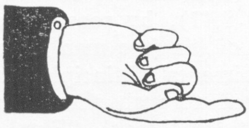
The Influence of Egyptian and Babylonian Science on later Civilizations, by R. J. Gillings.



IT IS JUST OVER 100 years since the key to the hieroglyphs of the Egyptians and the cuneiform of the Babylonians and Sumerians, was discovered by Western scholars. Before that, historians of the EXACT SCIENCES, were dependent upon earlier writers, none of whom could have had really first hand knowledge of the writings of two of the vanished NEAR EASTERN civilisations, those of Egypt and Babylon.

Even if we go back as far as Plato and Herodotus, our real knowledge of pre-Hellenistic science is of doubtful authenticity. Whenever some high authority was needed to support a theory or principle, the writer might ascribe some "discovery" to the Chaldeans or the ancient Egyptians, or even the Chinese. And that clinched the argument.

These immutable sources gained thus an unwarranted reputation, even as Aristotle's works did up to about the time of Bacon. Few dared dispute them. Thus, as the centuries drifted by, historians and writers generally, on the exact sciences, merely relied on the histories of previous historians, and so built up, amongst the genuine results of scientific research, a series of historic clichés, which even in the 20th century are still given credence.

"Why?" one may ask, "should we place the history of science, or indeed any history, on so high a level in modern studies?"

There are many answers to this question. I will give as mine, the introductory words of Thomas Cooper, graduate of Oxford, and Professor of Chemistry at Dickenson College, Pennsylvania (1811) in his first lecture.

> *"It appears to me", he said, "that the history of an art or a science, is a proper introduction to the study of it, as giving a clear and concise view of the manner in which improvements have been effected; as furnishing due caution against future errors, by exhibiting the mistakes of superior minds of olden times; and as rendering merited honour to those who have benefited mankind by their discoveries."*

If we accept the thesis, that a deep knowledge of the history, of whichever is our own particular discipline, is essential to the serious scholar, then it is also clear that our history must be reliable, authentic, and, as far as possible, from original sources.

To avoid remaining in the realm of generalities I will mention some of these clichés, which still remain with us.

1. The story of the apple falling from the tree on to Isaac Newton's head, thereby originating Newton's Law of Universal Gravitation and his Laws of Motion, is still given prominence in journalism and in the synthetic histories of science and philosophy.

2. Galileo's name is still linked indissolubly with the Leaning Tower of Pisa, from the top of which he is reputed to have dropped unequal weights, to show they reached the ground simultaneously.

These stories are both fictions, but pleasant ones.

3. The opening lines of Chapter I of Lancelot Hogben's "Mathematics for the Million". [Wonderful Title 16 impressions up to 1945], are . . .

"There is a story about Diderot, the encyclopaedist and materialist—". !!!

Certainly there was a story, but it was not history! In 1954, I traced it back to E. T. Bell (1937) (Men of Mathematics) to Florian Cajori (1919) (History of Mathematics), to De Morgan (1872) (Budget of Paradoxes), to D. Thiebault (1804 Paris). The "ultimate" origin was in Thiebault's "Mes Souvenirs de Vingt ans de Séjour à Berlin". The story is that in 1774 at the Court of the Empress Catherine II of Russia, the famous mathematician Euler proved to Diderot by algebra, the existence of God, . . . thus . . .

"Monsieur, $\frac{a + b^n}{n} = x$, donc, Dieu existe: repondez!"

It is enlightening to read the versions of these stories in their chronological order. Each historian adds a little touch of his own.

It reminds me of the fictional story told of the trenches in France during World War 1. A verbal message sent from the front line back to divisional H/Q beginning as, **"Send us reinforcements—we are going to advance"**, ended up as (after passing from man to man), **"Send us three and fourpence—we are going to a dance."**

We cannot here look at all the changes made. It must suffice to say that the originator of the story specifically stated in his book,

> "I do not assert the truth of any of these facts, I say only that they were talked about, and were believed by the inhabitants of the North."

and in the English translation of Thiebault's work (in 1806 Philadelphia), no mention of the story is made.

A full English translation of the story was not available until I published it in the **American Mathematical Monthly** in February 1954, together with, I trust, a "debunking" of the story, and a clearing of the characters of a very devout Euler, and a thoroughly competent mathematician, Diderot, neither of whom at all fitted the circumstances related by Thiebault.

4. Piazzi Smyth, astronomer-Royal for Scotland (1845) wrote a voluminous tome "Our Inheritance in the Great Pyramid" without ever being in Egypt, but relying upon measurements taken by a Mr Taylor, proved that an accurate (and modern) value of π was determinable, by relating the height, the base and perimeter of the pyramid, **if he used British inches,** and discarded the original Egyptian cubits and palms. He concluded somehow that Christianity (?) or at least a Christian God, was responsible for the pyramid and not the **Idolatrous** Egyptians. [d. 1900]. How much this "mystic and paradoxical" work is responsible for the fanciful and wondrous stories subsequently told about the Great Pyramid of Cheops, I can only guess, but it must have been considerable.

5. Let us go back further in historical time. If there is any one mathematical fact that the man-in-the-street remembers of his school days, it is Pythagoras' Theorem, which he recalls as **"the square on the hypotenuse".** He may also remember that Pythagoras celebrated his discovery of this theorem (Euclid I,47), by roasting an Ox, just as the residuum of his (the man in the street's physics is Archimedes' Principle, the principle of running naked through the streets of Syracuse, shouting out (in Greek), "Eureka! Eureka! I have found it!!"

We have no evidence at all that Pythagoras proved the famous theorem honoured with his name. Indeed oddly enough, the particular proof in Euclid's **Elements,** variously referred to as, "The Bride's Chair", "the Asses' Bridge", "the Pons Asinorum", "the Peacock's Tail", is the **only** proposition of that famous book, the proof of which Euclid is known to have been responsible for. The others were the work of previous geometers. Euclid was the master collator.

Indisputable evidence, that the so-called Pythagorean Theorem and its implications, if not its formal proof, was known over 1000 years before Pythagoras was born, comes to us from the Babylonian Clay tablets in cuneiform. Dating from -1900 to -1600, the famous tablet Plimpton 322, the oldest known document on number theory, belongs to the Plimpton Collection of Columbia University, New York. It has three columns of numbers in sexagesimals, giving 15 Pythagorean Triads, some of extraordinary magnitude, e.g.

1.10	6,480	4961	8161
1.4	13,500	12709	18541

This far transcends the trivial discovery that $3^2 + 4^2 = 5^2$; and the existence of some scribal errors (in Plimpton 322) notably the error of the sexagesimal, 3, 12, 1 for 1, 20, 25 (or 11,521 for 4,825), the explanation of which was sought by Assyriologists for many years, finally led to the understanding that the Babylonian scribe was using the rule, well known to the later Greeks, that primitive triads were derivable from the formulae,

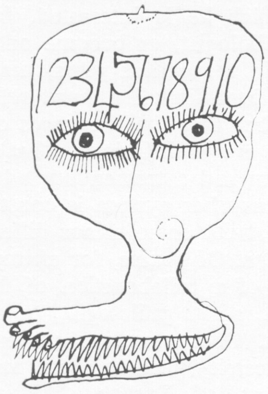
$$(p^2 + q^2),\ 2pq,\ (p^2 - q^2).$$

The explanation of this error, by me, in the Aus. Jr. Sci. Oct. 1953, establishing the credibility of the use of the formulae above, seemed after a decade, to have successfully withstood the criticism of the mathematicians. And so it turned out! O. Neugebauer of Brown Univ. Rhode Is., the world's greatest authority in this field, replaced 3 pages of the earlier editions of his book, "The Exact Sciences in Antiquity", (TESIA) in which he gave Dr Evert Bruin's interpretation of Plimpton 322, by no more than half-a-page explaining what I had written in Oct. 1953, in the 1962 Edition of TESIA.

There is an odd quirk to this story. In January of this year (1964) I published a brief article in Problem I of the Cuneiform tablet BM 34568 (dating from the Seleucid Kings, abt.-250) in Aus. Jr. Sci. It contained 19 problems on Pythagoras' Theorem.

Problem I was so simple that few Assyriologists looked at it critically. Thureau-Dangin had published a translation in, "Textes Mathematiques Babyloniennes" in 1938. The problem was to find the hypotenuse of a right-triangle given the two sides, 3 and 4.

Instead of squaring 3 and 4 and adding to get 25, and thus obtaining $\sqrt{25} = 5$ for the hypot-



enuse, the scribe writes, "add half your length to your breadth", so that $\frac{1}{2}$ of $4 + 3 = 5$, or he continues, you may, "add a third of your breadth to your length", so that $\frac{1}{3}$ of $3 + 4 = 5$, as before. Thureau-Dangin did not comment on this unexpected method of solution.

In pursuing the scribe's method to the other problems I naturally enough used the, by now accepted data, that,

$$(p^2 + q^2),\ 2pq,\ (p^2 - q^2),$$

to produce the pythogorean triads I spoke of earlier.

A reprint of this article being by me sent to Dr Evert Bruins of Holland, we are good friends, who, "bloody but unbowed", immediately responded with a letter (April 20 1964), in which he returns to the attack on these formulae, and again presses his own theory, that they used the formulae,

$$k,\ {}^{k}/2\ (\lambda + \frac{1}{\lambda}),\quad \frac{k}{2}\ (\lambda - \frac{1}{\lambda}).$$

Strength to his arm!!!

But I am in good company, and it is pleasing to see, that what one publishes in this particular field, is at least read carefully by some historians. In fact the two formulae are based essentially on the same theory. The difference is academic only.

6. Lastly let us examine the popular stories about the famous Thales, the "father of Greek Mathematics", and one of the "Seven Wise Men". He is usually credited with the theorem of "the angle in a semicircle", the "vertically opposite angles theorem", and similar triangles, for finding e.g., the height of a pyramid by the sun's shadow of a vertical stick. None of these is really authentic, and they are trivial enough to tolerate. **But** he is also credited with predicting an eclipse in -584 (May 28), as well as predicting a fall of meteors. I quote Neugebauer (Proc. Amer. Phil. Soc. Dec. '63).

> *"At no time of its existence could Babylonian astronomy predict that the path of a certain solar eclipse would cross Asia Minor. . . . Not before the Renaissance, could one compute eclipse paths, because this requires a much better knowledge of Solar parallax, than the observational methods of antiquity, restricted to naked-eye techniques, could provide.*
> *That Thales had even the faintest idea of the problems involved, is out of the question."*

7. I must mention that in this same journal, Neugebauer refers to the long standing cliché regarding the origin of geometry from the inundation of the fields in Egypt by the annual flooding of the Nile, as a **"simple nursery story"**.

We now look at the great mass of new detail, in the early history of Science of the pre-Hellenistic era, which has only in the last 100 years become available.

It is surely an odd circumstance, that the oldest known civilisations, become the subject of the most recent historical researches.

In speaking of the cuneiform clay tablets, and referring to the history of Science therein, I have confined myself, for obvious reasons, to the discipline of Mathematics. But for others of us in this general study, there are many other fields which are crying out for specialists' attention.

It should be understood that the decipherers of the cuneiform script, first called the language "Assyrian", but it was soon discovered that there was a "Babylonian" dialect, also an earlier and more ancient "Sumerian". The first two, are now called collectively "Akkadian", although the original name of "Assyriology" for the general study, is still retained. The same script, it was found, was used for other languages, such as those of the Hittites, Hurrians and Elamites, and the occurence of the tablets over the vast area of Asia Minor, and even the Islands of Crete and Cyprus, means that a tremendously wide field opens up to us. Clay tablets were even found in Egypt, at Tell-el-Armana, a circumstance at first disbelieved by Assyriologists.

Clay tablets in Egypt! Over 300 of them!!! They were thought to be **fakes**, and as such became scattered over Europe. Then someone discovered they were genuine, perhaps the earliest examples of international diplomatic correspondence. A hurried search for the scattered texts followed, by museums and universities.

Literally thousands of clay tablets have, and are now being unearthed, a medley of abundant and disparate matter of political and cultural detail, economic history, stories of creation, myths, religious texts, prayers, conjurations, Sumero-Akkadian dictionaries, Mathematics, Astronomy, Medicine, law, agreements, sales, records, legal documents, and economic texts of all kinds. In the library of Assurbanipal, copies of all important texts, written by skilled and apprentice scribes, trained in well organised schools, were deposited. It was probably the first and the largest lending library of antiquity.

Of upwards of a half-a-million tablets excavated from Irak, now **re-interred i**n European and U.S. museums, but mostly in the British Museum, only about 300 mathematical texts have been translated and published. Of these, about two-thirds are table texts, and one-third problem texts. The reciprocal table texts were of enormous extent. More than 300 tablets were omen texts referring to animals, plants, human beings, heavenly bodies, of unbelievable variety. Some 200 contain lists of Sumerian words and their Akkadian equivalents with additional readings. About 50 make a group of "epic" texts of fables, wisdom, proverbs, apotropaic (to avert evil) conjurations, and some of prayers. There is a Herculean task for the scholars who would relate the Assyriological data of the clay tablets to the Old Testament.

Tablets of sales, rentals, loans, marriages, adoptions, wills, letters, and records generally, probably total between 30 and 40 thousand. According to Oppenheim of the Oriental Institute, of Chicago University, Sumerian administrative and legal documents, might total more than three times that number!

The whole field of the study which comes under the heading of Assyriology, is now so wide, that hardly any one person can expect to cover all its facets. Most Assyriologists now confine themselves to a specific subdivision in which they are interested, and for which they are suitably qualified.

In the field of Mathematics, some spectacular successes have been achieved, and it appears that astronomy is rapidly catching up to its closely related parent subject, and may soon surpass it. The historian of medicine has here a really fruitful field for investigation, and there is a need for scholars in it. We may mention some subdivisions in which scholars and researchers are badly needed; in the histories of technology, metallurgy, economics, social sciences, law, anthropology and religion. And remember that the records, even though fragmentary and disparate, extend chronologically over two to three thousand years, and remember also, that it is less than 2000 years since the birth of Christ.

Whoever will venture into the field of Assyriology, must rely on translations of the specific tablets in which he is interested, from the linguist and philologist, or become one himself, in which case in the earlier years, maintaining his status in his own discipline, must suffer. And one must remember that the languages of the Cuneiform tablets are multifarious. That's where the mathematician had a tremendous advantage. The sexagesimal number system is constant throughout them all, with some minor differences in the early Sumerian. Of course, for example, someone might think of a collaboration of, let us say an M.B., Ch.M., and a philologist, or a lawyer and a philologist. Of course one at least, or both, would of necessity need to spend some years on the Continent of Europe, U.K., or U.S.A., because that is where the tablets are! And as far as I know, although we have University Schools of Archaeology, and History of Science, I do not know anywhere in Australia, where one could learn **as a student**, the Sumerian or Akkadian languages, nor for that matter, Hieratic, Demotic, or Hieroglyphic. Australian Archaeology confines itself mostly to statuary, ornaments, vases, monuments and architecture. I suspect that the course given at the University of N.S.W., is probably the only one of its specific kind in Australia.

It is my hope that there will be more in due time.

An address delivered to the Melbourne University School of History and Philosophy of Science, May, 1964.