at Kansas City. The Porter lectureships are provided through a gift from the late Dr. J. L. Porter, of Paola, to be used for the promotion of scholarship and research. The fund provides for a scholarship, and the balance of the income is devoted to the lectures.

THE last lectures in the De Lamar series at the School of Hygiene and Public Health of the Johns Hopkins University will be given on April 12, "The Immunology of Epidemic Influenza" by Dr. Thomas Francis, Jr., member of the staff of the International Health Division of the Rockefeller Foundation; on April 19, "Cellular Changes in Leprosy," by Dr. E. V. Cowdry, professor of cytology at Washington University; and at a date to be announced, "Sinanthropus pekinensis and Its Significance for the Problem of Human Evolution," by Dr. Franz Weidenreich, honorary director of the Cenozoic Research Laboratory of the National Geological Survey of China.

THE seventh International Botanical Congress will be held at Stockholm from July 17 to 25, 1940. The secretary of the congress, Rudorf Florin, writes: "As it is highly desirable that the Stockholm Congress should be truly international, your cooperation in deciding the places and dates of other botanical conferences and meetings, with a view to avoid any clashing, would be much appreciated. It would be of great advantage if the time between July 17 and September 1, 1940, could be kept free from other conferences, in order to enable botanists to attend the International Congress and participate in its excursions."

AN appropriation of \$220,000 has been approved by the regents of the University of California for the construction of the first of a group of life science buildings at Los Angeles. The money was made available through the sale of the Vermont Avenue campus to the Los Angeles Junior College. The first building in the new group will be an office and classroom structure. Other units will include a laboratory building and an animal house, for which no provision has as yet been made.

DISCUSSION

THE DENSEST POSITION OF HOMOLOGOUS BODIES

THE article on "The Shape of Compressed Spheres,"[1] by Professor Frederic T. Lewis, is of much interest. In the first place it seems to show that the physical laws in the microscopic world are identical with those of the world in which we live. There seems to be an economic striving in many of the phenomena of nature which are explained by means of the mathematical theory of maxima and minima. In the second place, it is pleasing to see that the most abstruse theories in pure mathematics have immediate practical applications in such subjects as anatomy, botany and biology. The intelligent layman can understand these subjects, even if he finds little interest in mathematics.

Professor Lewis writes: "After years of patient reconstruction, cells were found to be 14-hedral, so that bubbles, liquid drops, and semi-fluid bodies in aggregates which fill space could all be said to be of that one form. Yet there remained the anomalous conclusion that compressed solids are dodecahedral."

If the anatomists will allow us, we shall assume that there is a law of nature according to which the cells in space strive to take such positions that the gaps between them occupy as little space as possible. In other words, the cells strive to occupy as much space as possible, leaving the minimum amount of space unoccupied. It is then seen that the results of Professor Lewis's observations are interesting checks on the mathematical theory. To give a detailed account of this theory would require here more space than we have at our command. I may outline the method of procedure, however, and cite the mathematical results that have been found.

[1] SCIENCE, 86: 2244, December 31, 1937.

The general problem may be headed as follows: *Analytic formulation of the condition for the densest lattice-formed position of congruent homologous bodies in space.* I shall in the sequel make references to two works by the great mathematician, Hermann Minkowski, the one *Diophantische Approximationen* (= D.A.), the other *Gesammelte Abhandlungen* (= G.A.). The problem (D.A., p. 83) is: *A convex body K with center at the origin 0 is given. The body is supposed to be symmetric with regard to the origin. Determine a lattice in x, y, z with 0 as origin which besides 0 has no other lattice point in the interior of K, and at the same time offers a fundamental paralellopiped of least volume.*

For the body K we take here a sphere. It may be shown that by expressing x, y, z as linear forms in ξ, η, ζ with integral coefficients and determinant $= \pm 1$ and then using the substitutions

$$\xi = \lambda X + \lambda' Y + \lambda'' Z,$$
$$\eta = \mu X + \mu' Y + \mu'' Z,$$
$$\zeta = \nu X + \nu' Y + \nu'' Z,$$

we may so choose, x, y, z that six lattice points in X, Y, Z appear on the surface of the sphere, the problem being to determine the nine elements of the deter-

$$\Delta = \begin{vmatrix} \lambda, & \lambda', & \lambda'' \\ \mu, & \mu', & \mu'' \\ \nu, & \nu', & \nu'' \end{vmatrix},$$

minant, such that Δ be a minimum. The six lattice points in X, Y, Z determine a lattice octahedron, its six vertices being on the surface of the sphere while there are no other lattice points on its interior. The sphere being symmetric with respect to 0, each point on the surface of the sphere has a diametrically opposite point on the sphere. We may accordingly take the six lattice points as A, A_0; B, B_0; C, C_0 where A_0 is the opposite point of A, etc. Now to minimize the determinant above, we may minimize the tetrahedron OABC, and this leads to a cubo-octahedron (the part of an octahedron contained in a cube). The figure was drawn by a former student of mine, Dr. Paul Pepper. It is seen that the figure has 12 vertices and 14 sides (facets). It may be shown (D.A., p. 112; G.A., II, p. 21) that at the 12 vertices the given sphere presses against 12 other spheres, while (G.A., II, p. 49) each octahedron presses against 14 sides of the cubo-octahedron. It may be of interest to the anatomists to know that were space filled in the manner indicated by spheres and octahedra the volume of space occupied by the gaps between the spheres to the volume of all space is as $\pi/6 : 1/\sqrt{2}$, while that between the octahedra and all space is as $1:19$.

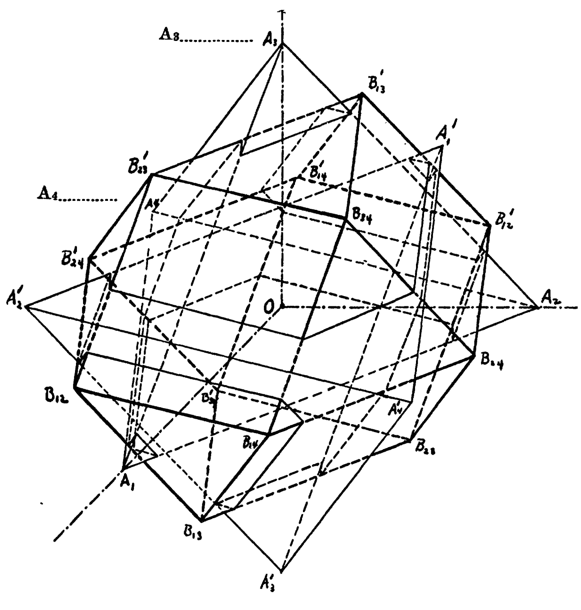

FIG. 1. The points A_1, A_2, A_3, A_4 are the vertices of a tetrahedron T; A'_1 A'_2, A'_3, A'_4 are those of T′, where T′ is the reflection (image) of T through O. B_{ij} (i, j = 1, 2, 3, 4) is the mid-point of the segment $A_i A'_j$, while B'_{ij} is the mid-point of $A'_i A_j$. It is seen that $B_{ij} = B'_{ji}$. The points B_{ij} constitute the set of vertices of a 14-faced convex polyhedron. Minkowski called this polyhedron a "cubo-octahedron" inasmuch as it is the portion of an octahedron contained in a cube. (See also statement at end of article.)

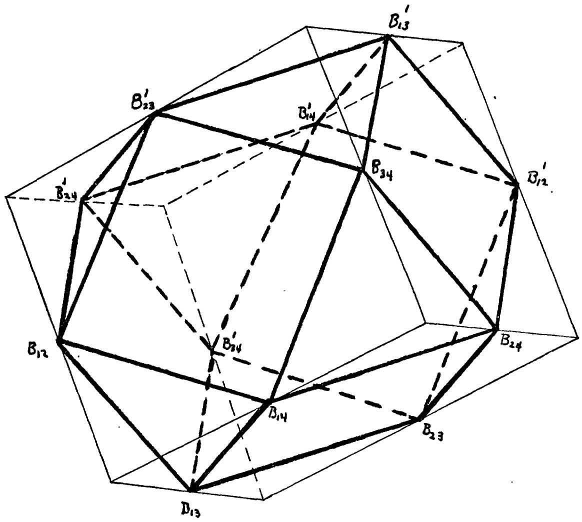

FIG. 2. The figure in heavy lines is the cubo-octahedron.

Sir D'Arcy Thompson's belief that "plastic spheres will yield dodecahedra on compression" seems well founded. The body K under compression is no longer a sphere. We shall assume that it is everywhere a convex body and symmetric with regard to 0. Observe that if the point P = (X, Y, Z) is on the boundary of K, then the *opposed* point $P_0 = (-X, -Y, -Z)$ is also on K. Then to be able to find the minimum (or the different existing minima) of Δ it is sufficient that the lattice in x, y, z be so chosen that in X, Y, Z:

(I) the lattice points X, Y, Z) = 1,0,0; 0,1,0; 0,0,1; 0,1,0; 1,0,1; 1,1,0 lie on the boundary of K;
(II) the points 1,0,0; 0,1,0; 0,0,1; 0,1,1,; 1,0,1; 1,1,0 lie on the boundary of K while (1,1,1) is outside the boundary;
(III) when (1,1,1) is also on the boundary as are also the other six points just mentioned.

We are assuming in all cases that no lattice point save 0 is on the interior of K. This being the case, no convex body can have a volume greater than 2^3 (= 8). Minkowski shows (G.A., Vol. II, p. 39 and p. 20) that the six lattice points and their opposed six points in (I) form the twelve vertices of the cubo-octahedron given above, while in (III) the seven lattice points and their opposites give the vertices of a rhombic dodecahedron.

In the case (II) it is seen that bodies formed by 12 planes (such bodies being nowhere concave) (G.A., II, p. 42) constitute a system of bodies in densest lattice formed placement. This case (II) seems in contradiction to Lord Kelvin's assumption. (Baltimore Lecture (1904), pp. 618 ff.) This case seemingly is a boundary case, and I judge possibly it is outside the domain of cytology. For the benefit of any one who wishes to study the paper in Minkowski's Gesammelte Abhandlungen, Vol. II, pp. 3 ff., it may be noted, as proved by Dr. Paul Pepper, that a tetrahedron, reflected through the origin, which is an interior point of the tetrahedron, does not produce the octahedron that Minkowski believed. The locus of mid-points of all line segments which begin in one tetrahedron and end in the reflected tetrahedron is the cubo-octahedron. In particular, the vertices of the cubo-octahedron occur as the mid-points of line segments joining a vertex of the first tetrahedron to a vertex of the second tetrahedron not the reflected vertex of the first-mentioned vertex (for in that case the origin would be obtained). Thus there are 12 vertices.

HARRIS HANCOCK

UNIVERSITY STATION,
CHARLOTTESVILLE, VIRGINIA

THE DISCOVERY OF THE FEMUR OF SINANTHROPUS PEKINENSIS

AMONG the extensive material recovered from Locality 1 at Choukoutein during the excavations of 1936–37 and subsequently prepared in the laboratory, Dr. W. C. Pei discovered two fragments of femora. The general appearance of these specimens led Pei to believe that they were of human origin and probably belonged to *Sinanthropus*. A careful study and comparison with human and anthropoid thigh-bones resulted in the conclusion that the femora undoubtedly belong to *Sinanthropus*.

One of these fragments, femur J, represents a portion of the middle of the shaft and measures 58 mm. The bone is completely fossilized and burnt, as is evident by the marked blackening of the entire anterior and medial surface and on the part where it was broken off. That we are actually dealing with a human femur is demonstrated by the form and size, but particularly by the existence of a rather distinct pilaster (Broca) which occupied the middle of the posterior surface and bears a well-developed linea aspera dividing into characteristic medial and lateral lips toward the end of the fragment.

The other fragment, femur M, embraces almost the entire diaphysis. Its length is 312 mm. This femur is also strongly fossilized. Like femur J this piece also shows a distinct pilaster running along the middle of the posterior surface and bears a linea aspera consisting of two lips. Estimated on the basis of the length of the preserved portion of the femur, the total length may have been 400 mm.

The femur of *Sinanthropus* has, in common with that of recent man, the general shape and the formation of a pilaster with a two-lipped linea aspera. In addition, there is a distinct suprapatellar fossa. On the other hand, the femur differs from that of recent man by its stoutness and the following specific features: (1) a very pronounced platymery of the entire length of the femur combined with the formation of a distinct pilaster; (2) a very faint curvature, the greatest height of which is located near the lower end of the diaphysis; (3) the transversal diameter of the shaft is narrowest near the lower end and gradually increases toward the upper portion; (4) there is a distinct but only faintly developed crista lateralis superior; (5) sections show that the cavity is narrow with rather thick walls, especially the anterior and posterior ones.

Femora of the Neanderthal group differ from the femur of *Sinanthropus* by their greater stoutness, the transversal diameter being narrowest in the middle of the shaft, by a much more pronounced curvature the greatest height of which is also located near the middle of the shaft, and finally by the development of a very strong crista lateral is superior. To what extent these differences are due to sexual characters is difficult to define. It seems that all the femora available of the Neanderthal group belong to male individuals, whereas I consider the two femora of *Sinanthropus* as belonging to females on account of the smallness of the two main diameters of the shaft.

When compared with the femora of great apes, those of *Sinanthropus* represent quite a different type. The general character of the shaft does not conform to any of them.

These discoveries of the *Sinanthropus* femora may also serve to shed some new light upon the problem connected with the *Pithecanthropus* femur.

Femur M of *Sinanthropus* differs from the *Pithecanthropus* femur by exactly those features by which it differs also from that of recent man. With reference to its popliteal surface the pronounced convexity of which Dubois considered typical for *Pithecanthropus,* the femur of *Sinanthropus* merely shows a slight convexity, as is common in recent man, the platymeric index of this region being 76.4 in *Sinanthropus* against 100.0 in *Pithecanthropus*.

It results from these facts that the *Pithecanthropus* femur is either one of recent man and with no close relationship to the skull-cap or it really belongs to the latter and thereby testifies that *Pithecanthropus* represents a much more advanced hominid type than *Sinanthropus*. I consider the first alternative to be the correct one.

My recently stated conclusion that *Sinanthropus* must have already adopted a completely upright posture has now been confirmed by the discovery of the femur. Since the total length of the femur (female) may have been about 400 mm, the stature of the woman can be estimated to have been circa 5 feet