the day's work; which is equivalent to saying that the efficiency of this vital machine, considered simply as prime mover, is $23\frac{1}{2}$ per cent. If efficiency of conversion of potential into dynamic energy of muscular work, internal as well as external, is considered, it is very possible that this figure may be doubled, and the efficiency to be taken in comparison with that of heat-engines may be somewhere between forty and fifty per cent. If the internal work of thought and of brain and nerve power is considered useful work, and the total compared with the energy supply, the efficiency will be a still higher figure, perhaps fifty or even sixty per cent.*

But the highest total efficiency of the best steam-engine yet constructed is but about twenty per cent., with its thermodynamic range of about 200° F. (111° C.) degrees, Fahr., and that of the best gas-engine is but about the same, with a range of ten times that extent. If the vital machine be a thermodynamic engine, therefore, its known efficiency, with no recognized temperature, range of heat 'let down,' is not less than twenty-five per cent. higher than, and may be twice as high as, the best heat-engines constructed by man. This is recognized by engineer and thermodynamist alike, as a *reductio ad absurdum*, and the vital engine is certainly not a heat-engine.

The facts regarding the distribution of potential energy to the various organs of the body; the development by each organ of its special form of product in new compositions or in a special energy; the localization of energy-transformations in the cells of the muscle, or other energy-producer; the accompanying liberation of carbon-dioxide from consumption of glycosic material; the utilization of a telegraphic, or rather a semaphoric, system communication between the mind or the interior automaton of the spine and cerebellum and the point of useful application of energy all: these are familiar to all physiologists.* Beyond these known phenomena lie the mysteries which the engineers, if possible more than the physiologists themselves, most desire to see completely solved. When they are thoroughly investigated and the operations of the vital machine become fully known, in all their details of energy-transformation, it may be possible to secure new prime movers of similarly high efficiency and thus to double the life of the race by prolonging the period marking the endurance of our supplies of potential energy in the coal-fields of the world. Should it prove that only by preliminary manufacture of fuel, in the form of sugars, can this result be attained, it may seem unlikely that, even when these operations are no longer mysteries, commercial applications of nature's methods can be expected to prove successful; yet when it is considered that the sugars are simply carbon and water, it will not be denied by either engineer, chemist or physiologist that a possibility still remains of effecting so enormously important an advance in the prime motors. If, further, nature's economies in light-production can be paralleled, the engineer may ultimately furnish heat, light and power, the three great products of his special labors of most value to the race, with insignificant wastes and approximately perfect efficiency and maximum cheapness. Given perfect efficiency of power-production and the main problem is solved. R. H. THURSTON.

CORNELL UNIVERSITY.

* Weisbach's Mechanics of Engineering; Rankine's Prime Movers; Thurston's Animal as a Prime Motor; Reynolds' Memoir of Joule.

* Foster's Physiology; Encyclopædia Britannica, Art. Physiology; Chauveau's Le Travail Musculaire.

HARSHBERGER ON THE ORIGIN OF OUR VERNAL FLORA.

BY way of a review of a paper by Mr. Henry L. Clarke, in the *American Natural-*

ist for September, 1893, XXVII., 769–781, entitled 'The Philosophy of Flower Seasons,' I have just contributed an article to the same journal, Feb., 1895, XXIX., 97–117, giving the results of local observations on the same subject. After my paper was in type, I found a short article in *Nature*, XXVII., 7, by J. E. Taylor, entitled 'The Origin of our Vernal Flora,' which suggested some reflections bearing upon the problem. These, with other thoughts relating to the subject, were too late to be incorporated in an article which was already of considerable length. A consideration of these items, however, may not be out of place in connection with an examination of the article by Mr. Harshberger, in SCIENCE, Jan. 25, 1895; New Series, I., 92–98.

Commenting upon the fact that it is usual to assign an Arctic origin to our mountain flora, but without giving references, Mr. Taylor says: "Seeing that temperature is so largely influential in explaining the distribution of flowering plants, it occurs to me that not only may height above the sea-level answer to northern distribution, but *seasonal occurrence* as well." Briefly, this covers Mr. Harshberger's propositions numbered 1, 2 and 3 on page 95.

Mr. Taylor observes that the early flowering plants blossom two or three months earlier in Great Britain than within the polar circle. For example, *Chrysosplenium oppositifolium* and *C. alternifolium* bloom 'in March or April; within the Arctic circle not until June and July, and even so late as August.' This suggests a general retardation of flower seasons as we go northward, and I have used this assumption as in part explaining the late blooming of some of the luxuriant, highly specialized groups, which MacMillan* calls 'north-bound.' In many of these, flowering is preceded by a long vegetative period. In the northward movement, if the vegetative period remains of the same length, it seems probable that the flowering would be later in consequence of this period beginning later.

*Higher Seed-Plants of the Minnesota Valley, 1892.

Mr. Clarke's paper is an elaboration of the idea of the preponderance of the less-specialized flowers in the early part of the season and of the more highly specialized flowers in summer and autumn, and I have criticised this theory from the standpoint of the local flora of my neighborhood, and have undertaken to account for flower seasons as a result of the competition of flowers among themselves and in correlation with the flight of the anthophilous insect fauna. The reader is referred to these papers for a more extended discussion of the relations of flower seasons and the specializations of floral structure.

Mr. Harshberger's observations upon the lull or break in the continuity of the floral procession, which he says at times occurs, is quite interesting. He says: "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 continental area."

There is a lull, however, which, at least as regards the entomophilous flora, takes place, not 'at times,' but regularly. The frost may, indeed, in many cases have a very definite effect in preventing plants from advancing into the spring months, probably indirectly, however, through its influence upon the vegetative state which precedes flowering. The time of the ice saints, according to Harrington,* is from May 19th to 24th, while the floral depression is later.

In the neighborhood of Carlinville, Ill., the entomophilous flora shows a slight de-

Harper's Monthly, LXXXVIII., 878. 1894. Article cited by Harshberger.

cline in June, and many of the groups show well marked June depressions, as will be seen from my curves (in article cited). The dominant families show maxima before June or after, but not one of them shows a June maximum. The depression sometimes occurs in very homogeneous groups, as the Scrophulariaceæ, there being no particular distinctions between the early and late ones. The gap sometimes separates species of the same genus. As a rule, the vernal flowers belong to plants of low habit which bloom in the woodlands, which are now warm and sunny, or upon the open grounds. About June the former become overshadowed by the leaves which have appeared on the trees, and the latter by the later more luxuriant vegetation. Thus the species of *Viola* and *Lithospermum* produce attractive flowers until about this time, when they either stop blooming altogether, or resort to the production of cleistogamic flowers.

One fact, which was not mentioned in my paper, but is shown in my curves, is that the groups of anthophilous insects show the same tendency to form early or late maxima, which emphasizes the importance of the correlations of the two sets of more or less mutually dependent organisms. The Syrphidæ, Empidæ and Andrenidæ show early maxima, while all of the other families show late ones. In the case of the dominant genera of bees, *Anthophora, Synhalonia* and *Osmia* reach their maxima early, but the other genera predominate late. *Nomada* breaks into a large early group and a small late one, just like *Andrena*, upon which it is parasitic.

In the case of our trees, I suspect that the flowers were always produced before the appearance of the leaves, an arrangement which would be most favorable to their anemophilous pollination. Mr. Harshberger certainly seems very wide of the mark in explaining the retention by trees of their adaptation for wind aid in transferring their pollen. In the first place, their height exposes them to the wind in such a way as to make wind pollination quite favorable, while the wind may also interfere with insect visits. The fact that the most highly specialized flower visiting insects are not so abundant in spring will not do, for they are not the insects which are most likely to favor incipient stages of entomophily. The less specialized bees (Andrenidæ) and the flower flies (Syrphidæ) are most abundant in spring, and they would be the most favorable guests in the less specialized states of insect-adaptation. Moreover, flower-loving insects are very abundant in the woodlands in the spring before the leaves appear, and that is the very time that the wind pollinated trees are in bloom. By resorting to entomophily, the trees would only come in competition with the terrestrial flora, which is more favorably situated for insect visits and is very attractive to the early insect fauna.

The author states that "Trees of abnormal habit frequently show atavism, flowering in the late autumn, if exceptionally warm." Such cases as *Hamamelis* are examples. I am inclined to Foerste's* view that the autumnal blooming is a case of precocious development of a spring flower. According to him, *Hamamelis* has distinct hibernacula and in cold autumns holds over until next spring.

If the generally accepted flower theory is true, one would expect to find the highest specialized flowers at that part of the season when the most highly specialized flower visiting insects are most abundant. But it is hard to understand how Mr. Harshberger could attribute this modification to the Lepidoptera. As far as adaptation for flower-pollination is concerned, the bees are beyond question the most highly specialized. Müller† says: "Bees, as the most

*Bot. Gazette, XVII., 3, 1892.

†Fertilization of Flowers, 595, 1883.

skilful and diligent visitors, have played the chief part in the evolution of flowers; we owe to them the most numerous, most varied and most specialized forms." The Lepidoptera have given rise to some highly specialized flowers, but I think it would be hard in a single case to show a probability that the incipient stages of irregularity were induced by their visits.

That the less specialized flowers are spring flowers is only true in a general way. From my present data it appears that the maximum of the entomophilous Choripetalæ is in August, though further observations may show a greater number in spring. Including the anemophilous species, the Choripetalæ will certainly show an early maximum, and that is the extent of the justification of their being called spring plants. The same is true of the entomophilous Monocotyledons. If the blooming seasons of all of the Monocotyledons of a given neighborhood be worked out, I doubt if they will show a vernal maximum, though the position of *Carex* may accomplish this result. The Gamopetalæ have a late maximum, but none of them are free from the competition of the Monocotyledons or the Choripetalæ.

It seems to me that Mr. Harshberger has contributed an important point in reference to the general positions of the flower groups by indicating the influence of the retreat of glacial winter. Making use of this suggestion we may suppose that, as the warm seasons became longer, a large proportion of the Monocotyledons and Choripetalæ moved northward, climbed the mountains or opened their flowers early. While the more highly specialized groups were by no means thus relieved from the competition of the less specialized, there can be little doubt but that in the later months they found a time when that competition was less severe. This may aid us in explaining what has struck me as a fact in the phænological habits of the flora of my neighborhood. I have indicated that the introduced plants, the aquatics and the degraded entomophilous flowers tend to prolong their blooming seasons, and have supposed that this results from their being more relieved from the competition which besets the other flowers. Although the data have not been arranged to test the point thoroughly, it has occurred to me that the later plants in general bloom longer than the early ones. (In investigating this proposition, it may be proper to eliminate some of the very late ones, whose seasons are not cut short by competition, but by way of preparation for the approaching winter.) The later species thus appear to have entered a position where competition was less severe. It may be, however, that they show the effects of competition less, merely on account of their superiority.

Mr. Harshberger attributes floral modifications to the 'irritating action of insects on vegetal protoplasm.' This suggests Henslow's* theory. As far as I know, that theory has not been accepted by any one who has made a serious investigation of the relations of flowers and insects, and for that reason it has not seemed justifiable to discuss it at length. It seems safe to say that it has not been shown that direct insect contact will induce floral modifications, or that the theory will account for the most ordinary facts of floral structure.

Finally, with regard to the literature, I notice that Mr. Harshberger quotes MacMillan (l. c.) without giving references. On consulting this author, I find that the general proposition of the early blooming of the less specialized plants and the late blooming of the more highly specialized is at least strongly suggested, and that too evidently on the authority of persons cited in a bibliographical list. The autumn-flowering of the Compositæ is distinctly stated. From his observations in Flanders,

*The Origin of Floral Structures, 1888.

MacLeod* concludes that the less specialized flowers, as well as insects, prefer the springtime, while the more highly specialized prefer the later months. This anticipates my statement of the same general result.

CHARLES ROBERTSON.
CARLINVILLE, ILLINOIS.

BRISSON'S GENERA OF MAMMALS, 1762.

IN 1756 Brisson published, in Paris, the mammal volume of his '*Regnum Animale in Classes IX Distributum.*' It is a quarto, with the descriptive matter in French and Latin, in parallel columns, and contains a folding table or key on which the generic names are given in proper Latin form. But since the work antedates by two years the 10th edition of Linnæus' *Systema Naturæ*, which by common consent is accepted as the starting point in Zoölogical nomenclature, the names cannot be used. Six years later, however, a second edition of Brisson appeared. It is a rare octavo, wholly in Latin, and was printed at Leyden in 1762 †. It is of special importance because it falls between the two editions of Linnæus that are available in Zoölogical nomenclature (10th Ed., 1758; 12th Ed., 1766), and hence may be considered, so far as the genera of mammals are concerned, as a part of the foundation of the nomenclature. The specific names are not exclusively binomial and cannot be used, but the generic names given in the keys (pp. 12–13 and 218) are in due Latin form, and are entitled to recognition.

Although the work was not printed until four years after the 10th edition of Linnæus, the 6th edition (1748) is the only one quoted. Still 25 of the 46 genera given are the same as those published by Linnæus in the 10th Ed. (1758). Of the remaining 21, ten are strictly synonymous with and antedated by Linnæan genera, and consequently cannot be used either in a generic or sub-generic sense. These are:

Brisson, 1762.		Linnæus, 1758.
Pholidotus	=	Manis
Tardigradus	=	Bradypus
Cataphractus	=	Dasypus
Hircus	=	Capra
Aries	=	Ovis
Musaraneus	=	Sorex
Prosimia	=	Lemur
Philander	=	Didelphis
Cetus	=	Physeter
Ceratodon	=	Monodon

The remaining eleven are introduced by Brisson for the first time and are entitled to recognition. They are:

Odobenus	Glis
Giraffa	Pteropus
Tragulus	Hyæna
Hydrochœrus	Meles
Tapirus	Lutra
Cuniculus	

Most of these are now in current use, but are attributed to later writers, and in several cases wrong species are taken as types. Carrying the date back to 1762 not only gives them greater stability, but also establishes the types in a satisfactory manner. All but one of the genera take Linnæan species for types, as follows:

The type of *Odobenus* is *O. odobenus* Brisson = *Phoca rosmarus* Linn., which becomes *Odobenus rosmarus* (Linn.) 1758. It thus seems as if the Walrus, after oscillating for a century and a half between *Odobenus* and *Trichechus*, might fairly claim a permanent abiding place.

The type of *Giraffa* is *G. giraffa* Brisson = *Cervus camelopardalis* Linn., which becomes *Giraffa camelopardalis* (Linn.) 1758.

The type of *Tragulus* is *T. indicus* Brisson = *Capra pygmea* Linn., which becomes *Tragulus pygmeus* (Linn.) 1758.

* Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek, VI., 1894.

† Regnum Animale in Classes IX. Distributum . . . Quadrupedum & Cetaceorum . . . A. D. Brisson . . . Editio altera auctior . . . Lugduni Batavorum . . . 1762.