than for the purpose of producing a joint publication. As a rule, however, the young discoverer works alone, and he will most likely find, before he gets to the publishing stage, that his first discoveries have been made earlier by others. He must choose his subject according to his own taste. Usually he will be led most easily to some fresh result, if he reads and digests with keen interest the latest publications of others upon some growing subject. He may, perhaps, perceive that one of these papers has not exhausted all the possibilities; or he may, by an alteration in the point of view, find himself enabled to obtain the same result by a much shorter and more satisfactory process. He must not fear that he is giving his mind to a subject too trivial. No matter how slight the addition which he makes to the sum of knowledge, it is yet an addition, and unless it is superseded by the doing of the same thing by some one else in a better manner, it is a permanent contribution to science. Some are helped greatly, at times, by working first on some numerical illustration of the problem in hand; others, again, by a preliminary geometrical representation; and the first path to any discovery is not usually the best. It is sometimes supposed that the mass of original work done in so many countries and published in so many languages makes it likely that any ordinary piece of work will be overlooked in the great mass. Nevertheless, *litera scripta manet;* and what may now seem an unimportant addition to an unimportant branch may probably one day, when that branch is no longer unimportant, and when its special history comes to be itself a topic of discussion, receive its due recognition. Meantime, every little helps. The most trifling addition to the actual sum of knowledge will be at least useful as a step to aid the next investigator; but whether important or unimportant, whether appreciative recognition comes or not, whether others are helped or no one takes notice, there is a degree of personal pleasure in the mere fact of origination which is the just and certain reward of every piece of successful investigation.

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NEW YORK.

THE ORIGIN OF OUR VERNAL FLORA.

THOSE who have collected flowering plants for many years, without a doubt have been impressed with the wonderful regularity and precision displayed in the successive flowering of different species, even genera of plants. The character of the vernal flora in the northern United States * depends on the seasonal development of plants belonging to different natural orders. Each plant, even orders of plants, have definite times of appearance, when their flowers open, fertilization takes place, and seeds are distributed. At times, a lull or break in the continuity of this floral procession takes place just before the true summer plants appear. Such a break seems to occur in the neighborhood of Philadelphia between the twenty-fifth day of May and the tenth or fifteenth day of June, when the first true summer plants appear. Curiously enough, this period corresponds with the time of the ice saints in the United States, when there is a possibility of frost over a large portion of our con-

* The advent of spring may properly be considered as taking place at the approach of an isotherm one degree higher than 42.8° F., the general limit of protoplasmic activity. There is no temperature in the extreme South, in the vicinity of the Gulf, below 43.8° on the average, and there is therefore no advent of spring; no real beginning of vegetation and reclothing of trees with leaves. On February 1st, the isotherm in question is found crossing the United States from the vicinity of Cape Hatteras on the east to the north of El Paso, then northward to the Pacific near San Francisco Bay. The phenomena of winter are to be found north of that line. See *Harper's Monthly Magazine*, May, 1894, page 874, article by Mark W. Harrington.

tinental area.* A floral calendar might be constructed with the dates of germination, seed discharge and death of annual plants, and it would be found that a plant year after year departs very little in the time of its appearance from the dates put down in this vegetal almanac. Take a common agricultural plant by way of illustration. The planting season for Indian corn is from the 1st to the 10th of May in favorable weather. One hundred and ten days from date of sprouting to date of ripening or security from frost is about the average season. In many cases in the corn belt, Nebraska for instance, the farmers are quite sure of at least one hundred and twenty days. All this goes to prove that each plant has a peculiarity of its own with regard to temperature and environment; that the sum of the mean daily temperatures from the time of sprouting until the time of seed discharge is pretty nearly a constant one, and that if a plant be watched for years in succession it will be found that this thermometric sum oscillates little either way from the plant's normal. It is desirable that our native plants should be investigated as to temperature conditions, for some rule must determine the appearance of plants, the time of flowering and the time of suspended growth. It is no haphazard process, but depends on fixed laws of growth and development. The daily appearance of new plants depends considerably more on the habits of their ancestors than on the controlling influence of present meteorological conditions.

Our forest trees show some very interesting peculiarities in their early spring development, which is apparently caused by their past conditions of growth and development. Heredity seems to play a very important role in their vegetative habits. The facts condensed in the accompanying table will help to elucidate this statement:

*See *Harper's Magazine*, May, 1894.

Plants wind-fertilized, flowering from March to June.	Cretaceous or Chalk Period.	Quercus (oaks), Fagus (beeches), Salix (willows), Platanus (plane-trees), Sassafras, Laurus, *Magnolia*, *Liriodendron*, (tulip-trees), Myrica (wax myrtles), Betula (birches), Liquidambar (gum-trees), Juglans (walnuts), Acer (maples).
	Post-Cretaceous.	Cornus (dog-wood), Nyssa (sour-gums), Fraxinus (ashes).
	Eocene.	Ulmus (elms), planera, Celtis, Carya (hickory), *Vaccinium* (blue-berries).
	Miocene.	Almus (alders), Carpinus (horn-beam), Negundo.

Italicized genera insect-fertilized.

It will be seen from this table that the more important genera of trees flower in the early spring. The cause for this is to be found in the past history of the plants, for if we arrange them, as in the table, as to their appearance in geological time, we discover that nearly all of them appeared before or during the Miocene (middle Tertiary or Mammalian Age) Epoch, when the northern hemisphere was many degrees warmer than at present, and when a mild climate extended far into the arctic regions. It is impossible to ignore the force of the testimony as to the continuous warm climate of the north temperate and polar zones throughout Tertiary (Mammalian) Times. We have in the lower Cretaceous (Chalk) Period an almost tropical climate down to the upper Eocene (Lower Tertiary), when it remains warm temperate, for instance, in central Europe and cold temperate within the polar area. It then gradually cools down and merges through the Pliocene (Upper Mammalian) into the Glacial Epoch. That being the case, it is highly probable that the season of growth of our forest trees during the Miocene Period was uninterrupted, and that flowers followed rapid vegetation, as night follows day. The Glacial Period succeeded with its cold acting as a disturbing influence, cutting off the growth of the trees sharply just before the flowers opened. The stately monarchs of the Pliocene forests began to change their habit and adapt themselves to the new meteorological condition, the ever increasing cold. The unopened flowers were enveloped by the yet undeveloped leaves, which became harder and firmer, forming membranaceous and resinous covered bud scales, as a protection against the ice and cold. Flowers thus protected remained dormant during the long glacial winter, and on the return of the next growing season opened their flowers for wind fertilization. This habit of early flowering became impressed so strongly on the plants that it became hereditarily fixed. Trees of abnormal habit frequently show atavism, flowering in the late autumn, if exceptionally warm. This apparently indicates that the cold cut into two periods the normal process of plant growth. The division, thus, of the period of growth into two unequal halves by the glacial cold explains why our forest trees have varied little during the process of time from a wind pollinated (anemophilous) state, because their floral organs are developed in the spring before the appearance of the most highly specialized flower visiting insects. Two causes have operated to keep our trees permanently in an anemophilous condition, first, the separation of the vegetative and reproductive stages by the cold of the Glacial Epoch, and their early spring flowering; and secondly, the association of trees together into forests, flower visiting insects loving essentially open glades, or areas devoid of timber.

More difficulty is experienced in explaining the appearance of the herbaceous vernal flora. In order to arrive at a clear understanding of the problem, a few statistics are necessary.

The following table compiled from a variety of sources arranged for convenience of presentation according to the system of A. L. Jussieu (now little used) will be of use as approximately showing the statistical systematic distribution of our spring plants.

			Darrach.[1]	Darlington.[2]	Gray.[3]	Rothrock.[4]	Burk.[5]
Dicotyledones	Polypetalæ	Stamina epigyna	6		—		3
		" hypogyna	91	61	86	75	22
		" perigyna	6	18	17	30	16
	Monopetalæ	Corolla hypogyna	13	12	9	11	17
		" perigyna	—	—	—	—	—
		" epigyna	8	5	9	13	9
	Apetalæ.		6	15	13	—	6
Monocotyledones.			26	15	12	—	21

A predominant number of the plants, tabulated in the foregoing table, fall into eight natural orders: Ranunculaceæ (buttercup family), Cruciferæ (cress family) Violaceæ (violet family), Caryophyllaceæ (pink family), Rosaceæ (rose family), Saxifragaceæ, Ericaceæ (heath family), Compositæ (sunflower family). The plants belonging to these eight natural orders form the major and characteristic part of our spring flora, and with the exception of the Ericaceæ and Compositæ (few in number) are all polypetalous (many petals, distinct), and monocotyledons hypogynous (stamens and parts below the ovary) in its make-up. The more complex and irregular flowered families appear later in the year. Now this order of flowering corresponds curiously with the order of evolution of the flowering plants, which was suppositiously as follows:

A. Monocotyledons. Wind Fertilized. Grasses, Sedges.

B. Dicotyledons.

1. Wind Fertilized. Trees.
2. True Insect Fertilized.
   (a) Polypetalæ. (Petals distinct, 4 or 5.)
   (b) Gamopetalæ. (Petals united.)

This comparison leads us to infer the ab-

[1] Darrach, Proc. Acad. Nat. Sci., Phila., 1860, 145; [2] Darlington, Flora Cestrica; [3] Gray Manual; [5] Rothrock, Flora of Alaska; [4] Burk, Flora of Greenland, Proc. Acad. Nat. Sci., Phila., 1894.

sence of true flowers until late geologic times, for it is only by the visits of insects and their irritating action on vegetal protoplasm that the most irregular flowers have been slowly evolved, for there is a broad parallelism between the more differentiated types of the vegetal kingdom and the appearance of the various orders of insects, which was:

GEOLOGICAL SUCCESSION OF INSECTS.

Devonian, Orthoptera (ear-wigs, grasshoppers), Neuroptera (ant-lions).

Carboniferous, Coleoptera (beetles).

Cretaceous Olite, Hymenoptera (bees), Hemiptera (lice), Diptera (flies).

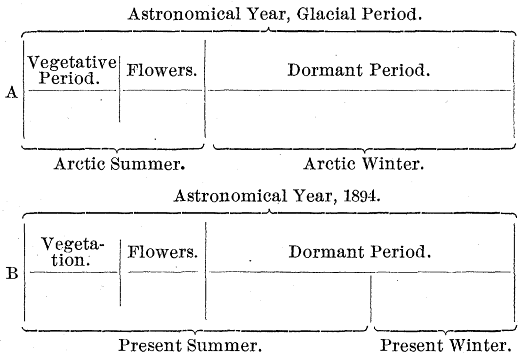
Tertiary, Lepidoptera (butterflies).

We know from the close association of insects and flowers that the insects were modified by their visits to flowers, and conversely that flowers have been changed to suit the visits of insects, and it is therefore not improbable that our most highly specialized flowers, and most irregular ones, appeared and were modified by the Lepidoptera in the late Tertiary time; for moths and butterflies are most highly specialized to insure cross fertilization, or allogamy. This variation in flowering plants must have been most strong at the close of the Miocene period, and after the retreat of the glaciers still more rapid than before, for it is probable that the intense struggle which took place by the migration and intermixture of forms of different kinds, occasioned by the change of environmental conditions, was a powerful factor in causing the striking variety of flowers and insects. The 'responsive power' of the protoplasm of the plants, acting in concert with the external impulses received from the environment, must have been strong after the disappearance of the glaciers, on account of the re-occupation of a barren glacial country by northward moving plants, whose protoplasm had become responsively mobile during the long continued struggle in the south.

It is not at all improbable that the polypetalous groups of plants were northern ones during the Miocene period, and that their flowering period depends on this past geographical position. Those plants which lived far north during late Miocene and Pliocene times were least modified, for it is likely that moths and butterflies were then few in number, and the time was not sufficiently long for change to take place before the glacial ice sheet moved southward, mixing the northern and southern types, and introducing a struggle which was to last until the ice disappeared by the temperate heat. Many tropical plants remained associated with the northern forms crowded southward by the glaciers, notwithstanding that a great number perished under the more rigorous conditions of a colder climate. When the glaciers retreated, the predominant polypetalæ adapted to a cold climate did one of three things: 1. They retreated northward. 2. They retreated up the high mountains. 3. They took almost exclusive possession in their growth of the spring months, for the temperature conditions are such as to suit well their hereditarily impressed preference for the cold.

These plants flower and mature their seeds quickly before the summer is well advanced, which mark them as physiologically adapted to the influences of the short glacial summer, alternating with the long glacial winter. This rapid growth production of flowers and seed in a short space of time is possible from the quantity of nutritive material stored up in the plant. The beet, turnip, parsnip and carrot are familiar examples of biennials with the reserve substance packed in the roots; the houseleek, lily and onion with the bases of the leaves enlarged and thickened to contain the stores of starch, sugar and proteids. Even under these favorable conditions, when the plant would be in a condition to grow most vigorously, every externally perceptible vital motion nevertheless ceases, and it is only after a dormant period of some months that growth commences anew, and this frequently under circumstances which appear far less favorable—especially at a conspicuously lower temperature. "This periodic alternation of vegetative activity and rest is in general so regulated that, for a given species of plant, both occur at definite times of the year, leading to the inference that the periodicity only depends upon the alternation of the seasons, and therefore chiefly upon that of temperature and moisture." A few well-known examples are selected for illustration. "The leaf-shoot and flowers contained in the bulb of the Crown Imperial commence to grow vigorously in the spring-time with us, even at the beginning or middle of March, when the soil in which the bulb has passed the winter possesses a temperature of 6–10° C.; the leaf-shoots protrude forcibly from the cold earth to grow vigorously in the but slightly warmer air. There would be but little to surprise us in this, if we did not at the same time notice the fact that a new leaf-shoot is already formed in embryo in the subterranean bulb in April and May; this shoot, however, does not grow to any extent in the warm soil during the summer and autumn. On the contrary, this favorable period of vegetation passes by, until at the end of the winter an inconsiderable rise of temperature above the freezing point suffices to induce vigorous growth; and as is well known, the same is the case with most bulbous and tuberous plants, as the meadow saffron, potato and kitchen onion."

"I have many times attempted to induce the tubers and bulbs ripened in autumn to put forth their germinal shoots during November, December and January, by laying them in moist, warm loose soil; but as in the case of the potato, as well as in that of the kitchen onion, no trace of germination appeared. If, on the other hand, the attempt is repeated in February, or still better in March, the germinal buds begin to grow vigorously even in a few days. It is evident that some internal change must have taken place in the tubers and bulbs during the winter months, when it is impossible to bring them into activity from their state of rest." Our spring plants in this agree physiologically with their arctic congeners. The period of rest described above in such early spring plants, as the winter aconite, crocus, Erythronium, etc., has in my opinion been due to the influence of the glacial cold hereditarily impressed on these plants in connection with the chemical changes which go on. The following diagrams will illustrate my meaning. Diagram B shows that the period of vegetative activity of our spring plants corresponds with an arctic or a glacial summer, while the dormant period corresponds with an arctic winter, although our present summer has encroached on the former glacial winter.



It was necessary for this rapid growth that the food material should be prepared beforehand, because the arctic or glacial summer is an exceedingly short one. Mr. Henry Seebohm,* in his presidential address before the Geographical Section of the British Association, gave a graphic description of the succession of the seasons in high arctic latitudes. A few sentences are worth quoting in this connection. He said that the stealthy approach of winter on the confines of the polar basin is in strong contrast to the

*See *Popular Science Monthly*, XLV., 138, May, 1894.

catastrophe which accompanies the sudden onrush of summer. "One by one the flowers fade and go to seed, if they have been fortunate enough to attract a bee or other suitable pollen-bearing visitor. The arrival of summer happens so late that the inexperienced traveler may be excused for sometimes doubting whether it really is coming at all. When continuous night has become continuous day without any perceptible approach to spring, an Alpine traveler naturally asks whether he has not reached the limit of perpetual snow. During May there were a few signs of the possibility of some mitigation of the rigors of winter, but these were followed by frost. At last, when the final victory of summer looked hopeless, a change took place; the wind turned to the south, the sun retired behind the clouds, mists obscured the landscape, and the snow melted 'like butter upon hot toast,' and we were in the midst of a blazing hot summer picking flowers of a hundred different kinds and feasting upon wild ducks' eggs of various species."

The polypetalous families which blossom early in the season, although old geologically speaking, have not been greatly modified since Pliocene times, because their flowers open in the spring before the Lepidoptera hatch out from their cocoons. It is obvious that every species of flower can only be visited and fertilized by those insects which occur at the time when the plant is in flower and in stations where it grows. The insect visitors of a plant are therefore limited by the season and by the time of day when it flowers, by its geographical distribution and by the nature of its habitat. The high northern polypetalæ have remained therefore regular while those plants growing in the southland have become highly irregular by the visits of numerous highly organized insects in great number near the equatorial zone. We must be cautious, however, in generalizing too broadly, for we can only call those parts perfect which fulfill their purpose in the life of the plant essentially well; that is to say, which under existing conditions insure the sexual reproduction of the species with particular success.

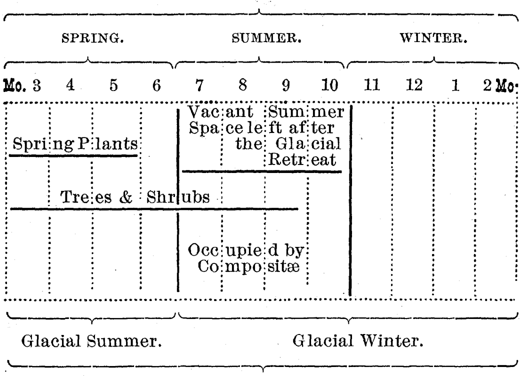
The Compositæ (sun-flower family), the highest expression of evolution amongst Dicotyledons, appeared latest in geological succession, for no undoubted form of them (Synantheræ) has been found farther back than the middle Miocene. Müller says:* "The numerical preponderance which this family has attained in species and genera (1000), and the extreme abundance of many of the species, are due to the concurrence of several characters, most of which singly, or in some degree combined, we have become acquainted with in other families, but never in such happy combination as in the Compositæ. The following points deserve special mention: (1) the close association of many flowers; (2) the accessibility of the honey as well as the plentiful secretion and security from rain; (3) the possession of a pollen mechanism, which renders cross fertilization certain in the event of insect visitors." It is a masterful order of plants most commonly met with in the late summer and autumn, flowering profusely until the heavy frosts of early winter, when they cast their seeds abundantly. An enumeration of the Compositæ growing in the vicinage of Philadelphia shows that the plants are essentially late summer growers.

FLOWERING TO FRUIT RIPENING.	NUMBER OF PLANTS.
April–May,	2
May–June,	4
June–July,	6
June–August,	4
July–August,	8
July–September,	15
August–September,	32
August–October,	35
September–October,	15
	121

* Müller, *The Fertilization of Flowers.*

These are the latest group of plants to appear geologically, they grow and flower in the warm season added to the short arctic summer by the retreat of the glacial winter. The following diagram will indicate more clearly what is meant, and will show why it is that the Compositæ of the north temperate zone are the characteristic herbaceous vegetation of the late summer and autumn months.

Present Astronomical Year.



Miocene Season of Growth.

The land area left bare by the retreat of the glaciers was one of low tension, although by the increase in the length of the summer (some three months) it had a climate in every way suited for the growth of plants. The country to the south was one of very high pressure tension, which must be relieved. The great strain was removed partially by the movement of plants to the northward. "Of all the plants which went south before the first invasion of the glacial ice sheet, none showed greater capacity for variation and improvement than the ancestral forms of the modern dominant family of Compositæ." Such plants in having seeds adapted to fly before the prevalent north winds had reached a low latitude, where great change of form took place owing to the intense struggle for existence. The composite plants were assisted northward by the same structural means as carried them south. Modified considerably into new forms by their migrations and life in the south, they retained their fondness for a warm climate. By the extension of the arctic summer, some three months, they had an opportunity for extensive migration over the country formerly ice bound.

It is thus from the high and low pressures, caused alternately by the glacial epoch, that the distribution of our flora in time has been accomplished.

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ON CERTAIN HABITS AND INSTINCTS OF SOCIAL INSECTS.

If the mere inductive evidence for the Lamarckian theory of the hereditary transmission of acquired characters be strong anywhere, it is assuredly in the region of nervous and mental phenomena. Romanes, whose reserve on the inheritance of acquired characters of a physical nature is everywhere manifest, admits that many instincts are due to the 'lapsing of intelligence.'* "Just as in the lifetime of the individual, adjustive actions which were originally intelligent may by frequent repetitions become automatic, so in the lifetime of the species actions originally intelligent may, by frequent repetitions and heredity, so write their effects on the nervous system that the latter is prepared even before individual experience to perform adjustive actions mechanically which in previous generations were performed intelligently."

Even Weismann, with all his wealth of imagination and capacity for elaboration of details, has nowhere attempted to trace out the mechanism for the evolution of instinct on the line of his 'germ plasm theory,' nor applied to it the manifold combinations of 'biophors' and 'determinants,' 'ids' and 'idants' which he assumes as the machinery of inheritance. So far the only

* *Mental Evolution in Animals*, p. 178.