

magnesia, sparingly soluble in cold dilute acetic acid. This combination takes place between 130° and 200° C., at which temperatures the magnesian carbonate tends to pass into the still less soluble state of magnesite, in which, as we have shown, it no longer shows any disposition to unite with carbonate of lime. Hence it happens that in all our experiments a portion of magnesite is mingled with the dolomite, and cannot be completely separated from it. Dilute acids slowly attack both, but unequally, so that we finally obtain a residue which contains carbonate of magnesia free from lime: but the solution having taken up a portion of magnesite, contains more magnesia than is required to form a dolomite with the carbonate of lime; so that we have from 53.0 to 60.0 p. c. of magnesian carbonate instead of 45.0 as in pure dolomite. In nature the combination of the two carbonates has doubtless taken place slowly, and necessarily at the lowest temperature, which is probably much below 130° C., so that we may suppose that it is only in the absence of a sufficient quantity of carbonate of lime that a portion of the magnesian carbonate has been converted into magnesite.

(To be concluded in the next No.)

ART. XX.—*Extract from the concluding part of a Memoir on the Botany of Japan, in its Relations to that of North America, and of other parts of the Northern Temperate Zone; by ASA GRAY.**

IT is interesting to notice that, notwithstanding the comparative proximity of Japan to Western North America, fewer of its species are represented there than in far distant Europe. Also,—showing that this difference is not owing to the separation by an ocean,—that far more Japanese plants are represented in Eastern North America than in either. It is, indeed, possible that my much better knowledge of American botany than of European may have somewhat exaggerated this result in favor of Atlantic North America as against Europe, but it could not as against Western North America.

If we regard the identical species only, in the several floras, the preponderance is equally against Western as compared with Eastern North America, but is more in favor of Europe. For the number of species in the Japanese column which likewise occur in Western North America, is about 120: in Eastern North America, 134; in Europe, 157.

Of the 580 Japanese entries, there are which have corresponding

European representatives,	a little above 8.48 per cent of identical species,	0.27
Western N. American representatives,	about	0.37
Eastern	"	0.61

* Extracted from the *Memoirs of the American Academy of Arts and Sciences*, new series, vol. vi.

So geographical continuity favors the extension of identical species; but still Eastern North America has more in common with Japan than Western North America has.

The relations of this kind between the floras of Japan and of Europe are obvious enough; and the identical species are mostly such as extend continuously—as they readily may—throughout Russian Asia, some few only to the eastern confines of Europe, but most of them to its western borders. To exhibit more distinctly the features of identity between the floras of Japan and of North America, and also the manner in which these are distributed between the eastern and the western portions of our continent,—after excluding those species which range around the world in the northern hemisphere, or the greater part of it, or (which is nearly the same thing in the present view), which are unknown in Europe,—I will enumerate the remaining peculiar species which Japan possesses in common with America:—

<i>In Japan.</i>	<i>In W. N. America.</i>	<i>In E. N. America.</i>
Anemone Pennsylvanica		A. Pennsylvanica
(Coptis asplenifolia?)	C. asplenifolia	
(Trautvetteria palmata)	T. palmata	T. palmata
Caulophyllum thalictroides		C. thalictroides
Diphylleia cymosa		D. cymosa
Brasenia peltata	[B. peltata]	B. peltata
Geranium erianthum	G. erianthum	
Rhns Toxicodendron	R. Toxicod., var.	R. Toxicodendron
Vitis Labrusca (Thunb.)		V. Labrusca
Thermopsis fabacea	T. fabacea	
Prunus Virginiana?		P. Virginiana
Spiræa betulæfolia	S. betulæfolia	S. betulæfolia
Photinia arbutifolia, in Bonin.	P. arbutifolia	
Pyrus rivularis?	P. rivularis	
Ribes laxiflorum	R. laxiflorum	
(Penthorum sedoides, China)		P. sedoides
Cryptotænia Canadensis		C. Canadensis
Heracleum lanatum	H. lanatum	H. lanatum
(Archemora rigida?)		A. rigida
(Archangelica Gmelini)	A. Gmelini	A. Gmelini
Cymopterus littoralis?	C. littoralis	
Osmorrhiza longistylis	O. longistylis	O. longistylis
Echinopanax horridus	E. horridus	
Aralia quinquefolia		A. quinquefolia
Cornus Canadensis	C. Canadensis	C. Canadensis
Viburnum plicatum		V. plicatum (lantanoïdes)
*Achillea Sibirica	*A. Sibirica	
*Artemisia borealis	*A. borealis	*A. borealis
Vaccinium macrocarpon	V. macrocarpon	V. macrocarpon
Menziesia ferruginea	M. ferruginea	M. ferruginea
(Boschniakia glabra?)	B. glabra	
*Pleurogyne rotata	*P. rotata	*P. rotata

<i>In Japan.</i>	<i>In W. N. America.</i>	<i>In E. N. America.</i>
(<i>Asarum Canadense</i> ?)		<i>A. Canadense</i>
* <i>Polygonum Bistorta</i>	<i>P. Bistorta</i>	
<i>Rumex persicarioides</i>	<i>R. persicarioides</i>	<i>R. persicarioides</i>
<i>Liparis liliifolia</i>		<i>L. liliifolia</i>
<i>Pogonia ophioglossoides</i>		<i>P. ophioglossoides</i>
<i>Iris setosa</i>	<i>I. setosa</i>	
<i>Trillium erectum</i> , var.		<i>T. erectum</i>
(<i>Smilacina trifolia</i>)		<i>S. trifolia</i>
<i>Polygonatum giganteum</i>		<i>P. giganteum</i>
(<i>Streptopus roseus</i>)	<i>S. roseus</i>	<i>S. roseus</i>
<i>Veratrum viride</i>	<i>V. viride</i>	<i>V. viride</i>
<i>Juncus xiphioides</i>	<i>J. xiphioides</i>	
(<i>Cyperus Iria</i>)		<i>C. Iria</i>
<i>Carex rostrata</i>		<i>C. rostrata</i>
<i>Carex stipata</i>	<i>C. stipata</i>	<i>C. stipata</i>
<i>Carex macrocephala</i>	<i>C. macrocephala</i>	
<i>Sporobolus elongatus</i>	<i>S. elongatus</i>	<i>S. elongatus</i>
<i>Agrostis scabra</i>	<i>A. scabra</i>	<i>A. scabra</i>
<i>Festuca pauciflora</i>	<i>F. pauciflora</i>	
<i>Adiantum pedatum</i>	<i>A. pedatum</i>	<i>A. pedatum</i>
<i>Onoclea sensibilis</i>		<i>O. sensibilis</i>
<i>Osmunda cinnamomea</i>		<i>O. cinnamomea</i>
<i>Lycopodium lucidulum</i>		<i>L. lucidulum</i>
(<i>Lycopodium dendroideum</i>)	<i>L. dendroideum</i>	<i>L. dendroideum</i>

The names enclosed in parentheses are of species which I have not seen from Japan; some of them inhabit the adjacent mainland; some are imperfectly identified. Those marked * are high northern species in America.

Of those 56 extra-European species, 35 inhabit Western, and 41 Eastern North America. And 15 are Western, and not Eastern; 21 Eastern and not Western; and 20 common to both sides of the continent. Eight or ten of these 56 species extend eastward into the interior of Asia.

On the other hand, the only species which I can mention as truly indigenous both to Japan and to Europe, but not recorded as ranging through Asia, are

<i>Euonymus latifolius</i> ,	<i>Fagus sylvatica</i> ,	<i>Blechnum Spicant</i> ,
<i>Valeriana dioica</i> ,	<i>Streptopus amplexifolius</i> ,	<i>Athyrium fontanum</i> .
<i>Pyrola media</i> ,		

Two of these species extend across the northern part of the American continent, and on to the Asiatic; another occurs on the northwest coast of America; and another, the *Fagus*, is represented in Eastern America by a too closely related species. It is noteworthy, that not one of these seven plants is of a peculiarly European genus, or even a Europæo-Siberian genus;—while of the fifty-six species of the Americo-Japanese region wanting in Europe, twenty are of extra-European genera; seven-

teen are of genera restricted to the North American, East Asian, and Himalayan regions (except that *Brasenia* has wandered to Australia); fourteen of the genera (most of them monotypic) are peculiar to America and Japan or the districts immediately adjacent; one is peculiar to our northwest coast and Japan; and eight are monotypic genera wholly peculiar (*Brasenia* excepted) to the Atlantic United States and Japan. Add to these the similar cases of other American species (nearly all of them peculiarly Atlantic-American) which have been detected in the Himalayas or in Northern Asia,—such as *Menispermum Canadense* (*Dauricum*, DC.), *Amphicarpæa monoica?* *Clitoria Mariana*, *Osmorrhiza brevistylis*, *Monotropa uniflora*, *Phryma leptostachya*, *Tipularia discolor?* &c.,—and it will be almost impossible to avoid the conclusion, that there has been a peculiar intermingling of the Eastern American and Eastern Asian floras, which demands explanation.

The case might be made yet stronger by reckoning some subgeneric types as equivalent to generic in the present view, and by distinguishing those species or genera which barely enter the eastern borders of Europe; e. g. *Cimicifuga foetida*, *Mœhringia lateriflora*, *Geum strictum*, *Spiræa salicifolia*, &c.

It will be yet more strengthened, and the obvious conclusion will become irresistible, when we take the nearly allied, as well as the identical, species into account. And also when we consider that, after excluding the identical species, only 15 per cent of the entries in the European column of the detailed tabular view are in italic type (i. e. are *closely* representative of Japanese species); while there are 22 per cent of this character in the American column.

For the latter, I need only advert to some instances of such close representation, as of

<i>Trollius patulus</i>	by	<i>T. Americanus</i> ,
<i>Aquilegia Burgeriana</i>	"	<i>A. Canadensis</i> ,
<i>Rhus vernicifera</i>	"	<i>R. venenata</i> ,
<i>Celastrus scandens</i>	"	<i>C. articulatus</i> ,
<i>Negundo cissifolium</i>	"	<i>N. aceroides</i> ,
<i>Sophora Japonica</i>	"	<i>S. affinis</i> ,
<i>Sanguisorba tenuifolia</i>	"	<i>S. Canadensis</i> ,
<i>Astilbe Thunbergii & Japonica</i>	"	<i>A. decandra</i> ,
<i>Mitchella undulata</i>	"	<i>M. Repens</i> ,
<i>Hamamelis Japonica</i>	"	<i>H. Virginica</i> ,
<i>Clethra barbinervis</i>	"	<i>C. acuminata</i> ,
<i>Rhododendron brachycarpum</i>	"	<i>R. Catawbiense</i> ,
<i>Amsonia elliptica</i>	"	<i>Tabernæmontana</i> ,
<i>Saururus Loureiri</i>	"	<i>S. cernuus</i> ,

and many others of the same sort,—several of which, when better known, may yet prove to be conspecific; while an equally

large number could be indicated of species which, although more positively different, are yet no less striking counterparts.

To demonstrate the former proposition, I have only to contrast the extra-American genera common to Europe and Japan with the extra-European genera common to North America and Japan. The principal European genera of this category are *Adonis*, *Epimedium*, *Chelidonium*, *Malachium*, *Lotus*, *Anthriscus*, *Hedera*, *Asperula*, *Rubia*, *Carpesium*, *Ligularia*, *Lampsana*, *Picris*, *Pæderota*, *Ajuga*, *Thymus*, *Nepeta*, *Lamium*, *Ligustrum*, *Kochia*? *Daphne*, *Thesium*, *Buxus*, *Mercurialis*, *Cephalanthera*, *Paris*, *Asparagus*,—to which may as well be added *Pæonia* and *Bupleurum*, the former having a representative on the mountains, and the latter in the arctic regions, of Western America, but both absent from the rest of our continent. Excepting *Pæderota* and *Buxus* (the latter a rather doubtful native of Eastern Asia), none of these genera are peculiar to Europe, but all extend throughout Asia and elsewhere over large parts of the world.

The following incomplete list of North American genera or peculiar subgeneric types represented in Japan and its vicinity, but unknown in Europe, presents a very different appearance. Those which are absent from the flora of Western North America are italicised.

<i>Trautvetteria</i>	<i>Philadelphus</i>	<i>Asarum</i> § <i>Heterotropa</i>
<i>Cimicifuga</i> (barely reaches Europe)	<i>Penthorum</i>	<i>Phytolacca</i>
<i>Illicium</i>	<i>Hammelis</i>	<i>Benzoin</i> & <i>Sassafras</i> ?
<i>Magnolia</i>	<i>Liquidambar</i>	<i>Tetranthera</i>
<i>Cocculus</i> & <i>Menispermum</i>	<i>Cryptotænia</i>	<i>Saururus</i>
<i>Mahonia</i>	<i>Cymopterus</i> ?	<i>Pachysandra</i>
<i>Caulophyllum</i>	<i>Archemora</i>	<i>Laportea</i>
<i>Diphylleia</i>	<i>Osmorrhiza</i>	<i>Pilea</i>
<i>Brasenia</i>	<i>Aralia</i> & § <i>Ginseng</i>	<i>Bœhmeria</i>
<i>Nelumbium</i>	<i>Echinopanax</i>	<i>Microptelea</i>
<i>Dicentra</i>	<i>Diervilla</i>	<i>Maclura</i>
<i>Stuartia</i> (& <i>Gordonia</i> ?)	<i>Mitchella</i>	<i>Juglans</i>
<i>Zanthoxylum</i>	<i>Oldenlandia</i>	<i>Abies</i> § <i>Tsuga</i>
<i>Cissus</i>	(<i>Siegesbeckia</i> , in Mexico)	<i>Chamæcyparis</i>
<i>Ampelopsis</i>	<i>Cacalai</i> (reaches E. Europe)	<i>Torreya</i>
<i>Berchemia</i>	<i>Gaultheria</i>	<i>Arisæma</i>
<i>Æsculus</i>	<i>Leucothoë</i>	<i>Arctiodracon</i>
<i>Sapindus</i>	<i>Pieris</i>	<i>Pogonia</i>
<i>Negundo</i>	<i>Clethra</i>	<i>Arethusa</i>
<i>Thermopsis</i>	<i>Menziesia</i>	<i>Dioscorea</i>
<i>Wistaria</i>	<i>Symplocos</i>	<i>Aletris</i>
<i>Desmodium</i>	<i>Ardisia</i>	<i>Coprosmanthus</i>
<i>Lespedeza</i>	<i>Boschniakia</i>	<i>Trillium</i>
<i>Rhynchosia</i>	<i>Catalpa</i>	<i>Clintonia</i>
<i>Sophora</i>	<i>Tecoma</i>	<i>Streptopus</i> § <i>Hekorima</i> ,
	<i>Dicliptera</i>	<i>Chamæcirium</i> ?

Photonia	<i>Leptandra</i>	Sporobolus
<i>Astilbe</i>	<i>Callicarpa</i>	<i>Arundinaria</i>
Mitella'	<i>Cedronella</i>	Adiantum
<i>Hydrangea</i>	<i>Amsonia</i>	<i>Onoclea</i>
<i>Itea</i>		

Here are about 90 extra-European genera or forms, 64 of which are absent from Western North America out of the tropics (the latter comprising a very large part of the most striking representative species), and almost as many more are divided between North America and extra-tropical (chiefly Northern and Eastern) Asia. About 40 of the latter are genera or groups of single, or else of two or few closely related species, peculiar, or nearly peculiar, to the regions just mentioned.

This list should be supplemented by those additional North American genera which have one or more closely representative species in the Himalayan region only, such as *Podophyllum*, *Pyrolaria*, &c.; and also by the numerous cases in which Eastern American plants are represented in the Himalayo-Japanese region by strikingly cognate, although not congeneric species; such as our *Macrotys* by *Pityrosperma*; *Schizandra* by *Kadsura* and *Sphærostema*; *Neviusia* by *Kerria* and *Rhodotypus*; *Calycanthus* by *Chimonanthus*; *Cornus florida* by *Benthamia*; *Prosartes* by *Disporum*; *Helonias* by *Heloniopsis*; and so of others, which have been mentioned in the former part of this memoir, and exhibited in the accompanying tabular view.

I had long ago, in Silliman's Journal, presented some data illustrative of this remarkable parallelism, and also more recently in my "Statistics of the Flora of the Northern United States" (vol. xxii, second series); where I had noticed the facts,—1. that a large percentage of our extra-European types are shared with Eastern Asia; and 2, that no small part of these are unknown in Western North America. But Mr. Bentham was first to state the natural conclusion from all these data,—though I know not if he has even yet published the remark,—viz., that the interchange between the temperate floras even of the western part of the Old World and of the New has mainly taken place *via* Asia. Notwithstanding the few cases which point in the opposite direction (e. g. *Eriocaulon septangulare*, *Spartina*, *Subularia*, *Betula alba*), the general statement will be seen to be well sustained. Also, in the Journal of the Proceedings of the Linnæan Society, 2. p. 34, Mr. Bentham "calls to mind how frequently large American genera (such as *Eupatorium*, *Aster*, *Solidago*, *Solanum*, &c.) are represented in Eastern Asia by a small number of species, which gradually diminish or altogether disappear as we proceed westward toward the Atlantic limits of Europe; whilst the types peculiar to the extreme west of Europe (excluding of course the Arctic flora) are wholly deficient in America.

These are among the considerations which suggest an ancient continuity of territory between America and Asia, under a latitude, or at any rate with a climate, more meridional than would be effected by a junction through the chains of the Aleutian and the Kurile Islands."

I shall presently state why connection in a more meridional latitude need not be supposed.

The deficiency in the temperate American flora of forms at all peculiar to Western Europe is almost complete, and is most strikingly in contrast with the large number of Eastern American forms repeated or represented in Eastern Asia. Of genera divided between Eastern North America and Europe, I can mention only *Ostrya*, *Nartheceum*, *Psamma*, the maritime *Cakile*, and perhaps *Scolopendrium*. *Hottonia* might have been added, but for a species accredited to Java. And if we extend the range across our continent, we add only *Cercis* and *Læstingia*. Of the ampler genera at all characteristic of the European flora, I can enumerate from the Flora of the Northern United States nothing more important than *Helianthemum* and *Valerianella*, two or three species of each, (but those of the former hardly congeners of the European ones,) adding that *Hieracia* and perhaps *Cirsia* are somewhat more plentiful in Eastern than in Western America. Let it also be noted, that there are even fewer Western-European types in the Pacific than in the Atlantic United States, notwithstanding the similarity of the climate!

That representation by allied species of genera peculiar, or nearly peculiar, to two regions, furnishes evidence of similar nature and of equal pertinency with representation by identical species, will hardly be doubted. Whether or not susceptible of scientific explanation, it is certain that related species of phænogamous plants are commonly associated in the same region, or are found in comparatively approximate (however large) areas of similar climate.* Remarkable exceptions may indeed be ad-

* The fundamental and most difficult question remaining in natural history is here presented;—the question whether this actual geographical association of congeneric or other nearly related species is primordial, and therefore beyond all scientific explanation, or whether even this may be to a certain extent a natural result. The only noteworthy attempt at a scientific solution of the problem, aiming to bring the variety as well as the geographical association of existing species more within the domain of cause and effect, is that of Mr. Darwin and (later) of Mr. Wallace,—partially sketched in their short papers "On the Tendency of Species to form varieties, and on the Perpetuation of Varieties and Species by natural Means of Selection," in the Journal of the Proceedings of the Linnæan Society, vol. iii. (Zoölogy), p. 45. The views there suggested must bear a prominent part in future investigations into the distribution and probable origin of species. It will hardly be doubted that the tendencies and causes indicated are really operative; the question is as to the extent of their operation. But I am already disposed, on these and other grounds, to admit that what are termed closely related species may in many cases be lineal descend-

duced, but the fact that they are remarkable goes to confirm the proposition. Indeed, the general expectation of botanists in this regard sufficiently indicates the common, implicit opinion. The discovery of a new *Sarracenia* or a new *Halesia* in the Atlantic United States, or of a new *Eschscholtzia*, *Platystemon*, or *Calais* west of the Rocky Mountains, would excite no surprise. A converse discovery, or the detection of any of these genera in a remote region, would excite great surprise. The discovery of numerous closely related species thus divided between two widely separated districts might not, in the present state of our knowledge, suggest former continuity, migration, or interchange; but that of identical species peculiar to the two inevitably would.

Why should it? Evidently because the natural supposition is that individuals of the same kind are descendants from a common stock, or have spread from a common centre; and because the progress of investigation, instead of eliminating this preconception from the minds of botanists, has rather confirmed it. Every other hypothesis has derived its principal support from difficulties in the application of this. A review of what has been published upon the subject of late years makes it clear that the doctrine of the local origin of vegetable species has been more and more accepted, although, during the same period, species have been shown to be much more widely dispersed than was formerly supposed. Facts of the latter kind, and the conclusions to which they point, have been most largely and cogently brought out by Dr. Hooker, and are among the very important general results of his extensive investigations. And the best evidence of the preponderance of the theory of the local origin of species, notwithstanding the great increase of facts which at first would seem to tell the other way,—is furnished by the works of the present De Candolle upon geographical botany. This careful and conscientious investigator formerly adopted and strenuously maintained Schouw's hypothesis of the double or multiple origin of species. But in his great work, the *Géographie Botanique Raisonnée*, published in the year 1855, he has in effect discarded it, and this not from any theoretical objections to that view, but because he found it no longer needed to account for the general facts of distribution. This appears from his qualified, though dubious, adherence to the hypothesis of a double origin, as a *dernier ressort*, in the few and extraordinary cases which he could hardly explain in any other way. His decisive instance, indeed, is the occurrence of the Eastern American *Phryma leptostachya* in the Himalaya Mountains.

ants from a pristine stock, just as domesticated races are; or, in other words, that the limits of occasional variation in species (if by them we mean primordial forms) are wider than is generally supposed, and that derivative forms when segregated may be as constantly reproduced as their originals.

The facts presented in the present memoir effectually dispose of this subsidiary hypothesis, by showing that the supposed single exception belongs to a not uncommon case. Indeed, so many species are now known to be common to Eastern and Northern Asia and Eastern North America,—some of them occurring also in Northwestern America and some not,—and so many genera are divided between these two regions, that the antecedent improbability of such occurrence is done away, and more cases of the kind may be confidently expected. However others may regard them, it is clear that De Candolle would now explain these cases in accordance with the general views of distribution adopted by him, under which they naturally fall,—so abandoning the notion of a separate creation.

I know not whether any botanist continues to maintain Schouw's hypothesis. But its elements have been developed into a different and more comprehensive doctrine, that of Agassiz, which should now be contemplated. It may be denominated the *autochthonal* hypothesis.

In place of the ordinary conception, that each species originated in a local area, whence it has been diffused, according to circumstances, over more or less broad tracts,—in some cases becoming widely discontinuous in area through climatic or other physical changes operating during a long period of time,—Professor Agassiz maintains, substantially, that each species originated where it now occurs, probably in as great a number of individuals occupying as large an area, and generally the same area, or the same discontinuous areas, as at the present time.

This hypothesis is more difficult to test, because more ideal than any other. It might suffice for the present purpose to remark, that, in referring the actual distribution, no less than the origin, of existing species to the Divine will, it would remove the whole question out of the field of inductive science. Regarded as a *philosophical* question, Maupertuis's well known "principle of least action" might be legitimately urged against it; namely, "that it is inconsistent with our idea of Divine wisdom, that the Creator should use more power than was necessary to accomplish a given end." This philosophical principle holds so strictly true in all the mechanical adaptations of the universe, as Professor Peirce has shown, that we cannot think it inapplicable to the organic world also, and especially to the creation of beings endowed with such enormous multiplying power, and such means and facilities for dissemination, as most plants and animals. Why then should we suppose the Creator to do that supernaturally which would be naturally effected by the very instrumentalities which he has set in operation?

Viewed, however, simply in its *scientific* applications to the question under consideration, (the distribution of plants in the

temperate zone of the northern hemisphere,) the autochthona hypothesis might be tested by inquiring whether the primitive or earliest range of our species could possibly have remained unaffected by the serious and prolonged climatic vicissitudes to which they must needs have been subject; and whether these vicissitudes, and their natural consequences, may not suffice to explain the partial intermingling of the floras of North America and Northern Asia, upon the supposition of the local origin of each species. Let us bring to the inquiry the considerations which Mr. Darwin first brought to bear upon such questions, and which have been systematically developed and applied by the late Edward Forbes, by Dr. Hooker, and by Alphonse De Candolle.

No one now supposes that the existing species of plants are of recent creation, or that their present distribution is the result of a few thousand years. Various lines of evidence conspire to show that the time which has elapsed since the close of the tertiary period covers an immense number of years; and that our existing flora may in part date from the tertiary period itself. It is now generally admitted that about 20 per cent of the Mollusca of the middle tertiary (miocene epoch), and 40 per cent of the pliocene species on the Atlantic coast still exist; and it is altogether probable that as large a portion of the vegetation may be of equal antiquity. From the nature of the case, the direct evidence as respects the flora could not be expected to be equally abundant. Still, although the fossil plants of the tertiary and the post-tertiary of North America have only now begun to be studied, the needful evidence is not wanting.

On our northwestern coast, in the miocene of Vancouver's Island, among a singular mixture of species referable to *Salix*, *Populus*, *Quercus*, *Planera*, *Diospyros*, *Salisburia*, *Ficus*, *Cinnamomum*, *Personia*, or other *Proteaceæ*, and a Palm (the latter genera decisively indicating a tropical or subtropical climate), Mr. Lesquereux has identified one existing species, a true characteristic of the same region ten or fifteen degrees farther south, viz., the Redwood or *Sequoia sempervirens*. In beds at Somerville referred to the lower or middle pliocene by Mr. Lesquereux, this botanist has recently identified the leaves of *Persea Carolinensis*, *Prunus Caroliniana*, and *Quercus myrtifolia*, now inhabiting the warm sea-coast and islands of the Southern States.*

The pliocene quadrupeds of Nebraska also show that the climate east of the Rocky Mountains at this epoch was much warmer than now. About the Upper Missouri and Platte there were then several species of Camel (*Procamelus*) and allied Ruminantia and a Rhinoceros, besides a Mastodon, an Elephant, some Horses

* These and other data, obligingly communicated by Mr. Lesquereux, have been published in the May number of the American Journal of Science and Arts.

and their allies, not to mention a corresponding number of carnivorous animals. These herbivora probably fed in a good degree upon herbage and grasses of still existing species. For herbs and grasses are generally capable of enduring much greater climatic changes, and are therefore likely to be even more ancient than trees. These animals must have had at least a warm-temperate climate to live in: so that in lat. 40° – 43° they could not have been anywhere near the northern limit of the temperate flora of those days; indeed the temperate flora, which now in Western Europe touches the Arctic Circle, must then have reached equally high latitude in Central, or Western North America. In other words, the temperate floras of America and Asia must then have been conterminous (with small oceanic separation), and therefore have commingled, as conterminous floras of similar climate everywhere do.

At length, as the post-tertiary opened, the glacier epoch came slowly on,—an extraordinary refrigeration of the northern hemisphere, in the course of ages carrying glacial ice and arctic climate down nearly to the latitude of the Ohio. The change was evidently so gradual that it did not destroy the temperate flora, at least not those enumerated above as existing species. These and their fellows, or such as survive, must have been pushed on to lower latitudes as the cold advanced, just as they now would be if the temperature were to be again lowered; and between them and the ice there was doubtless a band of subarctic and arctic vegetation,—portions of which, retreating up the mountains as the climate ameliorated and the ice receded, still scantily survive upon our highest Alleghanies, and more abundantly upon the colder summits of the mountains of New York and New England;—demonstrating the existence of the present arctic-alpine vegetation during the glacial era; and that the change of climate at its close was so gradual that it was not destructive to vegetable species.

As the temperature rose, and the ice gradually retreated, the surviving temperate flora must have returned northward *pari passu*, and—which is an important point—must have advanced much farther northward, and especially northwestward, than it now does; so far, indeed, that the temperate floras of North America and of Eastern Asia, after having been for long ages most widely separated, must have become a second time conterminous. Whatever doubts may be entertained respecting the existence of our present vegetation generally before the glacial era, its existence immediately after that period will hardly be questioned. Here, therefore, may be adduced the direct evidence recently brought to light by Mr. Lesquereux, who has identified our live oak (*Quercus virens*), Pecan (*Carya oliviformis*), Chinquapin (*Castanea pumila*), Planer-tree (*Planera Gme-*

lina), Honey-Locust (*Gleditschia triacanthos*), *Prinos coriaceus*, and *Acorus Calamus*,—besides an elm and a *Ceanothus* doubtfully referable to existing species,—on the Mississippi, near Columbus, Kentucky, in beds which Mr. Lesquereux regards as anterior to the drift. Professor D. D. Owen has indicated their position “as about 120 feet lower than the ferruginous sand in which the bones of the *Megalonyx Jeffersonii* were found.” So that they belong to the period immediately succeeding the drift, if not to that immediately preceding it. All the vegetable remains of this deposit, which have been obtained in a determinable condition, have been referred, either positively or probably, to existing species of the United States flora, most of them now inhabiting the region a few degrees farther south.

If, then, our present temperate flora existed at the close of the glacial epoch, the evidence that it soon attained a high northern range is ready to our hand. For then followed the second epoch of the post-tertiary, called the *fluvial* by Dana, when the region of St. Lawrence and Lake Champlain was submerged, and the sea there stood five hundred feet above its present level; when the higher temperate latitudes of North America, and probably the arctic generally, were less elevated than now, and the rivers vastly larger, as shown by the immense upper alluvial plains, from fifty to three hundred feet above their present beds; and when the diminished breadth and lessened height of northern land must have given a much milder climate than the present.

Whatever the cause, the milder climate of the fluvial epoch is undoubted. Its character, and therefore that of the vegetation, is decisively shown, as geologists have remarked, by the quadrupeds. While the *Megatherium*, *Myiodon*, *Dicotyles*, &c. demonstrate a warmer climate than the present in the Southern and Middle United States, the *Elephas primigenius*, ranging from Canada to the very shores of the Arctic Ocean, equally proves a temperate climate and a temperate flora in these northern regions. This is still more apparent in the species of the other continent, where, in Siberia, not only the *Elephas primigenius*, but also a Rhinoceros, roamed northward to the arctic sea-coast. The quadrupeds that inhabited Europe in the same epoch are well known to indicate a warm-temperate climate as far north as Britain, in the middle, if not the later post-tertiary. North America then had its herds of Mastodons, Elephants, Buffaloes or Bisons of different species, Elks, Horses, *Megalonyx*, the Lion, &c.; and, from the relations between this fauna and that of Europe, there is little doubt that the climate was as much milder than the present on this as on the other side of the ocean. All the facts known to us in the tertiary and post-tertiary, even to the limiting line of the drift, conspire to show that the difference between the two continents as to temperature was very nearly the same then

as now, and that the isothermal lines of the northern hemisphere curved in the directions they now do.

A climate such as these facts demonstrate for the fluvial epoch would again commingle the temperate floras of the two continents at Behring's Straits, and earlier—propably through more land than now—by way of the Aleutian and Kurile Islands. I cannot imagine a state of circumstances under which the Siberian Elephant could migrate, and temperate plants could not.

The fluvial was succeeded by the "terrace epoch," as Dana names it, "a time of transition towards the present condition, bringing the northern part of the continent up to its present level, and down to its present cool temperature,"*—giving the arctic flora its present range, and again separating the temperate floras of the New and of the Old World to the extent they are now separated.

Under the light which these geological considerations throw upon the question, I cannot resist the conclusion, that the extant vegetable kingdom has a long and eventful history, and that the explanation of apparent anomalies in the geological distribution of species may be found in the various and prolonged climatic or other physical vicissitudes to which they have been subject in earlier times;—that the occurrence of certain species, formerly supposed to be peculiar to North America, in a remote or antipodal region affords of itself no presumption that they were originated there;—and that the interchange of plants between Eastern North America and Eastern Asia is explicable upon the most natural and generally received hypothesis, (or at least offers no greater difficulty than does the Arctic flora, the general homogeneousness of which round the world has always been thought compatible with local origin of the species,) and is perhaps not more extensive than might be expected under the circumstances. That the interchange has mainly taken place in high northern latitudes, and that the isothermal lines have in earlier times turned northward on our eastern, and southward on our northwest coast, as they now do, are points which go far towards explaining why Eastern North America, rather than Oregon and California, has been mainly concerned in it, and why the temperate interchange, even with Europe, has principally taken place through Asia.

Brasenia peltata.—To the remarks upon the known range of of this species, I have now to add the interesting fact, that it exists upon the northwestern coast of America, having been gathered by Dr. Pickering, in Wilkes's South Sea Exploring Expedition, in a stream which falls into Gray's Harbor, lat. 47°. It must be

* For the collocation and communication of the geological data here presented, I am indebted to the kindness of my friend, Professor Dana.

local on the western side of the continent, or it would have been met with before. When this remarkable plant was known to occur only in Eastern North America and Eastern Australia, it made the strongest case in favor of double creation that perhaps has ever been adduced. But since it has been found to occur throughout the Eastern Himalayas and in Japan, and has now been detected in Northwestern America also, the case seems to crown the conclusions to which this memoir arrives.

ART. XXI.—*Supplement to an Enumeration of North American Lichens, continued*; by EDWARD TUCKERMAN, A.M., Professor of Botany in Amherst College.

THE species follow each other, as before, in the order of the arrangement proposed by Dr. Nylander, who has studied these plants in the light afforded by a knowledge which includes not only the external, but all the microscopical details. Some species, not North American as yet known, but of more or less interest in connection with our flora, are added in brackets.

COLLEMA APALACHENSE, Tuck. in litt., thallo stellato multifido imbricato crassiusculo fusco-viridi, laciniis plano-convexis apice subteretibus obtusis rugulosis, subtus pallidis; apotheciis innato-sessilibus planis rufescentibus margine integerrimo. Sporæ ellipsoideæ 3-septatæ diam. vix duplo longiores. Lime-rocks, Hancock county, Alabama, *Hon. T. M. Peters*.

COLLEMA TEXANUM, sp. nova, thallo orbiculari substellato imbricato crasso luteo-virescente, laciniis radiantibus elongatis subplanis profunde pinnato-laceris papulosis; apotheciis sparsis planiusculis rufis margine tumido integro. Sporæ minimæ fusiformes uniseptatæ.—Trees, Texas, *Mr. Charles Wright*. Resembles the more perfect forms of *C. pulposum*. Spores exceedingly small. I am indebted, for their detection and delineation, to my friend, the Rev. J. L. Russell.

LEPTOGIUM CRENATELLUM, sp. nova, thallo imbricato tenerissimo glauco-cinerascente, laciniis rotundatis crenatis denticulatis; apotheciis minusculis creberrimis sessilibus convexis pallido-fuscescentibus margine tenui pallescente subintegro evanescente. Sporæ ellipsoideæ 5-septatæ.—On trees in swamps, Brattleborough, Vermont, *Mr. C. C. Frost*.

LEPTOGIUM JUNIPERINUM, Tuck. in litt., thallo pusillo suborbiculari imbricato tenui plumbeo e lobis rotundatis adscendentibus crenatis subtus ad margines albo-fibrillosis; apotheciis sessilibus plano-convexis margine tenui demum evanido discum rufofuscum cingente. Sporæ ellipsoideæ apicibus acutæ 3-septatæ.—On the earth in cedar woods, Texas. *Mr. Wright*.

CALICIUM CURTISII, sp. nova, thallo byssaceo nigro (vel obsoleto) apotheciis minutis turbinatis disco subnitido nigro stipitibus brevibus ex albido rufescentibus demum nigris. Sporæ majusculæ ellipsoideæ vel elongato-ellipsoideæ (dactylinæ, *Koerb.*) fuscescentes simplices.—On the living bark of *Rhus typhina*, in Berkshire, Massachusetts; and of *Robinia Pseudacacia*, at the Hot Springs, Virginia, *Rev. Dr. Curtis*. The stipes like those of *Calicium* or *Coniocybe nigricans*, Fr. (not of Tuckerm. Synops. Lich. N. E. which is *C. subtile*, on Bark) but the apothecia quite different, and the spores very much larger than in that species; as in *C. eusporum*, Nyl., to which, and *C. byssaceum*, Fr., the lichen is probably nearest.

BÆOMYCES ABSOLUTUS, sp. nova, thallo crustaceo effuso tenuissimo submembranaceo læteviridi; apotheciis stipitatis incarnatis planis disco demum convexiusculo marginem tenuem excludente. Sporæ ellipsoideæ simplices hyalinæ. Biatora icmadophila, var. stipitata, Tuckerm. in litt. ad cel. Montagne.—On the earth, Alabama, *Mr. Peters*. [Mountains of Cuba, *Mr. Wright*. Venezuela, *Mr. Fendler*.] Representing possibly, in tropical America, both *B. ericetorum* (*B. roseus*, Auctt.) and *B. æruginosus* (*Biat. icmadophila*, Auctt.) but nearest to the last, which it seems to connect, naturally, with the first.

[*CLADONIA DACTYLOTA*, sp. nova, thalli squamulis amplis erectis subtus albo-pulverulentis podetia gracilescentia cylindrica membranaceo-corticata lævigata viridi-pallescentia e margine proferentibus, scyphis angustatis margine subincurvis denticulatis demum oblique prolifero-palmatis; apotheciis carneo-fuscescentibus.

Var. β , *symphycarpia*, podetiis elongatis scyphis subintegris (vel obsoletis) apotheciis conglomeratis.

Var. γ , *sorediata*, podetiis hinc inde, scyphisque, vel his oblitteratis apicibus clavatis cornutisve sorediis pulvinatis albis adsperis.—On the earth in the mountains of Cuba, *Mr. Wright*. Venezuela, *Mr. Fendler*. Differs from *C. fimbriata* as *C. digitata* differs from *C. deformis*. The primary form is hardly distinguishable from *C. digitata*, except in being whiter, and in the color of the apothecia. The white, cushion-like, powdery soredia, which, in what seems to be the commonest state, take the place of the apothecia, and are scattered over the smooth podetia (in the latter case appearing clearly to be deliquescent squamules) make perhaps the most striking, however an abnormal feature of this elegant *Cladonia*.]

STEREOCAULON NANODES, sp. nova, podetiis pumilis erectis cæspitose-conglomeratis subnudis validis tereti-compressis a basi vage apicemque versus fastigiato-ramosis albidis, phyllocladiis ad apices confertis e rotundato-subsquamaceis glaucis demum

pulverulentis; apotheciis terminalibus dilatatis demum convexis. Sporæ generis. *S. nanum*, Tuck. Synops. N. E. p. 46, pr. p.—Rocks near water, (Crystal Falls; Saco Falls; Upper Gorge of the Ammonoosuck) in the White Mountains. *S. nanum* of European authors (Fr. Lich. Suec. n. 59; Schær. Lich. Helv. n. 588; Moug. and Nestl. Crypt. Vog. n. 647) appears to be an atypical condition, and has not yet occurred with us, but I have hitherto taken the present as representing the perfect state of the species. The full development of our lichen seems however to indicate a different affinity, and to separate it from the section (*Chondrocaulon*, Th. Fr.) which includes *S. nanum*. It is perhaps rather nearer to *S. denudatum*.

STEROCAULON CHLORELLUM, sp. nova, podetiis pumilis erectis glabris nitidis subcompressis lacunosis stramineis fastigiato-ramosis, phyllocladiis ad apices confertis minutis rotundatis mox deliquescentibus pulverulentis; apotheciis—Rocks, Islands of Behring's Straits, *Mr. Wright*. At once distinguishable by its minuteness, smoothness, and pale-yellow or straw color. The granules (phyllocladia, Th. Fr.) are exceedingly small. The apothecia are as yet unknown.

STEREOCAULON? WRIGHTII, sp. nova, thallo cæspitose cartilagineo subfoliaceo glaucescente, ramis laciniæformibus adscendentibus extrorsum latioribus inciso-ramosis crenatis margine inflexis crispatis supra viridescentibus subtus nervosis tenuiter tomentosus; cephalodiis majusculis pulvinatis viridi-nigrescentibus plicato-rugosis demum floccosis; apotheciis—Rocks, Islands of Behring's Straits, *Mr. Wright*. With the habit of erect states of *Squamaria chrysoleuca*, but the cephalodia of *Stereocaulon*. It is perhaps not impossible that these little understood developments should occur outside of the present genus, or that this lichen should be *sui generis*. The crisped margins take often the shape of *Parmeliaceous* apothecia, thus increasing the general resemblance of the plant to a *Squamaria*. But it has also evident points of similarity to *Stereocaulon? pulvinatum*, Ach., an obscure Cape of Good Hope lichen, for specimens of which I am indebted to Dr. Sonder of Hamburg. The apothecia of this last also are unknown.

[ALECTORIA JAPONICA, sp. nova, thallo subcæspitose tereti rigido sorediis albis exasperato stramineo, ramis sterilibus ramissimis implexis attenuatis subfilamentosis, fertilibus simpliciusculis incrassatis, apicibus nigricantibus; apotheciis subterminalibus superficiali-sessilibus appendiculatis disco concavo demum expanso plano nitido castaneo. Sporæ majusculæ ellipsoideæ limbatae viridi-fuscescentes demum subhyalinæ.—On dead pine trees, Ayan, Japan, *Mr. Wright*. Nearest to *A. ochroleuca*, but differing very much in habit, and in fructification. The spores are not very unlike those of *Pertusaria pertusa*.]

[*RAMALINA DASYPOGA*, sp. nova, thallo filamentoso rigidiusculo fragili tereti lævigato viridi-fuscescente (pallescente) ramis elongatis dichotome ramosis ultimis acuminatis nodulosis; apotheciis concavis demum planis repandis margine tenui incurvo subcrenulato disparente. Sporæ ellipsoideæ uniseptatæ curvulæ hyalinæ diam. duplo longiores.—On trees and rocks in the mountains of Cuba, *Mr. Wright*. Allied to *R. usneoides* (Ach.) Nyl., which has also been found in Cuba, by the same unwearied collector, but differs in its regularly terete thallus, larger apothecia, &c. It is still more like a pendulous *Usnea*, or perhaps *Alectoria*; but possesses the spores of the present genus.]

CETRARIA CALIFORNICA, sp. nova, thallo cæspitoseo cartilagineo anguloso lacunoso-subcanaliculato opaco e viridi fuscescente, ramis irregulariter subdichotome ramosis patentibus, fertilibus superne incrassatis; apotheciis terminalibus appendiculatis margine dentato-fimbriatis demum convexis nigris.—On the bark of trees, Monterey, California, *Menzies*. Fronds in small, roundish masses, many branches diverging from a single base, with the aspect rather of a small, slender state of *Ramalina calicaris*, β , than of the erect *Cetrariæ*, to which, and in particular *C. tristis* and *C. aculeata*, it is indeed, if I mistake not, nearest allied. The station, upon trees, and on the coast of California, is a very unlikely one for *C. aculeata*, from which the present also differs remarkably in habit of growth, and in color. Though more than seventy years have passed since the venerable botanist who gave me these specimens collected them, they appear to be undescribed.

STICTA RAVENELII, sp. nova, thallo pusillo suborbiculari membranaceo appresso scrobiculato viridi-glaucoscente (fuscescente) laciniis elongatis sinuato-lobatis crenatis (glomerulis fruticulosus viridibus nunc aspersis) subtus fuscescentibus tomentosus; apotheciis sparsis margine inflexo persistente crenulato-sublobato. Sporæ elongato-fusiformes 1-3-septatæ virescentes diam. 12-20-plo longiores.—Trees, in the low country of South Carolina, *Mr. Ravenel*; Alabama, on trees, *Mr. Peters*; and also on rocks (the specimen dark brown), *Mr. Beaumont*; Mississippi, *Dr. Veitch*; Louisiana, *Dr. Hale*; (Cuba, *Mr. Wright*).—A smaller plant than either of the two species of this group, of the northern hemisphere, with much the lobation of *S. glomerulifera*, but the texture of *S. herbacea*, and distinguished, so far as my specimens go, from both, by its strongly pitted upper surface, and its crenulate-lobate apothecia, which rather approach those of some of the tropical members of the group, as *S. pallida*, Hook. The glomerules appear only on a Cuban specimen. They are quite like those of *S. glomerulifera*, but the largest do not exceed a line in diameter. The spores are more elongated than those of the species just mentioned, and appear to be differently septate.

[*STICTA WRIGHTII*, sp. nova, thallo subcoriaceo adpresso lævigato viridi-glaucescente, laciniis rotundatis sinuato-incisis crenatis subtus fuscis ambitu pallescentibus tomentosus, cyphellis plano-concavis albis; apotheciis sparsis elevatis extus mammillatis e concavo margine inflexo demum planis margine irregulari subevanescente. Sporæ late fusiformes uniseptatæ limbatae virescentes diam. c. 5-plo longiores.—On beech trunks, mountain sides, Hakodadi, Japan, *Mr. Wright*. With the apothecia, and the general aspect of *S. glomerulifera*, but differing in a rather more loose habit of lobation, it which it approaches nearer to the broader forms of *S. damæcornis*; in its spores; and most remarkably, in possessing in abundance, regular cyphellæ; which resemble those of *S. fuliginosa*, though also occurring urceolate, as in *S. damæcornis*. The genus *Ricasolia*, De Not., was originally constituted, to include the natural group of species to which the present belongs, on a mistaken comparison of the apothecia of these species, with certain abnormal apothecia common in other species of *Sticta*, which are now regarded, since the publication of Mr. Tulasne's important researches, as morbid conditions, infested by a parasitic cryptogam. (Tulasne, *Mém. sur les Lichens*, p. 123, note.) The species included in the group, agreeing as they do in many obvious features, were also once supposed to be destitute of cyphellæ, and the greater part, and in particular, the tropical ones, probably are so; but Fries and Delise testify to the occurrence of this development, however rarely, in both the old species of the northern hemisphere, while in the Japanese lichen, above-described, it is normal. This species may not improbably be found to occur also in North America.]

[*PHYSICIA?* *WRIGHTII*, sp. nova, thallo orbiculari imbricato tenui molliusculo polito pallide viridi (glaucescente) subtus albo venis minusculis prominulis villosis reticulato, hypothallo nunc crassiusculo byssaceo-lanuginoso cinerascete, laciniis planis irregulariter multifido-lacinulatis, ambitu latioribus palmatis, centro plus minus excrescentiis isidiomorphis cylindricis obsitis; apotheciis subcentralibus sessilibus disco plano luteolo margine crasso incurvo crenulato cincto demum flexuosis. Sporæ—On trunks of trees in dense woods, in the mountains of Cuba, *Mr. Wright*. With the habit of *Physcia*, but also a good deal resembling *Parmelia ambigua*. The species appears to be undescribed.]

LECANORA ASCOCISCANA, Tuck. herb. *Psoroma*, Tuckerm. suppl. &c. in *Amer. Journ. Sci.*, xxv, p. 424. There is something in this curious lichen which suggests a near affinity to *Psoroma*, as the genus is constituted by Dr. Nylander, but the fuscous, often a little curved and kidney-shaped, one-septate

spores indicate its true place in *Lecanora*, where it long stood in my herbarium. The spores resemble those (I owe the suggestion to Dr. Nylander) of *L. sophodes*, but the lichen is very distinct.

[*LECANORA CAMPALEA*, sp. nova, thallo crustaceo tartareo verrucoso-subplicato lævigato viridi-glaucescente (pallescente) hypothallo nigro insigni limitato; apotheciis appressis demum flexuoso-irregularibus disco tumente e rufo fusco-nigrescente margine thallode integro pallente. Sporæ suboctonæ elongato-fusiformes 5-pluriseptatæ diam. 10-15 plo longiores hyalinæ.—Trees, Island of Cuba, *Mr. Wright*. The affinity of this elegant lichen to *L. ventosa* is indicated, no less by the spores than by the external characters.]

[*BIATORA RHODOPIS*, sp. nova, thallo crustaceo effuso tenui cartilagineo-membranaceo lævigato rimuloso limitato glauco-cinerascente, intus miniato; apotheciis sessilibus hinc inde aggregatis demum difformibus margine tumidulo integerrimo lævi mox flexuoso saturate roseo discum subplanum nudum rufo-nigrescentem hypothecio crassiusculo nigro impositum cingente. Sporæ suboctonæ ellipsoideæ simplices diam. duplo longiores hyalinæ.—On bushes in the Island of Cuba, *Mr. Wright*. Differs remarkably from described species, but has somewhat of the general aspect of *L. domingensis*.

BIATORA VIRELLA, sp. nova, thallo crustaceo effuso incrustante subtartareo rugoso-granulato glauco-sulphureo, humecto viridi; apotheciis sessilibus margine tenui pallidiori integerrimo mox flexuoso evanido discum planoconvexum rufo-fuscescentem cingente. Sporæ minusculæ ellipsoideæ subfusiformes diam. triplo longiores hyalinæ.—On rocks in dense woods, in the mountains of Cuba, *Mr. Wright*. With the habit of *L. glebulosa*.

BIATORA PYRRHOMELÆNA, sp. nova, thallo e granulis minutis rotundatis mox subsquamaceis imbricatis glaucescentibus intus miniatis hypothallum crassum rufo-nigricantem ad ambitum prominentem interrupte obtegentibus; apotheciis ex hypothallo oriündis subplanis margine tenuissimo erecto flexuoso rufo-nigrescente discum nigrum nitidum hypothecio rufo impositum cingente, dein conglomeratis convexis marginem excludentibus. Sporæ minutæ ellipsoideæ simplices hyalinæ.—On trunks of trees near the ground, in the mountains of Cuba, *Mr. Wright*. Near to *B. parvifolia*, but differing as described.

BIATORA PHÆASPIS, sp. nova, thallo crustaceo effuso e granulis subsquamaceis mox corallinis pallide ochroleucis; apotheciis appressis rufo-fuscis flexuosis disco demum convexo marginem obtusum pallidiorem excludente. Sporæ fusiformi-cylindricæ 1-4-septatæ diam. 3-4-plo longiores hyalinæ.—Trees, Cuba, *Mr. Wright*. Also resembling *B. parvifolia* in general appearance,

but the spores connect the lichen rather with *B. vernalis*. It does not appear to be described.]

GYROSTOMUM CERTISII, Tuckerm. suppl. in Amer. Journ. Sci., xxv, p. 430, a determination made upon high authority, is referred by my friend Mr. Russell to *Lecidea*; and the spores, as his sketch fully shows, indicate that the lichen is probably only a small form of *L. disciformis* (*L. parasema*, Fr. *a*) in which the apothecia are a little urceolate. *G. urceolatum* is also referred to *Lecidea* by Dr. Nylander (Enum. Gen., p. 127) but seems to me to be remarkably distinguished by the structure of the apothecium, and the vermicular spores.

ART. XXII.—*On the Phenomena of Gemmation.*—Lecture before the meeting of the Royal Institution of Great Britain, by THOMAS H. HUXLEY, F.R.S.*

THE speaker commenced by stating that a learned French naturalist, M. Duvau, proposed many years ago, to term the middle of the eighteenth century, "l'Époque des Pucerons:" and that the importance of the phenomena which first brought to light by the study of these remarkable insects renders the phrase "Epoch of Plant-lice," as applied to this period, far less whimsically inappropriate than it might at first sight seem to be.

After a brief sketch of the mode of life of these Plant-lice, or *Aphides*, as they are technically termed; of the structure of their singular piercing and sucking mouths; and of their relations to what are called "Blights;" the circumstances which have more particularly drawn the attention of naturalists to these insects were fully detailed.

It was between the years 1740 and 1750, in fact, that Bonnet, acting upon the suggestions of the illustrious Reaumur, isolated an *Aphis* immediately after its birth, and proved to demonstration, that not only was it capable of spontaneously bringing forth numerous living young, but that these and their descendants, to the ninth generation, preserved a similar faculty.

Observations so remarkable were not likely to pass unheeded; but notwithstanding the careful sifting which they have received, Bonnet's results have never been questioned. On the contrary, not only have Lyonet, Degeer, Kyber, Duvau, and others, borne ample testimony to their accuracy, but it has been shown that, under favorable conditions of temperature and food, there is practically no limit to this power of asexual multiplication, or as it has been conveniently termed, "Agamogenesis."

* From the Proceedings of the Royal Institution of Great Britain, May, 1858,

Thus Kyber bred the viviparous *Aphis Dianthi* and *Aphis Rosæ* for three years in interrupted succession; and the males and true oviparous females of the *A. dianthi* have never yet been met with. The current notion that there is a fixed number of broods, "nine or eleven," is based on a mistake.

As, under moderately favorable conditions, an *Aphis* comes to maturity in about a fortnight; and as each *Aphis* is known to be capable of producing a hundred young, the number of the progeny which may eventually result from a single *Aphis* during the six or seven warm months of the year is easily calculated. M. Tougard's estimate adopted, (and acknowledged) by Morren, and copied from him by others, gives the number of the tenth brood as one quintillion. Supposing the weight of each *Aphis* to be no more than $\frac{1}{1000000}$ th of a grain, the mass of living matter in this brood would exceed that in the most thickly populated countries in the world.

The agamogenetic broods are either winged or wingless. The winged forms at times rise into the air, and are carried away by the wind in clouds; and these migrating hordes have been supposed to be males and females, swarming like the ants and bees! During the summer months it is unusual to meet other than viviparous *Aphides*, whether winged or wingless; but ordinarily, on the approach of cold weather, or even during warm weather, if the supplies of food fall short, the viviparous *Aphides* produce forms which are no longer viviparous, but are males and oviparous females. The former are sometimes winged, sometimes wingless. The latter, with a single doubtful exception, are always wingless.

The oviparous females lay their eggs, and then, like the males, die. It commonly happens also that the viviparous *Aphides* die, and then the eggs are left as the sole representatives of the species; but in mild winters many of the viviparous *Aphides* merely fall into a state of stupor and hibernate, to re-awake with the returning warmth of spring. At the same time the eggs are hatched and give rise to viviparous *Aphides*, which run through the same course as before. The species *Aphis*, therefore, is fully manifested not in any one being or animated form, but by a cycle of such, consisting of,—1st. the egg; 2nd, An indefinite succession of viviparous *Aphides*; 3rd, Males and females eventually produced by these, and giving rise to the egg again.

If, armed with the microscope and scalpel, we examine into the minute nature of these processes (without which inquiry all speculation upon their nature is in vain), we find that the viviparous *Aphis* contains an organ similar to the ovarium of the oviparous female, in some respects, but differing from it, as Von Siebold was the first to show, in the absence of what are termed

the colleterial glands and the spermatheca—organs of essential importance to the oviparous form.

In the terminal chambers of this "Pseud-ovarium," ovum-like bodies, thence called "pseud-ova," are found. These bodies pass one by one into the pseudovarian tubes, and there gradually become developed into young, living *Aphides*. As Morren has well said, therefore, the young *Aphides* are produced by "the individualization of a previously organized tissue."

The only organic operation with which this mode of development can be compared, is the process of budding or gemmation as it takes place in the vegetable kingdom, in the lower forms of animal life, and in the process of formation of the limbs and other organs of the higher animals. And the parallel is complete if such a plant as the bulbiferous lily or the *Marchantia*, or such an animal as the *Hydra*, is made the term of comparison.

Thus agamogenesis in *Aphis*, is a kind of internal budding or gemmation. If we inquire how this process differs from multiplication by true ova or "Gamogenesis," we find that the young ovum in the ovarium is also, to all intents and purposes, a bud, indistinguishable from the germ in the pseudovarium of the agamogenetic *Aphis*. Histologically there is no difference between the two; but there is an immense qualitative or physiological difference, which cannot be detected by the eye, but becomes at once obvious in the behavior of the two germs after a certain period of their growth. Dating from this period, the pseudovum spontaneously passes into the form of an embryo, becoming larger and larger as it does so; but the ovum simply enlarges, accumulates nutritive matter, acquires its outer investments, and then falls into a state of apparent rest, from which it will never emerge, unless the influence of the spermatozoon have been brought to bear upon it.

That the vast physiological difference between the ovum and the pseudovum should reveal itself in the young state by no external sign, is no more wonderful than that primarily the tissue of the brain should be undistinguishable from that of the heart.

The phenomena which have been described, were long supposed to be isolated, but numerous cases of a like kind, some even more remarkable, are now known.

Among the latter, the speaker cited the wonderful circumstances attending the production of the drones among bees, as described by Von Siebold; and he drew attention to the plant upon the table, *Cælobogyne ilicifolia*, a female euphorbiaceous shrub, the male flowers of which have never yet been seen, and which nevertheless, for the last twenty years, has produced its annual crop of fertile seeds in Kew Gardens.

Not only can we find numerous cases of agamogenesis similar to that exhibited by *Aphis* in the animal and vegetable worlds,

but if we look closely into the matter, agamogenesis is found to pass by insensible gradations into the commonest phenomena of life. All life, in fact, is accompanied by incessant growth and metamorphosis; and every animal and plant above the very lowest attains its adult form by the development of a succession of buds. When these buds remain connected together, we do not distinguish the process as anything remarkable; when on the other hand, they become detached and live independently, we have agamogenesis. Why some buds assume one form and some another, why some remain attached and some become detached, we know not. Such phenomena are for the present the ultimate facts of biological science; and we cannot understand the simplest among them, it would seem useless, as yet, to seek for an explanation of the more complex.

Nevertheless, an explanation of agamogenesis in the *Aphis* and in like cases has been offered. It has been supposed to depend upon "the retention unchanged of some part of the primitive germ-mass;" this germ-mass being imagined to be the seat of a peculiar force, by virtue of which it gives rise to independent organisms.

There are however two objections to this hypothesis: in the first place, it is at direct variance with the results of observation; in the second, even if it were true, it does not help us to understand the phenomena. With regard to the former point, the hypothesis professes to be based upon only two direct observations, one upon *Aphis*, the other upon *Hydra*; and both these observations are erroneous, for in neither of these animals is any portion of the primitive germ-mass retained, as is said to be, in that part which is the seat of agamogenesis.

But suppose the fact to be as the hypothesis requires; imagine that the terminal chamber of the pseudovarium is full of nothing but "unaltered germ-cells;" how does this explain the phenomena? Structures having quite as great a claim to the title of "unaltered germ-cells" lie in the extremities of the acini of the secreting glands, in the sub-epidermal tissues and elsewhere; why do not they give rise to young? Cells, less changed than those of the pseudovarium of *Aphis*, and more directly derived from the primitive germ-mass, underlie the epidermis of one's hand; nevertheless, no one feels any alarm lest a nascent wart should turn out to be an heir.

On the whole, it would seem better, when one is ignorant, to say so, and not to retard the progress of sound inquiry by inventing hypotheses involving the assumption of structures which have no existence, and of "forces" which, their laws being undetermined, are merely verbal entities.