on the top of the plant are left.

(275.) This operation is not going on in one plant alone, it is generally progressing in every plant in the field at the same time; leaf by leaf all dying, till, as I have just stated, a few only of the apical leaves are left.

(276.) Regarding the mode in which a whole field becomes attacked, I may observe that the vastator is a sad rover: he may frequently be seen travelling up and down the potatoe plant with his antennæ waving before him, as though he were uneasy, and did not quite like his situation.

(277.) From this restlessness, coupled with the fact that the insect is generally diffused over a field, I am inclined to believe that the potatoe is not the most agreeable food to the vastator, and I do not think it thrives quite so well upon it as upon plants which I shall hereafter describe.

(278.) So restless an insect is it, that when I have placed it upon one plant in my sitting-room, where other plants were also present, I generally found that part of the creatures had crawled to the other plants; in fact, I have observed that my specimens have wandered all over my library.

(279.) When these little creatures crawl over the skin, they produce a tickling, too exaggerated to be pleasant; in fact, their crawling is attended with a sensation which is quite painful. These little fellows look very majestic, marching with their antennæ extended before them.

(280.) When the creature first appears, he is to be found sparingly distributed over the larger leaves of the plant; but when the greater part of the plant is destroyed, and the insect has multiplied, great numbers may be found on a single leaf, as though they were determined utterly to annihilate it. The leaflet figured contained about eighty insects upon it.

(281.) They then become partially starved, enter into the pupa state, cast their skins, and emerge as winged insects, when they fly away, and leave no trace behind them save and except the destruction of the plant, and some few specimens which have been injured by the ichneumons. This fact is exceedingly remarkable, for on watching a piece of land, I have found scarcely one of the insects to be left behind, after the greater part had had their wings developed and had flown away. I think that from the period of birth it requires about a fortnight before the Aphis obtains wings and flies away.

(282.) The Aphides over a whole field take wing about the same period, and then a vast cloud of them is formed, which flies to some new locality, there to renew its ravages. This cloud appears in the distance in the form of a mist. I have seen the whole air filled with the flying insects. I have even observed the creatures to settle upon myself in the streets in the centre of London; and, in fact, wherever I have been, there have I seen the destroyer winging its way to commit further destruction.

(283.) When the plant is freed from its pest it will sometimes grow, and send forth new roots to nourish the stem, and the haulm will thus retain much of its vigor. If, however, the plant has been once seriously damaged, it will perish without a second attack of the Aphides, upon the principle which I have heretofore pointed out, namely, that a diseased potatoe will grow a diseased plant.

(284.) When the vastator attacks the potatoe, each leaf is separately destroyed, and the mischief may extend to the stalk and root. In many cases the progress of the disease is at first from above downwards.

(285.) The effect of the destroyer may be watched upon a sprig of potatoe placed in water: we then see very clearly the mode in which the leaf dies and withers up. The vastator passes over a field like a blast; it damages the root, lessens the vital power of the plant, and the insect then assumes the winged state and flies away.

(286.) This vastator does not commit the same amount of mischief upon every kind of potatoe. It dislikes those leaves where moisture is to be found on the under surface in the morning; and thus, according to the state of the plant, it passes over with greater or less rapidity.

(287.) The wild potatoe at Chelsea appears especially to resist its deleterious action, for although I found thousands upon the large leaves, yet they did not destroy it to half the extent that they would have done if they had attacked some of the more highly cultivated varieties of potatoe, and I am informed that all the tubers up to November 3d were quite sound.

(288.) When the insect has damaged the leaf of the plant, it is much influenced by wet weather: a shower of rain will fill the stems with water: and in consequence of the solid portion having been taken away by the insect, the moisture cannot cause the rapid growth of the plant which should take place under such circumstances.

(289.) The sap being thus in too fluid a condition, acts prejudicially, and the plant rots at the collar, the underground stems, various parts of the upper stem, the leaves, the fruit. After this disorganization all the effects which I have described when treating of the disease take place.

(290.) The amount of injury committed by the destroyer is in a great measure proportionate to the period of the growth of the plant at which it attacks it. If it attack it in the early part of the year, the plant is killed before the tuber is formed, and the worst damage is done; if at a later period, the starch is diminished in quantity; and if it attack the plant after the tubers are completely developed, then the creature can do but little injury.

(291.) It is from this cause we find that in the districts where the plant was affected in July, it did so much more damage than when it commenced its ravages in August.

(292.) The first appearance of the disease in a healthy and previously undamaged plant is always subsequent to the visit of the destroyer; and the amount of the disease, *cæteris paribus*, is directly proportionate to the number of insects which take away the vital fluid of the plant.

(293.) In subsequent chapters I shall prove that these important facts have their analogies; for I shall show that the same disease is produced by the same insect in different plants; and also that other species may produce similar disease in the plants on which they feed.

(294.) With respect to the potatoe plant, I have here to enforce that the winged creatures settle upon the larger or more vigorous leaves first, and produce young ones, which rapidly multiply. These suck the juices of the plant, causing the plant to die locally. They also cause the under-ground stem to rot at the collar, and thus effect the destruction of the entire plant, by completely separating the haulm from the roots.

CHAPTER XII.

TURNIP DISEASE.

White turnips, method of attack thereon (296, 297).—Effects of the attack (298—301).—Spiral vessels (302, 303).—Effluvia from rot (304).—Effects of time (305, 306).—Fungi (307).—Aphis brassicæ, description of, (309, 310); its habits (311, 312).—Swede turnip (316).—Conclusion (318).

(295.) Besides the potatoe the vastator attacks other plants; a fact which is important not only on account of the value of the plants which are destroyed, but also as showing that the same insect commits similar ravages on other plants.

(296) The plant attacked which is next in importance to the potatoe is the common white turnip. In this case the perfect insect commences its attacks by settling upon the larger leaves of the turnip when the plant is about four inches high, and there producing its young. Sometimes, however, it attacks it at an earlier period of its growth, even when in the seed leaf; and I have this day observed it in the Circus garden on plants barely out of the seed leaf.

(297.) These young ones continue to produce with great rapidity, and spread from leaf to leaf, until the whole plant is implicated. The larger leaves which were first attacked die first, and the others in succession, till the whole plant becomes disorganized.

(298.) Sometimes the plants affected present a curious appearance at the root, called "fingers and toes;" in fact the root becomes diseased, and these fingers and toes are multiplications of the root, and are thrown out by an effort of nature in order to compensate for the injury done to the main root or turnip. In this state the turnip dies, becomes withered and dried up, forming an example of gangrena sicca, analogous to the dry gangrene of the potatoe.

(299.) The manner in which the turnip dies is quite similar to that in the case of the potatoe; a portion of the leaf may go,—a portion of the stalk supplying nourishment to the plant may die,—or, lastly, the root or whole plant may perish.

(300.) If the bulk is fully formed, and the insects continue to prey upon the leaf, the collar of the turnip, that is, the joining point of the leaves and the root, begins at last to rot, and after the lapse of a short time, if the leaves are held in the hand and very slightly pulled, they will completely separate from the bulb.

(301.) This rot at the root does not take place in very young turnips; it is requisite that they should have attained a certain growth before that appearance is exhibited. The leaf, however, does not require that age, as I have seen young leaves curl, turn brown, and die at a very early period of their growth, though generally they attain a fair size before that occurs.

(302.) If a turnip be examined in a state not so far advanced in decomposition as in the instance which I have already described, it will be found to present a remarkable analogy with the rotten potatoe; and the spiral vessels certainly do appear to have some influence on the malady, probably from the excess of oxygen peculiar to that part of the bulb favoring the decay. (Plate VII., fig. 2.)

(303.) In the turnip, then, the disease appears at the spiral vessels, and extends inwards towards the centre. The part between the spiral vessels and the exterior does not seem so prone to take on the malady.

(304.) During the progress of the disease the most offensive odor is exhaled from the plant. It is much worse than the effluvia emanating from the diseased potatoe; and, in fact, when the turnip root is decayed, it is more damaged than the potatoe. In the turnip there is no starch to be left, and it, therefore, becomes a mere mass of offensive putrefaction.

(305.) From my observations, I should infer, that if we left turnips as long in the ground, comparatively with the development of the plant, as we do potatoes, the disease would be found to be equally extensive; but the fact is, we use turnips at an earlier period of the growth of the plant, and the disease does not appear to manifest itself very decidedly till the vegetable is depositing woody fibre.

(306.) We leave potatoes in the ground till the plant has run its course, has fruited and exhausted itself; whilst the turnip is employed in the first period of its growth, when it is but half developed, and before it has fruited and become exhausted. Notwithstanding this difference, however, the vastator destroys great masses of turnips, and causes them so to rot as to be totally unfit for use.

(307.) The turnip plant exhibits fungi, which come upon the leaf after the attack of the vastator, and thus we have another analogy between the potatoe and turnip disease. Berkeley has figured a fungus which he found on the Swedish turnip.

(308.) The vastator generally feeds upon the under surface of the turnip leaf, for, being a restless insect, impatient of the slightest intrusion, it generally crawls to the under side. In a sitting-room they feed indifferently upon either side of the leaf.

(309.) There is another Aphis which feeds commonly upon the turnip, and which is also highly destructive to it, but which we must be careful to distinguish from the vastator. This insect, which is apparently the Aphis brassicæ, may be known from the vastator by its whiter color, by its shorter antennæ, by its short abdominal tubercles, and by its more gregarious habit, the insects feeding in companies very closely together, like a flock of sheep, and seldom moving from their situation. The winged specimens may often be found dead in the midst of their offspring.

(310.) The Aphis brassicæ presents the peculiar rostrum and suctorial apparatus which I have before described as appertaining to the vastator, from which it is a different species, though also a true Aphis. The solitary habits of the vastator, and the gregariousness of the brassicæ, form strong distinctive characters in addition to those of form and color.

(311.) The first specimens which make their appearance on the plant are winged insects, which produce small larvæ; these rapidly grow, and produce others. As long as the plant is in a vigorous state the insect is transparent; afterwards it becomes olive-green; and when the plant begins to suffer from its ravages the insect turns reddish brown, takes the pupa form, and finally emerges with wings. I have a turnip plant growing in a glass, which has been nearly destroyed by the insect, and during the last two days it has been curious to observe how fast the insects have assumed the winged state to fly away before their supply of food entirely fails them by the perishing of the plant.

(312.) We thus perceive that the power of reproduction is proportionate to, and is indeed controlled by, the quantity of food; and when the food diminishes, the creature, instead of reproducing, obtains wings and flies away, to extend its species in more distant places. And here we have one of those instances with which natural history abounds, of the wonderful resources of nature. Those animal powers of the insect, which, as long as food was abundant, were employed in extending its progeny, are afterwards, when the supply becomes deficient and precarious, turned into a new channel, the result of which alteration is the development of wings. The little creature is not left by nature to perish in the wilderness which itself has made, but is thus furnished with efficient means to bear it away to more hospitable places.

(313.) To ascertain beyond all doubt that the vastator of the potatoe is the same insect as the vastator of the turnip, I have placed those obtained from the turnip on the potatoe, and those from the potatoe on the turnip. From this experiment I found that either plant was indifferent to them; but I noticed that the potatoe vastator seemed to like the turnip better than those from the turnip liked the potatoe.

(314.) I could not help observing how much more stationary and tranquil this insect became when placed upon the turnip; he appeared to have got just what he wished for, and to be in a high state of self-satisfaction, not wandering about in search of anything better suited to his taste: whereas, when on the potatoe, he never seemed to be quite comfortable, but would be strolling about and trotting over the leaf, instead of sitting down at once seriously to his victuals.

(315.) The most minute microscopical examination was made of the vastator from the two plants, but without detecting the slightest difference of structure.

(316.) The Swede turnip is also injured by the vastator; it is, however, attacked far more sparingly by this species, and to a far greater extent by the Aphis brassicæ. It is difficult to isolate the effect produced by the two species, and therefore I did not attempt the investigation.

(317.) A turnip, when it is growing very vigorously, seems, as it were, to throw off the insect, or in fact to grow quicker than the creature multiplies; the root gets the better of the attack, and the insect does not injure it to such an extent.

(318.) From the above account of the turnip disease, we see in the first place that the white turnip is visited with a malady identical in every respect in character with that of the potatoe: the leaf dies, the stalk dies, the root dies, and the two phenomena of gangrene, the dry and wet, are shown. In the second place, the same insect is found upon the plant previously to this change taking place; and, lastly, the disease appears at those parts of the plant which the creature punctures. Our argument is, therefore, cumulative, for two plants are attacked by the same insect, and this attack is followed by the same disease.

CHAPTER XIII.

BEET, SPINACH, AND CARROT DISEASE.

Beet attacked by the Aphis (319).—Mode in which the disease progresses (320—322).—Number of insects on a plant (323).—Another species of Aphis (324).—Spinach attacked (325).—Effects of attack (326).—Action of disease (327).—Effect of rain on diseased plant (328).—Carrot subject to the disease (329).—Operation of disease upon it (330,331).—Disease identical in all plants attacked (332).

(319.) THERE is another plant of very great importance which this destructive creature infests, and that is the beet-root, including the mangel-wurzel and all its other varieties. The leaves of the beet are frequently to be seen completely loaded with this animal.

(320.) There is a small field of beet in the Kentroad, where the large leaves were totally covered by a living mass of these creatures. In some plants portions only of the leaf were destroyed; in others more extensive mischief was effected; and in those plants where the malady had proceeded still further, the gangrene was propagated from the leaf down the stalk, and so on to the crown of the root, which last finally became affected. The insect destroys leaf after leaf, till in some cases the entire plant is killed. The growth of the plant is of course materially interfered with by the stripping off of its leaves, and in several instances I observed that the root was totally rotten. When the root is rotten the disease appears mostly close to the spiral vessels; and, from the number of these vessels in this plant, the whole speedily becomes affected. (Plate VII., fig. 6.)

(321.) In this plant I observed a fact which I have noticed in many other instances; viz. that the greatest amount of mischief is produced in the plant at that period of its growth when we may expect fibre to be deposited.

(322.) For this reason the whole plant seemed always to be more seriously deranged when it had prematurely run to seed; the small leaves of the stem were more seriously destroyed; the stalk was more injured, and the whole plant died.

(323.) I do not pretend to have counted the number of the vastator which may be found occasionally on a single plant; but I should say, confidently, that not less than 30,000 or 40,000 may be sometimes found on a large specimen.

(324.) There is another species of Aphis, a little black rascal, which also infests this plant, but I have not found it to a very great extent.

(325.) The gangrene also attacks the spinach; and this plant requires attentive consideration, because it appears to be very susceptible of injury.

(326.) When the vastator attacks this plant, it lives, according to its general habit, upon the under surface of the leaf, and sucks the juices in the usual manner; parts of the leaf then die or become gangrenous as the result: this, however, is a mere local mischief; but after a time, especially subsequently to rain, the collar of the plant becomes affected, and the entire plant dies at once.

(327.) The mode in which the disease manifests itself in this vegetable is precisely similar to that in the potatoe plant when the under-ground stem is affected; for in this case the upper portion of the root rots, while the root below and the stems above are sometimes not entirely destroyed; so that the plant is, as it were, cut in two or decapitated.

(328.) The appearance of the gangrene after rain is interesting, for it shows that the sap, when deprived of its solid parts by this animal, will no longer bear the addition of water; for in this state of things water so alters the qualities of the sap, that its effect upon the plant is positively poisonous, this vital fluid thus becoming totally unfit to perform the functions of life.

(329.) The carrot is a useful and important vegetable, which we employ for our nourishment as well as for the food of cattle. It however is attacked by the vastator, and rots under its influence. (Plate VII., fig. 1.)

(330.) The insect lives in the first instance upon the larger leaves, which it destroys locally in the different parts attacked. After a time the central portion of the top of the carrot begins to rot; this rot extends downwards through the pith, and onwards, till at last the leaves are completely separated from the root, as in the case of the potatoe and turnip, when the entire plant dies. On handling a plant in this condition, the top instantly separates from the root.

(331.) I believe that the carrot exhibits the effects of the disease in a greater degree when it is running to seed, as in that case it seems to become impatient of the injury inflicted by the insect.

(332.) The injury suffered by all these vegetables corresponds precisely with the mischief which the vastator works upon the potatoe; it is in fact a mere transposition of the damage from one plant to another. The insect punctures the leaf, sucks its juices, injures the sap, and causes either local death of the part first damaged, or the general death of the plant by inducing gangrene at the collar.

CHAPTER XIV.

THE APHIS VASTATOR ON OTHER PLANTS.

Solanum dulcamara and nigrum attacked by the vastator (334).—Its effect upon them (335).—Greenhouse and other species of solanum (336).—Atropa belladonna (337).—Hyoscyamus (338).—Tobacco not attacked (339).—Stramonium attacked (340).—Comparative effects on wild and cultivated plants (341).—Mode of operation (342).—Numerous cruciferous plants attacked (343, 344).—Horse-radish (345).—Tomato (346).—Vastator on Indian corn (347).—On wheat (348—351).—Not on the oat (352).—Wild barley grass (354).—Seedling pasture grass (355).—Jerusalem artichoke (357).—Nettle (358) —Mallow (359).—Heartsease (360).—Coreopsis tinctoria and Balsam (361).—Parsnip (362).—Chickweed (363) —Young elders (364).—Geranium molle (365).—Plantain (366).—Groundsel (367).—Shepherd's purse (368).—Spurge (369).—Marigold and Thistles (370).—Peach and Nectarine (371).—Celery (372).—Probably other plants also (373).—Remark (374).

(333.) It became a matter of very great interest to ascertain whether any other plants, besides the potatoe and the turnip, were affected by the vastator; and if they were, to what extent they were likely to suffer. To the investigation of this point, then, I gave my undivided attention, and to the results of this investigation I devote the present chapter.

(334.) I have found the insect upon the *Solanum dulcamara* and *nigrum;* on the first of these, when it grows about the hedges, I have never found many of the insects, for they do not appear to take a great fancy to this plant in this situation. However, upon this as well as upon the nigrum, I have found it in great abundance when the plant was growing in fields, and I have not unfrequently found every leaf so densely covered with this pest that scarcely any portion of the leaf was visible between the insects.

(335.) Their effect upon the nigrum and dulcamara, when in a wild and natural state, is to destroy each leaf separately, and in this way gradually to kill the plant. Upon some large, luxuriant specimens, which were growing on a dunghill, the insect was very abundant, and I found the roots gangrenous and ulcerated just below the ground, showing a similar character to that evinced by the potatoe.

(336.) Besides these solani, I have found it upon many greenhouse and other species, of which I need not enumerate the names, the fact being of importance only as showing the preference evinced by this aphis for this genus of plants.

(337.) The *Atropa belladonna* is in like manner affected; and I find quantities of the vastator on these plants in various situations.

(338.) I have also observed the vastator on a species of henbane, growing in the garden of Finsbury Circus; and I have just received a plant of the hyoscyamus from Stafford, with plenty of these insects feeding on it.

(339.) These creatures do not appear to me to like the tobacco plant, for after examining many species I have failed to detect a single insect, either in its winged state, or as a larva or pupa.

(340.) The stramonium is attacked by this creature, and its large leaves are often totally destroyed by its ravages.

(341.) In all these instances, the effects noticed are precisely analogous to those presented by the potatoe, but in these instances, the plants resist the attacks of the vastator better, being in a more uncultivated, and therefore a more natural condition. The wild potatoe resists the invasion to a much greater extent than the cultivated varieties, and these solanaceous plants present the disease in precisely the same character as the wild potatoe.

(342.) In some cases, a small portion of the leaf dies; in others, the effect is evidenced on a greater portion, or in the whole of the leaf. The larger leaves are generally first attacked; and when the plant is weakened, the insect migrates to the smaller leaves, and thus successively kills every portion of the plant: it then takes wing, and flies away to commit its ravages elsewhere.

(343.) Next to plants belonging to the order of the Solaneæ, those included in the order Cruciferæ appear to suffer most. Besides the turnip and the Swede, to which I have given a distinct chapter, I have found it upon the radish, the cabbage, the brocoli, the wild turnip, the mustard, the horse-radish, and other cruciferous plants.

(344.) The cabbage and brocoli, although they are infected with the vastator, are generally attacked by another Aphis to so much greater an extent, that the vastator is but of comparatively little consequence. The two kinds are frequently to be met with upon the same leaf, committing their ravages in company.

(345.) The large and vigorous leaf of the horse-radish might be supposed to be secure from injury from so small and seemingly insignificant an animal; yet the largest of its leaves will be totally destroyed by the insect's agency, and the plant will show a tendency to rot at the junction of the stem with the root. In this plant the disease appears in its early stage as minute points of discoloration, which are observable at the places where the creature feeds, and which enlarge and spread until ultimately the entire leaf becomes infected.

(346.) Upon the tomato, which has also been affected with a disease, I discovered winged specimens at the gardens of the Horticultural Society, but was not successful in finding larvæ or pupæ, perhaps because they had then all assumed their final state. At the garden, however, of my friend Mr. Terry, at Fulham, I found the insects in all stages in the greatest profusion.

(347.) The Aphis may also be occasionally found upon the Indian corn. I had it sparingly in the larva state upon some of the plants growing in my garden at Finsbury Circus; and, at the gardens of the Horticultural Society, I discovered it in the winged state upon the same vegetable in great abundance, but could not detect any larvæ.

(348.) In several instances I have found the creature upon wheat plants which were growing in or near a potatoe field; but I have nevertheless some doubts whether it can entirely live and thrive upon it.

(349.) I would invite particular attention to this question, for it will be a very serious matter if the insect can live and propagate freely upon this grain. In examining this subject, the naturalist must not confound another large Aphis, which also lives upon the wheat, with the vastator.

(350.) I procured two or three plants of wheat which had sprouted again after having been cut down with the sickle, and upon the green stalks of these I placed specimens of the vastator, which there lived and throve very well, and propagated their species. Since writing the above paragraphs I have had even further evidence of this insect preying upon the wheat.

(351.) This year the destroying cloud of vastators has not appeared till August. Supposing, however, that from their excessive numbers it should come before the grain is formed, there is no doubt that the creature might annihilate our crop.

(352.) I do not believe that this creature can live upon the oat. I have frequently examined oat plants in the midst of dying potatoes, where the remnant of the troop of the destroying Aphides were glad to find any domicile, but I have not observed a single plant infected. The oat is, however, assailed by a totally different Aphis, which is quite as partial and destructive to it as the vastator is to the potatoe.

(353.) I have placed the two species together upon an oat plant which was living in my sitting-room. In a few days the vastator had entirely disappeared, whilst the other species throve remarkably well, and is now existing in all its stages of development, feeding on the stalks of the young grain.

(354.) Upon the wild barley grass, however, I have found the vastator in great abundance, feeding and apparently thriving well upon the leaves, which very soon die, turn yellow, and decay under its destructive influence. This grass is also preyed upon by another Aphis.

(355.) A seedling pasture grass is liable to be attacked by the vastator, which kills leaf after leaf, till, in some cases which I have seen, the whole plant is totally destroyed by it. In this case the vastator is generally conjoined with another species, which is hairy and has no abdominal tubercles.

(356.) I am not aware that the vastator ever lives upon rye, buck-wheat, peas, or beans. The Aphis which attacks the pea, though equally destructive, is a very distinct insect from the vastator, as I shall hereafter point out.

(357.) I have found the vastator somewhat sparingly upon the Jerusalem artichoke, but certainly not to a sufficient extent to do mischief. Some artichokes supplied by a London greengrocer for the dinner table were hard at one end and soft at the other; but whether this has been the result of the malady, I am unable to state.

(358.) The common nettle is in some places attacked by the vastator. When this is the case, the leaves die principally at the edges and in the fleshy parts, in a manner precisely similar to that in which the potatoe suffers. At last the whole of the leaves die, and the plant becomes ultimately shrivelled. The root is found to be soft and watery, and shows a great tendency to rot, especially at the part where it joins the stem. The nettle is also attacked by another species of Aphis.

(359.) The mallow, also, is liable to the attacks of this insect; and when attacked, the leaf dies much in the same manner as is seen in the turnip; it turns yellow, at first partially and then totally, and leaf after leaf is destroyed.

(360.) The vastator also attacks the common heartsease much in the same manner as in the last instance; and when the plant has been attacked for a certain period, the stem generally begins to rot at its lower part, and the plant is doubtless eventually destroyed.

(361.) The *Coreopsis tinctoria* is liable to the attack of the vastator. The insect lives upon the leaves and destroys them as in other vegetables. In the garden balsam the Aphis injures the leaves partially or totally, and thus destroys its existence, and in this case the root swells about the collar.

(362.) The parsnip is infested by this insect sparingly. In this plant the leaves die from its attack, and lastly the root becomes affected. It is difficult to tell the precise influence the vastator has upon this plant, because another Aphis is also generally found conjoined with it. (Plate VII., fig. 5.)

(363.) I have found the vastator on the chickweed plant in some instances, but not as yet to such an extent as to cause extensive damage.

(364.) I have seen young elder trees infested with this Aphis, but I have not noticed much mischief as a consequence.

(365.) The *Geranium molle* has its leaves and stem, and in fact the whole plant, frequently destroyed by this insect.

(366.) The common plantain may also be found suffering from the effects of the ravages of the vastator.

(367.) Of all plants there are few, or perhaps none, so difficult entirely to destroy as the common groundsel. Every one knows that its eradication from the garden is scarcely to be effected; and yet this little insect can kill it entirely with great certainty. It will attack a very vigorous plant, and shortly the leaves begin to change color and shrivel up, precisely like the potatoe; the stem becomes distended with water, and presently dies. I could, in one particular field, have procured a large basket-full of specimens of this plant utterly destroyed by the vastator.

(368.) The shepherd's purse is killed in almost a similar manner, and to a similar extent, although a very hardy plant.

(369.) The common spurge is liable to be most extensively affected by the vastator; leaf after leaf dies, until the plant becomes a mere withered mass.

(370.) The marigold and several species of thistle are also attacked by the vastator, and perish in the usual way.

(371.) The peach and nectarine leaves are infested by this parasite: it generally kills the leaves partially.

(372.) The celery plant is commonly attacked to a small extent by the vastator: I have never myself seen the insect, however, upon this plant in sufficient quantity to do more than kill a leaf. There are complaints about this esculent, but I know not whether the injury complained of is referable to this cause. The plant is more likely to suffer when running to seed, than in its first year's growth.

(373.) Such is an enumeration of the plants which I have found to be affected with this parasite. And there is no doubt that this list might be very much extended, as I myself am adding to the number every day, and within the last two or three days I have even discovered it abundantly on the *Convolvulus battata*, or sweet potatoe. In this examination I have observed that cultivated plants, in which particular parts of the plant are excessively developed or hypertrophied, are more prone to injury than the wild plants of the same species. In the wild plants the injury generally spreads from leaf to leaf, whilst in the cultivated varieties it appears to attack root and leaf at the same time.

(374.) The above list shows how fearful an attachment this insect has to plants which are serviceable to man for food, as well as for medicine, well entitling it to the name which I have given it—the *vastator*, or "destroyer."

CHAPTER XV.

INJURIES SIMILAR TO THOSE CAUSED BY THE VASTATOR, PRODUCED BY OTHER APHIDES.

Aphides, numerous species of (375).—Aphis of the hop (376).—Aphis of the cabbage and turnip (377).—Aphis of the pea (378).—Instance of mischief by [Kirby] (379).—Bean aphis (380).—Apple-tree aphis (381).—Sugar-cane (382).—Aphis of larch (383).—Rose-tree aphis (384).—Aphis on couch-grass (385).—Aphides generally (386).

(375.) The species comprised in the family "Aphides" are a sad pest to the human race. It is quite uncertain how many there are,* for abstract science is so little appreciated, so little cared for or encouraged, that few can afford to spend their time in watching an Aphis; and thus, when great calamities come, men see not the cause, because they know not the insect.

(376.) The Aphis of the hop lives upon the leaves of that plant, and does so much damage, that in bad years its ravages will cause a reduction in the value of hops produced in Great Britain amounting to very near 3,000,000*l.* sterling. This year the insects threatened to destroy the crop, but suddenly a thunder storm swept every one of them from the face of the plantations, and so thoroughly were they annihilated, that when I sent to Kent to procure some specimens of this species, I received answer that there were none to be found.

* Stephens, in his "Systematic Catalogue of British Insects," has recorded forty-nine named species of the genus Aphis alone, and others appertaining to the several cognate genera.

(377.) The Aphis of the cabbage and turnip is very destructive to those plants; it is distinguished from the vastator by its white color, its short abdominal tubercles, and the structure of its antennæ. It is not nearly so active as the vastator, and remains for a long period in one place. It, however, destroys the leaf, and produces a similarly injurious effect upon the plant.

(378.) The Aphis of the pea is a very destructive species, and frequently causes our late crops of peas to rot entirely off. It is a noble-looking fellow, and about twice as large as the vastator. Its color is green, and it lives upon the leaves in the usual way; the mode in which it acts upon the pea being exactly similar to that in which the vastator affects other plants. The leaf is injured, the vigor of the plant is diminished; and the plant perishes either at the leaf, stem, or at the junction of the stem with the root; when the connection between the root and leaf being lost, the plant necessarily dies.

(379.) Kirby mentions that in 1810 the produce of the pea crops did not amount to much more than the seed sown, and that many farmers turned their swine into their pea-fields, not thinking the crop worth harvesting.

(380.) The bean also has its Aphis, which frequently causes an almost total failure of the crop. The bean leaf is injured, the stalks grow black, and the plant perishes, producing very little or no fruit. The gardeners generally conquer this animal by cutting off the tops of the plants with a sickle.

(381.) A small Aphis* attacks the apple-tree: it is called

* We here use the general term "Aphis," because the insect belongs to the family Aphides; it does not, however, strictly speaking, belong to the genus Aphis, but to the cognate genus Eriosoma, one

the *Aphis Lanigera*, and has a woolly body, and when crushed it is of so bright a red as to stain things with which it comes in contact. This Aphis lives upon the bark and roots; it is very destructive, and will kill even the largest trees in an orchard. Around the metropolis it destroyed thousands of trees; and when it spread into Gloucestershire, it almost caused the abandonment of the manufacture of cider. It began in a nursery in Sloane street, and spread over England, committing its ravages for a number of years. Sir Joseph Banks relates that it destroyed so many codlin trees in one garden, the rental of which was 50*l.* a year, as to almost annihilate the produce. This insect has lately been rather scarce, and though it still exists, yet it does but little damage at the present time.

(382.) The leaves of the sycamore, in some places, present a most remarkable maculated appearance, from large black spots as big as a sixpence. These are owing to a fungus which follows the attack of a noble Aphis, which honors this tree by sucking its vital fluid. In this instance we have a case of local death from the puncture of the Aphis.

The sugar-cane, according to Kirby, has its Aphis, which sometimes destroys the whole crop.

(383.) Kirby also states that the larch, in particular, is inhabited by an Aphis, which exudes a waxy substance, like filaments of cotton, and becomes so infinitely multiplied as to whiten the whole tree, which often perishes in consequence of the attack.

of the distinguishing characters of which group is well indicated by the generic name, which is made up of the words Εριον wool, and σωμα a body.

(384.) The rose-tree is commonly infested by an Aphis which feeds upon the tops of the shoots and the adjacent leaves; and I have been informed by Dr. Fergus that several trees have this year had nearly all their branches destroyed by its ravages. This Aphis seems to have a special aversion to cold water; a good syringing with which generally compels them all to relax their mischievous hold, and a second application commonly washes the whole tribe to perdition.

(385.) If there is one plant more than another remarkable for its power of resisting destroying agencies, it is, perhaps, the couch-grass; but I have observed that even this weed has its leaves attacked by a beautifully spotted Aphis, which gradually destroys them and kills the whole plant.

(386.) The family of Aphides is most numerous, and doubtless all the species act in an equally injurious manner. It is not, however, the purport of this work to give a history of the Aphis, and I quote these few instances merely to show that the vastator is not singular in injuring man by its attacks upon various plants.

CHAPTER XVI.

ON THE EXCESSIVE APPEARANCE OF PARTICULAR INSECTS.

Natural balance in the relative numbers of living creatures (387).—This balance occasionally disturbed (388).—Excessive appearance of Aphis vastator (389).—Instance at Brighton (390).—Insect plagues recorded in the Old Testament (391).—Kirby and Spence (392).—Ravages of the May-beetle (393, 394).—Ravages of several species of insects (395, 396).—Bostrichus typographus (397).—Locust plagues (398, 399).—Wasps (401).—Honeydew (402).—Controlling agents (404).—The exaggerated increase of particular insects not continuous (405).

(387.) We have now found that the gangrene of the potatoe is to be attributed to an excessive increase of the *Aphis vastator*. As a general rule, Nature has exquisitely contrived that every organic body should bear certain relations to other organic bodies, and hence the earth remains tenanted with a great variety of beings, and none are in excess to the detriment of the rest.

(388.) In particular instances, however, this balance of tenantry is disturbed, and occasionally some one insect becomes too redundant, and occupies more than its allotted space.

(389.) The excessive appearance of the *Aphis vastator* is an instance of this character; for to such an extent has it been recently found, that in a field of beet, less than a quarter of an acre in extent, there were countless millions of this parasite. It appears that some time previous to a thunder-storm this Aphis is apt to fly; and on September

9th I observed at Clapton a reddish cloud exterior to a thunder-cloud, and this was composed of myriads of the winged insects, which kept dropping here and there in such profusion, that by waving the hat numbers might soon have been caught. On examining the spiders' webs many were to be found adhering in each web. From this it is apparent that the excess of the vastator is analogous to other excesses heretofore known.

(390.) I am informed by Mr. Kennedy, that on the 14th of September, in this year, a cloud of Aphides passed over the Downs at Brighton, and such were their numbers that he became literally covered with them, and was very glad to turn his back to avoid their settling upon his face. Mr. W. R. Smee states, that he was informed by the inhabitants of Freshwater, Isle of Wight, that they had observed this year vast clouds of insects, or flies, appearing like a great mist, and they occupied five or six hours in their passage. Mr. W. R. Smee also states that he was informed by a farmer at Chichester that he saw insects settle in large numbers upon his potatoes. It is impossible to tell now what these troops of insects were, for neither Mr. Kennedy nor my brother can state with certainty. The former gentleman stated that they resembled a winged *Aphis vastator*, which I showed him.

(391.) The earliest account of an excessive increase of particular insects is to be found in the 8th chapter of Exodus, where it is recorded that the Egyptians were plagued with an immense multiplication of lice. We find also, in the same chapter, that the land was corrupted by reason of the swarm of flies. In the book of Joel is contained a beautiful and highly poetical description of the effect of this excessive increase of insects: "For a nation has come up upon my land, strong and without number;" and "the field is wasted, the land mourneth; for the corn is wasted, the new wine is dried up, and the oil languisheth." In the 2d chapter of the same book, verse 1 to 11, we meet with the most appalling description of another insect plague, where the insects are spoken of as "the army of the Almighty, strong to execute his word." In the 10th chapter of Exodus we find it recorded that a numerous swarm of locusts "covered the face of the whole earth, so that the land was darkened; and they did eat every herb of the land, and all the fruit of the trees which the hail had left."

(392.) If we turn to the charming work of Kirby and Spence, we shall find many instances of this excessive increase of various insects, showing that the present multitudinous appearance of the vastator is perfectly analogous with instances heretofore known.

(393.) In 1785 many provinces of France were so ravaged by the larva or grub of the cockchafer, that a premium was offered for the best means of destroying them: and some time ago eighty bushels of the beetle were collected by a farmer near Norwich. I remember also this pest visiting the Circus some years ago, and threatening to destroy every plant and every blade of grass there existing.

(394.) In 1688 the cockchafers themselves filled the hedges and trees in part of the county of Galway in such infinite numbers, that they were seen clinging to each other in clusters, like bees when they swarm. When on the wing they darkened the air, and produced a sound like that of distant drums. When they were feeding, the noise of their jaws might be mistaken for the sawing of timber; and in a short time the leaves of all the trees for many miles round were so totally destroyed by them, that at midsummer the country wore the aspect of the depth of winter.

(395.) In 1788 and 1794 two-thirds of the crop of cotton in Crooked Island, one of the Bahamas, was destroyed by a lepidopterous larva.

In 1734 and 1735 vast swarms of a beetle devoured almost every vegetable production of the island of Barbadoes, particularly the potatoe.

In 1786 the turnip crops in Devonshire were destroyed, to the value of 100,000*l*., by the turnip flea.

In 1735 the *Plusia gamma*, which is a pretty common moth with us, increased to such an extent in France as to infest the whole country. Vast numbers of the larvæ travelled from field to field, and in gardens devoured everything, leaving only the stalks and veins of the leaves.

(396.) In 1731 the oaks in France were terribly devastated by an excessive increase of *Hypogymna dispar* (the gipsy moth); and in 1797 many of the pine forests about Bayreuth suffered a similar injury.

In 1782 the brown-tail moth caused great alarm to the inhabitants of the vicinity of the metropolis, when rewards were offered for collecting the caterpillars; and the churchwardens and overseers of the parishes attended to see them burnt by bushels.

(397.) There is a small beetle, the *Bostrichus typographus*, which bores into the fir. This insect was particularly prevalent about the year 1665: it reappeared in 1757, redoubled its injuries in 1769, and arrived at its height in 1783, when the number of trees destroyed by it in the above forest alone was calculated at a million and a half, and the inhabitants were threatened with a total suspension of the working of their mines, and with consequent ruin.

(398.) One of the greatest occasional pests in the form of an insect is the locust. Orosius stated, that, in the year of the world 3800, Africa was infested with such infinite myriads of these animals, that, having devoured every green thing, and afterwards flown off to sea, they were drowned; and being cast up on the shore by the tide, they rotted, and emitted a stench greater than could have been produced by the carcases of 100,000 men. St. Augustine also mentions a plague "to have arisen in that country from the same cause, which destroyed no less than 800,000 persons in the kingdom of Masinissa alone, and many more in the territories bordering upon the sea.

(399.) In one year a million of men perished from the stench of the carcases of the insects; in another 30,000 died of starvation; and Barrow mentions that in 1784 an area of nearly 2000 miles was covered by them.

In 1778 and 1780 the empire of Morocco was so infested, that vast numbers of the inhabitants perished, and the roads and streets exhibited the unburied carcases of the dead.

(400.) These instances I have selected from the truly delightful work of Kirby and Spence; but I might mention many more instances from my own recollection. I have, however, given enough to show that the relation of particular insects to other parts of creation is sometimes disturbed, and that any species may appear in this exaggerated manner.

(401.) Our naturalist Gilbert White states that "in 1783 there were myriads of wasps, which would have devoured all the produce of my garden, had we not set the boys to take the nests, and caught thousands with hazel twigs tipped with bird-lime; we have since employed the boys to take and destroy the large breeding wasps in the spring."

(402.) "In the sultry season of 1783, honey-dews were so frequent as to deface and destroy the beauties of my garden. My honeysuckles, which were one week the most sweet and lovely objects that eye could behold, became the next the most loathsome, being enveloped in a viscous substance, and loaded with black Aphides or smother flies."

(403.) "On the 1st of August, about half an hour after three in the afternoon, the people of Selborne were surprised by a shower of Aphides, which fell in these parts. They who were walking the streets at that time found themselves covered with these insects, which settled also on the trees and gardens, and blackened all the vegetables where they alighted. These armies, no doubt, were then in a state of emigration and shifting their quarters, and might perhaps come from the great hop plantations in Kent or Sussex, the wind being that day north. They were observed at the same time at Farnham, and all along the vale at Alton."

(404.) Whilst recently on a short visit to Northaw Park, my attention was directed to the destruction which had this year taken place amongst the firs; and most elegant trees, of fifty years' growth, upon the lawn, were so much damaged, as to render it doubtful whether they would ever recover. I am informed also that in some places hundreds of these trees have been totally killed this year by the ravages of the insect, but I am uncertain as to the exact creature which has caused the injury.

Locusts are also said to have appeared in the east this year, and I know that many rare insects, as the Camberwell beauty, the death's head moth, and the unicorn hawk moth, have been taken this year more abundantly than usual.

(405.) Insects are kept in bounds by atmospheric causes, birds, bats, reptiles, and very many species of insects which prey upon others. Therefore, when one insect shows itself in too great abundance, we must look out for the particular destroyer destined by nature to keep it within its accustomed limits.

The human species has frequently been threatened with total destruction by the locust, and yet man still lives, and the locust has returned to its proper limits in the circle of creation.

The last two or three years the vastator has threatened millions of men; but, doubtless, at last the harmony of the universe will be restored, the super-abundance of the insects will be checked and controlled, and man will be saved from its attacks.

CHAPTER XVII.

RELATION OF THE VASTATOR TO OTHER APHIDES AND TO FUNGI.

Analogy between the different aphides (406—409).—Probable effect of the predominance of one species (410).—Destructive power of aphis (411).—Relation of fungi to aphides (412).

(406.) The numerous species of Aphis bear a strong analogy with each other; they all live upon the juices of plants, and are the prey of certain parasitic *Hymenoptera* which are smaller than themselves.

(407.) I have generally observed, when I have found any one species of Aphis in any particular spot, that other kinds were to be met with in profusion in the neighborhood: hence, it is not at all uncommon to find many kinds of Aphis in the same field, not feeding upon the same plant, but each upon its own proper food.

(408.) This, however, is not by any means an universal rule, for, although the vastator, the brassicæ, and various other kinds have been in great abundance this season, yet the hop Aphis disappeared on the commencement of a thunder-storm.

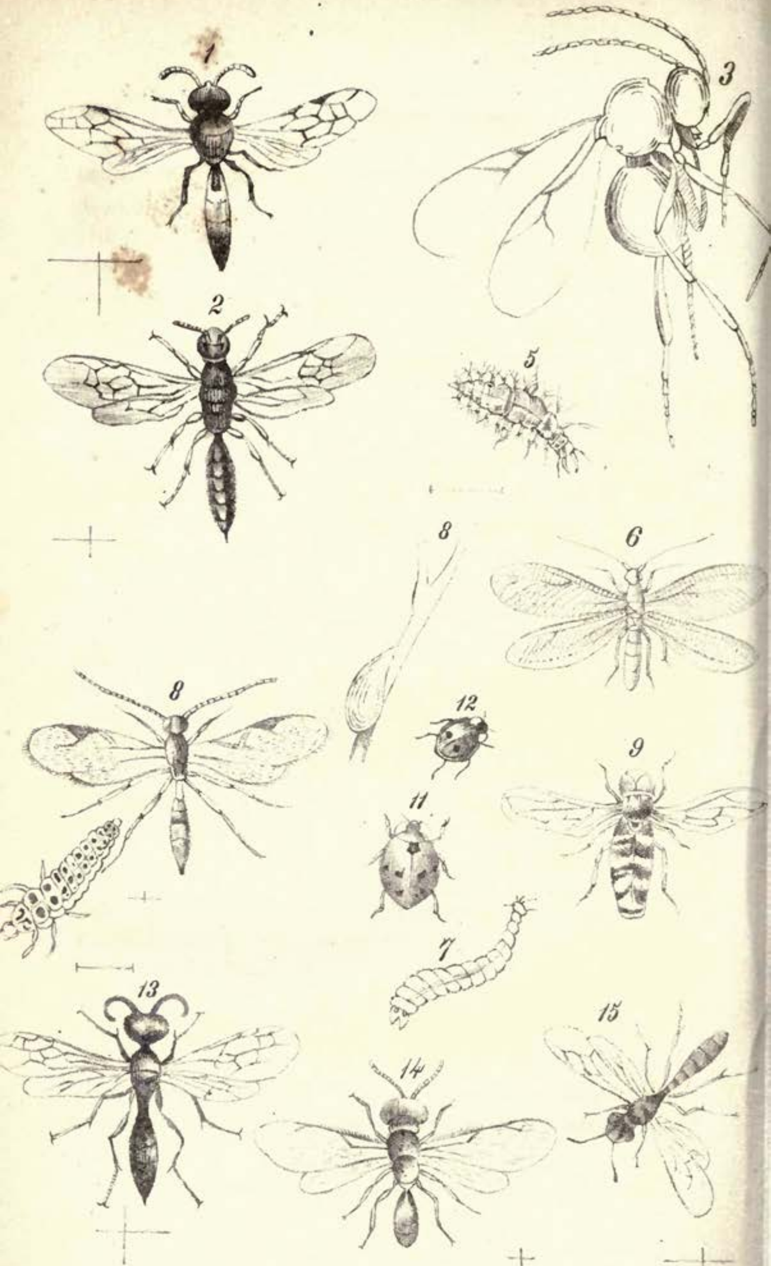
(409.) The brassicæ is so abundant this year that some of the greens supplied in London are covered with countless myriads of them, and hence we may infer, that this year it is not the balance of Aphides only which is destroyed, but the balance between the Aphides and their parasites.

(410.) From this view of the question, even more importance must be attached to the preternatural appearance of the Aphis; for, as perhaps every plant has some parasitical Aphis which damages its juices, it follows that the excess of one kind may ultimately injure all vegetable bodies.

(411.) This, indeed, gives us a fearful idea of the destructive character of the Aphis, and shows us that if one species is in excess, all vegetables may suffer.

(412.) There appears to me to be a very close relation between the injury committed by the Aphides and the appearance of fungi; for in numerous cases where I have

Pl. 10.



On Stone by Gratacap. Printed by H. R. Robinson.

observed fungi on the leaf, I have also noticed Aphides on the plant.

It is also a singular fact, that there is a word in the Hebrew language which means blight and mildew, collectively, meaning thereby Aphis and fungus.

The Aphis, however, only favors the growth of the fungus by injuring the vital powers of the plant; and, therefore, any other circumstance which can debilitate the plant doubtless may favor the appearance of the fungus.

CHAPTER XVIII.

NATURAL REMEDIES FOR THE PRESENT DISEASE AMONG PLANTS.

Animals destructive to aphides (413).—Coccinella (414, 415);—Profusion of (416).—The Gauze-wing (418).—Larvæ of Sylphidæ (419).—Parasitic Hymenoptera (420, 421).—Other Hymenoptera (422).—Earwing and species of Acarus (424).—Spiders (425).—The soft-billed birds (426, 427).—Ducklings (428).

(413.) The balance of creation is disturbed,—the *Aphis vastator* has increased to an alarming extent,—we must therefore inquire by what means this creature is generally kept within due bounds, and we shall find that numerous animals prey upon it.

(414.) The lady-bird or lady-cow (Coccinella), together with its larva, makes great havoc amongst the Aphides; and thousands of these creatures are to be found upon the potatoe, the turnip, and other vegetables, when the vastator is there. You will sometimes even be guided to the Aphis by the presence of the lady-bird.

(415.) Kirby and Spence say "that in France they regard these Coccinellæ as sacred to the Virgin; and call them 'Vaches à Dieu, Bêtes de la Vierge;'" and even in this country they are great favorites with children.

(416.) "In 1807 the shore at Brighton and all the watering-places on the south coast was literally covered with them, to the great surprise and even alarm of the inhabitants, who were ignorant that they were emigrants." I have heard also that at Ramsgate the entire cliff has been occasionally completely covered with this pretty little beetle.

(417.) There is no doubt that if we could breed these creatures by millions, we could annihilate the Aphis; but the vastator is such a sad rover, that I suspect it often escapes the beetle. The larva of the beetle is more destructive to these insects than the beetle itself. (Plate x., figs. 10, 11, 12.)

(418.) Kirby and Spence state that "there is a beautiful genus of four-winged flies, whose wings resemble the finest lace, and whose eyes are often as brilliant as burnished metal, the larvæ of which, Reaumur, from their being insatiable devourers of Aphides, has named the lions of the Aphides. When amongst the Aphides, like wolves in a sheep-fold, they make dreadful havoc; half a minute suffices one of them to suck the largest Aphis: and the individual of one species clothes itself, like Hercules, with the spoils of the hapless victims." (Plate x., figs. 5, 6, *Chrysopa perla*).

(419.) There are many species of *Sylphidæ* (a family of dipterous insects), which destroy Aphides. The larvæ of these creatures are armed with a singular mandible, furnished, like a trident, with three points, with which they transfix their prey. They lie at their ease under a leaf or upon a leaf, surrounded by such hosts of Aphides, that they can devour hundreds without changing their situation. (Plate x., figs. 7, 8, 9, *Scæva pyrastri.*)

(420.) Various hymenopterous insects are great destroyers of Aphides. There are some genera which deposit their eggs in the bodies of the Aphis; the egg grows and becomes a maggot, which eats up the creature, avoiding, however, the vital parts till the last. The Aphis when attacked by this parasite swells up, assumes a globular form, and at length dies and remains adherent to the leaf. Aphides in this state are to be found on every plant, and, indeed, upon almost every leaf which is affected with the insect. In a few days after the death of the Aphis, the inclosed creature eats a little circular hole and comes forth a winged insect. The insects which thus destroy the Aphides by thousands are called Ichneumons, but how many species there may be which actually attack the Aphis I am ignorant. I have figured two which have escaped from Aphides in my own possession. (Plate x., figs. 3, 4.)

(421.) These insects are very minute, and may be known at once from the winged Aphides by the total want of resemblance in every particular.

Curiously enough these creatures again have their parasites; for other Hymenoptera, the *Chalcididæ* for instance, deposit their eggs in the maggot of the already punctured Aphis; and thus we have an Aphis with a maggot within its body eating it up; and lastly, a maggot within this maggot devouring that also. I have figured an example of this parasite upon parasite. (Plate x., fig. 14, *Colax dispar.*)

In part verification of the lines :—

> "Great fleas and little fleas have smaller fleas to bite 'em,
> The smaller fleas have lesser fleas, so on ad infinitum."
> *Quoted in Stephens' Illustrations*, vol. vii.

(422.) There is another set of hymenopterous insects, which seize upon Aphides and carry them off to their habitation to feed their own children. It is said that thousands are thus killed. Examples of this order, which perform this friendly office to man, are to be found in the genera of Psen, Diodontis, Pemphredon, and Tropoxylon. (Plate x., figs. 1, 2, 13, 15.)

(423.) I have no doubt that the omnivorous and greedy wasp would have no objection to eat Aphides, if he could get nothing better. I formerly tried to press two or three colonies of wasps into my service, to make skeletons of small animals, but their voraciousness was so great, that they not only ate the flesh but the bones also.

(424.) I very much suspect that the earwing is a great devourer of Aphides, although it is stated that it is entirely a vegetable feeder. When I have gone at night with a lantern to see what the Aphides were about, I have frequently observed numbers of earwings very busy at the places where the Aphides greatly abounded, but I have not actually seen them devour them. There is a very beautiful *Acarus* which is always to be found in company with the Aphides. He seizes the Aphis, and appears to suck its juices. (Plate v., fig. 9.)

(425.) Numbers of black and other spiders doubtless prey upon Aphides, but I have frequently observed when the winged Aphis is caught in the spider's web, that the spider has not attacked it. Whether this arises from his having been surfeited with the great superfluity of this kind of food this year, or whether he does not like the flavor of them, I am at a loss to determine.

(426.) Doubtless Aphides form dainty food to the soft-billed birds, and if they would entirely live upon them, they would doubtless devour three or four thousand at a single meal. With regard to birds, however, a very important question is opened for our consideration; for if they prefer the parasites of the Aphis to the Aphides themselves, then their presence would be hurtful; if, on the contrary, they eat the Aphides and avoid the parasites, then they would act most beneficially.

(427.) When a schoolboy, I formed the idea of examining the crops of birds at various times of the day, and at all seasons of the year, so as to ascertain the number of insects, the kinds of insects, and all other kinds of food that they devour. Compelled, however, to live in London, and engaged in other matters, I ceased to pursue my plan, though I saw facts amply sufficient to astonish me at the vast collections of insects which the crops of birds contain.

I would advise the farmer to shoot various birds where the vastator abounds, and to examine their crops, to ascertain whether they prefer the creatures themselves or the parasites.

(428.) Ducklings, which delight in eating little insects, would also doubtless devour these destroyers of human food.

(429.) From the above observations, we find, that, although our most valuable vegetables are threatened with destruction by a little insect, yet curiously enough our hope of preservation from this calamity is in a great measure dependent upon the operations of another insect even more minute.

CHAPTER XIX.

RELATION OF THE GANGRENE TO OTHER DISEASES OF THE POTATOE.

The curl (430, 431).—Hollins' description; varieties of curl (432—434).—Putsche and Vertuch's description (435).—Curl probably identical with present disease (436).—Curl from attack of vastator (437).—The rust (438).

(430.) THE potatoe is affected with other diseases besides the gangrene, such as the curl, &c. The curl was so extremely prevalent some years ago, that the Society of Arts awarded a premium for the best remedy.

(431.) The curl, though very common at the commencement of the nineteenth century, has departed for many years, so that now we can only know the disease by report.

(432.) Hollins describes the half-curl, the curl, and the corrupted. "The half-curled plants have leaves somewhat long, and curl only in a moderate degree; they produce a tolerable crop if the summer be not very dry; but if otherwise, the produce will be small and watery."

(433.) "The completely curled potatoe plants are seldom more than six or seven inches high. They soon ripen and die. The potatoes are generally smaller than a nutmeg, of a rusty-red color, and unwholesome for food."

(434.) "The corrupted potatoes are those in which the vegetative power is nearly destroyed. These never appear above ground. The sets may be found at Michaelmas with the same appearance as when they were planted, with a few small potatoes attached to them."*

(435.) Putsche and Vertuch state "that the plants which are affected by this disease have an extremely meagre appearance. The stem is unbranched, brownish-green, or mottled, and here and there sprinkled with rusty spots, which penetrate to the pith; so that it is not white, but rust-colored, or sometimes black. The upper surface of the leaves is not so smooth as usual, but rough, wrinkled, curled, or crumpled. The leaves are far more sessile than usual, and not of an uniform brownish or dark green, but spotted. The passages for circulation, imbibition, and respiration, are none of them in a healthy state. The pith is often discolored or dried up, even in the young shoots. The starved plant often perishes early in autumn, when the tubers should be making their most rapid growth. These tubers are scanty and tasteless, juicy and almost unfit for food. Even the color of the outer coat of the tuber is changed. The same tuber is in parts brown, in parts of a dirty yellow, and sometimes the two tints run into each other. Some sorts of potatoe are more subject to the disease than others: it is more prevalent in flat countries than in more elevated districts."†

(436.) From these descriptions, I am much disposed to

* Trans. Society of Arts.

† Martius, quoted by "Gardener's Chronicle."

believe that our present gangrene is only an exaggerated form of the old curl. It is a common characteristic of the numerous family of Aphides to render the leaf of all plants which they attack curled; I have frequently noticed in my own sitting-room that the vastator curls the leaf of the turnip; and it must have been observed by very many how excessively distorted the leaves of the rose-tree become when suffering severely from the ravages of the *Aphis rosæ*.

(437.) I have found, on one or two occasions, a potatoe plant to be covered with the vastator, and that, instead of its being destroyed by the insect in the usual manner, the leaves exhibited the most exaggerated form of curl which could be conceived, for they were curled more than those of the most highly-curled parsley. However, I feel unwilling to pass an opinion upon a disease which I have not seen in its former prevalence.

(438.) The rust is another disease. It consists of a colored spot upon the leaves, which is at first small, but gradually increases, and at length overruns the whole leaf. Of this disease, however, I am practically ignorant.

CHAPTER XX.

THEORY OF THE DISEASE.

Resumé of the various supposed causes of disease (439, 440).—Vastator (441).—The disease (443).—Condition of plant causing death (444, 445).—Effect of disease on wild plants (446).—On cultivated plants (447).—Propagation from diseased sets (448, 449).—As to cessation of disease (450).—Relation of health of plant to the insect (451, 452).

(439.) We have now examined all the various effects which may influence the potatoe plant in its growth, and give rise to the disease. In the course of our investigations we have found that the action of temperature, light, soils, and manures, may influence the plant, but positive proof has been afforded that they do not produce the present alarming epidemic.

(440.) It appears, moreover, that vegetable parasites are sometimes present; but, upon an attentive examination, there are strong reasons to believe that they occur after the disease has been set in action, and that they grow in the decaying matter, as a beautiful provision against offensive putridity.

(441.) The case, however, is quite different with the animal parasites; for we have discovered that wherever the *Aphis vastator* exists, there the leaves perish, there the plant becomes injured, there its tubers and stems take on gangrene and die, and thus the disease is manifested.

(442.) In this way we have learnt the cause of the disease, and the theory of the disease is easily ascertained from a study of its cause.

(443.) The animal lives on the juices of the plant, which it extracts by means of the apparatus which it inserts into the cuticle of the leaf. This removal of one portion of the sap destroys its proper qualities; it can no longer return the material for the starch or cellular tissue essential to the growth of the plant. When the growth of the plant is arrested, the natural vital actions are impaired, and other actions, as those of putrefaction, or inorganic changes, take place; the plant ceases to live in different parts, and decomposition ensues.

(444.) The exact mode in which death occurs is intimately connected with the most obscure functions of the plant. Probably the sap continues to take water from the ground, but in failing to receive sufficient solid material from the leaf, becomes altered and impaired, and thus the plant is killed.

(445.) The essence of the disease is a disturbance of the relation existing between the leaf and the plant, and, consequently, the sap and parenchyma do not bear such proper relation as fits them for the performance of the vital functions; and this being the case, the vital functions necessarily cease, and the plant dies.

(446.) The injury inflicted on wild plants is usually confined to the leaf and adjacent stems, the roots, except in very rank growers, being not so much affected. In this way the plant may be gradually killed from above downwards.

(447.) We find that cultivated plants, where the underground stems are highly developed, will not bear the relation between the stem and the root to be interfered with; and for this reason the same number of insects will exert a far more destructive influence upon the cultivated, than upon the wild plant.

(448.) In plants which are propagated by the mere extension of the individual, as the potatoe is, the injury is to a great extent continued; because, when the relation between the leaf and root, between the fluid or sap and the cellular tissue or solid parts, becomes deranged, the plant will propagate the same diseased relation, and consequently reproduce the same injury.

(449.) The propagation of the injury from set to plant gives rise to all those phenomena which I have already described when treating of the potatoe gangrene, and is nothing more than a propagation of the mischief from one part of the plant to another.

(450.) In all human probability, the disease, under favorable circumstances, if the cause be not continued, will at last wear itself out and cease; but we have not at present had sufficient experience to ascertain this fact with certainty. Of course, cessation of the disease will almost absolutely require that the vastator shall not again renew its attacks upon the plant.

(451.) There is an exquisite relation existing between the effects upon the plant and the welfare of the animal. This creature cannot well live upon a very vigorous plant, because it would be drowned by the water transpired at night. Hence it generally commences upon leaves which have in a great degree lost their vigor. On placing insects upon the new leaves of very vigorous plants, I have observed that the creature has always been obliged to leave them. It commences upon the larger and nearly exhausted leaves; from these it passes to others, and so on till the entire foliage is affected.

(452.) The impairment of the health of the whole plant might lead us to suppose that it would cause the destruction of the creature. Not so, however ; Nature has wonderfully ordained that the exhaustion of the plant should have an influence upon the animal. When the plant no longer retains sufficient vigor to supply nourishment to the insect, the creature ceases to reproduce, it takes the pupa form, and finally emerges from that transitory condition in its final or more glorious state, when countless millions, in the form of a cloud, take flight, soar aloft, and traverse mountains, valleys, streams, lakes, seas, and even kingdoms, destroying in their progress some of the most useful foods of man.*

(453.) Such beautiful illustration of the perfection of nature almost compels the naturalist for a time to forget the great calamity which has happened to the human race by this little insect. This minute creature, which by itself may appear to be scarce worth our notice, when congregated in masses, becomes an army, terrible and invincible even to the English nation. Napoleon, with all his army, with all his bravery, never dared set foot on the English shore : this little insect has baffled science, politics, and power ; it has invaded our territories, it has, in spite of all our armies, fleets, and forts, come into our lands, and taken from our possessions the food destined to nourish our children.

* This destroying cloud, wafted about with the winds, settles here and there upon some ill-fated locality : hence the prevalence of a wind in one direction may influence to a great extent the more or less extensive damage in various aspects.

CHAPTER XXI.

FUTURE PROSPECTS OF THE DISEASE.

Mischief done to esculent vegetables, &c., by vastator (454).—Duration of insect pests: historical analogies (455).—Probabilities as to increase of the plague (456, 457).—Aphis brassicæ (458).—Insect destroyers of vastator (459).—Probable result of disappearance of vastator (460); of continuance (461); of increase (462).—Concluding remarks (463).

(454.) We have now seen that the gangrene of the potatoe is caused by the injury done to the plant by a small insect which has appeared in great abundance, and which attacks also the turnip, the beet, the carrot, the different Solani, various Cruciferæ, wheat, and Indian corn.

(455.) Upon examining historical records, we have also found, that when an insect has appeared in great excess, it has generally, after a time, disappeared, and the balance of nature has been again maintained.

(456.) In the present instance, however, although we have seen whole clouds of these Aphides,—although they exist by countless millions, yet we are not at all in a position to state that they have reached their climax.

(457.) It is possible that they may continue for some time longer, and that next year they may destroy not only the various vegetables which have hitherto been their prey, but may even annihilate the wheat.

(458.) The excessive appearance of this Aphis this year is not a singular fact, for the *Aphis brassicæ* exists in such abundance, that thousands are to be found on the leaves of plants sent to market; but it is strange that the Aphis of the hop has done but little or no mischief this season.

(459.) To suppose that the *Aphis vastator* will continue to increase, and cause actual famine, is to look at the dark side of the question, for we may hope that it has already reached its utmost limit.

This is, however, a question which time only can settle, and we must look anxiously for troops of ichneumons and legions of lady-birds to come and eat up the all-devouring creatures.

(460.) Supposing that the ravages of the insect cease or stop to a great extent, yet, however, the potatoe is diseased, and will grow diseased plants for some little time. I think, however, that we need be in no fear of permanent damage from this cause, for in all probability, the malady, under favorable circumstances, will wear itself out; and certainly, by industry, we may easily overcome this difficulty. If the disease does not stop when the insect departs from the potatoe, we have but to commence with sets derived from the sound tuber to obtain new crops; so that eventually we should be enabled to renovate our stores with good seed.

(461.) It is appalling, however, to consider the dark side of the question; for a continuance of the action of the insect upon the stalks of the diseased tuber would render the plants still further diseased; and if that be assisted by cold and moist weather, the crop may be nearly annihilated.

(462.) Moreover the insect is still on the increase; it was more abundant this year than the year before; and, judging by its effects, still more numerous than the year previous to that. We know it only in its progressive character, and we might even possibly have it ten times more numerous next year, and it might destroy to a tenfold greater extent our usual sources of food. Should this nation of destroyers appear next year much earlier than it has heretofore, it may produce the most disastrous results by killing all the most serviceable kinds of human food.

(463.) Upon the whole, let us buoy ourselves up with the hope that the plague has reached its utmost limit, that it may speedily cease, and that its effects are merely transitory. Let the husbandman be of good cheer, and remember, that if nature deviates for a time from its wonted relations, it always returns to its normal condition, and ultimately maintains the proper balance of animated beings. Let all people remember the promise in Malachi, "that God will rebuke the devourer for your sakes, and he shall not destroy the fruits of your ground."

CHAPTER XXII.

ARTIFICIAL REMEDIES FOR THE POTATOE DISEASE.

Division of subject (464).—Destruction of Aphis considered: by human means (465); by tobacco (466).—Effects of water, thunderstorm, on Aphis rosæ (467); on vastator (468).—Burning infected leaves (469).—Effect of leaf-burning in beet (470).—Quicklime (471).—Ducks and soft-billed birds (472).—Coccinellæ and ichneumons (473).—Wheat (474).—Early ripening (475).—Early potatoes (476).—Autumn planting (477).—Recapitulation (478).—Contagion (479).—Burning infected haulms (480).—Isolation of crops (481).—Means to be adopted over large districts (482).—Same means for all crops (483).—Propagation from healthy sets (484).—Generation of fibre (485).—Means of inducing this (486).—Sets (487).—Varieties resembling the wild potatoe (488).—Planting in sand or peat (489).—Dryness, warmth, and light (490).—Propagation of the young stalks (491, 492).—Requisites for healthy propagation (493, 494).—Diminished starch (495).—Starch cells (496).—Remedies which have been proposed (497).—Drying (498).—Cold and dryness (499).—Review (500).

(464.) The artificial remedies to be adopted to lessen the potatoe malady may be divided into four great classes. One class comprises those means which we should take to lessen the numbers of the insect, and thus strike at the root of the cause. The second class contains the treatment to be pursued for stopping the contagion. The third class comprises those remedies which are destined to prevent the continuance of the disease in the infected plant; and, lastly, we have to consider a fourth class, where we desire to lessen the baneful agency of the malady when it has actually occurred.

REMEDIES AGAINST THE CAUSE.

(465.) The absolute destruction of the Aphis by human means is doubtless an impossibility, and the only means which we could adopt would be to destroy the insect the moment it appeared upon the potatoe plant. This simple remedy is, however, exceedingly difficult to apply, even when we wish to protect a single plant. I had an infested plant in a pot at Finsbury Circus, and though I frequently tried to eradicate the insect, yet there was continually some one or other left; for these little rascals crawl into chinks and crannies, from which they come forth at their convenience, and rapidly multiply.

(466.) If the protection of a single plant be so difficult, how much more so must be the protection of the potatoe plants covering large tracts of land? We must conduct our campaign against the destroyer in this case by adopting a more wholesale remedy. On the small scale, the infusion or vapor of tobacco would destroy them, but it would be impossible for the agriculturist to employ that remedy over large fields.

(467.) Many kinds of Aphides are destroyed by water, and I had to lament the loss of several pet colonies of the *Aphis rosæ*, which were destroyed by the rain of a thunder-storm; and it is said that the hop plantations of the whole county of Kent may be cleared of their Aphides by a single thunder-storm. The cultivators of rose-trees practically syringe the infested trees, and so get rid of their pest.

(468.) Neither water nor thunder-storms seem to have much influence upon the vastator, further than that the electricity seems to occasion a great migration of these creatures. The vastator appears to cling very tightly to the plant by the suctorial apparatus contained in the interior of the rostrum, and its feet, too, seem well calculated to assist it in maintaining its position. Moreover, the destroyer lives generally at the under surface of the leaf, so that the leaf serves it as an umbrella to ward off the fluid.

(469.) It would certainly be a good plan, in many cases, to gather those leaves which are infested with the insects, and to burn them, before the creature has made any extensive progress. New leaves would doubtless be thrown out of the haulm; but this mode of proceeding would only be applicable to a very small extent in the potatoe plant.

(470.) With regard to beet root, however, I am decidedly of opinion that the removal of the infected leaves is the best course to be pursued. If they are left on the plant they perish, and thus become unserviceable; whereas, if they are removed before extensive mischief has been effected in the tissue, they may still afford useful nourishment to cattle. As, moreover, the insect first attacks the larger and more exhausted leaves, we should thus destroy masses of insects, which would otherwise progress to other and more important leaves.

(471.) The action of quicklime, sprinkled dry over the plants, is said to be particularly destructive to the Aphides; and I have seen several notices in the papers where persons had sprinkled lime empirically over the haulms the moment the disease appeared, which arrested the progress of the disease. This proceeding I should recommend to be largely tried, by sifting fine quicklime over plants as soon as the vastator appears.*

* Perhaps also various saline matters might be employed for the same object.

(472.) We might perhaps try the experiment of rearing large quantities of ducks, and turning them loose in infected fields to eat the vermin, as by that means we should convert the destroying insect into a source of profit to ourselves. It would be perhaps especially advisable to enact laws to prohibit the destruction either of the soft-billed birds or their eggs, as the number of insects they devour is almost incredible.

(473.) It would be impossible practically to breed lady-birds and ichneumons on any other but a very small scale, but we should be very careful to preserve these valuable natural devourers of the Aphides.

(474.) Should the wheat become seriously attacked, I really know not what remedy can be applied to destroy the creature; but I am in hopes that such may not be the case, or rather that the grain may be too forward when the pest appears, to be extensively damaged by it.

(475.) In considering the means to be adopted for the prevention of the disease, we should bear in mind that the creature has not come hitherto in great abundance till July or August; hence, if we could get the plants ripe before that period, we should cheat the insect of his spoil. It is impossible to tell how much earlier the insect may appear another year; but, as we can only act for the future by the consideration of the past, it would be advisable to use such plants as render their produce early.

(476.) With respect to the potatoe, the use of the early kinds is most strongly to be commended; and these should be employed, during the prevalence of the disease, as much as possible to the exclusion of the late varieties.

(477.) Johnson strongly recommends autumn planting as a means of preserving the potatoe plant against the disease; but I have found thousands of plants damaged which had been left in the ground all the winter from previous crops. Hence, taken by itself, this plan forms no protection, though, by tending to forward the growth of the plant, it may help to cheat the destroyer, and lessen the mischief.

(478.) The best means of destroying the cause is to pick off the insect when we desire to protect a single plant. To pull off affected leaves, or to sprinkle them with quicklime, when we wish to protect a larger number of plants. We should endeavor to get our produce ripe at an early period by using early kinds, and by planting early, perhaps even in autumn. We should protect lady-birds, ichneumons, and soft-billed birds; and we may try the effect of ducks to gobble up the parasites.

REMEDIES AGAINST CONTAGION.

(479.) We must remember that the mischief is eminently contagious, and that the destroyer may spread from one crop to another; therefore, especial care should be taken to prevent contagion. I have often traced the disease in turnips to their proximity to potatoes, disease in beet to its proximity to turnips; and I have traced the disease radiating from old infected haulms heaped together for manure.

(480.) Whenever potatoes are dug up, the infected haulms should be instantly burnt, in order to destroy the insect; and, perhaps, it would be a good plan when we find even the living haulms excessively affected, at once to pull them up and burn them. Marshall has long ago proved that cutting down the haulm lessens the crop of tubers, and Mr. Thompson tells me, that when the haulm was pulled up at the Horticultural Society's Gardens, the crop of tubers was less and the disease was worse. This plan is not, however, to be adopted for the benefit of the plant itself, but only for the purpose of destroying vast nations of the Aphides.

(481.) Every wise farmer would isolate the crops which are liable to be affected by the malady. He would not plant turnips, potatoes, beet-roots, and carrots in the same, or even in contiguous fields, but would distribute them over his farm as widely as circumstances will allow. The very worst case of the malady I ever saw was in a very small field, where potatoes, beet-roots, and turnips, were planted together. In this case the insects on the beets existed in countless legions.

(482.) All remedies of this character, to be of any value, must be universal; as a partial attempt to remedy contagion could be of but little benefit. The winged insect can fly from field to field, from parish to parish, and even from kingdom to kingdom; and when it attacks it multiplies with fearful rapidity. In order successfully to attempt the extermination of this pest, therefore, a whole country, or even all Europe, must devote its best energies to the cause. An occasional obstinate, pig-headed farmer ought not to be allowed to act contrary to the welfare of the whole country; and, perhaps, therefore, power might very advantageously be given to churchwardens, or other official persons, to adopt measures best calculated to cut off contagion.

(483.) The observations which I have just made have appertained chiefly to the potatoe; but it will readily be seen that they apply equally to the prevention of contagion in all other crops which are liable to be attacked by the malady, and all these measures should be employed in the spring.

REMEDIES AGAINST PROPAGATION.

(484.) The different varieties of potatoes are now diseased in most situations, and we have found that the malady is continued in future growths of the same individual. To prevent the propagation of the disease, without respect to a repetition of the cause, we have but to use sets from former perfectly undiseased plants, and unless the insect again appear, the plant which grows from such sets will be healthy.

(485.) As the attack of this creature operates principally by causing deficiency of the solid materials of the plant, we ought, if we desire to check the disease, to do everything in our power which conduces to the generation of fibre.

(486.) With this object in view, the plant should not be encouraged to throw out large succulent shoots in its early growth, but should rather throw out dry and arid shoots: in fact, the sort of treatment which would render other plants strong and fibrous would probably tend to render the potatoe sound.

(487.) I should be inclined to try the experiment of using but small portions of the potatoe for sets, such as scooped eyes, or potatoe peelings, although Marshall has ascertained, that, under ordinary circumstances, the crop is thereby materially lessened. These means would only be serviceable to restore the health of a diseased plant, not to arrest the malady at its commencement.

(488.) Perhaps it would be advisable to return as far as possible for a time to the cultivation of those plants which most nearly approximate in character to the wild plant; especially as we find that wild plants in general, and the assumed wild potatoe plant, resist much more effectively the ravages of the disease than the more highly cultivated varieties.

(489.) It has been currently stated, that, by planting potatoes in sand or peat, the disease has been lessened, and probably it would be sound philosophy to place the tuber under circumstances which may induce it to return as far as possible towards its original condition.

(490.) The exposure of the plant to a dry atmosphere, to a good temperature, and to abundance of light, would also doubtless assist in regenerating the plant, provided the insect does not again come and injure it.

(491.) Perhaps it might be advisable to allow the stalk to grow from the tuber two or three inches high, and then to detach it and use it as a set. By this plan we should throw the potatoe plant for its resources upon the leaves, and not upon the original set; and, doubtless, by attending to other circumstances influencing the result, we should thus place the plant in a good condition for regenerating its fibre.

(492.) One potatoe tuber, upon this plan, would send forth numerous shoots, and thus a great saving would be effected in the amount of potatoes used for seed. We may expect from the experiments of Marshall that this course would lessen the produce, and, therefore, this method would only appertain to the regeneration of the potatoe plant, with the view of obtaining again healthy seed from which to propagate our plants.

(493.) It is doubtless upon this plan, that a mere eye, left from a thoroughly rotten potatoe, has been found to produce sound tubers; as the plant, in this case, is from the very commencement thrown upon its own resources, and has to form its own starch and fibre from the leaves, instead of drawing at first diseased material from the set.

(494.) For the regeneration of a diseased plant we should employ dry, poor, unmanured soil; we should use small sets, and should have a dry and warm atmosphere.

REMEDIES AGAINST THE CONSEQUENCES.

(495.) We have now to consider the best modes of averting the consequences of the malady in the tuber. The starch which has been formed still exists in the diseased tuber, but in bad cases very little even of that material is formed; and no doubt the quantity of starch to the acre under cultivation is enormously diminished. It is possible practically to extract the starch, and preserve it for fattening cattle or for use in the arts.

(496.) It is quite manifest that we can do nothing to increase the starch in the empty cells, and, therefore, we can only preserve that which is already existing. The cells have a tendency to become broken down and useless, and the nitrogenized portion is liable to decompose.

(497.) I have already mentioned that in potatoes and other vegetables tending to rot from the present disease, the disorganization continues even when the plants are quite protected from the atmosphere; and, therefore, we cannot do much to lessen the mischief on this score. It has been proposed to dip slices of potatoe in dilute sulphuric acid, but it is useless as a practical treatment. It has been proposed, too, to expose the tubers to chlorine, but that also appears quite out of the question. If any chemical means are to be employed, I should recommend the vapor of strong pyroligneous acid; but I have no faith in any chemical remedy.

(498.) It has been said that by simply pinching or cutting a potatoe the disease is arrested; but this surely must be a mistake, as I have observed the malady proceed to total disorganization even in a thin section in a dry room. Potatoes might be dried, and thus preserved like the maglia of the Peruvians; but perhaps this process is not practically so useful as the extraction of the starch.

(499.) Perhaps, however, there is no plan for the preservation of the potatoe at all equal to simply placing it in a cold, dry atmosphere; and from this we may learn that potatoes should never be kept in large masses, whereby they are liable to become heated; for in fact everything that favors putrefaction helps the progress of the disease, everything that prevents decomposition retards the action of the malady.

(500.) In taking a review of the remedies for the potatoe disease, we have found that it is of fundamental importance to stop the cause by destroying the insect, and preventing the spread of the contagion. Secondly, we have considered the best means of stopping the propagation of the mischief; and, lastly, we have endeavored to ascertain the best treatment for curtailing the mischief of the disease in the tuber.

CHAPTER XXIII.

ON FAMINES.

Equalization of food (501).—Deficient crops (502).—Enumeration of famines (503).—Inefficient legislation as to public health (504).—Proposed remedy (505).—Duties of a council of health (506—508).—Precautionary measures (509).—Absolute duties of the executive (511—512).—Table of esculents attacked by vastator and other aphides (513).—Other nutritive matter (514—517).—Excise laws (518); the year 1845 (519); 1846 (520).—Concluding remarks (521—522).

(501.) In former periods of the world famines were more frequent than at the present time, because the means of equalizing the food were more imperfect. Now, however, railways, steamers, and ships, can soon carry abundance from the land of plenty to those regions where scarcity and famine exist.

(502.) The following list of famines will show that the world has suffered from scarcity of food, and no doubt may suffer again from a similar cause, should a great portion of the globe have deficient crops:—

(503.) A famine which lasted seven years 1708 B. C. at Rome, when many persons threw themselves into the Tiber; B. C. 440, in Britain, so that the inhabitants ate the bark of trees; A. D. 272, one in Scotland, when thousands were starved; 306, in England and Wales, when 40,000 were starved; 310, all over Britain; 325, at Constantinople; 446, in Italy, when parents ate their children; 450, in Scotland; 376, all over England, Wales, and Scotland; 739, another in Wales; 747, in Wales and Scotland; 792, again in Scotland; 803, again in Scotland, when thousands were starved; 823, a severe one in Wales; 836, in Scotland, which lasted four years; 954, famines in England; 864, 974, 1005, in Scotland, which lasted two years; 1047, in England; 1050, 1087, in England; a famine from 1193 to 1195, which led to a pestilential fever, in England; 1251, one so dreadful that the people devoured the flesh of horses, dogs, cats, and vermin; again in 1315, 1318, 1335, 1345, in England and France, called the "dear summer;" 1353, in England; 1389 and 1438, so great that bread was formed of fern roots; in 1565, two millions were expended on the importation of corn; one in 1748, at the Cape de Verds, when 16,000 persons perished; 1775, another in England; in 1798, again throughout the kingdom; in 1801, scarcity in Ireland, again in 1814, 1816, 1822, 1831.

(504.) In this country we are governed by individuals of three classes, viz., by men whose duty it is to provide for the welfare of the soul; by those whose profession it is to protect person and property; and by a third class, who possess their right by virtue of their ancestors. Those, however, who protect the body, are allowed to take no part in the great councils of the state; and even Jenner, Hunter, and Harvey, remained in their private capacity. From this cause the living remain amongst the exhalations of the dead; deleterious and poisonous adulterants are suffered to exist in our food; and habits of life are allowed which are in the highest degree prejudicial to the welfare of the community.

(505.) To prevent this, a council of health might be appointed to watch and report upon all external causes which can possibly affect the bodily health of the community.

(506.) The duty of such a council, at the present time, would be to ascertain what food is to be procured, and how it can be best economized. Moreover, they should prevent the employment of unwholesome food, and should take great care that all other external circumstances should as far as possible be so regulated that the pestilence attending upon famine may be averted, and that fever, diarrhœa, sickness, and excessive mortality, may be prevented.

(507.) When we know not whether this disease be still increasing, it would behove such a council to be stirring; to have weekly reports upon the progress of the insects from different parts of the kingdom; to do their best to cut short the cause of the malady; to apply new materials for human food; and to take care that such an economy of nutritious material be enforced, that no man should suffer from want of proper food.

(508.) All these conditions might a properly educated council of health fulfil; and, until this be accomplished, never will pestilence, famine, adulterated and damaged food be prevented from exercising their deleterious agency upon society.

(509.) Next year will be a very anxious period, as we are already using our old supplies of food. If, therefore, the insect continue to increase, it will be desirable to have reports from all parts of the habitable globe, upon the quantity of surplus food existing, that we may know at once where to apply.

(510.) It is absurd to suppose that it is the duty of Government to supply food, except under extraordinary circumstances. It is, moreover, impossible that Government can keep down artificially the price of bread for any time, without the most disastrous results.

(511.) To Government we have no business to look for our actual supplies of food, though the executive is clearly responsible, in cases of famine, to give the best principles to be pursued for the alleviation of the misery. They ought to know beforehand where food is deficient; they ought to know where food is in excess; and they ought to know the kind of food which should be imported to remedy the mischief.

(512.) Private individuals, private enterprise, must and would do the rest, if the price of provisions were not artificially tampered with. The more the executive regulates the principles, and the less it regulates the practice of the supply of food, the better will be the result permanently for mankind in general.

(513.) If we regard the following list of alimentary substances given by Pereira, we shall be enabled to form a feeble idea of the ravages which the vastator may commit.* If, moreover, we regard how large a proportion of the remainder are attacked by other Aphides, the numbers of which are influenced by the vastator, we may form a more correct estimate of the terrible injury which the vastator may effect.

Wheat V.	Plum A.	Pumpkins.	Asparagus.
Oats A.	Cherry.	Tamarinds.	Cabbage V.
Barley A.	Olive.	French beans.	Savoy V.
Rye A.	Apples A.	Scarlet beans A.	Greens V.
Maize V.	Pears.	Figs.	Cauliflower V.
Peas A.	Quinces.	Mulberries.	Brocoli V.
Beans A.	Currants.	Pine-apple.	Spinage V.
Lentils.	Gooseberries.	Strawberries.	Mustard V,
Chestnuts.	Cranberries.	Raspberries.	Lettuce.
Walnuts.	Elderberries V.	Blackberries.	Endive.

* The items marked V are those which the vastator has attacked; those marked A are those attacked by other Aphides.

Hard nuts.	Grapes.	Turnip V.	Rhubarb.
Cobed nuts.	Oranges.	Carrot V.	Garden artichoke V ?
Pistachio nuts.	Lemons.	Parsnip V.	
Stone pine nuts.	Citrons.	Jerusalem artichoke V.	Fern root.
Cocoa nuts.	Shadocks.		Iceland moss.
Almonds.	Cucumbers.	Potatoe V.	Ceylon moss.
Peach V.	Melons.	Leeks.	Mushroom.
Nectarine V.	Water-melons.	Garlic.	Morel.
Apricot.	Mallows.	Shallots.	Truffle.

(514.) In this list of vegetables used by man, we find that, if the vastator were to destroy in a great measure the various plants which it attacks, we could only supply the loss, and that very partially, by chestnuts, fern roots, and bark of trees.

(515.) There is, however, little reason to take so very dark a view of the case ; there must, in all probability, be some parts of the world where the crops are good and abundant, and whence we can obtain their superabundance.

(516.) The present scarcity has been met with a supply of Indian corn from America, but it is possible that a sufficiency of food might not exist over the globe for the purposes of mankind. And this year rye is being employed for the same purpose.

(517.) In such a case the council must endeavor to provide new kinds of food. Nutrition may be obtained from the bark of trees, as in Norway ; and doubtless, by care, the great famines which before devastated the world need never recur.

(518.) The excise laws might be at once examined, and the use of grain for the purposes of distillation might be prohibited, should any great dearth be apprehended, as spirits could with equal facility be made of sugar; sugar again might be made from other cheaper materials than grain, and by this substitution alone, a large quantity of grain would be available for food.

(519.) In the year 1845 scarcity existed throughout all Europe from a deficiency in the potatoe crop; and this year an even more alarming failure threatens these realms; so much so, that public prayers have been ordered in all the English churches and Jewish synagogues for its abatement.

(520.) In the present year, 1846, from one-half to two-thirds of our potatoes are destroyed, our grain is short, perhaps from the same cause our vegetables are injured, our cattle and sheep are scarce. The present year may be considered one of great scarcity, and to Ireland even one of absolute famine, for there scarce one potatoe exists. In Devonshire the crop of potatoes is so bad, that in some places three men only raised 160 lb. in a day. In this county potatoes are now selling at 1*l.* 1*s.* a bag, whilst the usual price is 2*s.* 6*d.* In Wiltshire, I am informed, that land which yielded 500 bushels last year, yielded only 50 this; and in Yorkshire the crop is sadly deficient. In Scotland, I am told, that good potatoes are worth 10*l.* a ton; and in London, where the usual price is 5*l.* or 6*l.* a ton, the present value is 10*l.* or 12*l.*

(521.) In estimating the present famine, we must not be unmindful that we are at peace with all the world, our commerce unshackled to procure food from distant climates. This equalization of food has prevented want; but, doubtless, had it been otherwise, this would have been one of the most dreadful famines in particular localities that the world ever saw.

(522.) Even now we do not know whether the injury is not rapidly on its increase, and what man can say that we may not have an absolute famine next year? Under these circumstances, it behoves us all to be up and stirring; philosophers to investigate, politicians to regulate, the people to carry out their laws: and having tried our utmost to avert the calamity, to trust that the Almighty "may remove far from us his great army which he sent amongst us, that our floors may be full of wheat, and that we may eat in plenty and be satisfied." *

CHAPTER XXIV.

ON THE APPLICATION OF DISEASED POTATOES.

Diseased potatoes as food (523).—Thompson's lectures: damaged wheat (524); effects of (525); difficulty of experimenting on animals (526).—Effects of mouldy food (527).—Probable effects of diseased potatoes on man (528—529); on animals (530—531); for fattening bullocks, feeding milch cows (532).—Used by bakers (533).—Vitiated food generally (534—535).—Starch (536—539).

(523.) It is difficult to foretell what may be the influence of large quantities of vitiated vegetable food on the human frame. By cooking we lessen the deleterious properties of the damaged portion; nevertheless, having the experience of the baneful effect of spurred rye, and other damaged grain, when used for food, we may infer from

* Joel, chap. ii.

analogy that the diseased potatoe may in some cases have a similar injurious action.

(524.) I can refer those interested in this subject to Thompson's Lectures on Inflammation, pp. 538 to 551, where the accounts given by different writers of the effect of the cockspur rye, or damaged wheat, over a period extending from 1676 to 1762, are abundantly collected.

(525.) The general effects observed were mortification of the extremities, particularly of the feet. In most instances the malady killed the patient, although, in some cases, he survived with the loss of the part affected.

(526.) It is important to observe, that, in experiments made on animals with damaged grain, the effect did not take place for a long period, and not then if the diseased grain did not bear a certain relation to the sound food. From these facts it is apparent that experiments, with the view to ascertain the effect of diseased potatoes on animals, must be carried on for a long period, and all the potatoes should be damaged. Experiments of this nature are surrounded by many practical difficulties. It would be highly desirable if farmers would make returns of any injuries supposed to arise to animals from using the damaged tubers.

(527.) Burnett quotes several curious cases of death having arisen from persons eating mouldy bread, mouldy pork, mouldy cheese, mouldy ham pie, where no recognizable poison, whether mineral or vegetable, could be traced, and, indeed, where the absence of all known poisons was ascertained. These cases are amply sufficient to warn us from eating damaged food.

(528.) Independent of these extreme effects, we may infer that less severe calamities may arise, such as the London surgeon daily observes occurring from imperfect nutrition; because, although the potatoe contains the starch in a normal condition, there is a deficiency in the nitrogenized portion, or, rather, the nitrogenized part, which is essential to the healthy performance of the vital functions, is damaged, and hence the use of diseased potatoes is likely to give rise to ulceration of the cornea, ulceration of the gums, and other maladies which arise from defective nutrition. Throughout this year I have, in my own practice, constantly noticed cases of peculiar ulceration of the mouth and gums, but I have been unable to say that they were actually to be attributed to the use of diseased potatoes.

(529.) There is very little doubt but that damaged potatoes, as well as all other injured food, may be a fruitful source of fever, ulceration of the bowels, and of diarrhœa. In fact, many practitioners have called attention to cases of English cholera which have arisen apparently from this cause.

(530.) The evidence which I have endeavored to procure about their influence on animals is contradictory. At a very large farm near London, the foreman told me that he employed them profitably when boiled for fattening pigs, and that he had used about forty tons for that purpose.

(531.) At a farm in Kent, I heard that the pigs and sheep were killed by eating diseased potatoes, and that, therefore, they could only employ the potatoes for manure.

(532.) Bullocks, I am told, have been fattened with good success, in Essex, with damaged tubers; and the greengrocers inform me that the diseased tubers are eagerly bought by the cow-keepers, as they are found to cause the animal to give abundance of milk.

Against this application I strongly protest, for the supply of wholesome milk is of great importance to the community; and I hope a law will be enacted to prevent this disgraceful practice from being continued.

(533.) The bakers also are not very particular about the state of the potatoes which they employ. Price, not quality, is their motto; and though they prefer the potatoes when sound, they do not particularly object to their being partially rotten. It is quite surprising to me that the present extensive adulteration of bread with alum should be allowed to exist for a single day; and whilst the bakers are allowed constantly to employ alum, I do not see why they should not also use vitiated potatoes, or any other noxious ingredient of which they can make a profitable use.

(534.) Notwithstanding the partial indemnity which appears to attend the use of damaged potatoes, I must express a strong conviction that the use of vitiated food of any kind is liable to give rise to disastrous results.

(535.) We are not only employing vitiated potatoes, but we are employing likewise milk produced from the same material, and from even worse material; for the cows are fed likewise on diseased beet and turnips.

Under these circumstances, disease and excessive mortality may be expected; for we may be influenced by diseased food through our milk and bread at breakfast; we may then have damaged vegetables at dinner, and return to damaged food for tea.

(536.) There can, however, be no possible objection to the separation of the good matter from the bad, and I have already pointed out that the starch is left nearly entire. This process has already been described, and the separated starch may be kept and stored up for future use.

(537.) When extracted, the starch may be employed for fattening cattle, when mixed with other substances; and, indeed, may be used for human food, when associated with skim-milk or cheese, to supply the deficient nitrogenized portions. The starch from the most offensive potatoe will make good puddings, or it may be mixed with flour for bread.

(538.) This starch might also be converted into dextrine for the purposes of the arts, and might be made into sugar for the production of spirits.

(539.) Upon the whole it is most desirable that the starch should be extracted from the diseased tubers, and used for the purposes of the arts, where it could not possibly commit any damage; whereas the use of diseased potatoes for human food, for bread, or for milch cows, should be strictly forbidden.

CHAPTER XXV.

THE BENEFITS AND THE DANGERS OF THE POTATOE.

Value of the potatoe (540).—Culture (541).—Nutritive power (542, 543).—Exclusive potatoe culture, moral effects (544); physical effects, the Irish (546, 547).—Dangers of (548).

(540.) The potatoe plant affords, for the labor and space required for its cultivation, more alimentary matter than any other plant whatever, and on that account is a valuable source of food for mankind.

(541.) Cottagers have but to dig the ground, plant the potatoes, earth them up, and gather them in, when they are at once ready for culinary purposes, without the aid of mills, machinery, or other preparation.

(542.) The plant, moreover, is competent of itself to supply every requisite for nutrition. It yields carbon for the lungs, nitrogen for the muscles, phosphorus and iron for the blood, lime for the bones, and in fact a human being might live upon potatoes alone.

(543.) In practice, every man with an acre of land can, by means of the potatoe, support himself and family; and, instead of requiring anything from without, may live independently and careless of all surrounding creatures and objects.

(544.) As a consequence of this, a nation of potatoe-eaters does not feel those relations and dependencies which bind other societies together. A man's own labor supplies him with food, and he cares not for nor requires any other man's assistance; hence, many of the social relations are destroyed; the relation between the laborer and the farmer, the miller and the baker, do not exist; and, in the end, each man is in his own person king, magistrate, and subject, not caring for the assistance nor fearing the displeasure of any other human being.

(545.) Nature has, however, put a barrier to the extension of this unsocial condition; for the potatoe can be preserved only one year, and a break in the continuity of the potatoe would at once, if the above state of things existed, restore the social relations.

(546.) This effect of depending too exclusively on the culture of the potatoe is fearfully exhibited in the Irish people, where the potatoe has begotten millions of paupers, who live, but who are not clothed; who marry, but do not work, caring for nothing but their dish of potatoes. If left to itself, this fearful state of things would have remedied itself; for, had the people the control of their own community, and had the potatoe crop failed to the extent to which it has this year, these people, having no relation with any other, would have been left to their own resources, which, being destroyed, would have left them without food.

(547.) Millions of human beings, desperate with hunger and untutored in laws, would have devastated the country; this would have aggravated the misery, and at last numbers would have perished of starvation, and the mutual relations of the survivors would have been re-established. Fortunately for the Irish people, they have a rich and powerful country to sympathize with and relieve them in their distress, and also desirous of alleviating their suffering.

(548.) A lesson is here taught to mankind, to lay up stores against the day of scarcity, and not to trust to so uncertain a thing as a crop of potatoes for subsistence, but always to cultivate a sufficiency of grain to be stored up and preserved against a time of scarcity and famine.

We thus find that the potatoe, from its containing every element of nutrition, is a valuable food, and to be freely cultivated, though considerable mischief may arise from excessive and improper planting.

RESUMÉ.

(1.) A POTATOE plant consists of a root to take up water.

leaf to deposit solid matter, and a stem with its tuber to supply nutrition.

(2.) The potatoe plant, as we cultivate it, is in a diseased or abnormal condition, having great excess of tuber and great deficiency of leaves.

(3.) The potatoe is employed chiefly on account of its starch and albumen, parts which it derives from the leaf.

(4.) The plant is subject to death at various parts, or a sort of vegetable gangrene.

(5.) This death, in the form presented by the present disease, is influenced, but not caused, by heat, light, electricity, moisture, soils, and manures.

(6.) It is, however, caused by the *Aphis vastator*, which punctures the leaf, sucks the sap, and destroys the relation between the leaf and the root, thus causing the leaf or some other part of the plant to become gangrenous, or, in other words, to die.

(7.) The vastator destroys, in the same manner, the turnip, the Swede, the beet-root, the cabbage, the brocoli, the radish, the horse-radish, the various wild solani, some kinds of henbane, the stramonium, the belladonna, the clover, the groundsel, the euphorbia, some sorts of rumex, the mallow, the shepherd's purse, the holy thistle, some kinds of grass, and will live upon wheat, the Jerusalem artichoke, the sweet potatoe, and doubtless many other plants.

(8.) After the attack of the vastator fungi grow, which growth is probably in many cases materially assisted by the prior attack of the Aphis.

(9.) Other kinds of Aphides will kill in the same manner apple-trees, the hop, the bean, the pea, the wheat, the oat, various grasses, geraniums, the rose, the larch, and doubtless many other plants.

(10.) The excessive appearance of any particular insect is no new fact, but has been before noticed in the locust, various caterpillars, the cockchafer, and in many other instances.

(11.) The excessive increase of one species of Aphis is generally attended with a corresponding increase in other species, so that human food may be attacked at all points.

(12.) Aphides are kept in subjection by ichneumons and other Hymenoptera; by various Coleoptera, as lady-birds; by some dipterous insects, and by spiders, birds, &c.

(13.) According to analogy the disease is doubtless transitory, and will pass over the globe and disappear. It may, however, yet increase, and kill millions from famine before it finally departs.

(14.) A diseased potatoe may grow a diseased potatoe, and thus propagate the malady; although it is also pretty certain, that a rotten potatoe, under certain circumstances, may grow a sound one.

(15.) We do not observe the effects of the disease to such an extent in those plants which we employ before they are required to develope their fibre, and therefore before they exhibit the gangrene to any very great extent.

(16.) The disease may probably be lessened by striking at the cause, and destroying the Aphis to as great an extent as possible—by employing birds for that purpose, by burning infected haulms, and isolating from each other all plants liable to be affected by the insect.

(17.) A diseased plant may possibly be rendered less liable in future to the disease, by causing it for some time to revert as much as possible to the wild state, which is to be effected by growing it in dry places, from a shoot or cutting of the stem, or small piece of sound potatoe, by applying to it but little manure, plenty of light, and selecting a sandy or peaty soil, and warm situation, the object being to obtain a sufficiency of leaves to develope fibre, and to repress over-abundant and very rapid growth.

(18.) Above all things we should take care, as far as possible, that the fibre is deposited in the plant at a period of the year before the insect becomes very abundant.

(19.) The potatoe plant is a plant of indolence, and politically injurious to the community when extensively employed, and the excessive cultivation of this esculent may cause alarming famines.

It has great advantages, however, from the quantity of nourishment which may be raised in a given space, and because it affords every material requisite for nutrition.

[illegible] and earthing it under glass [illegible] [illegible] of the [illegible] and pieces of [illegible] by applying to it [illegible] of light, and [illegible] a [illegible] warm situation, the object being to obtain [illegible] fibre, and [illegible] very rapid growth.

(12.) Above all things we should take care, [illegible] that the fibre is deposited in the plant at a period [illegible] before the [illegible] becomes very abundant.

(13.) [illegible] plant [illegible] and [illegible] injurious to [illegible] when [illegible] and the [illegible] cultivation of the [illegible] cause [illegible].

It has great advantages, however, from the quantity of [illegible] which may be raised in a given space, and [illegible] it affords [illegible] material [illegible] for [illegible].

APPENDIX.

I.

I SHOULD feel extremely obliged if agriculturists in all parts of England would transmit to me the following returns connected with the disease of potatoes, whenever they have the opportunity of procuring them.

Kind of Potatoe.	When Planted.	Nature of Soil.	What Manure used.

Total Produce.	Quantity of Good.	Quantity of Bad.	Month in which disease appeared.

(2.) With respect to the insect, I should also be glad if they would transmit to me frequent returns as to its numbers, and the plants it infests. In all cases where other plants, besides those already mentioned, are attacked, I should be glad if they would transm i a few of the insects in a pill-box, cut down so as to be nearly flat for inclosure in a note. Whenever the destroying cloud appears, I should like to have immediate notice.

(3.) As far as regards the destroyers of the insect, I should be glad also to be constantly informed of the progress of the lady-birds and ichneumons; and also, when the insects greatly abound, to have accounts transmitted of the actual number of insects contained in the crops of various birds.

(4.) I should like also to know whenever mischief appears to arise from the use of damaged potatoes by cattle or by man.

(5.) Should any other Aphis appear in any quantity, I should be pleased to receive specimens, as one Aphis in excess is apt also to be attended with a larger development of other Aphides

(6.) If by any chance this work should fall into the hands of foreigners, I should also feel under great obligations if they would favor me with similar returns.

If these returns are made to a considerable extent from all counties of England, and I should not lose as much money by the publication of this work as usually happens to the lot of scientific writers, I propose to make this Treatise expansive, by publishing continual Supplements, as occasion may require. The above tabular return is wanted directly; and, therefore, I solicit newspapers and magazines, the present great organs of knowledge, to copy it, that it may be immediately prepared.

In case these returns should be sent in any great numbers, I beg that the letters may be endorsed on the envelope, "Public," that I may open them at my convenience.

It has happened on former occasions that I have been unable to answer the various questions upon public subjects submitted to me, from my time being occupied with subjects which absolutely demand my prior attention. For all these omissions I hope the writers will excuse me, as, whenever my occupation would permit, I have rendered the information required to the best of my power.

APPENDIX II.

List of One Hundred and Sixty Kinds of Potatoes obtained from the Gardens of the Horticultural Society, with the Weight of each Tuber and the Sp. Grav., which will roughly indicate the Quantity of Solid Material, and consequently the value of each kind.

Kind and Color.	Weight of Tuber.	Sp. Gr.
Canada pine, white	1374	1·068
La Bernard, red	673·1	1·090
La Canterbury, white . . .	754.1	1·097
Durham, or mossy, white . . .	1087	1·094
Les Orphelines, white . . .	1190	1·103
Quarry, or low lines, white . . .	1425·1	1·071
American Native, white . . .	1098·1	1·073
Vaughan's Seedling, white . . .	850·6	1·109
Black's (la noir gros) . . .	1010	1·044
Purple Kidney	744·1	1·067
Yorkshire Red	805·4	1·058
Juane Tardive, white . . .	1675·4	1·099
Long Red Kidney	582·9	1·069
Carnichon jaune, dit la Parmentier, white .	1787·5	1·110
Bellows Nose, white	1582	1·088
Smooth Red Kidney	1526·1	1·083
Ormeskirkes, white	1084·5	1·079
Maisbury Red	223·75	1·075
White Kidney	1066	1·077
La feuille de Haricot, white . . .	555	1·094
White	1188	1·116
Bullock's Heart, white . . .	1186	1·088
The Honor of Westwald, pink . .	1043	1·078
Blue Red Marbled, brown . . .	523	1·094
Black Kidney, deep purple . . .	1390	1·095
La Bavière, white	1517	1·090
Cornish Kidney, white . . .	1278·5	1·077
La Jaune Seine Longue, brown . .	659·5	1·090

Kind and Color.	Weight of Tuber.	Sp. Gr.
Early Champion, brownish white	1117·5	1 087
Farmer's Seedling, do.	771	1·086
Hâtive de Mendon, purple	1066·5	1·044
Jaune Blanche, brown	1895	1·010
Le bon Pommir, red spotted	996	1·086
La souries jaune, white	650	1·092
La Beaulien Marbrée, purple	504·5	1·086
Chapman's New Spring Kidney, white	1500	1·080
English Khynsburgh, brown	1190	1·082
La Bleu de Forêts, red	1057	1·082
Walton Hall, yellow	558	1·084
La Jaune Haricot, brown	1285·5	1·087
Lanckman's Red, pink	1418	1·084
Early Walnut-leaved, brown	780·05	1·091
Brown's Potatoe, white	719·5	1·090
White-eyed Red	1128·1	1·098
La Chionèse, ou Sucrée, white	841	1·100
Spanish, white	872·5	1·082
Jaune Hâtive, brown	777	1·090
La Coton, pink	603	1 079
Champion, white	1207	1·099
Cruikshank's Early, white	1079·5	1·084
Large Yellow	1092 5	1 096
Raith, white	1389	1·092
La Batave, white	870	1·082
Shaw, white	2039·5	1·099
White Oporto, white	1014	1 095
Downton Yam, pink	1819	1·081
Devonshire Red	840	1·097
Knight's Seedling, 1, brown	600·5	1·086
July, white	1146	1·079
Everlasting, pink	1074·5	1·067
Philadelphia, brown	1203	1 098
Knight's Seedling, 2, purple	1025	1·083
Lady's Finger, purple	313	1·078
Leather Coat, white	883	1·078
Burrowe's Early white	1342·4	1·072
New Potatoe, white	901·6	1 077
Hotteshe's Potatoe, light red	699·9	1·079
Vitelotte, pinkish	996·5	1·076
Large Cattle, white	1319·5	1·056
Early Dwarf, pink	516·5	1 086
Dwarf, white	859·5	1·083
Petit Jaune, white	672·5	1·077
Angleterre Hâtive, white	1161	1·088
Goldfinch, white	613	1·085

Kind and Color.	Weight of Tuber.	Sp. Gr.
Seedling White	1349·25	1·094
Oxnoble, white	860	1·108
Hog's Goliah, light purple	1015·5	1 079
South American, white	1155·5	1·087
Early purple marbled	979·5	1·083
New Swiss Kidney, light purple	965·25	1·083
Bermuda, No. 2, white	2688	1·064
Robertson's, white	437·75	1·093
La Semi Rouge, pale pink	425·25	1·089
La Longbrin, pale pink	735·25	1·079
Pink (Oporto), do.	1832 5	1·082
Large Pale Red, do.	850·25	1·067
Large white, do.	1097·5	1·082
Lancashire Red	1028	1·086
Ormeskirkes Early Dwarf, white	1132·5	1·085
Oxnoble ?, white	1704·5	1·062
Bermuda No. 1, red spotted	1099·5	1 067
Large July, white	3018	1·084
Yellow	809·3	1·084
La Prime Rouge, pink	507 3	1 090
La Oxnoble, white	1163	1·095
Jersey Blue, purple	906·4	1·084
Pink Kidney	825·5	1·082
Red Kidney	761·8	1·091
La Rose Oeil, white	439·8	1·105
La Rose Jaune, pink	409·5	1·078
Bangor Rouge, red	1067·3	1·089
Violet de M. Sagaret, reddish white	428·4	1·097
Biscuit, red spotted	534	1·058
Potatoe Pannels, white	956·2	1·077
Ash-leaf Kidney, white	1363·1	1·074
Yorkshire, white	1131·4	1·103
Latige Couche, white	1953·4	1·081
Sweeney Seedling, red	566·5	1·080
Bread-fruit, white	926	1·096
Long Faint Red	1078	1 081
Potatoe from Hamburgh, white	1326·1	1 095
Golden Knob, yellow	1844	1·086
Round Black, nearly black	1182·1	1·079
La Truffe d'Août, red	800·8	1·100
Hâtive de Juin, white	2399·5	1·089
Holland Jaune, white	892	1·106
Housekeeper's Delight, white	1030	1·084
Rouge Pâle, white	548·1	1·070
La Blanche Longue, white	519·2	1·061
Mule, brownish	1083	1·093

Kind and Color.	Weight of Tuber.	Sp. Gr.
Bonne Bellot, red	830·4	1·094
Early Shaw, white	1247·6	1·069
Dutch, white	1522·5	1·078
Winchfield, light pink	664·2	1·088
La Jeanette, white	1069·1	1.083
La Degénerée, pink	447·1	1·095
Gloucestershire Pink	744	1·092
Flat White, yellow	811	1·093
Ouion, brown	1123	1·092
Neapolitan, white	995	1·087
Knight's No. 6, pinkish white	1206·5	1·052
La Guérine, brown	1074	1·089
Early bright Red Palatinate, white	553	1·090
Early Kidney, pink	914	1·076
New Grenada, white	714·5	1·085
Black la Violette, pale pink	418	1·086
La Jaune Cylindricei	481	1 083
Azores, pink	803	1·086
Large Yellow, La Grosse Irlandoise, white	531	1·011
Carnichon Rouge de Holland, pink	756	1·069
Grosse Jaune, white	756	1 084
Violette à Chaire Marbrée, pink	588	1·152
New Hundredfold, white	465	1·086
La Patagne, pink	720	1·100
Cambridge, white	663	1·067
Albion, white	794	1·076
Knight's Yellow Kidney	904	1 084
Rossshire, white	1056	1·086
Belle Ochreuse, pink	444	1·085
Round Red German, deep purple	574	1·086
Early Manly, yellow	622	1·089
Johnstone's Pink	557	1·096
Early Kidney, white	1434	1·078
Hollande, pink	273	1 079
Everlasting, pink	928	1 074
Golden, white	995	1·089
Mageniaise, pink	846	1 101
La Claire Bonne, red	1031	1·095
Girkin, brown	890	1·092
Pink-eyed	449	1·080
Chelsea Wild, white and red	1395·5	1·085

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