# Cryptography - Part 1

Feb. 20, 2025

# Recap question:

Feb. 20, 2025

A disease in the SIR model is estimated to have parameter values $\beta = 2$ and $\gamma = 1$. What is the herd immunity threshold for the disease?

The herd immunity threshold is

$$p_c = 1 - \frac{1}{R_0}.$$

To compute this, we need to find the value of $R_0$ . We use the definition of $R_0$ :

$$R_0 = \frac{\beta}{\gamma} = \frac{2}{1} = 2$$

so

$$p_c = 1 - \frac{1}{R_0} = 1 - \frac{1}{2} = \frac{1}{2}.$$

# Cryptography - Part 1

Feb. 20, 2025

By the end of this lecture, you will be able to:

1. Define substitution ciphers and Caesar ciphers
2. Decrypt Caesar ciphers using the brute-force method
3. Decrypt substitution ciphers using frequency analysis

**Cryptography** is “the art of writing in secret characters”. A cryptographer encodes messages before they are transmitted so that even if the encrypted message is intercepted by a hostile party, its meaning will still remain secret.

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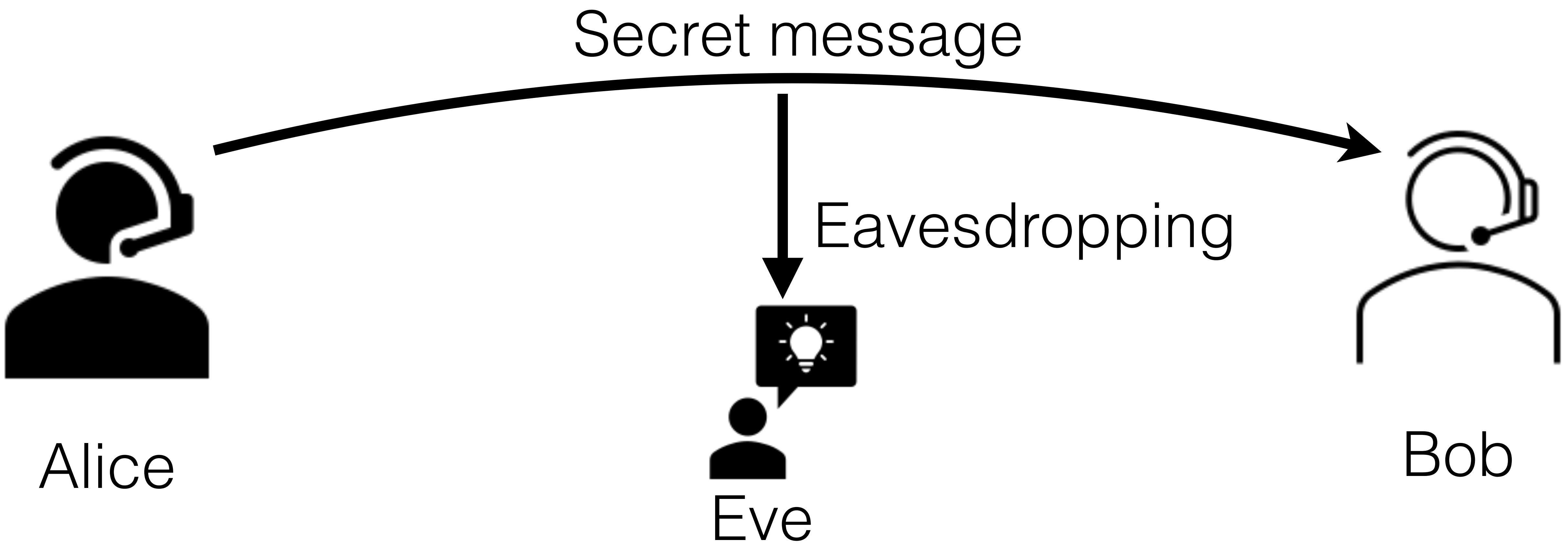
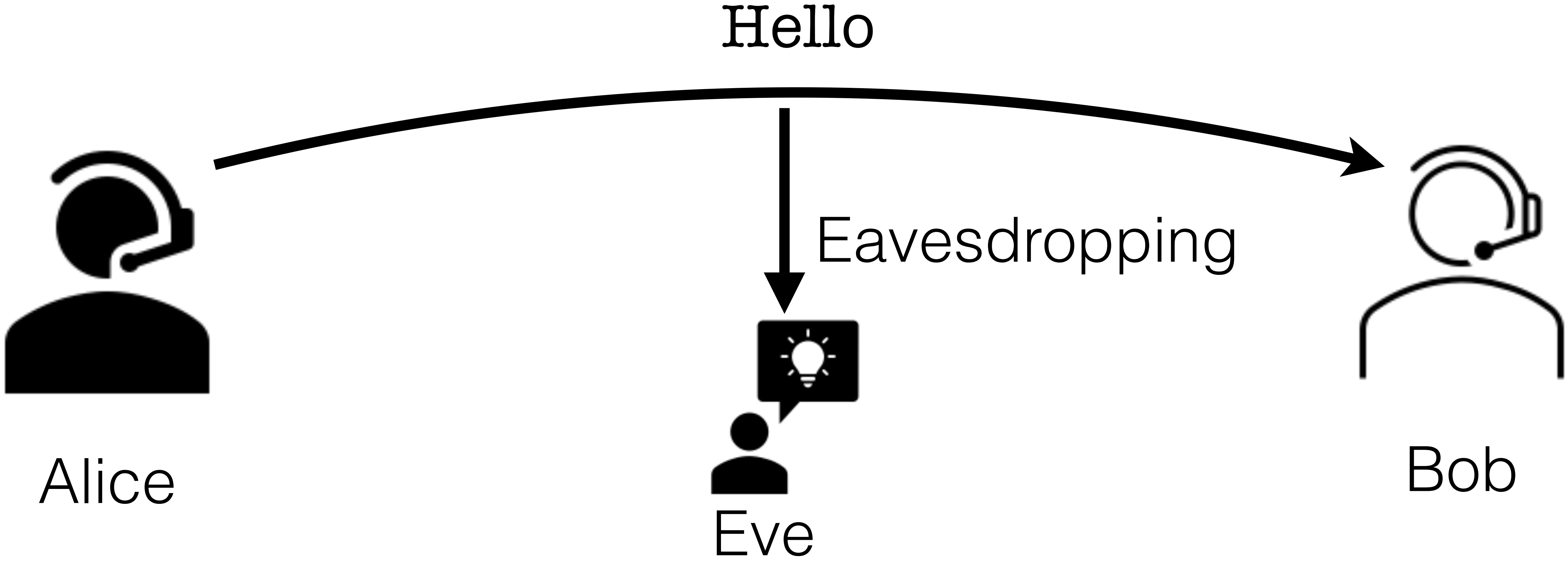
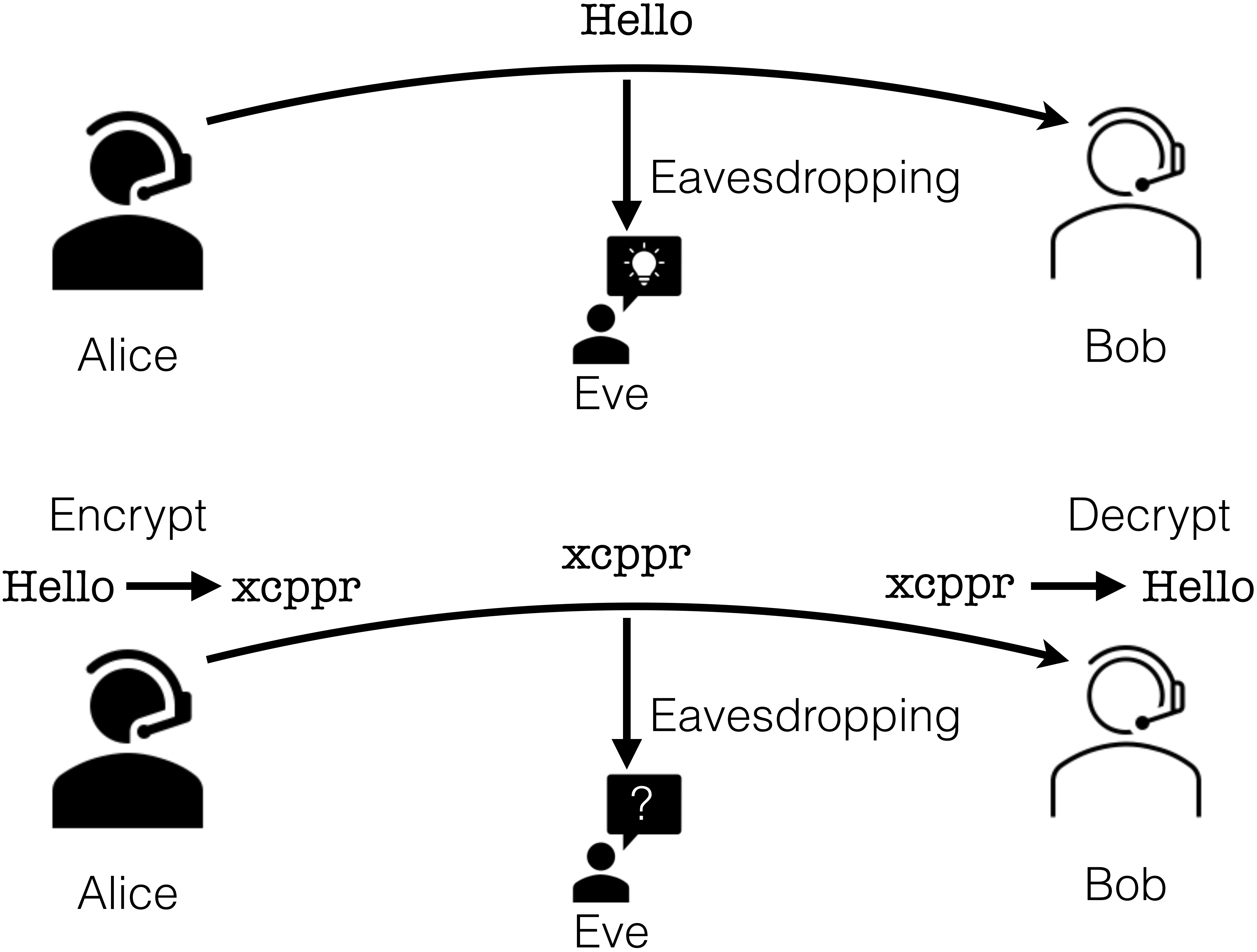



Hello
Eavesdropping
Alice
Eve
Bob


Hello
Eavesdropping
Alice
Eve
Bob
Encrypt
Decrypt
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Hello
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xcppr
Hello
Eavesdropping
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Alice
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Bob

In principle, only “friends” of the original cryptographer, who knows the secret recipe for decoding or decrypting, can decode the encrypted message to the original plain text.

A “code breaker” seeks to detect patterns in the encrypted messages that will lead to sufficient understanding of the encryption scheme to enable the discovery of a decryption method.

# Where is cryptography used?

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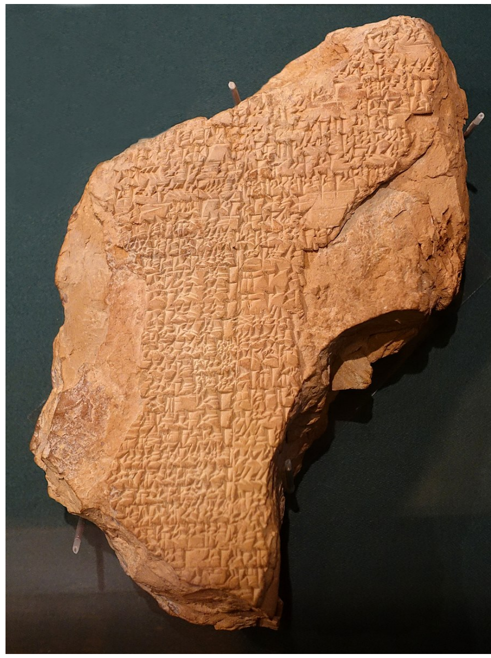

1500 BC: encrypted clay tablets to keep valuable information (recipe for pottery glaze) secret

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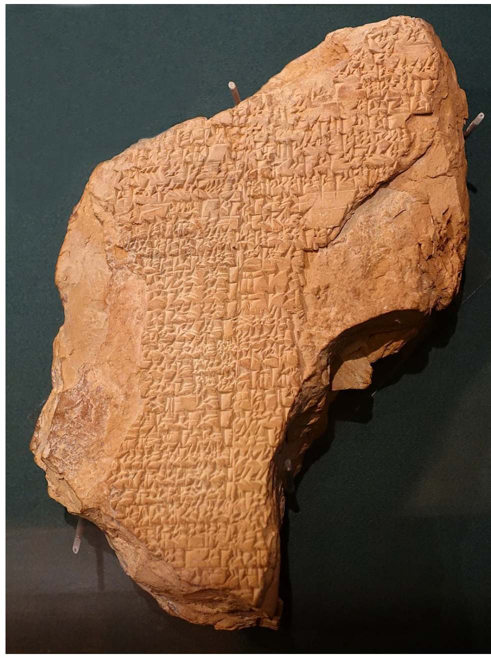

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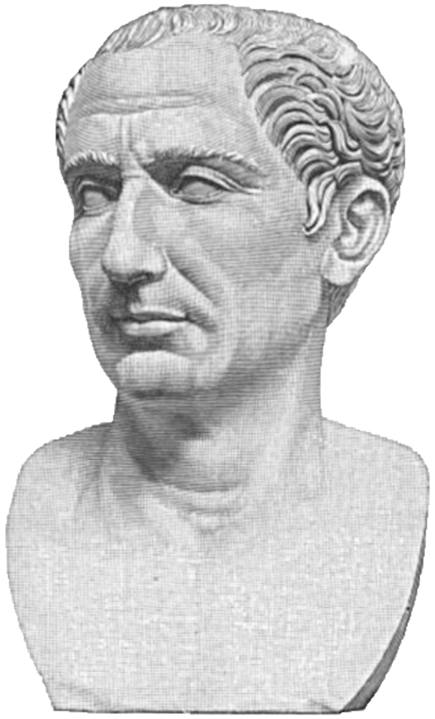

50 BC: Julius Caesar encrypted letters to generals at the frontlines

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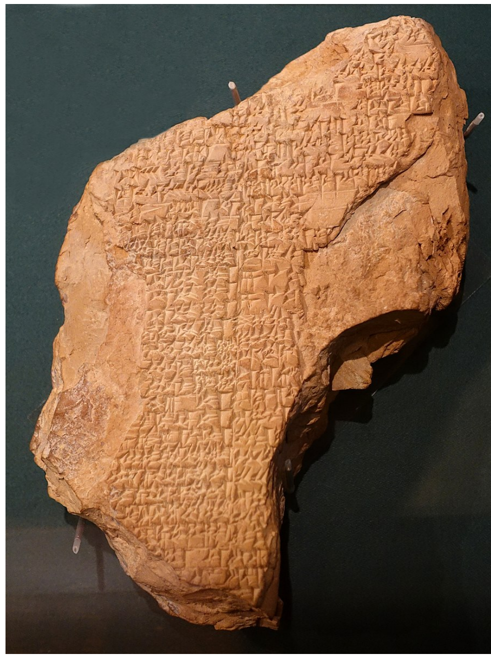

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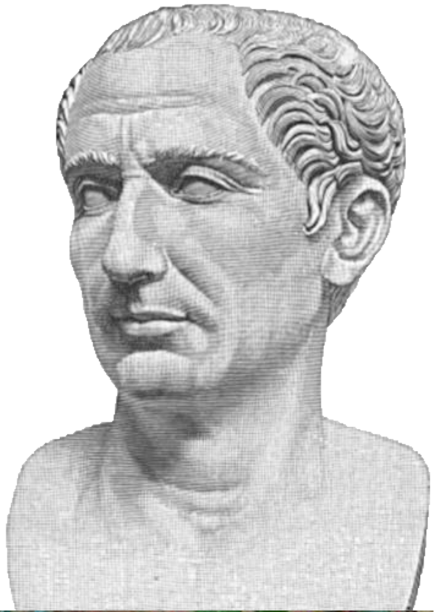

50 BC: Julius Caesar encrypted letters to generals at the frontlines

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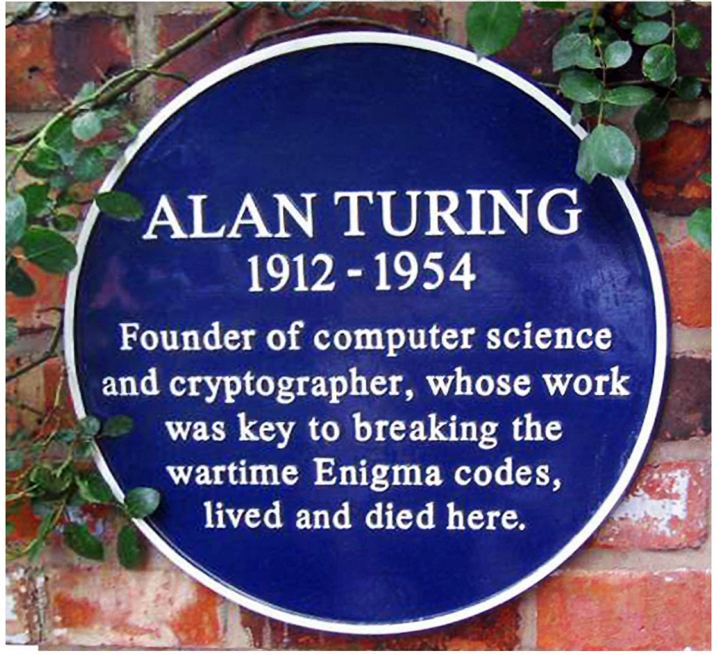
1940-1942 AD: British intelligence cracked the most secure German cipher (“Enigma”), contributing to the end of the war



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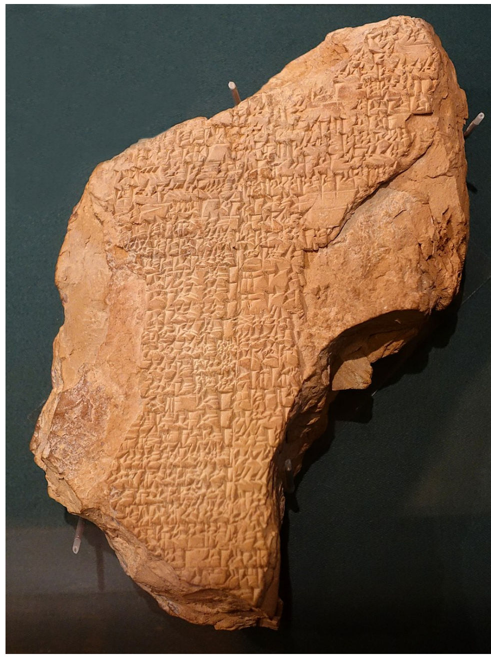

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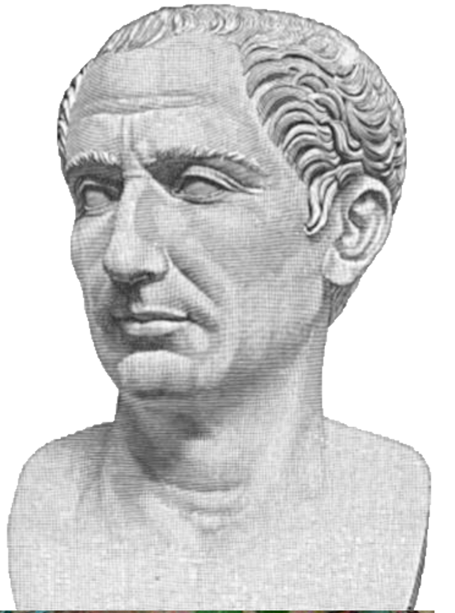

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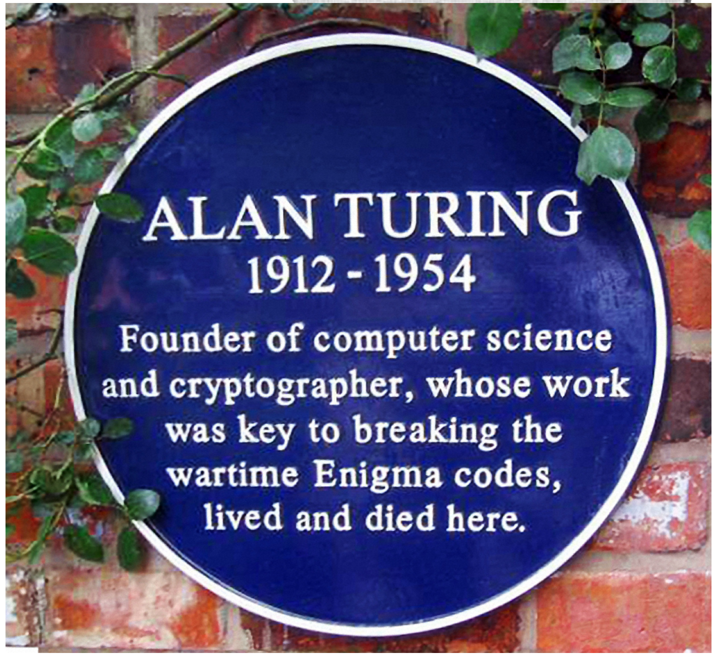
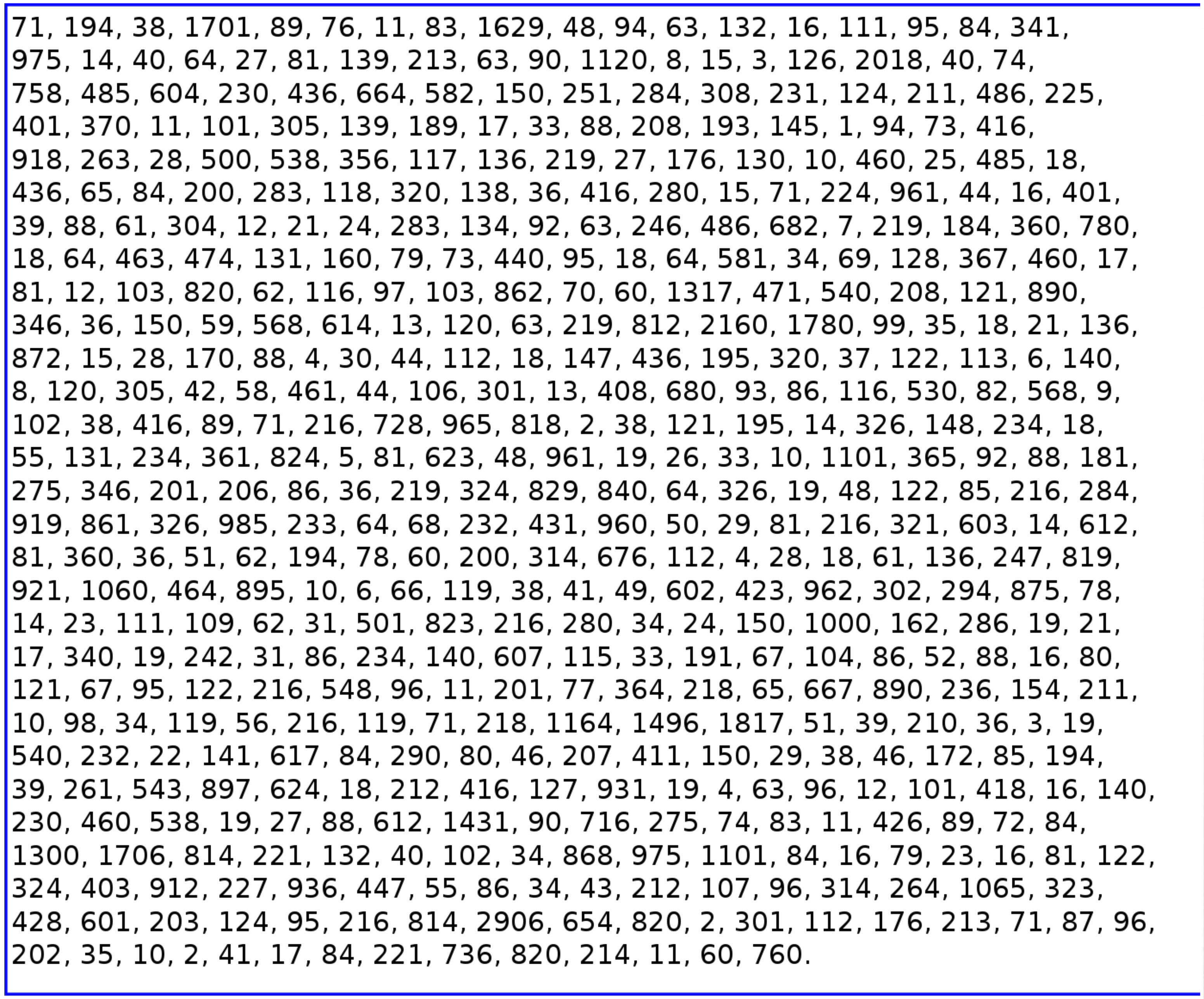


Today: logging into websites, sending emails, WhatsApp, verifying credit card information, cloud storage of pictures, …

https://en.wikipedia.org/wiki/File:Turing_Plaque.jpg

# Unsolved historical encryption techniques



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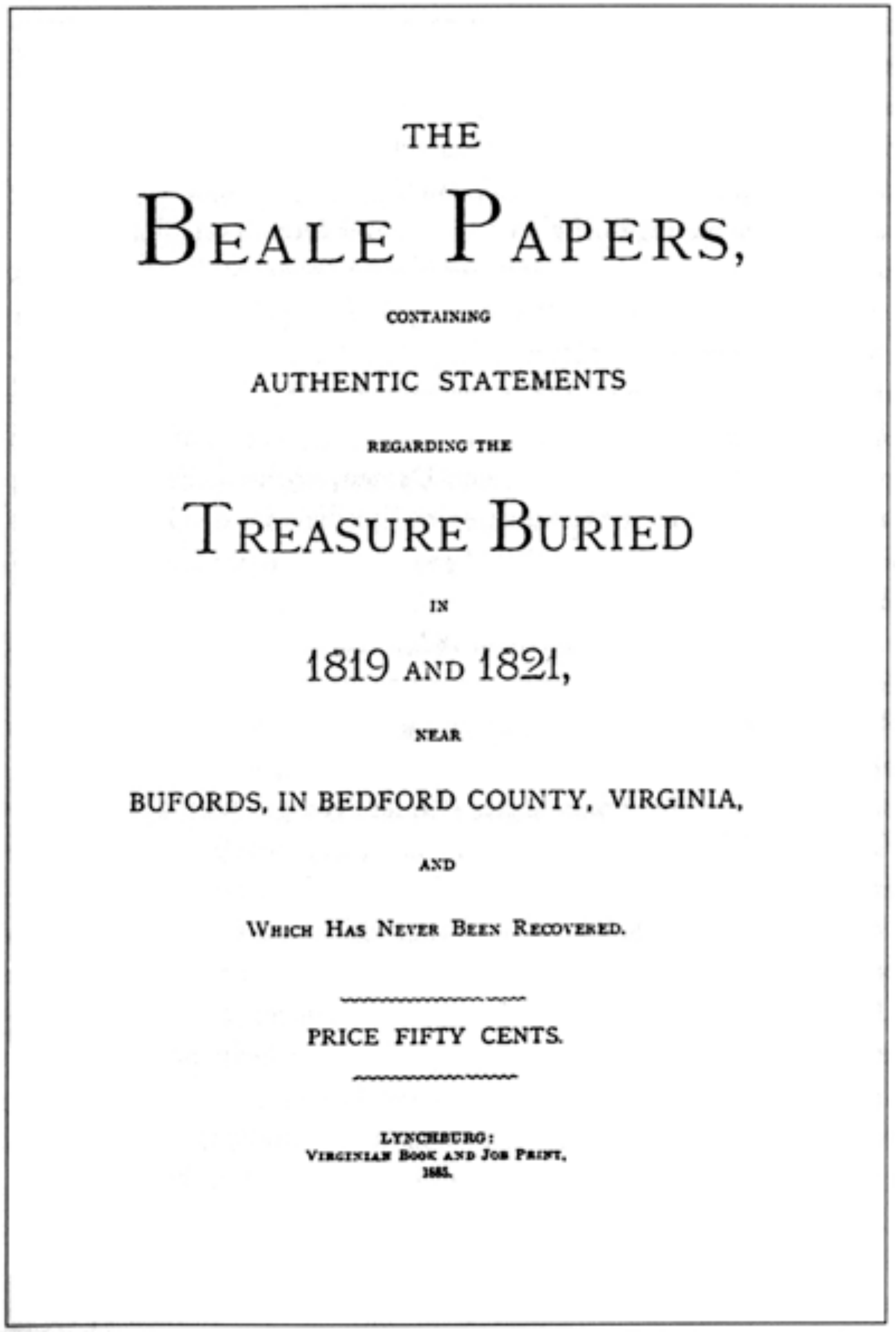

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BEALE PAPERS,

CONTAINING

AUTHENTIC STATEMENTS

REGARDING THE

TREASURE BURIED

IN

1819 AND 1821,

NEAR

BUFORDS, IN BEDFORD COUNTY, VIRGINIA,

AND

WHICH HAS NEVER BEEN RECOVERED.

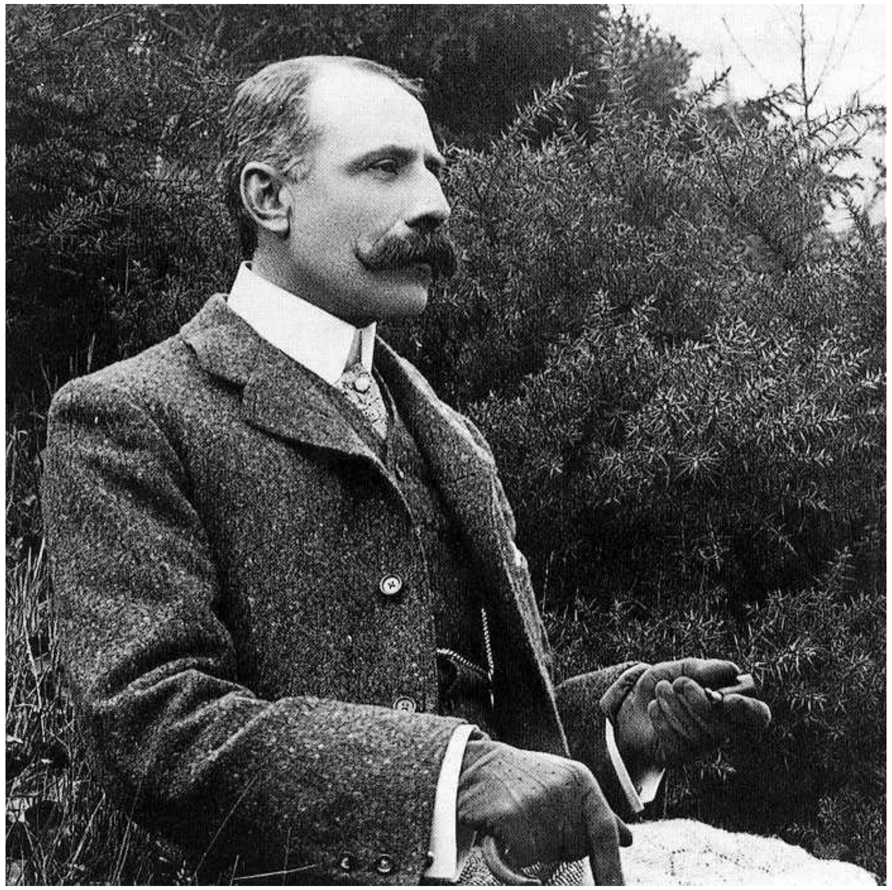
PRICE FIFTY CENTS.

LYNCHBURG:
VIRGINIAN BOOK AND JOB PRINT,
1885.

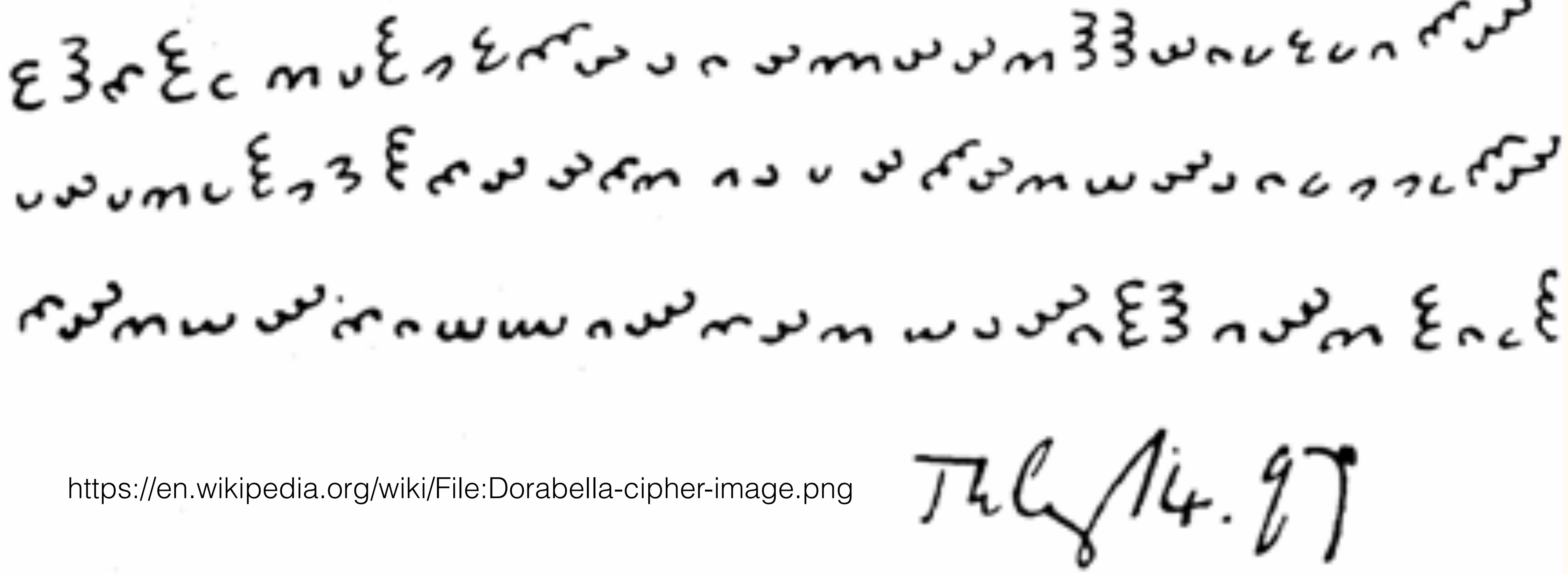
https://commons.wikimedia.org/wiki/File:Beale_1.svg

# Unsolved historical encryption techniques

Letter written by composer Edward Elgar to Dora Penny



https://commons.wikimedia.org/wiki/File:Edward_Elgar.jpg



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# Some (not very good) encryption techniques:

1. Ehay isay eryvay illysay

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   This message is just written backwards. The decrypted message is:

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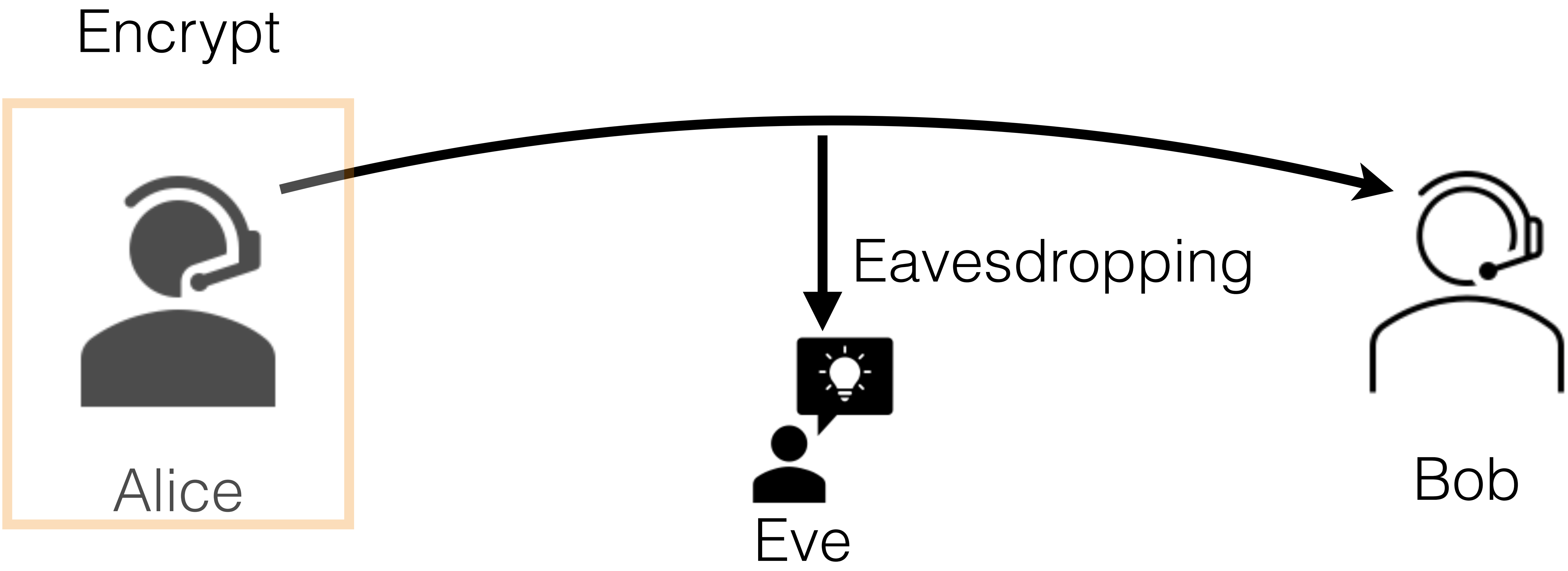
For the rest of today, we will discuss better techniques!

# Old standards: substitution ciphers

The oldest schemes replace the letters in the message one by one, following a fixed recipe.



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For example,

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How do we encrypt “Math alive”?

# Old standards: substitution ciphers

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# Old standards: substitution ciphers

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# Old standards: substitution ciphers

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# Old standards: substitution ciphers

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# Old standards: substitution ciphers

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# Old standards: substitution ciphers

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# Old standards: substitution ciphers

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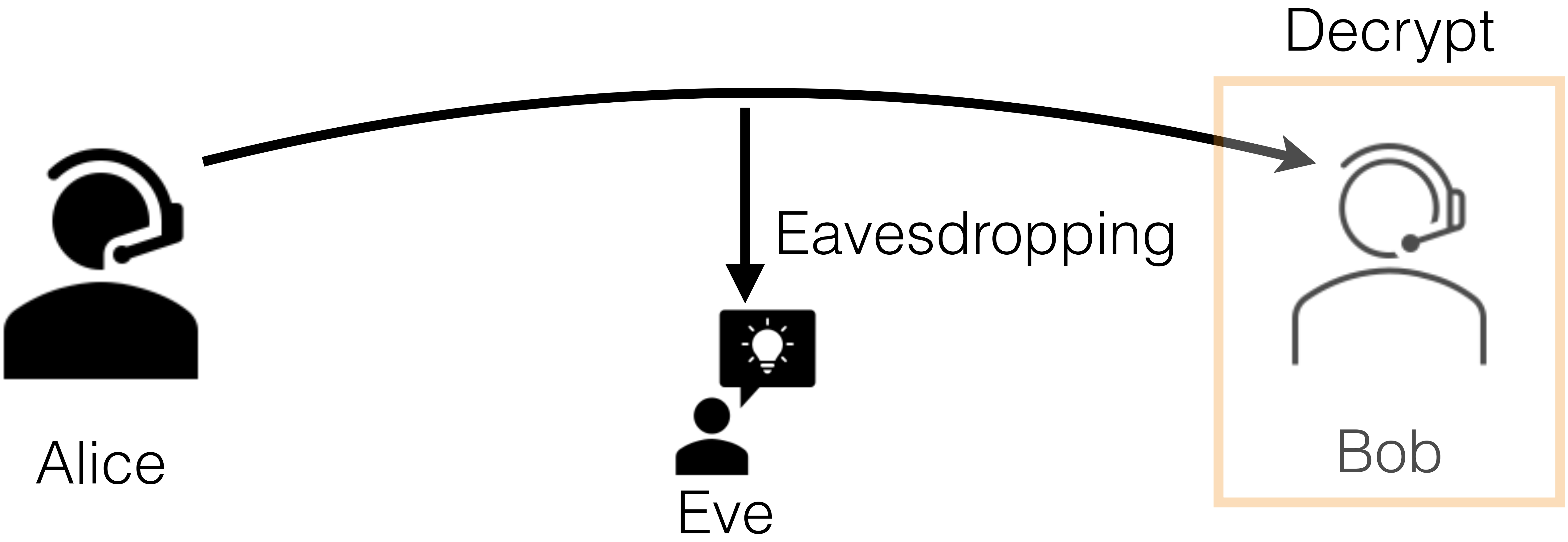
# Old standards: substitution ciphers

To decrypt, go the other way!



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For example,

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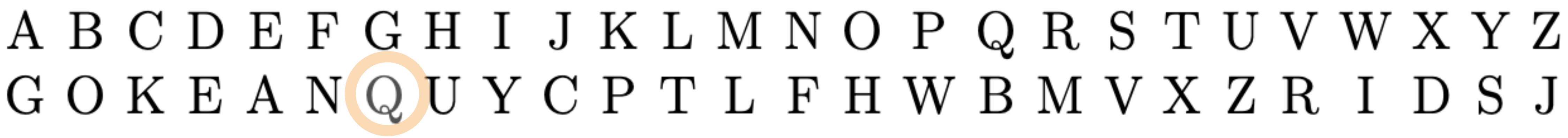
What does “QYMGNNAYVSATTHI” mean?



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What does “QYMGNNAYVSATTHI” mean?

GIRAF

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

GIRAFF

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

**GIRAFFE**

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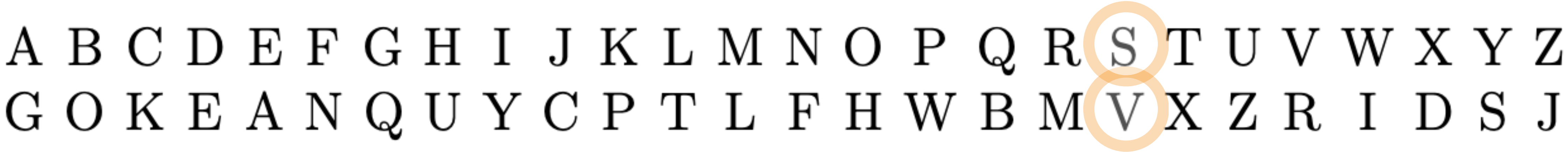
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

GIRAFFEI



| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

GIRAFFEIS

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

GIRAFFEISY

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

GIRAFFEISYE

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

GIRAFFEISYEL

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

GIRAFFEISYELL

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

GIRAFFEISYELLO

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| G | O | K | E | A | N | Q | U | Y | C | P | T | L | F | H | W | B | M | V | X | Z | R | I | D | S | J |

What does “QYMGNNAYVSATTHI” mean?

GIRAFFEISYELLOW

# Special substitution cipher used by Julius Caesar

Caesar ciphers (circular shift of alphabets):

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | A |

Shift by one step

# Substitution cipher used by Julius Caesar

Caesar ciphers (circular shift of alphabets):

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | A |

Shift by one step

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | A | B |

Shift by two steps

# Substitution cipher used by Julius Caesar

Caesar ciphers (circular shift of alphabets):

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | A |

Shift by one step

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | A | B |

Shift by two steps

⋮

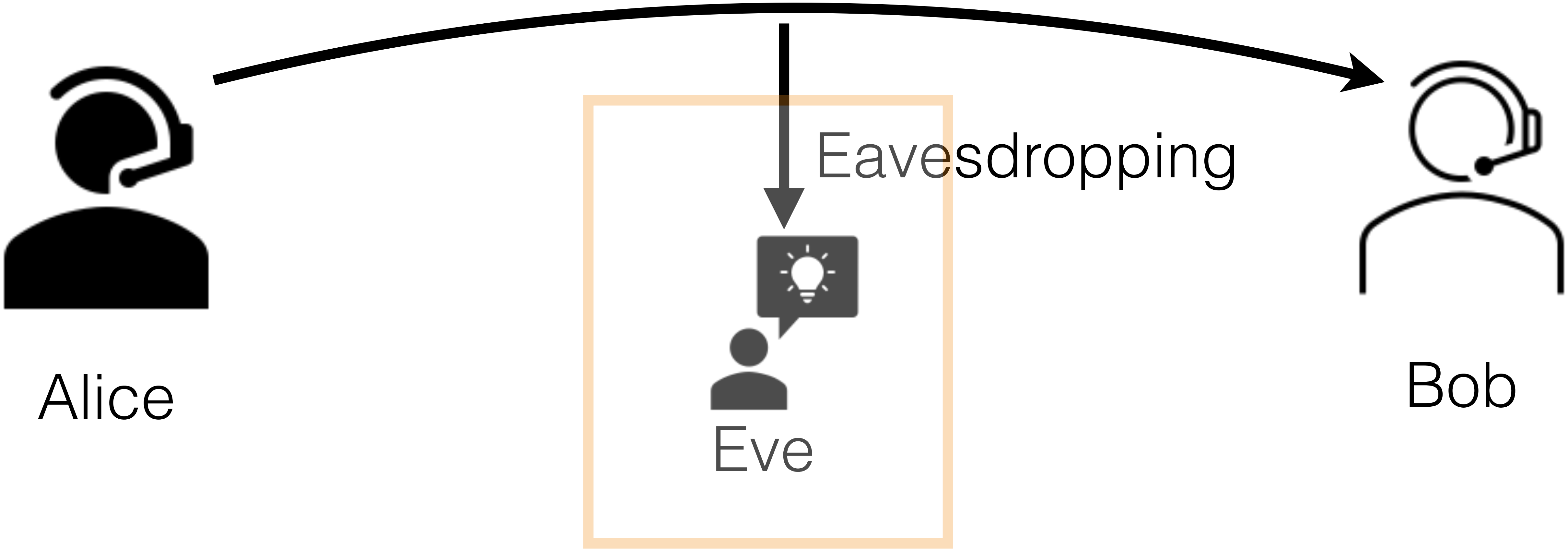
| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| Z | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y |

Shift by 25 steps

We choose a value for the shift (the “key”) between 1 and 25 and get one cipher

**Example:** the following was encrypted with a Caesar cipher, but we do not know the key that was used. Decrypt it anyways!

```
nqpiecnewncvkqpu
```



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Using shift 1 in the Caesar cipher:

mpohdbmdvmbujpot

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Using shift 1 in the Caesar cipher:

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Using shift 2 in the Caesar cipher:

longcalculations

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Using shift 1 in the Caesar cipher:

mpohdbmdvmbujpot ✗

Using shift 2 in the Caesar cipher:

longcalculations ✓

**Brute force decryption:** try every possible key.

Feasible for Caesar cipher

**Brute force decryption:** try every possible key.

Feasible for Caesar cipher (25 possible keys),

**Brute force decryption:** try every possible key. Feasible for Caesar cipher (25 possible keys), but not for general substitution ciphers, since there are a total of

$$26 \cdot 25 \cdot \ldots \cdot 2 \cdot 1 \approx 4 \cdot 10^{26}$$

keys.

**Brute force decryption:** try every possible key. Feasible for Caesar cipher (25 possible keys), but not for general substitution ciphers, since there are a total of

$$26 \cdot 25 \cdot \ldots \cdot 2 \cdot 1 \approx 4 \cdot 10^{26}$$

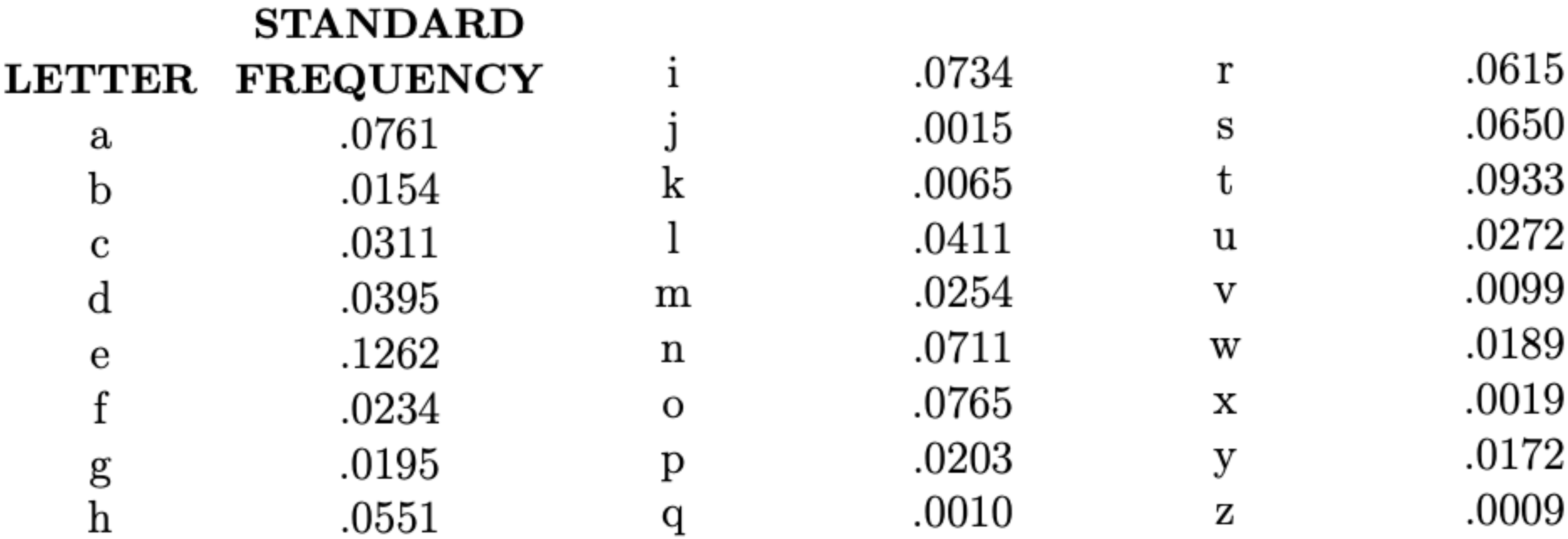
keys. Trying them all would take around 317 years on Earth's currently largest supercomputer.

zkbzkrphzkbihhwgrqwidlophqrzwdnhphwrbrxuilqlvkolqhrkpbkhduwlwe
uhdnvhyhubvwhswkdwlwdnhexwlpkrslqjwkdwwkhjdwhvwkhboowhoop
hwkdwbrxuhplqhzdonlqjwkurxjkwkhflwbvwuhhwvlvlwebplvwdnhrughv
ljqlihhovrdorqhrqdiulgdbqljkwfdqbrxpdnhlwihhoolnhkrphlilwhoobrxbrx
uhplqhlwvolnhlwrogbrxkrqhbgrqwpdnhphvdggrqwpdnhphfubvrphwlph
voryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodx
jkohwvjrjhwkljkwkhurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwlphf
rphwdnhdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxol
nhbrxujluovlqvdqhvrfkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhb
rxdqglzhzhuheruqwrglhorvwexwqrzldpirxqglfdqvhhexwrqfhlzdveolqglz
dvvrfrqixvhgdvdolwwohfklogwulhgwrwdnhzkdwlfrxogjhwvfduhgwkdwlf
rxogqwilqgdoowkhdqvzhuvkrqhbgrqwpdnhphvdggrqwpdnhphfubvrphwl
phvoryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjpho
dxjkohwvjrjhwkljkwkhurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwl
phfrphwdnhdzdonrqwkhzlogvlghfrphnlvvphkduglqwkhsrxulqjudlqbrxol
nhbrxujluovlqvdqhvrfkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhb
rxdqglzhzhuheruqwrglhzhzhuheruqwrglhzhzhuheruqwrglhfrphdqgwdn
hdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxolnhbrxuj
luovlqvdqhgrqwpdnhphvdggrqwpdnhphfubvrphwlphvoryhlvqrwhqrxjkd
qgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodxjkohwvjrjhwkljkwk
hurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwlphfrphwdnhdzdonrqw
khzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxolnhbrxujluovlqvdqh
fkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhbrxdqglzhzhuheruqwrg
lhzhzhuheruqwrglh

zkbzkrphzkbihhwgrqwidlophqrzwdnhphwrbrxuilqlvkolqhrkpbkhduwlwe
uhdnvhyhubvwhswkdwlwdnhexwlpkrslqjwkdwwkhjdwhvwkhboowhoop
hwkdwbrxuhplqhzdonlqjwkurxjkwkhflwbvwuhhwvlvlwebplvwdnhrughv
ljqlihhovrdorqhrqdiulgdbqljkwfdqbrxpdnhlwihhoolnhkrphlilwhoobrxbrx
uhplqhlwvolnhlwrogbrxkrqhbgrqwpdnhphvdggrqwpdnhphfubvrphwlph
voryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodx
jkohwvjrjhwkljkwkhurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwlphf
rphwdnhdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxol
nhbrxujluovlqvdqhvrfkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhb
rxdqglzhzhuheruqwrglhorvwexwqrzldpirxqglfdqvhhexwrqfhlzdveolqglz
dvvrfrqixvhgdvdolwwohfklogwulhgwrwdnhzkdwlfrxogjhwvfduhgwkdwlf
rxogqwilqgdoowkhdqvzhuvkrqhbgrqwpdnhphvdggrqwpdnhphfubvrphwl
phvoryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjpho
dxjkohwvjrjhwkljkwkhurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwl
phfrphwdnhdzdonrqwkhzlogvlghfrphnlvvphkduglqwkhsrxulqjudlqbrxol
nhbrxujluovlqvdqhvrfkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhb
rxdqglzhzhuheruqwrglhzhzhuheruqwrglhzhzhuheruqwrglhfrphdqgwdn
hdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxolnhbrxuj
luovlqvdqhgrqwpdnhphvdggrqwpdnhphfubvrphwlphvoryhlvqrwhqrxjkd
qgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodxjkohwvjrjhwkljkwk
hurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwlphfrphwdnhdzdonrqw
khzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxolnhbrxujluovlqvdqh
fkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhbrxdqglzhzhuheruqwrg
lhzhzhuheruqwrglh

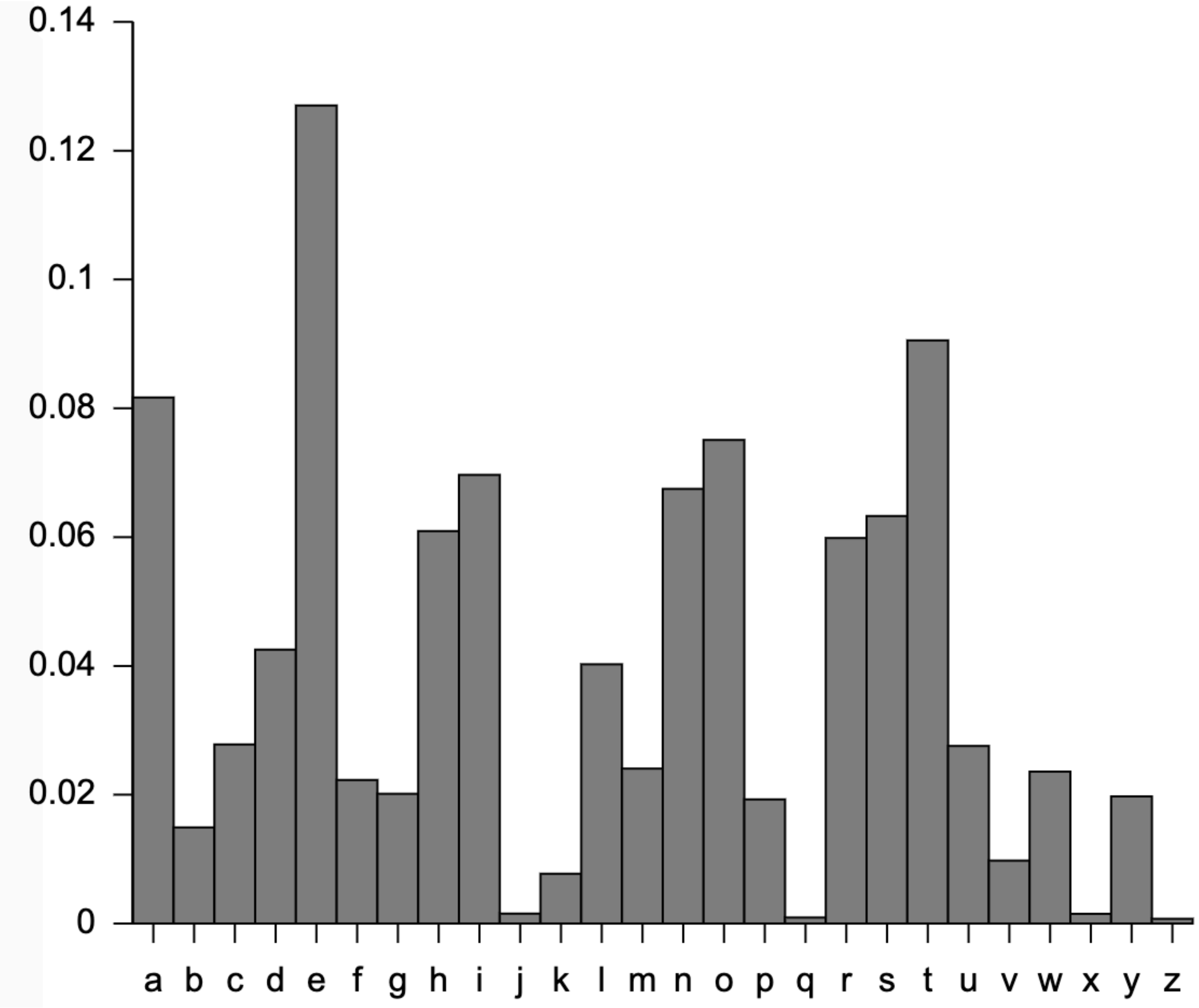
zkbzkrphzkbihhwgrqwidlophqrzwdnhphwrbrxuilqlvkolqhrkpbkhduwlwe
uhdnvhyhubvwhswkdwlwdnhexwlpkrslqjwkdwwkhjdwhvwkhboowhoop
hwkdwbrxuhplqhzdonlqjwkurxjkwkhflwbvwuhhwvlvlwebplvwdnhrughv
ljqlihhovrdorqhrqdiulgdbqljkwfdqbrxpdnhlwihhoolnhkrphlilwhoobrxbrx
uhplqhlwvolnhlwrogbrxkrqhbgrqwpdnhphvdggrqwpdnhphfubvrphwlph
voryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodx
jkohwvjrjhwkljkwkhurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwlphf
rphwdnhdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxol
nhbrxujluovlqvdqhvrfkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhb
rxdqglzhzhuheruqwrglhorvwexwqrzldpirxqglfdqvhhexwrqfhlzdveolqglz
dvvrfrqixvhgdvdolwwohfklogwulhgwrwdnhzkdwlfrxogjhwvfduhgwkdwlf
rxogqwilqgdoowkhdqvzhuvkrqhbgrqwpdnhphvdggrqwpdnhphfubvrphwl
phvoryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjpho
dxjkohwvjrjhwkljkwkhurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwl
phfrphwdnhdzdonrqwkhzlogvlghfrphnlvvphkduglqwkhsrxulqjudlqbrxol
nhbrxujluovlqvdqhvrfkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhb
rxdqglzhzhuheruqwrglhzhzhuheruqwrglhzhzhuheruqwrglhfrphdqgwdn
hdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxolnhbrxuj
luovlqvdqhgrqwpdnhphvdggrqwpdnhphfubvrphwlphvoryhlvqrwhqrxjkd
qgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodxjkohwvjrjhwkljkwk
hurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwlphfrphwdnhdzdonrqw
khzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxolnhbrxujluovlqvdqh
fkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhbrxdqglzhzhuheruqwrg
lhzhzhuheruqwrglh

If the language in which the plain text is written is known to the code-breaker, and if the messages contain a few sentences of text,



| LETTER | STANDARD FREQUENCY |
|---|---|
| a | .0761 |
| b | .0154 |
| c | .0311 |
| d | .0395 |
| e | .1262 |
| f | .0234 |
| g | .0195 |
| h | .0551 |
| i | .0734 |
| j | .0015 |
| k | .0065 |
| l | .0411 |
| m | .0254 |
| n | .0711 |
| o | .0765 |
| p | .0203 |
| q | .0010 |
| r | .0615 |
| s | .0650 |
| t | .0933 |
| u | .0272 |
| v | .0099 |
| w | .0189 |
| x | .0019 |
| y | .0172 |
| z | .0009 |

If the language in which the plain text is written is known sages contair



**ST**

**LETTER** **FR**

a
b
c
d
e
f
g
h

.0615
.0650
.0933
.0272
.0099
.0189
.0019
.0172
.0009

# Decryption example using frequency analysis:

zkbzkrphzkbihhwgrqwidlophqrzwdnhphwrbrxuilqlvkolqhrkpbkhduwlwe
uhdnvhyhubvwhswkdwlwdnhexwlpkrslqjwkdwwkhjdwhvwkhboowhoop
hwkdwbrxuhplqhzdonlqjwkurxjkwkhflwbvwuhhwvlvlwebplvwdnhrughv
ljqlihhovrdorqhrqdiulgdbqljkwfdqbrxpdnhlwihhoolnhkrphlilwhoobrxbrx
uhplqhlwvolnhlwrogbrxkrqhbgrqwpdnhphvdggrqwpdnhphfubvrphwlph
voryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodx
jkohwvjrjhwkljkwkhurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwlphf
rphwdnhdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxol
nhbrxujluovlqvdqhvrfkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhb
rxdqglzhzhuheruqwrglhorvwexwqrzldpirxqglfdqvhhexwrqfhlzdveolqglz
dvvrfrqixvhgdvdolwwohfklogwulhgwrwdnhzkdwlfrxogjhwvfduhgwkdwlf
rxogqwilqgdoowkhdqvzhuvkrqhbgrqwpdnhphvdggrqwpdnhphfubvrphwl
phvoryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjpho
dxjkohwvjrjhwkljkwkhurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwl
phfrphwdnhdzdonrqwkhzlogvlghfrphnlvvphkduglqwkhsrxulqjudlqbrxol
nhbrxujluovlqvdqhvrfkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhb
rxdqglzhzhuheruqwrglhzhzhuheruqwrglhzhzhuheruqwrglhfrphdqgwdn
hdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxolnhbrxuj
luovlqvdqhgrqwpdnhphvdggrqwpdnhphfubvrphwlphvoryhlvqrwhqrxjkd
qgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodxjkohwvjrjhwkljkwk
hurdglvorqjzhfduubrqwubwrkdyhixqlqwkhphdqwlphfrphwdnhdzdonrqw
khzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxolnhbrxujluovlqvdqh
fkrrvhbrxuodvwzrugvwklvlvwkhodvwwlphfdxvhbrxdqglzhzhuheruqwrg
lhzhzhuheruqwrglh

# Decryption example using frequency analysis:

zkbzkrphzkbihhwgrqwidlophqrzwdnhphwrbrxuilqlvkolqhrkp
uhdnvhyhubvwhswkdwlwdnhexwlpkrslqjwkdwwkhjdwhvwkh
hwkdwbrxuhplqhzdonlqjwkurxjkwkhflwbvwuhhwvlvlwebplvv
ljqlihhovrdorqhrqdiulgdbqljkwfdqbrxpdnhlwihhoolnhkrphlilw
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voryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhsp
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rphwdnhdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulq
nhbrxujluovlqvdqhvrfkrrvhbrxuodvwzrugvwklvlvwkhodvww
rxdqglzhzhuheruqwrglhorvwexwqrzldpirxqglfdqvhhexwrqfh
dvvrfrqixvhgdvdolwwohfklogwulhgwrwdnhzkdwlfrxogjhwvfd
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rxdqglzhzhuheruqwrglhzhzhuheruqwrglhzhzhuheruqwrglhfr
hdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbr
luovlqvdqhgrqwpdnhphvdggrqwpdnhphfubvrphwlphvoryhlvq
qgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodxjkohwvj
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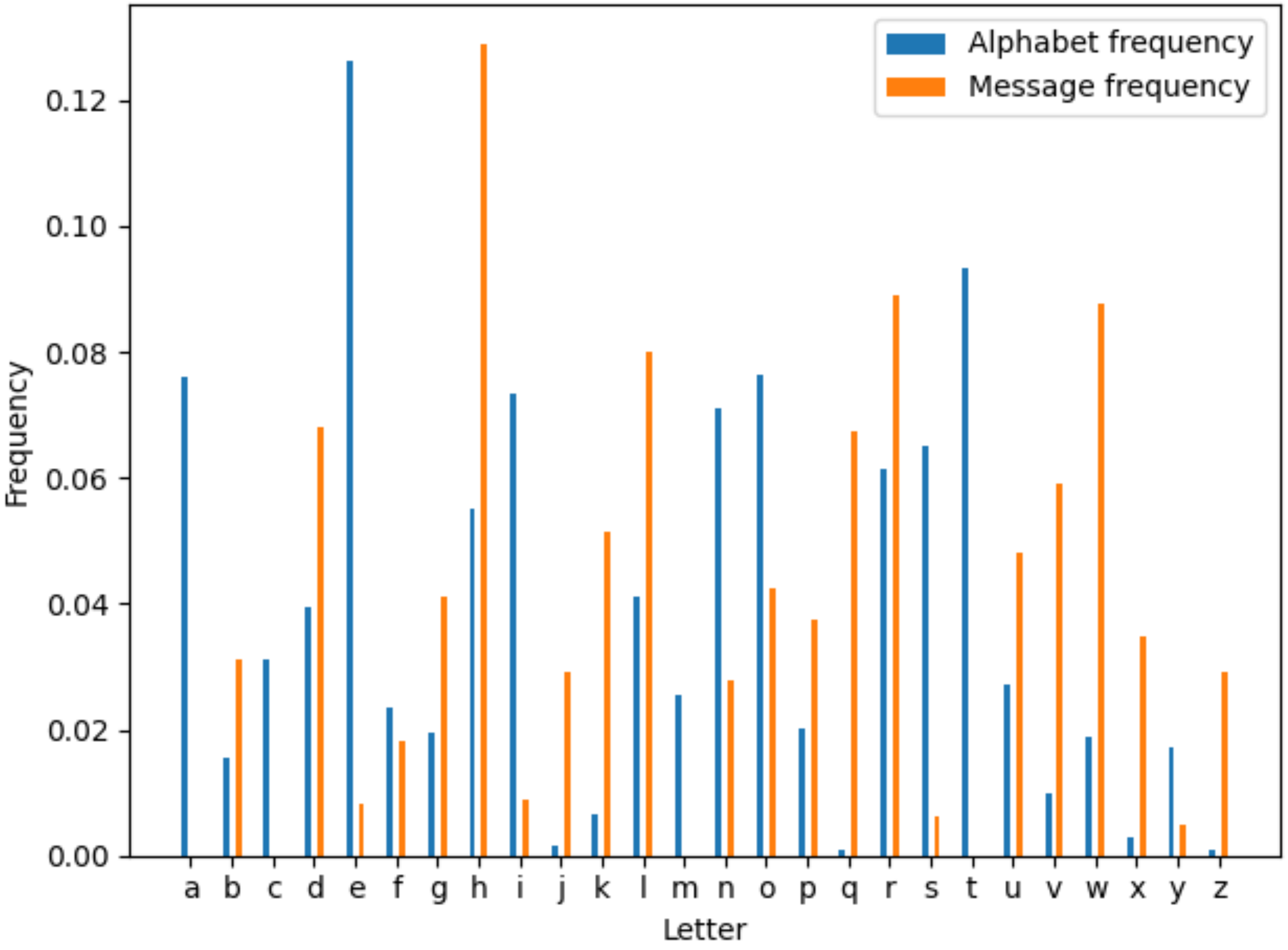

# Decryption example using frequency analysis:

zkbzkrphzkbihhwgrqwidlophqrzwdnhphwrbrxuilqlvkolqhrkp
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dvvrfrqixvhgdvdolwwohfklogwulhgwrwdnhzkdwlfrxogjhwvf
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phvoryhlvqrwhqrxjkdqgwkhurdgjhwvwrxjklgrqwnqrzzkbnh
dxjkohwvjrjhwkljkwkhurdglvorqjzhfduubrqwubwrkdyhixqlq
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hdzdonrqwkhzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbr
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qgwkhurdgjhwvwrxjklgrqwnqrzzkbnhhspdnlqjphodxjkohwvj
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khzlogvlghohwphnlvvbrxkduglqwkhsrxulqjudlqbrxolnhbrxuj
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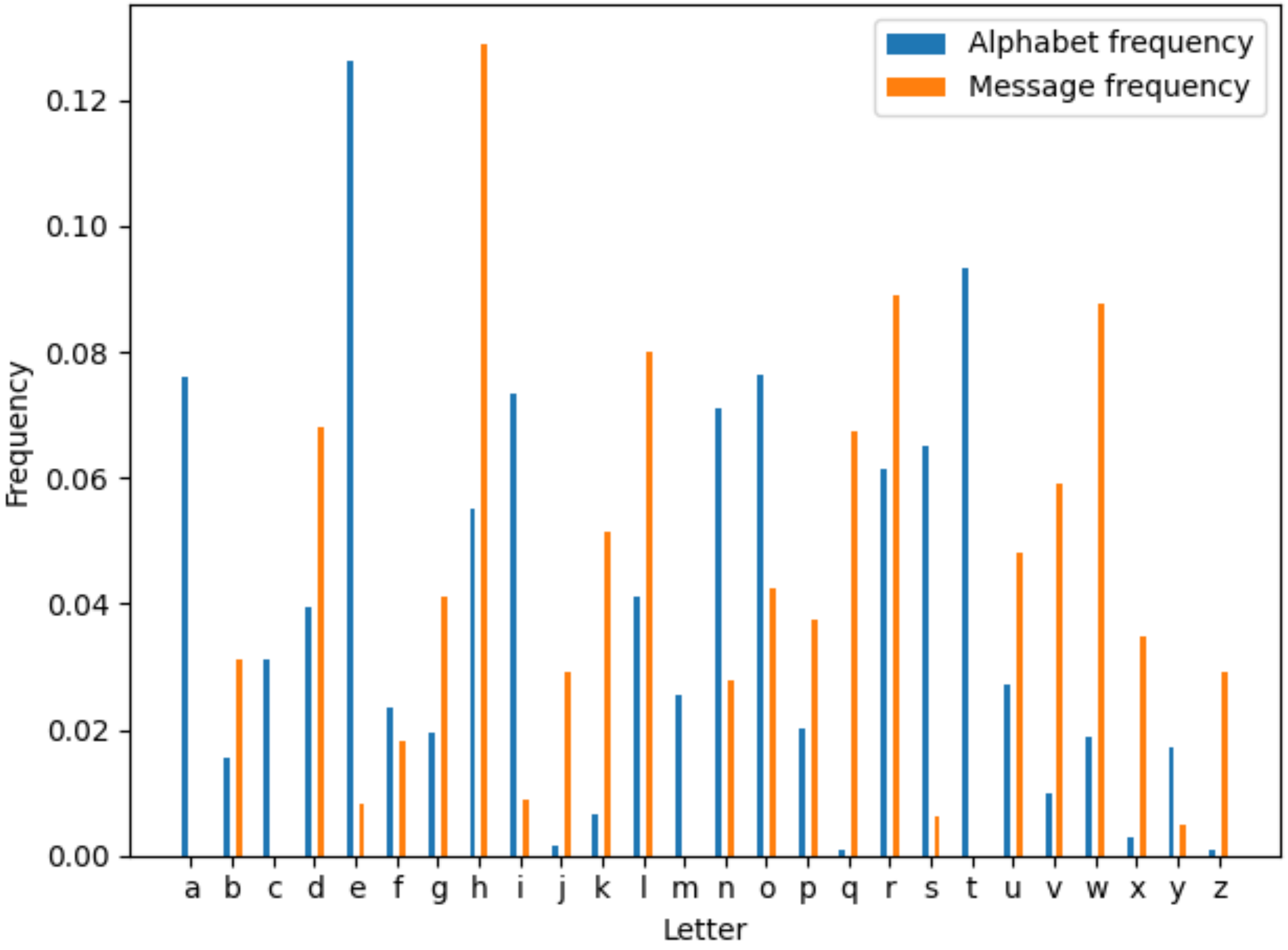


whywhomewhyfeetdontfailmenowtakemetoyourfinishlineohmyheartitbreakseverystepthatitake...
— Lana Del Rey

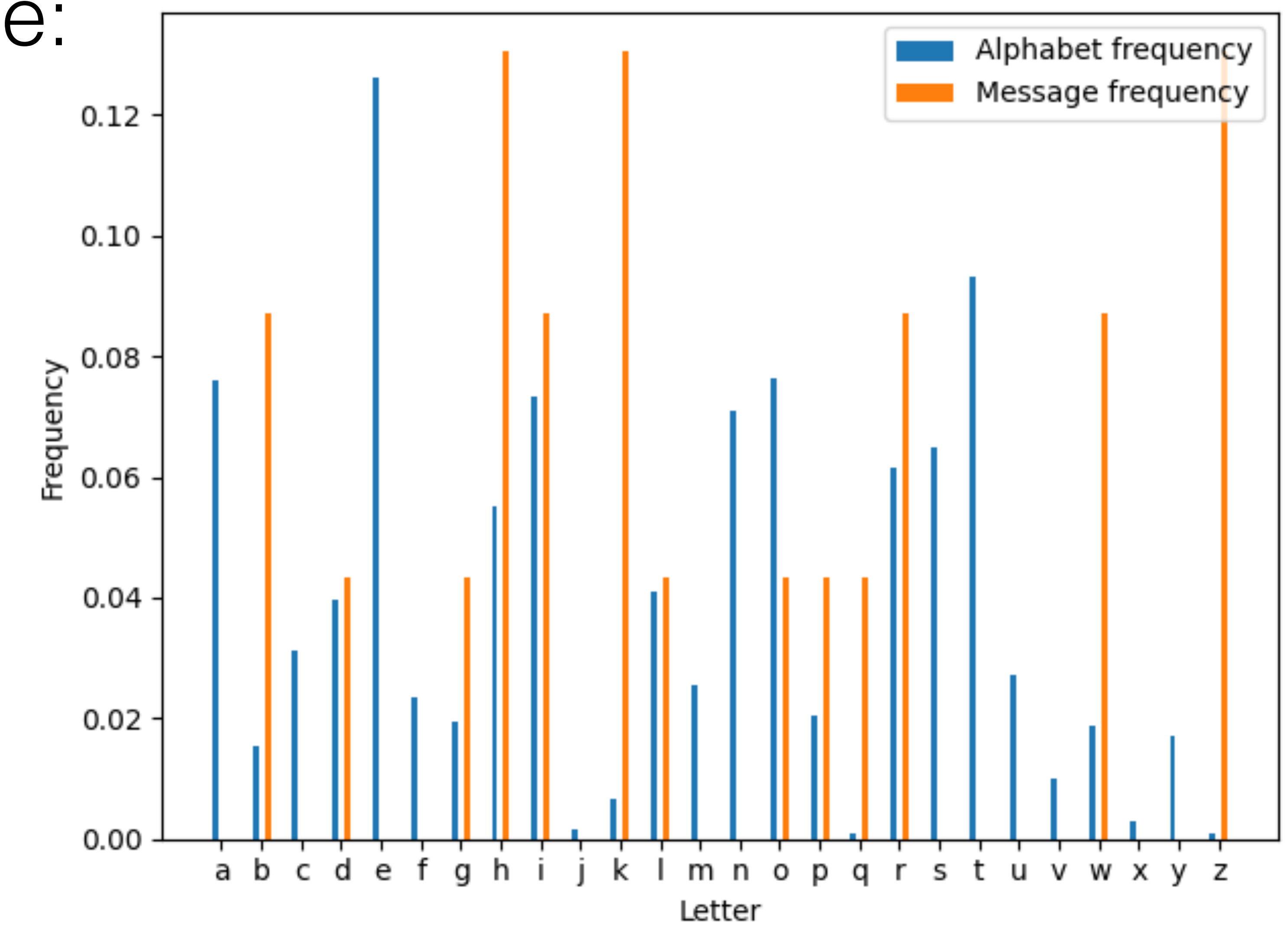
# Decryption example using frequency analysis:

The first part of the message:

zkbzkrphzkbihhwgrqwidlo

"decrypts" to:

etoetihaetonaasridsnlcu



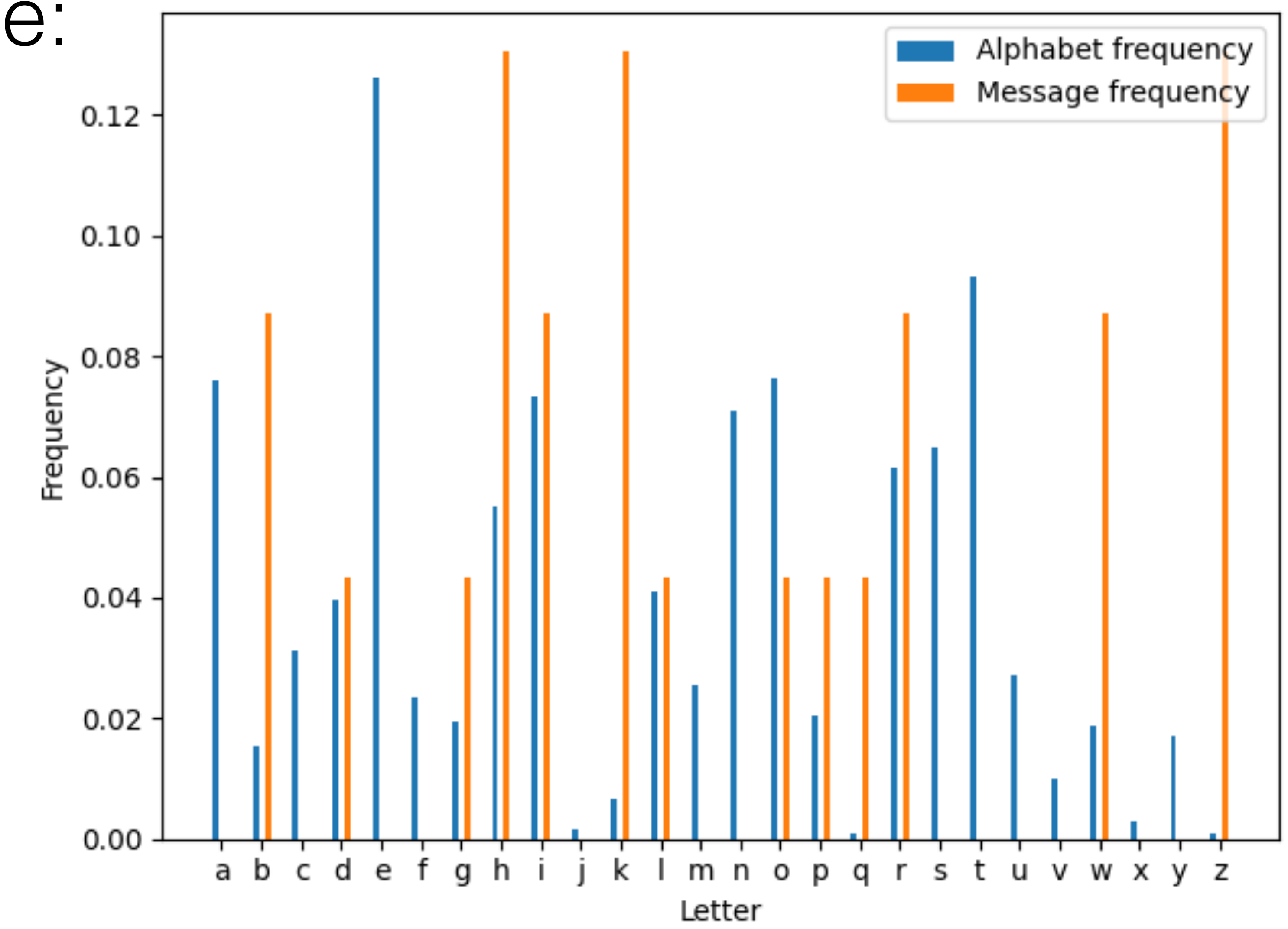
# Decryption example using frequency analysis:

The first part of the message:

zkbzkrphzkbihhwgrqwidlo

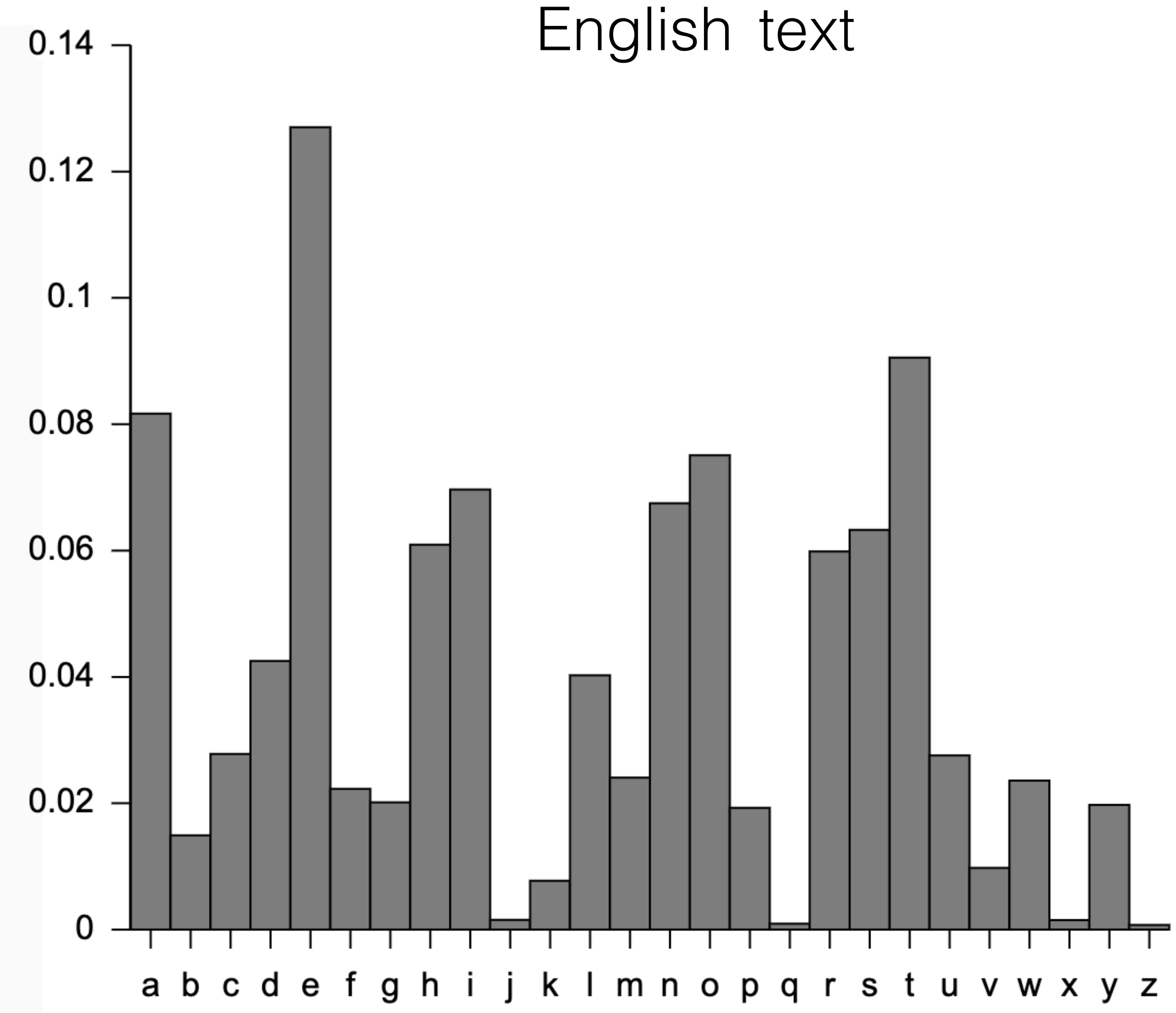
“decrypts” to:

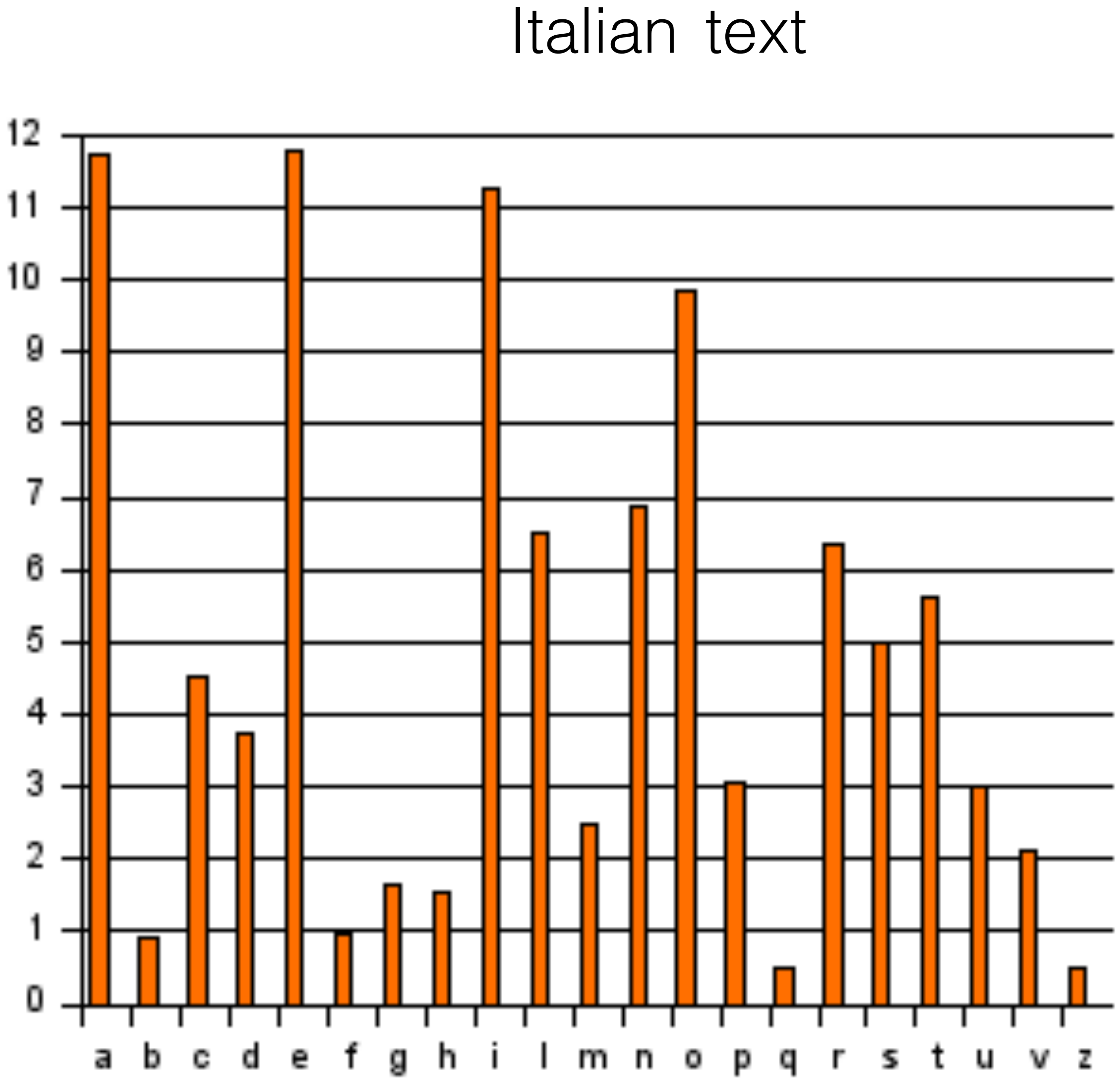
etoetihaetonaasridsnlcu



Does not work when message is too short!

# Decryption example using frequency analysis:





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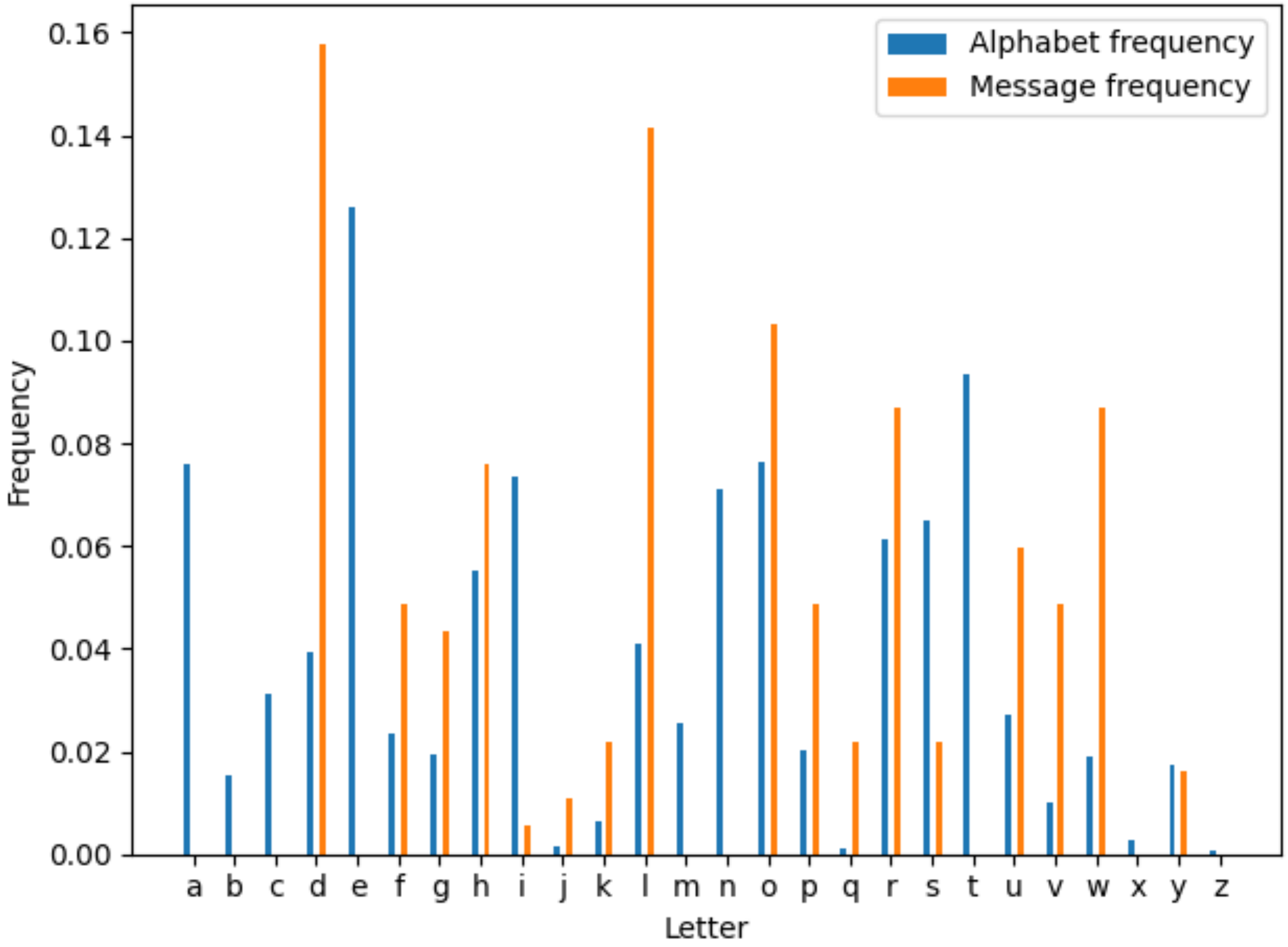
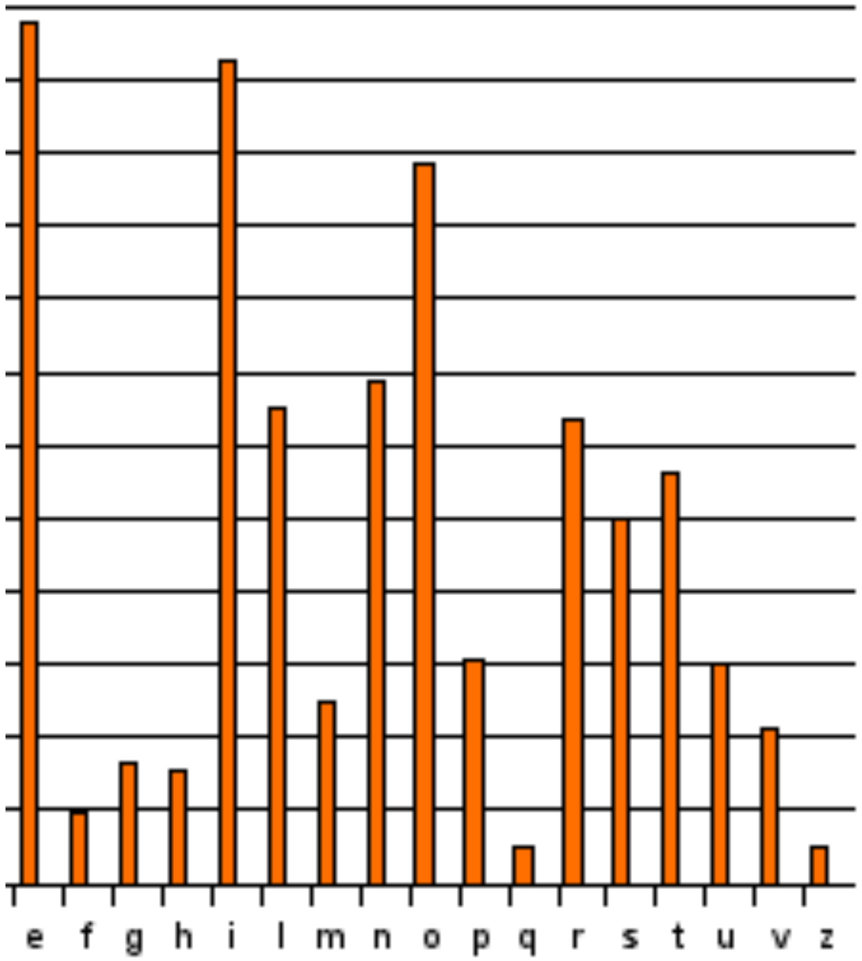
# Decryption example using frequency analysis:



Italian text



https://commons.wikimedia.org/wiki/File:Frequenze-alf_it.png

Does not work if message is in the wrong language!