

errors in the previous investigations. In the present investigation, slits have been used to limit the convergence in the incident beam, the polaroid has been replaced by a nicol prism as the imperfection of polarization introduced by the polaroid has been found to be quite serious and the collimation on the side of the spectrograph has been performed very carefully and with special reference to the correction introduced by the instrument due to oblique refraction. In this way, the intensities of the OX components of the 1084 line in calcite when the crystal is oriented in accordance with the second and the third rows of Table I, have been reduced to negligible proportions. We, accordingly, conclude that the experimental results in calcite are in full agreement with what may be expected of such a crystal. Most probably, the corresponding OX components in the case of NaNO_3 also will behave similarly under improved conditions of experimentation.

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¹ *Proc. Ind. Acad. Sci.*, 1939, 10, 197.

² *Ibid.*, 1940, 11, 62.

On the Weights of Old Indian Punch-Marked Coins

IN continuation of the work on punch-marked coins published in the July issue of *Current Science*,¹ I have the following announcements to make:—

1. The weight variances of the Mauryan period are much greater than those of the earlier period, at least on the evidence of coins found at Taxila. For the later hoard, which is in almost mint condition, the variance is, in grain units, 5.65, whereas the variance for all the coins of the earlier hoard is 1.49, and for single groups of coins in the hoard, as low as 0.14, which compares favourably even with modern machine-struck coins,

2. Proceeding on the assumptions that Walsh's descriptions² are substantially correct, and that my analysis (which makes the reverse marks 'periodic and regular checking marks') acceptable, it is found possible to arrange the main and most important groups of coins in the earlier hoard, in chronological order. These are: B.b.1, A.1, C.1, D.2, in Walsh's notation. The problem of assigning them to kings or dynasties is difficult on the basis of extraordinarily conflicting documentary evidence. But, as a tentative effort, I associate these coins in order with: Śiśunāga II; the (later) Śaiśunāgas; the Nandī or Nanda dynasty; and the Nava (= new, not nine) Nanda, Mahāpadma, who is to be taken as the immediate predecessor of Candragupta Maurya. The documents used are Pargiter's excellent collation of Puranic texts, the *Aryamañjuśrīmūlakalpa*, the *Mahāvamso*, the *Samantapūsādikā* and its Chinese translation, and some of the Jain tradition as reported in the encyclopædia, *Abhidhānarājendra*. It is, of course, quite possible to give different interpretation and weightage to these texts, and to reconcile their great divergences in a different way.

3. The coin samples are invariably skew-negative; and sometimes platykurtic because of a few badly underweight specimens which could be discarded by a certain criterion, based on the variance of the group itself, which I have had to use in the absence of any other evidence. But the skewness will always remain, and is in fact to be expected. The question now arises, does the z test apply to such distributions? If we assume that the frequency (probability) function has an expansion in weighted Hermitian polynomials about the mean value (surely not too restrictive an assumption), it is easily seen that a sufficient condition for the distribution of the variance to remain the same as for a normal distribution is that all terms of even order, except of course the constant term, should be absent from the expansion. This also ensures that all even order moments are the same as for a normal distribution. So, it is clear that all

tests based on variance alone—which excludes the *t* test, but allows the *z* test, Behrens's test, and others of the sort—are valid for a skew distribution provided there is no kurtosis. But it must be noted that these variances are to be taken about the, usually unknown, true or population mean; otherwise, the *z* test for skew populations is only a very good approximation for all but the smallest samples.

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¹ *Curr. Sci.*, 1940, 9, 312.

² *Archaeological Survey of India, Memoir* No. 59.

An Empirical Statistical Formula

FOR moderately asymmetrical distributions the empirical relation:

$$\text{Mean} - \text{Mode} = 3(\text{Mean} - \text{Median})$$

seems to hold good with a surprising degree of precision. In 1895, Karl Pearson proved the approximation for the Type III curve and in 1917, Doodson gave a proof for more general types of frequency distributions. But the simplest case of the triangular distribution defies the law in a remarkable manner not apparently noticed before, probably because of the artificiality of this case. It may be worth while to note the following facts, at least on account of their suggestiveness of other possible distributions where the law may be wholly denied:

(1) For a triangular frequency distribution,

$$4 < \frac{\text{Mean} - \text{Mode}}{\text{Mean} - \text{Median}} < 4 + 3\sqrt{2} < 8\frac{1}{2}.$$

(2) The greatest value $4 + 3\sqrt{2}$ occurs for a finite linear distribution starting from 0, and also for an infinite triangular distribution.

(3) The least value 4 corresponds, paradoxically, to the isosceles triangle distribution, for which all the three measures of location coincide and the ratio therefore takes an indeterminate form with the limiting value 4.

(4) The ratio of the differences (mean, mode) and (mean, median) is a homogeneous

fractional function of the ranges to the right and left of the mode.

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¹ *Philosophical Transactions*, 1895, 186 A, Pt. I, 343.

² *Biometrika*, 1917, 11, 425.

³ *The Annals of Mathematical Statistics*, 1938, 9, 176.

Mechanism of Swelling of Cellulose

WHILE studying the swelling of cellulose in aqueous solutions of neutral salts, ZnCl_2 , $\text{Ca}(\text{CNS})_2$, $\text{Zn}(\text{CNS})_2$ and of mineral acids HCl , HNO_3 , H_2SO_4 and H_3PO_4 , following observations were made.¹ With both the salt and acid solutions, when solutions are dilute there is a preferential absorption of the solute. This is distinctly noticeable until the concentration of the solution reaches values that cause high swelling. Further, there is a distinct preferential absorption of the cation of the salt at low concentrations of salt solutions and also in the initial stages of swelling in high concentrations. Neale² who made an exhaustive study of swelling of cellulose in NaOH made similar observations and concluded that swelling is caused by the initial formation of a sodium salt of cellulose, which then ionises giving a diffusible hydrogen ion and a non-diffusible cellulose ion, the principle of the Donnan equilibrium being applicable to such a system. The acidic nature of the cellulose suggests the possibility of the formation of zinc and calcium salts of cellulose, although such a reaction is out of question between cellulose and mineral acids.

It is also observed that swelling in these solutions is accompanied by the formation of hydrocellulose. This has been confirmed by measuring the fluidity, copper number and the dye absorption of the original cellulose and of the swollen material.

These results suggest the formation of some cellulose-salt or cellulose-acid complex of a type which results firstly in causing the swelling of the material and secondly in its degradation,