2. There are at least 11 dorsal vertebræ, perhaps two or three more.

3. The great comparative and absolute length (21 feet) of the cervical series, a striking analogy to that exhibited in the struthious birds.

4. The actual number of dorsals in Diplodocus seems to be 11, but cannot be definitely determined from our skeleton, and we must await further discoveries for its solution.

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Carnegie Museum.

PLANT GEOGRAPHY OF NORTH AMERICA. III.

THE LOWER AUSTRAL ELEMENT IN THE FLORA OF THE SOUTHERN APPALACHIAN REGION. A PRELIMINARY NOTE.*

In that portion of the United States which lies south of the Potomac and Ohio Rivers and east of the Mississippi, three principal orographical areas are readily distinguishable. These are generally known as the Pine Barren or Low Country (Coastal Plain), the Piedmont or Middle Country and the Mountains or Upper Country. Their respective characteristics—climatic, physiographical and biological—have been so often described in popular and scientific writings that to enumerate them here would be superfluous. So obvious are their distinguishing features, that no observant traveler fails to take note of them as he crosses the southeastern States.

The altitudinal limits of these three areas coincide roughly with those of three great continental life zones, *i. e.*, the Lower Austral Zone in its humid or Austro-riparian Area; the Carolinian Area of the Upper Austral, and the Alleghanian Area of the Transition Zone.*

The Coastal Plain, presenting but scant diversity in its orography, is occupied almost exclusively by a Lower Austral fauna and flora. In the Piedmont Region the surface of the country is less uniform and we encounter within its general boundaries many scattered localities where conditions permit the occurrence of Lower Austral or of Transition colonies amid the prevailing Carolinian life. But in the Mountain Region there exists such a variety of conditions that all the life zones from Lower Austral to Hudsonian are represented in places, although their limits are here very ill-defined, and the precise location of them presents many intricate problems.

Thus along the higher Smoky Mountains and the Blue Ridge, we find a typically Canadian forest of firs (*Abies Fraseri*), accompanied by such trees and shrubs as the yellow birch (*Betula lutea*), mountain ash (*Sorbus americana*), mountain maple (*Acer spicatum*), red elder (*Sambucus racemosa*) and wild red cherry (*Prunus pennsylvanica*). Other characteristically Canadian species like the striped maple (*Acer pennsylvanicum*), hemlock (*Tsuga canadensis*), white pine (*Pinus Strobus*) and the arbor vitæ (*Thuya occidentalis*) descend to much lower elevations (900 meters or less). Along the crest of the highest mountains of this region, usually at an altitude of 1,800 meters (6,000 feet) or upwards, a sparse Hudsonian flora is encountered. The green alder (*Alnus viridis*), and, of herbs, *Arenaria groenlandica*,

* In the matter of nomenclature, in this paper, I have followed that employed by Britton and Brown in their 'Illustrated Flora of the Northern United States and Canada.' But in order to be understood by readers who are not familiar with that nomenclature, I have added, in parentheses, the synonym generally current among American botanists before the adoption of the 'Rochester Code,' wherever a change has been made under that code.

* For a definition and description of these zones see Merriam in *Nat. Geogr. Mag.*, 6: pp. 220–238, Maps, 1894. Also, 'Life Zones and Crop Zones of the United States'; Bull. Div. Biol. Survey, U. S. Dept. Agric., 10: pp. 18–33, Map, 1898 (with a correction of the temperature data), in Science 9: No. 212, p. 116 (1899).

Potentilla tridentata, and *Trisetum subspicatum*, may be regarded as typical of this zone.

By far the greatest part of the surface of the mountain region is covered with an Alleghanian (Transition) flora. To this zone may be reckoned such woody species as the cherry birch (*Betula lenta*), species of Magnolia (*Umbrella, acuminata, Fraseri*), sugar maple (*Acer saccharum*), the big laurel (*Rhododendron maximum*), mountain laurel (*Kalmia latifolia*), etc. Mingled with these are black walnut (*Juglans nigra*), tulip tree (*Liriodendron tulipifera*), shag-bark and mocker-nut hickories (*Hicoria ovata* or *Carya alba* and *H. alba* or *Carya tomentosa*), white and chestnut oaks (*Quercus alba* and *Q. Prinus*), holly (*Ilex opaca*), chestnut (*Castanea dentata*), witch hazel (*Hamamelis virginiana*) and beech (*Fagus americana*, or *ferruginea*) which are perhaps somewhat more characteristic of the Alleghanian flora, but are hardly less abundant in the Carolinian.

The lower slopes of the mountains and the valleys between are largely occupied by extensions of the Upper Austral (Carolinian) Zone. Very characteristic species, especially along the streams, are buttonwood (*Platanus occidentalis*), river birch (*Betula nigra*), linden (*Tilia heterophylla*), hackberry (*Celtis occidentalis*), sweet gum (*Liquidambar styraciflua*), red mulberry (*Morus rubra*), sassafras (*Sassafras officinale*), persimmon (*Diospyros virginiana*), tupelo (*Nyssa sylvatica*), and species of pine, notably the scrub pine (*P. virginiana* or *inops*), and the yellow pine (*P. echinata* or *mitis*). Usually intermingled with these are numerous partially Transition species, *e. g.*, beech and American elm (*Ulmus americana*). The dried summer slopes add to this list such species as the chinquapin (*Castanea pumila*), sourwood (*Oxydendrum arboreum*) and black-jack oak (*Quercus marylandica* or *nigra*).*

Growing amid the often very large body of Carolinian forms, thus established in the region we are considering, there occurs a much smaller number of species which are most abundant in and characteristic of the Austro-riparian area of the Lower Austral Zone. Only two or three trees and comparatively few shrubs which are distinctly of the Lower rather than the Upper Austral Zone extend into the mountain region. But of herbs the number is a respectable one. Over one hundred species which are most abundant and most widely distributed in the Austro-riparian area are known to occur in the mountains at an elevation of 300 meters (1,000 feet) or more.

A faint indication of this Lower Austral element is perceptible as far north as West Virginia and southeastern Kentucky; while, on the mostly isolated granitic outcrops in northern central Georgia and northern Alabama, of which Stone Mountain is a type, it is so extensive as somewhat to obscure the mainly Carolinian character of the flora. In the former case the Austro-riparian forms are few and unimportant. In the latter instance the stations are so inferior in elevation, are so nearly isolated from the principal mountain chains and are so close to the main borders of the Austro-riparian area as to possess small significance as extensions of that area. Hence we had best confine ourselves here chiefly to that portion of the Appalachian Region which falls within the limits of North Carolina and Tennessee. Here we find some of the highest elevations of eastern North America; and therefore we are justified in regarding as of peculiar interest the presence in their neighborhood of numerous essentially Lower Austral forms of plant life.

It may be well to limit still further the scope of the present investigation by omitting from discussion species which do not reach

* I have purposely omitted from the above lists such species as are endemic in the Southern Appalachian Region, as being less suitable to indicate the general zonal relationships.

an elevation of 300 meters (1,000 feet). Below that altitude, the flora of the Southern Appalachian Region is mainly Carolinian, and the presence in its midst of numerous Austro-riparian forms would be expected. The occurrence of Lower Austral species at higher elevations, in the midst of a chiefly Transition flora is the phenomenon which demands our attention.*

Some of the species occurring on Lookout Mountain, but not reported from other stations in the mountains, *e. g.*, *Pinus Taeda*, *Cebatha carolina* (*Cocculus carolinus*), *Vaccinium arboreum* and *Spigelia marilandica*, also extend farther up the Tennessee Valley. Finally a considerable number of Lower Austral species, which are encountered rather rarely among the mountains, are frequent or common along the Tennessee River, near Knoxville (elevation 270 meters). We may cite:

Poa Chapmaniana.
Arundinaria macrosperma.
Arundinaria tecta.
Yucca filamentosa.
Agave virginica.
Centrosema virginiana.
Hypericum densiflorum.
Hypericum virgatum.
Callicarpa americana.
Aster concolor.
Tetragonetheca helianthoides
Helenium nudiflorum.

The Austro-riparian species which are met with in the region thus defined do not always grow scatteringly among Carolinian forms. Not infrequently, in peculiarly favorable localities, such as the diminutive pine barrens which cover sandy river bottoms and the dry, sunny lower slopes of the hills, they occur in numbers so pronounced that a botanist suddenly set down amongst them might be puzzled for a moment as to his zonal whereabouts. Yet a two or three hours' walk would take him through a typical Transition vegetation into that which is almost wholly Canadian. Two colonies of this character with which I am personally familiar are worthy of more detailed description.

Along the French Broad River below Paint Rock, North Carolina, and just within the limits of Tennessee, the stream is bordered by limited strips of flat land, which are mostly covered by a small growth of yellow pine (*Pinus echinata* or *mitis*), with frequent clearings among the trees. The altitude of the river-banks is here from 345 to 360 meters (1,150 to 1,200 feet) above the sea. In these groves the herbaceous flora is, as it were, a bit of the carpet of the coastwise pine-barrens, which has been laid down intact along the banks of a mountain stream. The following list of species, all of which are abundantly represented, indicates the character of this flora. It will be noticed that Gramineæ, Leguminosæ and Compositæ contribute a very large proportion.

Erianthus alopecuroides.
Andropogon argyræus.
Chrysopogon nutans var. *Linnæanus.*
Sporobolus asper.
Danthonia sericea.
Gymnopogon ambiguus (*G. racemosus*).
Triodia Chapmani.
Cratægus uniflora (*C. parvifolia*).
Morongia angustata (*Schrankia angustata*).
Cracca spicata (*Tephrosia spicata*).
Stylosanthes riparia.
Rhynchosia erecta.
Croton glandulosus.

* Naturally the extent of Lower Austral invasion is greatest along the water-courses of the region. Thus, in the valley of East Tennessee, which is in much of its length fully one hundred miles wide between the Great Smokies southeastward and the Cumberland Range towards the north and west, there occur at an elevation of 240 to 270 meters not a few typically Austro-riparian species which apparently do not penetrate those smaller mountain valleys which are situated above 300 meters. Examples are:

Agrostis Elliottiana.
Ampelopsis cordata (*Cissus Ampelopsis*).
Cynoctonum Mitreola (*Mitreola petiolata*).
Nemophila microcalyx.
Lithospermum tuberosum.
Diapedium brachiatum (*Dicliptera brachiata*).
Eupatorium incarnatum.

Vitis rotundifolia.
Hypericum Drumondii.
Bignonia crucigera (*B. capreolata*).
Elephantopus tomentosus.
Eupatorium aromaticum.
Chrysopsis graminifolia.
Silphium Asteriscus.
Silphium compositum.

Another noteworthy Austro-riparian colony occurs at a mean elevation of about 300 meters (1,000 feet), in the cañon-like valley of the Hiwassee River, in extreme southeastern Tennessee. Here the number of almost purely Lower Austral Gramineæ is particularly striking. Some of the most important species are:

Erianthus alopecuroides.
Erianthus contortus.
Erianthus brevibarbis.
Andropogon argyræus.
Andropogon Elliottii.
Paspalum purpurascens.
Panicum gibbum.
Panicum viscidum.
Danthonia sericea.
Uniola longifolia.
Poa Chapmaniana.
Decumaria barbara.
Baptisia alba.
Aralia spinosa.
Ptilimnium capillaceum (*Discopleura capillacea*).
Phlox amœna.
Melothria pendula.
Lacinaria graminifolia (*Liatris graminifolia*).
Helianthus angustifolius.

Lookout Mountain, especially near its southwestern end, in Alabama, harbors a notable colony of Lower Austral plants; but the precise altitudes at which most of the species occur are not known to me. Some of them which have not been reported from other stations in the mountains are:

*Pinus Tæda.**
Xyris communis.
Asimina parviflora.
Cebatha carolina (*Cocculus carolinus*).
Sarracenia flava (var. *oreophila*).
Crotonopsis linearis.
*Berchemia scandens.**
Vaccinium arboreum.
*Gelsemium sempervirens.**
Spigelia marilandica.
Yatesia læte-virens (*Gatesia laete-virens*).*
Chondrophora virgata (*Bigelovia nudata virgata*).

These three localities are but a few among many which could have been selected to illustrate the extension of Lower Austral species beyond the normal altitudinal limits of their zone. Hardly a warm lower slope or a sunny valley in the mountains but shelters a greater or less number of them. The mapping of these colonies is one of the nicest and one of the most interesting pieces of work that awaits the future investigator of local floras in this territory, for it goes without saying that it is impossible to indicate them on any general map of the Southern Appalachian region.

Let us now examine more in detail the composition of the flora which occupies these outposts of the Lower Austral Zone. A category which may be eliminated at the outset embraces those species which have been introduced into the mountains by the direct or indirect agency of man. Here belong a number of, for the most part, indigenous weeds which are common in waste and cultivated land in the low country of the southeastern United States, and which have penetrated the Appalachian region chiefly along the railways, *e. g.*:

Cynodon Dactylon.
Commelina nudiflora.
Croton glandulosus.
Croton monanthogynos.
Passiflora incarnata.
Polypremum procumbens.
Sitilias caroliniana (*Pyrrhopappus carolinianus*).
Eupatorium capillifolium (*E. fœniculaceum*).
Helenium tenuifolium.

Of the lower Austral species whose occurrence in the Appalachian region can not be referred to the agency of man, the greater number—about sixty per cent.—range elsewhere beyond the limits of the

* Occurrence on Lookout Mountain needs confirmation.

Lower Austral Zone as generally recognized.* In other words they have a latitudinal, as well as altitudinal, extra-zonal extension. Yet because of their much wider distribution and greater abundance within the proper limits of that zone, they are to be regarded as essentially Lower Austral species.

This majority becomes, however, a small minority and the percentage is reduced to about twenty-five, if we exclude species whose northward extra-zonal range extends only as far as eastern Maryland, Delaware or southern New Jersey. When we consider how largely the Carolinian flora of this latter section is diluted with Austro-riparian forms, almost to the obscuring of its true zonal relationship, we can not attach very great weight to the occurrence here of any particular Lower Austral species. Or, better expressed, the extension of such a species into the heart of the Appalachian region must be regarded as more significant than its occurrence in the Coastal Plain no farther north than southern New Jersey.

Of that large minority of Lower Austral species of the Appalachian region which exceed the general zonal limits in altitude but not in latitude, the following is a preliminary and, doubtless, very incomplete list:

Erianthus alopecuroides.
Erianthus brevibarbis.
Erianthus contortus.
Chrysopogon nutans var. *Linnæanus.*
Paspalum longipedunculatum.
Paspalam purpurascens.
Panicum gibbum.
Panicum longipedunculatum.
Triodia Chapmani.
Uniola longifolia.
Arundinaria macrosperma.
Cyperus echinatus (*C. Baldwinii.*)
Lilium carolinanum.
Ulmus alata.
Asimina parviflora.
Cebatha carolina (*Cocculus*).
Sarracenia flava (var. *oreophila*).
Parnassia grandifolia.
Decumaria barbara.
Morongia angustata (*Schrankia*).
Baptisia alba.
Psoralea pedunculata.
*Berchemia scandens.**
Vaccinium arboreum.
*Gelsemium sempervirens.**
Phlox amœna.
Callicarpa americana.
Yatesia laete-virens (*Gatesia*).*
Melothria pendula.
Elephantopus tomentosus.
Chondrophora virgata (*Bigelovia*).
Aster purpuratus (*A. virgatus*).
Pluchea petiolata.
Antennaria solitaria Rydberg (*A. plantaginifolia* var. *monocephala* Torr. & Gray).
Silphium compositum.
Tetragonetheca helianthoides.
Coreopsis auriculata.
Coreopsis major (*C. senifolia*).
Helenium nudiflorum.

The presence, at an elevation of 300 meters or more, of this considerable number of Austro-riparian species which nowhere else venture beyond the limits of their life zone, is, on the whole, the most noteworthy fact in regard to the Lower Austral element in the highland flora of the Southern States. Species of this category would appear to possess less general tendency to exceed their zonal limits than do those which range farther northward, and this enhances the interest of their occurrence in the mountains.

We now come to the difficult question of the probable past history of the Lower Austral plants which occur to-day in the Appalachian region. Are they relics of a flora once more widely distributed there, or are they the vanguard of an invading army from lower altitudes and latitudes? Al-

* The Austro-riparian Area, as defined by Merriam in various papers (recently in Bull. 10, Div. Biol. Survey, U. S. Dept. Agric.) reaches its most northern limits at the mouth of Chesapeake Bay; in extreme southwestern Indiana, southern Illinois and southeastern Missouri; and in southeastern Kansas.

* Occurrence in the Appalachian region as above defined somewhat doubtful.

though the answer must be largely speculative, it is hardly a pure assumption that both cases may be true in part. In studying this floral element, one soon reaches the conclusion that it comprises two categories of species which are markedly different not only in their systematic relationships, present distribution in the region and probable past history, but even, to a considerable degree, in their ecological constitution. But, in some cases, it is almost impossible to decide to which of the two groups a given species should be referred.

1. Plants of probably neotropical origin which have in all likelihood made their first appearance in the Appalachian region in geologically very modern times, probably after the close of the so-called Glacial Epoch. The following list embraces species which, from their distribution elsewhere, or from their affinities, are most likely to have had this history:*

Erianthus alopecuroides.
Erianthus brevibarbis.
Erianthus contortus.
Andropogon argyræus.
Andropogon Elliottii.
Chrysopogon nutans var. *Linnæanus.*
Paspalum longipedunculatum.
Paspalum purpuracens.
Panicum gibbum.
Panicum angustifolium.
Panicum longipedunculatum.
Panicum viscidum.
Muhlenbergia capillaris.
Sporobolus asper.
Gymnopogon ambiguus.
Triodia Chapmani.
Cyperus echinatus (*C. Baldwinii*).
Kyllinga pumila.
Xyris communis.
Commelina erecta.
Commelina hirtella.
Yucca filamentosa.
Agave virginica.
Pogonia divaricata.
Phoradendron flavescens.
Asimina parviflora.
Cebatha carolina (*Cocculus*).
Morongia angustata (*Schrankia*).
Cracca spicata (*Tephrosia*).
Stylosanthes riparia.
Bradburya virginiana (*Centrosema*).
Clitoria mariana.
Rhynchosia erecta.
Crotonopsis linearis.
Ascyrum stans.
Hypericum densiflorum.
Hypericum Drummondii.
Hypericum virgatum.
Rhexia mariana.
Jussiæa decurrens.
Gelsemium sempervirens.
Cynoctonum Mitreola (*Mitreola petiolata*).
Spigelia marilandica.
Callicarpa americana.
Gratiola sphærocarpa.
Gratiola viscosa.
Bignonia crucigera (*B. capreolata*).
Yatesia læte-virens (*Gatesia*).
Diodia virginiana.
Melothria pendula.
Elephantopus tomentosus.
Eupatorium album.
Eupatorium aromaticum.
Lacinaria graminifolia (*Liatris*).
Chrysopsis graminifolia.
Chondrophora virgata.
Pluchea petiolata.
Silphium Asteriscus.
Silphium compositum.
Tetragonotheca helianthoides.
Helianthus angustifolius.
Helianthus atrorubens.
Coreopsis major (*C. senifolia*).
Coreopsis auriculata.
Marshallia lanceolata var. *platyphylla.*
Helenium nudiflorum.

By far the greater number of species in the above list belong to groups, whether genera, tribes or families, which are chiefly tropical in their present distribution. Thus of the three most largely represented families, the Gramineæ belong chiefly to the tribes Andropogoneæ and Paniceæ; the Leguminosæ to Mimosæ and Phaseolæ; and the Compositæ to Eupatoriæ and Helianthoideæ. This category is furthermore remarkable in consisting almost entirely of herbaceous species. Most of them are of distinctly xerophytic structure, loving a dry sandy soil and much light and heat.

2. Plants, probably not of neotropical origin, which are, in several cases, probably the more or less modified descendants of that characteristic flora which in later Eocene or in Miocene time extended to high northern latitudes, also occupying the mountainous parts of what is now the North Temperate Zone.* Of this category, the number of identical species occurring both in the Coastal Plain and in the Appalachian region is notably smaller than in the first group. To be reckoned here, with more or less confidence, are:

Danthonia sericea.
Uniola gracilis.
Uniola longifolia.
Poa Chapmaniana.
Arundinaria macrosperma (?).
Arundinaria tecta (?)
Lilium carolinanum.
Ulmus alata.
Parnassia grandifolia.
Decumaria barbara.
Itea virginica.
Cratægus uniflora.
Cratægus rotundifolia.
Berchemia scandens.
Ampelopsis cordata.
Vitis rotundifolia.
Aralia spinosa.
Dendrium buxifolium (*Leiophyllum*).
Leucothoë racemosa.
Oxydendrum arboreum.
Gaylussacia dumosa.
Vaccinium arboreum.
Symplocos tinctoria.
Chionanthus virginica.
Antennaria solitaria.

Most of the species, as well as many of the genera, comprised in this second category are characteristic neither of tropical nor of high northern regions. They belong in great part to groups which are most largely represented at present in the mountainous parts of the Warm Belt of the Northern Temperate Zone, in both the Eastern and Western Hemispheres. Some of them, however, are of floral types which are to-day most highly developed in the tropics. Such are the species of *Arundinaria*, *Berchemia scandens*, *Ampelopsis cordata*, *Aralia spinosa* and *Symplocos tinctoria*. Yet the groups to which several or all of these species belong, formerly had a much wider extra-tropical distribution than is now the case. A few plants of this category, *i. e.*, the species of *Poa*, *Parnassia* and *Antennaria* belong to genera of mainly boreal and alpine distribution.

To be considered in connection with this second category of the Lower Austral species which occur both within the main limits of the Austro-riparian area and in the mountains, is a very significant group of genera which are represented in eastern North America by two closely allied species or group of species, one in the Coastal Plain, the other in the Appalachian region.

With the exception of *Clethra* (which is largely tropical) all these genera, like many of those represented by species of the second category, have their present center of distribution in the warmer part of the North Temperate Zone. This may be said also of the larger groups to which many of them belong, *e. g.*, the families Calycanthaceæ, Sarraceniaceæ, Hamamelidaceæ and Monotropaceæ, and the tribes Hydrangeæ of Saxifragaceæ and Andromedeæ of Ericaceæ. Some of them are known to belong to floral types which were very widely distributed in the Northern Hemisphere during the earlier part of the Tertiary, in not a few cases ranging as far north as Greenland and Alaska; and we may be permitted to con-

* According to De Saporta et Marion (Recherches sur les végétaux fossiles de Meximieux; Archiv. Mus. Hist. Nat. de Lyon, 1: 304–324 (1875), a vegetation of Magnolia, Lauraceæ, Liquidambar, Anonaceæ, Ilicaceæ, Liriodendron, etc., occurred on the mountains of southeastern France, at altitudes of 200 to 700 meters, during the Pliocene. That a similar flora flourished contemporaneously in the mountains of eastern North America would seem by no means unlikely. If so, the Pliocene flora of the Appalachian region must have borne considerable resemblance to that which prevails there to-day.

jecture that the ancestors of most of these genera whose actual history is still undisclosed were thus distributed during Miocene time. Very broadly speaking, several of these genera represent groups which appear to be on the wane, as distinguished from the dominant and, one may say, aggressive types of presumably neotropical origin to which the species of the first category chiefly belong.

Genus.	Coastal Plain Species.	Appalachian Species.
Butneria(*Calycanthus*).	*florida.*	*fertilis* (*glauca*).
Sarracenia.	*flava.*	*flava* var. *oreophila.*
Philadelphus.	*grandiflorus.*	*inodorus.*
		hirsutus.
Hydrangea.	*quercifolia*	*radiata.*
		cinerea.
Fothergilla.	*carolina* (*Gardeni*).	*arborescens.*
Stuartia.	*Malachodendron*(*virginica*).	*major.*
Clethra.	*alnifolia.**	*pentagyna.*
Monotropsis (*Schweinitzia*).	*Reynoldsiæ.*	*acuminata.*
Leucothoë.	*axillaris.*	*odorata.*
	*racemosa.**	*Catesbœi.*
Pieris.	*phyllyreifolia.*	*recurva.*
Mohrodendron (*Halesia*).	*dipterum.*	*floribunda.*
	parviflorum.	*carolinum* (*tetraptera*).

In another important respect the second category differs from the first, *i. e.*, in its ecological character. A majority of the species which it comprises are woody plants, shrubs, lianas or trees; and this majority becomes a large one if we take into account the list of representative species just given. The first category, as we have seen, consists almost wholly of herbaceous forms.

A considerable number of species of the second category, notably several of the woody plants with thick, more or less persistent, leaves is essentially xerophytic in structure. But the xerophilous leaf-structure is here in most cases probably a consequence of the long duration of that organ and a protection against winter conditions, rather than an adaptation to the effects of climate and soil during the growing season.

* Ranges beyond the northern limits of the Austro-riparian area.

On the other hand, the number of shade-loving tropophytes or mesophytes is decidedly greater than in the first category. The plants of the second category are more often scattered among Transition and Carolinian vegetation, showing generally little tendency to form well-defined Lower Austral colonies. Finally, they are, on the whole, less characteristic of the Austro-riparian area, as distinguished from the Carolinian area, than are many of the species of our first category.

Having thus segregated the two principal groups of species which constitute the floral element under discussion, are we in a position to draw conclusions as to its past history? The answer must be that it is possible as yet to formulate only broad generalizations which are hardly more than pure hypotheses. The paleontological record, during the period which doubtless witnessed the gradual rearrangement of the plant covering of the Southern Appalachian country in its present form, *i. e.*, from the Pleistocene to the present, is fragmentary in the extreme for the region in question. We can get only glimpses of what may have been the course of events. Here and there a headland can be seen, but the trend of the intervening shore-line is only to be guessed at.

That there is reason to modify the formerly current assumption that extremely low temperatures existed in the Northern Hemisphere during the Glacial Epoch is now urged by not a few authorities.* In a paper which advocates revision of preconceived ideas on this point, Vater † calculates that points in middle Germany which were not distant from the edge of the great Ice Sheet, possessed, during the Glacial Epoch, a mean annual temperature of 4° C., as compared with 10.6° C. at the present day. But even this amount of difference must have wrought great changes in the vegetation, and, if the same ratio obtained in eastern North America, we may well assume that no member of what constitutes to-day the characteristic Austro-riparian flora could have maintained itself in the Appalachian region, during the climax of the Ice Age.* For we must remember that the great glacier made its way southward as far as the present location of Cincinnati, on the Ohio River, and extended to the southern shore of Staten Island.†

We may premise, therefore, with considerable confidence, that any portion of the Lower Austral flora of to-day which may have inhabited the Appalachian region prior to the Pleistocene retreated to lower altitudes and latitudes when the Ice Sheet approached its most southern limit. If we were to maintain, on the other hand, that Lower Austral plants had survived the Glacial Epoch in the Appalachian region, we should be compelled to assume that species which had developed under the mild climatic conditions generally believed to have prevailed, even in high northern latitudes, during Miocene and Pliocene times, later adapted themselves to the considerably lower temperatures prevailing during the comparatively brief Glacial Epoch, and, after the close of that Epoch, readjusted themselves to the warmer temperatures which again held sway.‡

* Thus J. D. Whitney, who goes much farther than most geologists in reaction against previously entertained ideas as to the extent and importance of the Ice Sheet, remarks as follows in his well known paper on 'The Climatic Changes of Later Geological Times' (Contr. to Amer. Geology, Harvard University, Vol. 2, p. 268, 1888): "A general refrigeration of the earth could never have caused that peculiar distribution of snow and ice to which the term Glacial Epoch is commonly applied; and * * * the phenomena in question are entirely compatible with a higher mean temperature than now prevails." Again (p. 321): "We have no right to assume as having existed during the Glacial Epoch a period of intense cold, or even a lower mean temperature than that now prevailing over the earth." And (p. 387): "It is possible to lay aside all idea of explaining the phenomena of the so-called Glacial Epoch, by referring them to the extension of a general or Polar ice-cap over the land of the Northern Hemisphere. * * * The entire body of facts presented brings out most clearly the true condition of things, namely that the Glacial Epoch was a local phenomenon, during the occurrence of which much the larger part of the land-masses of the globe remained climatologically entirely unaffected." This author represents, however, an extreme view, which is rejected by many geologists.

† 'Das Klima der Eiszeit'; Sitzungsber. d. naturw. Gesellsch. Isis in Dresden, 1883, pp. 56, 57 (1884).

* A. C. Seward, in discussing 'Fossil Plants as Tests of Climate' (London, 1892), p. 50, after summing up the evidence *pro* and *con* which has been brought forward to prove that forests could have maintained themselves amid or very near the great glacier, decides against the possibility of such survival. On the other hand, we have no right to assume that a vigorous forest growth may not have continued to flourish in the greater part of the Appalachian region, at least at low elevations, throughout the Glacial Epoch. For, as the same author remarks, pines and even tree ferns thrive to-day at the very edge of the terminal moraines of New Zealand glaciers; while, in Alaska, some glaciers (notably the Malaspina) are largely covered with spruce, alder and other trees.

† The area supposed to have been covered by the Ice Sheet in North America has been mapped by Professor T. C. Chamberlin; 7th Ann. Rep. U. S. Geol. Survey, pl. 8 (1888).

‡ It will be objected that it is not always safe to argue from the present requirements of organisms (especially of genera and still larger groups), the

The difficulty of such an assumption is increased by the fact that some of the forms belonging to our second category have apparently undergone little modification since Pliocene times; and this may well be true of many of them whose past history is still unknown. To the average mind, the alternative hypothesis, that of an extensive migration of the less resistant species from the mountains to the warmer lowlands, is decidedly more thinkable.

As the Ice Sheet began to recede, and the climate of the Appalachian Region became gradually milder, approaching its present character, those species which had resided in the Appalachian Region before the Pleistocene, would have gradually returned thither; but as the climate of to-day is probably considerably colder than that of the Pliocene, it is to be presumed that this floral element now occurs at a lower altitude than that at which it flourished in pre-Glacial times. It may be assumed, furthermore, that the neo-tropical forms which constitute our first category, then began to make their way, for the first time, into the Appalachian Region.

To account for the presence to-day of representative species of certain genera (*e. g.*, *Stuartia*, *Fothergilla*) in the mountains and in the Coastal Plain, respectively, it is conceivable that after the final retreat of the great glacier, the increasing heat of the lowlands induced in some individuals of a single ancestral species, which had sought refuge there during the Ice Age, changes of physiological constitution and of structure which fitted them to endure a warmer climate than that to which they had previously been accustomed. Other individuals having gradually made their way to higher elevations on the heels of the retreating Boreal flora, settled finally in the valleys and on the lower slopes of the mountains, where they have remained up to the present day, perhaps with little variation from the Pliocene form.

If we assume, on the other hand, that forms contained in our list of representative species were enabled to survive the Glacial Epoch without migrating, *in toto*, from the Appalachian Region, an alternative hypothesis becomes possible.

In that case it may be conceived that while some individuals of each hypothetical Pliocene ancestral species maintained themselves in well-sheltered situations and were not forced to a change of abode, others escaped the changing environment by a gradual retreat into the warmer lowlands. The individuals which remained in the mountains were the direct ancestors of the present Appalachian species; while those which migrated and later accustomed themselves in the Coastal Plain to the increasing temperatures that ensued upon the close of the Glacial Epoch, gave rise to the Austro-riparian species that attract our attention to-day because of their close resemblance to Appalachian forms.*

It is true that this theory leaves unexplained the occurrence, both in mountains and plain, of identical species of the second

climatic conditions to which they have previously been adapted. This point is well brought out by H. von Ihering in a paper on 'Die neotropische Tropengebeit und seine Geschichte' (Engler Bot. Jahrb., vol. 17, Beiblatt 42, 1893). It is easily conceivable, for example, that vegetation as a whole has been accustoming itself, during long ages, to gradually decreasing heat. But, in the case which we are here considering, this objection cannot be allowed much weight, as the climatic changes have been more or less oscillatory, rather than progressive and have taken place within a (geologically speaking) comparatively brief period.

* It is not impossible that in some of these cases of representative species, differentiation of the allied forms may have taken place before the advent of the Glacial Epoch. But in most instances the relationship is so extremely close that we need not assume for them an older origin, especially as no other convenient hypothesis offers to account for their present distribution.

category, including such woody plants as *Decumaria*, *Itea*, *Callicarpa*, *Oxydendrum*, *Aralia spinosa*, *Vitis rotundifolia*, etc. A similar case is the presence of *Azalia viscosa*, an essentially Coastal Plain species, here and there in the mountains along with its mountain analogue, *A. arborescens*. *Leucothoë racemosa*, abundant in the swamps of the seaboard, is also found occasionally along highland streams, while a closely related and very similar species, *L. recurva*, is much more abundant in the mountains, to which it is confined. These are cases where the differentiation in distribution of corresponding forms, one in the Coastal Plain, and another in the Appalachian region, is either incomplete or has not taken place at all. But as no fact in biology is better known than the capacity of some species to endure a wide range of physical conditions, while others are fatally sensitive to comparatively slight differences of environment, this difficulty is not an insuperable one.

The initial appearance in the mountains of species of the first category, *i. e.*, those of presumably neotropical origin, was probably somewhat subsequent to the return thither of the Miocene Boreal forms of the second category, for most of the former require decidedly higher temperatures than many of the latter. But we know little of the history of such groups as are chiefly represented in this category and which make up a large part of the modern tropical American flora, *i. e.*, the above mentioned tribes of Gramineæ, Leguminosæ and Compositæ. Hence we must content ourselves with assuming that these species did not exist in the Appalachian region prior to recent geologic time, and that they constitute the most modern element of its flora.

It is more than probable that the hypothesis just outlined is very incomplete as to details and will be found not to account for all the phenomena. Instead of the comparatively simple progression of events which it premises, the fact is pretty well established that there was more than one advance and recession of the Ice Sheet, and that the mutations of the flora have been correspondingly intricate. But of the complex of factors which have been at work since the middle of the Tertiary in giving to this flora its present distribution, we know far too little to permit the elaboration of a more comprehensive theory. Until we possess a much larger body of paleontological evidence, and a better understanding of past climatic conditions, we must be content with some such working hypothesis.

When we come to inquire into the conditions of climate and of soil which permit the actual existence of numerous Lower Austral forms in juxtaposition to a Transition and even Canadian flora, we enter upon an investigation that is within the domain of exact research. Here we are dealing with things tangible, which can to some extent be weighed and measured.

First let us compare the climate of the Appalachian Region in the Southern States with that which prevails under the same latitude in the Austro-riparian area, directing our attention to the factors of temperature which have the largest effect in determining the zonal distribution of organisms. These are believed to be: (1) the normal number of days during the year which possess a temperature above 6° C. (43° F.); (2) the normal sum total of temperatures above 6° C. during the period thus defined;* and (3) the normal mean of the six consecutive hottest weeks.† In the following table data are given for four stations in the mountain region and for two of

* The factor which is believed to fix the northern and upper limit of the great life zones. See Merriam in *Nat. Geogr. Mag.*, 6 : 229–238, 1894. Also Life Zones and Crop Zones, Bull. Div. Biol. Survey, U. S. Dept. Agric., 10 : 54, 1898.

† The factor taken as determining the southern and lower limit of the zones, Merriam, l. c.

the most northern in the Austro-riparian area.

The Highlands station is cited here for the sake of comparison, but does not otherwise answer our purpose, its elevation being so great as to preclude the occurrence of any important number of Lower Austral species. Knoxville falls slightly below the minimum altitude to which this discussion was limited at the outset; but owing to its proximity to some of the most interesting colonies described above, and in the absence of the requisite data from points lying nearer them, it has seemed best to give it place in the table. The most useful data are those given for Asheville and for Valley Head. Both have an altitude of more than 300 meters (1,000 feet) above the sea, and at both points a considerable number of Austro-riparian forms is known to occur.

STATION.	Altitude.	Days with temperature above 6°C. (43°F.).	Sum total above 6°C. (43°F.).	Normal Mean of 6 hottest weeks.
Highlands, N. C.	3817 ft.	234	1970.5°C. (3547°F).	18.9°C. (66.1°F).
Asheville, N. C.	1981–2250 ft.	249	2604.5°C. (4688°F).	21.8°C. (71.3°F).
Knoxville, Tenn.	891–933 ft.	267	3090.5°C. (5563°F).	24.5°C. (76.1°F).
Valley Head, Ala.	1027 ft.	293	3049.0°C. (5488°F).	24.0°C. (75.2°F).
Norfolk, Va.	11–12 ft.	295	3359.5°C. (6047°F).	26.3°C. (79.3°F).
Memphis, Tenn.	117–273 ft.	307	3752.2°C. (6754°F).	27.2°C. (81°F).

At Asheville the normal sum total of effective heat is only about 80 per cent. of that at Norfolk, and slightly more than 66 per cent. of that at Memphis. The normal number of days of the year possessing physiologically effective temperatures is, at Asheville, about 85 per cent. of that at Norfolk, and about 82 per cent. of that at Memphis. At Valley Head, which is only about one-half as high as Asheville, and is considerably farther south, the normal sum total of heat stands to that of Norfolk in about the ratio of 11 to 12; and, to that at Memphis nearly as 4 to 5. The normal number of days of the year whose temperature exceeds 6° C. is only two less than at Norfolk. In short, Norfolk temperatures are farther below those of Memphis, than Valley Head temperatures are below those of Norfolk. The occurrence of many Austro-riparian species at Valley Head is therefore small matter for wonder. But in order to explain their presence at Asheville, and at other points along the French Broad River at elevations of 330 to 600 meters (1,100 to 2,000 feet),* where we find the temperature conditions as ordinarily expressed so different from those of the Austro-riparian area proper, other elements of the *milieu* must be brought into consideration. The two factors which are probably most effective in permitting those species to maintain themselves in what would seem to be an unfriendly environment are: (1) The amount of insolation; and (2) The nature of the soil.

1. *Insolation.* — A favorite situation in the mountains for colonies of Lower Austral species is on the southern exposure of hills, where the angle of inclination and the position with reference to the sun insure the greatest possible amount of insolation. The duration and intensity of the heat and light which such exposures receive from the sun on summer days must go far towards counterbalancing the effect of altitude in lowering the temperature during the hours of darkness, and in shortening the growing season. The flora of the Coastal Plain

* At Biltmore, N. C., with an altitude of 1,993 to 2,150 feet, occur *Arundinaria macrosperma*, *A. tecta*, *Hypericum virgatum*, *Helenium nudiflorum* and several other characteristic Lower Austral species.

under the same latitudes, while favored by the low elevation of the country, is less advantageously situated in that it does not usually receive the greatest possible force of the sun's rays during the hottest weeks of summer.

2. *Soil.* — The soil preferred by the great majority of Austro-riparian plants which are met with in the mountains, especially those of our first category, which are assumed to be of neo-tropical origin, is light, sandy and poor in organic matter ; consequently readily permeable to water and becoming quickly and strongly heated. It is very similar to the soils which cover a great part of the Coastal Plain. In a substratum of this character, whether on the lower slopes or in the river bottoms, we invariably find established the larger colonies of Lower Austral species. In consonance with their environment, most of them are xerophytic or hemi-xerophytic in structure, as is the case with a great portion of the vegetation of the coastwise pine-barrens.

On the heavier and consequently colder and wetter soils, and on slope exposures other than southern, the flora is always of predominately Transition character, at the same elevation or even, in places, descending to lower altitudes than are often reached on the opposite slope by Carolinian and Austro-riparian forms.

Unfortunately no investigations have yet been made in this mountain region which afford us exact data as to the amount of isolation received by plants growing in the situations described; nor have we the measurements of soil temperature which are necessary to the further prosecution of the present inquiry. A comparative study of this question in various parts of the Appalachian region and of the Coastal Plain, coupled with an investigation of the ecology of the vegetation along anatomical-physiological lines, would beyond all doubt yield results of the greatest interest and value. It is earnestly hoped that such an investigation can be undertaken in the nea future.

Thos. H. Kearney, Jr.

SCIENTIFIC BOOKS.

Gauss and the non-Euclidean Geometry. Carl Friedrich Gauss Werke. Band VIII. Göttingen. 1900. 4to. Pp. 458.

We are so accustomed to the German professor who does, we hardly expect the German professor who does not.

Such, however, was Schering of Göttingen, who so long held possession of the papers left by Gauss.

Schering had planned and promised to publish a supplementary volume, but never did, and only left behind him at his death certain preparatory attempts thereto, consisting chiefly of excerpts copied from the manuscripts and letters left by Gauss. Meantime these papers for all these years were kept secret and even the learned denied all access to them.

Schering dead, his work has been quickly and ably done, and here we have a stately quarto of matter supplemental to the first three volumes, and to the fourth volume with exception of the geodetic part.

Of chief interest for us is the geometric portion, pp. 159–452, edited by just the right man, Professor Staeckel of Kiel.

One of the very greatest discoveries in mathematics since ever the world began is, beyond peradventure, the non-Euclidean geometry.

By whom was this given to the world in print?

By a Hungarian, John Bolyai, who made the discovery in 1823, and by a Russian, Lobachévski, who had made the discovery by 1826.

Were either of these men prompted, helped, or incited by Gauss, or by any suggestion emanating from Gauss?

No, quite the contrary.

Our warrant for saying this with final and overwhelming authority is this very eighth volume of Gauss's works, just now at last put in evidence, published to the world.

The geometric part opens, p. 159, with