Rosetta Stone

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Abstract

In this assignment you will explore hieroglyphics and Egyptian arithmetic circa 1700 B.C.E.. You will be challenged to walk in the foot steps of the 19th century scholars who first deciphered Heiroglyphics using the Rosetta Stone.

Contents

1 Introduction

In this assignment you will explore Egyptian Numerals as they were written starting around 3000 B.C.E.. You will practice translating back and forth between Egyptian Numerals and Hindu-Arabic, explore how the Egyptians handled fraction, and see how they carried out multiplication. At the end you will try and *"decipher"* some hieroglyphics dating back to around 1700 B.C.E. by comparing English translations with the original Hieroglyphics. This is similar to what scholars did with the Rosetta Stone in the 19th century. You should start by reading about number systems in your text, *Sketch 1: Keeping Count*, and watching these videos about the Rosetta Stone.

Figure 1: Rosetta Stone

- The Not-So-Simple Process of Deciphering Hieroglyphs
  (https://youtu.be/oU88-BLmcmY)

1

- Decoding Egyptian hieroglyphs (the Rosetta Stone, Champollion, and Young)
  (https://youtu.be/Ju2JBoe9C7A)

For all of this assignment, particularly for the last two sections, keep in mind that it is effort that counts. You need to show your work as much as possible and explain your reasoning. I am perfectly aware that you can find many of the answers on the internet, but if you don't show work I won't give you credit. You can either write up your work neatly or type it up. I will include an appendix at the end of this assignment describing some ways to type up hieroglyphs.

2   Egyptian Numerals

2.1   Numbers

Recall that the Egyptians had different symbols for each power of 10 up to 1,000,000.

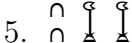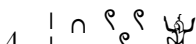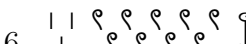|			
1	ı	10.000	𓆼
10	∩	100,000	𓂭
100	𓏤	1,000,000	𓁨
1,000	𓋔		

Table 1: Quick Number Reference

Using this we can translate back and forth between Hindu-Arabic and Egyptian Numerals.

1. 42

2. 57

3. 31,047

4. ı ∩ 𓏤𓏤 𓁨

5. ∩∩ 𓋔 𓋔

6. ıı ı 𓏤𓏤𓏤𓏤𓏤 𓋔

2.2   Fractions

When writing fractions the ancient Egyptians worked almost exclusively in unit fractions (fractions with numerator 1), that is they would have written $2/5$ as something like $1/3 + 1/15$. Using Egyptian numerals we would write this roughly as:

$$\overset{\frown}{ııı} + \overset{\frown}{ıı∩}$$

Here the symbol ⌒ indicates that it is a fraction. An exception to this notation is for $1/2$, which is written ⇌ instead of $\overset{\frown}{ıı}$. One possible formula for finding the unit fractions is:

$$\frac{2}{n} = \frac{1}{m} + \frac{1}{n(m)},$$

where $m = (n+1)/2$. For example we could write $2/7$ as $1/4 + 1/28$, since 4=(7+1)/2. Try using this formula for the following fractions:

7. $\frac{2}{3}$ 9. $\frac{2}{7}$ 11. $\frac{2}{11}$

8. $\frac{2}{5}$ 10. $\frac{2}{9}$ 12. $\frac{2}{13}$

This only works when n is an odd number. However, what is the simple way to write $2/4$ as a unit fraction? Why would this always work when the denominator is an even number?

One of the only exceptions to the unit fraction rule was $2/3$ which sometimes had its own special symbol

$$\text{⨅}.$$

From now on, for simplicity, we will write these fractions using lines or dots over Hindu-Arabic numerals so the above examples would be $1/3+1/15=\overline{3}+\overline{15}$ and $2/3=\ddot{3}$.

3   Egyptian Multiplication

Egyptian multiplication was built around the idea that it is easy to double numbers. If we want to calculate 15×6, we think of it as $15 \times 2 + 15 \times 4$ because $6 = 2 + 4$. Now all we have to do is use doubling:

$$
\begin{array}{c|l}
15 & 1 \\
30 & 2 \checkmark \\
60 & 4 \checkmark
\end{array}
$$

thus

$$
\begin{aligned}
15 \times 6 &= 15 \times 2 + 15 \times 4 \\
&= 30 + 60 \\
&= 90.
\end{aligned}
$$

Here are a couple more, slightly more complication examples with whole numbers.

$23 \times 17 =?$

23	1✓
46	2
92	4
184	8
368	16✓

$23 + 368 = \boxed{391}$

$35 \times 110 =?$

35	1
70	2✓
140	4✓
280	8✓
560	16
1120	32✓
2240	64✓

$70+140+280+1120+2240=\boxed{3850}$

What we can see in these examples is that Egyptian arithmetic trades complicated multiplication tables for doubling (multiplying a number by 2 or adding a number to its self) combined with addition. This

means you might need to do far more individual calculations but each one is a little simpler, this works well with their number system. Here is an example with some fractions.

$$13 \times 1\tfrac{2}{5} = ?$$

$1 + \overline{3} + \overline{15}$	$1\checkmark$
$2 + \ddot{3} + \overline{8} + \overline{120}$	2
$5 + \overline{3} + \overline{4} + \overline{60}$	$4\checkmark$
$10 + \ddot{3} + \overline{2} + \overline{30}$	$8\checkmark$

$$\left(1 + \overline{3} + \overline{15}\right) + \left(5 + \overline{3} + \overline{4} + \overline{60}\right) + \left(10 + \ddot{3} + \overline{2} + \overline{30}\right)$$
$$= \left(17 + \overline{2} + \overline{3} + \overline{4} + \overline{15} + \overline{30} + \overline{60}\right)$$
$$= \left(18 + \overline{10} + \overline{12} + \overline{60}\right)$$
$$= \boxed{\left(18 + \overline{5}\right)}$$

This is far more complicated than the calculations we would normally do, but you need to recall that they had a more simplistic additive notation for their numbers. Given their number system this algorithm makes sense for them.

Reflect on the Egyptian multiplication and check your understanding:

13. When we multiplied 23 by 17 why did we stop doubling when we got to 16?

14. When we multiplied $13 \times 1\tfrac{2}{5}$ where did the $1 + \overline{3} + \overline{15}$ come from?

15. When we multiplied $13 \times 1\tfrac{2}{5}$ how did we get that

$$4 \times 1 + \overline{3} + \overline{15} = 5 + \overline{3} + \overline{4} + \overline{60}?$$

16. Redo the calculation of 35×110, but this time double the 110 and not the 35.

17. Use the Egyptian multiplication by doubling to calculate 12×15. (Hint: we can write 12=8+4, both powers of 2.)

18. Use the Egyptian multiplication by doubling to calculate 25×18.

19. Use the Egyptian multiplication by doubling to calculate $9 \times 2\tfrac{2}{3}$.

On a final note, one advantage of Egyptian multiplication is that we can divide using the exact same method. If we want to calculate $22 \div 7$, we rewrite that as $22 \times (1/7)$ or $22 \times \overline{7}$. Then we can use the algorithm we already have.

$\overline{7}$	1
$\overline{4} + \overline{28}$	$2\checkmark$
$\overline{2} + \overline{14}$	$4\checkmark$
$1 + \overline{7}$	8
$2 + \overline{4} + \overline{28}$	$16\checkmark$

So we get a final answer of $3 + \overline{7}$, which is what we would expect if we used out modern algorithm for division to get $22 \div 7$. What this nicely highlights is that multiplication and division are very closely related operations.

4 Moscow Papyrus Problem 6

Now it is your turn to crack the Rosetta Stone. Figure 2 shows the calculations from problem 6 on the Moscow Papyrus which is about finding the dimensions of an enclosed region. You need to carefully compare the English translation to the Egyptian and see if you can answer these questions. [1]

Questions:

20. In line 2 the author speaks of *a set and 2 arurae*, this appears to be a measure of area. Reading through the rest of the text how many square units is this equal to?

21. This piece of hieroglyphs uses special symbols for $\overline{4}$ and $\overline{2}$ can you spot them? Looking at the way Egyptian multiplication works why might they have special symbols for these fractions?

22. How can we combine $\overline{2} + \overline{4}$ with 1 to get $1 + \overline{3}$? (Hint: what happens if you multiply $\overline{2} + \overline{4}$ by $1 + \overline{3}$?)

23. Using what you did in section 3, show how multiplying $1 + \overline{3}$ by a set and 2 arurae results in 16. (Hint: you need to answer problem 20 first.)

24. Where in the diagram of hieroglyphics can we see the author multiplying 3 by 4?

25. Which symbols seem to express the words *"you are to"*?

26. Which symbols seem to represent the word *"result"*?

English Translation of Problem 6:

1. Example of calculating an enclosure.

2. If you are told : An enclosure of a set and 2 arurae, the breadth having $\left(\overline{2} + \overline{4}\right)$ of the length:

3. You are to treat $\left(\overline{2} + \overline{4}\right)$ so as to find 1; the result is $1 + \overline{3}$.

4. [You are to take] this [12] which is in a set and 2 arurae $1 + \overline{3}$ [times]; result 16.

5. You are to calculate its square root; result 4-for the length, and the breadth has $\left(\overline{2} + \overline{4}\right)$ of it, namely 3.

6. The correct procedure:

$$
\begin{array}{c}
\overset{\displaystyle 4}{\boxed{12}}\ 3
\end{array}
\qquad
\begin{array}{c|c}
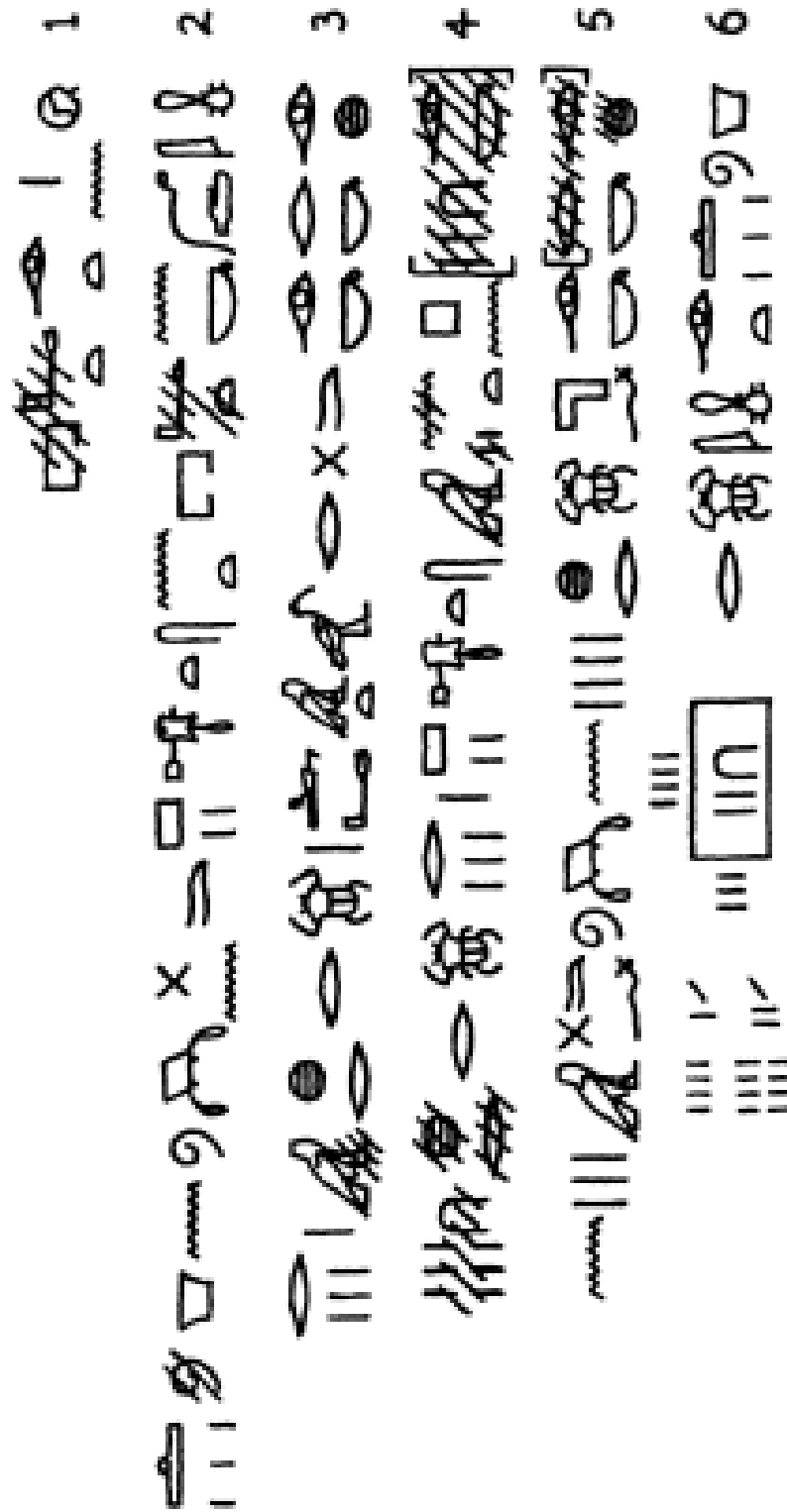4 & 1\checkmark \\
8 & 2\checkmark
\end{array}
$$

Figure 2: Moscow Papyrus Problem 6

5   Moscow Papyrus Problem 14

Repeat what you did above in section 4 with this more complicated example. Figure 3 shows the calculations from Problem 14 of the Moscow Papyrus for the volume of a truncated pyramid. Compare the English translation with the figure and try to answer these questions.

Questions:

27. Where is the author calculating 4×2?

28. Where is the author calculating 28×2?

29. Where on the diagram does the author write that $\overline{3}$ of 6 is 2?

30. What seems to be the symbol for squaring a number?

31. What might be the symbol for a sum?

32. Knowing what is supposed to be happening, can you glean where calculations are being done in the Egyptian sentences at the top of the hieroglyphics?

English Translation of Problem 14:

"If you are told: A truncated pyramid of 6 for the vertical height by 4 on the base by 2 on the top: You are to square the 4; result 16. You are to double 4; result 8. You are to square this 2; result 4. You are to add the 16 and the 8 and the 4; result 28. You are to take $\overline{3}$ of 6; result 2. You are to take 28 twice; result 56. See, it is of 56. You will find [it] right."
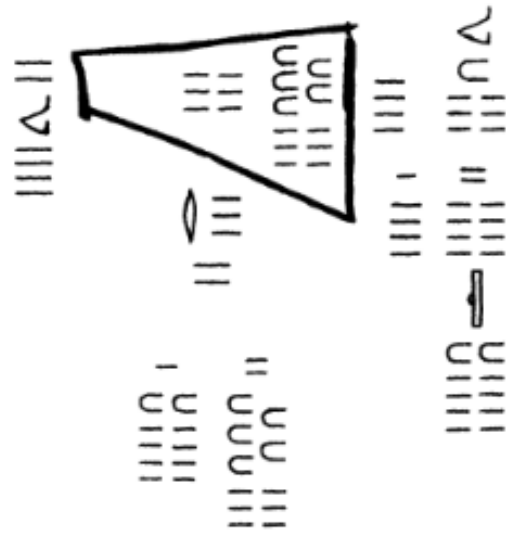
Figure 3: Moscow Papyrus Problem 14

Typing Hieroglyphs Appendix

If you are doing work with hieroglyphics and need to insert them in a document here are some ways to do that.

In LaTeX:

If you are using LaTeX to type up your work you can use the `\usepackage{hieroglf}` to typeset symbols. For example:

Some Numbers

```
\centering
\textpmhg{\Hone}\\
\textpmhg{\Hten}\\
\textpmhg{\Hhundred}\\
\textpmhg{\Hthousand}\\
\textpmhg{\HXthousand}\\
\textpmhg{\HCthousand}\\
\textpmhg{\Hmillion}\\
\textpmhg{\Hone-\Hone-\Hten-\Hten}
\textpmhg{\Hthousand-\Hthousand}\\
\pmglyph{\Hr:\textpmhg{\Hone-\Hone-\Hten}}\\
\reflectbox{\pmglyph{\HM}}
```

You can find lots of examples and tables of symbols here

https://ctan.math.illinois.edu/fonts/archaic/hieroglf/trypmhg.pdf

And the full documentation for the package here:

https://mirror.las.iastate.edu/tex-archive/fonts/archaic/hieroglf/hieroglf.pdf

As Graphics:

One way to insert hieroglyphics is to copy and past images into your file. This is a little sloppy looking and tedious but also simple. You can either Google the image you want, or use the a snipping/screen capture tool like Microsoft's Snipping Tool App (✂). Or you can go to a website like the Hieroglyphic Typewriter where you can use the virtual typewriter to find the symbol you want and then right click on it to copy and paste it into you document.

In Google Docs:

You can insert Hieroglyphs in Google Docs by following the directions here How to add hieroglyphs to Google Docs and Slides. This is a little tedious but they will have what you need. One way to speed this up is to find the character you need here Egyptian Unicode Block, then you can use the characters number code while inserting a special character by searching using that code and then double clicking on the image.
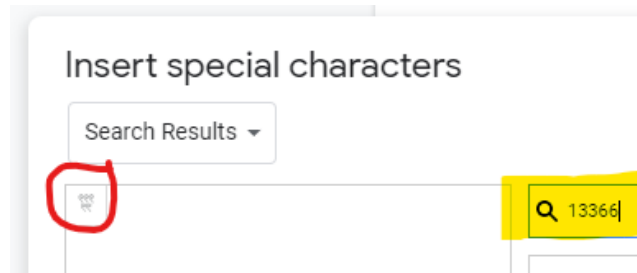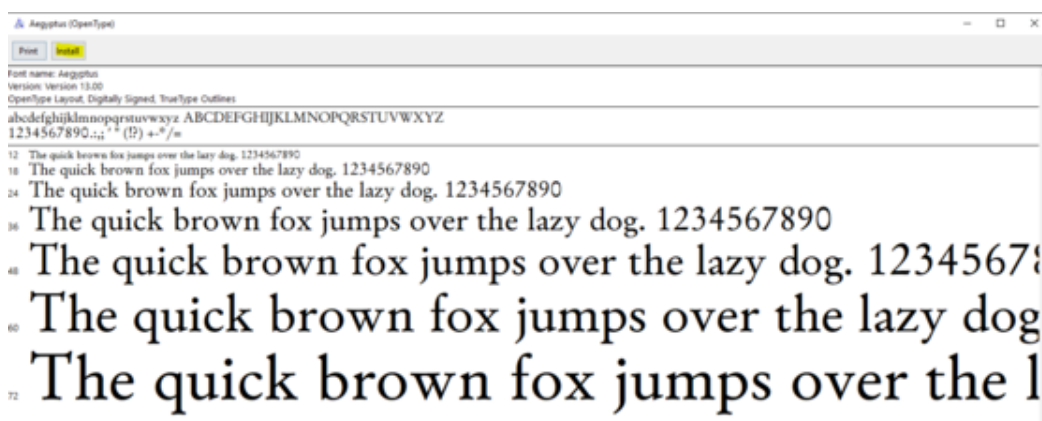
In Microsoft Word:

Microsoft Word can insert symbols in the same
way as Google Docs once you install the fonts. Here are directions for getting the fonts installed.

Click on the link (https://dn-works.com/ufas/) and go down and click the font that's called **Aegyptus**, you will download a zip file on your computer which you can then extract by double clicking on it. After extracting the file, you will need to click and run these two files:

| Aegyptus.ods | OpenDocument Spreadsh... | 394 KB | No |
Aegyptus.odt	OpenDocument Text	1,185 KB	No
Aegyptus.otf	OpenType font file	4,474 KB	No
Aegyptus.pdf	Adobe Acrobat Document	821 KB	No
AegyptusBold.otf	OpenType font file	4,108 KB	No

Click Install for both files:

This will install a new font on your computer that's called Aegyptus. Once the font is installed, you can open up Microsoft Word and search for the font:
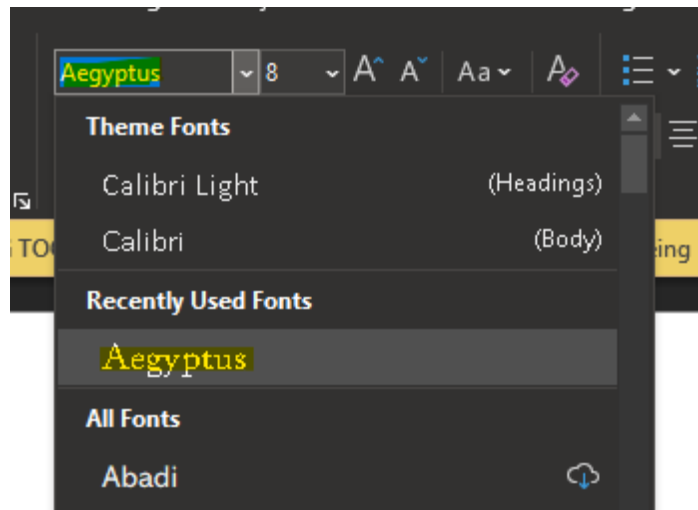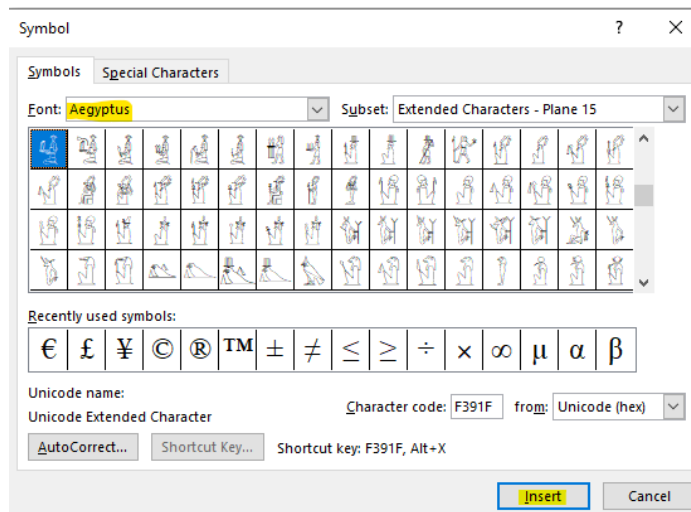
To view the hieroglyphs, click the Symbol icon (probably in the insert ribbon):
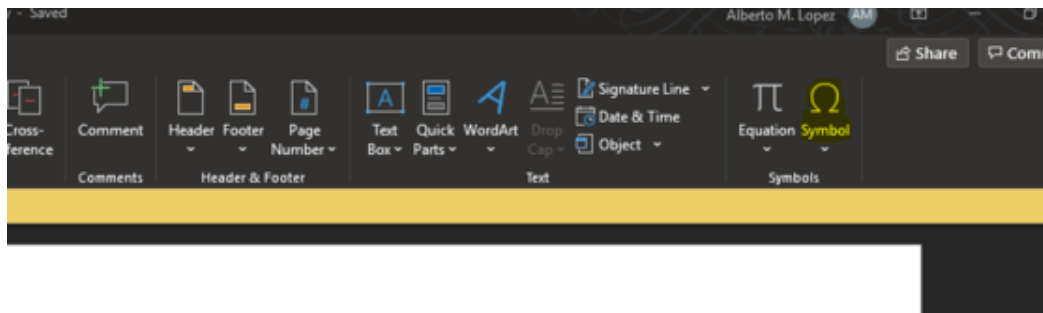
Click More Symbols:
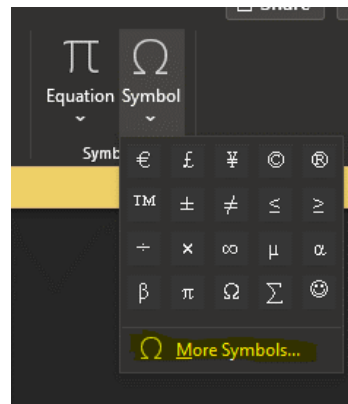
Choose Aegyptus as the font and Extended Characters as the subset, then click the hieroglyph you wish to insert:

You can also now use the unicode numbers mentioned above. In Microsoft Word you can insert unicode characters by typing the hex value of the character, e.g. `U+13366` then typing Alt-x:

To help you find the numbers quickly here are the unicode numbers for some basic symbols:

1	|	U+133FA
10	∩	U+13386
100	𓍢	U+13362
1,000	𓆼	U+131BC
10,000	𓂭	U+130AD
100,000	𓆐	U+13190
1,000,000	𓁨	U+13068
Fraction Symbol	⬯	U+1308B
Two Thirds Symbol	𓂌	U+1308C

Table 2: Quick Number Reference with Unicode

It is useful to notice that the 𓍢 symbol is U+13362 and looking at the unicode chart if I want six of those you can type the code U+13367 and press Alt+x to get 𓍧.