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ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

I.—*Report on the Diseases of Wheat.* By the Rev. J. S. Henslow, M.A., Professor of Botany in the University of Cambridge, and Rector of Hitcham, Suffolk.

At the general meeting of the Royal Agricultural Society, held at Cambridge, in July last, it was stated that none of the Essays which had been sent in were considered worthy of the prize proposed on the subject of diseases in corn. I have since then seen these essays, and it was evident to me that the authors were ignorant of many facts long known to scientific inquirers respecting the nature of these diseases, and the causes producing them. However valuable some of the remarks may have been, as the results of the personal and practical experience of their authors, these essays fell far short of what the Society really wanted. Upon my return home, it occurred to me that a report on the nature of the diseases in corn might be serviceable to those who wished to prosecute an inquiry into the modes of preventing or palliating them; and I determined to look a little into the subject, and, in case I could find sufficient leisure for preparing such a report, to do so. Although I was well acquainted with the fact that certain diseases in corn were owing to the attacks of fungi, I had never paid further attention to the history of these minute plants than was required for their comparison and classification with numerous others of the same tribe; and I had no idea that the diseases which they produced in corn had occupied so much attention, especially with continental writers, as this inquiry has now shown me to have been the case. Very accurate observations and experiments were made upon this subject during the last century, and these have been added to, and improved upon, by a numerous class of observers, down to the present day. Several of their works I have had no opportunity of consulting, as I have but few of them in my own library; and our public library at Cambridge is also deficient in many, especially among the more recent foreign authors. Having so lately turned my atten-

tion to this subject, and that too at a season when so little time was left for observation or experiment, I have very little to offer which can in any way be considered an advance on the knowledge already on record. I have, however, examined wheat infested by five species of parasitic fungi; by the ergot; by the little animalcule which produces the ear-cockle or peppercorn; and by the wheat-midge. As I have been able to satisfy myself of the accuracy of previous observers on many points connected with the diseases occasioned by the attacks of these plants and animals, I shall confine my report to an account of them. I must beg it to be understood that I am offering a very imperfect report of what is really known on the subject, and consequently that I can only propose a very defective sketch of what it may be right to attempt in making further experiments. I have, however, thought it better to give this report at once, rather than delay it for a twelvemonth: for it cannot be before then that fresh opportunities will have occurred for making more extensive observations.

Section I.—*Remarks on Parasitic Fungi.*

As I shall in the first place notice the diseases occasioned by the attacks of parasitic fungi, a few general remarks upon the habits of these plants may not be unacceptable to the agriculturist. All fungi grow upon some kind of organized matter, none of them deriving their nutriment directly from the soil, water, or the atmosphere, like other plants. They are of great importance in the economy of nature, by assisting in the decomposition of decaying or decayed animal and vegetable substances. A few of them appear to grow upon healthy subjects, but these may possibly most frequently have originated on a part where disease or decay had already effected some alteration in the tissue; and then, by spreading rapidly from thence, they may afterwards occasion the decay of other parts also. None of this tribe of plants attain to any great size, when we compare them with many species of flowering plants, or even with many of those of other neighbouring tribes (as the ferns, &c.), which never flower. Among fungi we find a multitude of extremely minute species, which it needs the skill of an experienced microscopic observer to detect and examine; and it is also among the very lowest of the several groups into which these minute fungi are classed that we must search for the few species that produce the fatal diseases in corn we are about to notice. But if these fungi are themselves so exceedingly small, how much more so are those reproductive bodies, analogous to the seeds of flowering plants, by which they are propagated and multiplied! So very minute are these sporules (as botanists term them), that they altogether escape observation by the naked eye,

and can only be just distinguished by the highest powers of the microscope. Many of these kind of fungi live beneath the scarf-skin, or epidermis, and within the very substance of certain plants. In the progress of their growth, they raise blisters under the epidermis, and, when arrived at maturity, they burst through it, and then form spots or irregular blotches of various colours, which are frequently orange, brown, or black. These spots (or *sori*) are masses of fructification, and are surrounded by the tattered edges of the ruptured epidermis. A vast number of these fungi are known to botanists. Like parasitic animals, they are restricted in their powers of attack, being able to live on certain species only, and even on particular parts only of particular individuals of these species. There is often a strong general resemblance between many of them; but a naturalist will readily detect such important differences between two fungi which may infest distinct species of plants, that he is compelled to consider them also as species distinct from each other. Thus it happens in the animal kingdom, that different species of flea, and different species of lice, can exist only on particular species of quadrupeds or birds. The flea which infests dogs is distinct from that which annoys man. So also with these parasitic fungi; some are restricted to one species of plant, some to another: but, generally speaking, most of them are capable of living upon more than one species of the same genus; where, of course, we might expect the resemblance in all points to be very close. Some fungi confine their attacks to the seed, others to the stem or leaves, and some even to one side only of the leaves. One of those which attack wheat lives only on the grain, another more particularly attacks the short stalk (*pedicel*) on which each flower is seated, whilst three of which we are about to speak are restricted to the straw, chaff, and leaves; but all five live at first beneath the epidermis, and not upon it. In this respect they bear a close analogy to those parasitic animals which live within the bodies of other animals, some immediately beneath the skin, others in the intestines, and others again within the very substance of the muscle. It is the extraordinary minuteness of the sporules (or seed-like bodies) of these fungi, which allows of their being absorbed by the roots, and probably also through the pores of the stem and leaves of plants; and then they are conveyed by the sap to the various parts where they are enabled to germinate, grow, and fructify. The sporules of fungi appear to be everywhere dispersed through the atmosphere, ready to germinate wherever they may find a dead or living subject in a condition suited to their attack. Common mouldiness, for instance, which so readily forms on many substances in moist situations, is the most familiar example of the inconceivable numbers in which the sporules of a minute fungus

are everywhere diffused. The difficulty of admitting such a universal dispersion of these sporules has induced some modern philosophers to support the old exploded theory of spontaneous generation. Of this theory, however, we may safely assert, in the present state of human knowledge, that it involves difficulties an hundred fold more inexplicable than any which attend on the opposed theory, which teaches us that all living creatures proceed from similarly organized beings, originally called into existence at the fiat of the Almighty. We shall therefore consider these minute fungi to be plants, which have proceeded from, and are capable of reproducing, their kind by means of those minute sporules with which direct observation has made us well acquainted.

Section II.—*On the Bunt, Smut-Balls, or Pepperbrand.* (*Uredo caries*, Dec.; *Uredo fœtida*, Bauer.)

The fungus which occasions this well-known and much-dreaded disease has hitherto been met with only in the grains of wheat. Its presence is readily recognised by the peculiarly disgusting odour of the infected ear. It may be detected in the young seed, even in the very earliest states of the flower-bud; and when fully ripe it most frequently occupies the whole interior of the grain, but without bursting the skin, so that the wheat-seed retains very nearly the same size and shape that it would have assumed had it been perfectly sound. When examined under the microscope, the bunt-fungus is seen to consist of vast numbers of extremely minute globules, of a dark colour, and which are at first attached to a mass of matted thread-like matter, analogous to what is termed the spawn in mushrooms, and other agarics—and which in those plants spreads underground, and frequently occasions the remarkable appearances called fairy-rings. It is not easy to see this spawn of the bunt-fungus, but the little dark globules called spores may readily be detected. They may be considered analogous to the seed-vessels of flowering plants, and each of them contains a mass of almost inconceivably minute sporules, by means of which the plant is propagated.

The reproductive powers of fungi are quite beyond our comprehension. Fries, one of our greatest authorities, has calculated that a particular fungus may contain 10,000,000 sporidia.* Mr. Bauer has accurately measured the spores of the present species, and finds their diameter is not more than $\frac{1}{1000}$ of an inch.

* The terms *sporæ*, *sporulæ*, *sporidia*, &c., have either been applied synonymously or vaguely by different authors. The more modern practice appears to be, to use *sporulæ* for the ultimate granules analogous to seeds; *sporidia* for the cases or vessels containing them; and *sporæ* for an additional covering, which sometimes includes several *sporidia*.

A single grain of wheat (estimated at less than the $\frac{1}{1000}$ of a cubic inch) would therefore contain more than 4,000,000 such spores; but it is hardly possible to conjecture how many sporules each spore contains, since they are scarcely distinguishable under very high powers of the microscope, and then appear only as a faint cloud or vapour, whilst they are escaping from the ruptured spores. A reference to Mr. Bauer's plate and account of this fungus, in the 'Penny Magazine' for 1833, p. 126, will furnish the inquirer with very accurate details of its structure and peculiarities.

When this disease prevails, it greatly deteriorates the value of the sample; imparting its disgusting odour to the flour, it makes it less fit for bread; but I understand that ready purchasers are to be found among the venders of gingerbread, who have discovered that the treacle, and whatever else they mix up with it, effectually disguises the odour of the fungus: if this in itself is really innoxious, there can be no objection to such a mode of employing the tainted flour; but some are of opinion that it is to a certain extent deleterious. Although the bunt-fungus confines its attacks to the young seed, it seems to be a condition essential to its propagation that it should be introduced into the plant during the early stages of its growth, and that its sporules are most readily absorbed by the root during the germination of the seed from which the plant has sprung. It has been clearly proved that wheat-plants may be easily infected, and the disease thus propagated, by simply rubbing the seeds before they are sown with the black powder, or spores, of the fungus. It is also as clearly ascertained that, if seeds thus tainted be thoroughly cleansed, the plants raised from them will not be infected. This fact is now so well established, that the practice of washing or steeping seed-wheat in certain solutions almost universally prevails. Upon simply immersing the grain in water, the infected seeds float, and on the water being poured off nothing but the sound ones remain in the vessel. This simple process, however, is never perfectly effective, because, in threshing the wheat, many of the infected grains (smut-balls) are crushed, and the spores are dispersed in the form of a fine powder, which adheres with considerable obstinacy to the surface of the sound grains, by means of an oily or greasy matter found in the fungi. In order to detach them thoroughly, it has been considered useful to add some alkaline ley to the water in which they are washed; because oil and alkali unite and form a soapy substance, and then the spores will no longer adhere to the surface of the grains of wheat. Lime, possessing alkaline qualities, has been long employed for the purpose. Common potash, and substances containing ammonia, as the liquid portion of stable manure, have also been used. But, as some persons employ brine, sulphate of

copper, arsenic, and a variety of other materials which do not possess alkaline properties, it is supposed that all these solutions act rather by destroying the vegetative properties of the fungi, than as a means of removing them from the surface of the grains. It may therefore be worth while to institute a set of experiments to determine which supposition is really correct. Perhaps some portion of the effect may be owing to the increased specific gravity of the liquid; or perhaps some portion of the solution may be imbibed by the steeped corn, sufficient to prevent the sporules of the fungus from germinating within the substance of the plant; just as corrosive sublimate, essential oils, and Russia-leather prevent the formation of mouldiness. I may also add that the temperature at which the solutions are applied may be of some importance.

SECTION III.—*On the Smut or Dust Brand (Uredo segetum).*

This disease is produced by another fungus, which is often confounded with the last. The smut-fungus, indeed, resembles the bunt-fungus in colour and shape, but its spores are not half so large, and it possesses none of that disgusting odour which characterises the latter. Although this fungus is generally supposed to attack the grain much in the same way as the bunt-fungus, only that it more thoroughly destroys it, this is not the case. M. Ad. Brongniart has shown, in the 'Annales des Sciences,' vol. xx., p. 121, that the smut-fungus destroys the ear, by first occasioning the innermost parts of the flower to become abortive, whilst the little stalks *(pedicels)* on which these are seated swell, and become very fleshy. The fungus then consumes the whole of this fleshy mass, and at length appears between the chaff-scales in the form of a black soot-like powder. It is stated, however, by others, that it does not confine its attack to the ear; and though I have not myself witnessed its effects on other parts, it is described as infecting both chaff, straw, and leaves. The spores, when ripe, burst through the epidermis, and disperse in the form of a black powder, resembling charcoal. Mr. Bauer has given figures, and an account of this fungus also, in the 'Penny Magazine' for 1833, p. 180. He there gives the dimensions of the fungus, by which it appears that the diameter of a spore is not more than the twenty-eight hundredth of an inch.

This disease is not so much dreaded as bunt, for two reasons; the spores have generally been dispersed before the corn is cut; and even when present in the flour they have no disagreeable odour. It is sometimes, however, very injurious, by diminishing the produce. It is comparatively rare in wheat, but very common in barley, and even more so in oats; rye does not appear to be sub-

ject to it. It has been observed in several grasses, and I have this year noticed it in the "common oat-like grass" (*Arrhenatherum avenaceum*). Like the bunt-fungus, so also may the smut-fungus be kept in check by carefully steeping the infected grain; but this process does not here appear to be so thoroughly effective as in the former case. Probably the earlier ripening of the spores causes the sporules to disperse in the fields, and so keeps up a greater out-door supply of them. If of two evils we might choose the least, it would certainly be more desirable that the corn should be attacked by smut than bunt. I know not how an idea has originated, which I find prevalent among farmers, that a little smut in the barley-crop is a good sign: I can only suppose they mean to say the less the better. It seems to be most likely that both bunted and smutted corn cannot be very noxious, as fowls which have been fed with them receive no injury. At the same time it is asserted that the straw of corn infested with the smut-fungus is distasteful to cattle; but I am not aware that any experiments have hitherto been made with a view of ascertaining whether it is actually injurious to their health.

Section IV.—*On the precautions to be taken against Bunt and Smut.*

Whatever some persons may hope, when they suggest the possibility of our effectually exterminating the bunt-fungus, provided a system of carefully steeping all seed-wheat were universally to prevail, the most sanguine calculations could never count upon the extermination of the smut-fungus with any prospect of success. Since the smut-fungus does not confine its attacks to corn, but is also found in the grasses which grow in pastures and by the road-side, a plentiful supply of sporules will always be kept up, to warrant our believing that we shall never expunge this species from the British Flora. Still we may feel assured that precautionary measures may materially lessen an evil which cannot be wholly avoided. Since the sporules of the two fungi which produce bunt and smut enter the plants they attack by absorption at the roots, and since they are buried with those seeds to whose surface they have attached themselves,—it is evident that too great care cannot be bestowed in procuring clean seed, or in purifying such as may accidentally be infected. From a variety of considerations, it has always appeared to me strange that practical agriculturists are accustomed to pay so little attention to the raising of pure seed-crops. There may be reasons, which I do not properly appreciate, that would render it inexpedient to cultivate a seed-crop apart from the rest of the produce raised on a farm; but I should have thought that it was always worth while for every farmer to set aside some portion of

ground to be more carefully tended than the rest, for the purpose of securing good and perfectly clean seed. Among other reasons for such a practice, he would then be able to weed his crop from every plant infected with bunt or smut, before the fungi ripened. The benefit of steeping wheat in some mixture or other being thoroughly established, but it being still uncertain to what cause the success of this practice should be attributed, a few experiments might be undertaken with a view to determine this point. These would tend to point out which of the numerous substances now in use were most likely to be really serviceable, and which of them might advantageously be dispensed with. I shall therefore venture to suggest, in the following sketch, the kind of experiments that may be called for; and they may readily be added to, or improved upon, by those who are willing to interest themselves in this inquiry. A parcel of thoroughly bunted or smutted seed should be divided into a number of small packets, each of the same weight; or, if very small, each containing the same number of grains. When any of these packets are steeped or washed, the floated grains, and the fungi which rise to the surface, may be kept apart for separate experiments, being carefully labelled "F. 1," "F. 2," &c., to show that they were obtained from the packets of seeds, "No. 1," "No. 2," &c., by this process.

No. 1. Seeds unwashed, to serve as a comparative experiment.
— 2. Washed in cold water only—(2*) in scalding water.
— 3. Washed in water with lime, the proportions specified.
— 4. Washed in water and brine.
  (a) Mixed in the proportion of 2 water to 1 saturated brine.
  (b) ,, ,, ,, 1 ,, 1 ,,
  (c) ,, ,, ,, 1 ,, 2 ,,
  (d) Saturated brine.
— 5. Washed in sulphate of copper.
— 6. Sprinkled, but not washed, with lime.

Another set of experiments may be prepared with clean corn, to be infected with the floating fungi obtained in washing the above.

No. 7. Rubbed with—
  (a) F. 2, to serve as a comparative experiment.
  (b) F. 3.
  (c) F. 4.
  (d) F. 5.

Another set may be prepared with clean corn, which should first be steeped in different solutions, and then rubbed with the fungi obtained by simply washing in water (No. 2).

No. 8. Steeped in lime, and rubbed with F. 2.
— 9. ,, brine and do.
— 10. ,, sulphate of copper and do.

These last may be repeated, by washing the seeds clean after they have been steeped, to remove any of the mixture that may adhere to the *surface*.

No. 11. Prepared as No. 8.
— 12. „ „ 9.
— 13. „ „ 10, &c. &c.

SECTION V. — *On the Rust, Red-rag, Red-robin, Red-gum, (Uredo rubigo, and Uredo linearis).*

I believe that, under the names here quoted, agriculturists have comprehended the attacks of what systematic botanists consider to be two distinct species of fungi, and which the experienced eye of the microscopic observer was alone likely to separate. They form yellow and brown oval spots and blotches upon the stem, leaf, and chaff; and when the spores have burst through the epidermis they are readily dispersed. Like those of the bunt-fungus and smut-fungus, they consist of very minute grains, but their colour is different, varying from orange-yellow to brown, and their shape is not so perfectly sphærical, especially those of *U. linearis*, which are usually oblong. Both these fungi are very common on corn and grasses. I have, within the last two months (of July and August), seen more of the Red-rag (*U. rubigo*), as it is here called, than of any other of these corn-pests. It abounded in the form of an orange powder which exuded from the inner surfaces of the chaff-scales, but was scarcely, if ever, to be seen in the skin of the seed; it might also be traced in patches beneath the epidermis of the straw, but I did not observe that it had burst through the epidermis anywhere, excepting on the inside of the chaff. It seemed to prevail more among the rough-chaffed wheats than others; and, in this parish, more especially in some fields of the variety called white-tunstall. At one time it appeared likely that these fields would be seriously injured by it, but, some warm sunny weather coming on, the Red-rag lost ground, and I observed that the sori, or spots from whence the spores exuded, turned deep-brown. This disease is not so injurious as the true mildew; but although I shall speak of the latter as if it were produced by a distinct species of fungus, and in compliance with the present opinions of most systematic botanists, still I am very much inclined to think that both diseases are occasioned by the same fungus, under different forms or states of fructification. I did not witness the fact, but was told that the reapers had noticed several patches of mildew among the white-tunstall alluded to above. I much regret that I did not see them. My chief reason for supposing it probable that rust may result from a particular form of fructification in the same fungus which produces

mildew rests upon what I consider to be a satisfactory observation made upon a closely allied species (*Uredo rosæ*) which infests the under surface of rose-leaves. It would be misplaced, in this report, to discuss a merely botanical question at great length, but I may perhaps mention that I have satisfied myself by direct observation that the fungus which first produces the orange-coloured spores of *Uredo rosæ* also gives rise to other spores, of a very different form (which botanists have considered to belong to a distinct genus, and have named *Aregma mucronata*). I have also met with a review of M. Unger's work 'Die Exantheme der Pflanzen,' in the second volume of the new series of the 'Annales des Sciences,' in which it is stated that M. Unger, who, in common with a few other observers, considers many species of Uredo to be morbid secretions from the juices of plants, asserts that they afterwards *change* their forms, assuming the appearances ascribed to other genera of minute fungi. But surely these plants are too distinctly, too regularly, and too beautifully organized, to be the products of disease, like worts or purulent matter in animals. They are also too closely allied to other fungi, which are undeniably true plants, to allow of our considering them in any other light. There are doubtless great difficulties in accounting for the manner in which the minute sporules of these fungi find their way in sufficient numbers within the substance of plants to produce the effects they do in certain seasons. But, after all, the difficulty of conceiving how this happens is not greater, or so great, as that of accounting for the manner in which thousands of minute animals, just visible to the naked eye, sometimes find their way within the very muscles of the living human body. Upon corresponding with the Rev. Mr. Berkeley (who is our chief British authority in this department of botany), he referred me to a paper, by Leveillé, in the XIth vol. of the 'Annales des Sciences,' in which Unger's hypothesis is clearly disproved, and these minute fungi shown to be true plants. With respect, however, to the identity of the *Uredo rosæ* and *Aregma mucronata*, Mr. Berkeley remarks,—"It is a point on which I could never completely satisfy myself; for the Uredo seems to be perfected, and drops its spores before the Aregma is produced, or when there are only a few spores remaining. It is, however, certain that several published Uredines are only states of Pucciniæ (the genus producing the mildew), e.g. *U. vincæ*, *U. menthæ*, &c. The early stage of *Puccinia pruni* is an Uredo. I have just been examining it." In a subsequent communication, and in reply to my remark that the Uredo was not *changed* into the Aregma, he observes, "I agree exactly with you that the Uredo fully developed never is produced into the Aregma; and I see the Aregma produced in the way you sketch it, from sausage-like

curved bodies arising from the receptacle of the Uredo, and containing globular orange bodies exactly like that of Uredo; but I am not at present prepared to assert that Aregma is only an altered form of Uredo." Perhaps I have said too much on this purely botanical question; but an independent testimony in microscopic observations is often of value; and repeated observations have fully satisfied me of the truth of what I have advanced.

It will now rest with agriculturists to observe whether mildew is not always preceded or accompanied by rust; and botanists must determine the manner in which the three forms of spores developed in these diseases are related—if indeed they really belong to the same fungus. My *conjecture* is, that, whilst one of the uredines (*U. rubigo*) is a particular form of spore, which does not undergo any further change, the other (*U. linearis*) is the young state of a distinct form of spore, which, when further advanced, is called *Puccinia graminis*. I may add that, in order to be quite positive that I had found the *U. linearis*, I sent Mr. Berkeley a specimen of the straw to ascertain his opinion whether I was correct in supposing that the three fungi were co-existing in the same plant. He replied, "I perceive in your culm *Puccinia graminis* intermixed with *Uredo linearis*, and a few bad specimens perhaps of *Uredo rubigo vera*." With Mr. Berkeley's opinion against me, I offer my conjecture to future observers with the greatest hesitation.

Section VI.—*On the Mildew* (*Puccinia graminis*).

If agriculturists appear to have confounded, under the name of rust, the attacks of fungi which botanists consider to belong to two distinct species; so also have they frequently applied the name of rust as well as mildew to the disease we are about to notice. It will be seen by what I have stated in the last section that I am inclined to consider these two diseases to be mere modifications in the attack of the same species of fungus, but that further observations are required to settle this question. For the present, then, we must consider the mildew-fungus not merely as a distinct species, but also as belonging to a different genus from the two rust-fungi. The form of its spores is indeed very different from those we have already noticed. Mr. Bauer long ago published figures in which all the forms of the mildew-fungus are accurately delineated. This plate accompanies a short account of mildew by the late Sir Joseph Banks, which was published as a separate pamphlet, but afterwards reprinted in the second volume of the 'Annals of Botany;' again, in Curtis's 'Account of Grasses;' and again, but without Mr. Bauer's figures, in the sixth volume of 'The Pamphleteer.' The ripe spores of this fungus are little intensely dark-brown club-shaped bodies, having the thicker end

divided into two chambers, each filled with sporules. They taper gradually at the base into a fine stalk. The sori (or patches of spores) are composed of multitudes of these bodies, which sometimes burst through the epidermis of the stem and leaves in such profusion that the whole plant appears as if it had been scorched. I have observed this fungus intermixed with the rust-fungi in a way which strengthens my opinion that they are identical; but I do not wish to discuss this point any further, as my observations on mildew have hitherto been very slight. The only example which this year came under my notice occurred in two fields at Audley-end, in one of which, Lord Braybrooke informs me "that wheat was never grown before, the ground having been sheep-walk, and absolutely worthless until it was ploughed up some years ago, and since been farmed on the four-course system. The ground being much exposed, and with a northern aspect, the ploughmen call it Freeze-land. The seed was supposed to be pure Talavera." The seed in the other field was Hickland's Prolific. As these fields were mildewed in a season remarkably free from this blight, these circumstances are worth recording; and in addition I may observe that the soil was poor chalk-land, and the field of Talavera surrounded on all sides by high hedges and plantations. The mildew in the other field was confined to one corner.

Section VII.—*On the precautions to be taken against Rust and Mildew.*

I have very little that is satisfactory to report on this head. I do not think it has been clearly determined by experiment whether the sporules of the rust and mildew-fungi are absorbed by the roots of corn, like those of the bunt and smut fungi; or whether (which seems to be the more prevalent idea) they enter through those minute pores on the stem and leaves which botanists term "*stomata*." The fungi at first make their appearance in little cavities seated immediately beneath these pores, which certainly looks very much as if the sporules entered there. The stomata are naturally exhaling organs, continually discharging, under the influence of light, a large proportion of the water imbibed by the root. But in moist weather this function is impeded—if, in some cases, it be not actually reversed—when it would be easy for the sporules to enter these invisible stomata with the moisture imbibed by them. The fact, however, stands in need of proof; and hitherto the evidence is more in favour of similar fungi being imbibed by the roots of the plants which they attack. Mr. Knight, indeed, who is high authority, particularly insists upon mildew being induced by foggy weather happening at a time when the ground is particularly dry: circumstances which we may readily understand as likely to convert the stomata

(or even the whole superficial tissue of plants) into imbibing organs. If the autumnal fogs really predispose wheat to the attacks of the mildew-fungus, we must agree with those who recommend the growth of early varieties in places subject to these fogs. It seems to be pretty generally admitted that spring-wheats are less liable to mildew than winter wheats; and that heavy soils are less subject to it than light ones. But, at present, the information on these points is very vague and unsatisfactory. We may safely conclude, that a generally healthy state of the plant, without any over-luxuriance of vegetation, is most likely to secure a crop against the attacks of the rust and mildew fungi; but, that whatever tends to render the plant sickly, whether it be excess of heat or cold, drought or wet, sudden changes of temperature, poverty of soil, over-manuring, shade, &c. &c., must be considered as a predisposing cause to these diseases. Supposing it were clearly ascertained that a corn-crop had imbibed the sporules of the mildew-fungus early in the season, might it not be advisable to feed it down by sheep? I ask the question in perfect ignorance of the propriety or practicability of such a course. The rust and mildew-fungi attack many grasses; and I have this year found the latter in great perfection in the Common Reed. It is evident, therefore, that we can never expect to exterminate these fungi; but that their sporules will always be found in our fields, ready to attack the corn-crops whenever these are brought into a state adapted to receive their influence. Whether remedial or palliative measures may not be discovered is an inquiry well worthy the attention of agriculturists.

Section VIII.—*On the supposed influence of the Berberry in blighting corn.*

A notion has long prevailed, not only in England, but on the continent, that the berberry-bush (*Berberis vulgaris*) is in some way or other frequently connected with the production of mildew in wheat. Sensible observers among practical agriculturists have persuaded themselves that this is really the case; and they have asserted that their conviction of the truth of this hypothesis rests upon the effects which they have themselves witnessed. I should have considered such testimony of far greater value, if I had found it opposed only by the contradictory convictions of scientific inquirers; for, however unlikely it may seem to the latter that the berberry could in any way produce the ill effects ascribed to its influence, there are too many mysteries in the works of nature hitherto unravelled, not to induce us to pause before we decide a thing to be impossible merely because we can see no reason for considering it to be at all probable. But, in the present case, even practical men are by no means

unanimous in denouncing the berberry. L. A. Staudinger, an experienced and enlightened cultivator, at Flotbeck, near Hamburg, has published his observations on Ergot and Mildew, made between 1799 and 1830; and, according to a review of them in the 'Archives de Botanique,' vol. ii. p. 285, he expressly contradicts the commonly received opinion. He also refers to some experiments of Hornemann, which were made in the Botanic Garden at Copenhagen, who planted wheat, and surrounded it with berberry-bushes, and repeated the experiment several times, without obtaining any mildew. A similar experiment was made (if I recollect rightly) by Jussieu in the garden of Trianon, with a like result. Mr. Knight also obtained only a negative result in experiments of the same kind; though in this instance he would have been misled (mildew having attacked the wheat), if he had not instituted a series of comparative experiments, which satisfied him that no just inferences could be drawn from what had happened to the wheat planted near the berberry. I have not had any opportunity of seeing more than a solitary case of berberry-bushes growing in the hedges of a wheat-field, which was in one of the fields already noticed at Audley-end. The wheat was certainly more mildewed in their vicinity than elsewhere; but then the bushes were precisely in that corner of the field where the soil was decidedly the worst, and which was also sheltered by lofty trees; so that here, at least, there was no positive testimony that the berberry was a predisposing or assisting cause; since the effect might equally be ascribed to the worse condition of the soil or to the shade of the trees. To those who feel as interested as myself in having this question settled beyond dispute, and who may possess the opportunity for doing so, I would suggest the following experiment. Let berberry-bushes be planted in the middle of some fields, and protected by fences. Let it be observed whether the corn grown in those fields is mildewed, and the circumstances under which this happens accurately noted; let all failures be equally recorded. If the results of these experiments should tell to the prejudice of the berberry, I would willingly travel many miles to be convinced, by personal inspection, that this pretty and botanically interesting shrub had really caused the evil imputed to it.

Section IX.—*On Ergot.*

Of all the diseases to which corn, or indeed any other plant, is subject, this is certainly the most extraordinary, from the strange effects it produces on the animal economy. It is well known that the punctures which certain insects make in the vegetable tissue, for the purpose of depositing their eggs beneath the epidermis of the living plant, induce a morbid action in those parts, which gives

rise to the production of peculiar excrescences termed galls. The oak-apple is an example; so is the useful and important article of commerce, the common nut-galls, which are also obtained from oaks. It has been supposed that the Ergot might be a production of a similar kind; or else, that it may be occasioned by the action of a parasitic fungus; or even, that it was itself a fungus; and it has accordingly been sometimes classed in systematic works with true fungi. Mr. Bauer, in the 18th vol. of the Linnean Transactions, fully confirms the opinion of those who consider the Ergot to be a monstrous development of the seed of corn, and other species of the grass tribe; and he has given most accurate drawings of this singular production, in all its stages of growth. He objects, as I conceive rightly, to the idea of its being produced by the action of a certain minute fungus, which is found equally on plants not producing the Ergot, as on those that do so; but an opposite opinion is maintained by high authorities. Be the cause of its production what it may, the Ergot is a monstrous state of the seed, in which the embryo, and particularly one part of it, is preternaturally enlarged, protrudes beyond the chaff, and often assumes a curved form, somewhat resembling a cock's spur (from whence the name of Ergot, which is of French extraction). It is black superficially, and of a spongy texture internally; containing much oily matter, so that it will burn like an almond when lighted at a candle. This production affords us a remarkable, but not uncommon example, of how slight an alteration in the proportions in which certain elements are combined may make a material difference in the properties of the same body. The few elementary principles which form flour, the very staff of life, are in some way so differently combined in this particular state of the grain from whence flour is obtained, that certain animals cannot continue to eat it for many days together, even in comparatively small quantities, without becoming diseased, and probably dying from its effects. The experiments which have been undertaken in order to prove this are unexceptionable of their kind, but painful to read; and having once been made, with the care and caution detailed by the Abbé Tessier, and others, we may hope that it will never be considered advisable to repeat them wantonly. They were made upon various animals, ducks, fowls, turkeys, pigs, &c. Such repugnance had these animals to the Ergot, that they preferred starvation to voluntarily partaking of it, even when it was mixed in small proportions only with good flour. When compelled to swallow it, they soon sickened, their limbs became inflamed, and their bodies gangrenous in various parts, and sometimes the flesh sloughed off, and death invariably ensued. In the case of a duck which was forcibly fed with flour mixed with the powder of Ergot, forming a seventeenth portion of the whole compound, drops of blackish blood oozed

from its nostrils at the end of five days; the beak soon afterwards changed colour, and the tongue rotted at the extremity; the animal died in ten days, after having taken altogether one ounce and seven grains of Ergot. In a turkey, the ill effects began to show themselves in seven days, and it died at the end of twenty-two days, having eaten eight ounces and four grains of Ergot. A pig died in twenty-three days, having eaten one pound two ounces of Ergot, which it was found very difficult to disguise in its food sufficiently to induce it to eat. With another pig the experiment lasted for sixty-eight days, and the animal had eaten twenty-two pounds six ounces of Ergot in that time: this formed about one-eighth the whole quantity of food with which it had been supplied. The effects produced in this last case were very decided; the joints of the legs became gangrenous, as well as the ears, and the flesh from the tail sloughed off. The importance and propriety of making these experiments will be readily admitted when it is known that they were undertaken expressly to test the probability of ergotted rye-bread being the cause of dangerous gangrenous epidemics among the poor in certain districts of France. The details of the sufferings to which these persons are occasionally subjected are shocking to humanity. Their extremities rot off; and some have been known to lose all their limbs, which, in the progress of the disorder, fell off at the joints, before the shapeless trunk was released from its torment. In one instance recorded by Tessier, a poor man, whose family were in a state of starvation, ventured to make bread of some ergotted rye which he had begged of a farmer, but had been cautioned by him against using it. It killed himself, his wife, and five out of seven of his children. Of the two which recovered from the effects of the Ergot, one became deaf and dumb, and had one of its legs drop off. I felt interested, whilst pursuing these researches, with an account preserved in the register of a neighbouring parish, Wattisham, which I shall venture to transcribe into this report; because it seemed to me probable, as soon as I first heard of the circumstance, that the effects there recorded may have been due to the presence of Ergot:—

"*Extract from the Parish Register of Wattisham, Suffolk.*

"The following is a circumstantial narrative of a very extraordinary and singular case that happened in this parish A.D. 1762:—

"On Sunday, January 10, 1762, Mary, daughter of John Weatherset, alias Downing, aged 16 years, was taken with a pain in her left leg, which in an hour or two sunk into her foot and toes; the next day her toes were much swelled, and black spots appeared upon them. By degrees the whole foot became swelled and black; the pain, which was now chiefly in her toes, was, she said, as if dogs were gnawing them; the blackness and swelling increased upwards, by slow degrees, till it

came near the knee, when the flesh of her leg putrefied and came off at the ankle with the foot, leaving the leg-bones bare. Her other foot and leg were affected in a few days, and decayed nearly by the same degrees and manner. Her thighs both swelled, and under her ham an abscess formed. The surgeon, seeing no perfect separation, did, on the 17th of April following, attempt to take off one of the limbs, near the knee, just above the corrupted flesh, but such an effusion of blood issued as to stop his attempt; he afterwards took off both her legs near the knee. She lived many weeks, and then died.

"Mary, the mother, was taken, very soon after her daughter, with the same kind of pain under her left foot, or, as she sometimes said, in her left leg; her toes, foot, and leg were affected in the same manner as her daughter's, and in a few days her other foot and leg also. Both her feet came off at the ankles, and the flesh rotted from the leg-bones, which continued bare about three months, and then rotted off. Her hands and arms are benumbed, and her fingers contracted, but not black; she is now almost well, and likely to live many years.

"Elizabeth, the next daughter, aged 14 years, was on the next day, viz. Monday, January 11, 1762, seized only in one leg and foot, which she could not set on the floor for three weeks, but stood all that time upon the other, leaning against the chimney; after which, being taken in the same manner in her other foot, she lay down; one foot mortified and came off at the ankle, the other leg near the knee.

"Sarah, the next child, aged 10 years, was taken on the same day as her sister Elizabeth, in one foot, which mortified and came off about the ankle. The toes of the other were affected, and broke, but healed again.

"Robert, aged 7 years, was taken on the Tuesday or Wednesday following, in both legs, which came off at the knees.

"Edward, aged 4 years, was at the same time taken in both feet, which rotted off a little below the ankles.

"An infant, aged two months, was taken from the mother's breast as soon as she was seized with the disorder. It was put out to nurse, and died within two months; when dead, its feet and hands turned black.

"John, the father of this unhappy family, was seized with the same disorder, about three weeks after the first was taken, in both his hands. His fingers became benumbed, contracted, and black. The nails of some came off, and two of them broke, but healed again. He complained much of darting pains in his hands, arms, legs, and back."

The popular belief in the neighbourhood, to this very day, supposes these unfortunate people to have been bewitched; and that they were thus visited as a judgment for their mal-practices!

In addition to the above, the event is commemorated on a tablet, let into the wall of the church, containing the following inscription:—

"This inscription serves to authenticate the truth of a singular calamity which suddenly happened to a poor family in this parish, of which six persons lost their feet by a mortification not to be accounted for. A full narrative of their case is recorded in the parish register, and Philosophical Transactions for 1762."

Guided by this reference, I find the case excited at the time great attention, both here and abroad; and that the symptoms were considered to be precisely similar to those which the ergot of rye produces in France. But it appears from an accurate inquiry which was instituted at the time into all the circumstances which might in any way be supposed to have brought on the disorder, that no rye had been used by this family. Rye was, I understand, very commonly the food of the poor, about that time: none, however, is now used here, and it is not grown in the neighbourhood. The circumstance which seems to have struck the persons who investigated this case as most likely to have been the cause of the misfortune, was the family having lived for some time on bad wheat. They were in the habit of using about two bushels of Revet-wheat weekly; and since Christmas, this had been supplied them by a farmer from the produce of a crop which had been laid, and which he had kept apart from the rest of his stock. The grain was discoloured: it made bad bread, and worse puddings. But it did not disagree with any one of the farmer's family, or others who used it, except one man in the village, who was affected by a numbness in both his hands for about four weeks, and whose fingers' ends peeled at the time the unfortunate family lost their limbs. There is no evidence that the presence of ergot was suspected in this wheat. Indeed, the ergot is seldom met with in any other corn than rye; and Tessier says, he never saw but one example of it in wheat, of which he gives a figure. Bauer also mentions having never found more than two ears of wheat infected by it. I have, however, found it this autumn in four different fields of wheat, and gathered more than a dozen specimens; and I find that some of the farmers here are sufficiently acquainted with it to satisfy me that it must be more common in wheat than has hitherto been suspected. Upon asking my miller to search for me, he very soon picked out about three dozen ergots from two bushels of Revet-wheat, which had been sent to be ground at his mill; and he said that he had left at least as many more in the sample. This wheat was grown in the next parish to Wattisham. A very cursory look into the mouth of a sack of gleaned wheat, then at the mill, also furnished me with three or four more specimens. Should the ergot ever prove abundant in any particular crop, it may be worth while to have it picked out,—both for the sake of purifying the sample, and also as a source of profit; for it is a highly esteemed and valuable medicine in skilful hands, but much too dangerous in its application to be trifled with by ignorant practitioners. I am, however, speaking of the wheat-ergot, as though it were an equally efficacious medicine with the rye-ergot; but I am not aware whether this is really the case.

I would wish to invite agriculturists to make inquiry in their several districts, whether the ergot does not sometimes prevail to an extent sufficient to induce a belief that it may be injurious to the health of the poorer classes, whose food is little varied, and who might thus be subjected to whatever evil influence a certain admixture of the ergot in their flour may be capable of producing. It may also be suggested to such medical men as have opportunities of witnessing those disorders to which the poor are more particularly liable, and which are generally ascribed to poverty of diet, whether these complaints may not sometimes be induced or fostered by the presence of this deleterious ingredient in the flour. Tessier states, that some humane proprietors in those districts of France where the gangrenous epidemic was prevalent, were in the habit of furnishing their labourers with rye that had been picked free from ergot, in exchange for any infected samples they might themselves have grown; and that after they had adopted this practice, their labourers were no longer attacked by the epidemic.

Section X.—*On the prevention of the Ergot.*

As the ergot is not known to prevail to an injurious extent in any other corn than rye, nothing has been said of the mode of preventing it in wheat. In rye, it is said to prevail most in wet and stiff land; and draining has been consequently suggested, as the obvious mode of diminishing the evil. The direct experiments which have been made with this view seem to have been sufficiently conclusive; and to have proved that more seeds become ergoted in proportion as the plants are kept wet at the roots, and grown in a clay soil. Perhaps it might be worth while to cultivate rye on this principle, for the sake of supplying the demand for ergot.

Section XI.—*On the Ear-cockle, Purples, or Peppercorn, (Vibrio tritici.)*

It is now just a century since Needham first made known an extraordinary fact concerning the blighted grains found in the ears of wheat infected by a disease known under the name of the ear-cockle, purples, or, as I find it called in this part of Suffolk, the peppercorn. The grains which are thus infected turn dark-green at first, and ultimately nearly black; and they become rounded, somewhat resembling a small peppercorn, but with one or more deep furrows on their surface. The husks of the chaff spread open, and the awns are twisted, by which means the infected ears are readily observable among the standing corn. Upon opening the blighted grains, they are found to be filled with a moist white cottony substance; but to contain no flour.

When Needham placed this cottony mass in a drop of water, under his microscope, he perceived to his surprise (as I did lately to mine, before I was aware that the fact had been previously noticed) that it was composed of a multitude of minute eel-shaped animalcules, which were in active movement, twisting and wriggling to and fro, like so many eels or snakes. The announcement of Needham's discovery summoned several observers into the field, of whom no one was more persevering or intelligent than Roffredi. His papers, in the fifth and seventh volumes of the "Journal de Physique," contain the results of more than five years' patient investigation into the economy of these minute creatures. In the "Philosophical Transactions" for the year 1823, Mr. Bauer has also given the result of his personal observations and experiments, carried through an equally long period, and without his having any knowledge of what Roffredi or others had already done so long before him. He has given faultless drawings of the animalcule (*Vibrio tritici*, as it is systematically named) from the state of the egg to its full growth, and as it is seen under the highest powers of the microscope. The disease which it occasions is said to be sometimes very injurious to the wheat-crop; but I presume it must be very local, for it was unknown to some of the earlier writers on the diseases of corn, who sought for it without success; and I could not learn, upon a limited inquiry, that it was known to the farmers near Cambridge, or at Saffron Walden. In this parish, however, it is well known, and my miller informs me that he often has samples of wheat much infested with it; and among what he calls the tail-corn (the last portions of a particular batch), he has found as much as half a peck in the bushel. He says, also, that when the cottony mass composed of the animalcules is extracted from the grain in the process of grinding, it does not pass through the cloth with the fine flour in the beating, but remains behind with the bran. When a sound grain of wheat is sown by the side of one infested with the *vibrio*, the young plant which springs from the former is not infected before March; but then the animalcules begin to find their way from the blighted grain into the earth, and thence into the young corn. They gradually ascend within the stem till they reach the ovule (or young state of the seed) in the flower-bud, even before the ear has shown itself. Roffredi believed that they do not increase in size till they have reached the young seed, but that after this they grow very rapidly, soon deposit a large number of eggs, and then die. Mr. Bauer has questioned the accuracy of Roffredi's observation, and supposes the specimens found in the stem to belong to another species. The young are hatched in about eight or ten days after the eggs are laid, and speedily attain to about the $\frac{1}{88}$ of an inch in length, and the $\frac{1}{1800}$

of an inch in diameter. When full grown, the vibrio acquires a monstrous size compared with one of the multitude which composes the cottony mass in the blighted grains, becoming a quarter of an inch long, and the $\frac{1}{80}$ of an inch in diameter. I am not aware whether any precise estimate of the numbers actually found in a single grain has ever been made, but a slight calculation will show us that not less than fifty thousand of the young *might* be packed in a moderate-sized grain of wheat. Mr. Bauer seems to think that more than one generation are produced in the course of a season. The most curious circumstance which observers have noticed in the economy of this animal, and which I have had an opportunity of fully verifying, is the wonderful property it possesses of retaining its vitality under circumstances in which we should have supposed it impossible that it could have lived. If a mass of them is suffered to become so perfectly dry that the slight touch of a hair might reduce them to powder, and they are again moistened in a drop of water, they will speedily revive, and become as active as before. They may thus be dried and revived many times before they are killed. Mr. Bauer states the limit to such revivals to lie between six and seven years. I happened to possess an ear of wheat infected with this disease, which had been sent me (I think) at least six years ago, but which I had not minutely examined before; and upon soaking some of the blighted grains in water for a few hours, the animalcules revived, and were quite as active as those I had found in the first fresh grains which I had been examining only two days previously. If the eggs are once dried, or even the young animalcules themselves before they have attained a certain size, they will not revive on being moistened. It does not appear that the vibrio naturally attacks any other corn than wheat; at least, it has not been observed to do so. But barley, rye, and oats may become infected by sowing them in the same hole with the grains of wheat which are filled with the vibrio. The experiment, however, succeeds with difficulty, and only to a small extent.

Section XII.—*On the prevention of the Ear-Cockle.*

When the infected grains are thrown into water, they float for a short time, but on becoming saturated with moisture, they sink; so that merely immersing the seed-sample in water would hardly suffice as a method for getting rid of the bad grains. I have observed that scalding water kills the vibrio; and this may suggest the possibility of exposing infected samples to a temperature that might be sufficiently high to kill these animalcules, without being so hot as to destroy the germinating powers of the corn. Perhaps the suggestion already thrown out, to grow seed-wheat apart from the general crop, may be here repeated.

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SECTION XIII.—*On the Wheat-Midge, (Cecidomyia tritici.)*

Nothing is more common in wheat-fields than to find one, two, or more of the flowers, in many ripe ears, defective in the grain, even though the parts of the flower had been well formed. This effect may be owing to a variety of causes; and among others, is frequently occasioned by a minute two-winged fly called the wheat-midge, (*Cecidomyia tritici.*) This fly may be seen in myriads, in the early part of June, between seven and nine o'clock in the evening, flying about the wheat, for the purpose of depositing its eggs within the blossoms. From these eggs are hatched small yellow maggots, which are the caterpillars (*larvæ*) of this fly; and by these the mischief is occasioned. Mr. Kirby, the now venerable patriarch of Entomologists, so long ago as 1798, gave an interesting account of the habits of this insect, to which the attention of naturalists had been directed by Mr. Marsham about two years before. These accounts will be found in the third, fourth, and fifth volumes of the "Linnean Transactions." It has been supposed that the wheat-midge caterpillars feed on the pollen after it has been shed from the anthers, and thus prevent the fertilization of the ovules, or young seeds; but it seems hardly likely that the pollen of one flower should be sufficient to support a single caterpillar, much less several, for a month or more. Mr. Kirby has suggested, what I should consider a much more plausible theory, that the caterpillars, with their heads immersed in the stigmata, live upon the juices secreted by the ovary, and thus obstruct its growth, whether it may have been fertilized or not. Be this as it may, these caterpillars are certainly, in some way, the cause of the non-development or abortion of the ovary, so that the grain never advances beyond the state in which it appears at the time the flower first expands. A figure of the fly and its caterpillar is given in the "Linnean Transactions;" and likewise in the "Magazine of Natural History," vol. i. p. 227, where Mr. Kirby has also given another figure, and a short notice of a different species of the same genus, called the Hessian fly, (*Cecidomyia destructor,*) which is particularly injurious to wheat in North America. This latter, however, does not deposit its eggs in the flower, like our own wheat-midge, but near the base of the straw, within which the caterpillars are hatched, and these devouring its substance cause it to break off near the root. The caterpillars of the wheat-midge are about the 12th of an inch in length, without legs, and of a citron-yellow colour; and when they are about to pass into the chrysalis (*pupa*) state, they spin themselves up in a very thin and transparent web, which is often attached to a sound grain, or to the inside of one of the chaff-scales. The chrysalis is of a reddish orange colour.

Section XIV.—*On precautions to be taken against the Wheat-Midge.*

Perhaps it may be thought unnecessary to take any precautionary measures against so insignificant an enemy as the wheat-midge; and possibly the actual damage which it occasions may generally be too trifling to make it worth the farmer's while to trouble himself about it. Mr. Kirby calculated that in a certain piece of wheat, of 15 acres, the loss would amount to about 5 coombs, or a twentieth part of the crop. Whether such a loss may be worth thinking about I am not sufficiently aware; but there is a strange economy in the insect tribe, by which particular species, in certain seasons favourable to their production, are enormously multiplied, and are then capable of producing very extensive havoc, though in most years their attacks are comparatively insignificant. I should therefore presume that any simple method which might be devised for continually checking the increase of the wheat-midge must be decidedly beneficial in the long run. Since the chrysalides of this insect lie secreted during the winter among the chaff, and the fly does not make its appearance till June, multitudes of them might easily be destroyed by burning or scalding the chaff after the grain has been threshed out. It has however been asserted, and I have myself observed the fact, that many of the caterpillars quit the ears and fall to the ground, where (it has been supposed) they change to chrysalides, and remain buried till their final metamorphosis takes place. It seems extraordinary that different individuals of the same species of insect should have habits so distinct as these—that whilst some spin a web within the chaff, others should bury themselves in the ground. I suspect (but have not fully verified the fact) that all those caterpillars which enter the ground have been ichneumonized, as entomologists term it. As it may be an object of some importance to ascertain whether this is really the case, (if ever agriculturists should think it worth while to attempt any remedial measures against the attacks of the wheat-midge,) perhaps I may be allowed to make a few remarks on this curious department of the insect economy. There is an extensive group of insects, collectively called ichneumons, though subdivided into many genera, which lay their eggs in the bodies of other insects, generally whilst these are in the caterpillar state. When these eggs are hatched, the young maggots which they produce (and which are the caterpillars of the ichneumons) feed upon the fleshy or muscular parts of the caterpillar they are attacking, carefully avoiding the vital parts. At length, the caterpillar they have thus been devouring alive, dies; or, as frequently happens, it changes to the state of a chrysalis before it is destroyed. The ichneumon caterpillars also pass to the chrysalis state, and either remain within the body

of the dead caterpillar, or come out of it before they assume the fly-state.

Each species of ichneumon is restricted in its attacks to one, or at most to a few, particular species of caterpillar; and the females instinctively proportion the number of eggs they deposit in each individual to the relative size of their own offspring, and that of the insect on which it is destined to prey. In some cases, a single egg is laid in a caterpillar; in others, some dozens. These ichneumons are obviously destined to restrain within due limits certain species of insects, which would otherwise inconveniently increase. Our wheat-midge has certainly one, and probably not less than three distinct species of these ichneumons appointed to keep it in check. One of these (*Platygaster tipulæ*) may be seen in July and August, actively engaged in examining the ears of wheat infested by the caterpillars of the wheat-midge. It is a minute black four-winged fly, with a sharp point at the tail, which it insinuates between the chaff-scales, and then pierces the caterpillars, depositing a single egg in every one it is able to reach. One ichneumon, therefore, destroys many caterpillars; and it is clear, if it were not for their friendly interference, our wheat crops would in a few years run a fair chance of being utterly destroyed. If my conjecture is correct, that it is only those caterpillars of the wheat-midge which have been punctured by the ichneumons, which quit the ears and bury themselves in the earth, there is thus a very effectual provision made for the preservation of the ichneumons; whilst, on the other hand, many of the midge chrysalides must necessarily be destroyed during the process of threshing the corn, and more might easily be got rid of with proper precaution. My conjecture is founded on the following observations made this autumn. I had observed no ichneumons about any of the ears of some wheat which had been attacked by the wheat-midge, and in the specimens which I brought home, many if not all of the caterpillars have spun up in the chaff-scales. But, in some other specimens, obtained later in the season, and on which I had seen the ichneumons busily employed, I found that many of the caterpillars came out of the ears, and buried themselves in some sand placed at the bottom of the vessel in which I had put them. At present they have neither spun nor changed to chrysalides. In the second volume of the "Magazine of Natural History," p. 292, is a notice by Mr. Gorrie on the effects produced by the wheat-midge; and he estimates the loss in the late-sown wheats, in Perthshire in 1828, to have amounted to one-third of the crop! And again, at p. 324, he says they destroy from three to five bolls per acre. He asserts that all the maggots had descended into the earth by the 1st of August, and advises their destruction in

that situation; but if (as I suppose) it is the ichneumonized caterpillars only which enter the earth, this would be destroying the farmer's best friends. A little closer attention to the habits of these insects another year, may enable some one to solve the doubt.

I am aware that in this imperfect report I have not noticed all the diseases to which corn is subject; and, among them, a certain semi-abortion of all, or most of the grains in the same ear; of which I have seen some examples in this neighbourhood, and have been favoured, by Mr. Pusey and Dr. Buckland, with other specimens from the neighbourhood of Oxford. In the latter situation, a whole crop was very much injured in this way. When this is the case, the entire plant (but more especially the ears) is covered with a minute blackish fungus, as though it had been powdered with soot. I do not believe, however, that this fungus (*Cladosporium herbarum*) is the original cause of the evil, but that it merely attaches itself, superficially, to these and many other plants after they have been brought into a state of decay. I had supposed this kind of blight, in some of the localities where I noticed it, to have been owing to drought, the crops growing in a stiff clay which had become thoroughly hardened; and Dr. Buckland formed the same opinion of the case which came under his notice. In other cases, I considered it was owing to the injury which had been done to the straw by high winds, which had much bent and bruised them. Such effects as these are hardly to be classed among the diseases of corn, and they are entirely a subject for the inquiry of the agriculturist. The attacks, also, of many insects and other animals, however injurious to the crops, are unaccompanied by any morbid affection of the plant, which might induce us to class such effects with those we have been considering; and it falls rather to the zoologist than to the botanist to notice them.

In concluding this report, I must express a hope that the reasons already adduced will be considered sufficient excuse for any inaccuracies. I have not written it as a scientific communication, but solely with the desire of directing the attention of practical agriculturists to what has already been done on the subject, and to point out what they themselves are required to do towards advancing our knowledge of the diseases in corn, and the modes of providing remedies against them.

J. S. Henslow.

Hitcham, Bildeston, Suffolk,
September 14, 1840.

In the observations I this year made upon the apparent diseases infecting my wheat-crop, I find that at one period, about the middle of July, the rust

was prevalent in a piece of golden-drop wheat sown the first week of November, 1839; but more especially in the headlands near a hedge on one side of the ground. The weather, however, appeared afterwards to be against the advance of the disease, but still my interest was excited, and I frequently inspected this particular headland. The fence was low, about three parts of the way down, but thick and of a considerable height in the remaining part. About the latter end of July I perceived the wheat in this portion of the field, immediately within the influence of the hedge, assume a dark colour, speckled about the ear, and by about the 14th of August, when the field was reaped, it had the appearance of being infected by this fungus: may not, then, this disease have been superinduced upon the rust, owing to the want of a free circulation of air, which the remaining parts of the field enjoyed?

W. Miles.

II.—*On Subsoil-Ploughing.* By H. S. Thompson, Esq.

[*Taken, by permission, from the Transactions of the Yorkshire Agricultural Society.*]

Public opinion is still much divided on the subject of subsoil-ploughing. Some very eminent farmers maintain that it is lost labour; while others, equally eminent, think no system of husbandry complete without it. When men of sense and experience differ respecting matters of fact which have come under their own observation, it will generally be found that, like the travellers disputing about the colour of a chameleon, neither would be wrong if he would only allow his opponent to be right. To take a case in point;—one farmer of my acquaintance drained deep, and used the subsoil-plough with every precaution and care, yet found it fail; another, following precisely the same plan, permanently improved the texture of the soil: both were anxious that their friends should profit by either the example or the warning, and lost no opportunity of making the result public. For want of a better term, both experiments were said to have been made on *stiff* soils: both are credible men; and the natural result of such conflicting testimonies is, that the question remains undecided. Here we feel the want of some acknowledged classification of soils founded on chemical analysis. No two witnesses could be more directly at issue than those alluded to above; and very possibly, both one and the other may have been quoted by the supporters or opposers of the subsoil-plough as triumphantly establishing their position. The moment, however, that the two experiments are referred to their place in the geological map, the