The fundamental condition, notwithstanding what Dr. Sheard may "believe," can be realized, and therefore blood flows can be deduced from the calorimetric data. The realization is naturally easier in thin than in thick parts, in parts whose chief blood flow is superficial than in parts where an important part of it is deeper. I have, as a matter of fact, always considered the hand as approaching most nearly to the ideal requirements because its dimensions and the distribution of the principal blood flow were the most favorable, and have never used the foot, in preference to the hand, except when necessary. This is not the place in which to recapitulate the rules which must be observed if the estimations are to be properly made. I have more than once been called upon for assistance by zealous but (in this matter) ignorant persons, who were violating the most obvious rules and were disappointed with the results.

Direct comparison of the results of the calorimetric method with that of other methods have given a satisfactory agreement. For instance, Utheim in Erlanger's laboratory compared the flow in the legs of dogs, measured by the stromuhr, with that deduced for the calorimetric observations. The agreement was good. Will Dr. Sheard inform us how this could be so if the calorimetric method did not give the blood flow?

I have myself laid great stress on securing data in human cases which serve as a test of the accuracy of the method. The most valuable of these data are in cases where a known mechanical interference with the circulation was produced. For instance, the innominate artery and right carotid were ligated for aneurism. The operation caused a great reduction in the right-hand flow. But there was a corresponding increase in the left-hand flow, so that the combined flows in the two hands remained unchanged (18.9 grams per 100 cc per minute before ligation and 18.8 grams after ligation). The cutting off of the path through the inominate obviously permitted more blood to enter the alternative route of left subclavian and left carotid. That the flow in the left carotid was increased after the operation was indicated by the increased throbbing and filling of the left temporal. The case was followed, as the collateral circulation opened up, for thirty-one days after the operation. The combined flow was twenty grams per 100 cc per minute seventeen days after the ligation. The ratio of right-hand flow to left-hand flow went on increasing steadily as the collateral circulation developed (1:4.5, 1:3.2, 1:1.8, 1:1.6 in successive observations). Only a very ignorant physiologist will believe that these numbers were deduced from data from which it was impossible to estimate the blood flow.

In another case (rheumatic endocarditis complicated by multiple emboli and thrombosis), studied along with Dr. R. W. Scott, the flow in the right foot became smaller (one fifth of that in left foot at the last examination), and before death the leg became much discolored. When the flow in the right foot diminished there was a corresponding increase in that in the left foot, and the ratio of combined foot flows to combine hand flows in the different examinations did not vary over four months. It was suggested (in a paper in the *Journal of Experimental Medicine*) from the reciprocal relation of the flow in the two feet that the obstruction was in the right common iliac and not, for instance, in the femoral. This was confirmed at autopsy about two months later. It would be inappropriate to claim that there might not have been an element of luck in the prediction. But it was made on the basis of blood flow measurements, and could only have been made on that basis. Numerous other instances could be given where any physiologist would at once recognize from the order of magnitude of the numbers and their relations to each other and to the anatomical or physiological conditions, that they must represent blood flows.

G. N. STEWART

WESTERN RESERVE UNIVERSITY

THE SHAPE OF CELLS IN MASSES

IN the issue of SCIENCE for June 18 is printed a communication from Frederic T. Lewis under the title "An Objective Demonstration of the Shape of Cells in Masses." This contains the following statement, page 608: "Meanwhile Lord Kelvin had found that a fourteen sided figure—a cube truncated by an octahedron —having six quadrilateral and eight hexagonal surfaces, solves the problem of dividing space without interstices into uniform bodies of minimal surface."

The statement is a correct expression of Lord Kelvin's claim as set forth in the somewhat famous Baltimore lectures of several years ago. But the claim is entirely wrong. Having been myself much perplexed by so direct and confident an announcement from such an eminent source, let me ask that a definite correction of a serious error be now made in order that others may be saved from being misled and perhaps from consequent mistakes.

The volume described, called the tetrakaidecahedron, does not possess the properties as stated. Equal volumes of this pattern will not fit together without voids, as a brief consideration of the diedral angles or angles between faces and the relations of these faces or a practical trial with models would at once have shown. Lord Kelvin's subsequent discussion of similar volumes with warped or distorted faces, which is referred to in Mr. Lewis's original papers, indicates that the error was later recognized

by its distinguished author, though the supplementary treatment was far from convincing.

This general subject was discussed at some length by the undersigned in a paper on "A Geometric Basis for Physical and Organic Phenomena" which was printed in SCIENCE for October 11, 1918. The same was afterwards privately reprinted under a general title, "Fundamentals of the Cosmos," with an addendum in which was outlined a still farther simplification of the basic principle referred to. This may be concisely formulated as follows: *In an aggregate of an indefinite number of points with equal intervals between neighboring points throughout, a grouping that will give both complete symmetry and maximum concentration or minimum total space occupied is impossible.* Herein is to be sought the key to the apparently anomalous or irregular forms which Mr. Lewis finds. His observations of the actual shapes of organic cells found in nature are exceedingly interesting and significant, but the conclusion he suggests that "cells in masses are typically tetrakaidecahedral" should, I think, be understood as meaning that this is a form to which natural organic cells often approximate; not one which they will ever be found actually to attain in groups or aggregates.

JOHN MILLIS

CLEVELAND, OHIO

THE BIG STONE GAP SHALE OF SOUTHWESTERN VIRGINIA

THE stratigraphic relationships of the Big Stone Gap shale and its bearing on the Chattanooga shale problem have long been an outstanding geological question. Ulrich, Bassler, Schuchert and others have regarded both as Mississippian in age. Kindle, David White, Butts and others have regarded them as Devonian. But neither group has been able to offer conclusive proof of its position. In Virginia the Big Stone Gap shale lies at the top of the Portage and, where recognized in the past, has always been overlain by lower Mississippian beds (Grainger and Price formations). Stose[1] made an effort to solve the problem by tracing the Big Stone Gap shale up from the southwest and the Chemung formation down from the northeast, but at no locality was he able to find them together.

The writer's studies in Tennessee[2] had led him to believe the Chattanoogan series entirely Mississippian, as held by Ulrich. Partially completed studies of the Big Stone Gap shale, especially in the vicinity of Mendota, have led him to alter that decision. Six miles northeast of Mendota a series of sandy shales and shaly sandstones were found above the Big Stone Gap shale, forming a ridge traceable for a considerable distance to the northeast, where it lies everywhere higher stratigraphically than the Big Stone Gap shale. In the shaly sandstones were found *Camarotoechia orbicularis, C. contracta* var. (identical with the small variety from the Maryland Chemung), and *Productella* cf. *hystricula,* all typical Chemung forms found in the middle Chemung of Maryland. The Big Stone Gap shale near Mendota is thus definitely Devonian in age.

The Big Stone Gap shale has been recognized for some ten miles northeast of Mendota, where it is found to be accompanied by an increasing number of sandstone and sandy shale beds. It would thus seem to be probably lower Chemung in age. Near Saltville a similar black shale was found in the base of the Chemung and is here tentatively correlated with the Big Stone Gap shale.

The completed study will be published shortly as a separate paper.

J. H. SWARTZ

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

A STOCK FOR THE MANGOSTEEN

ON the hacienda of Mr. John R. Schultz, Calauan, Laguna, Philippine Islands, in May, 1924, I inarched a seedling of the mangosteen, *Garcinia mangostana* L., on a plant of a native species of *Garcinia,* locally called *Bunag.* A successful union was rapidly established, and the grafted plant had made a good start when last I saw it shortly before leaving Manila for the United States in January, 1925. Photographs recently received from Mr. A. W. Prautch, Bureau of Agriculture, Manila, show that the plant now reaches to a man's hips and is in excellent condition.

The success obtained in this graft is of more than ordinary interest in view of the fact that for a period of some 25 years attempts repeatedly have been made to graft the mangosteen on more than twenty species of *Garcinia* and related plants, all, except the instance recorded, ending in failure.

The mangosteen is one of the most highly prized fruits in the world, but is particular in its climatic requirements, has a weak root system, and is of very slow growth, especially in the nursery stage. Therefore, unlike many other fruits, the mango, for instance, the mangosteen has never become widely disseminated, and still is grown on a comparatively restricted area and in small quantities, notwithstanding its unsurpassed eating qualities and good shipping qualities.

The *Bunag* not only is a plant of vigorous growth which may be expected to force the grafted plants

[1] Va. Geol. Surv., Bull. 24, 1923, pp. 48 to 52.

[2] *Amer. Jour. Sci.,* Vol. 7, 1924, pp. 24 to 30.