Mount Pleasant Oct. 26th
1808

Rev'd Sir

I am sorry that I was out of my Power to send you a copy of my two first Essays soon I now embrace the Opportunity of sending them by your Amiable Daughter. Accept of them as a small Testimony of my Esteem.

After perusing them I request the favour that you would send me your critical remarks. Here I am conscious much room for correction. I blush to think that they so little merit the applause with which they have been honoured.

If you can furnish me with any corrections or alterations or new hints on the subject

it would be esteemed an almost singular favour.

If you think the work on the whole merit the attention of the Publick be so good as hand these Essays to any of the Noblemen or Gentlemen in your Neighbourhood to whom the subject may seem to be of importance. Their remarks will be received with gratitude And I trust that when the whole work is finished it may be of some use.

Mrs Rennie joins me in kind regards to you & your family And I am ever Dr Sir

Yours Sincerely

Honoured by Miss McIntyre

The Revd
Doctor McIntyre

With a Parcel
Glenurchy

The Revd Doctor Macintyre
with compliments from the Author

ESSAYS

ON THE

NATURAL HISTORY AND ORIGIN

OF

PEAT MOSS:

THE PECULIAR

QUALITIES OF THAT SUBSTANCE;

THE MEANS OF IMPROVING IT AS A SOIL;

THE METHODS OF CONVERTING IT INTO A MANURE; AND THE OTHER ECONOMICAL PURPOSES TO WHICH IT MAY BE MADE SUBSERVIENT.

BY THE REV. R. RENNIE, KILSYTH.

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1807.

TO

THE PRESIDENT,

AND OTHER MEMBERS OF

THE BOARD OF AGRICULTURE,

THESE ESSAYS ARE DEDICATED

BY THE

AUTHOR,

AS A HUMBLE TESTIMONY

OF THE

HIGH SENSE HE ENTERTAINS OF THEIR

PATRIOTIC EXERTIONS

IN PROMOTING THE INTERESTS OF AGRICULTURE,

AND THE

IMPROVEMENT OF THE BRITISH EMPIRE.

MANSE, KILSYTH,
Oct. 1*st* 1807.

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ESSAYS

ON THE

NATURAL HISTORY AND ORIGIN

OF

PEAT MOSS.

INTRODUCTION.

NATURAL History is become the favourite study of all the nations of Europe. Great exertions have been made to elucidate every branch of this delightful subject. The vegetable, mineral, and animal kingdoms, have been surveyed with the most critical minuteness, and much light is daily poured in on every department of these.

The only branch that seems to have been overlooked is that of Peat Moss. Though it exists, nay abounds in every region of the north of Europe, and though it is every day under the eye of the philosopher, the natural history and origin of this substance has been neglected for ages.

By some it seems to be regarded as a mystery beyond the reach of science itself; by others it is looked upon as beneath their notice. While the chemist and natural historian, in a course of lectures, minutely describes every other substance, no attempt is made to elucidate the origin, or account for the distinguishing qualities of peat moss; and in no one language is there to be found a complete treatise on the subject. There are many loose hints thrown out occasionally, and a variety of chemical experiments have been made by men of science; but no author has hitherto collected these scattered fragments, or attempted to form a clear or satisfactory hypothesis on the subject, from a collection of well-attested facts.

Nothing can be a more convincing evidence of the universal neglect, and imperfect knowledge of this branch of natural history, than the many incoherent and inconsistent theories that have been espoused and defended, by men of distinguished talents of different nations.

In general they agree in supposing, that ligneous plants have chiefly contributed, in one shape or another, to the formation of that substance; but as to the manner in which that process has been effected they differ widely. Some suppose that moss is altogether formed by alluvion. They are of opinion, that it consists of the leaves and twigs of trees, washed down from the declivities and mountains into the vallies by rivers and floods; and that these, in a

course of ages, have been converted into moss by the mixture of reeds and aquatic plants. Others have supposed that it is a certain species of native soil, on which ligneous and aquatic plants naturally grow; and that these, by their continual decay, originally formed, and still continue to form moss.

Picard, Lemnius, Piganiol, and Grammaye are of opinion, that it is a congeries of bark, boughs, leaves, and roots of trees, or of whole forests, overset and immersed in water, mixed with grass and reeds.

Lentilius and Commelinus think that it is a marshy bituminous earth, mixed with ligneous and aquatic plants, putrified under water. They suppose that Holland, at one period, was an extended forest, and that this was overflown by an inundation of the ocean: That, of course, the wood thus overset sunk in the mud, and by the accession of particles of earth, deposited by the waters, formed the immense mosses of that country.

Stevinus thinks that it is a fat sulphuro-bituminous earth of rotten wood. He supposes that the leaves, &c. of trees which grew on rising grounds, after being reduced to earth, have been washed down into the vallies, and thus, in a course of ages, have been converted into moss. He adds, as a proof of this, that black rich mould, if frequently washed with water, yields a solution which, when filtered and evaporated, leaves a residuum of a sulphureous and inflammable nature like peat, and not distinguishable from it.

All these respectable authors agree in this general opinion, that moss is of vegetable origin, and that ligneous plants have chiefly contributed to the formation of it. As to the manner in which that process has been carried on, and the various changes and combinations that have been accomplished by it, they seem to have formed no clear or decided opinion.

Other authors, equally respectable, have supposed, that all moss is of mineral origin. Scheuchtzer was of opinion, that it is a mere fossile bituminous earth, only accidentally mixed with vegetable matter. Stahl was of a similar opinion. In his Fund. Chem. he says, that it is a bituminous mineral subterraneous substance. Morhoffius, in his Polyhist. calls it a mineral earth, and classes it with coal. He says, that it differs from mold, as it is more inflammable, and swims on water, whereas mold sinks.

Some have even supposed that moss is a primitive earth. Guiccardin and Oudhoff, &c. adopt this opinion. They imagined that it is a distinct species of earth peculiar to marshy levels: That, by the singular providence of God, this earth has been provided for the use of man: That, though partly carried off, the germ still remains; and, by the annual increment of aquatic plants and alluvial soil, it is renovated.

Others have supposed, that all mosses were originally lakes; that, when these were drained or filled up, they were converted into moss. The bitumen and sulphur they contained were supposed, by O'Dap-

per, to be the cause of this change, and of communicating inflammability to that substance. He therefore describes peat in the following words: "It consists of bitumen, asphalt, and naphtha, mixed with "leaves, &c. of trees and aquatic plants." He quotes Agricola de Ortu Subterran. in corroboration of this opinion, who says, that no fat earth is inflammable unless it contain bitumen and sulphur.

Some of the Dutch have supposed that moss is a marine production; that, being torn up from the bottom, and tossed about by the waves of the ocean, it is thrown ashore. The spongy reedy turf called *dary*, is, of course, they say, often found in the bottom of the sea near Antwerp, and elsewhere; they therefore conclude, that it has been originally formed there. It contains a liquid bitumen, and a portion of sea salt.

Others have supposed, that peat moss is a growing vegetable, *sui generis*. This opinion has been adopted by some of the Dutch writers upwards of a century ago, and Dr Anderson, in his Essay, strenuously defends it.

It is almost unnecessary for me to add, that some writers of distinction, and almost all the vulgar, are of opinion, that moss is of antediluvean origin. Dr Morton supposed that the strata of peat found in Northampton and other parts of England, with all the trees they contain, were deposited by the deluge. Every peasant is of opinion that this has been univer-

sally the case with all peat mosses, and that none are of more recent origin.

Such a variety of opinions, so discordant, clearly proves, that this subject has been either much neglected, or, at least, that the origin and natural history of peat moss has not been hitherto elucidated in a scientific and satisfactory manner.

This neglect is unaccountable, if not criminal. Whether we consider the vast extent of surface covered with moss in every kingdom of the north of Europe, or the various and important purposes it is calculated to serve, the subject must rise in importance in the estimation of every enlightened mind; and it must appear astonishing, that a subject so interesting and so important has hitherto been so much neglected.

It is utterly impossible for me accurately to ascertain the number of square miles covered with moss. It may, however, arrest the attention of the reader to give a rough guess at it.

I shall name a few mosses. These are by no means the most extensive; they are not selected as such; yet they may suffice to give a faint view of the vast extent of surface covered with that substance. At one period, perhaps, the whole of that surface was rich arable land, or, at another, an extended forest.

Hatfield moss, in England, seems to be of this description: It contains upwards of 180,000 acres. Some of the mosses in Ireland are still more extensive. Dr Boates speaks of one on the Shannon, fifty

miles long, by two or three broad. Carr, in his Stranger in Ireland, says, that the bog of Allan alone contains 300,000 acres. Blavier mentions some mosses in France, probably of much greater extent. The great marsh of Moutoire, near the mouth of the Loire, he says, is more than fifty leagues in circumference. And Mons. De Luc says, that the moss of Bremerford, near Bremen, is upwards of sixty miles long, by twelve or fifteen broad: At a moderate calculation, it must contain upwards of 600,000 acres. In other places of Holland, Germany, Poland, Prussia, Sweden, and Russia, I might point out some of double or treble that extent. To calculate the number of acres these may contain, would be an unavailing task; for though that calculation were correct, it could only give a very imperfect view of the vast extent of surface covered with moss in the north of Europe. Innumerable millions of acres lie as a useless waste, nay, a nuisance to these nations. The benefits that might accrue to Europe by a slight attention to this subject, are above all calculation. It is impossible for numbers to express, or the imagination to conceive, correctly, the extent of these.

I speak not of moss as a soil only; there are other economical purposes it is calculated to serve, of equal importance; yet the cultivation of it as a soil alone is important. The following statement, in the communications to the Board of Agriculture, will shew this in a satisfactory manner: It is said that, in Cambridgeshire alone, there are not less than 150,000

acres of waste unimproved fen. By a moderate improvement, these might be made to yield 10s. per acre, so that no less than 75,000l. of yearly rent might thus be added to that single county. According to Dr Halley, Cambridgeshire is only a seventieth part of England and Wales. If the above results be multiplied by 70, the number of acres that lie waste, may be 22,351,000 in these kingdoms alone. At a moderate rent of 10s. per acre, they might yield upwards of 10,000,000l. At 30 years purchase, these would add 300,000,000l. Sterling to the national capital.

The above is surely no more than an ideal calculation, and perhaps it ought not to be allowed to be correct. For, although Cambridgeshire be only a seventieth part of England and Wales, it is not probable that all that kingdom contains the same proportion of unimproved moor and fen, with that single county; yet the calculation is valuable; and the subject cannot be too often or too strongly pressed upon the attention of the public.

Beatson in the First Vol. of the Communications to the Board of Agriculture, calculates, in general, that there are upwards of 20 millions of unimproved mosses and moors in Britain. He supposes that there are upwards of seven in England, and 14 in Scotland.

The proportion of improveable fens and marshes and mosses, in Ireland, it is likely, is far greater than in either.

Is it not, then, astonishing, and is it not to be lamented, that a subject of such national importance has hitherto been so shamefully neglected? Is it not a reproach to every nation in Europe? Ought it not to be deprecated by all ranks? And ought not every potentate of these vast dominions to blush at the recollection? Shall they spend the treasures and the blood of their subjects in the wild schemes of ambition, in seeking to extend their dominions, and aggrandize their nation and their name by new conquests, while kingdoms lie uncultivated in their own empires, and myriads of acres of their richest vallies lie as a useless waste? If but one ten thousand part of the treasures wasted in one campaign, were devoted to the improvement of these uncultivated regions, then might the wilderness be made to smile, and the desart to bud forth and blossom as the rose; then might the voice of melody and health be heard in the peaceful cot of the lowly peasant, in place of the sound of the trumpet, and the alarm of war.

The heath covered mountain would no longer shew its unseemly front, but be cloathed in all the verdure of spring. In place of impassable fens, the waving corn and yellow harvest would adorn the vallies. The peasant would no longer need to pine for want of food or employment, or pant for distant climes. While the upstart tyrant and his creatures, in France, pant for honour, and pursue the path that leads to it, all drenched in blood, let Britons of all ranks direct their attention to the toils of a healthful, happy pea-

santry; let them diffuse the light of science over the British Isles, and point out and pursue the mighty plans of economical improvement, especially of the neglected fens and mosses.

Say that the task is arduous: say not that the difficulties are insurmountable, or that it is a forlorn hope to make the attempt. These difficulties are not once to be named with those with which the industrious Dutch have long contended, and at last surmounted. While they have converted seas into dry land, and impassable fens and lakes into fertile plains, let none despair of seeing the mosses of Europe converted into purposes equally important and useful.

It were a fruitless attempt in an obscure individual to endeavour to rouse the attention of the potentates of Europe to this subject: yet when I see such spirited attempts in Britain, and so many rapid improvements already made, and every day making, in every department of agriculture; and, more especially, when so many of the first rank and first talents in the kingdom, have formed patriotic societies for the encouragement of that most noble of all arts, I cannot but flatter myself, that even my feeble efforts may arrest the attention of some of my countrymen. And I hope the time is not far distant, when the Natural History of Peat Moss, like every other branch of that delightful subject, shall be elucidated.

It is the pride and distinguishing glory of Britons, that they excel all the world in the art of agriculture. Mons. Mirabeau, in France, was forced to acknow-

ledge this. "The English," says he, "have been "the first to establish the principles of agriculture in "Europe, and to discover that this is the foundation "of all other arts, and the very hinge on which all "commerce ought to turn." Don Jos. Volcarel was obliged to bear a similar testimony: "It must be "acknowledged," says he, "that England has open-"ed the eyes of other nations. These islanders have "discovered at last, after many schemes, that it is "agriculture alone which forms the source and ori-"gin of their greatness. If, on these principles, we "were to calculate the progress of that monarchy, "we would find their power to have increased in a "threefold degree, and that this has been augmented "in proportion to their improvement in this art." When I see such a testimony from the most enlightened enemies of my native country in her behalf, I feel an honest elation of heart; and when I think that the maritime power and flourishing commerce of Great Britain depend so much on her internal resources, and especially on the improvement of her soil, I am not without hopes that peat moss (the only part that has been neglected) shall soon arrest the attention of every patriot, and call forth the talents of the distinguished chemist.

To rouse the attention of all ranks to this subject, and especially that of the patriotic societies in Scotland, England, and Ireland, and, if possible, that of the Senate itself, is my great object. With this view I have, at my leisure hours, prepared a number of

essays on the natural history and origin of peat moss. These are ready for the press, and will be published in succession. I have likewise prepared a number of essays on moss, as a soil, a manure, a fuel, &c. &c.

The first five essays are entirely devoted to the natural history and origin of that substance. Till this be clearly ascertained, every attempt to improve it as a soil, or convert it into manure, must be hazardous. Experiments may be made, but, in that case, they are only made at random: And, perhaps, nine-tenths of these attempts have originated in ignorance, and therefore failed. Even of those which have succeeded, the greater part of that success may be ascribed to accident; and accidental discoveries, without knowing on what principles they proceed, cannot be deemed satisfactory.

To point out the origin and distinguishing qualities of peat moss; to ascertain, if possible, the chemical principles on which it may be converted into a soil or manure, or turned to other economical purposes; and, above all, to show that no disappointments ought to damp the ardour of Britons, or make them despair of success, is the great end I have in view in these essays.

In the prosecution of this subject I have felt the most pleasing amusement. It has been a fund of delightful recreation to me for years. Prompted by a sense of the importance of the subject, and still more encouraged by the polite attention of the Highland

Society and the Board of Agriculture, I have pursued the plan with perseverance.

My obligations to them are great and many. I feel, too, and am proud to express, the high sense of gratitude I owe to the Curators of the Advocates' Library, for the liberal manner in which they furnished me with the books they had, and even procured some from the Continent on the subject.

It might hurt the delicacy of individuals were I to express, in this public manner, my obligations to them. It is enough to say, I feel, and ever will retain, a grateful sense of these.

To the University of Glasgow, and every Member of that learned Society, I am under such obligations as I cannot, and therefore will not attempt to express.

ESSAY I.

ON LIGNEOUS PLANTS.

AN

ESSAY

ON THOSE

LIGNEOUS PLANTS

WHICH LAY THE FOUNDATION,

AND FURNISH MATERIALS FOR THE FORMATION

OF

MOSS.

THE natural history of Peat Moss is very obscure; and, it is probable, that it will never be fully elucidated. Many ingenious and plausible theories have been suggested upon the subject. Without enumerating all of these, I shall endeavour to state and support those which appear to me the most rational and consistent.

It is almost universally allowed to be of vegetable origin; and it seems to be the general opinion, that it is either a congeries of ligneous or aquatic plants, or of both. To these two sources all the mosses of the North of Europe may be traced.

In this Essay I shall confine myself to *Ligneous Plants:* and endeavour to trace up many of our mosses to this source.

SECTION I.

It is the opinion of eminent men, that the whole habitable earth was originally covered with woods; and that it continued to be so until mankind formed themselves into societies, and subdued these by fire or steel. Dr Darwin, in his Botanic Garden, gives this as his decided opinion, in so many words. St Pierre thinks that the whole earth, if left uncultivated, would become a forest. He thinks, that even the Alps and Pyrenees were once covered with wood.

It cannot be denied, that there are facts which tend to corroborate this opinion. I shall state a few of these, which are well known, and need no attestation.

1. When the earth is uninhabited, and allowed to lie in an uncultivated state, trees of all kinds spontaneously spring up and flourish, each in the soil and climate suited to its species.

2. Even land at present in cultivation, if enclosed, and allowed to lie waste, in the vicinity of a forest,

will speedily be covered with wood. The seeds of various trees are scattered over the surface; there they strike root, and spring up in abundance.

3. Most of the glens and precipices, especially in low sheltered situations, inaccessible to cattle, are covered with copse-wood.

4. Many regions of the earth, both in the old and new worlds (as they are called), when first explored, were one extended forest: And the remotest regions, which the traveller has never trod, in all probability, are similar to these.

Whether this opinion be well founded or not, it is certain that the north of Europe once abounded in woods and forests, more than now. It appears that trees have flourished even in the cold inhospitable climate of Lapland, where scarcely a tree or shrub is now to be seen.—They are dug out under the perpetual snows of that region.

It is impossible to trace the changes in the climate, and the consequent changes in the productions of different regions of the globe, up to a very remote period. History leads us back only a few hundred years. But we have both geographers and historians of credibility who bear testimony, that, eighteen hundred years ago, the north of Europe abounded in forests, in many places where scarcely a tree can now be seen.

Ptolemy is one of the most ancient of our geographers: and, considering the period at which he wrote, he is very correct. Let any person look at his map

of Europe, he will see, that, in the south of that quarter of the globe, there were few forests of any considerable extent. In Spain, Portugal, Italy, and Greece, there appears to have been none.

In the north of Europe forests appear to have been numerous and very extensive in his days. In Germany they are so immense as to make a very conspicuous figure in the map. Helvetiorum Sylva, Gabrieta Sylva, Hircinia Sylva, Somana Sylva, cover immense tracks, and give the whole of Germany, &c. the appearance of one extended forest, with only a few interstices of open land.

Ortelius corroborates the testimony of Ptolemy. According to his representation, Arduenna Sylva (now Ardennes) seems to have covered one third part of ancient Belgium. The Hircinian forest seems to cover more than one half of Germany:

Whereas, according to these geographers, there was not a single forest, of any considerable extent, in Asia, Africa, or the south of Europe. The Pyrenees are, indeed, represented as partly covered with wood at that period; but in no place is there the appearance of any forest so far south, excepting upon these mountains *.

The testimony of historians, upon this point, is equally decided and clear. Cæsar, Tacitus, Pliny,

* It is not asserted that no forests did ever exist in the south of Europe. The probability is that they did abound as much, if not more, than in the north.

All that I mean to insinuate is, that this was not the case at the period alluded to.

Pomponius, Strabo, and Tyrius, all agree, that the forests of the north of Europe were numerous and extensive.

I shall not give a detailed account of these forests. A few quotations respecting the extent and situation of the most remarkable may suffice.

Cæsar was the conqueror of Gaul; of course, he narrowly inspected that country, and points out its topography with minuteness: He gives a distinct account of the *sylva Arduenna* in his days: He calls it a forest of vast extent, and by far the greatest of all Gaul. He points out its limits: He says it reached from the Rhine, through the territories of the Treviri, to the conflux of the Schelde, and the Maese; so that it extended upwards of 500 miles.

Strabo gives a similar account of its extent. His words are "*efficiunt hæc quatuor millia stadiorum.*"

Pomponius describes Gaul as abounding in forests. He calls it "*Terra amœna lucis immanibus.*"

The Hircinian forest is described with equal precision. Pliny says, that it covered almost the whole extent of Germany. Cæsar and Pomponius both agree that it was no less than nine days journey in breadth, and 60 in length. It seems even to have been more extensive; for it is added by the same authors, that no man, in those days, had ever reached the extremity of it.

If we were to trust to etymology, the prevailing names of these districts would indicate that most of Germany, and a great part of the United Provinces,

was once covered with wood. The very name Holland indicates this. Degner observes that *Holt* signifies wood. Holland, therefore, must signify the woody country; and all those districts, whose names terminate in *holt* or *hout*, *would*, *woed*, *wolde*, &c. indicate that they were originally forests. Seven *wolden* is still the name of the seven forests of Friezland.

It cannot be doubted that the forests of the north of Europe were more numerous and more extensive 2000 years ago, than they are at present. It seems probable that they do not occupy one-fifth, perhaps one-tenth, of the space they did at that period.

This point I have been at some pains to establish. It would, however, tend to the elucidation of this subject, if we could ascertain the causes of this change.

SECTION II.

1. In proportion to the progress of agriculture forests decrease. Every new settler in North America clears a part of that country of wood, and converts it into a cultivated soil. A similar change,

doubtless, ensued in the North of Europe; and the more rapid the progress of agriculture, forests would disappear in proportion.

At the remote period of the Roman invasion, the inhabitants of the greatest part of the north of Europe seem to have been ignorant of the arts of cultivation. Like the wandering tribes of North America, they seem to have depended for their subsistence, in a great measure, on the spontaneous productions of the earth. They lived by the chace: or, if they had herds and flocks, these were but few in number, in proportion to what are now reared in that region.

This may be one cause why forests abounded at that period. Few were cut, with a view to cultivate the soil. The young plants, or seedlings, of every species, were suffered to spring up with less injury from man or beast. Besides this, the different arts, introduced into the north of Europe, occasioned a great consumpt of fuel. The forests that abounded would naturally present themselves as the readiest means of supplying that article. The quantity thus consumed, in France alone, from the want of coal, and other combustibles, must have been great; and economical writers have often raised the alarm that, by this means alone, the whole woods of France will soon be consumed.

2. Besides this, the rude nations of the north, at that early period, had a religious veneration for their

forests. They were all druids; they worshipped under every green tree; forests were deemed sacred to their deities; each had its peculiar divinity; and some trees were regarded as peculiarly sacred.

Maximus Tyrius mentions, that the OAK was worshipped by druids of every nation; that, for this cause, it was carefully preserved. He also adds, that the fir-tree was the favourite of the Danes, and preserved by them with equal care.

These two species were the most abundant of all the trees of the forest. To injure or destroy them would be deemed a deed of sacrilege; to preserve them would be esteemed an act of religious homage. But,

3. There were civil as well as religious motives, which prompted them to preserve these forests. These rude nations, at that remote period, made frequent inroads upon one another. Each was ready to fall a prey to his neighbour. When overpowered by numbers, or unable to meet the invading foe in open field they fled to their woods for succour and for safety. These offered a secure retreat; thither the enemy, though numerous, durst not pursue them.

The Roman historians bear testimony to this. They all agree that the inhabitants of Britain, and the north of Europe, retreated to their woods on every emergency. There they rallied; from thence they rushed forth, with impetuous fury, upon the foe. Cæsar mentions many instances of this. Cassibelaunus, after his defeat, retired beyond the Thames,

and took refuge in the woods and marshes: The Silures, when attacked by Agricola, did the same: Venutius, king of the Brigantines, imitated their example.

The same historian observes, that these nations had few cities or fortified places; that their woods, surrounded with a rampart and ditch, served them for a bulwark and strong-hold. As such they would be preserved with care.

The great object of the invader would be, on the contrary, to destroy them, and thereby cut off the natives from a secure retreat.

This leads me to point out,

SECTION III.

The Means by which these Forests were destroyed.

1. It will naturally occur to every one that *some of these have decayed through age.* This is the universal law of nature. Every herb, fruit, and flower fadeth. The lofty cedar, and the stately oak,

that have stood for ages, at last tumble into ruins; and the fashion of the world passeth away.

This account of the matter may appear satisfactory to some, perhaps plausible to all; but it is only plausible; and it will, by no means, account for the great and general wreck of these forests.

It is with the vegetable as with the animal kingdom; one generation goeth, and another cometh, in endless succession.

Every tree yields fruit after its kind; these naturally drop each species upon the soil suited to its production (that is, near the parent tree.) There they would spring up; and thus one generation would naturally supply the place of another. Du Hamel, accordingly observes, that the seeds of the fir tree, which drop in the forests of Bourdeaux, in August, open by the heat of the sun, and spring up so thick that it is necessary to thin them from time to time.

In place of a forest's decaying through age, it is probable that, in some situations, it may be renovated; and, it is certain, that the new generation must exceed the old, both in number of trees and extent of surface.

That this has been the case with some of our ancient forests, which now lie in ruins, appears probable, from the following circumstances :—

1. (*a*) The trees found in our mosses are, for the most part, perfectly straight. Even oaks, which are most apt to spread in a crooked branchy form, where

they have room to extend, are often found 90 feet long, without a bend, or the appearance of a bough.

2. (*b*) The roots of trees are often found so thickly studded in the subsoil of moss, that it is hard to conceive how they could extend to such a size in so small a place.

These circumstances render it probable, if not certain, that such forests have been originally very thick set.

There are other circumstances, that render it equally probable that one generation has risen upon the ruins of another.

1. (*a*) In many mosses one tier of roots appear perpendicularly above another; yet both are fixed in the subsoil.

2. (*b*) In some even three tier appear, in succession, the one above the other.

3. (*c*) In other cases, the branches of the trees that have been overset continue to grow, while the trunk decays. These branches send out new roots, which take a new hold of the soil, and thus form a new generation. In the Phil. Trans. No. 275, this appears to be the case in Hatfield moss, and elsewhere.

4. (*d*) It is a well known fact, in natural history, that the roots of many trees may be converted into branches, and the branches into roots. If the tree be overset, and the roots turned up, so as to have access to air and light, they vegetate like branches, and grow into trees: If, on the contrary, the branches be covered with earth, and thus cut off from access

to air and light, they are converted into roots, and serve the same purpose. Cordiner, in his antiquities of the North, mentions an instance of this in Mar Forest. A large pine, with spreading branches, arrested his attention. One of these branches, by the weight of timber, had reached the ground; there it had taken root; for many years it had grown; a new tree had sprung up from this new stock: By the impetuosity of the storm this new tree had been torn up; and the roots and branch, and tree that had sprung from it, hung high suspended in the air.

5. (*e*) Even, in some cases, trees are found still growing upon the ruins of others, after they have been converted into moss. De Luc mentions that, in Kidinger Moor, trees are still growing, though there is three feet of moss formed on the surface by the ruins of former generations. Dr Walker mentions a similar instance in the moss of Strathcluony.

All these circumstances combined, render it probable, that time alone will not account for the general wreck of our forests; at least, it appears certain, that they may survive for several succeeding generations, before they finally decay through age.

Other causes may be assigned, and no doubt have co-operated in this great catastrophe: nor can it be ascribed to one cause. We are not to suppose that every forest has undergone the same fate.

There are, however, evident marks,

2. That some have yielded to the storm, and been overset by hurricanes.

In every age, and in every quarter of the globe, the stateliest trees and the most extensive forests have been overset, or totally ruined, by the impetuosity of the tempest. Cæsar, Tacitus, and Pomponius, all agree that Gaul, in their days, was exposed to tremendous hurricanes. They speak of whole forsets being overset by tempests of wind. Tacitus, who knew both countries, describes Germany as being still more exposed to such tempests than even Gaul. He speaks of the largest oaks being thereby overset; and, he says, that their extended roots and branches and trunks, when thus overblown, gave them the appearance as if whole mountains were moved.

Thus trees which stood on the firmest foundation, and had the fastest hold of the earth, may yield to the storm; much more those which sprung up in a looser soil; and, most of all, those which had risen upon the ruins of former generations :—their roots would naturally sink into the mass of leaves and boughs and trunks in search of nourishment; of course, having a less firm hold, they would more readily yield. When the rains descended, and the floods came, and the winds blew, they would be more easily overset.

Besides this, if it happened that several feet of moss had been formed, during the growth of these trees, they would, on this account, more easily yield to the storm. Senebier shews, by experiments, that

a tree sunk in the earth, half its length, will speedily perish; the same must take place if it be sunk in moss. Chilled by this means, it must be checked in its growth, and readily yield to the impetuosity of the tempest.

Mons. De Luc, in a letter to me in January last, makes a similar remark:

"That there have been vast forests in the north of "Europe, which no more exist, is ascertained by his- "torical monuments; and it appears to me, that "peat mosses have been one of the causes of their "destruction: The accumulation of peat having "softened the soil, the winds must have blown down "the trees. Hence whole masses of the mossy sub- "soil has, by this means, been torn up; especially on "the banks of rivers and lakes. These have caused "those floating islands which still subsist in the coun- "try of Bremen, that I have described in my works.

"Trees thus overset must have sunk into the "mossy subsoil, and added to the mass of moss. In "this subsoil, the seeds they had dropped would "cease to vegetate. The attempt to plant new trees "on the spot has been vain; they are soon covered "with a grey moss, which speedily destroys them."

Dr Walker mentions a recent instance of this. In the year 1756, the wood of Drumlanrig was overset by the wind; and many forests, both in Britain and on the Continent, have, no doubt, suffered the same fate. Hence, in many mosses, the trees are all broken over within two or three feet of the surface;

their trunks all lie in the same direction, a proof that they have yielded to the same element.

In the British Islands, they mostly lie in the direction from S. W. to N. E. because our prevailing winds and heaviest rains come from that quarter. I have examined many mosses in this neighbourhood, and found this to be the case. The same is said of Hatfield, Phil. Trans. No. 275, and Dr Collet says the same of Berkshire moss.

Junius, in his Histor. Batav. mentions, that in many mosses in Holland, though not in all, immense trees are found; that their roots all incline to the N. W. and their tops to the S. E. He says, that this is a proof that forests once abounded in those regions, and that they were overset by north winds, or incursions of the northern ocean.

It is of little consequence in what direction the trunks are found lying. If, in any moss, they lie chiefly in one direction, the probability is, that they have been overset by the wind.

No doubt other causes have combined to overset these forests. The hands of men have been employed for this purpose, and there are evident proofs that some

3. *Have been cut down.*

A number of well attested facts lead to this conclusion: Historians, both ancient and modern, bear us out in forming it. As this is an important point,

and tends greatly to illustrate the origin of many of our mosses, I shall endeavour to establish it, upon the most unequivocal evidence.

(*a.*) There are evident marks of the hatchet in many of our ruined forests, and in the deepest mosses, both in the British Islands and on the Continent.

Numberless instances of this must have occurred to the reader; I shall only point out a few that have been carefully recorded.

The Rev. Mr Tait, in his account of Kincardine moss, mentions, that it has been originally a forest; that it bears evident marks of having been cut; that the stumps of the trees are generally about two or three feet high. At that height, he adds, the diameter of a tree is generally less, and therefore more easily cut: the cutter can better apply his strength than at a greater or less height. Hence, in Russia, where wood abounds, and is used for fuel, they cut it about the same height. Mr Tait adds, that there are clear marks of the hatchet still to be seen; that it seems to have been two and a half inches broad; that there is no reason to suppose that this forest was overset by the winds, for none of the trees appear to have been torn up by the roots.

Mr Ure, in his History of East Kilbride, mentions a similar case. "A few years ago, the trunk of a "tree, with part of the root, was dug out of a peat "moss near Renfrew. In the trunk, a little above "the root, was found sticking an iron hatchet, of a "very uncommon kind."

Mr Aiton, in his essay on peat earth, says, that he has seen many thousands of trees in mosses that had been evidently cut.

In the Phil. Trans. No. 275, similar instances are mentioned in Hatfield moss. Some of the trees found deep in the moss are chopped, some squared, some bored through, others half riven with great wooden wedges and stones; and broken axe heads, similar to the sacrificing axes of the Romans, are found in them.

Dr Leigh, in his Natural History of Lincolnshire, mentions, that the trees dug out of the fens of that county bear evident marks of being cut; that the marks of the hatchet are still fresh and obvious. He adds, that, in some of the deepest drains, trees were found cut, squared, and formed into rails, stoups, bars, &c. &c.

In Somersetshire, Cheshire, Lancashire, Westmoreland, Yorkshire, Staffordshire, and *other* counties, the same author observes, that there are similar marks *of the hatchet* to be seen. He adds, that in the Netherlands, France, Switzerland, &c. there are the same.

Mr De Luc, who narrowly examined the mosses on the Continent, mentions, that there are evident marks of the hatchet to be seen on the trees dug out of Kedinger moor. Pontus Henterus says the same of all the trees dug out of the mosses of Picardy in France.

SECTION IV.

Of the period at which these forests have been overset, and by whom.

It cannot be expected that we can ascertain at what precise period, or by whom these forests have been cut; there are only a few scraps of history to direct our researches.—I shall name a few:

(*b.*) It appears from the history of Britain, that some of our forests, which are now mosses, were cut at different periods.

Even the records of the British Parliament bear evidences of this. At one period, the extensive forests became a national nuisance; they harboured wolves and wild beasts of prey: these were destructive to the live-stock, and sometimes dangerous to the inhabitants.—By several acts of the Legislature these forests were ordered to be destroyed.

Edward the First ordered the trees of Wales to be cut and burnt. Pembrokeshire moss, of course, may have been formed upon their ruins. And it is certain, that the trees dug out of that moss bear the marks both of fire and steel.

When Henry the Second conquered Ireland, he did the same in that country. The object of that prince was to prevent the natives from having any harbour in their woods, and harassing his troops.

Dr Boates, in his Natural History of Ireland, observes, that trunks of trees are found near Castle-

Forbes, which have been burnt, and that the ashes are still seen lying on the stumps of these trees. He ascribes the destruction of them, first to the Danes, and afterwards to the English.

In the wars of the borders, John Duke of Lancaster, to avenge himself of the depredations the inhabitants had committed, set 24,000 axes to work at once to destroy the woods. Perhaps Lammermuir, and the mosses of the borders may owe their origin to this or a similar cause.

King Robert the Bruce, when he pursued the Earl of Buchan to Inverary, destroyed some of the forests in that neighbourhod. In the Statistical Account it is said, that the trees then cut down are still found under the deep mosses of that district.

Other intances might be mentioned; but we must look to a more remote period of history for a more complete illustration of this subject.

(*c.*) The records of the Roman history furnish us with more ample and satisfactory evidence.

To that restless and ambitious nation we must chiefly look as the cause of the ruin of the forests of the north of Europe. The object of the Roman emperors was not only to conquer the barbarous nations of the north, but to SECURE their conquest. They were not satisfied, therefore, with having extended their arms from the Caspian to the Baltic Sea, and from the Pillars of Hercules to the Hebrides, they sought to establish their extended empire, and

to secure it from the incursions of the nations they had subdued.

During the short intervals of peace which they enjoyed, we accordingly find that they employed the legions of Rome, and oftentimes the inhabitants of the tributary provinces, in cutting down the forests and draining the marshes. Tacitus states this in explicit terms. Dion Cassius and Herodian join their testimony to the same effect. Severus, in his last expedition to Britain, is not only said to have given general orders for the destruction of all the forests of these provinces he had subdued, but to have lost 50,000 of his soldiers in that undertaking in Britain alone.

Throughout the whole of Britain accordingly, and a great part of the north of Europe, there are still to be seen evident traces of the Roman power in the ruined forests, mosses, and moors.

Roman coins, or utensils, or the remains of Roman works, have been discovered deep in these mosses.

I. Many Roman coins have been discovered in Scotland. I mention a few instances; others will occur to the reader. They ought to be recorded.

In Possil moss, near Glasgow, a leathern bag, containing above 200 silver coins of Rome, were found.

In Dundaff moor, a number were discovered about forty years ago.

In Annan moss, near the Roman Causeway, an ornament of pure gold was discovered.

Many have also been found in the English mosses.

In Lincolnshire fens, two or three coins of Vespasian, with the head of that Emperor on one side, and the Roman eagle on the reverse, were discovered.

In Hatfield moss a variety of these coins were found near the root of a tree deep in the moss.

A thousand coins of the Emperor Victorinus were discovered in the marsh of Mazarion in Cornwal;

And some have been discovered in the mosses of the Continent.

In Low Modena Roman coins were dug out of the marsh 30, 40, and 50 feet deep.

De Luc mentions that similar discoveries have been made all over the Continent. Mr Heerkens, in his ELEGIA de Terra Groninguensi, speaks of a coin of the Emperor Gordian being found 30 feet deep in moss, and many other phenomena, which shews these mosses to be of recent origin.

Besides coins,

II. Many utensils, of Roman workmanship, have likewise been found in these mosses.

A Roman camp-kettle was found eight feet under a moss in the estate of Ochtertire.

In moss Flanders a similar implement was found. A Roman jug was found in Locher moss, Dumfriesshire. A pot and decanter, of Roman copper, was found in Kirkmichael parish, in the same county.

Two pair of vessels, of Roman bronze, were discovered in the moss in Glenderhill in Strathaven; and in the Isle of Sky a chest of Roman arms was found under moss.

Degner mentions similar instances on the Continent. He says that all kinds of coins, antique stones, with various inscriptions, fragments of arms, earthen pots, &c. are dug out of these mosses.

But it may be said these utensils and coins were only dropt through accident, and sunk in these mosses after they were formed; or that they may have been buried there on purpose, so that they are no proof that these mosses were formed over them since the period in which they were deposited. It may be proper to add, that,

III. The remains of Roman works have been also found deep in these mosses. Many of these must have been executed before these mosses had a being. In the Dullatur bog some Roman altars were discovered when the great canal was dug; these are lodged in the University of Glasgow, and may still be seen. In a moss in the immediate neighbourhood of this, a beautiful Roman altar, dedicated to the nymphs, was found: It is still standing at Nethercroy, in the parish of Cumbernauld, near the spot from whence it was dug. In Ardennis a beautiful marble altar was found, dedicated to Diana.

It may be said, however, that even these were buried or sunk in the mosses where they lay, long

after these mosses were formed. There are other remains of Roman works to which this remark can scarcely be applied.

The Rev. Mr Headrick, in his Essay, Vol. II. Com. Bd. Agr. mentions, that the Roman causeway was lately discovered in the moss of Mr Fulton of Hartfield, near Paisley; that it lies on a bed of moss; but that over it several feet of moss has been formed.

Girard in his Hist. of the Valley of the Somme, in the north of France, mentions, that a similar causeway was discovered near the village of Brevilly, under the moss. That it is clearly the work of mens' hands; probably of the Romans. As an evidence of this, he adds, that this is the common tradition of the country; that many of the old forts in the neighbourhood have Roman names, or allusions to that nation; that one is called the camp of Cæsar.

Abbe de Bæuf. clearly proves, that the forts near Pecquingy are Roman; and he thinks this causeway, and the banks that intersect the moss, are the remains of Roman works. Hence they are still called *viez* from *via*. And one is called *viez du camp*.

Lambardie, who made a general survey, and gives a minute description of the mosses of France, states it as his decided opinion, that, in Cæsar's time, the banks of the Somme, though now an extended morass, were covered with woods and lakes: That the inhabitants were therefore called by the Romans *Morini;* by the Celts, *Mourinin*, or the inhabitants

of the moors and marshes: that, having these woods and marshes as a secure and safe retreat, they were therefore the last of all the Gauls that Cæsar could subdue.

Lest any doubt should remain on this subject, I may refer the reader to the Rev. Mr Tait's account of Kincardine moss. There a discovery was made of the Roman causeway, which leaves no doubt that that moss was an extended forest at the time of the Roman invasion; and that it was cut down by them.

The Roman causeway can still be traced through a great part of Britain. In the neighbourhood of Kincardine moss these traces are clearly seen. It enters upon the south of the moss at Craigforth; on the north of the same moss, near the river Teith, it is still visible: while it communicates with the moss on both sides, it seemed to be interrupted there. Traces of it have, however, lately been discovered, in digging that moss. After the peat, eight feet deep, was removed, the remains of this road were laid open to view. It is twelve feet broad; it is not paved with stones like the rest of that work; it is constructed of trees from nine to 12 inches diameter. Those forming the first tier are laid in the direction of the road; over these, another tier of trees, of half the diameter, are laid across. The whole is covered with brushwood. The first tier of trees generally lies on the surface of the subsoil of clay. In the lowest and wettest places they are sunk, as might be expected, two feet below the surface of this clay.

The same author adds; It can scarcely be doubted, this is a Roman work connected with the Roman road, and forming a part of it. And he concludes,

That before the time of Agricola, this level was occupied by a forest: That about that period this forest was cut down by the Romans: That from these trees thus cut down, and suffered to decay on the marshy grounds, originated the vast body of peat moss which now covers that level: That the age of the moss, therefore, cannot much exceed 1700 years.

De Luc, from a general survey of the mosses of the Continent, draws a similar conclusion. He says, that all along the mosses and moors, which he examined, there are Roman antiquities to be found; that there are evident marks that many of these mosses were forests, at the period of the Roman invasion; and, that it is more than probable, that these forests were ruined by that power.

Demoustier, in his account of the fossil wood, discovered near Paris, observes, That it appears from Cæsar's account of Labienus's expedition against the Gauls under Camelogenus, that all the neighbourhood of that city was, at that period, woods and marshes: That the inundations of the Seine overflowed these: That Camelogenus retreated thither: determined to wait the attack of the Roman legions: That Labienus attempted to force a passage through the morass, by twigs and branches covered with sod: That he found this impracticable: That he therefore went up as far as Melun, and, mounting 50 boats

with soldiers, sailed down the stream into the city: That the Gauls set fire to the city, cut down the bridges, and placed themselves beyond the marshes: That they were there surrounded, and completely defeated by the Romans. Gobelinus mentions, that moss is found at the port of Paris, where these woods and lakes formerly lay.

I may add, that it would appear from the Roman historians, that London, at the same time, was surrounded by woods and marshes; and it is probable, that the extensive mosses found in the vicinity of that metropolis, in digging the docks at Deptford and Blackwall, and in all the marshes adjoining, originated from these *.

SECTION V.

Many of these forests were destroyed by fire.

I WAS not a little surprised at the remark of a very ingenious gentleman, upon this subject. When I hinted to him the probability that many of the forests of Europe had been consumed by fire, he said, he doubted much whether a green growing forest would burn at all. Perhaps others may entertain similar

* Blavier mentions, that the Roman causeway was discovered under the mosses near Calais, on the banks of the Seusel river.

And Mr Aiton mentions, that the remains of this same road has been discovered under the moss of Logan, in the neighbourhood of Kincardine moss.

doubts. To these I would reply, that innumerable accidents of this kind have happened over all Europe. Whole forests have thus been consumed in a single day. Rozier observes, that before the mendicant beggars were dismissed from France, the whole country was in a continual consternation; for, when they were refused any thing they asked, they threatened to set fire to the forests, and often put these threats into execution. He adds, that shepherds, by leaving small fires burning, often occasioned similar accidents.

He mentions two instances of forests kindling of their own accord. In the parish of St Cyr this happened in the year 1774. About 50 years before that, a similar accident took place in that neighbourhood. These both stood on a subsoil of moss. To this he ascribes the accident. He supposes, either that the moss was so dry, and the inflammable air so abundant, that it caught fire; or that it was owing to the pyrites which abounded in the moss, which kindles as soon as it comes in contact with the air. By such an accident whole forests may have been utterly ruined; for he observes, that the trees thus burnt in these forests were easily overset. The soil was so dried by the fire, and the roots of the trees so loosened, that the first gust of wind overset them.

Mathiole, in his Commentary on Dioscorides, observes, that the larix trees in Norway are overgrown with a species of fog or moss which kindles on the smallest spark: That he slept one night in these woods: That the shepherds set fire to this moss;

That the forest blazed and burnt with the rapidity of gun-powder, and diffused a most delicious odour all around.

Wedelius de Musco Terrestri says, that all the mosses contain an oleaginous inflammable matter. Some of these, he observes, if speedily dried, spontaneously take fire. Hence, he adds, whole forests have been consumed; these mosses being kindled by the heat of the sun, or by lightening, or a dry warm summer.

He says, that many instances of such accidents were known to him, especially in Holland, where such conflagrations have continued for weeks, and even months.

De Vries mentions many instances near Geethorn, Beukween, and Haula.

In 1567, one occurred by the carelessness of a shepherd.

In 1541, Guicard mentions, that another took place in Brabant.

At Stavoren in Friezland, a whole forest, with all the subsoil of moss, was consumed in the year 1222, and converted into large caverns and lakes.

In 1593, when the Spaniards were attempting to form a road near Sheouerbeck, the inhabitants set fire to the morass, and it burnt with such impetuosity as to consume every thing in its way. The whole morass was thereby rendered impassable by the caverns and lakes that were formed by the conflagration.

It is unnecessary for me to mention instances of similar accidents in Britain: That a few years ago, the fir woods of Melville in Fifeshire, and a vigorous young plantation in Baldernock in Stirlingshire, were consumed by fire. I only observe, that such is the conviction of the danger of similar accidents, that salutary laws have been enacted in almost every nation in Europe to prevent them. Many ingenious arts have been devised and used to arrest the fury of the flames, or extinguish them altogether. Degner describes the means used by the Dutch; and the Marquis de Tourbillie mentions the precautions he was obliged to use in France.

That many of the forests of the north of Europe have suffered this fate, seems to me absolutely certain. Many of these that now lie in ruins under the mosses bear evident marks of this.

Carr mentions that many of the trees found in the Irish mosses have been consumed by fire.

Degner mentions, that burnt trees are often found under the Dutch mosses. De Luc observes, that many of the trees found under the mosses of the Continent have fallen a prey to the flames. Dr Boates describes similar marks of fire on the trees dug out of the Irish mosses.

In many of the mosses of Britain, in the parishes of Strathaven, Applecross, Edzel, Kilbride, &c. in Scotland, and in Hatfield Moss, &c. in England, there are similar marks of fire. In many mosses which I have examined, especially those which lie

along the line of Hadrian's wall, there are similar appearances.

The stocks of the trees are found standing erect as they grew. These are generally broken over about two feet above the level of the original soil. Great quantities of ashes are found bye these roots; and the lowest stratum of these mosses is entirely made made up of ashes. Chips of charred wood abound in it. These are not only observable by the microscope, but obvious to the naked eye. I was somewhat surprised at this when I first observed it; but the more minutely I examined the peats dug from that stratum, I was the more convinced of the truth of what I state. I have seen many beautiful specimens of these peats. In some the chips of charred wood are smaller than a goose quill. They are so closely united, that they appear like a piece of net-work. In others, they are upwards of an inch in diameter; yet all these were dug out of the very bottom of a moss, from three to six feet deep. It is utterly impossible to examine such mosses, without concluding, that the forests which originally gave birth to them were consumed by fire. The whole of the lowest tier of peat has the appearance of powdered charcoal and chips of charred wood kneaded together.

By what accident, or by whom such forests have been consumed, must remain a secret.

There are, however, many circumstances that render it highly probable that the Roman legions were

the chief actors in this scene. These I shall shortly state.

1. No one nation, at that early period, ever extended their empire over all the north of Europe, but the Romans.

2. None had therefore such means, or so many powerful motives to prompt them to destroy these forests.

3. As none had such means or motives, so none seem to have formed the resolution, or given such general orders to this purpose.

4. The only remains of the ancient forests of Europe are to be found beyond the ancient limits of the Roman Empire.

5. Over all the extent of that empire, the ruins of these forests may still be traced in the mosses and marshes of Europe.

6. In most of these, Roman antiques may still be found:

7. And in none, so far as I have heard, have any relicts of any more ancient nation been discovered.

I have, therefore, no hesitation in concluding that many, if not most of the forests of Europe, were ruined by the Romans.

Their great object was the utter ruin of these forests. It is natural to suppose that they would adopt the easiest and most expeditious methods of accomplishing their end; and no method could be more speedy and effectual than the flames. It is natural to conclude, therefore, even though we had

little or no evidence of this, that these means would be often employed.

On this subject I cannot but notice a very remarkable paper in the Phil. Trans. No 275. The subject is Hatfield Forest. The account of it I give in the author's words:

"That the Romans did destroy great woods and "forests in these moors, marshes, and bogs, I come "now to prove. The common road of the Roman "armies was from south to north, by Lindum (Lin-"coln) to Sigiculum (a little burrow upon Trent), "from thence to Donum (Doncaster) where slept "a standing garrison of Crispinian horse. On the "E. and N. E. of the road between these two last "named places lay the borders of the Great Forest. "This swarmed with wild Britons, who were mak-"ing continual sallies from the same, and retreating "to it again; intercepting the provisions of the Ro-"mans, and destroying their carriages; killing their "allies and passengers; and disturbing their garri-"sons. This at length so enraged the Romans, that "they were resolved to destroy this forest. That "they might do it the more easily and effectually, "they marched with a great army against the same, "and encamped on a great moor near Tinningly, as "appears from the fortifications that may still be "seen.

"Near this it is probable that a great engagement "took place; for hard by it is a little town called "Osterfield. Now, as *field*, the latter part of the

" word, is never used to be added to any other but " where there has been a battle, so *Oster*, the former " part of the name, seems to tell us what Roman ge- " neral it was who fought, viz. the famous Ostorius, " whom all the Roman Historians assure us was in " those parts.

" Who got the victory is not so easy to say. No " doubt it was the valiant Romans, who, besides " multitudes of the Britons whom they slew, drove " the rest into the woods and forests that covered " this low country. Wherefore the Romans, that " they might destroy the enemy more easily, took " the opportunity of a strong S. W. wind, set great " fires to the forest, which, taking hold of the fir " trees, burnt like pitch, and consumed infinite num- " bers of them. When the fire had done what mis- " chief and execution it could, the Romans brought " their army nearer, and, with whole legions of cap- " tive Britons, chopped and cut down most of the " trees that were left, leaving only here and there " some great ones untouched, as monuments of their " fury.

" These, being destitute of their underwood and " neighbouring trees, were easily overturned by strong " winds. All these trees, falling across the rivers that " formerly ran through that low country, soon dam- " med up the same, and, turning it into a great lake, " gave origin to the great turf-moors that are here, " by the girations of the waters, the precipitation of " terrestrial matter, the consumption and putrefaction

" of rotten boughs and branches, the vast increase " of thick water-mosses, which wonderfully flourish " and grow upon such rotten grounds.

" Even now, since the drainage, and since that " ground is laid dry, for many miles, they are so " surged with water, and so soft and rotten, that they " will scarcely bear men to walk on them.

" Hence old Roman coins, axes, &c. have been " found near the roots of the trees that lie at the bot- " tom of these moors and levels.

" Hence, too, on all these grounds great numbers " of trees are found burnt, some in two, some length " ways, and some chopped and hewn.

" Hence some are found with their roots, and " others, as they have lain all along, have branches " growing out of their sides.

" Hence they lie bye their own proper roots, with " their tops to the N. E.

" But, to return to the Romans, as they were the " destroyers of this forest, so were they likewise of all " the others that grew on the low countries of Che- " shire, Lancashire, Yorkshire, Lincolnshire, Staf- " fordshire, Somersetshire, &c. &c. Yea, and of the " countries beyond the seas, where such trees are " commonly found."

I may add, that De Luc, who examined these countries, gives it as his opinion, that the Roman urns, and other antiquities found in the bottom of the mosses, are evidences that these forests were destroyed by that people.

SECTION VI.

Other means by which Forests have been ruined.

WHOLE forests have slidden down from the mountains, where they grew, into the adjacent vallies. Instances of such accidents are recorded. Kirwan, in his geology, mentions a case. In the year 1787, a whole side of a hill (near Meudon in France), covered with wood, descended 50 feet into a plain, and covered it to the height of 70 feet. Its descent lasted six years.

Dr Boats mentions a similar instance in Ireland. Upwards of four acres of a hill, near Clogher, slipped down from the declivity, carrying trees and shrubs, &c. and burying them in the valley, in the year 1712. Rozier mentions a similar case in Bohemia, 1770: Part of the mountain of Zeigenberg slid down 38 fathoms, till it reached the Elbe, with its trees standing partly erect and partly inclined.

Similar accidents may have happened elsewhere. By these not only forests may have been overset, but the water or rivers in vallies may have been pent up, so as to form a morass over such forests, and give origin to mosses.

It seems probable, too, if not certain, that some forests have been overwhelmed by inundations of the ocean. Those in the Basse Somme seem to have suffered this fate. It would appear, both from Cæsar's account of that district, and from Pontus

Henterus's survey of it, that the lower part of the maritime coast of Picardy was at one period overflown by the sea, though now a moss. Not above 500 years ago, salt works existed in that district; and soda of course may still be extracted from the mosses of Picardy.

Lentilius and Commelinus both agree in the supposition that Holland was once an extended forest; that this was overflown by the German Ocean; that this forest sunk in the mud, and, by the accession of particles of earth, formed the immense mosses of that country.

Picard mentions an instance that happened at Cimmerium before the Christian æra;

And there are historical records of similar instances. Westerman mentions a case in 1230, where the sea overflowed a woody region near Stavoren, where the subsoil was moss.

Schotanus supposes, that the mosses of Friezland originated in Norway, and were carried hither by the sea; that the vallies where they now lie were forests overwhelmed by this inundation. He says, many trees are found at the bottom of these, as monuments of what they once were.

He mentions a remarkable circumstance of two lakes near Cauches. The borders of these are covered with immense oaks. These are sometimes undermined by the billows, or torn up by the tempest, and swept away like floating islands, carrying these vast trees along with them.

The submarine forests on the east coast of Lincolnshire seem to have suffered a similar fate.

These are very extensive; they reach not only over all the fenny country, but far into the German ocean; in every respect they resemble the mosses in Hatfield and the adjacent fens. Dr Alderston observes, that wherever bores have been made, moor and peat earth is found on the same level, whatever the incumbent soil on the surface may be.

Joseph Correa de Serra, in his excellent paper upon this subject, mentions the species of wood found in this submarine forest, "That it is the same "as in the adjacent fens:

"That as in mosses, so in this forest, wood is "found fit for economical purposes:

"That the trunks of many of the trees are found "flattened like the Surturbrand and Bovey coal, "by the incumbent weight of sand:

"That the trees are found precisely in the same "positions as in most of our mosses. Some are "fastened in the original soil from whence they "sprung; the trunks of others are broken over; "the bark of some is perfectly fresh, especially of "the branches; the silvery skin, or outer membrane, is discernible.

"The subsoil is also similar, viz. a greasy clay. "This is covered, many inches deep, with rotten "leaves, whose form is scarcely distinguishable by the "naked eye; but when these leaves are put into

" water, they separate each from the other, *so that the* " *several species of the leaves may be discovered.*

" It is clear, that these trees are not water-borne, " but all grew upon the spot. Each trunk has its " corresponding root attached to its native soil."

As to the means by which this forest has been subdued, we can be at no loss to conclude, that it was by an inundation of the German ocean; and we must suppose one of two things; either that the surface of the sea has risen to such a height, as to overflow this forest, and lay it in ruins; or, that the soil on which it grew has subsided. The former of these suppositions is not consistent with geological facts: the latter is more probable; especially, as we know of instances where the shores of the sea have sunk many feet. At Venice, Pola, Lessa, Bora, &c. this happened. Borlaze records similar instances, too, in England; other instances might be mentioned; that in Yorkshire is well known.

I may add, that there are similar appearances on the opposite shores of the Continent; yet, from authentic evidence, we have reason to conclude, that the level of the sea, in those quarters, is the same as in Cæsar's time. The coast is still, in every respect, similar to what he describes it; the Roman ways still exist, and reach and terminate at the very spot which he points out.

So that if the sea has risen, so as to overwhelm these forests, it must have been prior to the period of his reign. Indeed, there seems strong reasons for

supposing, that these forests were overwhelmed at a much earlier period. On the coasts of Lincoln there is a stratum of solid soil above these trees, in many places 16 feet deep. To form this, would, in all likelihood, require many ages. Hence these forests are called, by the vulgar, *Noah's wood:* for they suppose that they are coeval with the flood.

It is unnecessary to enumerate all the places along the English coast, where the remains of forests are still discovered under the sea, at low water. Cambden specifies many, and Childry mentions a number. He says, that about two miles east of St Michael's mount, at low water, they cast aside the sand on the shore, and dig up turfs that are full of the roots of trees: on some of these trees they find nuts. Large trunks are also dug up by the tinners, which they suppose have lain there since the deluge.

On the coast of Cumberland, he observes, that similar discoveries are made.

He says, too, that the sandy shore on the coast of Pembrokeshire was laid bare in the reign of Henry II. by a violent storm. By this means great trunks of trees were discovered. Some of these, he says, bore the marks of the hatchet; and they lay so thick, that they seemed to be a whole forest in ruins.

Borlase mentions similar appearances on the coast of Cornwal. Great numbers of trees are found below sea-mark: especially oak, hazel, and willow: When the tide is in, these lie 12 feet under water.

There can be no doubt, that immense forests have, at one period, flourished on these coasts; and the probability is, that they have been overwhelmed by the ocean.

SECTION VII.

General Conclusions from the above facts.

First, That at one period, probably as late as the Roman invasion of these countries, *Britain and the North of Europe abounded in forests.*

The only exception to this seems to be Friezland and the Orkney Islands. The former seems to have been comparatively barren of wood, in the days of Pliny: he says, there were few trees in it; and there are few still.

The latter are described as a dreary waste, without tree or shrub. Solinus says of them "*vacant* "*homine, nec habent sylvas, tantum juncis herbis*

" *inhorrescunt, cætera earum nudæ rupes et arenæ* " *tenent.*" Torfæus gives a similar account of them in his days: he says, that in the year 890, they produced no wood; that Einar was the first who taught the inhabitants the use of turf as a fuel; that, on that account, he obtained the name of *Torf* Einar.

Mr Jamieson, who surveyed these islands a few years ago, represents them to be in much the same state as they were 1000 years ago. He says, that on a general view, " they present a wonderful scene of " rugged, bleak, and barren rocks; no tree, no " shrub relieves the eye, in wandering over the dreary " waste."

Yet these islands, as well as Friezland, abound in mosses. How these were formed, I shall endeavour to point out in my Second Essay.

Secondly, That these immense forests have fallen into ruins; some by accident, as by the tempest, or inundations of the sea; others by design, have been cut or burnt.

In place of immense forests of lofty pine and stately oaks, extensive marshes, moors, and mosses, now cover these regions: what a dreary dismal change must this have occasioned over all the north of Europe?

The fragments of these fallen forests may still be traced. The vast trunks of oak and fir found in these impassable morasses, like the stately ruins of an ancient edifice, give us some idea of the extent and

magnificence of these forests; and the marks of fire and steel point out the cause of their ruin.

Thirdly, That these ruined forests have laid the FOUNDATION *of* MANY *of the mosses of the north of Europe.*

This conclusion may appear to some more dubious: it is of importance to establish it. I shall, therefore, shortly state a few of those facts and circumstances which have led me to form it.

1. Many mosses now occupy the place of these forests. To be convinced of this, let any one read De Luc's minute detail of the mosses on the Continent, and compare this with the delineation of these countries by Ptolemy and Ortelius, or the Roman historians of that age, and he must conclude that this is the case. The very site of a great part of the immense forests of Hircinia, Semana, Ardennes, &c. is now occupied by mosses and moors, by fens and lakes.

2. Trees are found in most of the mosses of Europe. In nine-tenths of the British mosses they abound: of this I need not adduce evidence.

The same is the case with the Irish mosses. Dr King says, that "*trees are generally found at the* "*bottom, not only of the wet, but even of the dry red* "*bogs.*"

In the preceding pages, I have shewn, that the same is the case with most of the mosses in France.

I only add, that Blavier was so struck with this, that he says it is probable that all the French mosses were once forests. Ribaucourt also makes a general remark, that there is scarcely a valley in France without moss; that under this moss, wood is found.

Even in Holland, immense trees are found in many mosses, though not in all. Is it not natural to conclude that these mosses, for the most part, are the remains of ruined forests; otherwise, how came these trees to be found in them?

Degner tells us, that some of the Dutch suppose that these have grown up like subterraneous plants, after the manner of minerals and fossils: is not this directly contrary to the laws of vegetation? When was it ever known, or where was it ever seen, that a stately oak or fir was found growing in the deep caverns of a lake? Even supposing they had sprung up there, how have they been cut and burnt, &c. as they are often found? Have these caverns and subterraneous regions been peopled with inhabitants? Have their coins and hatchets, and other utensils, been so similar to the terraneous inhabitants, as not to be distinguished from them? Have they needed fuel? And, have their fires been kindled and kept alive in these lower regions?

He tells us farther, that others suppose that these trees have grown above the marsh, and sunk by their specific gravity to the bottom, where they now lie. If they grew upon the marsh, how have their roots been fixed to the subsoil, even of the deepest of these

morasses? Is it possible to conceive that a tree, by sinking in a marsh or lake, should strike its roots and tenderest fibres deep and wide into a solid mass of clay? Is it not much more reasonable to conclude, that this clay was the native soil from which the tree first sprung?

He adds, that others suppose these trees to be water-borne; that they have been carried by inundations of the sea, and lodged in lakes and mosses. That this may have happened in some cases, I have already shewn: that trees may have sunk in the ocean cannot be doubted. Dr Watson proves, by a number of simple experiments, that wood becomes specifically heavier than water after being steeped in it. A piece of fir, steeped 100 days, sunk in water at 60 degrees; oak and ash sunk much sooner. But, if all the trees in moss have thus been water-borne, how comes it that, in almost every moss, the trunk is found lying bye the root? Did these trunks, after performing their voyage, like dutiful children, return to be buried in the same grave with their parents? And how did each species, by some elective attraction, or magical charm, after being huddled together, return each to its proper soil, the oak to the clay, and the fir to the sand, from which they sprung?

Dr Anderson gives a still more learned, though not less ludicrous, account of the matter. He concludes, not only that moss is a plant *sui generis*, which continues to increase to an immense magnitude and indefinite age, but that, in its progress, it

envelopes trees and every other matter that comes in its way; and, in a learned note, he endeavours to shew, that this is nothing contrary to the course of nature; that similar instances of extraneous matter in growing vegetables have been discovered. He mentions two; the first is a hazle nut, found quite fresh, near the heart of a large beech tree; the second is a knife, found also near the heart of a large fir tree; and he endeavours to shew, that these cases are quite analogous to wood found in moss. He carries on the analogy still farther, and endeavours to shew, that animal matter, and even animals, have been preserved alive in the heart of trees; that this also is analogous to moss; that the carcasses of animals are found inclosed in the same manner, and preserved in the same state, in that substance; but that this is no proof that the trees found in moss grew upon the spot. His words are, "*It is true that wood is sometimes found* "*in moss, and it is equally true, that flies are found* "*in amber; but does it follow from hence that amber* "*is produced from decayed flies?*"

I shall not presume to follow up the Doctor's reasoning, nor attempt to trace the analogy he endeavours to establish; I only observe, that moss has been supposed to be a growing vegetable, *sui generis*, nearly a century ago, by some of the Dutch: That this hypothesis may be wholly the Doctor's own, as he insinuates in his preface, but that it is by no means new: That as it appeared at first to him (as he ac-

knowledges) only a *jeu d'esprit*, it is but fair to let him enjoy his own sport in his own way. I shall therefore dismiss this new species of vegetable from the list of plants, till its habits and qualities are distinctly ascertained. I would only suggest, that of all devouring monsters it must be the most dreadful, according to the Doctor's account; for, as I shall shew, ploughed fields, large trees, loaded boats, men and women, and the largest animals, houses, nay, streets and whole cities, have been swallowed up in its all-devouring jaws.

3. Most of the trees found in moss must have grown on the spot where they lie. Of this there can be little doubt.—The following facts will satisfy the reader of this.

The same species of trees which abounded in the ancient forests of Europe, are still found lying in ruins in moss. Pomponius and Pliny both agree that the fir, the oak, the birch, were the most prevalent in their days. Dr Guthrie states, that the same species form the greatest part of the Russian forests at present. It is unnecessary to prove that, in all the mosses of the north of Europe, the ruins of these species are found in the greatest abundance. This clearly proves that these mosses have been formed of the indigenous plants that prevailed, and still prevail, to grow on their native soil; that this congeries of vegetables has not been water-borne, or brought from remote regions or distant climes.

But it is equally certain, that the trees generally found in moss have flourished and decayed on the very spot where they are now found.

For, in the *first place*, Each species is now found lying prostrate on the very subsoil which is peculiarly adapted to its growth; if the subsoil of moss be clay, oak is the most abundant; if sand, fir prevails.

Secondly, It is well known that, in low warm levels, trees arrive at a greater size than on high mountains, or in colder regions; and that the size of trees diminishes in proportion to the height of the surface on which they grow. Dr Walker accordingly observes, that, in all the mosses of Scotland, the largest trees are found in the low-lying level mosses; and that the higher the mosses lie, the trees are proportionally smaller. Mons. De Luc makes a similar remark with regard to the mosses of the Continent. And both agree that this is a strong presumptive proof that these trees grew on the spot.

Thirdly, The trunks of many trees found in moss are still attached to their roots; these roots are fixed in the subsoil. Even when the trunk is broken off, it is generally found lying prostrate, near the parent root, which stands fixed in the native soil. These trees are often found standing erect as they grew. In many of the deepest mosses on the Continent this is the case: in the Isle of Man, especially, in the Marsh of Curragh, vast trees are discovered standing firm on their roots, though at the depth of eighteen or twenty feet below the surface.

Fourthly, All the roots of trees found in moss are thus fixed in the subsoil; they are seldom or never found lying loosely huddled together, or lying topsy-turvey, as if they had been water-borne. Accordingly Lord Dundonald observes, that this is a proof that the moss in which they lie neither gave birth to nor supported these trees, but the original subsoil; and that the ruins of these gave origin to, and furnished the materials for, the moss which now occupies their place.

Fifthly, The leaves and fruits of each species are found immersed in the moss along with the parent tree. The leaves and acorns of the oak, the cones and leaves of the fir, the nuts, &c. of the hazel, are all found huddled together in one mass on the spot where they grew. It is almost unnecessary for me to add,

Sixthly, The upper side, or surface of trees found in moss, is uniformly most consumed. An oak may be often seen where the upper half is so consumed that only the semi-diameter of the tree remains: this is a proof that such a tree, when it fell on the spot, had been half immersed in the mass of ruins; that half has been thereby preserved entire.

4. Instances are recorded in which wood has been converted into moss, or a bituminous substance similar to it, equally inflammable, and possessing all the other qualities of that substance. Dr Anderson denies this. I shall therefore mention a few cases in point.

Cordiner, in his Antiquities of the North, mentions a case. In describing Mar Forest, he says, "that part of the woods being fallen into decay, "ranges of vast trunks of trees, which have long "lain along the ground, are immured in moss. Their "perishing leaves, and dissolving branches, strewed "around, constitute the present soil, and are in "a great measure turned into one general mass of "vegetable earth.

"In some places where water has stagnated a-"mong the fallen trees, the morass is complete and "inaccessible; in others, the trunks are so com-"pact and firm as to afford a safe and dry path, only "now and then the specious heath gives way be-"tween the logs."

He adds, "of some trees one end may be dug "into peats, and the other sawed off and used as "good timber."

Dr Walker mentions another case of the wood of Drumlanrig, and the Earl of Cromarty speaks of another near Lochbroom. The Doctor says that this forest was overset by a storm about 60 years ago. Being neglected, and suffered to remain as it fell, it rotted on the ground; so that now the whole is nearly ripened into peat earth.

The case mentioned by the Earl of Cromarty is well known. It cannot but be interesting to the reader. I shall therefore state it in his Lordship's own words. He says, "That, in the year 1651, "when he was yet young, he visited the parish of

" Lochbroom in West Ross: That he there saw a " small plain covered with a standing wood of fir " trees: That they were then so old that they had " dropped both their leaves and bark: That he had " occasion to visit this forest fifteen years afterwards: " That, by this time, there was not a tree to be " seen: That the plain was covered with green moss: " That, in the year 1699, he saw that the whole " was converted into peat moss, from which the in- " habitants dug peats."

I may add that,

5. The names of mosses imply that they have originally been woods.

There are innumerable instances of this both in the British Islands and on the Continent of Europe. Immense tracts of moss, in which there is not a single blasted trunk of a tree standing, bear still the original name of wood or forest. This clearly proves, that, at the period in which they obtained that name, they were not mosses but forests; and that they retain still that name though in ruins.

It were an easy task to enumerate a variety of instances of this that have come under my own observation. It appears to me more satisfactory to observe in general,

First, That all mosses which bear the name of *wood*, *bank*, *shaw*, *calder*, &c. are of this description.

Secondly, That the names of many mosses indicate not only that they were once forests, but dis-

tinctly bear the name of the particular species of tree which prevailed most. Of this description are all mosses which bear the following names, Oak*shaw*, Aller*bank*, Ash*wood*, Birken*head*, Aller-*trees*, &c.

Thirdly, That all mosses in Britain and on the Continent, which are called forests, may be included in the above list. Many such lie along the line of Hadrian's wall. Easter forest, Wester forest, and Middle forest, &c. are the names of different districts where no vestige of a forest remains, excepting the vast trunks that lie in ruins in the adjacent mosses.

Fourthly, *Wolde*, *woed*, *wode*, *waelde*, all mean the same thing. They correspond to our English word *wood* or *forest*. All mosses on the Continent which bear this name, such as the Seven Wolden of Friezland, &c.; and those in the British Isles, such as Lincolnshire Woldes, the Waeldes of Kent, &c. &c. may be included in the above list.

Fifthly, Innumerable mosses on the Continent are called *holt*, or *hout*, or *boom*, or the names of them include these monosyllables. All of them signify the same thing, viz. *wood*. *Holtand* or Holland is the *woody country*. *Boomen*, &c. &c. signifies the same.

Lastly, The names of many mosses on the Continent are descriptive of the particular species of trees which prevailed in the forest while it stood, and which may now be traced in its ruins. *Note*-boom is the *hazel* or *nut-tree*: *Elzen*-boom is the ash; *Eyken*-boom the *oak*: *Piin*-boom the *fir*: *Birken*-

boom the *birch*: *Kien*-boomen the *pine*, &c. &c. All the mosses, therefore, bearing these names, must have not only been originally forests, but forests abounding with that distinct species of tree whose name they bear.

If all the mosses included in the above list, or bearing such names, or names of similar import, be allowed to have been at one period forests, we may conclude that the half, or perhaps the greater part of the mosses of the north of Europe are of this description.

From all these considerations combined, viz. That many mosses now occupy the place where forests once stood: That trees are found in most of the mosses of Europe: That most of these trees clearly appear to have grown and decayed upon the spot where they now lie: That there are instances recorded wherein ruined trees in forests have been converted into moss: and That many mosses still bear names which indicate that they have once been wood: from all these considerations combined, I hesitate not to conclude, that ruined forests have laid the foundation of many of the mosses of the north of Europe.

It seems equally natural to conclude from what has been stated,

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Fourthly, That some of these forests have been ruined by the Romans; and that the mosses formed on these ruins are of no earlier origin than the age of Julius Cæsar.

I say some, not all. There are mosses, no doubt, of very ancient origin: perhaps some may be coeval with the flood.

Part, too, of the moss may have been formed before these forests were overset. I have already mentioned instances in which two or three feet of moss was formed at the roots of the trees of a forest before these fell into ruins.

In all probability this has been the case in general.

But some, if not many mosses, seem to have been formed within 2000 years.

1. It is probable that all those in which Roman coins, axes, arms, and other utensils of that nation have been found, are of no earlier origin. It is remarkable, that of all the antiques found in mosses, by far the greatest *part are Roman.* No coins nor utensils of any other nation, so far as I know, at least none that would lead us back to a more remote period than the Roman invasion, have ever been discovered. The only exception to this that I have heard of, is that of a Phœnician canoe that was said to be found in moss.

Of this description are many mosses over the north of Europe. The mosses of Kincardine, Annandale, Ochtertire, Kirkmichael, &c. in Scotland; of Hatfield, Lancashire, Lincolnshire, and Cornwal, &c. in England; of Kedinger-moor, Picardie, and near Paris and Calais, in all of which Roman antiques, or relicts of Roman works have been found, are pro-

bably of no earlier origin than the age of Julius Cæsar.

2. It is equally probable, that the mosses that lie along the line of the great Roman road are also of this description. If Severus and other emperors gave so strict orders, and made such great exertions to cut down and destroy all the forests in the conquered provinces, it is more than probable that those which lay in the direct line of their march would be the first to fall a prey.

I have examined one district. I shall give a short detail of facts, chiefly with a view to induce others to make similar inquiries and satisfy themselves.

I live in the immediate vicinity of Hadrian's wall. All along that line, from the Frith of Forth to the Clyde, there is a continuation of mosses on the south and north of that wall. In most of the vallies, these mosses are obvious to the eye: they appear still on the surface: they have never been brought into cultivation, or converted into soil.

A great part of these vallies, however, are now rich meadows or arable land: Yet all along the banks of the Kelvin and Carron, these low lands lie on a *subsoil of moss.* Whether they consist of meadow, or pasture, or arable land, this is generally the case. After passing through the soil or sward, on the surface, which is from one to two and three feet thick, you come to four or five or ten feet of moss.

Through all this extent between the two Friths, the surface, for the most part, is waving; that is, it

consists of alternate hills and vallies. Yet in all these vallies, and even on the summits of the hills, if they be level, moss either forms the surface or subsoil. From the declivities it has indeed been washed away; on them little moss now appears; yet even on many of these sloping hills, which have submitted to the plough, there are evidences that wood once grew, and that moss once existed. The soil is still, in many places, a mixture of moss and clay. Many roots and trunks of trees are still dug up from time to time.

These remarks are not limited to one parish or county only; they apply to many. In the parishes of Falkirk, Slamannan, Cumbernauld, Monkland, Kirkintilloch, Cadder, Kilpatrick Easter and Wester, Renfrew, Paisley, Kilbarchan, Kilmalcolm, that is, all along the south of Hadrian's wall, these traces are to be seen; in Airth, Larbert, Denny, St Ninians, Kilsyth, Kippen, Campsie, Fintry, Baldernock, Strathblane, Drummond, and Bonhill, on the north of the wall, they are equally conspicuous.

A superficial observer may overlook these. As he passes along he sees few trees, and none of the remains of our ancient forests. He would never call this district *horrida sylvis*. Here and there he would discover a tuft of moss or heath, a trifling lake, or extended morass. The rich vallies would arrest his attention; the extensive meadows would please his eye; but, upon a closer inspection, he would find, that all these lie on a subsoil of moss. These mosses, too, all exhibit evident marks of their origin. The

trunks of large trees found in them shew that they were once a forest. Many of these trees, too, bear marks of their having been cut or burnt. The conclusion from this is natural, that as Britain was described, in the days of Agricola, to be hideous with forests; as these forests were industriously destroyed by the Roman legions, it is probable, that those which lay along the line of their march would first fall a prey to their fury; and it is probable, also, that many of these mosses, in the line I have described, were of no earlier origin. Were this allowed, it would include a considerable extent of moss.

But the same remarks apply to the whole mosses that lie along the Roman road, both in Britain and the Continent. The same traces have been discovered, accordingly, through the parish of Strathaven, &c. in Scotland. The same are still more distinctly marked, as I have already stated, p. 50. in the low countries of Cheshire, Lancashire, Yorkshire, Lincolnshire, Staffordshire, Somersetshire, &c. &c. in England. It is not to be expected that, in every stage of the Roman itinerary, such traces should now be detected; nor is it possible to point out the particular spots which were covered with wood, and those which were morasses, at that period.

It deserves, however, to be observed, that there is not one vestige remaining of the ancient forests which Cæsar describes, along the whole line of the Roman way, excepting in the mosses where the vast ruined trunks of trees now lie.

Cæsar landed at Portus Ritupenses. Round that spot, still the level lands all lie on a subsoil of moss. The probability is that, at that period, these levels were either morasses or woods.

He next directed his course to the Thames. The banks of that river were then impassable morasses, or impenetrable forests; now they are extensive meadows, or arable lands: yet, on either side of the river, the subsoil is moss; and large trunks of trees are dug out of this.

Through Suffolk, Norfolk, Lincoln, and Yorkshire, similar traces may be seen; the Roman causeway passes through the woods which are still standing, and the fens and mosses which probably were forests at that period.

In Lancashire, extensive forests stood at that period. These lie now in ruins, in the immense fens of that district. Chatmoss, Penwortham, Pillens mosses, &c. are probably the only remains of these forests.

Bodotria is supposed to be Fifeshire. Agricola engaged and obtained a signal victory over the natives in that kingdom; and Tacitus says, that the woods and fens covered the flight of the enemy. Though no traces of these woods can now be seen, yet, in the mosses of that county, the ruins of them can yet be detected. Within two miles of Lochleven there is a large morass, where there has been an extensive wood: and there are still the remains of a Roman camp, in the lands of Sir John Malcolm, hard bye this spot.

The probability is, that all those mosses, whose names indicate that they were forests, were ruined at that period; and, of course, are of no earlier origin; those, on the contrary, whose names bear that they were morasses, are of an earlier origin. Horsely and Dr Stukely both agree, that the word *car* signifies a *fen*. Mosses, therefore, whose names begin with this monosyllable, were probably morasses at a very early period. I need not add, that there are the same appearances in France and Holland.

It deserves, however, to be mentioned, as a very singular confirmation of this conclusion, that in Britain, in proportion as we advance northward, the traces of our ancient forests become more entire. Beyond the boundaries of the Roman empire, in Aberdeen and Inverness-shire, &c. where their arms never reached, in these districts alone the stately fragments of these forests still remain, as the sad and only relicts of their departed glory.

The same remark applies to the Continent of Europe in all its extent. Where are the lofty pines and stately oaks now to be found?—Where but in those regions which the Roman eagle never reached. In the remote circles of the German empire, in Poland and Prussia, and still more in Norway and Sweden, and the vast empire of Russia, there and there only can we see what Europe was, before it yielded to the power of Rome.

And could the art of man restore these ruined forests that lie buried in moss to their pristine glory,

what beauty would smile around every nation of Europe, where nothing but dreary wastes and dreadful desolation now reigns? What a barrier would these forests afford against every invading foe? What a source of national wealth and national greatness would they prove?

It is demonstrable that there is more oak lies buried in moss than would supply all the navies of every nation of Europe; and that there is more fir lying there, as a useless waste, than would answer every economical purpose which it can serve.

3. It is more than probable, it is almost certain, that wherever the Roman way can be traced under moss, especially when it appears, from authentic records, that wood existed upon the spot at the period of the Roman invasion, that the moss formed over that road is of no earlier origin. Instances of this have already been mentioned; many more may exist, though not recorded or known to me. There seems to be little doubt that Kincardine and Hatfield mosses were forests at that period; they, therefore, come under this description.

In the former of these, the Roman way has been traced; eight feet of moss has been formed over it. The conclusion is, that all this has been formed since that way was laid. In the moss of Hartfield, near Paisley, in the valley of the Somme, and near Calais, also in France, in Moss Logan, &c. &c. similar discoveries of that way have been made; and it is natural to form a similar conclusion as to these mosses.

When I mentioned this to an ingenious friend, he replied, that perhaps the Roman way was formed not before, but after the moss; and that it had sunk in this soft subsoil. In some places this may have been the case; it seems, however, clear and unquestionable, that Kincardine was a forest in which little or no moss existed at that period: for the road is not only formed of the wood, but the marks of the axe may be seen in the roots of the trees which are fixed in the solid subsoil of clay; besides, the road lies on this subsoil, without any moss below it; whereas, had it been originally laid on moss, and afterwards subsided, that moss, though compressed, must still have been discovered below the road, which is not the case. The eight feet of moss, therefore, which lies above this road, must have grown after it was formed, or since the reign of J. Cæsar. I only add,

Fifthly, That some mosses appear to be of much more recent origin than those I have mentioned.

I need not allude to Cordiner's account of Mar forest, which seems to be forming into moss; nor need I repeat what is said by Dr Walker and the Earl of Cromarty, of the mosses of Drumlanrig and Lochbroom.

There are other mosses that bear evident marks of recent origin. Mr Aiton, in his essay, shews that there is strong ground to believe that the forest of Paisley existed in the 12th century. In the charter of the foundation of the monastery there, the Great

Steward conveys to the monks the tithes of all the lands *below the forest of Paisley*. He says, that as late as the year 1460 and 1524, the tenants of Dunscaith-wood, in the vicinity of Paisley, were bound by the abbot *to keep the wood or forest, and to uphold and repair the dike round it;* yet, at this moment, there is not a vestige of that forest remaining, excepting the names Linwood, Fullwood, Woodhead, &c. &c. an extensive moss, many feet deep, over the low grounds, where it must have stood.

The probability is, that all this moss has been formed on the ruins of that forest, in the course of two, three, or four centuries.

The same author states it as probable, that the mosses in the upper parts of Strathaven and Avondale were of no earlier origin. This district formed a part of the forest of Selkirk. That forest seems to have extended over the upper parts of Ayrshire, Clydesdale, Peebles-shire, &c. It is ascertained that it existed as a forest in the 12th century. In the year 1180, Walter, the Grand Steward of Scotland, granted a charter to the Cistertian monks of Melrose. In that charter, he grants them in *pure alms* the whole pasture of this forest, as far as the marches of Douglas, Leshmahagow, and Glengivel; yet, in all that extent, there is not a tree remaining which can be considered as a relict of that forest. Four-fifths of the surface is covered with moss; and there is no other traces of it, excepting the names of Harwood, Neitherwood, Woodhall, &c. &c.

The conclusion he draws, is in the following words: "When I consider that the moors of Muir-"kirk and higher parts of Avondale formed part "of the forest of Selkirk, which is well known to "have existed in the 13th and 14th centuries; when "I look at the charter above quoted; and when I "find a great proportion of the land in these regions "still named by *wood* in the Saxon language, I am "warranted to conclude, that the parishes of Sorn, "Muirkirk, and the higher parts of Strathaven and "Leshmahagow, Douglas, &c. now almost wholly "covered with moss, were all growing forests at "and after the end of the 12th century."

Dr King, in his account of the Irish mosses, mentions several instances where there appears the clearest evidence of their recent origin. I name one. "There are many bogs of late standing in Ireland. "When O'Donald and Tyron came to the relief "of Kinsale, they wasted the country, especially "as they came through Connaught, which, by "means of the Earl of Clanrichard, was generally "loyal; and there is a great track of land now a "bog that was then a ploughed field. There re-"mains the mansion-house of my Lord in the midst "of it."

Dr Boates, in his Natural History, likewise mentions, that many of the Irish bogs seem to be of recent origin: he states the following instances: "Under a bog, five or six feet deep, a proper soil, "with the marks of the plough, and the form of

" ridges, were discovered." He adds, " That there are " few bogs removed but bear similar marks; particu- " larly in Armagh, Dundalk, Londonderry, Donne- " gal." He says, " that in the latter a plough was " found very deep in the bog, and a hedge with " wattles standing, five or six feet deep." He mentions, " that there are reports that the streets and " footsteps of a large town may be traced under a " moss in the north of Ireland."

M. De Luc mentions an instance on the Continent which also deserves attention. He says, that in digging a ditch in Davels moor, at the depth of four feet in the moss, was found the subsoil: that this formed an inclined plane. In this was found a trough or water-run, made of planks of wood, which shewed that it was a mill-trough. In the sand near this trough a wimble was also found. He says that he saw it, and that it differed nothing from a carpenter's wimble.

Here, he observes, is not only four feet of moss of recent origin, but a much greater depth; for all the lower level, at which this trough terminated, and in which the mill stood, is covered deep with moss.

It is almost unnecessary for me to observe, that the introduction of mills is of a modern date in Europe, and that the probability is great that the above moss is of very recent origin; it must have been posterior to the erection of that mill.

The above named author adds, that he has no doubt but, on a careful examination, many other

instances might be found, in proof of the recent origin of moss.

The rapidity with which moss might be formed and accumulated, in an extended level, is great.

An instance of this is mentioned by M. De Luc: near Bremerford there is a vast plain of this description. In that plain there is a village called Islerheim. The place itself is called Islerberg, or the town in the isle, or rising ground; yet he observes the whole is now a horizontal plain. At the time it acquired its name, and probably, when the village was first established, this spot must have been a rising eminence like an island; yet that appearance is gone; the adjacent moss has now risen to the level of its summit: so that what was once an island, has now disappeared, or rather it is now on a level with the adjacent moss.

As a proof of the recent origin of many mosses on the Continent, he makes a general remark, that the names and terminations of many places are German; that these are descriptive of the topography of the country. Of this he mentions four instances: *vorde*, *berg*, *holz*, and *thal;* the first signifies a *ford* the second a *height* or eminence, the third a *forest*, and the last a *valley;* hence these names are prevalent in many mosses. Bremerford, Ottesberg, Osterholz, and Lilienthal, he quotes as instances of this. These being all German names, he observes, is a proof, that the origin of the mosses,

which occupy their place is comparatively recent; that is, since the German language was introduced: That, at the period they acquired these names, fords, eminences, forests, and vallies, occupied these regions, which are now covered entirely with moss.

According to Pontus Henterus, the mosses in the lower parts of Picardy, along the sea coast, are of recent origin; he clearly makes it appear that these were overflown by the ocean at the distance of 500 years; and he attempts to prove, that salt works existed at that period where nothing but an extended moss now appears.

SECTION VIII.

Objections to the above hypothesis.

I AM aware that formidable objections have been made to this hypothesis.

Degner and Dr Anderson have both combated it with great keenness: the former sums up his objections under the following particulars:

" 1. That it is contrary to the common opinion of " the inhabitants of Holland.

" 2. That trees are not found in every moss.

" 3. That trees are often found buried where no " moss is formed.

" 4. Where trees abound, there are fewest mosses: " That they seem rather to retard than to expedite " the formation of moss.

" 5. That some mosses are found to be thirty feet " deep before we reach the wood: That it seems in- " credible that such immense quantities of that mat- " ter could be formed of wood: That the largest " and thickest forest could not supply materials suf- " ficient for the purpose: That one single acre of " moss contains more inflammable matter than twen- " ty acres of the finest forest.

" 6. That if forests are converted into moss, the " greatest part of Muscovy, Tartary, America, and " other woody uncultivated regions, would, long ere " now, have undergone that change, which is not the " case."

From all these considerations he concludes, " *that* " *moss is not formed of decayed wood.*"

The latter sums up his objections in stronger language, and marshals them in more formidable array. I shall state them, as they appear in this essay, in all their collected force: They may be reduced to the following heads:

" 1. That all vegetable substances, when dead, " decrease in bulk so much that they occupy not " above one hundredth part of the space they did.

" 2. That moss produces few vegetables; that " these tend rapidly to decay.

" 3. That the vegetable substance which forms " moss must therefore have been *one hundred* times " more bulky than the moss itself.

" 4. That mosses are found thirty, even forty feet " deep.

" 5. That the most abundant crop, on the most fer- " tile soil, will not cover the earth, when fresh cut, " half an inch deep; that, when rotten, it only co- " vers the earth one hundredth part of this.

" 6. That, therefore, it would require nine thou- " sand six hundred years to form a moss twenty feet " deep on the most fertile soil.

" 7. That moss produces not *one hundredth* part " of the crop of a fertile soil; therefore, it would re- " quire upwards of *nine hundred thousand years* to " produce twenty feet of moss earth on such a soil."

From all which he draws the following conclusions, and retires in triumph:

" Nothing can be so absurd, nothing so contra- " dictory to reason, and every known fact respecting " the decomposition of vegetables, than the whole of " the doctrine that has been implicitly adopted re- " specting the formation of moss, by means of decay- " ed sphagnum, or any other plant whatever."

This seems to me to be the sum of his objections: They are plausible, and seemingly strong; but their strength will appear imaginary, when brought to the test.

I shall endeavour to obviate these objections. My animadversions may appear severe; they shall be

made with candour. All the apology I plead is, that in the pursuit of science, and especially in the prosecution of a subject hitherto much neglected, and little known, *there is no beaten track in which we are all bound to tread.* On such a subject, we ought to set out with this motto, *nullius jurare in verba magistri*, otherwise there is an end to all fair investigation *.

The whole of his objections resolve themselves into one general point,

That if moss be formed of decayed wood, or any other vegetable substance, it must require an immense time to its formation. This, too, is the amount of Degner's fifth objection. As it is the most formidable at first appearance, I begin with it.

Let us suppose, for the sake of argument, (and the supposition will not appear absurd after what has been already stated) let us suppose, that what is now a moss was once a forest: Let us also allow, what the Doctor asserts as a well known fact, "that the thick-"est wood that ever grew, would not form a solid "body above two or three feet deep over the surface "on which it stood;" or, in the words of Degner, "That one single acre of moss contains more inflam-"mable matter than 20 acres of the finest forest."

* Few men have displayed more public spirit than Dr Anderson; and still fewer have devoted more of their time and talents to promote the interests of his country. If any expression that drops from my pen appear disrespectful, it is not intended. On the contrary, I feel, and ever will avow, great respect for him as an author.

Even upon this supposition the hypothesis I have suggested may be supported. There are a variety of considerations that come into the account, which seem to have been entirely overlooked by the ingenious Doctor and the learned Dutchman; the age of the forest, the annual accession of leaves, and seeds, and boughs, it must have yielded during all the period of its growth: the bark, and rind, and roots, after it was ruined, also must have added greatly to the mass of vegetable matter.

I shall endeavour to state, and follow up the Doctor's argument upon this supposition. Even upon his own *datum*, "That the thickest wood that ever "grew would not, when overset, furnish two or "three feet of moss," I hope to show, that the hypothesis I have endeavoured to support, is neither so absurd, nor so contradictory to reason, and every fact, as he asserts.

I. In the *first place*, The age of the forest must be taken into the account.

Many of our mosses certainly contain the ruins of aged forests; trees of an immense, nay almost incredible size have been found in them.

In Hatfield moss, which we have endeavoured to show was a forest 1800 years ago, fir trees have been found above ninety feet long, and sold for masts and keels of ships; oaks have been also discovered there upwards of 100 feet long. In No. 275. of the Phil. Trans. an oak is mentioned of the following dimen-

sions; one hundred and twenty feet long, twelve feet diameter at the root, and six at the top. No such tree exists now in the British dominions; perhaps few, if any, in Europe can be found equal to it. Twenty pounds Sterling was offered for it, which shews that it was in a state of tolerable preservation. A fir tree is mentioned by the same author no less than a hundred and fifty-three feet in length, and of proportional thickness.

Even in Scotland, and the higher regions of it too, where a tree will scarcely now strike root, some have been dug out of the mosses of very large dimensions. Mr Aiton speaks of an oak tree, dug up in the parish of Kilbride, upwards of sixty feet long, and, at the upper end, four feet circumference.

These stately plants, which now lie in ruins, could not have rushed up in a season, an age, or a century; they must have survived many generations of the human race. Upon a rough, but moderate calculation, we may suppose that such a fir would require some centuries to grow to such a size, and such an oak perhaps 1000 years.

Mr Tait, in his account of Kincardine moss, not only mentions the size of the oaks dug up, that some were fifty feet long, and three feet in diameter, but adds, that 314 circles, or years growth, were counted on the roots; yet some trees were larger: he speaks of one four feet, and another fifteen feet diameter at the surface of the clay.

All these shew, that mosses contain the ruins of aged forests.

Taking this for granted, it leads us on to considerations of great importance in the calculation; for,

II. In the *second place*, Every tree sheds its leaves annually. The oak has an abundant foliage; that of the fir is still more bulky. Where a forest is thick, as has unquestionably been the case in many of our mosses, the crop of leaves which it must have yielded annually, must have been equal in bulk to the richest crop of wheat on the most fertile soil.

Yet all these leaves must have dropt annually, during all the period in which the forest grew; say that this was only 500 years: even upon this supposition, the mass of vegetable matter thus formed must be very great.

Besides this, we cannot suppose that these leaves would cover the surface equally: each leaf would not drop to the root of the parent tree. Tossed by the winds and tempest, or washed down from declivities by the torrents, they must have been deposited in the sheltered corners, and deepest hollows of the woods; there, it is natural to conclude, they would be amassed annually in heaps; and while the declivities and eminences were stripped of leaves, these hollow levels would become the general depot of the forest.

I have often seen a mass of leaves, tossed by the winds into the hollow places of a wood, upwards of

a yard deep. Supposing that these, when they decayed and were compressed, would only furnish one quarter of an inch deep of materials for forming moss; even, on this supposition, we may account for a considerable depth of moss during the growth of any forest, at least in these hollow places; and it is only in low levels where deep mosses are found.

All the above mass was only the produce of one year. If the forest be allowed to have stood for 500 years before it fell into decay, these leaves, according to the above calculation, by dropping annually during all that period, would furnish materials for nearly twelve feet of moss, if annually accumulated in the same hollow.

It would tend greatly to illustrate this point, if we could shew that leaves have actually contributed to form moss in these hollows. From the accounts that we have of the mosses of Holland and France, Brabant and Britain, this seems to be the case.

I have already shewn that leaves have been discovered in Hatfield moss; that the several species may be distinguished. The same author who mentions this adds, "that many inches of the lowest "tier of moss consists of rotten leaves."

Similar appearances present themselves in Kincardine moss. In the Encycl. Brit. it is stated, "that "between the moss and the clay there is a stratum "*nine inches* deep, of a dark brown, or blackish "colour; that this is the remains of the leaves, &c. "of the woods before the moss was formed." Dr

Collet observes, "that the lowest tier of Berkshire "moss abounds with leaves," &c.

In the French mosses similar discoveries have been made. Demoustier, in the Journ. des Mines, mentions, that, in digging the foundation of the Pont de la Revolution at Paris, a kind of moss was found below the level of the river, divided into leaves and rubbish of vegetables, clearly distinguishable; that it exhaled a strong odour of sulphur.

De Boot says, that near Bruges, on digging fifty feet, whole forests were found; that the leaves and and trunks were so little altered, that the distinct species of the trees might be discovered: He says, even that the different series of leaves which had fallen annually may be distinguished.

Stevinus gives a similar account of the Dutch mosses, and states it as his decided opinion, "that the "leaves, &c. of fallen woods, washed down from the "rising grounds into the vallies, are, in a course of "ages, converted into moss."

In the Dict. Raisonne, similar appearances are mentioned to have been seen in the mosses of Brabant. I quote the passage in the words of the authors:

"In digging the peats in Brabant, at a place called "Pieland, they find below the sand a stratum very "hard and very compact, which is nothing else than "a mass of leaves of trees, &c.; the odour this emits, "(it is added), is insupportable: but, when exposed "to the air, this substances separates of itself into

" leaves, and one can easily distinguish that this whole " stratum is nothing but an immense mass of leaves " heaped together, and formed into a body. This " phenomenon (they add) proves, in a decisive and " satisfactory manner, the origin of moss."

Sir Joseph Banks mentions a still more striking circumstance: " He says, that he found a species of " schistus in Iceland, a great part of which consists of " leaves, evidently those of the alder, interposed be- " tween the lamillæ; that they were not the mere " impression, but the *real substance* of leaves, ap- " parently half charred."

St Fond mentions, that a similar schistus, with leaves in it, in a similar state, was discovered at Roche Sauve, in the Vivarais.

I need not add that Werner mentions that trees with branches and leaves petrified were found 150 fathoms deep, and that Rozier says that coal is sometimes discovered with leaves in it;

But I cannot pass over a remark of Dr Anderson, upon this point: he makes no hesitation in deciding, " that moss is an organized body, a growing plant, " *sui generis;*" and he mentions it as one of the " great outlines of the species, that mosses which pro- " duce the best peat, seem to be of a *foliated* texture. " When these are broken, they rise in flakes, which " have much the appearance of a congeries of leaves, " or rather hops pressed close on one another.

He adds, " that this very appearance has served " to confirm some in the opinion that moss is produ-

" ced from decayed wood, as they believe these are " the leaves of the trees preserved; not adverting " to this, that, by all their hypotheses, the trees have " been felled before the moss began to be formed, " and, of course, that their leaves must have fallen " to the ground, and been totally consumed before " the moss began to grow: nor would all the " leaves produced by any wood in the course of *a* " *hundred years*, while in a growing state, though " they had been all preserved from decay during " that period, have accounted for *half the quantity* " that is found in some mosses."

I am afraid that the Doctor is inadvertent himself; not attending to this, that some, if not most of the forests alluded to, must have stood, not for one or two, but for five or ten hundred years, as I shall shew afterwards; and that the leaves of oak, fir, and birch, have been discovered, free from decay, in the deepest mosses, nay, upwards of a hundred feet below the surface of the earth, where they must have remained many hundred years, without being diminished in bulk or consumed.

But I dismiss this article, and proceed to observe,

III. In the *third place*, That every tree yields seed after its kind. The oak drops its acorns annually, as well as its leaves; the fir sheds it cones: the former are numerous; the latter are much more bulky.

During all the period of its growth, and part of the time in which a forest falls into decay, the acorns

of the oak, the cones of the fir, and the nuts of the filbert, must have annually dropt. Blended with the leaves and the ruins of many generations, they must have added to the mass of vegetable matter.

Few of these, comparatively speaking, have been discovered in mosses; but, though they have disappeared, or may still lie deep in these fens, they have not been lost. They may, indeed, have undergone a partial, perhaps in some cases a total, disorganization; yet, even in this case, the vegetable matter of which they consisted would not be dissipated in air, or evaporate entirely, but remain among the ruins, and add to the mass.

There are, however, many instances in which these have been found deep in our mosses, in an entire and organized state. I shall mention a few; the reader may recollect many more; and they ought to be recorded.

Dr Leigh, in his N. Hist. of Lancashire, mentions, that many cones of firs are dug out of the mosses of that county.

Dr Collet says the same of the Berkshire mosses.

In the fens of Lincolnshire the cones of the fir tree are sometimes found entire, No. 275. Phil. Trans.; it is added, that they are found in whole bushels.

Ramazini assures us, that in Low Modena, not only roots of trees, but nuts, ears of corn, leaves, &c. are found 30, 40, and 50 feet, below the present surface.

And Piganiol says, that, in the mosses of Holland and France, not only innumerable trees are found, but that sometimes fruit-trees are discovered with their leaves and fruits; the oak with its acorns; the hazle erect, with its leaves and nuts, entire as they grew *.

These nuts and acorns, and cones, the produce of many hundred years, must have added a vast congeries of vegetable matter, and may have contributed their part to form moss.

I may add to this,

IV. In the *fourth place*, That, when a forest is thick, innumerable small twigs rot and drop off from time to time.

It were superfluous to offer any further proof, that many of the forests that now lie in ruins under moss have been very thick set. The trunks of most of these trees are perfectly straight; they have mostly attained an immense height; their roots remain closely studded in the soil from which they sprung. All these are evidences that they must have grown closely together; indeed, it is natural to suppose that this would be the case: for, where trees drop their seeds, and these are suffered to spring up with impunity,

* Mons. De Luc, in his letter to me in January last, says, that, in the mosses in the north of the Continent of Europe, a great number of resinous trees are found, and likewise the cones of that species.

(as Du Hamel states, in the forests of Bourdeaux), they uniformly grow up in a thicket.

I may refer to the reader, or to Dr Anderson himself, whether there are not the clearest evidences that this has been the case with many of the forests found buried in moss. He acknowledges, that "in the exhausted moss of South Fanthing, the roots and stumps of many very large oak trees are found standing; some of these are six and eight feet diameter, and yet they stand so closely together, that they are not more than three or four diameters distant from each other."

Now where this is the case, as Rozier observes of the forests of France, all the lower branches and twigs rot and drop off; so that we may see eighty feet of a trunk without one twig or low branch. This, too, must take place during all the period of the growth and decay of these forests; yet none of these twigs, few even of the branches of trees, are found in moss.

Leland, in his Itinerary, takes notice of this circumstance: "Oftentymes, in digging the moss or moor of Cholmley for pettes and turves, they fynd whole trees, some short, some veri long, without twig or bow."

I appeal to the reader whether this be not the case in mosses in general. Upon a narrow inspection, he will find all the small twigs blended with the moss; some in an entire organized state; some half decay-

ed; and some where the disorganization is almost complete.

These twigs, with the branches, which are also found sometimes in the same state, must have added, in the lapse of ages, a great accession of vegetable matter*.

There is a consideration of still more importance:

V. In the *fifth place*, Every tree has its bark and rind.

Du Hamel, a distinguished writer on forest trees, points out the quantity of bark which each tree produces in proportion to its size. He says that the bark of a fir tree, though only half an inch thick when young, is often an inch and a half when old. The oak, it is well known, is equally remarkable for the thickness of its bark, especially when it advances to a great age.

De Luc observes, that in the mosses on the Continent no fir nor oak is discovered but what is stripped of its bark. This is generally the case in Britain; the only exception is that which I have already noticed, that the bark is often found entire, and adhering to the under part of the tree.

* It is certain that the branches of a tree are the first part of it that falls into decay; the trunk falls next to these; but, after both have fallen into ruin, the roots remain entire in the soil for a long period. It is not, therefore, surprising, that more trunks than branches, and more roots than trunks, are found in an organized state in moss.

This bark has disappeared; or rather it has been blended in the common ruin. By this means, it must have added an accession of vegetable matter, and contributed its part to form moss: this is not only a natural, but an inevitable conclusion, and that it has been the case, there is the clearest evidence.

I have seen many beautiful specimens of peat which proves this; especially those dug out of a moss in this neighbourhood. The lowest stratum seems to consist almost entirely of a congeries of bark kneaded together; the organic structure of it may still be distinguished; the fibrous form of the inner rind is visible, and, though it appears to be often broken and crumbled into chips of one or two inches square, yet the thickness of the bark can be ascertained. I have this moment before me a specimen six inches long, three broad, and upwards of an inch and a half thick, although the outer layer seems to be gone. I can distinctly count upwards of thirty layers remaining; it smells still somewhat like fir, and burns with a bright flame, emitting a very fragrant odour. It cracks when held to a burning candle.—This specimen was dug out of a moss which abounds in fir wood.

That the whole bark of the tree to which this belonged has been buried in the moss, and contributed to form a part of it, cannot be doubted; and that the whole bark of every tree found in moss, whether that bark still adheres to the tree, or be found detached from it in a disorganized state, adds an acces-

sion of vegetable matter, is equally obvious. That peat moss may be imitated, and artificial peat made of bark is certain. Degner mentions, that in Westphalia, Drenthea, Velavia, &c. they mix the refuse of tanner's bark with cows dung, and dry it in the sun. In form, colour, and weight, he says, they can scarcely be distinguished from real peat. They are equal in quality as a fuel to the middle species of moss he describes; their ashes are similar.

As to the quantity of bark any forest may furnish, it is all conjecture. But since Dr Anderson is pleased to state his objections to the hypothesis I have endeavoured to support, with mathematical precision, according to the strict rules of arithmetical numbers, I shall attempt to reply to him in his own style. My calculation may appear fanciful, perhaps incorrect; it cannot be more fanciful, nor perhaps more incorrect than his, as stated in page 83 of this essay.

In order to calculate the quantity of bark a forest may yield, let us take one tree for an example:

Suppose it be the oak of Hatfield, above mentioned; say it was 120 feet long, 12 feet diameter at the base, and 6 at the top: then take the mean diameter for the whole, call it 9 feet,—this makes the whole tree 27 feet circumference: multiply this by the length; this gives 3240 feet of surface;—suppose the bark to have been only an inch and a half thick, this gives 4860 feet of bark. All this is independent of the top and branches: allow only a moderate

quantity for these, and call the whole 5000 feet in round numbers.

Yet this tree, from its immense height, must have stood in a thick forest. It could not have covered a great surface: say that it occupied four falls of ground. Even upon this supposition, the quantity of bark is great for that space: every fall contains thirty-six yards, every yard contains nine feet: four falls, therefore, contain 1296 feet. Yet this tree, on a very moderate calculation, must have yielded 5000 feet of bark, which gives nearly five inches of solid bark to the whole surface it occupied: this is certainly more vegetable matter than a thousand crops of the finest wheat would yield, if suffered to decay upon the soil.

All this matter, too, it would yield at once, viz. at the period of its ruin and decay.

When this accumulation of bark is added to the mass of leaves, and fruits, and twigs and branches, we can more easily conceive how materials may be furnished for the formation of moss.

It is of importance also to attend to another circumstance:

VI. In the *sixth place*, That some trees in every forest decay through age: That it is probable whole forests may have suffered this fate; especially where a subsoil of moss had been formed around the roots of the trees during the period of their growth. Chilled by this means, and checked in their growth, not only the bark but the white-wood might crumble away be-

fore the trees were finally overset. This is no imaginary case; the Earl of Cromarty mentions an instance that came under his own eye. His Lordship observes, that, when he saw the forest (alluded to in p. 66.) in ruins, the "trees were all blasted, the "bark was all gone, the white-wood was quite *rotten.*" Whether this all dropped off and crumbled down before the trees were overset it is not said; nor is it of any importance to the argument: for this one thing is certain, that it must soon have *mouldered* after the fall of the forest, and thus mixed with the mass of ruins.

It is equally certain, that the trees found in moss are generally, if not always, stripped of this white-wood; the red only remains: or, if any of the white-wood is to be seen, it is so soft, spongy, and porous, as scarcely if at all to be distinguished from the surrounding moss.

If this be allowed, that the trees which decay through age drop their white-wood sometimes before they be overset, and that all trees found in moss are mostly divested of it, the whole of this white-wood must have contributed its part to the formation of this substance. What proportion it may have yielded it is impossible to ascertain; it may be considered as nearly equal, if not in most cases greater, than the bark.

Hitherto, we have only considered the trunks and branches, I may add,

quantity for these, and call the whole 5000 feet in round numbers.

Yet this tree, from its immense height, must have stood in a thick forest. It could not have covered a great surface: say that it occupied four falls of ground. Even upon this supposition, the quantity of bark is great for that space: every fall contains thirty-six yards, every yard contains nine feet: four falls, therefore, contain 1296 feet. Yet this tree, on a very moderate calculation, must have yielded 5000 feet of bark, which gives nearly five inches of solid bark to the whole surface it occupied: this is certainly more vegetable matter than a thousand crops of the finest wheat would yield, if suffered to decay upon the soil.

All this matter, too, it would yield at once, viz. at the period of its ruin and decay.

When this accumulation of bark is added to the mass of leaves, and fruits, and twigs and branches, we can more easily conceive how materials may be furnished for the formation of moss.

It is of importance also to attend to another circumstance:

VI. In the *sixth place*, That some trees in every forest decay through age: That it is probable whole forests may have suffered this fate; especially where a subsoil of moss had been formed around the roots of the trees during the period of their growth. Chilled by this means, and checked in their growth, not only the bark but the white-wood might crumble away be-

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Hitherto, we have only considered the trunks and branches, I may add,

VII. In the *seventh place*, That the roots are also to be taken into the account. These also have their bark and rind. For the most part, the roots of trees found in moss, are stripped of both; of course, they must have added to the mass of vegetable matter. It is impossible to calculate or conceive what that quantity may have been.

But I have endeavoured to prove, that some of the ruined forests, found in moss, have been overset by the violence of the tempest, and that others have been burnt.

If this be allowed,

VIII. It must also add greatly to the account. The violence of the tempest would not only tear off many of the branches, but the sudden and tremendous crash of one tree upon another, would mangle the whole. The high twigs and branches would thus be torn and scattered about in wild disorder.

Nor would this only take place upon the supposition, that the forest yielded to the impetuosity of the tempest: when cut with the hatchet, the effect would be the same, with this additional consideration, that the chips cut out of such immense trees before they were felled would add greatly to the mass.

Above all, if it be allowed, that some of these forests were burnt, this must have added to the account. Wood, when green and growing, though it burn with fury, is not speedily or entirely consumed; that is, it is not altogether reduced to ashes; on the

contrary, a great part of it is only charred. The quantity of charr that a forest thus partially consumed may yield, we may calculate or conceive from the following statement:

Proust says, that wood, in general, yields nearly one-fifth part of carbon; that is, nearly 20 parts in the 100. The *pine* yields precisely this quantity; a green growing *oak* yields the same proportion; some species of wood yields more.

If so, what a prodigious quantity must a single tree, such as that found in Hatfield moss, produce? Let us, for the sake of illustration, give a rough calculation of it.

Say this tree was 120 feet long; call it only six feet square in all its length, though it must have been more; every running foot, upon this loose calculation, must have yielded 36 cubic feet of wood; the whole tree, therefore, must have contained upwards of 4000 cubic feet: supposing it afforded one fifth of carbon, this single tree must have yielded upwards of 800 cubic feet; and, if it occupied only four falls of ground, as we have stated, the carbon it contained, if equally spread over that surface, would cover it nine inches deep.

That charred wood has actually contributed to the formation of some mosses seems to me incontestable. As I hinted already, p. 46. some mosses I have examined bear evident marks of this; the lowest stratum seems to consist almost entirely of chips of charred wood; the fibres of the wood are still distinct;

its original form remains; it has still the clear black glossy colour of charcoal.

The peat it yields is almost as hard and heavy as coal; it burns with a bright flame; emits a great heat, and yields a lasting fire: in some of these peats the fibrous form of the wood is lost, and they appear a solid hard jet black substance, precisely similar to pounded charcoal firmly cemented together.

If we take all these into the account, we can be at no loss to find sufficient materials for a moss of considerable depth.

Hitherto we have argued upon the supposition, that there has been only one generation of such a forest; there are, however, incontestible evidences that some mosses contain,

IX. The remains of *two, and even three generations*, each rising in succession upon the ruins of the other.

De Luc mentions several instances on the Continent, where this appears to have been the case: In Kedinger moor, he says, there are still a few trees, the fragments of the former forest. Though the moss be three feet deep, it still bears stately oaks; their roots strike through the moss, reach the subsoil, and receive their nourishment from it: these trees, he adds, must at least be the *second or third generation of that forest.*

He likewise mentions many instances where a new generation springs up on the ruins of the old; and he observes, that "when he saw the roots and ruins

" of the old trees sheltering the young, it brought " him in mind of a number of children around their " grandmother." He adds, " the seeds of former " generations had taken root among the rubbish, and " sprung up to supply their place."

Dr Walker makes a similar remark on the moss of Strathcluony: He says, " That it has formerly " been a very thick extensive fir wood: That the trees " found in it have been deposited at different periods: " That large roots of fir trees which had evidently been " broken down by the winds, are found in it: That " some of these roots, with part of the trunk in their " natural position, were found at the bottom of the " moss, fixed in the gravelly loam from which they " had sprung: That above these was a stratum of " peat, three feet thick, evidently formed during the " growth and decay of these trees: in the same " place, the old roots of other fir trees were discover- " ed, two or three feet *immediately above* the former, " with their fangs spread horizontally, having three " or four feet of moss *above them.* It was clear " that these roots belonged to trees of *another* genera- " tion, and of a date much *posterior* to the former; " for they had only begun to grow after the trees rot- " ted in the loam had decayed, and after three feet of " moss had been formed by their growth and decay." Again, he adds, " Over these last roots, situated " three or four feet deep in the moss, an aged fir " was growing on the surface:—there were here *three* " generations, or, as it were, three tier of trees visibly " placed above one another."

He concludes, " This renders it probable, that " many of our deepest mosses have been formed by " two, three, or more generations of trees, which have " grown successively above one another, at different " and distant periods."

To sum up the whole account, let us suppose that these forests that lie in ruins in our mosses had each existed only 500 years before they were finally overset; that the whole leaves they had dropped in succession for so many ages, were tossed by the winds or washed down by the waters into the low levels; that the acorns and cones, &c. the bark and rind, the twigs and boughs; the whole wood, and roots, and trunks were all accumulated in one rugged, ruinous, and unseemly group; What an immense congeries of vegetable matter must thus be deposited by this simple and certain process of nature! To make the calculation complete, let us suppose that some of these mosses are the ruins of two, three, or more generations: on this supposition, more vegetable matter must be formed than many hundred thousand crops of the finest wheat on the most fertile soil.

Thus nature provides materials for the formation of moss; materials sufficient in quantity; materials, too, which do not speedily decay; materials which are not soon diminished in bulk; and materials which must of necessity have existed wherever any forest falls into ruins.

1. That the quantity of materials is sufficient will appear even from Dr Anderson's concession: for if a forest, when it falls into ruins, may yield sufficient matter for three feet of moss, we may safely allow that it would furnish three feet more, during the period of its growth, by its leaves and twigs, &c.; and if we suppose two or three generations to have succeeded each other, the account must be doubled or tripled.

2. That these materials do not (as the Doctor supposes every vegetable does) rapidly tend to decay, can be clearly proved. Leaves have been found 30, 40, nay 50 feet deep in moss, which had not undergone the smallest disorganization. Barks have been found equally entire. Birch bark of all substances seems to be least liable to decay; it is almost incorruptible. Pliny mentions, that the volumes that were buried along with Nerva were wrote on this: that though they had lain in the grave 400 years, they were perfectly entire. And Joseph Correa mentions, that the bark found in Lincoln fens, though it had probably lain five times that period, was perfectly fresh, especially that of the branches: that the silvery skin, or outer membrane, is discernible.

Even when exposed to the air, as well as buried deep in the earth, it is not liable to rapid decay.

Maupertius says, that among the numerous trees which lay on the ground in Lapland, destroyed through age, or blown down by the winds, many birch trees appeared whole, owing to the undecayed

state of the bark; but they crumbled into powder when trod upon: That the Swedes take the hint from this, and cover their houses with this *unperishable bark.*

Nay, even after the wood is not only decayed, but mineralized, the bark of trees has been found entire in an organized state. Mr Took mentions instances of this in Russian Lapland. In the martial springs of Ussona, &c. are discovered vast quantities of stems, branches, twigs, and leaves of birch trees, mineralized by iron; the texture of the wood is still visible; the tender white rind is preserved entire in its natural appearance.

In the copper mines of the Riphean mountains, similar instances are mentioned by Abbe Chappe. In these, and likewise in the Souxson mines, he says that pieces of wood are often found mineralized by copper; the internal part is almost reduced to charcoal; the copper is sometimes chrystallized in cells; the *bark* is still distinguishable; it is about four lines in thickness.

3. That these materials are not soon diminished in bulk, so as not to occupy one hundredth part of the space they did, as the Doctor supposes, is clear to demonstration. The leaves, and bark, and cones, and nuts, &c. of the trees found in moss, occupy nearly the same space as when they dropped from the parent tree.

Of this no proof is necessary: every one who has paid the least attention to the subject must be convinced of it.

The conclusion of the whole is, that the ruined forests of the north of Europe have laid the *foundation* of many of our mosses; I say only the *foundation;* on that foundation nature builds her work.

To point out the materials and progress of that work, by means of aquatic plants, &c. shall be the subject of my Second Essay.

The subject is difficult and intricate, but it is interesting and important;—it far exceeds my feeble powers. The short line of the human intellect never can fathom the depths of Infinite Wisdom displayed in his works; yet every physical fact we discover, throws a ray of light on the darkest and deepest subject, and elevates the soul with pure and solid satisfaction.

ESSAY II.

ON AQUATIC PLANTS.

if we fix our attention to any moss, we must take it as it now exists. In this case, we may, perhaps, discover what are the plants that now contribute to its increase; but it does not follow that the same plants contributed to its original formation, or subsequent growth, in every period of it.

Direct information on the subject cannot be expected; and I do not pledge myself to furnish it. Yet the task is not hopeless, nor do I think it by any means impossible, to ascertain what are the plants which first laid the foundation of moss, and furnished materials for its subsequent increase:

For, if moss be renovated when dug; if we can by any means ascertain what is requisite for this purpose; especially, if we can point out the period of time necessary; and, above all, the precise plants which have furnished the materials for this renovation; it is not an unfair or unphilosophical conclusion, that the same plants may have contributed to its original formation.

More especially, if it can be proved that the same aquatic plants still flourish in lakes and marshy grounds; that some lakes and marshes have by these been converted into mosses within the memory of man, or since a precise period: Above all, if it can be shewn that these very plants can be traced in moss, through all its depth, the above conclusion must, in that case, be corroborated; and we may thus form a distinct idea of the aquatic plants that have given origin to moss; of the period requisite for its formation;

and account for all the various appearances it assumes.

With this view I shall, in this essay, shew,

I. That many mosses, when dug, are renovated; and then point out,

II. What is requisite to this renovation. I shall,

III. State some facts to ascertain the time required for this purpose:

IV. Point out the aquatic plants which furnish the materials:

V. Shew that the same aquatic plants still flourish in lakes and marshes:

VI. Prove that many lakes and marshes have been converted into mosses by the growth and decay of these plants:

VII. That these plants may be traced still in an organised state in moss, through all its depth. I shall then endeavour,

VIII. To ascertain the distinguishing qualities of these plants.

IX. I shall attempt, on this hypothesis, to account for the various appearances moss assumes; for the vast depth to which it sometimes reaches; and the different situations in which it is found.

Lastly, I shall state some general conclusions.

The above is the plan of this essay. I allow that it is a circuitous way of ascertaining the point at issue; it appears to me, however, to be the only certain method, therefore I have adopted it.

SECTION I.

That Moss, when dug, is Renovated.

THIS is a point of the greatest importance: I shall, therefore, endeavour to establish it upon the testimony of those who have had the most extensive means of information.

Some ingenious men have denied that moss is ever renovated when dug. Lentilius and Commelinus are decidedly of this opinion. Girard, in his account of the valley of the Somme, also denies that there is any renovation of moss in that district: He says, that the pits dug on the banks of that river are converted into lakes; that they are not again filled up with moss.

General de Jean is of a different opinion: He says that, upon examination, he found that these pits in that district are filled with aquatic plants, which, in course of time, are converted into moss.

Ribaucourt is decidedly of the same opinion: He says, that, in favourable circumstances, new moss is formed, and fills up the place of the old which has been dug.

Mr Headrick, in his account of Swinridge moor, says, that the old peat pits there are filled up to the

surface with new formed moss; but that this is more soft and spongy than the old.

The Earl of Cromarty in his paper, to which I have already referred, plainly asserts, that moss is renewed after being dug. His words are,

" In wasted moss pits, where water hinders to " cut the earth to the bottom, these pits are filled " again, in a good number of years, with new spongy " earth, which, in progress of time, will come to " the consistency of peat moss as at first; and a " scurfy heath turf will grow on the top of it." This is not a mere conjecture of that Noble Earl; his assertion is founded on experience; he says he was an eye-witness of the fact.

Dr King, in his account of the Irish bogs, asserts the same thing. He says, " that the turf holes, " and little gutters dug in them, are again filled " with new formed moss."

Degner describes the Dutch mosses with minuteness: he gives it as his decided opinion, that they are often renovated when dug. He says that the pits and ditches are filled with aquatic plants; that these are converted into turf: that this new formed turf, though not so solid, compact, or heavy as the old, is equally inflammable, and, if allowed to ripen, that they are equal to the best. He adds, that this is not a mere conjecture; that he has seen it, especially in the neighbourhood of Craneburg. He says, that the mosses in that district are intersected with many ditches to drain them. In these ditches a vast

quantity of aquatic plants speedily rush up; these are converted into moss: the turf dug out of them is soft and spongy, but inflammable. When dried, these turf are sold to sailors; by them they are used for stopping leakes in their vessels.

As Mons. De Luc has had more opportunities of surveying the mosses of Europe than most men, I used the freedom to write him in January 1806. I requested information upon this and many other points. To this letter I received an immediate reply: With the greatest frankness he furnished me with ample information. I wrote him again, requesting his permission to publish his letters: to this request he readily yielded.

I shall avail myself of this advantage; but I rejoice to add, that *though this venerable philosopher be entered into his 80th year, he is preparing for the press an extensive and important work upon the subject of geology, from which I expect more ample information.*

In his first letter he says, he never saw more "peat moors than in summer 1804, when travel-"ling through Brandebourg, Mecklenbourg, Hol-"stein, and Shleswig, or with more peculiar circum-"stances." He says, "that three distinct kinds "of peat grounds may distinguished." His words are:

"The first of these kinds is very common over "all the north parts of the Continent of Europe. "The peat lies on horizontal parts of sandy hills,

" a little lower than the general surface; these levels " are covered with heath; the peat is commonly very " shallow; the surface is very rough, giving me an " idea of those lands in Ireland, where are bog-trot- " ters; it rises like mole-hills; the intervals between " these are a boggy soil of soft peat. I think, how- " ever, that the peat would thicken on these soils, " were it not the source of fuel for the inhabitants, " and constantly disturbed.

" This kind of peat grounds cannot answer my " main purpose, that of finding natural chronome- " ters, as they are constantly acted upon by men; " but if long and attentively studied by natural phi- " losophers upon the spot, they would be useful in " determining the cause of peatification (if I may be " allowed to coin that word.) This shallow peat is " a sort of incrustation on the sand. When the for- " mer is removed the latter is laid open; but *in time* " *this sand is again covered with peat.* If the pro- " gress of its renovation were studied, and experi- " ments made, these might tend to ascertain the " causes of this renovation."

" If this kind of peat ground lie on a much lower " level than the surrounding hills, it is sometimes " covered with thickets of trees; such as the *alnus*, " which is fond of moisture. These levels are im- " passable in wet weather; the peat is as soft as mud " between the stems, or rather pedestals of the trees: " It is not very deep, so that in summer, when plants " grow over it, one may go in to cut the wood."

The second kind of peat grounds he thus describes: "They lie on a lower level, not much above the "rivers, and are traversed by rivulets. I have "seen a vast extent of these in Brandebourg and "Brunswic. *When peat is dug from these, it is "renovated and grows up again.* These grounds "form horizontal meadows, on a sandy base; some "parts of them afford pasture in summer; in winter "they are too deep under water for this purpose: "other parts, not so deeply overflowed, with some "dressing, become good hay fields, and yield excel-"lent pasture in autumn.

"A third kind of peat ground particularly attract-"ed my attention in the survey of these countries. It "is connected with lakes, which appear innumerable "among the sandy hills, and of all sizes: these "form commonly a part of all the dales." The manner and rapidity with which moss is renovated and formed in these mosses, and by which these lakes are filled up, I shall state afterwards.

Suffice it to say, that, from a very careful and very extensive survey of all these kinds of peat grounds, he gives it as his decided opinion, that there is, in *all* of them, a renovation of the moss when dug.

From the above testimonies it appears certain, that moss grows up again, and is renovated in favourable circumstances. Every attentive observer must have seen instances of this, especially in low level *ket-moss*, as it is called, in this country; and

I cannot but solicit the attention of the public to this point. In order to assist their researches, I beg leave to mention a few circumstances, which will enable them to ascertain the fact.

1. The new formed moss in these old pits can easily be distinguished. It is always more soft, spongy, and porous than the old. The organization of the plants is obvious in the former; in the latter the organization is almost entirely gone, especially in the lower strata.

2. The new formed moss never adheres to the old. Picard takes particular notice of this: He says, "That when new moss is formed in the pits, it never "adheres to the old; that it can thus be easily dis-"tinguished, even at the greatest depth."

Mr Headrick makes a similar remark of Swinridge moor: He says, that the sides of the pit are still perpendicular and entire; that the old and new moss seem never to have coalesced. And he farther observes, that this new formed moss could not be occasioned by any earth or dust or moss blown into these pits; that it must be owing to the growth of the moss; for the surrounding surface is all covered with heath and herbage.

3. The marks of the spade may be seen in the old pits. Degner takes notice of this circumstance: He says, "that he was informed by workmen of credit, "that this is often the case at the depth of six and "seven feet in these pits:" He adds, "that they "shewed these marks to himself. That this was a

"clear proof, that moss had been dug by former "generations, on that very spot; and that the moss "they were then digging, was new formed since that "period."

4. Upon examining these pits, too, other circumstances may lead to this conclusion; sometimes utensils, &c. are found in them, which clearly ascertain the fact. I have in my eye an instance of this which occurred in the parish of Denny: four feet below the surface of a moss, the marks of an old pit were discovered; in the bottom of it some sheaves of flax were found; this flax was still entire, though brittle; when exposed to the air, it, however, speedily crumbled down.

It appears to me unquestionable, that this pit had been used for watering the flax; and it seems equally certain, that the four feet of moss above these sheaves had been new formed after that period.

I need not say, that utensils found in such circumstances are evidences of the same.

No doubt can be entertained upon this point; moss is certainly renovated in favourable circumstances; but, as Degner observes, this renovation is not always observed; and he assigns the following reasons of this: That in Holland, the ground from whence the turf is dug, is frequently cultivated; that moss is so valuable as a fuel, that it is greedily dug without allowing time for its renovation; that in some situations this renovation is slow in its progress, though in others very rapid: I may add to this, that it appears cer-

tain, that in some cases, too, there is no renovation at all.

There are certain requisites, without which it cannot take place, or may be greatly retarded *.

To point out these shall now be my object.

SECTION II.

What is requisite to the Renovation of Moss.

It appears, from undoubted evidence, that when the pits dug in moss are drained of water, and left dry, or when these pits are large or very deep, or when a current of water is permitted to pass through them, in all of these cases, there is little or no renovation of moss; that in order to expedite this process, it is requisite that the pits be left full of water; that

* It is generally allowed, that coal is likewise renovated when dug. Buffon in his Mineralogy, says, that he has seen this new formed coal. Mr Gennett says, that in the Liege mines this is the case: a bitumen impregnated with carbon, is said to transcide the veins which forms coal; and in 40 years these mines are filled up with this.

these pits be small, and not very deep; and, that the water in them be stagnant.

1. In the *first place*, It is requisite that the pits be left full of water: Dr Anderson himself, though he seems to doubt of the renovation of moss at all, and though he never saw an instance of it in Aberdeenshire, in the experience of 30 years, acknowledges, that this is the general opinion of the inhabitants of that county. His words are, "I acknowledge, that "where the Aberdeenshire mosses are wrought in a "foret, *i. e.* where the moss left is laid dry, they are "never supposed to grow; it is only when they are "pitted." This remark is founded on experience.

The Earl of Cromarty makes the same distinction: His words are pointed; "I have observed, that when "they dig the peats to the channel, or in places "where the waters run off and do not stagnate, the "mosses did not grow nor revive there again. This "moved me to order my tenants not to cut the moss "to the channel, nor in very large openings, but in "small pits, that they might grow more hastily." He adds, "The event answered my expectation." How plausible is his Lordship's account of the matter? How like the language of unadorned truth? How consistent with the experience of every candid, careful observer; and the general opinion of those who have examined the subject with precision?

I may add, that it is equally consistent with analogy; for if moss be renovated by the growth of

aquatic plants, as I shall endeavour to prove, it is impossible that this renovation can take place when the pits are left dry, and no aquatics can grow.

2. *Secondly*, His Lordship takes notice, that in small pits this process is more rapid than in very large openings. This remark tallies with the testimony of every other writer upon the subject.

Mr De Luc states this distinction from the experience of Mr Findorf: his authority is high; his opportunities of information were extensive; he was Commissary-General of Duvels moor for many years; and a curious enquirer into the natural history of peat moss. He says, that small pits are prefered to large ones; and he assigns the reasons of this: "They "prefer small pits, not so much for the sake of re- "novating the moss carried off; this is an object of "no importance to them, as it abounds so much in "these regions, it is more for the sake of their cattle; "for when the pits are small, they are *soon* filled "up, whereas large pits would require an age for "this purpose."

Degner makes a similar remark of the Dutch mosses: He says, that when a large pit is dug, and a large sheet of water is left exposed to the agitation of the winds, the vegetation of aquatic plants is retarded, of course, the renovation of the moss is checked; whereas, in small pits aquatics rush up with rapidity, and the renovation of the moss is proportionally rapid.

Poiret makes a similar remark; and he assigns a similar reason for it.

It may not be improper to add, that I have examined many mosses in this neighbourhood: the inhabitants all agree in affirming, that the moss pits of the above description are filled again with peat; and many assert, that they have dug new peat out of these old pits.

3. *Thirdly*, When these pits or pools are very deep, the renovation of moss is less rapid. In order to expedite the process, it is requisite that they be shallow. Poiret assigns the following reasons for this: That a greater variety of aquatic plants grow in shallow than in deep waters; in the latter, only those can flourish which float on the water, and require no soil to fix upon; in the former, both those which float on the water, and those which fix in the firm soil of the bottom, spring up and flourish, and thus promote the renovation of moss with more rapidity.

4. *Fourthly*, It is requisite that the waters in these pits be stagnant. If, on the contrary, there be a current in them, aquatic plants grow with less rapidity, or, though they grow, they are not converted into moss. They grow with less rapidity; for the seeds of these plants are floated down the stream: They do not, therefore, fix so readily, nor flourish so well, as in stagnant water. They are not converted into moss; for, as I shall shew hereafter, the current robs the water of those very qualities that are requi-

site to the formation of moss from aquatic or ligneous plants.

General de Jean observes, that, in stagnant pools, the progress of the formation of moss is perceptible to the eye: "That in some there is only a kind of "net-work begun on the verge; that others are half "covered over with it; while some are wholly filled, to the depth of two or three feet; that, after "a certain progress, these plants reach the solid base "at the bottom of the lake; that other plants rise "upon the surface; that these, by being exposed "to the influence of the sun and air, are dissolved "and reduced to common mold, forming a slight "soil over the moss; that this soil yearly increases "till the aquatic plants disappear; that meadow "grasses rise up and occupy their place; that these "meadows are at last consolidated; and, that the "plough can thus pass over this solid soil, where, "thirty years before, sheep could not pasture. This "progress, he says, is so obvious, that it cannot be "doubted."

He adds, that, under the soil, moss is still forming; and, he says, that the STILLNESS of the waters in these lakes, and the equable temperature, is peculiarly favourable to the growth of aquatic plants, as the calmness and equable temperature of the sea in polar regions is favourable for fishes.

Accordingly, Poiret observes, that when all the above circumstances combine, that is, when the pits are not drained of water, or too extensive in their

surface, or too deep, and especially where there is no current, that, in such favourable circumstances, the formation and renovation of moss is very rapid; that fish-ponds would soon be filled up by it, and canals would soon cease to be navigable; that they would all speedily be converted into mosses. He adds, that the Dutch are completely aware of this, but that their indefatigable industry in using every precaution prevents it. With this view, they either endeavour to give an occasional current to their canals, by the influx of the adjacent rivers, when they are swelled above the level of the sea at low tides, or carefully clear these canals of moss. He says, that without these precautions, compact moss would soon occupy their place.

From the above statement, it would appear, that there is no room for disputation upon this subject. One may assert that moss is renovated; another may deny it: Each may be right or wrong, according to the particular spots he had examined.

All depends upon circumstances: In some situations, moss may be, and certainly is renovated with great rapidity; in others this renovation cannot take place, or it may be so slow as not to be perceptible in an age.

Hitherto we have only endeavoured to ascertain the fact, that moss is renovated, and to shew what are the circumstances requisite to expedite this process.

It would be very satisfactory if we could form any conjecture as to the rapidity with which this process

is carried on, and the time requisite to accomplish it. I say, conjecture, for it is the utmost we can expect on this subject. Yet there are a variety of facts that render it probable that it does not require a long period.

These I shall state, in

SECTION III.

Time requisite for the Renovation of Moss.

Third place, Degner says, he was informed by the old inhabitants of credit, that ditches not too wide nor deep were filled anew with excellent turf, in 70, 80, or 100 years; but that this operation was much more rapid in a slimy than in a sandy soil.

He mentions, too, that it is a well known fact that a ditch 10 feet wide by 7 feet deep, is often so filled with aquatic plants, in 10, 20, or 30 years, that men and cattle may safely pass over it. He says, that though the bottom be loose and liquid, it is solid on the surface, and that in an age or two the whole would be ripened into turf.

Mr de Luc has been at great pains to ascertain the period requisite to the renovation of moss. He has stated a variety of facts with this view. He mentions, "That Mr Findorf assured him, that the pits "dug in Duvel's moor were in a few years filled up "with aquatic plants: That, in *thirty years* these "were converted into a firm, spongy substance. "That the solid surface of this, at the end of that "period, nourishes heath and other ligneous plants "that grow on the adjacent moor."

His observations were founded upon experience, and the accuracy of them is thus attested by De Luc, in the following words:

"*I saw* these pits in all their different stages: being "booted, I sounded some of them with a pole to "know *their age*; I then boldly stepped into the "floating bed, which *sunk under* me; by this means "I was half leg under water. The surface sunk and "rose according to the pressure; but with my pole "I easily felt the bottom, while the surface support-"ed me from sinking.

"Mr Findorf shewed me other pits where this "matted substance had reached the bottom; and "others so compact *that I walked* on them with as "much ease and safety as on the rest of the moor.

He further adds, "That the surface of these pits is "covered with all kinds of ligneous and aquatic "plants, that delight in such a soil; that these alter-"nately overtop one another; that the ligneous "plants make the greatest progress in a DRY SUM-

" MER, so that the surface seems to be *entirely* co-
" vered with THEM: That the reverse is the case in
" a RAINY SUMMER: That the aquatic plants over-
" top the ligneous and choke them, insomuch, that
" the whole surface seems to be entirely covered with
" a matting of aquatics, which, by decaying, form a
" soil for the ensuing season: That, if it continue
" rainy for a succession of years, these aquatic plants
" continue to prevail till a dry season ensue."

He adds, "This is so certain, that in the succes-
" sion of beds, or strata of the moss, these different
" species of plants are distinguishable. These strata
" are either composed of the roots and fibres of lig-
" neous plants, or of the remains of aquatic; so that,
" upon examining some of the cuts of the deepest
" canals, he saw *distinctly* the produce of the several
" years." He says "he could even distinguish by
" this means, the different produce of a *wet* and *dry*
" *season*, from the residuum each had left, as well as
" the gradual formation of moss, in all its progress,
" from the white, soft, and spongy, to the brown,
" hard, and black."

The general conclusion he draws seems to me natural and well founded. It is, indeed, contrary to the general AXIOM which Dr Anderson lays down, viz. that the produce of moss is small, and its progress in forming very slow. "The formation of
" peat moss," says De Luc, "*is thus obvious.*
" *The rapidity of its increase and renovation is*
" *equally so.*" With his usual accuracy he adds;

" one inch at the base is perhaps equal to the ma-
" terials of two feet at the surface; yet, even
" upon this allowance, the growth of moss, thirty
" feet deep, does not lead us back to *a remote*
" *æra.*"

I was so much struck with the above account, that I wrote the author of it again in January 1806. I requested him to furnish me with any farther information he could on this subject; and, if possible, to fix some *data* by which I could ascertain more accurately the period requisite to the renovation of moss. To this he gave an immediate reply; and in this his second letter he states the following particulars on this point in these words: " You ask me what time
" is requisite for the renovation of peat in the second
" kind of mosses I have described in my former let-
" ter? I cannot answer that question with certain-
" ty; but as I know such a ground near Brunswic,
" and as I am soon to write to a friend of mine there,
" I will beg of him to procure every information on
" this point, and communicate it to you.

" Yet I know that when peat is dug out of small
" pits, these are soon filled with good peat. There
" the conferva, the very first summer, fills the water
" with its green clouds; the sphagna thicken the
" bed it forms; and the growth of other aquatic
" plants is very rapid; so that, in the course of 30
" years, good peat may be again cut out of the same
" pits." He adds,

" The way in which I have seen peat cut in the " second kind of moss I have described in Brande- " bourg and Brunswic is this: A long ditch is cut " down to the sand, four, five, or six feet deep, in " the direction of the course of the water to some " rivulet. There the section of the whole moss is " seen on the side where this operation goes on. " They begin by cutting the turf on the surface to " a certain breadth, throwing it to the opposite side " of the ditch. Then about three or four feet of " good peat is cut, in the usual form of bricks, and " piled up to dry:—this is the work of summer. In " autumn this ditch begins to fill up with water, and " the peat is too soft to be cut. The next summer " another such slip is cut in the same manner, and " this process goes on yearly on the same side of the " moss. Meanwhile the peat grows again; so that, " at a certain distance of time, these pits are repaired " to their original level. There are many such " trenches in meadows of great extent which belong " to different parishes. These trenches are at that " distance from each other, that when the cutting is " arrived at the limit on one side, the work may be " begun again on the new formed moss on the other, " in the same manner as the regular cutting of trees " is carried on in a forest."

It has been stated already, that in some situations the renovation of moss is more rapid than in others. In the vicinity of Craneberg, this process seems to be uncommonly rapid. Degner, as I have shewn,

states that the mosses there are intersected with many ditches on purpose to drain them. In these a vast variety of aquatic mosses rush up; and though these ditches are cleared, in a few *weeks* they are filled again; so that they require to be cleared *often every summer*. This, he says, is not so requisite in winter. Yet if the weather be mild it is necessary, as they grow even then; and unless thus cleared, they are consolidated into turf.

I only add, that the Earl of Cromarty states, that some mosses grow up in a shorter time than others. This assertion is founded on his own experience; he was an eye witness of the fact. His words are:

"I have observed that pits which have been dug "since I *remember*, have grown up again with new "peats; and that, too, sometimes *oftener than once* "in the same pits."

That peat moss is renovated to a considerable depth seems therefore unquestionable: that this process does not require a long period, but is sometimes accomplished in an age or less, seems equally probable: that it has taken place in many moss pits in this parish, I am fully convinced:—But my attestation is utterly superfluous, after stating such a variety of well-attested facts.

It would, however, be highly satisfactory, and tend greatly to the elucidation of this subject, if we could ascertain precisely the species of aquatic plants which tend to expedite this process.

This is the subject of

SECTION IV.

Mons. De Luc has paid particular attention to this subject: he gives the following account of it, founded on the experience of Mr Findorf. In speaking of the renovation of the mosses of Bremen, he says, that

"It is customary to dig pits in these mosses. "These are about twenty feet long by six feet wide. "This shape and size is preferred, in order that they "may be able to throw out the water with a bucket "when they cut the pit. When these pits are form-"ed they are left, and allowed to fill up with water."

The manner in which moss is formed again in these pits, he thus describes:

"The *first* year they are filled with a mucous sub-"stance that swims on the water like a green cloud.

"The *second* year this substance is composed of "*fine threads*, knit together, and garnished with "very small leaves, and flowers, and seeds; so that "the water is filled with these nearly *two feet* deep."

"The *third* year this is covered with *(mousse a* "*long panaches)* mosses with creeping roots and

" leaves and branches. These cover the water en-
" tirely, arrest the dust, and all the seeds which float
" in the air. Thus it becomes a fit soil for aquatic
" plants, as rushes, reeds, grasses, &c. &c. which
" grow with great luxuriance.

" The fourth year these plants are so high and
" thick set, that they change the surface on which
" they grew, and sink with it in the water; yet the
" mosses reach again, and cover the surface, receive
" new seeds, and produce a new race of aquatic
" plants. These sink the surface or sward lower
" and lower, which, being always garnished anew
" with mosses within and without, at last reach the
" bottom of the water in a few years. The plants
" at the bottom then decay and die; compressed by
" the incumbent weight, they become somewhat con-
" solidated. Those on the surface also decay and
" drop in their turn. Descending by little and little,
" they at last occupy the place of the water, and fill
" up the whole pit; so that, in 30 years, its surface
" is so solid as to nourish heath and other ligneous
" plants that grow on the adjacent moor."

From the above account, we may learn, what are the precise plants which promote the renovation of moss. The mucous matter which appears the first year like a green cloud, no doubt consists chiefly of the conferva: To ascertain this, I applied to Mr De Luc himself. In his second letter, already alluded to, he says, that

" The green cloudy matter, I mentioned, is cer-
" tainly the conferva, a vegetable, the fructification of
" which has been discovered by microscopic observa-
" tions of one of my countrymen."

The growth of the second year may also be ascertained; the fine threads that knit together the mass, is most probably a collection of those aquatics whose roots and leaves are of a capillary form; such as the byssus or chara, vulgarly called horse-tail, equisetum, &c. The small leaves and flowers and seeds which cover the surface, are most probably the lemna or duck-weed. This certainly grows on the surface of water, in ponds, and frequently covers it all over; its roots are of a capillary form; and it is very rapid in its growth *.

The mousse a long panaches which he describes is no doubt the sphagnum. This Mr De Luc asserts, in his second letter to me, in these words:

* The lemna is very frequently found in the moss pits in this neighbourhood. I examined one which had been dug only a few months before; the surface of the water was nearly covered with the beautiful verdure of the small green leaves of this plant. Upon stirring the pond, I found that the roots reached upwards of six inches deep; all that space was, of course, filled with the fine delicate net-work, which the capillary roots of the plant had formed. I plucked up a part of these plants; I have kept them in water ever since, in a small glass bottle; they have flourished amazingly, and grown with rapidity; the whole water is now filled with them; and the interstices between the roots, are filled almost entirely with the conferva.

" The conferva begins to be the bed of the sphagna, " and thus contributes much to the preparation of " the mass of vegetables, which are turned into peat. " It fills the water with its green clouds the first sum- " mer; the sphagna thicken the bed; the growth of " other aquatic plants is very rapid."

From the above facts, it would appear, that the following aquatic plants furnish the materials for the renovation of moss in these pits:

The conferva, lemna, byssus, &c.

The sphagna, and other mosses.

The varieties of aquatic grasses, rushes, and reeds, &c.

Having endeavoured to establish the fact, that moss is renovated when dug, and to ascertain and point out a few of the aquatic plants which furnish the materials, I now proceed to shew,

SECTION V.

In the fifth place, *That the same species of plants have contributed, and still contribute to the original formation of many mosses:* this conclusion is natural and obvious.

On this important subject, I cannot but communicate the information I obtained from Mr De Luc, in his letter January 1806: He points out the plants that contribute to the formation of moss, and the process by which that is accomplished, in the following manner:

"*A third* kind of peat ground has attracted my "attention in the survey I took of Brandebourg, "Brunswic, and Shleswig: It is connected with "lakes.

"The bottom of every dale is a meadow, on a sub-"soil of peat; this, by gradually advancing into, con-"tracts the original extent of the lakes; and, it is "well known in that country, that many large lakes "have been converted into smaller ones, by the peat "advancing from the original shores, and many "places now meadows, and only traversed by a "stream, had still a lake in the middle of them, in "the memory of old people."

The manner and means by which this change is effected, he minutely describes in the following words:

"I have said that the peat gradually extends for-"ward in these lakes, contracting their surface. This "is occasioned by the following causes. The sandy "sediment carried into these lakes by streams, gra-"dually raises the bottom of them: The consequence "of this shallowness is the growth of common reeds; "these are like the van in the progress; these ad-"vance forward as the bottom of the lake is raised. "No peat appears among the reeds, nor even among

" the small aquatic plants which form a zone behind " them.

" 2. Behind the zone of reeds, another rises up: " It is distinct from the former; and it is composed " of different aquatic plants, which rise much less " above the surface of the water.

" This zone, which has a greater breadth in pro- " portion as the declivity of the bottom is small, " is not so thick as to prevent small boats passing " through it. These bend the plants in the water, " which is still clear; and these plants form, like the " twigs of basket-work, for the future peat. They " differ in their aggregates in different lakes, when " distant from each other. To enumerate the parti- " cular species of which they consist is difficult; I " shall only specify those which are found in the " lakes round Rostock, as delineated to me by Pro- " fessor Linek, of the University of Mecklenburgh " Strelitz; they are as follows: scirpus maritimus, " scirpus cæspitosus, scirpus pauciflorus, equisetum " palustre, equisetum fluviatile, eriophorum polysta- " chion, eriophorum vaginatum; the last of which " retains its form and appearance longest in the re- " mote peat *.

* This plant exhibits a very singular appearance in some mosses in this neighbourhood. It may be traced, in an organized state, to the depth of four feet. The roots and stems of it form a mass so hard, tough, and tenacious, that few edge-tools can pierce it. The interstices of the moss, which are formed of other plants, are soft and porous. When peat is cut out of

" 3. Behind this zone, the conferva begins to em-
" brace those plants with its green clouds; this forms
" the bed in which the different species of aquatic
" sphagna grow; these thicken the matting, and fa-
" vour the growth of common moss plants, on the
" more compact surface; there the little boats are
" stopped; the lake is no farther navigable; but the
" surface is still yielding, and will not support any
" great weight.

" 4. Behind this, another zone appears; it con-
" sists of the same kind of plants; but these are so
" interwoven, that the surface is more compact and
" bears more weight, though very elastic. On this
" zone some grasses appear. I have sometimes been
" drawn unexpectedly on this zone: At one time,
" being inattentive to the direction I had followed, I
" missed my way in retiring; by this means I was
" obliged to walk there a long time, half leg up, in
" water, before I could find a more solid ground:
" The surface that supported me was like a mattress;
" the water that rose was still clear.

" 5. Proceeding backward from this zone, the sur-
" face becomes more and more compact; many kinds
" of land plants begin to grow over it, especially
" where that surface, by being raised, is dry in sum-
" mer. There the tedum palustre, vaccinium occy-
" coccon, comerum palustre, erica tetralix, and va-

these, it can be easily torn asunder; that which is composed of the eriophorum, on the contrary, can scarcely be separated.

« rious kinds of grasses grow. Thus begins a zone « on which cattle may pasture in summer. There, « also, peat is formed, as may be seen by the colour « of the water; tinged into dark brown, it assumes « the colour of moss water.

« 6. From the beginning of this useful zone, still « backward, the ground becomes more and more « solid; hay may be made on it in summer, and it « yields a good pasture in autumm: Yet, even in « these grounds, there are dangerous places, on ac- « count of the small streams that pervade them.

« These can only be discerned by the different ap- « pearances of the grass that grows in them, known « only to the people of that country. There are fre- « quented paths which must be carefully kept. In « the line of these, plants are laid over these hidden « streams, which serve the purpose of bridges. In « going across these grounds at random, one may « sink suddenly very deep in peat-mud there accu- « mulated.

« This happened once to me, quite unawares; « luckily I could throw myself back on a more solid « path, and thus crawling out, I was quit for being « covered with peat-mud.

« This is the last zone that can be distinguished by « a decided difference in the progress.

« I have said before, that the succession of these « different zones, from the border of the water « towards the original border of sand, represents the « succession of changes that have taken place through

" time in each of the anterior zones, so that, in pro-
" portion as the reeds advance, new zones are form-
" ing behind the advancing reeds, on the same places
" which they thus abandon. That process is more
" rapid in lakes which are originally shallower, and
" slower in deep lakes. It seems even to be stopped
" in some parts where the reeds, which cannot ad-
" vance beyond a certain depth, approach the brow
" of a great declivity under water; there, the pro-
" gress, if continued, is not perceptible: But in
" lakes originally not very deep, and in which the
" sandy sediments are advancing all around, the reeds,
" forming a ring, gradually contracting its circum-
" ference, meet in the centre; and at last these reeds
" themselves vanish, so that, instead of a lake, a mea-
" dow occupies its place. In some of these meadows
" attempts have been made, either for ornament or
" use, to keep up a piece of water; but the attempt
" is vain, excepting at a great expence: for luxuri-
" ant aquatic plants soon occupy that space, and the
" peat, advancing rapidly, restores the meadow.

" Such is the process observed in almost all the
" dales, in *an immense extent of country*, by which
" *lakes and pools* are converted into meadows and
" mosses."

Mons. Poiret gives a similar account of the formation of moss from aquatic plants; he likewise specifies what kinds of plants contribute to this.

He says, that mosses are formed either

" *First*, In morasses, that is, in planes where the

" waters are shallow; in these, marshy plants abound." He enumerates some of them: " Grasses, mosses, " rushes, the scirpus, the (preles) horse-tail." Or,

" *Secondly*, In canals and deep lakes, where only " aquatic plants prevail." Among these he mentions the conferva, lemna, byssus, and potamogeton.

So that both he and De Luc agree, that the same plants which occasion the renovation of moss in pits, promote the growth of it in marshes and lakes.

Mr Poiret's account of the manner in which moss is originally formed, claims particular attention; more especially as he points out the plants which contribute to the formation of it.

I have already shewn that it is requisite to the renovation of moss, in the pits dug in it, that the waters be stagnant. Poiret observes the same thing when moss is formed in lakes or pools. He says, " That " if there be a current in these, or if they be much " agitated by the winds, as in great lakes, the growth " of aquatic plants is retarded; but when the waters " are stagnant and tranquil, and not very extensive " in their surface, that they are speedily stocked with " aquatics."

These he distinguishes into two general orders:

" First, those that float upon the waters, and re- " quire no soil to fix upon; Secondly, those which " fix upon the bottom of the lake."

Of the first order he names the conferva, lemna, byssus, &c. " These," he says, " are the first that " make their appearance. By annual increase they

" form a soft green crust over the water: this is " smooth, and seemingly solid till trod upon. This " first layer of vegetables floating on the surface sinks " to the bottom: at last they form a soil fit for the

" Second order. The seeds of these floated along " the surface of the water, sink to the bottom, and " supply that soil with a stock of plants fit for it." Of this order he names the following numerous species, " the potamogeton, the chara, myriophyl- " lum, ceratophyllum, &c. which adorn the bottom " of such lakes.

" These rush up with astonishing rapidity, and in- " crease annually, till the bottom of the lake, when " the waters are clear, may be seen like a rich fer- " tile meadow.

" These two genera of plants," he adds, " contri- " bute to furnish abundant materials for the forma- " tion of moss, and they are the grand basis of this " substance in such situations.

" But, upon the ruins of these, other more beau- " tiful and majestic plants rise up and adorn the sur- " face; the butomus, with its rosy red, the sagit- " taria, with its milk-white flower, the nenufar ne- " lumbo, with their yellow and purple hue, recline " on the surface of the lake."

He observes, in general, " that the most part of " the above plants, whether they float on the surface " or sink to the bottom, are of a pulpy, tender, and " spongy texture; their fibres are neither hard nor " tenacious; their roots, for the most part, consist

" of capillary tubes; they have no coriaceous nor " ligneous structure, of course they are more speedi- " ly dissolved or decomposed than marshy plants to " be described afterwards: they are converted into " a pulpy, black, and heavy substance, which sinks " to the bottom of the lake."

He farther observes, " that there are particular " causes which tend to expedite or retard this de- " composition, and furnish less or more moss." Of this he gives the following instance.

Mr Van Marum, in his letter to Mr De Faujas, observes, " that the conferva was singularly favour- " able to the formation of moss: that he had an ex- " ample of this in a fish pond: that though he cut " and carried off the aquatic plants which incommod- " ed the fish, or concealed them from his view, yet, " in four years, four feet of moss was formed in this " pond.

" During eight years after he had cleared the pond " of this moss, no conferva appeared. The myri- " ophyllum flourished in great abundance, which he " frequently removed; yet, when he emptied the " pond after this period, he found no moss in it. " From this he concluded, that the conferva was the " principal cause of the formation of moss.

" It appears, too, that the frequent clearing of the " pond of the aquatic plants retarded the process of na- " ture in the production of moss. Van Marum also " observes, that the conferva, in harvest, becomes " specifically heavier than the water: that it sinks to

"the bottom, and carries along with it the other aqua-
"tic plants: that thus their putrefaction is retarded,
"and the process of the formation of moss is pro-
"moted."

From the above account it appears obvious, that the same plants, in similar circumstances, tend to form moss in lakes, which promote the renovation of it in moss pits.

Poiret, however, observes, "that the moss formed
"of the above aquatics is always soft and slimy: that
"it is never fibrous, and ought to be distinguished
"from that in which the fibrous form of the origi-
"nal plant appears. The carbon it contains is like
"a small powder, as it proceeds from herbaceous
"plants. When it is the production of ligneous
"plants, it is frequently found in the organized form
"of the roots and branches of the original trees,
"though these are often bituminated as in coal; but,
"though loose and pulpy when lately formed, even the
"moss produced from aquatics by pressure becomes
"more compact and hard. It is sometimes pure;
"more frequently it is mixed with mud, or small
"particles of calcareous matter, or the shells of aqua-
"tic animals."

It is almost unnecessary for me to add, that Mons. Rozier gives a similar account of the origin and formation of moss in lakes: He says, "that all the
"genera of aquatic mosses, especially the ceratophyl-
"lum and myriophyllum, as above described, con-
"tribute their part; but he especially takes notice

" of the ranunculus aquatilis, and of the rapidity of " its growth :" He says, " that it frequently covers " a whole lake with its leaves and stems and flowers, " and gives it the appearance of an extensive mea- " dow : that he has plucked them three and four " fathoms long, reaching to the bottom of the lake : " that in winter the whole plant drops and sinks to " the bottom : that new shoots spring up next sum- " mer, nourished by the roots and decayed leaves of " the former : that, by this single plant, a deep lake " may soon be converted into moss."

It only remains, that we endeavour to ascertain what are the plants which contribute to the forma- tion of moss in marshes or shallow waters.

Poiret observes, " that the mosses formed in such " situations are distinct from those formed in lakes " or deep waters, and that they exhibit a different " appearance. Composed chiefly of the roots, stems, " and branches, of marshy plants, they form a loose, " porous, and elastic substance, retaining the organi- " zation of the original plant : these he calls by the " general name of fibrous moss.

" The plants which chiefly compose this kind, he " says, are reeds, scirpus, carex, rushes, iris, mosses, " and especially the hypnum and sphagnum, &c. " These cannot flourish but in marshes ; they perish " as soon as the ground is drained ; their roots must " be nourished by a moist soil ; while their stems rise " up above the water.

" When these are reduced to fibrous moss, they " scarcely undergo any decomposition ; their roots

" and stems retain their form for ages: over these " new generations of the same plants rise up; the " soil is thus annually raised, till the whole marsh is " filled with this species of fibrous moss many feet " deep."

How these plants are preserved, and retain so long their organization, is a phenomenon which claims our attention: it will furnish the subject of another essay. It may be proper to observe, however, that all plants are not equally susceptible of being thus preserved: Poiret takes notice of the aquatics, " that they are " more speedily dissolved: that the grasses, on the " contrary, whose leaves are dry and coriaceous, are " almost entirely preserved: that the mosses, above " all, retain their organic form for the longest period."

He farther observes, " that fibrous moss is often " found covered so deeply with alluvial soil above it, " that its origin must be traced back to the remotest " ages: that it seems therefore impossible to say how " long they may retain their organic structure, when " thus secluded from the sun and air; yet it seems " probable, that they must progressively pass into the " state of solid moss, totally disorganized."

He adds, " that this fibrous moss, though loose, " light, and elastic, may be hardened to such a pitch " by compression as to receive a polish like wood: " that when thus compressed, it can only be dis- " tinguished from wood by the horizontal strata, in " which may still be seen the fragments of the stems " and leaves of grasses preserved entire."

SECTION VI.

Sixth place, It seems probable, if not certain, *that many lakes in the north of Europe have been converted into moss*, by the growth and decay of these, or similar aquatic plants. That this has been the case, is the opinion of those who have had the best opportunities of information on the subject. I need not remind the reader, that De Luc states this to be a well known fact in Brunswic and Brandebourg. Picard says, that, according to historians, all the mosses in Holland were formerly lakes; and Poiret thinks, that it is beyond a doubt, that the largest and deepest lakes may be converted into marshes and mosses, and then into meadows, by aquatic plants: that these, by being consolidated, may ultimately become a soil fit for all the purposes of agriculture: He says, that many of the mosses and meadows of France appear to have been formed in this manner.

He thinks the whole valley of the Somme is of this description. Girard is of the same opinion: He says, that the whole valley has been formerly an

extensive lake: that this lake, by being partly drained, has been converted into a moss or marsh, with a river in the middle of it. He accordingly thus describes it: He says, "that it is covered with two feet "of soil; below this, there is from six to ten feet of "moss, from Amiens to Pecquingy; opposite to "Etoile, it is even 30 feet deep. The lower part of "the city of Amiens is built upon a subsoil of moss, "12 feet deep in some places; below this is a stra-"tum of marl; and below this marl, a bank of "sand and sea-shells: all this proves, that this moss, "however remote its origin may be, has been formed "since the sea receded from that spot."

Add to this, that the valley has risen considerably within a few ages: this is owing to the stagnation of the waters, which has occasioned an accumulation of aquatic and marshy plants, and, by that means, an accumulation of moss.

These waters, when the valley was low at first, behoved to be deep; they were then navigable lakes; accordingly, boats are found buried in these mosses in different places, and at different depths.

Poiret observes, that, at this early period, no fibrous moss would be formed, because marshy plants could not flourish in the deep waters. Aquatic plants would then abound; these have contributed to the formation of that ancient black compact moss, found in the lower strata.

But as the soil rose higher, the waters would, in proportion, become more shallow; marshy plants,

such as he described before, would supplant these aquatics: the wreck of these would at first form an intermediate kind of moss, partly fibrous, and partly compact.

At last the surface rising higher still, would become fit only for marshy plants; fibrous moss would therefore form the superior strata; there the roots and branches of marshy plants would form the component parts. This is precisely the case; and it shews that, at the formation of this buzin, or rushy reedy turf on the surface, the valley was only a marsh, though unquestionably a navigable lake at a former period.

Poiret adds, that it is true that fibrous peat is sometimes found in the bottom of very deep mosses; but he accounts for this phenomenon. He thinks, that, after the marshy plants had grown up, the water must have been stemmed, and formed a lake over what was formerly a morass; that this lake would, in time, be filled with aquatics, in the manner above described, and that these aquatics might give origin to the compact moss that now appears above the fibrous.

General de Jean is of the same opinion. He thinks that all mossy grounds were once covered with water; that aquatic plants, by their continual growth and decay, have filled up the space occupied by the waters, and given origin to moss; that, of course, these aquatic plants may still be detected in these mosses.

The above accounts corroborate this opinion; but the following considerations will, I trust, place it beyond the possibility of a doubt, that many mosses have been originally lakes.

1. Many of the deepest mosses in Europe are still in a liquid state. The deepest moss I have ever heard of, is that described by Mr Aiton in his essay. He says, that he lately attempted to sound Moss Mulloch in Avendale, and sunk wooden rods upwards of 40 feet without finding the subsoil. From the manner in which he describes this operation, I am led to conclude that this moss must be very soft, and in a semiliquid state.

The deepest moss in this neighbourhood is the Dullatur bog. Many attempts have been made to sound it. In some places it is so deep that these attempts have been fruitless. It seems to be precisely in a similar state with the deepest mosses in the valley of the Somme. The surface is covered with a solid but elastic mass of fibrous matter; below this is a black semiliquid pulpy moss: in one spot the water appears on the surface like a contracted lake.

Many of the deepest mosses on the Continent are of a similar description: Mr De Luc delineates them with all the minuteness of a careful observer. He says, that "the deepest mosses in Bremen are so "*thin*, that they may be considered in a liquid state: "that they are often of the consistency of a pulp "like rags preparing for paper: that the surface, "though more compact, is only a slight matting, not

" safe for man or beast to tread upon: that no per-
" son dare venture on them without planks: two of
" these planks is all that is necessary; each of these
" has a cord attached to it. After the traveller has
" laid down the first plank on the moss, he passes
" along it, dragging the second after him by the
" cord; this second he lays to the end of the first,
" and, lifting it, he carries it along with him in the
" same manner."

These mosses seem to be of the same liquid consistency, even to the greatest depth: for he adds, that " he sounded them with an instrument which " he carried along with him; that, without any ef-" fort, this instrument sunk by its own weight till it " reached the clay 36 feet deep."

If the deepest mosses be still in a semiliquid state, the probability is, that at a former period they were lakes.

2. These mosses thus pent up in the vallies are often swelled to such a pitch that they burst forth wherever there is a declivity, and overflow the adjacent fields. De Luc observes, that " this is no un-" common event on the Continent; that, on the " contrary, it is a danger dreaded by the inhabitants " of the mosses themselves, and also of the adjacent " vallies;—

" By the inhabitants of the vallies, for these are " sometimes overflown to a considerable depth with " this liquid stream of flowing moss, when it bursts " its former bounds. It is no less dreaded by the

" inhabitants of these mosses, for whole plots of this " spongy substance, when gorged up, are sometimes " swept away like a floating island, with all its trees " and cattle, and houses, and inhabitants. The ex- " ternal coat," he says, " is of a more solid consis- " tency than the internal mass; yet, like a torrent " of lava, when an opening is made, it will run like " a river, even though the surface seems not to " move."

It is almost unnecessary for me to add, that the inhabitants are under the necessity of using precautions to prevent such fatal accidents; they fix down the surface of the moss by large stakes and beams, driven into the subsoil, &c. &c.

Far less is it needful for me to specify and describe the numberless instances of similar accidents that have happened at different times in different kingdoms.

In Scotland, a number of accidents of this kind have occurred. That of the Solway moss is universally known; that of the Aberdeenshire moss, described by Dr Anderson, and of the moss of Kincardine, in the years 1792 and 1793, described by the Rev. Mr Tait, are well ascertained.

In Ireland, similar instances might be mentioned; as that of Charleville moss, in 1697, and that at Gartenmalach, described by Dr Ledwick as a kind of bog-dropsy.

The moving moss of Lancashire and that of Morle, in England, might likewise be pointed out.

The alarming inundations at Wishafen and other places on the Continent might also be mentioned.

But, without describing these, I only observe, that the probability is, that all those mosses which appear in this semiliquid state, have at one period been lakes.

3. It is a well known fact, that many of our deepest mosses are still in so liquid a state, that, like a lake swelled by a flood, they are frequently gorged up above their ordinary level. Their surface, by this means, alternately rises and falls, although they do not thus burst forth in a torrent. Almost every peasant has observed this; it is unnecessary to point out instances of it.

None can deny that many mosses, when drained, sink considerably, and some many feet. Dr King says, that the bog of Castle Forbes sunk 30 feet; Dr Mills allows that it sunk upwards of 15. This is a clear proof that this moss was in a semiliquid state. Upwards of one-half of its depth was filled with water; and many mosses are still in the state of lakes, only covered over with a thin matting of moss on the surface.

A very great proportion of the mosses in Holland and Friezland are of this description. They are accordingly all highest in the centre, that is, where the water has the least egress or opening. Picard observes this, and adds, that, by an accession of stagnant water, and the growth of aquatic plants, they rise and swell rapidly; they are, too, so porous and spongy, that they are called *Hol bol los*, that is, trembling

ground; or, *Het land leeft*, i. e. living land that moves.

In the Scotish dialect there is a similar distinction of quick and dead moss. By quick moss, however, is not meant, as Dr Anderson would insinuate, moss that lives, vegetates or grows, but that which trembles and shakes, or in which a person will sink. The word is used metaphorically in other instances. By quick-sands are meant, in the same sense, moving sands, in which a person sinks, or may be quickly swallowed up.

The quaking bogs in Ireland are of the same kind with those in Holland called living land, and in Britain quick-moss.

4. Another proof that many mosses have been originally lakes, is, that they contain the remains of the shell-fish and other exuviæ of animals which exist only in marshes or pools.

5. After the peat has been dug from the surface, many mosses again revert to their original state of lakes.

Degner describes the mosses in the neighbourhood of Utrecht. He says, "that, after digging a foot "and a half deep on the surface, they come immediately to the subterraneous water: that when the "moss is entirely dug out, all that remains is an extended lake: that, in 20 or 30 years, 60, 80, or "100 acres are sometimes cleared of moss in this "way." He adds, that,

" However sad and gloomy, and even dangerous " these lakes may be, they are not entirely useless. " After the moss is removed, the waters become " sweet, and fit for every domestic purpose. Fish " of the best quality abound in these lakes. These " are supplied by the canals and rivers that commu- " nicate with the mosses; and 100 families some- " times subsist by fishing on one such lake."

He observes farther, " that these lakes are some- " times drained at an immense expence, and con- " verted into a rich soil. They first surround the " lake with a mound, to prevent the surface-water " from flowing into it. By wind-mills they then " drain off the water of the lake: the little moss that " remains at the bottom they burn; by this means " the whole becomes a fertile soil.

" So that these mosses may be seen undergoing " the following changes: They first appear as a rich " meadow; then turf is dug from under this: a rich " supply of wood is often found under the turf. " When these are all removed, the whole appears " as an extensive lake, abounding with fish; and, at " last, when this water is drained off, it is converted " into a rich and fertile soil.

" To drain off these waters requires an immense " expence. In the year 1728, a certain nobleman " drained 800 acres by four mills; these cost him " 30,000 florins Dutch; and, before the whole was fit " for culture, it cost him 200,000 florins: besides,

" these mills required to be kept up at a great ex-
" pence annually, to carry off the superfluous water.

" The attempt to drain such lakes sometimes fails
" altogether; for, when the moss on the original
" surface is removed, the spongy bottom called *darry*
" (a particular species of moss which shall be de-
" scribed) rises up, and leaves a lake sometimes 30
" feet deep. To drain this is impossible; for, as such
" lakes are often far below the level of the sea, when
" it bursts its banks the whole may be overwhelmed
" in a deluge."

It is impossible to ascertain what progressive changes such mosses may have undergone. The wood found in them renders it probable that they were originally forests. The darry at the bottom (which consists almost entirely of reeds and rushes) would lead us to suppose, that these ruined forests had been converted into marshes in the next stage, when these rushes and reeds grew. The depth of the moss, and the liquid state in which it is still found, and their reverting again into lakes when the moss is removed, render it highly probable that they were, at a future stage, deep pools of water. In these pools it is probable the aquatic plants afforded materials for the black, loose, pulpy moss.

The account he gives of the different strata of these mosses corroborates this conjecture. He says, that the first stratum that appears after the surface is removed, is a blackish red moss, very tenacious, but soft and pulpy; this yields the best fuel, and is ge-

nerally about two feet deep. This appears to me to be produced by the aquatic plants which must have flourished when the whole was in the form of a lake.

The next stratum is somewhat redder, equally tenacious, but partly fibrous. This appears to me to have been formed partly by the marshy plants, and partly by aquatics.

The lowest stratum is much redder; it is so fibrous and spongy, that it appears to consist entirely of rotten wood: it is the worst fuel. This seems to me to have been formed of the ruins of the forest, when the whole was converted into a morass.

Some mosses in this neighbourhood exhibit the same proofs that, at one period, they were lakes. After digging four, six, or ten feet deep, the subterraneous water is laid open; this often rushes up with such rapidity, that the pit is filled to the surface before the person who dug it can escape out of it.

Degner states it as a well known fact, that, in many instances, peats are dug where a navigable lake once existed; not only in Zealand, which once lay under the ocean, but in many places, especially in Oldhampton.

This leads me to notice another circumstance that confirms this:

6. That boats and nautical instruments are often found in the deepest mosses.

It is superfluous to specify all the instances of this. I shall name a few.

Degner says, that pieces of ships, nautical instruments, oars, &c. are found in the Dutch mosses.

Girard, in his history of the valley of the Somme, mentions that, in the lowest tier of that moss, was found a boat loaded with bricks.

It seems to me inconceivable how ships, boats, and nautical instruments could exist in the depth of mosses, on any other supposition than that these were at one period navigable lakes, or arms of the sea.

I have only to add another circumstance that leads to the conclusion, that many mosses were at one period lakes.

7. The name they bear implies this.

Mons. De Luc, in his letters to me already alluded to, observes, that some of the dales on the Continent, now filled with peat, retain still the German name *See*: that the meaning of this word is *lake*: from whence he concludes, that these mosses were lakes in known times.

Picard observes, that many mosses on the Continent still bear the name of *poel*: that this is a proof that, at one period, they were pools or lakes.

It is almost unnecessary for me to add, that the words *fen*, *marsh*, and the terminations *brook*, *maer*, *goor*, &c. which are so prevalent over Europe, indicate the same thing. Innumerable mosses, and many cultivated low levels, bear these names. Degner takes particular notice of this.

He says, that many regions abounding in mosses are called *veen*-land, *veen*-grond: that *veen* signifies a muddy marshy soil. Hence the Saxon word *fenne*, and the English *fen*.

He says, that many other regions are called *brock*-land; that *brock* signifies a *lake;* that the names of many villages in Holland and Friezland have this termination: hence the inhabitants, in the time of the Romans, were called *Bructeri*, or the inhabitants of the laky country.

The words *moer*, *moeras*, *marse*, *mershe*, *maer*, he observes, signify a lake or marshy ground. *Moer* signifies that on which brushwood and ligneous plants grow; hence innumerable places are called by names having this termination, as Gravenmoer, Thesenmoer, &c. and the inhabitants were called Morini by the Romans.

Morass, or *mocras*, or *marse*, &c. denote a lake or laky country: He says they are derived from the verb *meer*, signifying to dissipate into small particles; because the waters which overflow these low vallies, by subsidence diffuse small particles of earth over them. That the German, French, Saxon, and Anglo-Saxon, names of the sea, are derived from this. In the German it is called *mere;* in French *mer;* in Anglo-Saxon *mere*; in Saxon *maer;* in Spanish *mar:* hence the inhabitants of these countries were called by Pliny, Marsatii; by Tacitus, Marsaci: and hence the names of places still bear this or similar

terminations, denoting that lakes abounded where mosses now occupy their place.

He observes, too, that the Flemish word *gor* or *goor* is the name of many mosses: that *gor* signifies a lake or laky soil: that the adjective *goor* signifies putrid, fetid, or subacid: that *vergooren* signifies to become acid by being stagnant, from the verb *goer*, *gier*, *geren*, to ferment: hence the Saxon name *gyra*, signifying a lake or marshy soil where waters ferment, and *goor* signifying a land new formed by alluvion: hence Cæsar calls the inhabitants Gorduni, *goor* signifying a lake, and *duyn* a sandy hill.

Girard, in his history of the valley of the Somme, takes notice of the etymology of that name: He says, that Somme, in Celtic, signifies water kept within bounds; that the Celtic word *mos* signifies water that spreads: hence the name *Mosa* to that river, as it frequently overflows and stagnates.

As the original Celtic name *mos*, is descriptive of the origin of peat, I have preferred it, and still am determined to retain it. I know that Dr Walker says, that peat is a word used in Scotland and in the north of England; that, till of late years, it has seldom been used by any English author: this to me is of little importance; nor shall I attempt to prove, that it was used by Leland in his Itinerary, as early as the year 1712, and by Dr Hans Sloan about the same period.

Granting that it is a Scotch word, it is a word universally understood in Britain; and when we speak

of peat moss, the meaning is equally obvious, as when we use the word peat earth, which is not in itself descriptive, or the word *turbary*, which is of foreign derivation.

As peat is descriptive of the distinguishing quality of that substance, inflammability, and moss, of its origin or situation, I think it preferable to retain it.

8. It is almost unnecessary to add, that those mosses from which soda and salt turf are dug, have, at one period, most probably, been salt lakes, or arms of the sea.

I have already shewn, that there is every probability that the lower parts of the coasts of Picardy, though now covered with moss, were once overflown by the ocean. I only mention, that the soda which may be extracted from the peat in that district, renders this highly probable.

It seems absolutely certain, that many of the mosses in Zealand have once been lakes of salt-water, or arms of the sea. Braak truf is accordingly dug out of these lakes; the water in them, like the turf, still contains salt. These turfs, when burning, emit, of course, a fetid odour; this odour is disagreeable, and by the Zealanders deemed dangerous; it communicates a livid death-like colour to the skin; it occasions a sickly squeamish feeling; sometimes it brings on a syncope and fainting fits: to remedy this, they sprinkle salt on the turf while burning. Degner, however, is of opinion, that this, in place of a remedy, only increases the evil: he thinks, that the white ef-

florescence that forms on the turf, is not owing to sulphur, as some have supposed, but to the salt it contains. As a proof of this, he says, that salt thrown on the turf emits a similar blue flame: that Hoffman, in distilling common salt with sand, observed the same whitish yellow efflorescence on the retort.

Many, if not most of the mosses in Friezland, appear to have originated in a similar manner. Much of that country, like Holland, still lies below the level of the sea; none of it rises far above that level; and the soil, in general, is so soft, that no solid foundation can be found for building their houses upon; they are under the necessity of driving piles into the solid subsoil, on purpose to form a proper foundation. Many of the mosses in that district, are, like the other Dutch mosses, impregnated with salt; they abound in what is called *braak torf*, or salt peat.

This is a proof that the site of these mosses was originally occupied by the ocean; else, whence comes the quantity of salt contained in them? This supposition becomes more probable, when it is considered, that much of that country has been reclaimed from the ocean, and that many different districts of it have been overwhelmed by inundations of the deep.

If it be granted, that all those mosses in Europe which are still in a semiliquid state, or have burst their barriers, or alternately rise and fall, or revert into lakes when the moss is removed, or contain pieces of ships or nautical instruments, or bear the name *poel*, &c. or contain salt and soda, were once

lakes, this list must include some of the largest and most extensive mosses in the world.

Having endeavoured to shew that moss is renovated, with the circumstances and time requisite; having also endeavoured to ascertain the aquatic plants which promote this renovation; that the same plants have contributed to the original formation of moss; and that many lakes in the north of Europe have thus been filled up with this substance, it only remains for me to shew,

SECTION VII.

That aquatic plants may be traced in most, if not in all moss. The organization of these is often so entire, that we can easily ascertain the distinct species that prevails.

I regret that I have not been able to collect such a variety of specimens as I expected. I am confident, that if a complete collection of these were made, there would be no difficulty in discriminating the distinct plants, of which all fibrous moss is formed.

I shall mention a few facts, which may tend to elucidate this subject.

In the *first place*, the conferva has been shewn to promote the renovation and growth of moss. This may still be traced in recent mosses; but in those of a more remote origin, it is in vain to expect this: the organs of this species are so small and delicate, that they cannot be distinguished after they have undergone a partial disorganization.

There are other tender plants of this description: The leaves of the lemna, and the delicate organization of this plant, cannot continue long distinguishable, when incorporated with such a mass of extraneous matter.

The byssus, &c. whose roots are of a hair-like or capillary form, may be more distinctly traced; and in the soft pulpy black moss, these roots, &c. are the cause of that filamentous form and appearance it assumes.

2. The organization, however, of other aquatics, may be, and has been ascertained with certainty. The hypnum is of this description; it may be traced deep in moss in a distinct organized form.

Mons. Faujas de St Fond mentions a beautiful specimen of moss as an instance of this. In the valley of Sanchy, at the depth of seven or eight feet, a moss was dug 11 feet thick; this seemed to be composed solely of the hypnum. He says, that "the species "resembled the hypnum adunum Lin. There seem-"ed to be no mixture of any other plant in this

" moss excepting some leaves of trees, equally well " preserved." He observes farther, that " the " depth of soil above the moss, and the many layers " of spongy elastic matter in the moss itself, clearly " evince that it must be of very ancient origin, and " must have remained in this state for many ages; " yet the organization of the hypnum is so distinct " and entire, that the stems, branches, and leaves are " all discernible."

The conclusion is obvious, that this plant has contributed chiefly to the formation of the moss he describes. Dr Walker thinks that the hypnum fluitans is one of the most luxuriant of this species. He says it grows two or three feet long in a season; and that, in the course of 20 years, it has formed a thin stratum of flow peat in Annandale.

3. Aquatic grasses may also be traced in moss. Poiret observes, that the leaves of these are dry, and the stems somewhat coriaceous; that, on this account, they preserve their organic structure long. Degner observes, that these, by rushing up in pits, contribute to the renovation of the moss. Though this be of recent origin, yet it yields fuel. It is light and spongy at first, but when left for 30 or 40 years it is consolidated into excellent turf.

When thus consolidated, he observes, that, upon examination, it consists of nothing but grasses with a small mixture of moss and mud. Hence it is called *groos*, or *groes*, i. e. grassy; and the peat dug from it is called *hey turf*, or grassy peat.

Dr Collet describes the best Berkshire peat as a compost of the branches, twigs, and leaves of trees, with grasses, straw, plants, and weeds.

Dr King gives a similar account of the Irish mosses. He says, that "Ireland abounds in springs. Grass "and weeds grow rapidly at the out-burst of these. "In winter, these springs swell and loosen all the "earth about them; the sward, consisting of the "roots of grasses, is thus lifted up by the water. "This sward grows thicker and thicker, till at last it "forms a quaking bog. As it swells higher and "higher, the grass and roots become more putrid: "mixed with mud and slime, the whole acquires the "blackness and consistency of a turf bog."

I will not attempt to enumerate the aquatic grasses that may be expected in moss. Doubtless, all the varieties may be found; and a careful observer, by the use of a good microscope, may easily ascertain the particular species found in any peat.

4. Rushes and reeds, I have shewn, contribute to the original formation and subsequent renovation of moss; it is certain, that they can still be traced in that substance in an organized state.

I have seen whole masses of moss that consisted almost entirely of rushes. Their original form and figure is still retained; they presented precisely the appearance as if they had been petrified, only, the coagulum, or cement, that bound them together, was black and soft. The moss on the surface of the valley of the Somme seems to be similar to this. Gi-

rard says it is loose and friable; yet the roots of reeds and rushes may be distinctly seen in it. Lambardie, in his view of the origin of this moss, says that the marsh is all covered over with rushes and reeds on the surface. He supposes, that, when the banks that crossed the valley and stemmed up the water were cut, these waters issued out; that this crust of roots reached the bottom; that the whole, by condensation and decomposition, were converted into moss.

Reeds may be traced in many mosses; especially in that species which seems to be peculiar to Holland, called by the Dutch *darry*. It is found most frequently along the sea coast. Degner says, that after the moss is extracted, they frequently come to slimy mud at the bottom; that sand is seldom discovered there. At other times a light, porous, spongy bottom, full of grasses and reeds, is laid open; this is called *darry*, or *derry*. In the heat of summer, this substance often rises up to the surface of the water in large masses; sometimes these are 100 feet long, by three to 10 feet deep, though this seldom happens in winter *.

* In the lake Derwent Water, a similar substance is sometimes found. It appears in the form of floating islands. These rise from the bottom of the lake: sometimes one and sometimes two appear in the year: Some sink to the bottom again in the space of 24 hours; others swim on the surface for six weeks, two months, or even longer: One rose in 1798, which was 180 yards long and 50 wide: Some of them have been found 21 feet thick.

This substance swims along the surface of the lake, and is, on this account, called *dryvend*-land, for the inhabitants can enter upon it, and move it about like a vessel. If it rest in one place for a number of years, it is covered with aquatic plants, reeds, and mosses. It is combustible; but the quality of the turf is inferior.

On account of its being thus moved about, it is often found in the sea. Hence the Dutch have supposed this and other kinds of mosses to be a marine production. Degner, however, observes, that it has

There can be no doubt that the substance of which these islands consists is a species of moss; for, excepting about two feet of the surface, (which consists of mud), the whole appears to be a congeries of leaves and roots of trees and other plants.

And it seems probable, that the moss found in this place is similar to what is called *darry*. Were I to hazard a conjecture, it would be this, that the name of the lake denotes this. *Darrie*, *derrie*, or *darink*, signifies a combustible matter: It is derived from the Danish word *darien*, to burn.

Derwent water, or Darink water, may denote the lake containing *darry*, or inflammable matter; but I mention this merely as a conjecture.

I only observe, that similar floating islands have been seen in Kinson Pool in Staffordshire. Dr Plott says that they consist of a kind of stringy bituminous earth. He speaks of two, about 20 feet broad, by 30 or 40 long, which appeared in 1680.

It appears that similar floating islands have existed since the days of Seneca and Pliny. Both these authors take notice of a lake near to Actila, a town of the Sabines, in which was a floating island.

unquestionably been carried to the ocean by alluvion. He thinks it probable that it may have been thrown out from the sea into some of the lowest districts of Holland, and afterwards covered over with moss and mud; but he adds, that this is by no means a proof, either that it was originally formed in the ocean, or that all moss is a marine production.

He thinks that, as it is certain that many mossy levels have been overwhelmed by the sea, this species of moss might thus be elevated and torn up by the winds and waves, and afterwards swept into the ocean. Hence, he observes, that it is only this spongy reedy turf that is found there, just as trees are found carried thither by alluvion.

This kind of moss is found at the bottom of the sea, near Antwerp, at the depth of 20 feet; and likewise in the bottom of mosses and lakes at Ziric Zeam. It is said to contain a liquid bitumen, and a portion of salt: Hence it is called *braak* turf. The nearer it is to the sea, the greater is the quantity of salt it contains, and the odour it emits is more fetid.

Whether the moss found in the bay of Oban, on the coast of Cornwall, Wales, and Cumberland, &c. &c. be similar to this, I have not had any opportunity of knowing. It is certain, however, that rushes and reeds contribute their part to the formation of moss. It is impossible for me to ascertain the particular species of each that prevails most in any particular spot; in general, however, we may expect the following species:

Scirpus lacustris, or the common bulrush;
Schænus mariscus, or prickly bog-rush;
Juncus conglomeratus, or the common rush;
Arundo phiagmites, or reed;
Scirpus cæspitosus, or deer's hair;
Juncus squarrosus, or wire bent;
Juncus articulatus, or spret, &c. &c.

And it would be desirable that every person who examines rush peat, would endeavour to ascertain the particular species of rush or reed that prevails in it.

5. The leaves, roots, and stems of the iris may often be traced in moss; every careful observer must have seen instances of this. These may be traced to a great depth, especially in black pulpy moss.

6. Heath may be likewise traced in moss. Mr Aiton is of opinion that heather peat does not exist. He allows that it grows on moss in almost every state we find it: But he says that it is extremely slow in its growth, and as slow of decay; that the bulk of earth it yields is so small as to be almost imperceptible; and he does not believe that the thousandth part of any moss was ever composed of decayed heather.

It cannot be denied that, on dry moorish grounds, heath is slow in its growth; yet, even in such situations, it contributes to the formation and renovation of moss. De Luc accordingly observes, that, in the plains of Twickel, it promotes the formation of peat. He says, that when the peat is dug out of the pools, the sand, which forms the subsoil, appears pure;

that it is speedily covered with water; that heath springs up spontaneously, and with *great rapidity* in these pools; that this water and heath constitute their part to the formation of new moss in such places; that even the rain-water which falls on the heath, when it is allowed to STAGNATE, leaves a sediment similar to moss, and acquires the brownish tinge of moss water.

This, however, is not the point I aim to establish. My object is to shew, that heath may be, and is detected as a component part of many mosses: it is even found in an entire organized form in those of the most remote origin. I have seen peat dug out of mosses in this neighbourhood at the depth of four and five feet, one half of which was composed of heath; the roots, branches, and even seeds of the plant could still be distinguished. Mr Tait, in his account of Kincardine moss, observes the same thing. He says, that, at the bottom of that moss, which is in some places 14½ feet deep, bunches of heath are found, far more entire than those found nearer the surface: that the roots of this plant are often seen fixed in the clay subsoil. Williams, in his essay on coal, describes a species of heath peat in the following words: "A foot and a half of the surface consists entirely of "the branches, roots, blossoms, and seeds of heath, "apparently not in the least decayed; the second "stratum below this is the same, only beginning to "decay; the third consists of flow moss; the last is "perfectly black, and of a close texture." He says,

that this is a description of moss Flanders, moss Kinhaw in Ardnamurchan, of Solway, and most of the Highland mosses.

It is not enough to invalidate this argument to say, that the heath is not reduced to earth; or that, because it retains its organic structure, it does not contribute to form moss. Upon the same principles, every plant I have named, whether aquatic or ligneous, may be banished from the list, for they are all found in an organised state; and the organization of them is often as entire as heath; yet all of them yield an inflammable earth; in other words, they form a part of moss.

Nor is it a sufficient objection, that heather may have grown uninterruptedly for ages, and yet no moss has been formed under it. Other circumstances, as I shall shew hereafter, are requisite to the formation of moss than the growth of those plants which form it.

On dry moors, such as those immense regions called *geest* on the Continent, where the water is not allowed to stagnate, the formation of moss, either by heath or any other plant, must be slow and imperceptible; but, on level plains, the growth of heath is rapid, and the formation and renovation of moss rapid in proportion.

7. Aquatic mosses may be detected at all depths in almost every peat; this is a very numerous class. Upwards of 300 species of mosses have been detect-

ed; they flourish in all low marshy soils where peat is found.

It is reasonable to expect, therefore, that they may all be traced in moss; accordingly, many peats seem to consist of nothing else.

King, in his account of the Irish bogs, says, that aquatic mosses abound more in Ireland than in any other kingdom: that the light spongy turf is nothing but a congeries of these: that he has frequently observed this before the turf was sufficiently rotten. He adds, "truly I impute the formation of the red "or turf bogs chiefly to this. On examining a sec- "tion of such mosses, this will appear obvious. The "sphagnum, and other moss plants, may be seen "growing fresh and vigorous at the surface; a foot "deep they exhibit marks of decomposition; and "deeper still, they are completely disorganized."

The woolly turf which Degner describes is probably of this description. He says, that it is full of filaments and organized matter: that it is therefore called by the Dutch *locke*, i. e. wooly, or *dractagtig*, i. e. filamentous.

That which is found near Craneberg is certainly similar to the red bogs of Ireland. It seems to consist almost entirely of mosses. Degner says he examined it. Besides pure aquatic moss, of a light yellow colour, and a few filaments of aquatic grasses, he found nothing else.

Mr De Luc, in his first letter to me, gives the following account of a similar turf. He says,

" I have brought a specimen of some peat of the " country of Shleswig; it has hardly any thing else " in its composition, than a ramified common moss. " I have let some of it stand a whole year in a bason " of water, always repairing the loss of water by eva- " poration, yet it did not change its shape, or tinge " the water: at last I took it to pieces, which was " but to force the separation of the interwoven threads " of the moss. I washed these separate tufts in the " water in which it had been steeped: though this " gave a turbid appearance to the fluid at first, yet " after being left to settle, it became clear. The par- " ticles mixed in the water, were of two sorts; one " of these floated on the surface, the other sunk to " the bottom of the bason. The former were only " small bits of moss, which had not undergone the " process of the separation of the molecules; the " other was a brownish powder, probably the divid- " ed molecules which produce the peat mud, and are " of a greater specific gravity than water.

" If the broken pieces of this specimen, (which " probably would produce the same effect after be- " ing sunk in water and more divided), can be of " any use to you, I will send to you with pleasure."

Ribancourt describes two species of peat found in France, similar to the above. The first is white and heavy, filled with shells, and mixed with much earth; this is called earthy peat. The second is brown, of a bright hue, very light and porous, full of openings;

it precisely resembles a collection of fog; it is therefore called *mossy* peat.

Both of these are of little value; they are seldom used as a fuel.

I have examined several mosses with care, and I am confident, that all the red mosses, or those of a reddish yellow, sometimes called flow moss, are of this description. Ket moss is similar to this; and that called in Ireland *old wives' tow* is of the same kind.

In place of specifying any particular moss, I would call the attention of the reader to this point. Let him examine this spongy light coloured peat, in the manner De Luc describes, and he will find, upon inspection, especially with a microscope, that it consists chiefly of a congeries of aquatic mosses.

I say mosses in general, for it were an endless and idle task to specify the particular classes. All the different species may be expected; and I have no doubt, but with proper care and minute attention in making experiments, they may be discriminated from each other.

There are some of these so bulky, that they can easily be detected by the naked eye; of this description, are the sphagnum, palustre, polytrichum commune, &c.: others are so minute, and their organization is so delicate, that they require the application of the finest microscope to detect their structure; of this description are the conferva, lemna, &c. &c.

I have only to observe, that Mr Aiton looks on this as a species of peat rarely to be found: He says, that it is only to be met with in a few lochs, flanks, or standing pools of water; that it scarcely merits notice.

From the most accurate and extensive researches I have been able to make, I am disposed to think otherwise. It seems to be the prevailing species over all Ireland; immense tracks of that country are covered with it. In Friezland, Brandebourg, Brunswic, Shleswick, Holland, &c. &c. it appears from Degner and De Luc to prevail. In many of the vallies of Scotland it is to be found; and perhaps no peat, of any particular description, (that is, where a particular species of plants abounds in it), is found in greater quantity or extent.

It were an easy task to swell the list of aquatic plants that have been detected in moss. I decline to particularize these any farther, and dismiss this point with one general remark, *that all the aquatics which flourish in mosses, marshes, or lakes, may be expected to be found.* Perhaps, by farther investigation of this important subject, a collection may be made from mosses of different kingdoms, exhibiting all the varieties of these plants; and why should not such an attempt be made? The subject is surely of sufficient importance; and it were worthy of any university or society in the kingdom to undertake the task. The expence and trouble of it is too much for any individual; to a society these would be trifling. I for

my part undertake to furnish a collection of specimens which deserve a place in any museum.

It may be useful to some of my readers to furnish a list of those plants whose growth is most rapid: De Luc says, that Mr Oeder is of opinion, that the following, by the rapidity of their growth, soon bury in our mosses the heath and other shrubs, and the grasses, reeds, and rushes, of our meadows, viz.

The conferva, with its green clouds;
The byssus and tremella; and, above all,
The sphagnum palustre.

Among the grassy plants which grow in abundance, he enumerates the eriophorum vaginatum, eriophorum polystachion, and carex cæspitosa.

Dr Walker, in his Essay on Peat, gives the following list of plants which generally occupy and cover the surface of moss in Scotland:

1st Class. *Noxious.*

1. Pinguicula vulgaris; white rot.
2. Hydrocotyle vulg.; marsh pennywort.
3. Drosera rotundifol.; } red rot.
4. ——— longifol.; }
5. Anthericum ossifragum; Lancashire asphodel.
6. Ranunculus flammula; spearword.
7. Caltha palustr.; marsh marigold.
8. Oenanthe crocata; hemlock drop-wort.
9. Pedicularis sylvatica; louse-wort.
10. ——— palustris; marsh louse-wort.
11. Myrica gale; gale.

2d. *Plants of no known use.*

1. Schænus nigricans; black bog-rush.
2. ——— albus; white bog-rush.
3. Scirpus palustr.; club-rush.
4. Juncus campestres; field-rush.
5. Cornus suecica.
6. Primula farinosa; bird's eye.
7. Lysymachia tenella; purple moneywort.
8. Pyrola minor; lesser wintergreen.
9. Lycopodium clavatum; wolf's claw.
10. ——— selago; fir-moss.
11. Sphagn. palustr.; bog-moss.
12. Polytrich. comm.; goldclocks.
13. Marium palustre.
14. ——— fontanum.
15. Bryum paludosum.
16. ——— scoparium.
17. ——— cæspititium.
18. Lichen rangiferinus; rein-deer moss.

With many lesser plants of the mossy tribe.

In Moss Water.

1. Utricularia minor; hooded milfoil.
2. Potamogeton natans; round leaved pond-weed.
3. Comarum palustre; marsh cinquefoil.
4. Carex vesicaria; bladder-grass.
5. ——— turgida.
6. Chara tomentosa.
7. Hypnum fluitans.

These, he observes, grow up in peat pits, and, by their rapid growth and decay, fill them again with new formed peat.

3d. *Plants of some Economical, Medical, or Mechanical use.*

1. Vaccinium occycoccus ; cranberry.
2. Rubus chamæmorus ; cloudberry.
3. Menyanthes trifoliata ; marsh trefoil.
4. Schænus mariscus ; prickly bog-rush.
5. Scirpus lacustris ; bulrush.
6. Arundo phragmites ; common reed.
7. Juncus conglomeratus ; common rush.
8. ——— effuscus ; hard rush.
9. Tormentilla erecta ; tormentil.

4th. *Gramineous Plants, affording Hay.*

1. Acra cærulea ; fly-bent.
2. Agrostis stolonifera ; marsh bent-grass.
3. Cynosurus cæruleus ; blue dog-tail grass.
4. Juncus articulatus ; spret.
5. Carex cæspitosa.
   ——- limosa.
   ——- trigona.
6. Carex gigantea.
7. Holcus lanatus ; soft grass.
8. ——— mollis ; creeping soft grass.
9. Triglochin. palustr. ; arrow-headed grass.

5th. *Plants serving for Pasture.*

1. Scirpus cæspitosus; deer's hair.
2. Eriophorum polystachion; } bog cotton, or moss-
——— vaginatum; } crops.
3. Nardus stricta; bent.
4. Agrostis capillaris; fine windstraw.
5. Aira flexuosa.
6. ——— montana.
7. Juncus squarrosus; wire-bent.
8. ——— flexuosus.
9. Erica vulgaris; heather.
10. ——— cinerea; } bell heather.
11. ——— tetralix; }
12. ——— incana; downy heather.
13. Carex atrata, and many small species.

6th. *Shrubby and Arboraceous Plants.*

1. Vaccinium myrtyllus; blae-berry.
2. ——— uliginosum; great ditto.
3. ——— vitis idea; red ditto.
4. Andromeda polifolia; marsh rosemary.
5. Arbutus uva ursi; stone-berry.
6. Juniperus communis; juniper.
7. Empetrum nigr.; crow-berry.
8. Salix pentandra; sweet willow.
9. ——— glauca: and smaller species.
10. Betula alba; birch.
11. ——— alnus; alder.
12. Scorbus aucuparia; rowan.
13. Pinus sylvestris; Scots pine.

The conclusion from this is obvious. If these plants are found growing on mosses, it is natural to expect that they may be traced in all their varieties, and in all the various stages of decay; and that such plants, whether in a state of organization or disorganization, have contributed their part to the formation of those mosses in which they are found.

I may add, that it is perhaps possible to ascertain the state in which any moss was when the several strata of it were formed, by discriminating the plants which prevail in it.

Sennebier observes, that the different species of aquatics require different soils. The nympheæ grow up in lakes of a firm bottom; in loose bottoms the chara abounds; the carex delights in those marshes which are dry in summer, but wet in winter; in deep waters, the sphagnum flourishes; the hypnum abounds in shady forests; gentiana lutea, veratrum, epanula drabæfolia, anchusa, stachys, fusca, prevail in meadows.

If this account be correct, (and surely it proceeds from high authority), we may, perhaps, make the following conclusions: That, where a stratum of moss abounds chiefly with the nymphea, the subsoil is firm; where the chara prevails, it is loose: That where the carex abounds, the moss, at the period in which this stratum was formed, was flooded in winter and dry in summer; where the sphagnum prevails, it was in the state of a lake: That where the hypnum forms the chief materials, a shady forest once

grew: hence leaves of trees were detected by St Fond in the lowest stratum he describes, p. 165 and 166.

And that where meadow grasses are chiefly to be traced in moss, that moss was in the state of meadow when this stratum was formed.

It may be proper to endeavour to ascertain some of the distinguishing qualities of those plants which promote the formation or renovation of moss, or which are detected in it.

This subject I reserve to

SECTION VIII.

Dr ANDERSON asserts, that moss produces few vegetables; that these tend rapidly to decay; that all vegetable substances, when dead, decrease in bulk, so that they do not occupy above one hundredth part of the space they did; that moss does not produce one hundredth part of the crop of a fertile soil.

We are now, in some measure, prepared to meet the Doctor; I shall, therefore, consider each of the above assertions.

I. That moss produces few vegetables is not strictly true. The foregoing list of plants that flourish even on our Scottish mosses, shews the contrary. It is true that it produces only marshy and aquatic plants, but a great variety of species of these may be seen in every moss. Almost all the varieties that flourish in marshes and lakes may be traced also in moss, and have therefore contributed to the formation of it; so that, with equal propriety, the Doctor might have asserted that the former produce few vegetables as the latter.

On decaying or decayed woods, which I have shewn lay the foundation of many mosses, a great variety of the musci flourish: some of these are rapid in their growth. De Luc mentions, that he has sometimes seen a matting of these a foot thick at the roots of rotten trees, or under their shade. Cordiner says, that the fallen trees of Glenlin are deeply immersed in these plants. The Earl of Cromarty also observes that the ruined forest he describes was all covered over with green moss.

It is of no avail to the Doctor's argument to say that this is no proof that these plants flourish in mosses. It is a proof of the point at issue, that they may have contributed largely to the original formation of them: for, if these ruined forests have laid the foundation of many of these mosses, the plants above described must have mingled with the mass, and added to it.

Even though this were doubtful, it is certain that many of the musci flourish in low marshy grounds; the sphagnum, &c. flourishes even in moss pits.

It may also be observed, that many of these plants are very rapid in their growth. I might have rested the evidence of this on the testimony of Mr Findorf, as stated in the 4th section of this essay. I may add, however, that De Luc takes particular notice of the rapidity with which aquatic plants rush up in the mosses of Bremen. He says, that it is hardly credible how speedily one tier succeeds and buries another, heaping thus layer upon layer of moss.

Some of the mosses in particular rush up and arrive at maturity in a very short period. Hedwidg sowed the seed of koelcreutera hygrometrica; in seven days the plant sprung; the roots appeared when the seed was placed in water in three days; in eight days the leaves were formed; and the plant was complete in twenty.

3. Some of these, too, flourish in the coldest climates, and in the coldest seasons of the year. Darwin in his Phytologia says, that the rein-deer moss vegetates under the snow, when the temperature is as low as 40 Farenh.

Even on the highest mountains their growth is rapid. De Luc mentions that, on the hill of Broken, near the Hartz mines, the vegetation of heath, myrtle, and all the species of moss, is so vigorous as to excite his astonishment; yet this mountain is ascertained to be upwards of 3000 feet above the level of the

sea. Heath and mosses are found on the top of the Andes and Mount Blanc.

Even though exposed to drought, the vegetation of these mosses, though checked, is not destroyed. Dillenius says, that he took a piece of moss from his herbary, which had been there for ten years: that this moss must, of course, have been completely dried; yet, when he left it in water for some days, it began to vegetate as if it had been newly taken from the earth.

Mosses, even when petrified at the roots, continue still to flourish on the surface. In like manner, though their roots, which sink deep in moss, seem to have decayed, the vegetation still advances over their ruins.

The seeds, too, of these plants float in the air: by this means they are universally diffused. When they reach any moist soil they fix upon it, and speedily rush up. The conferva is of this description. Dr Watson filled a tube with water, and sealed it hermetically at the top: that side which was next to the sun was speedily covered with a green film, the other side was not. Dr Priestly examined this, and found it to be a vegetable.

The rapidity with which this plant rushes up may be ascertained by a simple experiment. I have tried it myself within these few days. In a low level in this neighbourhood a ditch had been lately cut; ten days ago I made this ditch be stopped up so as to stem the water; to my surprise it is filled with con-

ferva, even on the 20th January. Some of the plants have already reached the surface in that short period, although the ditch be two feet deep.

It is unnecessary to point out the rapidity with which rushes, and reeds, and other aquatic plants grow.

The Doctor's first assertion, then, may be disputed, that moss produces few plants. If he mean annual plants, such as corn and wheat, &c. his assertion is well founded; or, if he mean only that mosses, when drained and laid dry, produce even few perennials, this may likewise be allowed.

But, in level mosses, where water is allowed to stagnate, the number of plants produced is great, and the luxuriance of their growth unequalled, even by the richest crop of wheat on the most fertile soil; and it is in such situations alone that moss is formed or renovated (as I shall shew in my third essay) to any considerable depth.

II. That the plants which grow on moss tend rapidly to decay, is an assertion which requires to be qualified.

In general, all vegetables tend rapidly to decay in certain circumstances. When exposed to the influences of the sun and air this is case. The alternation of moisture and drought, heat and cold, expedite this change; but it is not more rapid, even in these circumstances, in moss plants than other vegetables; on the contrary, many of these may

be preserved for a longer period than any other plants. All the varieties of heaths and mosses are of this description. It is not strictly true, therefore, that they tend rapidly to decay.

Far less can it be asserted, that these, or any other plants that flourish on moss, tend rapidly to decay when sunk in water, or shut up from the influences of the sun and air, as they are in moss.

Some of them are no doubt more susceptible of being preserved, even in this situation, than others.

I have already shewn, in the seventh section of this essay, that the hypnum, the aquatic grasses, rushes, and reeds, heath, and aquatic mosses, may be detected in a state of perfect preservation even in the deepest mosses, where they must have remained for ages.

The leaves and stems of these, which overtop the water, decay and drop annually; but the roots, and what remains of them under water, do not rapidly tend to decay; they often retain, for ages, their original organic form, otherwise they could not be discriminated in the lowest strata of the deepest mosses.

III. That all vegetable substances, when dead, decrease in bulk, so as not to occupy above the 100th part of the space they did, is an assertion which also requires qualification. If, by being dead, the Doctor means their ceasing to vegetate, the assertion is unfounded. The hypnum, the grasses, reeds, rushes, heath, and mosses detected deeply imbedded in peat, must have been dead for ages in this sense of the

word. It is inconceivable that they could continue to vegetate at the depth of 10, 20, or 30 feet of compact moss; yet these plants have not decreased in bulk a hundred fold; they have scarcely decreased at all; they occupy nearly the same space as they did when in a growing state; in form and size they can scarcely be distinguished from living plants of the same species.

If, on the other hand, the Doctor means by dead, their being disorganized, as they appear to exist in some mosses, even on this supposition, they must have occupied much more than 100th part of the space they did. Ligneous plants generally contain nearly one-fifth part of their bulk of carbon; that is almost an incorruptible substance; under water, or deeply imbedded in moss, it is entirely so.

Even those plants which are of a softer texture, and have no coriaceous nor ligneous fibres, contain much more than 100th part of their bulk of carbon.

IV. His assertion, that moss does not produce 100th part of the crop of a fertile soil, is very loose and incorrect.

Where moss is drained, its produce is indeed small; perhaps the Doctor does not under-rate it.

But in low wet mosses and lakes, where alone most grows to any perceptible degree, the crops it yields is great.

Some of the plants which flourish in such situations yield an annual produce, perhaps equal in bulk

to 20 crops of wheat. The ranunculus aquatilis, described by Rozier as rising from the bottom of a lake 18, 20, or 24 feet high, is of this kind. The produce of those moss plants which fill up the ditches in the peat moors of Craneburg, twice or thrice in one summer, are also of this description.

Besides, other considerations must be taken into the account. Most of the mosses, and many of the aquatics, which flourish on such soils, continue to vegetate all the year round; nay more, the vegetation of one, does not seem to check or retard that of the other, though closely interwoven together. Reeds and rushes may be seen on the surface of the water, fresh and full of vigour; while the conferva, the lemna, the byssus, potamogeton, &c. are equally vigorous below. Thus, innumerable crops of innumerable kinds are produced, not only annually, but some of them *continually*.

I need hardly mention, that as the temperature of the water in moss is almost always equable a few feet below the surface, and equal in all those regions where moss is found at that depth, that similar plants flourish in all these regions. In some, it would appear, they reach a greater size than others. The Marquis de Tourbillie mentions, that a species of rush grows in Bretagne, as high as a man on horseback. Dr King speaks of a coarse grass in the red bogs of Ireland, which rises as high as a man: the produce of either of these plants must be equal to the richest crop of wheat.

It would appear, from the foregoing facts, that the plants which promote the formation and renovation of moss, are possessed of the following qualities: They are, for the most part, extremely rapid in their growth; they do not rapidly decay; they are not much diminished in bulk; and, on all these and other accounts mentioned, they afford annually a much more abundant supply of vegetable matter than the most fertile soil. The rapidity with which moss is renovated in the pits dug in it, and the rapidity, too, with which it is formed in marshes and lakes, becomes less astonishing, because more easily accounted for.

There are other difficulties that may be accounted for upon the foregoing statement.

To obviate these shall be subject of

SECTION IX.

The great variety of mosses; the immense depth of some of these; the situations in which they are found; and the arrangement of the different strata of moss in different countries, have been considered

by some as insurmountable difficulties, and unanswerable objections to the hypothesis I have supported. It appears to me, that these may all be accounted for.

I. The varieties of moss may be easily accounted for from the foregoing facts. These varieties are considerable; many attempts have been made to classify them; some have distinguished them by their different colours, others by their density, compactness, or weight; some by the prevailing plants of which they are composed, and others by the appearance they assume, or the qualities they are supposed to possess.

Degner describes three kinds of moss in Holland: He distinguishes these by their colour; the uppermost stratum as black and tenacious, the next redder, and the lowest redder still. Ribaucourt makes a similar distinction of colour in the French mosses, into white, brown, and black. Dr Leigh says, that the Lancashire mosses are either white, gray, or black; but they all agree, that there are many intermediate gradations of colour.

Girard discriminates the moss of the valley of the Somme by its density or compactness: He says, that the uppermost tier is loose and friable; that the roots and branches of reeds and rushes may be traced in it distinctly. The second is more homogenous and solid, but still the fibrous parts of vegetables appear, though entirely converted into moss; the woody peat

is undermost, and seems to consist of the trunks, branches, &c. of trees.

Degner likewise distinguishes the different kinds by their weight: One species, he says, is light and spongy, another is somewhat heavier, a third heavier still, and he speaks of some species specifically heavier than water.

Dr Walker, in describing the different kinds of moss, distinguishes them by the prevailing plants that seem to compose them, into wood-peat, flow-peat, heather-peat, gramineous-peat: he adds three more classes, the inch-peat, consumed-peat, and water-borne-peat.

Dr Anderson distinguishes moss into two kinds, living and dead: by the former, he means moss still in a growing state.

Poiret makes only two kinds of moss, fibrous and compact: by the former, he means all kinds of moss where the organization of the vegetable matter may be traced: under the latter class he includes all mosses which have undergone a complete disorganization.

It is of little importance which of these modes of classification be preferred. It appears to me, however, that the colour of moss is by no means a correct mode of distinguishing the different kinds; the shades and gradations of colour are so different, and so delicate, that it is difficult, if not impossible, to ascertain the exact line of distinction between the different species by this means. In describing these, however, it might be proper to attend to the colour.

The density, compactness, or comparative weight of peat, is likewise a very uncertain standard; these depend so much upon circumstances, upon the pressure to which the peat is subjected, and the degree of moisture, &c. &c. to which it is exposed, that it is impossible to make them a rule of discrimination.

The mode suggested by Dr Walker and others, of distinguishing peat by the plants that prevail in it, seems equally imperfect. Were this rule to be strictly followed out, (as it ought to be, if it ever be adopted), we might find out many hundred species of peat, as many as there are different species of plants in its composition: to attempt this mode of classification would only lead to confusion.

Dr Anderson's distinction, into living and dead, is still much more exceptionable; it is a distinction which does not exist; it originates either in an error of judgment, as to the nature of that substance, or in a misapplication of a vulgar distinction or metaphorical expression.

Were I to give a preference to any, I would prefer Poiret's distinction, into fibrous and compact: These two classes include all kinds, excepting perhaps wood-peat; and, in describing the varieties of moss, it seems to me unnecessary to be more minute.

Yet, upon the supposition that it is necessary to distinguish all the varieties of moss, we may easily account for this variety from the above view of their origin.

1. The different trees, as the oak, birch, fir, nay, the different parts of the tree, as the bark, leaves, and twigs, of which moss is composed, must constitute a difference in the appearance of that substance: the variety of aquatic plants which enter into its composition, must also occasion a variety of colour.

2. The age and consequent compression which mosses undergo at different depths, must also occasion a difference in their density, compactness, or weight.

3. The situation in which mosses lie may contribute to occasion a variety in their density. In low warm situations vegetation is rapid; in proportion to this rapidity of their growth, plants are less compact: hence in low sheltered spots wood and other plants are more soft and spongy; in high exposed situations, where vegetation is slow, they are more compact. We may expect the same variety in moss, according to the different situations in which it is found; hence in low vallies, moss is generally more porous; in high exposed situations, it is more compact.

4. The subsoil also may occasion a variety of colour and consistency in moss; salt, sulphur, or iron, may be dissolved in the waters of the subsoil; being diffused through the moss, they must occasion a difference in the colour, qualities, and consistency of it.

As the same metallic veins assume different appearances, and possess different qualities within a small space, it is not surprising that the same should happen in mosses.

5. Alluvion may also occasion a difference; sand or slime, or calcareous matter, may be carried down from the adjacent hills into mossy vallies; these, incorporating with the moss, may occasion a difference in colour, consistency, and weight.

But there is a more formidable objection to the foregoing hypothesis,—the immense depth of many of these mosses: to obviate this shall now be my object.

II. The depth of mosses may be accounted for. The whole objections of Degner and Dr Anderson resolve themselves into this: that moss is often found 20 or 30 feet deep: that the most abundant crop, on the most fertile soil, would not cover the earth, when fresh cut, half an inch deep: that, when rotten, it will not cover the earth one hundredth part of this; and therefore, if moss be formed of decayed vegetables, it must require many hundred thousand years to produce 20 feet deep of that substance.

We are now better prepared to meet this objection.

It cannot be denied that moss is found upwards of 20 feet deep. Girard says that in some places of the valley of the Somme it is 30; Degner says, that many of the Dutch mosses are as deep as this; De Luc says, that in some places Kedinger moor is 36 feet deep; and Mr Aiton says, that Moss Mulloch in Strathaven is upwards of 40. The French mosses, according to Ribaucourt, are from six inches to 20 feet deep at an average. The Dullatur bog in this parish is upwards of 50 feet deep. The engineer of

the great canal sounded it some years ago, and found it like a liquid pulp till he reached the sand at the above depth.

The following remarks may obviate this objection, and account for the immense depth of many mosses.

First, It is a fact attested by many, I believe it is denied by none, that all the deep mosses on the Continent of Europe, or the British Isles, lie either in low vallies, or at least on a level. I have never seen nor heard of any moss on a declivity that exceeded four feet in depth; on the contrary, all these mosses which lie on such declivities, or even on a dry bottom, are very shallow. The moors in Britain of this description, and all the dry mosses called *geest* on the Continent seldom exceed the half of this depth. In the adjacent vallies or levels alone is moss ever found of the immense depth above described. If these shallow and deep mosses be coeval in their origin, whence comes this vast difference? The most natural way of accounting for this is by alluvion.

Supposing the site of all these mosses to have been originally covered with wood; that this has laid the foundation of them; upon this supposition, alluvion must have had a powerful and continual operation, not only during all the period the forest stood, but all that in which the moss was forming. The annual crop of leaves, small seeds, and twigs, &c. together with the loose light earth formed by these on the declivities, must naturally have been carried

down to the vallies and level plains by the rains and winter floods; deposited there, they must have added to the depth of these low lying mosses, in the same proportion as they diminished that of those on the declivities. Upon the supposition that the forest stood only for one or two generations of it, say 500 or 1000 years, the quantity thus carried down to these levels, and the difference of depth that this must have occasioned, must be great indeed; and if this cause continued to operate even after the final ruin of the forest, and during all the period in which the moss was forming on its ruins, and operates still, that difference must still be greater. In the course of ages, we may expect that the whole moss formed on the declivities will eventually be washed down into the vallies. Alluvion alone, therefore, may account for the depth of many mosses, and the shallowness of others *.

* The effects of alluvion will be most easily conceived, by stating a case in point. The river Elbe was suffered to overflow a plain of nearly two leagues extent; in 23 years it formed an alluvial soil on this surface of two *feet deep*. This soil was of clay; but had the river, in its course, passed over a loose moss or lighter soil, it must have formed a much deeper stratum in a shorter period.

Or if it had lain in the course of one of those liquid running mosses which burst their barriers, and one of these had rested on this valley, a moss of immense depth might have been formed at once on the spot; and, unquestionably, many mosses now exist in such situations which originated elsewhere, and have floated down in the way above described.

Secondly, I have stated that, in these low levels, all kinds of aquatic plants rush up with rapidity: that, in 30 years, moss is renovated by this means to the depth of seven or ten feet. The conclusion is natural, that, by the same means, moss may have been formed with equal rapidity in such situations.

Whereas on dry grounds, or on declivities where no aquatics grow, and no other plants rush up with such rapidity and in such abundance, the materials for forming moss must be few, and its growth proportionably slow.

Thirdly, I have shewn that these aquatic plants are not diminished in bulk to the degree that Dr Anderson supposes: that they are detected in moss to the greatest depth, in their original organic form, and occupying the same space they did when in a growing state; for, though these and every other plant be diminished in size when they undergo decomposition in open air, this is not the case when sunk under water or buried in moss: even a crop of hay or wheat, in such a situation, is not diminished in bulk; and if annually sunk in water or moss, it would retain long its organic structure and original size. This is still more the case with aquatic plants; they are preserved, at least the sphagna, and all the other species of moss, for a much longer period.

I may add,

Fourthly, That one half of the size of the most compact moss consists of water. Take a cubic foot of such moss, and squeeze it till dry, it will not oc-

cupy one half of the space; so that even in a moss 40 feet deep, even supposing it to be compact, though none such exists, we have only to account for 20 feet, the other 20 consisting of water.

Fifthly, I have shewn, that many of the deepest mosses on the Continent, and in the British Isles, are in a semiliquid state; and I believe there is not to be found in the world any moss 20 feet deep of a compact and solid consistency; two-thirds, perhaps three-fourths, of such liquid mosses consist of water.

Sixthly, I have shewn that some of these, when drained, sink 10, 20, or more feet, which is a proof that the greatest proportion by far of such deep mosses is water.

Seventhly, I have shewn, that many of these semiliquid mosses burst their original bounds; by this means alone a moss of 20, 30, or 40, feet deep, may be lodged, in a *single day*, in a low valley where no moss formerly existed; or if moss was formed there before, this inundation of new matter must have added greatly to the depth. Accordingly, mosses are found of considerable depth on low level grounds, which were formed originally elsewhere, and afterwards floated down, in the manner above described.

Eighthly, A moss 10 feet deep, if compact, contains as much vegetable matter as one 30 feet deep in a liquid state. They may, therefore, be coeval in their origin, and be the remains of the same plants: the difference of their depth may depend entirely on the above circumstances.

Thus, even upon Dr Anderson's own data, there is no need to account for moss 20 or 30 feet deep, as there is no instance I ever have heard of where moss is found nearly of that depth, excepting in low levels liable to the above operations of nature; all, or any of which, may account for the immense accumulation of that substance in such situations. Nor have we any cause to conclude with him, that it would require 900,000 years to form a moss 20 or 30 feet deep; on the contrary, if we take all the above considerations into the account, we may conclude with De Luc, that the rapidity with which moss is renovated, and may be formed in such situations, is obvious; and that the growth of moss, even 30 feet deep, does not lead us back to a remote æra. By alluvion and the rapid growth of aquatic plants, and especially by an accession of moisture, such an accumulation of liquid moss may be formed in a low level valley, in the course of a few ages; whereas on a declivity, by the operation of alluvion, the moss which was originally formed may be daily diminishing in depth; and on a dry bottom, where few aquatics can grow, and no plants rush up with rapidity, the growth of moss must be proportionally slow.

III. The situations in which moss is found may be accounted for on the foregoing hypothesis.

Moss is very generally diffused over the north of Europe. Guicciardini enumerates the different districts in Holland, Germany, and France, where it

abounds: He says, in general terms, that it is found at the mouths of all the rivers that empty themselves into the Baltic or German ocean. In Iceland and Russia it abounds, though it be little attended to, as they have a sufficiency of wood to supply them with fuel.

Ribaucourt says, there is scarcely a valley in France where moss is not to be found; that under the old forests, and even under many cultivated fields, it forms the subsoil.

Lamberville describes the mosses in France, and the names of the rivers on which it is found: He says, that it abounds most in the northern departments, especially on the Somme, and all its tributary streams; likewise along the rivers Esonne, Seine, Aine and Oise, Ecluse, Bressle, and the various streams that run into them.

In the East of France, he says, it is to be found in abundance; in Valois, on the rivers Mosselle, Meuse, &c.

In the south, it is less abundant, but it is found even there in the mountains: on the elevated plains of mount Jura; on mount Blanc; on the mountains of Cevennes, Pyrennees, and Auvergne, it is also found.

In the west of France, immense tracks of moss are to be found: on the right side of the Loire; on the banks of the Indie, Eure, and Iton, &c. it is also found in abundance.

It appears, too, that moss has been discovered in South America. Monardes describes a bituminous

earth dug at Peru, that possesses all the qualities of moss: He says, that they extract from it a liquid bitumen, which they use as a medicine; that they afterwards dry this earth and burn it: it lies in a marsh, and he says, that this marsh is bare of tree, shrub, or plant, of any kind. Mons. De Luc, in his first letter to me, mentions, that there are mosses on the mountains of Portugal and Spain: He says, he was informed of this by Professor Linck, who travelled through these countries, and paid attention to the peat grounds: He says, that, on the mountains where it is chiefly to be found, the peat is much like to that which abounds in the north of Europe; that it contains a great proportion of the scirpus cæspitosus; but that it is seldom found on low lands, excepting near the sea: This is of a different species; it is chiefly composed of the scirpus stolochænus, juncus acutus, and juncus maritimus, mixed with the roots of helodes and myrica gale, forming an indifferent peat, though tough. It is almost unnecessary for me to add, that peat is to be found in almost every valley of the British Isles.

But it is proper to observe, that it is sometimes found in the beds of rivers,—on a subsoil of bare rock,—under a bed of solid marl; and, even under the level of the sea.

De Luc takes notice of this as a difficulty which is not easily accounted for. He says, that there is no doubt moss is a vegetable substance; that we need only look to it to be convinced of this: That though

the compact moss at the bottom appear to be only a black earth, yet, even in it we may trace the roots and vestiges of the vegetables of which it is composed; and, if we pass by degrees to the surface, the organization of these vegetables becomes gradually more visible, till it appears distinct at last. The difficulties with regard to this substance, he adds, originate from two considerations: First, as to the cause of its formation; and, secondly, as to the situations in which it is found.

1. That it is sometimes found under the bed of rivers, stumbled him at first; but, as he had occasion to see it often in this situation, it awakened his curiosity, and, after a general survey of the whole coast, from the Elbe to the Meuse, he gives the following solution of this difficulty. He says, in general that one of two things must have happened in such cases, either that the river must have, at some period, changed its course, or that the moss found under its bed must have been moved, for it could never have been formed there. The following fact, which he mentions, removed all doubt upon this point: "On "the coast of the Ems the mosses were frequently "overflown by the river; they imbibed the water, "and swelled up, by this means, like a sponge. In "this state they often glided down as the river sub-"sided; there they remained in a semiliquid state. "An ingenious peasant seeing the cause of this, re-"solved to prevent it. He therefore cut off all com-"munication between the river and the moss, by

"means of a bank made of solid materials: piling "layer upon layer, as these sunk, they at last reach- "ed the bottom. From that time the moss was "never gorged up; what was within the bank re- "mained under the bed of the river, as formerly."

By this, or similar means, mosses may have glided down in a semiliquid state, and thus been lodged under the beds of rivers. Remaining there for ages, they may have been thus covered with a stratum of mud or clay; and thus alternate layers of moss and mud may have been formed at the mouths, or under the beds of rivers.

Accordingly, we find instances of this frequently occur along the coasts of the Baltic Sea and German Ocean, especially at the mouths of rivers. In boring to the depth of many feet, alternate layers of moss and clay and sand and slime are found. This can only be accounted for on the above hypothesis.

2. Mosses are sometimes found on a subsoil of bare solid rock. This is stated by Dr Anderson, with his wonted confidence, as an insurmountable objection against the hypothesis that is laid down in my first essay.—His words are, "What I conceive to be an "incontestible proof that moss may abound where "no wood ever existed, is, that the soil on the hilly "parts of South Uist, consisted entirely of moss, "without one particle of earth intervening between "it and the rock; and that rock was everywhere "a bed of solid granite, without a fissure in almost "any part of it, so that, wherever it formed a cavity,

" great or small, it was perfectly water-tight, like a " bason. I was at great pains to examine the hill " lakes which fell in my way, and these are nume- " rous, and I found no exception to this rule. In " these circumstances, I think it inconceivable, that " even wood of any kind could have existed before " the moss began to be formed."

He adds, " In the island of Lewis there is an ex- " tensive plain of about 30 miles in length, which " reaches nearly from sea to sea, and which is en- " tirely covered with moss. Its surface is very little " elevated above the level of the sea; and, in every " respect, its situation is so unfavourable for the pro- " duction of wood, as to render it extremely probable " none could ever have grown there."

In reply to this, I observe, that it is even conceivable that trees may have existed on the former of these islands. It is well known, that even on a bare rock, especially where there is a level or hollow, such as the Doctor describes in the island of Uist, a variety of moss plants will grow. As they accumulate, the moisture rises with them; they retain it like a sponge; and thus they form a soil fit for the growth of trees. De Luc mentions, that he has seen a detached block of stone covered with moss plants, upwards of a foot thick, and on this a large tree, growing as on its proper soil. That the island of Uist may have, at one time, been covered with wood, though originally a bare rock, is not inconceivable;

and that moss may have been formed on it, by a succession of aquatic plants, is equally conceivable.

As to the island of Lewis, it is certain that a forest once existed upon it. Though now destitute of growing timber, as the Doctor asserts, Mr Headrick says there are large trunks of oak, elder, birch, and especially of Scots fir, found in its extensive mosses. In the year 1800, that gentleman observed a considerable number of small stunted firs on the higher parts of that island, the remains of the antient and extensive fir woods.

If trees may have existed in Lewis, and even in Uist, and if aquatic plants may have flourished on both, as a favourable soil, there is no difficulty in conceiving how mosses may have been formed on these islands; nor is it unreasonable to suppose, that the same ligneous and aquatic plants which promote the growth of moss elsewhere, may have given origin to it there.

Even on the supposition that there is not one trunk or the smallest vestige of a tree in the above islands, or in the mosses they contain, still the origin of these mosses may be accounted for on the above hypotheses. Mosses and other aquatic plants may have furnished the materials; and the situation of these islands seems to be peculiarly favourable for the growth of these.

3. Mosses are found on the tops of high mountains, where a tree cannot now be made to strike root, or grow at all. Dr Anderson likewise takes notice of this: He says, that most of the hills on the west coast

of Scotland and the Hebrides are covered with moss, in situations so exposed to the winds and sea spray, that no wood of any kind has been seen to grow on such exposures. He might have added, that moss is found likewise on the Alps and Appenines, though now covered with perpetual snow; that they are found on the high mountains of Blocksburg, and even in the cold region of Iceland, in all which situations no tree nor shrub can now be seen*.

Yet, in all these situations, trees have been dug up out of these mosses; and in all of them aquatic plants have been found still in a growing state, even under the snow.

Whatever change of climate these mountains may have undergone, it is certain that the same ligneous and aquatic plants that form moss elsewhere are to be found there; so that these situations furnish the same materials, and (as I shall shew in the third essay), possesses the same advantages requisite to the formation of moss, as others where that substance abounds.

4. Moss is sometimes found in the bottom of the sea and of salt lakes. In such situations it could not be formed; how then can we account for the formation of it by ligneous or aquatic plants in such situations? Dr Anderson likewise takes notice of this:

* Villars mentions, that, in the canton of Oiseau, in the department of Isire, turf is found 7 or 8000 feet above the level of the sea, and 3000 above the level where trees now grow.

He says that, in the harbour of Oban, peat moss is found at the bottom of the sea, at the depth of 20 fathoms. All along the Dutch coast, and the shores of the Baltic Sea, the same phenomenon may be observed, &c. &c.

Yet even this may be accounted for on two hypotheses; either that the moss on the Continent has been carried by the current of the rivers into the sea, as often takes place with that particular species of peat called *darry* in Holland; or, that an inundation of the sea may have overwhelmed a part of the Continent where moss was already formed. Instances of both these events are recorded; and either of them may account for this phenomenon. I have mentioned some of these in my first essay, p. 52, 53; I shall name a few more.

The Baltic Sea, for instance, has made great inroads on Pomerania; it has overwhelmed in the deep the famous port of Vineto: the Norwegian Sea has formed many islands in that country by inundations: the German Ocean has buried under its waves the ancient Roman citadel, near to Call, which was formerly a sea-port town. A similar inundation separated Dodrecht from the mainland in 1421. In 1446, upwards of 10,000 souls were overwhelmed by an inundation in the territory of Dodrecht, and more than 100,000 in Friezland and Zealand.

That mosses may have been formed in these ill-fated districts before they were overwhelmed with the deep, is highly probable. But there are instances re-

corded in which this certainly was the case; and the dates of these are known: In the year 1717, the marsh of Wishhssen was buried in the deep, and the ruins of the ancient village may yet be seen under the waters. Fluiessen Meer was a wood in the year 489, when it was overwhelmed by the ocean. In 1222, the Zuyder Sea had no existence; it was formed at that period; till then it was a gulf. Yet it was partly inhabited, and contained a number of villages: A high sea, accompanied with an impetuous storm, overwhelmed all in the deep.

By similar inroads of the ocean, forests and mosses already formed may have been overwhelmed in different kingdoms; on the coast of Lincoln we have a striking example of this.

The mosses of Merionethshire, in Wales, which extend along the shore to Tomyn, reaching into the sea to an unknown extent, have probably undergone a similar fate.

5. Moss is often found under a deep bed of sand. This can easily be accounted for: On the Continent the dry hills called *duyns* consist of moving sands; these are often tossed by the winds, and thus flying about in all directions may have overrun these mosses. On the sea coast, where instances of this are often seen, they can be accounted for from similar causes; the winds and waves combine to move these sands: by their united operation, mosses may be buried deep in sand.

6. Moss is sometimes found under a bed of solid marl. Duhamel, junior, mentions an instance of this near the forest of Brotonne. It is 11 feet thick under the marl; it extends to upwards of 400 acres. This may be accounted for: It is certain that calcareous earth is often held in solution in water; the numberless petrifying springs which exist in all parts of the world are a sufficient proof of this; it were superfluous to enumerate these.

In general, I observe, that in Derbyshire, Yorkshire, Somersetshire, &c. and most of the counties in England, they abound.

These uniformly deposit the calcareous earth wherever they are allowed to stagnate. Some plants seem to have a more powerful attraction to it than others, or being more porous, they are more retentive of it. Mosses and liverworts are thereby petrified, while primroses and geraniums, which grow on the same spot, escape. Almost every species of vegetable, however, has been found in a petrified state; and bones of animals and other substances have submitted to the same change.

Some waters are so replete with this matter, that they speedily clog up the channels in which they run. An instance of this is mentioned at High Littleton, in the county of Somerset: A pipe had been constructed of an elm-tree, to convey the waters from a coal pit; though this was placed in a perpendicular direction in 1766, it was so obstructed by the sparry incrustation formed in the cavity, that it was no long-

er useful. In less than three years the miners were obliged to take it up. This incrustation was somewhat softer than marble, but harder than alabaster.

In Italy this process goes on in a very extended scale. The beds and banks of many rivers in that kingdom, but especially the basons in which the waters stagnate, are frequently filled up by this means.

Now, if any rill or river, impregnated with calcareous earth, happened in its course to run over a plane in which moss was formed, it is obvious that it must leave a sediment; this sediment being calcareous, would speedily be consolidated into marl or lime.

An instance of this I shall name. Mercatus says, that the river Velino, passing in its course the town of Reate, belonging to the Umbri, spread over the widely extended marshes, and formed the lake Velino. Overcoming its lofty banks, its waters were precipitated over a precipice; but the stony sediment it left so considerably filled up this cataract, as to shut up the waters, threatening to swallow up the adjacent fields of the Reatines. If the cataract was thus contracted, and at last shut up by the subsidence of calcareous matter, it is reasonable to suppose, that these extended marshes would be covered with a thick stratum of it; accordingly, it is said, similar inconveniencies were felt by the inhabitants. Every crevice was filled up with this matter, and all the loose soil over which these waters run was rendered

stony and barren, though formerly allotted for pasturage and corn.

Thus a stratum of calcareous earth may have been formed over a valley which was formerly a morass; and thus we may account for moss being sometimes found under a stratum of marl, or even of limestone.

It is known, too, that shells and calcareous matter are often found incorporated with the moss itself; these probably owe their origin to the shell-fish which existed in the marsh before it was converted into moss. If this marsh was occasionally overflowed by the sea, shell fish peculiar to that element may thus be expected. If the waters were fresh, other species may be looked for.

That innumerable shell fish may be found in many marshes is certain. It even appears probable, that they may exist and propagate after the marsh is partly converted into moss.

The Earl of Cromarty mentions an instance which renders this supposition less improbable. He says, that in a moss near the town of Elgin in Murray, though no river or water communicates with the moss, yet, for three or four feet deep, there are little shell fish resembling oysters, with living fish in them, in great quantities, though no such fish are found in the adjacent rivers, nor even in the water-pits in the moss, but only in the solid substance of the moss itself.

Dr Darwin justly considers this as a very curious fact. He thinks that it may account for the shells sometimes found on the surface of coal mines, and in the clay that accompanies these; and likewise for the stratum of shells which sometimes exists over iron ore.

At all events, it accounts for the shells and marl that is sometimes found incorporated with moss. It would be proper to search such mosses in order to discover what is the food of these fish. It is very improbable that the moss can furnish them any nourishment; and it appears that they do not live on the moss water, for in the water-pits dug in the moss no fish are found; and I shall have occasion to shew, that both moss and moss water are unfavourable to animal life; that few animals of any species exist in either, at least after the moss is formed. Perhaps the moss described by the ingenious Earl may have been, at that period, only a morass; and probably no living fish now exist in it. The reader who lives on the spot may examine this.

It is probable that the small shell-fish found in moss were either washed down into the level where such mosses now exist, or that they were formed there before, or during the time that the moss itself was growing. It is unnecessary to say that many species of shell fish exist in marshes and lakes; and it is well known, that water impregnated with calcareous earth, or carbonic acid, when it subsides in

such situations, consolidates these into marl, by enveloping and cementing them together.

Accordingly, marl found in such low levels always abounds with the same shell fish which are to be found in the adjacent heights. This is particularly the case in the Lake Constance, and along the banks of the Rhine, where shells are buried. Mr Coupe observes, that the same is the case at Corbeil, Hiere, St Thebant, Lagny, Chille, Montfermeil, Gagny, Montmorency, &c. &c.

Where marl is therefore found, either under moss or incorporated with it, the probability is, that it is formed of the shell-fish either washed down from the adjacent height, or of such as existed in that situation before the moss was formed, or while it was only a marsh or lake: it is not surprising, therefore, that it should be found above or below the moss, or incorporated with it.

7. Sometimes moss lies in alternate layers of coal. Du Hamel, junior, mentions an instance of this: He says that, in Provence, sometimes a foot or two of moss is found between two of coal. From the account he gives of that moss, it seems rather to resemble Bovey coal.

Beroldinguen mentions a curious case in Messner, one of the mountains of Hesse. The surturbrand was found there below a bed of basalt; yet the fibrous form and annular rings of the wood were distinct: Nay some logs were found cut into uniform lengths, bearing the marks of the hatchet and saw. He sup-

poses that this had been once a forest; that it had been overwhelmed by a volcanic eruption; that the coal and surturbrand were formed by this means.

I need scarcely mention, that,

8. Moss is sometimes found in Friezland and elsewhere, without any trees or evidences of ligneous plants. This is easily accounted for: Many mosses may have been formed entirely of aquatics; others may be water-borne. In either case, they must contain few or no trees. In the former case, none can be expected; in the latter, if the moss was in a fluid state, the trees, by their specific gravity, may have sunk in it before it flowed; the liquid loose moss alone being carried along the stream, no traces of its ligneous origin can be expected in it, after it has been deposited on its new base.

9. Dr Anderson takes notice of another fact, which he thinks does not quadrate with the idea that foggy peat consists of the sphagnum, &c. &c. "In most "mosses, (he observes,) there are found different strata "of different qualities. These are universally disposed "in different layers, so that the black peat sometimes "lies above the foggy peat, and *vice versa*. Now, if "it be supposed that the foggy is produced by the "sphagnum, &c. it must invariably have been found "on the surface only, and could never have been "formed below the good black peat."

In reply to this I observe, that it appears that it is only in Holland where this is the case. Degner says, that the best peat there is generally uppermost; that it is of a yellow brown colour; the spongy reedy

turf found deep in the bottom is not good fuel. In Groningen, he says, that the spongy peat is found on the surface, and the best below it.

In the mosses in Britain and on the Continent this is generally the case. De Luc states, indeed, that in the mosses of Bremen, the good and bad is sometimes found in alternate layers. But Mr Findorf gives a very plausible account of this: That, in dry summers, the ligneous plants prevail; in wet, the aquatic. That the alternate layers of black hard peat, the residuum of ligneous plants, and soft spongy peat, the residuum of aquatic mosses, &c. may thus be accounted for.

Nor is it unaccountable that, in the mosses of Holland, the fibrous spongy peat should form the substratum. These mosses all lie on a low level, little above that of the sea. In one stage of their formation, these may have been marshes. At that period reeds and rushes, and other aquatic plants, such as the sphagnum, may have flourished; thus materials may have been formed for the fibrous spongy peat called *darry*. At a future period, these mosses may have been overflown and converted into lakes. In this stage of their formation, the conferva, lemna, byssus, and other soft tender aquatics, may have flourished; these, by their rapid growth, may have furnished materials for the more compact and less fibrous peat on the surface.

The account that Degner gives of the stratification of the Dutch mosses corresponds with this.

" The surface of many of them is covered with " grass. After digging one or two feet through this, " the turf is laid open; the first tier of this is black- " ish red, very tenacious; it is, however, soft and " pulpy, and yields the best fuel. It is only about " two feet deep. The second stratum is somewhat " redder, equally tenacious, but still full of fibres. " The lowest stratum is much redder still; it is so " fibrous and spongy, that it appears like rotten " wood: this is the worst fuel. At the depth of " nine or ten feet, a sandy slime is laid open; this is " quite useless as a fuel."

If the reader consult what is stated in p. 128 and 129 of this essay, he will see how the above stratification of moss may be accounted for.

10. It has been questioned by some, and denied by others, that there are any mosses on the Continent of America.

Guicciardini says, that it is not known whether Asia, Africa, or America, contain any mosses, as no search has been made. Degner and Dr Anderson deny that there are any in these regions. The latter says that he has been assured, from very good authority, that there is not to be found on the whole continent of America a single particle of real and genuine peat moss. The former argues upon this as a fact: " If," says he, " forests are converted into moss, the " greatest part of Moscovy, Tartary, America, and " other woody uncultivated regions would have, ere

" now, undergone this change, which is not the " case."

To this I reply, 1*st*, That in woody regions, moss is of little value; it is never in request as a fuel, as the abundance of wood supplies its place. No efforts are made to search for it as a soil or a manure. The former can be procured in abundance; the latter is less requisite. Mosses, therefore, may exist in these regions, though no notice be taken of them.

2. Accordingly, in Russia they abound; many marshes and valleys in that empire are filled with it. This I am assured of from unquestionable authority.

Tooke, in his View of the Russian Empire, says, that in Siberia, there are abundance of morasses of different magnitudes. Towards the shores of the Frozen Ocean, for several hundred versts in width, is one prodigious watery morass, grown over with moss, and destitute of wood.

In the interior of the country are many smaller: He specifies four different kinds: 1. Low watery land; 2. Swamps which yield turf; 3. Bottomless morasses, which appear to be lakes overgrown; 4. Moss morasses, the deep and useless moss of which will permit neither grass nor shrub to grow.

3. In South America, at least on the Peruvian mountains, it has been discovered. I have also been informed by a gentleman who lived thirty years on the banks of the Mississippi, and had occasionally visited all the United States, that moss is frequently found in the vallies. He mentioned, that it is generally co-

vered with a green surface which conceals it from view; but below this many feet of moss is often found. He said that the skeleton of the bergamot in the possession of Mr Peel, was dug out of moss.

Till it be ascertained beyond a doubt that there is not to be found a particle of genuine peat in these regions, it would be superfluous to offer any reply to this objection, or to attempt to obviate this difficulty.

Having attempted to shew that moss is renovated, and pointed out the circumstances and time requisite, and the aquatic plants which promote this process; having also endeavoured to prove, that the same plants have contributed to the original formation of moss in marshes and lakes, and that many lakes and marshes have undergone this change; having likewise shewn that these aquatic plants may still be traced in their original organic form in many mosses, and pointed out a few of the distinguishing qualities of these plants, it only remains for me to shew to what General Conclusions this naturally leads us.

SECTION X.

GENERAL CONCLUSIONS.

I. The *first* general conclusion is, that moss is certainly of vegetable origin.

Some species may appear, at first sight, of doubtful origin; but the greatest part is obviously a congeries of vegetables. To be convinced of this, we need only to look at that substance. The organic structure of the very plants of which it is composed may be traced from the surface to the greatest depth. As might be expected, we may mark a progressive gradation from a state of perfect organization to an evanescent state, where this organization is totally destroyed.

In this last stage the origin of moss may appear dubious; and if it were only found in this state, it might be difficult to decide whether it was of vegetable or mineral origin; but, as the above gradation can easily be traced in every moss, it is fair and reasonable to explain the doubtful by the decisive, and the obscure by the luminous; and as most of mosses on the surface are clearly composed of a mass of vegetables, and as all moss, in all these gradations, is possessed of similar qualities, the conclusion is natural and irresistible, that they may all be traced to the same source.

Degner accordingly observes, that all moss, even the most compact, when diluted in water, and reduced to powder, if examined by the microscope, seems to consist of nothing but a congeries of leaves, branches, and roots of vegetables. He adds, that when the powder of peat is dried, it presents the same appearance. He therefore concludes, that it

is impossible to doubt that it is a congeries of vegetable matter.

II. *Secondly*, We may conclude that all moss is either composed of ligneous or aquatic plants; and that these furnish abundant materials for the purpose.

The leaves, the seeds, the twigs, the bark, and rind, with the roots, trunks, and branches of the former, lay the foundation of most mosses; over this the latter raises the superstructure.

On this supposition, it may be expected that ligneous plants would chiefly compose the lower strata; and that aquatics would abound most in the higher. This is accordingly the case wherever moss exists; even in those which seem chiefly to be composed of aquatics, and are still in a semiliquid state, wood is found at the depth of 10, 20, or 30 feet. Nine-tenths of the mosses of Europe are of this description.

No doubt, therefore, can remain as to the materials of which these are composed. The only point that may seem dubious is, whether these materials are sufficient for the purpose.

To remove all doubt on this particular, I shall give a rough calculation of the accumulation of these materials. To some this may appear fanciful. I may be condemned for building castles in the air. Of this the impartial public must judge; by their decision I am willing to stand or fall.

Supposing the forest which furnished the first materials for the formation of moss had stood only 500 years before it fell into ruins, the following calculation will be found moderate.

1. The leaves annually tossed by the winds, and washed down by the rains into the hollows of the woods, may have furnished, in that period, three feet of materials.

2. The seeds and twigs that dropped annually one foot.

3. The bark and rind, at the final ruin of the forest, six inches.

4. The white wood six inches.

5. The carbon of the wood, supposing it to be bituminated, nine inches.

Even on the supposition that this forest only stood one generation, five feet nine inches of materials are thus furnished: if it survived two or three generations, the account must be doubled or trebled, call it only ten feet, in round numbers.

Thus we have materials sufficient for a moss of considerable depth. But this is only the foundation of the building; over this an almost endless variety of aquatics rush up with rapidity. Supposing these only to add, in a century, three feet more materials, total 13 feet. By the continued operation of alluvion, and the other operations I have mentioned in the ninth section of this essay, and especially by an accumulation of moisture, equal in all moss to the half of its materials, and in many to the double of

them, we may safely suppose the above account to be doubled, say 26 feet.

Thus abundant materials are provided.

III. *Thirdly*, From the above account we may conclude, that many regions, now covered deep with moss, were at one period arable lands, at another forests, at a third lakes.

We may still trace these changes, and mark their progress in many mosses. For instance,

1. Under some mosses the marks of the plough, and even ears of corn and other grain, with various utensils of husbandry, have been found.

These are clear evidences that, at one period, the above surface was a ploughed field.

2. In these ridges a vast variety of trees are found, some standing erect, others fallen prostrate, but all with their roots fixed in this subsoil of arable land. This is a proof that, at a second and subsequent period, the surface was covered with a forest.

3. These trees are sometimes found immersed in moss of a semiliquid state, to the depth of 10, 20, or 30 feet; and aquatic plants, such as flourish in water, may be still traced through all its depth. Nothing can be a clearer proof than that this, at a third and subsequent period, has been a lake.

And, in this stage, some lakes are still found. Lough Neagh is an instance of this. Mr Smith, in his account of it, mentions, that part of this loch was formerly a forest: that this is the common tra-

dition among the inhabitants of that district: that it is probable, for much wood is found in it: that this wood is sunk in a kind of pulpy moss called mire, black at the bottom of the lake. If so, it will naturally be asked, why the whole loch has not been converted into moss? It is impossible for me to assign the reason. Perhaps the great extent of the surface, and the agitation of the waters by the winds, may be unfavourable for the growth of those aquatic plants which contribute to form moss; or, perhaps, the petrifying quality of the waters may be unfavourable for this purpose. If the aquatic plants above described grow in any sheltered bays of this loch, and if they are there accumulated, they may ultimately be converted into moss. This I mention merely to excite the attention of the intelligent part of the inhabitants of that district to the subject.

4. It is certain that, in other places, many lakes have been, by the above means, filled up and converted into mosses.

5. And it is equally certain that, at a subsequent period, these mosses, by consolidation, may have been converted into meadows, and afterwards into rich arable lands. Most of the fertile plains along the banks of rivers, in the north of Europe, are of this description; they, of course, generally lie on a subsoil of moss.

So that it is probable that many of these have, in the course of ages, undergone all the above changes, from arable lands to forests, from forests to lakes,

from lakes to mosses, from mosses to meadows, and from meadows to their original state of arable land; I call it their original state; but I think it probable that, before they were first cleared and cultivated, they were originally covered with wood.

It is natural to suppose, that many low levels, covered with wood, have been converted into morasses. The trees, by falling into decay, and stemming the course of rivers, may have occasioned such a stagnation of water as to cause this change. It is equally natural to suppose, that such low levels may have been converted into deep lakes. The mouths of rivers may have been so stemmed, by accidents such as I have described, p. 51 and 52 of my first essay, as to raise the waters in the valley to a level above all the plants and trees that originally sprung up and flourished in it. If this valley was of small extent, and the lake formed in it favourable for the growth of aquatic plants, the whole waters may have been first covered over with a matting of these. By consolidation, and the continual accession of vegetable matter, the whole lake may have thus been converted into a moss.

All those mosses which are deep, and contain trees, some standing erect and others prostrate on the original subsoil, and especially those which contain a rushy, reedy peat above these trees, and a black compact moss above this, seem to me to have undergone these changes; and the vast extent of mosses of this description over Europe, probably origi-

nated in this way. It were superfluous to enumerate instances of this. I shall only specify two; the first is Low Modena, which seems to have undergone all these changes; the second is the bog of Monela in Ireland, which seems to have been subjected to a similar succession. Ramazini describes the former; Carr, in his Stranger in Ireland, delineates the latter.

The stratification of the vicinity of Modena is somewhat singular. "The surface of the valley is "now a rich arable field. At the depth of 14 feet "below this, it is said that the rubbish and ruins of "an ancient city were discovered. Paved streets and "pieces of mosaic work were found at this depth: "below this the earth is solid, and seems not to have "been moved: lower down is a loose moist soil, mixed with vegetables; and, at the depth of 26 feet, "entire trees, such as filberts, with nuts, and a great "quantity of branches and leaves have been dug up. "At 28 feet deep a stratum of soft chalk, mixed "with shells, was discovered. This stratum is 11 "feet thick. Below this, at the depth of 40 or 50 "feet, there is to be found the soil of a low marshy "country, full of sedge, reeds, shrubs, roots of "trees, nuts, ears of corn, leaves of trees, branches, "and boughs." He even describes the species of wood. He says, that oak, elm, walnut, ash, and willow may be distinguished. "Some of these trees "are broken down, othere stand still upright as they "grew. Among these are found old Roman coins, "marbles, stones squared and cut by the hands of

" men. Each tree is found on the soil most adapted " to its production. The fir roots are fastened in the " sand, the oak in the clay."

The whole of this valley, he says, was a lake in the reign of Julius Cæsar. The surface is now drained and consolidated, and converted into arable land.

It seems obvious to me, that this valley has undergone all the changes above described; at one period it has probably been arable land; hence the ears of corn, &c. which have been discovered: subsequent to this it seems to have been overgrown with wood; hence the trunks and roots of trees: this wood seems afterwards to have been converted into a morass; hence the sedges and reeds, &c. which are found: this morass seems to have been after this consolidated by alluvion; hence the stratum of soft chalk and shells.

Above this, another generation of a forest seems to have sprung up; hence the other tier of branches and leaves of trees. This second generation seems to have undergone the same fate with the first; the moist soil mixed with vegetables above it, seems to be the remains of the marshy plants that must have sprung up after this forest was also converted into a morass.

This morass seems again to have been consolidated, probably by alluvion; hence the stratum of solid earth: on this the city seems to have been built; hence the paved streets, &c.: the 14 feet above this seems to have been formed after the city was overwhelmed with some inundation.

Whether the lake that existed on the spot at the age of Julius Cæsar was thus formed, it is impossible to decide. If so, however, the 14 feet of solid soil above this city, must have been formed since that period.

That many low lying vallies in different parts of the world have undergone similar changes, is not only probable but certain. The mosses of Ireland exhibit similar proofs of this: in digging deep into these, recumbent forests upon forests are found, with a layer of earth between.

This leads me to notice the other instance mentioned by Carr, in his Stranger in Ireland: He says, "that the bog of Monela is not far from the bog of "Allan: stumps of trees are still visible on the sur- "face of the former; under these lies a stratum of "turf 10 or 15 feet deep: under this, a tier of "prostrate tress is discovered; beneath these another "stratum of earth is found of considerable depth: "and below this a great number of stumps of trees "are found, standing erect as they grew. Thus, "there is a succession of three distinct forests lying "in ruins, one above the other."

He says, "Some of these mosses have been per- "forated deeper than 50 feet: at the bottom of "many of them, he observes, arable land has been "discovered, bearing the marks of the plough, and "formed into regular ridges."

These fragments of the natural history of mosses, may furnish us with some faint ideas of their origin

and formation. If we were to discover the hulk of a ship, or even a few beams, sunk in the ocean, we would be at no loss to say, that these were the remains of a wreck. The size of these beams might easily lead us to distinguish between the wreck of a frigate and a first-rate man of war. The state of preservation in which these are found, might give us some idea of the period at which the wreck happened.

It is precisely so in examining the history and origin of peat mosses. The ruined forests found in these leave us no doubt that they have been partly formed of the wrecks of these. The size and species of trees lead us to conclude what must have been the age of the forest when it fell into ruins. The state of preservation of these trees, and the depth of soil formed above them, may give us some faint idea of the period at which they fell. The remains of aquatic plants, reeds, and rushes, &c. found above them, give us likewise an idea of the cause of their ruin; and, the stratification of the soil, exhibits a view of the changes it has undergone in the lapse of ages.

IV. It is obvious, from the above statement, that moss, in favourable circumstances, is renovated with rapidity; it seems reasonable to conclude,

Fourthly, That it may have been originally formed with equal rapidity in similar circumstances.

The quantity of materials which a fallen forest may yield, has been calculated. The rapidity with which

aquatic plants may contribute to its subsequent increase, may be conceived from the following considerations:

First, These plants are generally very rapid in their growth; this point is fully established in the foregoing pages.

Secondly, Most of them vegetate, and even flourish, in the coldest climates, and some of them continue to grow all the year round.

Thirdly, While they are rapid in their growth, they are generally slow in decay, especially when immersed in water.

Fourthly, In this medium they are not diminished in bulk, but occupy nearly the same space that they did while in a growing state.

In place, therefore, of yielding only 100th part of the vegetable matter which a fertile soil produces, they must contribute more than the richest crop of wheat on the most fertile soil.

Mr De Luc says, that this is the case even on the lofty mountains of Blocksberg. His words are, "the "plants which continue to grow by the moisture of "the air above, and of the moss below, heap up "*twenty times* more materials annually than an or-"dinary soil produces."

From all these considerations combined, it appears reasonable to conclude, that moss may be formed with great rapidity in such situations.

Lastly, We may conclude, that (in place of requiring 900,000 years to form a moss 20 feet deep), the

deepest mosses which exist may have been formed, by the above natural process, in a much shorter period; and that the origin of these does not lead us back to a very remote æra.

Hitherto I have only endeavoured to ascertain what are the materials of which moss is composed, and to shew how these have been accumulated together. Were I to stop here, my object could not be attained; and, as all moss contains certain chemical qualities, different from recent vegetables of the above description, some doubts might still remain as to the origin of that singular substance.

It remains for me to shew, that these materials must naturally undergo certain chemical changes in the lapse of time; to point out precisely what these changes are; to ascertain the causes of these changes, and the consequences of them; and to point out the precise state in which these materials now appear; in other words, to shew what moss really is;—

This I reserve as the subject of the third and fourth essay.

I cannot, however, take leave of the public at this time, without pleading some apology; the length of these essays, and the loose style in which they appear, require this.

My great object has been to collect facts; and every fact that seemed to elucidate the subject, I have stated fully: this is the cause why these essays have swelled to such a size, and why they appear to be so

prolix. I cannot but flatter myself, that they may be valuable on account of this collection of facts, and on this account alone. As to the conclusions I have drawn from these, and the hypothesis I have stated, they may be false and ill founded. Of this the impartial public will now judge; and I leave them at full liberty to controvert every conclusion, and tear up every hypothesis root and branch: in place of feeling mortification, I shall rejoice to see the subject elucidated by an abler pen. All the favour I ask, (and I solicit it with importunity), is this, that if I have misrepresented any fact, or overlooked any thing of importance, they will be pleased to signify this without delay. It is on this account that I have resolved to publish these essays first, as they lay the foundation of my work; and before the subsequent part of it be published, I expect to receive much information, and many strictures.

As to the style, I acknowledge it is loose and desultory. In this shape it is not fit to meet the eye of the judicious critic; it claims the chastisement of the public; and all the apology I can plead, is, that elegance of style has not been my aim: perspicuity and precision is the utmost height of my ambition.

George Ramsay & Co. Printers,
Edinburgh, 1807.

ERRATA.

P. 20. l. 9. for Somana read Semana
P. 77. l. 8. for Woodhead, &c. *&c.* read *and*
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P. 121, *Note, foot,* for transcide, read transude
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