NATURAL HISTORY OF THE DANISH LICHENS

ORIGINAL INVESTIGATIONS BASED UPON NEW PRINCIPLES

BY

OLAF GALLØE
PH. D.

PART I

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> *Omnis vera cognitio speciei e cognitione individui.*

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IN MEMORIAM

E. WARMING

BIBLIOGRAPHY

Lynge, Bernt: Index specierum et varietatum »Lichenum exsiccatorum«. Kristiania 1915, 1920.

Lindau et Sydow: Thesaurus literaturæ mycologicae et lichenologicae. vol. I—V, Berlin (Gebrüder Borntraeger).

Bioret, G.: Revue des travaux parus sur les lichens de 1910 à 1919 (Revue générale de botanique, tome XXXIII, 1921.

Zahlbruckner, A.: Catalogus lichenum universalis. Berlin (Gebrüder Borntraeger).

— Flechten. (Engler u. Prantl, Natürl. Pflanzenfamilien, Teil I*).

Tobler, F.: Biologie der Flechten. Berlin 1925 (Gebrüder Borntraeger).

Smith, Annie Lorrain: Lichens. (Cambridge Botanical Handbooks). Cambridge 1921.

Galløe, O.: Danske Likeners Økologi. (Botanisk Tidsskrift, 28). København 1908.

— Forberedende Undersøgelser til en almindelig Likenøkologi. København 1913.

— The Lichen Flora and Lichen vegetation of Iceland (in The Botany of Iceland, edited by L. Kolderup Rosenvinge and E. Warming, vol. II, part. I. Copenhagen and London 1920).

Lynge, Bernt: Lichens from Bear Island. (Resultater av de norske statsunderstøttede Spitsbergenexpeditioner, Bind I, Nr. 9. Oslo 1926.

— De norske Busk- og bladlaver (Lichenes Thamno- et Phylloblasti Kbr.) Bergens Museums Aarbog 1910.

Fries, Th. M.: Lichenographia Scandinavica. Upsaliæ 1871—74.

— Lichenes arctoi. Upsaliæ 1860.

— Lichenes Spitsbergenses. (Kungl. svenska Vet.-Akad. handl. Bd. 7) 1867.

Vainio, E.: Lichenographia Fennica I and II (Acta Societatis pro Flora et Fauna Fennica. Helsingforsiæ 1921—1922.

Deichmann Branth og E. Rostrup: Lichenes Daniæ. (Botanisk Tidsskrift III) 1869.

Deichmann Branth: Lichenes Islandiæ (Botan. Tidsskrift, Bind 25) 1903.

Hellbom, P. J.: Bornholms lafflora (Bihang till K. svenska Vet.-Akad. handlingar, Band 16, Afd. III, Nr. 1) 1890.

Mathiesen, F. J.: Laver (in Rostrup, Vejledning i den danske Flora II) København 1925.

Fischer-Benzon: Die Flechten Schleswig-Holsteins. Kiel und Leipzig 1901.

Pissarschewsky, A.: Aufzählung der bisher in Russland aufgefundenen Flechten. Moskau 1897.

Elenkin, A.: Lichenes Floræ Rossiæ mediæ. Dorpat 1906—11.

Hazslinszky: Magyar Birodalom zusmó-Flórája (Flora Lichenum Hungariæ). Budapest 1884.

Steiner, F.: Prodromus einer Flechtenflora d. griech. Festlandes. 1898.

JATTA: Sylloge Lichenum Italicorum. Trani 1900.

STIZENBERGER: Lichenes Helvetici. St.-Gallen 1882—83.

BOISTEL: Nouvelle Flore des Lichens de France. Paris 1902—03.

HARMAND: Lichens de France. Paris 1905.

SMITH, ANNIE LORRAIN: A monograph of the British Lichens, part I (London 1918); part II (London 1911).

LINDAU, G.: Die Flechten. Kryptogamenflora für Anfänger, Bd. III. Berlin 1923.

INTRODUCTION

It is a matter of general knowledge among lichenologists how difficult or even impossible it is to determine a lichen individual occurring in nature, that is, to find out to what species it belongs. With some hesitation the lichenologists will at length trace it to some species in the hope of having hit the mark and being in accordance with the author of the species in question, and finally that the said author — if he had the opportunity of seeing the individual — would acknowledge it to have been »truly determined«. What importance are we to attribute to this expression? Evidently it may be used with at least two meanings: the individual in question bears an absolute resemblance (morphological, anatomical etc.) to the individual which the author formerly had before his eyes at the first description of his species, that is to say, it is related to it by similarity, or: the individual in question is genealogically related to the original specimen of the author. We must consider each case separately.

Relationship by similarity. In botany a widespread respect for original specimens still predominates; people often make great efforts to have the individuals, found by themselves, compared with original specimens, obtained from the authors, in order to establish the identity of their own specimens with these. Evidently, however, the supposition underlying the importance of such an effort must be strictly limited if it is not to be illusory. The supposition must be that the author has defined his species absolutely clearly and left only one specimen as type specimen for future comparison in cases of doubt. For, if he has based his original description on several specimens and left us several type specimens, we can no longer rest assured that these really belong to the same species or the same elementary species, and thus the importance of the comparison with the type specimen is much weakened.

Everybody knows that the majority of descriptions of species dating from earlier times are not based on such single specimens, but that the descriptions were even often made at a time when microscopical technique was very undeveloped so that the author's own opinions as to the limitation of species were very uncertain. If one were to submit to the earlier lichenologists a whole collection of species which are well separated according to the ideas of the present time, they might determine them all as belonging to one species!

It is, therefore, very praiseworthy and wise that the authors have left behind them type specimens for later comparison; but absolute agreement between original descriptions and original specimens is not to be expected.

The author will in most cases have compiled his description after an examination of several specimens, and by so doing he will often undoubtedly have formed a description based upon a collective species, which would now no longer be considered to be an elementary species.

In cases of doubt the result would then be this: if the description is not sufficient to allow of the identification of an individual found (and this is almost always the case), a comparison will be made with the type specimen or the type specimens. But here several practical difficulties present themselves: frequently these type specimens do not exist any longer, or there are several of them, so that it is doubtful which of them (in the case of a collective species) is the genuine one, or they are spread all over the world, so that it is extremely difficult to get an opportunity of having a look at them. Some of these difficulties might be overcome, if there existed a central place where type specimens were kept. I should like to suggest the possibility of having an international institute established where all the type specimens of the world were gathered together, and where, for all time to come, all »new species« were registered, so that the investigator could either go himself to such an institute with his material in order personally to compare it with the originals, or send his materials for »proper determination« to the specialists holding appointments at the institution. In this way the individual investigator would be saved much trouble and inconvenience, and much time would be saved. Let us suppose for one moment that such an institute has been established, that it contains good original specimens which fulfil all the above mentioned conditions, and that in this institute we can have our material determined in the best possible manner, — what results have we now arrived at?

We can now with great certainty determine the resemblance which specimens collected bear to each other, and their relationship by similarity. But will this suffice? No, clearly not. The genetic relationship still remains to be determined.

One question constantly confronts the lichenologist, when examining specimens which are very much alike: do the specimens represent varieties of the same species, due to difference in age or habitat, or are they different species, that is elementary species? Here a careful study in nature can give us hints as to the right solution of the problem, but certainty can be reached solely by culture-experiments.

I have mentioned this on a former occasion (»Botany of Iceland« vol. II, 6 pag. 106 et seq.) and I will not say any more about it here.

At the present moment, however, we have neither this international institute for housing type specimens nor one for the culture of lichens and the examination of genetic relationship of lichens. We have not even a universally used good method of description by means of which others can ascertain whether their specimens of lichens are related by similarity to this or that particular species. The establishment of the two above mentioned institutes is, no doubt, beyond the powers and reach of a single person. The very minute examination of the species, however, can be made by any single investigator provided that the right method is adopted. I propose to discuss this method here at some length.

Description of individuals. In the »Botany of Iceland« I mentioned for the first time and recommended this method of examining the individual: that is, the description of each separate individual. This is a decided break with the previous method of botanists or at any rate of lichenologists. While up to the present date descriptions of species have been formed as a sort of average description of several or even many individuals, which were supposed to belong to the same species, by which method one ran the risk of committing — and, indeed in several cases decidedly did commit — the error of comprising in the same description several closely related species, my method is quite different. It is as follows:

The description of species is based on one single individual which I describe morphologically and anatomically in full detail. In doing so, I certainly avoid any mistake which might arise from a description of several closely related elementary species. If I have used several specimens, as I have done on more than one occasion, I describe each of these separately, because, if afterwards — in spite of everything — a little doubt should arise whether specimens A, B, C, etc. really belong to the same species, one may with certainty depend upon the individual descriptions of these specimens, and one will not run the risk of finding them merged into a collective description, the details of which are quite inextricable.

I maintain that this simple method is new to lichenology, and has undoubtedly certain great advantages which will be easily seen by any botanist familiar with the principles of pure culture, whether these relate to micro-organisms or higher plants, seeing that these principles are employed in the study of heredity etc. Perfect similarity of pure culture would consist in actually employing for cultural experiments the very individual described, in order to examine the qualities of its offspring, its heredity, its dependance on external conditions, hybridization with other species etc. But here the similarity would be at an end. In numerous cases the specimens, examined by me, were dead herbarium specimens, even though I have in many cases and by preference examined living specimens, which I had recently gathered.

Among the objections which may be urged against the individual description, the most important is the following: every individual has — in spite of indubitable common specific features — its peculiar stamp. If we want to undertake a description of a species, can this be based on more than one individual? Shall we not end in such a splitting up of species that the notion of species would vanish into thin air. Indeed, the systemic works of late years seem to tend in this very direction, old collective species being split up again and again. This is undoubtedly a very disagreeable drawback, which may especially be of consequence to comparative geographical studies of lichens where the object is to compare the lichen-flora and lichen-vegetation of various geographical territories. Objections have been made against this very division, in this country e. g. by Deichmann Branth. The greatest difficulty, however, in the way of this elaborate splitting up of species into smaller ones, does not in reality consist in the circumstance that the species is split, but in the fact that each of all these new smaller species will be given its new separate name, so that there will be a superfluity of new names, which will make absurd the extent and the meaning of the old names of species, especially if the old names are retained beside the new ones. This is just where I think we may proceed in quite another way: if I find various types within one group of individuals which I suppose to belong to the same species (e. g. *Lecidea elæochroma*) I describe a typical specimen of each — without giving them new names (see under *Lecidea elæochroma*). I am thereby enabled to express that I consider them to be related to one another as species (which for the present is only an assumption until culture-experiments can satisfy me) and also that every type has been so closely described after examinations based upon one single individual that it cannot be split up into further units.

How many types should be described in each species? This is a matter for judgment, as it may be continued indefinitely. Even after the closest examination one may of course go on seeing distinctions right down to the single individuals, but to continue giving names to each of these might perhaps carry the thing too far — even in the eyes of the most enthusiastic lichenologists. And moreover it is most confusing and completely superfluous.

As a rule it will be possible to distinguish types which comprise many individuals of an appearance so alike, that even the keenest and most critical observer must suppose them to belong to the same species and accordingly give them the same name. But, to tell the truth, it must be admitted that here there is room for individual judgement and consequently also for mistakes; but no method can avoid these, and this does not reduce the importance of the fact that the species (or type) to which a specimen is traced, is a well described single individual with which it may be compared and in accordance with which it may be given a name.

I have chosen the names I use myself in this work according to the following principles: I have first examined the single specimen as carefully as possible, and then I have endeavoured to find in the literature on the subject as detailed a description as possible — in the case of the present *Lecidea*-genus, chiefly in Th. Fries' »Lichenographia Scandinavica
tion which seems to correspond minutely to the individual examined by me, I have given it the name used in the work quoted, regardless of whether it is the oldest or not. In the present work therefore the names used are almost exclusively taken from Th. Fries' work. I have entirely omitted any discussion of synonyms. Ac-

cordingly if we find in Th. Fries' work a number of synonyms for each name of a species, Fries alone must be held responsible for these synonyms. I do not express an opinion myself as to their correctness, I should only be able to do so, if I had seen all the original specimens concerned and submitted them to an investigation as close as the one which I have made of the specimens examined in the present work. Such a thing was quite apart from my purpose which has by no means been the study of synonyms; still less has it been the criticism of the individual opinions of lichen-systematists as to the limitation of species etc.

My intention has been to pursue studies of the natural history of the lichens of Denmark and to show what types we have in this country. I hope that other lichenologists will be able to recognize them in nature after my descriptions. To make the descriptions as clear as possible I have illustrated them by carefully drawn figures. Even the most minute description cannot possibly show the structure of a species as plainly as a figure. All the figures have without any exception been drawn and painted by myself with the use of an Abbe's drawing apparatus both as far as the morphological figures and the anatomical figures are concerned.

I must emphasize that the specimens selected to be drawn, have been chosen so as to show as many as possible of the characteristics of the species so that one — by studying the pictures alone — can make actual inquiries into the development of the apothecia from their origin to their old age, their relative size etc. In this way one may also draw comparisons as to the size of the spores, the size of the apothecium, the thickness of the hyphæ etc. etc., since the magnifications of the figures are always stated. Thus I have to a large extent been able to omit many details from the text itself.

The reader will look in vain for any description of consistently carried out chemical investigations, more especially any chemical diagnostics, because I have gradually come to believe their value to be very small. It does not follow on that account that chemical tests are without any value at all. But I have frequently found that chemical tests act only in patches upon a thallus or that the reactions otherwise give information of a very doubtful and disputable value. I want, however, to emphasize that just as I consider it an error to generalize as regards the value of chemical tests, so I think it wrong to decry their value. At any rate I attach much less importance to this whole question than do several other lichenologists, and in my opinion the chemical reactions have been considerably over-estimated, more especially the iodine reaction and the chlorine reaction. But the KOH reaction may doubtless often be a valuable help in a diagnosis.

When in future I speak about the biological qualities of any particular species, about its distribution in the pure geographical sense and about its occurrence in plant societies, this means that my observations apply to a varying number of individuals which are absolutely related to each other by similarity in the above mentioned sense.

About the real genealogical relationship of the individuals existing in nature, cultural experiments should in future be made, but the present work is not a place for entering upon a more detailed discussion of such experiments. These will be extremely long and difficult, as far as one can judge from previous experiments. The introduction to such experiments must necessarily be a careful investigation of types as they exist in nature, and this is the object of the present work, which must therefore of course by no means be considered as a final, but as a fundamental work on which future investigations may be based.

LECIDEA ACH.

Phylogeny. From the taxonomist's point of view it would seem very desirable to form some idea as to the phylogeny of each individual genus or species. It can only be hypothetical, however.

Palæontological investigations give us no information, as no fossils, which might be supposed to be closely related to any of the species of *Lecidea,* are known. So we can have recourse only to a comparative investigation of such plants as live at the present time and by their structure seem to be related to the recent species of *Lecideas.*

The question which we put to ourselves briefly and clearly is therefore the following: What is the origin of the genus *Lecidea;* of what type were its ancestors?

Ever since SCHWENDENER put forward his theory of the dual nature of lichens, a fungus in symbiosis with algæ, the idea that the genus of *Lecidea* was derived from primitive algæ *(Pleurococcus)* in symbiosis with Ascomycetes, has been generally accepted.

We can picture to ourselves the conditions under which such a symbiosis may have originated by studying the biology of recent *Lecideas.* We must suppose such a symbiotic condition to have originated on the bark of a tree or on bare wood, or possibly on humus in places where only a moderate light prevails, and from the following reasons:

Pleurococcus occurs most frequently on an organic substratum; the Discomycetes are saprophytes (or parasites) which originally occurred only on an organic substratum, not on stone or on mineral soil. The symbiotic state is therefore bound to have occurred first on wood, on bark or possibly on humus, where both symbionts may originally have occurred in a free condition.

Very likely the symbiosis originated in places with intense or at least moderate light, since no *Lecideas* occur in dark forests e. g. forests composed of *Picea excelsa* where the light is very poor, whereas *Pleurococcus* may very well be found in a free condition in such forests. It will be understood that the algæ could not become lichen gonidia under such conditions when we bear in mind that they would suffer from want of light and fare badly in consequence of their being surrounded by the hyphæ of the fungus.

A certain minimum of light will thus be required if the initial formation of lichens is to succeed, but no investigations as to the exact amount of light required have as yet been made beyond the observations I have made myself in Danish forests. Here we find, as already pointed out, that the lichens are absent from the darkest forests of *Picea excelsa,* whereas the slightly lighter beech forests with mild humus are richer in lichens, containing among other species also *Lecideas (Lecidea elæochroma* and others).

That it is actually the conditions of light which determine the lack of lichens in dark *Picea* forests, and not for instance the chemical composition of the tree-bark, is proved by the fact that *Picea* when exposed to the light by the felling of the neighbouring trees will be covered with lichens in the course of a short time.

There is nothing to prevent the supposition that several distinct Discomycetes may each separately have initiated a lichen symbiosis, in which case *Lecidea* would be of polyphyletic origin. The great variety in the structure of the apothecium of Lecidea seems to suggest this possibility. But whether the origin be mono- or polyphyletic it is most probable that all species on pure mineral soil and on stone are of secondary origin and are derived from more primitive species on organic substrata, seeing that Discomycetes unaccustomed to a lichen-symbiosis could hardly be expected to initiate a symbiosis on pure stone without first having gone through a process of adaptation on an organic substratum.

But from these primitive species which were at first probably only facultative lichens (such are still known among certain groups of lichens, as the Caliciaceæ) all recent species are in all probability derived; I shall, later on, go more closely into their probable mutual relationship.

It might, however, be interesting not only to trace the evolution which has taken place from the primitive species up to the recent ones, but also to follow the evolution in the opposite direction down through the Discomycetes and the still older prototypes of the latter, — in other words: the probable phylogeny of the Discomycetes.

Common to all Discomycetes is a fruit which, when fully developed, is provided with an open, uncovered hymenium composed of a variable number of spore-sacs or asci, intermingled with numerous vegetative paraphyses of varying structure.

It is known that we meet with the same structure in the discocarpous lichens, and consequently also in the genus *Lecidea.* In the latter case the fruit is button-shaped, in the beginning deep, cup-like and constricted and is called the apothecium, the structure of which we shall get to know better under the headings of the individual species. Frequently its structure changes from a concave to a convex shape which means that it passes through a series of stages of development beginning with pezizoid forms and ending in helvelloid forms.

In other genera of lichens the helvelloid form of the fruit is still more marked, e. g. in *Sphyridium*, *Bœomyces* and others.

If we endeavour to trace to their origin the prototypes of the discocarpous lichens and the yet more remote prototypes of their ancestors, the Discomycetes, there are especially two groups among the cryptogams to which we must direct our attention: the Phycomycetes and the Florideæ.

Followers of BREFELD have always maintained that the ascus of the Ascomycetes and the polysporous sporangium of the Zygomycetes were homological organs.

It depends principally on the nature of the nuclei of the above-mentioned two sporangia, the ascus and the sporangium of Zygomycetes, whether this view is justified or not. In the case of some Ascomycetes it has been proved — and this is a well-known fact — that the ascus in its younger stages contains two nuclei originating from a process of fertilization which takes place by an oogonium entering into open connection with an antheridium, and the nuclei of the antheridium penetrating into the oogonium, where they do not, however, always fuse immediately with the nuclei of the oogonium: they may remain there in pairs until the oogonium by the formation of ascogenous hyphæ develops bi-nucleated asci. In these asci the two nuclei unite, and by continued divisions several (often 8) nuclei with a surrounding cytoplasma are formed; after further growth (formation of a wall etc.) they finally develop into ascospores.

The types of ascus-formation hitherto described in the Ascomycetes, however, exhibit considerable variety; tbe oogonium is either provided with or devoid of a trichogyne. By the fertilization through the antheridium the oogonium may be transformed into an ascus either immediately or more indirectly, and the ascogenous hyphæ may ultimately develop into asci; therefore it is rather uncertain whether the processes of the fertilization observed in the Ascomycetes are all homologous. Furthermore, only a limited number of Ascomycetes have as yet been investigated in respect to their process of fertilization, so it is still uncertain whether fertilization is a usual process which often occurs, or wbether it is becoming rudimentary.

At any rate there seems to occur among the Ascomycetes most often a self-fertilization, and this excludes hybridization; therefore inheritance must be supposed to follow the rules which apply to homozygous organisms. But scarcely any definite investigations have as yet been made into this question.

The ascospores and all the hyphæ developed from them (mycelium, vegetative thallus) are considered to be haploid. We may thus discriminate between a diploid sporophyte and a haploid gametophyte. If the process of fertilization mentioned here, and generally known to take place in Ascomycetes, does actually occur in these fungi, it may indeed prove an insuperably difficult task to homologize the ascus with the sporangium of the Zygomycetes, the latter being of asexual origin. The resemblance between the fertilization process of the Ascomycetes on the one hand and that of the Oomycetes and Florideæ on the other hand has been pointed out; some authors have ventured from this resemblance to draw the immediate inference of a more intimate relationship between these groups. For my own part I want to express my doubts as to the existence of any close relationship between the Florideæ and the Ascomycetes and through these the lichens. On the other hand I consider it very probable that the Phycomycetes, especially the Oomycetes, recent or extinct, may include the prototypes of the Ascomycetes as well as those of the lichens, as I consider the ascogonium to be homologous to the fertilized oogonium of the oomycetes, or, possibly homologous to the zygospore of the Zygomycetes; and I consider the conidia of the Ascomycetes to be homologous to the zoosporangia occurring in the Oomycetes (or the sporangia occurring in the Zygomycetes).

It might indeed be very interesting to compile a detailed account of the probable homologies between recent Phycomycetes and Ascomycetes, but as it would probably lead too far here, I will confine myself to discussing in rather more detail the question of the florideæ-like structures supposed to have been found in the lichens.

Several investigators (STAHL, BAUR, DARBISHIRE a. o.), have described a process of fertilization which reminds one of that found in the Florideæ, a curved multi-celled oogonium, immersed in the thallus from which it sends a thread-like trichogyne up above the surface of the thallus, being stated to occur in *Physcia, Collema* and some few other species. Similar trichogynes are described in numerous *Cladonia* species, but the oogonium belonging to the latter trichogynes does not, however, appear to be curved.

The probable course of the process of fertilization itself is described by BAUR who has observed a pycnoconidium — in *Physcia* and others — adhering to the upper part of the trichogyne, and he believes that he has seen the resorption of the separating cross-walls, which probably takes place in order to make a passage for the nucleus of the pycnoconidium which may be supposed to make its way down into the oogonium. This process has, however, never actually been observed.

If the process has been correctly observed it appears to be strikingly floridean (or perhaps oomycetean). On the other hand there are many obscure points in connection with this observation which compel me for the present to look upon it as unsatisfactory and unconvincing.

The pycnoconidium adhering to the trichogyne has not been proved to be a pycnoconidium at all, as the means by which it might be possible to identify it do not even exist. It might just as well be any other pycnoconidium-like body (fungus-conidium, etc.) as a lichen-pycnoconidium.

The contents of the pycnoconidium (nucleus, cytoplasma) have not been seen to enter the oogonium, which means that the most essential feature of the process of fertilization has not been observed at all.

Nothing is known about the nuclei of the oogonium, as to whether the nucleus of the pycnoconidium unites with the nucleus of the oogonium, or, whether they possibly keep separate for a certain period and only unite at a later stage in pairs in the ascus, as is the case with other Ascomycetes.

It must therefore be emphasized that the development of the ascus in the lichens is still unknown in its most important details, and especially that fertilization has not been definitely observed.

Only one thing is definitely known, that in a large number of lichens, including the *Lecideas,* systems of hyphæ clearly distinguishable and composed of rather large hyphæ are found in the apothecium under the hymenium, i. e. in the »hypothecium«; these hyphal systems appear in any well-stained section, and from them the asci develop, which are found in the hymenium in all stages of development.

Nothing decisive is known as to how this ascogenous tissue and the ascogenous hyphæ have originated, so there is still a wide field open for investigation in the future.

The principal questions which present themselves for answering in this connection are the following:

1) Have the ascogenous hyphæ arisen from a fertilized oogonium?

2) If so, how does such fertilization take place?

3) How do the nuclei in the cells of the ascogenous hyphæ act? Do they occur in pairs in each cell as a »syncaryon«?

4) Do the nuclei divide independently of each other and finally unite in the ascus? And is the outcome of this process a diploid nucleus?

5) At what time does next reduction division take place in the event of fertilization?

If Baur's observations on the process of fertilization are correct, which I consider rather doubtful and which are in any case as yet unproved, there will be vast possibilities for the investigation and interpretation of the lichens occurring in nature, as there will be the possibility of hybridization and the resultant development of an abundance of different types. It is possible that hybridization does occur, but I do not consider it likely, — not because I want to find an easy excuse for dismissing a possibility which might be embarrassing in the study of lichens — (such things have happened before in lichenology, e. g. in the earliest times of the SCHWENDENER theory!) — but because the following facts seem to support me in my view:

1) Fertilization by means of pycnoconidia is known nowhere else among Ascomycetes (excl. Laboulbeniaceæ) from which the lichens undoubtedly are derived.

2) The function of the pycnoconidia, if they did take part in a process of fertilization, would not be the same as in other Ascomycetes where they are asexual means of propagation (conidia).

3) The pycnoconidia in lichens have, in several cases where the matter has been investigated, been shown to be capable of forming a lichen-thallus when allowed to germinate in association with algæ. It is not likely that they have the double function of producing a new lichen-individual without previously fusing with an egg cell, and of acting as spermatia.

4) In several lichens the pycnoconidia are entirely absent, — and fertilization by their intervention is consequently out of the question.

5) In several lichens, also in the species of *Lecidea*, the apothecia occur in great numbers and in all possible stages of development, whereas no pycnoconidia occur at the same time. To this feature — which I have observed in many species of *Lecidea* — I attach a very great importance. For if the pycnoconidia are spermatia, i. e. male sexual cells, they must be expected *either* to occur periodically according to the seasons, to accomplish the fertilization, and then to disappear, which eo ipso will involve a periodical development of the apothecia, *or*, they must appear during long periods, perhaps all the year round; and it would consequently be possible to find apothecia at any stage of development all the year round. Now the apothecia are actually found as stated (in this country at least) all the year round in all stages of development, and we might then expect to find pycnidia at any time also. But this is not the case: The pycnidia are in many cases absent, and appear on the whole to be rare in Danish species of *Lecidea;* so they cannot play any important part as conidia, much less as spermatia.

Everything seems to suggest that the process of fertilization as described by Stahl and Baur does not take place but that the organs described by them have been wrongly interpreted.

Alternation of generations in the modern sense of the word, that is, an alternation between diploid and haploid stages of development, is according to the above statement not yet known in the case of lichens.

If fertilization takes place — no matter in what way — then it is possible that a differentiation between diploid and haploid stages may also exist. But it is not even certain, whether a regular alternation between the stages with single and double numbers of chromosomes must necessarily take place in connection with fertilization. It is still uncertain what importance may be attributed to the actual number of chromosomes present.

Perhaps we are rather inclined, bearing in mind what we know of the phanerogams, to overrate the mere numerical proportion. Is it not more likely that the qualities of the fusing nuclei are infinitely more important than their number of chromosomes? And furthermore, is the structure of the vegetative nuclei of lichens known? Do they possess a fixed number of well differentiated chromosomes? This is not known. The hyphæ of lichens are generally so small and the nuclei of the cells so diminutive that their structure is still unknown in detail.

Even if the occurrence of an alternation of generations may be observed in the future, it can already now be said, that two independently living generations do not exist in the same way as among the higher Archegoniata or among the Uredineæ.

Another question which is not, I think, generally understood, needs closer investigation. What is the deeper biological significance of self-fertilization in lichens, fungi, and all the organisms concerned?

In such species in which cross-fertilization occurred in the earlier stages of their phylogeny by means of which their sexual nuclei from being haploid became diploid as regards the numbers of chromosomes, it is comprehensible that a self-fertilization will always involve the advantage that the number of chromosomes and thereby the mass of chromatin will acquire a normal diploid aspect. One is moreover tempted to believe that it is not only a reduction in the number of chromosomes and the mass of chromatin which is attained by the reduction division, but also a differentiation between the qualities of each of the two kinds of sexual cells, male and female, so that fertilization is necessary in order that these differentiated qualities may again be united. But this process merely serves to unite the temporarily separated kinds of chromatin, so that nothing new has been added.

In most of the Ascomycetes so far investigated self-fertilization alone has been observed. What is its significance? Will the spores, which are the final result of fertilization, possess the same hereditary qualities as any purely vegetative reproductive organs such as conidia, detached fragments of the thallus, etc.?

The importance of an investigation as to whether cross-fertilization can actually take place, has been pointed out in the above.

We have now briefly reviewed the taxonomic relationship of lichens and shall now only mention some facts in connection with the probable course of their phylogeny and its causes.

That the species of *Lecidea* originate from one or more species of Discomycetes which perhaps even today still occur as free fungi in nature, is very probable. It would, however, hardly be possible to trace such fungi, as the structure of no apothecium of a *Lecidea* is ever really similar to that of any known Discomycete — even if we disregard the difference of fungi from lichens in the structure of the thallus. It is in any case probable that the transition from a Discomycete to a lichen, i. e. its entry into symbiosis with the algal gonidia, has also by correlation influenced the structure of the apothecium, and it is therefore no longer possible to point out its prototype among the Discomycetes, just as it is impossible for instance to trace with certainty the wild growing ancestors of the cereals, even though they probably exist up to this day.

Among the most primitive species of *Lecidea,* which really seem to be closely connected with their prototypes among the Discomycetes, we have in Denmark several very interesting species provided with a crustaceous thallus, e. g. *Lecidea quernea, elæochroma* etc.

These corticolous species may be supposed to represent the lowest stage in the series of *Lecideæ* which have in the course of time migrated from the bark of trees to other substrata such as soil, stone etc., and there developed into different species. This does not, of course, mean that these species are the actual ancestors of all our other species; we know nothing about that. But it is most probable that considering their primitive structure and primitive substratum, i. e. the bark of trees, the above mentioned and similar primitive species represent the first stages in the series of *Lecidea*.

To what agency is the evolution of these species due?

We have now touched on the question of the origin of species generally, and its causes, — a question which is, indeed, very comprehensive and by no means limited to the origin of the species of lichens, but which every biologist is obliged to consider, and with regard to which he must take up a definite standpoint when making his investigations, and which will probably never find such a comprehensive answer put into few words and in such a schematic form as the great classical champions of the evolution theory have tried to give —. On the contrary, I think experience more and more tends to indicate that the origin of species has many and very intricate causes which only long and laborious investigations can possibly make clear, whereas it cannot now be anticipated whether it will ever be possible to trace the phases of the formation of new species in the same way as it is possible to trace the phases of even very intricate chemical processes, where it is possible in many cases beforehand to foretell the final result of the course of a series of reactions. To put matters briefly: will it ever be possible for us to settle the following question:

Let us take *Lecidea elæochroma* as an example —

1) How would it change in the course of time when migrating a) from one climate to another b) from one group of competitors to another c) from one substratum to another?

2) Have any inner evolutionary tendencies of the species sufficient influence to induce any changes in it when the external conditions remain unchanged?

3) What will happen in the case of hybridization?

4) What is the effect of correlation?

5) What has happened to this species in the course of time—what is the course of its phylogeny from the earliest stages?

The last of these questions must unfortunately remain unsolved. The earlier evolution of the individual species we can only guess at from good fossils (these are very unlikely to be found as far as lichens are concerned!) or by very accurate morphological investigations of recent species.

The other questions we may perhaps be able to answer to a limited extent by future experimental investigations.

As regards the influence of altered climatic conditions, it is, of course, to some extent possible to make experimental investigations, but these have, however, never actually been carried out. Observations, made in localities with different climates, seem to prove that strong light will stimulate the formation of pigments in the cortex of the lichens and make the cortex very thick. Excessive moisture will have a very active influence on the growth of the gonidia, and thus further promote the formation of soredia and the formation of a thin cortex. But numerous details still need careful investigation.

Geology has given us numerous instances which show that the climate in any one territory can change very considerably, and that such changes will involve alterations in the flora and vegetation in such a territory, e. g. in the Middle and North of Europe after the ice age. But in this case we have no certainty as to whether a change in the climate as such will give rise to new species, though there is abundant evidence that it will cause migration and thereby alteration in the composition of the flora.

We also do not know whether any one species during its migrations is really capable of adapting itself to a new climate, or whether it requires certain definite conditions as to the temperature, which may put a stop to any further migration. Experiments teach us that the same species cultivated in alpine and in lowland territories will show widely differing aspects, but it is not known whether anything similar is taking place spontaneously in nature. In this connection it would be interesting to submit relic plants for instance from Denmark's post-glacial tundra to a closer investigation in order to ascertain whether by the development of physiological or morphological qualities they would show adaptations to the altered conditions under which they occur in the present time.

A priori it seems possible that species accustomed to a definite climate and incapable of migration or adaptation to new climates exist as well as other species possessing the ability to do so. But we know very little in this respect, and there is here a wide field for investigation.

Competition with other individuals will to a considerable extent influence the external appearance of lichens. When for example crustaceous lichens meet on the same substratum they will often both stop growing, and a margin of thallus, often dark, will be formed. Among the fruticose lichens competition will stimulate the formation of vertical podetia and consequent formation of haptera between the individuals. Doubtless a lichen species placed among competitors new to it will be forced either to succumb or to develop new qualities which, should they become transmissible, will transform it into a new species. The number of species, which may be supposed to originate in this way, is in reality endless, since the species through their migration all over the globe may well be supposed capable of forming an infinite number of combinations or plant associations which are constantly making fresh demands on the powers of adaptation of the species, and can thus constantly bring about the formation of new species. I am personally inclined to consider this particular factor, namely competition, as one of the most powerful of all those effecting the evolution of species.

If a species migrates from one substratum to another, for instance from bark to stone or soil, — a migration which has undoubtedly taken place in numerous cases — it will most probably result in the development of new varieties and species. For instance all orthotropic radially built fruticose lichens have no doubt originated as adaptations to life on a soil substratum, since they occur only there and cannot in consequence of their qualities of structure live on any other substratum. I have called attention to this fact in my »Preliminary Investigations«. Likewise a rocky substratum is, in physical respects, quite different from a substratum of bark, and rock lichens have thus developed peculiarities of structure which their ancestors on the bark of a tree did not possess, e. g. distinct areolation in the crustaceous lichens, and the formation of persistent rhizoids in the fruticose lichens. Among fruticose lichens on soil these are most often short-lived and evanescent.

In this connection it must be borne in mind that not only may migrations from one substratum to another become important in connection with the evolution of species, but also physical and chemical changes in the soil on which the species are living may act in the same direction.

Undoubtedly the substrata of plants undergo considerable changes in the course of time, especially where it is a question of geological epochs. Enormous territories which at one time formed a rocky substratum have in the course of perhaps millions of years been transformed into friable soil, and the latter is also constantly changing under the influence of rain which washes soluble nutritive substances out of the soil. Such substances are not necessarily replaced by further decompositions of inorganic materials. The lime of the Danish soil is constantly being washed out, and it is not naturally replaced, and this is what probably happens in numerous other cases. The uppermost layer of the earth's crust, which consists of friable soil, is changing chemically all over the world, and if continued for thousands of years this process must be of the greatest significance in connection with the adaptation of the species and the resultant further evolution of new species. This may explain why a virgin forest, when cleared by man, has been able to recover only with great difficulty, even though the soil remained untouched. The change in the vegetation, which in the course of time takes place on any soil, and which never really becomes stationary, is perhaps due principally to the above mentioned process.

Bare alpine soil is often covered by lichens in a definite succession ending in alpine *Alectoria, Cladonia,* or *Stereocaulon* carpets, which in their turn are building up peaty soil. This, in the course of thousands, or it may be millions of years, will form a substratum to which the old plants must either adapt themselves and give rise to new physiological species, or become extinct and thereby make room for quite other species.

Rocky substrata remain almost unchanged, provided the products of their decomposition are removed from their surface by rain etc. If this is not the case, however, the possibility of a changed vegetation or flora is always present, and I have pointed out before that a change is actually taking place. But it is not clear whether this will lead to the formation of new species. I have also pointed out before, that the bark of a tree, an important substratum for lichens, is changing in each individual case with the advancing age of the tree. This may perhaps not result in the evolution of new species, though the development of new species of trees and consequently of new substrata may influence the formation of new lichen-species, as the new substratum would compel the lichen to face new chemical problems. The resinous bark of conifers would harbour lichens different from those of trees bearing ordinary flat leaves.

The same can be said of the leaves of the trees themselves. On a perennial leaf lichens may occur, whereas on the short-lived deciduous leaf that will not be the case.

It is an open question, as already mentioned, whether hybridization occurs among lichens, and whether, if it does, it is of importance in regard to the formation of new species; I have reason to doubt it.

Some biologists maintain that the formation of new species may be due to still another cause; namely, that every species may have an inherent evolutionary tendency, an impulse to develop into something quite new. It cannot be denied that such an impulse may actually exist, although its nature would be difficult to understand.

In reality there is something quite mysterious in the fact that palæontology, in connection with investigations of recent species, teaches us that all the species on the earth have been, for thousands of years, in a condition of constant change, that species are constantly arising and constantly dying out, so that without doubt millions of species have existed during the geological epochs.

It is perhaps difficult to understand how these innumerable species can all be adaptations to external conditions, and that the type of external conditions, to which the plants on this earth are exposed, has not long since caused the formation of a certain number of species exceedingly well adapted to these conditions. Since, on the contrary, new species are being and have constantly been formed, is it not a sign that slow alterations and modifications take place in the cytoplasm, alterations that are not caused by external agents but which are able, by constantly entering into interrelationship with external agents, to give rise to new spiecies?

The idea cannot be rejected without further consideration, but I realise that it will be very difficult to prove experimentally. Moreover, it is difficult to imagine the actual nature of such a tendency.

(1) It has been thought that there may exist a kind of psychic condition which cooperates in the development of species. Practically all modern investigators have abandoned the theory, giving curiously short sighted reasons for doing so, whereas the real reason has been, as a rule, that such a theory is too difficult to utilise in scientific practice.

Leaving out of consideration the objections to this theory — they are mostly not worth considering — there still remains unsolved this question which may be formulated as follows: do psychic processes take place in all organisms simultaneously and in connection with the material metabolic processes? If so, does this psychic condition exert any influence on the course of the material processes and thereby also on the course of the development of species? Or are they merely secondary by-products of the material processes.

I personally have no doubt that psychic processes take place side by side with the material processes, even though there is no likelihood of this ever being proved.

I have also no doubt that material processes can be affected by material means. Numerous illustrations from human life witness to this fact.

On the other hand, however, I am convinced that psychic conditions can affect the course of material processes, even though here again there is no likelihood of irrefutable proof ever being forthcoming in support of such a view. But if Psychologists should ever succeed in furnishing proofs, a far-reaching perspective will be revealed into the »Terra Incognita« which is at present one of the darkest in the domains of Science, namely, the problem of the action and reaction between material and immaterial processes — the ancient and yet ever young problem —. I fear that in this problem we meet one of the most formidable obstacles which prevent us from penetrating into the fundamental causes of evolution.

I personally, however, am most inclined to the view that the faculty present in the organism of choosing in many cases between several possibilities (of choosing or rejecting various kinds of nutrition, various degrees of light, various temperatures etc.) is of a psychic, immaterial nature which, however, at the same time produces in a high degree material consequences, which may be considered significant not only in respect to the individual concerned, but also to its offspring and accordingly to the phylogeny of the species.

(2) It might also be thought that the evolution which takes place in organisms is pure and simply part of the general, material, and cosmic evolution, through which all matter and all forces by action and reaction are constantly creating something new, new consteallations of stars, new celestial bodies, new geological phenomena, new organisms. But just as little as the science of physics can explain to us the reason why cosmic evolution takes place at all or why the whole world has not once for all come to rest, to a state of equilibrium, and to a complete standstill, just as little can we comprehend why the chemical structure of organisms has not once for all come to a state of equilibrium, which would exclude any formation of new species. It really seems as if organisms are in an unbalanced condition which brings about a constant although extremely slow change, such as is indicated by palæontological discoveries.

If such an evolution takes place, the extremely important question presents itself; whether, in the case of each separate species, it follows a definite course which it will traverse in the course of time, unaffected by the external conditions to which it is exposed. Or, on the other hand, is its course disturbed and also affected by its surroundings?

I myself have no doubt that each separate species both attempts to follow its own course and at the same time is influenced by its surroundings in the ways I have indicated.

In reality the theory of a slow change in the qualities of the species—as a link in the entire cosmic evolution—whether it may be thought due to psychic or material causes, or to both in conjunction, or whether it may be thought to be derived only from the qualities present in the species or also to be affected by external conditions, stands in opposition to one of the most generally accepted doctrines of the theory of heredity, concerning the independence of the genotype from external conditions. I shall later give my reasons why I consider this doctrine to be false, unproved, and based on observations of too short duration.

But, even if we accept the theory of an evolutionary tendency present in the species, we need not presuppose a constant tendency towards a »higher« development, which means, I suppose, a more highly differentiated structure and function. It is, indeed, very often the case that a retrograde evolution involving loss of organs and loss of function occurs not only during the ontogeny of the species, but also during the phylogeny; as for instance in the case of the structure of various parasitic fungi (and phanerogams), which indicate a retrogade evolution resulting in a simplification of structure and perhaps also of functions. A complete or even a predominating tendency in the direction of a »higher« evolution during the phylogeny of the species cannot be taken as the standard rule, and all postulates in this respect must be rejected as not generally valid and still less as representing any general biological law.

It might, however, very well be supposed that external conditions i. e. conditions new to the existing species, brought about new structural formations in it, of apparently quite unimportant qualities and peculiarities; in the same way as, for instance, various external conditions may cause the very same mineral to crystallize in a number of different ways, forming crystals of numerous shapes, as in the case of calcite, quartz, etc.

Such new structural features need not at all stand in any intelligible relation to the causes which have produced them, but may only appear as the resultant force in a parallelogram of forces, the sides of which represent external conditions on the one hand and the inherent qualities of the species on the other.

That, for instance, the Colorado beetle (Leptinotarsa) in Tower's famous experiments acquires certain new colour-designs does not stand in any intelligible relation whatever to the altered conditions, but seems to be quite accidental and of no consequence. They are probably correlative alterations in connection with inner, unknown, real (physiological), adaptations to the new conditions. Perhaps numerous structural peculiarities of the species are of such a category.

We have now to touch upon the question of the importance of correlation. It is most probable that one single modification or adaptation during the evolution of the species cannot occur as an isolated phenomenon, but that it will frequently involve or necessitate other greater or lesser modifications which may seem quite incomprehensible to us—like the above mentioned colour-designs. — These may be as inevitable as in the case of the double decomposition of two salts which results not only in the formation of the salt to obtain which we have made the decomposition, but also of one more, which will, as a by-product accompany the former as a natural consequence of the process. How great the importance of such correlative modifications is, cannot be seen at a glance but most probably it is very far reaching and warns us to be cautious and not to see in every phenomenon an adaptation to external conditions, since some phenomena may perhaps be correlative and secondary products.

In order that an alteration occurring in a species, whether induced by external conditions or internal evolutionary tendencies, may become of importance to the formation of a new species, it must, of course, be really inherited by the offspring. The theorists of earlier times were not always very careful in this respect, but often took it for granted that a quality once acquired would be transmitted to the offspring. We now know that this is not the case. On the contrary, in most individuals, striking new features are not inherited. A certain, often extreme conservatism prevails, as it seems.

These reflections on the causes of the evolution of species are, in the main, closely related to the Lamarckian theories.

DARWIN's special reflections on the importance of selection in regard to the development of species are, it is true, a necessary supplement to the causes mentioned here of the formation of new species. It is of course clear that only such new formations — whether resulting from a direct adaptation to, or directly caused by the influence which the life conditions exercise on the species—which are adapted to the external conditions will be preserved by selection, whereas all other formations must disappear.

But even though it is now generally admitted that the above conditions (climate, edaphic influences, competition, correlation, hybridization, internal evolutionary tendencies,) have separately and collectively a predominating influence on the formation of new species, we unfortunately lack completely — and shall never have the opportunity of obtaining—any information as to how the phylogeny of the individual species has developed in the course of time. We also lack information as to what agents have cooperated in the formation of new species, and in what order these agents have been at work.

This is a great calamity for taxonomy. For it is the final object of taxonomy to place all the species on the earth in the order in which they have developed from each other (which can only be done very inadequately in the way usually adopted by writers of handbooks on taxonomy) and where possible also to discover the agents which have been at work during their development. We shall never reach this goal. Our ideas will always remain imperfect in this respect since it is quite certain that no man has ever witnessed the creation of any new species of lichens, nor, even if he had done so, would he have been able in any one particular case to point out or ascertain the cause of its creation.

Our ideas about the origin of species must therefore as a natural consequence always be limited to suppositions of a quite general form.

The theory of evolution was put forward by taxonomists and morphologists who sought in this theroy an explanation of the large number of different species that inhabit and have inhabited the globe.

Today we who are working to solve the problem of the classification of species must acknowledge the force and ingenuity of the two principal ideas of the evolution doctrine, Lamarckism and Darwinism, and we cannot by any means accept the objections recently made in regard to both of them, objections which I shall very briefly touch on.

It has been argued against Lamarckism that personal qualities acquired by a single individual under the direct influence of external conditions (e. g. nanismus or the contrary, abnormally large leaves or the contrary, etc.) cannot be transmitted to the offspring since the alterations of any one species is in all respects kept within a certain limit of an average standard from which no permanent deviation occurs.

If this idea were right and this rule were universally valid with no exceptions it would mean a total bankruptcy of the whole evolution idea and consequently of Lamarckism. It would be neither more nor less than a proclamation of the immutability of species.

But all palæontological, ontological, comparative-morphological, teratological, and bio-geographical facts speak so plainly for continuous evolution and against such immutability of the species that no true naturalist, with the least knowledge of these facts, can find any other reasonable explanation.

Against the belief now almost universally accepted that the species are keeping within certain limits of an average standard which cannot be altered, very strong and weighty objections may be made.:

1) The mutations occurring spontaneously and during experiments show that deviations from the probably very usual inertia, which is causing many species to keep within a certain limit of an average standard, may take place. There is nothing to prevent the assumption that the creation of numerous species is caused by a gradual accumulation of imperceptibly small mutations. And if this is the case: Where is the limit between an alteration of the type and the accumulation of infinitely small mutations? This is an argument based upon assumption. It is not a phenomenon which can be observed in nature.

2) The experiments carried out in order to prove that a deviation from the type is impossible have been too few in number and kept under observation for too short a period to be looked upon as decisive evidence. What significance can after all be attached to the observation of a very small number of species, chosen at random from among about half a million species known on this earth, during a period of 20 to 30 years? It is impossible to believe that just these species should be typical of the ability or lack of ability of all existing species to modify their type. The sceptic must demand far more numerous observations to feel sure of his ground.

3) The experiments carried out hitherto in order to prove the immutability of a type have, apart from the faults already stated, another and much more serious

fault, viz. that the conditions under which the cultures of species are carried out do not resemble those existing in nature. How could it be possible for us to imitate for instance the conditions arising as a consequence of a slow chemical change in the substratum, which has been in progress for millions of years and by which the species are probably being slowly forced to change; first in physiological respects, which are difficult to observe, and later (in correlation therewith) in anatomical and morphological respects, which are clearer. In our experiments we move a plant from one substratum to another and thus shorten the natural process by perhaps some millions of years! And yet we imagine that the experiments can give us a decisive answer to the question; whether the characters acquired in the course of the experiments can be transmitted or not. They cannot be, of course, and it would be absurd to expect it. Let the experiment be continued for a term of years equal to that of the process going on in nature and the result will probably be different! Physiologists have not however the time to make experiments extending over so long a period. It is absurd to expect the sceptic to attach any importance to evidence produced by experiments carried out over so short a period.

Scarcely one experiment on the effect of external conditions and the transmission of acquired qualities can stand a critical test, when we compare the conditions under which the species may be supposed to have developed in nature with the conditions they are offered during the experiments.

In the present age many objections are raised against Darwinism among which the most important are these; that personally acquired qualities are not transmitted, which objection has been mentioned and pointed out as untenable in the above, and that selection, the principal point in Darwin's theory, cannot create anything new but at most cuts away evolution's wild shoots i. e. qualities which would make the individual less fit to exist.

That selection is of great importance on account of its pitiless elimination of all useless new qualities is quite evident, and natural science owes a great deal to Darwin for having pointed this out.

On the other hand most naturalists strangely and quite illogically dispute the importance of the fact that selection is itself creating something new. To them I would say:

1) We must remember that the qualities of all existing beings were gradually acquired in the course of time, and that they have been exposed to the test of selection.

2) The ability of any one species to develop into a new species is not only dependent on the external conditions under which it is living but also to a great extent on its own qualities, all of which were acquired and subjected to the test of selection.

3) The very possibility of a further development of the species will therefore be dependent in an overwhelming degree on the selection made during earlier periods.

It is difficult to understand how so many adaptations have become a permanent heritage, but it must be left to the investigators of the problem of heredity to solve this question; they must however make it a point never to deny the fact of adaptation even though no explanation of its origin can at present be given. If the investigators take up the position that all adaptation is only a result of selection, they will undoubtedly get into a blind alley where the empiricists cannot follow them.

In order to understand completely the nature of the individual or the phenotype, it is necessary to examine 1) which of its qualities are the results of permanent inheritance, 2) which are due to an inheritance which for its realization continually requires the influence of external conditions, 3) which are the results of ontogenetic adaptation (which may therefore possibly disappear completely on the death of the individual), 4) which are the results of hybridization or even the results of yet unsuspected causes. It is evident that the analysis of these questions is still very incomplete.

NATURAL HISTORY
OF THE DANISH LECIDEA SPECIES

The spore. In all Danish species the spore is unicellular and provided with a wall varying very much in thickness. Common to all species is a shape approximating to that of an ellipse, sometimes, however, more oval and sometimes more spherical, like a ball. The size varies considerably in the different species. The size of the spores in the individual specimen may also vary to some degree.

The structure of the wall is not known in all its details; thus nothing is known as to whether the wall is viscid or dry when ripe, a question of some importance for the understanding of its mode of dispersion and its attachment to the substratum when it is on the point of germinating.

Nothing is known about the germination since it would only be possible to examine this process by special culture experiments which would decide the direction of early growth, polarity, the mode of branching, etc. of the first hypha or hyphæ.

Morphology. The thallus developed by the germination of the spore (conidium, soredium) is perhaps always orbicular when quite young, if no external agents influence its growth and thus alter its shape. This is, however, only a supposition which can not be easily proved in the case of each individual species, since it would require a lucky discovery of young specimens with apothecia in identifiable stages of development; and of these I have only seen very few. No doubt external agents will to some extent have a disturbing influence on the shape; seeing that each individual specimen will generally have to struggle with other individuals to find room on the substratum; and this will have the effect of making the plant very irregular in outline, or the nature of the substratum may cause it to develop another shape than the orbicular. Thus individuals on bare dead wood will always have an oblong elliptic outline, the longest diameter being parallel to the fibres of the wood, and on smooth bark they will have the same outline but with the longest diameter at right angles to the longitudinal axis of the tree, as will be shown more in detail later on. But if we look at the »geometrical shape« of the crustaceous thallus, as BIORET expresses it, I think it is most often orbicular.

It is impossible to observe the meeting of the youngest mycelial hyphæ and the gonidia in the case of naturally developed specimens; since they cannot be identified as germs of *Lecidea* in that young stage. So we must look to future culture experiments for an answer to this question.

Later on, when the specimen is fully developed and possesses apothecia in a determinable stage, it is possible to distinguish between various types: the granulate and the crustaceous thallus (hypophloeodic or epiphloeodic and intermediate shapes, the epixyline and endoxyline, the epilithic and endolithic and the epigeic).

The granulate thallus is composed of a more or less distinct, mycelial margin of hyphæ which grows in a radial direction from the centre of germination of the lichen, and is devoid of gonidia. At some distance from the margin a few isolated roundish thalline granules provided with gonidia occur, probably formed on the very spot where the mycelium met with the proper gonidia under free conditions; whether these came to be on the surface of the thallus, or were lying on the substratum when they were reached by the growing mycelium of the lichen. Both cases are likely to occur in nature. The older parts of the thallus round the centre of germination are composed of more densely crowded granules which are pressing against each other, and are to some extent forcing each other to choose a direction of growth vertical to the substratum; and this has the effect of gradually forming a thicker thallus composed of partly confluent granules. This type which is probably the most primitive among the lichens, occurs for instance in the *Lecidea lucida* (see below under this species).

The continuous crustaceous thallus is in its fully developed state of a rather varying aspect: hypophloeodic or epiphloeodic, epigeic, epilithic, indistinctly endolithic, endoxyline, or epixyline.

The hypophloeodic thallus occurs among specimens of *Lecidea elæochroma* where the thallus is completely covered by the periderm of the plant which is supplying the substratum. It is probably so only in young stages of the individual and it will later on become more or less distinctly epiphloeodic. In any case it is a fact that I have met with some specimens which were partly hypophloeodic and partly epiphloeodic, and again others which were completely epiphloeodic. That they really represented various stages in the development of the same species is evident from the fact that they are in all other respects alike as regards the structure of their apothecia etc.

Also among these hypophloeodic or epiphloeodic specimens the thallus makes a distinct impression of having developed from a mycelium which formed small cushion-shaped gonidia-containing thalline granules at the point where the gonidia and the mycelium came together, and these granules by further growth will coalesce into a more continuous thallus which, like the granulate thallus, may grow in thickness (i. e. vertical to the substratum).

The epigeic crustaceous thallus resembles completely, as regards development and structure, the epiphloeodic, being provided with a mycelial margin devoid of gonidia. This in most cases may very well be supposed to have been formed by more or less confluent, originally isolated granules which may at last form a very even thallus, but it may also retain part of the original independence of the granules and form small cushion-shaped protuberances which are continuous only at their common basal layer.

The epilithic thallus is in several species a continuous thallus more or less finely granulated or uneven on the surface, whereas in other species it is distinctly split up into areoles, which are as a rule confluent. The areoles may have been formed by the partition of greater areoles or independently near the mycelial margin of the thallus.

Here and there it may be very slightly developed and consist only of very small granules which spread in narrow strips among the mineral grains of the substratum; so that the thallus with a slight magnification (up to 20 times diameter) seems to be entirely absent. On separating the mineral grains from one another a thallus devoid of gonidia will however be discovered; it penetrates into the stone between the mineral grains and is continued over the surface of the stone in the form of a very slightly developed epilithic thallus provided with gonidia (e. g. *Lecidea auriculata* and *Lecidea elæochroma*).

The endolithic and endoxyline thallus is described more in detail under the individual species (e. g. *Lecidea rupestris* and *Lecidea turgidula*).

Anatomy of the thallus. The first mycelium formed by the germination of the spore (conidium, soredium, thallus fragment) has not been observed in any Danish *Lecidea*. In the fully developed thallus one may distinguish a rhizoidal zone, a medullary layer, a gonidial layer, and a cortical layer. These may be more or less distinctly separated from one another or be so confluent in primitive species as to make it practically impossible to separate one from the other. This is more distinctly seen in the more detailed description of the separate species.

The rhizoidal zone partly grows downwards into the substratum and partly centrifugally outwards from the centre of germination, and in several species it forms the pure mycelial gonidia-less margin growing all over the substratum, partly on the surface of it and partly down into it. I have found this to be very distinctly the case in several species, especially in bark-lichens (*L. elæochroma*), but also in several stone lichens (*L. pantherina*) where it forms a tissue, sometimes dark, almost black, radiating in all directions.

The medullary layer in the case of most species consists of densely interwoven hyphæ frequently running in an inextricable confusion without any distinct direction of growth and with very small intercellular spaces, often so narrow as to be almost invisible. In other species the hyphæ run distinctly vertical to the substratum.

The hyphæ of the rhizoidal zone are most often long-celled; in the medullary layer they are often short-celled. Their walls are as a rule relatively very thick. It is for instance frequently observed that the wall (especially in the medullary layer) is of the same thickness as the lumen of the cell.

The gonidial layer is made up of gonidia and hyphæ. The gonidia vary much in size in the same specimen, and are arranged in distinct groups. Their outline is sometimes almost orbicular, sometimes distinctly oblong, which is evidently the result of pressure on the part of the hyphæ. They are of a *Pleurococcus*-like structure. The hyphæ are, probably in all species, very closely applied to the gonidia, and their walls are somewhat thinner than those of the hyphæ of the medullary layer. The individual cells of the hyphæ are frequently almost iso-diametrical or slightly oblong. In Danish species they do not from haustoria into the gonidia.

The type of the cortex varies very much: in primitive hypophloeodic species there is no distinct cortical layer, the hyphæ forming but a thin layer outside the outer gonidia, and being composed of living cells provided with cytoplasma. Among epiphloeodic species the layer of cortical hyphæ is frequently thicker but it is likewise composed of living cells. Finally there are also species whose outer cortical layer is formed by thick mass of dead compressed hyphæ, a sort of cuticle.

The apothecia develop apparently without any order on the thallus, in such a way however that young apothecia constantly arise near the margin of the thallus, as the thallus gradually spreads over the substratum. At the same time new apothecia are constantly being formed on the old parts of the thallus among the old apothecia, so that old and young are mixed up in an irregular way. They always seem to be formed in gonidia-provided parts of the thallus, never at a purely fungal margin nor on purely fungal tissues where these occur in old parts of the thallus.

The principal features of their mode of development are as follows: in the deeper parts of the thallus a roundish mass of rather large-celled hyphæ is at first formed, and from this hyphæ composed of long cells extend upwards. An adherent of the view that lichens originated from florideæ might be tempted to use the expressions »carpogonium« and »trichogyne« about these formations, and would then have to maintain that each apothecium is developed from several carpogonia with their trichogynes.

I have found in *L. elæochroma* (see below) the depth at which the carpogonia are situated to be somewhat above the gonidial layer, but the gonidial and medullary layers pass into one another so gradually, and are so difficult to distinguish from each other, especially in the particular species investigated, as to make a separation of a gonidial layer and a medullary layer quite artifical.

In the species investigated the »trichogynes« did not reach up to the surface of the cortex, but whether this means that they were not yet fully developed or whether the fact justifies the conclusion that they do not serve the purpose of fertilization at all is a question which must be left open for the present.

The more elaborate structure of the cells of the »carpogonium« and especially the behaviour of the nuclei I was unfortunately unable to examine in the present specimen, much as I should have liked to acquire some insight into this particular question.

The specimen investigated offered no solution of the question as to whether fertilization takes place, and, if so, in what manner.

The sections showed on the other hand quite clearly the further development: under the primordial apothecium a funnel-shaped mass of hyphæ is formed, the calyx, which is continued down into the medullary layer by parallel hyphæ, the future base of the apothecium, stipes (see *Lecidea elœochroma*, specimen 10). In the cavity of the funnel (calyx) lies the remaining portion of the primordial apothecium. It is composed partly of carpogonial hyphæ and partly of vegetative hyphæ which together form the future hypothecium. Now comes the final process, the formation of the paraphyses and the asci which do not develop until the whole apothecium is raised almost to the level of the cortex. The process itself, during which the apothecium is growing and breaking the cortex, takes place in the following manner: the hyphæ of the stipes are stretching through intercalary growth so far as to be able to lift the whole calyx upwards together with the hypothecium contained in it. When this is done the layer of paraphyses is formed by vertical threads from the vegetative hyphæ of the hypothecium, whereas the asci are not forced up till later on between the paraphyses. The asci arise from the ascogenous hyphæ, the former carpogonial hyphæ, which have lost their »trichogynes« during the development of the hypothecium, and have moreover been separated from one another by the paraphysogenous hyphæ of the hypothecium as these latter were forcing their way in between them, the hyphæ being far more numerous and far more bulky than the ascogenous hyphæ.

The young apothecia of the species investigated had as yet no asci in the hymenium, the surface of the latter being on a level with the cortex.

The apothecium now breaks through the cortex of which numerous remnants are to be seen on its surface, and then it is fully developed.

The structure of the fully developed apothecium and its further growth must now be more closely described.

The very young apothecia, just visible with the aid of a pocket-lens, are in most species deeply cup-shaped and provided with a thick proper margin, i. e. the margin of the above mentioned calyx which serves to raise the primordial portion of the apothecium, viz. the hymenium, and the hypothecium up through the cortex. The hypothecium includes the ascogenous and paraphysogenous hyphæ, and above is the fully developed hymenium with the asci and the paraphyses.

Later on the apothecium becomes more plane or even convex, and the proper margin may thus gradually seem to disappear completely.

This is taking place in such a way that 1) the calyx is growing in a vertical direction, and its surface being first concave may gradually grow convex 2) the hypothecium is growing in a radial and a vertical direction, and 3) the hymenium is growing in a radial but not in a vertical direction, so that its surface »discus« becomes larger and larger and gradually forces the proper margin towards the surface of the cortex in such a way as to make the margin invisible when the apothecium is seen from above.

The growth of the hypothecium seems to continue as long as the apothecium exists. The ascogenous hyphæ are continually dividing and forming new asci, and are distributed over the whole hymenium in such a manner that they are separated from one another in a centrifugal direction by the continous growth of the intervening paraphysogenous hyphæ. It consequently seems as if this is taking place in the case of ascogenous as well as of paraphysogenous hyphæ.

The hymenium is also growing in a centrifugal direction (away from the centre of the circular disk) in such a way that new asci and paraphyses are constantly growing up among the older ones. This is not taking place in any definite order; it is therefore possible as shown on several of my tables to find quite young asci scattered among old and ripe ones over the entire hymenium, and perfectly ripe asci may vice versa be found close to the proper margin, which shows that there can be no doubt that the growth is taking place in a centrifugal direction since the disk is constantly getting larger, but the growth is nevertheless intercalary.

The ascus when fully developed is a club-shaped cell varying in length and provided with from eight up to sixteen spores, the former number being by far the more frequent. The wall is very often much thickened towards the apex of the ascus, a feature which may perhaps play an important part in the shedding of the spores—a process the details of which are not yet known.

The paraphyses are vertically placed and many-celled hyphæ. They are usually slightly branched at the top. The outer limit of the wall separating them from the neighbouring paraphyses is generally invisible or very indistinct, the paraphyses being conglutinated into a very tough and elastic mass, — a feature which may perhaps also be of some importance in regard to the obtaining of the requisite tension of the tissue for the evacuation of the spores. The apex is in some species slightly clavate and some kind of pigment will also as a rule occur here giving the disk of the apothecium its characteristic colour. As regards the basal part of the paraphyses it most frequently is only slightly coloured or at least of a fainter hue than the tips; the paraphyses are often almost colourless at the base. The apices of the paraphyses rise above the asci closing round the latter so as to form a thin layer which has been called the epithecium. Not until the ascus is ripe does it seem to become elongated so as to be almost on a level with the paraphyses, but it will hardly ever reach up to, much less above, this level. The spores must therefore be supposed to be simply forced through the epithecium.

Types of apothecia. When the genus *Lecidea* is subdivided it is not the rule to follow any particular principle in the classification, some of the groups being characterized by the structure of the spore, others by the form of the thallus, or by the colour of the apothecium (*Biatora* with non-black apothecia: *Eu-Lecidea* with black apothecia). Whether such a classification of the groups actually signifies their true relationship, or whether it is only a mere practical, diagnostic classification is doubtful. If we are to form an opinion as to the mutual relationship of the species i. e. the phylogeny by which one species may be supposed to have developed from the other, it cannot be done by an arrangement in parallel groups but must be illustrated by their pedigree or a genealogical tree the branches of which show the place of each individual species, more correctly our hypothetical view as to their place. From a phylogenetic and taxonomic point of view it would be the ideal to know the details of such a pedigree, and to know the development which the species have gone through in the past. But we are far from knowing it, and as a natural consequence we shall never be able to do more than theorise on the matter. The individual species as we know them today are to us like blossoms gathered from the same tree: from the bunch we are no longer able to discern where each individual blossom was situated on the tree.

We may however have some ground for our phylogenetic conjectures, especially in the structure and ontogeny of the apothecium. There is some chance here, as in the case of higher plants, that the apothecium as well as the flowers may give a more reliable idea of the relationship than the vegetative organs alone, but we must not leave the possibility out of consideration that the apothecium may also in course of time have undergone alterations in relation to the vegetative parts. If we had exactly the same structure of the apothecium in two or more species differing in vegetative respects, it would be easy to conclude their phylogenetic relationship. But on the contrary it is perhaps often more likely, even if two sister-individuals (by mutation or otherwise) once have become the ancestors of two species differing in their vegetative structure (e. g. with crustaceous or with squamose thallus) that the differentiation in these two different species will not have failed to affect the structure of the apothecium but will show its influence here, so that the two new species will also in this respect be more or less different.

This is however interfering with the classification to an incredible extent, especially considering the slight differences we have to work with in the case of the species of *Lecidea*.

As mentioned before however there is some probability that the apothecia show a truer picture of the mutual relationship of the species than the vegetative organs taken by themselves, and we will therefore look a little more at the principal types of apothecia, but we must at the same time bear in mind that the small number of species at hand in Denmark can not give a comprehensive idea of the taxonomy of the whole genus *Lecidea*. That would require a far more thorough knowledge of the species occurring in foreign countries than it is possible to get until all species have been investigated at least in as detailed a manner as the Danish species described here.

The most marked types of apothecia which occur among our species are the following:

1) the apothecium is from the very beginning convex with no visible macro-

scopic proper margin. All its inner parts, the stipes, the hypothecium, the hymenium, the calyx, are slightly coloured.

2) the apothecium is from the very beginning cup-like, concave, and only gradually becomes plane or convex, the margin being in some species persistent but in others becoming fradually smaller through the growth in area of the hymenium which forces the margin back.

The latter type comprises many variations, the single species having either dark coloured, (as a rule brown) or almost colourless stipes; or it has either a dark or a colourless calyx, and colourless or again bluish, greenish, or olive brown paraphyses.

In fact the structure of the apothecium with its fairly constant appearance is the only good taxonomic diagnostic in the genus. No determination of a *Lecidea* can be made with certainty except by a microscopic examination, — a fact to which even very practised lichenologists have not always paid due attention.

The **pycnidia** apparently occur spread irregularly over the thallus just as is the case with the apothecia. They seem to be rare in most of our species and have been so far observed only in *L. elæochroma, L. auriculata, fuscoatra,* and a few other species.

If one inspects the surface of the thallus under a low power of about 60—70, small dark ostioles of them may be found in these species. It is of course very difficult to isolate such very tiny organs as these and to cut sections of them; preparation must take place under the microscope, and even the cutting of a section must be controlled under the lens, section after section, with the frequent result that the whole attempt is in vain, especially in the case of the stone lichens; since small grains of minerals present close to the pycnidium may cause the sections to tear and then all the work will have been wasted. It requires much patience and is constantly presenting new problems in microtome technique. To this must be added the fact that we have no guarantee that all the ostioles of the pycnidia are dark and thus visible on the usually lighter background of the thallus. If the ostiole is light it cannot be seen, so there will be a possibility of the pycnidia occurring without being observed.

It must however be borne in mind that in such a case it would probably be possible to find them if many sections of the thallus were cut. This is a proceeding which I have used very extensively in all our species; I may therefore safely assume that as I have only seen them in a few species in spite of all my precautionary measures, it means in all probability that they are actually rare.

In the investigated species the wall of the pycnidia consists of dark hyphæ which form a flask shaped perithecium, with the narrow end upwards, formed by small-celled densely interwoven hyphæ. On the internal side of the wall of the perithecium a hymenium — formed of hyphæ — is developed, with the hyphæ radiating inwards to the cavity of the pycnidium, and each cutting off a straight or curved conidium at the tip.

Soredia occur in several species. In some such species the thallus is of a very loose structure with no distinct cortical layer (*L. lucida*) whereas in others the soredia are confined to certain places or soralia of varying size, where they break through, while the surrounding thallus is corticated (*L. elæochroma* etc.). The individual soredium consists of a small group of gonidia enveloped in a tissue of hyphæ. As a rule it is not sharply limited but merges with several others into a dust-like mass.

Biology. As regards the biological importance of each individual organ in general there is not much to say as far as the species of *Lecidea* are concerned; further references will be found under the individual species.

The hypothallus consists in several species of a mycelial tissue of dark hyphæ radiating outwards at the margin of the thallus as has been previously mentioned. It spreads all over — or in the case of the hypophloeodal bark-lichens inside — the substratum and probably captures free gonidia in the substratum. In this connection it must however be emphasized that it is necessary to be very cautious before drawing this general conclusion as to its function. In several cases it seems very probable to me that each lichen individual has only to capture one single gonidium during the first stages of germination of the spore (or pycnoconidium); so that all later gonidia are the offspring of this first one. But it must further be mentioned that both means for obtaining gonidia are likely to occur, and that it is in most cases impossible to settle by an examination of the structure in what way any particular lichen increases the number of gonidia in its thallus.

In some few cases however it seems almost certain that the hypothallus does constantly capture fresh gonidia from without. Thus small isolated cushion-shaped areoles containing gonidia are found at a considerable distance from their fellow-areoles and surrounded by a hypothallus devoid of gonidia, in *L. pantherina*, or *L. elæochroma*, or *L. auriculata*, etc. This seems to suggest that each areole has arisen at a spot where the hypothallus during its growth has met with an algal gonidium on the substratum, or where an alga has been blown on to the hypothallus by the air.

In *L. elæochroma* I observed the peculiar phenomenon that such newly formed small gonidia containing areoles, grey in colour, were in places lifting the dark hyphæ of the hypothallus from the substratum, and at first were covered by these as by a fine net-work, but subsequently broke through the former by their continued growth and seemed ultimately to destroy them, the grey areoles carrying up the remnants of the dark thallus on the surface of their cortex.

This suggests that the gonidia have originally in this case come to lie on or in the periderm of the host plant, and that the hyphæ of the hypothallus have grown over them, and that the colourless hyphæ required for the formation of a grey areole have then later on developed from the dark hyphæ.

Occasionally the hypothallus, as in *L. pantherina*, and possibly in many other stone-lichens, may form small thalli devoid of gonidia and scattered about on a thallus which is otherwise provided with gonidia. One may even meet with the phenomenon — very clearly seen in *L. auriculata* and many other species — that a netshaped thallus is spread over the substratum (in the species concerned a rocky substratum) the network being represented by a grey thallus whilst the »meshes« are either bare of any lichen and show the grains of the substratum or they are partly occupied by a hypothallus which contains no gonidia. In such places there is often a good opportunity for seeing the first formation of the areoles. In the cases where the thallus is reticulate it probably means that it has in the course of its growth attacked the most valuable mineral grains first. It is quite clear that the empty meshes in the reticulate thallus are occupied by insoluble grains of quartz, which the lichens seemingly reluctantly begin to spread over when other possibilities have been exhausted. There is no question of a hereditary tendency to a »netformation«. On substrata poor in quartz the same species may be almost continuous and show no empty meshes.

When the hypothallus in the course of its growth meets the hypothallus from another lichen-species growing in the opposite direction, or another individual of the same species, they will begin to compete for space, but the course of such competition is in most cases unknown. This does not preclude the possibility that one individual will gradually conquer the other so as to continue its own growth at the expense of the other individual. In nature one individual is often seen growing close up to another individual without any distinct mycelial margin separating the two. It may even happen that no distinct limit is to be found between individuals provided with thalli that are alike in habit. It is just possible that growth may be taking place in one individual whereas the other is gradually dying. It is also possible however that both individuals may stop growing and keep each other in check. It is further possible that the two individuals may merge and fuse, thus forming one entity. In Lecidea tenebrosa I have observed a case of competition for space where the attacked individual was clearly being forced back.

On tree bark, cases are known of individuals having formed a mutual boundary by means of a black mycelial margin as for instance in the case of *L. elæochroma* (see below). This has usually been considered a proof that marginal growth of the individual has ceased, but this cannot be considered a proof.

The meaning of the term »hypothallus« is not quite clearly understood by lichenologists. Thus one often meets with the following phrase: »Thallus greyish——— rests on a black hypothallus«, or a similar expression which seems to suggest that the author considers the hypothallus to be the deepest lying part of the thallus, under the medullary layer — which the name itself also indicates. If the word is to be used in this meaning it will be synonymous with the »rhizoidal zone«, but it must then be mentioned that the latter is hardly ever, or at any rate very seldom, black but is formed of colourless hyphæ; whereas only the mycelial hyphæ radiating at the margin of the thallus, and the hyphæ in the form of net-shaped thalli extending into the otherwise empty meshes, may be black.

The crustaceous thallus is the only form of thallus met with in Lecidea. It spreads over the substratum at a rate of growth which is not known exactly in the case of any Danish species. The squamose thallus found in the sub-genus *Psora* is not dealt with here, *Psora* being treated as a separate genus. A foliose or fruticose thallus does not occur in any Lecidea. There are also no special organs of the thallus such as cilia, haptera, cyphellæ, isidia, or the like, known to occur in *Lecidea.*

I have found cephalodia in several species, e. g. in *L. uliginosa* and *L. flexuosa* which are found on soil, but I have not found any in lichens from other substrata. They are described in detail under the heading of the various species. I should only like to mention that in no case has it been possible to prove that an attack on the cephalodial-gonidia has been made by the hyphæ of the lichen. Whether the cephalodial-gonidia are of any importance whatever to the lichens, or whether they are mere accidental and indifferent guests cannot be settled by mere reference to the structure. It can be said that they do not appear to be necessary for the wellbeing of the lichen concerned.

The apothecia. Their growth has been mentioned above. In this country they probably shed spores at all seasons. But it is not known how these are dispersed. It is, however, most probable that they are dispersed partly by the wind and partly by the rainwater and partly by small insects that are always creeping about in great numbers on bark-substrata.

The fact that the spores are small and light, that the lichens on the whole often occur in great quantities fully exposed to wind and weather, tells in favour of the theory that the dispersion is in many cases due to the agency of the wind. The fact that specimens are often found on the bark of a tree in lines along which rain-water runs down the tree trunk, seems to suggest that dispersal in certain cases is due to rain-water. Dispersal by insects is likely, owing to the fact that many species of small insects can be observed on the bark of trees with soredia attached to their limbs and bodies, and they may be supposed to disperse the spores in a passive way.

The pycnidia which are rather rare in nature shed large numbers of conidia, perhaps at all times of the year — but this is not known for certain. The evacuation of the conidia has not been observed in the *Lecideas* (whereas it has been observed in *Xanthoria* for instance, where I have found them shed by thousands in a drop of mucilage formed in the pycnidium). It is very remarkable that nothing is known as to their functions. They may be spermatia, but whether they really are so is quite unknown. They may act as conidia, as is the case of some few lichens in which they have already been observed in culture to develop into lichens when grown with their respective algal gonidia. It would take too much time to go more closely into the question of their probable phylogenetic origin and significance, as has been done in part above.

The soredia are usually supposed to be organs of propagation, though their germination and further development into normal lichen-individuals has never been observed in any *Lecidea*. They are probably dispersed in the same manner as the spores.

As regards the biological and physiological functions of the cells and the tissues only the more important phenomena will be briefly mentioned here in reference to the natural history of the individual species. The rhizoidal zone spreads into the substratum and attacks it in widely different ways according to the nature of the substratum, bark, soil, stone, other plants (parasitic lichens), which will be described more in detail below.

The importance of the medullary layer or more correctly its proper functions in the life history of a lichen are not known in detail. One may perhaps venture to say that it is not adapted to any special function at all. In and from it all the other tissues such as the gonidial, cortical, apothecial, and pycnidia tissues are gradually being differentiated. Moreover it is the conducting tissue for an exchange of food material between the rhizoidal zone on the one hand and the gonidial and cortical layers on the other.

The hyphæ of the gonidial layer are often very shortcelled, almost isodiametrical, and they closely surround the gonidia. The gonidia themselves are pleurococcoid. I have investigated a very important question, namely, the relation between the gonidia and the hyphæ, more closely in anatomical respects in order to ascertain how far the gonidia are made use of by the hyphæ. I have in the case of each individual examined whether haustoria are found to penetrate into the gonidia or not. This problem cannot as a rule be solved by the observation of sections of the lichens but must be investigated by crushing them, in order to isolate the gonidia in large numbers when they can be investigated without any danger of an erroneous interpretation which thick sections may give rise to. In this way it has been proved that no haustoria are to be found in any of the Danish species.

The growth of the single groups of gonidia takes place in the manner that the single gonidia divide very frequently and are gradually separated from one another, the hyphæ making their way in between the gonidia thus forcing them apart. Single gonidia of all sizes and ages may therefore be found in all groups of gonidia.

If the gonidia are strongly overshadowed by the growth of the apothecia which cut off the light from the underlying gonidia, or by the overlapping growth of some parts of the thallus, or by the thallus being overgrown by neighbouring lichens, the gonidia will die and lose their contents; but it is always possible to demonstrate the presence of the old walls. It is quite plain that in such cases the contents of the gonidia are absorbed by the lichen although it is not possible to observe any haustoria. It is thus most likely that diffusion of material is taking place through the gonidial and the hyphal walls.

In all other cases the mere anatomical investigation of our Danish species of *Lecidea* has proved that the utilization of the gonidia does not consist in their gradually being killed and absorbed, but in an osmotic relationship to the hyphæ without the medium of haustoria, and apparently without suffering the least injury.

This must not however be taken to be a feature characterizing all lichens generally. I do not wish to express any definite opinion as regards this point, but I am no longer in doubt that it holds true in the cases of all the species investigated here.

The cortex of the lichens does not protect against complete desiccation of long duration but it may be able to retard it for a considerable time. Its development varies in different species, being to some extent in accordance with the ecological conditions, as I shall point out later.

As regards the seasonal biology of the lichens, i. e. their life story at different times of the year nothing at all is known. Whether they assimilate more vigorously at one time than at another, whether their fruiting is dependent on weather conditions and seasons is not known at all. Here there is a wide field for future investigation not only of *Lecidea* but of all our lichens generally. It is usually supposed that they assimilate equally at all seasons, and it can be observed that they have apothecia of all sizes at every season, but whether this means that they thrive equally well at every time of the year in our mild climate is not known, though it seems likely.

No definite observations have as yet been made as to the length of life of the individual species, interesting as it would be to get information on this point, in order to be able to decide its speed of growth. It is however a fact that all species are perennial and doubtless live many years.

It is often observed that the lichens die out in the centre of the thallus, whereas they are still growing like a fairy ring at the margin. It may be accident that this has not actually been observed in certain species of Lecidea, though it is likely to occur there too. It is not easy to settle at present whether the death of an individual is due to internal or external agencies. It cannot be settled whether an individual would be immortal if it lived under permanently favourable external conditions, but we shall refer to this puestion later when mentioning some of the more important ecological features.

Ecology. The Lecideas in Denmark have hitherto been found growing on the bark of trees, bare wood, soil, stone, and as parasites on other lichens or in a few cases on dead plant remains (mosses, liverworts, etc.). I have many years ago in my book on the Ecology of Danish Lichens related what is known about their occurrence in nature and their distribution in plant-societies. At that time only the general features of the ecological and sociological questions were discussed, and endless details in this respect are still left to be investigated in nature. My immediate object here is to relate what I have been able to conclude from investigations carried out in the laboratory. A full description of these details must be sought for under the heading of the separate species, whereas the main features are put forward here.

Lecideas on bark The rhizoidal zone of these species spreads into the bark of a tree and grows into its crevices and fissures. Other investigators, especially LINDAU and BIORET, have made investigations as to the way in which the hyphæ attack the periderm, and have arrived at the conclusion that the hyphæ are not able to attack or dissolve the cellulose. I venture, with more caution, to suggest that it has not been possible to prove whether they are able to dissolve the cellulose or not. It is almost impossible to determine by means of a microscope what the lichens are in search of, but it may well be suggested — if the cellulose is not actually dissolved — that there are two more possibilities: the lichens may absorb inorganic material with which the walls of the periderm-cells may be impregnated, or they may dissolve the dead cell-contents. It is not however clear whether they obtain organic matter in this way, thus acting as hemi-saprophytes, or whether they keep strictly to the inorganic matter: and even microchemical methods of investigation would not easily decide the question. The hyphæ clearly act chemically on the walls of the cells, at any rate in some cases, since I have found lumps of tissues for instance in L. elæochroma and L. quernea as well as isolated cells of the periderm, most often cork, with bleached and discoloured cell-walls. But no details are known as to how the bleaching takes place or what it means.

The quality of the bark, as a substratum, is of great importance for the well-being and development of the lichens, not only in chemical but also in physical respects, especially as regards its mode of growth. A detailed investigation of various Danish species of trees as substratum for epiphytes and parasites is in reality still wanting, although there is doubtless a close connection between the well-being of the lichens and the nature of the periderm. There is already in floristic respects a peculiar difference between *Quercus* and *Fagus*, *Fraxinus* and *Conifers*, etc. It is apparent that this must be a consequence of their chemical and physical nature, but many problems are here waiting to be investigated.

In physical respects there is a characteristic difference between smooth bark and scaly bark which in a peculiar manner affects the growth of the lichens on it.

In the secundary growth of trees with a smooth bark, especially *Fagus*, the periderm is constantly being stretched in a tangential direction. This has the effect of forming transverse markings, sometimes very distinct, in the periderm.

Anatomically the periderm is characterized by the cork separating in the form of minute scales, limited by cracks in the longitudinal direction of the stem, in such a way that new small spaces are constantly being formed, and into these the rhizoids of the lichens may penetrate. A radial section of the periderm will therefore show small lamellæ of the cork, placed more or less on edge, embedded in the lichens. It is not possible for any of these scales of cork to fall off the stem when the latter is covered with lichens.

Sometimes secundary growth may be very irregular, so that late in the summer the periderm may burst rather suddenly thereby cracking the crustaceous lichens which grow on it. These may then show numerous fissures which run in a longitudinal direction along the stem. The wounds thus produced are shown very distinctly in *L. elœochroma* (specimen 5). They may heal over by hyphæ growing down from the margin of the wound into the gap and covering it by a continuous tissue, thus regenerating the normal thallus of the lichen. Generally the bursting of the periderm will not take place so abruptly or suddenly as to cause such distinct fissures or wounds on the lichens. Frequently however indications of fissures are found, when the thallus of the lichens consists of alternating strips of quite young and a little older portions of thallus in the longitudinal direction of the stem of the tree.

It is really extraordinary that the bark lichen is attached to a substratum the surface of which is increasing in area and therefore stretching the lichen in one fixed direction. It has thus a chance of covering a large surface not only by continued growth at the margin but also intercalarily. There is no need for it to cease growing, not even when its margin meets other lichens growing on the bark, and it is probably due to this circumstance that crustaceous bark lichens with a decaying centre are hardly ever seen on smooth bark, for the lichen will be stretched as long as the periderm itself is being stretched by the secundary growth of the tree. When at length the growth of the tree ceases, the outer conditions will in several respects have altered so much that crustaceous lichens will no longer be able to thrive on it but will be succeeded and killed by other species, either by being overgrown or in other ways. It is very interesting to investigate closely all the minute details of the successive development of the lichen vegetation on each individual species of tree in a free condition or in forests. This I have done in my work on the Ecology of the Danish Lichens.

The outline of the crustaceous lichens on the smooth-barked stem is most frequently more or less oblong and elliptic with a longitudinal axis running transversely to the longitudinal axis of the stem of the tree. This has been seen and pointed out long ago, first by LINDAU and then by me. BIORET maintains that this feature is only »apparent«. It is however a fact which cannot be disputed, whereas the explanation of the cause of this phenomenon may be disputed. I have not myself ventured to explain it but have merely pointed out that it is so, whereas BIORET thinks that there is a very close connection between the structure of the periderm and the outline of the crustaceous lichens. He contends that the oblong and elliptical shape only occurs in the case of a periderm, the cells of which are stretched, thus favouring the penetration of the hyphæ in a certain direction, whereas a more circular outline will occur when the cells of the periderm are more isodiametrical in shape, thereby not favouring the penetration of the hyphæ in any particular direction.

This explanation in itself seems very plausible, but it should not be applied generally before being more thoroughly tested. The very circumstance that the cells of the periderm are often stretched transversely to the longitudinal axis of the stem of the tree may in the last instance be a result of the secundary growth of the stem so that the oblong shape of the lichens — in spite of the doubt expressed by BIORET — may nevertheless be an effect of the secundary growth of the tree.

On deeply cracked barks, as found in *Quercus, Alnus, Pinus,* and several other trees, the conditions of the crustaceous lichens differ in all essentials. A young lichen germinating on such a periderm will not be stretched superficially by the secundary growth of the tree and has no chance of intercalary growth, whereas it may continue its growth downwards into the furrows between the ridge-shaped scales of the periderm as a new substratum is constantly being formed by the secundary growth.

On such stems one seldom meets with such distinctly limited and regularly elliptical *Lecideas* as one finds on smooth-barked trees.

The corticolous *Lecideas* may have a distinct hypophloeodic thallus but they may also be completely epiphloeodic. It seems probable that in several cases the hypophloeodic thallus occurs at an early stage and later on by a continued growth breaks through and pushes the covering lamella of the periderm off and becomes epiphloeodic. Generally speaking there will scarcely ever be a really marked difference between the epiphloeodic and hypophloeodic thalli as was formerly thought. BIORET also emphasizes this fact and in my opinion he is perfectly right.

The duration of life of each single lichen individual depends on various circumstances. It seems able to live as long as the external conditions favouring its growth remain undisturbed. To put it more concisely: it is impossible to prove that the death of a lichen is due to internal causes as long as it can get the right amount of light etc. and as long as new substrata are available, as is the case on trees with a smooth bark. It is therefore on these trees that large and well formed individuals are most often met with. But it is impossible to say whether theoretically a lichen could live for ever provided only new substrata were available when required.

In practice however the substratum will gradually fail to meet the requirements: other lichens may stop the marginal growth of the individual in question. The tree will grow old and its secundary growth may even cease altogether. As a consequence of these occurrences the external conditions will alter. The tree will die out at its crown, or the trees next to it may fall, leaving it exposed to the light; quite new conditions of life will thus suddenly arise for the lichens, the way will immediately be open for other species better fit for the new conditions and they will take possession of the stem. Foliose or fructicose lichens often cover and thereby kill the crustaceous lichens.

As to the correlation between the structure of corticolous *Lecideas* and the external conditions other than those connected with the nature of the substratum, as light, moisture, etc. nothing is known. In these respects too, more comprehensive observations remain to be carried out as to the occurrence of the species in nature, in order to enable a judgement to be arrived at as to their probable adaptation to their surroundings.

Lecideas on bare wood. In general all *Lecideas* occurring on bare wood actually have or at any rate soon acquire an oblong and elliptical outline; the longest axis of the ellipse being parallel to the fibres of the wood. It is not difficult to see the cause of this phenomenon. The rhizoids grow with greater facility along than across the fibres, and one frequently sees the hyphæ running in long-stretched wood-cells along the fibres.

My sections of lignicolous *Lecideas* show that the attack by the hyphæ on the wood is not clearly seen, but they spread in such wood-cells as have been opened to the hyphæ from external causes, which are not owing to the lichen; when for instance the surface of the wood cracks both along and across the fibres owing to the effect of the incessant change from a moist to a dry state and vice versa, or of other causes.

The cortical, gonidial, and medullary layers which are closely applied to the surface of the wood exhibit no other structural features than those mentioned above, which may be said to represent special adaptations to the life on dead wood, either morphologically or anatomically. No Danish *Lecidea* is known to possess a thallus totally hidden in a wooden substratum, that is analogous to the hypophloeodic thallus in the corticolous lichens, but in *Lecidea turgidula* the greater part at any rate of the thallus is hidden in the wood. This species is therefore endoxyline.

The wooden substratum does not increase in area, being dead. From the day on which it is laid bare and becomes accessible to the lichens it neither grows nor regenerates. The individual lichen will therefore never be stretched by the substratum as is the case on smooth barked trees, so we get here only marginal but no intercalary growth. The oldest parts of the thallus near the centre of germination must therefore gradually become senile and may even run the risk of dying out; I have however not had the material under observation which would show such to be the case. In our climate dead wood will only be able to exist a few years; it will decay and the lichens growing on it will be replaced by other plants, and this circumstance renders it difficult to study what is happening to the lichen during the period in which it would be natural for it to grow senile.

The nature of the wooden substratum is constantly changing chemically by oxydation or decay in various ways. It need not take place equally rapidly in the various kinds of wood, as *Quercus, Pinus,* etc. A special ecological and sociological problem arises which calls for solution in connection with the study of the structure of the different woody substrata and the natural history of the lichen vegetation on such substrata.

Lecideas on soil. There are not many species of *Lecideas* on soil in Denmark, because they require uncultivated soil which is rarely disturbed by ploughing or other operations injurious to the lichens. The localities in which crustaceous lichens most frequently occur are: the heath, the dunes, and in some places in the glades of the forests. Earlier, in my work on the Ecology of Danish Lichens, and the Lichens of Iceland, I have already described the conditions required for the well-being of crustaceous lichens, which briefly stated are the following: a soil which is not disturbed by digging or ploughing nor by animals such as worms nor exposed to violent winds; a habitat as open and free as possible from overshadowing or other disturbing competitors. Such are the very conditions realized more or less successfully on the heaths, and partly in the dunes, where the soil however in most places is a little too mobile for crustaceous lichens, and in the forests, where as a rule they will sooner or later succumb to other plants and therefore occur only in a few places open to the light.

The rhizoidal zone of the humicolous *Lecideas* penetrates the upper layers of the soil to the depth of a few millimetres, and makes its way between the grains of minerals, dead plant remains, etc., frequently forming regularly limited circular spots on the soil. I have observed species chiefly on the raw-humus under heather (*Calluna*), *Picea, excelsa,* and beech (*Fagus*). On acid soil the rhizoids will penetrate the substratum in all directions, but it is impossible to ascertain by the microscope whether they dissolve or attack the particles of soil. It would therefore seem most probable that they live on the products of decomposition which are constantly formed in the substratum, and it would likewise seem most probable — but it has not yet been proved — that they themselves secrete dissolving acids which serve to further such a process of decomposition.

The medullary and gonidial layers which are above the level of the surface of the earth do not present any structural features which may be regarded as specific adaptations to the nature of the substratum. Purely crustaceous species with a continuous thallus and such as have a scaly thallus are known here; as well as species devoid of any cortex, or thickly corticated, etc.

A peculiar feature in the humicolous *Lecideas* is the occurrence of cyano-gonidia which I have observed in *L. uliginosa. L. granulosa,* and several others.

The gonidia found seem to be chance guests met with by the lichen during its growth over the substratum. I have seen both *Gloeocapsa* and palmelloid *Chlorophyceæ* represented, and have observed that the hyphæ of the lichens grow in between the single cells of the algal groups and even, though rarely, into their gelatinous walls. It would therefore seem possible that the gonidia are utilized in the same manner as are the normal gonidia; I have not found haustoria anywhere, nor have I observed any signs of gonidia being killed by the hyphæ. For further information I must refer to the figures of each individual species.

Little is known of the length of life and cause of death of the terricolous *Lecideas.* In a few localities I have observed an immense vegetation of densely crowded individuals e. g. of Lecidea granulosa (as on BORRIS HEAT in Jutland) and *L. uliginosa* (in numerous places in beech and *Picea excelsa* forests). But in all these cases it seems as if the habitat has only for a short term of years been accessible to the lichen in question, since other vegetation was seen threatening to overrun and eradicate the lichens. External conditions will thus be apt to limit the length of life of the individuals, when the margins of the individual lichens touch one another so that the whole space is occupied, or when other plants (*Calluna, Picea, excelsa, Fagus*) are invading the habitat.

It is a different matter when we consider how the species are able to hold their own under other conditions, when the substratum remains entirely at their disposal i. e. free from any competitors. Each single individual may then attain a very great size by spreading centrifugally over the substratum. I have however never had the opportunity of observing individuals which were so old that their centre was clearly showing signs of senile decay.

The occurrence of very young apothecia scattered among the old ones on the older parts of the thallus seems to suggest the possibility of the thallus being able to keep up its vitality for a longer period. But the impossibility of a renewal of the substratum under the lichen (as on smooth-barked trees) in addition to the circumstance that it does not stretch in area, must, in all probability, in the end result in the exhaustion of the substratum. The impossibility of meeting the requirements of the lichen must involve the dying out of certain parts of the latter, whatever the relation to the neighbouring competitors may be. It is not quite clear how these facts are to be explained in detail; they must be due to inherent causes, when the individual dies on account of its hyphæ failing to penetrate into the earth to a sufficient depth, in order to secure a continued supply of food material for the lichen, so that the thallus may develop upwards towards the light. The lichen apparently begings to grow old the very moment when, on account of its innate qualities, boundaries are being set to its continued growth — as if a standstill in growth meant senile decay which would ultimately result in death, although we have not the slightest knowledge as to the nature of those internal conditions which cause the setting up of boundaries, thus preventing the *Lecidea* species from forming a fruticose thallus or any other organ that could be of momentary benefit to future thriving.

These considerations however may help us to understand why the fruticose lichens represent a more favoured biotype. They are better adapted to subsist because they frow vertically upwards, at the same time forcing their hyphæ deeper into the substratum. They are able to provide for their growth during many years, even when growth over the substratum has long ago been stopped by neighbouring individuals. They may even subsist possibly for centuries — as WAINIO supposes to be the case with certain species of *Cladonia* — and overrun and extinguish the crustaceous lichens when the latter in consequence of any of the above mentioned causes begin to die out.

Lecideas on Stone. Denmark can show great variety of stone substrata formed in the Ice Ages: Granites, porphyries, basalts, gneiss, slate, sand-stone, limestone, etc., for the most part in the form of boulders of varying size carried to land by the ice and scattered everywhere on the fields or collected by man and used for stone walls. Solid rocks are also found over large areas: granites and basalts on the island of Bornholm, the older cambrian and silurian rocks in the same place, the lime in Stevns Klint, Bulbjerg, Møens Klint, and other places. A preliminary and brief description of how the lichens are distributed on these substrata will be found in my essay on the Ecology of Danish Lichens, but there is still a great deal of work to be done: a detailed investigation of the distribution of the species on each of the various above mentioned substrata, and an investigation as to their possible adaptation to these substrata, should be carried out.

In my »Preliminary Introduction to a General Lichen Ecology« I have mentioned the facts known at that time as to the way in which the lichens attack and decompose the substratum. Only a few important features referring to the Danish *Lecideas* will be mentioned here.

They are provided with a rhizoidal zone which attacks the substratum and assists in the process of decomposing it. The attachment to the substratum is so close that it is impossible to separate the individual completely from it in such a way as to prevent it from carrying away a number of mineral grains which take up the space of the rhizoidal zone; and this circumstance makes it difficult or sometimes almost impossible to prepare a section tolerably complete for anatomical investigations. I have not made a detailed investigation as to how the lichens attack the individual minerals. This would demand a particular cinvestigation of long duration such as has for many years been carried on in foreign countries in such an excellent manner by E. Bachmann and a few others.

My own observations have in the main been confined to proving that quartz in all the species investigated is hardly ever attacked by the hyphæ, a feature which has likewise long ago been pointed out by Bachmann. It is a peculiar fact that a great many of the species of *Lecideas* (*L. pantherina, auriculata, lapicida* etc.) run radially over the substratum covering almost all the grains of minerals except the quartz. Such uncovered grains of quartz are often seen rising up through the lichens, the hyphæ of which have avoided this substratum as useless and insoluble. When the growth of the lichen is gradually limited by neighbouring individuals, the hyphæ begin to overrun these grains too and finally they are also covered; but they are evidently the last to be occupied by the hyphæ, which seem to spread in search of a new substratum and are prevented from occupying such grains of minerals as are rich in nutriment because they have already been occupied by other parts of the thallus.

I found for instance in the *L. auriculata* a very peculiar specimen showing how the rhizoidal zone was creeping along the border of the grains of quartz, forcing its way into the surrounding grains of feldspar and mica etc. and down under the grains of quartz, thus directly undermining them. One could lift them up and disclose the underlying densely interwoven tissues of hyphæ which had corroded the richly nutritive grains of minerals and dislodged the grains of quartz from their connection with the former.

The medullary layer which continues into the rhizoidal and gonidial zones with no distinct boundaries may in some species become very thick and seems to be able to grow in thickness for a considerable period.

The thallus may often be rimose or areolate: it is however impossible to point out any sharp or distinct boundary between these two forms of the thallus. There is in no other respects any principal difference between this form of the thallus and the rather more evenly continuous but slightly ridged and granulate form, found for instance in bark lichens. And yet the areolation occurring in stone lichens may often be very marked, with deep fissures in the thallus so that the areoles are often covered with a thick cortex on their surface and a somewhat thinner cortex on their sides. The gonidia will often fail to form a distinct continuous layer between the areoles, in that they are only found in the areoles themselves, not in the intervals between them.

It is not immediately evident why the stone lichens should present this structural feature, whereas its importance seems fairly evident biologically. If a few drops of water are poured on to a dry areolate *Lecidea* it will be seen that they wil very quickly be absorbed by the lichen while they are spreading along the furrows by capillary attraction and are passing into a net of channels leading to all the areoles. Then they spread into the areoles which are on the sides covered only by a thin cortex which is easily permeated. It would thus seem as if the furrows between the areoles constitute a mechanism supplying water which operates in a very perfect manner. It may in this connection be pointed out that the marked areolate form of thallus is very common among *Lecideas* which occur on very dry substrata. It is essential here to economize and distribute the water in as perfect a manner as possible. The cortex is at the same time best adapted to resist the effects of a drought. Several of the species concerned are provided with a very thick cortex on the upper surface of the areole.

The areoles may also be a means to prevent the tearing of the thallus as a whole. The furrows between the areoles will open out and become much broader when the lichen thallus contracts during a drought. This proves that the areoles of the thallus too have contracted. Let us imagine a smooth and continuous thallus devoid of any furrows or fissures exposed to intense desiccation. It will crack in an irregular manner and run the risk of being severely injured by cracks which may have a fatal effect if frequently repeated, owing to the alternation of moist and dry conditions. Such occurrences are however avoided in the areolate *Lecideas* by virtue of their structure.

A lichen individual growing on a stony substratum is possibly prevented from further growth as soon as it comes into contact with any neighbouring lichens, owing to the inability of the substratum to expand. Its vertical growth at right angles to the substratum may still be continued for some time, but this means merely that the thallus is growing thicker. At last this kind of growth also ceases in consequence of unknown internal and physiological peculiarities. The individual will then gradualy show signs of senile decay, but we know nothing as to the course of this process.

Nothing is yet known as to whether neighbouring individuals stop growth when touching one another. One individual may continue its growth at the expense of another individual, and the latter may gradually succumb. The problem can only be satisfactorily and conclusively proved by continued observation of individuals in situ.

I have long ago explained one stage in the senility of crustaceous lichens and their subsequent complete decay. When conditions are no longer favourable for crustaceous lichens it is a very common thing to see foliose lichens (*Parmelia, Physcia,* etc.) or fruticose lichens invading the localities and killing the crustaceous lichens by overshadowing or starving them out. It remains to be seen whether certain crustaceous lichens are capable of displacing other crustaceous lichens.

LECIDEA (BIATORA) RUPESTRIS.

ACH.

(Plate 1—2—3).

The specimen investigated was found on »Limsten« i. e. limestone formed of bryozoa. It is composed of numerous small portions of the thallus scattered over the substratum. Each portion varies very much in size and outline. The very smallest is composed of only a small number of almost globular or ovoid cells, densely crowded and with yellow-brown walls. They are placed in a single layer on the substratum and are connected with thread-like, colourless long-celled hyphæ, which penetrate the former, assisted probably by secretion of an acid, which is able to dissolve and decompose the chalk. I did not succeed in discovering any gonidial alga in the very youngest granules of the thallus. Granules of this kind might be supposed to be »germs«, the result of the germination of the spore. This is disproved however by the fact that they exceed, in mass, the spores which without the assistance of the gonidia would not be able to form so much organic matter. They seem however in all places too to be in connection — by the aid of hyphæ — with the nearest portions of the thallus containing gonidia, but have no visible epilithic hyphæ connecting them with the latter.

The older larger grains of the thallus are provided with gonidia, although I have not succeeded in finding out how the gonidia originally reached them. They may be supposed to have arrived with the dust on the surface of the stone or on young thallus-areolæ and to have thus been captured by these hyphæ. The fully established areoles have undoubtedly in many cases arisen through the coalescence of originally separate areoles, which have grown up close to one another and have therefore a very irregular outline. They are epilithic. The colour of each grain is partly whitish-green, partly very deep greenish-grey. Examined more closely the darker spots prove to be parts where the original spheroidal hyphæ have been raised from the substratum and through the intercalary growth of the underlying hyphæ have been scattered over the surface of the areoles.

This distribution of colour in spots can only be seen if high magnifying powers are used, but otherwise the areoles will seem to be of the same grey colour.

The areoles have a rather homogeneous structure of hyphæ, there being apparently no clear difference between the hyphæ of the cortical, gonidial, and medullary layers. Among the general hyphæ are found in places small numbers of the spheroidal brown-walled hyphæ, which make up the original mass of the areoles, and which in the fully established areoles are found, as already mentioned, partly on its surface and partly also in the deeper-lying endolithic parts. It is difficult to say anything definite about their biological significance. (Similar hyphæ have been found in several other lime-lichens, but their function has always been a difficult problem).

The apothecia are situated on the areoles and are at first convex with a fairly regular circular outline. They have no distinct margin. The colour is yellow or ochraceous. They turn red with KOH.

The hyphæ run parallel through the stipes and radiate from there in all directions. The hypothecium has distinct ascogenous hyphæ. The asci are clavate, with 8 spores about 12 μ long.

At the top of their outer surface the paraphyses, especially in the epithecium, are covered with very numerous small yellow grains, which are stained a cherry colour with KOH. The other inner parts of the apothecium are almost colourless.

Pycnidia were not observed.

LECIDEA (BIATORA) QUERNEA.

Dicks.

(Plate 4—5—6).

On oak-bark.

The thallus is bright yellow and very thin, so that the form of its surface is quite dominated by the roughnesses of the oak-bark.

The cortex is very thin, so that the thallus in spots has a somediose aspect. It is however doubtful whether soredia can ever really become loose. Gonidial, medullary and rhizoidal layers are rather similarly built. The gonidia are generally collected in a specal gonidial layer, but here and there gonidia are also found deeper down among the lamellæ of the periderm of the oak-bark.

The oak-bark is, where it is enveloped in the hyphæ of the lichen, greatly destroyed with walls fallen in, and partly discoloured. It cannot be decided by means of the microscope, whether the cell walls are attacked by the hyphæ or not.

The apothecia are scattered without any order all over the thallus, young and old being mixed together. At first they are convex, without any margin, and continue to have this form also during their later growth. They are originally of a bright reddish brown, but gradually turn dark reddish brown. The hyphæ run parallel through the stipes, and radiate from there in all directions inside the apothecium. The hypothecium has very distinct ascogenous hyphæ. The limits between the paraphyses are indistinct. Asci are clavate with 8 spores (length 10—12 μ).

All the inner parts of the apothecium are yellowish in various bright shades. Among the upper apices of the paraphyses are found numerous, very small brown grains of colour, giving the apothecium its brown colour. In some of the asci are also found brown grains of a matter, which was not subjected to close examination.

Pycnidia were not observed.

LECIDEA (BIATORA) LUCIDA.

Ach.

(Plate 7—8).

The examination deals with a specimen from *Kongskilde* near *Sorø*. (Museum botanicum Hauniense).

On a bit of flint, near Sorø.

The thallus is thin, crustaceous, sorediose, and lemon coloured. The margin shows up clearly in places in the form of radiating colourless hyphæ; in other places the outer margin is formed by sorediose grains. Some big soredia are found outside the margin apparently free, which may have been torn off and carried away by water, by wind, or by animals. They may possibly have arisen from spores which came into touch with free algæ and then formed soredia. It is impossible to settle in what way they originated. At any rate the slightest touch of the thallus is sufficient to set soredia free and to break up the thallus. Further from the margin the thallus is thicker and consists of sorediose and loosely connected grains. As it dries up after being moist, fissures are formed. The thallus does not show a differentiation into cortical, gonidial, medullary, and rhizoidal zones. Its yellow colour arises from small yellow grains found on the outside of the hyphæ especially in those parts of the thallus which are richest in gonidia.

The apothecia are apparently formed without any order on every part of the thallus and they break through the soredial layer. They are at first very convex, but later on more plane without any visible margin; they are of a darker yellow shade than the thallus. The older apothecia are often quite light-brown and are raised only slightly above the level of the thallus, which to a certain extent hides their margin. The hyphæ of the apothecium radiate from the stipes outwards in all directions and vertical to its surface. The boundary between stipes, hypothecium (with the indistinct ascogenous hyphæ) and hymenium is indistinct. Stipes and hypothecium are colourless. The paraphyses are thick, short-celled, and covered at the tips with numerous yellow grains which easily separate when teased out in a preparation and then they show Brownian movement. The asci are clavate and have thick walls. The spores are unilocular, oblong or slightly ovoid, and measure about 3 μ long (they were only found isolated from the asci by teasing out some material).

Pycnidia were not found.

The species is probably reproduced partly by spores and partly by soredia.

LECIDEA (BIATORA) FUSCA.

SCHÆR.

(Plate 9—10—11—12).

Specimen 1. (on the ground).

The thallus is very thin, almost evanescent, and granulate. The form of its surface is quite dominated by the roughnesses of the substratum.

The cortical layer varies very much in thickness, and is formed by hyphæ which merge into each other. The hyphæ of the gonidial layer have very short cells and are very dense. The structure of the medullary layer is very similar to that of the gonidial layer and is continued without a sharp transition into the rhizoidal zone. Particles of humus and slightly altered dead remains of plants are found in great numbers in the rhizoidal zone.

The apothecia are scattered without any order all over the thallus. They are fairly regularly circular or somewhat angular with thick persistent margin. This is almost quite black, while the disk (especially when in a moist state) is of a somewhat translucent reddish black.

The hyphæ run parallel through the stipes and radiate from there in all directions inside the calyx, on the surface of which they stand erect. The hypothecium shows no distinctly marked ascogenous hyphæ. The asci are numerous, most of them (on this specimen) being still unripe, long and thin. Length of spores about 9—12 μ. The inner parts of the whole apothecium are brown; the hyphæ of the stipes are light, in the calyx considerably darker, the outer surface of the stipes, however, being again a little lighter.

The hypothecium is also a somewhat darker brown, while the paraphyses are a very light brown, almost colourless.

Specimen 2. (on the ground).

This specimen accords in colour and structure of thallus, both morphologically and anatomically, so completely with specimen 1, that they cannot be distinguished from each other.

The apothecia are, as regards their inner structure and colour, exactly like those of specimen 1. The reason why this specimen is specially mentioned and illustrated is only that the apothecia are very much crowded and later, when older, grow somewhat larger, and more convex with an evanescent margin.

LECIDEA (BIATORA) GEOPHANA.

Nyl.

(Plate 13—14—15).

On the ground.

The thallus is thin, continuous, gelatinous, and greenish-grey. The form of its surface conforms to the unevenness of the substratum.

The cells of the cortex are all living and are densely interwoven, without any distinct outline. Gonidial and medullary layers are not clearly outlined. The rhizoidal zone consists of loose hyphæ with long cells.

Apothecia are scattered without any order all over the thallus. At first they are convex and they retain this convexity in old stages. They are always black, though when moistened they become a slightly transparent red.

The hyphæ run in the usual way parallel through the stipes and radiate from there to the outer surface of the calyx.

The stipes, calyx, and hypothecium are all brownish and the hymenium is almost colourless or slightly brownish.

Asci cylindrical or narrow clavate with about 16 small globular spores (4—5 μ long).

Pycnidia were not observed.

In the specimen investigated the thallus was attacked by *Gloeocapsa*, which was mixed up with the hyphæ and with the normal gonidia. In the cortex several specimens of *Gloeocapsa* were very distinct; other specimens on the contrary were very indistinct, so much so that the cell cavities of *Gloeocapsa* and of the fungal hyphæ became very much alike, the cells of *Gloeocapsa* being almost colourless and of the same size as those of the hyphæ. Several specimens of *Gloeocapsa* were also observed in the gonidial and medullary layers. The hyphæ penetrate the gelatinous walls of the alga in all directions but in very small number. No haustoria were observed. In places where *Gloeocapsa* occurred, the normal gonidia seemed to suffer by its presence, the chloro-gonidia being to a large extent discoloured and even dead. This may perhaps be due to the gelatinous walls of *Gloeocapsa* not being penetrable to gases in the degree necessary for the nutrition of the normal chloro-gonidia. The presence of *Gloeocapsa* is doubtless a pathological phenomenon. It is evident that the hyphæ are not able to make full use of these algæ as they are of the normal chloro-gonidia.

LECIDEA (BIATORA) GRANULOSA.

Ehrh.

(Plate 16—17—18—19—20—21).

Specimen 1, from *Gaardbo* in *Jutland* on pure humus.

In the specimen investigated which is a fragment only, the thallus has no natural margin. It consists of numerous clearly defined granules, which in vertical sections appear connected by a colourless rhizoidal zone. The grains themselves are light greyish. They have a distinct cortex, which on the whole is nearly structureless; here and there however the cells show distinct lumina. The hyphæ of the gonidial layer are short-celled, and run for the most part perpendicularly to the cortex. The hyphæ of the medullary layer have more elongated cells, which downwards are evenly continued in the rhizoidal zone which penetrate the upper layers of the soil. In the thallus were observed below an apothecium a group of palmelloïd *Chlorophyceæ,* the gelatinous walls of which were penetrated in all directions by hyphæ. The latter do not send haustoria into the alga, and this shows no signs of suffering by the presence of the hyphæ inside the lichen. It is not clear from a microscopical examination whether any symbiosis exists between the hyphæ and the alga, though it is probable.

The young and old apothecia are scattered about without any order on the granules. Below them no gonidia are ever found. As the granules when young always contain gonidia, the latter must have disappeared or must have been pushed aside during the development of the apothecium, a phenomenon very common in *Lecidea.* Dead gonidia could not however be made out. The colour of the apothecia at all stages of development is almost like that of the yolk of an egg, or perhaps rather more brownish-yellow in the oldest of them. The youngest of them are deeply cup-shaped and the oldest are always provided with a distinct margin, but otherwise more plane or even a little convex, often greatly undulate at the margin. Inside they are of a very faint yellowish shade in all parts, stipes, calyx, hypothecium and hymenium. The apices of the paraphyses are not more deeply coloured than the other parts, but the hypothecium may be of a slightly deeper yellow. It is difficult to make out the course of the hyphæ even in very thin sections. The ascogenous hyphæ are not very large or easily discernible in the hypothecium. Asci are clavate with rather big spores about 12 or 14 μ long.

Neither soredia nor pycnidia were found.

Specimen 2 from *Sødal* on oak-wood.

This specimen is distinguished from specimen 1 merely in that it is growing on oak-wood, not on soil. The thallus is morphologically and anatomically the same in both cases; in specimen 2 there are however found a number of soralia i. e. soredia-forming centres on the thallus. The structure of the apothecia is morphologically and anatomically the same in both specimens, but the youngest apothecia in specimen 2 are of a faintly greenish shade and do not assume the yellow-brownish tinge till later, and they then also become slightly more convex. The similarity of the two specimens is however so great that they undoubtedly belong to the same species.

Specimen 3 from *Grib Skov* (forest) on peaty soil, under *Picea.*

The thallus consists of small granules which are largely broken up into soredia. The structure of the apothecia is morphologically and anatomically quite like that of specimen 1 but the colour is different, all the young apothecia being provided with a light greenish-grey margin and a darker, deeply verdigris disk. By and by there also appears a yellow colour in the older apothecia, so that they may in the end be variegated, green and yellow in colour. The interior parts of the apothecia show only very little colour, being now greenish, now yellowish, and varying in conformity with the externally visible shade of colour of the apothecium.

To the specimen here described might be added many others, the species obviously varying very much, but mainly in respect of the presence or absence of soredia, and the colour and outline of the apothecium.

Some specimens have apothecia which are almost circular in outline, and cup-shaped; others again have at first a quite regular circular outline which in the end becomes very sinuose; at the same time the disk becomes very convex and the margin somewhat evanescent. The colours also vary greatly. Apothecia may be found with verdigris disk and a lighter green margin, others with bright yellow disk and margin, again others at a later stage with deep brown disk and margin, and finally yellow and green variegated apothecia. In some specimens one of these shades of colour is predominant, and in others another of them, but very rarely are specimens found where both of the colours cannot be traced, even if one of them is predominant. Frequently for instance individuals are met with in which nearly all apothecia are green, but in a few of them a trace of yellow will be found — or other specimens, having for the most part yellow apothecia, will have among these a few of greenish shades. Generally it appears that young apothecia are greenish, later on becoming either a still darker green and yellow, or entirely yellow which gradually passes into brown.

This great richness in form and colour makes it all the more urgent to base the description of species on certain single individuals, to avoid mixing up all the many forms which may perhaps turn out to be micro-species.

Personally I have no doubt that they are all very nearly related to one another.

There exists probably a very close relationship between *Lecidea granulosa* and *Lecidea flexuosa*, so close in fact that perhaps they really are but one species.

LECIDEA FLEXUOSA.

(Fr.) Nyl.

(Plate 22—23—24—25).

Specimen 1, on oak-wood, *Sødal.*

The thallus is composed of small grains joined at the base; these form a greenish-grey granular incrustation of the substratum. The grains (areoles) overlap. Grains overshadowed in this way lose their gonidia, of which it is not possible even to detect the walls by application of chlor-zinc-iodine. In the course of this conpetition some of the areoles may reach quite a great height. The areoles possess a cortex composed mainly of dead cells with colourless walls, the deeper layers consisting of living cells provided with walls of a faintly brownish colour. The cortex is thickest at the surface of the areoles and thinner on the sides. The hyphæ of the gonidial layer are short-celled and run more or less in a direction vertical to the cortex. The hyphæ of the medullary layer consist of larger cells. They are continued evenly into the rhizoidal layer, which penetrates into the substratum (oak-wood). The hyphæ of the rhizoidal layer are longer-celled than those of the medullary layer and they branch profusely among the cells of the wood. It is practically impossible to say whether the hyphæ themselves break into the cells or whether they enter there only after the cells have become ruptured in some other way. It is also impossible to say whether the hyphæ corrode the cell-walls or not. An examination of the structure may be taken to favour either view.

The apothecia arise irregularly, young and old occurring side by side. The youngest are fairly regularly cup-shaped, but later on become more irregularly cup-shaped with a distinct margin, more rarely with an indistinct plane-convex disk. Margin and disk are always black, whatever the age of the apothecium. The hyphæ run from the stipes, united in a bundle, in a direction more or less perpendicular to the surface of the calyx. The ascogenous hyphæ of the hypothecium are not very distinct. The asci are clavate with thick walls at the top. The spores have a length of 4—6 μ. The paraphyses are cylindrical and short-celled. In the internal parts of the apothecium colour is distributed as follows: stipes, hypothecium, and asci are of a faintly brown colour; in very thin sections they appear almost colourless, while the apices of the paraphyses and the peripheral portions of the calyx are brownish with a greenish tinge.

Pycnidia were not found.

Soredia were found here and there on the areoles of the thallus.

Specimen 2, found on the ground, *Almind Sø*, near *Viborg*.

This specimen agrees in all essentials with specimen 1 as regards the structure of both thallus and apothecium etc.

It is mentioned separately because several portions of both thallus and apothecia contained numerous cyanogonidia; they were therefore abnormal. The normal portions of the specimen will not be referred to here as they resemble those of specimen 1. The abnormal portions are described here in detail.

The cyanogonidia belonged to a species of *Gloeocapsa*, and were found in large numbers outside and inside the thallus, closely surrounded by the hyphæ of the latter. In most cases the hyphæ closely surrounded the normal *Pleurococcus* gonidia, thus resulting in the formation of sorediose masses of the usual appearance. These soredia were connected by the gelatinous masses of the *Gloeocapsa*, which were interwoven with the hyphæ that connected the soredia. The hyphæ did not enter the cells of the *Gloeocapsa* by means of haustoria, and it was not possible to see whether the fungus gained any advantage by this symbiosis. In the same way it is of course impossible to ascertain by the aid of the microscope whether the lichen gains any advantage by the association of its fungus with the normal gonidia. No true cortex was formed when *Gloeocapsa* cells were present; a few scattered hyphæ only, covered the thallus. The thallus as a whole becomes disorganized by the presence of the cyanogonidia. Most of the apothecia were disorganized by the presence of *Gloeocapsa*, being cauliflower-like in shape and branched to form irregular hypertrophied black structures, showing a convex surface.

Sections showed that the direction of the hyphæ was that usual in the normal apothecia — they run parallel from the stipes, standing erect on the actual surface of the calyx. An hymenium was formed only occasionally in each apothecium and even then no spores were formed.

Gloeocapsa occurred in masses among the hyphæ of the apothecium, and mostly in the peripheral parts, and were less numerous in the stipes. Below these quite deformed and functionless apothecia the thallus was quite devoid of normal gonidia but contained several *Gloeocapsa* cells. The impression one gets is that portions of the thallus containing *Gloeocapsa* cells were in a pathological condition. The lichen cannot thrive indifferently on *Cyanophycean* algæ, and on *Pleurococcus*.

LECIDEA GELATINOSA.

FLK.

(Plate 26—27—28).

The thallus of the specimen investigated grew on the ground and was without its natural margin. It is smooth on the surface and slightly gelatinous, greenish-grey, and here and there provided with light coloured soralia.

The cortex consists of short-celled hyphæ, in the outer layers of which is deposited a non-crystallized pigment. Many of the cells were living, while others seemed to be dead and empty.

The gonidial layer is clearly separated from the medullary layer. They both consist of short-celled, densely interwoven, slightly gelatinous hyphæ. The rhizoidal zone is densely filled with particles of humus.

The soredia are irregular in outline and consist of gonidia surrounded by short-celled hyphæ.

The few apothecia are spread over the thallus in no order. At first their outline is more or less orbicular; later on it becomes very irregular. When young their margin is light, almost pseudo-lecanorine, later on it disappears completely. Young apothecia are slightly convex, later on they become more or less flat or convex but never concave. They are greenish-black.

The hyphæ run parallel through the very short stipes and radiate from there in all directions towards the calyx, on the surface of which they stand perpendicular.

The hypothecium passes gradually into both stipes and hymenium. Asci with 8 spores (about 12—14 μ long).

The paraphyses are closely conglutinate.

The whole interior of the hypothecium is faintly brownish, stipes, calyx, hypothecium, and hymenium. The outer surface of the calyx and the top of the paraphyses are all darker brown.

Pycnidia were not observed.

LECIDEA COARCTATA.

Sm.

(Plate 29—30—31—32—33—34).

Specimen 1. (on soil). Had a thallus without natural margin. It is whitish-grey, smooth, uninterrupted, with only a few fissures, formed by the drying up of the thallus.

The cortical and gonidial layers have closely interwoven hyphæ; the medullary layer is of a looser texture with larger intercellular spaces and more long-celled hyphæ. The rhizoidal zone is also formed by long-celled hyphæ.

The apothecia grow out without any definite order, young and old occurring side by side. The young ones are nearly circular in outline, but often they gradually become more or less sinuate. They break through the cortex in a peculiar way, big masses of the cortex being raised up and lying at first on the margin and the disk of the apothecium. The margin may on this account take on a pseudolecanorine appearance, which however gradually disappears. The disk is of various shades of a rusty colour; the oldest disks are very dark.

The stipes is short and is continued into quite a shallow calyx. The hypothecium is clearly separated from the hymenium. The latter has long distinct paraphyses and very large clavate asci with large ellipsoid spores (length about 16—18 μ).

The inside of the apothecium is slightly brown in colour, the calyx only, being darker. The apices of the paraphyses are also darker.

Specimen 2 has a thallus growing on stone; it was examined more in detail in order to ascertain whether there was any difference between the specimens growing on stone and those growing on soil. They showed so great a conformity in structure that the description may be limited to an explanation of the figures.

[LECIDEA RIVULOSA.]

Ach.

(Plate 35—36—37—38—39).

This species is recorded by Hellbom in »Bornholms lafvar«; but no Danish specimen is represented in any Danish collection to which I have access; it is doubtful therefore whether it should be included in the Danish flora. Nevertheless it is just possible that it really does occur in Denmark, and therefore I have examined a Swedish specimen.

The thallus grows on the bark of the birch. The margin is composed of radiating colourless hyphæ, which spread below and on the surface of the substratum. The thallus is thin and slightly warty on the surface. The roughness of the substratum is distinctly visible through the thallus. The colour is greenish-grey.

The inner structure is more or less homoeomerous. The cortex is composed of cells with indistinct and compressed cell lumina. It is not easy to separate the gonidial and medullary layers from one another, the gonidia developing between the lamellæ of the bark forming the substratum.

The apothecia are scattered irregularly over the thallus, young and old standing side by side. They are uniformly orbicular with a thick persistent margin. The colour is dark brown.

The hyphæ of the stipes are loosely interwoven and form a spongy tissue with numerous intercellular spaces. In the calyx the hyphæ are dense and radiate in all directions to the surface on which they stand erect. The hypothecium is also dense, with indistinct ascogenous cells. The paraphyses are slender, the asci clavate with 8 curved spores (about 10—12 μ long).

The apices of the paraphyses and the outer parts of the calyx are brown; all the other inner parts of the apothecium are colourless.

LECIDEA BOTRYOSA.

Fr.

(Plate 40—41).

The specimen investigated was found on a rotten stump of *Pinus*.

The thallus forms a dark almost black layer over the substratum and has a very indistinct outline. It is composed of numberless very small granules, which to a great extent are coralline, branched, and joined together at the base. Some have *cyanogonidia*, others on the contrary *chlorogonidia* of the usual pleurococcoid type.

The chlorogonidial granules are covered by a cortex composed of living cells, the outer ones of which are coloured by a brown, non-crystallized pigment, deposited mainly in the outer parts of the cell walls, while the inner parts of the wall are almost colourless. The cortex has no intercellular spaces: the hyphæ stand more or less perpendicular to the actual surface of the thallus. The gonidia are pleurococcoid. The medullary layer is composed of loosely interwoven and long-celled hyphæ.

The cyanogonidial granules have a cortex which is thinner and composed of one or two layers of cells of the same structure as those of the chlorogonidial granules. The gonidial and the medullary layers have the same structure as the cortex and are devoid of intercellular spaces; they are both colourless.

It is impossible to determine by simple microscopical inspection to which species of *Cyanophyceæ* the gonidia belong. Possibly a pure culture may settle the question.

The whole cyanogonidial granule is somewhat gelatinous and the walls of the gonidia are not clearly bordered, which suggests that the hyphæ of the lichen fungus penetrate into the gonidial wall.

Both types of granules, cyanogonidial as well as chlorogonidial, are morphologically alike and cannot be distinguished by means of a low magnification. Moreover many of the granules contain both types of gonidia.

At their base all granules are joined together in a common rhizoidalzone, composed of long-celled hyphæ, which penetrate into the substratum.

The apothecia are irregularly scattered over the thallus. At first they are concave, later on they become convex. The hyphæ run parallel through the stipes and radiate from there in all directions inside the calyx, on the surface of which they stand erect. The paraphyses are distinct and slender; the asci are clavate with big oval spores, each containing a big oildrop.

The colours of the inner parts are seen in the figures.

Pycnidia were not observed.

LECIDEA ULIGINOSA.

SCHRAD.

(Plate 42—43—44—45).

The thallus grows on peaty soil and is made up of crowded small brown granules (areolæ), joined at the base by a common basal tissue which penetrates into the substratum. The thallus is orbicular in outline when it grows free and unhindered by other plants.

The cortex is thin and consists of hyphæ which in part at any rate will stain. The brown colour is due to a non-crystallized pigment deposited in the walls of the outer hyphæ.

The hyphæ of the gonidial and medullary layers are gelatinous, with or without minute intercellular spaces. The rhizoidal zone penetrates into the upper surface of the soil by means of spreading hyphæ, that make their way between the grains of minerals and particles of humus. The rhizoidal hyphæ are partly brown in colour.

In the specimen investigated big groups of a *Gloeocapsa* were found in the thallus serving as »gonimia«, deep down in the thallus and on the surface.

A few hyphæ penetrate the gelatinous walls of the *Gloeocapsa* but do not form haustoria, and they do not kill the algal cells. It is uncertain whether the lichen derives any benefit from this symbiosis. The alga appears to live its own life unaffected by the lichen, while the latter becomes misshapen in the parts of the thallus where the alga occurs.

The apothecia are found with young and old ones mixed up without order. When young they are concave, with a thick, radially slightly wrinkled margin, but gradually they become plane or convex and the margin disappears. The colour is at all ages dark brown with various shades of olive brown or almost blackish brown.

The hyphæ in all parts of the apothecium are gelatinous and they are not easily separated. The cytoplasma is clearly seen. The hyphæ run parallel through the stipes, radiating from there in all directions inside the calyx, in the outer parts of which they are somewhat sinuose with very thick brown walls. The limit between hypothecium and hymenium is quite indistinct. The asci have 8 spores (about 10—12 μ long).

The paraphyses are conglutinated.

The hymenium is at any rate partly stained blue by J + KJ.

The hyphæ of the stipes are brown, yet transparent even in very thick sections. In the calyx the brown colour is darker, in the hypothecium considerably lighter. This is also so in the paraphyses, the tops of which are a deeper brown.

Pycnidia were not observed.

LECIDEA ERYTHROPHÆA.

FLKE.

(Plate 46—47—48).

On the bark of *Fraxinus excelsior* (*Knivholt*).

The thallus is light grey, thin, smooth, and with very few and indistinct cracks and wrinkles. The specimen investigated is imcomplete and without a natural margin.

The cortex is thick, made up of colourless hyphæ, which for the most part seem dead; only the deeper layers are clearly living and stain with erythrosine.

The hyphæ of the gonidial layer are small-celled.

The medullary layer is continuous with the rhizoidal zone. The boundary line between the thallus and the substratum is clearly marked.

The apothecia arise in no definite order. When young they are deeply cup-shaped with a distinct margin, and fairly regularly orbicular. The older ones gradually become more convex and lose their margin, and are more or less uneven on the surface. All apothecia are, when dry, almost black (with a slightly reddish tint); when moist they are brownish or reddish and somewhat transparent. The inner parts are of a faintly brownish colour as regards stipes, hypothecium, and hymenium. The brown colour is more noticeable at the tips of the paraphyses and the calyx.

The hyphæ run parallel through the stipes and spread out from there in all directions towards the surface of the apothecium, to which they stand perpendicular.

The paraphyses are regularly cylindrical and brown at their tips. The asci are narrow, thick-walled and contain 8 unilocular narrow spores about 12 μ long. The hymenium becomes blue on the addition of iodine. The ascogenous hyphæ in the hypothecium are not very distinct. Pycnidia were not observed.

[LECIDEA TURGIDULA].

Fr.

(Plate 49—50).

The species is referred to by I. P. Hellbom: »Bornholms lafvar, 1890«, but no Danish specimen is represented in any Danish collection which is accessible to me. I have therefore examined a specimen collected in Sweden, and placed the specific name in brackets to indicate that it is doubtful whether the species occurs in Denmark. It is probable however that it will in due course be found and that is why it is mentioned here.

The thallus is partly endoxyline, growing on the dead wood of *Pinus*. Almost colourless, or faintly yellowish, and very small patches of very irregular outline occur scattered all over the substratum. Each patch is an areole that breaks out from the substratum, forcing thin lamellæ of the wood up above the level of the substratum, thus continuing to be endoxyline. Very small parts of the thallus may become quite free from the covering wood-cells, when they would be called epixyline.

The thallus is homoeomerous, and composed of loosely interwoven hyphæ and scattered gonidia, no cortex, gonidial, medullary, or rhizoidal layers being differentiated.

The apothecia apparently arise in the most superficial portions of the thallus. They are at first concave and possess a thick and distinct margin; later on they become convex and semi-globular. The colour is black or partly brownish. In a moistened state they become faintly bluish.

The hyphæ run through the stipes, radiating from there in all directions inside the calyx, on the surface of which they stand erect. The paraphyses are slender and conglutinate. The asci are long, narrow, clavate, with small spores (8—9 μ long). The internal portions of stipes and hypothecium are colourless. The paraphyses are bluish, with brownish apices. The calyx is brownish.

Pycnidia were not observed.

LECIDEA PANTHERINA.

Ach.

(Plate 51—52—53—54).

The specimen investigated (on granite) has a thallus with a black margin. Where big grains of quartz rise above the level of the stone, they are covered later than grains of felspar and mica, and so the thallus may for a long time be interrupted. Gradually even the grains of quartz are overgrown, so that dark margins, of the same structure as the dark margins of the main thallus, are formed quite in the middle of the thallus. These »inner margins« have no predominant direction of growth and may grow partly in the direction towards the centre of the thallus, and partly in a centrifugal direction.

On the black margin, wherever growing, the light grey areoles of the thallus gradually appear, and being mixed with the black parts of the thallus give it as a whole a grey-black mottled appearance. The areoles are more or less plane.

The youngest black margins are formed of black-walled hyphæ devoid of gonidia and often form a peculiar network over the whole substratum.

The areoles have a thick, dead, and colourless cuticle, which is continuous with the living, thick, small-celled cortex. The hyphæ of the gonidial layer run chiefly perpendicular to the cortex. This is also the case with most of the hyphæ of the medullary layer.

The apothecia stand irregularly on the thallus, apparently partly between and partly on the areoles. When they are found between the areoles, they arose probably on an areole, which they have by their further growth suppressed and overgrown. They are often crowded and irregular in outline. When they break through the cortex, small fragments of the cortex at first are found on the margin, but these later on disappear and the apothecium becomes quite black. The margin is thick and persistent. The apothecia do not rise much above the level of the cortex. The hyphæ run parallel through the stipes; from there they radiate in all directions perpendicular to the surface of the calyx. There is a distinctly colourless (ascogenous) hypothecium. Asci are clavate with 8 big spores (about 16—18 μ long).

The hyphæ of the stipes are dark brown, becoming on their way through the calyx almost colourless, and at length brown again in the outer (peripheral) parts of the calyx. The hypothecium is colourless.

The paraphyses are at their tips deeply blackish-green, otherwise they are colourless.

Pycnidia were not observed.

LECIDEA LAPICIDA.

(ACH.) ARN.

(Plate 55—56—57—58—59—60—61).

The specimen investigated was found on a stone and had a thallus with a black margin. The grey areolate thallus begins just behind this margin with well separated areoles with narrow chinks between them. The areoles are more or less incised in the margin and plane above. Thier colour is an ashy grey; some of them are partly brown from rust, and their vertical sides are, in the case of some, dark, almost black, and in the case of others on the contrary, grey. Here and there single grains of quartz project from the substratum into the thallus. They are gradually overgrown by radiating black hyphæ.

On the surface of the areoles the cortex has a thick, dead cuticle. Beneath it follows a living cortex formed of short-celled hyphæ, the outer surface of which is here and there completely covered by very small particles of rust.

On the sides of the areoles the cortex is living, without a cuticle and consists of short-celled colourless hyphæ or of short-celled hyphæ with walls that are grey owing to the presence of a non-crystallized pigment.

The hyphæ of the gonidial layer are short-celled and much richer in intercellular spaces than the cortex.

The medullary and rhizoidal layers for the most part consist of short-celled hyphæ, and are rich in intercellular spaces. The rhizoidal hyphæ are slightly longer-celled than the medullary hyphæ.

Particles of rust lie on the surface of the walls of the hyphæ in great quantities in the deeper layers of the cortex and just below the gonidial layer, above in the medullary layer. On the other hand the deeper layers of the latter together with the rhizoidal zone appear to be free from rust. One has the impression that the rust is deposited in the spots where it is likely to do the least damage to the lichen.

The apothecia are distributed without order, young and old ones being found close together. They arise on the grey thallus, but gradually become so large that they often completely cover the areoles on which they were formed, and so appear to be placed between the areoles. At first they are rather orbicular, but gradually they become quite irregular in outline, partly owing to their being densely crowded so that they press against each other, partly owing to the margin being sinuose or lobate or deeply incised. They have at all ages a thick, distinct margin. The very young ones may have masses of the cortex of the vegetative thallus still on the margin. The hyphæ run parallel through the short stipes, radiating from there in all directions inside the calyx and they stand perpendicular to the surface of the latter.

The hypothecium is almost or quite colourless. The paraphyses are slender with faintly clavate tops. The asci are clavate with 8 spores (about 10—12 μ long). In the stipes the hyphæ are light brown, but they become quite colourless where they pass through the calyx, and dark brown again in the outer layers of the calyx. Hypothecium and hymenium are colourless except the top of the paraphyses, which are brown with a shade of bluish-green to black.

Particles of rust occur also in the apothecium, especially in the stipes and calyx; but they were not observed in hypothecium and hymenium.

Pycnidia were not observed.

The likeness between *Lecidea pantherina* and *lapicida* is very great; they seem really to represent one species only. The most conspicuous difference seems to be the chemical reaction of the medullary hyphæ, which becomes blue on the addition of iodine in the case of *Lecidea lapicida,* but not so with *Lecidea pantherina.* There is also a difference in the coloration resulting from the addition of KOH, L. pantherina becoming red, L. lapicida faintly or not at all red.

LECIDEA LITHOPHILA.

ACH.

(Plate 62—63—64—65—66—67).

Speciman 1 (on stone) is a fragment only, the thallus of which has no natural margin. It is light and greyish-white with a rough surface and irregularly crowded areoles. These may overlap here and there. Among the hyphæ of the cortex dead and living cells are found, almost all with distinct cell cavities, but there is no cuticle. The cortex also covers the sides of the areoles, and the fissures between these are therefore not due to desiccation of the thallus. The hyphæ of the gonidial and medullary layers run vertically to the surface of the areole, and this influences the position of the gonidia, so that these too are arranged in elongate, vertically placed groups.

The apothecia are scattered, young and old being mixed. Their outline is irregularly sinuate. The disk soon becomes plane and continues to be so, though it is slightly undulating and rough, but never distinctly convex.

The margin is thin and more or less persistent. The apothecia break through the cortex in various ways. Some of them become free very quickly, others for a long time retain fragments of the thallus, which partly covers the margin and gives it a pseudo-lecanorine appearance, but at length these apothecia too break through and then are appressed and only slightly raised above the level of the cortex. The hyphæ run in the usual way through the stipes, the latter however being so short (the whole apothecium is very short) that they almost immediately radiate in all directions to all parts of the apothecium and run upwards in a slanting direction towards the surface of the cortex of the thallus. The tissue of the stipes has numerous intercellular spaces. A very thick and distinct ascogenous hypothecium is present. The paraphyses are slender, the asci rather thick, clavate, with 8 spores (about 18—20 μ long).

The hyphæ of the stipes are mostly colourless, but here and there they form a narrow, very dark, almost black outer calyx, which is always black at the top (margin), but may also be black in the deep lying parts, which touch the thallus. This distribution of colour however is not the same in all apothecia. The calyx, hypothecium, and almost the whole of the hymenium are colourless; only the apices of the paraphyses are generally brown (some of them being colourless).

Pycnidia were not observed.

Specimen 2 (on stone) has a thallus, the margin of which is black and radiates outwards. Otherwise it is greyish-white, uninterrupted, only here and there with distinctly limited areoles, but with deep winding furrows between them. In places it has somewhat darker spots. Morphologically the difference between specimens 1 and 2 is not very great, as specimen 1 may perhaps also have had a black margin, although nothing definite can be said in this respect. The inner anatomical structure in every way corresponds to that of specimen 1, except that possibly the gonidia are rather more distintcly arranged, as in chains. In a specimen which had been teased out, numerous dead and empty gonidia were found.

Haustoria were not found.

The apothecia are scattered without any order, young and old being mixed up. They are irregularly sinuate and have a distinct persistent margin, with a plane or slightly convex disk. Only the quite young apothecia are concave. They are often crowded or confluent. Such pseudo-lecanorine stages as are shown in specimen 1 were not met with.

The inner structure in every detail recalls that of specimen 1. except for the distribution of colour which is different; the calyx appearing quite black. The hyphæ of the stipes appear to run more regularly in a vertical direction towards the surface of the calyx, whilst in specimen 1 they run upwards in large numbers and stand vertical on the surface of the thallus.

Pycnidia were not observed.

The two specimens (1 and 2) when compared, show so remarkable a similarity and so few differences that they must undoubtedly be considered as belonging to the same species. In this respect, certainty can only be obtained by cultural experiments. E. **Nylander** who determined specimen 2 regarded it as a form (»steriza«) of *Lecidea contigua.*

LECIDEA PLANA.

Lahm.

(Plate 68—69)

On stone, (the wall of *Randbøl* churchyard).

The thallus is very thin, dark grey with a smooth, somewhat granular surface.

The upper layer of the cortex is coloured by very small grains of colour. It is short-celled and appears to be living for the whole of its depth. The hyphæ of the gonidial and medullary layers are almost like those of the cortical layer. Deeper down they pass quite evenly into the more long-celled rhizoidal hyphæ, which make their way into the stony substratum.

The apothecia are scattered, young and old being mixed, and they are very numerous. The youngest of them are fairly regularly oval or circular in outline, but gradually become sinuate at the margin. Here and there they are crowded in groups of 2 or 4 and then squeeze each other during their continued growth. From the beginning they are plane or a little concave, and they continue to preserve this form.

The margin is thick and prominent. Both margin and disk are quite black. The hyphæ of the apothecia run parallel in the stipes, in the usual way, radiating from there in all directions vertically to the surface of the calyx. In the stipes the hyphæ are long-celled with plenty of intercellular spaces.

In the hypothecium the ascogenous hyphæ are not particularly distinct. The asci are clavate, spores 10—14 μ long. The paraphyses are thick and short-celled. Their upper half or third is black with a faint greenish tinge.

The distribution of colour is as follows: stipes and hypothecium are quite colourless; the lower parts of the paraphyses are (in thick sections) very faintly greenish, almost colourless, and their apices are black with a greenish tinge.

The calyx is in the inner parts (nearest to stipes and hypothecium) quite colourless. The peripheral parts are black with a faint brownish tinge towards the inside.

Pycnidia and soredia were not observed.

LECIDEA AURICULATA.

Th. Fr.

(Plate 70—71—72—73—74—75—76—77—78—79—80).

Specimen 1. On a stone corroded by blown sand (Gneiss).

The thallus has a white rhizoidal zone hidden in the stone and making its way between the grains of the minerals, which it corrodes deeply, thus contributing to their decay and disintegration. Grains of quartz are not corroded but both felspar and mica are. On the surface of the stone the thallus is only seen in very narrow stripes, outlining the otherwise naked mineral grains, which on closer inspection appear undermined and covered on their under side by white rhizoidal hyphæ, which thus penetrate into the stone in all directions to the depth of a few millimetres. The epilithic and therefore visible portion of the thallus appears, when more strongly developed, to be divided into indistinct dark greenish areoles cohering at the base.

The cortex consists of dead hyphæ, the outlines of which are rather indistinct. The outer hyphæ have greyish walls. The hyphæ of the gonidial layer are densely interwoven and short-celled; it passes gradually into the rhizoidal layer, the hyphæ of which have long cells and are loosely woven. In many places the single cells are very irregular, probably through pressure from the surrounding mineral grains.

The apothecia are placed in rows along the narrow thallus, their place being thus determined by and dependent on the form and size of the grains of minerals. Their outline is at first circular or oval, but by and by they become very sinuate, and where they are crowded together they may become misshapen. At first they are concave, but later on plane or slightly convex with a thick margin, which persists in almost all apothecia.

The hyphæ run parallel through the stipes and from there radiate in all directions inside the calyx, on the surface of which they stand erect. The ascogenous hyphæ of the hypothecium are very indistinct; the asci are clavate with 8 small spores (about 7—8 μ long).

The paraphyses are slightly clavate at their apices.

Colour is distributed in this way: the hyphæ in the stalk are colourless at the base, but turn dark brown at the apices, when they approach the hypothecium; during their passage into the calyx they are partly colourless, and partly of a faint brown colour, and they end by being almost black with a greenish tinge when they reach the outer surface of the calyx. The hypothecium is brown. The paraphyses are faintly green (in thick sections deeply green) with black spots.

Pycnidia were not observed.

Specimen 2 (on sandstone).

The thallus is of the same structure as in specimen 1. The apothecia are very irregularly shaped, the older ones being subdivided into irregular, kidney-shaped areoles by fissures.

Such an apothecium is at first probably single, but by continuous growth it becomes irregular. It is possible however that it may have arisen by the fusing of several neighbouring apothecia.

Pycnidia were not observed.

Specimen 3 (on stone).

The thallus is thinly areolate, and grey with confluent areoles.

Grains of minerals can be seen to project through the thallus here and there.

Apothecium, as in specimen 1.

Specimen 4 (on stone, Læsø).

The thallus shows conspicuous black hyphæ radiating at the margin, and forming at a short distance from this a continuous greyish thallus, on which arise light grey pulvinate areoles.

The remainder of the thallus resembles specimen 1 in its structure.

The apothecia resemble in form, structure, and colour specimen 1.

Pycnidia were found on the thallus-areoles in large numbers. They were immersed and have black ostioles. They also show a black perithecium wall, from which colourless hyphæ either radiate or run slantingly towards the ostiolum. The conidia are formed on these hyphæ.

Specimen 5 (on stone).

The thallus consists of a strongly developed rhizoidal zone formed of white endolithic hyphæ. The hyphæ make their way in between the grains of minerals and corrode them — with the exception of the grains of quartz. A very scantily developed thallus is found on the surface of the stone consisting chiefly of very small scattered areoles, the outline of which is more or less round; they are quite plane, their diameter being often less than one tenth of a millimetre. It is very difficult to determine whether they are connected to one another, for they appear to be quite separate. Thus it might appear very likely that each represents a separate germ.

Cutting a very thin slice off the stone and staining the section strongly with iodine green, I succeeded in making it clear however that they were all connected together by very delicate hyphæ, passing from areole to areole across the surface of the stone.

The cortex is black and composed of hyphæ running vertically to the surface. The outer cells have brown walls. The gonidial and medullary layers show short-celled hyphæ.

The apothecia are in every way of the same structure as those in specimen 1. The only difference is that the paraphyses of the apothecia examined are reddish (being of a greenish colour in all other specimens); they have however dark greenish apices.

Pycnidia were not observed.

LECIDEA MACROCARPA.

(Dc.) Th. Fr.

(Plate 81—82—83—84—85—86—87—88).

Specimen 1. From a sandstone boulder at Tolne (The specimen has formerly been determined by Th. Fries).

The thallus is on this specimen a fragment without any natural margin. It is very thin, so that the grains of sand of the substratum are clearly seen through it and dominate the form of its surface. It is quite light-grey. It cannot be stained with J + KJ. It was impossible to prepare from the thin thallus a piece for cutting on the microtome. Its anatomical structure has therefore not been very accurately investigated.

The apothecia are scattered without any clear order, young and old being mixed together. They are at first cup-shaped with a distinct margin, fairly regularly circular. Later on they grow flat or convex, and the margin may disappear in the larger apothecia. The hyphæ run parallel in the usual way through the stipes and from there they radiate inside the calyx, on the surface of which they stand erect. The hymenium is stained blue with J + KJ. The asci, when ripe, are provided with 8 spores, about 10—15 μ long.

The colour is distributed as follows: the stipes and the calyx are dark brown, even in thin sections almost opaque. The apices of the paraphyses are of the same colour.

Besides, the paraphyses and upper hypothecium are colourless even in thick hand sections.

Pycnidia were not found on this specimen.

Specimen 2. The specimen investigated (on granite from »*Hammeren*«, *Bornholm*) has a thallus with a distinct dark margin and it touches a specimen of the same species. At a little distance from the margin the thallus is still greyish black and there arise gradually small whitish portions, the beginning to the areolæ. The fully developed thallus is areolate with plane or somewhat convex areoles which can attain a great thickness.

The black margin of the thallus contains no gonidia. The areoles have a thick cortex composed of living cells. The cortex covers even the vertical sides of the areoles, but disappears gradually towards the bottom of the cracks. The hyphæ stand almost perpendicular on the surface. No cuticle is developed.

The hyphæ of the gonidial layer are densely interwoven and are separated by indistinct intercellular spaces. The medullary layer is very thick with irregular hyphæ and with numerous small intercellular spaces.

The apothecia, young and old, are arranged in no definite order and are occasionally confluent. The very young ones are more or less regularly orbicular; the older ones are often in part confluent, in part sinuose. They stand above the level of the thallus. The margin is thick; the disk gradually becomes irregularly convex.

The inner structure of the apothecia is similar to that of specimen 1, also its coloration. In the specimen investigated ripe asci and spores were altogether wanting.

The thick areolate thallus and irregular apothecia of this specimen differ clearly from those of specimen 1, but the inner structure of the apothecium and mainly the disposition of its colours are just as in specimen 1. One might suppose that they both belonged to the same species. The thick thallus of specimen 2 and also the numerous apothecia may be supposed to be due to their habitat, the nutritive granite, while the thin thallus of specimen 1 is caused by the sandstone, which is poor in food materials.

The question however cannot be decided otherwise than by pure culture.

Specimen 3. This specimen (on a piece of bark, lying on the ground in the forest of *Bakkesvogn* and *Brudager*) was formerly determined by Th. Fries as »*Lecidea platycarpa* (*Ach*) *Th. Fries*, *corticola*«.

The thallus has no natural margin (the specimen is a fragment), it is very thin, and the form of its surface is completely dominated by the host plant's periderm which is peeling off, so that it is entirely covered by it as by a continuous layer. The colour is light green.

The cortical, gonidial, and medullary layers, and the rhizoidal zone merge into each other without abrupt transition. The cells of the cortex are living. No clear order of the hyphæ of the gonidial or medullary layer could be made out. The hyphæ of the gonidial layer form no haustoria to the gonidia.

The apothecia are scattered, young and old, among each other without any order. They are fairly regularly circular, with a distinct margin, also in old apothecia. At first they are somewhat concave, later on plane, and sometimes even a little convex, but never pronouncedly so.

The hyphæ run as usual in parallel bundles through the stipes, radiating from there in all directions inside the calyx, on the surface of which they stand erect. Asci clavate, with 8 spores, 14—15 μ long. The stipes have dark reddish-brown hyphæ, which during a part of their way to the surface of the margin are of a much lighter brown colour, to turn quite dark brown again on having reached the margin itself. The hypothecium is colourless, as are also the paraphyses at the base, whereas their apices are brown.

Pycnidia were not observed.

LECIDEA ALBOCOERULESCENS.

(WULF.) SCHÆR.

(Plate 89—90—91).

The specimen investigated was a fragment only, having lost its natural margin, growing on stone.

The thallus is ash-grey with a few spots of a somewhat darker grey shade. It is rimose or areolate. Not all the cracks represent accidental fissures, due to the drying up of the thallus, as they are provided with a distinct cortical layer.

The cortex has a thick, distinct cuticle composed of dead colourless hyphæ. It is continued into a living cortex composed mainly of erect hyphæ, the uppermost cells of which have dark walls and an aspect like a top-cell.

It is not quite clear how the cuticle is renewed. Apparently single hyphæ rise from the cortical layer above the level of the cortex, spread horizontally outwards, and are gradually changed into dead cuticle.

The cortex is continued down the outer sides of the areoles (fissures) but gradually disappear at the bottom.

The hyphæ of the gonidial layer are very densely interwoven, mostly stand erect, and very much resemble the hyphæ of the cortex.

The medullary and rhizoidal layers have much longer hyphæ, and they are rich in intercellular spaces, in which there are numerous mineral particles from the substratum.

The apothecia are scattered, young and old being found side by side. In some places they are confluent, but in most cases they have more or less regular circular outlines. They are situated on or only little above the level of the cortex. The margin is very thick and persistent; the disk is provided with a thick whitish-grey pruina.

The hyphæ run parallel through the stipes and from there radiate in all directions towards the margin, on which they stand erect.

There is a quite distinct, colourless hypothecium of ascogenous and paraphysogenous hyphæ. The paraphyses are branched towards the top, and not much thicker in their upper parts.

The asci are long, clavate, but in the specimen investigated they were all unripe and without spores.

The pruina is apparently the remainder of the cuticle which covered the apothecia before they broke through the cortex. The thick and high proper margin, which is the first to break through, is therefore soon free, while the deeper lying disk keeps its pruina for a long time. It is doubtful whether it persists in really old apothecia, at any rate it becomes stretched by the horizontal growth of the disk. The present specimen however does not tell us anything about this as the biggest (about 1 mm in diameter) were still young and without any spores.

The hyphæ of the stipes are of a deep dark brown, and on their way to the margin they become considerably lighter for a short distance, but on the outer surface of the latter they are again dark brown.

The real (ascogenous) hypothecium is colourless and so are the asci and paraphyses; only the apices of the paraphyses are olive-brown. All the coloured hyphæ have their pigment deposited mainly in the outer layers of the walls, the inner being colourless.

Pycnidia were not observed.

LECIDEA CRUSTULATA.

(ACH.) KÖRB.

(Plate 92—93—94—95—96—97—98).

Specimen 1, on stone.

The thallus in the present specimen has no natural margin. It is very thick and smooth and exhibits narrow cracks. The colour is light grey.

The cortex is (at any rate in places) brownish owing to exceedingly small particles of rust, which are deposited on the outer surface of the hyphæ. This is not clearly separated from the gonidial layer. The hyphæ of the latter do not exhibit any distinct direction of growth or any other definite arrangement. Their walls are thick.

The medullary layer has thick-walled hyphæ. The apothecia are irregularly scattered over the thallus, young and old close together. At first they are almost orbicular, cup-like, with a thick margin. Gradually they become plane or convex with a persistent margin. They have a shiny surface.

The hyphæ run as usual parallel through the stipes, radiating from there out to the calyx, on the surface of which they stand erect.

The asci are clavate, with 8 spores about 16 μ long. The stipes, calyx, and the tips of the paraphyses are a deep reddish-brown. The remainder of the hymenium is colourless.

Pycnidia were not observed.

Specimen 2, on stone (shist), *Grib Skov.*

The thallus has a very irregular, wavy outline and is very thin and smooth, and for the most part a deep greyish-black. In places, without any order, it is lighter grey, and such spots appear as small areoles on a dark background (formerly it would have been described as »having grey areoles on a dark hypothallus«).

Both the grey and the black parts of the thallus are provided with gonidia, which can be seen easily on teasing out some material.

The cortex has many dead hyphæ among the living ones. In some places the hyphæ run distinctly parallel to the surface of the thallus. In others they run more perpendicularly. The dark colour is due to a non-crystallized pigment in the walls of the hyphæ, which are here and there covered with particles of rust.

The apothecia arise on the thicker light coloured areoles; they are more or less regularly orbicular at first and concave with a thick margin; later on they are plane or convex, often with a margin, which may however disappear.

The hyphæ run as usual parallel through the stipes, radiating from there in all directions inside the calyx, on the surface of which they stand erect. The paraphyses are branched at the tips. Asci are numerous and on this specimen almost all unripe. A few of them had spores, measuring about 14—16 μ in length.

The hypothecium has distinct ascogenous and paraphysogenous hyphæ, which easily separate from one another.

The stipes, margin, and tips of the paraphyses are dark brown. The brown pigment is contained in the outer layer of the cell-walls, the inner layers of which are colourless.

Hymenium and hypothecium are colourless.

Pycnidia were found in great numbers on the dark parts of the thallus. Their ostioles are raised a little above the level of the thallus and contain numerous narrow, elliptic conidia (about 4 μ long).

Specimen 3, on stone. The specimen investigated was collected by HELLBOM in Bornholm and named as *Lecidea fuscorubens*. I think this is wrongly determined and I regard the specimen as a form of *Lecidea crustulata*, because it agrees very closely with other forms described in the present work under the name *crustulata*.

The thallus is greyish, smooth, thin, and provided with shallow fissures, i. e. it is indistinctly areolated. The cortex is composed of small cells; in its upper part it is coloured greyish owing to a non-crystallized pigment. Other details as regards the gonidial and medullary layers can be seen in the figure.

The apothecia have the same structure and colour both morphologically and structurally as *Lecidea crustulata*, specimen 1. The spores are about 10—14 μ long.

LECIDEA FUSCOATRA.

L.

(Plate 99—100—101—102—103—104—105—106—107—108).

Specimen 1, on stone (*Ravnholt*).

Thallus crustaceous, with a dark almost black faintly crenate margin. Just behind this begins a border of very small, low, and convex warts, which represent the first stages in the development of the areoles of the thallus. Further in follows the older, fully developed thallus, which is distinctly areolate and rimose. The young areoles are almost plane and have a very irregular outline. The older ones are often much thicker and have a convex surface. Upon examining a single old areole, one will find that it is shining and variegated in colour. It is for the most part brown of different shades in the convex parts of the areole, whilst it is greyish in the concave parts. The margin of the areole is often a lighter greyish or greyish-brown. The areoles overlap here and there. The cortex has on the outside a thick cuticle formed by the dead and compressed hyphæ. The whole cortex is thinner on the sides of the areoles and more weakly developed than on the upper surface. The hyphæ of the gonidial layer are short-celled and densely interwoven, the gonidia varying very much in size. The medullary layer is of a looser texture with numerous large intercellular spaces and it is continuous with the very loose tissue of the rhizoidal zone. The hyphæ of the gonidial and medullary layers stain reddish-violet with ZnCl + J, while the cuticle, cortex, and rhizoidal zone remain colourless.

The apothecia arise without order on the areoles. The young apothecia are plane with a distinct margin and regular orbicular or slightly irregular outline owing to mutual pressure when they are crowded. The older apothecia are always plane or only slightly convex, but often with a very irregular outline, and a distinct margin. They are often somewhat pruinose.

The course of the hyphæ of the apothecium is as usual: In the stipes they run parallel and radiate inside the calyx and the hypothecium, and stand almost perpendicular to the surface of the apothecium.

The ascogenous hyphæ are not easily visible as the hypothecium is dark brown.

The asci contain 8 spores, which are about 14 μ long, and contain oildrops.

The apothecium exhibits the following coloration: stipes and hypothecium are dark, appearing opaque brown even on very thin sections, the calyx being very faintly coloured in its inner parts, while the outer layers are dark. The paraphyses are brown at the top only, otherwise they are almost colourless. On very thick sections a faintly brownish shade is visible throughout the hymenium.

Pycnidia are numerous but mainly in the younger parts of the thallus.

The ostioles are slightly dark. They contain numerous rod-like conidia measuring about 12 μ in length.

Specimen 2 (from *Rørtang*), on stone.

This specimen has in every respect the same structure as regards the thallus as specimen 1, but differs from it by having all the older apothecia convex and without margin. The internal parts of the apothecium are also like those of specimen 1.

Specimen 3, on stone, has a thallus with a margin, which is black in some places, and light brown in others. The margin passes into a flat portion having exactly the same structure as specimen 1. Then follow the fully developed areoles.

Each single areole is shining, angular, slightly plane or convex, and brown in colour with a lighter grey edge.

Cuticle, living cortex, gonidial, medullary and rhizoidal layers have the same structure as specimen 1.

The apothecia are situated on the areoles and break through their surface, covered for a short time by the cortex which gradually disappears. They soon become very convex with an obsolete margin. The inner structure is the same as in specimen 1, as regards stipes, calyx, hypothecium, paraphyses, asci and spores.

Pycnidia are situated on the areoles. They are immersed and contain rod-like slender conidia about 10—12 μ long.

Specimen 4 (on stone). This specimen differs from specimen 1 mainly by having a whitish grey thallus and convex apothecia. The cause of the peculiar light colour of the thallus is easy to see from a microtome-section: the cuticle is much thicker than in specimen 1 and very farinose, and it peels off on the slightest touch. For that reason it reflects the light and appears white.

Below the dead cuticle follows a living, thick cortex, the upper cells of which have faintly brown walls. The thallus then appears brownish (as in specimen 1), when the cuticle is removed. In all other aspects the thallus is of the same structure morphologically and anatomically as specimen 1.

The apothecia are of the same internal structure as in specimen 1 (see the figures); they soon become convex and lose their margin.

The specimen belongs to the group of *Lecidea fuscoatra*, which has been named »*grisella*« FLK. I think it is closely related to *fuscoatra*.

[LECIDEA FUSCOCINEREA]

NYL.

(Plate 109—110—111—112).

This species is referred to in HELLBOM's »Bornholms lafvar«. It is not represented in any Danish collection accessible to me, and it is doubtful therefore whether it is really to be included in the Danish flora. Yet it does probably occur in our country. It is therefore described here. The specimen described was collected in Sweden.

The thallus has a narrow black margin, composed partly of single radiating hyphæ, and partly of narrow flat strips which anastome to form a net-like thallus. The areoles are angular and irregular by mutual pressure, and gradually arise on the black margin. Their surface is convex. The colour is dark brown and glistening.

The cortex is provided with a dead, colourless cuticle, which disappears on the sides of the areoles. Below this dead, follows a living cortex, composed of short-celled hyphæ, which stand more or less perpendicularly to the actual surface of the thallus. The upper cells just below the cuticle have a dark, brownish wall. The gonidial and medullary layers consist of short-celled hyphæ. The areoles as a whole may be very high, because the medullary layer is very thick. Only the upper parts of the medullary layer are colourless; the remainder is composed mainly of brown short-celled hyphæ.

The apothecia are situated on the surface of the areoles, 1—4 to each areole. They are oblong and irregular in outline with a thick persistent margin. The disk is flat or uneven.

The hyphæ run in the usual way parallel through the stipes, radiating from there in all directions inside the calyx, on the surface of which they stand erect. The ascogenous cells are not distinct. The paraphyses are slender. No ripe asci nor ripe spores were observed.

The apices of the paraphyses, the outer parts of the calyx and the stipes are brown. Otherwise the internal parts of the apothecium are colourless.

The pycnidia have a narrow, indistinct ostiolum and a colourless immersed perithecium, consisting of a very small-celled tissue composed of hyphæ, which radiate towards the centre of the perithecium. The sterigmata bear small straight conidia.

LECIDEA INTUMESCENS.

(Fw.) Nyl.

(Plate 113—114—115—116—117).

The specimen investigated was found growing in part on *Lecanora sordida* and in part on the bare rock.

The thallus is crustaceous and olive-brown in colour. The margin is in parts very dark, almost black. Small olive-brown areoles are developed on it. At a short distance from the margin the thallus has a slightly uneven surface or it is indistinctly areolate. Here and there it is slightly lobed.

Owing to its growing on the distinctly areolate thallus of *Lecanora sordida* one may get the impression that the *Lecidea* itself is areolate. But that is not so.

The relation of the two species to one another is the following.

When *Lecidea intumescens* growing on the areoles of *Lecanora sordida* reaches the edge of an areole, it is faced by the task of having to reach the next areole beyond. If the intervening crack is so narrow that the sides of the two areoles are in contact, then the *Lecidea*-thallus grows across the crack without entering it. If the crack is deep and the distance between the areoles considerable, the hyphæ of the *Lecidea* will grow down the sides of the one and up the sides of the other areole. If the gap is fairly broad only, but yet not narrow enough to be disregarded the Lecidean hyphæ form a very smooth shallow thallus on the sides of the areole, and this thallus will become thicker, and even slightly squamulose, when it reaches the top of the next areole. If the gap is very broad, even the vertical sides of the *Lecanora* areoles are covered with small squamules, and at last if the gap is very large indeed and even exposed to the light at the bottom (when for example the

Lecanora-thallus is in part dead) the *Lecidea* forms small squamules of its own on the bare bottom. The figures illustrate and explain this matter more clearly.

The cortex of the older parts of the thallus is provided with a thick cuticle, which later on covers the upper surface of the thallus, becoming more indistinct or finally disappearing from the sides of the areoles, and from the younger portions of the thallus.

The gonidial layer has few intercellular spaces. The medullary layer is thick, of a loose texture, and with extensive intercellular spaces. It is continued without a sharp limitation into the rhizoidal zone, which penetrates the thallus of *Lecanora sordida*, with the hyphæ of which it is so closely mixed up that it is often impossible to say which hyphæ belong to the one and which to the other species. In the end the *Lecanora* dies and is totally destroyed by the *Lecidea* and generally becomes brownish, having lost its gonidia.

After a general survey it seems certain that *Lecidea intumescens* is semi-parasitic. as it has its own gonidia. But one cannot put aside the possibility, that it has taken some food from the rocky substratum, here and there sending its own hyphæ in between the areoles of *Lecanora sordida* or perhaps even penetrating the thallus of the latter when this is destroyed. That *Lecidea* really does reach the rocky substratum between the *Lecanora* areoles is certain. Purely anatomical investigation however does not show whether *Lecidea* obtains all the necessary food from the rocky substratum or only a small portion from the *Lecanora* thallus, or whether the destruction of the *Lecanora* thallus is due merely to being overgrown by the *Lecidea* and owing to its being overshadowed.

The apothecia arise without any order, young and old side by side, and they become irregular in outline owing to lateral pressure. At first they are concave, later on more plane, and always provided with a thick margin. The hypothecium is colourless or faintly brownish, stipes and calyx however are dark brown, the rest of the apothecium being colourless. The spores are about 10 μ long.

Pycnidia were not observed.

LECIDEA TENEBROSA.

Fw.

(Plate 118—119—120—121—122—123—124—125).

Specimen 1. The specimen investigated, (growing on granite, *Bornholm*) has a thallus, the margin of which is dark grey and plane. From this dark part areoles arise which are lighter in colour though they remain a dark grey passing into a deep brownish shade. They are scattered near the margin but crowded together nearer the centre of the thallus where they form very convex areoles separated by deep fissures.

The cortical layer has a thick, colourless, and dead structureless cuticle. It is continued into a living cortex consisting of vertical hyphæ, the uppermost cells of which have very dark walls. The cortex is continued far down over the sides of the areoles, but in colour it gradually becomes less dark. The hyphæ of the gonidial layer run more or less regularly perpendicular to the cortex and a similar arrangement of the hyphæ can be observed far down in the medullary layer.

The apothecia occur singly or they may be crowded together on each areole. They are at first immersed, but in the end they raise at any rate the margin above the level of the cortex. Their outline is fairly regularly circular, but gradually it becomes irregularly sinuate.

The hyphæ run parallel to one another through the stipes and spread out cup-like up towards the margin, perpendicular to the cortex of the thallus. There is a distinct, almost colourless or at any rate very weakly brownish (ascogenous) hypothecium from which the clavate asci arise and also the thread-like, branched paraphyses. The spores are about 11 μ long.

The hyphæ of the stipes are brown; on their way towards the cortex of the thallus they turn a light brown colour (on very thin sections they appear colourless) when on a level with the hypothecium and hymenium, only to change colour to a dark brown in the margin (when on a level with the tips of the paraphyses). Some of the tips of the paraphyses are dark green, others seem quite colourless.

Pycnidia were not observed.

Specimen 2. On sandstone.

The thallus has a black margin composed of radiating hyphæ, which join in a narrow, thin margin. This only covers the substratum in part. Outside the continuous margin occur scattered, black spots of the same appearance as the margin. During a very close examination of preparations (deeply stained with *erythrosine*) it became clear that all these scattered portions of the thallus were connected with one another and with the margin partly by a few epilithic hyphæ, and partly also by endolithic hyphæ.

All the black portions of the thallus are alike in structure and are composed of epilithic almost black hyphæ, which creep over the substratum and form a cortex with almost globular cells. Below this is a deeper lying tissue of smaller, more oblong cells with lighter coloured dark-greyish walls, followed by an endolithic rhizoidal layer of colourless hyphæ. Very few gonidia were found here and there in the deeper parts of the black thallus, apparently resting directly on the rocky surface. The dark detached parts of the thallus outside the more continuous margin arise apparently in places, where the radiating, epilithic, or endolithic hyphæ from the margin find free gonidia on the surface of the rock, with which they enter into symbiosis. They are thus the first beginnings of the areoles, which later on become greyish-brown in colour.

Inside the black margin of the thallus follows the other thallus, composed of angular areoles with plane or faintly convex surface. All the areoles are connected with one another at their base.

The cortex of the areoles has a cuticle of dead, compressed, colourless cells, formed of the outer cells of the cortex which gradually die off, lose their colour, and become compressed. The outer cells of the cortex just below the cuticle are almost globular, with dark walls. The deeper layers of the cortex are composed of colourless but living cells. The hyphæ of the gonidial and medullary layers are short-celled and run almost upright in the thallus. It was easy in numerous cases to follow out single hyphæ and observe their course from the medullary layer through the gonidial layer and cortex right out to the surface of the latter and also to observe their ramification.

The apothecia are situated upon the areoles, frequently one to each areole. They are immersed, the surface of the hymenium being at the level of the surface of the thallus; here and there the margin is just slightly higher than this level. The apothecia are fairly regular in outline and have almost the same colour as the thallus, or they may be slightly darker.

The hyphæ run parallel through the stipes and from there vertically upwards to the surface of the thallus, forming an indistinctly developed calyx and a very indistinct margin.

The hypothecium is very distinct, being composed of small cells. Ascogenous cells are not easily seen.

The paraphyses are very slender and very short-celled, not thickened at the top, and they separate easily from one another.

The asci are narrow and slightly clavate. Ripe spores were not observed.

The colour of the epithecium is due to some extent to the numerous dark cells of the cortex, which originally covered the apothecium. They remain on the surface of the epithecium, closely fixed to the apices of the paraphyses, which are themselves almost colourless.

The calyx is almost colourless; yet just below the hypothecium it is a faint brown. Hypothecium and hymenium are almost colourless.

Pycnidia were not observed.

The specimen examined shows a very interesting biological phenomenon, in that it grows side by side with a sterile indeterminable thallus of a crustaceous lichen, probably a *Lecanora*, with which it is struggling for room for further growth. The *Lecidea* seems to be the more successful as it sends out black, radiating hyphæ into the spaces left between the areoles of its competitor, where these are separated from one another. The *Lecidea* in part is overgrowing the areoles of the other lichen.

This observation is suggestive of the way in which crustaceous lichens generally struggle with one another when growing on stone. They do not necessarily stop growing when they touch. It is actually possible that one specimen may overgrow the other and thus conquer the space occupied by it. The question of the competition among crustaceous lichens needs to be investigated more closely as we still know very little about it.

LECIDEA ERRATICA.

KÖRB.

(Plate 126—127).

The thallus is very thin and dark grey, almost black. Spread over its surface are numerous brownish-grey, thicker parts, coursed with cracks. The darkest portions of the thallus are the younger stages of development. Later on the lighter coloured make their appearance. The cortex is dark. The gonidial layer is composed of short-celled hyphæ. The medullary layer is poorly developed. No preparations of the rhizoidal zone of this specimen were obtained.

The apothecia grow out in no definite order, young and old being mixed together. At first they have a very distinct margin and are more or less circular. For some time they remain flat with a distinct margin. As they grow older, they become convex and lose their margin.

The hyphæ run in the usual way parallel through the stipes, and then radiate in all directions inside the calyx on the surface of which they stand erect. The ascogenous hyphæ of the hypothecium are not very distinct. The asci are large, and clavate with 8 spores, 8—10 μ long.

Distribution of colour: The stipes is of a deep brownish black, and in thicker sections opaque. The hypothecium is also very dark, but in very thin sections it appears that some of the hyphæ are almost colourless. The internal part of the calyx is colourless, the outside is black. The apices of the paraphyses are black with a greenish shade.

Pycnidia are numerous, the ostiole being surrounded by brownish hyphæ. The conidia are short, ellipsoid, and measure about 2 μ in length, and are frequently provided with 2 highly refractive drops (of oil?)

LECIDEA ELÆOCHROMA.

ACH.

(Plate 128 to 158).

Specimen 1 (on young smooth bark of oak).

The thallus has an oval outline with the longest diameter lying at right angles to the longitudinal axis of the tree.

The margin is slightly darker than the rest of the thallus which is of a greyish-green colour. The surface is very smooth and is uninterrupted by any fissures. The thallus is occasionally covered by the decayed bark of the substratum and the lichen is therefore hypophloeodic in places, but otherwise it is epiphloeodic. The cortex is very thin, and is made up of distinct cells. The gonidial layer is loose in texture and passes imperceptibly into the rhizoidal zone. The latter penetrates between the loose lamellæ of the bark, and thus helps to separate them.

Portions of the bark of the substratum are closely surrounded by the mycelium of the lichen, and they are destroyed and split into fragments, so that the lumen of each cell becomes compressed. Yet it is impossible to determine even with the aid of the microscope whether the lichen attacks the periderm chemically or not. Arguments can be found in support of either view.

A small plant of *Lecanora albella* with a single apothecium was found on the specimen under examination, and was completely surrounded by the *Lecidea*. It seemed powerless to grow any further.

The apothecia are scattered irregularly on the thallus, young and old being found side by side.

At first they are concave with a thick margin and a very regular orbicular outline. Later on they become plane, with a thick margin, and at length they become convex without a margin.

The hyphæ run parallel through the stipes and radiate from there in all directions inside the calyx, on the surface of which they stand erect. The hypothecium is thick and colourless. The paraphyses are slender and separate easily from one another. The asci have 8 spores (length about 14—18 μ).

In the stipes the hyphæ are brownish but on the way outwad to the calyx they lose most of this colour and become greenish or bluish on the outer surface of the calyx. Hypothecium and paraphyses are mainly colourless; yet the apices of the paraphyses are bluish-green. In very young apothecia the colour of the outer surface of the calyx and the tips of the paraphyses is generally a pure bluish-green, but in older apothecia the colour becomes more brownish.

The pycnidia have a distinct ostiolum raised slightly above the level of the thallus.

The conidia are long and curved.

Specimen 2 (on bark). The specimen consists of numerous small, closely crowded thalli, in touch with one another by their margins, which form black lines. They are very similar in regard to structure etc. Yet only one thallus has been described, in order to avoid every possibility of an error which might arise from an average description of all the specimens.

The thallus is epiphloeodic, thin, greyish, and of the same structure as the epiphloeodic parts of the thallus of specimen 1. The dark margin of the thallus was very closely investigated. It consists of hyphæ with thick walls of a grey colour due to the presence of a non-crystallized colouring matter deposited in the outer layers of the walls.

The hyphæ force their way between the lamellæ of the bark of the substratum. The greyish thallus begins farther back, and is provided with gonidia. As the gonidial groups are pushed out towards the margin of the thallus, the dark tissue in the margin itself becomes differentiated into the usual lichen tissues (cortex, gonidial layer, medullary layer, and rhizoidal zone).

The morphology of the apothecia is seen in the figures.

Pycnidia were observed in great abundance. They have a distinct ostiolum and contain long curved slender conidia.

Specimen 3. This specimen was carefully investigated on account of its black »hypothallus« and distinct method of development of its thallus. The specimen is very small and consists of several individuals separated from one another by dark lines, and living on the smooth young bark of a tree, the specific name of which could not be determined.

It shows very plainly the development of the thallus which takes place in the following way: along the margin there is a black »hypothallus«, consisting of numerous dark brown hyphæ which are richly branched and are in part hypophloeodic, in part epiphloeodic. The periderm splits off — owing to tension due to growth — in thin lamellæ like the much larger lamellæ of the periderm of trees with a scaly bark, as *Pinus, Ulmus* etc. Here and there in the »hypothallus« groups of crowded hypophloeodic cells occur, the meaning and the later development of whcih could not be clearly made out in this specimen. Very possibly some cells of the substratum specially rich in food material have called forth this abundant cell formation, or the latter may represent the beginning of the gonidia-containing areoles. It must be emphasised that this possibility is only a supposition, since I have not succeeded in finding gonidia in any one of the cell-groups.

The first gonidia-containing areoles are formed inside the periderm without any order. I have only seen the fully developed areoles; their first stages of development are therefore unknown. They grow larger and gradually change from a fairly regular roundish to a quite irregular form. At first they are covered by the periderm, but later on they are more or less exposed as the lamellæ of the periderm become separated from each other by growth, and the thallus of the lichen overruns the lamellæ and covers them with its mycelium. The areoles of the thallus exhibit for some time on their surface the remains of the »hypothallus«. This means that the hypothallus when encountering the gonidia overran them and thus formed the primary cortex of the thallus. This cortex later on breaks up into portions which become separated from one another by the further growth of the lichen, so that later on they are seen only as dark spots distributed irregularly over the surface of the fully developed lichen. Along the margin of the thallus the primary cortex is preserved as a dark continuous border.

Specimen 4, on bark of Cratægus.

This specimen was investigated mainly because it bore well marked soralia with light green soredia, thus differing from specimens previously examined.

Otherwise the thallus was of the same structure as in specimen 1. The apothecia conform entirely to those of specimen 1, both as to the size of the spores, and the slender, very loose paraphyses, and the distribution of colour in the inner parts etc.

Specimen 5, on *Acer platanoides.*

This specimen was investigated mainly because it showed a series of fissures originating from the secundary growth of the plant forming the substratum.

At the end of summer the bark of the tree splits and forms numerous narrow fissures owing to the secundary growth of the stem during the summer. The fissures run parallel to the longitudinal axis of the stem and both bark and the lichen-thallus on the bark crack. The deeper parts of the latter are exposed. The fissures formed in this way are healed over by regeneration which takes place in a way described in detail in the figures. Otherwise the specimen is of the same structure as specimen 1 in regard to the apothecia (spores, asci, paraphyses, stipes, calyx, etc.).

Specimen 6, on bark.

This specimen has a thallus, the margin of which is sorediose and the centre quite smooth, showing here and there narrow fissures formed by the drying up of the thallus. The whole thallus is straw-coloured. The apothecia are in all respects of the same structure and colour as those of specimen 1.

Specimen 7, on *Fraxinus excelsior.*

This specimen is very striking, the apothecia having a light disk of much the same colour as the thallus. It was found on a close investigation that all apothecia were almost completely without a hymenium. It was impossible to see from sections whether this was due to the attacks of an insect or other causes, or whether it was congenital. One apothecium alone was normal shaped but it had not yet got ripe spores.

Specimen 8, on bark.

This specimen was investigated mainly because it has a thallus which is nearly orbicular, while all the other specimens described owing to their growing on the bark of trees have an oval outline. This specimen too grows on bark, but on a flaky bark of a tree, the specific name of which could not be determined. The separate flakes of this bark are not stretched by the growth of the tree but are simply split off. It is clear that under these circumstances one would not expect to find an oblong thallus.

The cells of the periderm forming the substratum are isodiametric, and so do not favour the growth of the lichen in any one particular direction. Bioret would probably connect the orbicular outline of the lichen-thallus with the isodiametry of the periderm cells, and there is some justification for this.

But the outline of the thallus may be due to the fact, that the cells of the periderm have not become stretched during growth — and possibly the isodiametry of the periderm cells may be due to the same cause.

The thallus is slightly yellowish-green, finely granular but not sorediose.

The apothecia, the distribution and morphology of which is seen in the figures have a disk that becomes somewhat lighter when moistened, whilst the margin remains black. Paraphyses, asci, and spores are the same as in specimen 1.

Specimen 9, on bare wood.

This specimen which many years ago was determined as a form of *Lecidea elæochroma*, I will still describe under that name, though with some hesitation.

The thallus is oblong, stretched in the direction of the fibres of the woody substratum and made up of numerous small granules, which are joined by a common basal part. They do not grow in any definite direction, but remind one of the thallus of *Psora* and they really form a transition from the genuine crustaceous to the squamulose thallus. The young granules (or areoles) are low and convex, later on they become more squamulose and can even overlap one another.

The cortex is mostly dead, and consists of indistinctly limited hyphæ. Here and there single living cells or groups of such are seen among the dead ones. In the cortex much finely granular rust-coloured matter occurs as a deposit on the surface of the cell-walls.

The gonidial layer has very loosely interwoven hyphæ; the medullary layer is still looser in texture, with large intercellular spaces. The rhizoidal layer penetrates into the woody substratum, and the hyphæ run mainly along the cells of the wood and along the pith-rays. It is not possible to say whether the substratum is attacked chemically by the hyphæ or not.

Old and young apothecia are scattered irregularly over the thallus. The youngest are concave but soon become convex without a margin. The hyphæ run in bundles through the stipes and radiate from there in all directions inside the calyx and the hymenium. In the hypothecium the ascogenous hyphæ are large and distinct. In the stipes there occur numerous big drops of an oil-like substance. Asci and spores are like those of *Lecidea elæochroma*, specimen 1, but the paraphyses are not free as in all the specimens hitherto described, but are conglutinate. The tips of the paraphyses are bluish-green to olive-green. The rest of the apothecium is more or less bluish-green to olive-green in the margin, calyx, stipes and hypothecium.

Pycnidia were not observed.

The form of the thallus, the early convexity of the apothecia, the internal colour (mainly greenish) of the latter, and the conglutinate paraphyses plainly separate this specimen from all the specimens previously mentioned. Owing to the similarity of the spores, the blue apices of the paraphyses, the structure of the calyx, I still believe that it is related to them.

The olive-green shade of colour in the inner parts of the apothecium may be supposed to have originated from a mixture of the very two colours that are common to all the preceding specimens, namely: brown and bluish-green (or pure blue).

Specimen 10, on bare wood.

The thallus is drawn out in the direction of the fibres of the woody substratum. It is flat and broken up by fissures, the fissures due to the drying up of the wood going completely through the thallus of the lichen. They are most distinct when parallel to the fibres of the wood, but some are also plainly visible when running across them.

The cortex is thick, and consists of hyphæ without distinct outlines and without distinct cell-cavities. The gonidial and medullary layers are considerably more densely woven than those of specimen 9 (which was also found on dead wood).

The hyphæ of the rhizoidal zone penetrate into the woody substratum and take an intercellular and intracellular course. It was impossible to make out whether the walls of the wood were attacked by the hyphæ or not.

The apothecia arise without any order on the thallus, young and old being found close together; they are either orbicular or from mutual pressure angular, and for the most part they stand in rows corresponding to the fibres of the substratum. The younger ones are concave with a thick margin, the older ones are convex without a margin. The principal stages in their development were investigated and found to take the following course in the present specimen. In the thallus above or between the gonidia arise the coiled »carpogonia« with trichogynes in crowded groups, so that each apothecium develops from several carpogonia. The trichogynes had not in this specimen reached the surface of the thallus. It is impossible to say whether this means that they were not fully developed or that they would not at all reach the surface.

The behaviour of the nuclei during the development could not be determined. Gradually a calyx is developed below the carpogonia and this is provided with a stalk (stipes) composed of vegetative hyphæ. In the hollow of the calyx the carpogonia which give rise to an apothecium are surrounded by numerous vegetative hyphæ. When the young apothecium still lies below the surface of the thallus, a hymenium is already formed by the vegetative hyphæ in the calyx; it consists only of paraphyses; asci are still absent. The apothecium now breaks through the surface of the thallus by the stipes growing in length and lifting the calyx and its contents of paraphyses and other vegetative hyphæ (which give rise to all further paraphyses) together with the carpogonia through the cortex of the thallus, portions of which can for some time be seen on the disk of the apothecium. Not until the apothecium has broken through the cortex and is situated on its very surface, do the asci grow up from the carpogonia of the hypothecium and get wedged in between the paraphyses. Thus many very young apothecia without asci are to be found on the thallus. The carpogonia lose the trichogynes at an early stage; they become invisible as soon as the paraphyses are formed. The remainder of the ascogenium remains in the hypothecium and in time forms new asci.

Microtome sections did not show whether fertilisation takes place, and if so, how and at what stage in the plant's development. In the fully developed apothecium the hyphæ run as usual parallel through the stipes and then radiate from there in all directions inside the calyx. In the young apothecia they run upwards in a direction towards the cortex. The paraphyses easily separate from one another. The asci are clavate and provided with 8 spores.

The pycnidia have a slightly dark ostiolum and an immersed flask-shaped perithecium formed of densely interwoven small-celled hyphæ with brown walls.

The colourless conidia-bearing hyphæ are formed from the inner surface. The conidia are 17—18 μ long, and are slender and curved.

Specimen 11, on stone.

The specimen investigated had lost its original margin.

The thallus is rather thick and slightly verrucose, uneven, and rimose, and greyish in colour. Where it spreads over grains of quartz, no single hypha nor any dark »hypothallus« is visible as in many other crustaceous lichens, but in such places the thallus is servediose or farinose.

The cortex occasionally consists of living hyphæ, but for the most part of dead hyphæ, which exhibit no clear structure. Numerous very small rust-like granules are visible in the cortex. It is difficult to say whether these grains represent a mere excretion which is later got rid of with the dead cortex, or whether they act as a protection for the gonidia against too intense light. The gonidial layer and the medullary layer consist of loosely interwoven and small-celled hyphæ. The rhizoidal layer is of still looser texture with extensive intercellular spaces and long-celled hyphæ.

The apothecia are irregularly spread over the thallus, young and old apothecia being mixed together. Their outline is at first rather orbicular or slightly sinuose, later on more distinctly sinuose. The apothecia have at first a thick margin, which they often retain as they get older. The disk is concave or plane, a few apothecia showing a slight convexity. The hyphæ run parallel through the stipes and radiate from there in all directions into the apothecium. The hypothecium is clearly outlined and provided with distinct ascogenous hyphæ. The ascus has 8 spores (length about 14 μ). The calyx has very thick peripheral hyphæ, which are slightly greyish-black at the top. The figures clearly show the distribution of colour in the internal parts of the apothecium. The paraphyses easily separate from one another.

The pycnidia are flask-shaped; the ostiolum is, like the wall of the perithecium darkish brown in colour. It is lined by the conidia-bearing hyphæ. The conidia are slender and curved.

Specimen 12, on stone.

This specimen is a yellowish grey and highly sorediose. Otherwise the apothecium has in every way the same structure as that of specimen 11.

Pycnidia were not observed.

Specimen 13, on sandstone.

The thallus spreads over the sandstone. It consists of single hyphæ (»hypothallus«) and strands of hyphæ that spread among and partly over the grains of sand and form here and there very small thallus-areoles about 0.1 mm in diameter. Numerous colourless rhizoids penetrate into the stone.

The anatomy of the areoles was not investigated closely.

The apothecia are scattered without order over the substratum and doubtless arise in the areoles containing gonidia. They are at first concave and possess a thick margin and a somewhat irregular outline. In the end they are convex without a margin. They are occasionally crowded. The colour of the inner parts of the apothecium differs from all the preceding specimens in that the tips of the paraphyses and the calyx (at the periphery) are dark olive-green, whilst the stipes and hypothecium are a very faint brown colour, or almost colourless. Asci and paraphyses are otherwise the same as in all the previous specimens, the paraphyses easily separating from one another and the spores (8 in each ascus) being large and elliptical in shape.

LECIDEA VITELLINARIA.

Nyl.

(Plate 159—160).

The specimen investigated was found growing on the thallus and apothecia of *Lecanora polytropa* in the vicinity of *Skaarup*. This species is probably a parasite. Only the apothecia can be clearly distinguished, the specimen having no definite thallus.

The apothecia have a stipes which originates deep down in the apothecium of *Lecanora polytropa*. No distinct line limiting stipes and hypothecium can be made out. The hyphæ run as usual parallel through the stipes, radiating from there in all directions to the margin of the apothecium, on the surface of which they stand erect.

The paraphyses are clavate, with 8 spores (10—12 μ long). The hyphæ of the stipes are a little brownish, or almost colourless, being a little darker where they touch the hyphæ of the *Lecanora*. The calyx is very dark brown on the outer surface. The paraphyses are blue at the top and almost colourless at the base.

Pycnidia were not observed.

The nature of the parasitism in this species is not quite clear. It is difficult to see whether the apothecia have an independent thallus or not. One cannot settle what belongs to the thallus of *Lecidea* and what to that of *Lecanora*; no distinct limit can be pointed out between the hyphæ of both. It cannot even be determined whether the *Lecanora* suffers any damage by the symbiosis with the *Lecidea;* the hyphæ of the former seem to remain quite undamaged both in the apothecia and in the thallus attacked by *Lecidea*. Nor do the gonidia show any extraordinary development; they seem in all respects quite normal.

This species seems to be nearly related to *Lecidea elæochroma*.

PLATES

PLATE 1.

LECIDEA (BIATORA) RUPESTRIS
ACH.

Fig. 1. Epilithic areoles, which in places are dark greenish-grey owing to the spheroidal cells. 2 apothecia. (×45).

Fig. 2. Section of thallus with large spheroidal hyphæ, a group of gonidia and small-celled hyphæ. (×450).

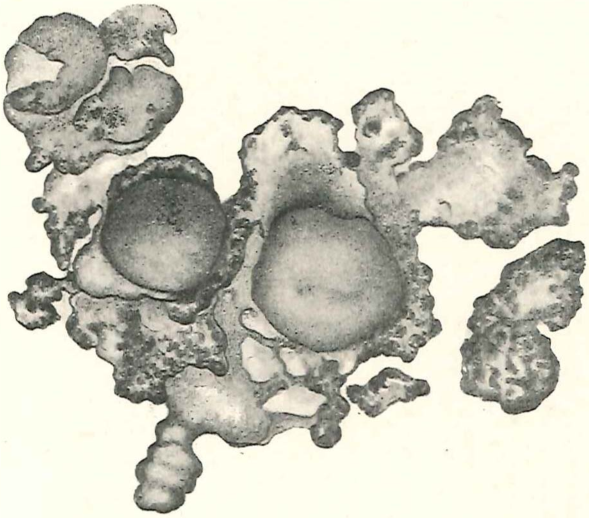


Fig 1

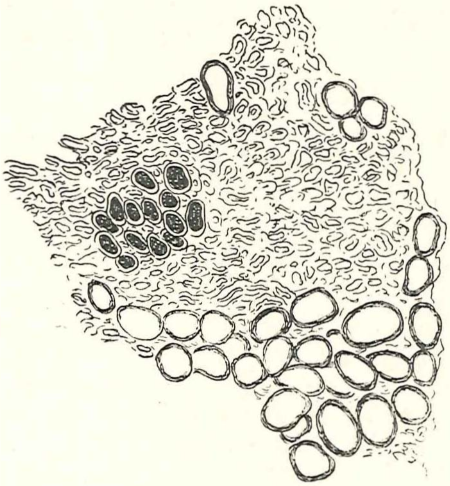


Fig. 2

O. Galløe del.

LECIDEA (BIATORA) RUPESTRIS Ach.

PLATE 2.

LECIDEA (BIATORA) RUPESTRIS.

Ach.

Fig. 3. Above, rhizoidal hyphæ picked out of the limestone.

Below, 2 groups of spheroidal hyphæ (seen from above) spread over the substratum, (directly below them are found in the substratum those hyphæ which are shown above in the fig.) (×450).

Fig. 4. Margin of apothecium with distinct coloured grains among the paraphyses, several unripe and one ripe ascus with spores, and distinct ascogenous hyphæ. Thallus with distinct gonidia. (×450).

PLATE 2.

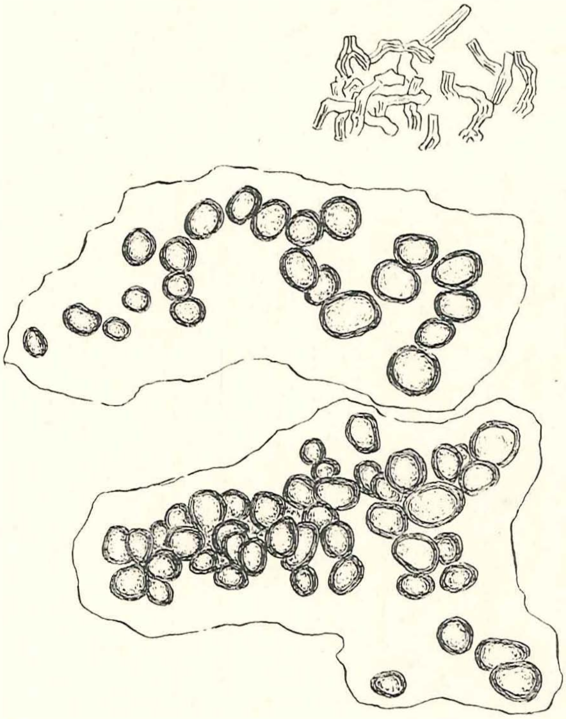


Fig. 3

Fig. 4

O. Galløe del.

LECIDEA (BIATORA) RUPESTRIS Ach.

PLATE 3.

LECIDEA (BIATORA) RUPESTRIS.

Ach.

Fig. 5. General view of thallus. All these areoles are probably connected through a common rhizoidal part inside the stone, but it is just possible that they are really separate individuals. (× 15).

Fig. 6. An apothecium showing the distribution of colour. (× 60).

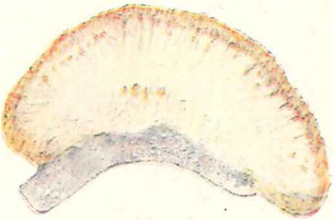


Fig. 6

Fig. 5

O. *Galløe del.*

LECIDEA (BIATORA) RUPESTRIS Ach.

PLATE 4.

LECIDEA (BIATORA) QUERNEA.

DICKS.

Fig. 7. To the left: Distribution of colour in the apothecium. (×60). To the right: Two apothecia. (×15).

Fig. 8. Thallus with apothecia in all stages of development. (×15).

PLATE 4.

Fig. 7

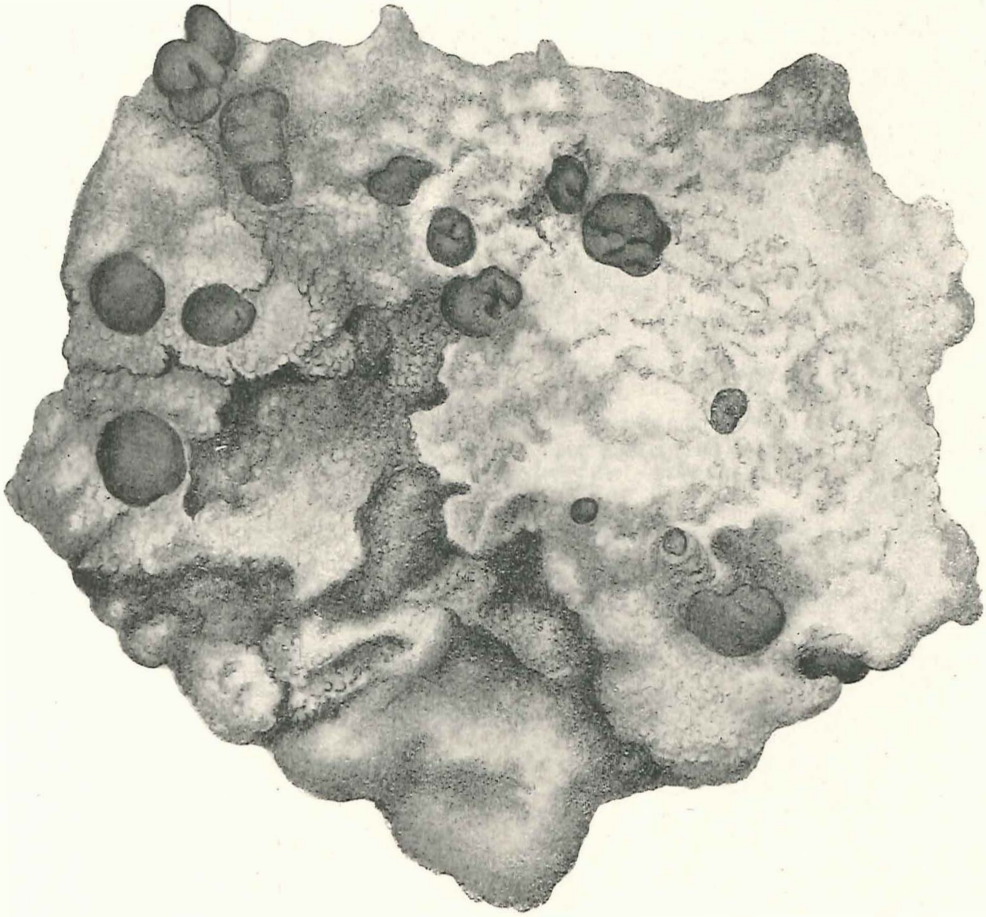


Fig. 8

O. Galløe del.

LECIDEA (BIATORA) QUERNEA Dicks.

PLATE 5.

LECIDEA (BIATORA) QUERNEA.

Dicks.

Fig. 9. Section of thallus with an apothecium. The upper layer of the periderm of the oak is discoloured, perhaps through the attack of the lichen. The deeper lying layers, on the contrary, are of a dark colour. (×60).

Fig. 10. Thallus with numerous dark remains of destroyed oak-bark. The thallus is in this spot partly hypophloeoidal with gonidia situated among the lamellæ of the periderm. (×450).

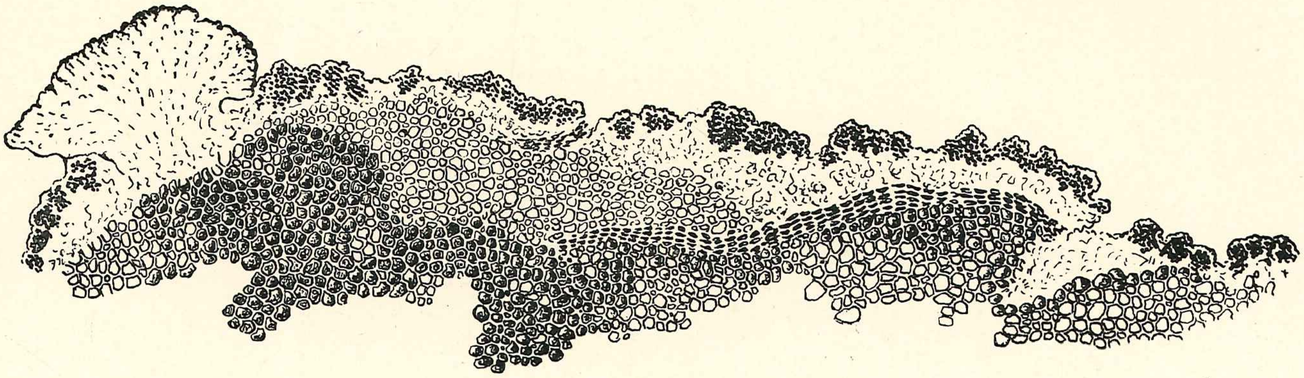


Fig. 9

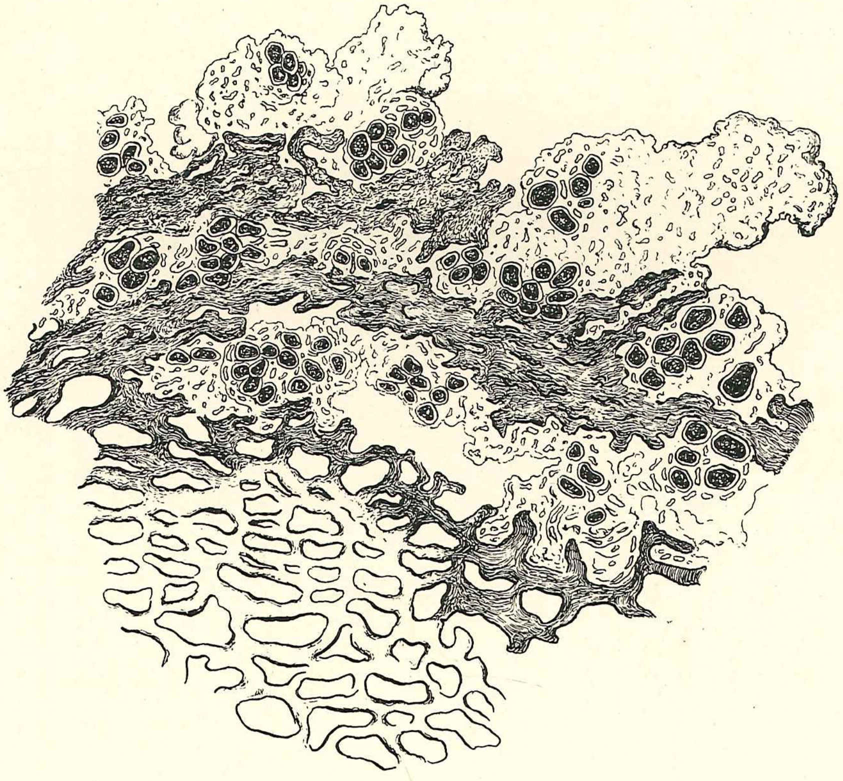


Fig. 10

O. Galløe del.

LECIDEA (BIATORA) QUERNEA Dicks.

PLATE 6.

LECIDEA (BIATORA) QUERNEA.

DICKS.

Fig. 11. At *a* a greatly destroyed lamella of the periderm is coming out through the thallus. It has compressed cell lumina; the boundary line between the lichen and the oak-bark is indistinct. (×450).

Fig. 12. Margin of apothecium, at the foot to the right bordering on the thallus; the latter with 10 gonidia. To the right of the apothecium a spore. (×450).

Fig. 13. Hymenium and asci, and, in the epithecium, numerous very small grains of colour. In the hypothecium very distinct ascogenous hyphæ are seen. (×600).

PLATE 6.

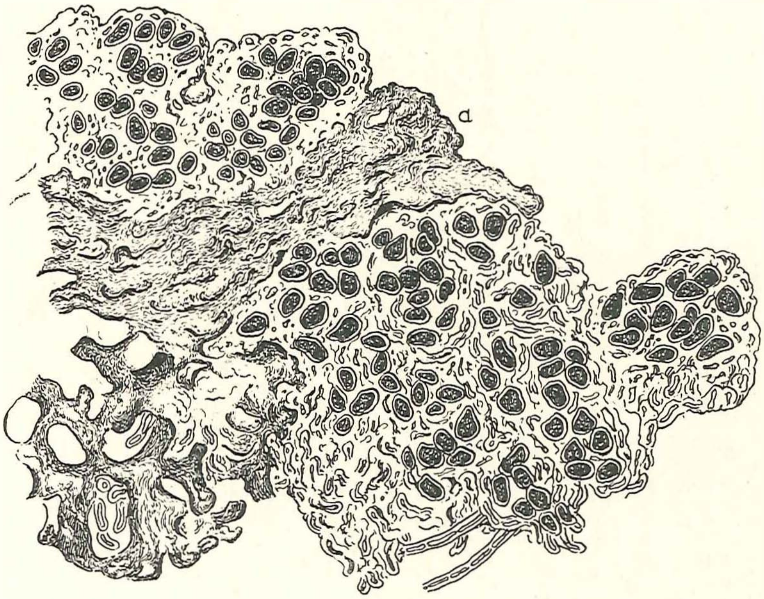


Fig. 11

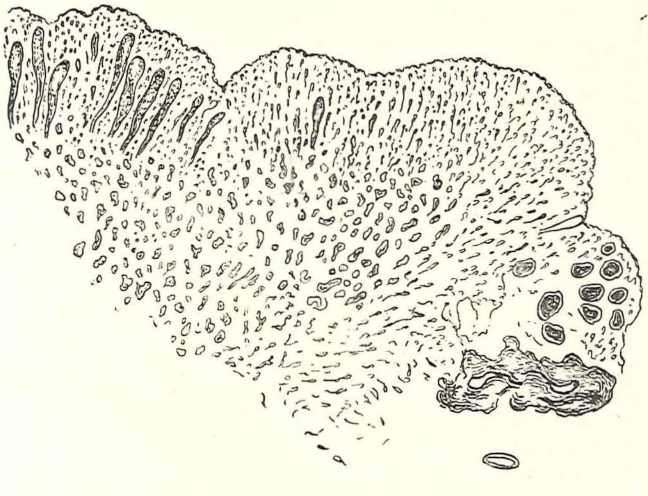


Fig. 12

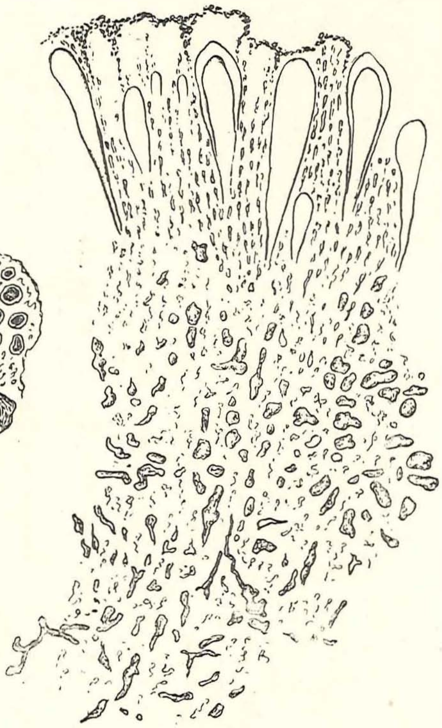


Fig 13

O. *Galløe del.*

LECIDEA (BIATORA) QUERNEA Dicks.

PLATE 7.

LECIDEA (BIATORA) LUCIDA.

ACH.

Fig. 14. Distribution of colour in the apothecium. (×60).

Fig. 15. Margin of thallus showing (to the right) here and there free hyphæ radiating outwards, and outside these some isolated small thalli (about the origin of which see the text). The darker parts to the left in the drawing are the bare substratum (flint). (×45).

Fig. 14

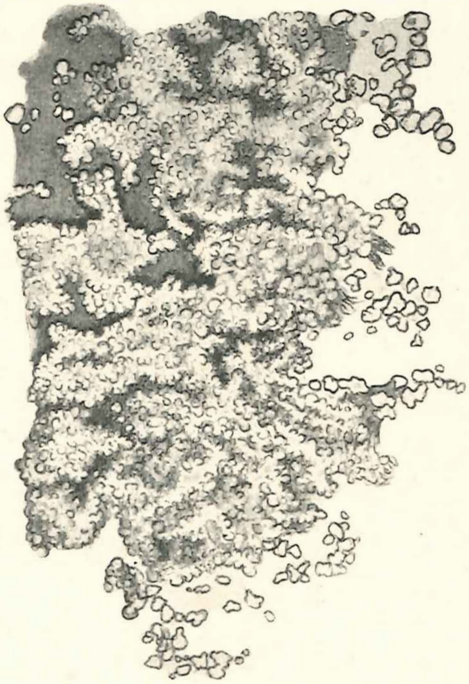


Fig. 15

O. Galløe del.

LECIDEA (BIATORA) LUCIDA Ach.

PLATE 8.

LECIDEA (BIATORA) LUCIDA

ACH.

Fig. 16. Part of thallus with fissures (the dark, broad, ribbon-formed parts) caused by drying up, and three apothecia more or less concealed by the thallus. (×45).

Fig. 17. Vertical section of thallus with gonidia and hyphæ. (×450).

Fig. 18. To the right a vertical section of apothecium and thallus. (×60). To the left a portion of the hymenium with 3 young (sporeless) asci and paraphyses. (×450).

PLATE 8.

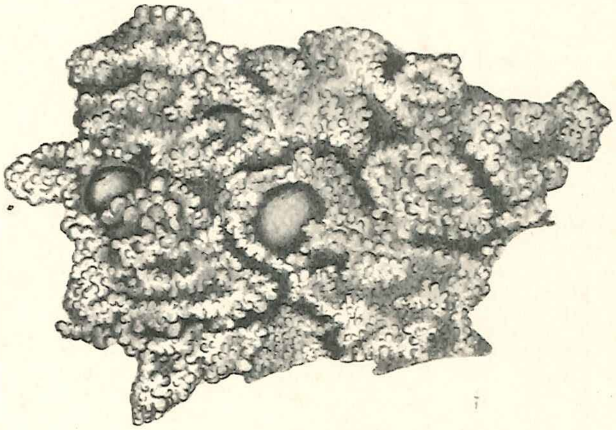


Fig. 16

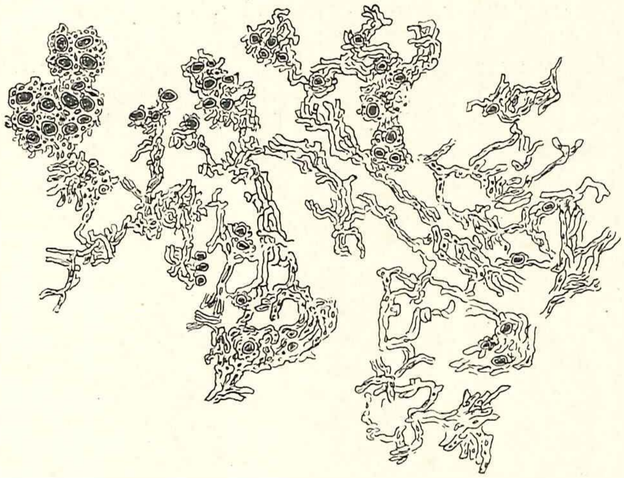


Fig. 17

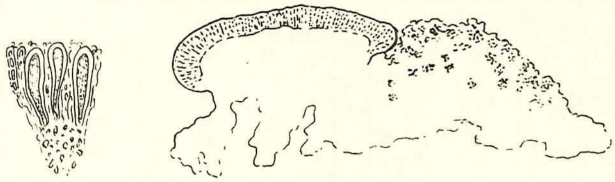


Fig. 18

O. *Galløe del.*

LECIDEA (BIATORA) LUCIDA Ach

PLATE 9.

LECIDEA (BIATORA) FUSCA.

SCHÆR.

Specimen 1 and **specimen 2.**

Fig. 19, specimen 1: Distribution of colour in the apothecium. (×60).

Fig. 20, specimen 2: Two apothecia (in moistened state) and a section of an apothecium. (×60).

PLATE 9.

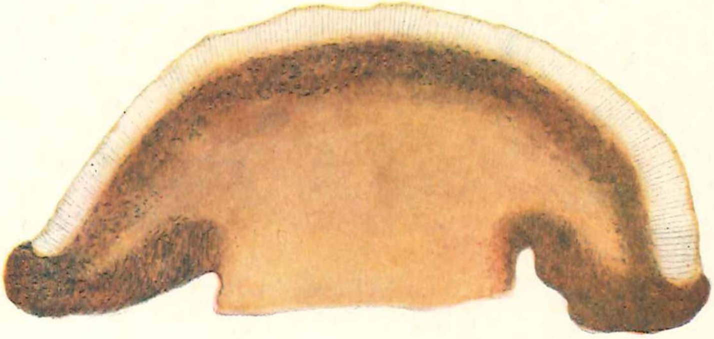


Fig. 19

Fig. 20

O. Galløe del.

LECIDEA (BIATORA) FUSCA Schær.
(Specimen 1 and 2)

PLATE 10.

LECIDEA (BIATORA) FUSCA.

SCHÆR.

Specimen 1.

Fig. 21. Thallus with apothecia at all ages. (×15).
Fig. 22. Margin of the apothecium. (×450).

PLATE 10.

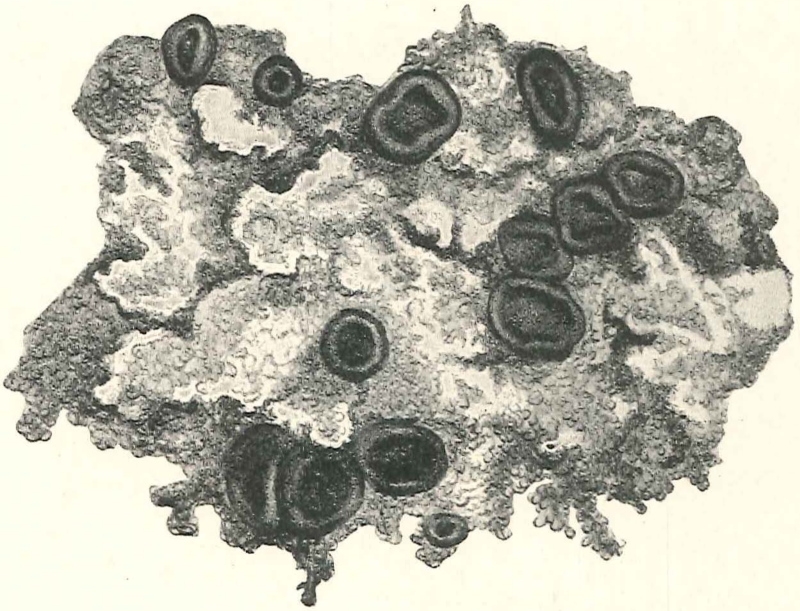


Fig. 21

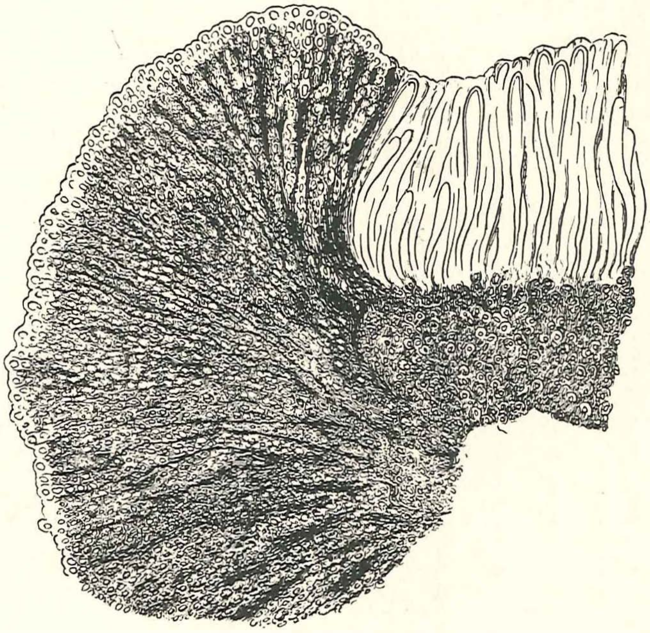


Fig. 22

O. Galløe del.

LECIDEA (BIATORA) FUSCA SCHÆR.
(Specimen 1)

PLATE 11.

LECIDEA (BIATORA) FUSCA.

SCHÆR.

Specimen 1.

Fig. 23. Vertical section of thallus; at *a* remains of a moss leaf. (× 450).

Fig. 24. Apothecium. (× 60).

PLATE 11.

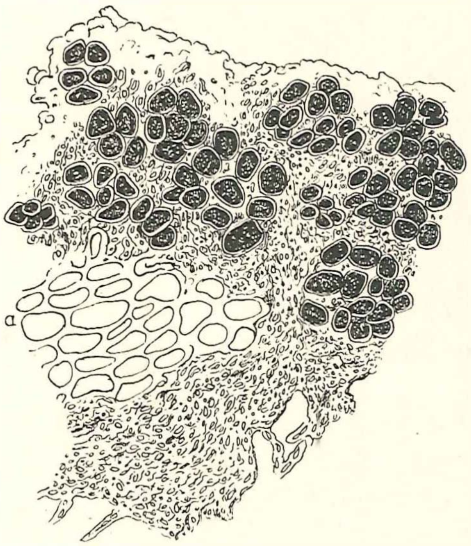


Fig. 23

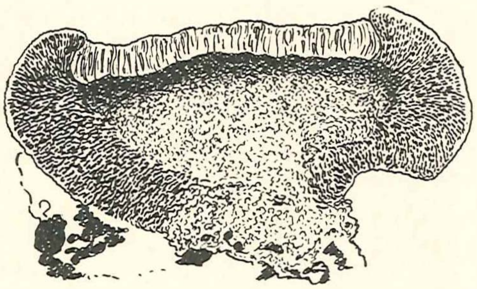


Fig. 24

O. Galløe del.

LECIDEA (BIATORA) FUSCA Schær.
(Specimen 1)

PLATE 12.

LECIDEA (BIATORA) FUSCA.

SCHÆR.

Specimen 2.

Fig. 25. Apothecia at all ages. At a young specimens of *Lecanora tartarea*. (×15).
Fig. 26. Apothecium. (×60).

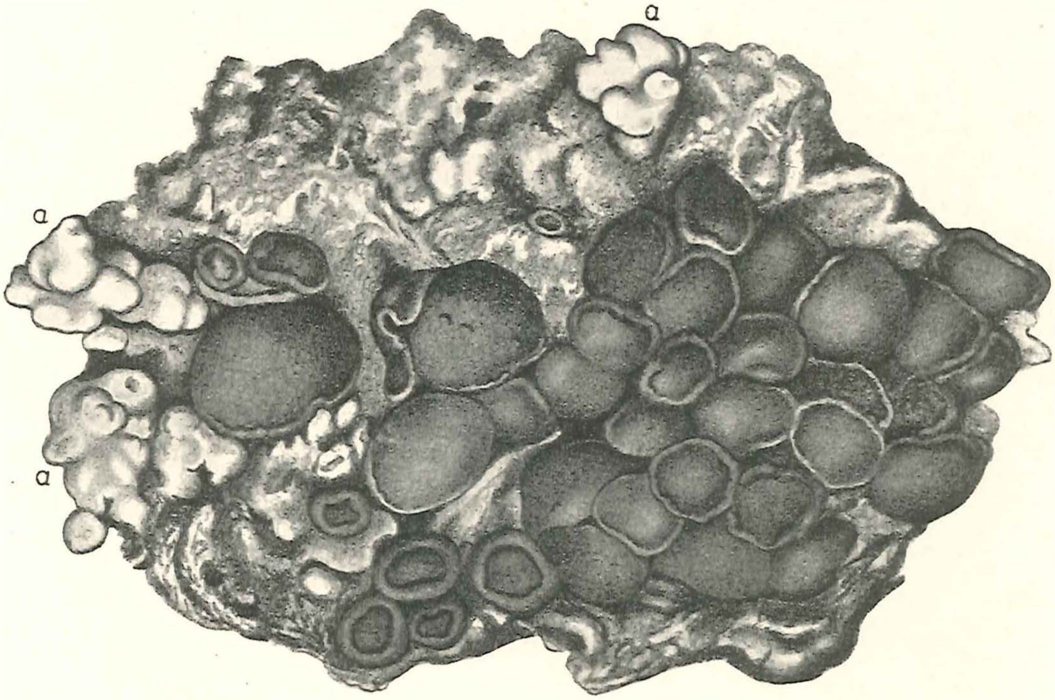


Fig. 25

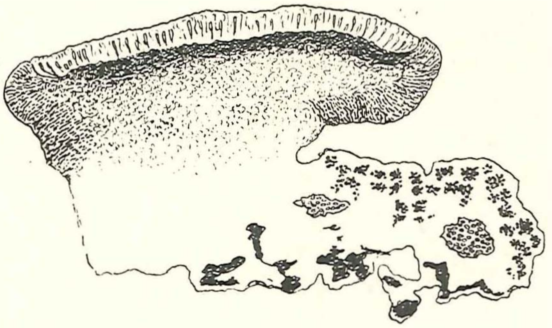


Fig. 26

O. Galløe del.

LECIDEA (BIATORA) FUSCA Schær.
(Specimen 2)

PLATE 13.

LECIDEA (BIATORA) GEOPHANA.

NYL.

Fig. 27. Thallus with apothecia. (× 15).

Fig. 28. Portion of thallus with 4 apothecia in various stages of development. (× 45).

Fig. 29. Above, an apothecium. Below, the same in vertical section.

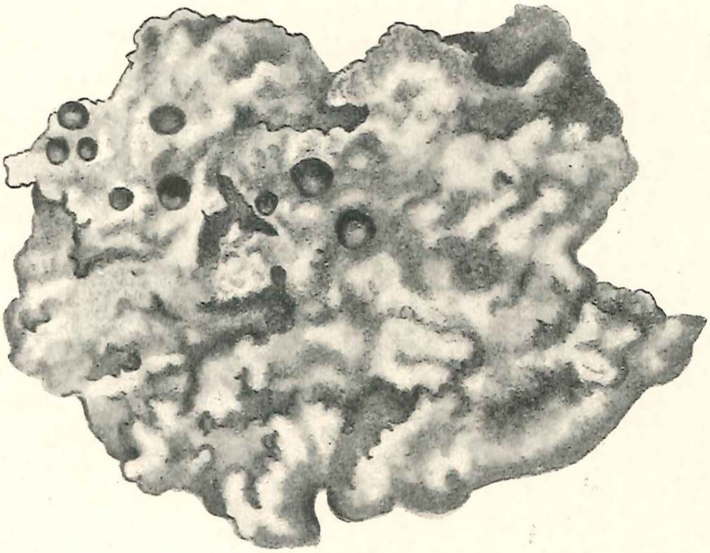


Fig. 27

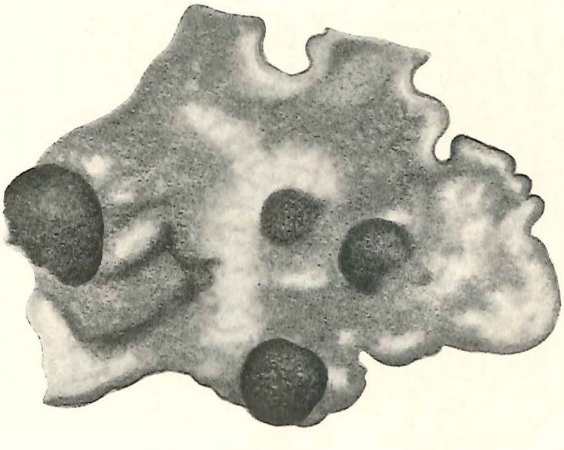


Fig. 28

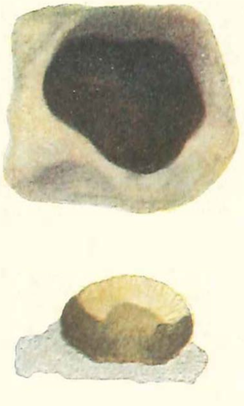


Fig. 29

O. Galløe del.

LECIDEA (BIATORA) GEOPHANA Nyl.

PLATE 14.

LECIDEA (BIATORA) GEOPHANA.

NYL.

Fig. 30. Fragment of thallus in vertical section. The black parts are the chlorogonidia. (×60).

Fig. 31. Portion of normal thallus with chlorogonidia. Below, the rhizoids. ×450).

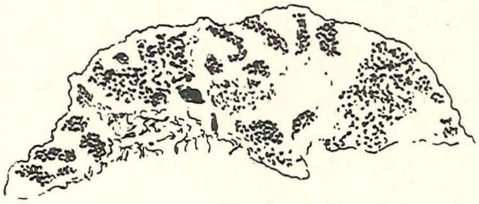


Fig. 30

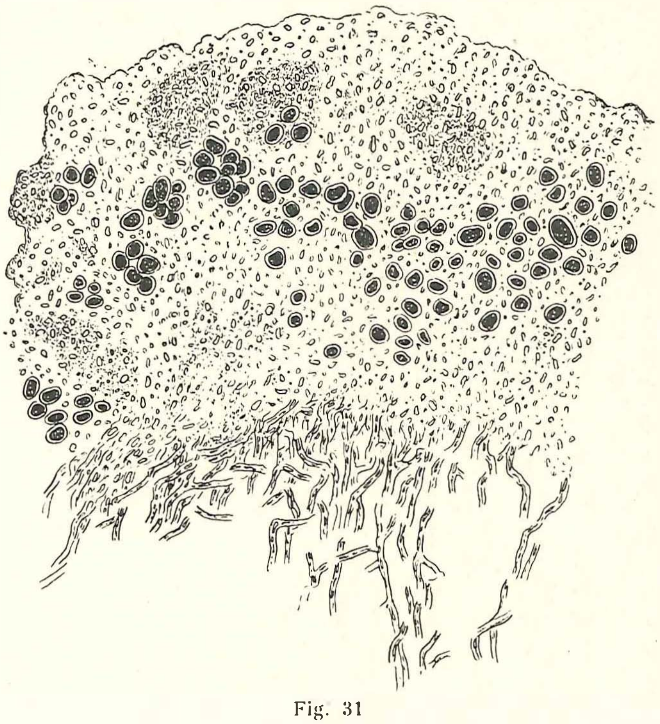


Fig. 31

O. Galløe del.

LECIDEA (BIATORA) GEOPHANA Nyl.

PLATE 15.

LECIDEA (BIATORA) GEOPHANA.

NYL.

Fig. 32. Portion of thallus containing *Gloeocapsa* (at *a* several specimens are very distinct because the cell-wall is double: at *b* the limits between the cells are not visible; the hyphæ penetrate the gelatinous matter).

Two groups of normal chlorogonidia, some of which are discoloured and dead, injured by the presence of Gloeocapsa. (×600).

Fig. 33. Ascus with spores. (×450)

PLATE 15.

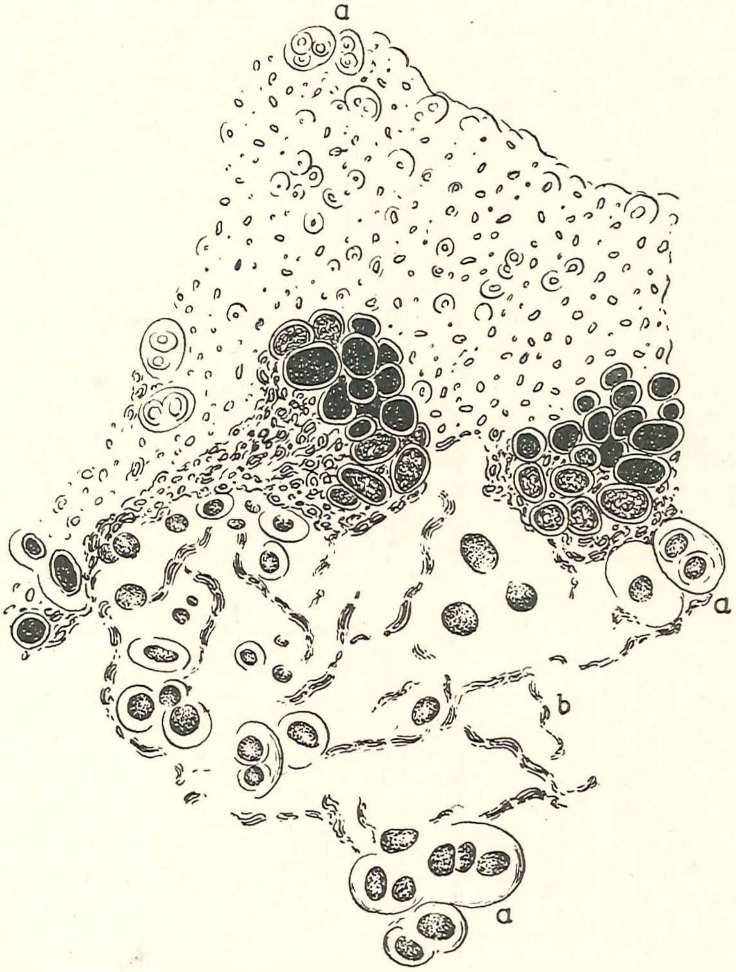


Fig. 32

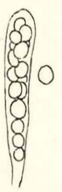


Fig. 33

O. Galloe del.

LECIDEA (BIATORA) GEOPHANA Nyl.

PLATE 16.

LECIDEA (BIATORA) GRANULOSA.

EHRH.

Specimen 1, specimen 2 and specimen 3.

Fig. 34. Specimen 1, to the left: thallus with apothecia. To the right: section of an apothecium.

Fig. 35. Specimen 2, thallus with apothecia (×15).

Fig. 36. Specimen 3, to the left: thallus with apothecia. (×15). To the right: section of apothecium. (×60).

PLATE 16.

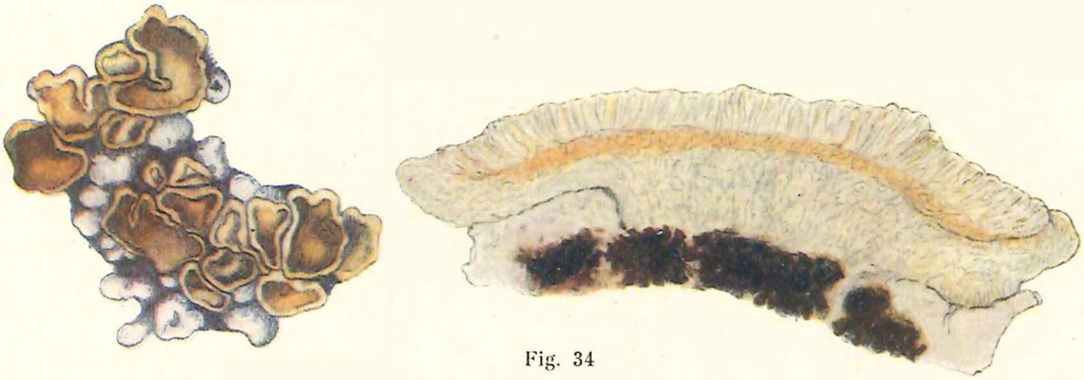


Fig. 34

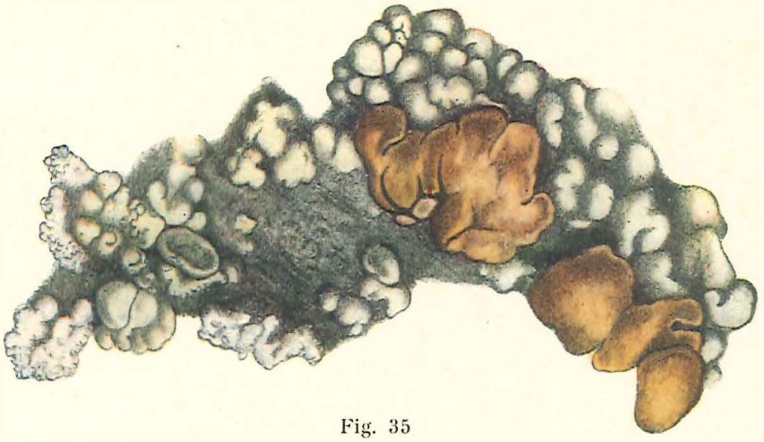


Fig. 35

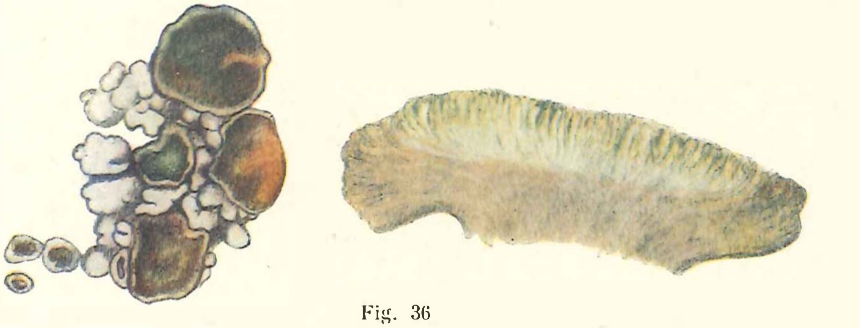


Fig. 36

O. Galløe del.

LECIDEA (BIATORA) GRANULOSA Ehrh.
(Specimen 1, 2 and 3)

PLATE 17.

LECIDEA (BIATORA) GRANULOSA.

Ehrh.

Specimen 1, from *Gaardbo.*

Fig. 37 and 38. Part of the centre of the thallus with apothecia. (×15).
Fig. 39. Margin of thallus. (×15).

PLATE 17.

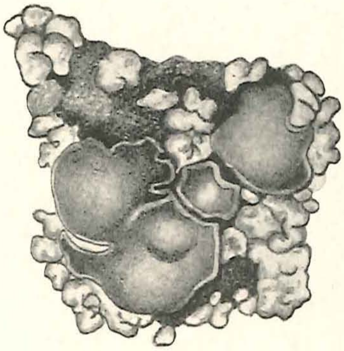


Fig. 37

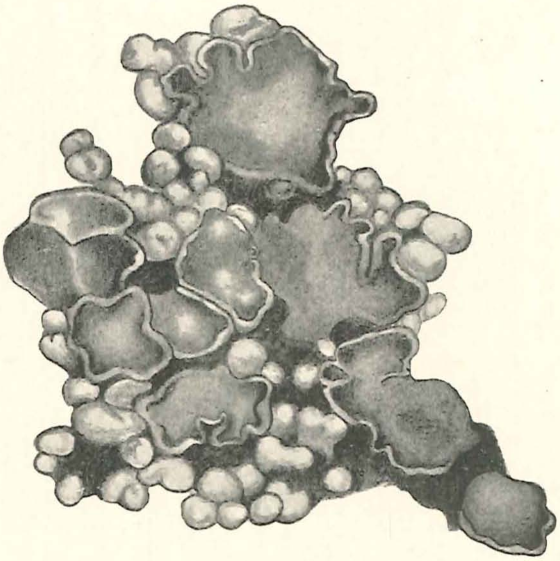


Fig. 38

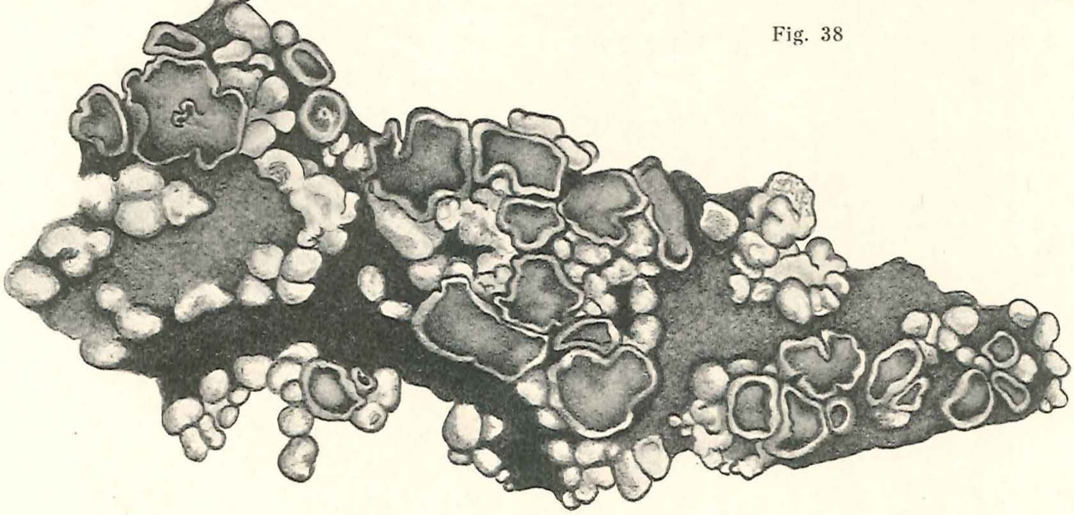


Fig. 39

O. Galløe del.

LECIDEA (BIATORA) GRANULOSA EHRH.
(Specimen 1)

PLATE 18.

LECIDEA (BIATORA) GRANULOSA.

EHRH.

Specimen 1.

Fig. 40. Section of thallus with 2 apothecia. The black spots at the bottom of the section are particles of humus. (×60).

PLATE 18.

Fig. 40

O. Galløe del.

LECIDEA (BIATORA) GRANULOSA Ehrh.
(Specimen 1)

PLATE 19.

LECIDEA (BIATORA) GRANULOSA.

EHRH.

Specimen 1.

Fig. 41. Cortical, gonidial, and medullary layers. (×450).

Fig. 42. Hyphæ from the rhizoidal zone with black granules of humus. (×450).

Fig. 43. Group of palmelloïd *Chlorophyceæ* in which a bundle of hyphæ is branching. A fragment of thallus just below an apothecium. (×450).

Fig. 44. Margin of an apothecium, and a spore. (×450).

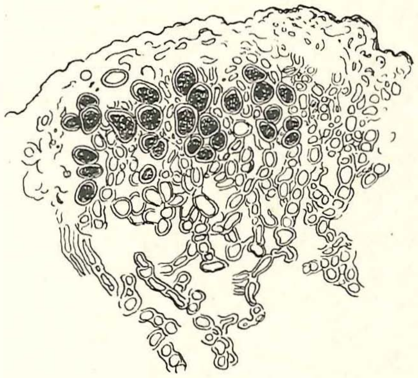


Fig. 41

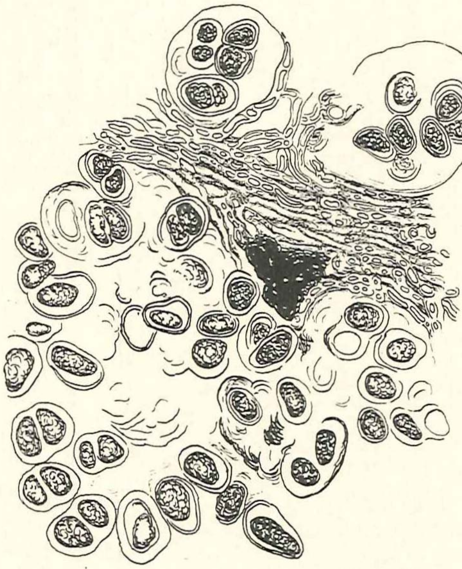


Fig. 43

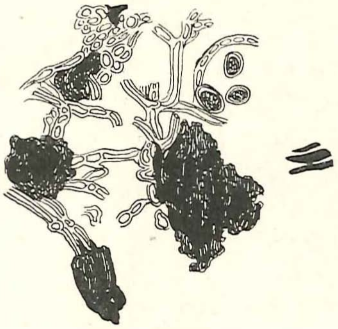


Fig. 42

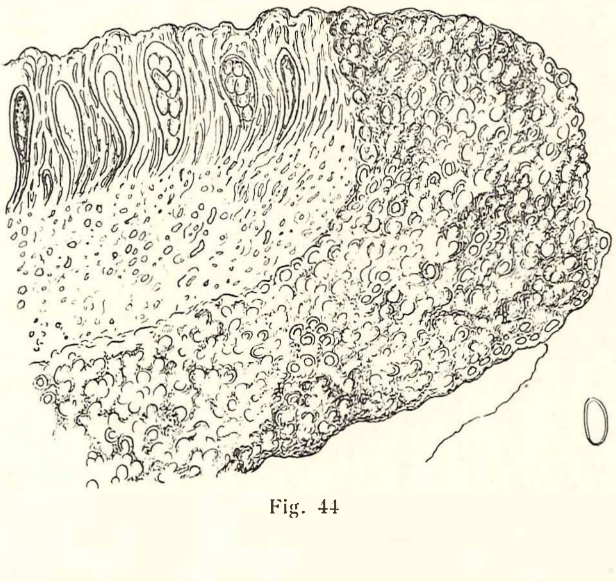


Fig. 44

O. Galløe del.

LECIDÈA (BIATORA) GRANULOSA EHRH.
(Specimen 1)

PLATE 20.

LECIDEA (BIATORA) GRANULOSA.

Specimen 2, from *Sødal.*

Fig. 45. Section of thallus and apothecium. (×60).

Fig. 46. Grain of thallus, with a cortex rather thick on the upper surface, but thinner on the sides of the granule. (×450).

Fig. 47. Margin of apothecium. (×450).

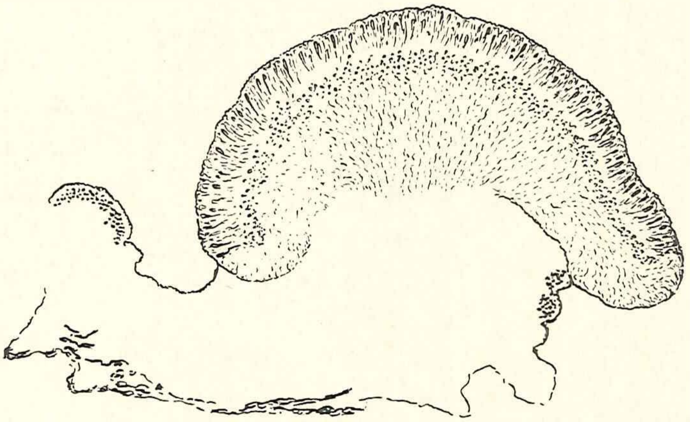


Fig. 45

Fig. 46

Fig. 47

O. Galløe del.

LECIDEA (BIATORA) GRANULOSA EHRH.
(Specimen 2)

PLATE 21.

LECIDEA (BIATORA) GRANULOSA.

EHRH.

Specimen 3, from *Grib Skov.*

Fig. 48. Grains of the thallus mostly broken up into soredia. Apothecia in all stages of development. (×15).

Fig. 49. Section of thallus with soredia and (below) dark grains of humus. (×60).

Fig. 50. Soredia. (×450).

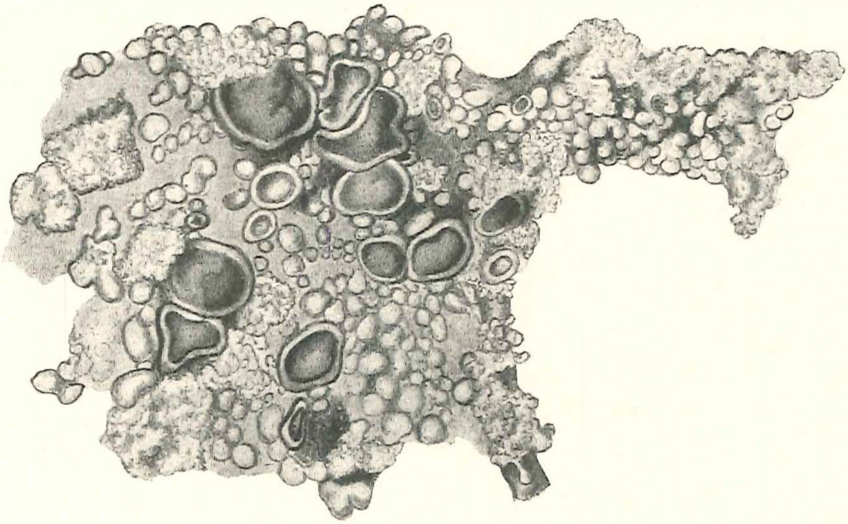


Fig. 48

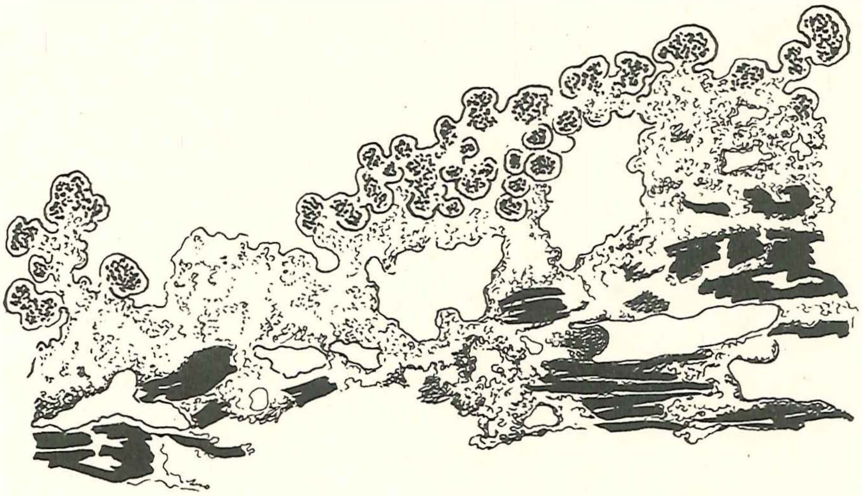


Fig. 49

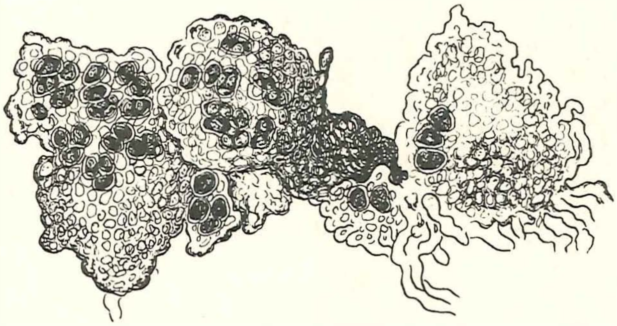


Fig. 50

O. Galløe del.

LECIDEA (BIATORA) GRANULOSA Ehrh.
(Specimen 3)

PLATE 22.

LECIDEA (BIATORA) FLEXUOSA.

(FR.) NYL.

Specimen 1 and **2.**

Fig 51. Specimen 1, Distribution of colour in the apothecium. (×60).
Fig. 52. Specimen 2, Distribution of colour in the apothecium. (×60).
Fig. 53. Specimen 2, Destroyed apothecium with three almost normal (yet sporeless) hymenia; it has been destroyed by *Gloeocapsa*. (×60).

PLATE 22.

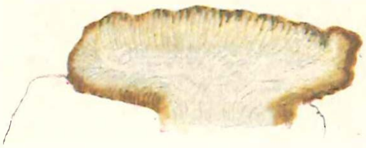


Fig. 51

Fig. 52

Fig. 53

O. Galløe del.

LECIDEA (BIATORA) FLEXUOSA (Fr.) Nyl.
(Specimen 1 and 2)

PLATE 23.

LECIDEA (BIATORA) FLEXUOSA.

(Fr.) Nyl.

Specimen 1, *Sødal*, on oak.

Fig. 54. Thallus, the grains of which are in places sorediose (above to the left). (×15).

Fig. 55. Apothecia in all stages of development. (×60).

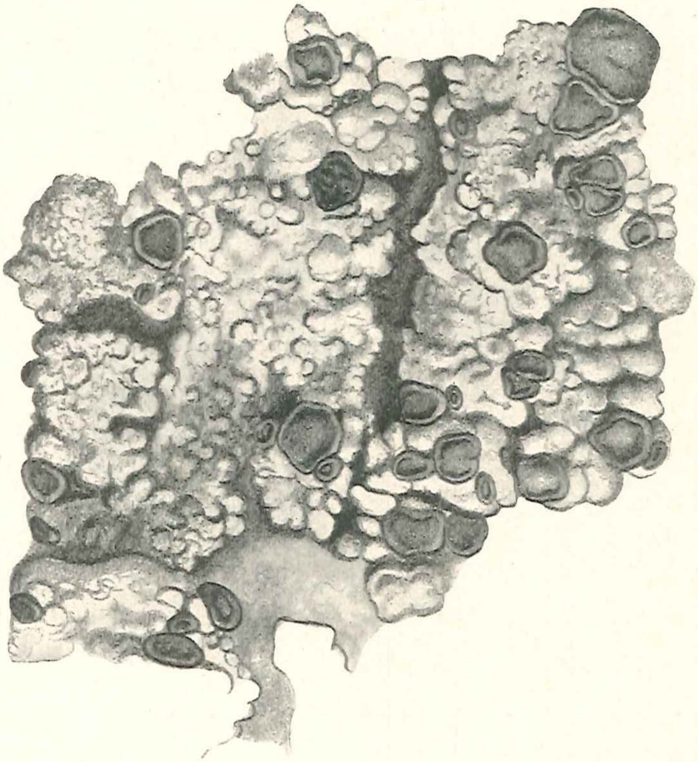


Fig. 54

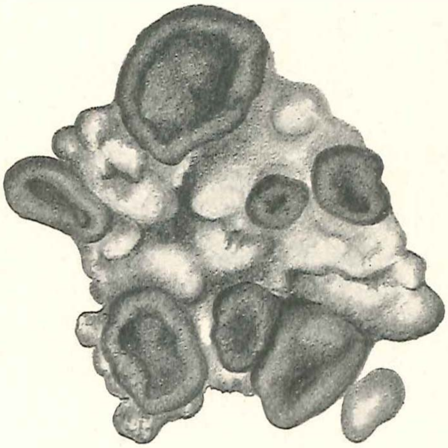


Fig. 55

O. Galløe del.

LECIDEA (BIATORA) FLEXUOSA (Fr.) Nyl.
(Specimen 1)

PLATE 24.

LECIDEA (BIATORA) FLEXUOSA

(Fr.) Nyl.

Specimen 1.

Fig. 56. Section of thallus; on the left below are seen some thalline granules devoid of gonidia. At the bottom of the section a layer of oak-wood is seen.

The section of the apothecium is not median. (×60).

Fig. 57. Grains of thallus. Quite on the left is seen a relatively tall grain. This shows how narrow and tall thalline warts may become through competition with neighbouring grains. (×60).

Fig. 58. Portions of cortical, gonidial, and medullary layers. (×450).

Fig. 59. Hyphæ from the rhizoidal zone, branching in the cells of the oak. (×450).

Fig. 60. Margin of apothecium. (×450).

Fig. 61. Paraphyses and asci with ripe spores. (×450).

PLATE 24.

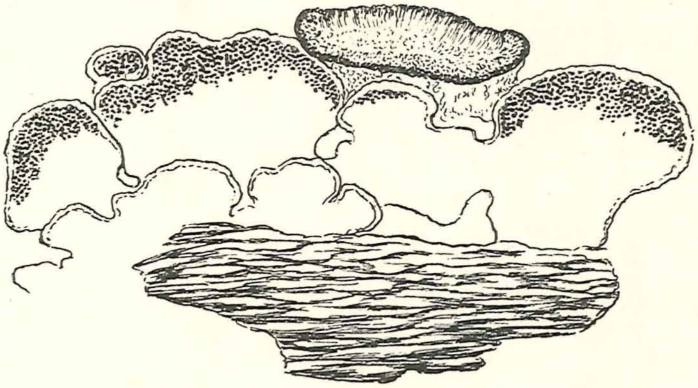


Fig. 56

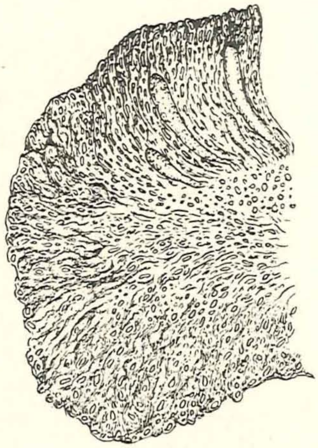


Fig. 60

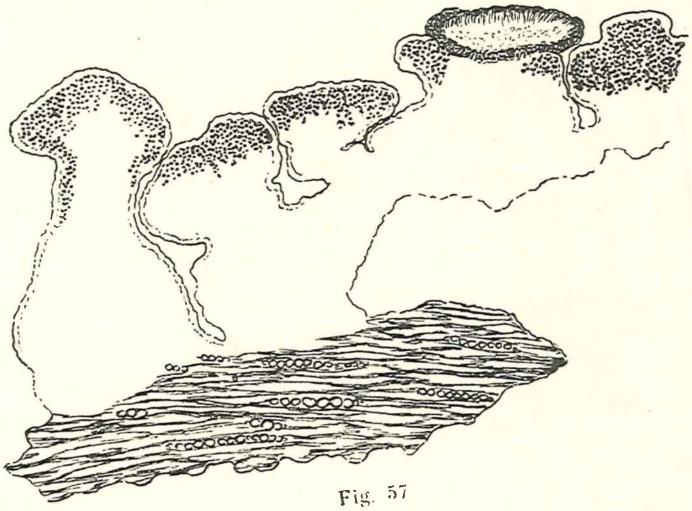


Fig. 57

Fig. 61

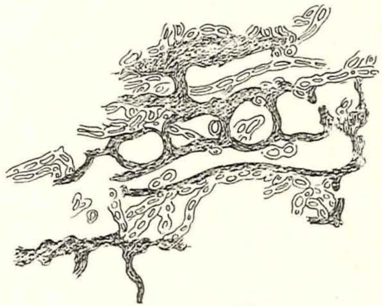


Fig. 59

Fig. 58

LECIDEA (BIATORA) FLEXUOSA (Fr.) Nyl.
(Specimen 1)

O. Galloe del.

PLATE 25.

LECIDEA (BIATORA) FLEXUOSA.

(FR.) NYL.

Specimen 2.

Fig 62. A normal apothecium. (×15.)

Fig. 63. A cauliflower-like apothecium deformed by *Gloeocapsa*, (see plate 22 fig. 53). (×15).

Fig. 64. Part of thallus with cells of *Gloeocapsa*. The two hyphæ above represent the reduced cortical layer; 4 normal soredia with *Pleurococcus* and with connecting hyphæ, branching in the gelatinous sheath of the *Gloeocapsa*. (×450).

Fig. 65. Surface of a destroyed apothecium. The *Gloeocapsa* is situated in the very place where a normal apothecium would have its hymenium. The hyphæ are seen to branch inside the jelly of the *Gloeocapsa*. (×450).

Fig. 66. Asci with spores. (×450).

PLATE 25.

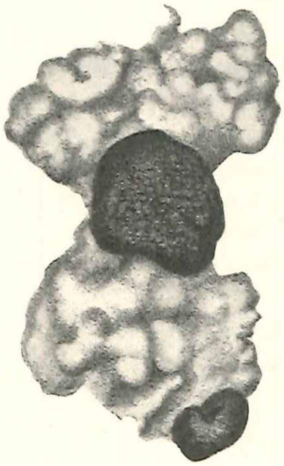


Fig. 62

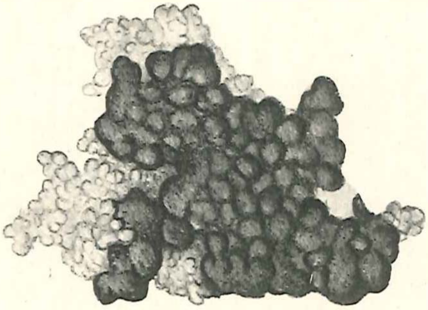


Fig. 63

Fig. 66

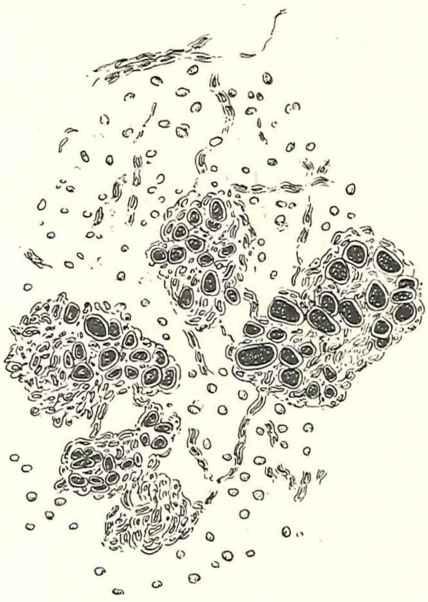


Fig. 64

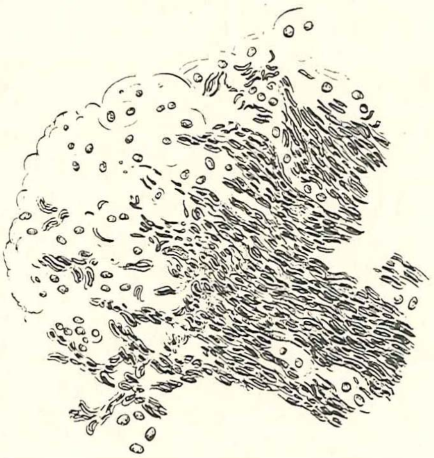


Fig. 65.

O. Galloe del.

LECIDEA (BIATORA) FLEXUOSA (Fr.) Nyl.
(Specimen 2)

PLATE 26.

LECIDEA (BIATORA) GELATINOSA.

FLKE.

Fig. 67. An apothecium seen from above (× 15) and a section of an apothecium. (× 60).

Fig. 68. Thallus with 7 apothecia of different ages together with some soralia. (× 15).

PLATE 26.

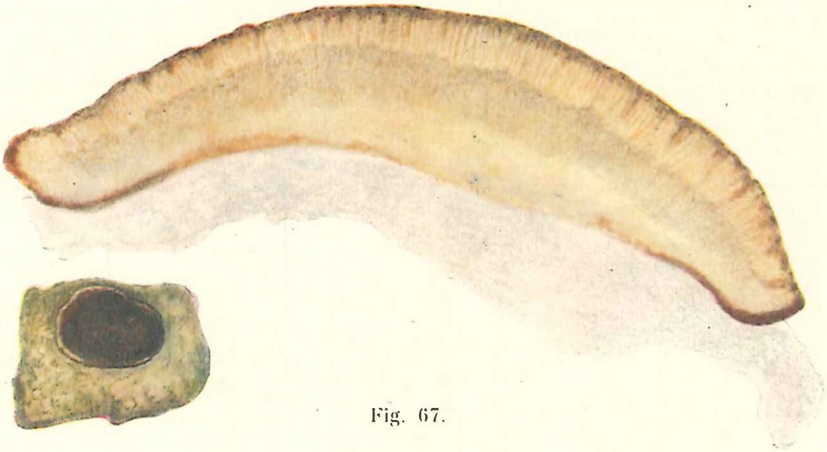


Fig. 67.

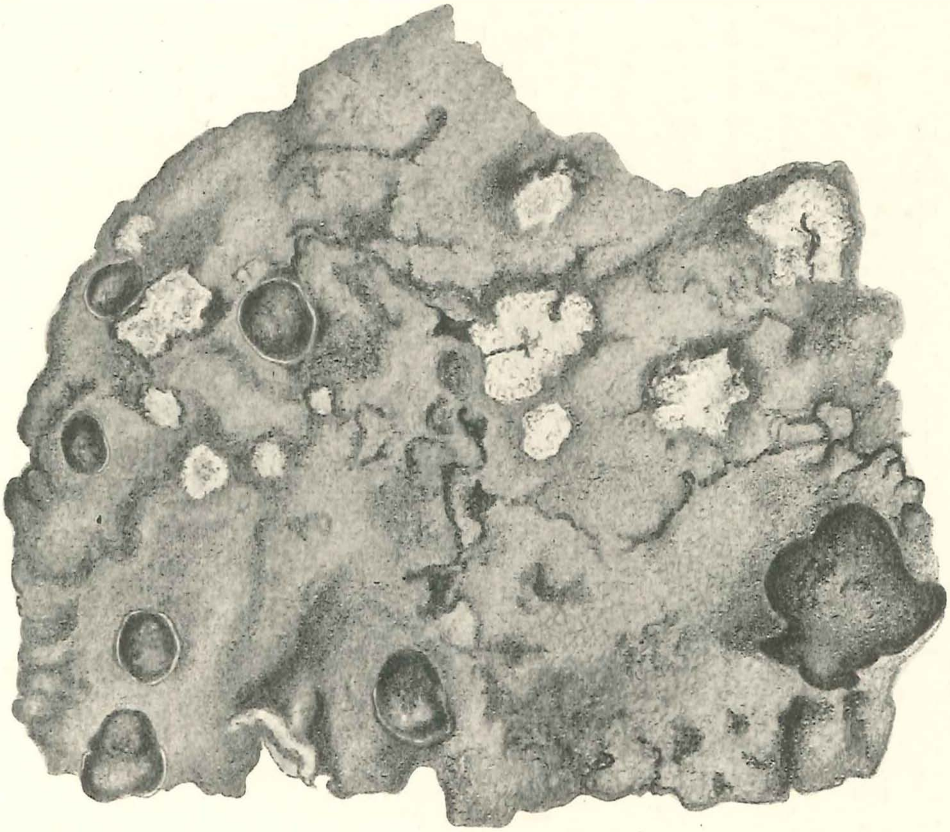


Fig. 68

O. Galloe del.

LECIDEA (BIATORA) GELATINOSA FLKE.

PLATE 27.

LECIDEA (BIATORA) GELATINOSA.

FLKE

Fig. 69. Two soralia. (×45).
Fig. 70. A young apothecium. (×60).
Fig. 71. A ripe apothecium. (×45).
Fig. 72. Thallus with an apothecium; all the dark spots in the rhizoidal zone are particles of humus and indeterminable plant remains. (×60).

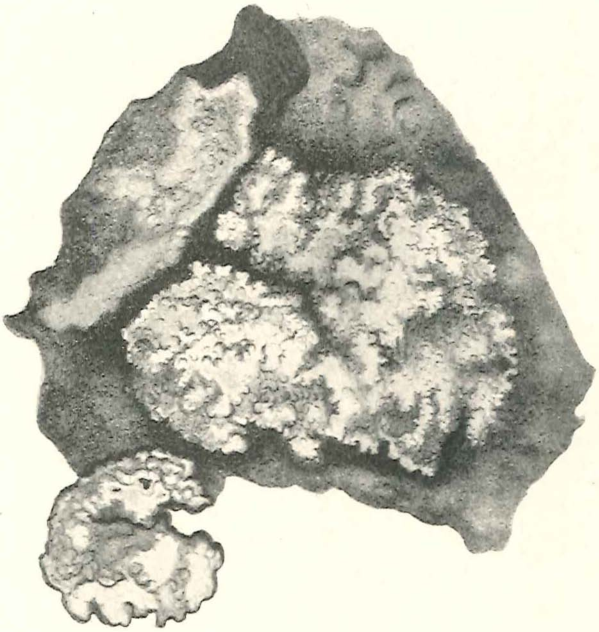


Fig. 69

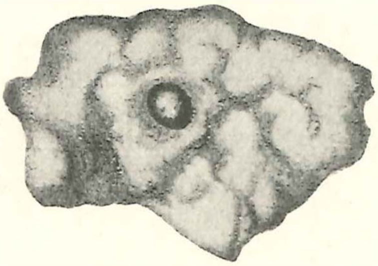


Fig. 70

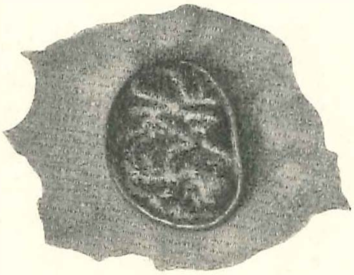


Fig. 71

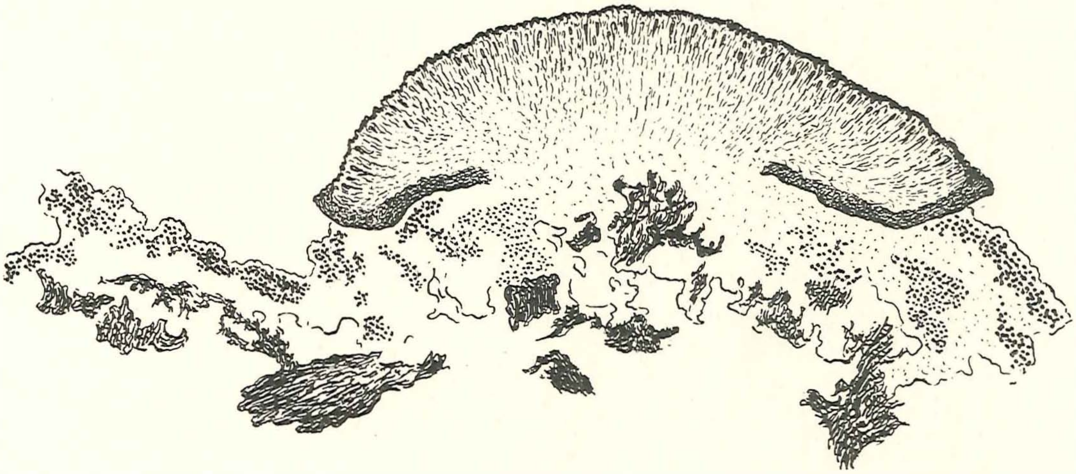


Fig. 72

O. Galloe del.

LECIDEA (BIATORA) GELATINOSA Flke.

PLATE 28.

LECIDEA (BIATORA) GELATINOSA.

FLKE.

Fig. 73. Section of thallus. All the dark portions below represent particles of humus. (×450).

Fig. 74. A soral. (×450). Some grains of sand are seen below to the right in the section.

Fig. 75. Margin of the apothecium with ripe and unripe asci. (×450).

PLATE 28.

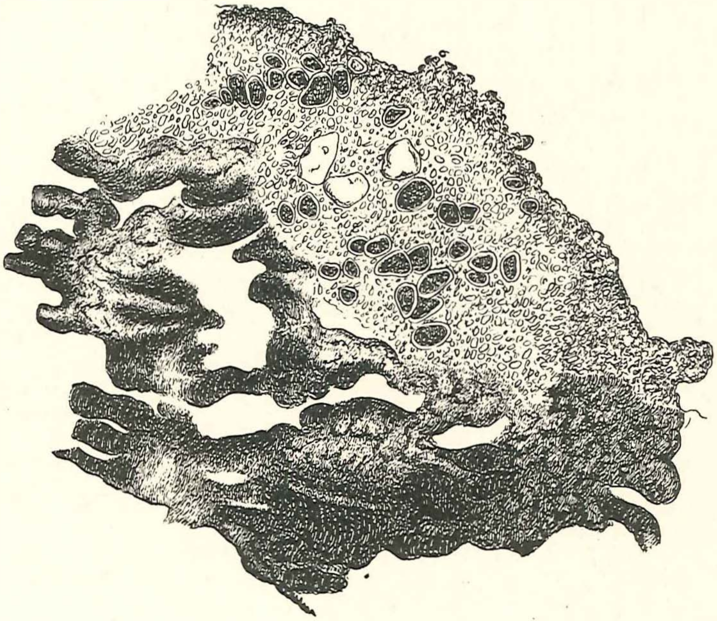


Fig. 73

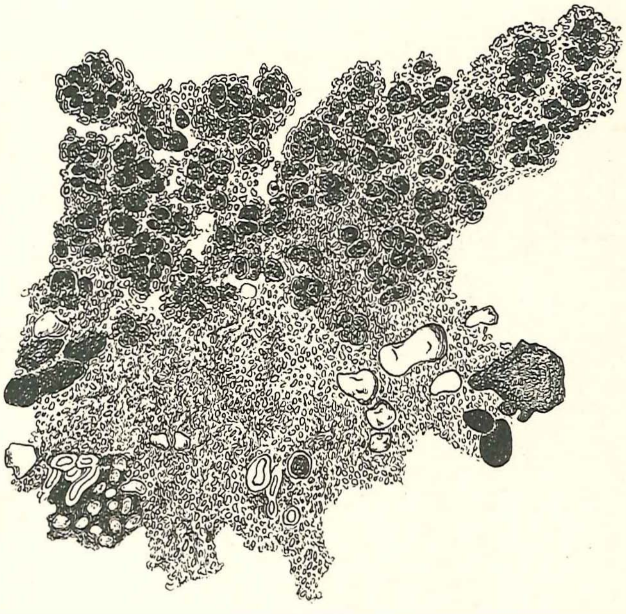


Fig. 74

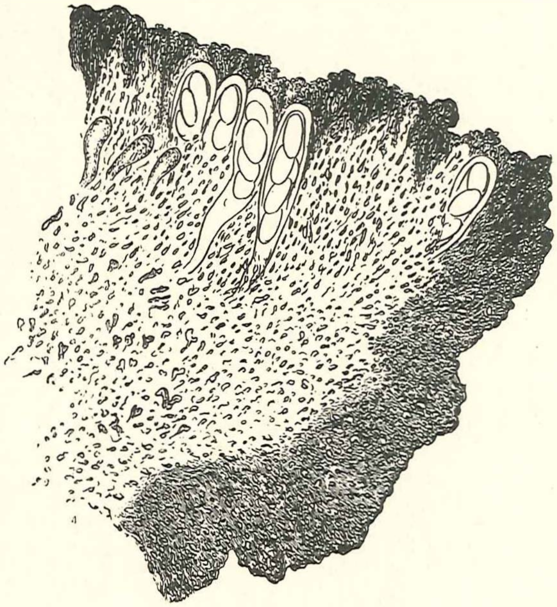


Fig. 75

O. Galløe del.

LECIDEA (BIATORA) GELATINOSA Flke.

PLATE 29.

LECIDEA (BIATORA) COARCTATA.

Sm.

Specimen 1 and **Specimen 2.**

Fig. 76. Specimen 1, two apothecia in vertical section. (×60).

Fig. 77. Specimen 2, four apothecia seen from above (×15) and an apothecium in vertical section. (×60).

PLATE 29.

Fig. 76

Fig. 77

O. Galløe del.

LECIDEA (BIATORA) COARCTATA Sm.
(Specimen 1 and 2)

20

PLATE 30.

LECIDEA (BIATORA) COARCTATA.

Sm.

Specimen 1.

Fig. 78. Thallus with apothecia in various stages of breaking through. (× 15).

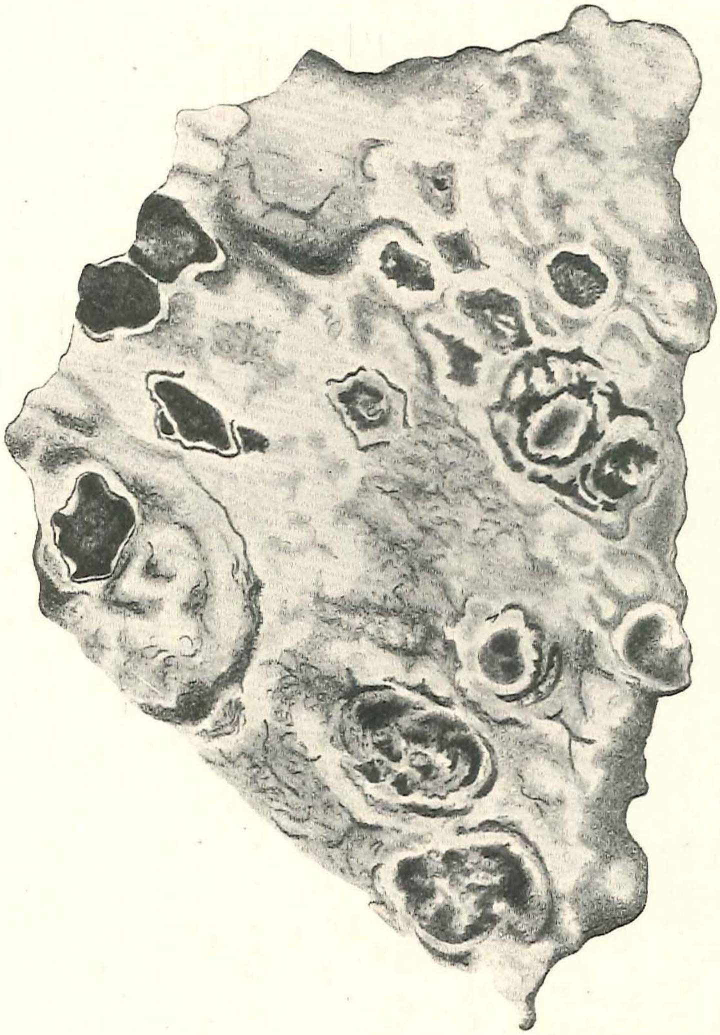


Fig. 78

O. Galløe del.

LECIDEA (BIATORA) COARCTATA Sm.
(Specimen 1)

PLATE 31.

LECIDEA (BIATORA) COARCTATA.

Sm.

Specimen 1.

Fig. 79. Thallus with apothecia, of which some have a pseudo-lecanorine margin. (×15).

Fig. 80. Section of thallus. Above gonidia; all the dark parts beneath are masses of humus. (×60).

Fig. 81. Section of thallus. Below to the left: some masses of humus. To the right: a grain of quartz. (×450).

Fig. 82. Section of apothecium; on its surface are remnants of the cortex of the thallus. (×60).

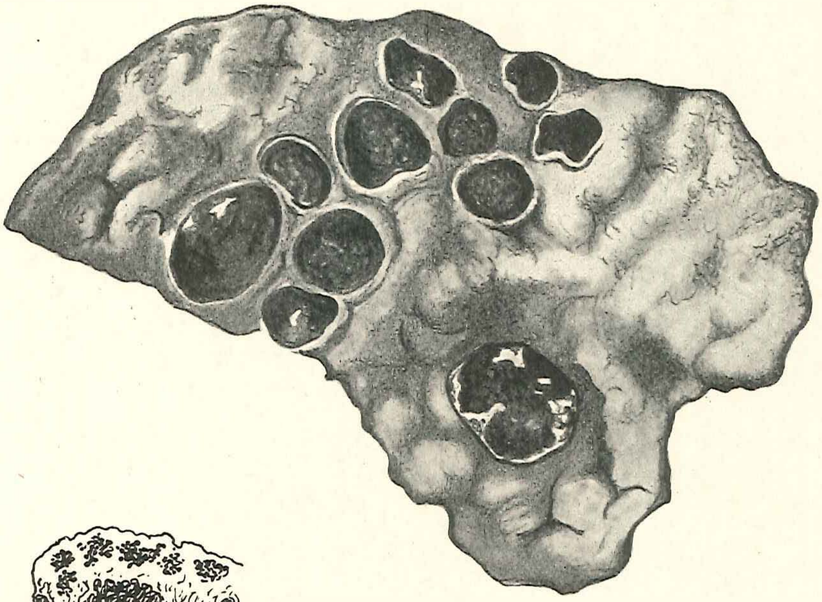


Fig. 79

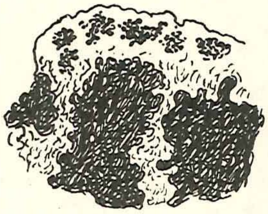


Fig. 80

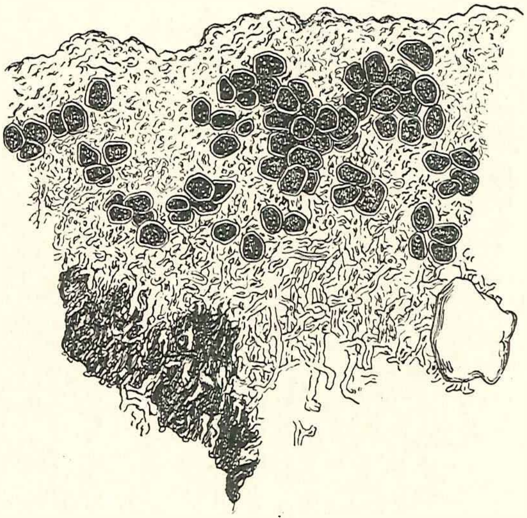


Fig. 81

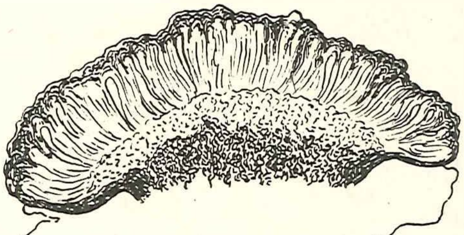


Fig. 82

O. Galløe del.

LECIDEA (BIATÒRA) COARCTATA SM.
(Specimen 1)

PLATE 32.

LECIDEA (BIATORA) COARCTATA.

Sm.

Specimen 1.

Fig. 83. The margin of the apothecium with thick layers of the thalline cortex on the hymenium and a pseudo-lecanorine margin on the outside of the proper margin. To the right: 2 spores.

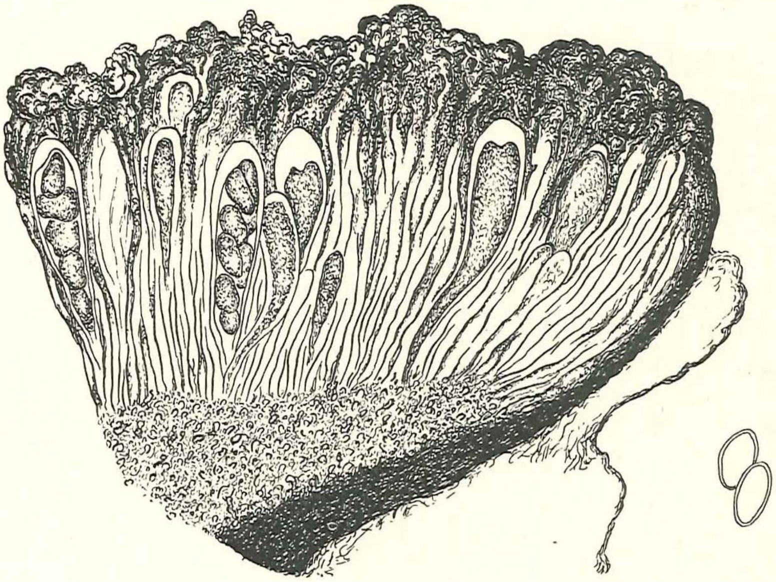


Fig. 83

O. Galløe del.

LECIDEA (BIATORA) COARCTATA Sm.
(Specimen 1)

PLATE 33.

LECIDEA (BIATORA) COARCTATA

Sm.

Specimen 2.

Fig. 84. Thallus smooth with narrow fissures, more numerous than in specimen 1 (on soil). Apothecia all with pseudo-lecanorine margin. (×25).

Fig. 85. Thallus with apothecia in all stages of development. (×15).

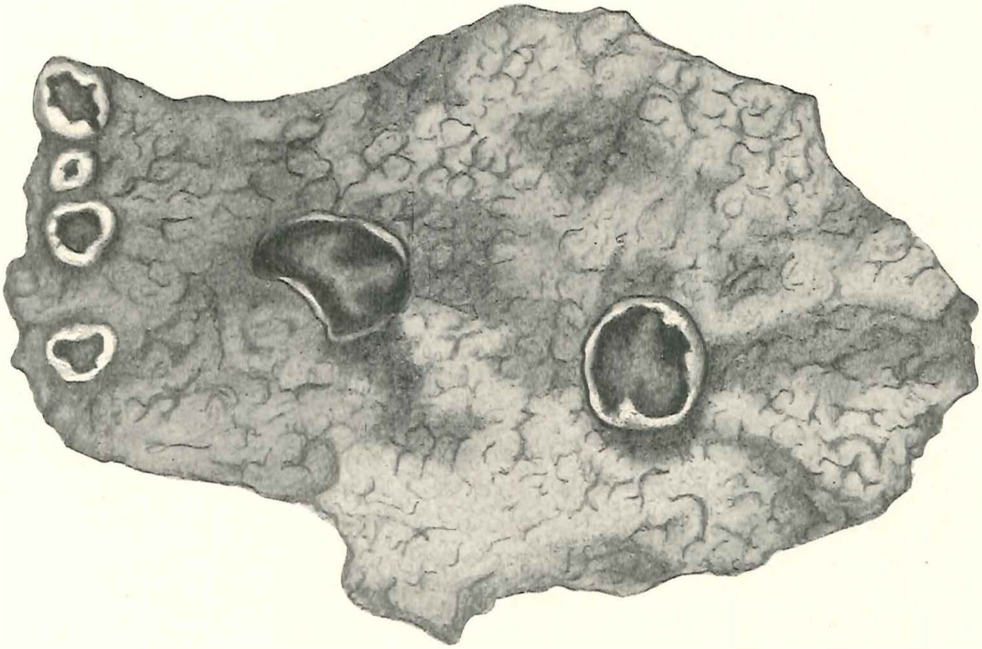


Fig. 84

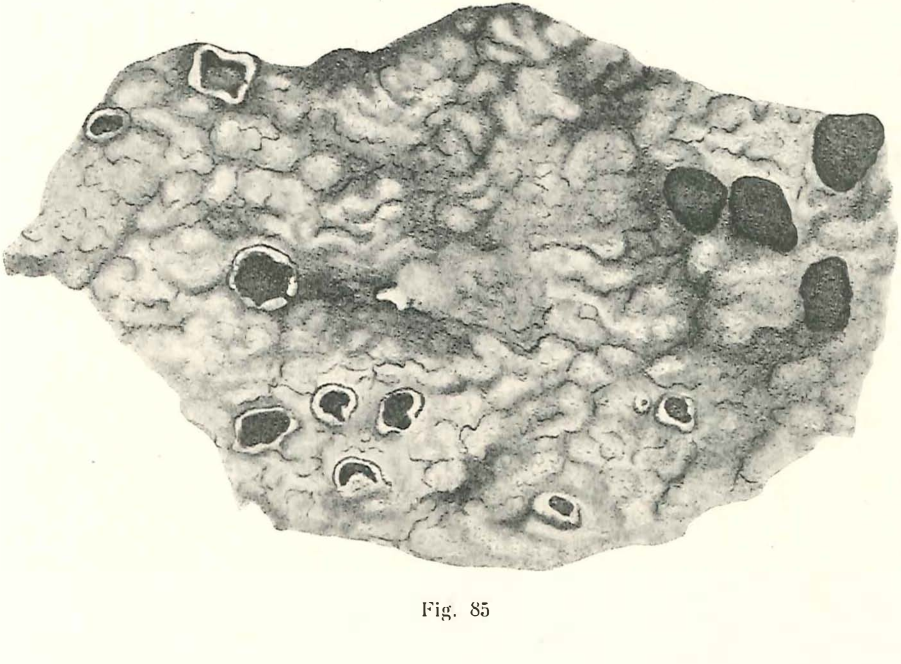


Fig. 85

O. *Galløe del.*

LECIDEA (BIATORA) COARCTATA SM.
(Specimen 2)

PLATE 34.

LECIDEA (BIATORA) COARCTATA.

SM.

Specimen 2.

Fig. 86. Two apothecia with remnants of thallus at the top and on the outside of the proper margin. The thallus has here a slightly areolate appearance; at *a* is a thallus margin (formed of white radiating mycelial hyphæ). (×60).

Fig. 87. A quite biatorine apothecium and beneath it (at *a*) two young apothecia which have not yet broken through the surface of the thallus. Here too the thallus is somewhat areolate. (×60).

Fig. 88. Apothecium with remnants of pseudo-lecanorine margin. It is shortly stalked and concave. (×60).

Fig. 89. Apothecium with very irregular outline; partly with pseudo-lecanorine margin.

The figures 86—89 were taken from specimens growing close together on the same stone. They appear to be parts of the same thallus, but it is just possible that they may have grown up each from its own spore. The hymenium of each is, in moistened condition, rather transparent and reddish brown in colour.

PLATE 34.

Fig. 88

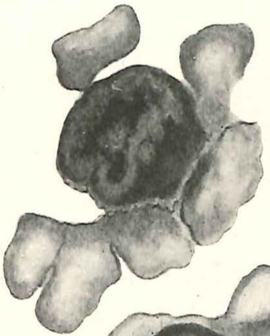


Fig. 89

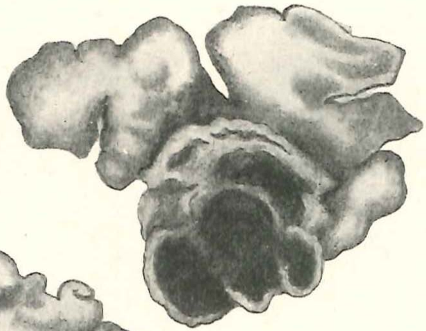


Fig. 87

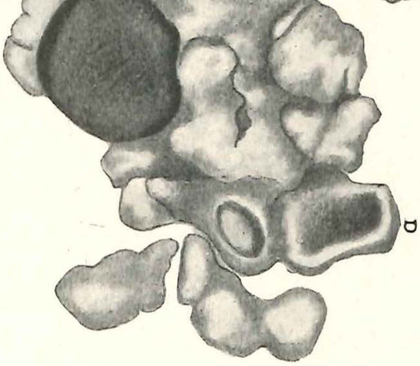
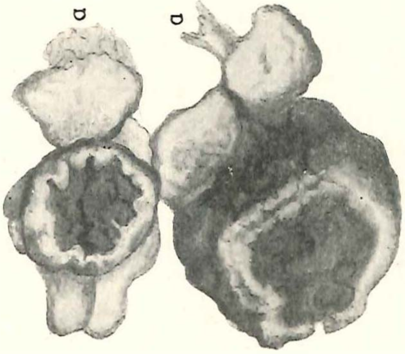


Fig. 86



O. Galløe del.

LECIDEA (BIATORA) COARCTATA Sm.
(Specimen 2)

21*

PLATE 35.

[LECIDEA (BIATORA) RIVULOSA].

ACH.

Swedish specimen.

Fig. 90. Thallus with apothecia. (×40).

Fig. 91. Vertical section of an apothecium. (×60).

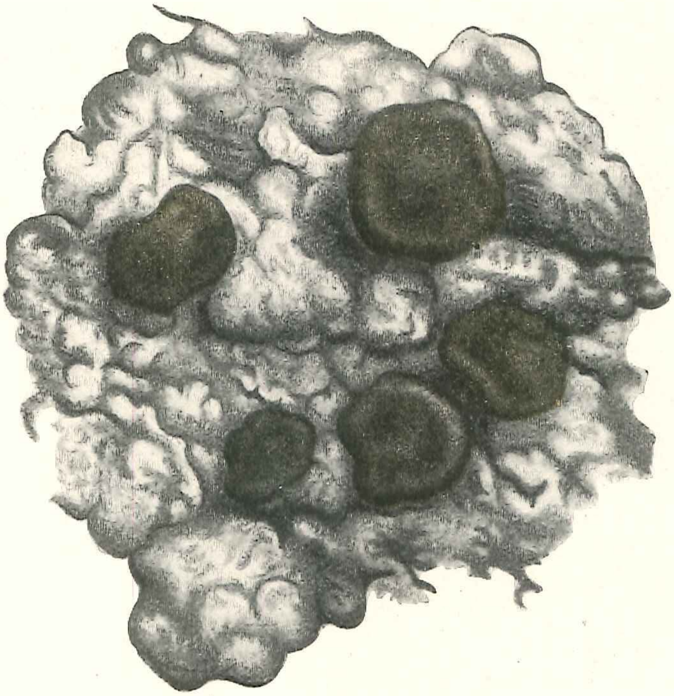


Fig. 90

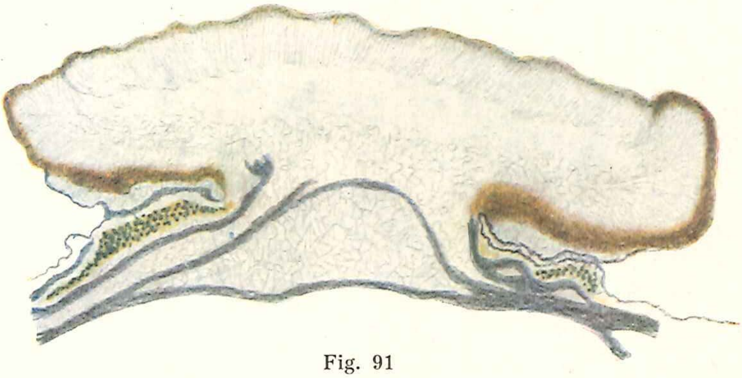


Fig. 91

O. *Galløe del.*

[LECIDEA (BIATORA) RIVULOSA Ach.]
(Swedish specimen)

PLATE 36.

[LECIDEA (BIATORA) RIVULOSA].

Ach.

Swedish specimen.

Fig. 92. Thallus on bark of *Betula*. The bark is peeling off and bursting on account of the tension caused by the secundary growth of the tree. Note the newly formed cracks. Note also, that the thallus is slightly transversely striped (at right angles to the longitudinal axis of the stem, i. e. horizontally in the figure) in accordance with the secundary growth of the tree. (×5).

Fig. 93. Thallus with apothecia. (×15).

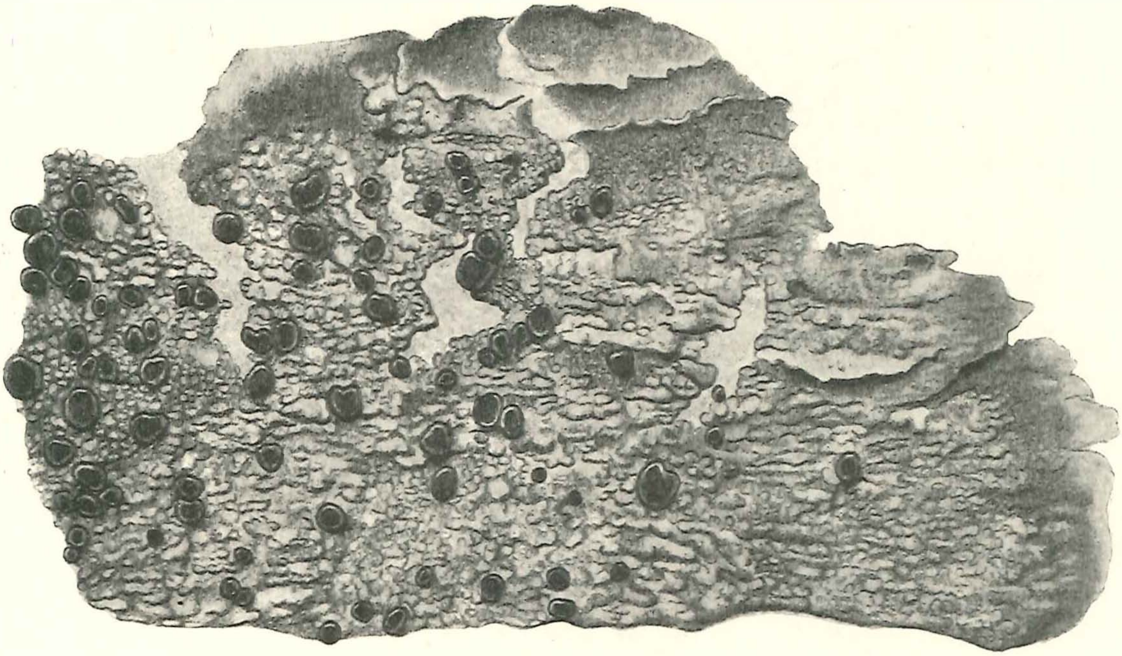


Fig. 92

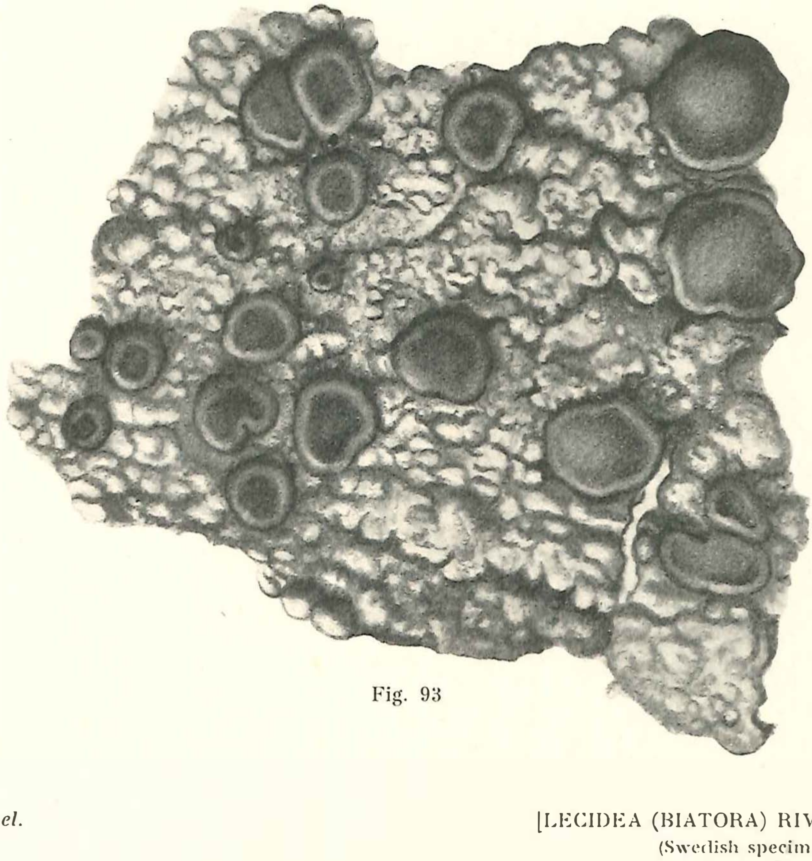


Fig. 93

O. Galløe del.

[LECIDEA (BIATORA) RIVULOSA Ach.]
(Swedish specimen)

PLATE 37.

[LECIDEA (BIATORA) RIVULOSA].

Ach.

Swedish specimen.

Fig. 94. Section of thallus, more or less homoeomerous. Several lamellæ and portions of the bark of the substratum (of *Betula*) are visible in the thallus. Between these are the gonidia; the thallus then is partly hypophloeodic. (×450).

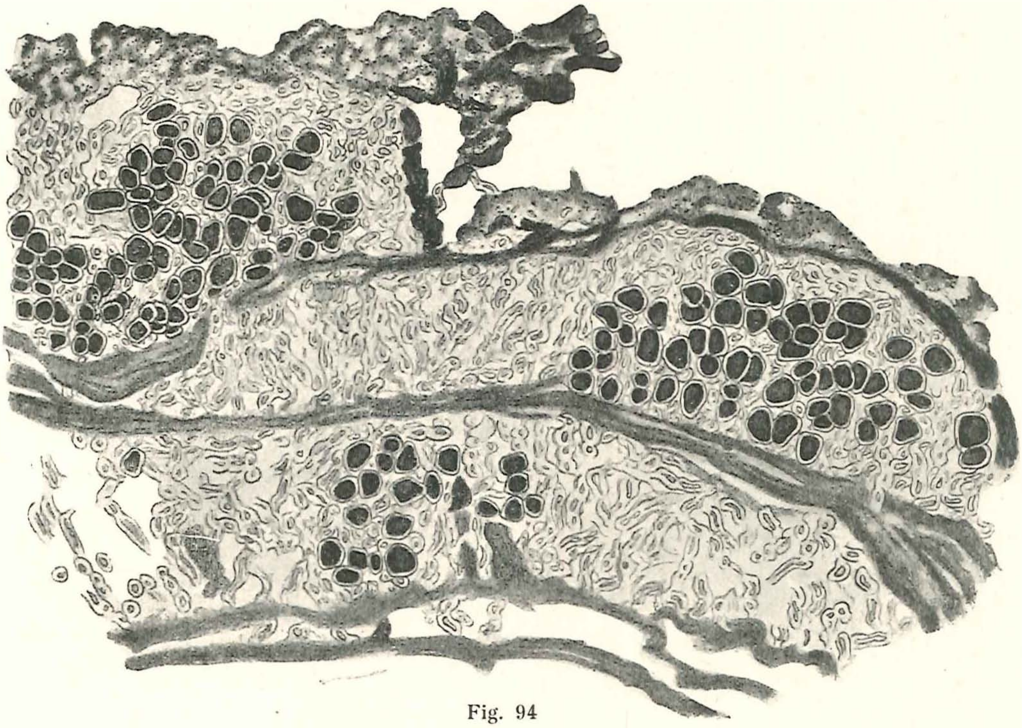


Fig. 94

O. Galløe del.

[LECIDEA (BIATORA) RIVULOSA Ach.]
(Swedish specimen)

PLATE 38.

[LECIDEA (BIATORA) RIVULOSA].
Ach.

Swedish specimen.

Fig. 95. Section of thallus with two apothecia. (×60).

PLATE 38.

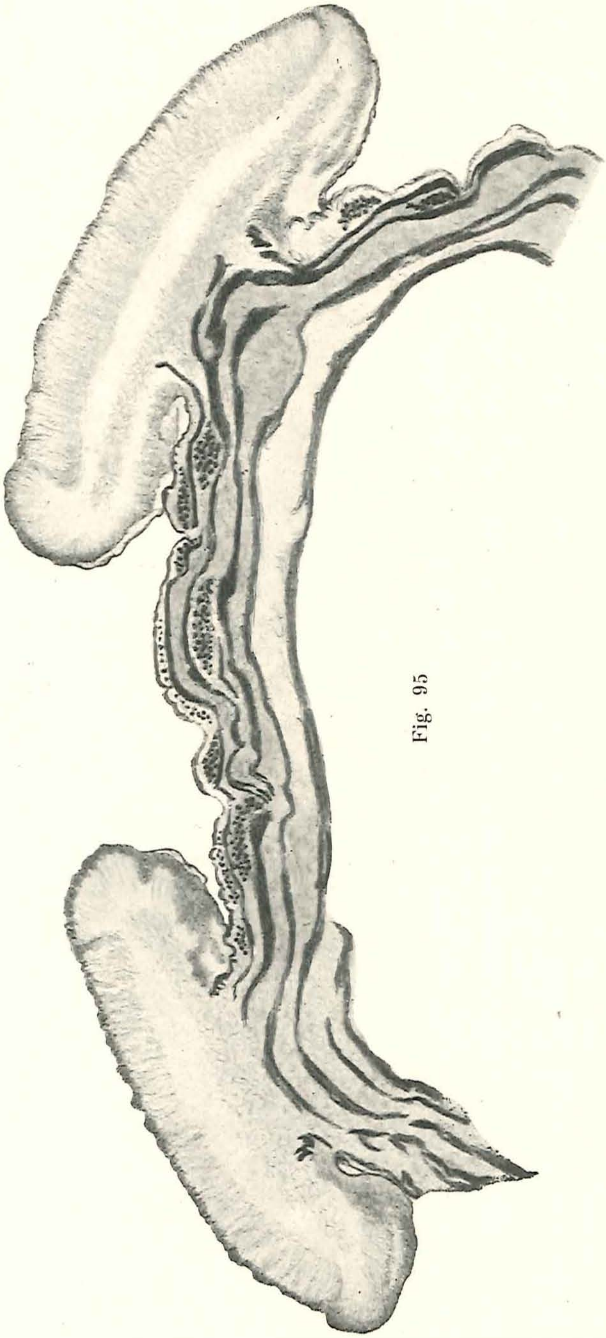


Fig. 95

O. Galloe del.

[LECIDEA (BIATORA) RIVULOSA Ach.

(Swedish specimen)

PLATE 39.

[LECIDEA (BIATORA) RIVULOSA].

ACH.

Swedish specimen.

Fig. 96. Margin of apothecium, showing the paraphyses, the dense hypothecium, the loosely plectenchymatous stipes, the dense calyx, on the surface of which (below to the right) two portions of the thalline cortex are to be seen still adhering to the calyx, though the latter has already broken through the cortex; (see also the apothecia in fig. 95 which show the same structure). 6 curved spores are figured. (×450).

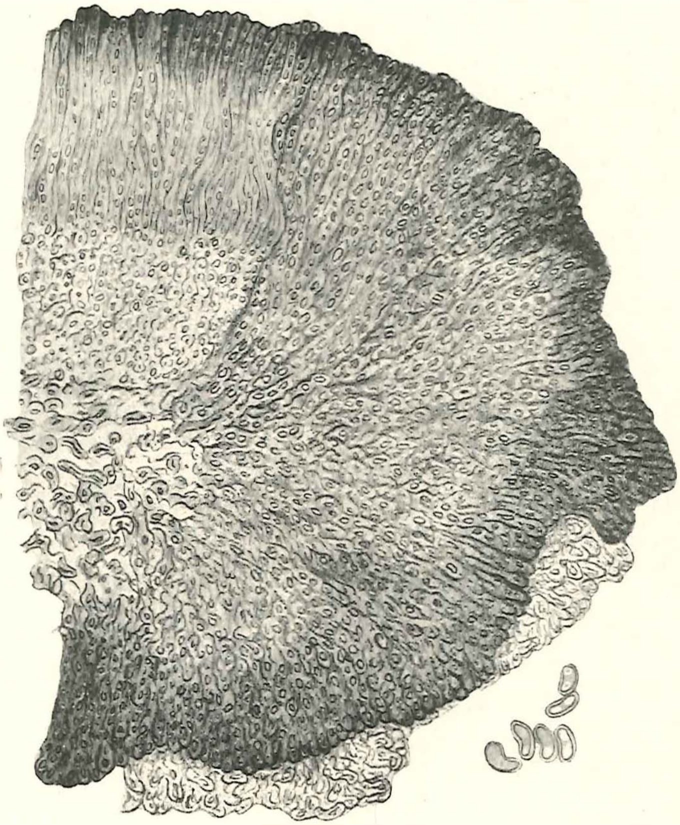


Fig. 96

O. Galløe del.

[LECIDEA (BIATORA) RIVULOSA ACH.]
(Swedish specimen)

PLATE 40.

LECIDEA (BIATORA) BOTRYOSA.

FR.

Fig. 97. Apothecium in vertical section. (×60).

Fig. 98. Part of a rotten stump of *Pinus*, on the top surface of which the lichen forms an almost black, very thin layer. The numbers indicate the limits between the annual rings of the wood. At *a* and *b* and several other places squamules of a *Cladonia* are visible. (×5).

PLATE 40.

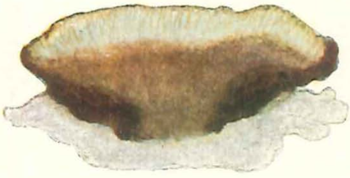


Fig. 97

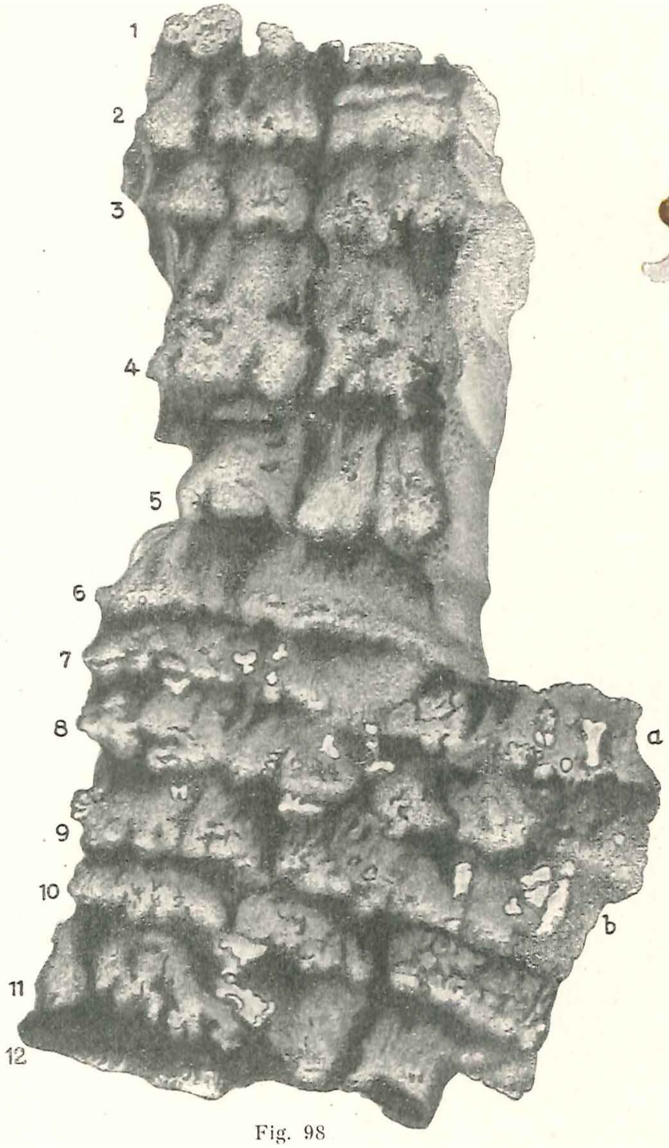


Fig. 98

O. Galløe del.

LECIDEA (BIATORA) BOTRYOSA Fr.

PLATE 41.

LECIDEA (BIATORA) BOTRYOSA.

Fr.

Fig. 99. To the left: a plan view of the thallus with 4 apothecia. To the right: two coralloïd parts of the thallus seen from the side. (×45).

Fig. 100. Grain of the thallus seen from above, showing the cortex, the cells of which are in close touch all round without intercellular spaces and are composed of hyphæ, the outer layers of the walls of which are brown in colour. The inner layers of the walls are colourless. The cavity of the cells cannot be seen, as the preparation is not stained. The numerous gonidia situated just below the cortex are omitted from the figure. (×450).

Fig. 101. Vertical section of a thallus grain which contains chlorogonidia. The cells of the outer cortex are brownish owing to the presence of a non-crystallized pigment. All lumina are distinct and stain well. The hyphæ of the gonidial layer are very small and densely interwoven, without or with very few intercellular spaces. The medullary layer and rhizoidal zone have extensive intercellular spaces. (×450).

Fig. 102. A coralline grain of the thallus teased out. (Compare fig. 99 to the right).

No intercellular spaces are present. The cells have distinct lumina. The gonidia are *Cyanophyceæ*. (×450)

Fig. 103. Margin of the apothecium. 3 spores. (×450).

PLATE 41.

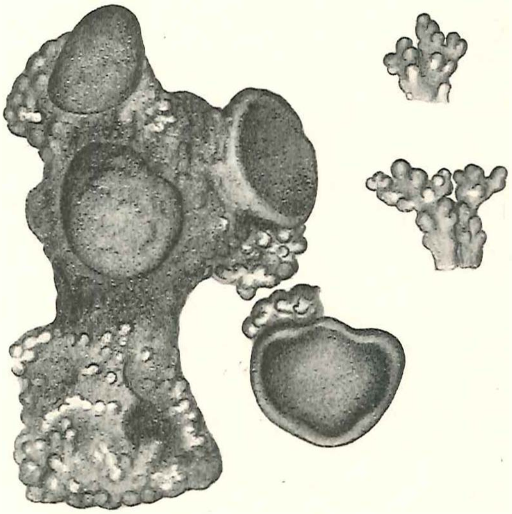


Fig. 99

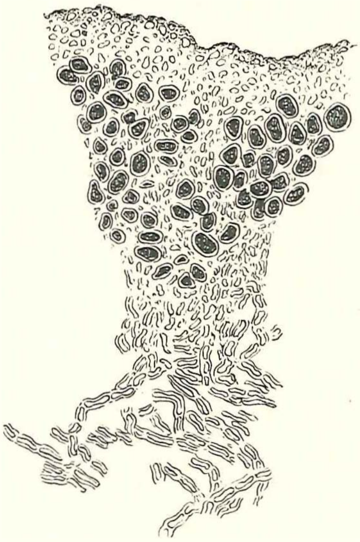


Fig. 101

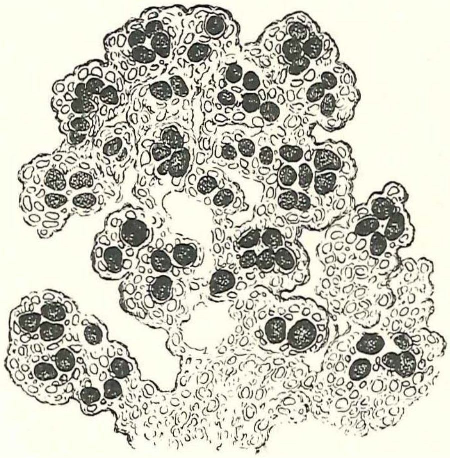


Fig. 102

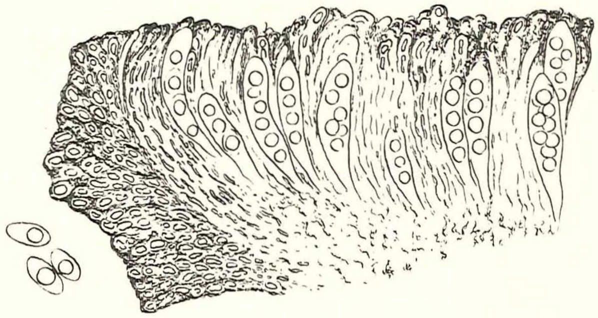


Fig. 103

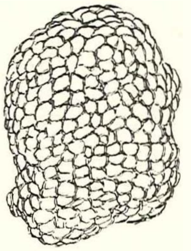


Fig. 100

O. Galløe del.

LECIDEA (BIATORA) BOTRYOSA Fr.

PLATE 42.

LECIDEA (BIATORA) ULIGINOSA.

SCHRAD.

Fig. 104.	Apothecium in vertical section. (×60).
Fig. 105.	Thallus (granulose) with apothecia of various ages. (×45).
Fig. 106.	A group of old, convex and confluent apothecia without margin. (×45).

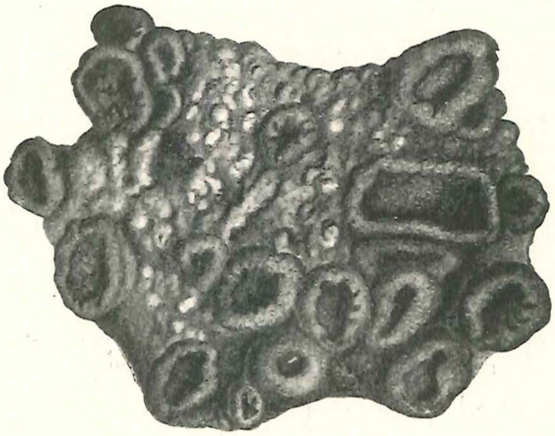


Fig. 105

Fig. 104

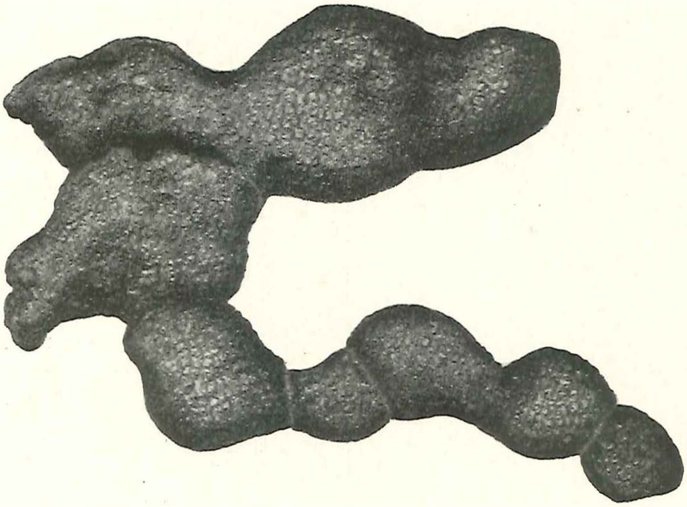


Fig. 106

O. Galløe del. LECIDEA (BIATORA) ULIGINOSA Schrad.

PLATE 43.

LECIDEA (BIATORA) ULIGINOSA.

SCHRAD.

Fig. 107. Section of thallus. All the dark portions in the rhizoidal zone are particles of humus. (×60).

Fig. 108. Section of thallus with an apothecium and a group of *Gloeocapsa* to the right of the apothecium. (×60).

Fig. 109. A grain of thallus with cortex, gonidial and medullary layers. The dark portions below in the thallus are particles of humus. (×450).

PLATE 43.

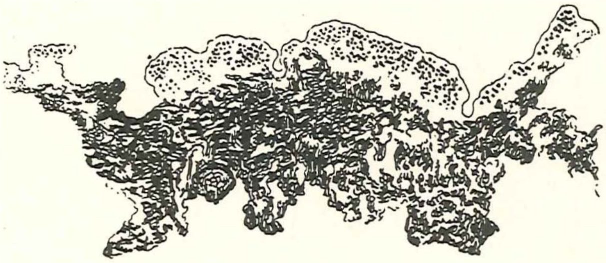


Fig. 107

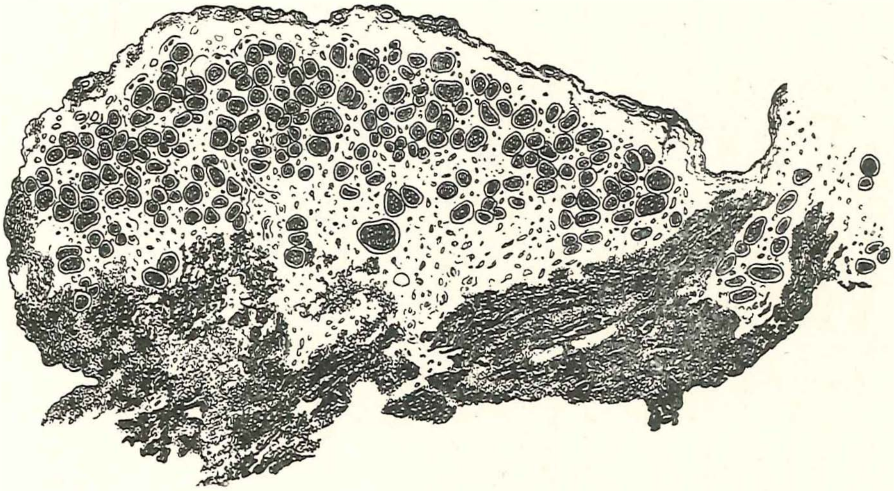


Fig 109

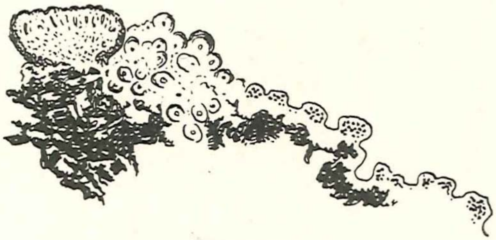


Fig. 108

O. Galløe del.

LECIDEA (BIATORA) UTIGINOSA Schrad.

PLATE 44.

LECIDEA (BIATORA) ULIGINOSA.

SCHRAD.

Fig. 110. A group of *Gloeocapsa* from the surface of the thallus, partly covered by the hyphæ. Some single hyphæ penetrate the gelatinous sheath of the *Gloeocapsa*. Above to the left: 3 *Pleurococcus*-gonidia are visible. To the right: a mass of humus. (×450).

Fig. 111. A group of *Gloeocapsa* cells, covered by the cortex of the thallus (at *a*) and penetrated by single hyphæ. (×450).

PLATE 44.

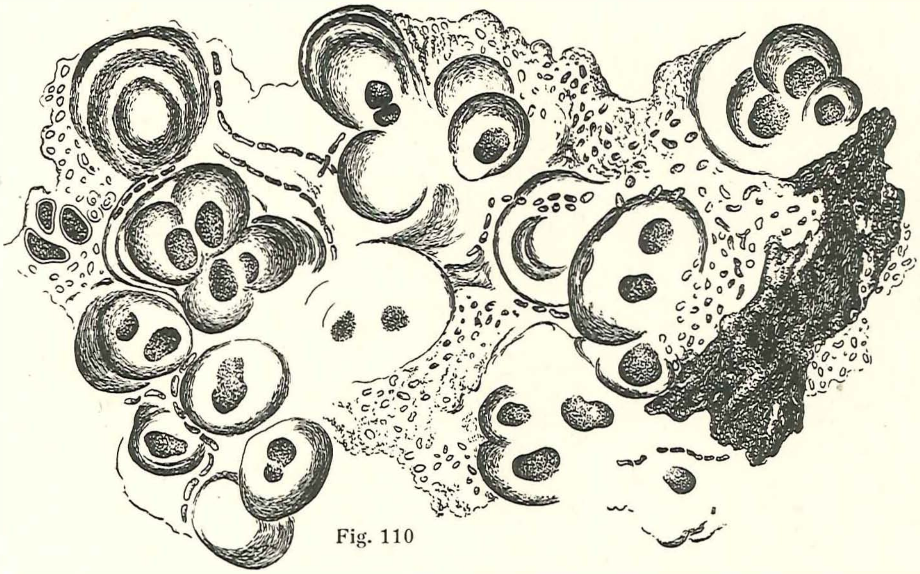


Fig. 110

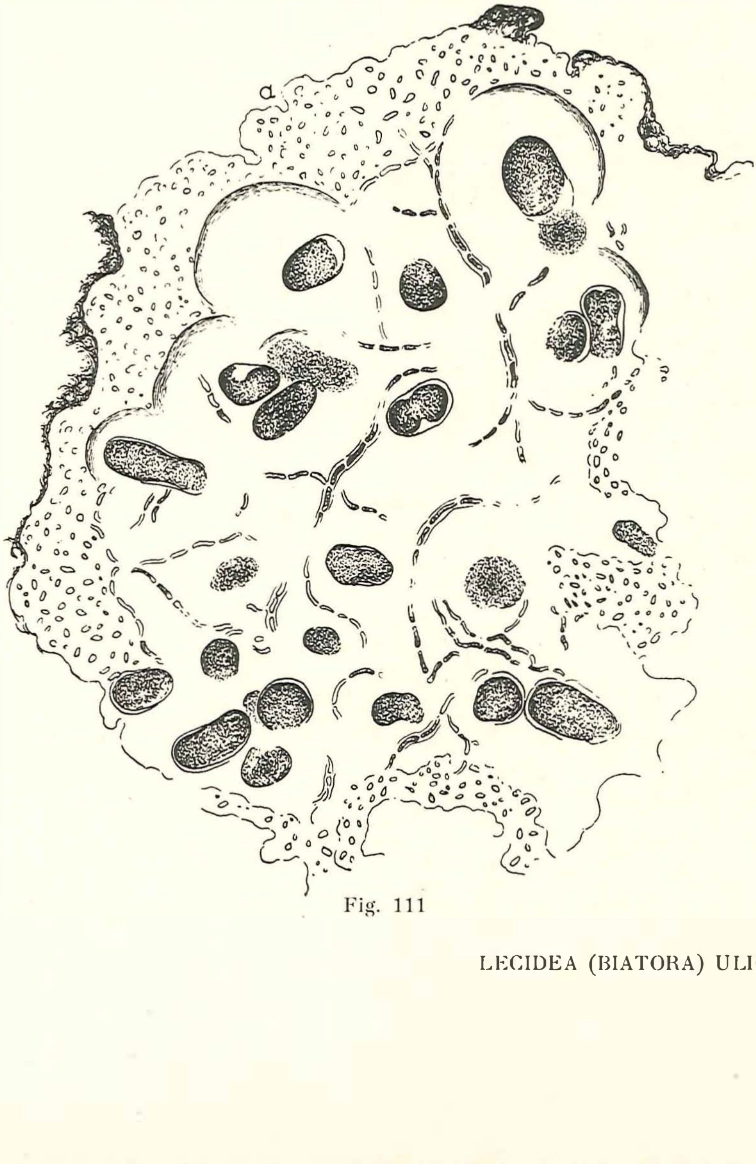


Fig. 111

O. Galløe del.

LECIDEA (BIATORA) ULIGINOSA SCHRAD.

PLATE 45.

LECIDEA (BIATORA) ULIGINOSA.

SCHRAD.

Fig. 112. 4 apothecia and granules of the thallus All the dark portions below in the thallus are humus. (×60).

Fig. 113. Margin of an apothecium with an ascus. The limits between calyx, hymenium, and hypothecium are quite indistinct.

Fig. 114. Brown rhizoidal hyphæ. (×450).

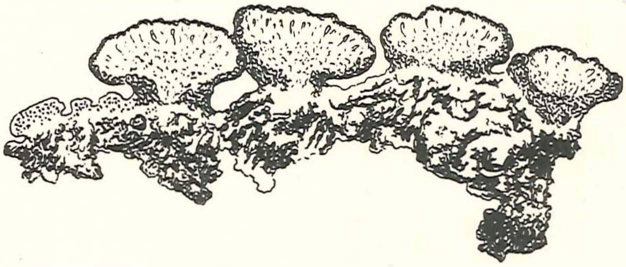


Fig. 112

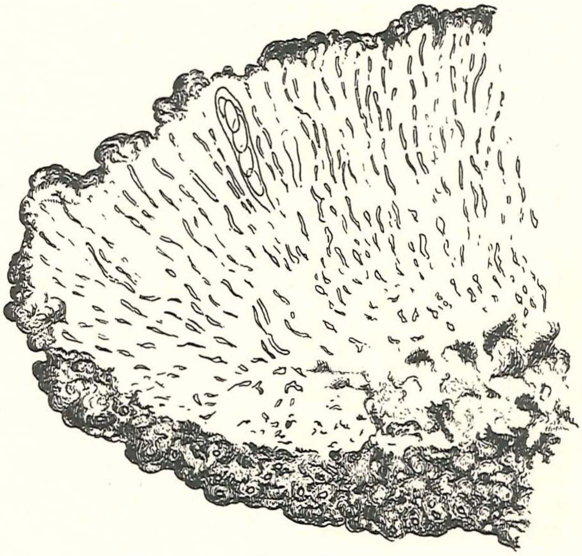


Fig. 113

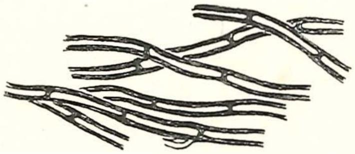


Fig. 114

O. Galløe del.

LECIDEA (BIATORA) ULIGINOSA Schrad.

PLATE 46

LECIDEA (BIATORA) ERYTHROPHÆA.

Flke.

Fig. 115. Thallus with apothecia of all ages; on *Fraxinus*. (×15).
Fig. 116. Thallus with young apothecia. (×60).

PLATE 46.

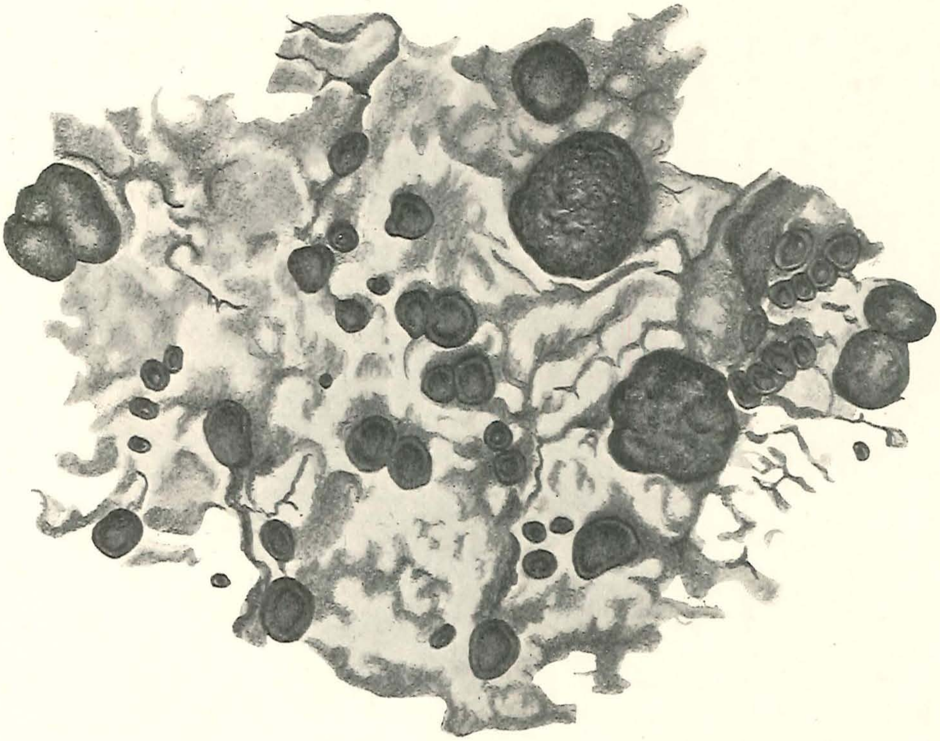


Fig. 115

Fig. 116

O. Galløe del. LECIDEA (BIATORA) ERYTHROPHÆA Flke.

PLATE 47.

LECIDEA (BIATORA) ERYTHROPHÆA.

FLKE.

Fig. 117. Section of thallus with an older apothecium; the periderm of the ash is visible below. (×60)

Fig. 118. Section of thallus with a young apothecium (×60).

PLATE 47.

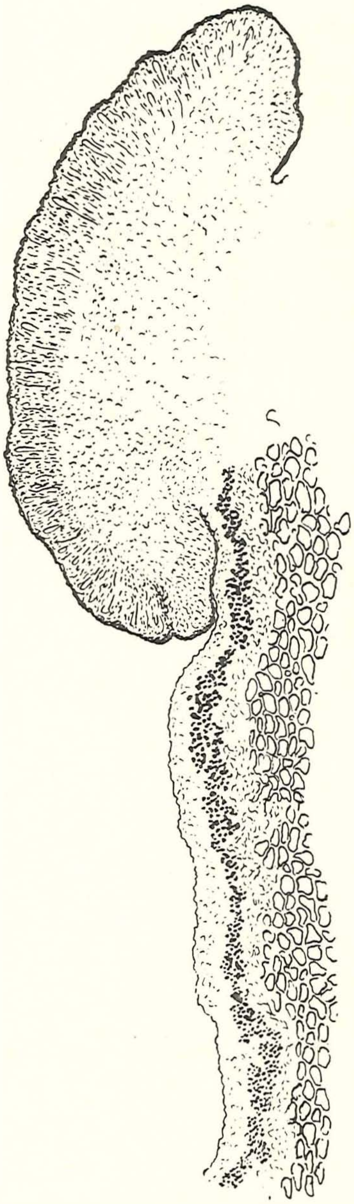


Fig. 117

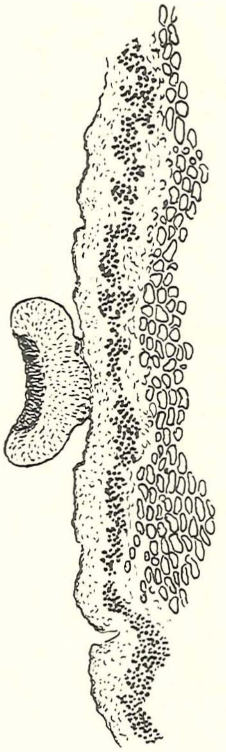


Fig. 118

O. Galløe del.

LECIDEA (BIATORA) ERYTHROPHÆA Flke.

PLATE 48.

LECIDEA (BIATORA) ERYTHROPHÆA.

FLKE.

Fig. 119. Section of thallus. The cells of the periderm are visible below. Some are empty and some show the remains of the living contents. (×450).

Fig. 120. Section of the margin of an apothecium. Below: a part of the thallus. (×450).

Fig. 121. Section of hymenium from the centre of the apothecium. To the right: a spore. (×450).

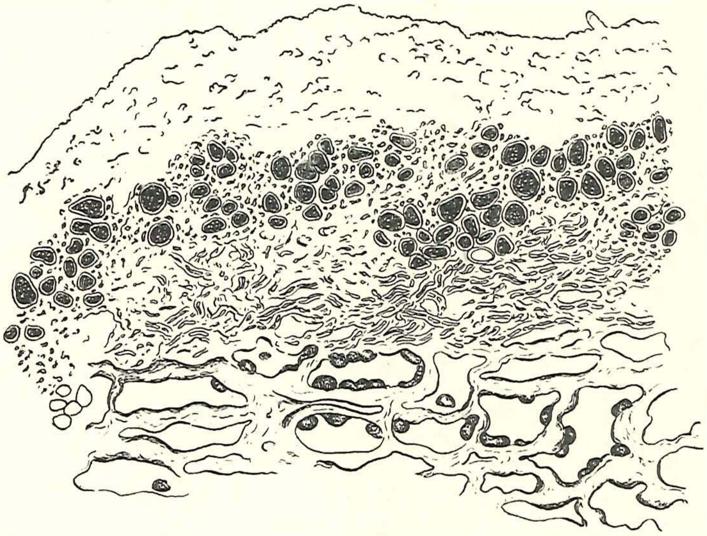


Fig. 119

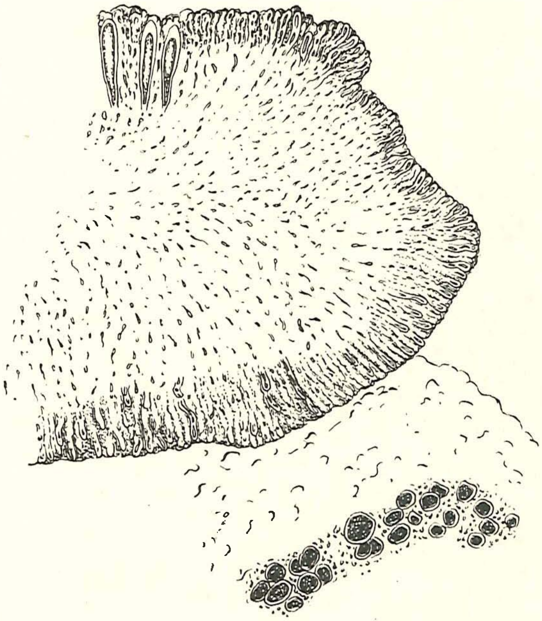


Fig. 120

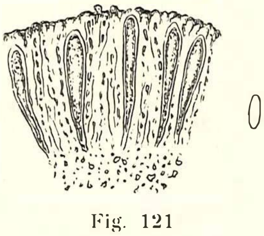


Fig. 121

O. Galloe del.

LECIDEA (BIATORA) ERYTHROPHÆA Flke.

PLATE 49.

[LECIDEA (BIATORA) TURGIDULA].

Fr.

Swedish specimen.

Fig. 122. Two apothecia in vertical section. (×60).

Fig. 123. Thallus (yellowish patches) growing on dead wood of pine (*Pinus*). Apothecia in all stages of development. (×40).

Fig. 122

Fig. 123

O. Galloe del.

[LECIDEA (BIATORA) TURGIDULA Fr.]
(Swedish specimen)

PLATE 50.

[LECIDEA (BIATORA) TURGIDULA].

Fr.

Swedish specimen.

Fig. 124. Thallus with an apothecium. (×60)

Fig. 125. Thallus growing inside the wood-cells of a pine (*Pinus*). Margin of the apothecium. 3 spores. (×450).

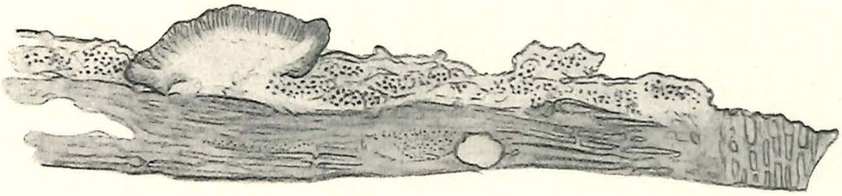


Fig 124

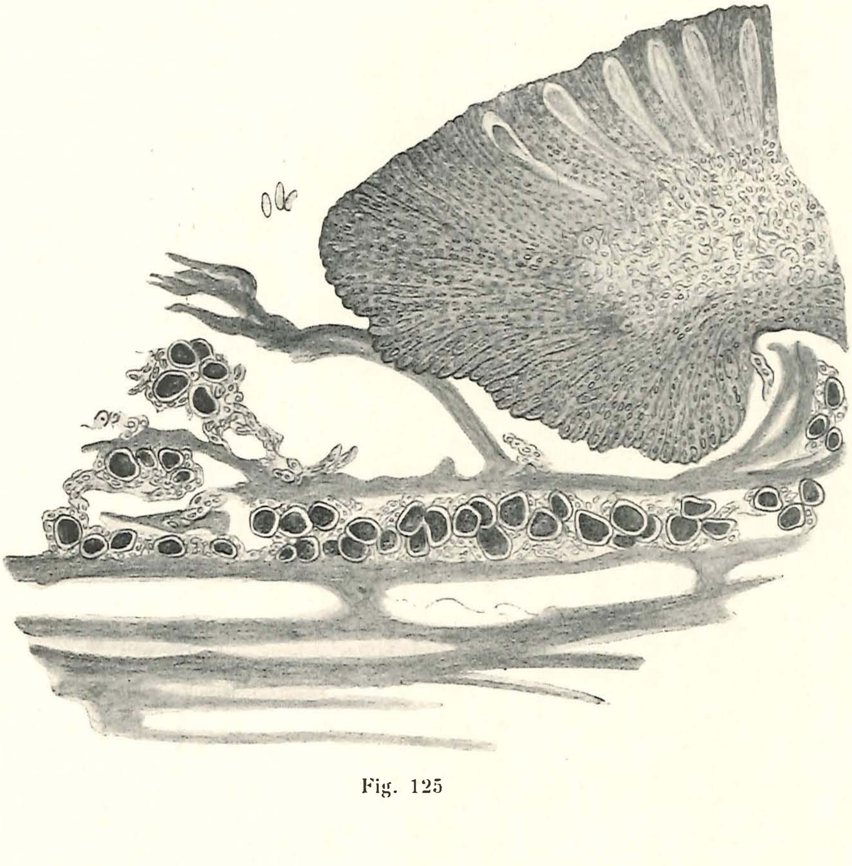


Fig. 125

O. *Galløe del.*

[LECIDEA (BIATORA) TURGIDULA FR.]
(Swedish specimen)

PLATE 51.

LECIDEA PANTHERINA.

Ach.

Fig. 126. Distribution of colour in the apothecium. (×60).

Fig. 127. Thallus with young, (dark spots) and older (lighter) areoles. At the very border below in the figure a single grain of quartz can be made out, which rises above the thallus. It is about to be overgrown by two dark margins. Much the same is seen above to the left. (×15).

Fig. 126

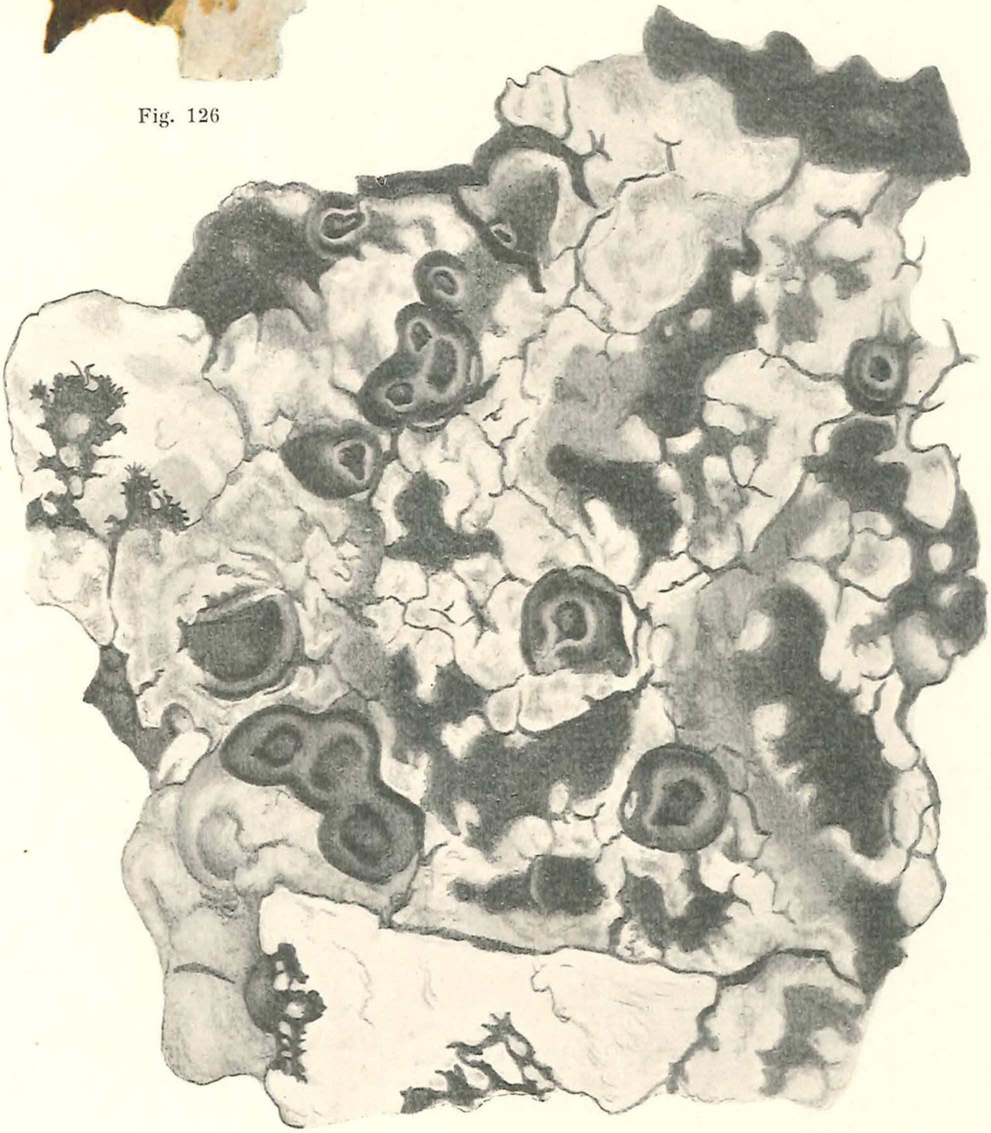


Fig. 127

O. Galløe del.

LECIDEA PANTHERINA Ach.

PLATE 52.

LECIDEA PANTHERINA.

Ach.

Fig. 128. A big grain of quartz, which is about to be overgrown by a black margin, on which young light areoles are in course of formation. (×45).

Fig. 129. 5 very young apothecia about to break through the cortex of the thallus. They are still quite white on the margin from adhering portions of the cortex. (×45).

Fig. 130. Below: an apothecium with still adhering portions of cortex; above: a single one that is quite free. (×45).

PLATE 52.

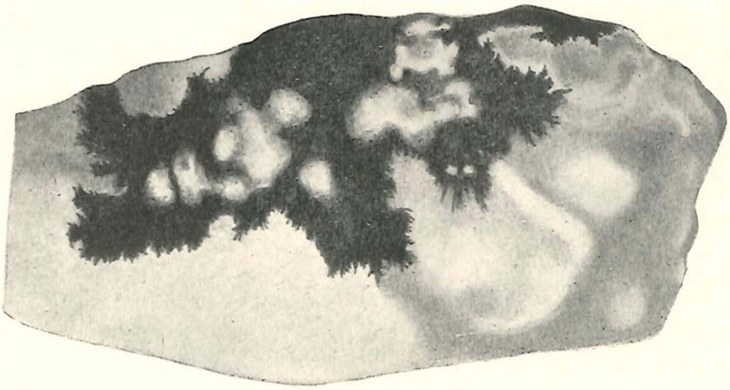


Fig. 128

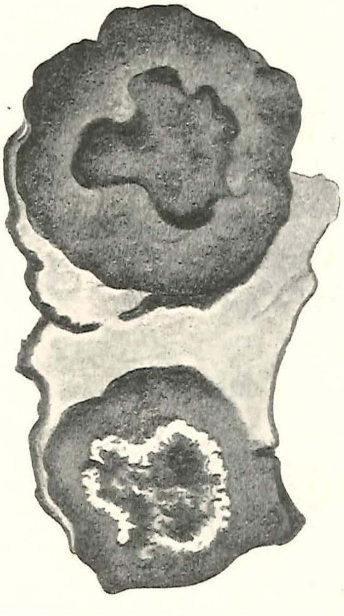


Fig. 130

Fig. 129

O. Galløe del.

LECIDEA PANTHERINA Ach.

PLATE 53.

LECIDEA PANTHERINA.

Ach.

Fig. 131. Black retiform »margin« on a grain of quartz. All the light spots are empty meshes in the net. (×60)

Fig. 132. Single, black-walled hyphæ from the network in fig. 131. (×450).

Fig. 133. Section of an apothecium and a portion of the thallus. The dark lines in the hymenium are portions of the sinuose margin cut by the knife as they curve towards the middle of the apothecium. (×60).

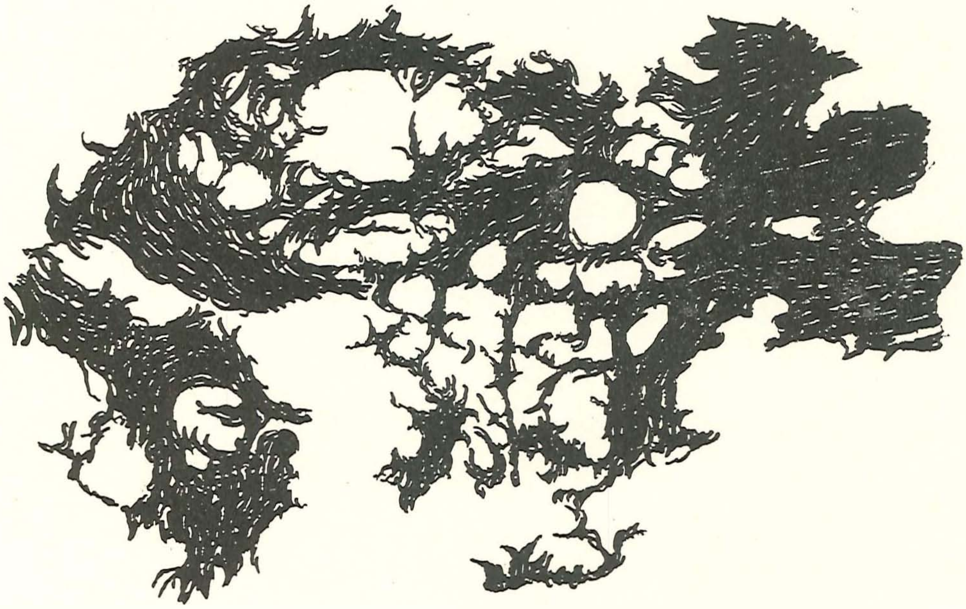


Fig. 131

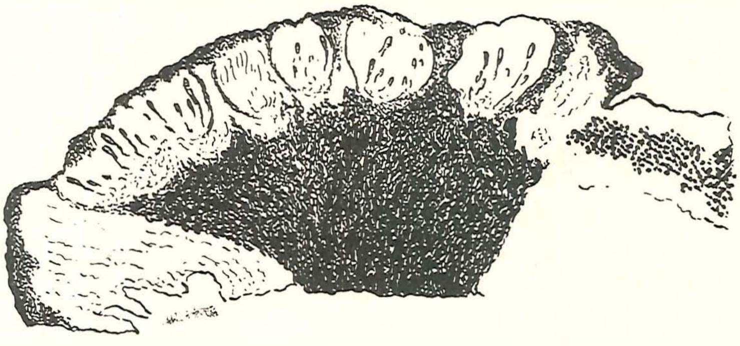


Fig. 133

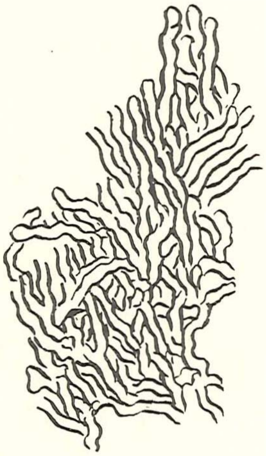


Fig. 132

O. Galløe del.

LECIDEA PANTHERINA Ach.

PLATE 54.

LECIDEA PANTHERINA.

Ach.

Fig. 134. Margin of an apothecium with a portion of the hymenium. Above to the left: remnants of the cortex of the thallus are visible on the dark margin. (×450).

Fig. 135. Portion of the thallus in vertical section. (×450).

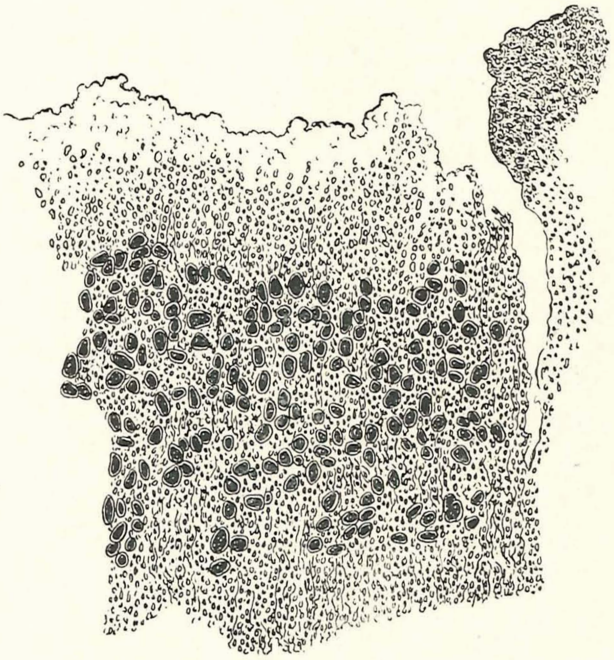


Fig. 135

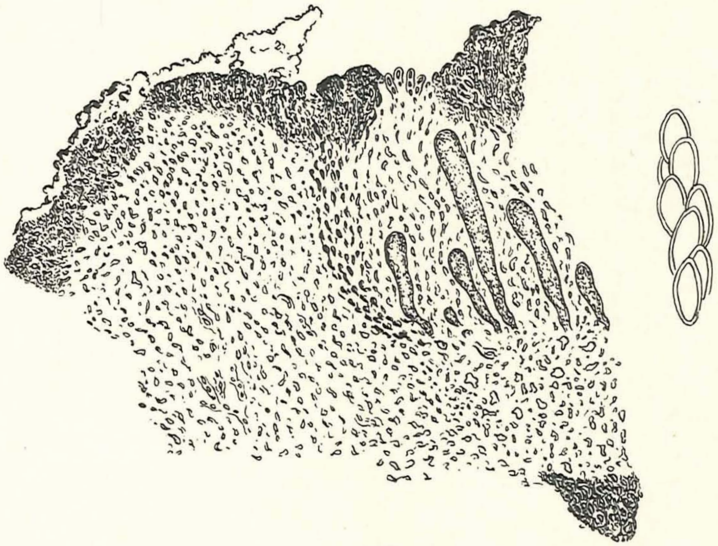


Fig. 134

O. Galløe del. LECIDEA PANTHERINA Ach.

PLATE 55.

LECIDEA LAPICIDA.

(ACH.) ARN.

Fig. 136. Apothecium in vertical section. (×60).

Fig. 137. Thallus with young apothecia. The white spots are grains of quartz that rise up through the thallus. They will be overgrown by dark hyphæ later.

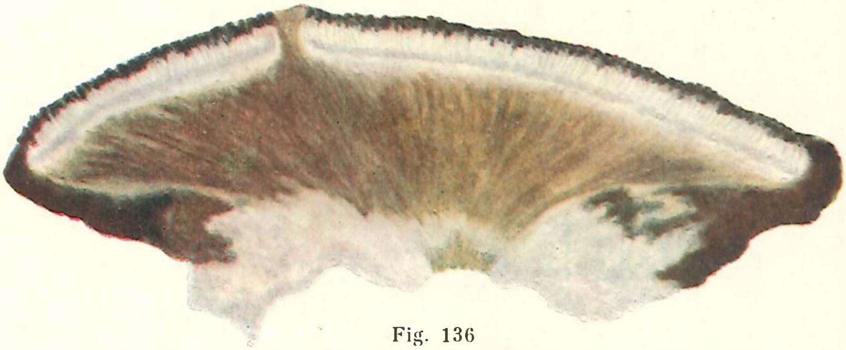


Fig. 136

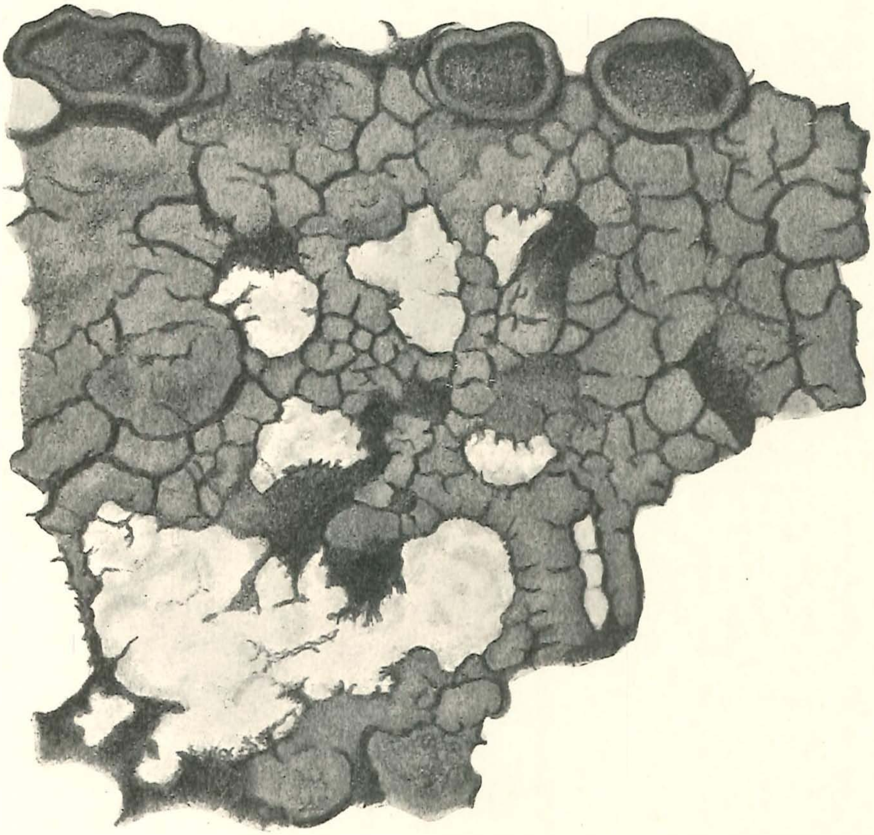


Fig. 137

O. Galløe del.

LECIDEA LAPICIDA (Ach.) Arn.

PLATE 56.

LECIDEA LAPICIDA.

(ACH.) ARN.

Fig. 138. Thallus with apothecia of all ages. White grains of quartz with dark hyphæ are seen. (×15).

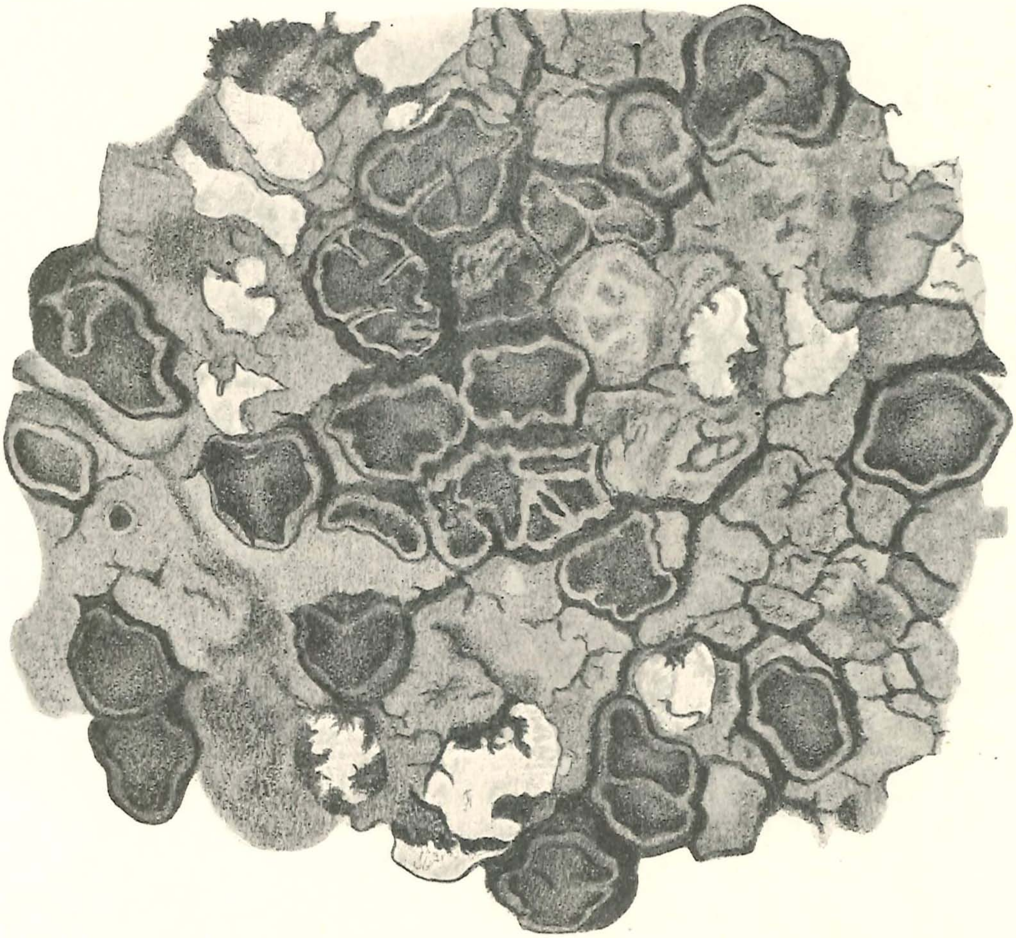


Fig. 138

O. Galløe del.

LECIDEA LAPICIDA (ACH.) ARN.

PLATE 57.

LECIDEA LAPICIDA.

(ACH.) ARN.

Fig. 139. Margin of thallus, (black) with young areoles (grey) on a big white grain of quartz. (×45).

Fig. 140. Two young apothecia that have broken through the surface of the thallus. (×45).

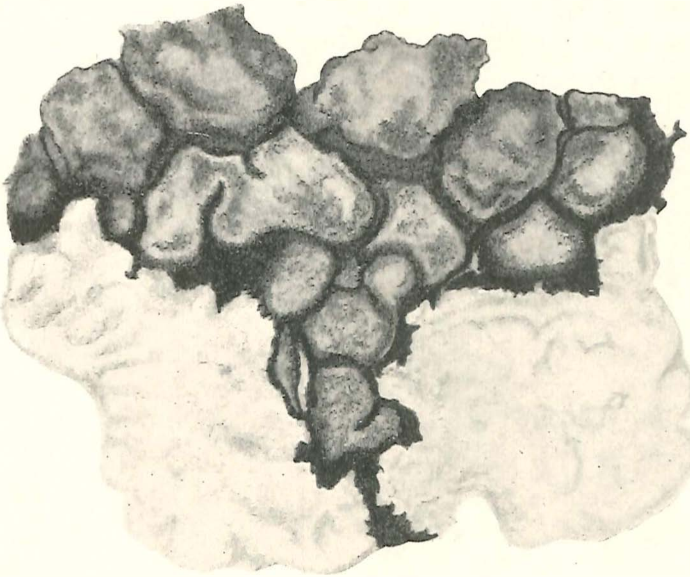


Fig. 139

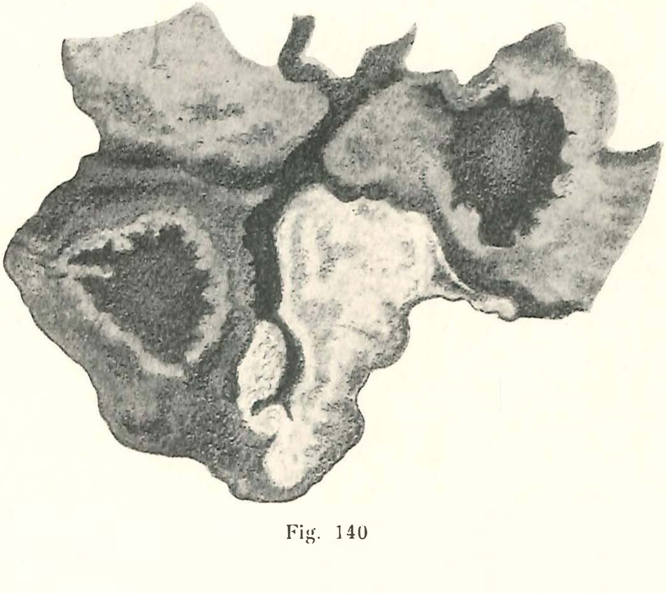


Fig. 140

O. Galløe del.

LECIDEA LAPICIDA (Ach.) Arn

PLATE 58.

LECIDEA LAPICIDA.

(ACH.) ARN.

Fig. 141. Part of an areole. The gonidia are represented by round, black spots. The remainder, of a grey colour, represent the rust-coloured portions of cortex and medullary layers. (×60).

Fig. 142. An areole, the sides of which (to the right and to the left) are black. Many particles of rust can be seen.

Fig. 143. Margin of an areole; on the horizontal surface the cortex is provided with dead cuticle; below it are seen numerous particles of rust (outside the gonidia). The sides of the areole (to the right) have a living cortex, but no cuticle. (×450).

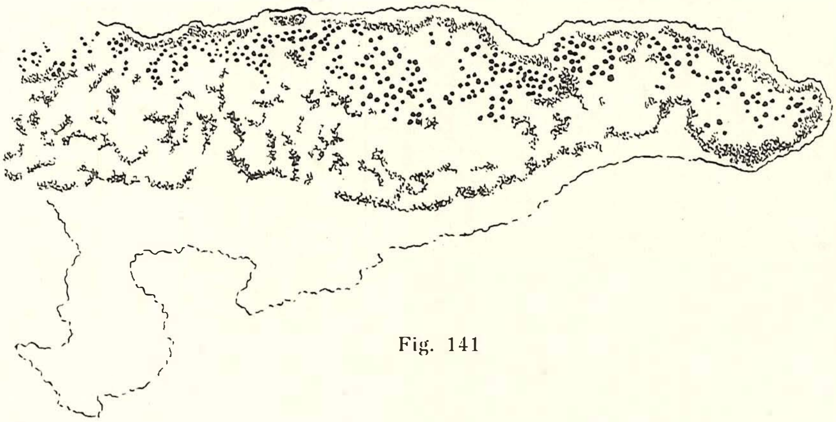


Fig. 141

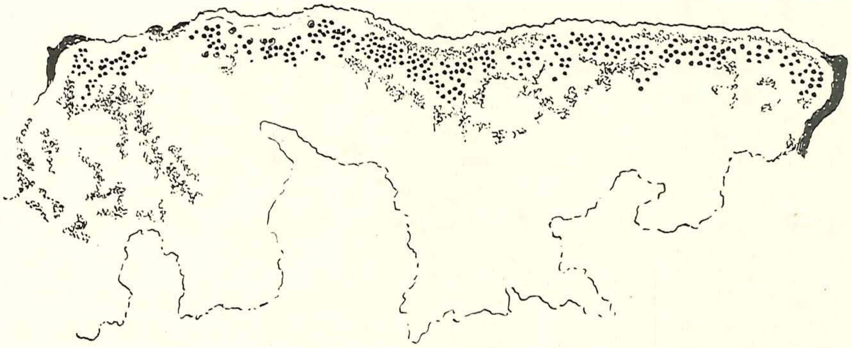


Fig. 142

Fig. 143

O. Galløe del.

LECIDEA LAPICIDA (Ach.) Arn.

PLATE 59.

LECIDEA LAPICIDA

(ACH.) ARN.

Fig. 144. Part of a thallus-areole. Below the dead cuticle are numerous, closely packed particles of rust; also below in the medullary layer, but scarcely any in the gonidial layer. (×450).

Fig. 145. Hyphæ from the cortex on the dark (black) vertical sides of an areole. The contents of the hyphæ are living and will stain. (×450).

Fig. 146. Hyphæ from the medullary layer below the rust-coloured portions, provided with numerous separated grains of minerals. (×450).

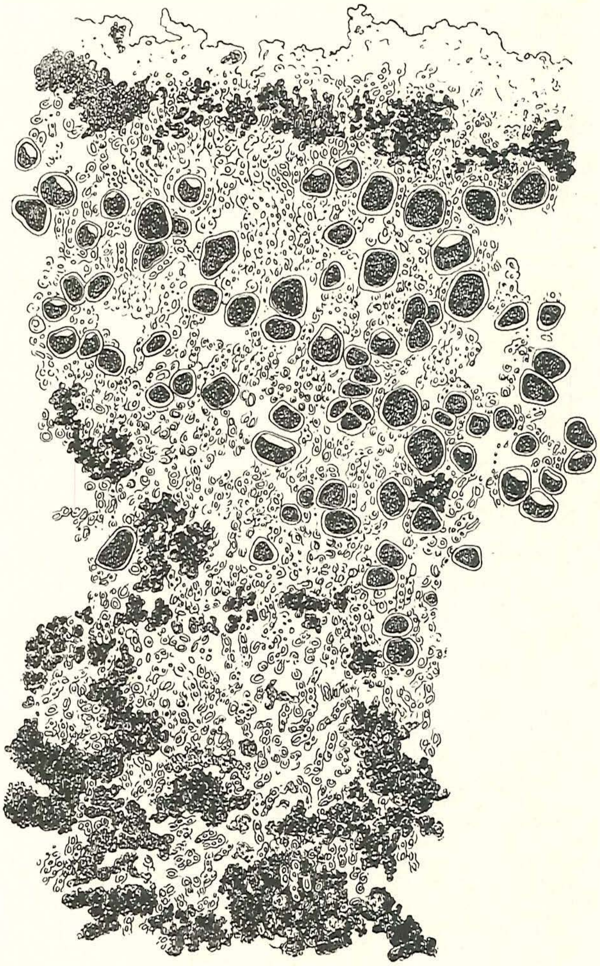


Fig. 144

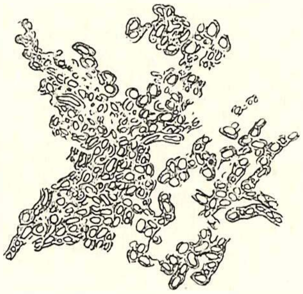


Fig. 145

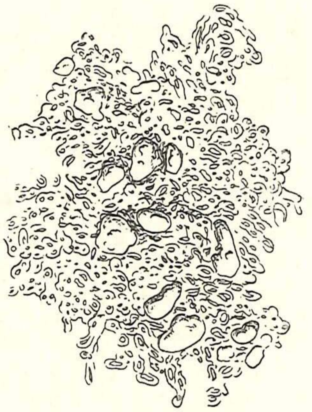


Fig. 146

O. Galløe del.

LECIDEA LAPICIDA (Ach.) Arn.

PLATE 60.

LECIDEA LAPICIDA.

(ACH.) ARN.

Fig. 147. Apothecium. The dark spots forming a zone on the stalk, and on the inner side of the calyx are cells incrusted with particles of rust. (×60).

Fig. 148. 2 contiguous apothecia. The hyphæ in the stipes radiate very distinctly. (×60).

Fig. 149. Apothecium. (×60).

PLATE 60.

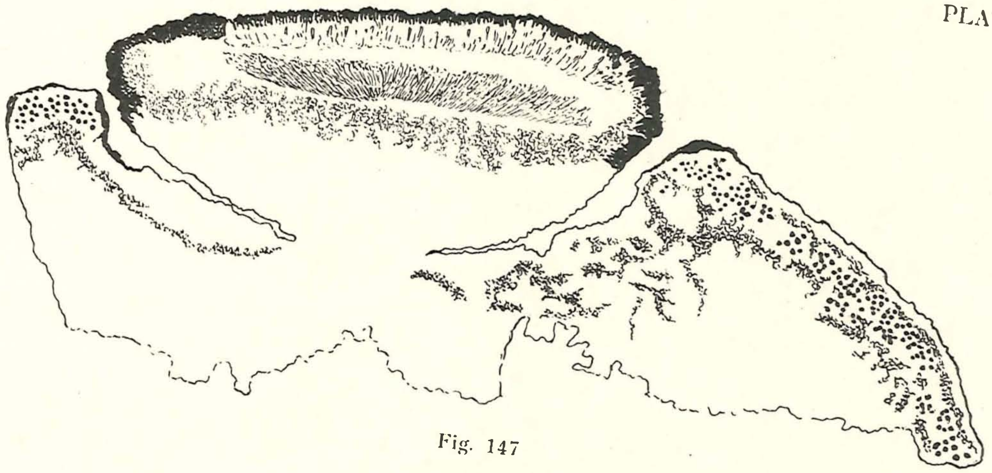


Fig. 147

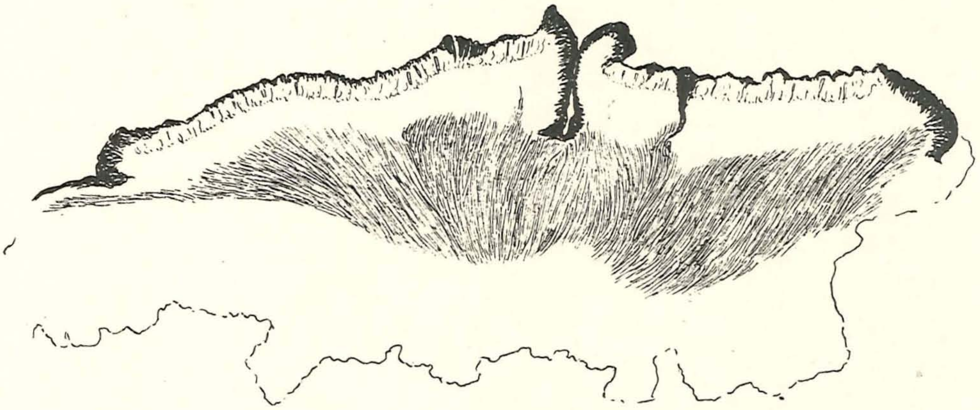


Fig. 148

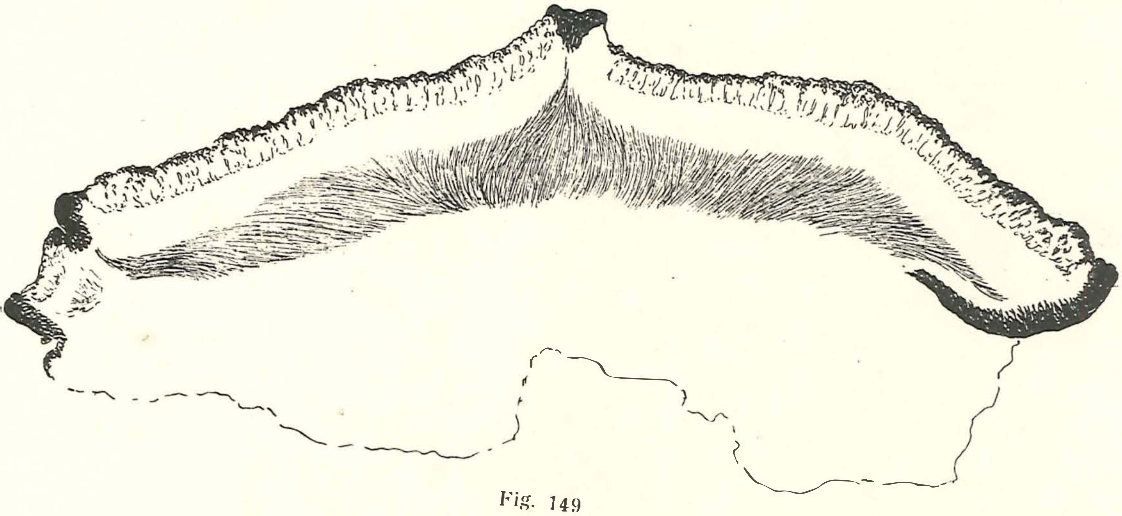


Fig. 149

O. Galloe del.

LECIDEA LAPICIDA (Ach.) Arn.

PLATE 61.

LECIDEA LAPICIDA.

(Ach.) Arn.

Fig. 150.	Margin of apothecium. (×450).
Fig. 151.	Paraphyses, young asci, and a spore. (×450).
Fig. 152.	Hymenium and a part of the hypothecium. (×450).

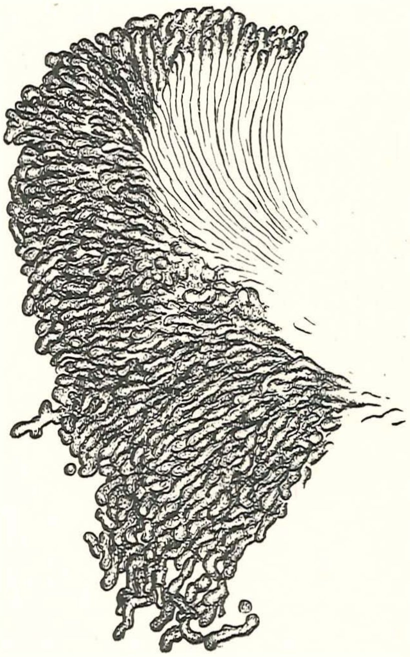


Fig. 150

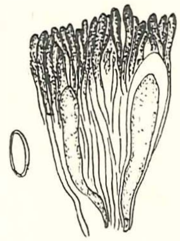


Fig. 151

Fig. 152

O. Galløe del.

LECIDEA LAPICIDA (ACH.) ARN.

PLATE 62.

LECIDEA LITHOPHILA.

Ach.

Specimen 1 and **specimen 2.**

Fig. 153. Specimen 1, apothecium in vertical section. (×60).
Fig. 154. Specimen 2, apothecium in vertical section. (×60).

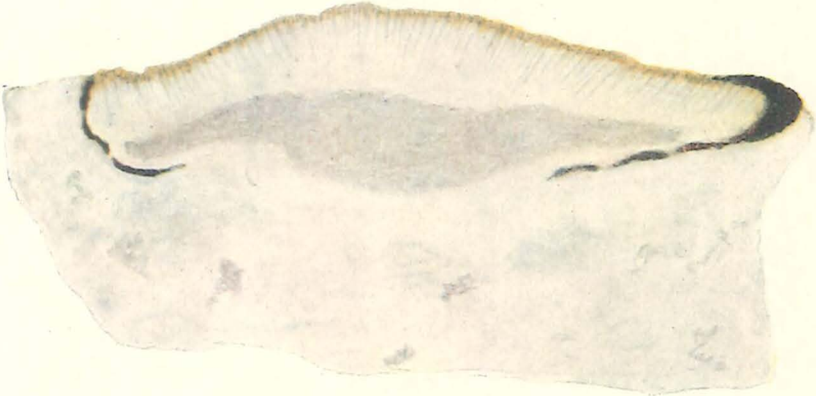


Fig. 153

Fig. 154

O. Galløe del.

LECIDEA LITHOPHILA Ach.
(Specimen 1 and 2)

PLATE 63.

LECIDEA LITHOPHILA.

Ach.

Specimen 1.

Fig. 155. Thallus with apothecia at various ages, and stages of breaking through. (×15).

Fig. 156. Thallus with corticated areoles, pa

Fig. 155

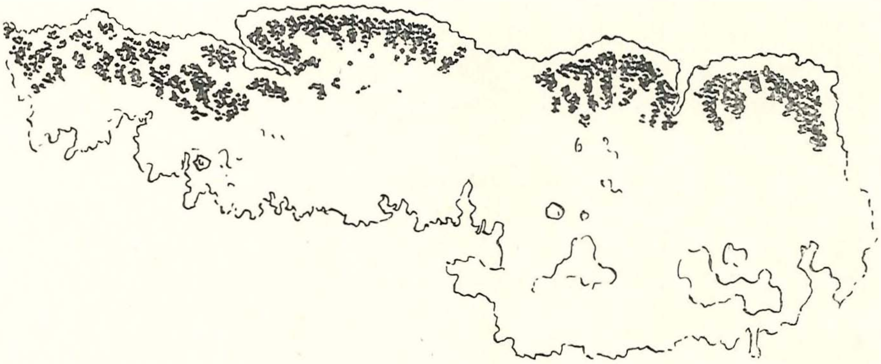


Fig. 156

O. Galløe del.

LECIDEA LITHOPHILA Ach.
(Specimen 1)

PLATE 64.

LECIDEA LITHOPHILA.

ACH.

Specimen 1.

Fig. 157. The border between two areoles. (×450).

Fig. 158. Apothecium with black margin. Below the hymenium are seen the hypothecium and the white stripes, and under that a slightly black layer of the calyx. (×60).

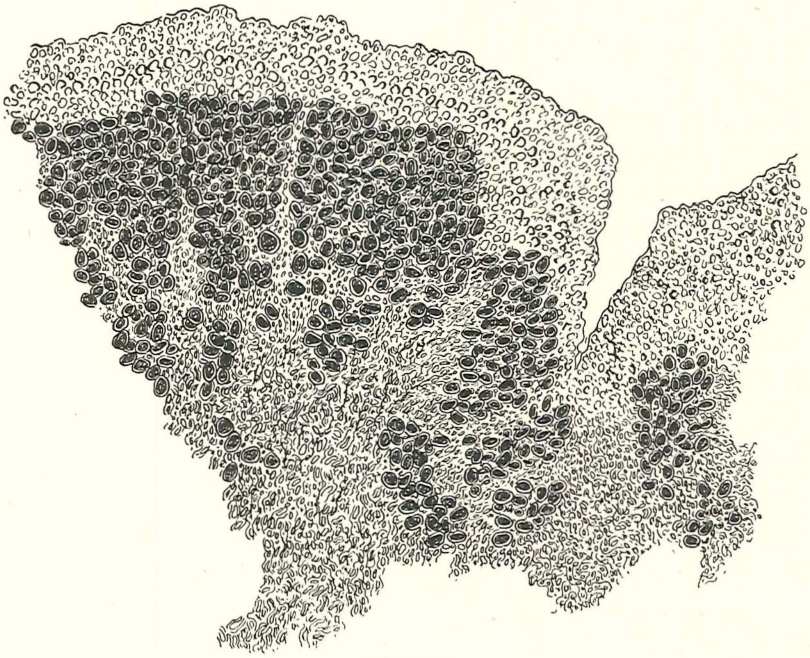


Fig. 157

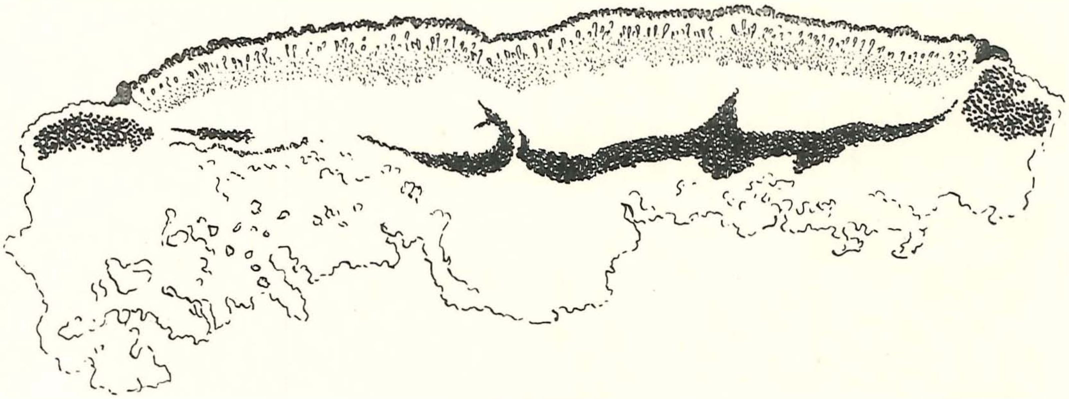


Fig. 158

O. Galløe del.

LECIDEA LITHOPHILA Ach.
(Specimen 1)

PLATE 65.

LECIDEA LITHOPHILA.

Ach.

Specimen 1.

Fig. 159. Margin of the apothecium. To the right of the hymenium is the margin, partly black, but it continues downwards colourless, where it borders on two groups of gonidia.

Fig. 160. Part of the hymenium and hypothecium (×450). To the right: an ascus. (×600).

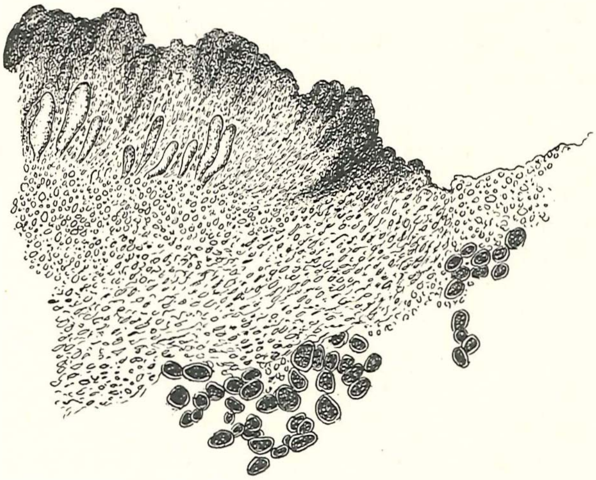


Fig. 159

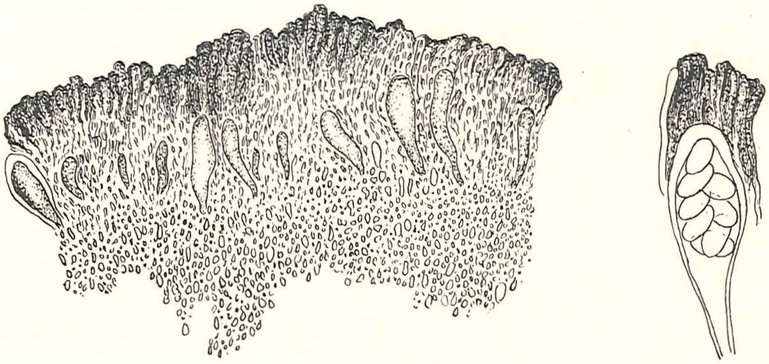


Fig. 160

O. Galløe del.

LECIDEA LITHOPHILA Ach.

(Specimen 1)

PLATE 66.

LECIDEA LITHOPHILA.

Ach.

Specimen 2.

Fig. 161. Thallus with apothecia in various stages of development. Above to the left is the margin of the thallus (black, radiating outwards). (× 15).

Fig. 162. Two young connate apothecia near the margin of the thallus; the latter is black and is overgrowing a large grain of quartz. (×60).

Fig. 163. An areole with gonidia in chains. (×450).

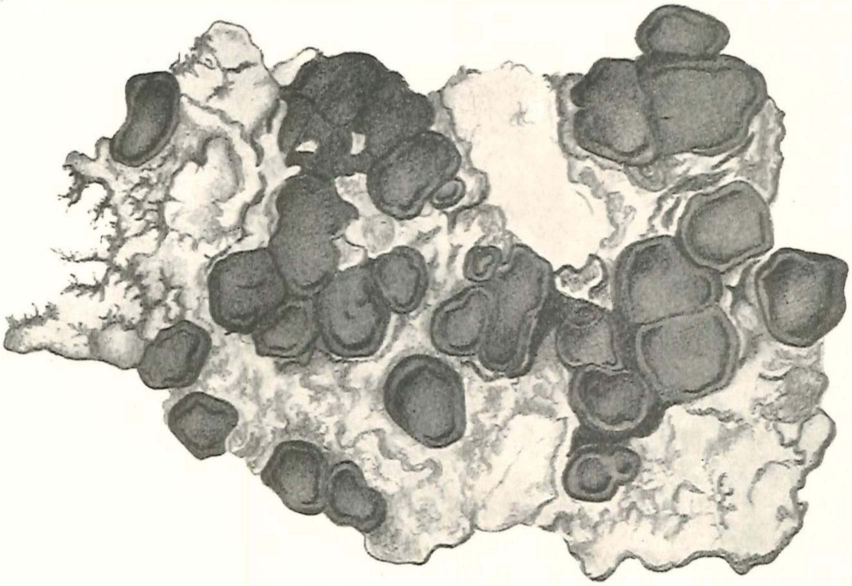


Fig. 161

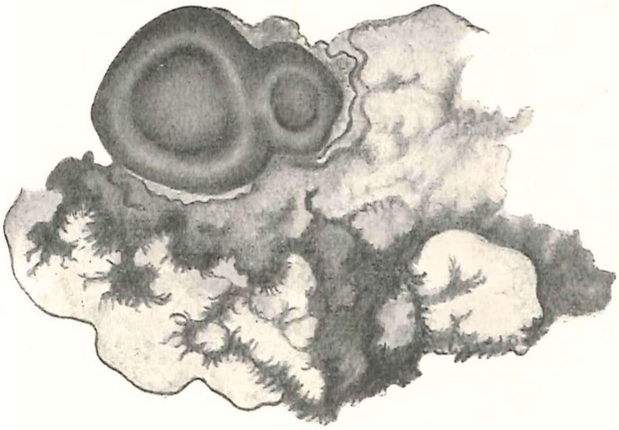


Fig. 162

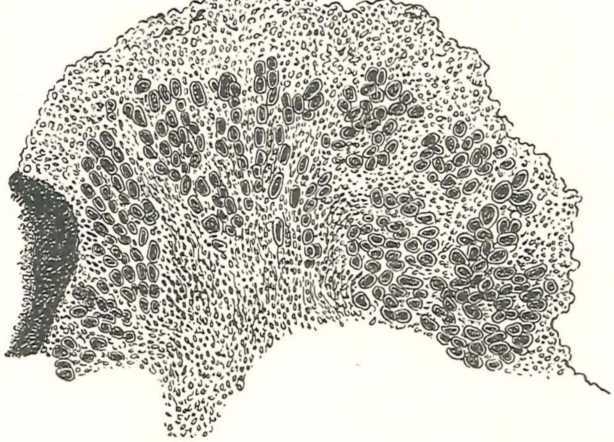


Fig. 163

O. Galløe del.

LECIDEA LITHOPHILA Ach.
(Specimen 2)

PLATE 67.

LECIDEA LITHOPHILA.

Ach.

Specimen 2.

Fig. 164. Apothecium. (×60).
Fig. 165. Margin of apothecium bordering on the thallus (to the right). (×450).
Fig. 166. Paraphyses, young ascus, and a spore. (×450).

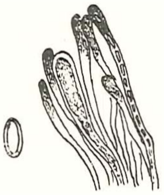


Fig. 166

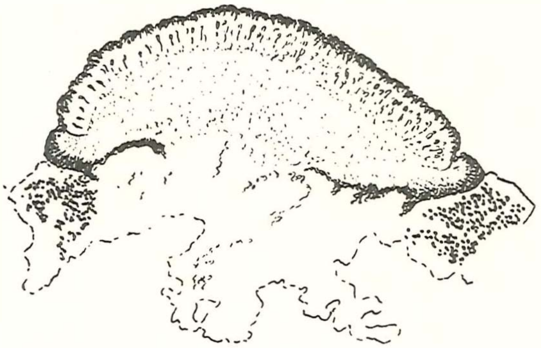


Fig. 164

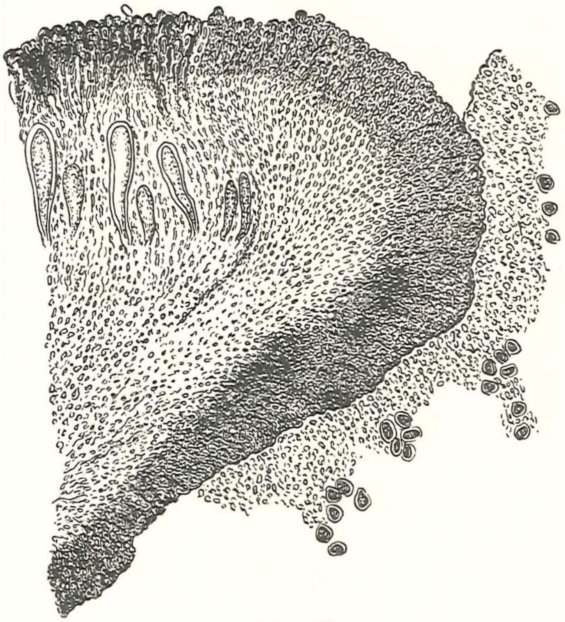


Fig. 165

O. Galløe del.

LECIDEA LITHOPHILA Ach.
(Specimen 2)

PLATE 68.

LECIDEA PLANA.

LAHM.

Fig. 167. Apothecium in vertical section. (×60).

Fig. 168. Thallus with apothecia at all ages. (×15).

Fig. 169. Apothecia. (×45).

Fig. 170. Thallus, vertical section through cortex, gonidial and medullary layers. (×450).

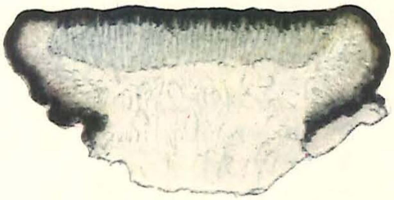


Fig. 167

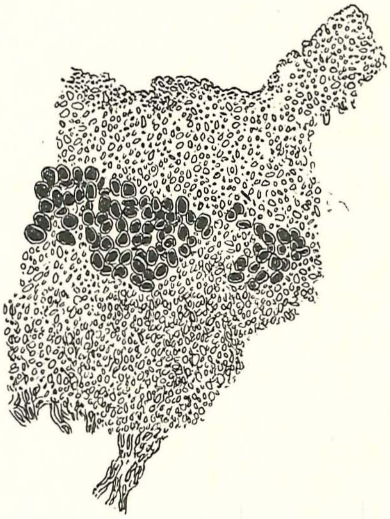


Fig. 170

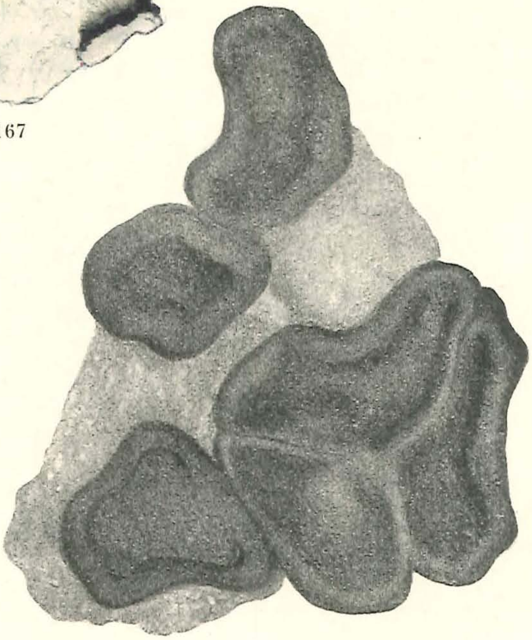


Fig. 169

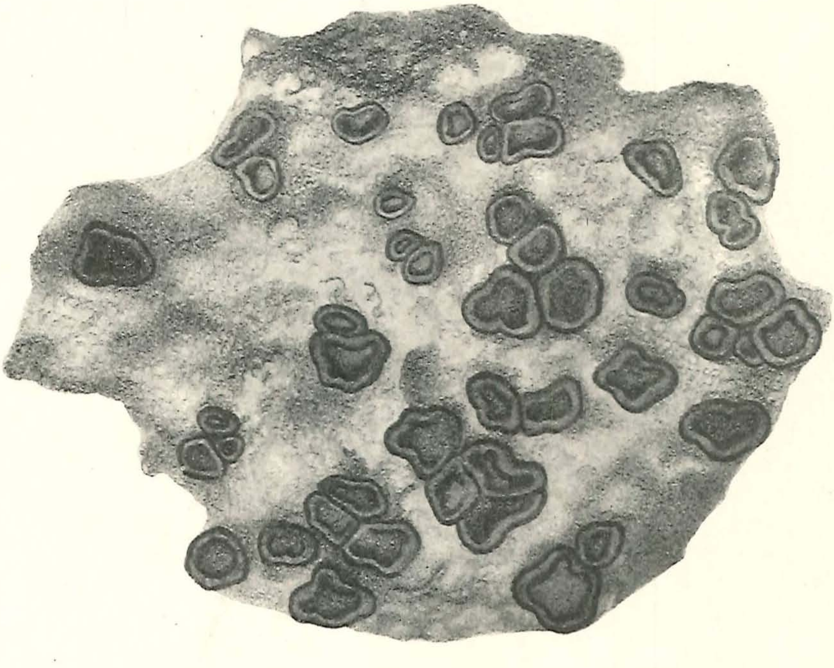


Fig. 168

O. Galloe del.

LECIDEA PLANA LAHM.

PLATE 69.

LECIDEA PLANA.

LAHM.

Fig. 171. To the left: 2 apothecia in median section; to the right: 1 apothecium cut just outside the axis. (×60).

Fig. 172. Part of apothecium with paraphyses, asci, hypothecium, and upper part of stipes. (×450).

Fig. 173. Margin of apothecium and 1 spore. (×450).

PLATE 69.

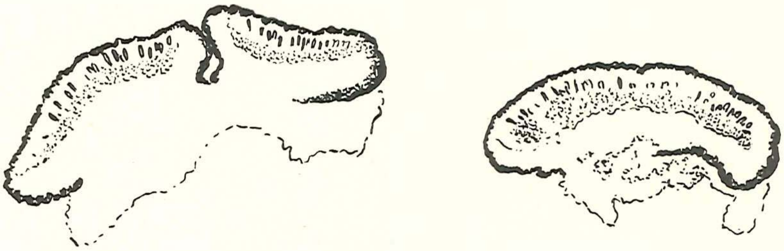


Fig. 171

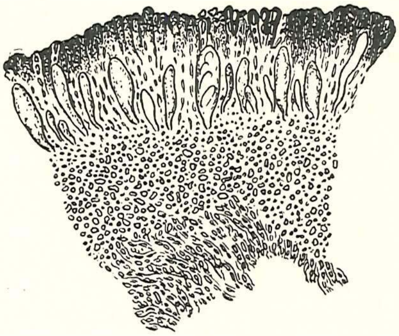


Fig. 172

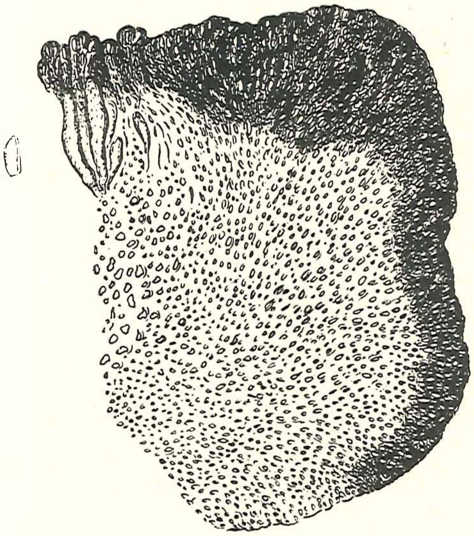


Fig. 173

O. Galløe del.

LECIDEA PLANA Lahm.

PLATE 70.

LECIDEA AURICULATA.

Th. Fr.

Specimen 1 and **specimen 5.**

Fig. 174. Apothecium in vertical section. (×60).
Fig. 175. Apothecium in vertical section. (×60).

Fig. 174

Fig. 175

O. *Galløe del.*

LECIDEA AURICULATA TH. FR.
(Specimen 1 and 5)

PLATE 71.

LECIDEA AURICULATA.

TH. FR.

Specimen 1.

Fig. 176. A sand-corroded stone, the right side of which faced the west (the most common direction of the wind) and has been ground smooth. On the left (the lee side) the lichen with its narrow reticulate thallus-stripes, on which the apothecia are situated. The open meshes of the net represent the bare surface of the stone. (To the right of the Lecidea was found a sterile and indeterminable thallus of another crustaceous lichen. (×4).

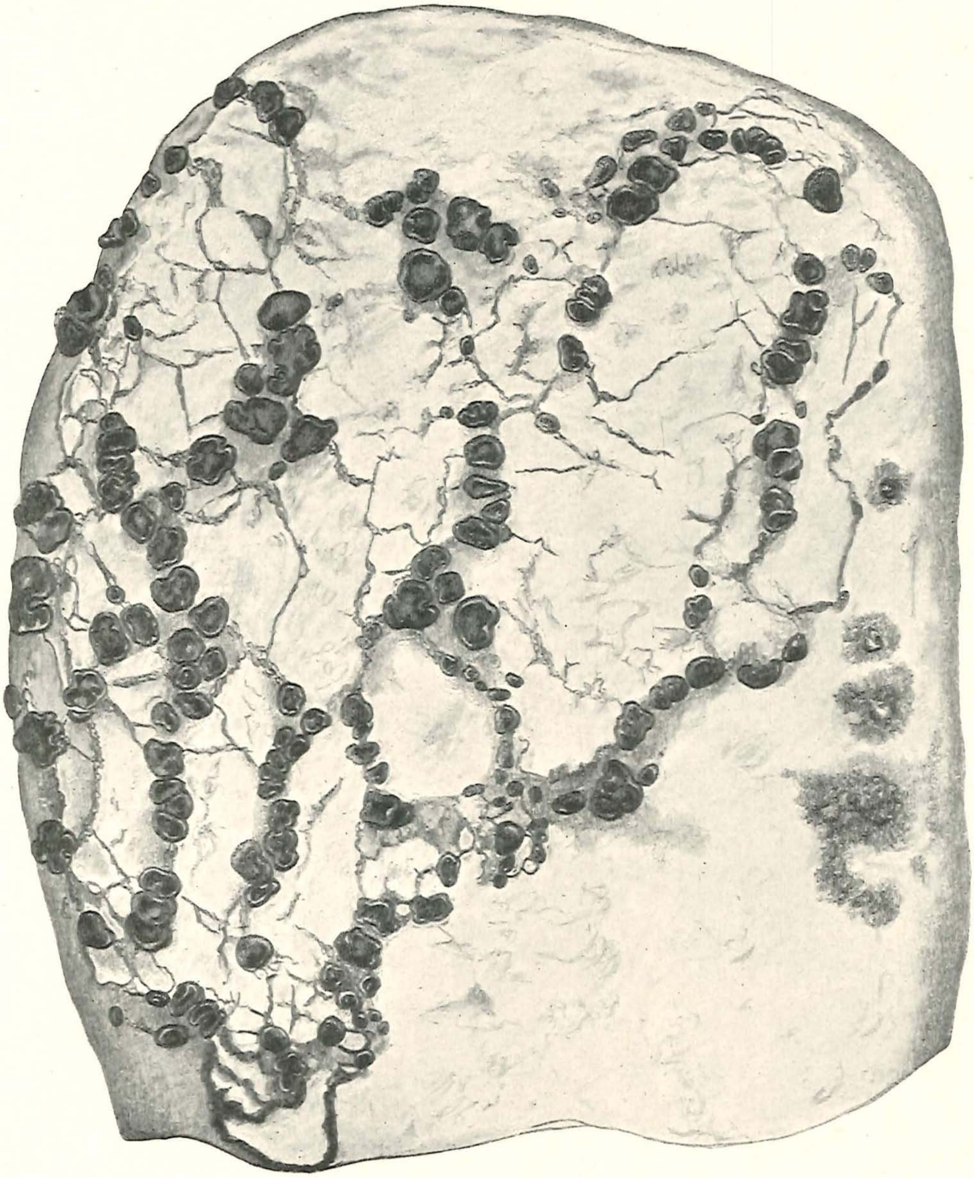


Fig. 176

O. Galløe del.

LECIDEA AURICULATA TH. FR.
(Specimen 1)

PLATE 72.

LECIDEA AURICULATA.

TH. FR.

Specimen 1.

Fig. 177. Fragment of the same stone as in fig. 176, showing the narrow, grey, thallus stripes (with apothecia) and the (white) naked grains of minerals. (×15).

Fig. 178. Vertical section of thallus (cortical and gonidial layers). (×450).

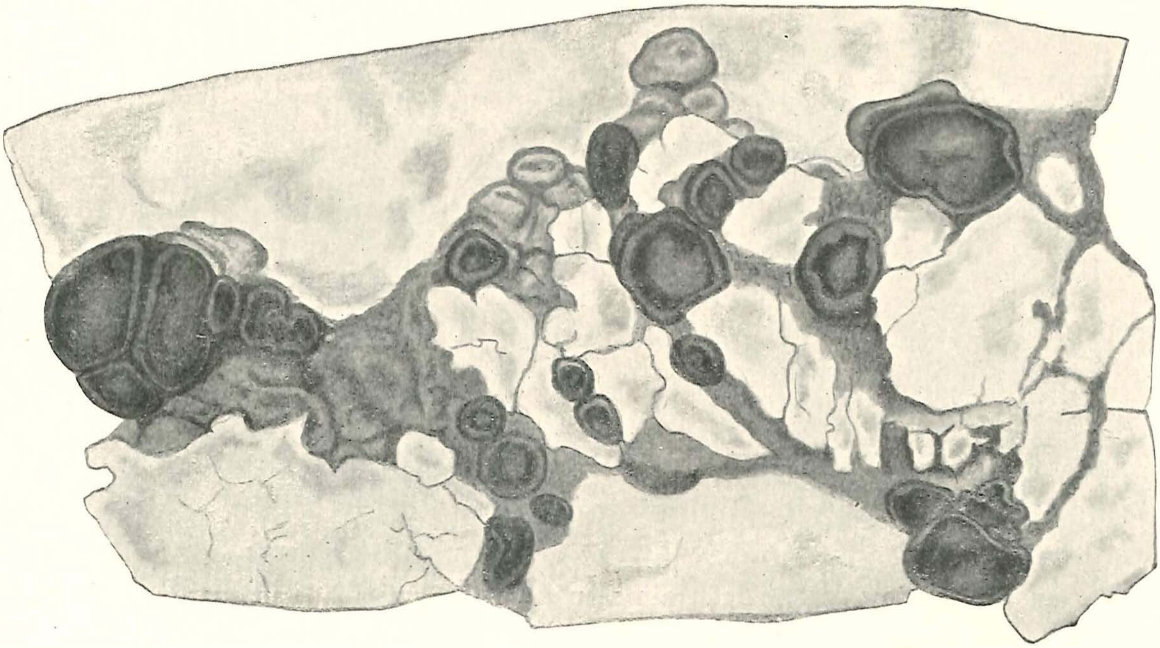


Fig. 177

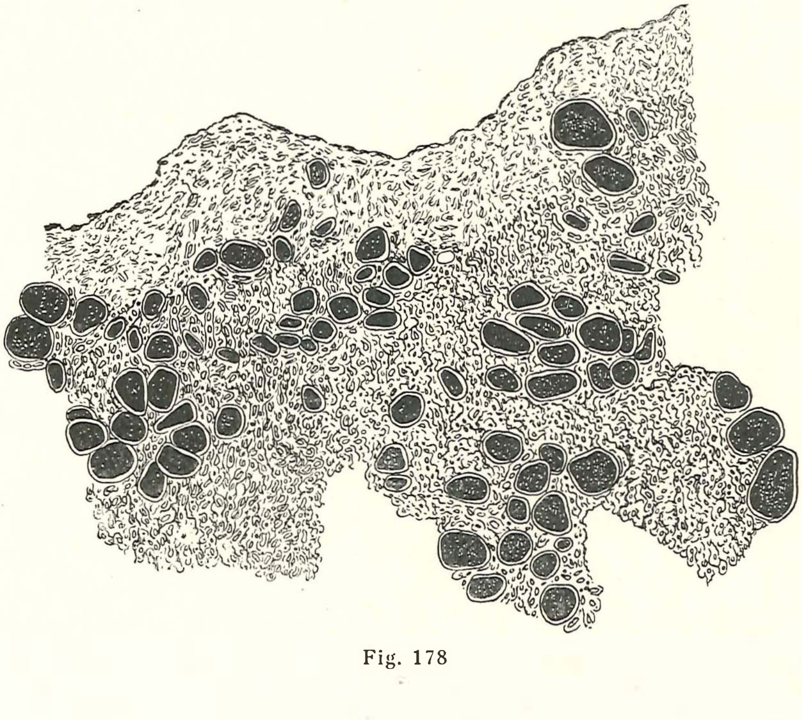


Fig. 178

O. Galløe del.

LECIDEA AURICULATA TH. FR.
(Specimen 1)

PLATE 73.

LECIDEA AURICULATA.

Th. Fr.

Specimen 1.

Fig. 179. Below: a mineral grain seen from the under side and partly covered by rhizoidal hyphæ in irregular shapes and with cells of unequal length. Above: some hyphæ a little higher in the stone, and near its surface where the rhizoidal zone and the gonidial layer meet. Three gonidia. (×450).

Fig. 180. Vertical but not median section of apothecium. (×60).

Fig. 181. Vertical but distinctly tangential section of an apothecium. (×60).

Fig. 182. Margin of the apothecium, an ascus, three isolated ripe spores, and part of the hymenium with three unripe asci and distinct paraphyses. (×450).

PLATE 73.

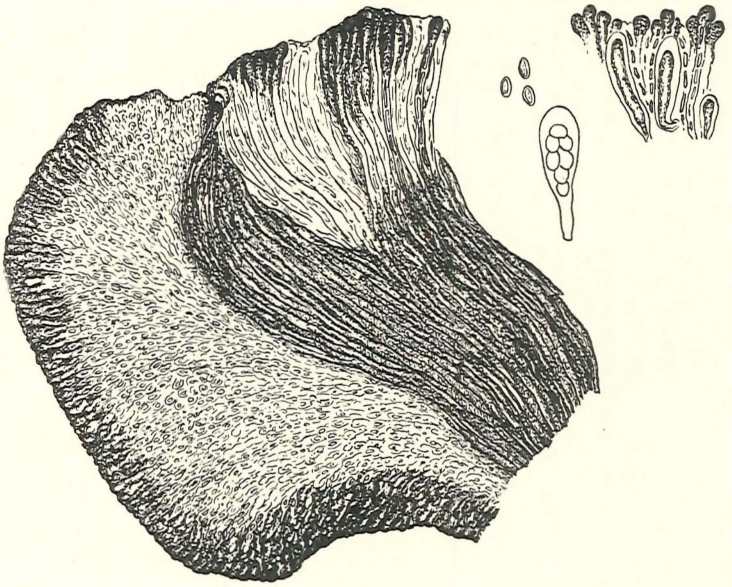


Fig. 182

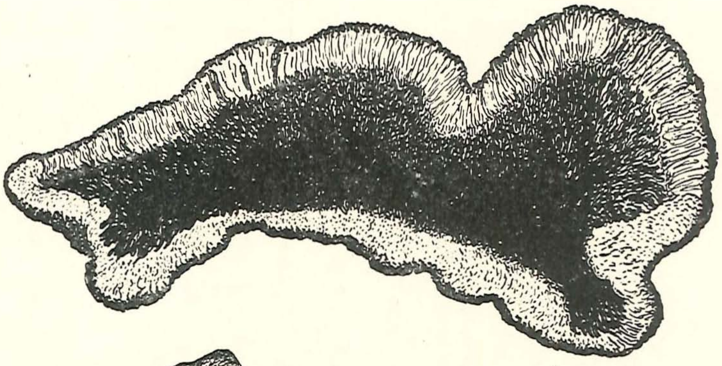


Fig. 181

Fig. 179

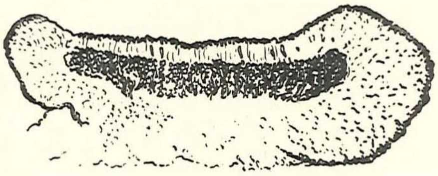


Fig. 180

O. Galløe del.

LECIDEA AURICULATA Th. Fr.
(Specimen 1)

PLATE 74.

LECIDEA AURICULATA

TH. FR.

Specimen 2.

Fig. 183. Old, very irregular apothecia, connected by narrow stripes of almost black thallus, surrounding the (white) grains of sand. (×15).

PLATE 74.

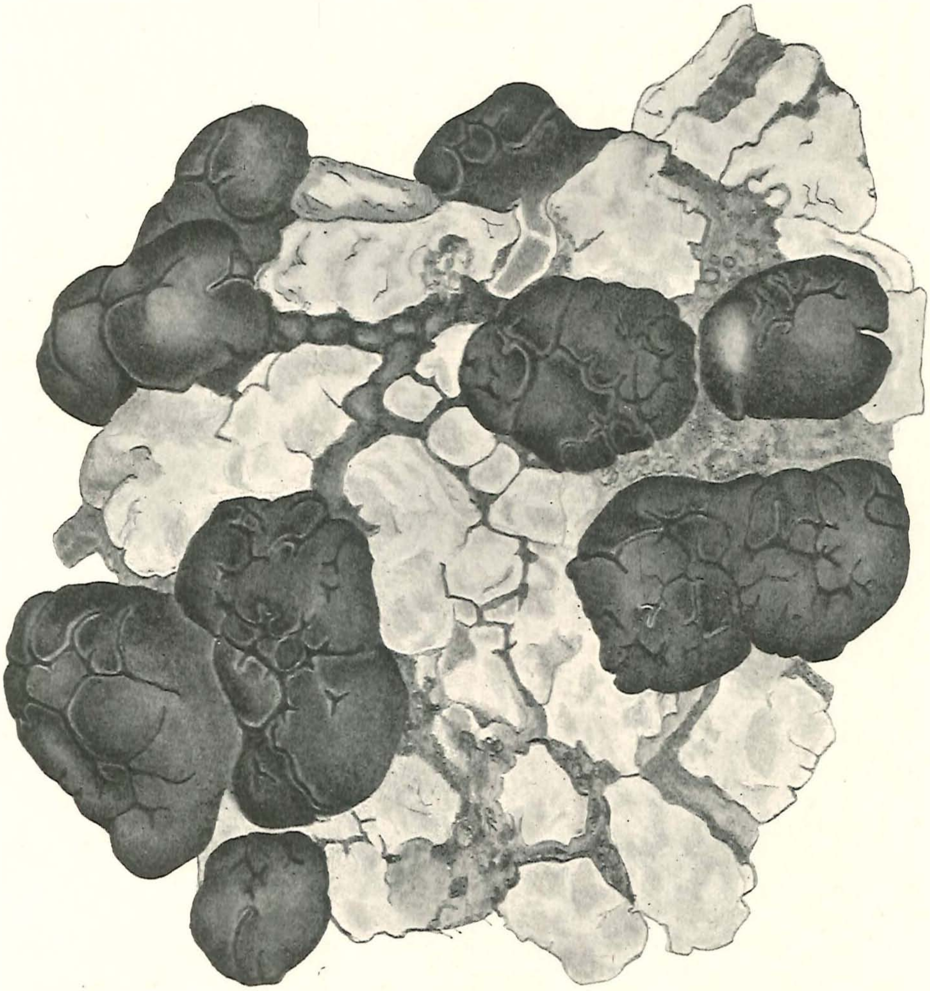


Fig. 183

O. Galløe del.

LECIDEA AURICULATA Th. Fr.
(Specimen 2)

PLATE 75.

LECIDEA AURICULATA.

TH. FR.

Specimen 2.

Fig. 184. Young crowded apothecia, their shapes having become irregular by pressure from neighbouring apothecia.

Fig. 185. Vertical section of a very irregular apothecium; in structure and colour it resembles specimen 1. (×60).

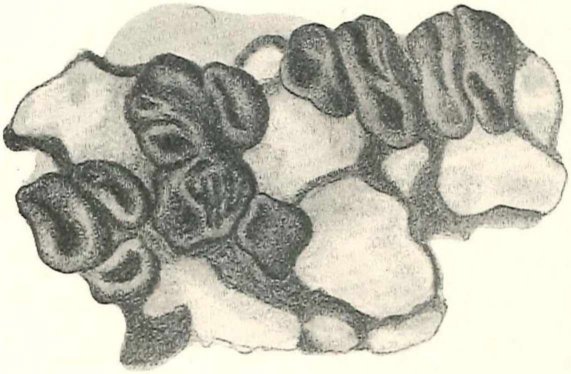


Fig. 184

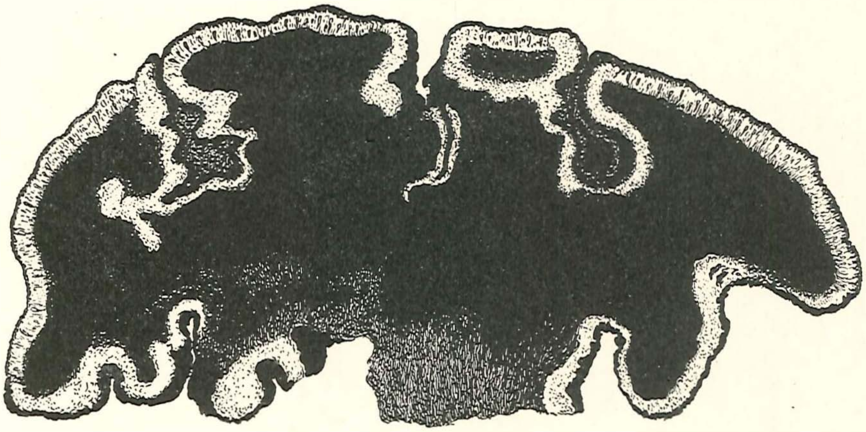


Fig. 185

O. Galløe del.

LECIDEA AURICULATA TH FR.
(Specimen 2)

PLATE 76.

LECIDEA AURICULATA.

TH. FR.

Specimen 3.

Fig. 186. Thallus with five apothecia. In several places white grains of sand are seen projecting through the thallus. (×15).

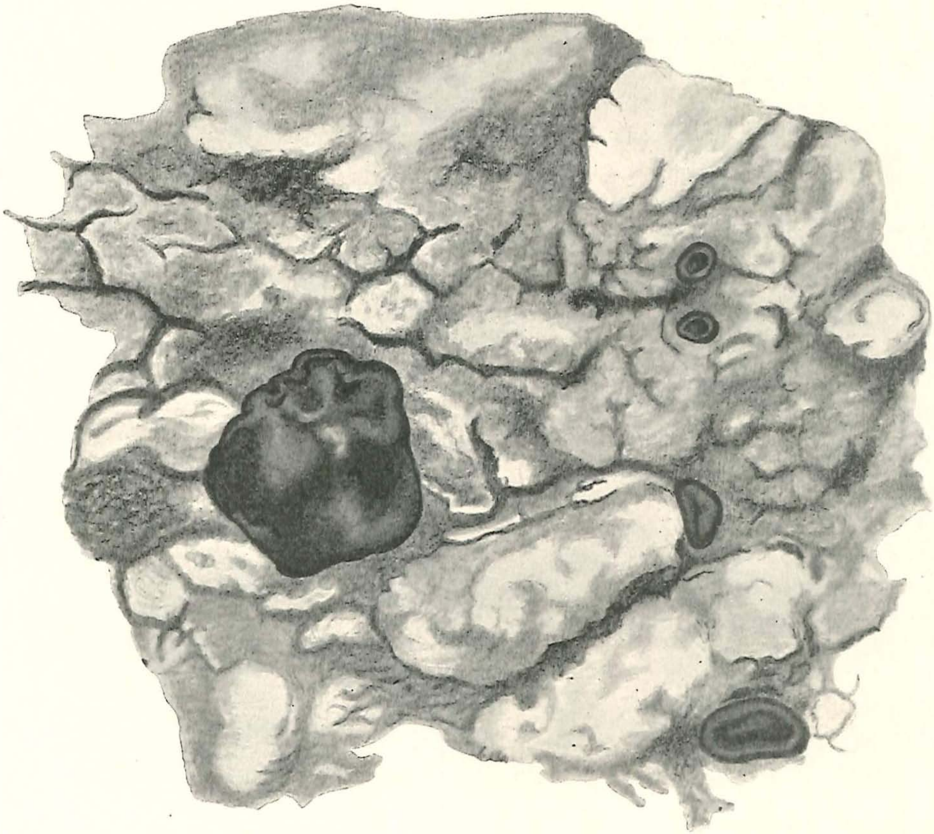


Fig. 186

O. Galløe del.

LECIDEA AURICULATA TH. FR.
(Specimen 3)

PLATE 77.

LECIDEA AURICULATA.

TH. FR.

Specimen 4.

Fig. 187. Thallus with black and radiating marginal hyphæ, and grey areoles, and an apothecium. (×45)

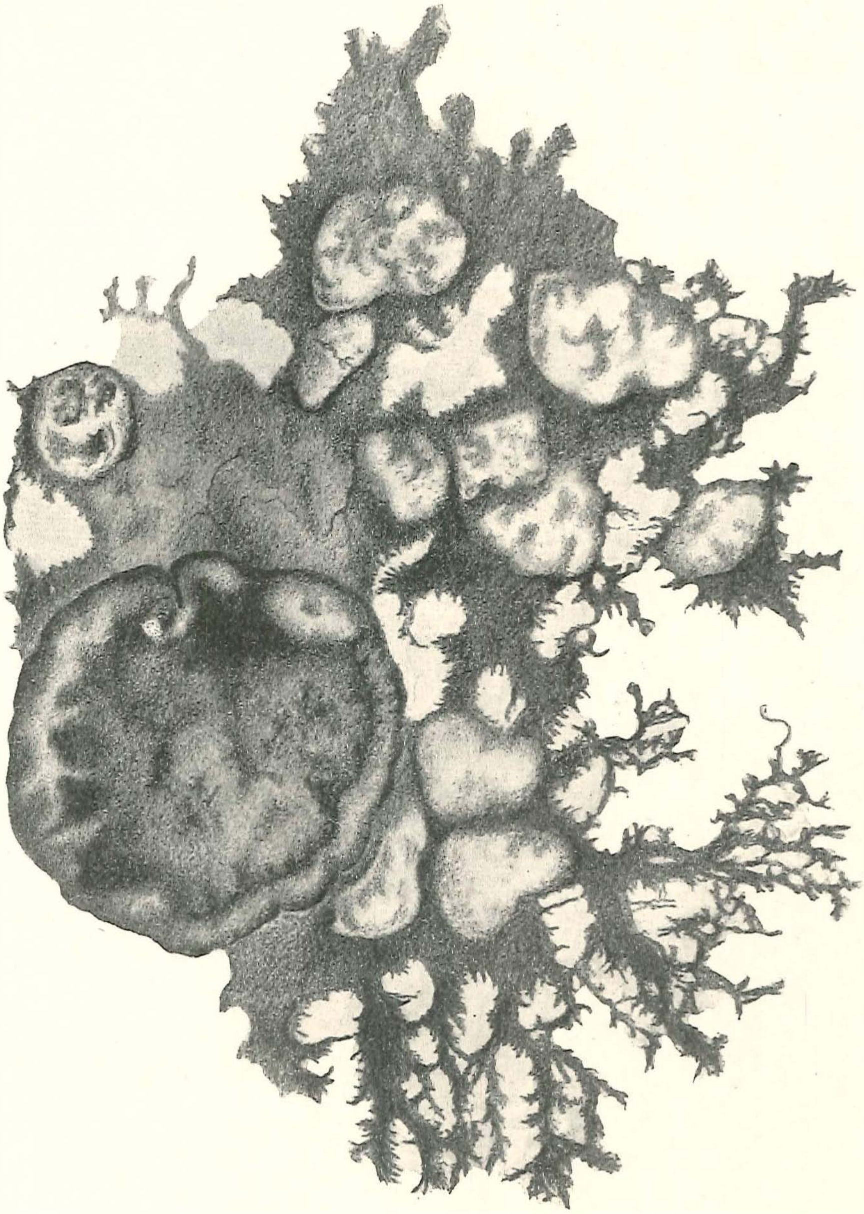


Fig. 187

O. Galløe del.

LECIDEA AURICULATA TH. FR.
(Specimen 4)

PLATE 78.

LECIDEA AURICULATA.

TH. FR.

Specimen 4.

Fig. 188. Part of thallus with the ostioles of several pycnidia. (×45).

Fig. 189. Vertical section of an apothecium (×60), with an ascus and some isolated paraphyses. (×450).

Fig. 190. Three pycnidia, the middle one cut in an almost median section. (×450).

PLATE 78.

Fig. 190

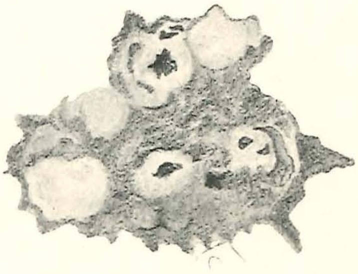


Fig. 188

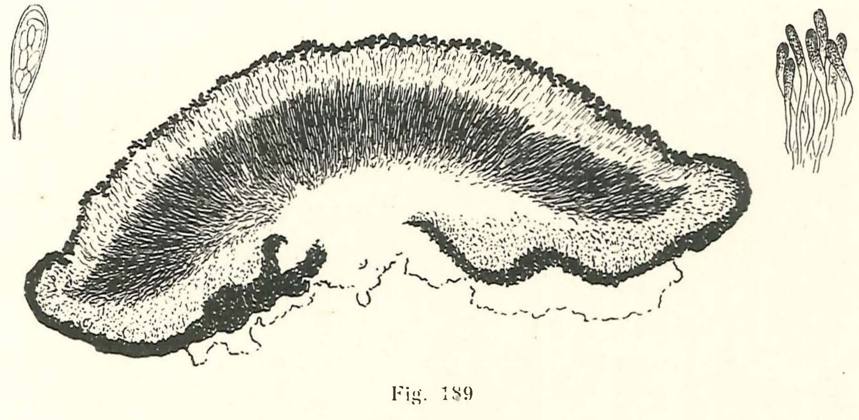


Fig. 189

O. Galløe del.

LECIDEA AURICULATA Th. Fr.
(Specimen 4)

PLATE 79.

LECIDEA AURICULATA.

Th. Fr.

Specimen 5.

Fig. 191. Thallus composed of small black areoles. The large white spots are grains of quartz. Apothecia in all stages of development. (×15).

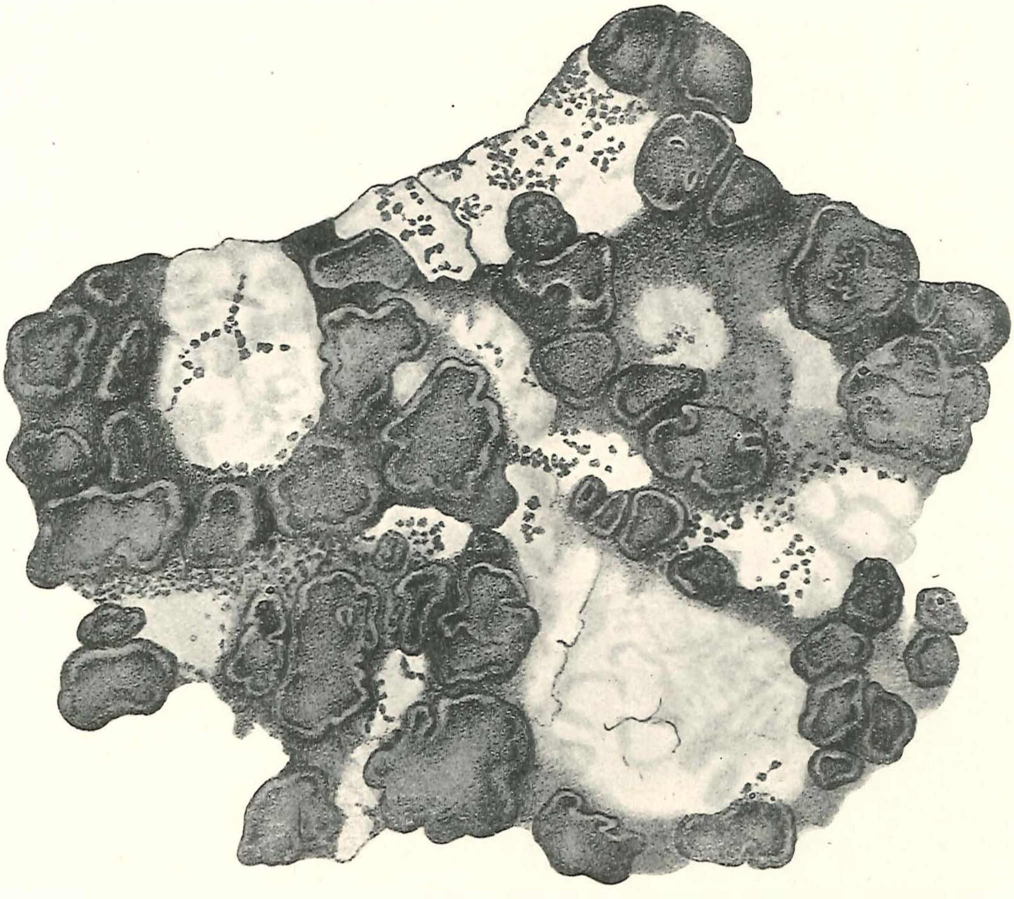


Fig. 191

O. Galløe del.

LECIDEA AURICULATA Th. Fr.
(Specimen 5)

PLATE 80.

LECIDEA AURICULATA.

TH. FR.

Specimen 5.

Fig. 192. Below to the right: 5 thallus-areoles connected by delicate single hyphæ (on a grain of quartz). Above: a young apothecium. To the left: an older one with 9 thallus areoles. (×45).

Fig. 193. Above to the left: hyphæ of the cortex seen from above. To the right the hyphæ of the cortex in longitudinal section. Below the cortex is the gonidial layer, and lower still the medullary layer.

Fig. 194. Young ascus, paraphyses and spores. (×450)

PLATE 80.

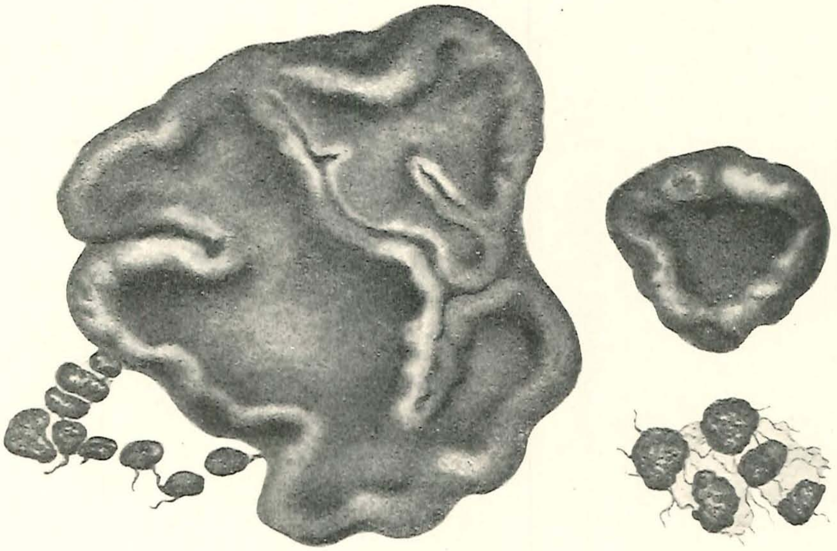


Fig. 192

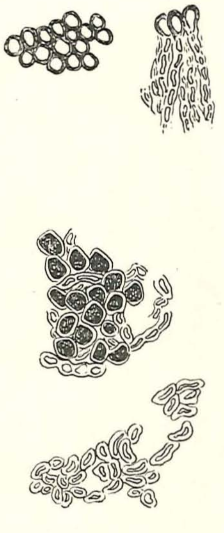


Fig. 193

Fig. 194

O. Galløe del.

LECIDEA AURICULATA Th. Fr.
(Specimen 5)

PLATE 81.

LECIDEA MACROCARPA.

(Dc.) Th. Fr.

Specimen 1, specimen 2, and **specimen 3.**

Fig. 195. Specimen 1, apothecium in vertical section. (×60).
Fig. 196. Specimen 2, apothecium in vertical section. (×60).
Fig. 197. Specimen 3, apothecium in vertical section. (×60).

Fig. 195

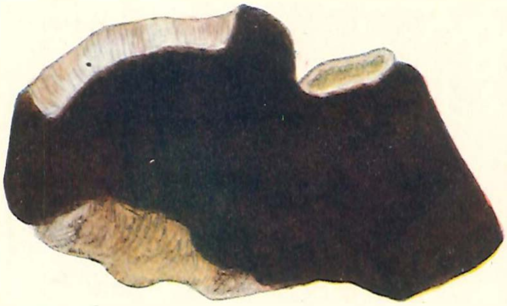


Fig. 196

Fig. 197

O. Galløe del.

LECIDEA MACROCARPA (Dc.) Th. Fr.
(Specimen 1, 2, 3)

PLATE 82.

LECIDEA MACROCARPA.

(Dc.) Th. Fr.

Specimen 1.

Fig. 198. Plan view of thallus. The grains of sand of the substratum are the chief cause of the rough, verrucose surface. (×15).

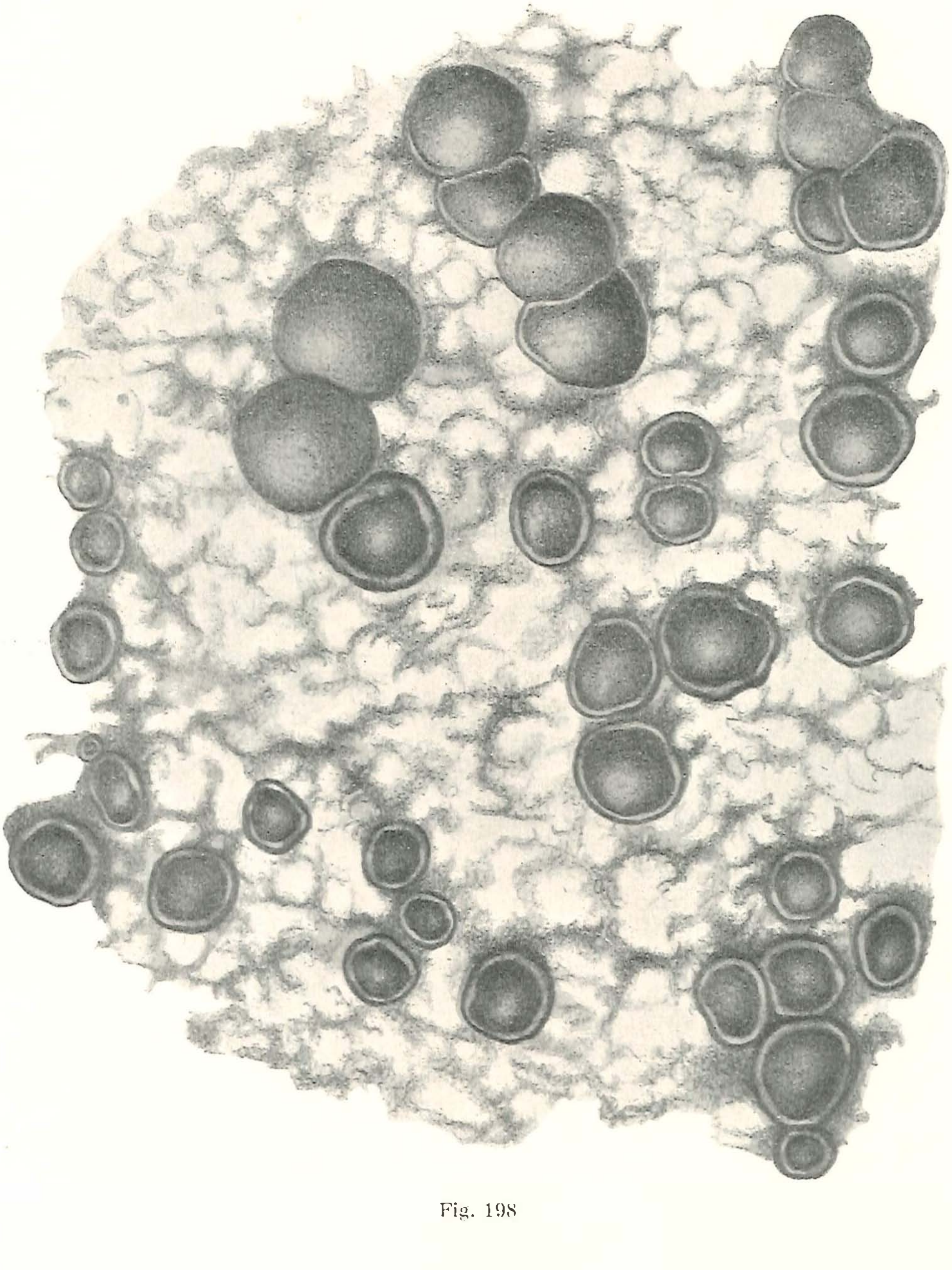


Fig. 198

O. Galløe del.

LECIDEA MACROCARPA (Dc.) Th. Fr.
(Specimen 1)

PLATE 83.

LECIDEA MACROCARPA.

(Dc.) Th. Fr.

Specimen 1.

Fig. 199. Section of apothecium. (× 60).

Fig. 200. Fragment of hymenium with asci in various stages of development, hymenium, and part of stipes. To the left: a spore. (× 450).

PLATE 83.

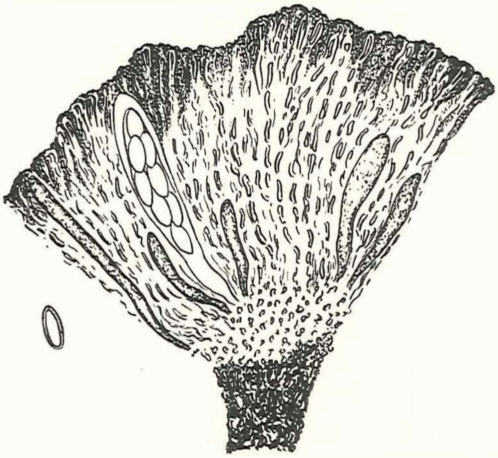


Fig. 200

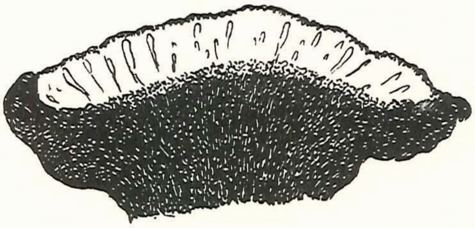


Fig. 199

O. Galløe del.

LECIDEA MACROCARPA (Dc.) Th. Fr.
(Specimen 1)

PLATE 84.

LECIDEA MACROCARPA.

(Dc.) Th. Fr.

Specismen 2.

Fig. 201. Below: the black margin of the thallus, which towards the centre becomes grey and develops light areolæ. To the right: a long, grey, narrow, young thallus in a fissure of the substratum. (× 15).

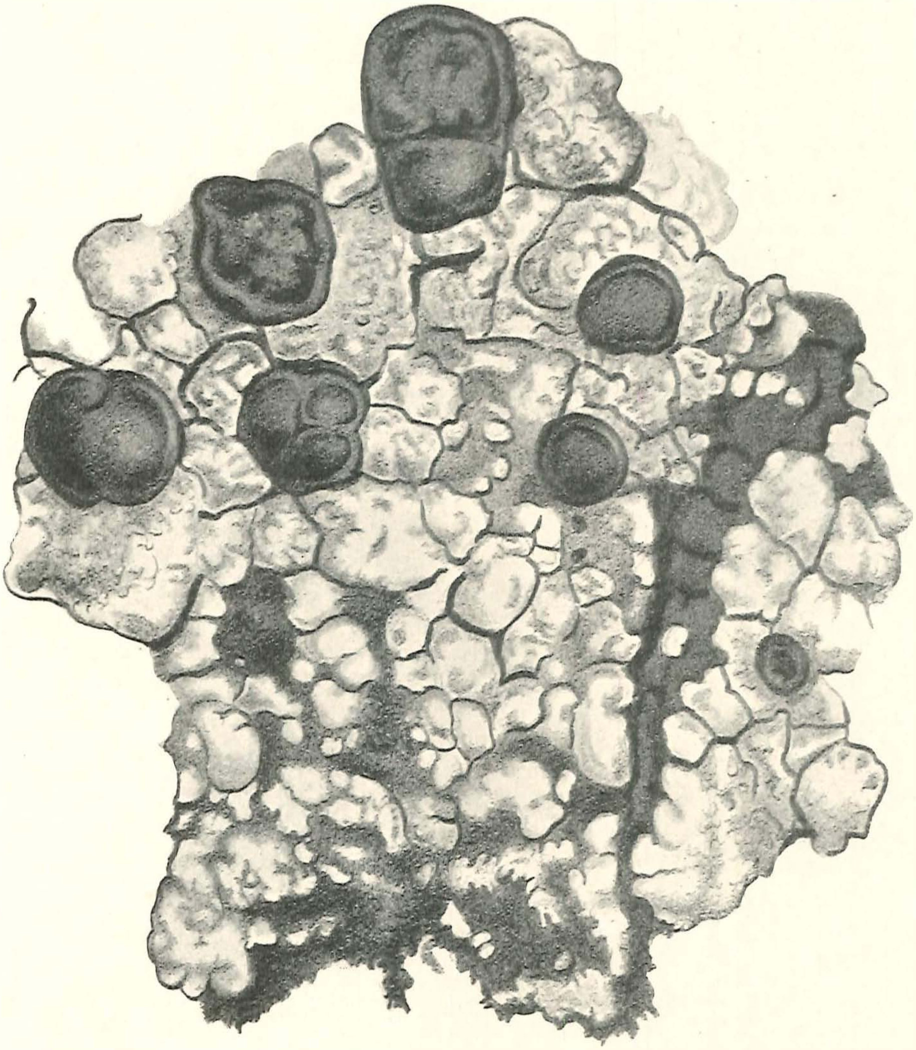


Fig. 201

O. Galløe del.

LECIDEA MACROCARPA (Dc.) Th. Fr.
(Specimen 2)

PLATE 85.

LECIDEA MACROCARPA.

(Dc.) Th. Fr.

Specimen 2.

Fig. 202. Part of thallus near the centre, with several older irregular apothecia.

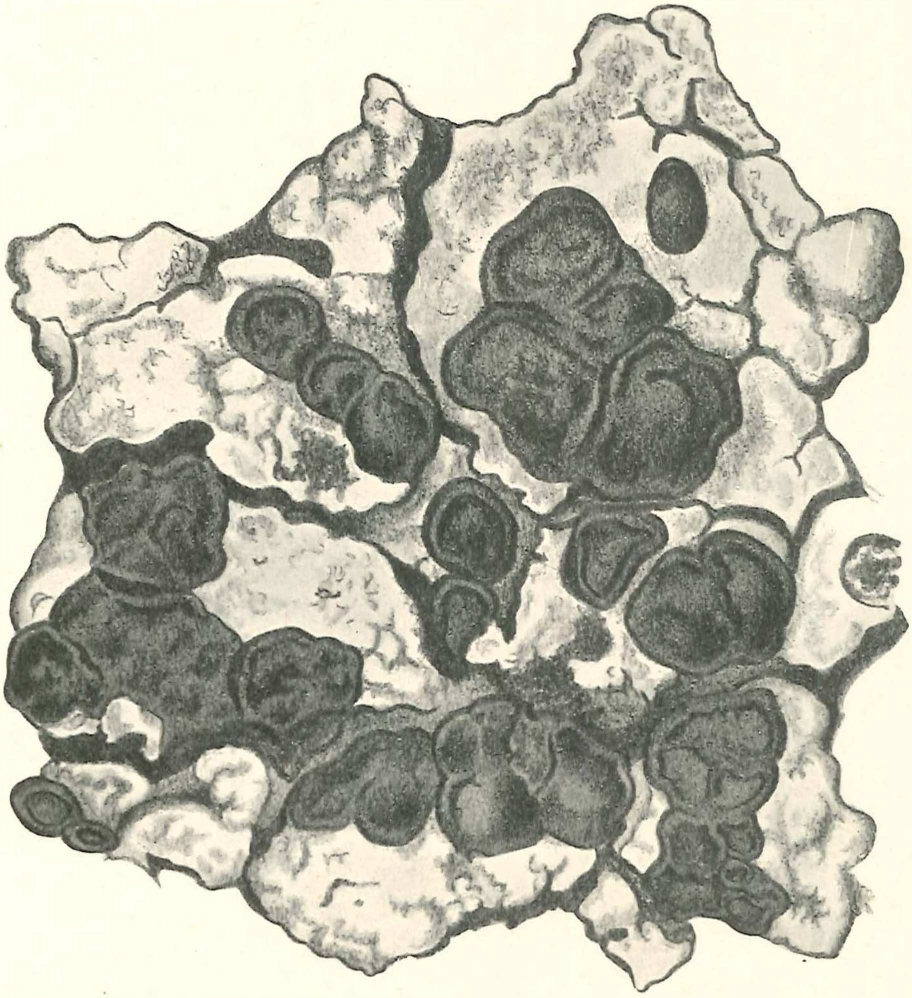


Fig. 202

O. Galløe del.

LECIDEA MACROCARPA (Dc.) Th. Fr.
(Specimen 2)

PLATE 86.

LECIDEA MACROCARPA.

(Dc.) Th. Fr.

Specimen 2.

Fig. 203. Section of two contiguous areoles of the thallus. Note how the cortex gradually disappears on the surface of the areoles almost to the level of the gonidia. (×60).

Fig. 204. Above to the right: the cortical and the gonidial layers. Below to the left: the somewhat more irregular medullary layer, richer in intercellular spaces. (×450).

PLATE 86.

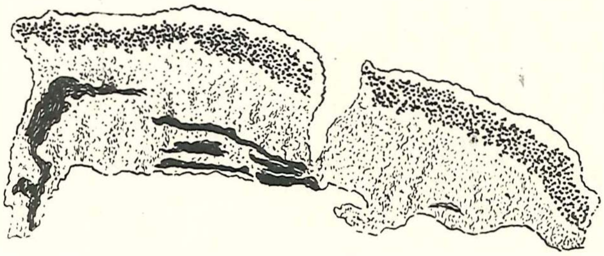


Fig. 203

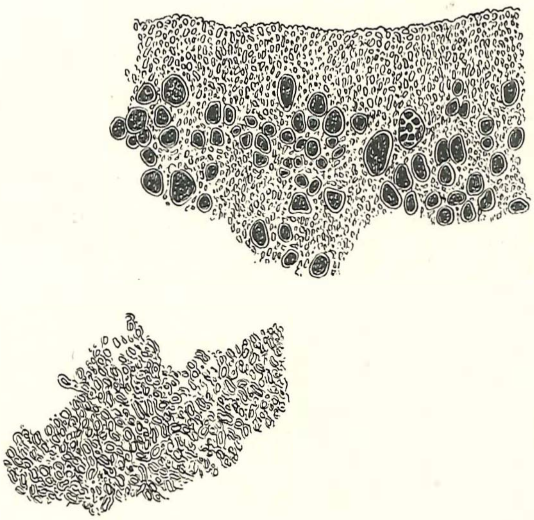


Fig. 204

O. Galløe del.

LECIDEA MACROCARPA (Dc.) Th. Fr.
(Specimen 2)

PLATE 87.

LECIDEA MACROCARPA.

(Dc.) Th. Fr.

Specimen 3.

Fig. 205. Thallus on a piece of bark; it can be clearly seen through the thallus that the lamellæ of the periderm peel off.

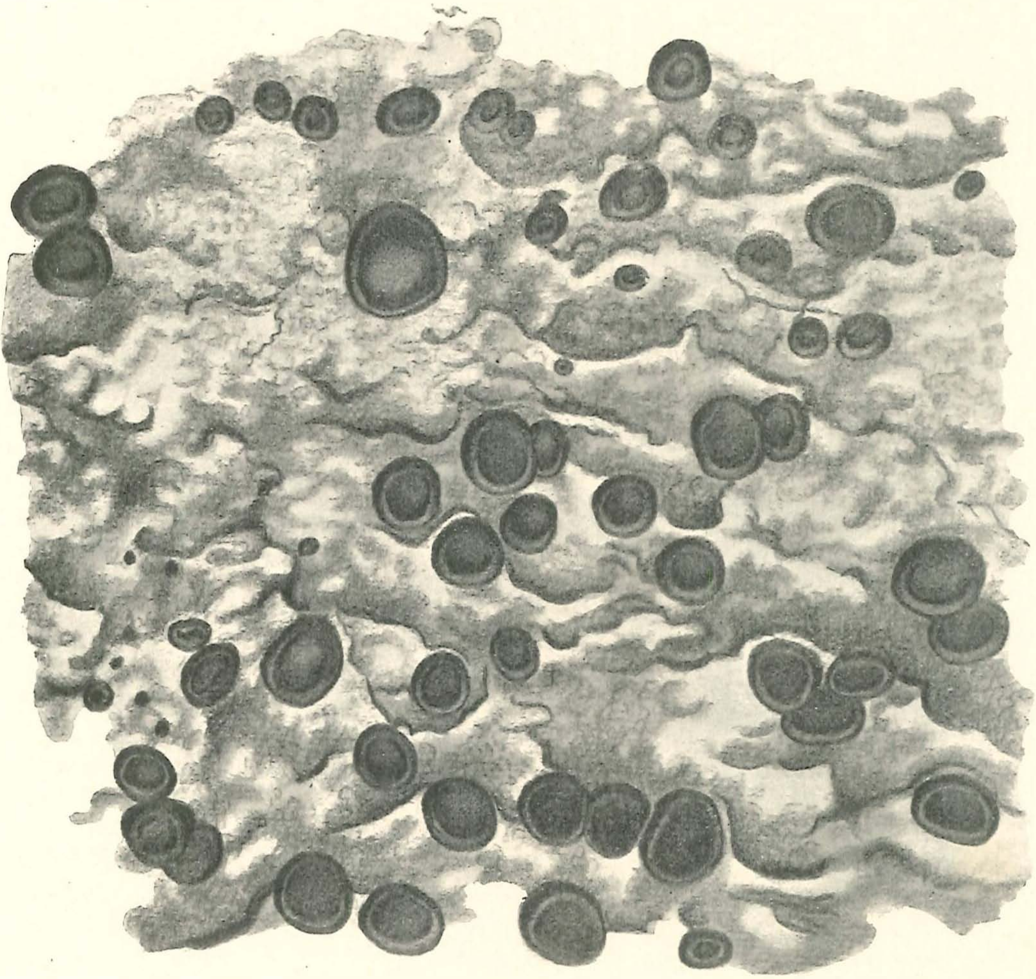


Fig. 205

O. *Galløe del.*

LECIDEA MACROCARPA (Dc.) TH. FR.
(Specimen 3)

PLATE 88.

LECIDEA MACROCARPA.

(Dc.) Th. Fr.

Specimen 3.

Fig. 206. Apothecia. (×45).

Fig. 207. Vertical section of thallus with an apothecium. Below: the periderm of the plant forming the substratum. (×60).

Fig. 208. Vertical section of thallus with (merging into each other) the cortical, gonidial, and medullary layers and the rhizoidal zone, situated on the periderm cells of the plant forming the substratum. (×450).

Fig. 209. Vertical section through the margin of the apothecium, showing how the hyphæ run, asci in different phases of development, the colourless hypothecium, and the distribution of colour in stipes and margin. (×450).

PLATE 88.

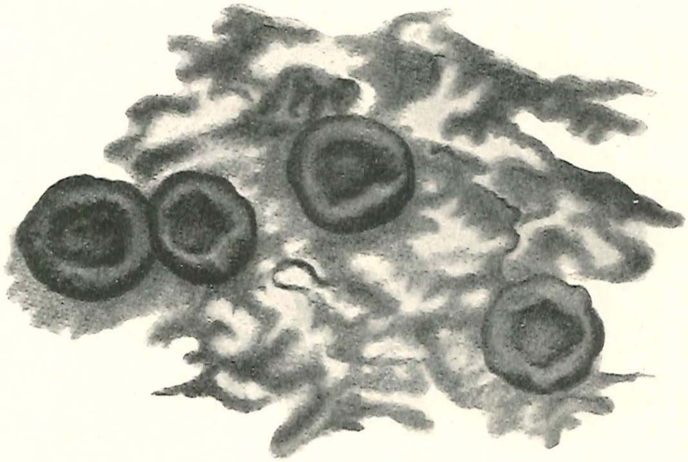


Fig. 206

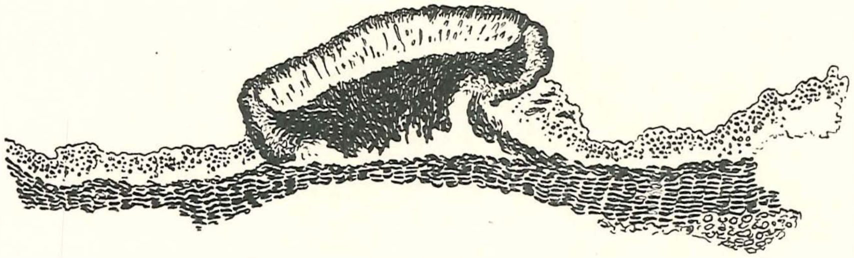


Fig. 207

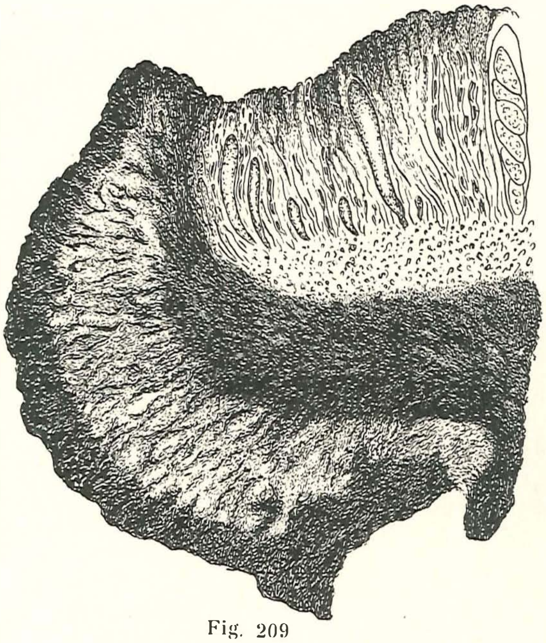


Fig. 209

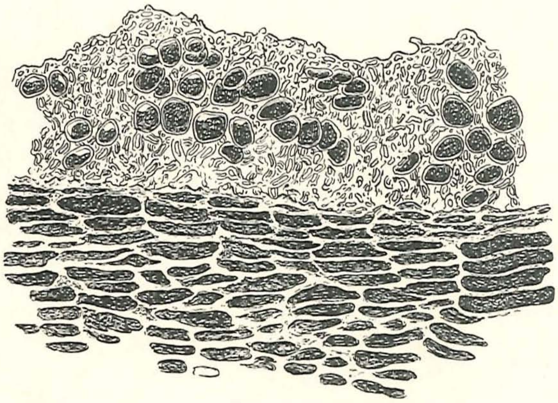


Fig. 208

O. Galløe del.

LECIDEA MACROCARPA (Dc.) Th. Fr.
(Specimen 3)

PLATE 89.

LECIDEA ALBOCOERULESCENS.

(WULF.) SCHÆR.

210. Apothecium in vertical section; the pruina is very thick and colourless. (×60).

Fig. 211. Fragment of thallus with cracks and with apothecia of all ages, partly confluent and with thick pruina. (×15).

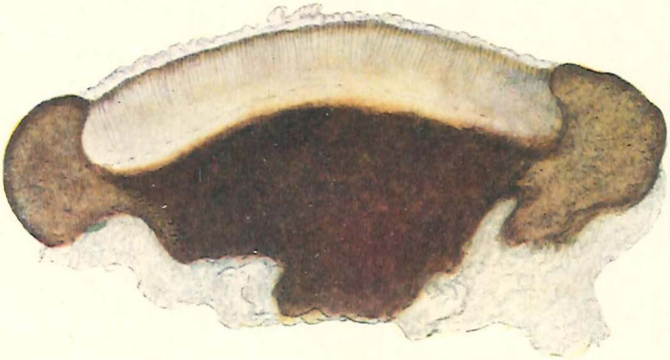


Fig. 210

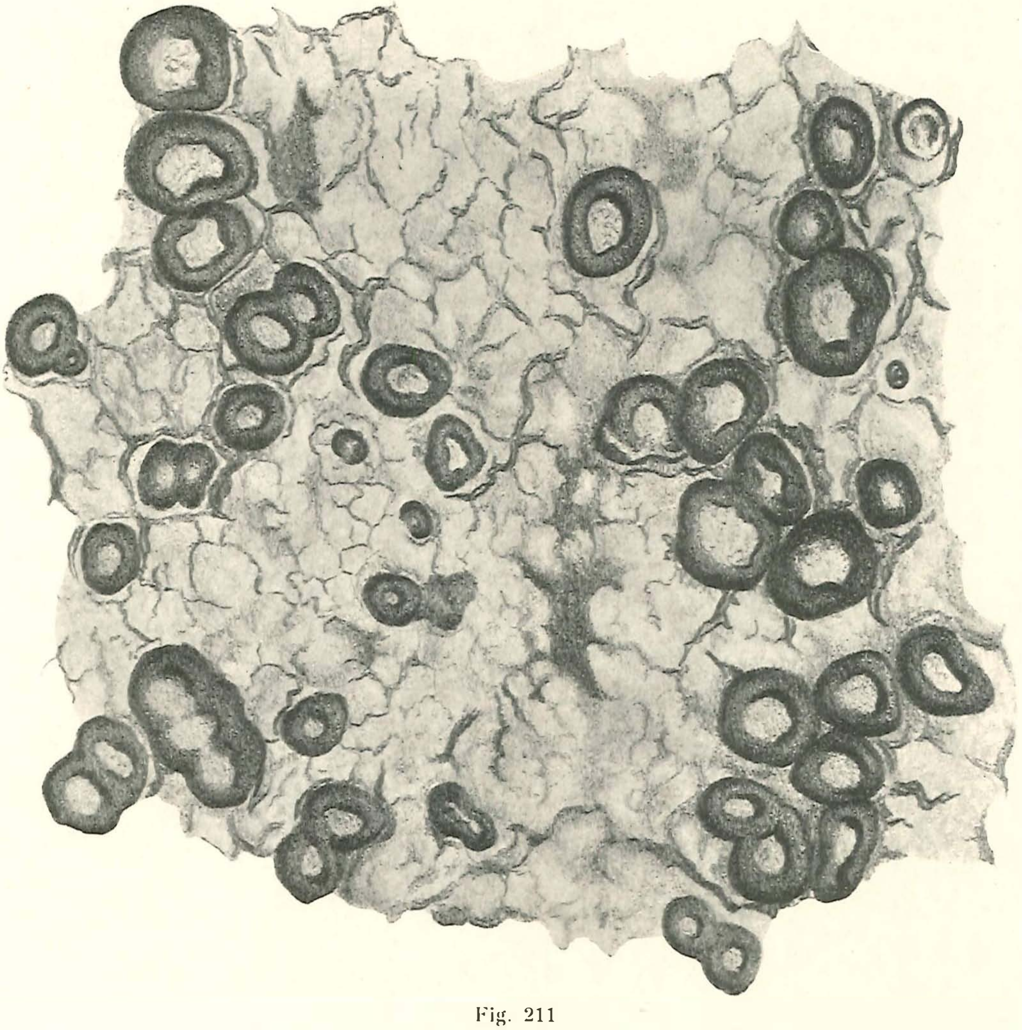


Fig. 211

O. Galløe del.

LECIDEA ALBOCOERULESCENS (WULF.) SCHÆR.

PLATE 90.

LECIDEA ALBOCOERULESCENS.

(WULF.) SCHÆR.

Fig. 212. Thallus showing that quite young apothecia (to the right) have a pruina also on the margin before the latter breaks through the cortex. (×45).

Fig. 213. Section of thallus, where two areoles touch a third (at the top of a crack in the thallus); showing the dead cuticle, the gonidial layer, the medullary and rhizoidal layers, in which numerous particles of minerals can be seen. (×450).

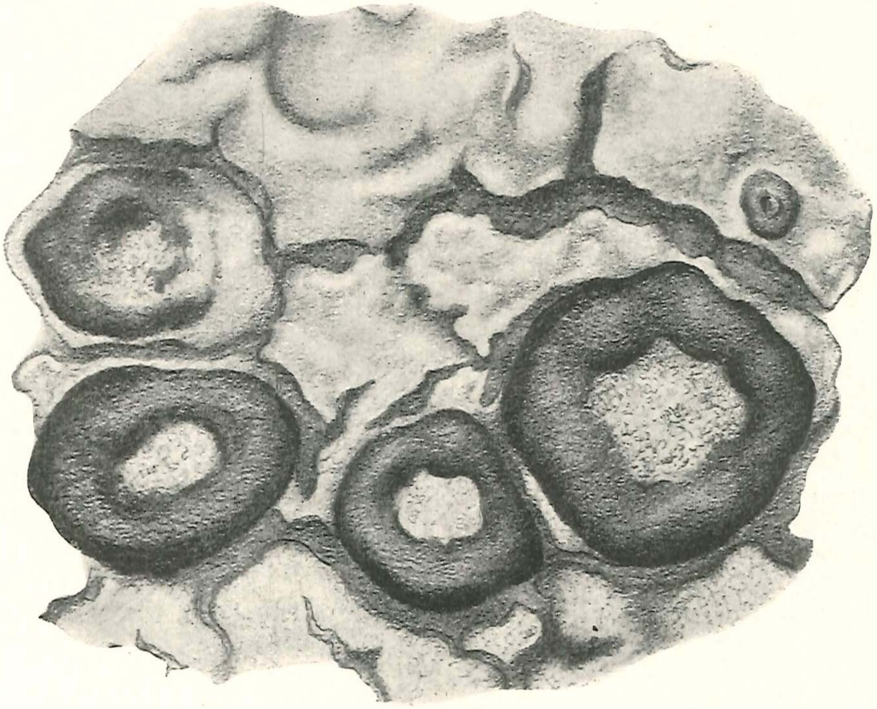


Fig. 212

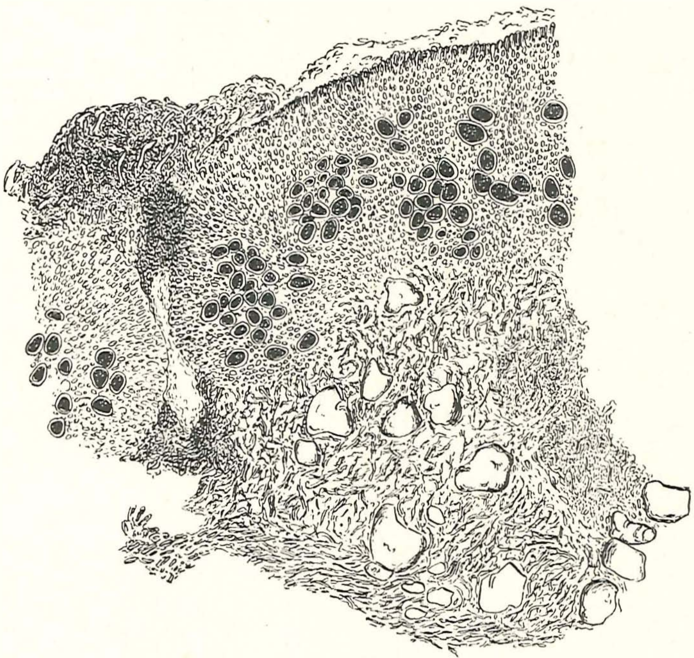


Fig. 213

O. Galløe del.

LECIDEA ALBOCOERULESCENS (Wulf.) Schær.

PLATE 91.

LECIDEA ALBOCOERULESCENS.

(WULF.) SCHÆR.

Fig. 214. 2 contiguous apothecia with thick pruina on the disk. (×60).

Fig. 215. Section through the margin of an apothecium with distinct hyphæ. Below the young asci a distinct colourless (asc [illegible] that the dark-brown hyphæ in the calyx. (×450).

Fig. 216. Section of the hymenium with unripe asci and colourless hypothecium. In this section the pruina has disappeared (possibly in the course of the preparation).

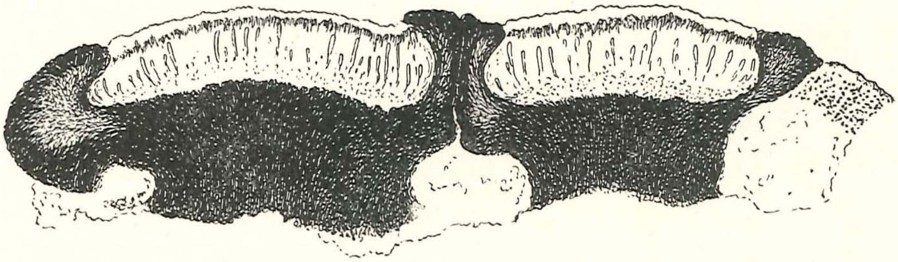


Fig. 214

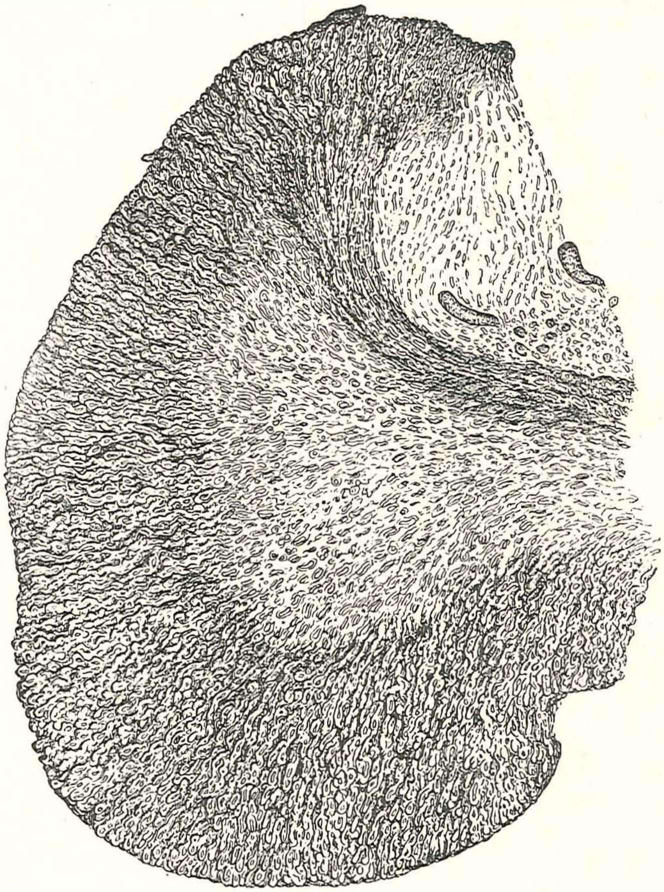


Fig. 215

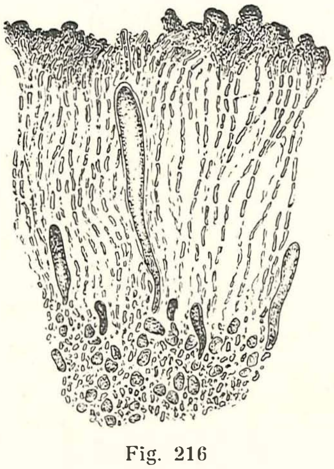


Fig. 216

O. Galløe del.

LECIDEA ALBOCOERULESCENS (WULF.) SCHÆR.

PLATE 92.

LECIDEA CRUSTULATA.

(ACH.) KÖRB.

Specimen 1, 2 and specimen 3.

Fig. 217. Specimen 1, apothecium in vertical section. (×60).
Fig. 218. Specimen 2, apothecium in vertical section. (×60).
Fig. 219. Specimen 3, apothecium in vertical section. (×60).

Fig. 217

Fig. 218

Fig. 219

O. Galløe del.

LECIDEA CRUSTULATA (Ach.) Körb.
(Specimen 1, 2, 3)

PLATE 93.

LECIDEA CRUSTULATA.

(ACH.) KÖRB.

Specimen 1.

Fig. 220. Thallus with apothecia of all ages. (×15).

Fig. 221. Part of thallus with 7 apothecia. (×45).

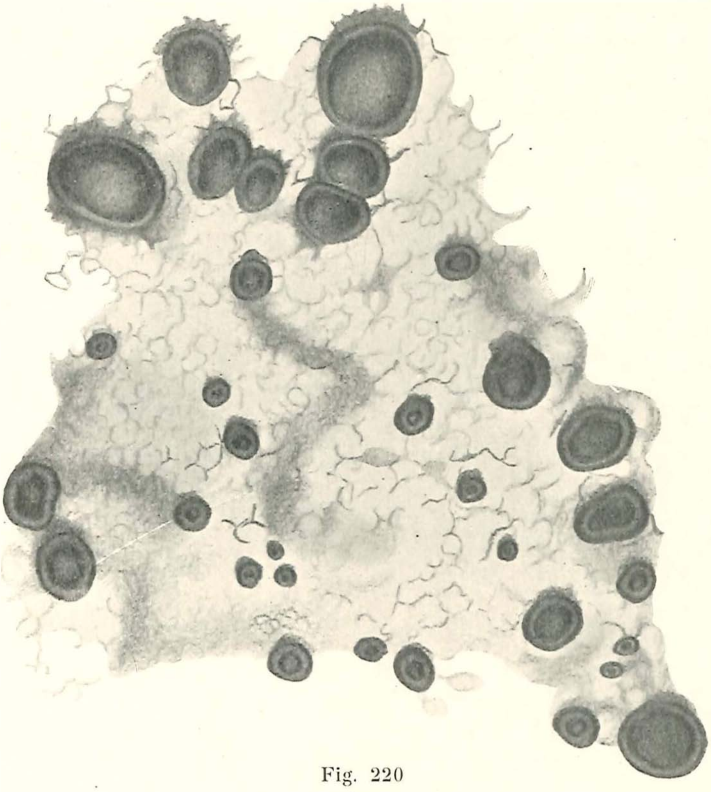


Fig. 220

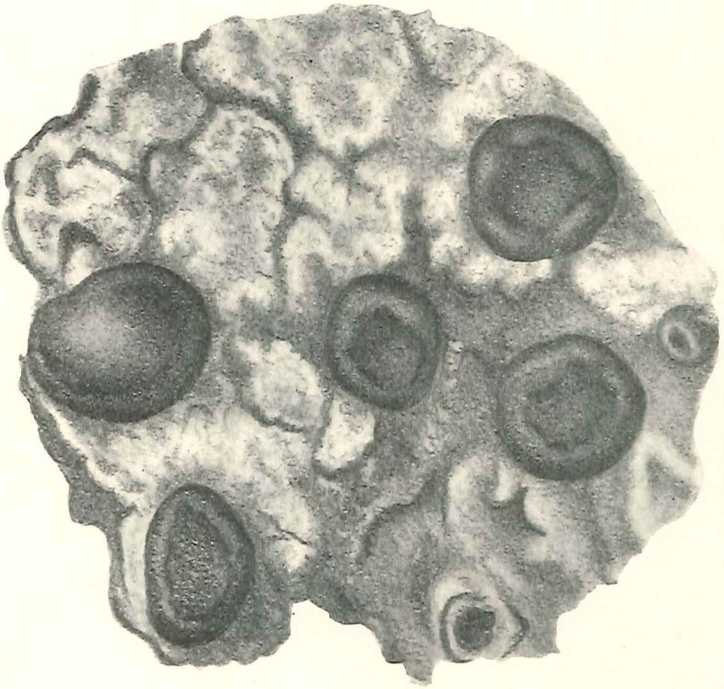


Fig. 221

O. Galløe del.

LECIDEA CRUSTULATA (Ach.) Körb.
(Specimen 1)

PLATE 94.

LECIDEA CRUSTULATA.

(ACH.) KÖRB.

Specimen 1.

Fig. 222. Part of thallus; to the left two particles of quartz. (×450).
Fig. 223. Two apothecia. (×60).
Fig. 224. Margin of the apothecium and a spore. (×450).

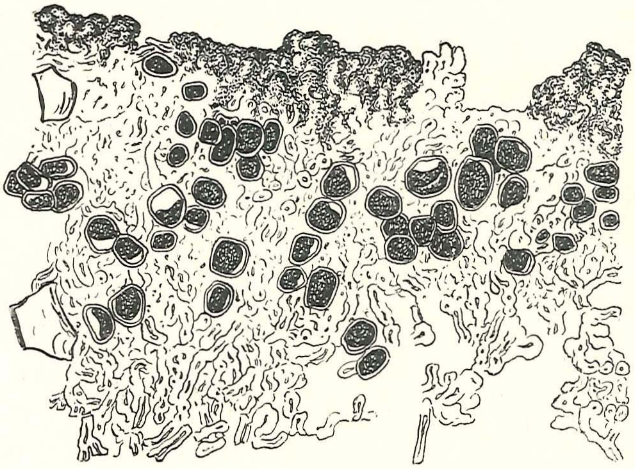


Fig. 222

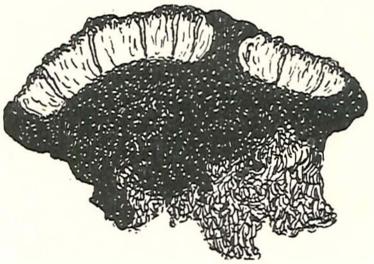


Fig. 223

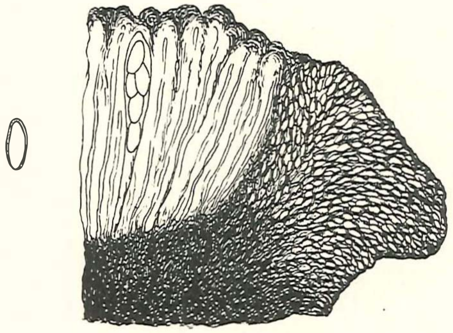


Fig. 224

O. Galløe del.

LECIDEA CRUSTULATA (Ach.) Körb.
(Specimen 1)

PLATE 95.

LECIDEA CRUSTULATA.

(ACH.) KÖRB.

Specimen 2.

Fig. 225. Thallus with alternate dark and light parts, both of which contain gonidia. Apothecia in all stages of development. (×15).

Fig. 226. Portion of thallus with dark and light parts, together with 5 apothecia. (×45).

Fig. 227. Fragment of the thallus-margin consisting of black hyphæ. The bare empty parts represent the substratum (stone). The centre of the thallus lies above in the figure. (×60)

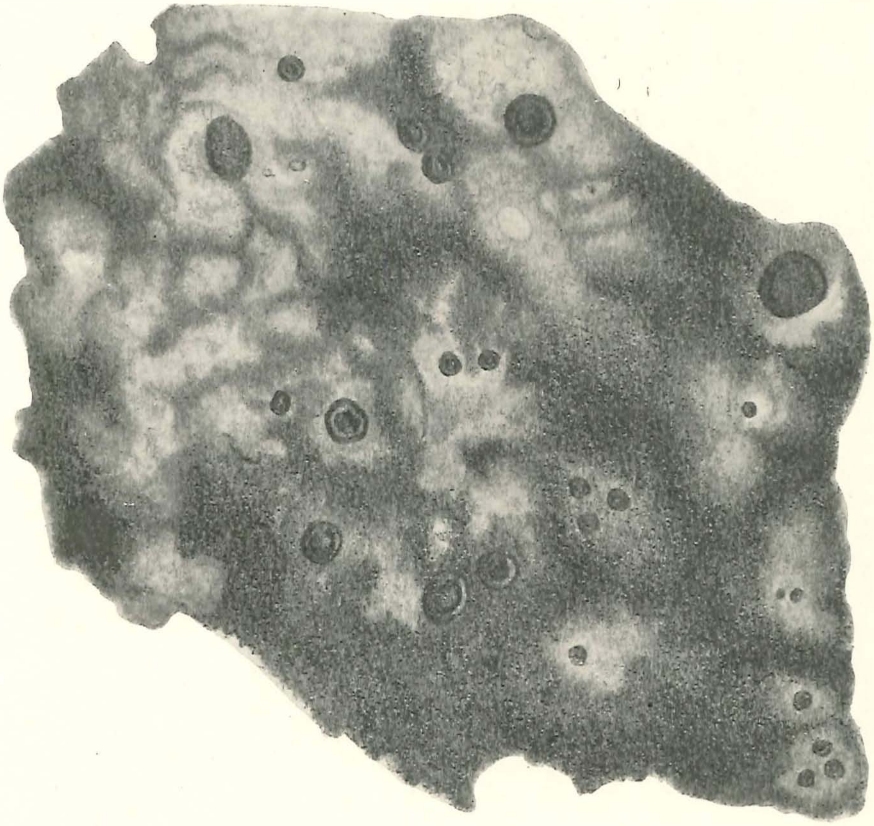


Fig. 225

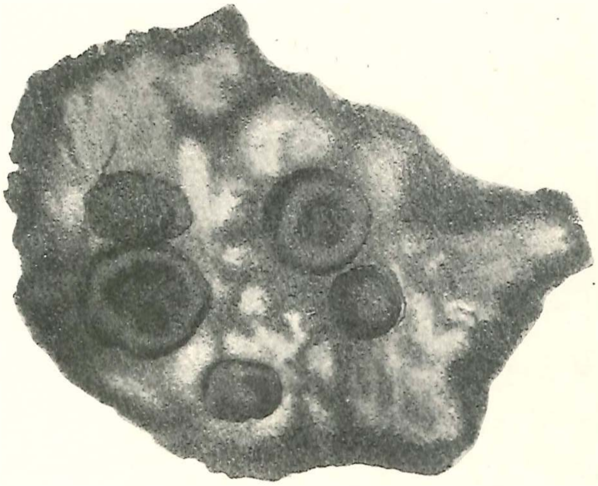


Fig. 226

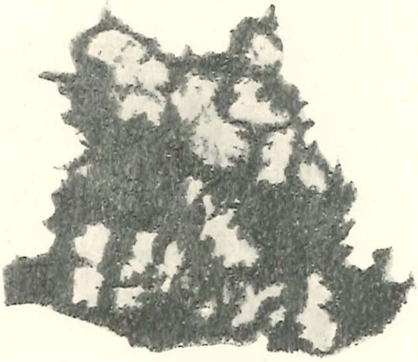


Fig. 227

O. Galløe del.

LECIDEA CRUSTULATA (ACH.) KÖRB.
(Specimen 2)

PLATE 96.

LECIDEA CRUSTULATA.

(ACH.) KÖRB.

Specimen 2.

Fig. 228. Portion of thallus, with dark and light parts and some cracks. Above to the left: 4 distinct ostioles. (×45).

Fig. 229. Vertical section of thallus. Below, fragments of the rocky substratum are visible. (×450).

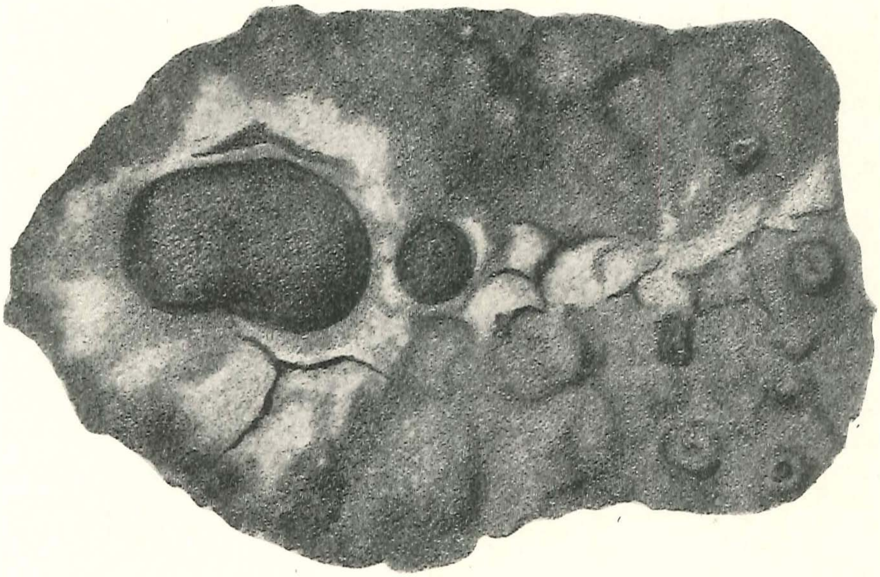


Fig. 228

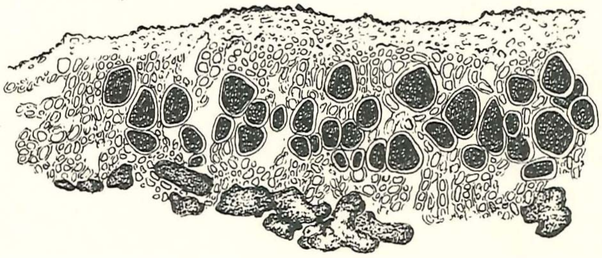


Fig. 229

O. Galløe del.

LECIDEA CRUSTULATA (Ach.) Körb.
(Specimen 2)

PLATE 97.

LECIDEA CRUSTULATA.

(ACH.) KÖRB.

Specimen 2.

Fig. 230. To the right: a section through the margin of the apothecium (with young asci). Above to the left: a spore. Below to the left: a portion of the hymenium from a pycnidium, with conidia in situ. (×450).

PLATE 97.

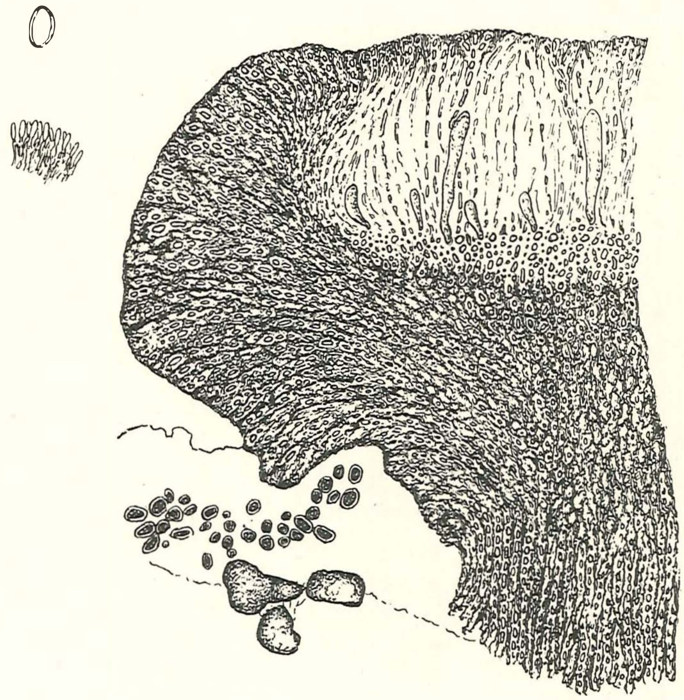


Fig. 230

O. Galløe del.

LECIDEA CRUSTULATA (Ach.) Körb.
(Specimen 2)

PLATE 98.

LECIDEA CRUSTULATA.

(ACH.) KÖRB.

Specimen 3.

Fig 231. Portion of thallus. (×15).

Fig. 232. Portion of thallus, with a young concave, and three older convex apothecia. (×45).

Fig. 233. Portion of thallus, with four still concave apothecia. (×45).

Fig. 234. Section of thallus, showing the boundary between two areoles; note the cortex covering even the vertical sides of the areoles. (×450).

Fig. 235. Hymenium, hypothecium, and a spore. (×450).

PLATE 98.

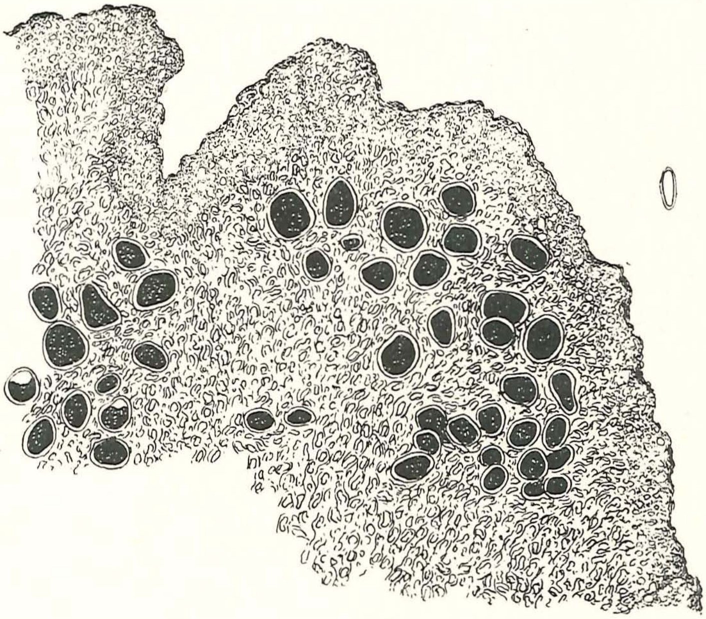


Fig. 234

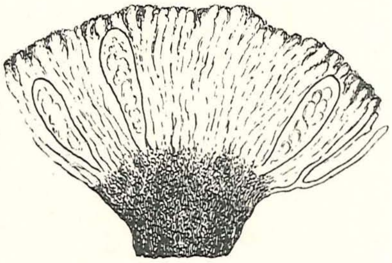


Fig. 235

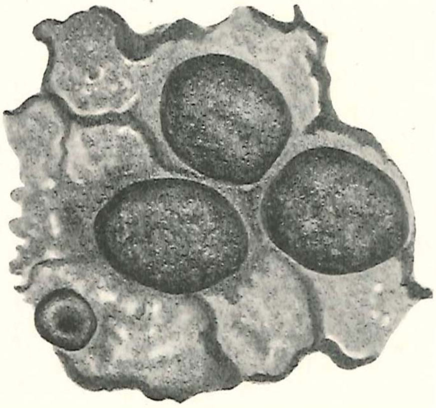


Fig. 232

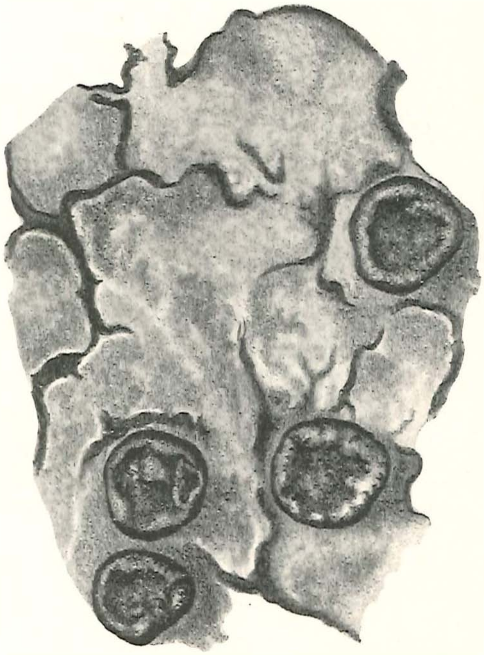


Fig. 233

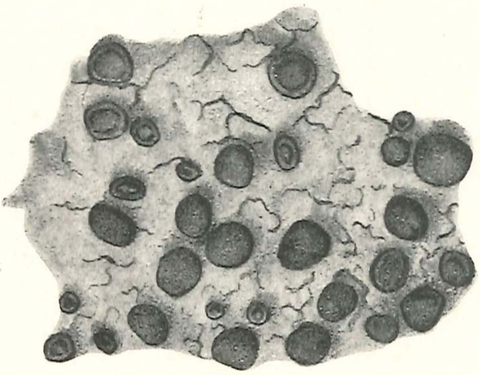


Fig. 231

O. Galløe del.

LECIDEA CRUSTULATA (Ach.) Körb.
(Specimen 3)

PLATE 99.

LECIDEA FUSCOATRA.
L.

Specimen 1, 3 and 4.

Fig. 236.	Specimen 1, vertical section of the apothecium. (×60).
Fig. 237.	Specimen 3, vertical section of the apothecium. (×60).
Fig 238.	Specimen 4, vertical section of the apothecium. (×60)

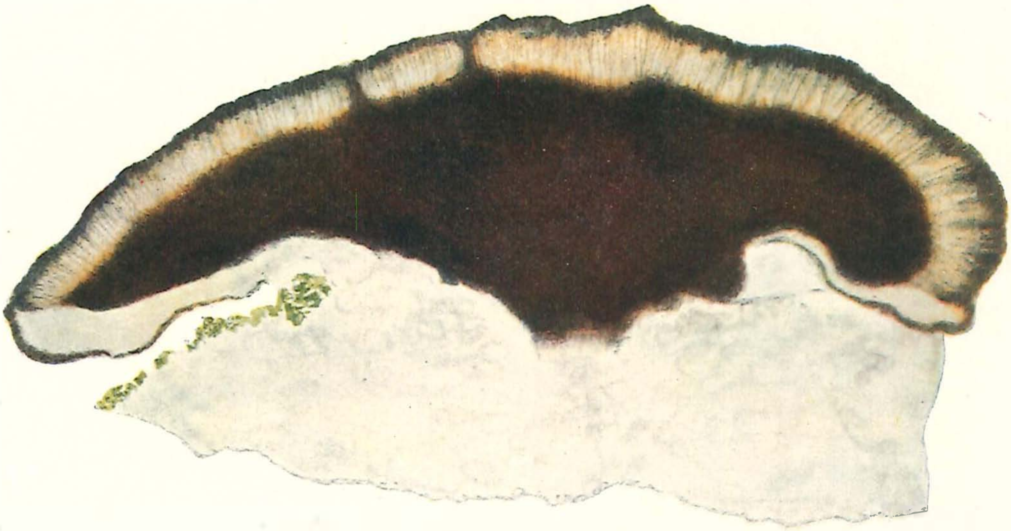


Fig. 236

Fig. 237

Fig. 238

O. Galløe del.

LECIDEA FUSCOATRA L.
(Specimen 1, 3, 4)

PLATE 100.

LECIDEA FUSCOATRA.

L.

Specimen 1.

Fig. 239. Margin of the thallus and young areoles, with 6 ostioles. (×15).

Fig. 240. Areoles with young apothecia. (×15).

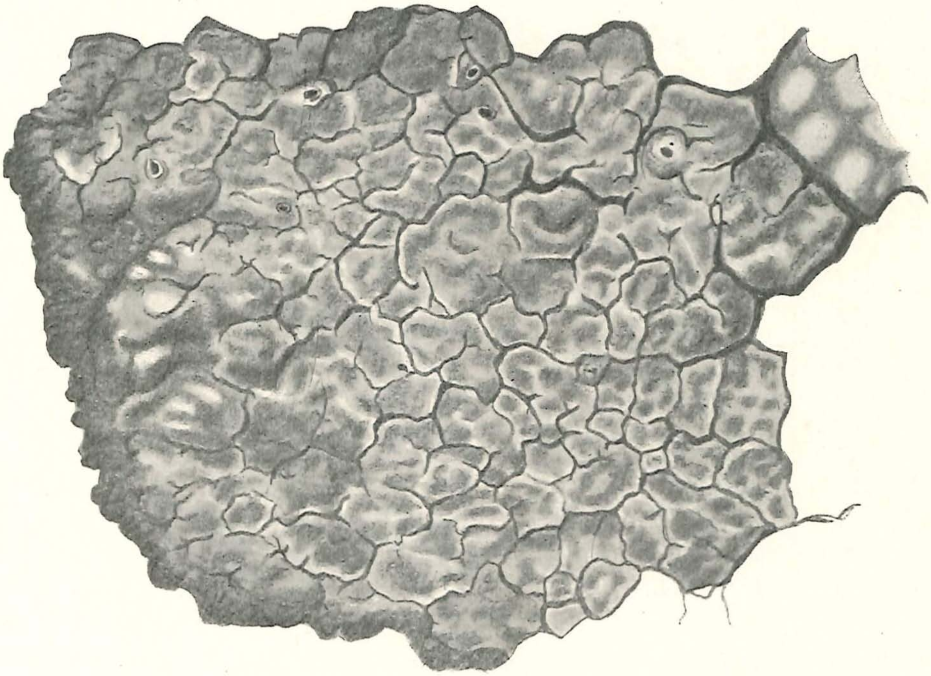


Fig. 239

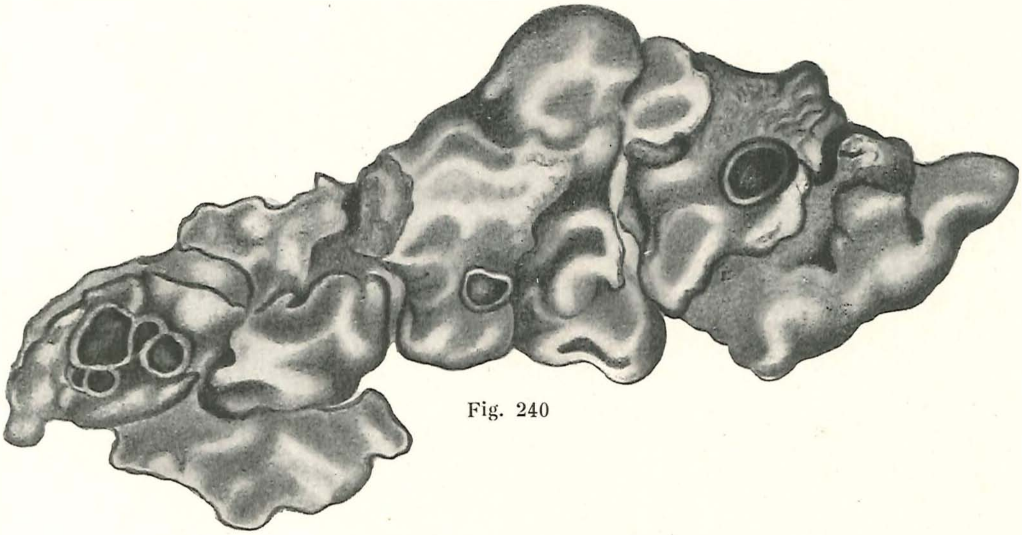


Fig. 240

O. Galløe del.

LECIDEA FUSCOATRA L.
(Specimen 1)

PLATE 101.

LECIDEA FUSCOATRA.

L.

Specimen 1.

Fig. 241. Areoles with older apothecia. (×15).

Fig. 242. An old areole, showing the variegated surface (the light parts are shining and brown, the darker ones are somewhat opaque and greyish), and smaller cracks, due to the drying up of the thallus. (×15).

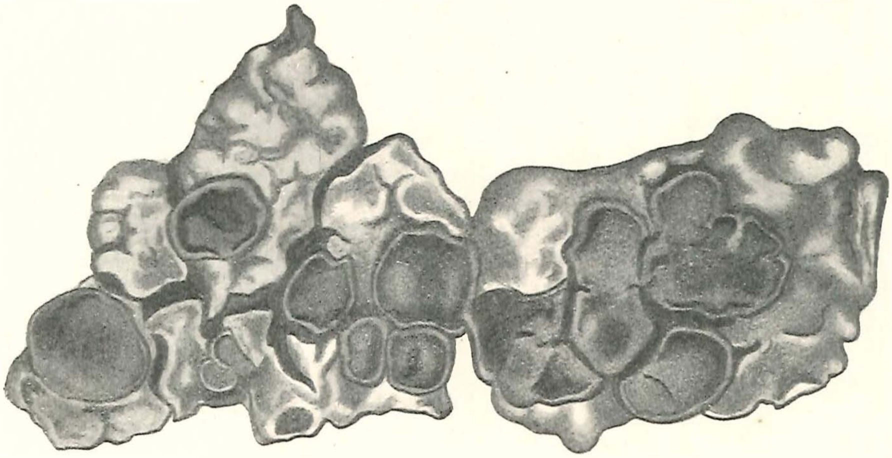


Fig. 241

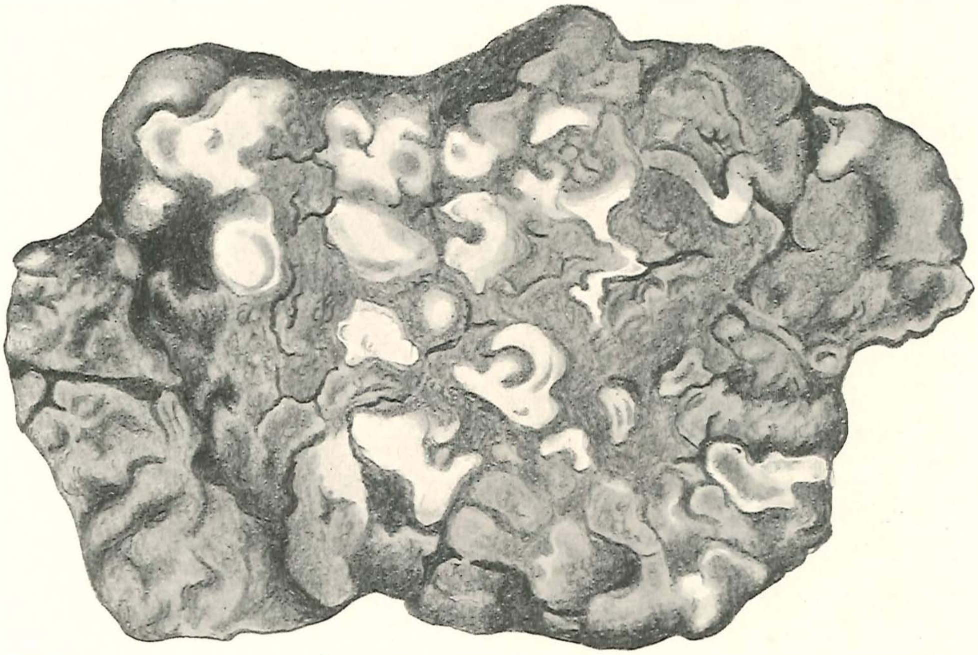


Fig. 242

O. Galløe del.

LECIDEA FUSCOATRA L.
(Specimen 1)

PLATE 102.

LECIDEA FUSCOATRA.

L.

Specimen 1.

Fig. 243. Two areoles which overlap each other slightly. The figure shows distinctly a cuticle, cortex, gonidial and medullary layer together with a loose rhizoidal zone in which numerous scattered grains of minerals are visible. (×60).

Fig. 244. Two apothecia, beneath the stipes of which the hyphæ of the medullary layer are slightly brownish in colour. (×60).

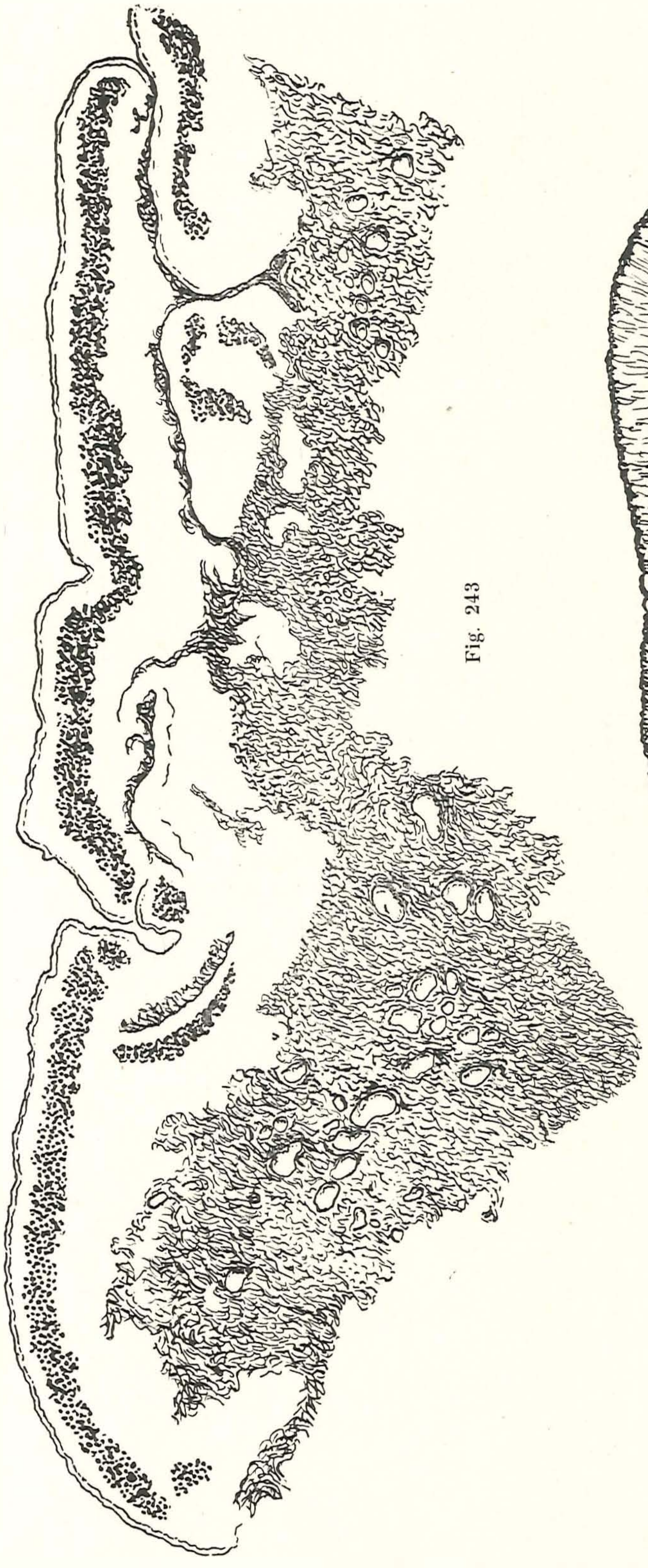


Fig. 243

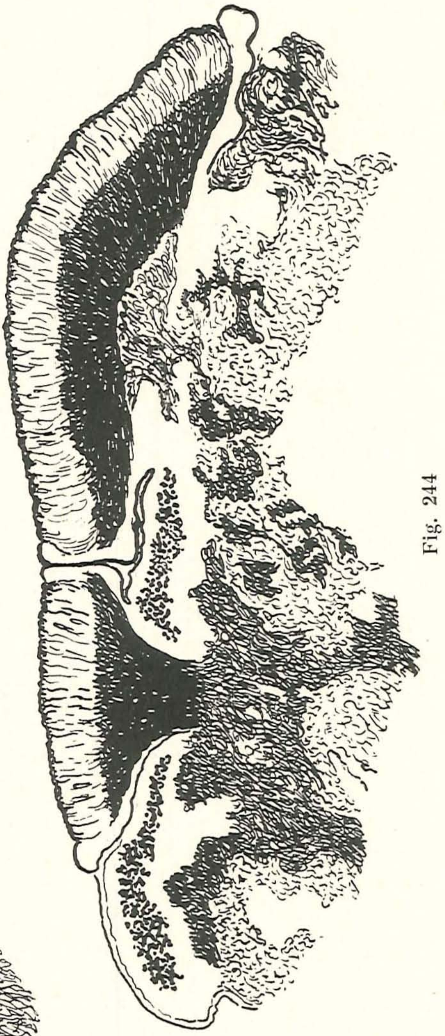


Fig. 244

O. Galløe del.

LECIDEA FUSCOATRA L

(Specimen 1)

PLATE 103.

LECIDEA FUSCOATRA.

L.

Specimen 1.

Fig. 245. Section of thallus, with cuticle, cortex, and gonidial layer. (×450).

Fig. 246. Hyphæ from the transition layer between the medullary and rhizoidal layers (×450).

Fig. 247. Margin of apothecium, with 2 spores (above) together with two conidia (below). (×450).

PLATE 103.

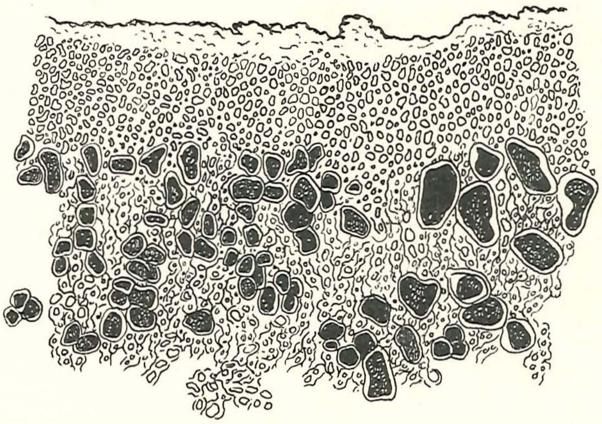


Fig. 245

Fig. 246

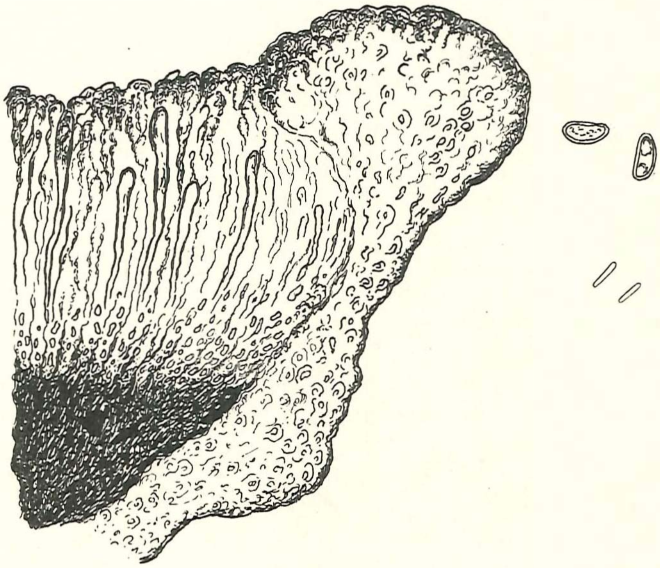


Fig. 247

O. Galløe del.

LECIDEA FUSCOATRA L.
(Specimen 1)

PLATE 104.

LECIDEA FUSCOATRA.

L.

Specimen 2.

Fig. 248. Thallus with apothecia. (×15).

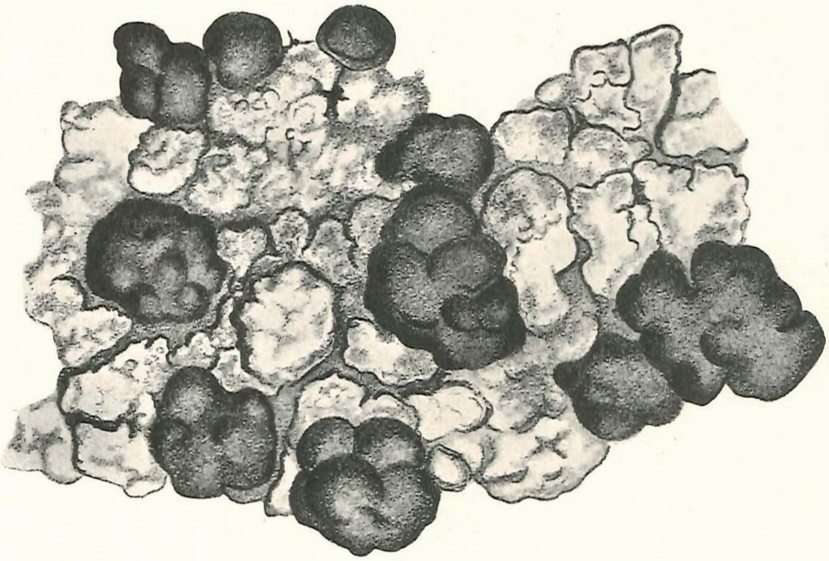


Fig. 248

O. *Galløe del.*

LECIDEA FUSCOATRA L.
(Specimen 2)

PLATE 105.

LECIDEA FUSCOATRA.

L.

Specimen 3.

Fig. 249. An areole. To the left a large dark spot represents a portion of an apothecium removed in the section. The areole has a distinct, thick cuticle and a living cortex. Note the cortex on the vertical sides of the areoles. (×60).

Fig. 250. Section of an areole with its margin (to the right). The cuticle is dead, smooth, and transparent, so that the brown colour of the upper cortex is visible. The cortex is composed of living cells, the upper ones of which have brown walls, coloured by a non-crystallized pigment, while the lower ones are colourless. The gonidial layer is short-celled, the hyphæ standing here and there distinctly vertical to the cortex. The medullary and rhizoidal layers have long cells and numerous intercellular spaces. To the right in the medullary layer are seen several grains of quartz. Above to the right the living cortex of the margin of the areoles is rather loose and somewhat spongy and devoid of pigment. The areoles therefore often seem to have a grey or white margin which can even be seen with the naked eye, (see also fig. 252). (×450).

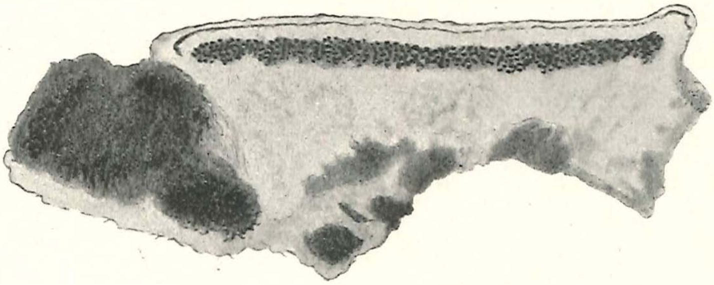


Fig. 249

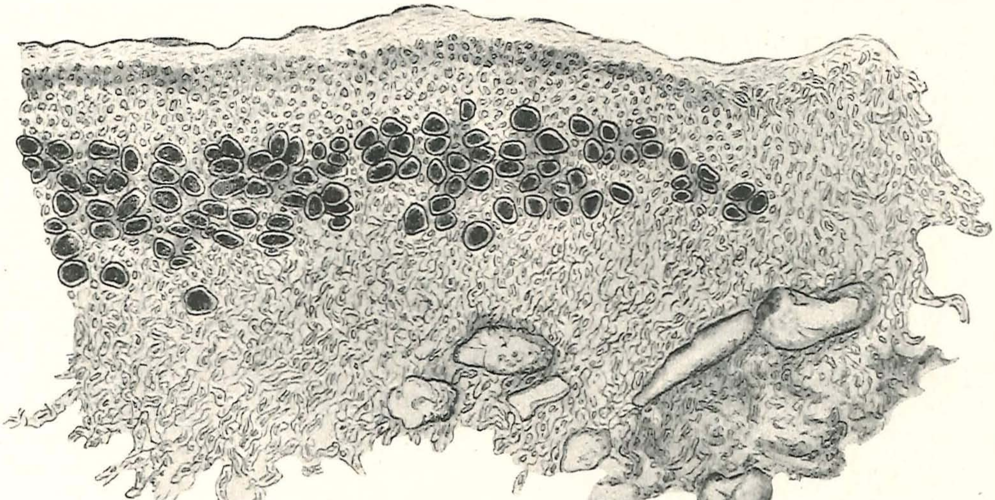


Fig. 250

O. Galløe del.

LECIDEA FUSCOATRA L.
(Specimen 3)

PLATE 106.

LECIDEA FUSCOATRA.

L.

Specimen 3.

Fig. 251. Thallus with apothecia. (×5).

Fig. 252. Two areoles. The right one contains two young apothecia more or less covered by the cortex. The left one contains some pycnidia, the ostioles of which are visible. Both areoles are bordered with grey (see explanation of fig. 250). (×40).

PLATE 106.

Fig. 252

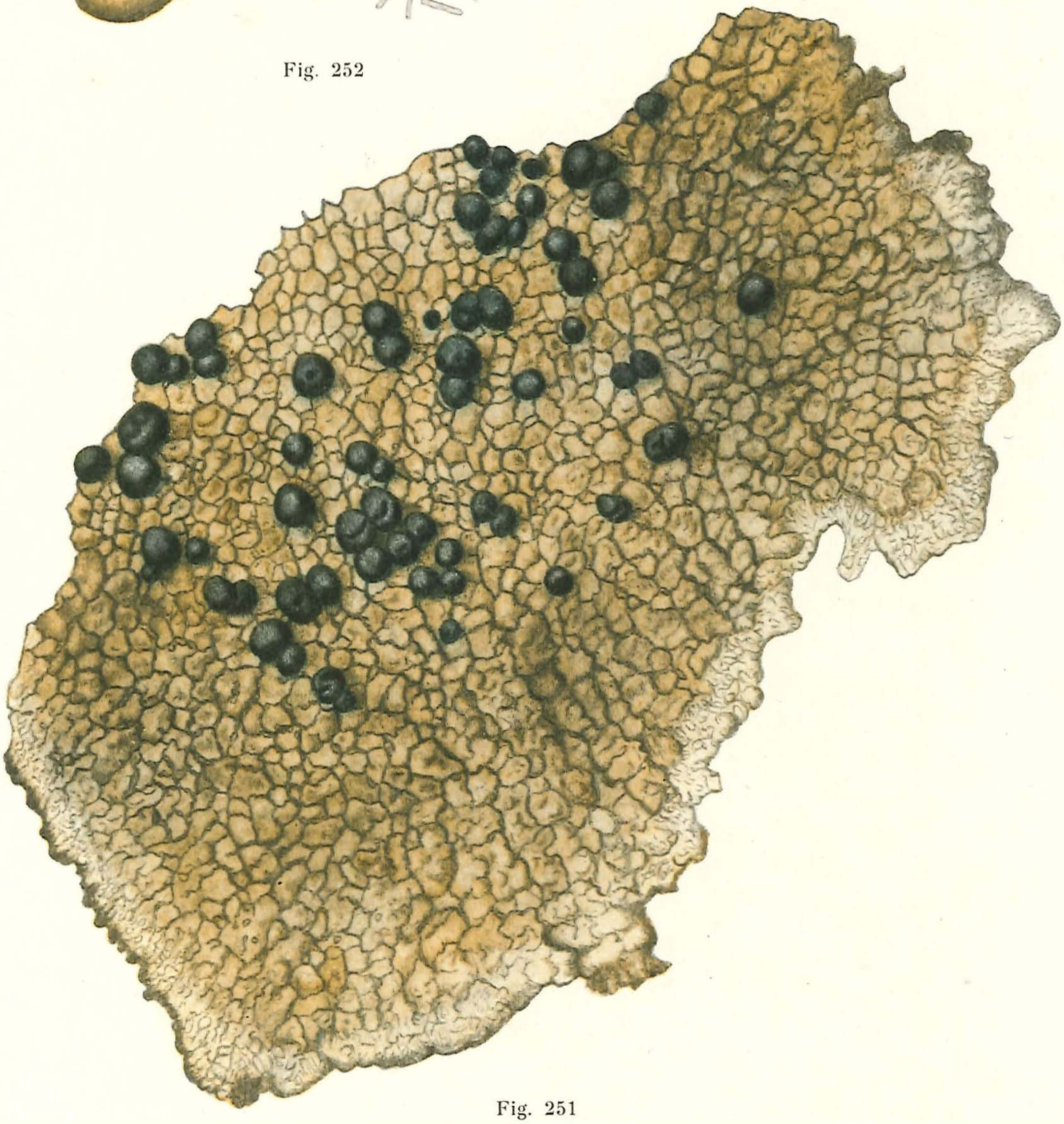


Fig. 251

O. Galløe del.

LECIDEA FUSCOATRA L.
(Specimen 3)

PLATE 107.

LECIDEA FUSCOATRA.

L.

Specimen 4.

Fig. 253. Portion of areolate thallus with whitish-grey areoles and an apothecium. In the areoles above to the right, contiguous to the apothecium, an ostiolum of a pycnidium is seen. (×40).

Fig. 254. A single areole. Note the thick farinose cuticle and the cortex on the vertical sides. (×60).

PLATE 107.

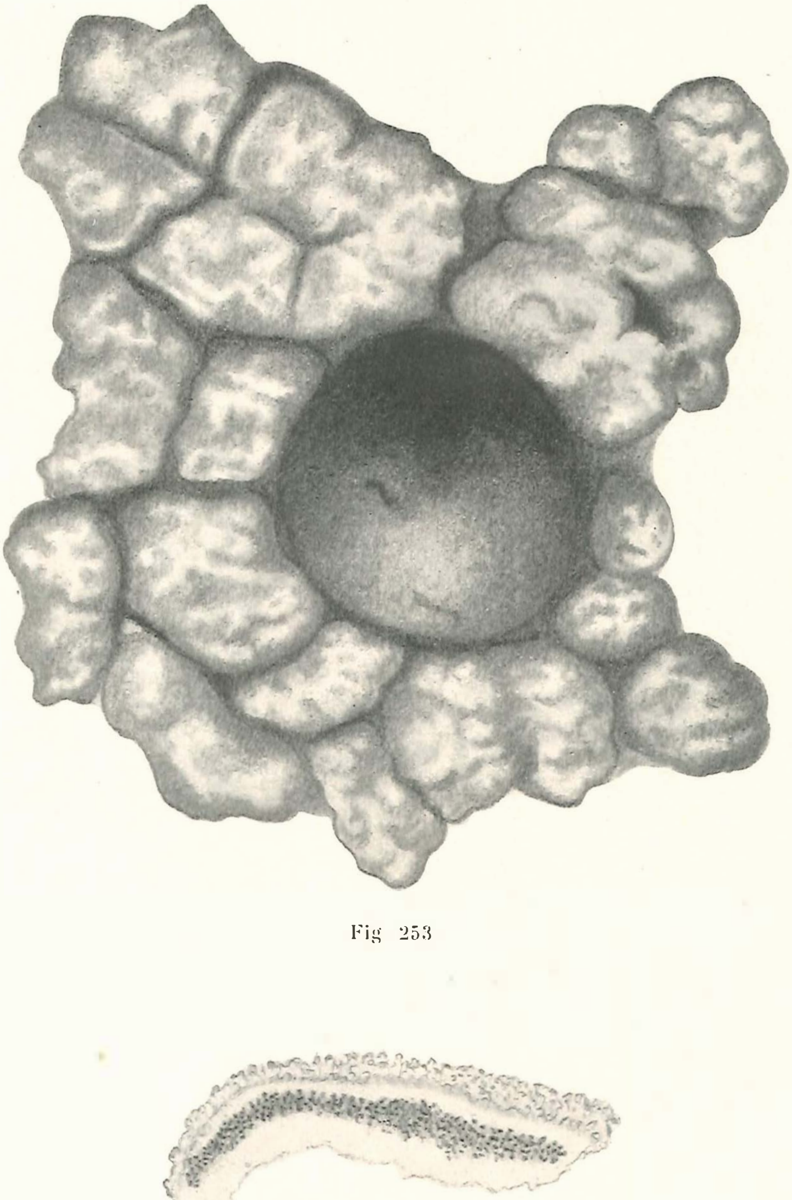


Fig. 253

Fig. 254

O. Galloe del.

LECIDEA FUSCOATRA L.
(Specimen 4)

PLATE 108.

LECIDEA FUSCOATRA.

L.

Specimen 4.

Fig. 255. Section of thallus with cuticle (a), brownish cortex (b), colourless cortex (c), and gonidial layer (d). Below the latter follows the medullary layer. The colour of the upper cortex is due to a non-crystallized pigment in the cell-walls. (×450).

Fig. 256. Part of hymenium, with a thin pruina and slender, cylindrical paraphyses (greenish-brown at the top), and numerous young asci. Below the hymenium is the hypothecium (colourless) and the upper part of the calyx (dark brown). (×450).

Fig. 257. Radiating hyphæ from the surface of the margin; the tips are brown and the lower parts are almost colourless. To the right a spore (about 14 μ). (×450).

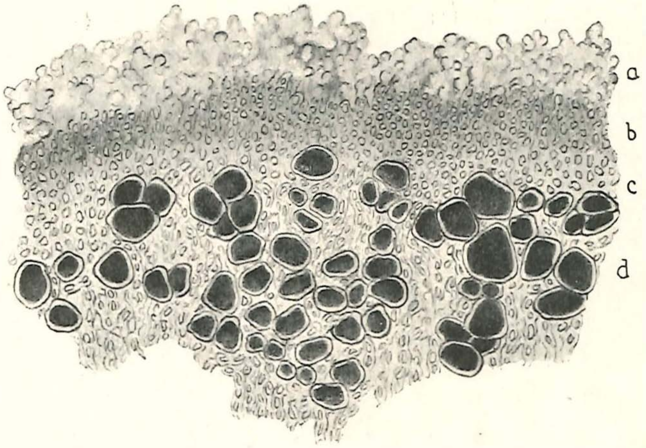


Fig. 255

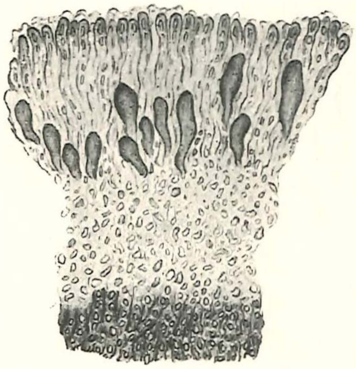


Fig. 256

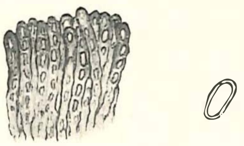


Fig. 257

O. Galløe del.

LECIDEA FUSCOATRA L.
(Specimen 4)

PLATE 109.

[LECIDEA FUSCOCINEREA].

NYL.

Swedish specimen.

Fig. 258. An areole and two apothecia, showing the brown colour of the medullary layer and of the outer parts of the apothecium. (×60).

Fig. 259. Margin of the thallus, with radiating dark hyphæ. (×45).

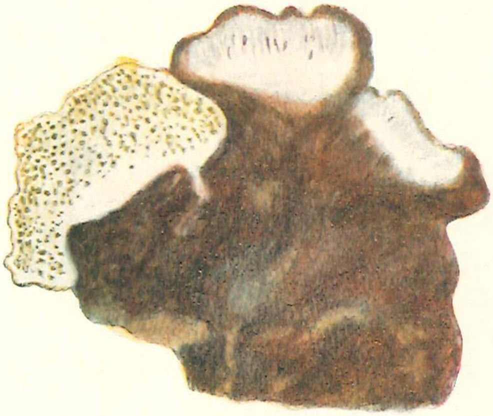


Fig. 258

Fig. 259

O. Galløe del.

[LECIDEA FUSCOCINEREA Nyl.]
(Swedish specimen)

PLATE 110.

[LECIDEA FUSCOCINEREA].

NYL.

Swedish specimen.

Fig. 260. Areoles of the thallus with apothecia. (×40).

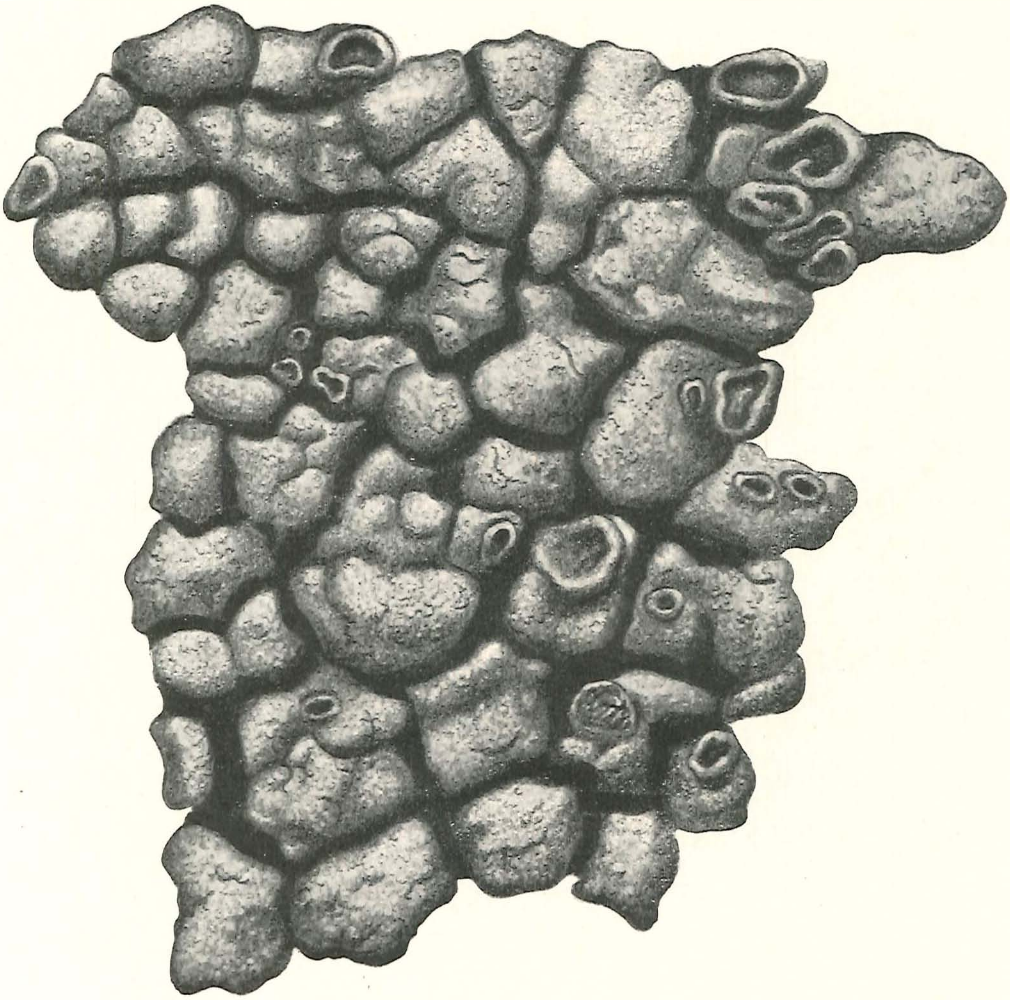


Fig. 260

O. Galløe del.

[LECIDEA FUSCOCINEREA Nyl.]
(Swedish specimen)

PLATE 111.

[LECIDEA FUSCOCINEREA].

NYL.

Swedish specimen.

Fig. 261. To the left two areoles with dark medullary layer and an apothecium. (×60).

Fig. 262. Two areoles with dark medullary layer. (×60).

Fig. 263. Section of two neighbouring areoles. Note the cuticle and the dark upper cortex. (×450).

Fig. 264. Part of the medullary layer. (×450).

Fig. 265. Margin of the apothecium, with young unripe asci. (×450).

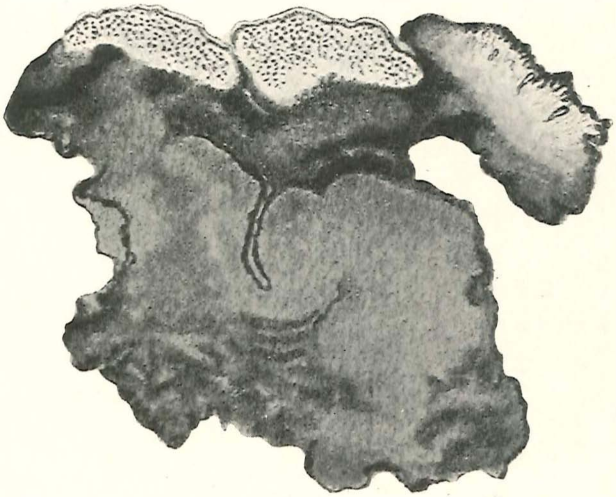


Fig. 261

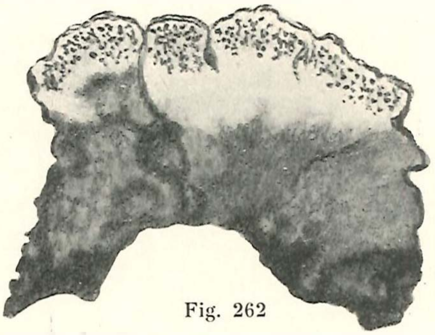


Fig. 262

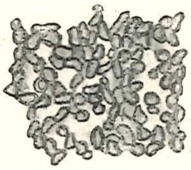


Fig. 264

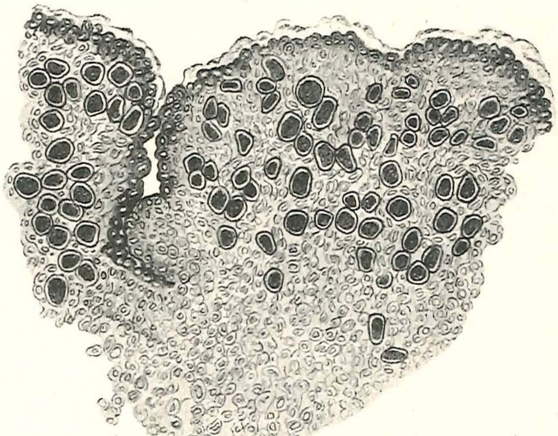


Fig. 263

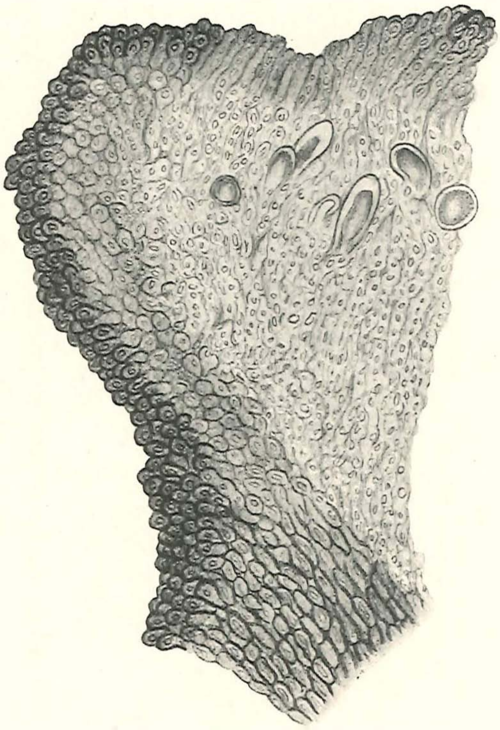


Fig. 265

O. Galløe del.

[LECIDEA FUSCOCINEREA NYL.]
(Swedish specimen)

PLATE 112.

[LECIDEA FUSCOCINEREA].

NYL.

Swedish specimen.

Fig. 266. A pycnidium. (×450).

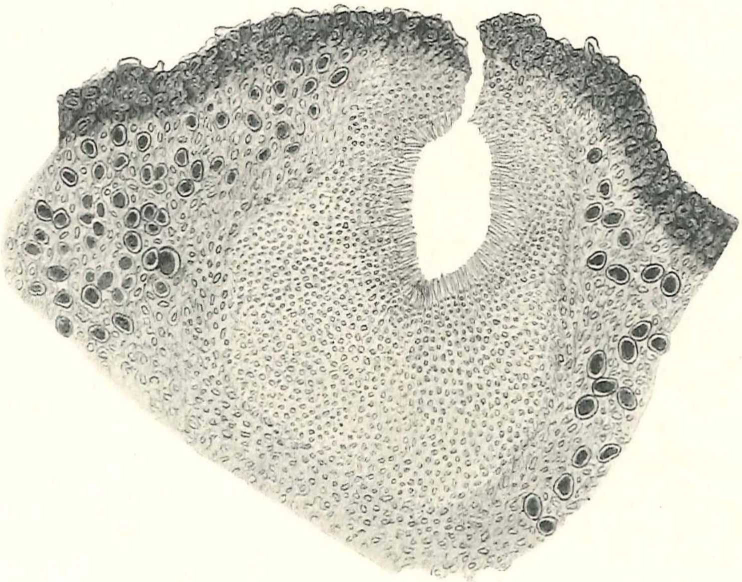


Fig. 266

O. Galløe del.

[LECIDEA FUSCOCINEREA Nyl.]
(Swedish specimen)

PLATE 113.

LECIDEA INTUMESCENS.

(Fw.) Nyl.

Fig. 267. Thallus with very distinct gonidial layer and cortex. Below, the medullary layer passes gradually into the destroyed thallus of *Lecanora sordida*, which is partly brown. (×60).

Fig. 267

O. Galløe del.

LECIDEA INTUMESCENS (Fw.) Nyl.

PLATE 114.

LECIDEA INTUMESCENS.

(Fw.) Nyl.

Fig. 268. The big, rough, brightly coloured areoles belong to *Lecanora sordida* of which several areoles (below) are still unattacked. A single areole (below in the middle) is only partly covered by the *Lecidea*, the others are completely covered by it. In the figure above a space is seen between the areoles of the *Lecanora*, into which the Lecidea has penetrated and where it covers the space by a thin thallus. (×15).

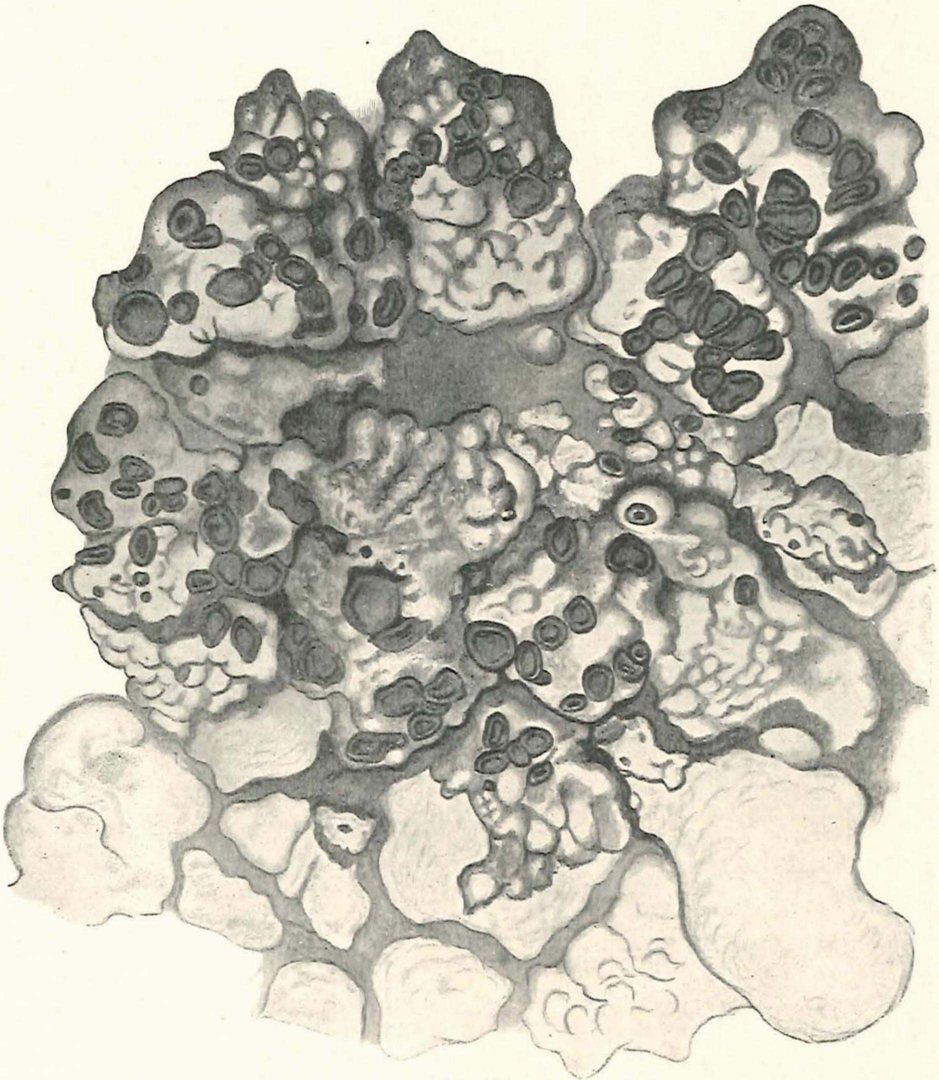


Fig. 268

O. Galløe del.

LECIDEA INTUMESCENS (Fw.) Nyl.

PLATE 115.

LECIDEA INTUMESCENS.

(Fw.) Nyl.

Fig. 269. The dark thallus with apothecia is *Lecidea intumescens*, which by means of a dark narrow margin has grown over the narrow crack between the areoles of *Lecanora sordida* (the brighter areoles below and to the left in the figure. (× 45).

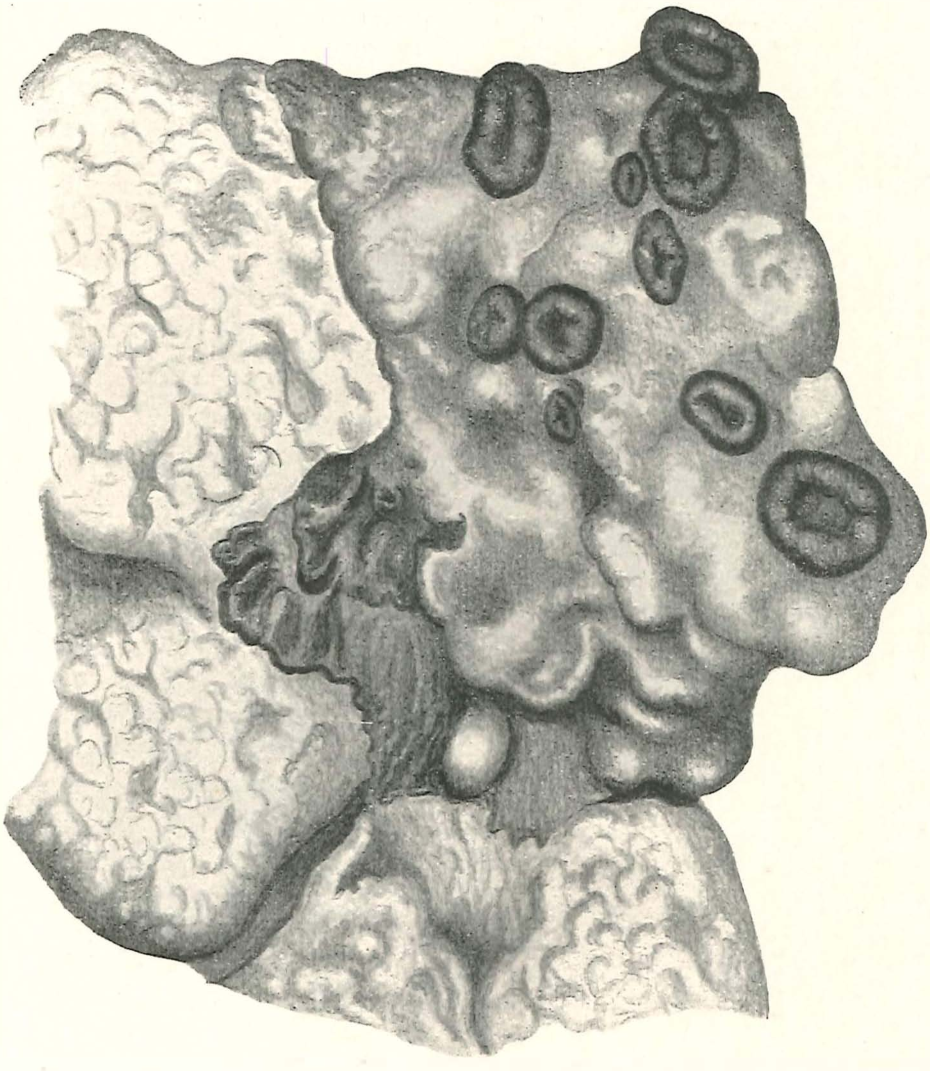


Fig. 269

O. Galløe del.

LECIDEA INTUMESCENS (Fw.) Nyl.

PLATE 116.

LECIDEA INTUMESCENS.

(Fw.) Nyl.

Fig. 270. An areole of *Lecanora sordida* cut off and shown obliquely from below (the big light plane portion is the medullary layer of *Lecanora sordida*). The sides of the areole are completely covered by the brown, thin thallus of *Lecidea intumescens,* which in parts consists of small areoles and on the upper surface of the *Lecanora areoles* is areolate. (×15).

Fig. 271. Thallus which has spread over the destroyed thallus of *Lecanora sordida.* (×60).

PLATE 116.

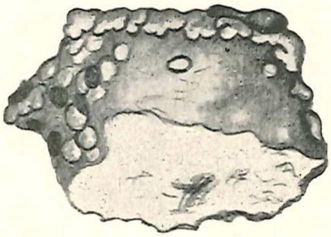


Fig 270

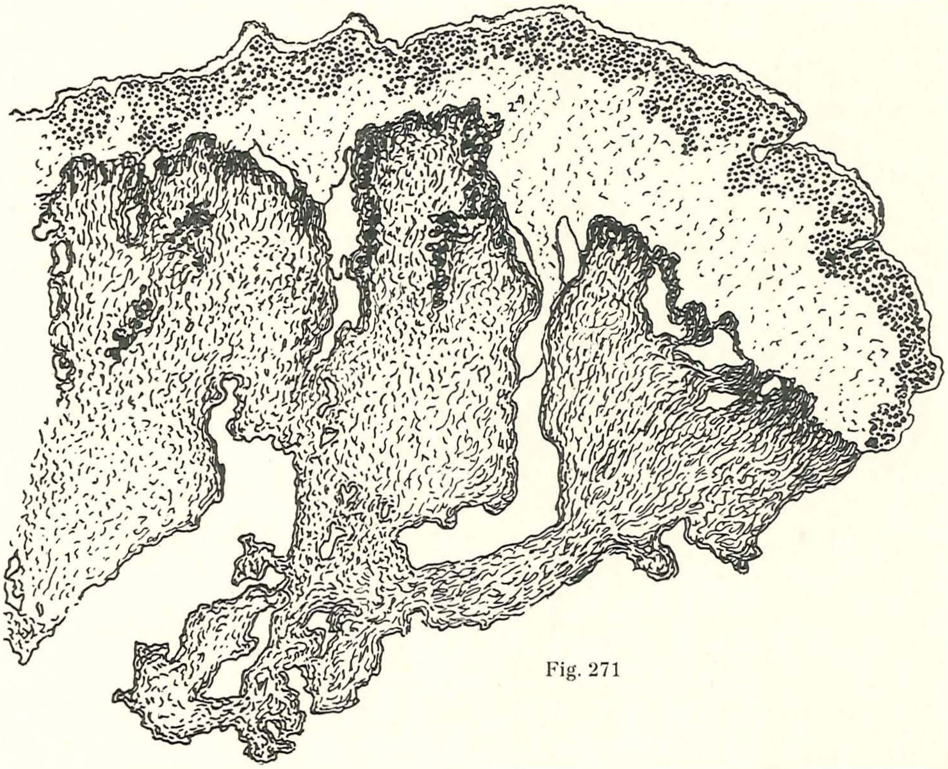


Fig. 271

O. Galløe del.

LECIDEA INTUMESCENS (Fw.) Nyl.

PLATE 117.

LECIDEA INTUMESCENS.

(Fw.) Nyl.

Fig. 272. 4 apothecia partly in median section and partly in tangential section. Below the thallus of the *Lecidea* is seen the destroyed thallus of *Lecanora sordida*. To the right a spore (about 10 µ long). (×60).

Fig. 273. Fragment of a thallus with cuticle, gonidial layer and medullary layer. In this section nothing is seen of the *Lecanora*-thallus. (×450).

PLATE 117.

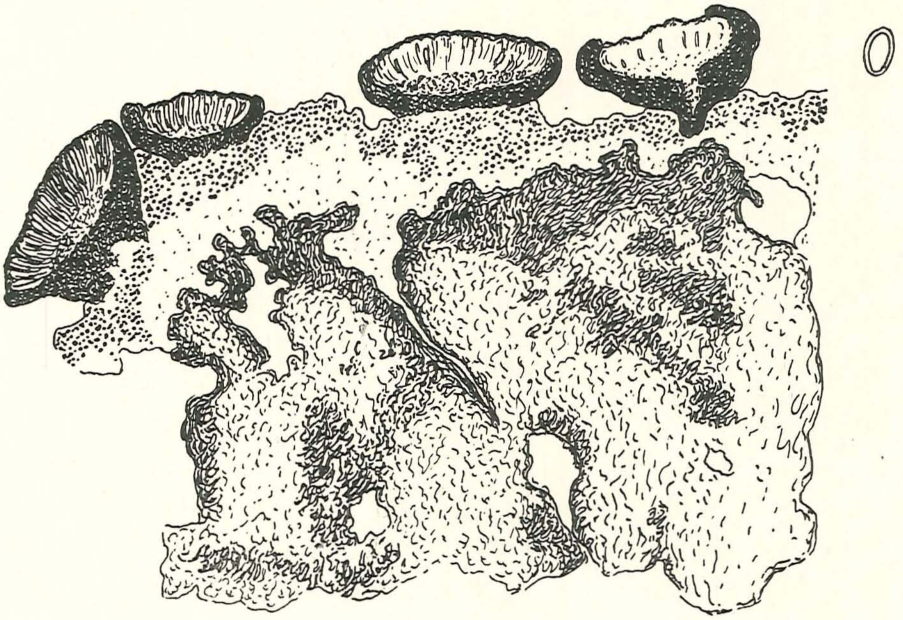


Fig. 272

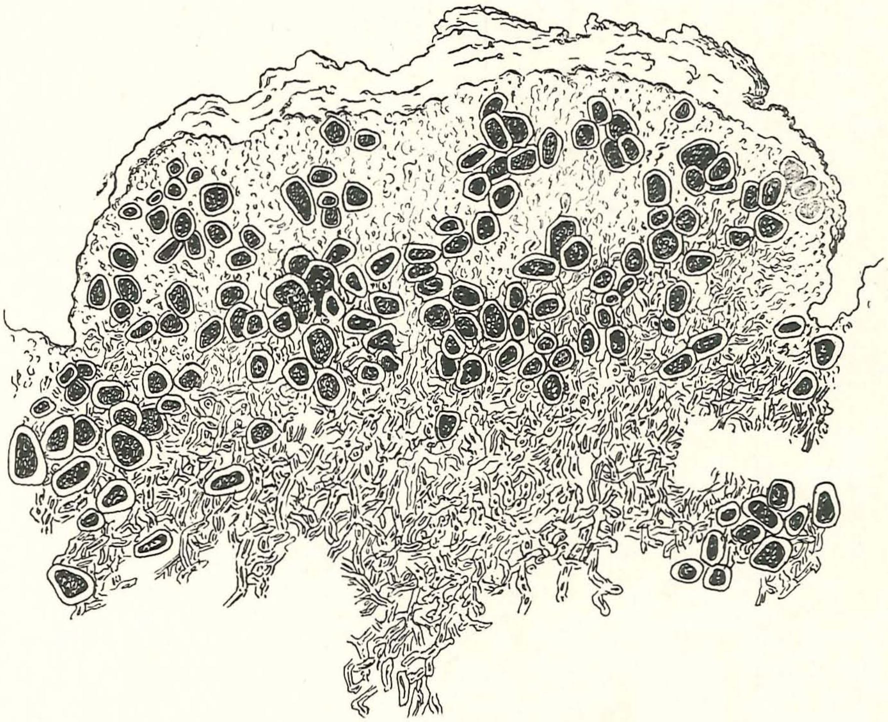


Fig. 273

O. Galløe del.

LECIDEA INTUMESCENS (Fw.) Nyl.

PLATE 118.

LECIDEA TENEBROSA.

Fw.

Specimen 1.

Fig. 274. Apothecium. (×60).

Fig. 275. Margin of thallus. (×15).

Fig. 276. Thallus near the margin. Thin, smooth, dark-grey thallus with somewhat lighter coloured areoles, which are scattered. (×15).

Fig. 277. Thallus near the middle. Areoles crowded. (×15).

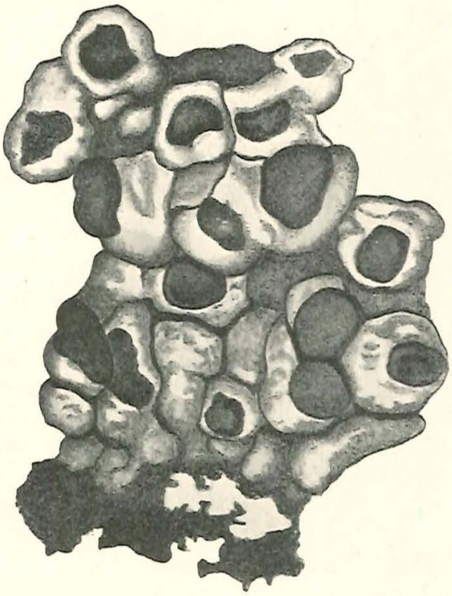


Fig. 275

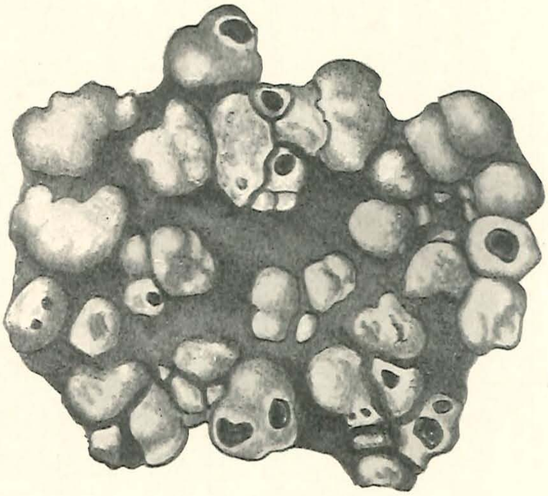


Fig. 276

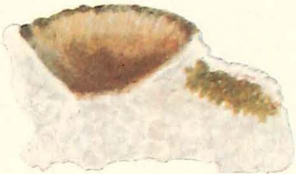


Fig. 274

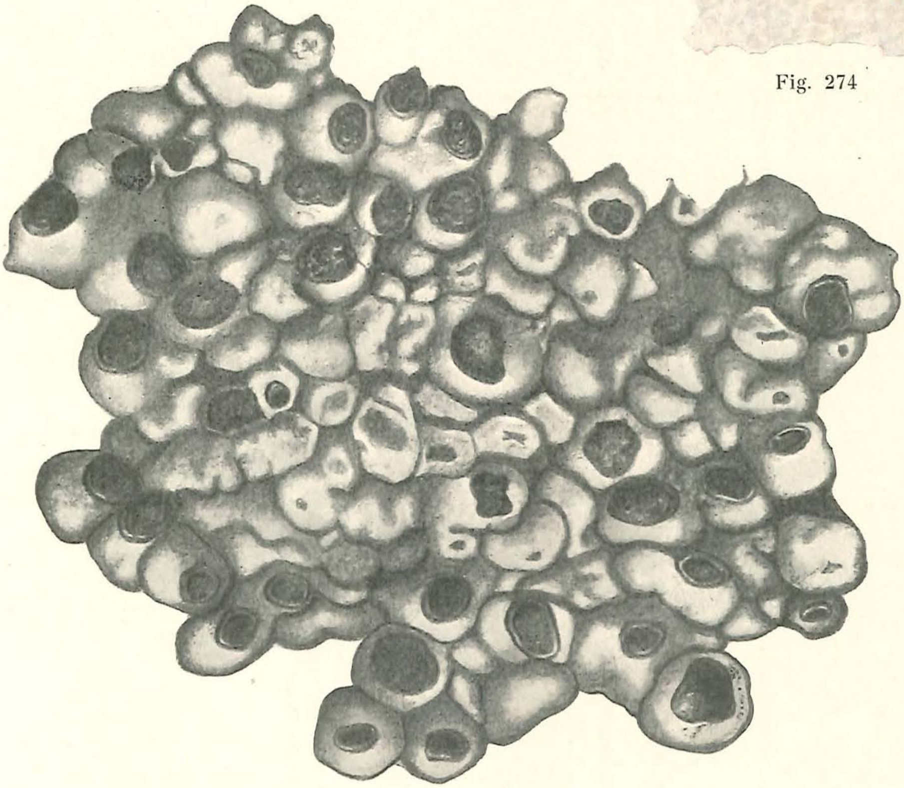


Fig. 277

O. Galløe del.

LECIDEA TENEBROSA Fw.
(Specimen 1)

PLATE 119.

LECIDEA TENEBROSA.

Fw.

Specimen 1.

Fig. 278. Four areoles with apothecia of various ages. (×60).

Fig. 279. Areole with apothecium, a distinct cuticle which however disappears at the sides of the areole. (×60).

Fig. 280. Young, rather plane areole. (×45).

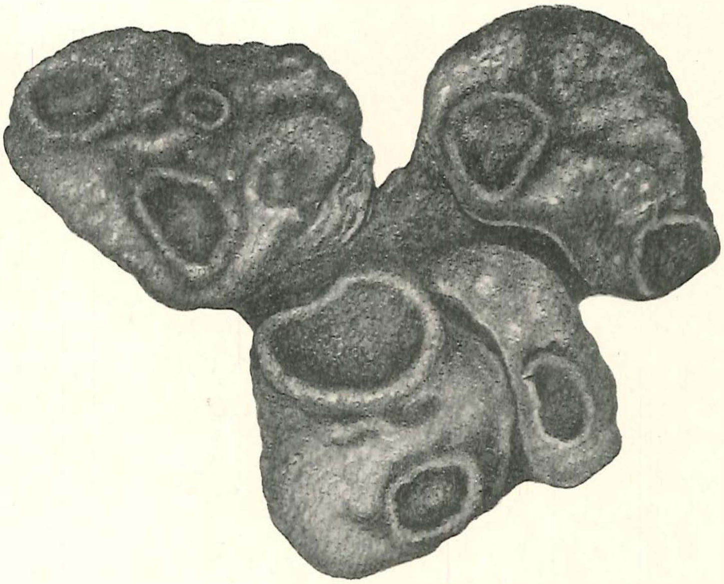


Fig. 278

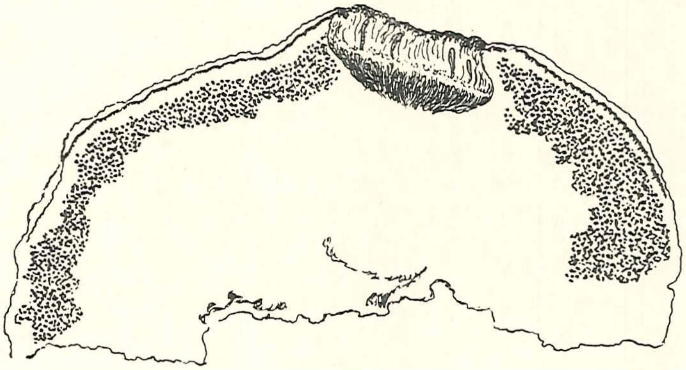


Fig. 279

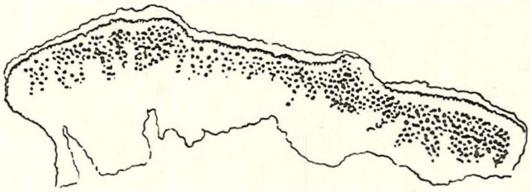


Fig. 280

O. Galløe del.

LECIDEA TENEBROSA Fw.

PLATE 120.

LECIDEA TENEBROSA.

Fw.

Specimen 1.

Fig. 281. Areole with older apothecium. (×60).

Fig. 282. Section of areole with cuticle, showing the vertical hyphæ of the cortex (with dark cells at the top), gonidial and medullary layers. (×450).

Fig. 283. Margin of apothecium, contiguous with the tissue of the thallus (to the left); a spore, an ascus and a paraphyse. (×450).

PLATE 120.

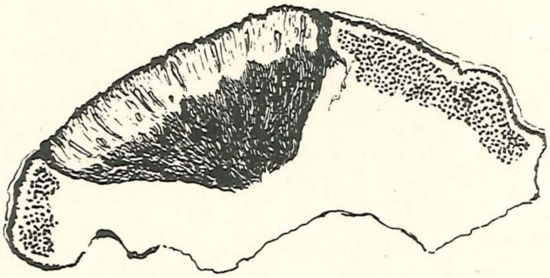


Fig. 281

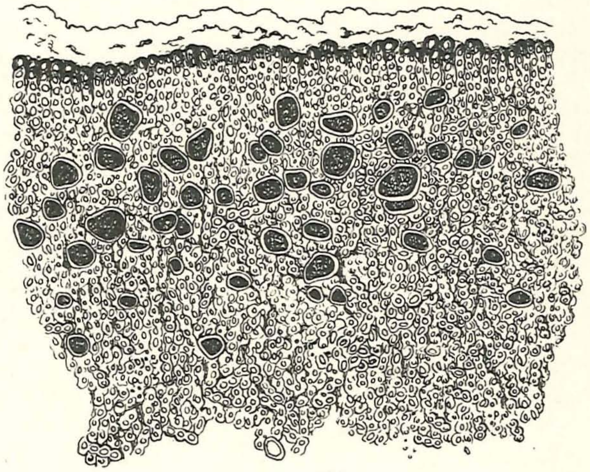


Fig 282

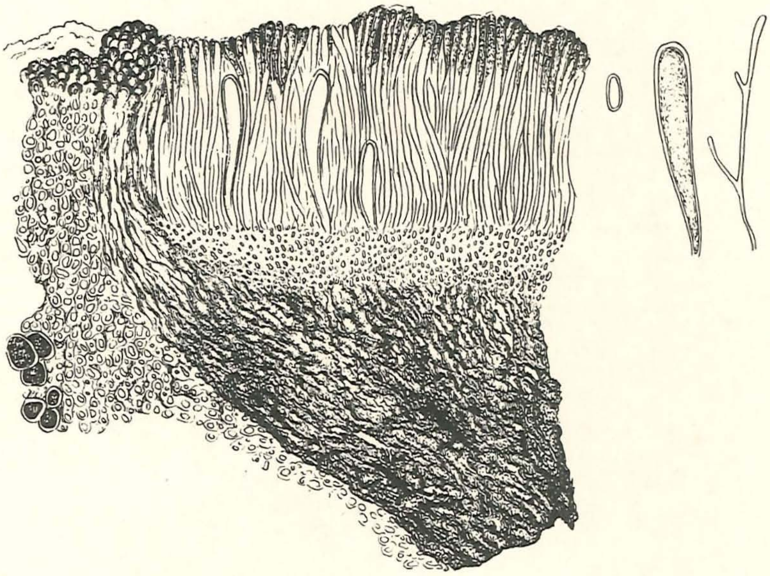


Fig. 283

LECIDEA TENEBROSA Fw.

O. Galløe del.

PLATE 121.

LECIDEA TENEBROSA.

Fw.

Specimen 2.

Fig. 284. Portion of thallus with apothecia. (×40).

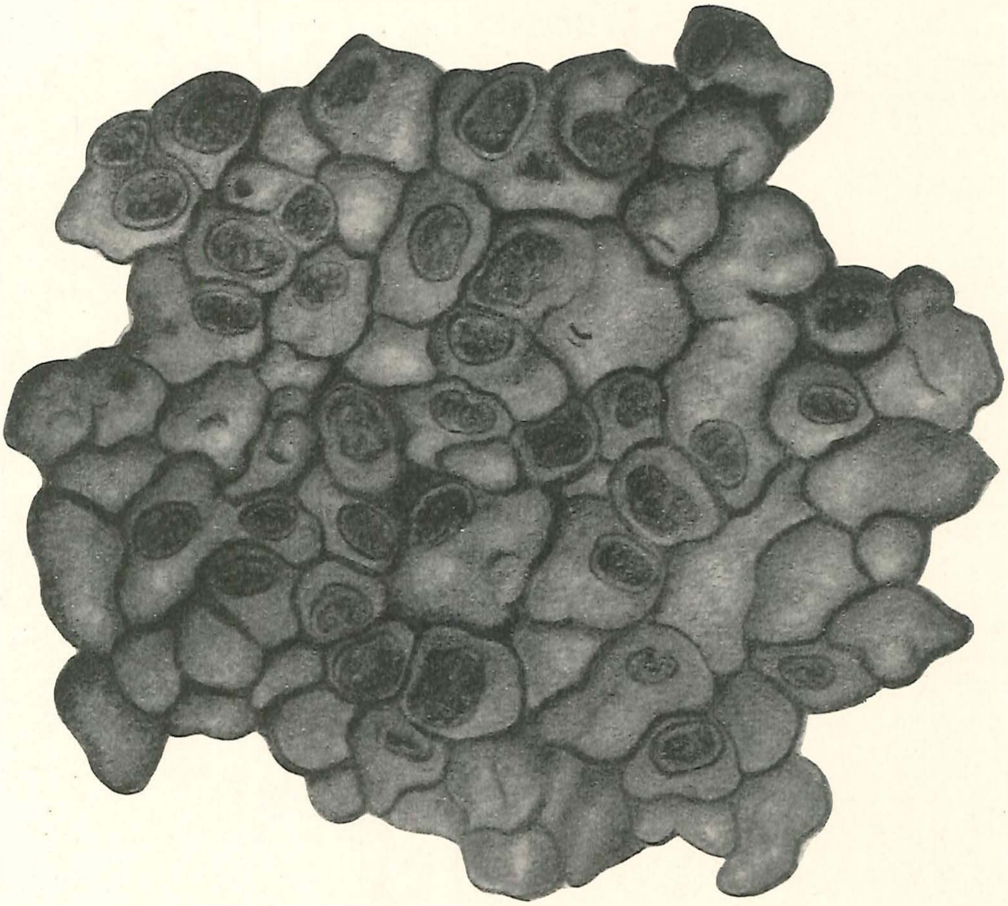


Fig. 284

O. Galløe del.

LECIDEA TENEBROSA Fw.
(Specimen 2)

PLATE 122.

LECIDEA TENEBROSA.

Fw.

Specimen 2.

Fig. 285. Two thalli bordering on each other. The one is of a dirty white *(Lecanora)*, the other is dark *(Lecidea tenebrosa)*. From the latter black marginal hyphæ spread over the substratum and penetrate in between and also grow over the thallus of the *Lecanora*. A part of the *Lecanora* is about to lose touch with the other parts of the *Lecanora* and to be destroyed by the *Lecidea*. (× 40).

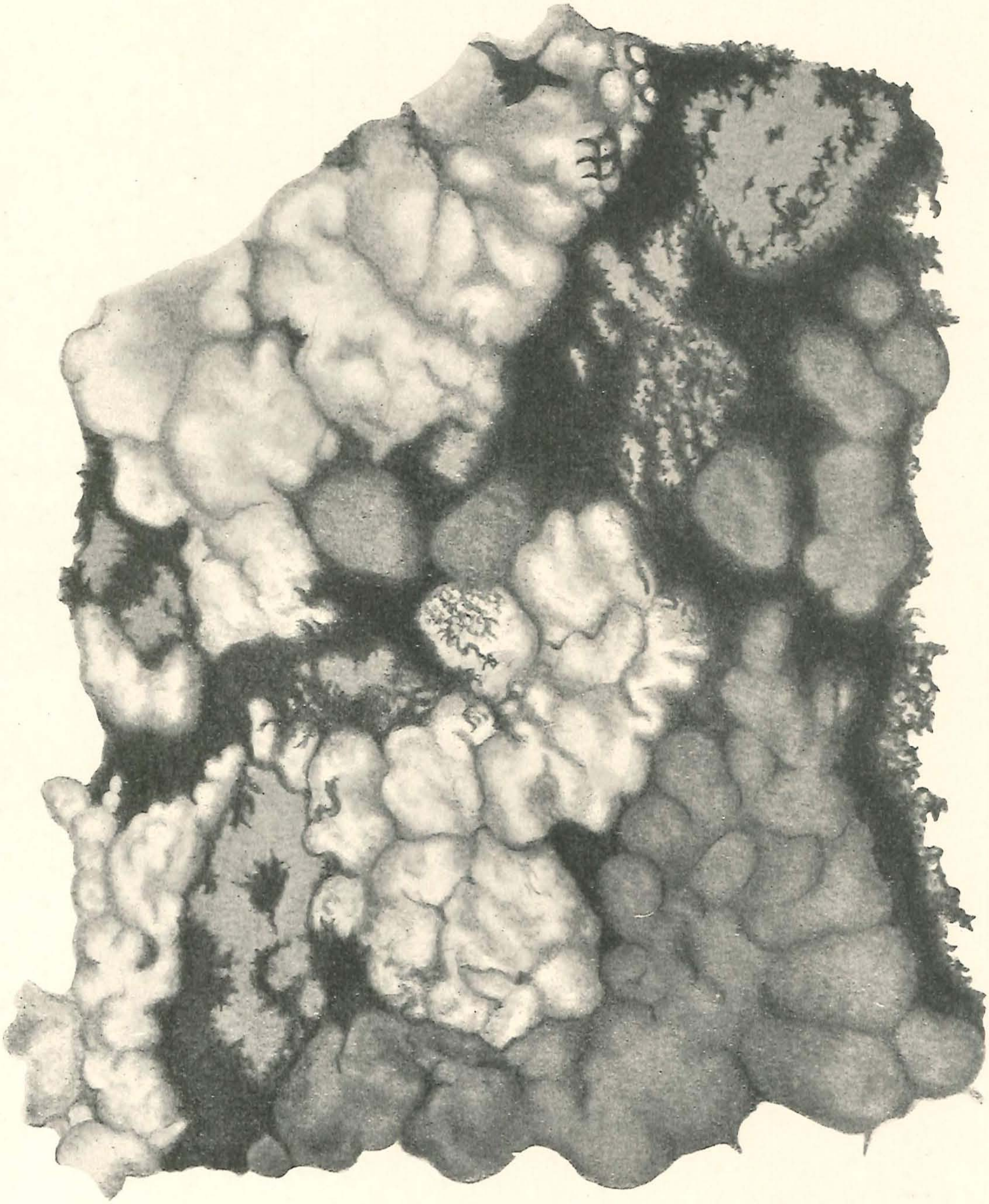


Fig. 285

O. Galløe del.

LECIDEA TENEBROSA Fw.
(Specimen 2)

PLATE 123.

LECIDEA TENEBROSA.

Fw.

Specimen 2.

Fig. 286. Above: some white areoles of a *Lecanora* over which several black hyphæ of *Lecidea* have grown; the black portion is the margin of the thallus of the *Lecidea*, the older parts of which are not shown in the figure. Each spot-like, dark part of the thallus develops later on into an areole. The grey background represents the substratum of stone. (×40).

Fig. 287. Below: the dark margin of the *Lecidea*. Above: the greyish thallus of a *Lecanora*, between and over the areoles of which are scattered black hyphæ coming from the *Lecidea*. (×40).

Fig. 288. Young areole. (×140).

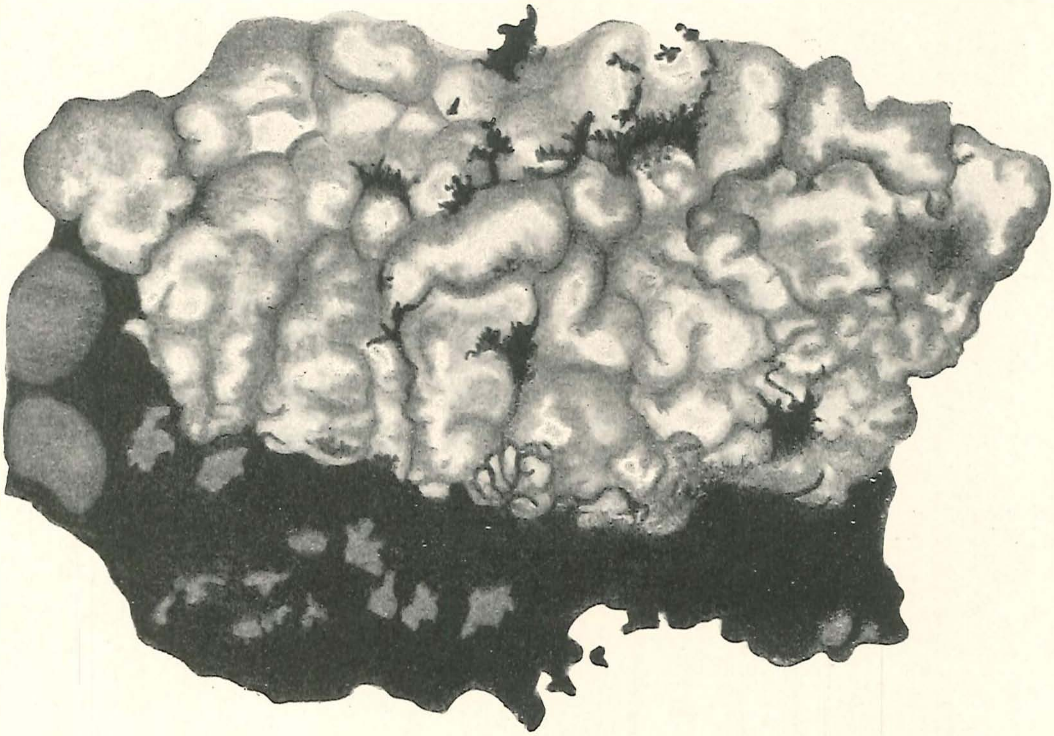


Fig. 287

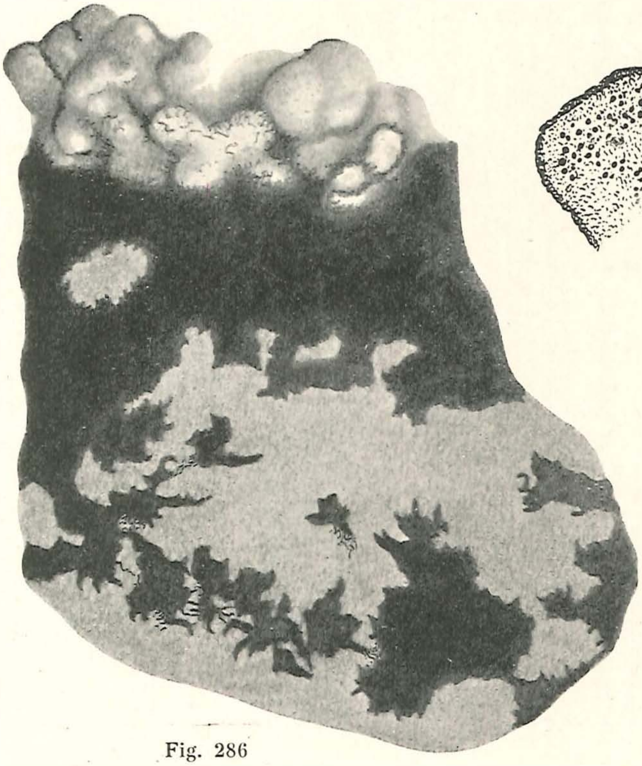


Fig. 286

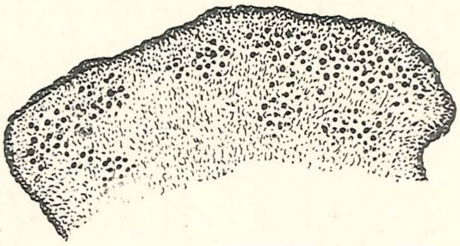


Fig. 288

O. Galløe del.

LECIDEA TENEBROSA
(Specimen 2)

PLATE 124.

LECIDEA TENEBROSA.

Fw.

Specimen 2.

Fig. 289. Old areole. (×140).

Fig. 290. Part of an areole. Above to the left: part of the cortex (×600), showing the boundary line between cuticle and cortex. (×450).

Fig. 291. Hyphæ and gonidia from the margin of the thallus. (×450).

Fig. 292. Isolated radiating hyphæ from the margin of the thallus. The ends of the hyphæ are dark, the other parts are lighter in colour. (×450).

Fig. 293. Margin of the apothecium immersed in an areole.

Fig. 294. Hymenium. (×450).

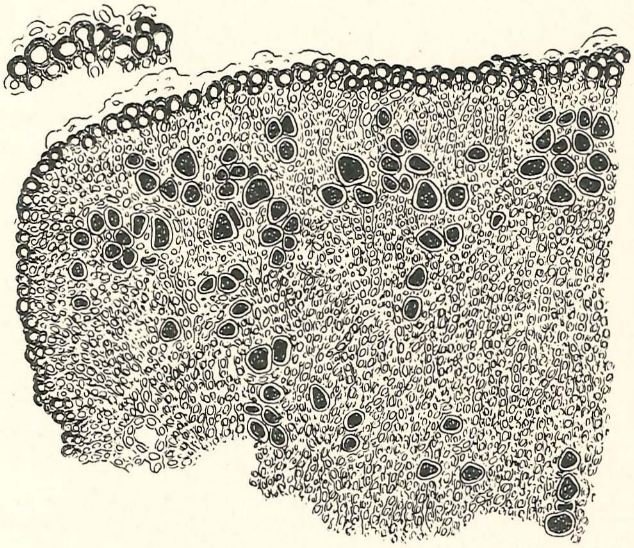


Fig. 290

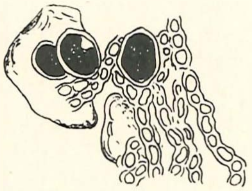


Fig. 291

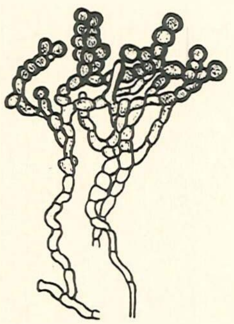


Fig. 292

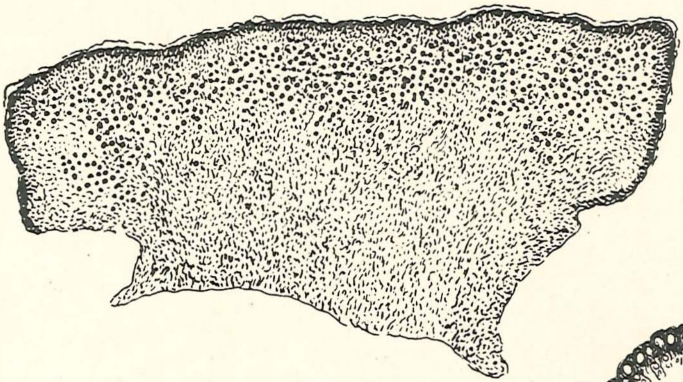


Fig. 289

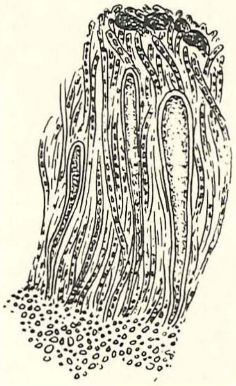


Fig. 294

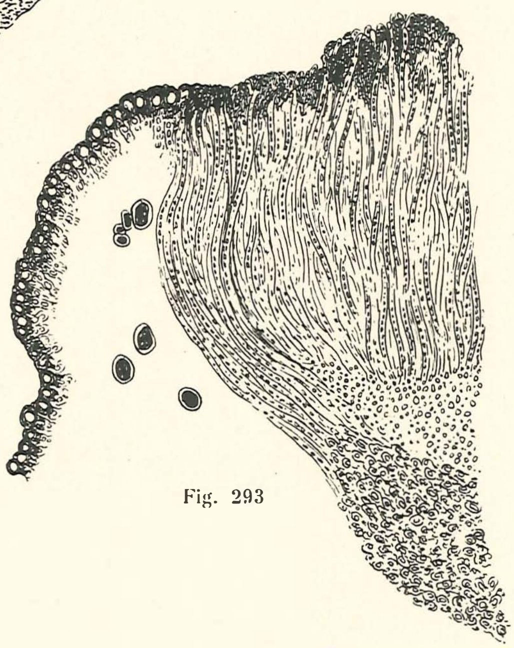


Fig. 293

O. Galløe del.

LECIDEA TENEBROSA Fw.
(Specimen 2)

PLATE 125.

LECIDEA TENEBROSA.

Fw.

Specimen 2.

Fig. 295. The dark thallus of *Lecidea tenebrosa* bordering on the greyish thallus of *Lecanora*. (×6).

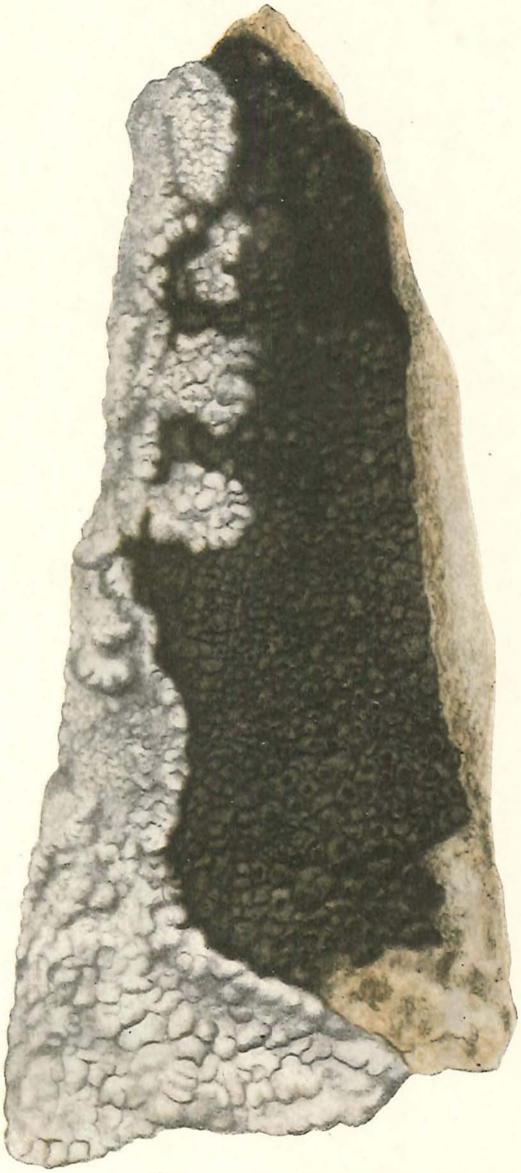


Fig. 295

O. Galløe del.

LECIDEA TENEBROSA Fw.
(Specimen 2)

PLATE 126.

LECIDEA ERRATICA.

KÖRB.

Fig. 296. Apothecia in vertical section. (×60).
Fig. 297. Thallus with apothecia. (×15).

PLATE 126.

Fig. 296

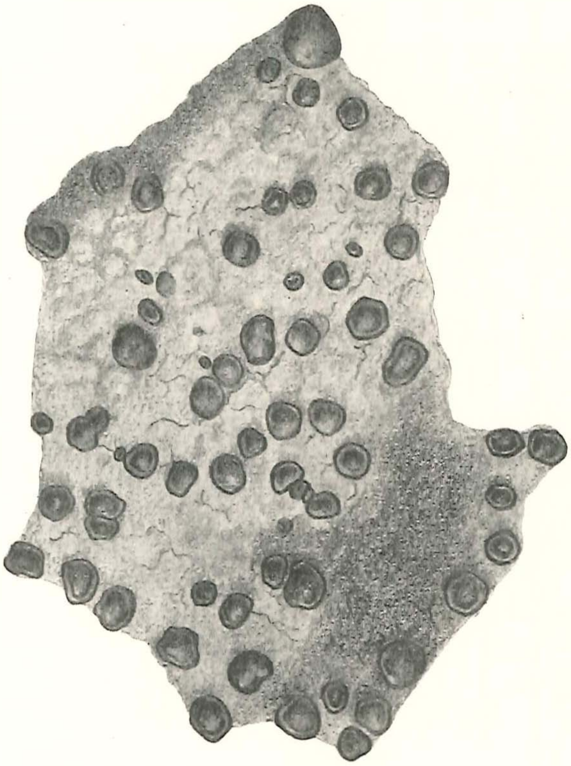


Fig. 297

O. Galløe del.

LECIDEA ERRATICA Körb.

PLATE 127.

LECIDEA ERRATICA.

KÖRB.

Fig. 298. Thallus with apothecia in various stages of development and 2 ostioles of pycnidia. (×45).

Fig. 299. Vertical section of thallus. (×450).

Fig. 300. Vertical section of an older apothecium. (×60).

Fig. 301. Part of hymenium, a spore and 5 conidia. (×450).

Fig. 302. Margin of the apothecium. (×450).

PLATE 127.

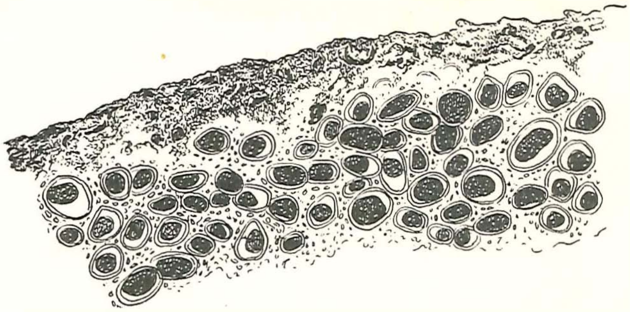


Fig. 299

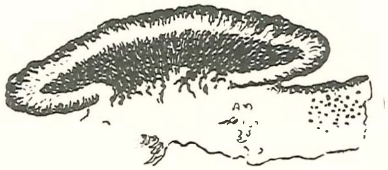


Fig. 300

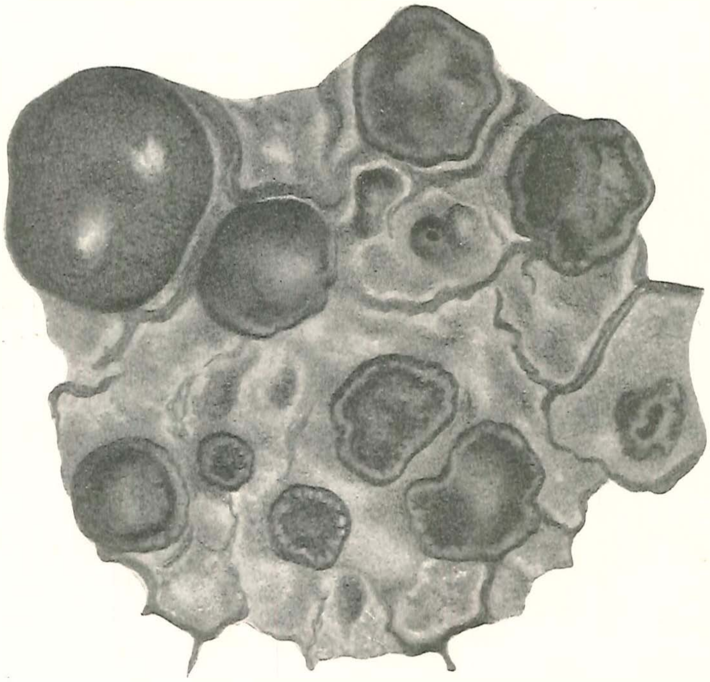


Fig. 298

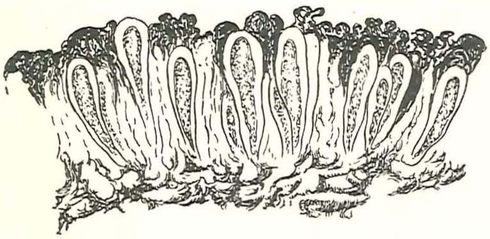
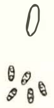


Fig. 301



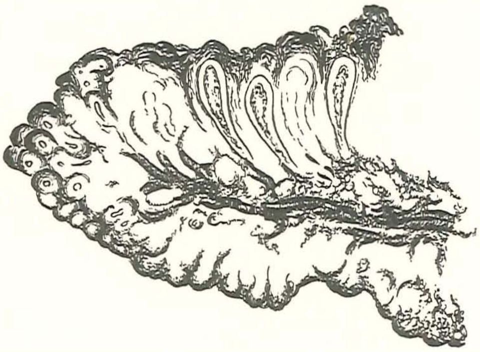


Fig. 302

O. Galløe del.

LECIDEA ERRATICA Körb.

PLATE 128.

LECIDEA ELÆOCHROMA.

ACH.

Fig. 303. Specimen 1. Apothecium in vertical section. (×60).
Fig. 304. Specimen 2. Apothecium in vertical section. (×60).
Fig. 305. Specimen 3. Apothecium in vertical section. (×60).
Fig. 306 a and b. Specimen 4. Apothecium in vertical section. (×60).
Fig. 307 a and b. Specimen 5. Apothecium in vertical section. (×60).

PLATE 128.

Fig. 303

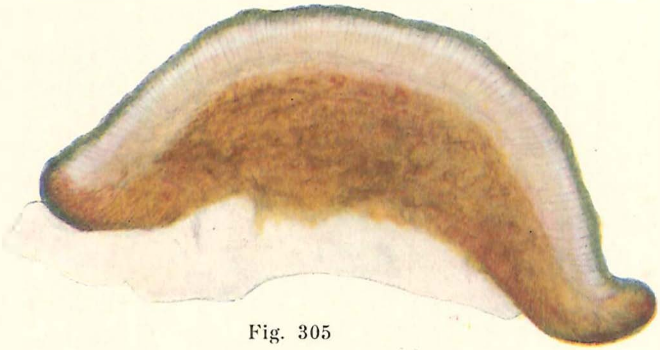


Fig. 305

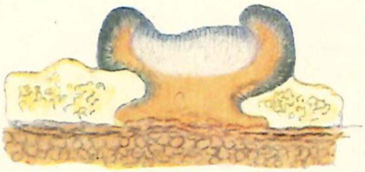


Fig. 304

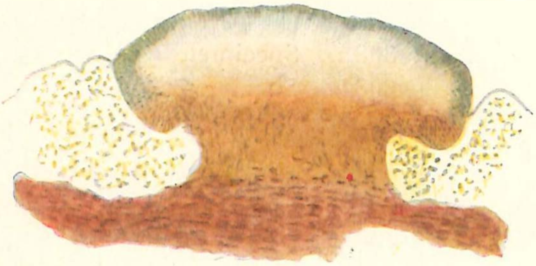


Fig. 307 a

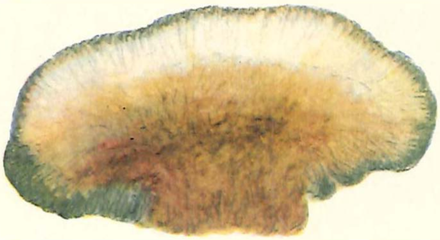


Fig. 306 a

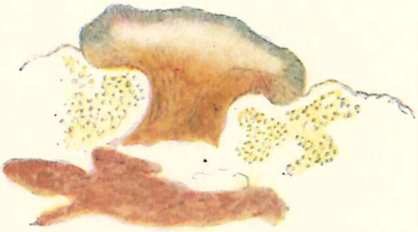


Fig. 307 b

Fig. 306 b

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 1, 2, 3, 4, 5)

PLATE 129.

LECIDEA ELÆOCHROMA.

ACH.

Fig. 308 a. Specimen 7. A young, normal but still unripe apothecium. (×60).

Fig. 308 b. Specimen 7. Part of an abnormal apothecium, almost completely without a hymenium; the hypothecium is well preserved. (×60).

Fig. 309 a. Specimen 8. A young apothecium. (×60).

Fig. 309 b. Specimen 8. An older apothecium. (×60).

Fig. 310. Specimen 9. Apothecium. (×60).

Fig. 311. Specimen 10. Two apothecia. (×60).

Fig. 312. Specimen 13. Apothecium. (×60).

PLATE 129.

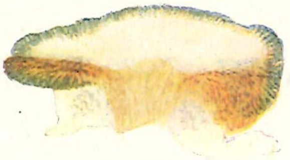


Fig. 308a

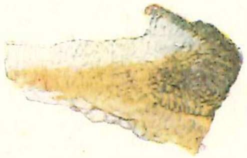


Fig. 308b

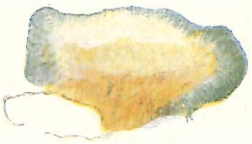


Fig. 309a

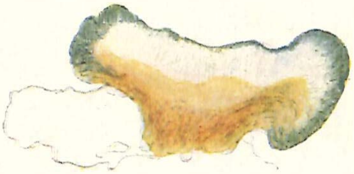


Fig. 309b

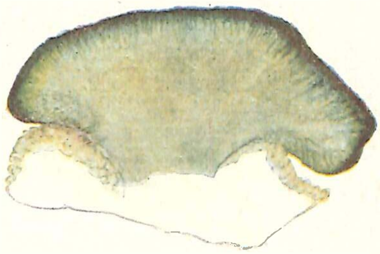


Fig. 310

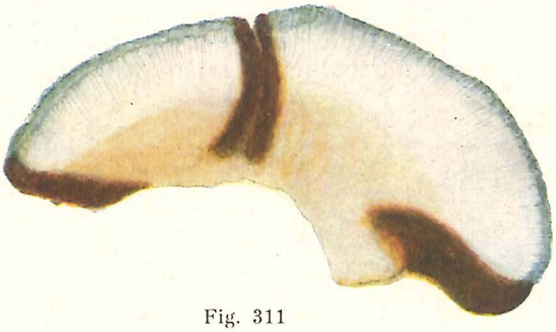


Fig. 311


Fig. 312

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 7, 8, 9, 10, 13)

PLATE 130.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 1.

Fig. 313. Thallus with apothecia in all stages of development. Below to the right: a young thallus of *Lecanora albella*. (×15).

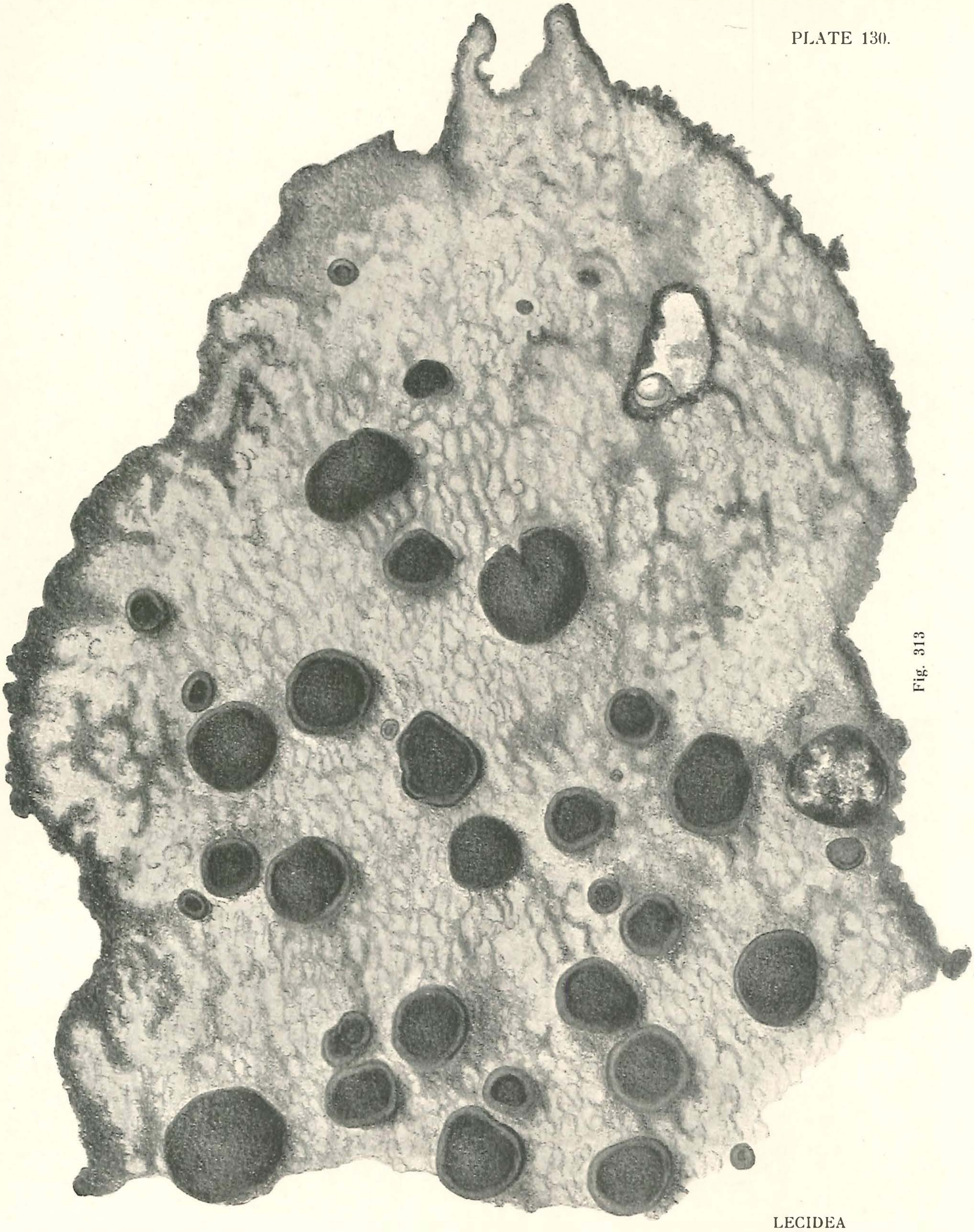


Fig. 313

O. Galløe del.

LECIDEA
ELÆOCHROMA Ach.
(Specimen 2)

PLATE 131.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 1.

Fig. 314. Section of thallus (on bark of oak) with an a apothecium; several fragments of oak bark are seen on the surface of the thallus. (The thallus is partly hypophloeodic. (×60).

Fig. 315. Section of a partly epiphloeodic thallus with loosened cells of the oak bark invested by the mycelium of the lichen. To the right: 3 gonidia. The neighbouring hyphæ do not send haustoria into the gonidia. (×450).

Fig. 316. Section of a partly hypophloeodic portion of the thallus, on the surface of which fragments of the oak bark are seen (by *a*). To the left below, a group of gonidia are seen covered by the oak bark. (×450).

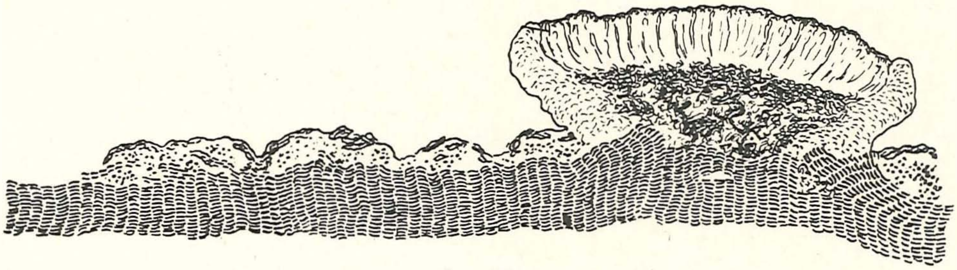


Fig. 314

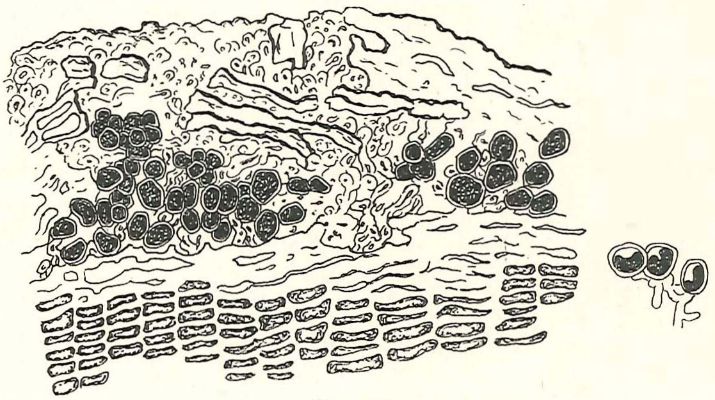


Fig. 315

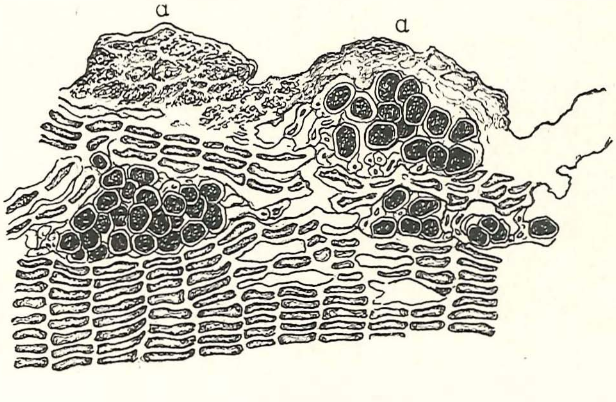


Fig. 316

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.

PLATE 132.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 1.

Fig. 317. Hyphæ from the rhizoidal zone between the destroyed lamellæ of cork with its compressed cells; above: 2 empty gonidia. (×450).

Fig. 318. The margin of the apothecium; (to the left below: a portion of the thallus). To the left above: 2 spores. (×450).

Fig. 319. A pycnidium.

Fig. 320. Conidia on their sterigmata. (×450).

Fig. 321. Paraphyses from a young apothecium. At their tips they are bluish-green and bear on their outer surface very small grains of some substance, the nature of which could not be determined. (×450).

PLATE 132.

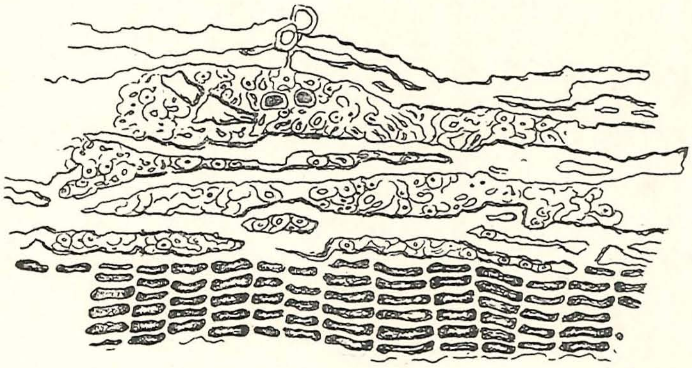


Fig. 317

Fig. 318

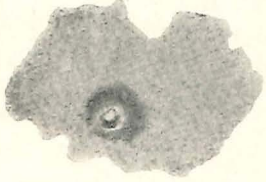


Fig. 319

Fig. 320

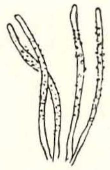


Fig. 321

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 1)

PLATE 133.

LEDIDEA ELÆOCHROMA.

ACH.

Specimen 2.

Fig. 322. Numerous individuals separated from one another by dark margins of the thallus. (×15).

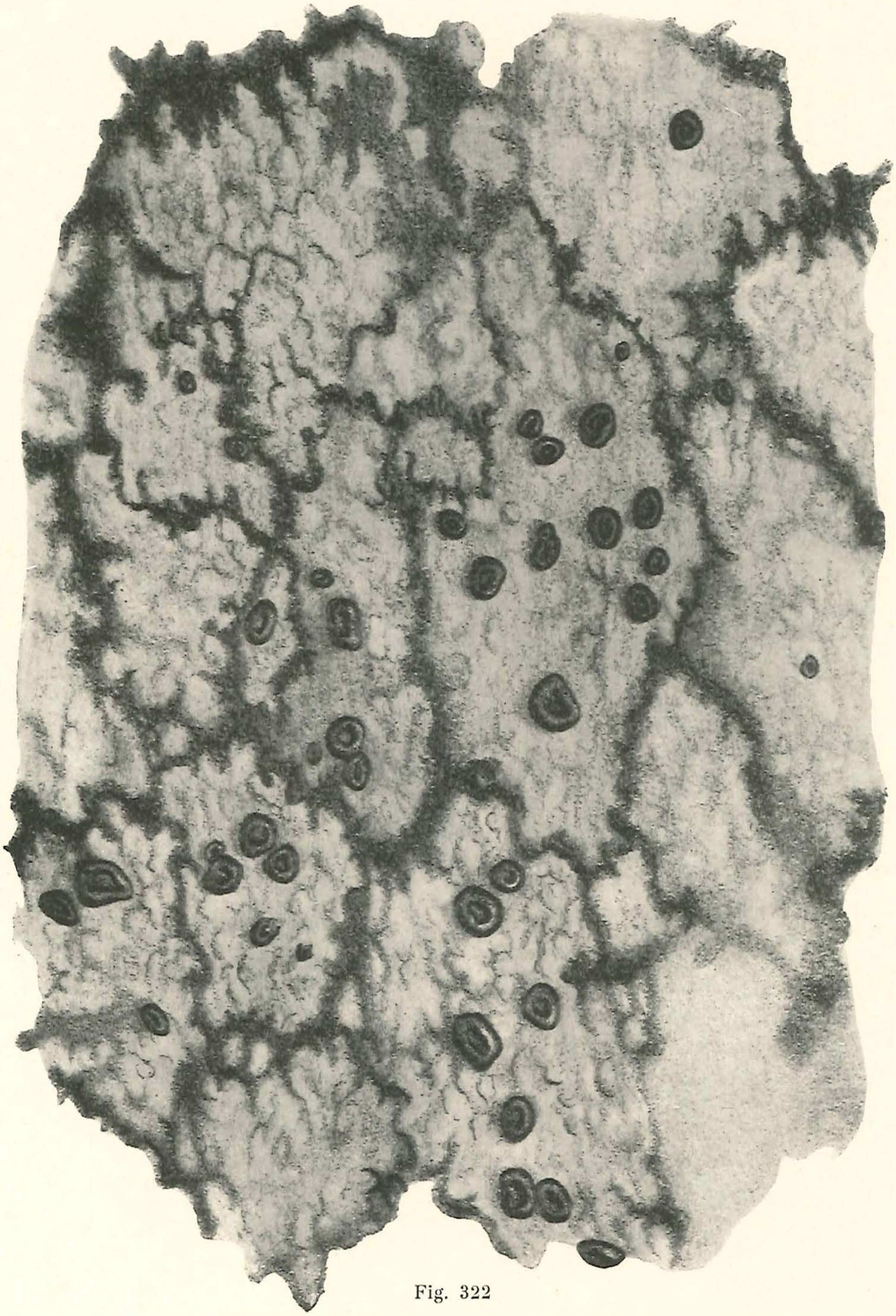


Fig. 322

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 2)

PLATE 134.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 2.

Fig. 323. Section of the margin of the thallus still attached to the periderm of the substratum, the lamellæ of which are badly destroyed. To the left the dark margin of the thallus is shown with thick-walled grey hyphæ. To the right: the thallus with its gonidia. (×450).

Fig. 324. Thallus with pycnidia. (×45).

Fig. 325. Thallus and apothecium on bark. The apothecium young, without asci. (×60).

Fig. 326. Portion of a young apothecium without asci. At *a* a layer of the thallus-cortex raised up by the apothecium when breaking through the surface of the thallus. Paraphyses slender, easily loosened from each other, blue at the tips, and on the outer surface covered with very small grains of some substance that was not further examined. Hypothecium colourless; the ascogenous hyphæ not distinctly visible. The hyphæ of the outer layers of the calyx have thick blue walls. To the right of the figure, 3 isolated paraphyses with grains. (×450).

Fig. 327. Tissue from a pycnidium. with three separate conidia. (×450).

PLATE 134.

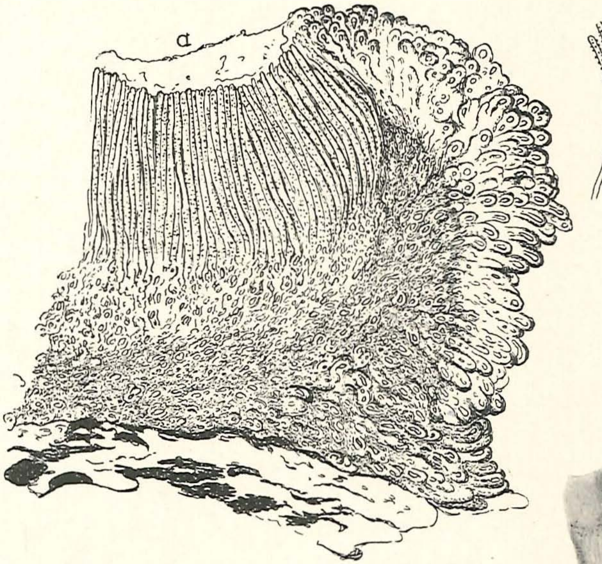


Fig. 326

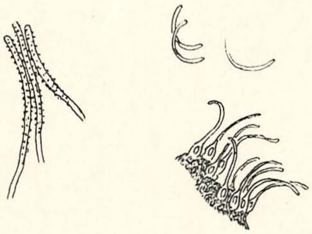


Fig. 327

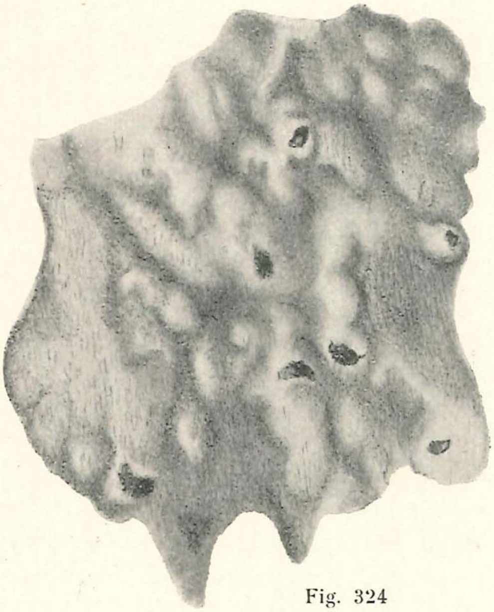


Fig. 324

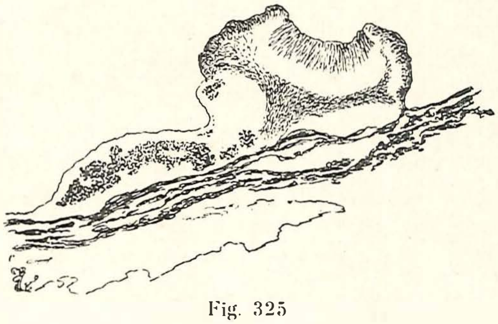


Fig. 325

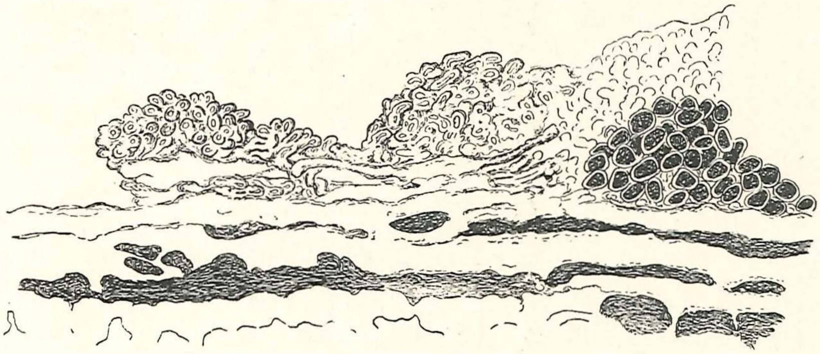


Fig. 323

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 2)

PLATE 135.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 3.

Fig. 328. Two young individuals on bark, separated from one another by a dark border along the line *a* to *b* in the figure. The individual investigated and described is the one to the right of the line. It shows at *c* a hypothallus formed of dark partly hypophloeodic partly epiphloeodic radiating hyphæ. It is seen too at *d* where it is mixed with young brightly coloured areoles, which are at first hypophloeodic, later on epiphloeodic. At *e* the areoles form a continuous thallus — with apothecia in all stages of development. (×15).

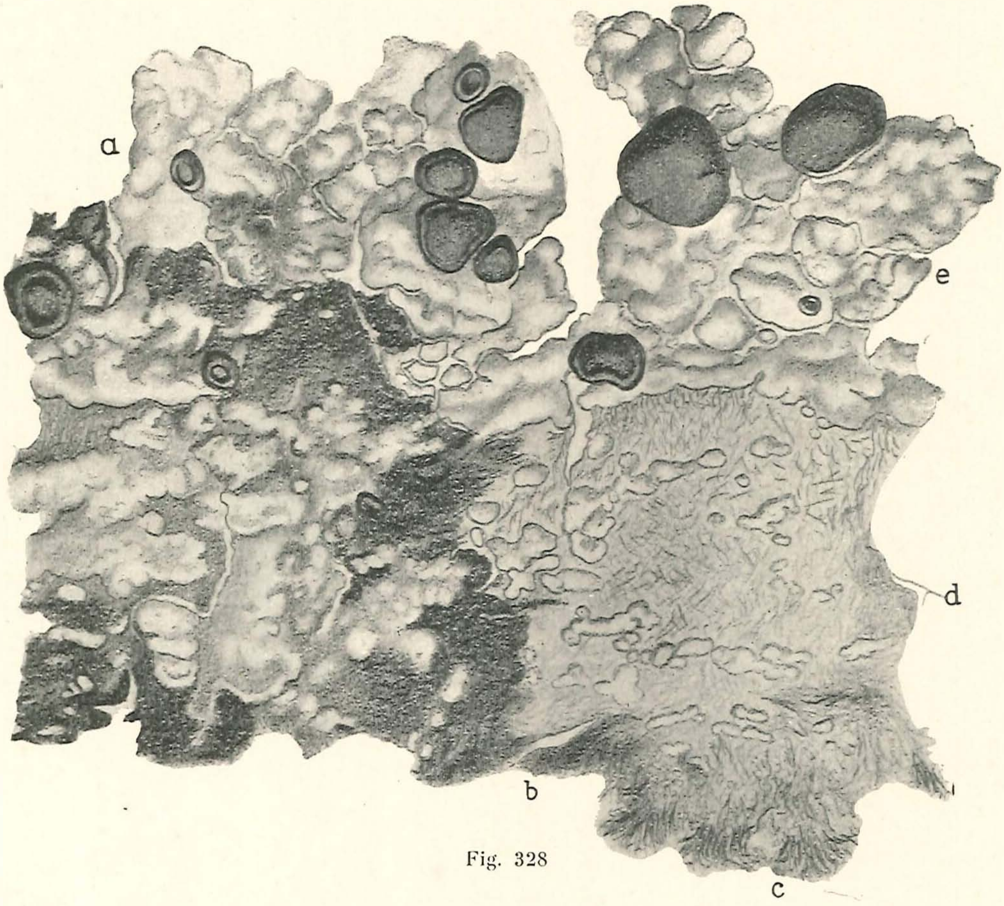


Fig. 328

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 3)

PLATE 136.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 3.

Fig. 329. Young areoles (the figure is taken from the part marked *d* in fig. 328. At *a* and *b* it is seen how the dark hyphæ are raised to the surface of the areoles and by the further growth of the latter are broken up and disintegrated. (×60).

Fig. 330. The figure is taken from the part marked *c* in fig. 328. The hyphæ of the "hypothallus" seen from below, crowded together in groups. Above them at *a* are seen the cells of the periderm of the host plant. Their greatest diameter is at right angles to the longitudinal axis of the tree. These hyphæ then are hypophloeodic. (×450).

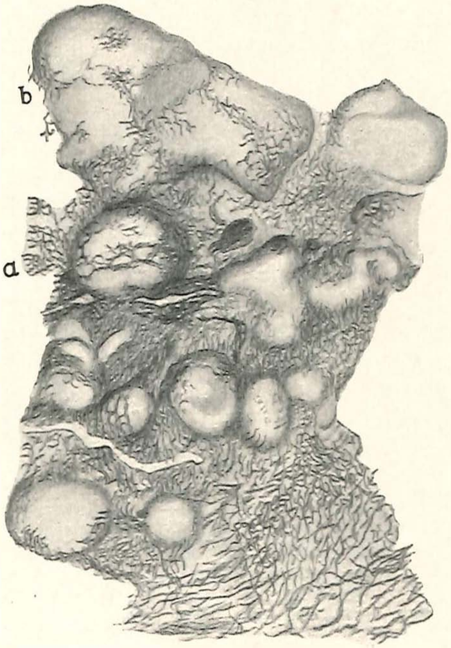


Fig. 329

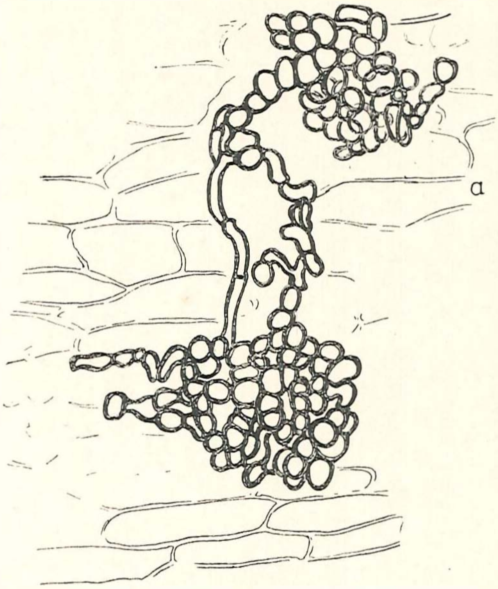


Fig. 330

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 3)

PLATE 137.

LECIDEA ELÆOCHROMA.

Ach.

Specimen 4.

Fig. 331. Thallus with a few narrow fissures formed by the drying up of the thallus, and with numerous light soralia and with apothecia in all stages of development. (×15).

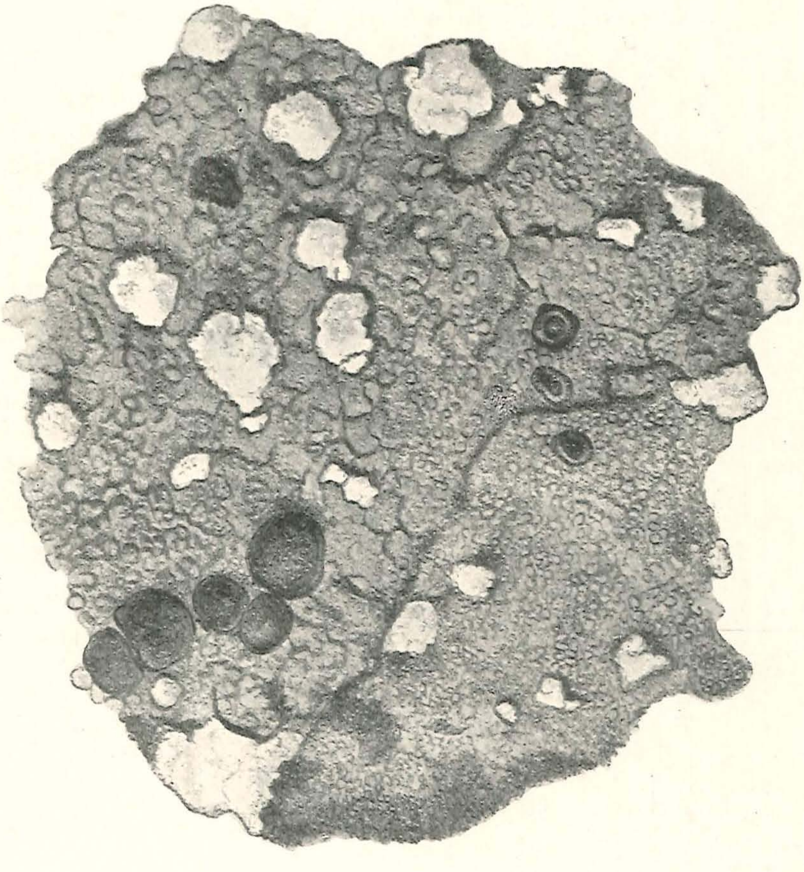


Fig. 331

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 4)

PLATE 138.

LECIDEA ELÆOCHROMA.

Ach.

Specimen 5.

Fig. 332. Thallus with apothecia in all stages of development; they are smaller than those in specimen 1 but have the same internal structure. On the thallus numerous shallow fissures are seen; they run parallel to the longitudinal axis of the substratum bark and are caused by the secundary growth of the tree affording the substratum. (×5).

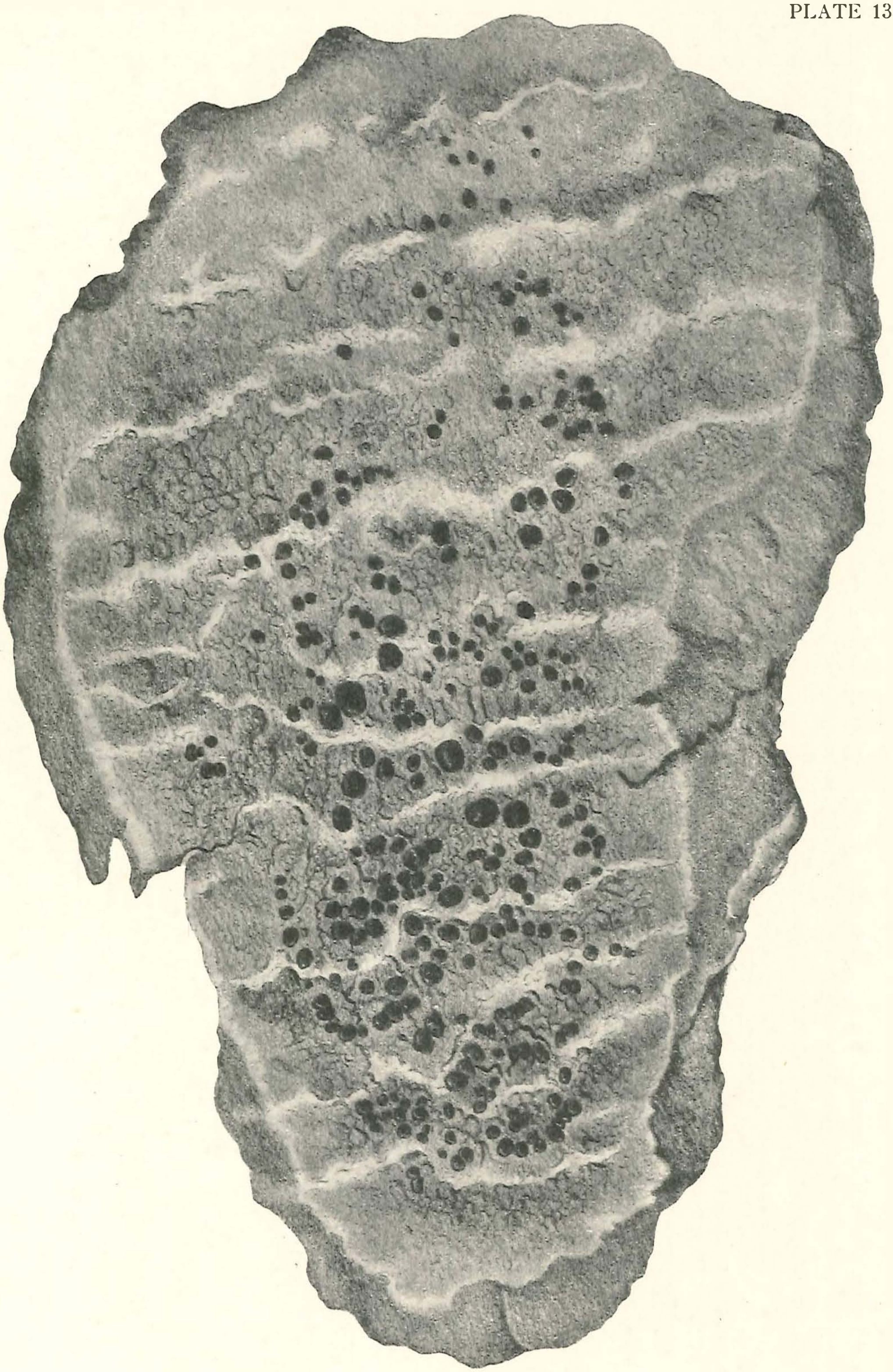


Fig. 332

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 5)

PLATE 139.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 5.

Fig. 333. Thallus with apothecium on the substratum plant. At *a* is a fissure formed by the secundary growth of the substratum (separately drawn in fig. 335). (×60).

Fig. 334. Section of thallus, which is clearly limited below by a cork lamella. The remains of another, older lamella are seen scattered in the thallus; some of them are open and empty, others are still closed and filled with a brownish substance. (×450).

Fig. 335. The figure represents fig. 333 at *a* but is more highly magnified. It shows how a thallus fissure formed by the secundary growth of the substratum may heal, the hyphæ on the left side of the fissure growing downwards to the bottom, carrying with them a few gonidia and thereby forming a cover over the wound. To the right of the fissure numerous empty peridermal cells from the substratum are seen. (×450).

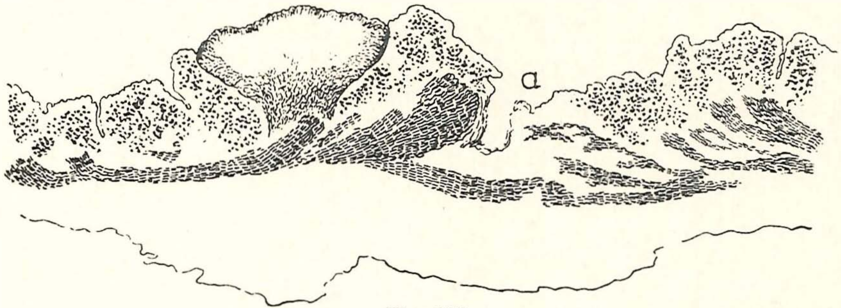


Fig. 333

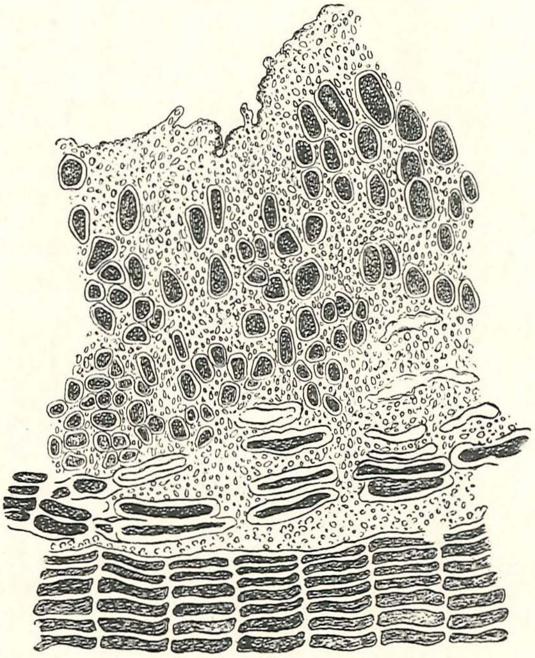


Fig. 334

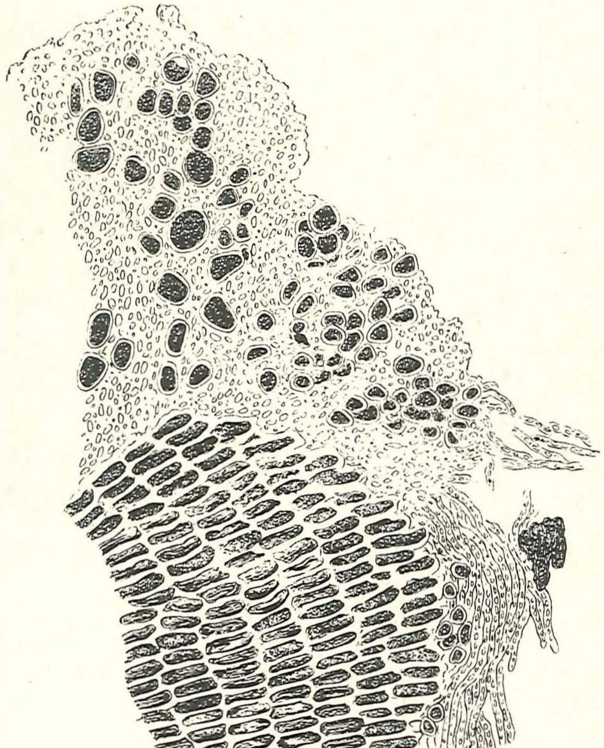


Fig 335

O. Galløe del.

LECIDEA ELÆOCHROMA ACH.
(Specimen 5)

PLATE 140.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 6.

336. The slightly sorediose margin of the thallus. (×15).

337. The smooth centre of the thallus with fissures due to drying up, and with apothecia in all stages of development; (the four, round, dark spots above to the left are young apothecia about to break through the surface of the thallus). (×15).

Fig. 338. Apothecium. The tips of the paraphyses are bluish-green and the basal parts of them are of the same colour, only much weaker. The proper margin is a dark bluish-green, the rest of the calyx being more brownish; stipes brownish; hypothecium faintly brownish. (×60).

Fig. 339. Ascus with spores and **7** paraphyses. (×450).

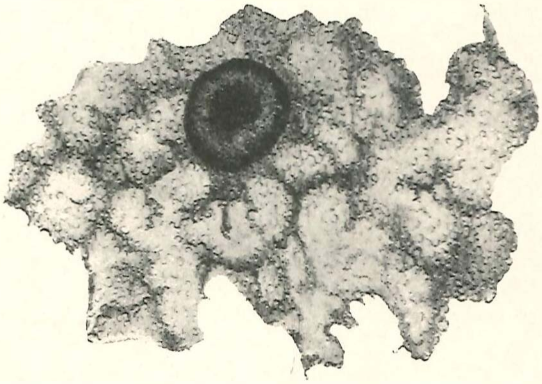


Fig. 336

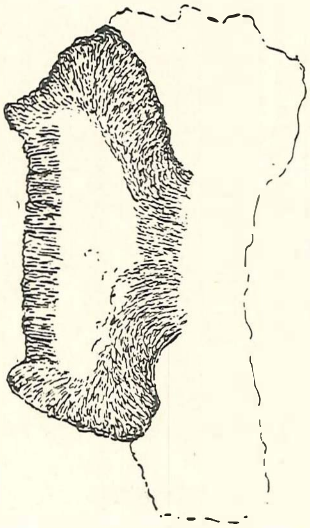


Fig. 338

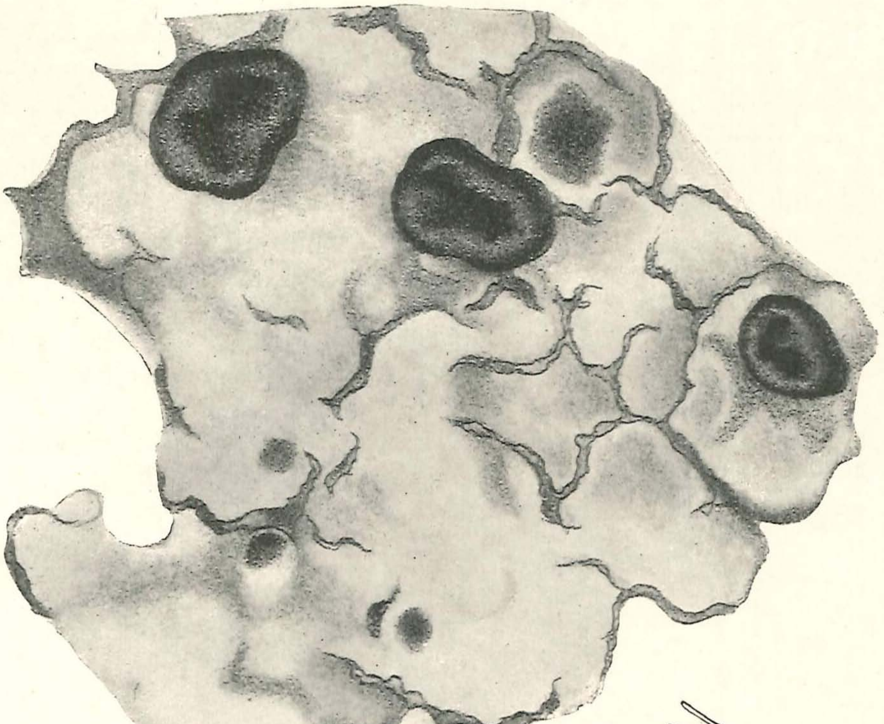


Fig. 337

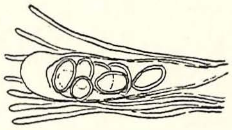


Fig. 339

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 6)

PLATE 141.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 7.

Fig. 340. This specimen is seen in the figure above to the left and is separated by a dark border from the other individuals. It has apothecia with a light disk, almost devoid of a hymenium. In one apothecium only was a small portion of the hymenium normal near the margin of the apothecium. It had normal paraphyses and spores, but these were not yet quite ripe. (×15).

Fig. 341. Paraphyses and ascus with unripe spores, taken from the small portion of the hymenium that remained untouched near the margin of the apothecium fig. 308 b (plate 129). (×450).

Fig. 342. Cells from the periderm of the bark of the ash, which formed the substratum of the present *Lecidea elæochroma*, specimen 7. They are isodiametric, while the thallus of the lichen on the contrary has a longitudinal axis which is much longer than the transverse axis. This fact refutes the theory of BIORET who says that corticolous lichens usually have an oblong thallus, not as a result of the secundary growth of the tree, but because the periderm cells of the substratum are stretched at right angles to the longitudinal axis of the tree. BIORET's theory does not accord with this case, as the cells of the periderm in question are not stretched at all.

In the case of *Lecidea elæochroma*, specimen 8, we shall meet with an example which speaks in favour of BIORET's theory. The theory can therefore be said to have no general validity.

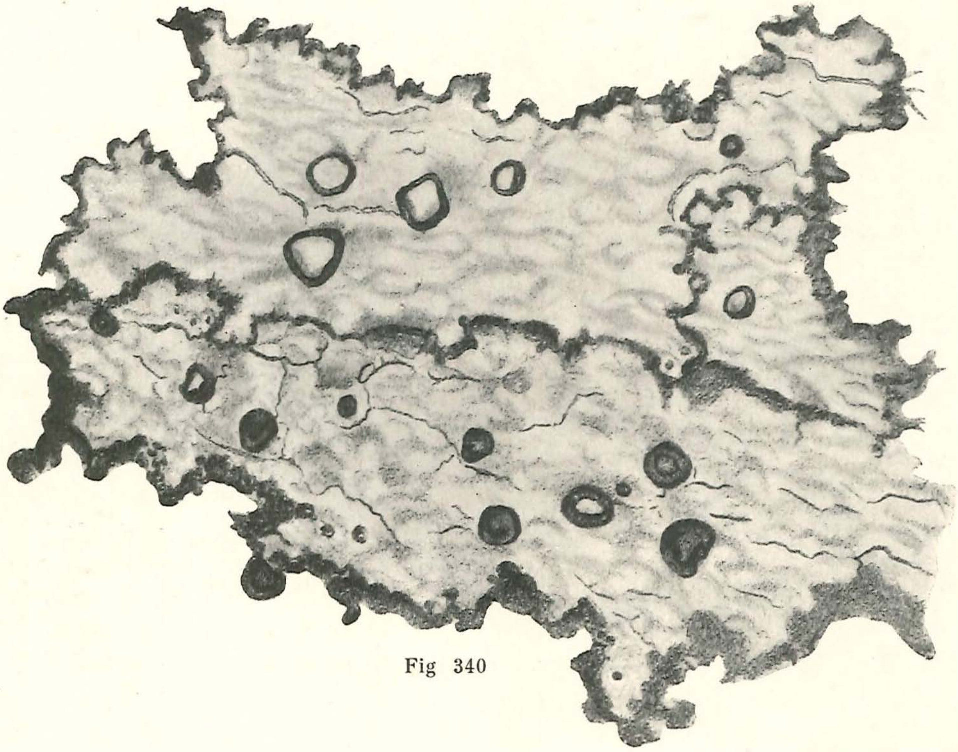


Fig 340

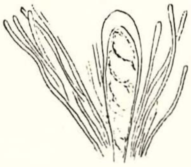


Fig. 341

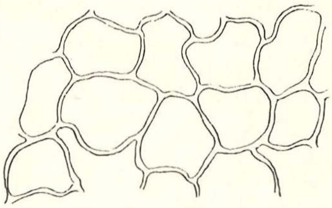


Fig. 342

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 5)

PLATE 142.

LECIDEA ELÆOCHROMA.

Ach.

Specimen 8.

Fig. 343. Thallus with apothecia in all stages of development. Below, the cells of the periderm are seen. (×15).

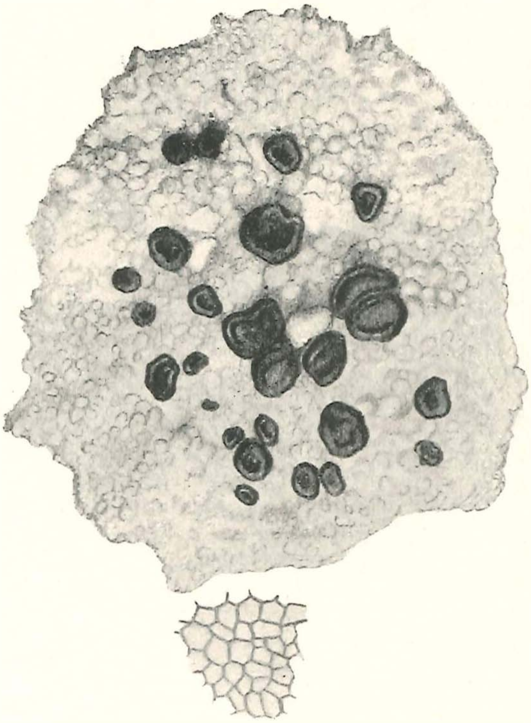


Fig. 343

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 8)

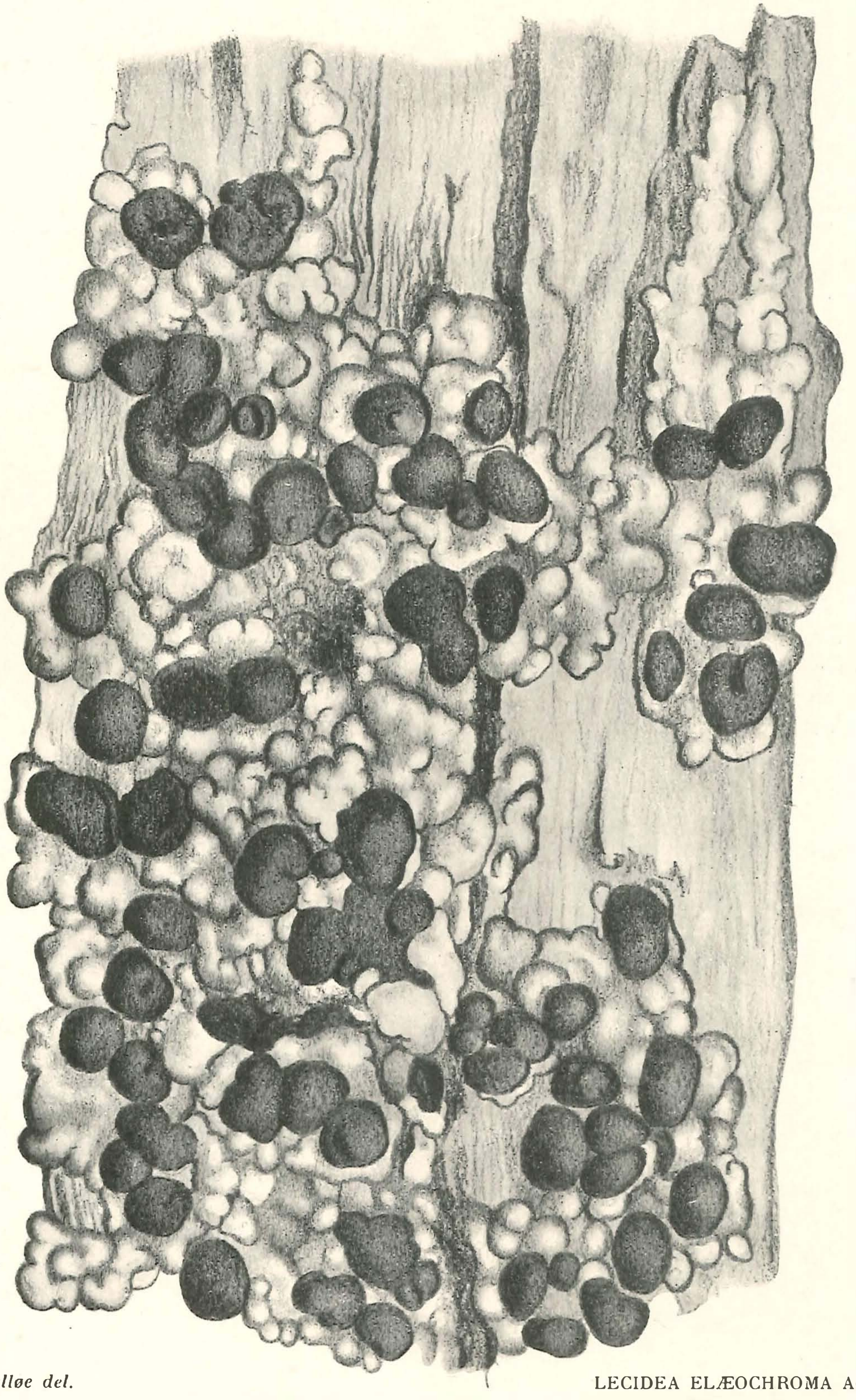
PLATE 143.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 9.

344. Thallus with apothecia. (×15).



O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 9)

Fig. 344

PLATE 144.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 9.

Fig. 345. Thallus on the woody substratum (in which pith rays are seen in transverse section). Note that the sqamules of the thallus partly overlap one another. Above the gonidia a layer of coloured grains is seen in the cortex. (×60).

Fig. 346. Two apothecia on the thallus. Note the thick medullary layer and the coloured grains above the gonidial layer. (×60).

Fig. 345

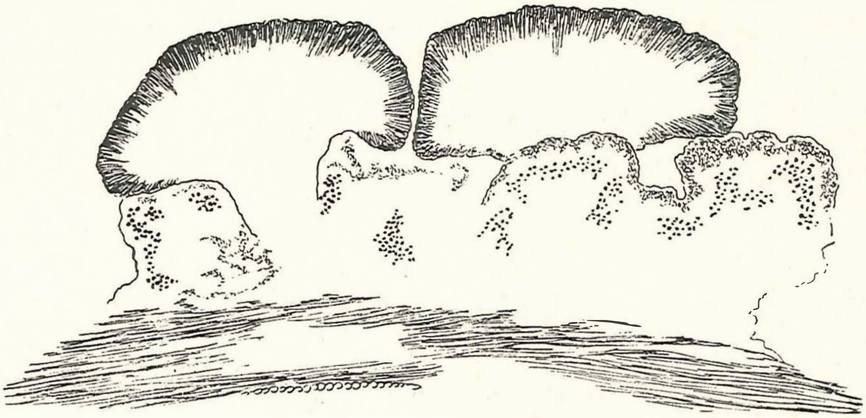


Fig. 346

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 9)

PLATE 145.

LECIDEA ELÆOCHROMA.

Ach.

Specimen 9.

Fig. 347. Squamule. At *a* is seen a group of living cells. At *b* a destroyed wood-cell. In the cortex numerous small grains of colouring matter are seen. (×450).

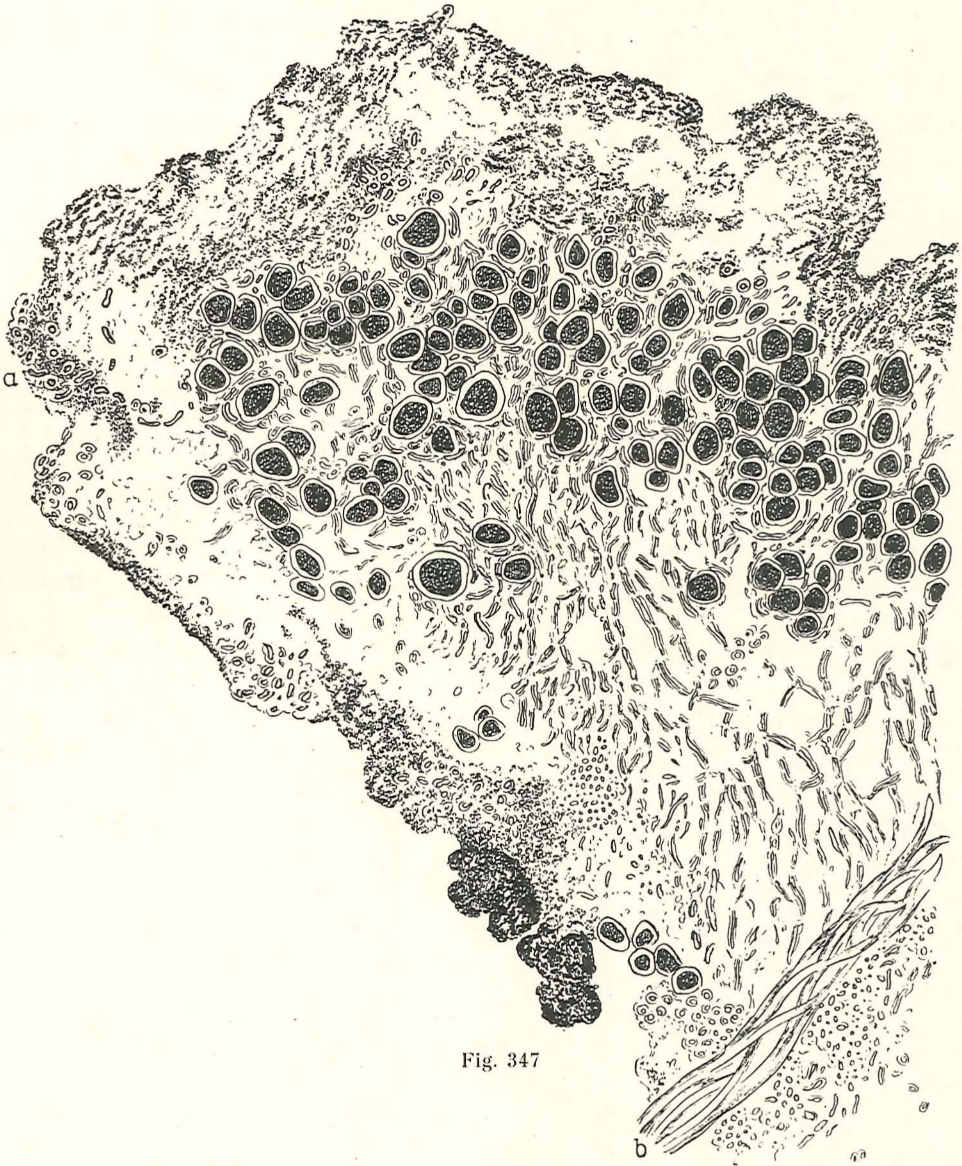


Fig. 347

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 9)

PLATE 146.

LECIDEA ELÆOCHROMA.

Ach.

Specimen 9.

Fig. 348. The woody substratum with destroyed wood prosenchyma (at *a*), in which are seen a few hyphæ (with distinct cell-lumen); at *b* a pith-ray in transverse section, with numerous hyphæ in transverse section. (×450).

Fig. 349. Margin of apothecium. At *a* ascogenous hyphæ; at *b* oil-like drops in the stipes. (×450).

Fig. 350. Ascus and paraphyses. (×450).

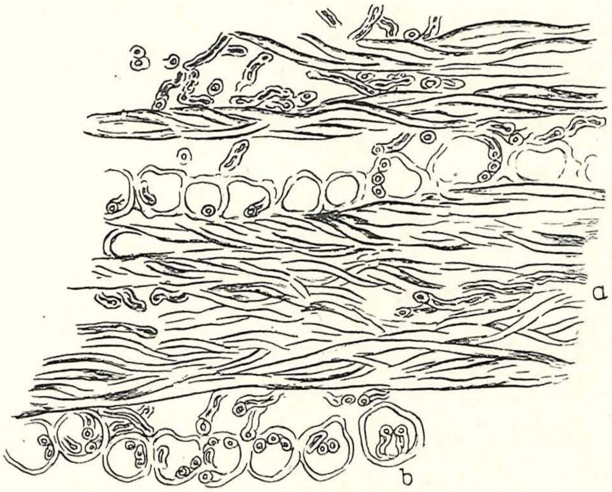


Fig. 348

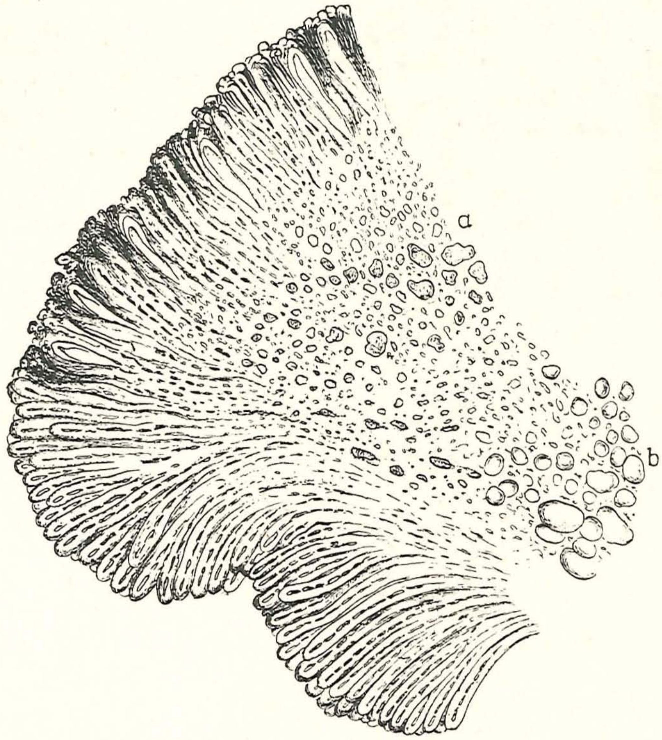


Fig. 349

Fig. 350

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 9)

PLATE 147.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 10.

Fig. 351. Thallus with apothecia in distinct rows parallel to the fibres of the wood and exhibiting all stages of development. Above to the left in the figure a specimen of *Lecanora (subfusca)* can be seen. (× 6).

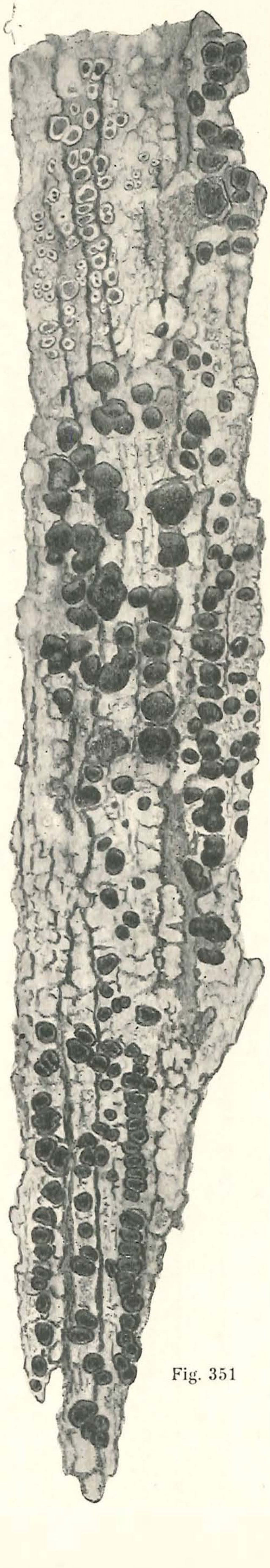


Fig. 351

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 10)

PLATE 148.

LECIDEA ELÆOCHROMA.

Ach.

Specimen 10.

Fig. 352. (A fragment of fig. 351), young apothecia. Thallus showing fissures due to drying up, running parallel to the fibres of the wood. (×15).

Fig. 353. (A fragment of fig. 351). Old apothecia. Thallus with fissures due to drying up. (×15).

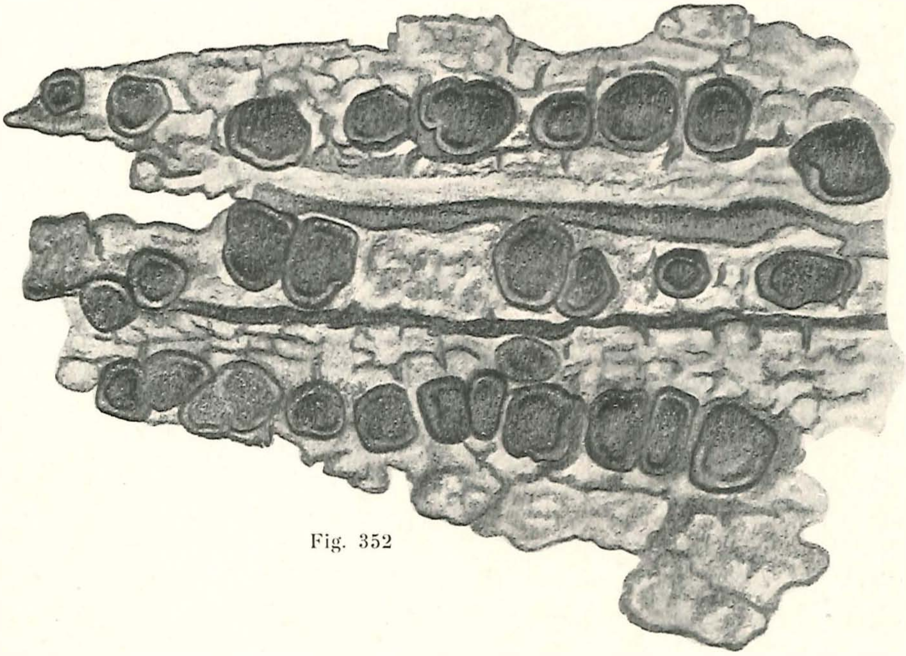


Fig. 352

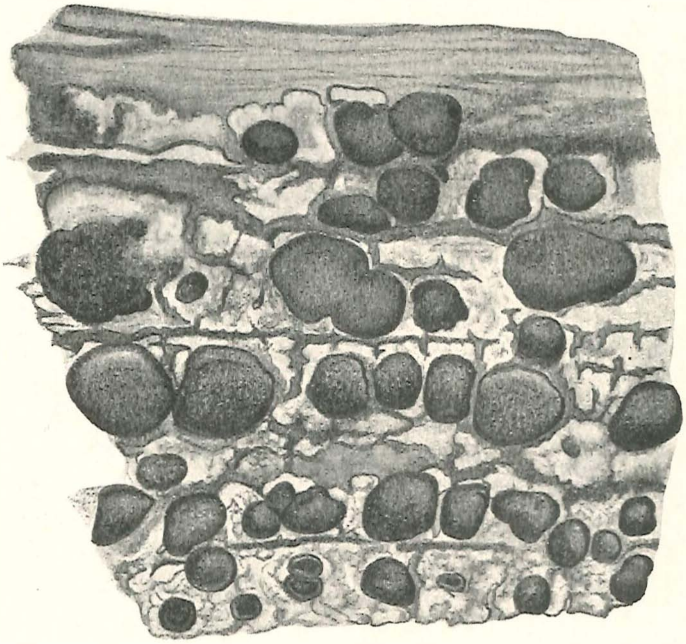


Fig. 353

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 10)

PLATE 149.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 10.

Fig. 354. A young apothecium and several pycnidia. (×45).

Fig. 355. 5 young apothecia in various stages of breaking through the cortex. To the left an apothecium still with a slightly pseudo-lecanorine appearance caused by portions of the thallus adhering to it. To the right an apothecium with two granules of thallus on the margin and disk. They will disappear later on. (×45).

Fig. 356. Margin of the thallus with groups of "carpogonia" provided with trichogynes. The left group near the margin of the figure shows the arrangement of the thalline hyphæ that later on will change into the parathecium (i. e. calyx and stipes). Portions of the cortex are dark. Below to the right, some gonidia. (×450).

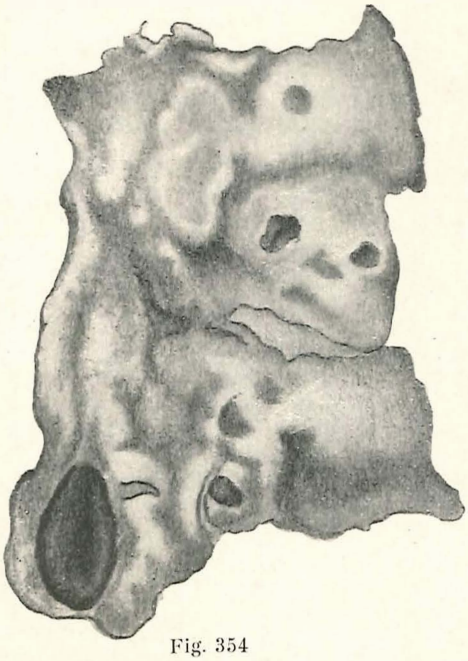


Fig. 354

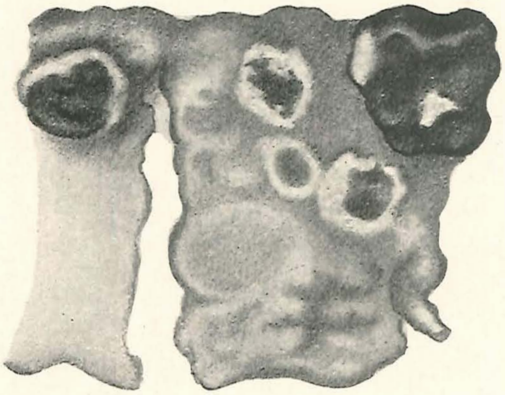


Fig. 355

Fig 356

O. Galløe del.

LECIDEA ELÆOCHROMA ACH.
(Specimen 10)

PLATE 150.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 10.

Fig. 357. Thallus with two apothecia. (×60).

Fig. 358. Cells from the woody substratum containing hyphæ (transverse section). (×450).

Fig. 359 Older part of thallus with an unrecognisable and decomposed particle of the substratum below to the right. (×450).

Fig. 360. Section of a very young apothecium still covered by the thick cortex (parts of which are rather dark). Below follow the paraphyses (but no asci); below the paraphyses is the hypothecium, the separate hyphæ of which in the present section were very difficult to see and are therefore not drawn. Under and around the hypothecium the dark *calyx* and *stipes* are seen. To the left in the figure is a group of gonidia. (×450)

Fig. 361. Ascus and paraphyses. (×450).

PLATE 150.

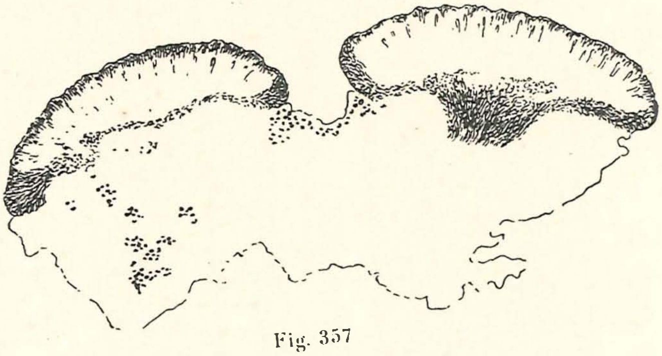


Fig. 357

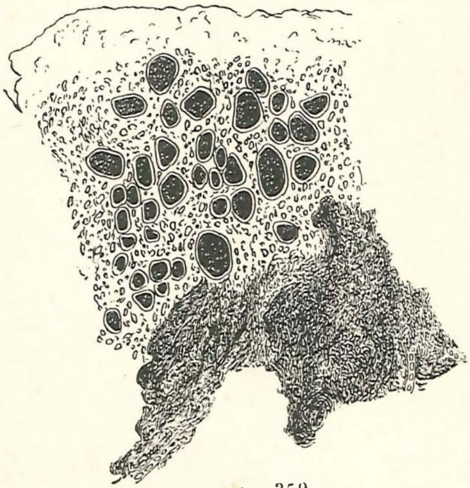


Fig. 359

Fig. 358

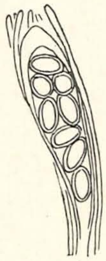


Fig. 361

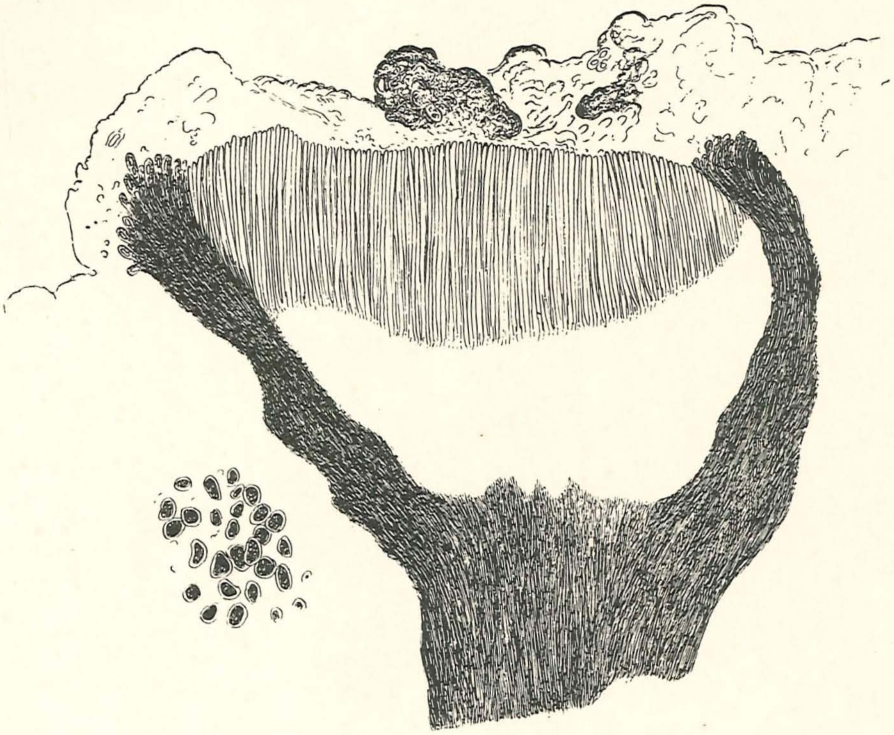


Fig. 360

LECIDEA (BIATORA) ELÆOCHROMA Ach.
(Specimen 10)

O. Galløe del.

PLATE 151.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 10.

Fig. 362. Pycnidium in longitudinal section. (×450).

Fig. 363. Part of the pycnidial tissue with conidia and conidia-bearing hyphæ. (×450).

Fig. 364. Ostiole of the pycnidium. (×60).

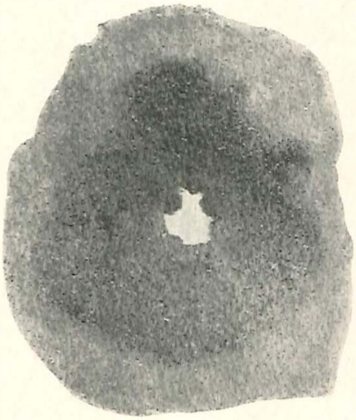


Fig. 364

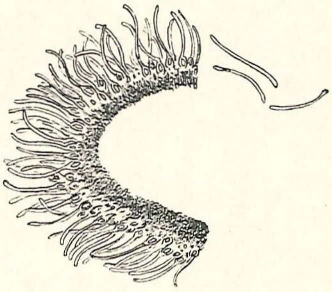


Fig. 363

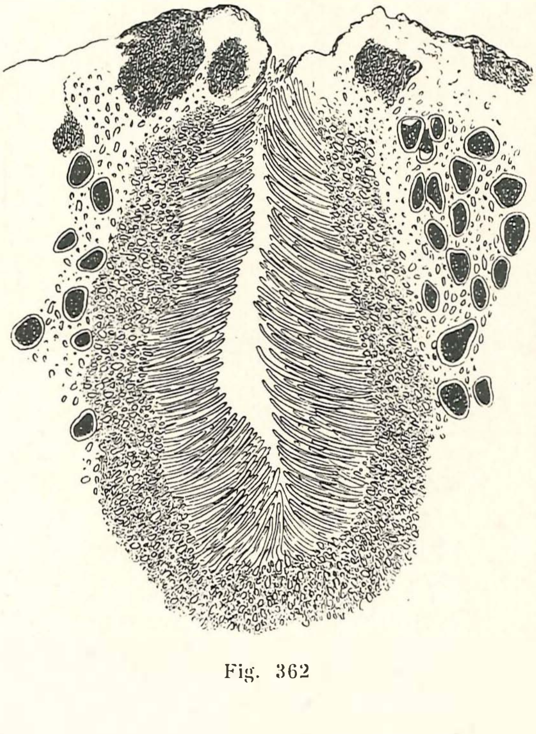


Fig. 362

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 10)

PLATE 152.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 11.

Fig. 365. Thallus with apothecia of all ages. (×15).

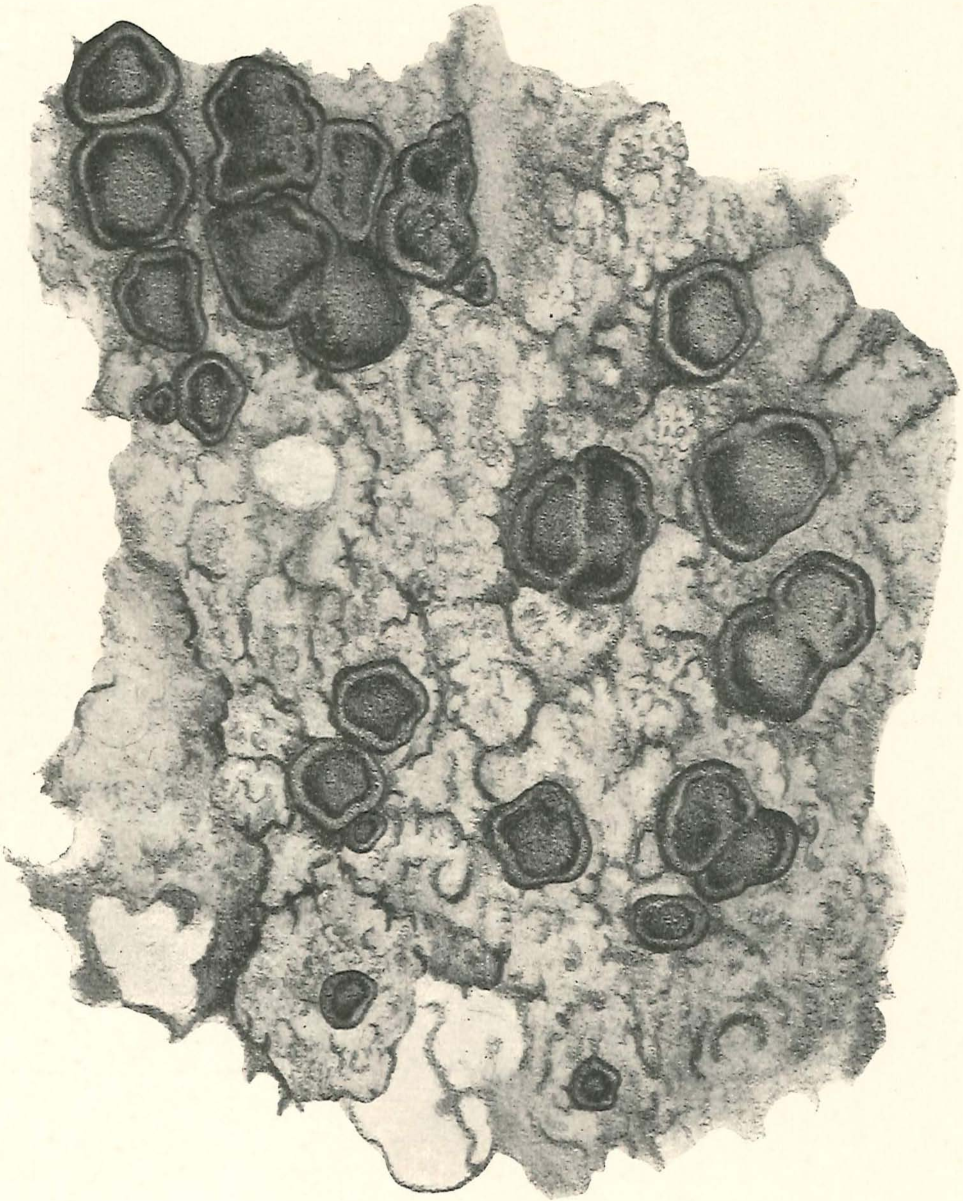


Fig. 365

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 11)

PLATE 153.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 11.

Fig. 366. The grey, clearly outlined part of the figure is a young thallus which is spreading over a large grain of quartz. No radiating hyphæ are visible in this specimen. (×45).

Fig. 367. Thallus with verrucose and rimose surface. Below and among the groups of gonidia the rust-like grains are shown as shaded parts. To the left in the figure a pycnidium is visible. (×60).

PLATE 153.

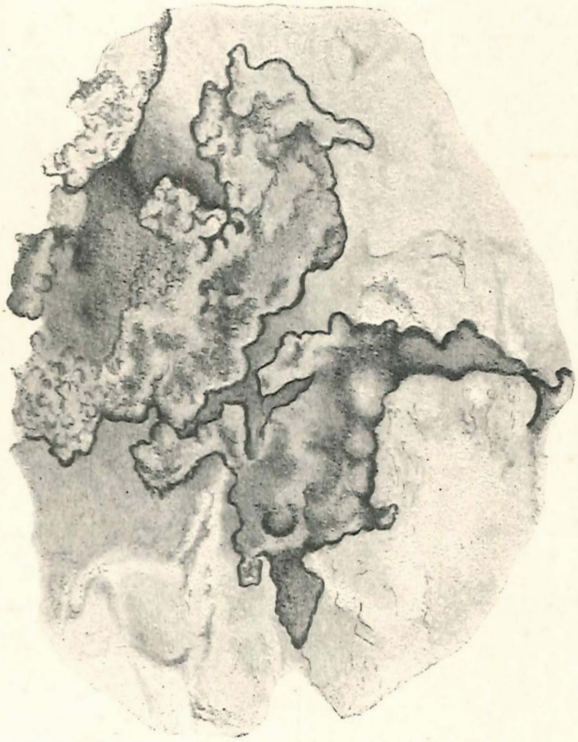


Fig. 366

Fig. 367

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 11)

PLATE 154.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 11.

Fig. 368. A fragment of fig. 367. The margin of a thallus-areole, which partly overlaps the other parts of the thallus (fig. 367 *a*). The cortex at this point is living and contains much pigment (e. g. at *a*), while the part at *b* is living, yet colourless. Great quantities of the same pigment are found below and among the gonidia. (×450).

Fig. 369. The centre of the thallus. At *a* the cortex is living, at *b* it is dead. Even here plenty of pigmentation is visible around the gonidia. (×450).

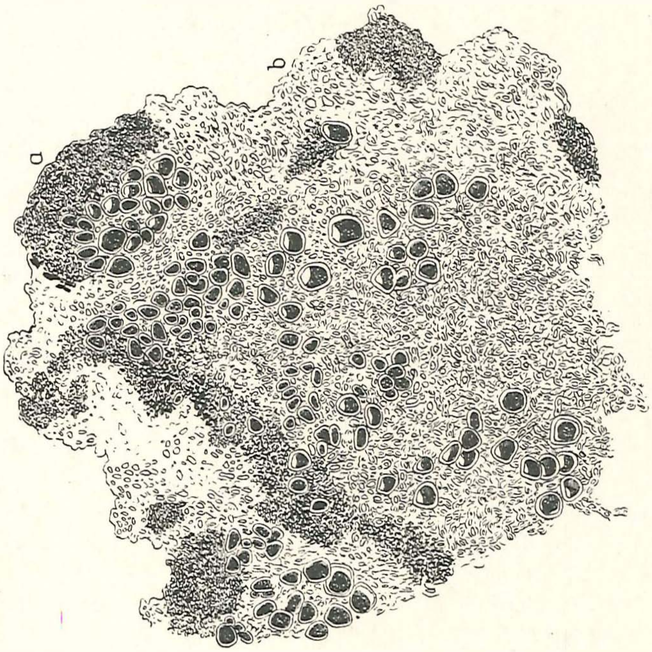


Fig. 368

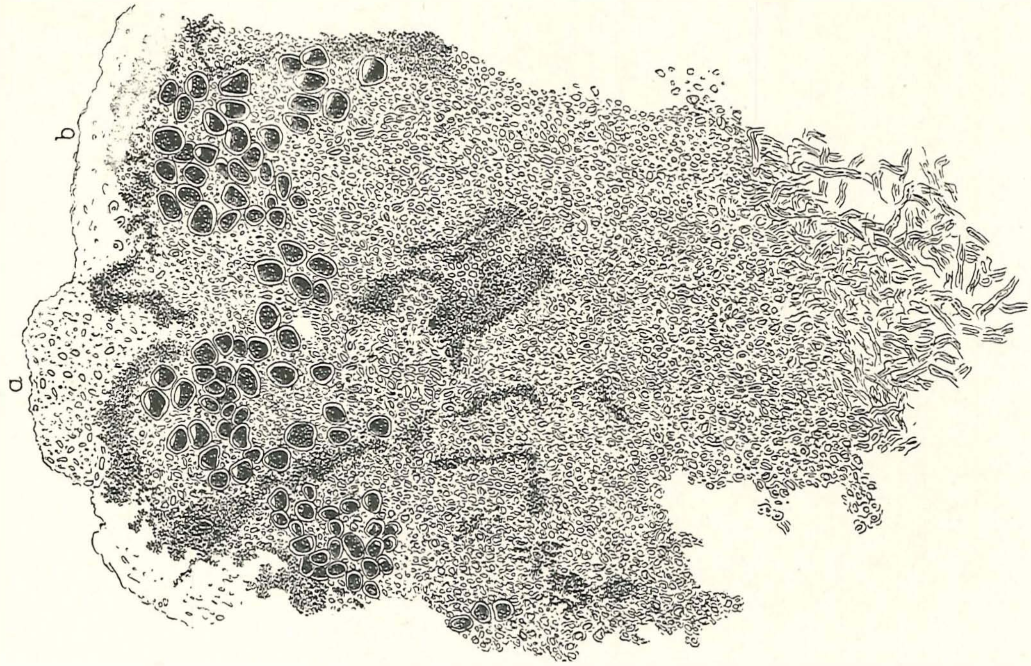


Fig. 369

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 11)

PLATE 155.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 11.

Fig. 370. Apothecium. (×60).

Fig. 371. Margin of an apothecium. The paraphyses are greenish, at the top dark greenish (on thick section). The hypothecium is of a faint brown; at *a* the inner brownish part of the calyx, at *b* the thick-walled part of the calyx, the inner portion of which is faintly coloured, while the outer parts (towards the periphery) is dark grey. (×450).

Fig. 372. Ascus and paraphyses. (×450).

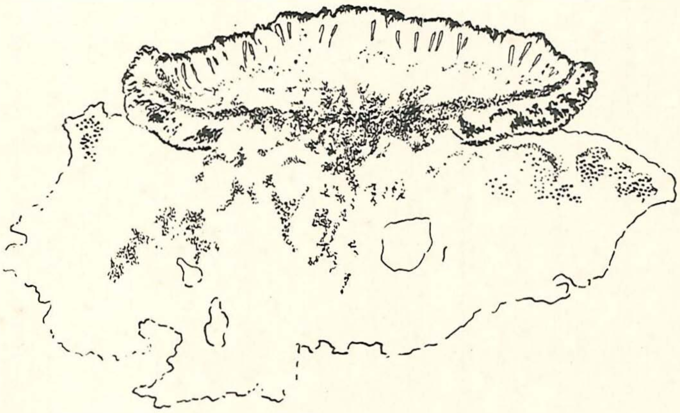


Fig. 370

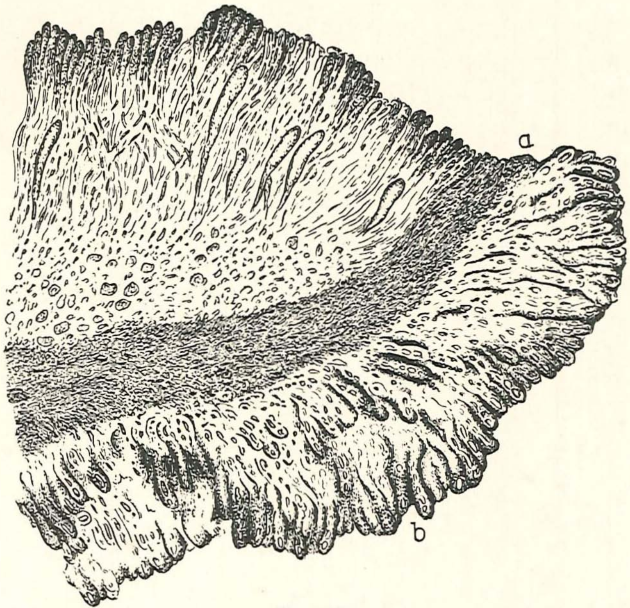


Fig. 371

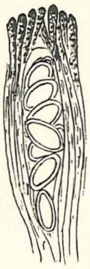


Fig. 372

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 11)

PLATE 156.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 11.

Fig. 373. Pycnidium in almost median section. The hyphæ in the uppermost part of the neck are colourless in the section shown, while they are coloured (brown) right up to the cortex of the thallus in the other sections. To the right of the neck a group of gonidia is visible. To the left of it a spot of pigment. To the right of the figure some hyphæ and conidia from the hymenium of the pycnidium.

PLATE 156.

Fig. 373

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 11)

PLATE 157.

LECIDEA ELÆOCHROMA.

ACH.

Specimen 12.

Fig. 374. Thallus (with several cracks due to drying up). Three apothecia. (× 15).

Fig. 375. Fragment of the servediose surface of the thallus. (× 45).

Fig. 376. Section of the servediose thallus. (× 450).

Fig. 377. Apothecium, the inner structure of which is entirely the same as in specimen 11. (× 60).

Fig. 378. Ascus and paraphyses. (× 450).

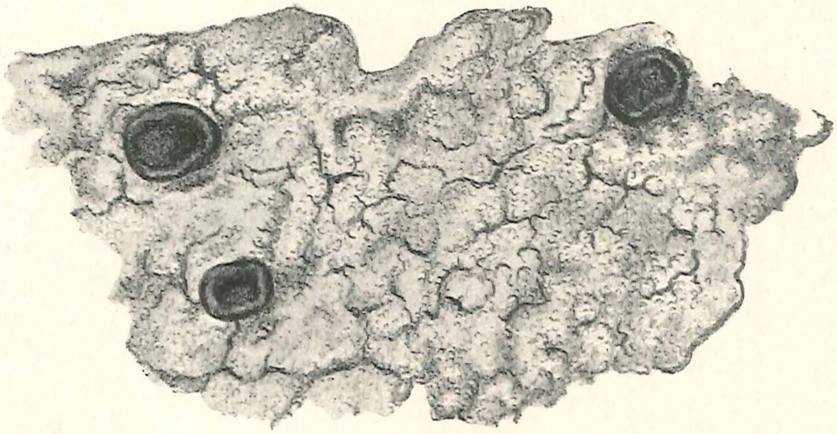


Fig. 374

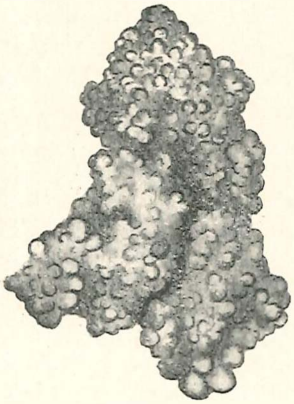


Fig. 375

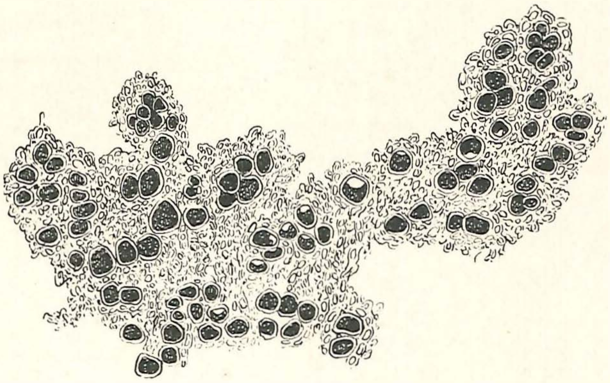


Fig. 376

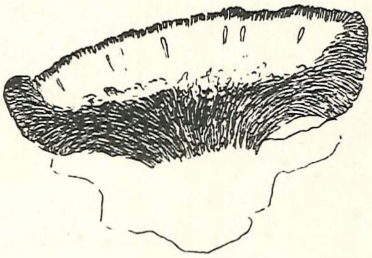


Fig. 377

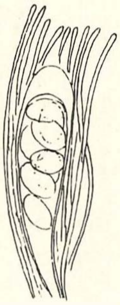


Fig. 378

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 12)

PLATE 158.

LECIDEA ELÆOCHROMA.

Ach.

Specimen 13.

Fig. 379. Thallus on sandstone, the single grains of which show white in the figure. The narrow strands of hyphæ spread between them. Apothecia in all stages of development. (×15).

Fig. 380. A grain of quartz with rather large thalline areoles (dark spots) connected by strands of hyphæ. (×40).

Fig. 381. 4 apothecia. Two of them (below to the left) are plainly situated on a thalline areole. (×45).

Fig. 382. Ascus and paraphyses. Note the unripe ascus to the right, the wall of which is much thickened. (×450).

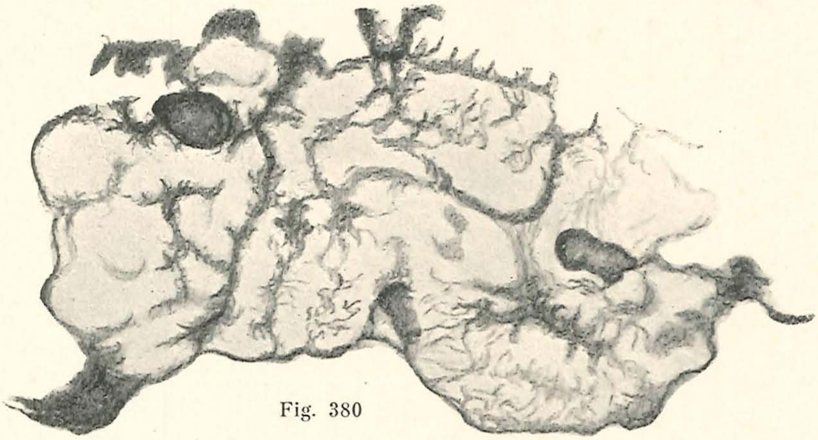


Fig. 380

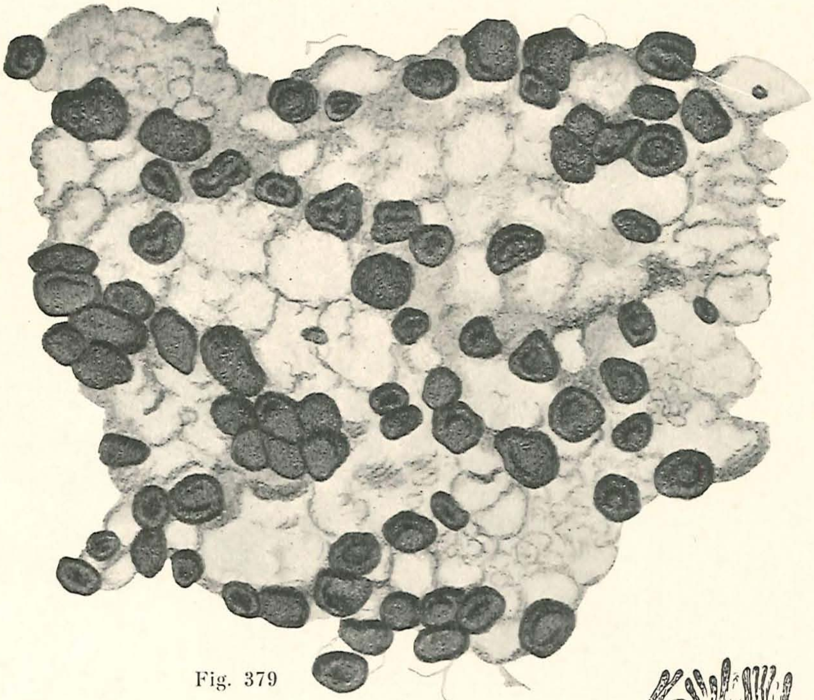


Fig. 379

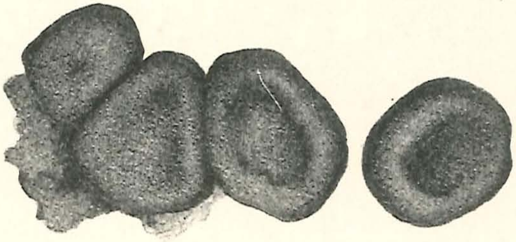


Fig. 381

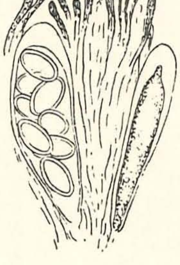


Fig. 382

O. Galløe del.

LECIDEA ELÆOCHROMA Ach.
(Specimen 13)

PLATE 159.

LECIDEA VITELLINARIA.

NYT.

Fig. 383. Apothecium, growing on the apothecium of *Lecanora polytropa*. (× 45).

Fig. 384. Apothecia growing partly on an apothecium and partly on the thallus of *Lecanora polytropa*. (× 45).

Fig. 385. Vertical section of the apothecium growing on the apothecium of *Lecanora polytropa* (below the hymenium of the latter several gonidia are seen). (× 60).

Fig. 386. The same section as fig. 385. By the side of the apothecium of *Lecidea* a part of the hymenium of *Lecanora polytropa* is seen, provided with immature (and undamaged) asci. (× 450).

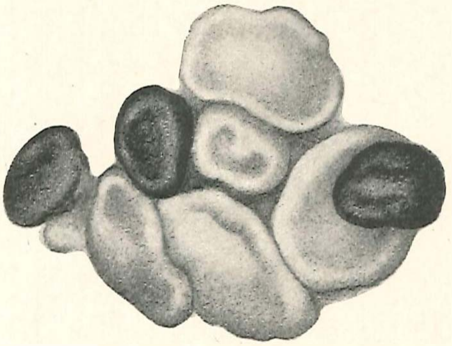


Fig. 384

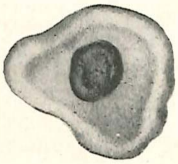


Fig. 383

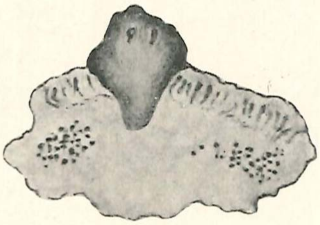


Fig. 385

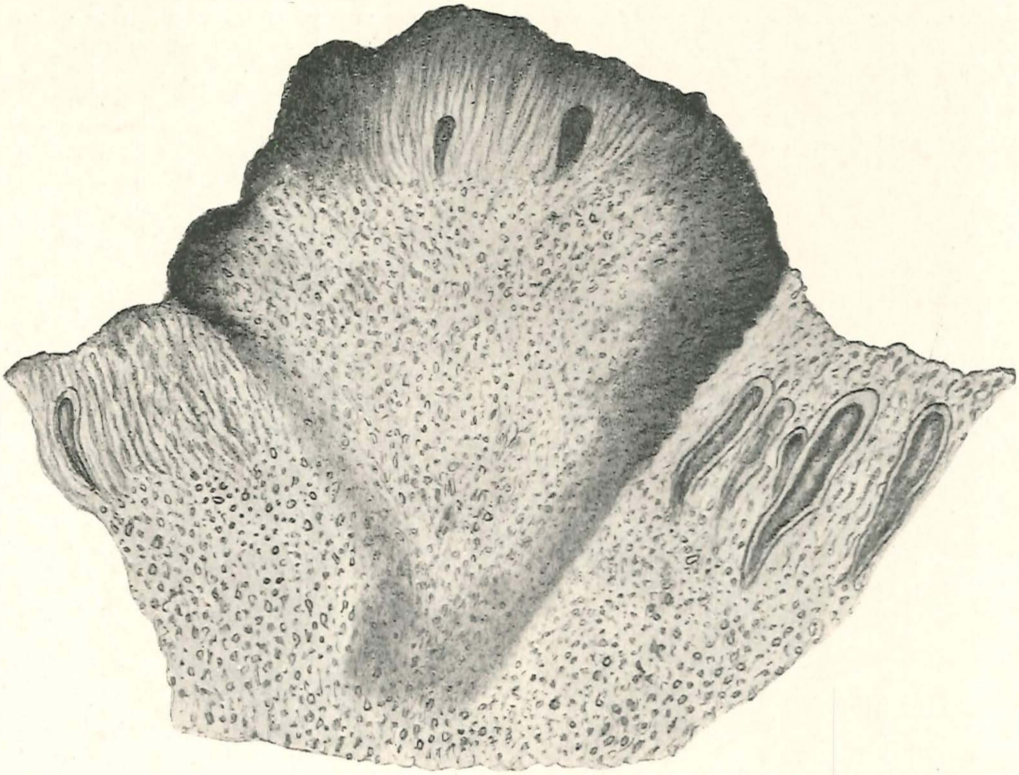


Fig. 386

O. Galløe del.

LECIDEA VITELLINARIA Nyl.

PLATE 160.

LECIDEA VITELLINARIA.

NYL.

Fig. 387. Ascus and paraphyses. To the left: a ripe spore. (×450).

Fig. 388. To the left: an apothecium of *Lecidea*. To the right: the thallus of *Lecanora polytropa*, so little damaged that one might quite well take it to be the thallus of the *Lecidea* itself. In the thallus are seen gonidia, colourless (white) grains of quartz and irregular (dark) grains of hornblende. (×450).

Fig. 387

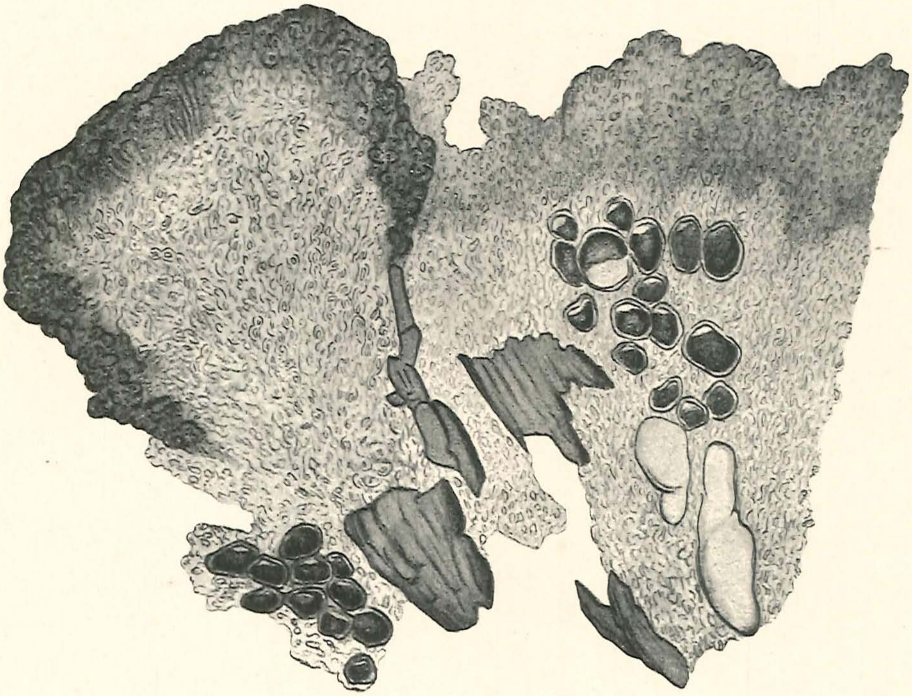


Fig. 388

O. Galløe del.

LECIDEA VITELLINARIA Nyl.