should have more attention than it seems to get. The whole matter of metamorphosis in insects has been looked at too much from the angle of the systematists, who have found "incomplete" and "complete" metamorphosis a convenient taxonomic character, and of the nature study teachers, who have found it a subject of fascinating interest to children. The true biologic significance of the process has been pretty consistently overlooked. Montgomery does well to recall attention to it and to suggest an interpretation of it of great interest.

However, before accepting this interpretation, or any other, or following it too far, we should be sure we know the actual state of affairs represented to us by the phrase "complete metamorphosis." This commonly suggests, first, the externally obvious, apparently violent and radical changes from larva to pupa to adult, and, second, the interesting internal phenomena of the histolysis of the larval parts and histogenesis of the imaginal parts. But we are very likely to let a type or example of this total performance represent to us the whole range of the phenomenon, which is misleading. For as a matter of fact every gradation can be found among insects from the simple going over, with little or considerable transformation, of larval parts into adult parts, as taken to be characteristic of "incomplete" metamorphosis, to the radical disintegration and disappearance of the larval parts with the fundamental new building of the imaginal parts from isolated histoblasts, taken to be characteristic of and common to all insects of "complete" metamorphosis.

During the last few years, various students in my laboratory (particularly Mr. Powell) and I myself have given some special attention to the phenomena of insect metamorphosis, and have been able to break down any inherited belief of ours (or belief acquired from tradition and text-books) of the discontinuity of "incomplete" and "complete" metamorphosis. We have found insects of incomplete metamorphosis (Hemiptera) showing some of the characteristic phenomena of complete metamorphosis and insects of complete metamorphosis (Coleoptera) showing characteristics of incomplete metamorphosis. And these not as individual variant or aberrant cases, but as conditions characteristic of the development of species.

That is, if the insects with more specialized complete metamorphosis, as flies, ants, etc., are to be looked on as metagenetic in character (*i. e.,* "with a life cycle consisting of two or more individuals with alternation of sexual and asexual reproduction"), and the insects with most generalized incomplete metamorphosis as having a continuous (non-metagenetic) life cycle, the question arises as to where, in the insect class, the difference first appears. And if the whole process of metamorphosis differs in its most specialized and its most generalized states only in degree; if a complete series of intergrading or connecting states exists (as really does); where is the opportunity to interpret this process in the case of certain insects as true metagenesis, and in the case of others as a true continuous non-metagenetic life cycle?

VERNON L. KELLOGG
STANFORD UNIVERSITY, CAL.

BOTANICAL TEXT-BOOKS

IT is a pretty dull week when some one does not put out a new botanical text-book intended for high-schools, colleges and universities, and not infrequently these consist of 300 to 600 pages each, covering a wide range of topics. The great diversity of training given in the colleges of our country and of Europe, makes it next to impossible for any capable man to produce a book all sections of which will fit a large number of teachers. I think we may well learn a lesson regarding this multiplicity of books from the teaching of English literature.

Instead of compelling each member of a class to purchase complete sets of Burke, Patrick Henry, Webster or Clay, select speeches of these men are printed separately, which are inspiring and can be used by the students according to their different tastes. So here in botany, why should not some one, by this plan, prepare a considerable number of pamphlets, each suited to the needs of some teacher, which his own judgment will lead him to select. It usually discourages a student somewhat to buy a large text-book, one half or one third of which is used in his classes, and the rest omitted.

W. J. BEAL

SPECIAL ARTICLES

THE PROBABLE ORIGIN AND PHYSICAL STRUCTURE OF OUR SIDEREAL AND SOLAR SYSTEMS[1]

MAINLY because of the very high, and for certain reasons inadmissible, temperature heretofore obtained when Newton's law of radiation is employed, astronomers and physicists hold that this law can not be used for determining the effective surface temperature of the sun.

That Newton's law of radiation is just as true for the sun as is the law of gravitation, and that the sun's surface temperature can only be determined by means of this law will now be demonstrated.

Let us conceive that the sun's total radiant energy S (per unit of time) is concentrated in an ether vibration at the sun's center. Let the temperatures t_0 and t be taken as the measures of the intensity of vibration at the distances r_0 and r; we can then at once write

$$\left(\frac{S}{t_0 r_0^2}\right) = \left(\frac{S}{tr^2}\right), \tag{1}$$

hence

$$t_0 = t\left(\frac{r}{r_0}\right)^2. \tag{2}$$

Now let us conceive that a thin spherical shell of lampblack having the radius r_0, and coinciding with the sun's surface, receives and transmits in each unit of time the total energy S, the temperature t_0 of this shell will then be the same as the temperature of the sun's surface, and the temperature t in any exterior similar shell of radius r must necessarily be such as to satisfy equation (2), for to assume any gain or loss through the substitution of the total energy S given out by the surface shell in place of the energy S given out by the central vibration would be contrary to the law of the conservation of energy.

Now to find t_0 the temperature t, at the earth's distance from the sun, must first be found, and *just here is where inadmissible errors have been committed in past determinations.*

I offer the following extremely simple method for determining the absolute temperature of space:

Let D denote the diameter of a mirror (or objective) having the focal length F, the linear diameter d of the sun's focal image will then be $d = 2F \tan \theta$, in which θ is the angular semi-diameter of the sun. (For our present purpose d depends only on F and θ and is independent of D.) Let T denote the measured absolute temperature in the sun's focal image, then, if we neglect for the present the effects due to atmospheric absorption, we can at once write for a theoretically perfect telescope

$$\frac{T}{t} = \left(\frac{D}{d}\right)^2. \tag{3}$$

The expression for the absolute temperature of space is therefore

$$t = T\left(\frac{d}{D}\right)^2. \tag{4}$$

Now let a denote the factor by which T must be multiplied in order that the product shall equal the surface temperature t_0 of the sun; we then have

$$a\frac{T}{t} = a\left(\frac{D}{d}\right)^2 = \frac{t_0}{t} = \left(\frac{r}{r_0}\right)^2, \tag{5}$$

from which we find

$$a = \left(\frac{d}{D}\right)^2 \left(\frac{r}{r_0}\right)^2, \tag{6}$$

in which all the quantities are known. The expression for the effective surface temperature t_0 of the sun is therefore

$$t_0 = t\left(\frac{r}{r_0}\right)^2 = aT. \tag{7}$$

My observational work has been carried on with the aid of three mirrors which I constructed to continue investigations under way at the time of my departure from the Lick Observatory. The first two of these telescopes are briefly described in No. 539 of the *Astronomical Journal;* the third mirror has an aperture of two feet and a focal length of three feet. The definition of this last-men-

[1] Extract from a still unfinished paper.