April 1852

Note. The author's "Illustrations of the Lichens", (consisting of

I. A series of Drawings, illustrative of their Structure and Classification;

II. A series of Dyed fabrics &c., illustrative of their Tinctorial Properties; and

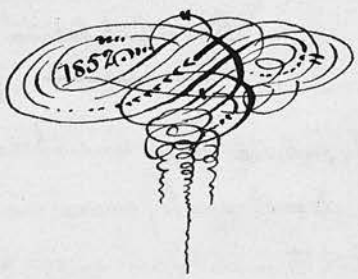
III. A series of Preparations, exhibiting the effects of Reagents on their Colouring matters;)

besides a separate series of Fluid & other preparations, (containing, inter alia, Specimens of their Colouring products, Commercial Orchella weeds, Archil & Cudbear &c.,) being obviously of such a Nature as not to admit of incorporation with this Thesis, & being intended **to be retained by the author**, have not been sent in along with the following Thesis, but the Author will be glad to exhibit them if requested.

The Lichens

COMPRISING

I. THEIR ANATOMY, ORGANOGRAPHY, AND PHYSIOLOGY,
II. ___ TAXONOMY OR CLASSIFICATION,
III. ___ GEOGRAPHICAL DISTRIBUTION,
IV. ___ UTILITY



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"Natura maxime miranda in Minimis" Linn.

"In Minimis Natura praestat"
Pliny.

"The Man,
Whom Nature's works can charm, with God himself
Holds converse"

"Religious use of Botany" R. I. Thornton M. D. 1824.

"Some are reddish, some brown, some grey some black,
And they're puckered, edged, buttoned, or fringed front back,
Some are lying like Leather close under your feet,
Some, waving from Trees in the Forest, you'll meet."

Miss Twamley - In Miss E. Holt's Collection of
"Great Exhibition" of 1851. Class 4. № 128.

"Think of the Beauty, which God has spread abroad for our use;
its profuseness in desert spots, where none can see it; its
minuteness, so that much can only be discovered by a
Microscope; and its extent, embracing all things."

Sewell's Margaret Percival Vol. 2 P. 435.
quoted from Leighton's Angiocarpous Lichens. 1851.

"Il en est de l'amour des plantes comme de l'amour de Dieu qui les
a créées, il n'inspire point la jalousie mais le prosélytisme; l'homme
qui l'éprouve n'a d'autre pensée que de le faire éprouver à d'autres"—

Payer Botanique Cryptogamique. Paris 1850. Préface P. 6.

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PREFACE.

In laying before the Medical Faculty of the University of Edinburgh, as an Inaugural Dissertation, preparatory to Graduation, the following "**Thesis** on the **Anatomy, Organography** and **Physiology** of the **Lichens**," it appears necessary to mention that it forms only a small portion of the Thesis I had originally contemplated, which want of Time (& other circumstances, which I need not here particularize) have prevented my completing. I had intended, in endeavouring to investigate, more fully than has hitherto been done, the Natural History of the humble & despised, but highly interesting, family of the Lichens inter alia:

I. To make a **Series** of **Microscopical Drawings** of types of all the British genera (at least), with a view to contribute as much as I could to the little at present known of their minute Anatomical Structure. I have been enabled to examine comparatively a very small number of genera, chiefly from difficulty in obtaining specimens & appropriate Instruments; and even many of my rough Pen-&-Ink Drawings made under Ross' & Nachet's Microscopes, I have not had time to copy.

II. To examine Microscopically more especially their **Reproductive organs**, with a view to determine the existence or absence of **Antheridia** and **Spermatia**, which have been recently alleged to occur in many (if not all) Lichens. This Branch of investigation I had only time to commence.

III. A series of **Chemical Analyses** of the **Ash** of the various species, with a view to determine their Inorganic Constituents, — a subject to which as yet little or no attention has been directed.

IV. A series of **Chemical Investigations** into the Nature, affinities & uses of their multiform **Colorific Principles**, and **Colouring matters**, about which, tho' much light has recently been thrown on the subject by Stenhouse, Schunck, Will & Dumas, Laurent & Gerhardt & others, a very great amount of confusion & doubt still exists.

The above Chemical Investigations I have been unable at all to enter upon.

V. a series of Experiments on their **Physiological & Therapeutic uses** & actions of Lichens & their active Principles (i.e their **Use in Medicine**); this Tribe of plants having, in former days & more particularly in Northern Europe (in many parts of which they abound, comparatively, in the absence of the higher types of vegetation) been considered a complete Materia Medica, — a Panacea. This subject also I was prevented entering on.

VI. a series of Inquiries into their **Tinctorial** & other properties, whereby they are (& might be still further) made subservient to the useful & fine Arts — I have made a considerable number of experiments (in fact on all the species, of which I could obtain a sufficient supply) but the results naturally fall under the 4th section of my Thesis ("Utility") which I have not been able to overtake. For a considerable amount of Information on this subject, I am indebted to various Exhibitors at the "Great Exhibition" in London last year, several of whom kindly favored me with Specimens of Commercial Orchella weeds, — fabrics dyed with Archil & Cudbear &c. —

VII. a complete series of authentic Specimens of the various genera, species & varieties of **Lichens used in the Arts**, in different parts of the world, — & more especially in **Dyeing**. I have at present merely a Nucleus for such a Collection.

VIII. a series of **Dissections** and correctly named **Specimens** of at least the British genera, illustrative of the **Classifications** of this family by various authors, — and of the Botanical characters on which such classifications are severally founded. This series falls under the 2nd section of my Thesis ("Taxonomy or Classification") which I have been obliged to omit.

IX. *Illustrations of the* **Geographical Distribution**, of this most widely-diffused family, over the world, by means of Statistical & other maps, Tables &c, — falling, however, under Section 3d of my Thesis ("Geographical Distribution") likewise reluctantly omitted, — as were also several other minor Series of Investigation & Illustration —

In studying the Literature of Lichenology (there also I have to regret inability of access to a considerable number of Books on the subject, chiefly foreign ones, which would seem not to have a place in our Metropolitan Libraries) I have collected a considerable mass of notes (& perhaps inter alia some new information) which I had classified, preparatory to arranging & transcribing them, into the 4 following heads or sections:

I. The Anatomy, Organography & Physiology of the Lichens;
II. Their Taxonomy or Classification;
III. Their Geographical Distribution over the world: and
IV. Their Utility (in Medicine, the Arts &c.).

Of these sections, I regret exceedingly that I have been enabled (& that to a limited extent) to arrange & transcribe my notes on the 1st section only (viz: their Anatomy &c.). It will therefore be seen that the following Thesis contains only a very small amount (certainly not more than 1/4) even of the mere Notes on the subject, which I had collected & which want of Time &c. have prevented my arranging & extending. I hope therefore that it will be looked upon rather as an Intention, than as an actual Result, — as a mere Nucleus of a projected Aggregate —

I have been careful, so far as I am aware, to acknowledge whatever has in any shape been borrowed, and I have therefore appended to the various Facts or Theories mentioned in my Thesis, as well as to the Drawings, Preparations &c. contained in my "Illustrations", which have been so borrowed or copied, the original authority, to whom I am indebted for them —

I have added to the Thesis, an Appendix, containing such Notes & Memoranda &c. as I consider merely explanatory & supplementary, or such Information as I found I had omitted in its proper place, or had acquired after the body of the Essay had been written — I have also appended:

1. a Glossary, or Technology of Lichenology;*
2. a List of Preparations, exclusive of the Drawings &c. in the "Illustrations";
3. A small contribution to the "Literature" of Lichenology, in the shape of a List of Books containing information thereon.

* omitted from want of Time

INTRODUCTION.

My attention has been attracted to the Natural History of the obscure Cryptogamic family of the Lichens, on account of the comparatively ambi-guous & low position in the scale of vegetable Life, which they are at present compelled to hold, chiefly from our deficient knowledge of their actual Beauties, structural, physiological & utilitarian. The whole subject of the Cryptogamia has ever been a fertile source of difficulty & discussion; but, gradually, one after another of its individual families has been raised from its previously degraded state of supposed "low organization" & worthlessness to its true position in the vegetable Kingdom, — to its just relation to col-lateral families & to the so-called "Higher plants" (the Phanerogamia) —, by the persevering, laborious & accurate Investigations of careful observers, assisted by the Microscope. But the Lichens appear always to have been considered, structurally & functionally, the most difficult, obscure & incom-prehensible family of the Cryptogamia & have therefore uniformly been a neglected Tribe — Indeed, until very lately, they were regarded as "scarcely distinguishable from saline efflorescence", — in a word, as little higher, in point of organization, than the sterile rocks, on which many of them grow & which alone they were supposed fit to adorn — One chief cause of the great difficulties, which are unquestionably attachable to the examination of the Lichens, is their Polymorphous & Protean nature; — considerable changes in their external appearance, — characters &c following even very slight climatal changes & other variations in the external circumstances, to which they are peculiarly exposed — But the very obscurities & difficulties connected with their Investigation should be, I think, the strongest incentives to study them patient-ly & carefully, — to wrestle with & master the whole subject of their structure functions &c, so as ultimately to place it on a true Scientific footing — I cordially agree with Mirbel, in the following remarks: "Les difficultés ne " doivent pas nous rebuter — L'intérêt, qu'excitent en nous les phénomènes de " la Nature, ne se mesure pas à la grandeur des êtres dans lesquels ils " se manifestent, et la gloire de nos découvertes est d'autant mieux acquise, que

" que nous avons rencontré plus d'obstacles pour parvenir à la con-
"-naissance des faits - D'ailleurs, voulons-nous prendre une juste idée du
" Règne végétal, nous devons l'examiner dans toutes ses modifications,
" rechercher et circonscrire ses limites autant qu'il est en notre pouvoir,
" et nous appliquer à saisir les rapports délicats qui unissent par des
" nuances graduées, ces poussières impalpables, ces filets déliés, ces
" lames irrégulières, ces masses de formes variées et bizarres où l'œil
" ne distingue que faiblement la trace de l'organization; à ces superbes
" végétaux qui cachent leur cime dans les nuages, et couvrent de leur
" ombre épaisse la terre dont ils sont le plus bel ornement." * The families
of the Ferns, Mosses, Algæ & Fungi have each had their numerous admirers
& describers, who have written hundreds of Books, & drawn thousands of
accurate & beautiful plates, illustrative of their structure &c - But, compara-
-tively speaking, the Lichens have, in all ages (& perhaps even at the present
day?), been stigmatized as of an organization so low (if organized at all?),
as to be beneath the attention of a scientific Observer; - as being propa-
-gable by modes of Reproduction perfectly anomalous & abnormal; - as a
sort of intermediate series between the mineral & vegetable kingdoms; -
e.g. as being often a mere accidental result of "Equivocal Generation" in
other vegetable organisms; - in fact as a kind of "Noli-me-tangere" family,
which the majority of Botanists have preferred to avoid rather than investi-
-gate - Tho' last, however, not least; for, if they have their difficulties &
defects, they have also their own inherent Beauties, whereby, as Baskerville
says, "a Lichen is as perfectly fitted to the condition it is intended to
"fulfil, & its organs as completely adapted to that purpose, as the stately
"Palm or the magnificent Forest Tree". † They are says Müller "Äusserst
"schwierige aber auch inhaltsreiche Pflanzenfamilie" ‡

There is ever a peculiar interest connected with the Study of the more minute
& occult pages of the Book of Nature, which cannot be felt when we regard her
more attractive & more easily intelligible works; - the human mind has a natural
longing after the Infinite - "Invisible vegetation," says a writer in Chambers'
Journal, "presents a field of contemplation as varied & wondrous, tho' perhaps
not

* Mirbel Elem. de Botanique Vol. I. P. 420. † q. Lindley's Veget. Kingdom.
‡ Morphologischer Grundriss der Familie der Flechten by Camille Montagne. Trans. by Dr. Karl Müller v. Bot. Zeit. May 16/57.

"not so gorgeous, as the visible display of green foliage & blossoms of every
"tint & shade of brilliant colour, which sparkle in the summer sun. There
"is something exceedingly interesting in tracing Nature to her ultimate &
"simplest forms.— The human mind delights to speculate either on the vast
"or the minute."* "In minimis Natura praestat" was the opinion of Pliny aff.
& the great Linnaeus— Man must naturally be anxious to become acquain-
-ted with the structure & functions of plants, which strew his path wherever
he roams over the wide world;— whether he visit the ice-bound shores of
the Arctic regions, or the stifling heats of the Tropical Jungle;— whether
he climb the Himalayas or the Andes to the verge of eternal snows,— or
ramble in the luxuriant vallies at their base;— tho' he should be led among
the most barren rocks, far removed from the "higher" types of vegetation,
still he will find species of this humble family accompanying & cheering
him, (as did the tiny mosses to Mungo Park in the vast African desert)—
Lichens are, says Mirbel, "les dernières formes organiques sous lesquelles aff.
"se manifeste la vie végétale."†

Glance for a moment at the part, which Lichens play in the grand aff
Economy of Nature,— as the humble, but indispensable, Pioneers of all 44
vegetation,— as the obscure & despised means, which ultimately pave the way
for the reign of the "Monarchs of the Forest"— From their peculiar power
of slowly, but effectually, disintegrating the hardest (even siliceous) rocks,
the Crustaceous Lichens gradually prepare a scanty bed of mineral soil,
to which by their decay they add a small amount of vegetable soil,— thus aff
preparing a nidus for the growth of higher species of their own family
(foliaceous species)— They appear, in fact, destined by nature to cover with
vegetable soil the very spots most in need of it— The Foliaceous Lichens,
again, by their decay, contribute a still greater amount of vegetable soil, aff
which is now fitted for the growth of Mosses: and these, by the gradual process
of decay & enrichment of the soil, are in progress of time, succeeded by
Lycopodiums, Sedums, Saxifrages & Grasses— While yet the vegetable soil
is comparatively meagre, the Umbelliferous & Labiate families,— the Heath,
Vaccinium

*Chambers Journal Oct. 11/57. †Mirbel Vol. I. P.

Vaccinium & Honeysuckle make their appearance; & when, in course of Time, it has become increased by the slowly accumulated débris of years, the Birch, Juniper & Willow uprear themselves, where formerly perchance a few miserable Cladonias or Hypnums alone could find subsistence. These, in their turn, give place to the mightiest trees of the forest, and thus, says Professor Balfour, "The most despised weeds lay the foundation for the Denizens of the "Woods &, in progress of Time, the sterile rock presents all the varieties of "Meadow, Thicket & forest." * Lichens are therefore the origin alike of the luxuriant vegetation of the isolated Coral Island of the vast Pacific & of the boundless forests of the Northern Continents. The mightiest Trees of the Forest, which have "braved 1000 years", ultimately become "Massed with age", and "more frequently owe their destruction to the silent attacks of parasitic [?] lichens "than to the ravages of Storms". Lichens are also "one means of that gradual, "but never ceasing disintegration, or decay, which is wearing down the densest "& loftiest pinnacles of the earth" † Dr. Asa Gray remarks, these "so-called "useless Plants create a soil, which will in time support the higher plants of "immediate importance to man & the higher animals, but which could never "grow & perfect their fruit if left, like their humble, but indispensable, Re- "decessors, to derive an unaided subsistence directly from the inorganic "world" ‡

Mirbel, speaking of the Distribution of Lichens on the Mountains of Jamaica, (This remarks are equally applicable to their horizontal & vertical distribution all over the world) says", Ainsi les moindres plantes dans l'ordre de la perfection organique, "occupent la base et le sommet de cet immense amphithéâtre, dont les gradins "intermédiaires sont ornés de tout ce que le Règne végétal produit de plus riche "et de plus varié." ‖

"Nothing", says Professor Lindley, "can be more varied than their appearance" We find them as "grey, yellow & brown stains on old walls & ancient churches"; their apothecia often presenting a lettered appearance; others are found on Trees & Rocks, "forming broad patches of various Colours, some being of the richest golden yellow; "... some again hang from the branches of venerable Trees, which they clothe with "a shaggy beard of grey, & finally a few start up upon the heath, gray & deformed, "but eventually fashioning themselves into tiny goblets, the border of which is "studded with crimson shields." § As a mere Contribution to the Picturesque, they

* Manual of Botany P. † Edin. Encyclopædia art. Lichens. ‡ Botanical Text Book P.
‖ Mirbel Vol. I. P. § Lindley's Vegetable Kingdom P.

they might claim a share of admiration & gratitude, - adorning as they do what would otherwise be uninteresting, naked, gloomy rocks, by "bestowing "tints of a delicate pea green & primrose, which it is not necessary to be a "Botanist to admire" *

Their affinities also contribute to render them highly interesting. By some of their products, they are connected with several members of the Phaenogamia eg we find orcin & its derivatives, allied in chemical composition &c to the Salicylic series of organic substances derived from the Willows &c; - Fumaric (or Lichenic) acid occurring alike in Cetraria Islandica & Fumaria officinalis; Chrysophanic acid alike in Parmelia parietina & common Rhubarb; Oxalic acid existing in many species of Lichens & Phaenogamia at the same time &c &c -

In an article "On the Foods derived from the Cryptogamia", &c in the Pharmaceutical Times (Febry. 6/1847), Mr. Coventry remarks, "The age of "flowerless plants" "is inscribed in Physical, rather than human Chronicles - They were among "Creation's earliest Medals, - eminently belonging to the globe's prehuman epochs - "The stunted Lichens, we now crumble to the dust, are perchance the Types of a "flora, whose every feature was extent, variety, beauty & sublimity; - Lichens, not "as now, rugged, lifeless crusts, but rioting in the treasures of a primeval atmos- "phere, fraught with the life-blood of vegetable developement" - Again, Thwaites, in an article on the Gonidia of Lichens, says: "It is highly interesting to observe "in these lower plants a typical character of essential structure, binding together "numerous species of various forms, & enabling us to distinguish, at once, in other "species, resemblances of analogy from those of affinity; so true is it that, in "the smallest natural groups of organized structures, the same great principles "are to be discovered when carefully sought for, which exhibit themselves so "obviously in the larger divisions of the Kingdom of Nature" †

Lichens are chiefly known at present as furnishing Archil & Cudbear to the Dyer, - the nutritive Iceland Moss to the Convalescent from febrile disorders, - the "Reindeer Moss" as fodder to the Reindeer, (the chief wealth of Lapland), and the "Tripe de Roche" to the famished Traveller in the Arctic regions, - but these are a very few indeed even of their Economic uses -

Whether we regard them - as the Pioneers and founders of vegetation all

* Ann Radcliffe q. Edinr. Encycl. art. Lichens. † Annals of Nat. History Vol. III. P.

P. 38-39. all over the Globe;— as the most extensively diffused family of the vegetable Kingdom;— as clothing, with a picturesque Covering, the otherwise sterile & naked rocks, even to the limits of perpetual Snow;— as adorning alike the "Brave old oak" & the primied Tower, stamping them with the indubitable marks of venerable age;— as yielding for the use of the Arts, colours of the most beautiful hues;— as serving, in arctic regions, often to sustain the life of the intrepid Traveller, who would otherwise perish;— as constituting almost the sole food of the Reindeer & other Cattle in Lapland & other regions of the north;— or, as having been (said to be?), in former days, considered Specifics in many (if not in all) acute diseases;— and conceive they are worthy of a due share of scientific observation & research— In a word, we cannot but admire the beautiful adaptation of means to an end exhibited by the great author of all in the organization of this humble Tribe as in all surrounding nature— When we consider — the hard Coriaceous P. 13. P. 14. texture of many species, which enables them to brave the snow & the Tempest; — the Fixure, or viscid exudations, which enable them firmly to cling to P. 58. surrounding objects for support;— the loose cellular texture of all, whereby P. 20. P. 14. they can very readily imbibe moisture;— the power possessed by many of them of quietly, but surely, disintegrating the hardest rocks, so as to convert P. 67. their surface, in progress of Time, into a suitable medium for the germination of the seeds of the so-called "Higher" plants, & thus gradually pave the way for the maturation of the "fruits of the Earth";— the exceedingly minute 68-69. size & delicate nature of their spores, whereby they may be wafted in myriads by the gentlest breath;— the beautiful provision for their Reproduction P. 60. in spite of adverse external circumstances, by their possessing a secondary & supplementary kind of Reproduction (ie by Gonidia or gemmation) in case of failure or prevention of the primary means (Spores), & by these Spores & gonidia germinating readily from any point of their surface;— the great P. 73. abundance of the nutritive species precisely where & when they are most wanted (ie in the inhospitable Polar regions), & numerous other Beauties of adaptation, which we could easily particularize did space permit, our

mind?

minds must be naturally led "to look from Nature up to Nature's God,"
& to exclaim, with the Psalmist, "O Lord! How manifold are thy works!
in wisdom hast thou made them all; the earth is full of thy Riches."

I

Anatomy, Organography and Physiology

I. Their ANATOMY, ORGANOGRAPHY and PHYSIOLOGY.

Elementary Cellular Tissue.

Derivation of the word LICHEN. The obscure, but interesting, Family of Cryptogamic Plants, whose Structure, Properties &c we are about to consider, has derived its name "**LICHEN**", (according to various authors), either from the Greek word "λειχην, a **Wart**, which the Fructifications often resemble; * — or from some of the members of the family being supposed capable of curing the papular disease, so common among Mankind, called "**Lichen**"; † — or from resembling, in external appearance, the **Papules**, which characterise that Disease †

Derivation of the word "Lichen".

From fructification resembling Warts or Papules of Lichen

In proceeding at once to the examination of the Microscopical Anatomy, Organography & Physiology of the Lichens, I would only advert *en passant* to one circumstance viz: that, in this Family, we see beautifully exemplified the Combination of two circumstances apparently contradictory, viz: a prodigious variety in external form & character in different species, and a complete Homogeneity of Tissue in each ‡, inasmuch as their Structure is wholly formed of **CELLS** & their various combinations. I shall therefore first notice the character of the "**Vegetable cell**", as it occurs in the Lichens, — constituting the Elementary Tissue, by a combination & modification of which, the various Compound Tissues or Organs of these Plants are produced, before going on to the detailed Description of these organs themselves. And I shall consider this cell under two heads (as it occurs in all plants) viz:

Variety of Form & Homogeneity of Structure in Lichens.

Structure &c to be considered under 2 heads
I. Vegetative Cell
II. Reproductive Cell

I. THE VEGETATIVE CELL AND

II. THE REPRODUCTIVE CELL.

* Smiths Engl. Flora Vol. 5 P. 129.

† Amoreux "Recherches et experiences" sur les Lichens &c

‡ DeCand. Vegel. Organography. Trans. Kingdom Vol. 1.

Vegetative Cellular tissue.

THE VEGETATIVE CELL.

Form &c of Vegetative Cell.

FORM & Arrangement. The vegetative-cell of Lichens seems to consist, at the earliest period at which it has been noticed, of a **Gelatinous globule**, easily soluble in water, which gradually, in progress of growth, becomes converted into a Microscopical Vesicle or **Utricle**, whose wall is formed by an elastic transparent **Membrane**‡. The **Form** of this Vesicle depends on the degree of pressure to which its Circumference is subjected & other accidental Circumstances, as in the higher plants. Thus it may be **Globular, Cylindrical, Hexagonal** &c. By the superposition of spherical or globular cells, **Moniliform Filaments** are produced, such as characterize the Thalline structure of the Collemata. By the elongation of the cells, or by superposition & subsequent disappearance of the septa or Partitions of contiguous cells, are produced **TUBES (Tubules, Tubilles, Fibres?)**. The aggregation or combination of these Tubes constitutes the **Medullary or Tubular Tissue** of the Lichen-Thallus (**Tela contexta** of Schleiden &c — the erroneously so-called "**Fibrous Tissue**?") which consists of very long, fibrilliform, thin, dry, tender, forked & branched cells, "intimately interwoven & variously mixed with each other"* Dr. Martin Barry mentions the occurrence of a "flattened Filament or **Fibrilla**", which he describes as sometimes **annular, coiled, spiral** &c in Lichens (as well as in the mature Blood Corpuscle of Man & the Mammalia — birds — Amphibia — fishes — in the root-stem petiole & leaves of the higher plants &c)†. Many authors formerly looked upon the Tubes as true Vessels, Canals &c; but we have no evidence of the existence in Lichens of any tissue analogous to the **Vessels** of the higher plants, tho' bundles of interwoven or isolated Tubules may certainly often greatly resemble them. Sprengel (& many of the older Lichenologists) regarded the Lichen-tissue as "not distinctly cellular", but as "fibrous, compact or gelatinous". The

Tubular

Fibres?

Vessels?

speaks

* Schleiden — Scientific Botany. ‡ Schleiden

† On Fibre — Phil. Trans. for 1842. Part I. p. 89.

Vegetative Cell.

speaks of some species (e.g. Endocarpon) as being "formed of nothing but pure precipitation from the vegetable juices, except here & there some slight rudiments of a cellular organization" — * With regard to the **Combination** or connection of the cells in the Lichen-Thallus, Schleiden remarks, the "Connection of the elementary individuals is so loose in Lichens, that we cannot well distinguish between an individual Developement of the Plant and a repeated Composition of the same; or in other words between growth & the formation of Buds (gemmation)" † As to the **Distribution** of the two forms of Cells above-mentioned in the Lichen-Thallus viz: the **round cell** & the **elongated** or **tubular cell**, De Candolle states that, generally speaking, we shall find the latter in those parts of Lichens, which resemble stems or Branches, — the former, in those, which are like foliaceous expansions ‡

State of Aggregation

Distribution

I deem it unnecessary here to dilate on the various forms & modifications of the Lichen-cell, as I shall have very frequent occasion to refer to & describe these when treating of the structure of the Thallus & of the structure & history of the Developement of individual species; and for ample illustration of the same I beg to refer to the "**Illustrations**" —

Composition of Cell-membrane (and Cell-contents.

P. 5. **COMPOSITION.** — "The **Cell-membrane** is stated, by the majority of observers, to consist of **Cellulose**", but by others, as variously composed of h. 32. **Lichenine (Lichen-Starch)**,[2] or of a substance intermediate in proper- p. 30. -ties between them. **Payen** remarks that, in respect of its consisting of Cellulose, this Cell-membrane is exactly like that of the higher plants, from which it differs merely in its degree of Tenuity. He states that the Cell-membrane of Cetraria Islandica, when properly cleaned, is rendered blue by the action of Iodine; — that it dissolves, like Starch, in Soda; — that its jelly contains a Hydrate of **Starch** & **Inuline**; — and that, even when cleaned successively & thoroughly by various reagents (Water, Alcohol, Ammonia, Acetic acid & Ether), Iodine continued to cause the developement of the blue color. He found it entirely soluble in Potash, like the albumen of Dates. He believes this Cell- 33.

Cellulose, Lichenine or an intermediate Substance

membrane

* Sprengel's Cryptogamia ‡ Organographie végétale

† Schleiden's Scient. Bot.

Cell-membrane. Composition.

membrane different from the thickened Cell-wall of some of the higher plants, (eg the thick cell-wall of the Albumen of Phytelephas & Dracæna) in being more rapidly, from its greater tenuity, dissolved. Judging from the similarity between Starch & Cellulose in chemical composition & in the transformability of both into Dextrine & Sugar, he thinks it probable that this Cell-membrane may consist of a substance intermediate in composition between these.* **Mulder** says the Cell-membrane gradually dissolves in

Effects of Re-agents on it.

boiling water, so as to become thin & loose, instead of thick & solid, as formerly. When thoroughly boiled & extracted by Alcohol, Ether, Muriatic Acid, Water, dilute Potash &c, the final residue is nothing but **Cellulose**, and the name of "Amylaceous Tissue", which has been applied to the structure of many species (eg. Cetraria Islandica) he therefore regards as erroneous. He looks upon the Tissue of Cetraria Islandica, as consisting, besides real Cellulose ($C_{24}H_{21}O_{21}$), of a peculiar substance, transformable by boiling into **Lichenine**. The same author, however, considers Lichenine & Cellulose to be one & the same substance, — the former being merely an impure form of the latter. If this be the case, we see at once the reason of the various Composition of this Cell-membrane, as laid down by different observers. †

Reparation of Cellular Tissue by Exudation of a Green Juice?

On tearing a portion of the cellular-tissue, (eg from the epidermic surface of the Thallus of a Crustaceous Lichen) it is stated that we shall find it becoming **green**, on exposure to the air & light, — & that this circumstance is especially noticeable in such species as adhere to rocks — **Ramond** believes this to be the result of the "Extravasation of a peculiar **Juice**", but nothing apparently is known either of the nature of this juice, or of the Phenomenon itself ‡

*Payen "Sur la Composition chimique du Tissu propre des Végétaux" q. Ray Society. Rep. on Botany 1845.

†Mulder. Veget. Animal Physiology P. 198. ‡Edin. Encycl. art. Lichens. De Candolle. Veget. Organography. Trans. Kingdom Vol. I.

D.P.16. **CELL-CONTENTS. NUCLEUS.** Nageli states that he never saw a Cell-contents
Cell-nucleus in Lichens, but this negative evidence is certainly no proof of its Non- Nucleus.
L.P.5. -existence, for it occurs normally in all classes & orders of plants & its non-obser- Does it exist?
-vance here may be partly due to the minute size of the nascent cell, or other
circumstances.* Pareira however, speaks of the "nucleated cells of the medul-
-lary layer" of Cetraria Islandica.†

P.34. **MUCILAGE. (Protoplasm. Cytoblast)** A viscid, mucilaginous, nitrogenous Mucilage.
material, which is originally homogeneous, but afterwards becomes granular, forms
forms an investing layer on the inner surface of the Cell-wall constituting
the "Internal Utricle" of Harting & Mulder, the "Primordial Utricle" of "Primordial
Mirbel. It presents the same characters that it does in the primary cells of Utricle".
the higher plants viz: is rendered of a brownish color by the action of Iodine which is
-is made more distinctly visible by strong Hydrochloric acid & diluted Sul- difficultly
-phuric acid, — is seen, in the young state of the cell, to contract under the influ- distinguishable
-ence of Iodine & separate from the outer cell-wall, — & subsequently disappears,
from being incorporated with the Cell-wall‡ But, according to Mohl, this "Prim-
-ordial utricle" is very difficultly distinguishable in the Lichens & the discovery
of it in this family belongs to Mohler & Knop, who first found it in the genus
Usnea. It occurs" in the round green-celled layer", especially in those Lichens
with a dense, foliaceous Thallus (eg Stieta flomulifera = Parmelia flom.?)‖ Some
authors seem to regard the Cell, as "empty, or filled with a grumous matter, in "Grumous" matters
a loose & indefinite state of aggregation."§

30. **LICHENINE (Lichen-Starch)** a variety of common Starch, somewhat re- Lichenine.
-sembling the Jelly of Sea-weeds (whose formula is variously stated as $C_{12}H_{10}O_{10}$ as a
& $C_{24}H_{21}O_{21}$) is mentioned by some authors as forming a Deposit or incrusting Cell-deposit.
layer" in the primary Cell-wall."⊙ It has been most generally observed in
the cells of Cetraria Islandica. Pagen, from the result of his earlier investigations,
avers

* Nageli on the Cell-nucleus. Rep. on Botany. Ray Society for 1846. P. 225. ‡ Balfour's Botany P. 7.
† Pareira's Mat. Medica — Cetr. Islandica. ‖ Mohl on the Vegetable Cell. Trans. in Taylor's Scientific Mem. Vol 4.
§ Penny Cyclopaedia art. Lichens
⊙

Lichenine. occurs in the Cell in the form of Globules?

avers that it does not exist in the form of **Globules**, "but forms the membranes & contents" of the elementary organs of Lichens.* But subsequently, in a paper read before the Société Philomatique, he states that he had seen it under the Microscope "united in small balls"*; tho' Pereira thinks it probable he had mistaken the cells themselves for Starch-granules† Again, Link holds that it does not occur in a globular form & Pereira, in reference to Link's opinion, says "If, by amylaceous matter, is to be understood starch granules, which are rendered blue by Iodine, my observations confirm his statement"† The author last mentioned also states, that, tho' a general blue tint is produced by the action of Iodine in the subcortical layer of Cetraria Islandica, yet "none of the cells or granules become blue". Mulder mentions its occurrence "in the fine Capillary cells" in the form of numerous little globules, soluble in boiling water.‡ Meyer found that Amylum in fresh Lichens was colored blue by Iodine;* & the same effect is produced by Iodine on the Septa of the cells.—

Effects of Iodine on it.

Inuline. Action of Iodine on it.

INULINE. Pereira hints at its probable existence, "in the nucleated cells of the Medullary layer" of Cetraria Islandica, judging from the circumstance that they become of an amber color, when acted on by Iodine†—

Lichenine & Inuline & the other contents of the Lichen-cell will be more fully considered, when I come to treat of the "Composition" and "Products" of the Lichens—

Chlorophylle. Usually Green. in form of Granules.

CHLOROPHYLLE. (Chromule) tho' normally **green**, (which is the color it exhibits in the greater number of Lichens, when moistened,) may be variously colored (eg **yellow**, as in Parmelia parietina; **brown** as in Parmelia Stygia; pure green as in Borrera ciliaris)— It consists of minute **colored granules**, lying loose or aggregated in the Epidermic cells, or in those parts of the plant

* Comptes R. Institut de 1837. P. 128. Trans. Report on progress of veget. physiology in 1837. Meyer & Francis
† Pereira Mat. Med. Vol. 2 Part. I. ‡ Mulder's Physiology ?

plant which are exposed to the light*—

Cell-Contents.

SPIRAL DEPOSITS. It has generally been laid down by authors that no traces of Spiral Developement have ever been discovered in Lichens. But this is probably a mistake—I have already mentioned that D. M. Barry believes in its existence & we shall hereafter see that there are very strong grounds for supposing that genuine Spiral filaments occur (tho' certainly not to a great extent) in ~~the~~ various Kinds of the Reproductive Lichen-cell—

Spiral Deposits.

Do they exist?

WARTY EXCRESCENCES, or Knotty Deposits occasionally occur in the **Interior** of the Lichen-cell—Schleiden describes them as "projecting irregularly into the cavity of the long, fibrous cells of Peltidea canina. One or two Cavities are often distinguishable in the interior of such warts, and "separated by a definite line from the surface of the organ, to which they adhere, as if they were adherent cells".† We know nothing of their Developement or real nature, but Schleiden supposes the Cause of their existence to be the unequal nourishment of the Cell,—particular isolated spots of the inner surface of the Cell-membrane, being more freely supplied with nutriment than the rest—

Warty or Knotty Deposits.

Nature & Cause both doubtful?

Little is, as yet, known of the Contents of the Filamentous or **Tubular Tissue**—Schleiden states it usually to contain a clear colorless juice,—sometimes **Air**†

Air.

INTERCELLULAR SUBSTANCE seems in many Lichens to contain, if it does not entirely consist of, **Lichenine**. Pereira mentions its occurrence as a non-granular, starchy matter, in the Intercellular Tissue of the subcortical Layer of Cetraria glauca, as evidenced by the action (the

Intercellular Substance composed of Lichenine

* Grays Botan. Text Book. P. † Schleiden Scientific Botany P.

Intercellular Substance

(the production of a blue color) by Iodine on it. It probably also exists in the apotheeia of the same plant, between the Theca & the Paraphyses.* Schleiden remarks "The semifluid, gelatinous matter between the cells, especially of the Utricular layer [of Lichens] presents a Transition from Intercellular substance to gum." He regards this substance as a probable Secretion by the Cells.†—

a Secretion of the Cell?

Multiplication of the Vegetative Cell. by Parietal Cell-formation.

DEVELOPEMENT. The Reproduction of the vegetable-cell takes place by what Nageli calls, **Parietal Cell-formation**, which is characterised by I. Division of the Contents of the Parent cell usually into two portions II. The formation, round each of these portions, of a perfect membrane", which, at the moment of its origin, is in contact, partly with the Parent Cell-wall, partly with the corresponding wall of its fellow secondary cell or cells".‡ Each parent-cell thus uniformly gives rise to two so-called "**Secondary**" Cells—

Intercellular Cell-formation. Does it exist?

INTERCELLULAR CELL-FORMATION. In reference to this point, Nageli remarks that there originally exists in Lichens, "a thin-walled, Parenchymatous, Cellular tissue & the cells subsequently separate, while gelatine make its appearance between them". He has therefore no belief in the existence of an intercellular Cell-formation in Lichens.‡—

Having thus briefly glanced at the characters of the Vegetative Lichen-cell, in its **individual** Condition, I proceed now to consider it as a **constituent** of that Compound Tissue or Organ, which may be said to constitute (with the exception of the organs of Fructification) the whole Lichen-plant, I mean the **Thallus**.—

*Pereira Mat. Med. V. 2 Pt 1. † Scientific Botany ‡ Nageli on Veget. Cells. Ray Socy. Rep. Bot. for 1849.

Compound Cellular Tissue.

Compound Tissues.

THE THALLUS.

aff. P. 43.

In taking a downward survey of the scale of Vegetable Life, we find one after another of the Organs chiefly characteristic of the higher Plants gradually disappearing, and, when we descend so low as the Lichens, all these Organs have become reduced to what we may consider their primitive form, or in the words of Dr. Asa Gray, we have "the Type of Vegetation obscurely shadowed forth in its most reduced form."* Below the Hepaticæ, the distinction into stem, root & leaf is completely lost - In the Lichens, we find **no Polarity**, or regular opposition of root & stem, (evidencing growth in 2 opposite directions); **no true Epidermis**[1]; no distinct Sexual Organs; the Indications of an **Axis** are generally very obscure & their homogeneous Tissue is most usually evolved in **flat**, more or less **indefinite Expansions**, or **rounded masses**, which, even when foliaceous, have **no** vestiges of **Stomata**.[2] This Non-symmetrical Expansion, which constitutes a kind of Frond, is called the **Thallus** (Θαλλὸς a green Leaf) & is formed by "the assemblage, interlacing or more regular union of the purely cellular, but often filamentous components"* This organ, (which is also termed the **Universal Receptacle** by Acharius) represents, in function, (tho' not in appearance), the **stem, root & leaf** of the Phanerogamia & indeed may be considered as a Fusion or combination of these three organs, whose offices it performs - Schmiglein regards the Thallus as a Corticated body, in which we find, confused in one mass, tho' in distinct layers, the **root** (fistulous cells), the **trunk** (Sepra), and the **leaves** (Gonidia)† In many Lichens, which adhere by one surface to rocks & other

Thallus

a Representative of Stem, Root, and Leaf.

aff. P. 14. & P. 17.

2 aff. P. 13. & P. 27.

aff. P. 27.

P. 21. P. 83.

*Grays Botanical Text-book P. †Schmiglein's Botanico-anatomical plates.

Thallus a Simplification or Fusion of the Stem, root & Leaf of the higher Plants

other substances, the whole lower surface of the plant corresponds (according to some authors) to the **Root**, while the upper surface, exposed to the Light, fulfils the office of **Leaf**. Schleiden remarks, "there are no morphologically definite parts of the Plant." * But, the absence, in the Lichens, of organs of such import to the "higher" plants as root, stem, leaf &c. certainly does not prove them to be **Imperfections** of Nature, as they have over & over again been stated to be; but we must consider them as **Simplifications** merely of the Type, which is fully realized in the highest Phanerogamous plants." † Some species are apparently **destitute of a Thallus**, "but, as it is very rare, it must be regarded as a true abortion, or else supposed that it is of such tenuity as to escape our vision." ‡ In the Graphidea, for instance, we seldom or never see the whole Lichen-plant, for "the plant expands itself within those parts of plants (usually Barks of Trees) which serve as a Basis to it & subsequently, after destruction of the covering, nothing remains but the naked Sporocarp." *

Thallus sometimes evanescent

Forms of the Thallus

FORMS OF THE THALLUS. — According to Tuckerman, the Thallus is typically **horizontal** or **vertical** This division of these two Types are

1. When its position is horizontal

I. HORIZONTAL.

a. **Crustaceous.** (often somewhat lobed at the Circumference, or **squamulose**)

b. **Foliaceous** (Leaf-like) (becoming sometimes, in degenerate states, Crustaceous).

II. When Vertical

II. VERTICAL

a. **Subfoliaceous** — (Compressed)
b. **Fruticulose** — (Terete)

} Of these the **Filamentous** and **Pendulous** Thallus are degenerations ‖

* Scientif. Botany P. Schl. † Gray's Bot. Text-book P. ‡ Fée Essai sur les Cryptogames des Ecorces exotiques officinales. Trans. N.E.L.

‖ Tuckermans Synopsis of the Northern Lichens

In *Cladonia* & *Stereocaulon*, we find a vertical Thallus (**Podetium**) arising from the primary horizontal Thallus & this Podetium is often besprinkled with a kind of **secondary horizontal Thallus**, in the form of Leaf-like scales* — Fée divides it according as it is **adherent** or **free**; the former being a Thallus, which is intimately applied to surfaces & adheres to them by all its parts, not by the aid of Fibrillæ or rootlets (*Crampons*), but by an immediate contact of its molecules with those of the supporting substance; — the latter being one, which is superposed on surfaces (e.g. *Collema*, some *Cornicularieæ* &c.), — which adheres by *Fibrillæ* (e.g. *Parmelia* or *Peltigera*) or which is fixed by a sort of sucker (*Crampon*) (e.g. *Umbilicaria*, *Usneæ* & several of the (*Ramalineæ*) — I subjoin M. Fée's Tabular Representation of these two kinds of Thallus, with their modifications —

Forms & Modifications of the Thallus — Podetium

V. P. 58.

Fées Tabular view of the Forms of the Thallus.

- **THALLUS**
  - **Adherent**
    - Difform
  - **Free**
    - Surface heterogeneous
      - Membranaceous.
      - Gelatinous
      - Coriaceous
    - Surface homogeneous
      - Laciniated tending to become flattened
        - Fistulous
        - Solid
      - Ramified tending to become rounded
        - Fistulous
        - Solid
      - Filamentous †

Other Lichenographers have divided & subdivided the Thallus to a very great & needless extent — By some authors, (carrying out the division of the higher plants, according to their organs of vegetation, as promulgated by Cæsalpinus) it has been divided into **Cellular** & **Fibrous**; by others into **Frondose** & **crustaceous**, (which characterises the higher lichens) and

Division of the Thallus according to other authors

* Synop. of North. Lichens P. † Fée Essai sur les Cryptogames &c. P.

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Forms & Modifications of the Thallus.

and **Pulverulent & gelatinous** (characterising the lower)* It has likewise been distinguished as **arborescent, ramified, coriaceous tiled, tartareous, leprous** &c, according to its Consistence, as well as form – For general purposes, however, it is sufficient to regard the Thallus as **Foliaceous, Crustaceous or Pulverulent** – these different forms depending on the mode, in which the cells are developed & combined.

For further information on the Technology & characters of the Thallus, I beg to refer to the "Glossary", the "Explanation of the Illustrations" & the "Illustrations" themselves. —

Circumstances which contribute to produce the great Variety (in form, color &c) of the Lichen-Thallus viz: Exposure to air Light Heat – also Nature of Soil Moisture &c.

CAUSES OF VARIETY in the form &c of the Thallus. No class of plants is more plastic in form & texture & none more amenable to climatal & other external conditions than the Lichens, & the result is, as we should expect, an almost infinite variety in Form (as well as in Color, Structure, Properties &c) – This is not the place to do more than merely glance, en passant, at the principal causes, which operate in so signally altering their physical characters – The subject will fall to be considered more fully under the head of "Epirrheology" in the section on Geographical Distribution‖ – The amount of Exposure to **Air & Light** has probably a great influence in determining the form & structure of Lichens – When equally exposed, the Thallus is similar, in its whole surface & is usually erect & cylindrical – stem-like (e.g. Usnea. Cladonia) or compressed (e.g. species of Roccella) – In the foliaceous or scaly Lichens, which are horizontal in position, the upper surface, or that exposed to the action of the air & light, is firmer harder & more colored than the lower, which is usually softer, more tender & paler in color.‡ According to Fries, Lichens are subject to very great interruptions (& consequently modifications) in growth by atmospheric

*Martius. Flor. Brasil. Vol. I. P. 52. †Belfour Botany P. 550. ‡De Candolle Vegel. Organography Trans. Kingdom V. I.

‖ Omitted from want of time.

The Thallus. — Causes of Variety in its form &c.

Atmospheric changes, the activity of their vegetative functions being suspended during drought & restored in damp seasons — A result of the frequent interruptions to growth from vicissitudes of the weather &c (& another cause of variety) is that the vegetation of a Lichen is often renewed under circumstances so different from those under which the life of the individual commenced, as to cause quite a different & perhaps opposite* future development. Very anomalous & irregular forms are also often produced by the Coalescence, or growing together, of parts† — The nature of the Gonidic Reproduction (Gemmation) may be a fertile source, if we agree to the statement, that "The simpler the organization, the greater seems the tendency to irregular sprouting & the greater, of course, the dissimilarity between individuals of the same species."†

Modifications by Coalescence of Parts &c.

Consistence of the Thallus varies between extremes of Hardness and Softness.

CONSISTENCE of the Thallus varies from the leathery toughness of some of the crustaceous Lichens, to the soft perishable gelatine of the Collemata — I have already incidentally mentioned, when describing the Divisions of the Thallus, a few of the terms used to denote the different degrees of Consistence — Eg. we speak of the Thallus being **Crustaceous, coriaceous, squamulose, leprous, membranaceous, cartilaginous, gelatinous, pulverulent** &c. In the pulverulent Lichens — (in the Coniothalami & some Columellar Lichens) says Schleiden, "the plant is so perishable, that we scarcely find anything beyond naked Sporocarps."‡ Some lichens are so entirely gelatinous, as closely to resemble the Algæ & Tremellæ —

Appendages on the surface of the Thallus.

SURFACE of the Thallus may be **smooth**, or it may be, to a greater or less degree, roughened or covered with **tubercles, pustules, papules,** or **warts** of different kinds, or with pulverulent masses (**Soredia**); or it may be **ciliated,** — indented with **Lacunæ**, or fissured &c — The lower surface of the Thallus, in many species, is

* De Cand. Vegel. organy. 0.1. † Edin. Encycl. art. Lichens ‡ Scientif. Bot. Trans. Lankester. P.

The Thallus — Appendages on its Surface — Rhizinæ or Fixuræ their probable Nature

is furnished with delicate **Fibrillæ**, which some authors have regarded as true **Rootlets**, serving at once to fix the plant & probably also to absorb Nutriment - But these fibrils are merely elongated **cells**, (Fistulous Cells) continued from the lowermost cellular layer of the Lichen & are most probably intended merely as a Support to the Plant, - inserting themselves firmly into the fibrous tissue of Barks of Trees & other Bases of Support. - It is still maintained, however, that, in some species (e.g Psora), these appendages are to be considered as true roots, being at the same time nutritive & fixative organs* - Species, whose principal Habitats are Rocks or trees, De Candalle states, are destitute of such rootlets, but adhere to supporting surfaces, "by means of a little **Disc** at their base."*2

adhesive Discs.

Colors of the Thallus very various but far inferior in brightness & richness to the Colors exhibited by the higher Plants

COLOR of the Thallus is as varied as its Form & as amenable to climatal conditions - The older Lichenologists were exceedingly fond of minutely classifying every shade of color of the Lichen-Thallus, but I consider it quite superfluous here to notice more than one of such Color-systems viz: that of Fries & even it, I shall glance at very briefly - He divides the Colors of the Thallus into 4 Series, each having its peculiar Variations or shades, as follows:

Fries' division or Classification of them

I. From **Pale-green** becoming **glaucous** (which runs into Pale-green, cæruleseent & white) -

II. From **Yellowish-green** — **Ochroleucous** (passing into yellowish-green & albescent.) -

III. From **Dark-green** —— **fuscous** or **olivaceous** (graduating into dark green, olivaceous, cinereous, greyish-fuscous & dark chestnut)

IV. From **Pale-yellow-green** — **lemon-colored** (which passes into pale yellow, orange red & vermilion red.) †

*De Cand. Vegel. Organg. Vol. I. P.

†Tuckerman Syn. North. Lichens.

The Thallus.

Its Colors.

Various Shades of Brown Green Yellow Orange-red &c.

I consider the Technology of Lichenology already too greatly (needlessly) extended to admit of any addition to it in the shape of compound (ambiguous) terms, descriptive of the minutest shade of color — The color varies greatly even in the same individual, according to the Hygrometric state of the atmosphere* The normal color of most Lichens, when moistened, is **green**; when dry, they exhibit various shades of **white, black, green, yellow** or **orange-red** — The color depends on the Chlorophyll, contained in the cells of the sub-cortical layer, variously modified by the opacity or transparency, — thickness or thinness, of the superjacent superficial Cellular-layer — In Borrera ciliaris, the Thallus is of a pure green color, the gelatinous cortical layer being transparent; but, in the majority of Lichens, (in the dry state) the color is more or less blended with grey, according to the different thickness of the Cortex*

p. 38. 44, 45, P. 15. 42. 26. P. 15.

Structure of the Thallus

Composed of 3 layers.

I. Cortical.

II. Gonimous

III. Medullary

each of these consisting wholly of some Modification of Cellular Tissue

P. 9 13. 19. 20 42. P. 40.

STRUCTURE. The Thallus is generally found to consist (on perpendicular section) of 3 layers viz: **I. Cortical**, consisting of more or less closely aggregated, firm, dense cells (often colorless) of various shapes. **II. Middle** or **Gonimous**‡, consisting of an infra-cortical, discrete layer† of the peculiar reproductive cells (which I shall consider under the head of "Reproductive Cellular Tissue") called **Gonidia**, which characterise the true Lichens; and **III. Medullary**, often soft, cottony or downy, formed by an interlacing of the Tubular (or fibrous?) tissue, intermixed with Cells — of these, the middle or gonimous layer is always of a bright green color (depending on the Chlorophyll-contents of the constituent cells); the other two layers are normally colorless or whitish‖ In **Crustaceous** species, Lindley says, the Cortical & Medullary layers differ chiefly in Texture, in the former being colored, the latter colorless; but in the **fruticulose** or **foliaceous** Lichens

*Schleiden Scientif. Bot. †Schmiglein Plates ‡Tuckerman Syn. North. Lichens

‖Maout's Leçons de Botanique

The Thallus. Its Structure illustrated by the Microscopical Anatomy of Borrera ciliaris

Lichens, the Medulla is distinctly floccose, in the latter occupying the lower half of the Thallus, in the former surrounded by the cortical layer.* Schleiden remarks, the most complicated species (e.g. **Borrera ciliaris**) consists of a three-fold layer - The greater mass of the Lichen consists of the ordinary Lichen-tissue viz: long, thin, dry, usually forked & ramified & rather loosely interwoven cells or tubes (**Medullary layer**), which curve outwards on the external surface & gradually pass into shorter cells, more closely packed together & firmly connected by much intercellular substance, — and often into detached cells, whose character is very difficultly recognizable, as that of cells at all (**Cortical layer**) - On the limit between these two layers, lie larger or smaller groups of roundish cells containing Chlorophylle & exhibiting, in most instances, a distinct Cytoblast (**Middle or gonimous layer**) - Let us suppose two Lichens of the structure, just mentioned, placed in apposition, by their under surfaces, and we have the structure of the flat upright Lichens (e.g. **Cetraria**), the thinnest forms of which are the **Usneæ** & **Alectoriæ** - In Crustaceous Lichens, the tubular tissue is more or less frequently absent, & is replaced by **Cells** of a more gelatinous consistence, but slightly elongated & mostly placed vertically on their base. The **Gelatinous** Lichens consist of **convoluted Filaments**, formed by the superposition of Spherical cells, containing Chlorophyll & imbedded in a softish, gelatinous intercellular substance, so that it is often impossible to distinguish them from the species of Undina† - Thwaites states that the Thallus of the **Collemata** "consists of a number of **moniliform filaments** & also of delicate anastomosing **cylindrical filaments**, immersed in a more or less firm Gelatine - "But, when more carefully examined, the structure is found to consist of numerous

Structure of the Gelatinous Lichens

*Lindley's Veget. Kingdom †Schleiden Scientif. Botany P.

"numerous **Nostoc-like vesicles**, closely adhering & among which ramify
"the anastomosing filaments - The cellular **Cuticle**, investing the Thallus of
"some species of Collema (or rather of Leptogium Fries.) is a modification, merely,
"of the anastomosing filaments, as can be proved by the structure of some
"allied plants - What has just been described is the ordinary structure of Collema
"& Leptogium, but in **Collema nigrum**, each frond corresponds to a single
"Nostoc-vesicle, which becomes invested with a cellular cuticle & has external
"to this the characteristic anastomosing filaments, which, with those of other
"similar fronds, go to form the filamentous substratum or kind of thallus,
"upon which the fronds of this species are situated" - "In the true Lichens,"
Thwaites goes on to say, "there may be traced a very similar structure, only,
"instead of Nostoc-vesicles, we find groups of cells very nearly resembling those
"of the Genus Pleurococcus (Meneghini) around these cells, which increase in
"number by continual subdivision, the anastomosing filaments or modifica-
"tions of them become developed, just as in Collema nigrum"* The structure of
Synalissa vulgaris, which is externally similar to the Collemata, but
internally is represented in its essential elements by some of the lower
algæ, is also described by the same author*, as follows; "A number of
"single cells (or binate when undergoing subdivision) are scattered throughout
"the gelatinous substance of the plant most thickly towards the Periphery
"of the cylindrical branches of the fronds - Each cell is found, on careful inspec-
-tion, to be surrounded by its definite amount of gelatine & to be situated
"at the extremity of an ultimate ramification of the numerous anastomosing
"filaments, which pervade the whole mass of the Plant" -

The Thallus
Its Structure

The Collemata and their Microscopical Anatomy

"The structure of the **Stem** (so to speak) or vertical rounded Thallus
of several species is very analogous to that of the Laminarioid algæ (e.g.
Lessonia) - D. Hooker describes the structure of the stem of **Usnea melax-
-antha** (an antarctic species) in the following terms: "The central Thread
is

Structure of the Usnea

*G.H.K. Thwaites "On the Gonidia of Lichens"
Ann. Nat. Hist. Vol. III - P. 219.

The Thallus. Its Structure — Anatomy of the Stem-like Thallus of the Usnea

"is very large, composed of concentric layers of dense, horny, red cellular tissue, "gradually passing into a soft, white **Pith**, enclosing a **cavity** - Around this "horny thread, whose edges are sharply defined, are arranged **concentric layers** of a spongy cellular substance, which again, are enclosed in a cortical "layer, as dense as the central & to which the yellow & black hues of this "Lichen are always confined - Thus, proceeding from the circumference, there is "1st A horny, colored, cortical layer, answering to what is called the "cortical layer of Lessonia & to which, in that plant, the colored Chromule "is chiefly confined. —

"2nd The layers of intermediate lax tissue, successively deposited, tho' much "more obscurely so than in Lessonia -

"3d The Central Thread of Usnea, which is a stout axis answering to the elliptic "tic core of Lessonia, but in this Lichen, becoming so lax, towards the centre, "as to enclose a cavity in the older stems *"

Structure of the Thallus of Genus Sphærophoron

The same author describes the Thallus of the Genus **Sphærophoron** as consisting of a "firm, crustaceous, transparent Cortex, whose inner edge "is sharply defined, enclosing a mass of longitudinally-arranged, matted, "curved, dry filaments - These filaments are cylindrical, terete, sparingly supplied "with very short ramuli & truncate or obtuse at either extremity: they entirely "surround the nucleus of the very immature Apothecium". †

Development of the Thallus and the Circumstances modifying it.

DEVELOPEMENT of Thallus. According to Schleiden, the **Spores** develope (in a way of which we know nothing) **cells**, usually **round**, which spread out flat on subjacent surfaces (constituting a **Protothallus**). By degrees, larger globular cells are formed on this, while the upper & under surfaces becoming more closely connected & the lower face a little elongated in a vertical direction, form a plant (**Thallus**) of crustaceous aspect (**Thallus crustaceous**), whose outline usually appears very irregular & dependent on accidents. In other forms

* Hooker's Cryptogamic Bot. of Antarct. Voy. of H.M.S. Erebus & Terror. Part 9. P. 215.

† Ibid. P.

forms, the Tissue is developed between the upper & lower layers, & then the — *The Thallus.*
plant assumes more definite & independent lobed forms (**Thallus foliaceous**), — *Its Developement*
whose outline is generally circular — Irregular bundles of interwoven tissue
often separate from the lower surface, serving as Organs of Attachment (Rhizinæ) — *Foliaceous Thallus*
U.P.14. (**Rootlets**) — This form of Thallus (foliaceous) is usually more or less closely
App. P.39. appressed to the supporting surface: sometimes it is fastened, only at the — *Rhizinæ*
middle point, by a small adhering Disc (e.g. in the Genus Umbilicaria): or — *Discs.*
it may rise freely & then appears, in flat ramifying forms, which always
admit of being distinguished from the succeeding form by the inequality of
their two surfaces — In the highest forms, the cellular mass rises to form
multifariously ramifying Bands ~~&~~ or threads of greater or less thickness (**Thallus**
fruticulose) — From the circumstance of developement taking place uniformly, — *Fruticulose Thallus.*
from one point of the spore in all directions, & the plant being usually
attached to some supporting surface, a **round outline** is the commonest
form of the Thallus: but this is liable to considerable modification by the
form of the surface, on which the Lichen grows & by "the specific structure of
the Lobes" — * By some authors, it is maintained that all Lichens are origin- — *Moisture*
-ally developed in humidity & in fact at this period of their growth, mere — *as affecting the*
Phyceæ or **Confervæ**; but as soon, as the humidity diminishes, the — *Developement of the Thallus.*
"under part dies & an inert **Leprous** crust is formed, which ultimately
"becomes the basis of the plant — Hence Lichens consist of two distinct sorts
"of tissue viz: **living cellules**, forming the vegetative part of the plant &
"**dead cellules**, the cohesion of which is lost — [When separate the former
"cellules are stated to constitute **Palmella botryoides**, & the latter
Lepraria.] "Of these two sorts of matter, the Leprous is incapable of perpetu-
-ating the Lichen, while every part of the living stratum has been ascertained

to

* Schleiden Scientif. Bot.

The Thallus — Its Development — The Hypothallus

to become reproductive matter"* Tuckerman states that the three layers of the Thallus are evolved from a **Hypothallus** — "the elementary state "in which the layers are confused & discernible afterwards as **Cylindrical** "**cells**, and also as **fibres** on the under side of foliaceous lichens & forming "the base closely adnate to the matrix in crustaceous ones."†

Histories of the Development of

"There is really very little known at present of the **Laws** of **Lichen** —**Development**— Meyer, Wallroth & others have, to a certain extent, investigated the subject, but various circumstances have conspired to render their observations of little practical value—

Function of the Thallus —"—

FUNCTION of the Thallus is the **Absorption** or Imbibition & **Assimilation** of **Nourishment** for the growth of the plant— The cellular tissue of the Thallus is peculiarly adapted for rapid & easy imbibition, especially of moisture, being very dilatable & capable of absorbing very large quantities & even storing up water, like the succulent species of the higher plants.‡ The rapidity of Endosmose is also proved by the following circumstances viz: I. That, tho' Lichens are frequently desiccated by continued Drought, the least amount of rain restores their freshness; and II. That, when part only of a Lichen-Thallus is immersed in water, we speedily find the whole plant saturated & the progress of the absorption can often be traced by using colored liquids‡ This absorption takes place by the whole surface of the plant, which is suitably furnished with a porous cellular (but not true or isolateable) Cuticle— We have no evidence of any **Circulation**, or progressive movement of the **Sap**, nor are there visible any **Vessels**, or other channels, for such Circulation. The whole Thallus probably acts the part of the **Leaves**, submitting the Sap to the action of air & light, & the function of **Respiration** is probably performed thro'

Absorption — Assimilation — Endosmose — Circulation? — Respiration?

*Lindley's Veget. Kingdom P. †Tuckerman Synopsis North. Lichens P. ‡De Cand. Vegel. Organog.

thro' the **Pores**, which some aver exist in the Epidermis, which, however, is certainly destitute of true "**Stomata**"— The fluids of the plant are thus finally fitted for the process of **Assimilation**, in which every constituent cell takes part & form various Products & Secretions— The Function of the cellular rootlets (**Rhizinæ**), I have already mentioned, are supposed to be merely **fixative** & to have nothing to do with the absorption of nutriment— In the performance of the function of Respiration, or **Digestion**, more or less **Oxygen gas** is evolved in different species. De Candolle states that all those parts of Lichens, which are green, or capable of becoming so under water, disengage this gas on exposure to the sun's rays; but that no such evolution occurs in the denser & less colored parts of the plant.* We should expect this *a priori* from knowing that superjacent to these green parts, the Cortical or Epidermic layer of Lichen-tissue is thinnest & most transparent— Sprengel, however, expressly denies the occurrence of any evolution of Oxygen in any part of the plant, or at any period of its existence— "The juices, being so concentrated", says he, "no Oxygen is extricated by the influence of Light & a green color is but seldom observed in them" (Lichens) †

Among the Phanerogamia, we find the number & size of the Stomata regulating the Transpiration of fluids from the surface of the Leaf, and in plants with a dense Epidermis, cutaneous exhalation is less vigorous than where it is thinner & softer— In connection with these circumstances, it has been remarked, that the peculiar nature of the Leaves of some plants (e.g. the Phyllodia of Australian plants) has probably a relation to the dry nature of the climate ‡— May we not, by a similar reasoning, believe that the dense cortical layer of the Lichen-thallus, which has no stomata, is the kind of Epidermis, which Nature has selected as best suited for all the varieties of Climate situation &c, to which Lichens are exposed?

Functions of the Thallus.
— "—
Deficiency of Respiratory Organs
Function of the Fixurae?
Evolution of Oxygen? by the green parts of Thallus.
Probable advantages of the Deficiency of Stomata, Epidermis &c in the Lichen-Thallus.?

*De Cand. Vegel. Organog. †Sprengels Cryptogamia ‡Belfours Botany P. 105.

Growth of the Thallus

—"—

I. Sources of Nourishment

SOURCES OF NOURISHMENT.

Lichens are generally defined to be "Aerial plants, nourished by the whole medium in which they vegetate" From the atmosphere, they absorb Watery vapour, Carbonic Acid & ammonia, assimilating or fixing as proximate principles, the Hydrogen, Carbon & Nitrogen these contain — Many authors maintain that Lichens derive their whole nourishment from the Atmosphere, during the whole period of their existence; others state, more cautiously, that "During part of their growth, they appear to be capable of deriving most of their nourishment from the atmosphere"* If the atmosphere be the sole reservoir of their nourishment, then whence originate the Inorganic constituents, which all Lichens contain in greater or less quantity? — If they do not absorb a certain amount of nourishment from supporting substances, how are we to account for the salts of Potash, Soda, Lime, Magnesia, Iron &c, which we find in their ash; unless, certainly, we suppose that, from the very intimate Connection between many Lichens (Crustaceous) & subjacent bodies to which they are attached (Rocks — tree-barks &c), portions of the latter have been separated with the former & subjected, along with them, to Analysis: and this must occasionally occur — It comes therefore to be an important question whether & how much nourishment Lichens derive from substances to which they may be attached — Many circumstances favor the idea that they do derive a considerable portion of their constituent inorganic elements, at least, from these supporting substances — The well-known property possessed by many species of corroding or literally "eating their way" into even the hardest rocks has given rise to the belief that they must feed on these rocks to a certain extent: tho' some authors hold out this very fact as a proof to the contrary, supposing it impossible to derive much, if any, nutriment from rocks of such a nature as the hardest Lime-

stones

To what extent from Atmosphere — Organic Constituents of Food

To what extent from Soil or Bases of Support — Inorganic Constituents of Food.

Corrosion of Rocks, Adhesion to Barks &c as favoring view of Derivation of Inorganic Constituents at least from Bases of Support?

*Balfours Botany P. 557.

-stones, Sandstones, Granites &c.* Fée states that the Lichens growing on Cinchona Barks sometimes partake of their bitterness† & Martius mentions, as the result of an intimate knowledge of Tropical Lichens, that the Character of the Matrix or Barks on which they grow is all-important to be kept in view in examining such Lichens, since they often derive a great part of their physical & chemical properties therefrom‡ I entirely agree with Dr. Asa Gray in thinking, that, "tho' probably [these] plants can draw "their whole nourishment from the air, it does not follow that they do so — In "Nature, the races of plants that will grow at the entire expense of the air "(eg Lichens, — besides Masses, Ferns, many succulent Phanerogamia &c.) gradually "form a soil of vegetable mould, during their life, which they increase in "their decay & the successive generations live more vigorously upon the inheri-"tance, being supported partly on what they draw from the air & partly on the "ancestral accumulation of vegetable mould." ‖

Growth of Thallus

I. Sources of Nourishment

Chiefly from Atmosphere?

But probably also partially from Soil &c

GROWTH of the Lichen-Thallus is **Exogenous** (i.e the Thallus is increased by circumferential additions)§. But it differs from what is usually understood by exogenous growth, as applied to the higher plants, in several particulars & inter alia that it does not occur at regular periods, but is exceedingly irregular & **interrupted**, from the very great susceptibility of the Lichen-tissue to alterations from climatal changes &c. The structure of some of the higher Lichens (eg species of Usnea) strongly resembles, in many points, the structure of an Exogenous tree, to which they have long been compared by Lichenologists — In reference to the Structure of Lessonia fuscescens (one of the Laminarioid Algæ), which is very analogous to that of Usnea Melaxantha, Dr. Hooker says of the stem, "on being cut across, the curious

Nature of Growth

Exogenous? But characterized by Interruptions in Development & Modifications dependent thereon

Structural Analogy of the Stem? of Usnea to an Exogen?

*Berkeley q. Lindley's Vegt. Kingdom †Essai sur les Cryptogames &c ‡Martius Flora Brasil.

‖Grays Bot. Text. book P. §Schimper's Plates.

Growth of Thallus

II. Its Nature

Exogenous?

Structural Analogy between Usnea (Lichens) Lessonia (Algæ) and an Exogen?

"curious appearance of Concentric elliptical rings, in many respects similar "to, tho' very different from those of an Exogenous Trunk, is very evident. "These rings surround a lance-shaped, pale line, which occupies the broad axis "of the compressed stem, without reaching across it & appears to afford some "rude indication of the age of the plant, tho' of this we could by no means "satisfy ourselves." — "The analogy between the mode of growth exhibited by "this genus & an Exogenous tree is, tho' incomplete, very obvious. Both increase "by layers deposited outside one another, within a Cortical substance, & "both contain an axis of tissue different from that forming the greater part "of the Trunk: here, however, there are no traces of medullary rays" — "It is singular that this, the most arborescent of the Algæ, & the beautiful "Usnea Melaxantha, the most Tree-like in form of the Lichens, are nearly "the only plants of the orders to which they respectively belong, conspicuously "presenting even a semblance, if it be no more, to a growth that indicates "an increase by periodic accessions to the Circumference." *

III. Accessories to Growth

ACCESSORIES TO LICHEN-GROWTH. The principal circumstances, which favor the germination of the Lichen-spore & the subsequent development of the Lichen-Thallus, are certain degrees of Moisture, Temperature, Air & Light —

Moisture. — Its Degree — Small amount required

1. MOISTURE. Neither Germination nor vegetation will take place at all, unless under the influence of a certain degree of moisture — "Placed almost on the lowest degree of organization", says Sprengel, Lichens "often require "nothing for their conservation, but the moisture of the atmosphere, precipitated "on the naked masses of rock" † The **Degree** of Moisture necessary is less than that required for other Cryptogamic plants; "we therefore find them "[Lichens] flourishing in comparatively dry Climates, with moderate Temperature, "but attaining perfection in the moist season of the year" ‡ The powerful influence

* Hooker's Cryptog. Bot. of Antarct. Voy. of Erebus & Terror. Post. q. P.

† Sprengel's Cryptogamia

‡ Royle's Botany of the Himalayas P.

Growth of Thallus.

Accessories to Development

Moisture

Excess prejudicial.

Submerged Lichens?

Transformations dependent on Moisture

Effects of Drought

influence, which the degree of moisture exercises over Lichen-growth, is well illustrated by the interruptions or alterations in Lichen-development, which invariably succeed changes in the hygrometric state of the Atmosphere. Many authors, however, probably attribute too much power, in this respect, to moisture, when they regard Lichens as mere Abortions caused by deficiency of water; as "Aërial Algæ," whose character has been completely reversed by the unusual combination of external Circumstances - Fries, for instance, considers them as "Types of Algæ, born in the air, interrupted in their development by the deficiency of water & stimulated into forming a Nucleus (or receptacle of Sporules) by Light." * While, therefore, a constant & certain Amount of moisture is necessary for Lichen-growth, excess is as decidedly prejudicial - As a general rule, no Lichen is ever found growing, normally, if at all, under water (there are, according to some authors, a few exceptions); & in very damp situations, if Lichens grow at all, they do not develope their Apothecia, and are otherwise so much altered in character, as to be nearly indistinguishable from the Hydrophyceæ (Algæ) (eg the Collemata &c). † But if Plants, in such a condition, be removed from their moist habitat & exposed to the sun, their Algoid characters gradually disappear, while the Lichenoid become more apparent (as evidenced by the development of the Apothecia &c) † Accordingly, Collema limosum, flaccidum &c have been found, when surcharged with water, to become converted into Nostoc lichenoides, foliaceum &c † Acquaintance with the Laws of such Metamorphoses has enabled Fries to discover many Swedish Lichens with Apothecia, which had hitherto been found Sterile (eg Parmelia consplea — sanguinosa — gelida &c) & even artificially to cause Sterile Lichens to become fruitful (eg Alectoria jubata &c) † It seems to be generally admitted, however, that Lichens suffer more from Drought than moisture - Dr Hooker & others

Appx. P. 45.

* Royle's Bot. of Himalayas. † Fries q. Lindley's Veget. Kingdom

Accessories to Lichen-Growth —

Moisture and its effects on Developement

others have particularly noticed, that it often happens that the same species, which attain a very moderate or minimum developement in the Northern Hemisphere, reach a much higher or maximum developement in the Southern, apparently owing to the more uniform Temperature & humidity; & the same has been, over & over again, found to occur among species inhabiting both cold & dry & warm & moist climates — App. 38 41

2. Temperature — Degree required? often very low.

High temperature a cause of increased Developement.

thereby indirectly affecting Commercial value &c.?

II. TEMPERATURE. — An elevated Temperature is less <u>essential</u> to the germination & growth of Lichens, than to any other family of plants; for they are the most universally distributed of all plants, occurring in every climate & season, — growing with facility in every degree of temperature above zero — Indeed their structure seems best adapted for temperate & arctic climates", being naturally fitted to resist heat & cold, dryness & wetness —"* But, <u>cæteris paribus</u>, elevated Temperature has the same effect in stimulating the developement of Lichens, as it has in the case of the higher plants, ie we find them attaining their maximum Luxuriance & producing their Apothecia most abundantly in the Tropics, (where, besides increased Temperature, they are generally also under the influence of increased Light & moisture.) — Mirbel states that a much greater number of Lichens are endowed with qualities suited to a high Temperature, than to a very low one; & he proves this very satisfactorily by the Statistical distribution of Lichens from the Poles to the Equator† — Moreover, we find that, "In warmer Countries "they acquire a firmer Consistence & appear to form secretions of a peculiar "Kind, in much greater abundance than in the northern parts of the world — "<u>Orchil</u>, for instance, grows in Britain & the Canaries, & Botanists can detect no "external differences between the plants of these two Countries; yet, in the "latter, its dyeing matter is secreted so abundantly that Canary samples "fetch from £250 to £350. per Ton in the market, while the English are V.P. 44. App. P. 36 41.

Value of Orchella weeds from hot & temperate climates.

* Edinr. Encycl. Art. <u>Lichens</u>. † Mirbel Élémens de Physiologie végétale. Vol. I. P.

"are unsaleable"*

Accessories to Lichen-Growth

III. LIGHT AND AIR — The necessity of the presence of Light as a stimulus to Lichen-growth is illustrated negatively by the fact, that Lichens, very rarely indeed, occur in Mines, Caverns, Cellars &c, from which Light is totally or partially excluded, tho' other conditions (as to Heat & moisture &c) may be quite favorable — Deficiency of this stimulus also accounts for the circumstance, that, in the same species, apotheeia are much rarer in the fissures of Mountains & Shady groves, than in places fully exposed to the sun's rays† And by fully exposing to the light, the same plants that have been found barren in situations where this stimulus was absent, they have been caused artificially to produce apotheeia abundantly!

Exposure to Light and Air

Difference of Developement in the Light and Shade.

DECOMPOSITION of Organic Bodies unquestionably assists the developement of many species; and the advocates of the Doctrine of "Equivocal Generation" go so far as to say that it causes or originates Lichen-development?

Organic Decomposition and its effects.

But the deficiency of Moisture, Heat, Light &c seems to have a less powerful influence in arresting developement or causing death among Lichens than in any other family of plants — They often grow in circumstances least favorable to vegetation — A total absence or excess of light, — the extremes of humidity or dryness, — scorching heat or freezing cold, absolute privation of vegetable soil, & even a deficiency of Carbon, cannot prevent their developement — Hence they are of no mediocre importance in the grand Economy of Nature‡

Deficiency (partial or total?) of ordinary Accessories to Growth does not prevent Lichen-Development.

*Penny Cyclopaedia Art. Lichens. †Fries & Lindley Veget. Kingdom. ‡Mirbel. Elemens. Vol. I.

Chemical Composition.

CHEMICAL COMPOSITION OF LICHENS.

I. ORGANIC CONSTITUENTS.

I. Organic Constituents.

1. Carbon
2. Oxygen
3. Hydrogen
4. Nitrogen &c

The mass of the Lichen-tissue, when analysed, is found to consist chiefly of **Carbon**, combined with **Oxygen**, and **Hydrogen**, in the form of Cellulose, Lichen starch, Inuline, Gum & Mucilage, Sugar &c. **Nitrogen** also enters into ~~their~~ its composition, but in much smaller quantity —

II. INORGANIC CONSTITUENTS, as determined by analysis of the ash of various Lichens;

II. Inorganic Constituents.

1. Chlorine

Chlorine, as a Chloride, combined with Sodium in the shape of common salt (Chloride of Sodium): found chiefly in maritime species (eg the Genus Roccella - Orchella weed): occurs also in Litmus —

2. Sulphur

Sulphur, combined with Oxygen, as Sulphuric Acid, in combination with Lime & other bases: occurs in Litmus, Roccella tinctoria &c —

3. Phosphorus

Phosphorus, in union with Oxygen, as **Phosphoric acid**, usually combined with Lime &c: occurs in Litmus - Roccella tinctoria - Cetraria Islandica &c -

4. Potassium

Potassium, united with Oxygen, as Potash, combined with various acids (Tartaric - Carbonic &c). Bitartrate of Potash is a constituent of Cetraria Islandica & Carbonate of Potash is found in Litmus —

5. Sodium

Sodium, united with Oxygen, as **Soda**, or with Chlorine, as the **Chloride of Sodium**; both of which occur in the Roccellas & other maritime Lichens —

6. Calcium

Calcium, united with Oxygen, as **Lime**, which is combined with various acids (Carbonic, Sulphuric, Tartaric, Phosphoric & **Oxalic** &c). The Carbonate & Sulphate occur in Litmus & the Tartrate in Cetraria Islandica, Roccella tinctoria &c, the Phosphate in Cetraria Islandica &c — & the Oxalate[2] in a very great number of Lichens, among which may be mentioned, as containing it in great abundance, Variolaria amara, V. faginea

7. Magnesium

Magnesium, united with Oxygen, as **Magnesia**, which is found in Roccella tinctoria —

Chemical Composition

II. Inorganic Constituents.

8. Aluminum

9. Silicon

10. Iron

Per Centage of Ash in Lichens.

Manganese?

aff. p. 25 26. **Aluminum**, combined with Oxygen, as **Alumina**, occurring in Roccella tinctoria, Litmus &c. —

aff. p. 24. 25. 26. **Silicon**, in union with Oxygen, as **Silica**, also occurring in Roccella tinctoria, Litmus &c. It has frequently been noticed that Lichens growing on Siliceous rocks contain more Silica, in their ash, than those in other situations* —

aff. p. 24. 25. 26. 42. **Iron**, combined with Oxygen, as a **Peroxide of Iron**, found in Roccella tinctoria, Litmus &c. — John of Berlin states that specimens growing on the summit of Fir trees contain an unusual amount of this salt — "a curious illustration of the peculiar powers, which [Lichens] "possess of separating the inorganic matters presented to them in "their food" †

The Chemical composition of the Lichens varies very much with changes in external circumstances (eg differences as to situation & soil — moisture, heat &c.) — We find particular salts predominating in aff. p. 26. species inhabiting particular localities (e.g. salts of Soda, Lime &c. in species whose habitat is the Sea-coast — The ashes of Lichens constitute about 8 per cent. of the dried plants; but in many species the amount greatly exceeds this proportion —

aff. p. 42. I am not aware that **Manganese** has, as yet, been detected in Lichens, but judging from the Colour of the Thallus of many species, I have little doubt that it exists —

*Parsina Mat. Med. Vol. 2. Part 1. †Lindley's Veget. Kingdom. P.

Products and Secretions

PRODUCTS AND SECRETIONS OF LICHENS.

I. Amylaceous matters.

I. AMYLACEOUS SUBSTANCES.

Lichenine

1. LICHENIN (LICHEN STARCH.)

Forms Cell-membrane?

——may be said to occur in almost every part of the Lichen-plant—It forms the membrane of the vegetative cell & of the Thecæ of most species, according to some authors;

Where occurs chiefly?

& it is also found in these cells themselves & in the intercellular spaces. But it is neither confined to the Thallus, nor is it of universal occurrence even there, if the action of Iodine, in producing a blue color, is to be considered an accurate test—For instance, Mr. Dickie failed to detect it either in the Thallus or Thecæ of Baeomyces, tho found it in the Thecæ, but not in the Thallus of Collema.* "The presence or absence of Lichenine

Its presence supposed to corroborate Analogy between Lichens & Algæ?

in certain species has been regarded by many as corroborative of the analogy between these species & species belonging to other Cryptogamic families—"As a proof of the close analogy between the Lichens & some "Algæ, Raspail, in his Organic Chemistry, states his belief that the colors "of many marine Algæ depend on a peculiar Combination of Iodine with "Starch, & that he has succeeded in tinging some Lichens with Iodine "so as to resemble some Algæ".* And, deficiency of Starch, in the genus

Absence in Baeomyces?

Baeomyces, is considered one proof of its close affinity with the Fungi, which contain no Starch (so far at least as the presence of starch can be exhibited by Iodine).*

Effects of Reagents

Lichen-starch is rendered of a blue color by the action of Iodine;

Formula and Composition

& according to Schnedermann & Knopp, Muriatic acid converts it into a transparent jelly† Mulder gives the formula as $C_{12}H_{10}O_{10}$. & considers it very closely analogous to Cellulose,—and as intermediate between Dextrin & Common Starch—Lichen-tissue, when boiled in water, (eg Cetraria islandica),

State of Combination?

produces a gelatinous substance, similar in composition to common starch, but varying in several species—In what form this Starch exists in the plants.

*Dickie on the Reproductive organs of the Lichens—Magazine of Zoology & Botany Vol. 8. P. 166.

†Pereira Mat. Med. Vol. 2. Pt. 1.

Products and Secretions
I Amylaceous matters
Lichenine
Its Chemical Nature and Affinities.

plants is at present matter of discussion – Minute globules are found in the Lichen-cells, soluble in boiling water; but their number is insufficient to account for the very large amount of Lichenin obtainable from the cellular tissue of many species * – It may not be a substance merely dissolved during boiling, – a ready-formed matter, – but a product from some of the "constituents of the plant which enclose the cell-substance" † When pure, Lichen-starch is stated to be nearly colorless, – tasteless, – swelling up into a transparent jelly with cold water, & entirely soluble in hot – Its solution, when boiled, forms pellicles like milk, which adhere to the sides of the vessel – Gregory states that its solution is <u>not colored</u> by Iodine, tho' its jelly is rendered blue: that it is convertible, by dilute & boiling Sulphuric acid, into **Sugar**, & by Nitric acid into **Oxalic and Saccharic acids** ‡ – It is retentive of water &, in the moist state, is white, but, on drying, becomes yellowish, ¶ – in thin plates transparent, – tough – nearly odourless – Hot solution decomposed & precipitated by Diacetate of Lead: & yields a dingy <u>green</u> with Iodine, ¶ according to some, yellowish <u>brown</u>, according to others – It has been stated to be **Poisonous**, (tho' on what grounds I cannot guess); – & it is said to possess the alkaline property of combining with acids, tho' it does not form crystallizable salts with them ¶ – It consists of

Physical and chemical characters.

V.P. 34. 36.

Convertibility into Sugar, Oxalic acid, Saccharic acid &ca

Ed. 33.

Hydrogen	7·24	or nearly	10 Equivalents	= 10	=	6·66
Carbon	39·33	"	10 "	= 60	=	40·00
Oxygen	53·43	"	10 "	= 80	=	53·34. ¶

Obtainable from Cetraria Islandica

Payen prepared it from <u>Cetraria Islandica</u>, &, after drying at 100°, found it analytically to be represented by the formula $C_{12}H_{10}O_5$ § – With Potash, Lime, Oxide of Lead & Tincture of Galls, the habitudes of Lichenine & common starch are the same ♀

* Meyen's Physiologie
† Mulder's Physiology P.
§ L'Institut for 1837
‡ Gregory's Organic Chemistry P. 498.
¶ Penny Cyclopaedia Vol. 13. Art. <u>Lichenine</u>.
& Rep. on progress of Veget. Physiol. in by Meyer & Francis. 1837.
♀ Ure's Dict. of Science Last. Art. Dyeing.

Products and Secretions.

1. Amylaceous matters.

2. Cellulose.

Forms the Cell-membrane?

Chemical Composition and affinities.

Formulæ

Preparation

State of Combination.

II. CELLULOSE.—' seems to be considered by most authors as forming the Membrane of the Lichen-cell- Payen, in his researches on Cellulose, found pure Lichen-Cellulose to consist of C. 44.70 H. 6.21 O. 49.09 * and he believes that Lichenine is neither more nor less than an impure form of Cellulose. Fromberg repeated & confirmed Payen's experiments- He found Cetraria Islandica, after exhaustion with Soda (1 part to 10 of water), & then with water & alcohol, to consist of C. 46.88 H. 6.18 O. 46.94. which in a Second experiment was slightly varied viz:— C. 45.85 H. 6.22 O. 47.93 †

As the result of extensive experiments on the Cellulose of plants, he states its formula to be $C_{24} H_{21} O_{21}$.- It is obtainable from all plants & from every part of these plants, without exception, "simply by separating every other substance, by means of Solvents;" and is generally prepared by digestion with Alcohol, Ether, diluted Potash, Muriatic acid & water.† Payen remarks, "the proper Tissue of all plants, which have been previously exposed to the Influence of these solvents, leaves a substance, which is identical for all of them,- which contains Carbon & the elements of water- which is isomeric with Inuline & therefore may easily be changed into Starch & Sugar & in its turn may possibly be produced from dextrin,- the change in this instance consisting only in the loss or addition of water."†

* Ann. de Sciences Nat. Aug! 1840. P. 73. q. Mulder's Physiol.

† Mulder's Physiol.

Products and Secretions

I. Amylaceous matters.

3. Inuline.

In small quantity.

In Cetraria Islandica

Chemical Composition and affinities.

III. INULINE, according to Payen & other authors, exists, tho' in small quantity, in Cetraria Islandica – It is colored yellow by Iodine: its formula, when insoluble in cold water, is probably $C_{12} H_{10} O_{10}$. Mulder believes that the greater part of Lichenine consists of a Starch, which resembles Inuline in being colored yellow by Iodine, & common Starch, in being precipitated by basic Acetate of Lead*. He considers Inuline as intermediate in composition &c. between common Starch & Sugar (& Lichenine as intermediate between Dextrin & common starch); these two substances (Lichenine & Inuline) serving to fill up the interval in the series of the Four chief constituents of all plants (viz: Cellulose, Starch, Dextrine & Sugar,) by which their mutual transition is made to appear less abrupt – When, to a decoction of Cetraria Islandica, sub-acetate of Lead is added, a precipitate is thrown down, which is found to consist entirely of **Amylate of Lead**, the Inuline being retained in Solution – If we now pass a stream of Sulphuretted Hydrogen through the filtered Liquid, only a little uncrystallizable sugar is thrown down, but the Inuline is obtained after again filtering & evaporating –

Value of Lichens (from their Amylaceous constituents) as Food, in Materia medica &c.

"The presence of Amylaceous & Mucilaginous substances in many species of Lichens has endowed them in no mean degree with **Nutritive & Demulcent** properties, which has caused their extensive use as articles of **Food** by many of the lower animals & even by Man himself, – chiefly in Arctic regions. The highly nutritive qualities of Cellulose, which exists so abundantly in Lichens, may be explained by its easy convertibility into Dextrine (which again is convertible into Starch, Gum, & Sugar) – These various substances, which are so important for the maintenance of the vital functions of animals, are probably all producible from the same cellulose, "simply by a change in its physical character, and a new chemical arrangement of its constituents, – the chemical composition of all being nearly identical" † Cellulose, in fact, is to plants

Nutritiveness of Lichen-Amylum

Convertibility into Dextrin Sugar &c.

* Pereira Mat. Med. Vol. 2. P. 1.

† Mulders Physiol.

Products and Secretions

plants what Gelatine is to animals: they form together the cells in these two Kingdoms"†

II. Gummy and Saccharine Substances.

II. GUMMY AND SACCHARINE SUBSTANCES.

1. Gum & Mucilage in small quantity in Cetraria Islandica, Evernia prunastri. &c.

1. GUM AND MUCILAGE—occur, in small quantity, in a considerable number of Lichens, in all probability, & in a few species, in such amount as to have been at one time employed in the arts—It has been chiefly found in Cetraria Islandica, Evernia prunastri, Sticta pulmonaria, Ramalina fraxinea & farinacea—M. Georgi, (who made a series of experiments to determine the amount of mucilage in various species of Lichens) found Ramalina farinacea, Cetraria glauca, Parmelia physodes & Sticta pulmonaria yielded a mucilage, which, when dried, became as transparent as Gum arabic*—Amoreux, in repeating Georgi's experiments, found it also in Evernia prunastri, Ramalina fraxinea, Peltidea canina & Parmelia caperata—

Transparent? on drying

2. Sugar small quantity in Cetraria Islandica

2. SUGAR—occurs in very small quantity & has only been detected in a very few Lichens—Berzelius & others mention the existence of upwards of 3 per. Cent. of Uncrystallizable Sugar in Cetraria Islandica—

III. Mannite in small amount in Roccella Montagnei &c.

a. MANNITE—Will probably be discovered in one or two Lichens. A few of its derivatives have already been noticed (e.g. Dr. Stenhouse mentions the occurrence in Roccella Montagnei of **Erythro-mannite**, a sweet crystallizable body—and the quinto-nitrated Erythro-mannite, a detonating Compound, analogous to quinto-nitrated Mannite.‡

† Mulders Physiol. * Mém. de l'Acad. de Pétersbourg. Ann. 1779. q. Amoreux Recherches &c.

‡ Proceed. of Philos. Socy. of Glasgow—1848-9. Vol. 3 P. 82.

Products and Secretions

III. WAXY AND RESINOID SUBSTANCES.

III. Waxy and Resinoid matters

1. WAX occurs but in minute quantity & has principally been found in Cetraria Islandica, Parmelia parietina & Roccella tinctoria —

Wax, Resins. in small amount

2. RESINS [redacted] likewise [redacted] occur [redacted] in small quantity: & have been detected inter alia in Parmelia parietina & Roccella tinctoria (from the latter of which Nees von Esenbeck extracted a Brown resin — soluble in alcohol & Ether & becoming brownish red with Ammonia)*

IV. FATTY AND OILY SUBSTANCES.

IV. Fatty and Oily matters.

1. STEARINE, mentioned by Herberger, as occurring in Parmelia parietina.†

1. Stearine

a. LICHESTEARIC ACID ϕ (λειχήν a lichen and στέαρ fat) is found inter alia in Cetraria Islandica — Its characters, as given by Pereira, are: When pure, quite white, consisting of pearly crystalline flakes — odorless — but has an acrid taste — Soluble in alcohol — Ether & the volatile & fatty oils: but insoluble in water — At 248° Fahr., it melts, & congeals, on cooling, into a Crystalline mass — Cannot be volatilized without decomposition — Dissolved by alkalis & precipitated from its alkaline solution by acids — Formula $C_{29} H_{25} O_6$ — Among its salts may be mentioned:

Lichestearic acid.

Physical and Chemical Characters.

Formula and Composition

Compounds

Lichestearate of Potash, — a white, indistinctly-crystalline powder —

——— " ——— Silver ($Ag O, C_{29} H_{24} O_5$) a greyish-white powder —

——— " ——— Lead ($Pb O, C_{24} H_{24} O_5$) a white powder —

——— " ——— Baryta, — a greyish-white powder —

——— " ——— Ammonia, — a crystallizable salt* —

2. ROCCELLIC ACID — ϕ occurs in Roccella tinctoria — "It is crystallizable, insoluble in water, soluble in Alcohol & Ether — It has most of the properties of a fat acid & its salts, with the alkalis, resemble

2. Roccellic acid.

Physical and Chemical Characters.

*Pereira Mat. Med. Vol 2 Pt 1.

†Buchner's Repertor. 1834 q. Pereira Mat. Med.

ϕ Vide Liebig & Kopp's Annalen. Thomson's Org. Chem.

Products and Secretions

IV. Fatty and Oily matters.

3. Volatile oils?

resemble Soaps" Formula $C_{17} H_{15} O_{31} HO$?*, or, as Mulder gives it, $C_{17} H_{16} O_4$†: but Schunck states it as $C_{24} H_{28} O_6$‡ Fusible about 250°¶

3. VOLATILE OILS — have been detected in small quantity in a few species (eg. Herberger mentions them in Parmelia parietina §) —

V. Organic acids

V. ORGANIC ACIDS

1. Oxalic

Amount of Oxalate of Lime in various Lichens.

1. OXALIC ACID exists, in the form of Oxalate of Lime, in a considerable number of Lichens & in some species in very large quantity — In Variolaria faginea, Braconnot found 29.4 p. cent of Oxalic acid, combined with 18 of lime & in nearly equal abundance in several granular & crustaceous species. He remarks, that this salt bears the same relation to the Cryptogamia, that Carbonate of Lime does to Corals, or the Phosphate to the bones of the higher animals — Its proportion decreases in Lichens as they loose their crustaceous texture & acquire a Cartilaginous or membranaceous one, tho', even in Cartilaginous species, it often exists in considerable quantity — Variolaria faginea has actually been proposed for use on the large scale, for the Manufacture of Oxalic acid; & Hooker mentions, on the authority of an eminent French chemist, that it was at one period (Year 1833 — it may still be) employed in France for this purpose, on a very extensive scale §

Some species proposed as a Commercial Source of Oxalic acid

2. Tartaric.

in combination with Potash & Lime

2. TARTARIC ACID occurs chiefly in the form of Bitartrate of Potash, and Tartrate of Lime, in Cetraria Islandica, Roccella tinctoria & other species —

§ Smith's Engl. Flora Vol 5. P. 169.

* Gregory's Organic Chem. P. 430.

† Mulders Physiol.

¶ Christison's Dispensat. Art. Lacmus.

‡ Lond. Ed. & Dublin Philos. Mag. 1848. Paper by D. Schunck on Stenhouse's discoveries

§ Buchner's Report. q. Pereira Mat. Med. Vol. IV.

Products and Secretions

V. Organic acids

3. Gallic and 4. Tannic impart astringency to several species.

3. GALLIC ACID ——— } occur, tho' in small quantity, in
4. TANNIC ACID (TANNIN.)— } several Lichens — Berzelius detected Gallic acid in Cetraria Islandica;* & Sprengel mentions that Stieta Pulmonaria contains Tannin in such quantity, that in some parts of Norway & Sweden, this Lichen is employed in Tanning† —

5. Fumaric and its occurrence in the Phanerogamia

5. FUMARIC ACID (LICHENIC PARAMALEIC ACID.) was discovered in Cetraria Islandica by Pfaff‡ When extracted from this Lichen (or from Fumaria officinalis, in which it also occurs, — or when made from Malic or Maleic acids) it consists of Micaceous scales, requiring 200 parts of cold water for solution — Soluble in alcohol. Formula $C_4 HO_3, HO = \overline{Fu}\, HO$.¶

Composition &c

VI. BITTER PRINCIPLES.

VI. Bitter Principles.

1. Cetraric acid

Its seat —

Physical and chemical Characters.

1. CETRARIC ACID (CETRARIN.) exists abundantly in Cetraria Islandica, from which it has chiefly been obtained — It resides in the Cortical layer of the Thallus of that Plant, chiefly as Cetraric acid, but as a Cetrarate — Its characters, as given by Pereira, are the following: When pure, it consists of shining, minute, acicular crystals — Intensely bitter — non volatile — infusible, without decomposition, — Nearly insoluble in Water, to which however it imparts a better taste, when boiled in it — Soluble in boiling alcohol, crystallizing in great part on cooling — Sparingly soluble in Ether & quite insoluble in fixed & volatile oils — Soluble in Caustic & carbonated alkalis — and precipitated from its alkaline solution by acids — Formula $C_{34} H_{16} O_{15}$ ‡ of its salts, I may merely mention the

Formula and Composition

Cetrarate

* Annales de Chimie 90. 277 q. Pereira Mat. Med. 2d. P. 1. † Sprengel's Cryptog. P.
‡ Pereira Mat. Med. 2d P. ¶ Gregory's Organ. Chemistry P. 416.

Products and Secretions

VI. Bitter Principles.

I. Cetraric acid

Its Compounds with Ammonia

Cause of the Brown Color of Thallus?

a. **Cetrarate of Ammonia** — Formula $2NH_3, C_{34}H_{16}O_{15}$ — It is a beautiful yellow salt, with a faint ammoniacal odour, — soluble in water, gradually acquires a brown color on exposure to the air — Schnedermann has endeavoured to explain the production of the **Brown Colour** of the **Thallus** of **Cetraria Islandica**, by supposing, that the Cetraric acid, contained in the cortical layer of the Thallus, absorbs Ammonia from the atmosphere, & the Cetrarate of Ammonia, formed in this way, becomes brown by exposure to the air*? V. P. 14.

With Iron.

Cause of Red Spots &c on Thallus.

Alkaline Cetrarates yield a red precipitate with β. Salts of Peroxide of Iron (**Cetrarate of Iron**). As the ashes of Cetraria Islandica have been found to contain Iron, Schnedermann accounts for the occurrence of the **Red spots**, which are seen occasionally at the base of this Lichen, by assuming the presence of this salt, which may have been produced by the action of the Cetrarate of Ammonia on the Ferruginous Constituent? V. P. 14.*

With Lead

γ. **Cetrarate of Lead** ($2PbO, C_{34}H_{16}O_{15}$) forms a yellow, flocculent Precipitate*

With Copper

δ. **Cetrarate of Copper** is thrown down, as a green precipitate, from a decoction of Cetraria Islandica, by a Mixture of Sulphate of Copper & Potash*

Preparation of Cetraric acid

Cetraric acid is usually prepared by exhausting Cetraria Islandica by means of Sub-carbonate of Potash & Quicklime†

*Pereira Mat. Med. V. I. Ps. †Coventry "On the foods derived from the Cryptogamia &c Pharmaceut. Times Feby. 6/47.

Products and Secretions

VI. Bitter Principles.

2. Picro-lichenine

Chemical Characters

2. PICRO-LICHENINE ♀ is a Crystalline bitter, found in Variolaria amara — In contact with Ammonia, & with the access of air, "it is changed into a reddish-yellow matter, which finally deposits "yellow crystals, not bitter — With access of air, it yields, with Am- "-monia, a deep-red, very soluble matter." *

Amarythrine

Varioline

Stictine &c occurring in minute quantity in particular species

AMARYTHRINE $(C_{22}H_{12}O_{14}^{*})$ ♀ }
VARIOLINE ——— ♀ } are bitter principles, which have been mentioned, by various authors, as occurring in several species of Variolaria — (Kane - Lindley - Gregory &c); but of these, as well as of **STICTINE** (so called from being found chiefly in Sticta Pulmonaria) our information is exceedingly scanty & imperfect —

Bitter principles impart Febrifuge Tonic & Purgative Properties &c to some species

The presence of pure bitter principles in many Lichens formerly led very extensively to their use as Febrifuges, Tonics, Stomachics &c (e.g Variolaria amara, faginea & discoidea, Parmelia parietina, Cetraria Islandica, & Sticta Pulmonaria); and, where these principles were of an acrid character, the Lichens containing them were found to possess Purgative qualities (eg various species of Gyrophora) —

V.P. 14.

pp. P. 18

VII. COLORING MATTERS

VII. Colouring Matters.

constitute certainly the most important products of Lichens. They are divisible into two great groups or divisions viz:

divisible into

I. Colorific Principles and

II. Colouring Principles

1. COLORIFIC PRINCIPLES, or substances, which are **colourless**, while in the plants containing them, but, under the influence of Ammonia & atmospheric Oxygen, (in other words by Oxydation) they yield **Coloured** or **colouring** substances, the greater number of which, tho', by no means identical, have usually been classed by authors under the general name of **Orcéine** — In the majority of cases these

Chemical Characters of Colorific Principles

* Gregory Organ. Chem. P. 457 ♀ Vide Thomson's Organic Chemistry

Products and Secretions

VII. Colouring matters.

these Colorific principles are organic **Acids**— The precise nature of the Chemical changes, which take place in the conversion of the Colorific principles into Orcine, seems at present to be matter of dispute— "Some are not directly converted into Colored substances, but into **intermediate** substances, (eg Lecanoric acid, before being converted into Orcéine, become Orcine)— Liebig, assuming the formulæ given for these three bodies by MM. Schunck, Will & Dumas, proposes the following Theoretical Explanation :——

Chemical Peculiarities affinities &c of the Colorific Principles.

Theories of Liebig &c

Lecanoric acid ($C_{18} H_8 O_8$) gives out 2 atoms of Carbonic acid $C_2 H_4$ & becomes Anhydrous Orcine $C_{16} H_8 O_4$, which with 3 atoms of Water $H_3 O_3$ will yield 1 atom of Crystallized Orcine $C_{16} H_{11} O_7$; and 1 atom of crystallized Orcine, with 1 atom of Ammonia & 5 of Oxygen, ($C_{16} H_{11} O_7 + NH_3 + 5O$) will yield 1 atom of

Orcéine $C_{16} H_9 NO_7$ and 5 of water.——

But, as the accuracy of the data on which Liebig founds his Theory, has been repeatedly questioned, the Conclusions drawn therefrom cannot safely be relied on *—

Peculiarities of the Colouring Principles

2. COLORING PRINCIPLES. —ie. colored substances either existing ready-formed in the Lichen, or produced by the action of Ammonia & air on the Colorific principles, (and in this case they are generally **Nitrogenous**)— V.P. 14.

a third group whose Composition, affinities &c are imperfectly known?

To these two groups, a third may perhaps be added viz: Those substances, whose composition & properties are so imperfectly known at present, that their true affinities (& consequently Classification) cannot be accurately determined— Stenhouse, Schunck & several other authors have lately contributed greatly to extend our knowledge of the Colorific & Coloring principles of the Lichens, but it must be confessed that, even yet, a very considerable degree of doubt & obscurity overhangs the whole subject—

* Pereira Mat. Med. V. 2. P. 1.

I. COLORIFIC PRINCIPLES.

Introduce here, from Pereira's "Materia medica", the following Table, furnished to him by Dr. Stenhouse of London, of the chief Colorific principles of various Lichens &c. :

Lichens.		Colorific principles.		Colouring principles		Authority
Commercial names.	Locality	Names	Formulæ	Name	Formula	
So. American Orchella-weed	Lima &c.	Alpha-Orsellic Acid	$C_{32}H_{15}O_{13}+HO.$	Orcéine	$C_{18}H_{10}NO.$	Stenhouse
Cape Orchella-weed	Cape of Good Hope	Beta-Orsellic acid	$C_{34}H_{18}O_{14}+HO.$	"		"
Angola — " —	Angola, Africa	Erythric acid	$C_{20}H_{10}O_{9}+HO.$	"		"
Terelle moss (Lecanora parella)	Switzerland	Lecanoric "	$C_{18}H_{8}O_{8}$	"		Schunck
Tartareous moss (Lecanora tartarea)	Norway	Gyrophoric "	$C_{36}H_{18}O_{15}$	"		Stenhouse
Pustulatous moss (Gyrophora pustulata)	"	"	"	"		"
Ragged hoary Lichen (Evernia prunastri)	Scotland	Evernic "	$C_{34}H_{15}O_{13}+HO.$	"		"
Usnea florida, plicata and hirta &c.	Germany	Usnic "	$C_{38}H_{17}O_{14}$	"		Rochleder & Heldt.
Rein-deer moss (Cladonia rangiferina)	"	"	"	"		"
Ramalina fastigiata & calicaris	"	"	"	"		"

Table of their Sources, Chemical Composition &c.

Detailed Enumeration

Bp. 49.
App. p. 15. 16.

1. ORSELLIC ACID.

Orsellic acid a variety. in Roccella tinctoria

Chemical Characters &c.

a. ALPHA-ORSELLIC ACID, [1] — the colorific principle of Lima (thick) Orchella weed (Roccella tinctoria). Pereira, following Stenhouse, gives the following as its characters: Prepared by maceration in milk of Lime & adding Hydrochloric acid in excess to the filtered solution. By this means, a white, gelatinous precipitate is thrown down, which, after being washed & dried, is dissolved in warm alcohol, & the solution, on cooling, deposits stellate, prismatic crystals of the acid — Nearly insoluble in cold water — sparingly so in boiling water

[1] Vide Liebig & Kopp annalen.

Products and Secretions.

III. Colouring matters.

I. Colorific Principles

alpha-Orsellic acid

Formula and Composition

water,— pretty soluble in cold Alcohol & Ether & readily so in boiling alcohol— Reddens Litmus — Forms crystallizable salts with the alkalies & earths — Presence may easily be detected by the deep blood-red color, which it instantly strikes with a solution of Hypochlorite of Lime,— the color soon changing to yellow & gradually disappearing — A solution of alpha-orsellic acid in Ammonia, on exposure to the air, soon assumes a bright red color, which is gradually converted into a dark purple* Stenhouse's formula is $C_{32} H_{16} O_{14}$.† V.P. 15.

Beta-Orsellic acid in Roccella hypomecha

Chemical Composition &c

β. BETA-ORSELLIC ACID,§ — the colorific principle of Cape of Good Hope Orchella weed ("Roccella hypomecha"). Stenhouse states it to be intermediate in properties between Alpha-orsellic & Erythric acids, tho' it bears most resemblance to the former. Crystallizable — Solution yields a fugitive Blood-red color with Hypochlorite of Lime & its Ammoniacal solution also acquires a red color on exposure to the air, as in the case of alpha-orsellic acid* — Stenhouse's formula $C_{34} H_{18} O_{15}$.† App. P. 15.16

2. Erythric acid. in Roccella fuciformis

Chemical Composition &c

2. ERYTHRIC ACID§' (Schunck & Stenhouse),— the Colorific principle of Angola & Madagascar Orchella weeds (Roccella fuciformis) Stenhouse obtained so much as 12 p. cent of the crude acid by Maceration in Milk of Lime — Its properties are feebler than the Alpha- & Beta-Orsellic acids,— but it agrees with them, in being crystallizable, & in yielding red-colored compounds with Ammonia,— and in its reaction with Hypochlorite of Lime* — Schunck's formula is $C_{42} H_{23} O_{21}$; & he considers it a Compound of Lecanoric acid & Picro-erythrine, or, in other words, Erythrine-Lecanoric acid — '2p. 49. App. P. 15. V.P. 15.

* Pereira Mat. Med. V. 2 Pt. 1. P. 928 4g.

† Lond. Edr. & Dub. Phil. Mag. 1848. Schunck on Stenhouse's discoveries.

§ Vide Liebig & Kopp. Annalen. Thomson's Org. Chem.

Products and Secretions

III. Colouring matters.

1. Colorific Principles

3. Lecanoric acid in Lecanora parella &c.

Chemical Composition, Derivatives &c.

3. LECANORIC ACID (LECANORINE.) – the Colorific principle of Lecanora parella –, according to Schunck – Gregory mentions its occurrence in Lecanora tartarea, Variolaria Lactea &c.* It is extractable by Ether, forming minute, white crystals, – insoluble in water, – soluble in alcohol & Ether – When heated with alkalis (eg Baryta) a carbonate is deposited, & a sweet substance remains in solution, crystallizing on evaporation, which is **Orcine** ($C_{16}H_8O_4$ = Lecanorine minus 2 eq. Carbonic Acid C_2O_4) With boiling alcohol, Lecanoric acid yields a solid crystallizable Ether:

Lecanoric Ether[2] ($C_{18}H_8O_8 + C_4H_5O = C_{22}H_{13}O_9$) †

The formula given by MM. Laurent & Gerhardt is $C_{16}H_{14}O_7$ for Lecanorine ‡

4. GYROPHORIC ACID–, Colorific principle of Lecanora tartarea & Umbilicaria pustulata [Stenhouse] –

4. Gyrophoric acid in Lecanora tartarea &c.

5. EVERNIC ACID ϕ – Colorific principle of Evernia prunastri (Stenhouse). Rochleder & Heldt found not Evernic, but Lecanoric acid, however, in Evernia prunastri – Schunck gives the formula $C_{36}H_{17}O_{15}$ & regards Evernic acid as composed of Lecanoric &

5. Evernic acid in Evernia prunastri

Evernesic acid – Composition &c.

a. **Evernesic** acid ($C_{18}H_{10}O_8$) On this Theory, it may happen that Evernia prunastri contains Lecanoric acid alone, as was found by Rochleder & Heldt, – or combined with Evernesic acid, the form of Evernic as found by Stenhouse †

* Gregory's Organ. Chem. P. 460.

ϕ L. Liebig & Kopp. annalen

† Lond. Edinr. & Dublin Philos. Mag. 1848. Schunck on substances discovered by Stenhouse in Roccella tinctoria &c.

‡ Ibid. Laurent & Gerhardt on Orcine & its derivatives

Products and Secretions

III. Colouring matters.

I. Colorific Principles.

6. Usnic acid. in Usneæ, Cladoniæ, Ramalineæ &c.

State of Combination

Influence on Color of the Thallus.

e.g. of the Parmeliaceæ, Usneæ &c.

6. USNIC ACID (USNINE) Knop found it in several species of Usnea (e.g. florida, hirta, plicata &c.); Rochleder & Heldt discovered it in Cladonia rangiferina, Usnea barbata & Ramalina calicaris; &, in addition to these species, Stenhouse detected it in Ramalina fraxinea & Evernia prunastri. - Stenhouse gives the formula $C_{38}H_{24}O_{10}$ - & mentions that it is most easily prepared by macerating any of these Lichens in milk of Lime & precipitating the filtered solution by Hydrochloric acid* - Lindley mentions that Usnine exists in greatest abundance in the Sulphur-yellow Lichens, where it probably occurs in a free state: and that the Apothecia of Lichens, which contain Usnine are generally similar in color to the Thallus, or brown, reddish-brown or Carmine red. (the latter colors, either in the Apothecia or Thallus, being probably produced, "by the action of "the alkalis & earths of the vegetable salts in these Lichens, the Ammonia of the rain water assisting the chemical action of the "Usnic acid, which is otherwise insoluble in water."). Cladonia rangiferina contains Usnic acid probably - the state of an earthy salt. "If we suspend, in a glass, over a solution of Carbonate of ammonia, "pure yellow specimens of Lecidea geographica, (which sometimes also "possesses a yellowish-green color), they gradually become covered "with Carmine-red globules: and, after frequent washings, they "completely loose their contained Usnic acid & acquire a grayish- "white color like dead Lichens. The Parmelia & Usneæ, when "treated similarly with Ammonia, & dried, acquire a brownish- "black color; and a similar change takes place naturally "when removal from a moist & shady situation (where they exhibit "a brilliant green color) exposes them directly to the heat of the "sun†. The apothecia of the Cladoniæ too acquire a brown tint, "when ached on in the same way by Ammonia, - or with

* London, Edinr. & Dub. Philos. Mag. for 1848. Dr. Stenhouse on alpha- & beta-orcine

† Chemical gazette for 1844. P. 182. & Lindley Vegtl. Kingdom P. 49.

Products and Secretions

VII. Colouring matters.

1. Colorific Principles

with the advancing age of the plant. The production of the various colors other than yellow in the above instances (green, red & brown & their different shades & intermixtures) is said to depend on the Oxidation of the Usnic acid (which is per se yellow), in combination with bases by exposure to the air."* V.P.15.

ERYTHRINE† is a principle, similar to Erythric acid, which was discovered in Roccella tinctoria by Heeren. It is prepared by boiling the Lichen with alcohol. Gregory remarks, "It is probably a product of decomposition of some substance analogous to Lecanorine. When exposed to the air, along with Ammonia, it slowly becomes red & finally yields a brown bitter compound, which dissolves in fixed alkalis with a purple color."‡ 11.p.49. V.P.15. 64.

Erythrine in Roccella tinctoria

Preparation, Composition &c.

PSEUDO-ERYTHRINE.— † Gregory says "is a similar substance [alluding to Erythrine] occasionally obtained, & occasionally altogether wanting, in the alcoholic solutions of the Lichens. It is evidently subject to decomposition, when its solutions are boiled."† It seems to be an **Ether**[2] (solid & crystallizable) produced by the action of boiling alcohol on ~~Alcohol~~ Erythrine. & analogous to Lecanoric Ether‡ 2b.p.49.

Pseudo-Erythrine.

Chemical Nature?

ERYTHRILINE†◊ is a principle, differing somewhat in composition from both Erythrine & Erythric acid, tho' analogous to both, found by Kane in Roccella tinctoria. Kane's formula for it is $C_{22}H_{16}O_6$, while Schunck gives the formula $C_{42}H_{29}O_{17}$ & considers it a Compound of Lecanoric acid & Roccellic Acid with 2 eqv. of water, in other words as Roccellic-lecanoric Acid‡◊ aff. P.15. 'V.P.

Erythriline in Roccella tinctoria

Composition?

*Chem. Gaz. 1844. 182 & Lindley Veg. Kingdom P.49.

†Gregory's Organ. Chem. P.460.

◊ Vide also Liebig & Kopp's annalen & Thomson's Organ. Chem.

‡Lond. Edinr. & Dub. Philos. Mag. 1848. Schunck on Stenhouse's discoveries.

◊ Vide also Kane in Ann. de Chimie & de Physique

Products and Secretions

III. Colouring matters.

1. Colorific Principles

Minor Principles:

Picro-Erythrine

Pseudo-Orcine

Orcellesic acid

Erythrelesic acid

Variolarine and their Chemical Nature &c?

Orcine a product of Decomposition

divisible into

Alpha-Orcine and Beta-Orcine

Preparation, Composition &c

There are many other minor colorific principles (or principles found accompanying & analogous to these), which it is unnecessary here to do more than merely mention en passant. They are inter alia:

PICRO-ERYTHRINE — ♁ (C_{34} H_{23} O_{20}) Stenhouse; (C_{44} H_{16} O_{14}) Schunck, who proposes altering its name to that of **Erythrierine***— app. P. 16.

PSEUDO-ORCINE — ♁, (C_{10} H_{13} O_{10}) Stenhouse; (C_{22} H_{28} O_{22}) Schunck v. p. 49. who proposes calling it in future **Erythrucine*** app. P. 16.

ORCELLESIC ACID — ♁ } Schunck regards as Compounds of
ERYTHRELESIC ACID — ♁ } Lecanoric Acid, with 1 equiv. of water i.e. app. P. 16

C_{18} H_8 O_8 + HO = C_{18} H_9 O_9.*—

VARIOLARINE —, which occurs in Variolaria dealbata, is probably, as Gregory suggests, a result of the decomposition of some of the principles already enumerated†—

ORCINE ♁ is a colorless, sweet, crystallizable substance, produced by the decomposition of many, if not all, of the preceding principles,— intermediate in composition & properties between these principles & the nitrogenised colouring matter **Orcéine**. Stenhouse & others regard Orcine as divisible into two distinct substances termed: — app. P. 16

α. **Alpha-Orcine** } the former of which is usually prepared
β. **Beta-Orcine** } by boiling Lecanoric or Erythric acids, or any similar colorific principle, with excess of Lime or Baryta: the latter by the destructive distillation of Usnic acid‡— When Lecanoric Acid &c are heated with alkalis (eg Baryta) a Carbonate is deposited & Orcine remains in solution— "The same change takes place when Lecanorine "is boiled with water or even with ordinary alcohol & for this reason

* Lond. Edinr. & Dublin Phil. Mag. 1848. Schunck on Stenhouse's discoveries

‡ Ibid. Stenhouse on alpha & beta-orcine

† Greg. Org. Chem. P. 461.

♁ Vide also Liebigs & Kopps Annalen d. Chim.

Products and Secretions

III. Colouring matters.

I. Colorific Principles.

alpha- and Beta- Orcine.

Physical and Chemical Characters

Composition &c.

Derivatives

I. Bromorcine

Composition and affinities.

Relation between Orcine and its Crystallizable Derivatives.

"reason Orcine alone is obtained when the Lichens are extracted "by these Solvents."* As given by Gregory, it possesses the following characters: Forms large transparent crystals,—is very soluble in water—has a sweet taste—When anhydrous, may be distilled un-changed—Mixed with Ammonia & exposed to the air, it gradually acquires a deep blood-red color forming the nitrogenised Colouring matter Orcéine—Formula of the **Anhydrous Orcine** ($C_{16}H_8O_4$ ie. Lecanorine minus 2 eqv. Carbonic acid C_2O_4): of **Crystallized Orcine** = $C_{16}H_{11}O_7 = C_{16}H_8O_4 + 3HO$—Liebig's formula (which was generally recognized by chemists before the analyses of MM. Dumas Will & Schmeck) was $C_{16}H_{16}O_4$ for Dry Orcine; & $C_{16}H_{16}O_4 + 3$ eqv. for Crystallized Orcine—But, from the results of the experiments of the last-named chemists, it would appear that these substances will be respectively more correctly represented by the Formulæ, $C_7H_8O_2$, and $C_7H_8O_2 + aq$.† Robiquet gives the formula $C_{18}H_{11}O_8$ for Orcine (which he considers analogous to the Erythrine of Heeren) as obtained by him from Variolaria dealbata‡ In **Bromorcine** ($C_7H_5Br_3O_2$) a new derivative of Orcine, discovered by MM. Laurent & Gerhardt, we find 3 eqv. Hydrogen, replaceable by 3 eqv. Bromine—According to these chemists, the general result of the many analyses of Orcine, is that it belongs to the **Salicylic series** of compounds, & is isomeric with the Saligenine of Pelletier† The following abstract of the "Relation between Orcine & its crystallizable derivatives," is given by MM Laurent & Gerhardt also:—

"Lecanorine", by ebullition with Barytes water, gives Carbonate & Orcine[2] i.e. $C_{16}H_{14}O_7 + HO = 2(CO_2 + C_7H_8O_2$
(Lecanorine) (Orcine)

Pseud-erythrine

1/p. 43.

2/p. 49.

* Gregory's Org. Chem. P. 460.

‡ Christison Dispensatory P. 584.

† Lond. Edr. & Dub. Phil. Mag. 1848. MM. Laurent & Gerhardt on Orcine & its derivatives. Trans. from Comptes Rendus Août 1848.

Products and Secretions

VIII. Colouring matters.

Relation between Orcine & its Crystallizable Derivatives.

II. Lecanorine, by boiling with Alcohol & an alkali, yields Carbonate Orcine & Pseuderythrine i.e

$$C_{16}H_{14}O_7 + C_2H_6O = CO_2 + C_7H_8O_2 + C_{10}H_{12}O_4$$
(Lecanorine) (Alcohol) (Orcine) (Pseuderythrine)

III. Boiling alkalis transform Pseuderythrine into Carbonate, Alcohol & Orcine ie. $C_{10}H_{12}O_4 + H_2O = CO_2 + C_2H_6O + C_7H_8O_2$
(Pseuderythrine) (Alcohol) (Orcine)

IV. Orcine, by the united action of atmospheric Oxygen & Ammonia, becomes converted into Orcéine (a red, uncrystallizable Colouring matter, ie $C_7H_8O_2 + O_3 + NH_3 = 2H^2O + C_7H_2NO_3$.
(Orcine) (Orcéine)*

Doubts and Difficulties as to the true nature and affinities of the Colorific Principles of Lichens.

It is generally admitted, by all Chemists & Botanists, that our knowledge of the true nature of the Colorific principles of the Lichens is very imperfect & obscure: & one great cause of the doubt & confusion overhanging the whole subject is the very often opposite results arrived at by various Analysts, even in the Examination of the same species — For instance, in Roccella tinctoria, which of all the Lichens, has been most frequently selected for Investigation analytically, on account of its important product Orchil, the discrepancies between the results obtained are very striking — Heeren discovered his Erythrine in it: Kane his Erythrylnie & Schunck his Erythric Acid; & Stenhouse 3 different substances, in as many varieties of this Lichen: all these bodies differing, more or less from each other, in composition & properties (at least as described by their respective discoverers) — In the case cited, the important question arises, are these 6 substances really distinct?, or are they not rather the same principle, modified to a certain extent, by the different processes used in their extraction & by the different Varieties of the Plant yielding them (produced by situation, moisture, temperature &c)? — "If all these investigations be correct," says Schunck

Investigations of Heeren, Kane, Schunck, Stenhouse &c

*Comptes rend. Acad 1848. Trans. in Lond. Edin. & Dub. Phil. Mag. 1848. Laurent & Gerhardt on Orcine & its derivatives.

Products and Secretions

VIII. Colouring matters.

I. Calorific Principles.

Their True Nature, and affinities.

Schunck, "the same plant (according to variety from place of growth &c.) "produces sometimes one, sometimes another of six different bodies, each "of which may entirely supply the place of any one of the others — This "would be (were it true) contrary to analogy, for it is more usual to "find plants differing totally in character producing the same substance, "than for the same plant in different circumstances secreting different "substances" * Again Evernia prunastri yielded to Rochleder & Heldt, Lecanoric acid, & to Stenhouse, Evernic acid — It cannot, however, be denied that Roccella tinctoria (& it will probably be found to occur in the case of other Lichens also) does produce very different substances, according to the different influences of ~~surrounding~~ external conditions upon it, but all these have certain affinities, — certain properties in common — According to Schunck,

Characterized by certain common Properties. viz:

1. All yielding Red Colouring Matter
2. Bitter principle
3. Transformation into Carbonic acid & orcine
4. Convertibility into Ethers.

I. They all yield **Red Colouring matters**, when dissolved in **Ammonia** & exposed to the **air** —

App. P. 15.

II. **Erythrine**, **Erythryline** & **Erythric acid** all produce, under certain circumstances, a **Bitter** substance.

III. **Erythric acid**, **Alpha** & **Beta-Orsellic Acids** &c are decomposed by alkalis into **Carbonic acid** & **Orcine** (accompanied in the case of Erythric acid by **Pseudo-orcine** — according to Stenhouse) —

IV. All the above-mentioned substances, with the addition of **Lecanoric acid** &c, yield, with boiling Alcohol, — solid crystallizable **Ethers**, which are similar, if not identical, in composition & properties — They are thus probably all representable by the formula $C_{22} H_{13} O_9$ (**Lecanoric Ether**): & if this Theory be correct, all the substances above enumerated must contain, in a free or combined state, **Lecanoric acid** * —

* Lond. Edr. & Dub. Phil. Mag. 1848.
Schunck on Stenhouse's discoveries.

Products and Secretions

VIII. Colouring matters.

II. Colouring Principles.

II. COLORING PRINCIPLES.

app. P. 23.

1. Orcéine

Orcéine. Product of Oxidation of Orcine.

1. ORCÉINE—is the Nitrogenised Colouring matter, produced by the oxidation of Orcine, under the influence of Ammonia & atmospheric air. Crystallised Orcine $C_{16} H_{11} O_7$ ($C_{16} H_8 O_4 + 3HO$) with the addition of 5 eqs. Oxygen & 1 of Ammonia (NH_3) yields 1 eq. Orcéine = $C_{16} H_9 NO_7$ & 5 eqs. water $H_5 O_5$—This change is precisely analagous to the Conversion of Phloridzin into Phloridzéine"; and in this manner", Mulder remarks," artificial colored substances are formed, which are no "doubt similar to those occurring in some flowers"—From the fact that "the colored substances of plants are produced by the oxidation "of colorless bodies", he deduces," that, therefore, these require Oxy- V. P. 14. 15. "to obtain their color—that this Oxygen is absorbed from the air & "that consequently, thin objects, such as the Petals—[Lichen—Thallus &c.] "if they contain such a colorless body, will more readily become "colored the thinner they are"—* Kane describes two blue compounds obtainable from orchil under the names of

Composition, Affinities

divisible into alpha- and Beta- Orcéine.

Alpha-orcéine and ($C_{18} H_{10} NO_5$)—
Beta-orcéine ($C_{18} H_{10} NO_8$.)†—

2. Chrysophanic acid.

2. CHRYSOPHANIC ACID—(Parietin, Parietinic acid, Parmelia yellow—Rhabarbarine—Rhabarbaric acid—Rhéine—Rheumine) is the golden-yellow coloring matter of Parmelia parietina‡ (so called from χρυσός gold & φαίνω I shine)—It has been described by Dr Robert Thomson, Merberger & others, but it was but imperfectly known till Schlossberger & Dopping made the very interesting discovery of its complete identity with the yellow coloring matter of Rhubarb—Its name of Chrysophanic acid was bestowed on it by Rochleder & Heldt‡, on account of its splendid color

2. Chrysophanic acid in Parmelia parietina &c

Occurrence also in Rhubarb?

app. P. 25.

* Mulder's Vegel. & Animal Chemistry P. 825.

† Gregory's Org. Chem. P. 461.

‡ Ann. de Chimie & Pharm. 3e. 48. 512. 1843. Chem. gazette No. 2. P. 167. 1844.

‡ Found also in Squamaria elegans & other Lichens Gregory. Org. Chem P. 454.

§ q. Pereira Mat. Med. No. 2.

Products and Secretions

VIII. Colouring matters.

II. Colouring Principles.

2. Chrysophanic acid

Existence in Rhubarb.

color – Parietin by Dr. R. D. Thomson* & Parmelia yellow by Herberger† from its being the coloring matter of Parmelia parietina; but it has long been known under the names of Rhein, Rhemmin, Rhabarbarin &c., as obtained from Rhubarb, in the form of a yellow, crystalline, granular matter. It occurs in Russian & Canton Rhubarb ‡ & in the roots of Rheum Rhaponticum & Rumex obtusifolius. It is usually prepared from rhubarb by the action of Ether in Robiquet's displacement apparatus. When pure, it is of a beautiful, clear, yellow color – odourless – tasteless – in the form of granular masses, which exhibit little tendency to crystallization – Tolerably soluble in hot rectified Spirits of wine, not very soluble in ether, even when boiling, & almost insoluble in cold water, tho' more soluble in boiling – When heated, it evaporates, emitting yellow fumes, which condense in the form of yellow flaccules a portion of it becoming at the same time carbonized ‡ – It dissolves in alkalis, producing a beautiful red color, on which account it has been proposed as a Test for Alkalis by Dr. R. D. Thomson* – If a potash-solution be evaporated to dryness, the red color changes to violet & then to a beautiful blue – It dissolves also in Sulphur acid (Oil of Vitriol) producing a beautiful red solution, from which water precipitates yellow flocculi ‡ The natural yellow color of the acid is heightened by the addition of a drop of Nitric, Muriatic or Sulphuric acid ‖ – Its formula, according to Rochleder & Heldt, is $C_{10} H_8 O_3$ §; according to Gregory $C_{10} H_4 O_3$ or $C_{40} H_{16} O_{12}$ ¶ —

Physical and Chemical Characters

Composition

Formula

PARMELIA-RED is the name given by Herberger to a coloring matter, analogous to the above, (tho' differing from it in its red color,) which he detected in the same Lichen, Parmelia parietina ‡ –

Parmelia Red. in Parmelia parietina.

* Lond. Edinr. & Dub. Phil. Mag. 1844. q. Pereira Mat. Med. V. 2

† Buchners Report. B. 47. S. 179. 1834

‖ Dr. R. D. Thomson

§ Ann. de Chim. & Pharm. B. 48. S. 12. 1843.

‡ Pereira Mat. Med. V. 2. P. 1357.

¶ Org. Chemistry P. 454.

Products and Secretions

— VII. Colouring matters.

— II. Colouring Principles

3. Vulpinic acid in Evernia vulpina

3. VULPINIC ACID —— (Vulpuline, Parmelochromine, Strychnochromine) is the Coloring matter of Evernia Vulpina —

Erythroleine Erythrolitmine Azolitmine Spaniolitmine and their occurrence in Litmus.

ERYTHROLEINE — ($C_{26}H_{22}O_4$ Kane); ($C_{52}H_{44}O_4$ Dumas)[††] —

ERYTHROLITMINE —— ($C_{26}H_{23}O_{18}$ Kane); ($C_{52}H_{44}O_{12}$ Dumas)[†] —

AZOLITMINE —— (a nitrogenised coloring matter — Kane) —

SPANIOLITMINE —— ($C_{18}H_7O_{16}$ Kane) ——

Nature, Composition and Affinities according to Kane.

The above 4 substances are, according to Kane, the coloring matters of **Litmus**: the first being a red fluid, the other three solids of a purple color, of which Azolitmine is the principal constituent of Litmus[*] — "There are properly speaking," he says, "only two characteristic Coloring "matters in Litmus, the Erythrolitmine & the Azolitmine; "for the Erythroleine is colored crimson-purple only by al-"kalis, & the Spaniolitmine occurs but very seldom — In the "Litmus of commerce, these coloring substances are combined "with Lime, Potash & ammonia, [this combination giving "rise to the blue color of Litmus, its constituent coloring "matters being naturally red] & there is mixed up in the "mass a considerable quantity of chalk & sand"[†] — Dr. Kane's results however are not to be relied on, were it only for this reason, that he entirely overlooked the presence of

Fallacies?

Adulteration of Litmus with Indigo &c.

Indigo in Litmus, so that, "what he regarded as colored "educts are probably only colored products"[‡]?

[*] Gregory Org. Chem. P. 461. † Philos. Trans. 1840. P. 198. q. Pareira Mat. Med. V. 2.

‡ Pareira Mat. Med. V. 2. †† Chemistry applied to arts & manufactures Pharmaceut. Times Decr. 26/1846

Chem. Gazette. V. 1. P. 167. 1842.

Products and Secretions

VII. Colouring matters.

II. Colouring Principles.

According to Gélis, Litmus contains 3 Coloring matters, of which one is soluble in Ether & orange-red; another soluble in alcohol & blood-red; & the third soluble in water; the second being the chief ingredient of the Dye—All yield blue compounds with alkalis— Dumas gives the formula $C_{36} H_{20} Az_2 O_{10} + \frac{1}{2} H_2 O$ for Azolitmine*— "There is great confusion as to the real number & composition of the Coloring Principles of Litmus & it must be confessed that an accurate & complete analysis of this substance is still (notwithstanding all the experiments that have been made on it) a desideratum in Botanical-Chemistry—† Constituents of Litmus?

ERYTHROLEIC ACID—($C_{26} H_{22} O_8$) Kane & ($C_{52} H_{44} O_8$) Dumas†, is a coloring matter, of an acid nature, found in Archil (along with Alpha & Beta-Orcéine) by Dr. Kane— Erythroleic acid in Archil?

LICHEN-BLUE—(Litmus-blue—Litmine?) is the name given by Pereira & others to the peculiar, blue coloring-matter of Litmus (viz. its aqueous Infusion), which has been regarded either as a Modification of **Orcéine**, (or an allied principle,) or as a Compound or mixture of several coloring principles— Its characteristics, as given by Pereira, are as follows: Soluble in water & alcohol, concentrated colored solution being purple, when viewed by transmitted light—pure blue, when diluted—By transmitted Candle-light, exhibits a reddish color—Aqueous infusion neither reddens Turmeric paper, nor precipitates Solution of Chloride of Sodium— containing therefore

Litmus-Blue?

Its true Nature Composition &c.

Physical and Chemical Characters.

Opp. P. 26.

*Gregory Org. Chem. P461. †Chemistry applied to the arts & Manufactures Pharmaceut. Times Dec. 26/1846.

Products and Secretions

III. Colouring matters.

II. Colouring Principles.

Litmus Blue

Physical and chemical Characters

Use as a test of acidity.

therefore no free alkali or alkaline carbonate - Reddened by acids & many of the metallic salts (eg Corrosive sublimate, Sulphates of Copper & Iron &c.) The infusion, which has been reddened by acids, has the blue restored by alkalis, alkaline earths, alkaline & earthy sulphurets, alkaline carbonates, soluble borates, tribasic phosphate of soda, alkaline cyanides &c. Infusion decolorized by Chlorine & alkaline hypochlorites - & certain deoxidizing agents (eg Sulphuretted Hydrogen, Hydrosulphuret of ammonia, Sulphurous acid, the Hyposulphites, nascent Hydrogen (produced by adding Hydrochloric acid & Zinc to the aqueous infusion) & protosalts of Iron - If an infusion be left in contact with Sulphuretted Hydrogen, in a closely stopped bottle, for some days, it becomes colorless, but reacquires its color on exposure to air or Oxygen. Lichen-blue is distinguishable from all other Vegetables blues by its reaction with acids & alkalis; the greater number of the latter (eg Red Cabbage or Violets) being rendered green by alkalis, while the former undergoes no such change - Moistened Litmus, laid on Turmeric paper, reddens it, but this reddoness is dispersed by heat.*

Chlorophylle

Nature and Characters.

CHLOROPHYLLE may merely be mentioned en passant as an abundant & universally diffused Coloring matter - "It is of a nature allied to that of **Wax**, soluble in ether & alcohol, insoluble in water."† aff. p. 25. 26. V. P. 6.

*Pereira Mat. Med. V. 2. †Greg. Org. Chem. P. 456.

Products and Secretions.

VII. Colouring matters.

II. Colouring Principles.

Chlorothal.

Chemical Properties &c.

Minor Principles of unknown Nature & affinities.

VIII Miscellaneous Products.

1. Extractive matters.

2. Protein Compounds.

Gluten

Gliadine.

3. Lignine?

aff. P. 23.

CHLOROTHAL — (*Thallochlor*) the green coloring matter of Cetraria Islandica — Its properties are those of a weak acid — Soluble in Ether, Alcohol & Petroleum — Distinguishable from "Chlorophylle", by being little or not at all soluble in Hydrochloric Acid *

Besides the pretty large list of Colorific & coloring substances enumerated in the preceding pages, various authors have described many secondary or collateral principles, obtained during the preparation of those I have already mentioned: but, of these, so little is known of a definite or specific character, that it would be altogether useless here even to mention them — Indeed, the whole subject of the Color-Products of the Lichens is one demanding fresh & extended investigation & that too by observers, who are at the same time Chemists & Botanists —

aff. P.

VIII. MISCELLANEOUS PRODUCTS. —

aff. P. 23. 24. 26.

EXTRACTIVE MATTERS are almost constantly set down in Analyses as constituents to a greater or less extent of various Lichens, but, of the real nature of such substances, little or nothing is known — Various

PROTEIN COMPOUNDS — have also been stated, by some authors, to be found in a few Lichens: inter alia

P. 25.

aff. P. 18. 21. 24.

GLUTEN, or *Vegetable Fibrine* (e.g. in Cetraria Islandica as "Amylaceous fibrine" † & in Roccella tinctoria ‡) —

aff. P. 25.

GLIADINE — (in Parmelia parietina, according to Herberger) ‖

aff. P. 31. 25.

WOODY FIBRE (*Lignine?*) is mentioned by Herberger, also, as occurring in Parmelia parietina ‖

* Pereira Mat. Med. V. 2. † Berzelius Traité de Chimie V. 6. 251. q. Graves Hortus Medicus P. 179.

‡ M. v. Eisenbeck. Brandes' archiv. d. apothekervereins Bd. 16. S. 135. q. Pereira

Products and Secretions

VIII. Miscellaneous Products — Poisonous Principles?

A POISONOUS PRINCIPLE — has been assumed by some to exist in Evernia vulpina, but, until this plant is really proved to be poisonous, there is no necessity for the supposition of a poisonous principle, whose existence has never been demonstrated — P.P.3

¶ [Phosphoric acid in combination with Lime — as Phosphate of Lime — mentioned by Berzelius as occurring in Cetraria Islandica] App. 23, V.P.2

Before passing on to the consideration of the Reproductive Cellular Tissue & its functions, I have only to make a very few

General Observations on some attributes of Thallus.

GENERAL OBSERVATIONS
on some properties of the Lichen-Thallus.

And first with regard to its

1. Age of Lichens — Circumstances favoring their Longevity

AGE — Lichens are **Perennial** plants: and one result of the many interruptions, to which their growth is liable from climatal & other changes, is, that they possess the curious faculty of remaining for years unchanged in external appearance & internal structure, & thus attaining a degree of Longevity, that would certainly not be *a priori* expected in plants so completely cellular & so insignificant — Dr Withering mentions a case under his own notice, where the parts of fructification of the same Lichen remained visibly unaltered for 10 years; * — & Vaucher noticed the same individual of Lobaria [Sticta] pulmonaria attached to the same spot of the same tree, after the lapse of 45 years † — App. P. 21.

Instances of extreme age

* Edinr. Encycl. Art. Lichens. † De Cand. Veget. Organog. Trans. Kingdom Vet. P.

¶ Re-introduced here per incuriam. Vide Page 28.

Attributes of the Thallus.

2. Corrosion of Rocks.

By what agency produced?

Acid exudations?

Moisture?

Advantages of such Corrosion in the Economy of Nature (Formation of Humus Vs)

Theories of Fée, De Candolle Vs

aff. P. 31.

aff. P. 38.

CORROSION OF ROCKS Vs, to which Lichens may be attached for support, is a very curious property, the real cause or nature of which has long been & still is a puzzle to Botanists. Many of the lower (coarser?) species, in particular, appear to corrode, disintegrate & literally "eat their way" into the hardest rocks, barks Vs (e.g Species of Lepraria, Lecidea & Verrucaria): nay we even find some (e.g Verrucaria rupestris & Patellaria (Opegrapha) cenebrina) completely invading their apothecia in the solid rock. Due to this singular property, is one of the great uses of this humble family in the grand economy of nature. In progress of time, such Lichens cause the "Rocks of Ages" to crumble & decay, forming by their débris, a soil suitable at first merely for higher species of the same family, (e.g of Gyrophora Bæomyces & Stereocaulon.) These continue the disintegrating process, so as to form a midus for Mosses, which are gradually succeeded by the Gramineæ, Sedums, Saxifrages Vs, & finally by the "Monarchs of the Forest".* The important question hence arises, By virtue of what power or principle in the Lichen-Thallus is this Corrosion or Disintegration occasioned? Authors seem divided in opinion as to whether this depends on the exudation of a corrosive **Acid**, by the lower surface of the Lichen-Thallus, or simply on the retention of **Moisture**, another property, with which Lichens are well known to be endowed. "By what Mechanism", Fée remarks, "can the Plants so delicate pierce a substance so hard?. Is it a disintegration of the rocky molecules, by means of an acid principle, or by the "moisture, which they constantly preserve?, or is it a scattering of these "molecules by the vegetative force?"† De Candolle is of opinion that an exudation of fluid, of some sort, takes place from the lower surface of the Thallus, which dissolves the inorganic materials of the rock, entering into

Combination

aff. P. 23, U. P. 28.

aff. P. 37. Prof. P. 6.

aff. P. 21.

*Mirbel Eléments. V. I. P 446. †Fée Essai sur les Cryptogames Vs. P.

Attributes of the Thallus

combination with them.* And, on the other hand, many believe that Lichens, "by retaining moisture, facilitate decomposition & promote the formation of soil"†

3. Mode of Adhesion to Bases of Support

ADHESION to supporting Surfaces.— Many Lichens (especially of those species, which grow upon Tree-barks) attach themselves, by means of delicate, cellular *Fibrillæ*,— (sometimes denominated *Rhizinæ* or *Rootlets*) which insert themselves very firmly among the fibres of Barks &c.— Others, (particularly those, which inhabit Stones & rocks) adhere most intimately by little *Discs*,* or suckers,— according to some authors, or by a sort of *Cement*,‡* formed by the union of an acid exudation from the Lichen, with the inorganic materials of the rock, according to others—

V. P. 11, 19.

aff. P. 3

Rhizinæ (or Fibrillæ)

Adhesive Discs.

Viscid Exudations.

V. P. 14, 19.

4. Odours

ODOURS— Several Lichens have been stated to be possessed of a fragrant smell or aromatic scent— For instance, *Lecidea aromatica* is said to emit a very striking, fragrant smell when bruised;‖ & *Collema fragrans* is "remarkable, when moistened, for its very sweet, aromatic scent, not unlike the *Spiritus volatilis aromaticus* of the apothecaries, tho' of course much fainter"‖ Borrer thinks this odour is quite accidental in *Collema fragrans*, but he states that the same odour is often noticed in other pulpy *Collemata*, especially if dried & afterwards moistened.‖ And Somerby says that "*Lecanora tartarea* may be known, even without fructification, by a peculiar pungent alkaline smell, when moistened"§ The principles or secretions, on which these odours depend are as yet quite unknown— **Volatile Oils** have been detected in several Lichens, but I am not aware if the so-called *Aromatic* Lichens are among the number—

Aroma in Lecidea aromatica Collema fragrans &c

Source

Dependent on Volatile oils?

* De Cand. Vegel. Organog. V. 1.

† Popular Cyclopædia art. *Lichens*

§ Engl. Botany V. 5. P. 156.

‡ Edinr. Encycl. art. *Lichens*

‖ Smith's Engl. Flora V. 5 P.

Attributes of the Thallus.

Reparative Power

Its origin?

Lichens are stated to be "highly endowed with a **REPARATIVE POWER**;"* but we certainly know nothing of its nature or modus operandi—

The subjects I have mentioned, under the head of "General Observations", are of very great interest & importance to the scientific Botanist; but I am not aware that any Experimental Investigation has ever been instituted with a view to the elucidation of any of these points— Till direct, accurate & extensive experiments are made, I am afraid that we must remain in entire ignorance of the true Duration of Lichen-life, of the nature of the Reparative Power of the Lichen-Thallus, (apart from Reproduction by Sporidia or Gonidia) —of the nature & seat of the odorific properties of many species,— of the true varieties of Connection between Lichens & supporting surfaces, of the nature & cause of the Corrosion & disintegration of even purely Siliceous rocks by many species &c— We have also a very great deal yet to learn of the structure, Products & Reproduction of Lichens; for, at present, not a single branch of Lichenology can be said to be established on a definite & sure scientific footing—

Deficiency of specific and accurate Investigations of the attributes of the Lichen-Thallus and their Causes.

* Edin. Encycl. art. Lichens.

Reproductive-Cell.

THE REPRODUCTIVE CELL.

Lichen-Reproduction 2-fold

1. By Corporeal Division

2. By isolated Parenchyma cells

The majority of Lichenologists & Botanists, in general, seem now to be of opinion that the reproduction of the Lichens takes place in two ways; I. By **Corporeal division** (ie. by **Sporidia**, which are equivalent to the ovules of the Phanerogamia & which serve to perpetuate the **Species**); and II. By **Gonidia** (ie isolated or single Parenchyma cells, which are peculiar to & therefore characteristic of the true Lichens & serve to reproduce the **individual**). The Sporidia are contained in elongated, membranaceous cells, "**Thecæ**", that, along with a mass of vertical, filiform cells, "**Paraphyses**", with which they are intermixed, appear on the surface of the Thallus, in the form of little colored Cups or Lines; with a hard disc & surrounded by a rim*, usually denominated **Shields** or **Apothecia** — The Gonidia occur scattered over the surface of the Thallus, in the shape of light, powdery masses called "**Soredia**" — Lindley considers the whole interior of the Lichen-Thallus to consist of Reproductive matter, which bursts thro' the upper surface in the two forms just mentioned (apothecia & Soredia) *

V.P.87. 88. App.P.

V.P.91. 88.

App.P. 21.22.

V.P.60. 61.

Agents concerned in these 2 kinds of Reproduction.

The Sporidia being the most normal [so to speak] mode of reproduction in Lichens, — (common to them with other Tribes of plants) would naturally appear first to demand attention, but I prefer first noticing the Gonidia, as being intermediate in function between the strictly Vegetative & the Reproductive Cell, fulfilling the duties of both, — as a Vegetative cell, which, in particular circumstances, is endowed with the faculty of reproducing at least the Individual —

*Lindleys Introduct. to Botany V.2. P117

I. GONIDIA, (SOREDIA — GONGYLI.)

Reproductive Cell.

1. Gonidia (intermediate between Vegetative & Reproductive Cell performing functions of both.

Nature and Analogies

Gonidia (γόνη, generation + εἶδος resemblance — so called from their "Capability of becoming developed into new plants, when separated from the parent structure"*) are usually stated to be the "Separated cellules of the Medullary Layer of the Thallus";† but, properly speaking, they are the individual cells of the Gonimous, middle or subcortical layer of the Lichen-Thallus — as the Gonimous layer, these "simple, living vegetating cells"‡ form a series or a continuous tissue, immediately below the Cortical layer of every true Lichen, thro' which, however, they generally burst & scatter themselves on the surface of the Thallus, as irregularly shaped, powdery masses called "**Soredia**," or sometimes in the form of Cups called "**Cyphelia**." "The propagating cells", Schleiden remarks, "are firmly enclosed in the Parenchyma of the parent plant, forming one continuous tissue till their separation from it."‡ Their

Formation of Soredia & Cyphelia

Form is generally **spherical** or subspherical; they are usually of comparatively large size, consisting of a delicate, transparent membrane, which may become variously thickened, and they appear to be similar in composition, development &c to the ordinary vegetative cell — They differ, however, from the ordinary Cellular tissue in possessing, according to Thwaites, the following peculiarities: "Frequent irregularity in form — want of correspondence in size — slight attachment to each other or to the filamentous tissue surrounding them — and their aggregation in certain parts of the structure."* Wallroth divides the Gonidium into 2 kinds according to the thickness of the Cellwall viz: **Hologonidium** (corresponding to Kützing's Leptodermatinic-gonimic Cell) & the **Mesogonidium** (corresponding to Kützings Pachydermatinic-gonimic cell)‖

Form

Structure

Peculiarities

Nature of the Cell-wall.

*Thwaites on Gonidia of Lichens. Ann. Nat. Hist. V. 3. P219. ‡Schleiden Scientif. Botany
†Lindley-Balfour ‖Kützing "Die Umwandlung niederer Algenformen — Höhere"&c

Reproductive Cell.

1. Gonidia.

Colour.

Contents.

Color of the Gonidia is normally **Green**, depending on the contained granules of Chlorophylle, which are usually aggregated round a distinct globule or nucleus - Wallroth & other authors describe the Gonidia as of different colors, & give them names accordingly, eg. **Chlorogonidia, Chrysogonidia** (corresponding to Kützings "Xanthogonimium Pachyderme-linische Stufe") &c - Lindley avers that they are "always green" *, so far as my own observations have gone, I agree with him - app. P. 6. app. P. 5.

Mode of Multiplication

Agency in Trichen-Reproduction

REPRODUCTION. The Gonidia multiply themselves by **Fissiparous** or **Merismatic division**. Körber says - "The **individual propagation** "takes place thro' means of Soredia, which form new individuals, thro' an "**intercellular developement**. This intercellular developement is pre- "pared in the mother-cell by the circumstance that the primary gonidi- "-um, which at first is a distinct Spherical cell, develops the organiz- "-able mucus contained in it into elementary globules. Further, the orig- "-inal mother cell is absorbed as soon as this is effected & the soredium app. P. 8. 22. 40.

Nature of the Soredium

"has issued from the Thallus - The Soredium is therefore nothing more "than the contents of the mother cell, which have become free & which "develope a connected cellular tissue from those new cells (globules),

Körber's views

"which are combined together by means of the formative mucus. These- "new cells therefore seem to be a kind of Cytoblast from the original, "now-absorbed mother cells, which, however, are still capable of ~~form~~

Link's Strictures thereon

"transforming themselves" †. Commenting on Körber's theory, Link says, that with regard to Lobaria (Stieta) Pulmonaria, for instance, which has large Soredia, "there is not a word of truth" in it - "The internal placentent matter of this Lichen, according to Link, bursts thro' the external cellular integument (which has nothing to do with Soredia) to form the Soredium

* Vegt. Kingdom P. † Körber De Gonidiis Lichenum. Rep. of Silesian Soey. 1840. q. Ray Soey. Rep. on Botany for 1845.

II. APOTHECIUM. (Shield - Conceptacle Involucre Sporocarp - &c).

Reproductive Cell.

In the Aggregate -

2. Apothecium Nature Structure

aff. P. 31. 37. 44. **STRUCTURE.** The Apothecium Structurally is merely a modification of the ordinary cellular tissue of the Lichen Thallus, from which it differs chiefly in Color & in the peculiar arrangement of the filamentous tissue of the Medullary layer, of which it seems essentially to consist - Lindley considers it as a **Nucleus** of the medullary layer of the Thallus, which bursts thro' the cortical layer, coloring & hardening by exposure to the air, in the form of little discs* - Opinions of Lindley, Eschweiler &c. Eschweiler also regards it as a portion of the filamentous tissue of the medullary layer, bursting thro' the cortical, in the form of a Shield, which contains a "Nucleus, consisting of a flocculent gelatinous substance."* "The forked & branched tubules of the medullary tissue become converted in the apothecium into vertically-arranged, filiform & elliptical cells, called aff. P. 144. **Paraphyses** & **Thecæ** (which contain the Sporidia) - Essential Constituents. These two structures may be said essentially & exclusively to constitute the apothecium, tho' Itzigsohn & other authors are endeavouring at present to add another constituent viz: "Antheridia" - Schleiden defines the Sporocarp or Apothecium to be, "A number of [Thecæ) combined together in a definite form, with the special parts of the plants, which enclose them"† - Position as to Surface of Thallus. It is usually more or less **elevated** above the **surface** of the Thallus, tho' it may also be **immersed** in its substance -

aff. P. 31. 44. **FORM** of the apothecium is typically **Round**, tho' it may normally occur **oblong & linear** - To give a general idea of the various forms ~~in~~, which, according to most authors, the apothecium presents, I subjoin the very excellent Tabular arrangement of Fée - And for farther information on this head I beg to refer to the "Glossary" & the "Illustrations" - Form

*Lindley Vegel. Kingdom P. †Scientif. Botany P.

Reproductive Cell.

in the Aggregate

Apothecium.

Form.

Tabular view (after Fée).

- APOTHECIUM
  - Stipitate
    - Globular (PODETIUM)
    - Scyphuliform (PILIDIUM)
  - Sessile
    - Linear (LIRELLA.)
    - Rounded
      - Hemispherical (TUBERCULUS.)
      - Discoid
        - Marginate
          - Applied (PATELLULA.)
          - Fixed to centre (SCUTELLA.)
        - Emarginate
          - Ciliated (ORBILLA.)
          - Non-ciliated (PELTA.)
      - Spherical
        - Concealed in Thallus (GLOBULUS.)
        - Superficial
          - Always closed (CEPHALODIA.)
          - Decaying with Age (CISTULA.)
      - Cupulate (CUPULA.)
      - Turbinated (GYROMA.)
      - Capillary (TRICA.)

Colour. COLOR of the apothecium is usually darker & richer than that of the rest of the Thallus, very often exhibiting different shades of brown, brownish-red, red, reddish-yellow, black &c. The color is sometimes exceedingly bright & beautiful, e.g the bright crimson shields of Scyphophorus coccifernus — V.P. 44.

Mode of Development DEVELOPEMENT. It is mentioned by several authors, that, in the earlier stages of its development, the apothecium is covered by an extremely fine Membrane, which is regarded by some as analogous to the Involucrum or Volva of the Agarics & whose function, according to Acharius, is to protect the apothecium while young & tender* Dr Balfour states that the apotheeia "appear on the frond in the form of Protuberances of various kinds, consisting of an outer layer of thick-walled, rounding cells, denser than the tissue of the Thallus & of different color & of an internal medullary layer of Paraphyses & Sporangia, lying perpendicular to the outer layers. The fructification gradually projects more from the surface & either remains covered with the outer layer or bursts thro' it. When it remains closed, there is a Nucleus in the centre." "Sometimes the Cortical

Apf. P. 10. 31. 37. 44.

Primary Envelope or Involucre

Formation of its Nucleus within Thallus.

Gradual Projection above Thallus.

* Edin. Encycl art. Lichens.

Reproductive Cell.

in the aggregate Apothecium

Mode of Developement

Schleiden's Observations on the gradual Developement of the Constituent parts of the Thallus.

Evolution of the various Organs from the Nucleus.

"cortical matter forms a Border round the fructification, at other times "it grows up in the form of a stalk (Podetium)" * According to Schlei-den, the developement of the Sporocarp consists of the following stages: "At wholly indefinite parts of the surface [of the Thallus?] is formed a "semicircular channel-shaped or more or less spherical or cylindrically "closed layer of delicate-walled, closely-packed, roundish Cells, which "sometimes appear colored" (eg in Lecidea Sanguinea) —[when forming "a rim round the developed Sporocarp, called **Excipulum proprium**] "On the inner surface of this layer, there gradually appears a second, com-"posed of thin, filiform cells, (**Paraphyses** – Saftfäden) arranged verti-"-cally on the preceding layer (**Lamina proligera**) – In a short time "we see single, broader, **elliptical**, tender-walled cells (**Sporangia** – "**Thecæ** or **Asci**) growing up between the Paraphyses & soon becoming "filled with a viscid substance. During this process, the whole Sporo-"-carp has been gradually approaching nearer & nearer to the surface "of the Thallus, being always covered by a substance, the tissue of which "it is very difficult to determine, but which appears to be partly the "product of the Paraphyses? frequently occurring as a black finely gran-"-ular mass (eg especially in the Pyrenomycetes & Pyrenothalami [Limpr.]) "and partly in the subsequently expanded shields, composed of a thin "lamella of the cortical layer of the Thallus & is sooner or later destroyed. "Remaining in this closed condition as a **Nucleus**, it forms the "fruit of Pyrenomycetes & Pyrenothalami (Sporangia angiospora nuclea "praedita Meyer). But it more frequently bursts thro' the upper surface, "spreads itself more or less into a linear Cup, (**Lirella**) or disc-shaped "Apothecium (**Patella**) [Sporocarpia angiospora laminam gerentia: "Meyer] – In bursting through, the apothecium sometimes raises around

it

aff. P. 37.

* Balfour's Botany P. 550.

Reproductive Cell. in the Aggregate

it a portion of the upper surface of the Thallus, which then appears "as a margin (Margo thallodes - Excipulum thallodes). Or it may "grow more decidedly out, so as to raise the Sporocarp on a pedicle "(Podetium) varying in height."* It would appear that the mode

Apothecium — Development of Crustaceous, foliaceous, and pulverulent Lichens.

of developement is the same in Crustaceous Foliaceous, as in Pulverulent Lichens — The subject of the History of the Developement of the Apothecium (or its constituents) is one which has as yet attracted very little attention among Lichenologists — Meyer has described it so far as visible to the naked eye — as occurring in different species of Cladonia — To Schleiden, chiefly, who observed it in Borrera ciliaris, Lecidea sanguinea, Sphærophoron coralloides, Calicium trachelinum, Parmelia subfusca &c, we are certainly indebted for the little information we possess on the subject† —

app. P. 27.

Deficiency? of accurate Investigations.

Constituent Reproductive-Cells.

Theca

III. THECÆ. (Sporangia - Asci - Spore-cases. Spore-sacs or Elytræ. &c.) —

Nature

The Thecæ of Lichens are generally defined to be elongated cells, found only in the Apothecia, containing Secondary cells or nuclei, in sets usually of Four or multiples of Four, which are the Spores - Schleiden defines them shortly to be "the Parent-cells forming & inclosing the spore" —

app. P. 31.

Structure.

STRUCTURE. The Thecæ consists of a Membrane, or primary Cell-wall,

Cell-wall.

which is usually transparent & delicate, containing a fluid, in which the

Internal Lining.

Sporules are immersed. On the inner surface of this membrane, in many cases, we find one or more layers formed from the mucous or gelatinous

Mucus or Gelatine?

contents of the Cell, deposited as lining coats or membranes (Verdickungs-Schichten) e.g. in Borrera ciliaris† The young Sporangia of Lecidea sanguinea have, according to Schleiden, a "thick, gelatinous wall" —

*Schleiden Scient. f. Botany. P.

†For the developement of the Sporocarp & its constituents in Borrera ciliaris vide "Entwickelungsgeschichte von Borrera ciliaris" by Dr. G. von Holle. Botanische Zeitung 25 July 1852.

Reproductive Cell.

Constituent Reproductive Cell of Apothecium

Thecæ.

Composition of Cell-membrane

Starch? or some modification thereof

COMPOSITION. The Thecal Membrane is composed of an **Amylaceous** matter, as proved by the action of Jodine on it – Dr. Dickie found the Thecæ of many Lichens (e.g. Pertusaria communis) rendered blue by Jodine – "If therefore", says he", the action of Jodine entitles us to infer "the presence of Starch, the Lichenal Theca must be a peculiar modifi- "-cation of it – Raspail states that each Starch-globule is capable of pro- "-ducing, in its interior, other smaller globules, which are (at one period) "attached to the inner parietes of the mother cell – If this be true a "Lichenal Theca may be considered a globule of Starch of a peculiar form, "producing in its interior other globules ie Sporules?" *

27.

app. P35 37.

Form of Thecal-Cell.

FORM – The most usual form of the Lichen-Theca is that of an **elongated** or **elliptical Cell**, but this form is liable to great modification & variation in different species – In Sphærophoron tenerum, for instance, the thecæ are **filiform** cells, containing a great number of Sporules, vertically arranged, & so densely packed, that each Theca resembles a **Moniliform filament** –

31.

Contents. Mucus Spiral arrangement? Sporidia

CONTENTS of the Theca consist, at first, of a granular, homogeneous, slimy or mucous mass, of a slightly yellowish, brownish or greenish color, which appears to be composed of Protein Compounds & a fatty oil † This mass gradually becomes more viscid & is arranged so as to present an appearance, according to Schleiden &c, resembling Intestinal Convolutions: from this the Spores are subsequently developed –

Period of Development

DEVELOPEMENT. of the Theca is probably always subsequent to that of the Paraphyses, among which they gradually grow up, – gradually inserting themselves between them –

* Dickie on the Reproduct. organs of the Lichens. Mag. of Zool & Bot. V.3. P.166.

† Dr. J. v. Holle. "Entwickelungsgeschichte von Bor. cil." Bot. Zeitung July 25/57.

Reproductive Cell.

Constituent Reproductive Cells of Apothecium

Thecæ.

Position with regard to Paraphyses, Hypothecium &c.

POSITION &c. The Thecæ generally occur aggregated, interposed vertically between the filiform Paraphyses, than which they are usually a little shorter — Schinzlein, however, mentions them as being "Marginate more or less exserted" — Their lower or thinner extremity is inserted into or connected with the Cellular Tissue of the Hypothecium — In process of time, having fulfilled their office (ie the protection & nourishment of the Spore up to maturity) the Thecal cells fine way or lacerate, usually at their apex (or broadest end); the Spores escape by the fissure thereby made, & soon after this, the Thecæ die — In most Lichens the Thecæ are long closed, but in some cases they open early & the Spores then lie free on the apothecium. (Sporocarpia gymnospora of Meyer — Coniothalami &c.) —

Rupture Death and decay of Thecal-Cell.

Re

Sporidia

IV. SPORES, (Sporidia Sporules. &c.).

Nature. and Analogies.

The Spore may be called the Acotyledonous, Cellular Embryo of the Lichens As D. Asa Gray remarks, the Lichen-Spores "are of the most reduced "simple kinds, — mere single cells, containing granular matter, but not giving "rise to more cells, or bilding up any structure whatever till germination" Their diminutive appellation (Sporules or Sporidia) in fact indicates their reduction to the last degree of simplicity. Acharius, in his "Lichenographia Universalis", (1810) mentions the Thecæ & Sporidia under the names of Cellulæ & Vesiculæ, & the ultimate Spores contained in the Sporidia, as Gongyli.* —

Structure.

Cell-membrane

Composition and Peculiarities.

STRUCTURE. The Cell-wall of each Spore consists essentially of a fine, pp. 8-36-37 transparent, gelatinous membrane, somewhat resembling that of the Thecæ, from which it differs, however, in not being colored blue by Iodine, according to Dickie† This Cell-wall varies greatly in consistence & thickness in

* Leighton's Angiocarpous Lichens p.

† Mag. of Zool. & Bot. U.S. p. 166.

Reproductive Cell.

Constituent Reproductive Cells of Apothecium

Sporidia

Cell-membrane

Structure

Characters of its different Coats.

in different species, according to the quantity of gelatinous matter deposited in the form of lining Coats or layers, on the interior of the original investing Membrane,— and in many cases on its exterior also— According to Hallé, the Cell-wall of the mature spore of Borrera ciliaris consists (exclusive of Thickening-Deposits) of **3 Coats**, the most external of which corresponds to the (primary) Cell-membrane, while the other two are the product of the (secondary) Spore-cells ("Tochterzellen") * The spores of many species have a very distinct **outer Covering**, of a hardened Mucous substance, (e.g Parmelia Parietina, where "this covering forms hollow Hemispheres, covering both ends of the Spores, connected by a narrow Strip of the same substance" † in fact greatly resembling the Pollen-granules of the Genus Pinus— In Borrera ciliaris, the Spores possess a very dark, blackish-green color, & it is very difficult to determine whether this color is attributable to a similar coating or thickening, or to the color & nature of its cellular contents † **Excrescences** of various kinds are occasionally met with on the outer surface of the Cell-wall, caused by the adhesion of abortive or imperfectly developed Spores to the perfect Spores, thereby giving rise to the appearance of horns Joints &c † Besides these, various **Markings** are very common on the Cell-wall,— perhaps produced by Cracks or fissures in the secondary Thickening-deposits—

Appendages to the Cell-wall external and internal

Excrescences Markings &c of various kinds

aff. P. 35. 37.

FORM. The normal or typical form of the Spore appears to be the **ovoid, subglobose** or **elliptical**: but it varies very considerably in different species: thus we have also fusiform, linear,— oblong,— doubly-cordate &c Spores. According to Nägeli, Cells produced by Free Cell-formation, as the Lichen-Spores are, ought always to be some modification of the **globular** or **ellipsoidal**, with regard to form ‡ Spores have been divided, by many authors, into **Single** and **Double-Spores**, according as they have been developed from

Form.

Typical form ovoid

its Varieties.

Division into Single & Double.

aff. P. 37.

aff. P. 39.

* Bot. Zeitung July 25/51. † Schleiden Scientif. Botany P. ‡ Nägeli on the Vegetable Cell Ray Socy. Rep. Bot. for 1849.

Reproductive Cell.

one or from two or more Cell-nuclei* — They may also be divided

Constituent Reproductive Cells of Apothecium —

into **Simple**, and **Septate or Compound**, — the former being single Cells destitute of, and the latter possessing a varying number of Septa, partitions or Loculaments — Some Spores are apparently "**Margined**,"

Sporidia.

but the "so-called Margined Sporidia have no true margin, the Sporidi-

'Division into Simple and Compound.'

-um being a hyaline Sac, that appears like a margin under the Micro-

-scope"*†

Colour.

COLOR of Spores is also very various: thus we find them possessing yellow, green, brown, black, red, purple & all intermediate shades & mixtures of these —

Contents.

CONTENTS. The Spore contents seem to consist, in many cases, of a

Fluid and Granular.

"**Fluid**, in which float numerous globules of irregular shape & size";† at other times of a **Granular mass**, which is seldom colorless (e.g

Nucleus?

yellow in Borrera ciliaris)‡ A **Nucleus** has never been detected in the Lichen-Spore in the earlier stages of its developement & has seldom been seen even in its mature or perfect state & indeed Nägeli describes the developement of the Spore, as an Example of Free Cell-formation without visible nucleus‖ The nucleus has certainly been seen, however, in some cases & is then probably **primary** (ie round which the Spore-cell has really been developed) — It has most frequently been observed in the case of certain Compound Spores, "where the two nuclei already present themselves in the single cell & the division of the cell consequently follows"§ Traces of a **Spiral Deposit** on the Spore-wall are occasionally met with, eg Schleiden mentions that the thickened walls of the spores of Lecidea sanguinea often exhibit a spiral arrangement of the thickening matter* —

Primary Nucleus of Compound Spores.

Spiral Deposits?

Affs. P. 30.

§ Nägeli on the Cell-nucleus. Ray Socty. Rep. on Botany for 1846.

* Schleid. Scient. Bot. P. † Dickie Mag of Zool & Bot. V. 3. P. 166.

‡ Holle Botan. Zeitung July 25/57. ‖ Nägeli Vegel. Cell Ray Socy. Rep. on Bot. 1849.

Reproductive Cell.

Constituent Reproductive Cells of Apothecium.

Sporidia

Position with regard to Thecæ and Apothecium

POSITION of the Spores in the Thecæ is generally regular—, being usually arranged either in a Row in the **axis** of the **parent-cell**, or having some other definite relation to this axis* Dr. Dickie, while he could see no connection between mature Spores & the walls of mature Thecæ,—the spores floating quite loosely in the circumambient fluid,—throws out a hint that some connection might possibly be traced in very young Thecæ† tho', as a general rule, the Spores are **contained in Thecæ** till maturity, yet, in many species, they are **naked** or **free**, lying on or among the Paraphyses—In many of the Angiocarpi, (e.g species of Verrucaria—V. nivea-atra—rudis Dr.), there are no Thecæ, the "sporidia being innumerable "free, agglutinated into a mass, which dissolves, as in many fungi."‡

app. P. 31-37.

Number

app. P. 37.

NUMBER of Spores usually contained in each Theca is **Four** or some multiple of Four (e.g very often Eight)——

Mode of Multiplication or Developement

Free Cell-formation and its Modus operandi according to Nägeli.

app. P. 28. 30.

DEVELOPEMENT,—of the Spore, from the Contents of the Theca, takes place by, what Nägeli calls, **Free Cell-formation** & which he describes as follows: 1. A nucleus originates in the contents of the Parent Cell— 2. This accumulates, on its surface, by attraction, a greater or smaller quantity of such contents, which, at least, at the Periphery, consist of homogeneous mucilage—This portion of the Contents becomes coated by a Membrane, over its entire surface"* The Lichen-Germ-Cell, he says first appears in the Thecæ, "sometimes as homogeneous drops of mucilage, "sometimes as little, hollow globules,—the former in the clear, diluted, "the latter in the dense, mucilaginous Cell-contents of the Theca—In both "cases, the nascent Spore-cell exhibits a definite outline & a distinct "membrane only at a subsequent epoch"* The Primary Spore-cells therefore arise from **Nuclei** in the more or less fluid or viscid contents of the Thecæ,—being **Single-Spores**, if developed from a single Nucleus, and **Double-Spores**, if from 2 or more Nuclei—¶ In Lecidea sanguinea according

Nuclear Development in Single and Double Spores.

app. P. 30.

* Nägeli on Vegel. Cell Ray Socy. Rep. Bot. 1849. † Mag. of Zool. & Bot. V. 3. P. 166.

‡ Leighton Angioc. Lichens P. ¶ Schleiden Scient. f. Bot. P.

Reproductive Cell.

Constituent Reproductive Cells of Apothecium — Sporidia —

Their Intra-thecal Development according to Schleiden.

according to Schleiden, the thick, gelatinous Thecal membrane encloses a narrow Cavity, filled by a mucous mass, in which from 8 to 12 Sporidia are originally developed, only 1 or 2 of which however ultimately attain maturity or perfection — There gradually appears on the gelatinous wall of the Sporangium, a thicker more internal Lamella, — "formed probably by the pressure of the expanding Contents, — which is gradually pressed outwards & at last becomes so blended with the outer bounding surface that it alone incloses the ripe spore." * Schleiden considers the development of the Spore analogous to that of the Pollen-granules in the Embryo of the higher plants — Many Spores are developed simultaneously & they generally remain more or less coherent.

Origin of the Cell-membrane

Is it a Secretion? or a Deposit?

Theories of Nägeli, Schleiden, Schwann &c.

With regard to the **Origin of the Cell-membrane** of the Spore, various authers have looked upon it as originating in one of two ways I. That it is a **Secretion** from a portion of the Thecal-contents, which have become isolated previous to the formation of a spore — This view is upheld chiefly by Nägeli, who defines it to be "an Investment, lying upon the surface of the contents, secreted by the contents themselves" — therefore a Secondary production — II. That it is a **Deposit** from the fluid of the Parent-cell, surrounding the isolated portion of contents: & this Theory is principally supported by Schleiden & Schwann † — The Cell-membrane probably exists for some time before it becomes visible to the eye, but the period & mode of its first development is as yet matter of great discussion —

Mode of Multiplication

The **Multiplication** of individual Spores takes place **fissiparously**, ie. by Spontaneous fission or division into two. —

* Schleiden Scient. Bot. P. † Nägeli on Vegel. Cell. R.S. Rep. Bot. 1849.

app. p. 8. 38.

GERMINATION.—The Escape of the Spore, when mature, takes place by the laceration & subsequent death of the Thecal-cell—"In the Angio- "-carpi, the mature Sporidia escape from the ruptured Asci thro' the Pore "or perforation at the Apex of the Perithecium"* Acharius considers that the "gelatinous substance of the gemmiparous plate, being brought "into a state of solution by continued moisture during autumn & winter, "the Gongyli probably then escape & germinate"† The Spore is **Heterorhizal**, ie Germination takes place from any, but from a fixed point, on its surface. During germination, the cellular constituent parts of the Spore become most distinct & visible. According to Holle, the germination of the Spores of Borrera ciliaris is attended with the following changes: We find, at one extremity of the Spore (usually the apex), that the color of the Cell-contents becomes clearer & a bulging, which is gradually converted into a Knob or button-shaped projection, is formed.—This swelling is apparently produced by the bursting of the outer membranous coat, & the projection, thro' the fissure, of a prolonga- -tion of the two inner coats.—Scattered about or surrounding this tub- -ular prolongation, may sometimes be noticed numerous cells & fila- -ments,—developed probably from secondary cells,—often cohering more or less firmly & sometimes growing in such a direction as to form a kind of Sheath round the original Spore.—During this process, the form of the Spore itself is generally little altered—, the Cell-membrane how- -ever acquiring a shrivelled & somewhat opaque appearance & the Cell-contents apparently sometimes diminishing.—I am not aware that, as yet, any observations have been made on the development from the Spore of the various layers of the Lichen-Thallus—

Reproductive Cell.
Constituent Reproductive Cells of Apothecium
Sporidia
Escape from Theca.
Mode of Germination and Changes induced thereby
Observations of Holle on Spores of Borrera ciliaris.

*Leighton Angioc. Lichens P. †Edin. Cyclop. Art. Lichens.

Reproductive Cell.

Constituent Reproductive cells of Apothecium.

Paraphyses. Nature Structure Position Contents.

Septa, Projections &c

V. PARAPHYSES.

STRUCTURE. The Paraphyses are *Cylindrical, single filaments,* (or "verästelte Fäden"), which, along with the Theca, constitute the essential structure of the Apothecia. Their lower extremity is inserted into, or connected with, the cellular tissue of the Hypothecium, — while their upper end usually consists of a more or less bulging, globular, more or less colored head. The Paraphyses of Borrera ciliaris, according to Holle, contain, in their interior, numerous colorless granules or globules, — & often exhibit annular *projections* or bulgings inwards (Ausbauchungen) of the Cell-wall, & sometime genuine Cross-membranes or *Septa* ("Quermembranen").* The Paraphyses constitute the "Compact, firm, smooth & pellucid" Lamina proligera or gemmiparous plate of Acharius, — and the Seminal layer of Sprengel.† app. P.

Development Origin from Hypothecium?

Morphological Significance?

DEVELOPEMENT. We know that the Paraphyses always precede the Theca in existence, but we are as yet in entire ignorance of their mode of development from the Hypothecium. Many authors regard them as merely *abortive Theca*, but this theory is completely disproved by the facts that the Paraphyses are very distinctly antecedent in existence to the Theca, the latter growing up between the former & differing from them ab initio in volume & appearance —

* Botan. Zeitung July 25/57. † Edin. Encycl. Art. Lichens.

VI. ANTHERIDIA. (SPERMOGONI of Tulasne.)

Reproductive Cell.

Constituent Reproductive Cell of Apothecium?

Antheridia.

Position on Thallus.

Nature?

Theories thereanent

Structure

Contents.

Itzigsohn's description of the Antheridia of Cladonia alcicornis & Borrera ciliaris.

We find, on the Thallus of many Lichens, minute black or brown spots or warts, which have been long familiar to Lichenologists, but the true nature of which has always been, & still is, a subject of great discussion & difficulty. By some, they have been considered as parasitic Fungi (e.g. Leptorea, Phyllosticta &c of the order Pyrenomycetes) to whose structure they seem to bear a very close resemblance — By others they are regarded as peculiar & parasitic species of Lichens; while others still believe them to be anomalous or irregular fructifications of the Lichen, on whose Thallus they occur — Very lately it has been asserted by Dr. H. Itzigsohn & other German Botanists, that these "point-like" bodies are "Globules", "Conceptacles" or peculiar kinds of "Perithecia", containing Corpuscles, which exhibit the appearance & vital properties of the true Spermatozoa or Phytozoa, as met with among the higher Cryptogamia, and therefore genuine "Antheridia" — Itzigsohn describes them as occurring in Cladonia alcicornis as "small, mostly "stalked, globular bodies at the tips of some of the lobes of the Thallus, "easily detected by the naked eye, but not occurring on all specimens, on "account of the seemingly diœcious inflorescence"* — They have been chiefly examined however by him & others in Borrera ciliaris, where they are larger & occur "on the upper side, at the base of the lobes of the Thallus, "and are distinguishable by their brownish color, from the young apothecia, "which are green,"* constituting in fact, what are familiar to every Lichenologist, the minute brown points or warblets on the upper surface of its Thallus — Structurally, these Antheridic "globules," or "point-like Conceptacles," are "little Utricles, filled with a mucilage, in which swim

* Itzigsohn on the Antheridia of Lichens. Botan. Zeitung & Botanical Gazette July 1850.

opp. P. 22-31.34.

P. 31.

Reproductive Cell.

"swim Cylindrical Corpuscles of extreme tenuity animated with

Constituent Reproductive Cells of Apothecium?

"a molecular? motion"* They are sometimes imbedded in the substance of the Thallus, their presence there being usually marked

Antheridia

in such cases by an obscure point or prominence — More frequently, however, they are intimately connected with the parenchymatous

Position on Thallus.

tissue of the Lichen, but are recognizable by their peculiar color — In some cases, the antheridic utricle seems to possess "special walls & may

"be removed entire from the tissue, in which it seems to grow as a foreign

"& parasitic body, e.g. in Parmelia physodes"† The Conceptacle may be

Structure

simple, — a single utricle —, or Compound, ie divided by processes or partitions, more or less perfect, into Loculi, or sinuous Cavities — What-

Re

ever be the nature of its internal organization, it is stated that it

Opens on surface by a Pore.

Opens on the surface of the Thallus by a rounded Pore, — by little converging Slits, or by irregular Chinks — Tulasne denies that these

Analogies to true Antheridia of Hepaticæ &c

bodies are strictly analogous to the Antheridia of the Mosses & Hepaticæ, as averred by Itzigsohn — He grants that they resemble the Anther-idia of some of the Hepaticæ (eg the Stemless Jungermanniæ) to a certain extent viz: "inasfar as a white, gray or brownish, mucilaginous

Arguments pro & con.

"pulp is effused by both"; but here he considers the resemblance to cease, "the composition of this mucilage & the structure of the organ

"in which it is elaborated being different," in the two cases — Flotow

Opinions of Itzigsohn, Tulasne. &c

believes that these peculiar Conceptacles occur only on particular Lichens & on particular parts of these Lichens; while Tulasne & others regard them as of universal occurrence on the Lichen-Thallus — In some Lichens, Tulasne avers they are so abundant on the Thallus as to exclude all apothecia (eg Endocarpon fluviatile & E. hepaticum). Even

* Von Flotow. q. Tulasne on Reprod. organs of Lichens 'Comptes rendus' March 24/1851. trans. in Ann. of Nat. Hist. August 1851.

† Ibid

Reproductive Cell. Antheridia. Nature?

app. P. 28. granting that these bodies are so abundantly diffused, the question has arisen & has been greatly discussed, especially in Germany, as to whether they are bona fide organs of the Lichen in which they occur, — portions of & formed from its tissues, or merely foreign & parasitic structures, having their nidus on its Thallus? — Considering the uniformity of their occurrence in all Lichens, & other circumstances, most authors seem now agreed in regarding them as really belonging to, & organically forming part of, Lichens — Grounding on the slight structural analogy between the "point-like Conceptacles" of Lichens & the Antheridia of the algæ, Muscı, Hepaticæ &c, Tulasne objects to the former being denominated or classified with true "antheridia" — But such a ground alone is probably not a sufficient reason for excluding them, for, tho' the Antheridia of some tribes resemble each other (e.g Mosses & Ferns), those of other classes (e.g algæ & Salviniaceæ) have "scarcely any parity of structure, either between themselves or with the "former". *

Analogy with true Antheridia of Muscı, algæ, &c ?

Opinions of Tulasne &c

app. P. 34. According to Schleiden, "the Mucus, in certain cells of the An- "theridia [?] of Lichens, presents the aspect of a Spiral filament, "with from 1 to 2½ turns — Its history is but little known, — especially "its relation to the soft mucous layer, — and whether the Cells, in which "these spiral filaments are developed, are usually perfect cells or "only Nuclei ie. Hollow Cytoblasts" †

Contents Mucus Spiral arrangement?

* Tulasne 'Comptes rendus' March 24/51. Ann. Nat. Hist. August 1851.

† Schleiden Scient. f. Bot. P.

Reproductive Cell.

VII. PHYTOZOA. (SPERMATOZOA, SPERMATIA.)

Contents of Antheridia. *Spermatia.* *Nature*

The Conceptacles, or so-called "antheridia", I have just mentioned, contain corpuscles of extreme tenuity, which Itzigsohn considers as "**Animal-cules** endowed with a movement of Translation,"* & therefore calls "**Spermatozoa**" — When the antheridia of <u>Cladonia alcicornis</u> or <u>Borrera ciliaris</u>, says Itzigsohn, "are pressed flat between plates of glass, thousands of Spermatozoa make their appearance, exactly like those of the Polytricha & of Marchantia, but shorter than those of the Charae."† app. P. 32.33

Analogies. *Discovery of Itzigsohn.* *Subsequent Investigations of Rabenhorst, Schacht, Tulasne &c.*

They have been chiefly examined & described by Itzigsohn, Rabenhorst, Schacht, Tulasne & others as occurring in the little brown tubercles or wartlets, scattered so abundantly over the upper surface of the Thallus of <u>Borrera ciliaris</u>, which crumble to pieces on pressure, being resolved into distinct little straight **Rods** or **Filaments** —

Structure *Physical Characters.*

They are described by Tulasne as "linear bodies, short & slightly curved, or elongated & thin, strongly curved into an arc, or more or less flexuous, but apparently always destitute of <u>Cilia</u> or other appendages," — having an average thickness of less than $\frac{1}{1000}$ Millimetre & a length of not less than the $\frac{3}{1000}$ Millim. (some of them however being 8 or 10 times as long, but none thicker)* —

Origin from Lenticular Cells? (Sperm cells?) *Motions* *Opinions as to their true Nature.*

Itzigsohn asserts that they are developed "like the Spermatozoids already known", within **lenticular cells**, app. P. "seemingly imbedded in the green tissue of the Lichens", which exhibit, app. P. under certain circumstances, peculiar lively motions; and that, after the antheridia of any Lichen (e.g. the warts of <u>Borrera ciliaris</u>) have been macerated for a week or 10 days in water, the Spermatozoa, which they set free in thousands, exhibit rapid & vigorous movements of an in-

-<u>dubitably</u>

*Tulasne. 'Comptes rendus' March 24/51. Ann. Nat. Hist. August 1851.

† Bot. Zeitung — g. Bot. Gaz. July 1850.

Reproductive Cell.

Contents of the Antheridia?

Spermatia.

Circumstances under which their peculiar motions exhibited.

as detailed by Itzigsohn, Rabenhorst &c.

Opposed Theories as to true Nature of such Motions

Animalcular?

or

Molecular?

-dubitably animal nature. Dr. Rabenhorst repeated very carefully
app. P. 31-32. 33-34. Itzigsohn's Experiments on the Spermatozoa of Borrera ciliaris, with
the following results: He laid a small portion of the Thallus, richly
P. 31. 33-34 covered with the little brown warts, in a glass vessel, half-covering
it with water, & protecting it from dust by a Bell-jar, — which stood
in his Studio, where the temperature was seldom under +10° or above
+20°. (Reaumr.? = 54° & 77½° Fahr.) — For six successive mornings, he care-
fully examined, under the Microscope, one or two of the little warts
squeezed between plates of glass & always with the same result viz:
the discovery of the little rods or filaments, which however exhibited
no motion — On the 7th. morning, he noticed the membrane [?] pointed
out by Itzigsohn, — & the Spermatozoa now tumbling about in the
liveliest manner — Their movement is indubitably of an animal
nature: they bend & twist their bodies, — dive into the deep, so as
apparently to stand on their head, — they do not progress unswerving-
-ly in a straight direction, but in a serpentine manner. According
to him, their Diameter is about 1/2000 Millimetre, — their length about
10 times as much — Intermixed with the Spermatozoa, he says, he
noticed a Monad, like Monas Crepusculum, but not in great numbers,
~~which in some cases~~ He was surprised to find, that, when occasion-
P. 34. app. P. 33. -ally a one of these Monads happened to strike against or disturb
P. 29. a Spermatozoon, apparently in repose, the latter endeavoured, by
twisting itself, to avoid or form a defence against the former *
Itzigsohn, however asserts, that Rabenhorst mistook for a Monad
the lens-shaped cells described by the former, as the parent-cells
('Mutterzellen') of the Spermatozoa, which commence, as soon as the

* 'Bestätigung der Spermatozäen von Borrera' by Dr. Rabenhorst in a letter to Dr. Itzigsohn. Bot. Zeitung 21 February 1851.

Reproductive Cell.

Contents of the Antheridia.

Spermatia

Nature of their peculiar Movements.

Molecular? or Animalcular?

Seat of the Sperm-cells and Spermatia

Warts spread over Thallus

In Apothecium?

the Spermatozoa are about to issue from them, to exhibit lively movements; and if one of these animalcules should have partially escaped from its parent cell (eg a portion of its tail) such a cell would certainly very much resemble a monad & might easily be mistaken for & described as such.* Dr. Hermann Schacht, who also carefully examined the Spermatozoa of Borrera ciliaris, found them, on first examination, to exhibit a lively tremulous motion, without changing their position. After maceration in water for 10 days (but not during the first 8 days) this motion become greatly more vigorous, being composed essentially of a succession of jerks, - progressive & regressive, very analogous to, tho' slightly weaker than, the peculiar movement of the Phytozoa ("Spiralfäden") in Ferns &c.; but materially different from Molecular motion, for which, on the first day only, he mistook it. He noticed them also in the young apothecia of the Lichen (tho' not so abundantly as in the brown warblets) - as screw-shaped (spiral) bent filaments ("schraubenförmig gebogene Fäden"). Scattered among the Spermatozoa, he detected a number of colorless, little, globular cells, & in one at least, he perceived a lively motion, resembling that exhibited by the Phytozoic cells ("Spiralfädenzellchen") of the Ferns &c.; so that, tho' he did not actually see a Spiral filament in any one of them, yet he was inclined to consider these Cells as the Sperm-cells of the Lichen, - the birth-place† of these Spermatozoa ("Ursprungsstätten") †

aff. P. 31-32-34.

aff. P.

aff. P.

Opposed views of Fulasne, Kützing & von Flotow.

Fulasne, Kützing & von Flotow also followed the directions given by Itzigsohn for seeing the peculiar movements of the Corpuscles, but they totally deny that they exhibit the vital or animal motions attributed

* Bot. Zeitung 21 Feby. 1851.

† 'Das Mikroskop und seine anwendung insbesondere für Pflanzen-Anatomie & Physiologie' q. Bot. Zeitung 22 August 1851.

Reproductive Cell.

attributed to them by him, but only "confused movements," which precisely agree with "Molecular Trembling" as described by Brown. Tulasne, moreover, states that, far from seeing the so-called Spermatozoids "originate in special cells, like the Spermatozoids "of the Muscineæ, I have satisfied myself that they are developed "on the surface of a basidigerous Hymenium, & owe their "origin to an acrogenous vegetation".* According to him, they originate like Acrogenous spores, — isolated or twin, from cells, which form the inner wall of the Conceptacle (or Antheridium?), or "laterally from Moniliform Filaments, or various processes, lining the "cavity". "Sometimes a long filament, which becomes divided into a "variable number of corpuscles is developed in place of one of these "corpuscles".* In their Genesis or development, therefore, these Corpuscles are (according to Tulasne & others) quite dissimilar from the true Spermatozoids, "which originate in the interior of special "cells, from which they disentangle themselves, soon after their "exit from the antheridium". One & perhaps the only distinct point of resemblance between these Corpuscles is their equal tenuity — In some species of Verrucaria (e.g. V. Aromaria) & some other Lichens, it is stated that the apothecia, at a certain stage of development, contain, besides the ordinary Spores, the Itzigsohnian Corpuscles (or bodies very similar?) — In development, these corpuscles precede the Spore-cells, "for the young apothecia are densely filled with the "first, before the second have acquired a recognizable form".* From their Coexistence in the same apothecia with true Spores, some authors have concluded that these Spermatoza (of Itzigsoh) or Spermatia (as they are termed by Tulasne, — who intends by using

Contents of the Antheridia?

Spermatia?

Movements.

Origin according to Tulasne.

Genesis unlike that of true Spermatozoa?

Points of apparent resemblance.

Period of Development.

Coexistence in Apothecium with true Spores.

App. P. 31-32. 33-34.

* Tulasne 'Comptes rendus' March 24/51. Ann. Nat. Hist. August 1851.

Reproductive Cell.

Contents of the Antheridia? Spermatia?

Theories as to their true Nature & Affinities founded on Structural Analogy

Period of Developement &c

using that word merely to convey the "idea of a body destined in some way to the function of reproduction") are only young or imperfectly developed Spores — Flotow, for instance, regards them as "Spores in a rudimentary condition, destined however subsequently to become perfect reproductive organs" * This Supposition, however, is rendered improbable by their extreme & uniform dissimilarity in form, size & mode of generation — Without, however, in any way prejudging their nature & function, it is noteworthy that the Spermatia "precede the Endothecal Spores, "exactly as the Antheridia of the Ferns & Equiseta precede the ori- "gin of their seminiferous Capsules" *

Whole subject of Supposed Male organs still sub judice

Many series of careful accurate & extensive microscopic observations will, I fear, require still to be made, before the true nature & functions of the (so-called provisionally) Antheridia & Spermatozoa (& in fact the whole subject of Lichen-reproduction) are placed on a pure Scientific footing —

* Tulasne 'Comptes rendus' March 24/53.
Ann. Nat. Hist. August 1853.

FUNCTION OF REPRODUCTION.

Reproduction of Lichens.

FUNCTION OF THE GONIDIA.

Specific functions of the Constituent Reproductive Organs

Function of the Gonidia.

Gemmation?

The Gonidic Reproduction of Lichens has generally been considered as analogous to the process of **Gemmation**, or Propagation by means of **Buds** in the higher plants— Schleiden, in speaking of the reproduction of Lichens, says the "Entire "specific formative power, from which they proceed, is present & expressed "in each single piece— Hence their Propagation by accidental or normal "division, each piece becoming a new individual"* He is of opinion that reproduction by Gonidia (**Soredia**) is not a property peculiar to Lichens & not a process at all similar to the formation of buds in the Phanerogamia, but "simply an evidence that, under favorable "circumstances, every vital vegetating cell of a plant may grow into "a Plant"— For "a strict individualization of each cell is at variance "with the regular formation of organic fructification, where the "individuality of the separate cells appears most circumscribed & "checked"* From comparative observations on the Collemata & the true Lichens, Thwaites has been led to conclude that the "Gonidia are the essential parts of the Structure of the Thallus, "& only **accidentally** acquire the **function of Gemmæ**, "just as the individual Cells of other plants assume the propa-"-gative function under peculiar circumstances"† And he regards them as the analogues, with regard to function, of the **Nostoc-Vesicles** of the Collemata— Schnizlein considers them analogous to the **Leaves** of the higher plants‡ Whatever their real nature (or analogy) may be, (& we may consider this subject as still

Essential parts of Thallus?

Function of Gemmæ accidental?

Opinions of Thwaites?

Structural Analogy to Nostoc-vesicles?

Functional Analogy to Leaves?

V. append. P. 2. 40. 43.

app. P. 21. 22. 27. 43.

app. P. 31.

V. P. 9. app. P. 40.

* Scientif. Botany P.

† G. H. K. Thwaites. Botanical Gaz. april 1849.

‡ Lond. Bot. Peaks.

Lichen-Reproduction.

still subjudice) we know that the Gonidia (or Soredia) propagate either on the original Thallus, forming foliaceous or squamul-

Function of Gonidia.

"-ose expansions, or external to the original Thallus, forming "new Individuals of the parent Thallus" *

Function of Apothecium

FUNCTION OF APOTHECIUM. — The apothecium, or Sporocarp, is probably, as Schleiden says, a mere Envelope for the Spores,

Envelope for Spores?

"facilitating & regulating their distribution by its hygroscopic qual-"ities" † We do not know that any special function is performed,

Morphological Significance of the Paraphyses.

or in what manner the process of reproduction is subserved by the Paraphyses, Hence we conclude for the present at least) that they possess merely a morphological significance. Hedwig

App. P. 21

Analogy between Apothecium and Flower, Fruit &c of Phanerogamia

believed the apothecium to be the Female flower of the Lichen, but acharius argued against its being the Fruit, from the little resemblance between it & most varieties of fruits or fructifications already known, — from its absence or rare occurrence in some species & from the uniform occurrence of Gonidia (Gongyli) in Lichens. ‡

Function of Theca

FUNCTION OF THECÆ. Of the function of the Thecæ in its relation at least to the Development of the Spore, very little is at present known — It is probably inter alia intended to protect

Spore-Envelopes?

the "delicate Spore-Cell against injurious agencies & humidity, "till in a condition to assimilate foreign matters for itself" †

Analogy to Ovaries, Carpels &c of Phanerogamia.

Thecæ have often been considered, by various authors, as analogous, functionally (tho' not structurally) to Ovaries or Carpels ‖?

* Tuckerman Syn. North. Lichens P. † Scient. Bot. P. [Schleiden]
‡ Edin. Encycl. art. Lichens. ‖ E.g. Library of Useful Knowl. art. Botany P. 117.

Lichen-Reproduction

Function of the Spore.

Specific organs of Reproduction.

Result of Fecundation?

Analogy to Ovules, Seeds.

Bulbs,

Pollen &c. of Phanerogamia?

Analogy to Sporangia?

v. append. P. 2.27. **FUNCTION OF THE SPORE** The function of the Lichen-Spore, I have already stated, is the Reproduction of the Species & is the principal & surest means of propagating the plant, (the Gonidic reproduction being probably so far supplementary & subtitutional) - One class of authors believe the Spores to be the result of Fertilization or **Fecundation**, - of the union of 2 kinds of reproductive Cells, (Sperm-Cells & Germ-cells) as in most other plants; while another class totally deny this [& indeed the whole subject is presently sub judice] Many authors have reckoned them analogous to **Ovules** or **Seeds** (e.g Meding, De Candolle &c.)? De Candolle considers the word "Spores" merely a provisional name for bodies, which serve to reproduce the Species like seeds; "for, when it has been app. P. 31. P. 21. "proved that they are the result of Fecundation, we must call them app. P. 21. "seeds, but if the contrary then they are to be looked upon as "**Bulbs**."* Some of Schleiden's followers have been particularly app. P. 28. fond of comparing Spores to the **Pollen** of higher plants, both of them being contained in a Case or Capsule, which is a Theca in the first case, an Anther in the second - But such views are wholly fanciful & their upholders forget apparently that the "first, when "discharged, is at once fit for germination", while the "second must "be transmitted to an ovary, matured in an ovule & supplied with a "store of nutriment, before it is capable of independent existence"† Other authors (eg Maout) have regarded the Septate or partitioned Spores as true **Sporangia**.

* Vegel. Organog. V. 2. † Balfour's Botany P. 246.

Lichen—Reproduction.

FUNCTION OF THE ANTHERIDIA AND SPERMATIA.—The peculiar Conceptacles, which I have already described, & which have been termed "Antheridia" by Itzigsohn, & "Spermogoni" by Tulasne, are regarded, by these & other authors, (tho' they differ as to their true analogies), as **Male Organs** of reproduction—In speculating on the nature of the function of these bodies, it is important to bear in mind the periods of developement & maturity of the Spermatia (the supposed male) & the Spores (the supposed Female reproductive cells)—And it has accordingly been stated that the Spermatia, even when coexisting in the same apothecium with the Spores, always precede these in existence: thereby strengthening the probability of their supposed Male function. Others have supposed them Organs of **Gongylary** or **fissiparous** reproduction, but such a view is rendered improbable by their "extreme tenuity & the otherwise abundant provision for this mode of reproduction by the Soredia, which every Lichen possesses in some shape".* But, we must remember, that the very existence of these Antheridia & their contents is doubted & even absolutely denied by Observers of the highest reputation—Schleiden, for instance, denies the existence of such bodies in apothecia & remarks, that, "not a single fact can lead us to infer that they are at all connected with the function of reproduction," and, that, everything, which has hitherto been written on the subject of Antheridia, consists solely of "fine-spun fancies founded upon decidedly false Analogies".† We must therefore consider with Lindley

App. P. 22. 31.

Function of Antheridia and Spermatia?

Supposed Male Organs?

Arguments in favor of this view

Organs of Gongylary or Fissiparous Reproduction?

Arguments against this view

Existence of Antheridia & Spermatia as yet doubtful?

* Tulasne 'Comptes rendus' March 24/51. Ann. Nat. Hist. August 1852.

† Schleiden Scientif. Bot. P.

Lichen-Reproduction

Function of Antheridia & Spermatia?

Opposite Theories?

Lindley (for the present at least) the names Antheridia, Pistillidia &c as applied to Lichens, as "merely theoretical expressions "& unconnected with any proof of the parts, to which they are "applied, performing the office of Anthers & Pistils — If it should be 22. "assumed, as it has been by some, that they do represent sexual "organs, it is to be remembered, that it is a mere assumption, "unsupported by sufficient evidence."*

General Considerations on the REPRODUCTION OF LICHENS.

General Observations on Lichen Reproduction.

app. P. 8. 45. The fructification of Lichens may be said always to have been the "Pons asinorum" of Lichenologists, — and even still is a Botanical problem of very difficult solubility — Extreme views of the nature of their Reproductive organs have been adopted by different classes of authors — One set of Botanists, for instance, believe that Lichens are propagated by bodies exclusively the result of Fecundation, as occurs in the higher plants: another asserts that there is no such thing as fecundation in Lichens, but that reproduction takes place by simple Division of the plant, ie by unfecunded germs; while a third class adopt intermediate views — I shall merely glance briefly at a few of the chief arguments advanced by the upholders of these respective Theories: and first with regard to the

True nature of Reproduction in Lichens. still ambiguous?

Theories on the subject.

V. app. P. 2-27. "FECUNDATION THEORY" as applicable to the Lichens. From its having been found, that in almost all other plants, the union of two kinds of reproductive cells (or the fecundation of a Germ cell by the contents of a Sperm cell) is necessary for the production of Spores

"Fecundation" Theory as here applicable

* Lindley Vegel. Kingdom P.

Lichen—Reproduction. Theories. "Fecundation" Theory

Spores or analogous reproductive bodies From the occurrence of spores in Lichens, it has been argued that these Spores must be the result of fecundation— But have we any proof of its existence?— In proceeding to answer such an inquiry, our first aim must of course be to discover whether Lichens possess any organs to which a male function can be attributed (i.e which can produce the Sperm-cells)— for there can be no doubt as to the organ, which produces the Germ-cell (ie- the female part of the function of Reproduction)— I have already mentioned that "Farinaceous efflorescences", Tubercles Warts of various kinds, were supposed by the older Lichenologists to be endowed with a male function under the belief, that they were masses of Pollen— Jussieu, for instance, gives very distinctly the characters of the Male & female organs as follows: Male "Farina fundi "inspersa, aut verrucæ eidem immersæ, granulosâ turgidæ massâ "mox evaindâ"— Female "Scutella sessiles aut substipitatæ, "cape subrotundæ et marginatæ, margine integro aut denticulato, "interdum linearis oblongæ, aut convexæ sphæroideæ, pulvere fa- "rinoso fatæ"— * Some authors have considered as male organs "nearly globular parcels of pulverulent matter, collected at "the extremity of certain lobes of the Thallus"; others Lacunæ, or cavities scooped in the Thallus, which it was asserted contained Polliniform matter † The most persevering supporters of the Fecundation Theory, however, when driven from every stronghold of their opinion, have been compelled, very ingeniously too, to suppose, either that the Pollen is produced by the Margin of the Shields, which is usually rolled inwards at the period of their first

app. P. 28.

Existence of Fecundating Organs?

Supposed Male and Female Organs.?

app. P. 31.

Erroneous views as to the Nature of Warts and Tubercles, Soredia, Lacunæ. &c.

app. P. 21. 22. & P. 69.

app. P. 22. 43.

Mistaken analogies to Pollen &c

app. P. 22 43.

app.

Supposed mode of Fecundation.

* Genera Plantarum 1791. † De Cand. Vegel. Organog. V. 2. P.

Lichen-Reproduction. Theories.

p. 28. "first development of these organs, which must be supposed to be "that of flowering; or that the Fecundating matter is contained in "the same Cavities as the Ovules."* But we have no proof, nay not even a probability, (now that the structure of Lichens is comparatively well known) of any such structures being fitted to perform such a function, and all these organs, of whatever kind, occur in such a limited number of Lichens, that we cannot conceive them subserving solely or chiefly the important function of Reproduction, but, if at all, a much less important function, either in nature or degree. We have therefore many & cogent reasons for totally repudiating all such Doctrines of the seat of the Male reproductive function, as matters of mere Theory — mere fabrics of an overstrained fancy in search of materials wherewith to rear a projected structure. Mirbel, speaking of the views of those, who since the time of Camerarius, have endowed all plants with sexual organs, says, "Ces idées absolues venaient de la tendance "trop ordinaire de l'esprit humain à généraliser les faits particuliers, "tendance d'autant plus forte, que nos connaissances sont moins "avancées"† More lately, the peculiar Conceptacles, - the "Antheridia" of Wigsohn, - have been asserted to be Male organs; but this fact has certainly not as yet been sufficiently established. But, supposing even that the fecundating fluid is not contained in any distinct organ analogous to an Antheridium &c, yet it has also been recently stated that the supposed Male reproductive Corpuscles, - the Spermatia, - coexist in the same organ with the Spores in the Apothecium; but this point also is still matter of

"Fecundation" Theory.

Supposed Seat of Male organs.?

p. 31.

p. 21.

Opinion of Mirbel.

p. 22.

Antheridia and Spermatia in relation to Reproduction.

app. p. 31.

p. 22

* De Cand. Vegel. Organog. V. 2. P.

† Mirbel Elémens. Vol. 1. P.

Lichen—Reproduction

Theories.

"Fecundation" Theory.

of active discussion. In speculating on the nature of the Reproductive Cells found in Lichens, we must always keep in view the relative periods of developement & maturity of the male & female organs of reproduction in other tribes of plants viz: the developement & decay of the male previous to the developement of the female organ,— the function of the former being limited to fecundation— Hence, we will arrive at the conclusion, that the more fugacious the bodies under examination are, the more likely are they to be male organs of Reproduction— one cause of the great confusion & doubt overhanging the subject of Lichen-reproduction is that the reproductive organs have almost always been examined in the mature state, "when we should no more expect to find male organs, than stamens in Phanerogams, "when their seeds are ripe" * Itzigsohn states his belief that his Antheridia "are only furnished with Spermatozoa in the "Spring; therefore the observations must be made at the "proper time" † Hedwig has the merit of having first pointed out this source of fallacy,— as applicable to the Lichens equally with other Cryptogamia,— particularly directing attention to their early developement— In reference to the subject of Fecundation, De Candolle states that three facts are specially to be borne in mind viz:

Antheridia & Spermatia in relation to Reproduction.

Period of Developement &c as proof of supposed Male functions?

Sources of Fallacy in determining supposed Functions of Organs.

Opinions of De Candolle, Hedwig. &c

I. That the fecundating organs or fluids have escaped & may still escape the powers of our Microscopes, tho' they really exist.

II. If the germ to be fecundated & the fecundating fluid be contained in the same cavity, we may not be able to see the

sexual

* De cand. Refel. Organog. V. 2. † Bot. Zeitung & Bot. gaz. July 1850.

Lichen-Reproduction Theories.

sexual organs, tho' fecundation may really take place—

III. That, as several of the Phanerogamia are propagated by unfecundated germs, tho' they are possessed of genuine fecundating organs, the same thing may take place among the Lichens—

Theory of Lichen reproduction by "UNFECUNDATED GERMS", (i.e. by **Simple division**)

Theory of Reproduction by Unfecundated germs

v. app. P. 2-27 45. Some authors, denying totally the existence of fecundation in Lichens, aver that they are propagated wholly by a kind of **Gemmation** (ie by Cells, which they consider analogous to **Buds** or **Bulbs** &c of the higher plants)— A Lichen is preeminently a collection of **Phytons** (as they are termed by Candolle) † "a "plant, composed of numerous individuals, each having a sort of "independent existence, all contributing to the general growth of "the Compound individual, formed by their union" * We know that the Gonidia (or Soredia) propagate the individual, for they have been actually seen to germinate by Micheli & many other observers since his time † But, it is asserted by many, that in many, if not in all, cases, reproduction takes place solely by these powdery masses — or Soredia — This occurs, for instance, according to Sprengel, in those species, which seldom or never possess (apparently?) Apothecia, e.g. Lecidea fustulata?, which is very common in Sweden, but rarely exhibits fructification; its whole surface "being covered "with this powder, standing on particular branchy pedicles, which, "wherever it is carried by the winds, produces new plants" † Fructification is also very rare, he says, in Parmelia jubata, — scortea, — chalybiformis, — melaloma, — Cetraria fallax, — nivalis, — glauca — Lecidea cechumena,

Gemmation?

Gonidic Reproduction.

app. P. 31.

In cases where Lichens barren (ie. no Apothecia) Gonidic Reproduction alone?

* Balfour's Botany P. † Sprengel's Cryptogamia P.

Lichen-Reproduction. Theories.

Theory of Unfecundated Germs i.e. Multiplication by Simple Division.

Arguments from Universal occurrence

Sufficiency of such Reproduction.

Opinions of Lamarck, Richard, &c

Modus Operandi of Unfecundated Germ-Reproduction.

cechumena β difracta, Lichen bicolor & pubescens &c all which, however, propagate with great facility* — Multiplication by simple division, we know, is of universal occurrence in the vegetable Kingdom; & it might be asked (& has repeatedly been asked) what is the necessity for Fecundation in such plants as Lichens, where other means, so ample & so complete, have been provided by Nature for the perpetuation of the species? But, we also know, that, in the greater number of plants, this mode of Reproduction, independent of fecundation, "requires the concurrence of a greater number "of physiological circumstances than are usually met with in "nature [in fact demanding the assistance & co-operation of man] "& fecundation is then the natural form, which replaces it, inuring "the perpetuation of the Species" † The very names applied, by some authors, to the Tribes of plants now included under the term Cryptogamia (eg "Agamæ" of Lamarck, "Inembryoneæ" of Richard) imply the belief that the plants, which they are employed to designate, are in reality destitute of flowers or fruits or their analogues, — & reproduced wholly by simple unfecundated germs — Gaertner looked upon both Spores & Sporidia as a peculiar kind of Germs or Buds, which he denominated "Propago" & described as "a simple germ, without leaves, or regular shape, — in some "cases, naked & in others, covered with an Envelope" ‡ When mature, according to him, they separate from the parent plant, and are dispersed like the Seeds of other plants & so far thus analogous, — but physiologically they are more analogous to Buds

J.

*Sprengels Cryptogamia P. †De Cand. Vegel. Organog. V. 2.

‡ Edin. Encycl. Art. Lichens.

Lichen-Reproduction. Theories. Theory of Unfecundated Germs.

If, in bulbiferous & viviparous species of the Phanerogamia, reproduction by simple division is provided (besides the ordinary propagation by seeds, which these plants possess) for the sure perpetuation of the species, in circumstances unfavorable to the germination & development of seeds, how much more should we a priori expect this to be the case with the Lichens, which are exposed to "being successively "scorched, drenched & frozen on the same barren rocks"?* Besides the simplification of the structure of Lichens might lead us to expect a corresponding simplification in mode of Reproduction — Sprengel remarks that Reproduction by unfecundated germs prevails more in the descending scale of vegetation, as the structure becomes simpler, beginning perhaps in the Fern-tribe, — prevailing to a greater extent among the Mosses & Hepaticæ, & becoming most prevalent among the Lichens & Confervæ.† Acharius also holds that Lichens are only reproduced gemmiparously (i.e by Bud-knots of Gonogyli), thus corroborating Gærtner's view — This gemmiparous Reproduction, were it true, would form a remarkable exception to the generally-received & long-established Doctrine, "that the only genuine reproduction in vegetable nature "must be effected by seeds" (Knight)* — Fée states that the Reproduction of Lichens takes place by Leminules, which, not being the result of fecundation, are to be considered as kinds of Offsets-Suckers-buds, Propagula &c — Sprengel ridicules the necessity of supposing the existence of Male organs in Lichens, — remarking that "it is pre-"-sumptuous in man to prescribe to infinite wisdom general Laws, "which tho' followed in the formation or propagation of some crea-"-tures, can be dispensed with in the more simple formation of others.

Simplicity and Sufficiency of such Reproduction. Occurrance in other Cryptogamic families. Opinions of Acharius, Gærtner &c. Exception to the "Omnia ex ovo" Theory. Opinion of Sprengel.

aff. P. 28

aff. P. 31.

h. P. 31.

*Edin: Encycl. art. Lichen. †Cryptogamia P.

Lichen-Reproduction

Theory of Reproduction partly by Organs of Fecundation partly by Gonidia.

Other authors take an intermediate ground, — they support exclusively neither the Fecundation nor Gemmation Theories, but admit the existence of <u>two</u> distinct kinds of Reproductive bodies, Spores & Gonidia, declining however to specify their true nature, or the exact part that each plays in the performance of a function common to both.

APPENDIX

NOTES AND ADDENDA.

1.

THEORIES OF EQUIVOCAL GENERATION as applicable to the DEVELOPEMENT AND METAMORPHOSIS OF THE LICHENS.

Lichen-Developement

"The Doctrine of Equivocal Generation among the Lower Plants has long been a favorite Theory with many Botanists of no mean reputation, especially in Germany — These gentlemen believe that, there exists in the Vegetable Kingdom, a "Common matter of vegetation", consisting of simple, globular cells, each of which is endowed with the "Vital principle"; that such cells have no intrinsic or specific Powers of reproduction, but that their Developement, into the most various forms, is solely dependent on the atmosphere & other accidental external circumstances, to which they may happen to be exposed — That is to say, if the "Vital principle" of such matter, which is of universal Diffusion, be called into action on a bare wall or sterile rock, it will become a LICHEN; if in a moist dark cellar, or mine, or on dead or putrid organic substances a FUNGUS; if under water an ALGA? The particular conditions, as regards Temperature + Light — moisture — surrounding medium & other casual circumstances, are thus supposed to determine the Developement of these rudimentary Cells, and many Facts have been adduced (e.g. that a Conferva is never found growing in air, or a Lichen in water) in support of this opinion — Some such Theorists assert that many different Primary forms of matter always produce the same species of Plant; others, that one species may be transformed into another, or that different Genera may be produced from the same

App. P. 43.

"Equivocal Generation" Theory as applicable thereto.

Opinions of Kützing &c.

Influence of Temperature, Moisture, Light &c on the Metamorphoses of the Cryptogamia.

Anomalous Transformations

Lichen-Development

"Equivocal Generation" Theory as applicable thereto.

same original seeds. They declare, moreover, that the Faculty of Reproduction is not peculiar to the Spores, but is common to every constituent cell, in proof of which, it is mentioned, that if a Lichen be reduced to a fine powder, such powder (tho' the Spores be carefully excluded) will reproduce a "Lichen-like" Plant—There are some even, who believe

Anomalous Reproduction.

the Reproductive Power of the Spores to be very anomalous, supposing them capable of becoming Plants under one set of Conditions & Animalcules under others"[2]* MEYER believes that "decomposing vegetable & some inorganic matters are equally capable of assuming organisation under the influence of water & light;"† and KÜTZING (in an Essay which I will immediately notice more fully) goes so far as to say that "from one & the same organic material, even when it has acquired form & colour, different vegetables may be developed, which according to the circumstances of ~~surrounding~~ medium are Algæ, Fungi, Lichens or Mosses; and that, even the Spores of these, when produced, are capable of generating Plants belonging to different orders."‡ ?

Opinions of Meyer & Kützing.

"Accidental" Development of Algæ, Fungi, Lichens &c

This Doctrine appears in another form viz: the Belief that the Decomposition of Organic Bodies gives rise to Organic bodies of an Inferior Type, whereby the Cryptogamica are supposed to be the result of the Decomposition or Degeneration of the Phanerogamica, the so-called "Higher" Plants. Were it necessary, abundant proofs might be adduced of the complete Untenability & Error of such a Doctrine, in all its phases, but I think these are by no means called for in the present Essay—

Doctrine of "Degenerative" Development.

As an illustration merely of the various Theories, I have just mentioned, & not as throwing any new Light on the subject of the Development of the Lichens, I introduce here the substance of so much of Kützing's Observations & Theories on the Metamorphosis of the Protococcus-cell

*Libr. of Useful Knowledge. Art. Botany p. 107.

†"Über die Entwickelung d'der Flechten" q. Lindley Veg. Kingdom

‡"Die Umwandlung niederer Algenformen in höhere &c"—q—"-

Lichen-Development "Equivocal Generation" Theory as applicable thereto.

-cell, as relates to the development from it of Lichen-Tissue - I will first very briefly enumerate his principal Divisions of the Elementary vegetable Tissues, & then glance at his History of the Transformation of the Protococcus -cell (which he regards as the original Type of all vegetable-tissue) & of several other members of Cryptogamic families, into Lichens - This will enable me to illustrate, at once, 3 points viz. 1st. This Theory, so cherished by Continental Naturalists especially, of "Equivocal Generation" & Progressive Development in Nature. 2nd The ingenuity with which Facts may be adapted to preconceived Theory, and made a Basis for a superstructure erected by a fertile imagination & subtle fancy† - Kützings Essay* has only served to corroborate in my mind (on careful perusal thereof) what I must confess to have been a preconceived opinion viz: that the primary constituent cells not only of the Cryptogamia (but of Vegetables in toto) are to the eye very much alike, if not identical; but, who can presume to say at this very early period of their existence that out of one cell there shall arise a Lichen, out of a second an Alga, from a third a Moss & so on; or who can predict from the mere external appearance of such a rudimentary cell what part any combination of external circumstances may cause it to play on the grand stage of Nature - The Germinal vesicles of many animals are originally identical, so far as the eye alone can judge; but we know that one is endowed with a "Vis Vitæ" under the influence of which it is gradually developed into an Elephant, while a second becomes merely a Mouse! And can it be said, in such a case, that the diversity in the development of these two vesicles has

Kützing's Views.

Influence of external Circumstances in causing Anomalous Development and Metamorphoses

Improbabilities and Fallacies.

† 3d. The "Cacoëthes scribendi" of certain Botanists, as regards Botanical Technology, the very nature of the technical terms employed by Kützing, being almost per se sufficient to discourage all attempts to study this Essay -

* "Die Umwandlung niederer Algenformen in höhere so wie auch in Gattungen ganz verschiedener Familien und Classen höherer Cryptogamen mit zelligem Bau" published in the "Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. 2d Verzameling 1te Deel."

Lichen-Development "Equivocal" Generation Theory as applicable thereto.

has been occasioned by diversity in the external circumstances, to which these vesicles were exposed,—a Tropical Jungle in the one case,—an obscure nook of a Dwelling house in the other.? Certainly not— I believe the rudimentary Vegetable cell to be in precisely the same condition— Each cell has a Specific & unchangeable destiny & external circumstances have certainly a very great influence in modifying its mode of Life & may even cause its abortion or death, but they have no power to alter its Vital properties, so far as to endow it with the appearance & character of a specifically or generically different Plant— It is obviously impossible for man, tho' he may create a complete change in surrounding influences, to make a corresponding alteration in the life of such a primary cell & especially to predict what & how much change will correspond to such altered Circumstances— I therefore consider the whole Theory of "Equivocal Generation" as the manufacture of an exuberant fancy, acted on by preconceived erroneous opinions—

Improbabilities and Fallacies.

KÜTZING,

Kützing's Divisions of the Elementary Vegetable cell.

then, divides the elementary Tissues of the lower plants into 5 Primary groups ("Hauptformen"—"Primäre Entwickelungsstufen"), which he subdivides so as to constitute Secondary, Ternary, Quaternary &c groups— They are

I. The Spherical Type and its Sub-divisions.

I. THE SPHERICAL. The original Type, from which all the others are developed. (Die Urform aus der sich alle übrigen nur denkbaren entwickeln) This group is represented by Microscopic utricles or vesicles (Kügelchen oder Bläschen)— The "Secundäre Entwickelungstufen" of this group are the

I. Gonimic	III. Synaptic
II. Entagonimic	IV. Entosynaptic

A. THE GONIMIC consists of "Das einzelne, uneingeschlossene, unverwachsene, freie, einfache vegetabilische Bläschen oder Kügelchen". This Cell-type is further divided, according to its

Size

Kützing's Divisions of the Vegetable Cell.

a. Size, into Micro-gonimic and Macrogonimic

b. Color, into Achromatic, and

Chromatic, constituting according to the Coloring-matter

I. The Spherical Type and its Sub-divisions.

Chlorogonimic, (Green)
Xanthogonimic, (Yellow)
Chrysogonimic, (Golden-yellow)
Erythrogonimic, (Red)
Phäogonimic, (Brown)
Glaukogonimic, (Blue)

Gonimic-Cell Series.

c. Cell-wall ("Zellensubstanz").

Division according to Size, Colour, Nature of the Cell-wall.

1. Myxodermatinic: "Unvollkomenen gonimischen "Kugelchen sind blos mit einer Schleimhülle um- "-geben, deren Substanz noch so geringe Festigkeit " hat, dass sie oft in ihrer äussern Begrenzung " nicht erkannt werden kann, und in flussige " Materie überzugehen scheint. Die Begrenzung " dieser Schleimkügelchen nach innen, gibt " sich jedoch deutlicher durch eine bestimmte, " aber sehr kleine & mit anderer masse an- "-gefullte Höhlung zu erkennen."

2. Pachydermatinic - "Bei weiterer Entwickelung "verhärtet jedoch der Schleim & wird Knörpel- "-artig" —

3. Leptodermatinic: "Endlich ziehet sich die "Hülle noch mehr zusammen, wird dadurch " dünnhäutig, verliert aber auch dadurch "ihre schleimige & knorpelige Beschaffen- " heit." —

Reproduction

Kützings Divisions of the Vegetable Cell.

I. Spherical Type & its Sub-divisions.

Gonimic-Cell Series.

Division according to Nature of Reproduction.

d. Reproduction,

1. **Entoschismatic** — By Division ("Theilung")
"Die Trennung von Innen heraus geschichet,
"auch besonders die Trennung des innern
"Kerns in zwei, drei, vier oder mehr Theile
"zur folge hat" —

2. **Ectoblastetic**. (By lateral budding — ("Seitliches Sprossen".) "Das Neugebildete an der
"äussern Hülle auch aus der Substanz
"derselben entstehet" —

a. **Periblastetic** — By the production of several young Buds on the outer surface of the Parent cell — "Mehrere junge Keime
"ergeugen sich ringscherum, an der
"Aussenfläche des Mutterkügelchens" —

The Myxodermatinic, Pachydermatinic & Leptodermatinic are each further subdivided into Achromatic & Chromatic minor groups —

Entogonimic Synaptic & Entosynaptic Series.

The **Entogonimic**, (like the Gonimic), **Synaptic & Entosynaptic** — "Secundäre Entwickelungsstufen" are subdivided in precisely the same way as the Gonimic, according to their
I. Size, II. Colour, III. Nature of Cell-wall,
and IV. Mode of Reproduction —

The next "Hauptform" is the

II. Nematic Type & its Sub-divisions

II. NEMATIC, which is developed from the Spherical cell, by its elongation in one direction, or by superposition ("Aneinander-reihen") —

Represented by Filaments, Fibres, Theca — the "Secundärstufen" of this Type are, as in the former case, I. Gonimic, II. Entogonimic, III Synaptic, and IV. Entosynaptic. —

The Mode of Development of this Type is 3-fold

viz:

Kützings Divisions of the Vegetable Cell

II. Nematic Type

Its Sub-divisions

a. **Orthogenetic.** "Wenn ein Faden aus einer – Kugelform sich "entwickelt, welche seiner Entwickelungstufe in jeder Be- "-ziehung entspricht (e.g. ein entogonimischer Faden aus " der Entogonimischen Kugel"—

b. **Hypogenetic** "Wenn ein Fadengebilde auf einer ver- "-hältnissmässig niedrigern Entwickelungstufe stehet " als die sphärische form, aus welcher es sich entwickelte

Hypergenetic "ein Fadengebilde, welches eine ver- "-hältnissmässig höhere Entwickelungstufe an- "-zeigte, als die entsprechende Kugelform aus " welcher es ursprünglich hervorging." (e.g. entoga- "-mimische Fäden aus ursprunglich gonimischen " Kugelchen)"—

III. Phyllodic Type

III. PHYLLODIC. Formed, either from the Spherical cell, by "anwachsen "hinter- und nebeneinander"; or from the Nematic, by increase laterally ("in der Breiten-dimension") or by the union of several adjacent Filaments – Represented by the Leaf—

IV. Stelechodic Type

IV. STELECHODIC. Formed from any of the 3 former Types, by increase in all dimensions ("Ausdehnen & Anwachsen") Examples the Trunk or Stem – subdivisible into

I. Spherical, II. Nematic, III. Phyllodic.

V. Sorenmatic Type and their Sub-divisions and Combinations.

V. SORENMATIC. Includes the various Combinations of all or any of the preceding groups into an aggregate mass – "Höhern individuellen Einheit." – Divisible into

I. Spherical, II. Nematic, III. Phyllodic,

and IV. Stelechodic

Kützing goes on to divide & subdivide the preceding Groups & subdivisions almost ad infinitum, but such a minute Analysis, I do not think demands a place in this Essay—

Lichen-Development. "Equivocal Generation" Theory as applicable thereto.

The following Propositions are laid down by Kützing, as the result of many years patient examination of Cryptogamic Plants, — inter alia

I. "Dass alle zelligen Cryptogamen aus einem und demselben or-
"-ganischen Stoffe durch Urbildung, (Generatio originaria), Fortbildung,
"(Morphosis), und Umbildung (Metamorphosis) sich erzeugen können."

Opinions and Propositions of Kützing.

II. "Dass aus einer & derselben organischen Materie, selbst wenn sie schon
"Gestalt & Farbe hat, sich verschiedene Vegetabilien entwickeln können,
" welche, nach Verhältniss des umgebenden Mediums, entweder Algen,
" Pilze, Flechten, oder Moose sind." —

III. "Dass die grünen oder anders gefärbten Sporen der zelligen Krypto-
"-gamen sich auf eine Weise entwickeln können, wodurch sie ver-
"-hindert werden die art, von der sie stammen, fortzupflanzen,
" dagegen in der Entwickelung eine solche Richtung nehmen, dass
" dadurch ein Gebilde entsteht, welches nicht nur in der Art,
" sondern auch in der Gattung, Familie & Klasse von der Mutter-
" -pflanze verschieden sein kann."

IV. "Dass die eingeschlossene Kügelchen der zusammengesetztern Zellen-
"-pflanzen den freien, ungebundenen Protococcus-Kügelchen genau ent-
"-sprechen, und wesentlich beide nicht von einander verschieden sind
" & dass die Art & Weise ihrer fernern Entwickelung blos von dem
" grade des Gebundenseins oder Freiseins abhängig ist." —

Anomalous Transformations of the Protococcus-Cell according to Kützing.

V. That the well-known **Protococcus viridis** gives origin, accord-
-ing to circumstances, to

1. Conferva muralis, C. tenerrima & other species
2. Torula tenera
3. Protonemata (P. velutinum &c.)
4. Oscillatoriæ
5. Sphærozygæ
6. Nostoc
7. Vaucheriæ (V. Dillwynii &c.)
8. Mosses (Bryum annotinum. B. cæspiticium. B. argenteum. Funaria hygrometrica. Polytrichum aloides. Dicranum heteromallum. Gymnostomum truncatum &c. —)
9. Lichens &c. (Parmelia parietina. P. murorum. Cenomyce pyxidata. &c.)

Lichen-Development.

"Equivocal Generation" in connection therewith.

Transformation of the Protococcus-cell into Lichen-tissue. Kützing's belief in the Metamorphosis of the Protococcus into Lichens rests chiefly on the following grounds: That these plants almost always occupy contiguous sites on moist walls, trees &c., or are mutually intermixed; & that the Green Protococcus often becomes converted or passes into a black or dark brown powdery stratum, in which we can often discover rudiments of young Lichens (eg. Parmelia parietina or P. subfusca, which he seems to regard as different states of the same species [P. parietina] dependent on an altered condition of moisture &c.— If we take, from the lower & damper part of the trunk of a Tree, where the Protococcus & some young Lichens are contiguous, a portion of the green powdery matter intermediate in position between them & examine it with the Microscope, we shall be able to see the mutual developement actually going on. Such matter consists of the **Synaptic** Protococcus-cell ("Synaptische Protococcusformen") more or less combined with **Sorenmatic** granules ("Sorenmatischen gränchen"), among which occur also **Entogonimic** (Chraumatic. Wallroth.) & **Entosynaptic** forms in progress of coversion into the **Phyllodic** series ("Phyllodische stufen"). The latter give rise, by means of **Ectoblastetic** and **Periblastetic** developement, to filaments having the characters more or less of the **Achromatic** type, which he denominates **Ecto-und-Periblastetic-nematic**.— These filaments are gradually developed both upwards & downwards,— interlace,— & become intimately connected with the Entogonimic & Synaptic globular cells (Kügelchen) to form a compound Tissue,— his "**heteromerischen Flechtenthallus.**"— In the earliest stage of developement of the Thallus of Parmelia

Anomalous Metamorphoses of the Protococcus-Cell according to Kützing.

Proofs?

Development of Parmelia parietina. &c

Lichen-Developement "Equivocal Generation" in connection therewith —

Metamorphoses of the Protococcus-Cell according to Kützing.

Parmelia parietina the upper layer is composed of Entosynaptic & lower Phyllodic series & the Chloro-synaptic cells are so loosely aggregated that each individual can be distinctly recognized. But this cellular Isolation or Individualization gradually ceases as the constituent cells become more intimately connected, so as to form a regular cellular Texture — Immediately underlying this Epidermic Stratum, occurs a layer of Chlorogonimic cells, — usually loose & unconnected; & below this, colorless filaments, which become gradually more & more inter-woven, till they lose their individuality & combine to form an irregular, indistinct, filamentous tissue — These filaments are the result of the Ecto-blastetic-nematic developement of the Pachydermatinic cell-membrane ("Zellenhülle") — aff. P. 40

Developement of Parmelia parietina, P. subfusca [?] P. murorum [?] &c.

Parmelia subfusca, [?] which is always found growing beside Parmelia parietina, is developed in a precisely similar way. — as is also —

Parmelia murorum [?] The rudimentary green cellules are at first isolated, but gradually become more & more closely aggregated, while here & there isolated apothecia ("Schüsselchen") make their appearance & finally a regular Thallus is formed by an aggregation of globular Entosynaptic, ento-macrogonimic and periblastetic-nematic cells ("grümchen"), very firmly bound together by the periblastetic filaments, which form its under layer —

Proofs? of Developement of Parmelia parietina from Protococcus viridis. —

In the "Linnaea" (VIII. 3. p. 350.), Kützing remarks, "Keinem Beobachter, der "nur irgend etwas Aufmerksamkeit dieser Gegenstande geschenkt hat, "wird entgangen sein, dass sehr häufig an den Bäumen wo die Parmelia "parietina sitzt, sich auch Protococcus viridis befindet. Untersucht man "die Flechte mit dem Microscope, so findet man dass ganz dieselben Pro-"tococcuskügelchen mit in die Substanz des Laubes verwebt sind; und in der

Lichen-Development. "Equivocal Generation" Theory in connection therewith.

"der That ist auch dieser Protococcus die erste Veranlassung zur Erzeugung
"der Parmelia parietina" – And, again, "An den Bäumen nach oben zu erzeugt
"sich nur Parmelia parietina, unten an der Basis siehet man Fäden von
"Protonema hervorgehen" –*

UNGER mentions the Transformation of ULVA TERRESTRIS into Parmelia parietina in the following terms; "Merkwürdig und im Ein-
"klange mit dem angeführten ist es, dass an eben solchen orten (wo die
"Ulva terrestris wächst) sich die Parmelia parietina gern zu
"entwickeln sucht – Ich bemerkte es allenthalben und überall sehr deut-
"lich, dass mehr nach unten im Feuchteren sich die Ulva, obgleich
"sehr sparsam und kümmerlich, zu bilden versuchte, weiter oben aber
"die grüne Farbe von loser Anhäufung der Protococcusblasschen herrührte,
"noch weiter aufwärts dieselbe Masse grumiger und etwas ins Gelbliche
"spielend wurde. allmählig liess sich endlich der Thallus jener Flechte
"genau unterscheiden. Die grünen bläschen, klein, aber meist grösser,
"als im losen einfachen Zustande, bilden dann dass stratum corticale &c."*

Transformation of Ulva terrestris into Parmelia parietina

Külzing also describes the Transformation of the

Protococcus into Iepraria incana (Ach.) I. atra ( ) I. flava (Ach.)
Cladonia pyxidata (Schaer.) &c.

Metamorphoses of Protococcus Nostoc commune &c.

Nostoc commune & lichenoides &c. into Collema limosum (Ach.)
Collema corniculatum (Hoffm.) Thrombium (Weber.) &c.

and numerous other collateral Metamorphosies into members of other (Cryptogamic families) from these he draws the Conclusion before referred to, viz: that, under different Circumstances & Conditions, the same Organic substances may attain a different specific or generic development – Supposing such Transformations to have an actual existence, what is the

Cause

* Külzing's Essay P. 95.

Lichen-Developement —

Anomalous Metamorphoses or Perverted Developement its supposed Causes.

according to Kützing.

Cause of such a capricious or perverted **Developement**? The degree of **Moisture, Temperature, Light** the nature of the **Soil** & other Circumstances, individually, tho' capable of exercising undoubted influence over Plant-growth, are not sufficiently powerful to produce effects so varied & opposite — E.g. a difference in the degree of humidity may cause the same Protococcus-cell, which would give rise to Parmelia muroram &c. in one situation (a dry open exposure on the top of a wall) to produce an Alga or Fungus in another (a dark damp fissure of the same wall). But we have exceptional cases of Algæ growing on places perfectly dry, & masses, Lichens & Fungi growing in very moist situations (even under water — While therefore, he considers these external agents unable, individually, to produce alterations so striking, he believes them conjointly perfectly capable of doing so, — in a word the true Cause? of the metamorphoies just mentioned —

II.

Nature of the Conidia

Kützing's researches lead him also to make the following remarks

"Das Keimpulver, oder die Brutzellen (**Gonidia**) so fest in die Flechten-
"-substanz verwebt sind, dass diese nicht vom Winde fortgeführt werden
"können" —

"Das der Begriff von Art, Gattung, Familie & Klasse (**Distinction**
"**of Species, Genus** &c.) bei den Cryptogamischen Zellenpflanzen
"schwankend sein muss".

III.

Protococcus-Cell as a Type.

Agardh, (in his "Biologie der Pflanzen" p. 132), considers the **Protococcus** "als das typische Element für die Organe im ganzen
"Pflanzenreiche" *

* Kützing's Essay P. 1.

IV.

Structure of Lichens.

Sprengel, (in his Cryptogamia), says "Never is there the least appearance, in any "Lichen, of **Spiral vessels**, or spurious Tracheæ, & seldom of a completely "distinctive **Cellular structure**. Rudiments of cells are sometimes, tho' "seldom, met with on the lower surface of the lobated Lichens, where their "destination seems to be to absorb the moisture of the soil"—

Absence of Spirals, Vessels, Stomata &c.

In the Article "Lichens" of the Edinburgh Encyclopædia, it is stated, that there occur "no kind of circulatory vessels in Lichens & seldom indeed "can the structure be shewn to be either distinctly cellular or vascular"—

De Candolle, (Vegetable Organography Vol. 2.), mentions that the **Vessels** in Lichens are probably replaced by bundles of elongated Cellules & the **Stomata** by imperceptible pores— The entire mass of the Lichen-plant is composed of one substance, which assumes different shapes & performs different functions without **Division into distinct organs**— **Thallus** is a convenient name for indicating (in one word) every part of the Lichen-plant, which does not subserve reproduction (Acharius Synopsis Lichenum), ie. the mass of the Nutritive Organs— The descriptions of the various parts of the Lichens, which we meet with in the older authors, as resembling different organs of the vascular plants (eg apparent stems, leaves &c.) must be looked upon as mere Metaphors & depend on these writers having totally overlooked the homogeneity of the Lichen-Tissue—

Nature of the Thallus.

V.

Position of Lichens in the Scale of Vegetation.

Up to a very recent date, (comparatively speaking), the Lichens were uniformly regarded as "imperfectly organized,"— of "low organization,"— scarcely distinguishable from inorganic matter— Willemet, (Lichénographie économique), considers them the Link connecting the mineral with the vegetable Kingdom; and Amoreux (Recherches et expériences sur les Lichens &c.) almost denies them the semblance of vegetables & looks upon them as scarcely distinguishable from certain figured stones (eg the great resemblance between Graptolithus nappalis & the Lichen geographicus - [Lecidea g.?])

VI.

Structure of Lichens.

Eschweiler, (in Martius' Flora Brasiliensis Vol. 1. P. 53.), refers to the existence in many Lichens of "the simplest possible analogue" of a true **Epidermis**, as an external layer of peculiar structure & characterised by its great

Deficiency of a true Epidermis

capability for imbibing & assimilating water — It is cellular (usually consisting of perfectly **Hexagonal cells**) in the Frondose & in some Crustaceous species, — & especially in Sticta, Peltigera, Solorina, & certain of the

Hexagonenchyma

Collemata (Leptogium & Mallotium), — but not in Stereocaulon, or the greater number of the Collemata —

VII.

Divisions of the Thallus of Brazilian Lichens according to Martius.

Martius divides the Thallus of Brazilian Lichens, (which grow chiefly on tree-barks) according to their Consistence & form, as follows: ——

I. **CRUSTA** mazoidea "quae intus spongiosa, extus e prominentiis latius-
"culis inaequabilis, sicca durinscula, macerata
"molior et diffluens, communiter colorificans

II. —— vitrea "quae rigida, in lamellas pellucidas facile recedens,
"cultro pasilis est ——

III. —— cerata "quae valde laevigata, nitidiuscula, omnes corticis
"rimas obducit: strato corticali pellucido et plur-
"imum colorato ——

IV. —— ossea "quae durissima, minime rigida, nec nisi ferro
"acuto impressiones accipit, eoque derasa in
"pulverem tenuissimum solvitur —

V. —— laminosa "quae tenuis, aequabilis, laeviuscula, saepius pru-
"nosa vel nitore quodam metallico indata
"coherens et tenax, a cortice facilius sejungenda
"est. (Flora Brasil. Vol I. P.)—

VIII.

Colour of the Lichen-Thallus and its Causes

According to Kützing, each newly-formed superficial layer of colorless cells of the cortical portion of the Lichen-Thallus gradually becomes incorporated with the preceding ~~the~~ or deeper layer, & this union is accompanied by the gradual change of the green into a yellow color of the Thallus, tho' the Microscope shows the individual constituent subcortical cells to be as green as originally – This proves that the yellow-color of the Thallus does not depend solely on the **Colour** of the superficial cells, but on the attenuation ("Verdünnung & Schwaechung") of the color of the subjacent green cells by passing through the superjacent white or colorless & denser cellular tissue – But, if this superficial tissue is by any means rendered more transparent, (eg by moisture), the green color of the subjacent Gonimic cells shines through undiluted – From this circumstance Parmelia Jarietina & other Lichens are uniformly greener in moist situations.*

Opinion of Kützing.

IX.

Colorific Principles of Lichens.

Schunck considers *Alpha- & Beta-Orsellic Acids* the same, & proposes the formula $C_{34}H_{18}O_{14}$. He regards Orsellic Acid as a compound of Orcin & Lecanoric Acid (ie Orcine-Lecanoric acid). He also considers *Erythryline, Erythric acid & Evernic acid* (besides Orsellic acid), as "Coupled "acids, in which Lecanoric acid forms the acid ingredient; & might therefore "be called respectively Roccellic-lecanoric, Erypicrine-lecanoric & Everne-"-sine-lecanoric acids" – "They resemble those coupled acids, which consist "of a simple acid united with neutral bodies, & which saturate the same "quantities of any base as the simple acid contained in them e.g. "Hippuric acid (which may be regarded as a Compound of Benzoic acid & "Glycocoll minus 2eqs. water.)" † It must be borne in mind that this "Coupled acid" theory of Schunck's is, in the meantime, merely provisional

Opinion of Schunck as to their Composition and Affinities.

thrown

*Kützing "Die Umwandlung niederer Algenformen in höhere &c."

†Lond. Edinr. & Dublin Philos Mag. 1848., Schunck on Stenhouse's discoveries.

thrown out merely as a hint & requiring multiplied & careful observation to corroborate (or to falsify) it—

X.

Colorific Principles of Lichens.

Mulder gives the following Table of the "New Coloring matters discovered by Dr. Stenhouse"*

Discoveries of Dr. Stenhouse.

Name.	Formula.	Plant whence obtained.
Alpha-orcellic acid	$C_{32}H_{15}O_{13}, HO.$	Roccella tinctoria from So. America
Alpha-orcelesic "	16 8 7, HO	
Beta-orcellic "	34 17 14, HO	Roccella tinctoria Cape of Good Hope
Beta-orcelesic "	?	
Roccellinic "	38 17 15	Roccella Montagnei
Erythosic "	20 10 9, HO	
Erythrelesic "	?	
Picro-Erythrine	34 24 20	
Pseudo-Orcine	10 13 10	
Evernic Acid	34 15 13, HO	Evernia prunastri.
Evernesic "	18 9 7, HO.	
Orcine	16 11 7	This formula still only empirical best obtained from Usnea florida & Cladonia rangiferina.
Usnic acid	38 17 14.	

all these substances yield beautiful Colors, when subjected to the action of Hypochlorite of Lime & other re-agents—

Minor Colorific Principles.

Telerythrine ($C_{12}H_{10}O_{10}$) Kane, Strychnerythrine & a host of provisional "bodies" or "substances" A. B. C. D, αβγ &c have been discovered & described, with the effect apparently of only further mystifying & confounding a subject already sufficiently difficult & obscure—

* Mulders Vegel. & Animal Chemistry

XI.

Colouring Principles.

According to Hornemann's Analysis, **Chrysophanic acid** (the "yellow coloring matter of Henry") constitutes of

Existence of Chrysophanic acid in Rhubarb.

Russian Rhubarb.	9.583	p. cent
English — " — (Chinese?)	9.166	"
Sicilian — " — (English?)	2.187	"
Lucaes analysis gave in Rheum Emodi	7.500	"

Brande's — " — Chinese Rhubarb:

Pure Rhabarbaric Acid	2.0	
Impure — " —	7.5	
Gallic acid, with some rhabarbaric acid	2.5	

Physical and Chemical Properties.

Schlossberger & Dopping conclude, from chemical examination of Rhubarb, that its flavour, — relation to chemical reagents, — & therapeutic properties depend on the conjoint operation of the resin, the yellow coloring matter & an extractive, modified perhaps by the other ingredients. The color of Rhubarb is not solely due to the Chrysophanic acid, but also to Erythro-fine, a red resin, one of its three resins. An aqueous infusion of Rhubarb yields with the alkalis (Potash, Soda & ammonia) a reddish-colored solution (soluble alkaline Chrysophanates); with Lime-water, a reddish precipitate (Chrysophanate of Lime); & with various metallic solutions, metallic Chrysophanates &c. It has long been known that the medicinal use of Rhubarb renders the secretions & more especially the Urine colored deeply by it & it would at first sight appear as if the Chrysophanic acid were the cause, but Schlossberger's experiments* prove that the color in these secretions is produced by the Rheoretine & Erythroretine (2 of the Rhubarb-resins) & not by this acid, which, when pure, neither operates on the bowels nor colors the urine."†

Researches of Schlossberger, Dopping &c.

* Pharmaceut. Journal V. 8. P. 190. 1848.
† Pereira Mat. Med. V. 2.

† Pereira Mat. Med. V. 2.

XII.

Position of Lichens in the Scale of Vegetation.

Sprengel* seems to have had very primitive ideas of the true position of the Lichens in the scale of Vegetation: considering their affinity to "unorganized nature" as very striking. He says that, in the "Herpetic "Lichens (e.g. Pulveraria, Lepraria, Spiloma), or the lettered Lichen (Opegrapha) "of our rocks & trees," "you will scarcely find anything, that will lead "you to suspect the presence of vegetable nature." "They are distinguished "from Saline efflorescence merely by a little difference in their form: "and, occupying the lowest degree on the scale of Organic bodies, are, as "it were, the first rudiments of vegetation."—

Opinion of Sprengel.

Nature of the Colouring matters.

He considers the **Colouring matter** of Lichens as a "pure extractive," therefore "soluble in water & obtained by simple infusion", "but is not in this state sufficiently adherent to Woollen stuffs,— thus "requiring, in dyeing, the previous addition of either acids, wine or alum"

XIII.

Divisions of the Thallus.

The author of the article "Lichens", in the Edinburgh Encyclopædia divides the **Thallus** as follows:— It may be a

I. Thin flat **Crustaceous** expansion ——————
II. **Foliaceous** & lobed ——————
III. Branched & **Shrub-like** ——————
IV. Pulpy or **Gelatinous** mass ——————
V. Mere Powdery matter ——————

Composition, Structure, &c. of Thallus.

According to him, "in the humid state, the Parenchyma of the cortical layer "of the Thallus is somewhat gelatinous, in many species consisting, to the "extent of half its weight, of **Mucilage & Gelatine**." The cortical layer of the Thallus has "scarcely any signs of organization in its texture," while the Medullary layer is usually "soft, cottony or fibrous & apparently vascular"—

* Cryptogamia ?

XIV.

Chief Constituents of Lichens—

"The chief **Constituents** of **Lichens** are, according to Schnizlein*,—

I. a **Starchy** material, ——————

II. a **Bitter** principle, and ——————

III. a **Resinous** pigmentary matter—

Opinions of Schnizlein, Sprengel, &c

According to the author of the article "Lichens" in the Penny Cyclopædia, they are:—

I. a peculiar kind of **Gluten**, resembling **Starch**,

II. a **Bitter** secretion, and ——————

III. a **Resin**, combined with an Unctuous **Colouring** matter, yielding purple, yellow & brown dyes—

Sprengel† states that the "Cortical substance contains the Precipi-
"tates of the Vegetable juices, in that concentrated & perfect form, in which
"we observe them in the rudiments of the young Lichens & the Pulveraria"—

Colorific Principles—

Usnic acid, (which occurs most abundantly in Lecidea geographica & Parmelia parmentosa &c.), "acts a conspicuous part, by its various Meta-
"morphases & combinations, in the alterations of color of many Lichens"— Usnic acid

In all, however, it is probably accompanied by "yellow or green **Resins**, Its influence in producing and altering Colours—
"which in common with it, partake of the property of becoming red by
"Ammonia & exposure to the air"; this red however being destroyed by
Sulphuretted Hydrogen—"The shields of the Cladonieæ contain, near the
"fruit-bearing vesicles, quill-shaped ~~(shaped)~~ cylindrical cells, which are
"colored pale red at the base, but darker towards the apex, by a coloring
"substance, which dissolves in Ammonia & potash with a Wine-red,—
"in Sulphuric acid with a Carmine-red color; the sulphatic solution
"is precipitated by water, the alkaline solution is not decolorized by
"Sulphuretted Hydrogen"P

*Anatomico-botanical plates. †Cryptogamia P. PLindley's Vegt. Kingdom P.

XV.

Structure of Lichens.

The author of the article "Lichens", in the Penny Cyclopædia, remarks:

Nature and Analogies of the Thallus.

"The membranous or other Expansion, which, in these plants, [Lichens], consists of a combination of Stem & Leaf, is of the most unequal & uncertain degree of Developement: in some species, appearing like mis-shapen leaves, spreading over the surface on which it grows; in other cases, rising up as a Stem of various figures, but always more or less unsymmetrical & in many instances, constituting little more than a stain upon the face of a Tree or rock. This is the **Thallus**."

Crustaceous, Foliaceous & Pulverulent Thallus.

Some Lichens, says De Candolle*, "are formed only of a **Crust**, composed either of Foliaceous **Scales** (eg Squamaria & Pabellaria) or of small **Stems**, very close together (eg Isidium); or of a granulated or **Pulverulent** matter, which may be considered as a mass of indistinct scales, or imperceptible Trunks (eg Lepra & Coniocarpon)".

Nature of the Podetium according to Schleiden.

Schleiden† remarks, that it is comparatively a rare circumstance, that a Lichen rises "**Stem-like** & free from the base, either by the erection of the lobes (eg Borrera, Evernia &c), or by some real difference of developement, where the plant develops linearly upwards, instead of laterally & superficially: thus, consequently exhibiting the same surface as it had previously done while recumbent".

Structure of "Stem" of the Usneæ.

The "**Woody Stem**" of Usnea florida is formed, according to Sprengel‡, "of a loose Bark, formed by precipitation of a hair-and-dust-like intermediate substance, & of a woody **Pith**, composed of closely aggregated Canals." "The difference between the woody pith & granular bark is particularly exemplified in the formation of the seminal Tubercles & discs of several Lichens. In Usnea, for instance, the orbillæ consist almost entirely of an elongation of the woody pith, the outer part being a continuation of the granular cortical substance of the plant. In several species of Usnea &c, we see the cortical substance peel off in horizontal rings, leaving the woody pith in the form of Threads".

according to Sprengel.

* Vegel. Organography. Trans. by Kingdom Vol. 1. P. † Principles of Scientific Botany. P.
‡ Cryptogamia P.

XVI.

Age of Lichens.

Schleiden* remarks that, occasionally on the Primitive rocks, Lichens may be seen, which, from their slow growth, we might consider at least "1000 years old."—

XVII.

Consistence & Structure of the Thallus.

Fée† states that the Organization of the **Thallus**, which is commonly designated "Foliaceous", "Filamentous", or "Arborescent" is **cartilaginous**, & its organic molecules contained in a continuous network, formed of **Nervules**, more or less delicate, but always visible to the Microscope & often to the Naked Eye—

Structure of the Ramalineæ &c according to Lord Dundonald.

Lord Dundonald describes the branched Tree Lichens (eg Ramalineæ &c.) as consisting of

I. An outer **skin** or **Cuticle**, ——————

II. Below this a green **Resinous** matter & ——

III. The remainder of the plant consists of **Gum**,— a matter analogous to animal substance,— and a small amount of **Fibrous** matter, not dissolved by boiling or by the action of alkaline salts‡——

XVIII.

Nature of the Soredia & Gonidia & their relation to Reproduction

Opinions of Sprengel, Michali &c.

With reference to the **Soredia**, i.e the Gonidia scattered on the surface of the Lichen Thallus in the form of a Pulverulent matter, Sprengel says,¶ "a superficial observation only could give rise to the idea that this "powder is the analogue of Pollen", an opinion, which has been chiefly "defended by Hedwig, but without producing any proofs in its support, ex- "-cpt what are founded on a misconceived Analogy." From observations on Cenomyce pyxidata & other Lichens, Michali was led to consider this powder as the **Seed** of the plant,— & the fructification or apothecia, as performing the function of the **Flower**, an opinion, which has

*Scientific Botany. P. †Essai sur les Cryptogames &c. P. ¶Cryptogamia P.

‡Edin. Encycl. Art. Lichens.

Nature of the Soredia, Gonidia, Nartlets &c of Lichens & their relations to Reproduction.

but little to recommend it"—* "But, if we consider it as Cortical Substance, endowed with the faculty of germinating, this Theory will coincide with the observations of every author, (eg Schreber, Schmidel, Flörken &c)—These observers had noticed, that, in the immediate neighbourhood of mature Lichens, numbers of young Plants sprang up, exactly in that direction, in which the rain or winds had probably washed or blown "the germinating powder from the mother plant"—This powder,

Opinions of Schreber, Schmidal, Flörken, Sprengel &c

says Sprengel, as well as the germinating Papillæ, [Warts or Tubercles?], & proper Seeds [Spores?], "are formed by precipitation from the very "concentrated proper juices" of the Lichen—According to him, also, **Tubercles** originate in the cortical substance [?] of Lichens & may exist without, or coexist, on the surface of the Thallus, with, Apothecia—They occur, for instance, on Usnea plicata β dasopogon, "only "on specimens destitute of Orbillæ; but, in Parmelia conspersa & "Stereocaulon paschale, they coexist with the Apothecia—

Supposed Seats of the Male functions and theories therewith connected.

Up to the time of Acharius, Medwig's views of the **Male function** of the "mealy tubercles & warty excrescences" were generally received by Botanists—Under the Microscope, he found these structures to consist wholly, as they really do, of a series of more or less loosely aggregated Cells, each containing a **Granular matter**, which he declared was **Pollen**—"When the tubercle acquires a "deep brown color, it is mature,—the pollen escapes & the tubercle "becomes black—Here then, we have something like a **Male flower**, "especially in the eyes of one bent on extending the sexual hypothesis "to Plants of every tribe"—†

*Sprengel's Cryptogamia P. †Edin. Encycl. art. Lichens.

CHEMICAL ANALYSES

XIX.

of various Lichens, illustrative of the Chemical Composition, Products & Secretions of the Lichens.—

CETRARIA ISLANDICA.

Analysis of Cetraria Islandica.

Berzelius in 1808 found it to consist, in 100 parts, of — 1. according to Berzelius.

Green Wax,	1.6
Yellow Extractive matter,	7.0
Bitter matter,	3.
Uncrystallizable Sugar,	3.6
Gum,	3.7
Starch,	44.6
Starchy Skeleton,	36.2
Gallic acid,	a trace
Bitartrate of Potash, Tartrate of Lime, Phosphate of Lime	1.9
	101.6 *

In 1844-5, it was again analysed by Schnedermann & Knop, who found in it — 2. according to Schnedermann & Knop

Amylaceous matters,
- a. Lichenine (Lichen-Starch), —
- β Inuline, —

Cetraric acid, —
Lichesteric Acid, —
Fumaric (Lichenic) Acid, —
Chlorophalle (Phallochlor), —
a Neutral substance, called provisionally "the Body C," by Schnedermann, who states that it occurs in tolerable quantity, is white, tasteless, insoluble in water, Ether, oils, alkalis & acids & difficultly soluble in hot spirit †

Prousk's analysis gave of — 3. according to Proust.

Bitter Extractive,	3.
Matter, soluble in hot water,	33.
—"— insoluble —"—	64.
	100.

The "matter soluble in hot water" be believed nearly allied to Starch and like

* Ann. de Chimie 90. 277 q. Pereira Mat. Med. V. 2. P. 919

† Ann der Chim. und Pharm. B. 4. S. 144. 1845. & q. Pereira Pharmaceut. Journal V. 5. 1846. P. 427

Analysis of Cetraria Islandica

3. according to Proust.

like it, precipitated by Infusion of Galls, – but differing from it by not being "glutinous" & in the solid matter of the Jelly contracting & separating from the fluid as Curd from whey." – The "matter insoluble in hot water," he considers analogous to Gluten.*

4. according to Hoffmann.

Hoffmann found, in 1 lb. of Calcined Cetraria Islandica,

Fixed Alkaline salt,	4 Grains
Calcareous earth,	112 "
Sand,	15 "
Insoluble Siliceous earth,	34 "
Iron,	a small quantity. †

ROCCELLA TINCTORIA.

Analysis of Roccella tinctoria-

1. according to Nees v. Esenbeck.

Fr. Nees von Esenbeck found it to consist of

Brown Resin, (soluble in alcohol & ether & becoming brownish-red with Ammonia),
Wax,
Glutinous matter,
Insoluble Starch,
Yellow Extractive,
Yellowish-brown Gummy matter,
Lichen-starch,
Tartrate & Oxalate of Lime, } from the adherent sea water.
Chloride of Sodium ‡

Investigations of Heeren Kane Schunck &c

The principal investigations on the Colorific principles of the Roccella tinctoria & the other Orchella weeds are those of Heeren, in 1830[1] – Kane, in 1840[2] – Schunck, in 1841 & 1846[3] – Rochleder & Heldt, in 1843[4] – Knop, in 1844[5] & Stenhouse in 1848[6]

[1] Schweiggers Jahrb. d. Chem. 1830 & Buchners Repert. B. 38 S. 21. [2] Phil. Trans. 1840. P. 273 [3] ann. d. Chem. & Pharm. 1842 & Mem. of Chem Soc. of Lond. 1846. [4] ann. d. Chem & Pharm 1848. [5] " " 1844. [6] Phil. Trans. 1848. P. 63.

* Journ. de Physique q. Edinr. Encycl. Art. Lichens. ‡ Brandes Archiv d. apothekerverein B. 16. S. 135. q. Pereira Mat. Med V. 2. P.

† Commentatio de variis Lichenum usu. (1787.).

Mr. Wood, of the Royal College of Chemistry, London, gives the following Analysis of the Ash of Roccella tinctoria, — Analysis of Roccella tinctoria

Silica,	51.26
Peroxide of Iron,	3.84
Lime,	12.03
Magnesia,	1.08
Soda,	4.43
Sulphuric acid,	2.87
Carbonic, "	5.67
Phosphoric, "	.64
Alumina,	8.02
	99.84. *

2. according to Wood.

PARMELIA PARIETINA.

Analysis of Parmelia parietina

According to Herberger, contains: — according to Herberger.

I. Colouring matters,
- Parmelia-yellow,
- Parmelia-red,

II. Alimentary principles,
- Glikadin,
- Sugar,
- Starch,
- Gum,

IV. Medicinal Substances,
- Soft resin,
- Bitter matter,
- Volatile Oil, — besides

V. Wax,

VI. Stearine,

VII. Chlorophylle,

VIII. Woody fibre. †

* This analysis, I copied from a note in the Collection, No 47 - Class. 2. of the "Great Exhibition" in London last year, — exhibited by Messrs Mood & Bedford of Leeds —

† Buchners Report. Bd 47. S. 179. 1834 q. Pereira Mat. Med. V. 2.

LITMUS.

Analysis of Litmus—

In its ash there are found

Carbonate of Potash,	Alumina,
Carbonate, or Sulphate of Lime,	Silica,
Traces of Oxide of Iron,	Sulphuric Acid,
Chlorine,	Phosphoric " *

Physical & Chemical Characters of its coloring matters

In the commercial form of Litmus, (Litmus Cakes), we find at least 2 distinct Coloring Matters: —

according to Kane, Pareira. &c.

1. The proper coloring matter of Litmus, — derived from the Lichen used in its manufacture, — & which Pareira calls provisionally "Lichen-blue"

2. **Indigo**, (the existence of which in Litmus seems* entirely to have escaped the observation of most Chemists & Botanists) — Its presence may be proved by the following tests: The Coppery lustre produced on a Litmus cake by scratching with the nail: production of a blue solution of Sulphate of Indigo by digestion in Sulphuric acid: the formation of Crystals & the Vapor of Indigo (known by its characteristic odor & reddish violet color) * —

If we throw Litmus cakes into diluted Hydrochloric acid, there is copious effervescence, — a solution of <u>Chloride of Calcium</u> is obtained, — & a quantity of <u>siliceous sand</u> remains undissolved — If, again, we ignite a cake in the outer cone of the flame of a Candle, "a whitish violet tint is communicated to the flame, indicative of the presence of Potash" * —

STICTA PULMONARIA.

Analysis of Sticta pulmonaria — according to John.

John of Berlin found it to contain

Resinous Chlorophylle,	2.
Insoluble matters,	80.
Bitter Extractive,	8.
Salts &c.,	3.
Lichen-Starch.	7
	100. †

* Pareira Mat. Med. V. 2 P. 931.

† L. Gmelin Handb. d. th. Chem. Bd 2. S. 1357. q. Pareira

XX.

Analogies of the Thallus and Apotheeia.

According to Acharius, the
Thallus serves the purpose of a Universal Receptacle.
Apotheeia are ——— Partial Receptacles
and may either be
Regular or True, ie when of a similar structure, in various species, so as to constitute a generic character.
Accessory, ie when variable or irregular, so as to afford only Specific distinctions *

according to Acharius.

XXI.

Nature of Lichen-Reproduction according to Meyer.

From sowing the Spores & Gonidia of Lichens, Meyer came to the conclusion inter alia, that like other imperfect plants, they may owe their origin either to an Elementary or Reproductive Generative "power;" by the latter of which, young secondary plants are produced, similar to the Parent-plants; — that the "pulverulent matter" of Lichens is subject to a "kind of indefinite propagation", the spores being the only bodies, which can really "multiply the species" †

Results of "sowing" Spores & Gonidia.

With an intention had time permitted, to examine microscopically the Germination of Spores & Gonidia, I sowed inter alia a quantity of the Soredia of Ramalina fraxinea & some other Lichens in flower-pots in a sort of Wardian Case, which stands in my Studio, but from not having imitated Nature in supplying the proper kind & degree of accessories to development, my results were most unsatisfactory — I intend however making a series of more careful Experiments on a future occasion —

* Edinr. Encycl. art. Lichens.

† Meyer "Ueber die Entwickelung der Flechten"
Fries Plant. Hom. 224
q. Lindley's Veget. Kingdom.

XXII.

Existence of Seminiferous Perithecia on the Thallus of Lichens.

Investigations of Tulasne.

Tulasne states, that "on the dissociated Thallus of Verrucaria Epidermidis, Seminiferous Perithecia & other smaller Conceptacles, containing only the linear Corpuscles or **Spermatia**, occur, scattered & intermingled, so that it is impossible to avoid regarding these two kinds of Perithecia, as belonging to one & the same plant — the same thing, he avers, may be proved, by an examination of similar organs in many crustaceous Lichens, (eg Urceolaria scruposa, U. cinerea, Lecanora atra, L. circinata, Placodium murorum, P. radiosum, Squamaria lentigera &c), and also in several foliaceous ones, (eg Parmelia tiliacea, P. aipolia, P. acetabulum, Gyrophora hirsuta, Umbilicaria pustulata, Sticta pulmonaria, S. glomulifera, S. herbacea &c) *

XXIII.

"Fecundation" Theory as applied to the Reproduction of Lichens.

Even Linnaeus thought the Reproduction of all plants (& of course Lichens among the rest) must necessarily take place by means of **Seeds** (the result of **Fecundation**, — implying therefore the presence of **Male & Female Organs of Reproduction**), as the following Extracts from his "Philosophia Botanica" may serve to illustrate:

Opinion of Linnaeus.

"Omne vivum ex ovo; per consequens etiam Vegetabilia generum Semina esse ova, docet eorum finis, sobolem Parentibus conformem
"producens" .....

"Omnia ex Ovo" Theory.

"Proles non ab ovo tantum, nec a genitura sola, sed ab utrisque
"simul prodire, probant animalia, hybrida ratio, anatomia .....
"Ovum non fecundatum germinare negat omnis Experientia; adeoque
"et ova vegetabilium" .....

* Tulasne on Reproductive Organs of Lichens — 'Comptes rendus' March 24/57. Trans. in Ann. Nat. Hist. August 1857.

"Omnis species Vegetabilium flore et fructu instruitur etiam ubi
"visus easdem non assequitur" .....
"Vegetabile omne flore et fructu instruitur, ut nulla species bis
"destituta" ..... *

XXIV.

Mohl is of opinion that the **Spores** of the Cryptogamia (Vide alia Lichens) are produced like the **Pollen-granules** of the higher plants, ie from organs, which may be morphologically regarded as **modified Leaves**. †

Analogies of the Spores according to Mohl.

XXV.

The peculiar vital **Motion** of the **Phytozoa**, with which we are as yet acquainted, consists chiefly, according to Schleiden, (when these Corpuscles are in contact with water), of a "Rotation round the axis "of the spiral, which is shortly changed (according to the Law of the "Archimedean Screw) into a Progressive movement", which is liable to modification, according to the varying width & diameter of the "Spirals". **Molecular Motion** on the other hand is a mere Quivering, exhibited in Cells in a fluid of sufficient tenuity, by very minute Corpuscles, either of an organic or inorganic nature. The precise Cause of this motion seems to be entirely unknown, but it suffices for my present purpose to know that it has at least "no connexion with the Life of the Cell", in which it may happen to exhibit itself. ‡

Nature of the Phytozoic-motions

Vital? or Molecular?

Opinion of Schleiden.

* Philos. Botan. Linnaei q. Mirbel. Elémens Vol 1. ‡ Scientif. Bot. P.
† Meyer & Francis' Report on Progress of Vegel. Physiology in 1837.

Development of the Double-Spore and Secretions of the Spore-Cell according to Schleiden.

XXVI. According to Schleiden, the **Double-Spore** of Lichens is formed, like the Protococcus-Cell, i.e. two new cells are produced within the Mother-Cell, in which they lie for a time loose, but at last destroy it, than becoming "new free organisms" — The same authority states that the Spores of some Lichens are coated with a peculiar **Secretion of the Spore-cell** — This substance is usually of a yellow color, tho' it is sometimes also blue, red, brown, green &c; and it apparently differs "from all known assimilated "vegetable substances, in this, that it is affected not at all, or but "slightly, by concentrated Sulphuric acid," — being sometimes however rendered more opaque & occasionally also of a purple or reddish tint.*

XXVII.

Free Cell-formation and Individualization according to Nägeli.

Nägeli describes, what he calls, "**Free Cell-formation**" (by which the Lichen-Spore is formed) as follows: A greater or smaller part of the Contents [of the Thecæ?] becomes isolated, — or even the whole contents — On the surface of this, is formed a complete membrane, which is wholly free at its outer surface, — i.e it is in contact, neither with the wall of the Parent-cell, nor with the walls of its fellow-secondary Cells.† According to him, also, **Individualization** (i.e. the formation of a **Nucleus**), consists in the Isolation of "Solitary minute Portions of the contents "in the interior of the rest of the Contents of the Parent Cell" †

* Schleiden Scient. Bot. P. † Nägeli on Vegt. Cells R.S. Report on Botany 1849.

VI. XXVIII. Mirbel considers **Propagula** as peculiar to Agamous plants, — in which he says, they occur, either as a superficial powder [Soredia of Lichens?], or contained in Ovaries [~~Warts, Tubercles~~ &c of Lichens ??] — **Seminules**, on the other hand, he regards, as common to the Agamæ & Cryptogamæ — In the Cryptogamæ, they are developed in Ovaries, which have performed the function of true pistils; in the Agamæ in Conceptacles —, a kind of Ovaries, but which, never having performed the office of Pistil, have no trace of Style or Stigma *—

Reproduction by Gemmation &c according to Mirbel.

XXIX.

Pareira states that the Lichen- apothecium (Fructus) consists of a

Receptacle, and a _____

Proligerous layer (Lamina proligera), which is composed of

Spores, either **naked**, or _____

inclosed in Spore- cases, (Asci- Thecæ)

united to form a

Nucleus - or disposed on a

Disc †_____

Structure of the Apothecium according to Pareira -

XXX.

I should hesitate, from the very few opportunities I have as yet had of investigating the subject, to pronounce any decided opinion as to the existence in Lichens of such organs as "Antheridia" & their contents- ("Spermatia") or of their probable functions and affinities, in relation to Reproduction, — (and particularly of the Nature of the alleged Phytozoic- movements); but I may here simply state the results of a few very rude Microscopical observations, made before beginning the more careful examination of the subject —

Observations on the so-called "Phytozoic" Movements -

1. Following out the directions given by Dr Itzigsohn [in the Botanische Zeitung] for best developing the peculiar vital motions of the Spermatia, I macerated portions of the Thallus of Borrera ciliaris, containing

* Elémens de Botanique Vol I. P. † Mat. Medica V. 7. Pt. I. P.

Observations on the Nature of the so-called Phytozoic Movements.

containing, on its surface, numbers of the little brown Warts or Tubercles, (which are said by him to be true "Antheridia") in common spring water, in a Glass tumbler, placed in a closed Cabinet, in a room whose temper-ature ranged from 55° to 60° F., for Periods exceeding 7 days (before which he says the peculiar lively motions are never exhibited) - At any time sub-sequent to this period, on squeezing these warts between glasses, as di-rected, & examining with powers ranging from 270 to 580 of a Hachet Microscope, I certainly saw numbers of "distinct, little, straight rods or filaments", agreeing precisely in appearance & in the nature of their move-ments, with the description of "Spermatia" given by Itzigsohn, Tulasne, Rabenhorst, Schachtl &c. They were wriggling about, - diving down, darting back & forwards, - with the greatest liveliness; - in fact I witnessed exactly the Phenomena described by Rabenhorst. - When viewed from above downwards, - lying on their edge they presented the annexed appearance: but when seen lying on their sides the annexed

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Characters of the Spermatia?

II. For the same periods, & under precisely the same conditions, I also macerated portions of the Thallus of many other Lichens, which contain-ed, on their surface, a greater or less number of similar Warlets: besides portions of Wartless-Thalli, - apothecia, & Soredia of several species - On examining these in the same way (with the same Microscopic powers, after the same period &c.) I found precisely the same bodies, exhibiting the same lively motions: and this too, whether I examined Warts, thallus per se, apothecia or Soredia; or [what was still more remark-able?] the scum, or any portion of the water, in which these Lichens had been macerated. - Certainly these rod-like bodies did exhibit "Move-ments of an indubitably animal nature", "composed essentially of a succession of jerks, progressive & regressive", serpentine wrigglings &c.; but I could not discover any essential organic connection between them & any part of the Lichens. - When we consider the conditions under which such bodies are developed (ie vegetable decomposition) & the nature of the Phenomena exhibited by them, we can, I think,

have little doubt that they are Infusoria; which are always generated in such Circumstances – They are probably a species of Vibrio (agreeing most closely with Ehrenberg's Vibrio tremulans – or sometimes resembling Spirillum tenue).

III. Macerated portions of the Thallus, apothecia & Soredia of several species in ordinary Spring water, for very short periods (a few minutes to a few hours), but otherwise under the same conditions as in the above experiments & even when a Lichen, fresh or dry, was merely moistened or saturated with water, & was immediately (or however short or long comparatively the interval between maceration & examination) squeezed between glass plates & examined with powers 270 to 580 ut supra, I noticed myriads of molecules or globules of the annexed ——— appearance, exhibiting the liveliest motions – And it is important to

all magnified 580 (Nachet's microscope)

notice that these molecules were observed equally whether the Lichen used was fresh & recently collected, or taken from a herbarium in which it had lain dried for months & years; but they certainly appeared most numerous & their movements most lively, when the Lichen was quite fresh & moist. While the Gonidic-cells, Spores, Theca, or portions of the Lichen tissue &c were perfectly stable or immobile, on the field of the Microscope, between them were flowing tiny currents of these minute globules or particles, – which were of similar appearance, in all the Lichens examined, – & each of which might be seen to exhibit peculiar jerking or spiral motions, – apart from the movements caused by the mere currents of water &c – These molecules strongly resemble in appearance & in the character of their Movements certain Monads (e.g. Ehrenberg's Monas Crepusculum): and the important question hence arises, Whether are such particles Monads (ie Infusoria), endowed with their proper animalcular motions; or mere isolated or disintegrated molecules of the

Observations on the Nature of the Phytozoic Movements?—

the Lichen Tissue,— or the molecular escaped contents of the ruptured Spores, Gonidia or alleged antheridia &c ?, exhibiting merely "Molecular" movements.— The latter opinion appears the more probable viz: that these corpuscles are inanimate & isolated molecules of the Lichen Tissue & that their motions are essentially "molecular"; but even granting these propositions, we have still to determine inter alia:

1. Their source: ie whether they are the escaped contents of the Sperm cells ("antheridia") & therefore "Phytozoa",— or whether they issue from the ruptured Spores, Gonidia &c
2. Their function (if any?) in relation to reproduction,— points which I have not yet had time to investigate—

Sperm-Cells? and their contents.

IV. In my casual examinations, I have not as yet seen any "Globular" bodies, agreeing in character with the descriptions given by German authors of the "Antheridia", unless, certainly, Cells of the annexed appearance (which I have frequently noticed in Parmelia parietina & other Lichens), apparently possessing in their interior a spiral filament, may be regarded as such.— These Cells appear to me, however, to be Gonidia or other component Cells of the Lichen Tissue, which have been ruptured & are now emptied of their contents;— the marking on their Cell-wall being the tear or crack (with a slight puckering up of its edges) where the Cell has given way, to the pressure of the glasses during Microscopic examination.— Such cells never exhibit any "Movements of Translation"—

XXI. It may be interesting to notice here *en passant* (tho' I intended to have done it more fully in another section of my Essay) that the physical Characters of the Spore have been lately applied, so far as the *Angiocarpous* Lichens are concerned, to the Diagnosis of Lichen-species. It has certainly long been felt that the ordinary Botanical characters, taken from the external appearance of the Thallus, apothecia &c. of Lichens, have greatly failed in enabling us to distinguish, accurately & easily, their species & genera &, to supply this defect, the Revd. Mr. Leighton, conceiving that the spores might be made to furnish more constant, & therefore more easily applicable, *specific* characters, has recently published a Work on the "The British species of angiocarpous Lichens, elucidated by their Sporidia."* I have had few opportunities of examining the *Angiocarpi*, but, while investigating the Microscopical anatomy of the *Gymnocarpi*, I had also often thought, that in the *majority* of cases (tho' I am still very doubtful if in *all*) the spores *alone* might yield sufficiently distinctive characters, to indicate artificial separation into *Species*, but certainly not into *genera*. From the very few even of the *Gymnocarpi*, I have as yet had time to examine, I should hesitate to say that the *Spores* *per se* will furnish specific distinctions for the Lichen-family *in toto*, but I can safely aver that the characters of the Spores, Thecæ &c., along with the anatomical structure, of any given Lichen, will be found, both in the *Angiocarpi* & *Gymnocarpi*, to be very valuable auxiliaries to the usual Botanical characters of the plant, as derivable from its external appearance &c., in determining its Species & genus. Mr. Leighton remarks "Every Botanist is fully aware how valuable & available "a character is afforded by the form & external markings of the seeds in "very many species of Phaenogamous plants; the correct determination of "the species frequently depending exclusively thereupon. Analogous reasoning "leads us to the conclusion that the *form* & *septa* of the Sporidia in *Cryptogamic*

Application of the Characters of the Spore to the Diagnosis of Species.

H. P. 36. P. 39.

* Published by the Ray Society. 1851.

Application of the Characters of the Spore to the Diagnosis of Species.

"Cryptogamic Plants would present similarly useful characters - Investi-
"-gation proves the correctness of this Conclusion. Owing, however, to the min-
"-uteness of the parts, the delicacy & care required in the manipulation
"& the employment of high magnifying powers, these organs in the family
"of the Lichens, at least, do not seem to have hitherto received that
"attention, which their importance really demands. This field of research,
"fertile tho' it actually is, may therefore be said to be comparatively a
"new & untrodden one, more especially as regards British Lichens.
"Lichenists have been, indeed, long aware of the existence & general conforma-
"-tion of these particular organs, but it is believed have never applied them
"to characterise or determine species..... To make the forms of
"the Sporidia characteristic of genera, except in a very few instances, would,
"it is conceived, lead to an almost endless subdivision, if fully carried
"out - Their real value rather seems to be as a distinguishing & confirm-
"-atory specific character."

XXXII.

Specific and generic distinctions and their difficulties.

In reference to the specific characters & divisions of the Lichens, Dawson Turner says, "Some Botanists, anxious to create new species, have not
"made among these, the same allowances as among other vegetables, for
"differences, caused by the several periods of their age, by their situation,
"by the substances on which they grow, or by the aspects to which they
"are exposed..... Great difficulties are unquestionably opposed
"to our researches among the Lichens, but these difficulties are in-
"-creased tenfold, if we examine them, without at the same time en-
"-deavouring to trace them through their various gradations, or if we
"form opinions, without having seen them in different states, for no error
is

" is more pernicious than that of those Botanists, who promise them- Specific and Generic distinctions.
" -selves to acquire a knowledge of them by means of their Herbaria
" alone, as, however useful single specimens of this Tribe may be, for the
" sake of reference, the naturalist, that puts too much reliance on them,
" will find as soon as he meets with the plants in their places of growth,
" that he has studied at home for little else than to confuse others
" & bewilder himself."*

XXXIII.

"What purposes", says Sowerby, "these inconsiderable productions answer Uses in the Economy of Nature—
" in the all-wise Economy of the Creation, we cannot always determine: but
" we know enough to be certain that each species is propagated & preserved
" by the same laws as the most splendid offspring of a Tropical climate,
" & we may be as certain that nothing is made in vain..... Minute
" Caterpillars feed on some of them (e.g. Phalena Tichenella)..... We know of
" one end, which they all answer in decay viz: the formation of vegetable
" mould, which being washed into the crevices of the stones, it is found upon,
" serves to receive & nourish the seeds of other vegetables."†

XXXIV.

Alluding to the developement of the constituent parts of the Apothecium Developement of the Apothecium of Sphaerophoron tenerum
of Sphaerophoron tenerum, an antarctic species, Dr. Hooker remarks "No
" Lichen exhibits so well the successive developement of the "Lamina
" proligera" in the same apothecium - A vertical section of the youngest
" fruit shows two strata, parallel to, or rather concentric with, one another.
" of these, the upper is fully ripe long before the bursting of the apo-
" -thecium - It consists of innumerable, filiform asci, containing from
" 8 to 30, or more, sporules - The sporules are vertically arranged & so densely

* Dawson Turner on 4 new British Lichens - Linnaean Transactions Vol. 7.
† English Botany Vol. 5. p. 334.

Development of the Apothecium

"densely packed that each ascus resembles a Moniliform filament; the "lower are smaller, the upper gradually larger; none however attain "their full size till after the absorption or disappearance of the walls of "the asci, when they escape as Spherical bodies, surrounded by a narrow "transparent margin." *

XXXV.

Thalline hairs.

arborescent hairs occur on the Thallus of many of the Lecidiacea†

XXXVI.

Growth in Caverns, Mines &c.

Referring to some species, which inhabit Caverns mines &c (e.g. Lichen verticill-atus), Humboldt says "Végétant dans une obscurité profonde et perpetuelle, "elles tapissent les parois des grottes souterraines et la charpente qui sou-"tient les travaux des mineurs. J'ai reconnu les mêmes espèces dans les "mines de l'Allemagne, de l'Angleterre, et de l'Italie, comme dans "celles de la Nouvelle-Grenade et du Mexique, et dans celles de Hualgay-"oc au Pérou" ‡

XXXVII.

Vertical Distribution on Andes, Himalayas, Alps &c.

Speaking of the Vertical range of Vegetation, as exhibited in the ascent of the mountains of Tropical regions, Humboldt remarks, "We now reach "the bare Trachytic rocks, on which the lowest tribes of plants flourish-"Parmelias, Lecidias & Sphærias, with their many coloured sporules, form "the Flora of this inhospitable zone. Patches of recently fallen snow now "begin to cover the last efforts of vegetable life & then the line of eternal "snow begins" They occur at a height of above 16,000 feet on Chimborazo, "& are the last plants met with in ascending Teneriffe, the Himalayas, "or the alps, where "they struggle up to the imperishable barrier of per-"petual snow" ‖

* Cryptogam. Bot. of antarctic Voy. of Erebus & Terror. † Martius Fl. Brasil. V.1.
‡ Mirbel Elemens de Botanique V.1. P. ‖ Q. Balfour's Botany P.

Specific & generic Diagnosis.

XXXVIII. In reference to the specific & generic distinction or diagnosis of the Lichens, Eschweiler remarks "; Distinctio dispositioque Lichenum diffi- "-cillima quippe ..... (inter alia) eorundemque proclivitatem ad natur- "-am fungorum, ut apothecia non raro sine Thallo oriantur, vel eadem " unius speciei in Thallo alterius vigeant." *

XXXIX.

Specific distinction

Of the Lichen-family, says Sprengel, it is "more difficult to obtain a precise Idea, an account of the great Latitude allowed to it by the general consent of Botanists"..... "Vegetables, whose propagative Organs are so simple, " cannot possibly be distinguished by a few essential characters, but we " are under the necessity of having recourse to the whole of the Characters, " both natural & artificial, to arrive at a proper & exclusive definition"..... Horizontal Distribution.

Again "Scarcely is there a Tree in the torrid or frigid Zone not covered, " at some period of its existence, by Lichens; for, unconfined to any particular " Climate or degree of Latitude, wherever there occur mould, stones, rocks, " or trees, Lichens are sure to be found"..... The same author speaks of the Cryptogamia as "the secret recesses of the Sanctuary of Nature". "Nature", says Pliny, "never appears more perfect & wonderful than in her " minutest works."†.....

XL.

The following Notes are extracted from the "Botanique Cryptogamique"‡ of Payer, whose description of the structure, classification &c. of the Lichens (so far as it goes) is the simplest & safest & therefore the best, that I have as yet seen.

Structure of Spores.

Spores are either Simple (ie composed of a single Utricle or cell) or Septate (ie composed of several utricles, placed end to end or superimposed)—

The whitish filaments, which spring from the lower surface of the Thallus (Common receptacle) [& which have been variously called Fixurae, Rhizinae &c.]

* Martius Fl. Brasil. V. 1. P. 54. † Sprengel's Cryptogamia ‡ Paris 1850.

Structure of Thallus.

but which generally anastomose so as to form a sort of soft cottony felt, constitute the "Mycelium", which is the origin of all Lichens, as of all Fungi. The Spore, in germinating, always gives birth to this Mycelium, in the form of a membrane, which the Microscope shows to be composed of a mass of delicate filaments very intimately & compactly interwoven — This membrane bears most resemblance to the Mycelium of Trichia & was placed like it, by the older Mycologists, in the genus Mesenterica. While, in the greater number of [redacted] Fungi, the Mycelium remains permanent during the life of the plant, ministering to the nutrition of the plant, by its power of ready imbibition, it is but temporary & transient in Lichens, where, however, it gradually gives rise to the more permanent granular or foliaceous expansion of the Thallus, which, in fact, is only its permanent functional substitute. This Phenomenon is analogous to that exhibited by the genus Opuntia (Cactaceæ), whose leaves are nearly totally abortive & are replaced, so far as regards respiration, by branches, which become flattened & acquire a green colour —

Rudimentary Thallus i.e. Mycelium.

Its functions & analogies.

Proofs that Lichens derive Nutriment essentially from the Atmosphere — Phenomena depending thereon.

On the circumstance of Lichens deriving their essential nourishment wholly from the atmosphere depend the following Phenomena inter alia:

1. That we find in the interior of their spherical Utricles (Gonidia) the same green matter (Chlorophylle), which occurs so abundantly in those parts of the higher plants, which are exposed to the air & light & subserve the function of Respiration —
2. That, placed under Water & exposed to the light, they disengage Oxygen gas, like the Leaves of the Phanerogamiæ —
3. That, when lacerated, their naturally whitish tissue becomes green —

As tending to prove that Lichens do not depend on the Soil, rocks, trees or other bases of support, for nourishment, the following circumstances may be cited:

1. We often find the same species growing on very different supporting substances. e.g Usnea barbata & Evernia prunastri, which generally occur

on

Proofs that Lichens derive Nutriment essentially from the Atmosphere

Trees often also develope themselves on Rocks or the soil. Cladonia & Peltigera again are essentially Terrestrial Lichens.

2. In such cases, Lichens seem to seek rocks, trees &c. for the purpose of finding more favorable climatal conditions for their developement. Thus many, which grow on Trees in one Country (or one part of a Country) may inhabit Rocks in another, (or in a different part of the same Country). Eg. Parmelia fusca, which usually inhabits Trees occurs on Rocks in the plains of Scandinavia & on the surface of the soil in the High-Alps. And Borrera ciliaris, Lecanora parella & Evernia prunastri, essentially Tree-Lichens, are found on Rocks on the sea-coast. One great climatal influence exercised by particular soils on Lichen-developement is undoubtedly the superior temperature possessed by such soils. We find Lecanora decipiens, which is universally distributed & grows on very different supporting substances in the middle of France, occurring in the north, only on Calcareous soils, — because these most readily absorb heat (hence they are called by Agriculturists "Terres chaudes", in opposition to argillaceous soils, which are "Terres froides.") Thus, such soils present in a northern Latitude, the heat requisite for the growth of Southern plants. Hence also the reason, why, in arctic regions, Lichens generally grow on Rocks, which are soonest heated by the Suns rays: and, why, in the Tropics, on the other hand, they most frequently occur on Trees, whose foliage forms a protection against the scorching heat of a vertical Sun.

Influence of Climatal changes on Lichen-developement

A good example of the great Variety, which Changes in external Circumstances produce on the external appearance & internal Structure of Lichens, is the Parmelia varia, a truly Protean vegetable — so-named from the thousand different Phases it presents according to station, soil, moisture &c. But, notwithstanding, the capricious & varied forms assumed by Lichens under the influence of different climatal & other conditions, we often find that the particular mode & place of growth &c. bestow such a peculiar character

on

Influence of Climatal Changes on Lichen-Metamorphoses.

on any given Lichen, that we may be enabled to determine its origin & the kind & degree of external circumstances to which it has been exposed, from its physical characters alone!— Differences in situation &c appear often to have the same effect in metamorphosing the Generative as the vegetative organs, eg Parmelia caperata P. perlata &c, which according as they are developed on Rocks or Trees may have their reproductive Organs fully evolved, abortive or suppressed.

Influence of the Soil on the Colour & Consistence of the Thallus.

While the soil & other bases of support do not furnish to Lichens the nutrient materials essential for their developement (viz: the Carbon, Hydrogen & Oxygen) they still yield accessory inorganic matters, which contribute greatly to the Consistence & especially the Colour of their Thallus— If the soil abound in the oxides of Iron, the colour of the Thallus will probably be some shade of red, ochreous or ferruginous; if oxides of Manganese, rose or purple; or if Carbonate of Lime, it will possess a cretaceous, whitish appearance.

Influence of Light on the Colour of the Thallus.

Light appears to possess a most capricious & inexplicable influence on the colours of the Lichen-Thallus, various species being often, under the same conditions as to Light, very variously coloured— Parmelia Chrysophthalma & P. chlorophana become pale when exposed to Light, while in the same circumstances the colour of Parmelia parietina & P. murorum is greatly heightened. Again Calicium Trachelinum possesses very bright colours, tho' growing in cold & shady situations; while many Tropical species exhibit but very feeble ones.

Structure of the Thallus.

The Thalline tissue is composed essentially of 2 kinds of Utricles or Cells viz: the Cylindrical (ie the filamentous) and the Spherical (ie the Gonidic). With regard to their relative distribution:

Horizontal type.

In the Horizontal Thallus, the cylindrical cells occupy the lower surface, the spherical the upper— If the spherical preponderate over the cylindrical, the Thallus assumes the form & consistence designated

—naked

Structure of the Thallus.

-nated Crustaceous; but if the opposite holds good & the Cylindrical Cells predominate, the Thallus becomes Foliaceous - Between the Crus-taceous & foliaceous forms, there are almost endless intermediate & often very puzzling states.

If the cylindrical cells exist alone, the Thallus is called "Stuppeus"

Vertical type.

In the Vertical Thallus, ~~for~~ the Spherical cells form a sort of bark, in-closing or surrounding the cylindrical —

Gonidia.

The Spherical cells (Gonidia) are always full of green matter (Chlorophylle) & are capable, in certain circumstances, of dissociating themselves from the parent Thallus & reproducing the Lichen, like Spores - This disaggregation, when it does occur, always begins about the centre of the Lichen, which becomes centrally pulverulent & circumferentially foliaceous, - gradually passing entirely into a mass of greenish or yellowish powdery matter (according to the Species) - The nature of this pulverulent matter was wholly mistaken by the older Lichenologists, who looked upon it as con-stituting distinct species of Lichens (hence their genera Lepra & Variolaria)

Their Contents

Mode of Reproduction.

Uses of Lichens in Economy of Nature.

Two circumstances chiefly contribute to render Lichens peculiarly fitted to clear the way for the growth of the Phanerogamia viz:

1. That they pass thro' the different Phases of their existence in an incredibly short space of Time (in many cases) and
2. That they multiply themselves, in a manner, ad infinitum; their repro-ductive corpuscles making up by numbers for deficiency in size —

Hence, why many species spring up suddenly under our very feet, we know not how; hence, why, before the existence of good Microscopes, which made evident to our senses the extremely minute size of their Sporidia, many Lichens were believed to be the results of "Spontaneous Generation" —

Definition of term "Thallus" (Payer).

Payer applies the name Thallus to designate those filaments or mem-branes

Definition of term "Mycelium" (Payer.)

-branes whose cells contain Endochrome, as in the Algæ & Hepaticæ; while he restricts the term Mycelium to similar filaments or membranes, whose cells are destitute of such Endochrome, as in the Fungi (including among them the Lichens)—

Hymenium

Its Structure and Forms.

The aggregate of the Thecæ & Paraphyses constitutes the "Hymenium" This may rest on (or arise from) the cortical or medullary layer of the Thallus (Hymenium strato medullari vel corticali impositum); or on a special tissue (Hymenium strato proprio impositum)— But whether the basement-tissue be medullary, cortical or special, the Hymenium is capable of assuming the most varied forms eg In Usnea, it is hypocrateriform,—or saucer-shaped,—flat in the centre & elevated at the margins— If the edges of the Hymenium (apothecium) come nearly into contact, the result is a more or less globular Conceptacle (Perithecium), which opens to the surface by a Pore (ostiolum)—

Monstrosities by adhesion.

It often happens that several apothecia (special receptacles) are in mutual contact, become agglutinated & produce a general Cupule, indented, however, or distinctly marked by the constituent individual cupules (or apothecia),— forming a compound organ analogous to the common Receptacle of the Synantherece (Compositæ) eg Cladonia— Or, the union may be still more intimate, occurring at the base or apex of the apothecium, —often giving rise to the most anomalous & puzzling forms—

Uses of Lichens in the Economy of Nature.

"Sans elles, point de végétation possible, et, par suite, point d'animaux herbivores, point de Carnivores; sans végétaux, ni animaux, l'homme ne pourrait exister".....*

"C'est par l'accumulation des Cadavres de myriades d'entre "elles que se forme cet humus, dont les Propriétés bienfaisantes sont

depuis

* Payer Botanique Cryptl. P.I.

Uses of Lichens in the Economy of Nature.

" depuis longtemps reconnues, tant il est vrai que, dans le monde phys-
" -ique, comme dans le monde moral, la mort mène à la vie."*.....

" Sur les écorces ou sur les rochers, aux ardeurs du soleil, il devient
"friable et se réduit en poudre par le moindre frottement; mais la pluie
"lui rend bientôt la vie en même temps que la souplesse et la fraicheur†"

Endosmose.

"Les végétaux les plus élevés apparaissent donc sur les ruines des plus
"infimes et profitent de leurs dépouilles; mais, tôt ou tard, la mort les
" surprend et les Cryptogames reprennent alors leur empire; elles assiègent
" leurs trones immenses, s'y multiplient rapidement, et décomposent à leur
" ces géants de l'organisation végétale. Quelques années leur suffisent
" pour les réduire en poudre et rendre ainsi à la terre les matériaux,
" qu'ils lui avaient empruntés..... Les Cryptogames poursuivent
" leur action désorganisatrice partout, et les ouvrages des hommes n'ont
" pas plus à l'abri que les œuvres de la nature — Les édifices les
" plus solides, lorqu'ils sont abandonnés à eux-mêmes, se couvrent
" d'une végétation inférieure qui parvient, tôt ou tard, à les faire tomber
" en ruines — Si donc, comme nous l'avons démontré, toute végétation
" commence par les Cryptogames, il est vrai de dire aussi que toute
" végétation finit par elles"‡

Power of Disintegration —

Germination Theory?

....."La théorie de l'emboîtement des germes à été universellement
" abandonnée, et.... grâce à d'excellents microscopes on a pu rechercher
" avec certitude les diverses phases par lesquelles passe un être supérieur
" pour de simple utricule qu'il est dans l'origine, parfaire son dével-
"-oppement et atteindre son degré normal de complication‡"—

Unfinished

* Paper Bot. Cryptog. P.1. † Ibid. P. 89. ‡ Ibid. P. 2

Unfinished

LIST of PREPARATIONS &c.

made by myself, or obtained from other sources, in the course of my Experiments on the Tinctorial Properties &c. of the Lichens. †

I. FLUID PREPARATIONS.

I. AMMONIACAL INFUSIONS.

[Made by macerating the Lichens in very small fragments (or powdered) in a very weak solution of Liquor Ammoniæ, for about a Month, without the aid of exposure to atmospheric air, or to heat. ——]

1. Alectoria jubata ——
2. Borrera ciliaris ——
3. —— furfuracea ——
4. —— pulverulenta ——
5. Cetraria glauca ——
6. —— Islandica (Iceland moss.) ——
7. —— nivalis ——
8. Cladonia rangiferina (Reindeer moss.)
9. Evernia prunastri ——
10. —— vulpina ——
11. Gyrophora cylindrica ——
12. —— murina (Velutous moss.)
13. —— pellita ——
14. —— proboscidea ——
15. Lecanora tartarea (i.e Cudbear)
16. Parmelia omphalodes ——
17. —— parietina ——
18. —— perlata ("Canary Rock moss.")
19. —— physodes ——
20. Peltidea canina ——
21. Ramalina fraxinea ——
22. —— Scopulorum ——
23. Roccella tinctoria (Canary Orchella weed)
24. —— " (Cape de Verde ")
25. —— " (Thick Lima ")
26. —— fuciformis (Thin — " ——)
27. —— Montagnei (Angola " ")
28. Stereocaulon paschale ——
29. Sphærophoron coralloides ——
30. Sticta flava ——
31. —— pulmonaria ——
32. Umbilicaria pustulata ("Pustulatous moss")
33. Usnea plicata ——
34. Scyphophorus cocciferus ——
35. —— deformis ——
36. —— pyxidatus ——
37.
38. Lec. ventosa
39. Urc. [illegible] ?
40.
41. Not had time to determine
42.
43. the species
44.
45. Parl. communis?
46.
47.
48.

(37–48: Scraped from the Rocks at Hunter's Bog Arthur Seat.)

† This is exclusive of nearly 2000 Drawings – Specimens – preparations &c. contained in the "Illustrations of the Lichens" (I. Structure & Classification & II. Uses & Properties).

II. Decoctions.

[Made by boiling the Lichens, in coarse fragments, - with water, to which a very little Carbonate of Soda has been added, (to facilitate the extraction of the color) - for Periods varying from a quarter of an hour to an hour.]

49. Cetraria Islandica _____
50. Cladonia rangiferina _____
51. Gyrophora cylindrica _____
52. Pettidea canina _____
53. Parmelia omphalodes _____
54. _____ parietina _____
55. _____ physodes _____
56. Sticta pulmonaria _____

III. Aqueous Infusions.

[Made by simple maceration of the Lichens Nº, in coarse fragments, in cold water, to which a little Carbonate of Soda has been added (to facilitate the extraction of the colors) — for Periods varying from two nights to a Month.]

57. Cetraria Islandica _____
58. Cladonia rangiferina _____
59. Cudbear (Ground - commercial) _____
60. Litmus (Cakes - as imported from Holland)
61. Parmelia parietina _____
62. Ramalina fraxinea _____

Samples of Commercial Liquid Archil.

1. Common "Archil Liquor" - as met with in the shops of Oil-& Colormen in all our great Towns - From an Oil-& Colorman, Tottenham Court London - Bad quality - depositing a thick brownish mucous sediment. Botanical & commercial source unknown

2. _____ Dº _____ From an Oil-& Colorman, Oxford Street London - Good quality. Botanical & Commercial source unknown.

3. _____ Dº _____ From a Druggist's in Edinburgh. Good quality - said to have been manufactured in Liverpool - Botanical source unknown

The commercial archil Liquors are, in all probability, chiefly manufactured from one or other of Roccella fuciformis or R. tinctoria - or from a mixture of both

Many other Lichens however are also used in the manufacture of archil. For example Messrs Benj. Smith & Son of London, Wholesale archil manufacturers &c, employ inter alia the following:

a. Canary orchella weed (Roccella tinctoria) from the Canary Islands ——
b. Cape de Verde orchella weed (—— " ——) —— Cape de Verde Islands
c. Angola —— " (R. Montagnei) —— Angola, Africa.
d. Lima (thin) —— " (R. fuciformis) —— Lima – South America
e. —— " —— (thick) —— " (R. tinctoria) —— " —— " ——
f. Canary Rock moss (Parmelia perlata) —— Canary Islands ——
g. Velutous moss —— (Gyrophora murina) —— Norway & Sweden ——
h. Pustulatous moss (Umbilicaria pustulata) —— " ——

Again, a sample of mixed orchella weeds, employed in the manufacture of archil by a Huddersfield manufacturer, I found to consist chiefly of varieties of Roccella fuciformis & tinctoria – source not ascertained ——

4. Red Liquid Archil. Manufactured by B. Smith & Son, London, from Roccella Montagnei ("Angola orchella weed"). From the "Great Exhibition" Class 4. No. 68.

5. Blue —— " —— Manufactured by the same parties, from the same lichen. Also from the "Great Exhibition" Class 4. No. 68.

6. } Commercial archil –, diluted in different degrees, – showing the effect of the presence or
7. } absence of atmospheric air – in increasing or destroying its Color – (as is also exhibited in Infusion of Litmus).

8. Residual Archil Liquor – from which a Lake has been thrown down by Alumina

9. Tincture of Cudbear – not stronger however (in regard to intensity & brightness of Color) than ordinary aqueous or Ammoniacal Infusions —.

II. Solid Preparations.

Samples of Cudbear.

1. Common Commercial Cudbear - (ground or powdered). From an Oil & Colorman, Oxford Street, London. Botanical & Commercial Source unknown

2. ——— " ——— From a Colormans, Tottenham Court Road, London. Inferior quality - Botanical & Commercial source unknown

3. ——— " ——— From a Druggist's in Edinburgh - Botan. & Commerc. Source "

4. ——— " ——— Manufactured by B. Smith & Son, London, from "Angola Orchella weed" (Roccella Montagnei) ?- Excellent quality From the "Great Exhibition". Class 4. No. 68. ———

5. "Best Royal Patent Cudbear" - Manufactured by I. Robinson & Co., Archil & Cudbear Manufacturers, Huddersfield. Excellent quality. Botanical source not mentioned. From the "Great Exhibition" Class 4. No. 72.

6. Best "Patent Liquid Cudbear" - also manufactured by the above parties - Botanical source & mode of manufacture not mentioned Perhaps essentially an ammoniaco-aqueous Infusion, thickened & the color brightened by foreign matters? From the "Great Exhibition" Class 4. No. 72.

As met with in Commerce, "Grown Cudbear" presents great variety with regard to Quality. The test of quality seems to be the high degree of Pulverization & the bright redness of the color. Its botanical source was formerly, & probably still is, to a great extent, Lecanora tartarea. Liquid Cudbear appears to be of but recent introduction & is probably seldom or never to be met with in commerce. The adulterations of Cudbear (if any?) I have not had time to examine either chemically or microscopically.

Samples of Lichens employed in the Manufacture of Archil and Cudbear.

I. "Orchella weeds."

1. Canary-weed (Roccella tinctoria) Canary Islands
2. Cape de Verde weed (— " —) Cape de Verde "
3. Angola weed (R. Montagnei) Angola
4. Lima (thin) (R. fuciformis) Lima So. America
5. — " — thick (R. tinctoria) — " —
6. Mixed weeds (R. fuciformis & tinctoria? chiefly) Whence not mentioned. From "Great Exhibition"

Imported by B. Smith & Son, London. From the "Great Exhibition" Class 4. No. 68.

Imported by J. Robinson & Co., Huddersfield Class 4. No. 72.

II. Canary Rock Moss (Parmelia perlata) Canary Islands
III. Pelutous Moss — (Gyrophora murina) Norway
IV. Pustulatous Moss. (Umbilicaria pustulata) "

Imported by B. Smith & Son, London. From the "Great Exhibition" Class 4. No. 68.

V. Lecanora tartarea (Cudbear) From the Perthshire Highlands —

Samples

of the following Lichens, after maceration, for a month, in very dilute Ammonia.

1. Alectoria jubata —
2. Borrera furfuracea —
3. — pulverulenta —
4. — ciliaris —
5. Cetraria nivalis —
6. — Islandica (Island moss.) —
7. — glauca —
8. Evernia prunastri —
9. Gyrophora cylindrica —
10. — murina (Pelutous moss.) —
11. — pellita —
12. — proboscidea —
13. Lecanora tartarea (Cudbear) —
14. Usnea plicata —
15. Umbilicaria pustulata (Pustulatous moss) —
16. Parmelia parietina —
17. — omphalodes —
18. — physodes —
19. — perlata (Canary Rock moss.)
20. Peltidea canina —
21. Ramalina fraxinea —
22. — scopulorum —
23. Roccella tinctoria — (Canary weed) —
24. — " — " — (Cape de Verde weed)
25. — " fuciformis (Lima thin) weed)
26. — " Montagnei (Angola weed —
27. Scyphophorus pyxidatus —
28. — deformis —
29. Sphaerophoron coralloides —
30. Sticta flava —
31. — pulmonaria —
32. Stereocaulon paschale —

Jca Jca

Samples - after simple Decoction in water - of

1. Cetraria Islandica (Island moss)
2. Cladonia rangiferina (Reindeer moss)
3. Gyrophora cylindrica (Tripe de Roche)
4. Peltidea canina
5. Parmelia omphalodes
6. _____ physodes
7. Ramalina fraxinea Vca

Parmelia parietina - after maceration in Urine for a month

Ramalina fraxinea - after maceration in Water for a month

Aqueous Extracts of 1. Cetraria Islandica
2. Cladonia rangiferina
3. Ramalina fraxinea

Ash of _____ 1. Cetraria Islandica
2. Cladonia rangiferina
3. Ramalina fraxinea

Litmus - as imported into this country from Holland - (ie. in fragments of Parallelopipeds or little oblong cakes) - From J. F. Macfarlan & Co. Edinburgh.

Lake - precipitated from commercial archil by alumina

Cudbear - after extraction of the color by decoction

Besides several hundred Specimens of **British Lichens** -

partly collected by myself round Edinburgh &c - but chiefly contributed by the Botanical Society of Edinburgh, Professor Balfour, Messrs George Lawson, John Kirk, Jas. Kerr Jr.

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