of a citron color. On some plants the petals are more or less laciniate on the margin. Frequently they are five in number, sometimes six, often eight. The number of pistils is not fixed, and the bifid cotyledon and broad rim of the torus, both traits normally characterizing the true *californica* (the smooth perennial), are often as elusive as the other characters.

The color especially lends itself to modification by selection. Burbank once found a plant with a crimson streak like a red thread at the base of each petal. Saving the seed, he obtained through selection alone a poppy with the flowers all crimson. Seedlings from Burbank sometimes have pinkish flowers, almost white.

Eschscholtzia has certain advantages over the evening primrose for experimental purposes. It is a natural species occurring by the million in its habitat. Though very difficult to transplant, it grows readily from the seed. It is therefore not a garden variant, nor a suspected hybrid. *Œnothera lamarckiana,* thus far the subject of most mutation experiments, though cultivated in Europe, is American in origin. No one, I believe, has yet ever found it growing wild anywhere.

In any event, accurate studies of the variation in *Eschscholtzia* should be interesting and repaying.

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THE TEMPERATURES OF METEORITES

IN the last number of SCIENCE[1] Dr. George P. Merrill discusses some matters connected with meteorites. With regard to their temperature he says, "it seems certain that they have been wandering for an indefinite period in space and at a temperature of 'absolute zero.' At the time of entering our atmosphere it is fair to assume that they are cold throughout to a degree of which we can have no conception." It has seemed to me worth while to examine roughly what temperature a meteorite might reasonably be expected to have just before it enters the atmosphere of the earth. The meteorite has certainly been for some time exposed to radiation from the sun, and it may well be that its temperature is much higher than the absolute zero.

[1] SCIENCE, 55, p. 675, 1922.

To get some idea as to the temperature suppose that the meteorite is a sphere with a black surface, and that the material of which it is composed is a perfect conductor of heat. The temperature of this sphere is determined by the condition that the rate at which it loses heat by radiation equals the rate at which it receives heat from the sun. The condition is expressed by the equation

$$4\pi r^2 \sigma \theta^4 = \pi r^2 b \frac{e^2}{d^2}, \qquad (1)$$

where r stands for the radius of the meteorite, σ for the constant in the Stefan-Boltzmann radiation formula, θ for the absolute temperature of the meteorite, b for the solar constant, and e and d for the respective distances of the earth and the meteorite from the sun. If we take σ as $1.279 \cdot 10^{-12}$ cal./cm².sec.deg.⁴ and b as 1.93 cal./cm².min. (1) leads to

$$\theta = 282\sqrt{\frac{e}{d}}. \qquad (2)$$

Thus if black spheres which conduct heat perfectly were placed at the same distances from the sun as the several planets, (2) shows that the temperatures of these spheres would be the following:

At the distance of

Mercury	180° C.
Venus	58° C.
Earth	9° C.
Mars	—45° C.
Jupiter	—149° C.
Saturn	—182° C.
Uranus	—209° C.
Neptune	—221° C.

We see that in the neighborhood of the earth such a sphere would have a temperature above that of melting ice!

But a meteorite is not a perfect conductor of heat. Suppose we apply the above method of reasoning to a sphere which is a perfect non-conductor of heat, covered, except along a narrow equatorial line, by a thin layer of a substance which is a perfect conductor of heat and is black. The conducting layer forms two separate caps, and if one cap is turned toward the sun and the other away from the sun we find, when the sphere is as far from the sun as the earth is, that the cap which faces the sun will have a temperature of about 62° C. The other cap will be at the absolute zero of temperature, so that the average temperature of the sphere will be about —105° C. We may, therefore, conclude that if a meteorite were spherical and black its temperature when near the earth would lie between —105° C. and +9° C.

If the meteorite is not a perfect conductor of heat the temperature of the inside will not usually be the same as that of the outside. The amount by which the temperature of the inside differs from that of the outside will depend in part on the thermal conductivity of the meteorite and in part on the rapidity of motion toward the sun or away from it, as well as on the distance from the sun. Suppose that the meteorite is a sphere and has a diffusivity of 0.01 cm.²/sec. This is about the diffusivity of limestone and is less than that of granite. Suppose further that this sphere is at the absolute zero of temperature and is suddenly placed where its surface is maintained at 9° C. Then for a sphere 10 cm. in diameter I find[2] that at the end of fifteen minutes the difference between the temperature at the center and that at the surface will be less than 15°, at the end of twenty minutes the difference will be less than 5°, and at the end of thirty minutes it will be less than 0.2°. If the meteorite travels 100 kilometers a second it would require nearly five days to go a distance equal to that from the orbit of Venus to the orbit of the earth. So, unless the meteorite travels much faster than 100 kilometers a second, or is much more than 10 cm. in diameter, it seems likely that the temperature of the inside can not be very different from that of the outside. This, of course, is before the meteorite enters the atmosphere of the earth.

As another way of attempting to get some idea as to the temperature of a meteorite suppose we consider the temperature of a cylinder. Let the cylinder be at the same distance from the sun that the earth is. Let the ends of the cylinder be black, and let one of them point directly at the sun. To simplify matters suppose that there is no radiation from the sides of the cylinder. Then the heat which reaches the end that is turned toward the sun is partly radiated from that end and partly conducted to the other end and there radiated. From this condition we obtain the equations

$$\sigma(\theta_1^4 + \theta_2^4) = b \tag{3}$$

and

$$\theta_1 = \theta_2 + \frac{l\sigma\theta_2^4}{k}, \tag{4}$$

where θ_1 and θ_2 stand for the absolute temperatures of the two ends of the cylinder, and l and k stand for the length and thermal conductivity of the cylinder. Taking k as 0.008 cal./cm.sec.deg., which is about the value for granite, equations (3) and (4) lead to the following results.

Length of cylinder	Temperatures of ends		Average temperature of cylinder
1 cm.	61° C.	63° C.	62° C.
10 cm.	52° C.	70° C.	61° C.
100 cm.	4° C.	98° C.	51° C.

In the actual case there would, of course, be considerable radiation from the sides of the cylinder, so that the temperatures would be lower than those given in the above table.

Although these calculations do not tell us precisely what the temperature of a meteorite may be expected to be just before it enters the atmosphere of the earth, they do seem to be sufficient to indicate that that temperature is nearer to 0° C. than to the absolute zero of temperature.

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[2] From eq. (44) on p. 133 of Ingersoll and Zobel, *The Mathematical Theory of Heat Conduction.*

THE BUREAU OF STANDARDS

TO THE EDITOR OF SCIENCE: Considering the enormous interest taken even by the non-discriminating newspaper public in the achievements of the Bureau of Standards, which scientific men are justly proud of as one of the greatest physical laboratories of the world, using physics in its proper sense of including chemistry and engineering, or ap-