A third class of observatories are those intended for instruction in astronomy. The requirements in this direction are so different from those necessary to research that it is impossible to combine the highest efficiency in both directions with the use of the same instruments. The number of observatories especially designed for pure instruction are very few in number. The instruments necessary for the purpose are of the simplest kind; indeed, so far as mere training is concerned, the engineer's level, transit, and theodolite can be made to serve most of the purposes of the astronomical student. What the latter really wants is that training of the eye and the mind which will enable him to understand the theories of instruments, the methods of eliminating the errors to which they are subject, and the mathematical principles involved in their application. In this, as in nearly every department of professional education, we may lay it down as a rule that the wants of a liberal and of a professional education are, so far as the foundation is concerned, identical. We are too prone to lead the student into the minute details of a subject without that previous training in first broad principles which, though it may not immediately tell on his progress as a student, will be felt throughout his life to whatever field of work he may devote himself. Such a transit instrument as Hipparchus might have made,—a wooden level mounted on an axis and supplied with slits to serve the purpose of sights,—properly mounted in the meridian, could well be made to take the place of the transit instrument for purposes of instruction. Scarcely any higher skill than that of a cabinet-maker would be required in its construction. The object at which the student should then aim would be, with the aid of this instrument, to determine the error of his clock or watch within a few seconds. If he is really acquainted with the principles of the subject, and has his eyes properly trained, he will have no difficulty in soon learning to do this.—(*North American Review*).

MICHIGAN FLORA.

By CHARLES F. WHEELER and ERWIN F. SMITH, Hubbardston, Michigan.

The following interesting sketch forms the preface to a catalogue of the Phænogamous and vascular Cryptogamous Plants of Michigan, Indigenous, Naturalized and Adventive, which can be obtained of W. S. George & Co., of Lansing, Michigan:

The climate of the Upper Peninsula of Michigan is colder than that of the Lower Peninsula, the surface is considerably broken, especially in the western part, and the flora is in many respects decidedly northern, resembling in part that of British America, and in other respects like that of N. New England and Canada. Pines, firs, cedar, larch, junipers, elms, poplars, black ash, basswood, maples, and birches, are the principal trees. *Pinus strobus*, the prevailing species southward, is here largely supplanted by its more northern and less valuable congener, *P. resinosa*, whose tall, slim trunks are, however, in good demand for driving piles. Under-shrubs, like *Rubus Nutkanus* and *Taxus baccata*, var. *Canadensis*, are common, and indicate a tendency toward northern types that we find more strongly developed in the herbaceous plants. Among the latter we note as found rarely, or not at all, in the Lower Peninsula, but frequently northward, and often having a high northern range, such plants as *Anemone parviflora*, *Viola Selkirkii*, *Potentilla frigida*, *Stellaria borealis*, *Saxifraga Aizoon*, *S. tricuspidata*, *Pinguicula vulgaris*, *Castillea pallida*, *Halenia deflexa*, *Physalis grandiflora*, *Tofieldia*, *palustris*, *Salix adenophylla*, *Eriophorum alpinum*, *Aspidium fragrans*, etc., etc.

The influence of climate on vegetation may be summed up in a few words. The climate of the Lower Peninsula is not as severe of as that of the Upper, nor so even, but is subject to frequent, sudden, and extreme changes of temperature—as great a variation during the winter season as 53° Fahr. in less than 24 hours having been recorded. Such rapid changes more or less affect vegetation, especially the tender branches of cultivated trees, which are sometimes seriously injured. In one or two instances a like effect on our forest trees has been noticed. The annual range of temperature is about 116°, and the annual mean 46°. Of rain-fall, including what falls in form of snow, we have, yearly, about thirty inches. Our snow-fall is much less, for the same latitude, than that of New York and New England. In the center of the peninsula, we seldom have more than a few inches at a time.

The proximity of the Great Lakes exerts a marked influence in equalizing the temperature and the effects are marked upon our flora.

Trees like *Liriodendron Tulipifera*, *Asimina triloba*, *Cercis Canadensis*, *Gleditschia triacanthos*, *Cornus florida*, *Nyssa multiflora* and *Morus rubra*, which belong to Ohio and Central Illinois, have crept northward, favored by the mild influence of the lake winds, through the central and western part of the Lower Peninsula, often beyond the middle, and the same is true of smaller and less noticeable plants.

As might be expected from the uniform surface of the peninsula, the flora is much alike throughout. Probably three-fourths of our species are common to all sections, though by no means equally distributed; some being very abundant in one district and rare in another at no great distance. In most cases such change is due to soil rather than to difference in elevation, temperature, or atmospheric moisture.

The Lower Peninsula is covered with a deep drift of alternating sands, clays and gravels, and the flora of any section depends chiefly on which of these happens to lie uppermost. With reference to its flora, the Peninsula may be roughly divided into two great divisions—the hard-wood and the soft-wood lands; one representing the Appalachian flora, and the other, the Canadian.

The hardwood country lies south of latitude 43°, and consists of very fertile sand, clay, or loam, mostly cleared of the original forest, and largely cultivated.

The sandy or stony drift of many river valleys in this section supports a heavy growth of oak, frequently interspersed with walnut and hickory, while the margins of the streams, and the neighboring swamps, abound in soft maples, swamp and chestnut oak, white and black ash, elm, hackberry, sycamore, butternut and similar trees. Willows, dogwoods, viburnums, and buttonbush, are common shrubs in the swamps; and hazel, hawthorn, wild cherry and plum, June berry, witch-hazel, etc., are abundant on the dryer ground.

On the uplands, and away from streams, clay, loam, and a peculiar blackmuck soil, supersede the sands and gravels of the valley. The prevailing timber here is beech and maple and oak forest in about equal proportions. Beech and maple (*Acer saccharinum* and var. *nigrum*) generally grow together, forming magnificent forests of great extent. The best wheat farms are usually found on uplands near streams, where the oak timber gradually shades into beech and maple. Plains of fertile sand covered with a low, or scattering growth of oak (oak openings) are frequent, and always very desirable for farming purposes. Four species of oak are usually found on such plains—*Q. alba*, *macrocarpa*, *coccinea* and *tinctoria*.

Marshes densely covered with tamarack are common in this part of the State, and nourish in their thick shade such plants as *Drosera rotundifolia*, *Sarracenia purpurea*, *Rhus venenata*, *Ribes rubrum*, *Chiogenes hispidula*, *Salix candida*, *Smilacina trifolia*, *Pogonia ophioglossoides* and *Calopogon pulchellum*. Arborvitæ, red cedar and black spruce are comparatively rare.

A similar tract of soil and timber occurs in the upper end of the Peninsula, north of a line drawn from Thunder Bay west to the head of Grand Traverse Bay. This is commonly known as the "Traverse Region," and has a flora much like that we have just described, with the exception that some of the southern species disappear, and northern ones begin to take their place, or if found growing further south, here first become frequent.

The littoral flora of Little Traverse Bay is rich in interesting species, among which may be mentioned a small form of *Cakile Americana, Lathyrus maritimus, Potentilla Anserina, Tanacetum Huronense, Artemisia Canadensis, Cnicus Pitcheri, Juncus Balticus, Triticum violaceum, T. dasycarpum*, a peculiar form of *Bromus ciliatus, Calamagrostis longifolia, C. arenaria, and Equisetum variegatum.* The flora of the low dunes at the head of the Bay comprises, among others, the following species: *Juniperus Sabina*, var. *procumbens, Prunus pumila* and *Cornus stolonifera*, half buried in the drifting sand, *Hypericum Kalmianum, Salix glaucophylla*, and varieties, *Lilium Philadelphicum*, etc. In a moist depression were found *Arabis lyrata, Coreopsis lanceolata, Arctostaphylos Uva-ursi, Primula farinosa, Lithospermum hirtum, Triglochin maritimum*, var. *eltaum, Carex aurea, C. Œderi*, etc., etc. In thickets near the shore were found *Abies balsamea, Picea alba, Sheperdia Canadensis, and Rubus Nutkanus.* Deep forests of hemlock and yellow birch (*B. lutea*) mixed with a fine, tall growth of striped maple (*A. Pennsylvanicum*) are frequent, having underneath a tangled growth of *Taxus baccata*, var. *Canadensis*, and under all a carpet of *Lycopodium annotinum.* Alternating with these are sandy plains covered with a dense growth of *Vacciniums*, yielding a great abundance of fruit. Sugar maples and basswood are also abundant in this region, and reach an immense size. In fact, finer groves of maple it would be difficult to find in any part of the State.

The pine country proper lies between the two tracts we have thus described, and embraces about 15,000 square miles. It is composed largely of sand hills and plains, either scantily furnished with vegetation, or densely covered with pine forest. Argillaceous tracts wooded with beech and maple also occur, like oases in a desert; and swamps abound, with the usual lowland timber. Forests of hemlock spruce are frequent, and there are occasional ridges of oak. Birch (*B. lutea*) also begins to be a common forest tree, and attains a large size. The usual timber of the barrens is Jack Pine (*P. Banksiana*). Climatic and other influences have combined to produce groves composed entirely of this species of large size and of great beauty, for, instead of being "a straggling shrub, or low tree" (Gray), it rises, often 50–60 feet, straight and symmetrical. All through this region *Pinus strobus* is the prevailing species and furnishes most of the lumber, but *P. resinosa* is frequent as far south as Clare county, and occurs sparingly in the northern part of Isabella county, which appears to be its southern limit.

Such is the general character of the sylva down to about latitude 43°, but in the western part of the State, owing perhaps to moister climate, or to favorable soil, hemlock spruce is more abundant, and reaches much farther south, nearly or quite to the Indiana line, and the same is true of white pine.

Portions of the counties of Clare, Missaukee and Roscommon represent an undulating plateau, which is 700–800 feet above the level of the great lakes, and has an interesting flora, as yet little studied. This region was examined in June, 1876, and revealed a number of northern plants. In the southern part of Clare county were found *Ledum latifolium, Kalmia glauca, Physalis grandiflora* (not before found south of the Upper Peninsula), *Corydalis glauca*, and *Geranium Carolinianum*—the two latter species growing luxuriantly in the deep woods, after fires. In the shade of the Jack Pines grew *Prunus pumila, Potentilla tridentata* (not before observed in Lower Peninsula), *Krigia Virginica, Arctostaphylos Uva-ursi, Linaria Canadensis, Kœleria cristata, Carex Houghtonii*, etc., etc. Near Houghton Lake were found *Adlumia cirrhosa, Ribes lacustre, Dracocephalum parviflorum, Streptopus roseus*, and *S. amplexifolius*; and in Muskegon river, near its source, *Potamogeton lucens. Pinus resinosa* was noticed frequently, growing with common pine, and near the center of Clare county it became more abundant, forming groups. Single individuals stretch upwards 150–160 feet, their clean, copper-colored boles often rising 100 feet to the first limbs.

The flora of the deep pine woods is interesting, though rather monotonous. Very little undergrowth is found, and their gloomy recesses nourish only such plants as love thick shade. Here the club-mosses (*Lycopodiums*) find a congenial home, and flourish luxuriantly, while *Clintonia borealis* covers the ground. The great round-leaved orchid (*Habenaria orbiculata*), with its tall, greenish spike and twin leaves close to the earth, is also frequent and striking. We shall also meet *Mitchella repens, Smilacina bifolia, Trillium grandiflorum*, perhaps, and a few ferns, particularly *Asplenium Filix-fœmina*, and *Phegopteris Dryopteris.* Other species occur, of course, but not so abundantly. In more open places, and on ridges, we meet *Rhus aromatica* and *Comptonia* along with wintergreen (*Gaultheria*) and trailing arbutus (*Epigea)*, and are often fortunate enough to find the wax-white, fragrant flower of *Moneses uniflora* or *Polygala paucifolia*, hiding its shining leaves under a wealth of showy pink blossoms.

The floral treasures of the pine region lie, however, in its swamps and lake borders rather than in the deep woods. Therein grows *Linnea borealis* in all its delicate beauty, carpeting the ground, and close at hand, the odd, brown-purple flower of *Cypripedium acaule* and the small yellow blossom of its water-loving relative *C. parviflorum.* In such swamps, or within a stone's throw of them, may be found many other plants of equal interest, such as *Medéola Virginica, Ledum latifolium, Andromeda polifolia, Kalmia glauca, Lonicera oblongifolia, Cardamine pratensis, Gerardia aspera, Mitella nuda, Eriophorum vaginatum*, etc. On lake margins we shall find *Lysimachia* and the blue *Pontederia* and more rarely, *Nesœa* and *Eleocharis quadrangulata.* The lake itself, most likely, will be full of *Nymphœa, Nuphar, Utricularius*, and a world of *Potamagetons* and similar water weeds. Shrubby *Vacciniums* line the bluffs, and here and there gleam the white trunks of paper birches against the dark background of pines.

In the thick-pine country, where the lumberman's axe has let in the sunlight, new plants spring up freely. Here, *Prunus Pennsylvanica* and poplars are frequent, and the blackberry is omnipresent. *Aralia hispida* and *Physalis pubescens* are also peculiar to such land, and in August *Gnaphalium decurrens* may be seen whitening thousand of acres.

One seldom beholds a drearier sight than a dead and deserted lumber region. The valuable trees were all felled years ago, and the lumberman moved on to fresh spoils, leaving behind an inextricably confused mass of tree tops, broken logs, and uprooted trunks. Blackberry canes spring up everywhere, forming a tangled thicket, and a few scattering poplars, birches, and cherries serve for arboreal life, above which tower the dead pines, bleached in the weather and blackened by fire, destitute of limbs, and looking at a distance not unlike the masts of some great harbor. Thousands of such acres, repellant alike to botanist and settler, can be seen in any of our northern counties.

In certain districts considerable beech is found associated with the pine. The soil of such tracts is usually of better quality, and can be rendered productive without much labor. It may be noticed that in such cases the pine also grows thriftier and makes better lumber.

Sections of this and the Traverse region of Michigan are still sparsely settled, or not at all, and have been visited rarely by botanists. Consequently, we may expect many editions to our flora, as well as corrections, when this region is as thoroughly known as the south half of the State now is; our ignorance, rather than nature's parsimony, explaining why we have so few species credited to us. The most promising field for the botanist evidently lies in the Houghton Lake region and northward, and in the upper Peninsula, many parts of the interior of which are botanically unknown.

Our flora, as here presented, contains in all 113 families (orders), and 1,634 species. The composites claim the largest number of species, 182—about one-ninth of all. Sedges follow with 176 species; grasses, 139; rosaceæ, 61; ferns, 56; leguminosæ, 55; figworts, 46; mints, 40; mustard and crowfoot, 39 each; heath family, 35; and umbelliferæ, 27. We have 165 trees and shrubs, about 20 of which are valuable timber trees. At least 40 of our trees and shrubs are worthy of cultivation for ornament. Sugar maples and elms are commonly planted, while the tulip tree, basswood, Kentucky coffee tree, black walnut, and butternut, among deciduous trees, and hemlock, white pine, black spruce, arbor vitæ, and red cedar, among evergreens, deserve more attention. About 20 species of woody and herbaceous native climbers are frequent, and some are worthy of cultivation, (see State Pomological Report of '79 for a list.) Ninety medicinal plants are admitted into the U. S. Pharmacopœia, 45 belonging to the primary list, and an equal number to the secondary, while a number of others deserve attention at the hands of Pharmacists.

It may be stated in conclusion that, in the preparation of this catalogue, we have spared no pains to make it thoroughly reliable, a majority of the species enumerated having passed through our hands, and the remainder being admitted only on good authority. We have preferred to make a *useful* rather than a a *large* catalogue, and, on this ground, we have rejected a number of species, some of which may yet make good their claim to be considered as part of our flora. We cannot hope to have escaped all errors, and crave charitable judgment for any such the kind reader may discover, trusting that they may be found errors of omission rather than of commission.

In our arrangement of orders, we have preferred, as more convenient, to follow the 5th edition of Gray's Manual rather than later works. The vexatious subject of synonomy has received considerable attention, and will, we believe, be found brought down nearly to date. Further observations will be published from time to time in the form of addenda, towards increase of which we solicit correspondence and contributions from all parts of the State.

IONIA, MICH., January 20, 1881.

DISRUPTION OF PLANETARY MASSES FROM THE PRIMEVAL NEBULA.

V.

BY EDGAR L. LARKIN.

It has been shown in this series that the gaseous sphere could not have parted with any form of ring known to geometers. All varieties of segmental rings were examined, and their displacement found impossible by known laws of mechanics. The nebula subsided from space to the dimensions of the orbit of Neptune, else its assumed rotation could not have been equal to the orbital velocity of that planet.

Indeed, it must have revolved faster, for matter along the line of the centre of gravity of the ring moved with the rate that Neptune now has. Then the outside of the ring moved faster and the inside slower than the Neptunian velocity. But the inside was required to move with greater rapidity than any other point to exceed attraction and disrupt the mass. From this consideration alone the doctrine of ring detachment is subverted.

We are now to demonstrate that no particle whatever can be detached from a revolving sphere whether gaseous, fluid or solid, by any force known to man. Tangental force in no case overcomes radial, being unable from known physical laws, which teach that not an atom ever left a rotating cosmical mass. We have made calculation of the maximum effect of tangental force on matter on the equator of the sphere when coincident with the orbit of Neptune, radius being 2,780,000,000 miles. And if the solar parallax is modified, bringing Neptune somewhat nearer, the figures will not be in material error. It is a law of mechanics that if matter is thrown off the periphery of a revolving sphere by force evolved by rotation, the detached portion always, when maximum power is exerted, traverses a line tangent to the curvature at the point of departure. If a revolving globe should burst, the pieces would be projected along tangental lines and never rise higher. But what is a tangent to the Neptunian orbit, and what is its departure from the curvature of that mighty sphere whence Neptune's mass is said to have been detached? It is apostulate of the Hypothesis that the nebula was a sphere, else it could not have parted with matter in the form of a ring. We adopt the idea that it was round, and for the purposes of trigonometry imagine the surface to have been as level as still water. We are in search of the departure of the tangent from the curve at different distances along the equator, to learn how far tangental force was able to project matter above the periphery.

The length of 1″ of arc on the equator of the nebula was 13,478 miles, and we made selection of 8″ of arc or 107,824 miles to find the amount of its deflection from the tangent. The curvature cannot be detected by tables of logarithmic functions carried to the sixth decimal place—thus:

$$
\begin{array}{lrl}
\text{log. sin. } 1' & = & 6.463726 \\
\text{log. } 60 & = & 1.778151 \\
\hline
\text{log. sin. } 1'' & = & 4.685575 \\
\text{log. } 8 & = & .903090 \\
\hline
\text{log. sin. } 8'' & = & 5.588665 \\
\text{and} & & \\
\text{log. tan. } 1'' & = & 4.685575 \\
\text{log. } 8 & = & .903090 \\
\hline
\text{log. tan. } 8'' & = & 5.588665
\end{array}
$$

That is, the logarithmic sine and tangent of 8″ are the same; hence the arc cannot be told from a straight line by ordinary tables. This being the case, radii drawn to the centre from each extremity would be equal in length, and it follows that any particle of matter on the equator of the primeval sphere, after having traversed more than a hundred thousand miles under the influence of tangental force, was no further from the centre than when it started, making the formation of a ring, or detachment of an atom, alike impossible.

Not deeming it true that an arc of such length had no curvature, and not having logarithmic tables for exact computation of functions near their limits, we were obliged to use the cumbersome method of natural sines, cosines and tangents, carrying the calculation to the twentieth decimal place to secure accuracy.

To find the cosines of such minute arcs use was made of the formula—Cos. $= 1 - \frac{1}{2}$ sin.^{2}, and for secants—Sec. A $= \frac{1}{\text{cos.}}$A.

Applying these formulæ to the arc of 8″ it was found that the secant was only 1.94 miles longer than the radius. That is, the curvature of the sphere at any point distant 107,824 miles from another, made a point of tangency, is less than two miles! Let us watch the career of an atom destined to be cast off the equator to