

evaporated again. Everywhere we find a cyclical process in the material universe.

What about the mental universe? Surely there we find growth, development, increase of value, rise in status; the lower organisms becoming intelligent creatures, then developing into man. And what of man? If his death is the end of him, the value of his existence may be doubtful. But if, as I know, that is not the end of him, then there may be infinite progress in store. The cyclical machinery of the physical universe is employed to develop value in the mental and spiritual universe; just as the revolution of a fly-wheel may be the means of turning out a woven fabric

of beauty and design. The fabric will age and turn to dust: so may a picture or a statue. But what about a poem or a piece of music? They have in them the seeds of immortality, and if great enough, will last so long as humanity endures. All things last for ever, if what we have been saying is true; but while the physical things last by a kind of evolution of cyclical change, the evolution of spiritual things has no necessary regress. They advance continually through higher and higher stages towards perfection. This, I take it, is the real meaning of evolution. This is why the physical universe exists. This is the real aim and purpose of the ultimate and infinite term "God."

Surveys of the Great Pyramids.¹

By Sir W. M. FLINDERS PETRIE, F.R.S.

THERE seems a periodicity in the attention to the size of the Great Pyramid: the French survey 1799, Howard Vyse 1838, my survey 1881, and now Mr. Cole's survey in 1925, are at nearly equal intervals. The difficulty in measurement results from the Arab destruction of nearly the whole of the fine sloping blocks of casing, about 3 feet thick, thus leaving the inner core of masonry in steps, and further, the banking of the ruins up to 20 or 30 feet against the faces, which obstructs the base. The last remains of the lowest course of casing are only a short length in the middle of each side, and the purpose of this recent survey was to utilise more of these points of the original casing than had been seen before, such being more accessible since the removal of large quantities of the fragments, for making the road and building an hotel. In 1881 it was a risky affair to sink pits in loose rubbish 20 feet deep; I only escaped burial by a few seconds; seventeen shafts were sunk, but the casing edge was only found once on each side. In 1925 it was possible to uncover the casing over lengths of between 45 and 170 feet on different sides, and the use of such further material was very desirable in order to define the faces more precisely.

The 1925 survey was in two parts: (1) the prolongation of the alignment of the remaining portions of casing out to the corners by theodolite sighting, and (2) the survey of these produced corners by triangulation. The general order of accuracy that should be sought is indicated by the levels of the pavement, of which the mean error is only 0.21 inch; certainly it would be easier to achieve equality of length than of level. The method of setting a theodolite over an estimated edge of sloping casing, and then of telescopic estimation of such an edge at more than 100 feet away, is a risky process on the sand-blasted, pitted and chipped surfaces. The differences between 1881 and 1925 surveys depend on a third of an inch in such estimations. After that, the results depend on the 1925 triangulation for fixing the corner intersections by a chain of eight points joined by a traverse around the pyramid; this had a difference of 9.6" = 2.7 inches if on the whole distance, which was distributed equally in the reduction. The 1881 survey included the whole pyramid in a single triangle, the discrepancies of which averaged

0.04 inch; these station marks can always be re-used, as they were drilled in the rock, and the co-ordinates were all published.

The results of the two surveys are, in inches of length of the side and angular orientation of face:

	1881.	1925.
N. side	9069.4 - 3' 20"	9065.1 - 2' 23"
E. side	9067.7 - 3' 57"	9073.0 - 5' 30"
S. side	9069.5 - 3' 41"	9070.5 - 1' 57"
W. side	9068.6 - 3' 54"	9069.2 - 2' 30"
Mean	9068.8 - 3' 43"	9069.4 - 3' 6"
Mean differences	0.7 12	2.3 1 12

There is a check on the estimated prolongation of the sides in 1925, as there is the 1881 estimate of the planes touching the core masonry. These were:

	1881.	Difference to Casing 1881.	Casing 1925.
N.	9002.3 - 4' 35"	+1' 15"	+2' 7"
E.	8999.4 - 5' 26"	+1' 29"	- 4"
S.	9001.7 - 5' 23"	+1' 42"	+3' 26"
W.	9002.5 - 5' 39"	+1' 45"	+3' 9"
Mean	9001.5 - 5' 16"	+1' 33"	+2' 10"
Mean differences	1.0 20	10	1 8

As the planes of the core could be estimated within an inch of variation (=23") this is a useful check. It shows that the casing was adjusted 1' or 2' differently after the core was built. The divergence of the 1881 casing lines from the core have only 10" irregularity; the 1925 results show 1' 8" of irregularity; as this latter is equal to 3 inches on the length of the side, the core is competent evidence in favour of the 1881 survey. It may also be observed that a building with mean error in level of 0.2 inch is more likely to have a lineal error of 0.7 inch found in 1881 than of 2.3 inch found in 1925.

On all grounds it seems highly desirable to settle more precisely the exactitude of the most accurate human work of such large size. Station marks are needed at the side of each end of the lines of casing observed, to be connected with the more accurate triangulation of the 1881 net, which has less than 0.1 inch probable error in stations. Offsets should be taken between the new stations to the estimated edge of the casing all along. These would show how exactly the straightness was maintained, on which depends all evidence for prolongation of the short lengths of remaining casing.

¹ "Determination of the Exact Size and Orientation of the Great Pyramid of Giza." By J. H. Cole. (Survey of Egypt, Paper No. 39; Government Press, Cairo.) 1925. 8vo. 9 pp. 1 pl. 10 P.T. (25. 1d.).

The bases of some of the other pyramids are also known from my surveys. That of King Sneferu at Meydum immediately preceded the Great Pyramid, and was planned on a similar system of measures. Both have the proportion resulting from the height being the radius of a circle equal to the circuit of the base, the angles found being

By π theory	$51^{\circ} 51' 14'' \cdot 3$
Khufu's pyramid	$51^{\circ} 50' 40'' \pm 1' 5''$
Sneferu's pyramid	$51^{\circ} 52'' \pm 2' ?$

The dimensions found are :

Khufu's, height 7, circuit 44, $\times 40$ cubits.
Sneferu's, ,, 7, ,, 44, $\times 25$ cubits.

The modulus of design being thus 40 or 25 cubits shows the deliberate intention to embody the proportion of 7 : 22. The cubit required would be 20.61 or 20.66 respectively, and the best examples of early masonry elsewhere show a cubit between 20.62 and 20.65 inches. The mass of theories, which extend from good reason into a morass of impossibilities, would be too much to touch on here.

The accuracy of construction of the measured pyramids is, in inches :

Dynasty.	King.	Place.	Base.	m.d.	Azim.	m.d.
III	Sneferu	Meydum	5682.0	6.3	-24' 25"	5' 30"
IV	Khufu	Gizeh	9068.8	.7	- 3 43	12
IV	Khafra	"	8474.9	1.5	- 5 26	33
IV	Menkaura	"	4153.6	3.0	+14 3	1 50
XII	Senusert II.	Lahun	4168.5	1.9	- 2 8'	2 30
?	?	S. Dahshur	7459.0	3.7	- 9' 12"	4 3
			2064.6	1.1	-14 8	10 12

From these measures it seems that Menkaura and Senusert II. laid out 200 cubits as a base, and the South Dahshur pyramids are of 360 and 100 cubits on each side.

In the XIIth dynasty the passion for accuracy led to regarding that as the finest sacrifice in honour of the dead; the granite sarcophagi, which were never intended to be open to examination, or even seen, have mean errors from a straight line, and from true planes, of 1 in 15,000, or on one edge 1 in 23,000. No race ever seems to have appreciated so keenly the charm of perfection of work as did the magnificent men of the pyramid age.

Current Topics and Events.

IN a recent series of papers in the *Chemical News* (Oct. 30, Nov. 6, 13, 20 and 27) Messrs. Druce and Loring put forward claims that they have identified the elements of atomic number 75, 85, 87 and 93 by an X-ray examination of certain manganese salts. The element 75 is that recently isolated by Noddack and Tacke (rhenium), the others are in the radioactive region. An examination of the evidence on which these claims are based suggests that it is far from sufficient definitely to establish them. The element 75 is identified by two lines, 1.430 and 1.233, which are taken to be the α_1 and β_1 lines of its *L* spectrum; 85 by two lines, 1.086 and 0.895; 87 by a single line 1.040, and 93 by two lines, 0.895 and 0.693, the 0.895 line being the same as that used for the identification of the element 85. Of these six lines four, 1.430, 1.233, 1.040 and 0.895, are within error limit identical with the $K\alpha$ line of zinc and the three strongest lines ($\alpha_1, \beta_1, \gamma_1$) of the mercury *L* spectrum. The authors quote a control experiment in which a six hours' exposure with a copper anticathode gave only the copper spectrum. This is rather surprising, as mercury is used to evacuate the tube and brass for the window of the tube and the slits of the spectrometer. Also, in a recent experiment made elsewhere and suggested by past experience, a two hours' exposure with a copper anticathode and apparatus similar to that used by the authors gave, in addition to the copper lines and the silver and bromine absorption bands, lines which were identified with the zinc $K\alpha$, the mercury $L\alpha_1, L\beta_1$, and $L\eta$ (?), and other lines at 0.950, 0.72 and 0.67. These are of doubtful origin but are possibly due to irregularities in the crystal oscillation or imperfections in the crystal. The authors in their papers give at least five lines which they observed and are unable to explain, although from the other six lines they identify four elements.

MR. HAROLD J. COOK, in a communication to *Science* for November 25, maintains that "good

dependable evidence of human artifacts in the Pleistocene of America" has at last been found. The evidence in question comes from a point near the Colorado River, near the south-eastern end of the Staked Plains and near the little town of Colorado, Texas, on Lone Wolf Creek. The first work leading up to the discovery was done in the summer of 1924, when fossil animal bones were discovered by Mr. Nelson Vaughan. The site was visited by Mr. Cook, who checked the geology of the area in May 1925. In taking up a large block of material containing the articulated ribs and vertebrae of a fossil bison, of which the whole skeleton was discovered in association and splendidly preserved, the first artefact, a point, was found under the cervical vertebrae. A second point was found under the femur, and a third was found "in position with the body of this skeleton." These artefacts are large arrow heads or lance points, and are of unexpectedly fine workmanship, being more refined than modern types found in the area, and of distinct culture and design. It is suggested that the animal had been wounded and died on this spot, as the condition in which the remains were found appears to preclude the possibility of its having been water-borne or otherwise deposited. A number of other fossilised remains have been found, but in the season just past no further evidence of man has been brought to light. These fossils occur in valley gravels solidly cemented by calcareous deposits which rest between the present stream erosion and the old triassic walls of the former valley. Everything points to these deposits being entirely undisturbed. Similar bones and types were found in all places where fossils could be located, and included, besides the extinct bison—*Elephas*, *Equus*, and *Camelus* or *Camelops*, as well as others at present unidentified.

THE Linnean Society of New South Wales has just issued a history of its fifty years of activity since its foundation in 1874, for "The cultivation and study of the science of Natural History in all its branches,"