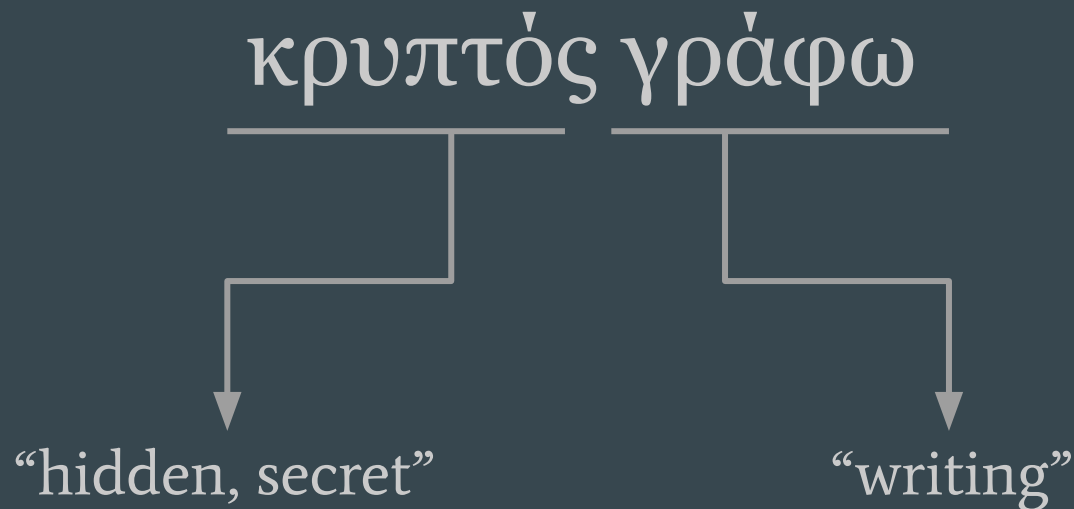


# Cryptography



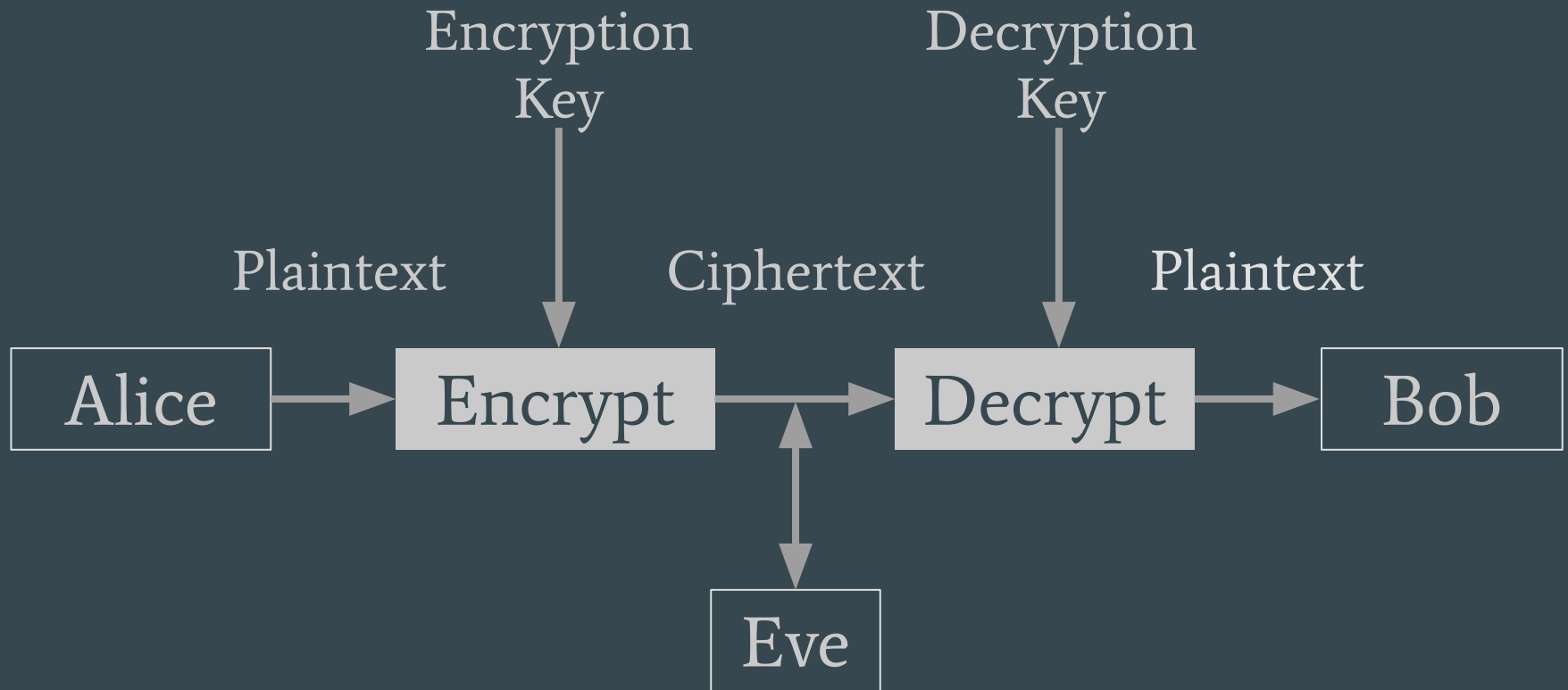
A Brief History and Introduction  
MATH 314

# What is cryptography?



- **Cryptology**  
Study of communication securely over insecure channels
- **Cryptography**  
Writing (or designing systems to write) messages securely
- **Cryptanalysis**  
Study of methods to analyze and break hidden messages

# Secure Communications



- **Symmetric Key:** Alice and Bob use a (preshared) secret key.
- **Public Key:** Bob makes an encryption key public that Alice uses to encrypt a message. Only Bob has the decryption key.

# Possible Attacks

Eve (the eavesdropper) is trying to:

- Read Alice's message.
- Find Alice's key to read all of Alice's messages.
- Corrupt Alice's message, so Bob receives an altered message.
- Pretend to be Alice and communicate with Bob.

# Why this matters

- **Confidentiality**  
Only Bob should be able to read Alice's message.
- **Data integrity**  
Alice's message shouldn't be altered in any way.
- **Authentication**  
Bob wants to make sure Alice actually sent the message.
- **Non-repudiation**  
Alice cannot claim she didn't send the message.

**Going back in time...**

# 5th century BC

Secret writing and **steganography** saved Greece from being completely conquered by the Persians.

- Invisible Ink
- Shaved head



# Steganography vs. Cryptography

**Steganography** hides the existence of a message.

**Cryptography** hides the meaning of a message.



# Back to 5th century BC

Lysander of Sparta used a scytale for encryption.



# Back to 5th century BC

The sender wraps the message around a rod of a fixed diameter.

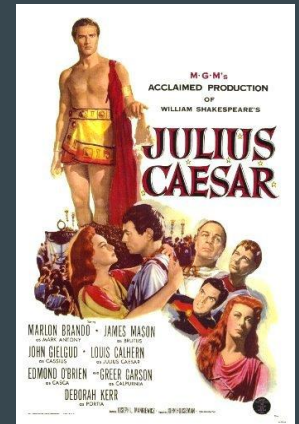
Example: “Help me I am under attack.”



- To decrypt, just wrap strip around a rod of the same diameter.

# 1st century BC

Dramatized  
based on the  
Shakespeare  
play.



Julius Caesar used a cipher (now known as the “Caesar cipher”)

Idea: Encrypt message by shifting the alphabet 3 letters.

Example: “Et tu, Brute?”

Plaintext:     ABCDEFGHIJKLMNOPQRSTUVWXYZ

Ciphertext:    DEFGHIJKLMNOPQRSTUVWXYZABC

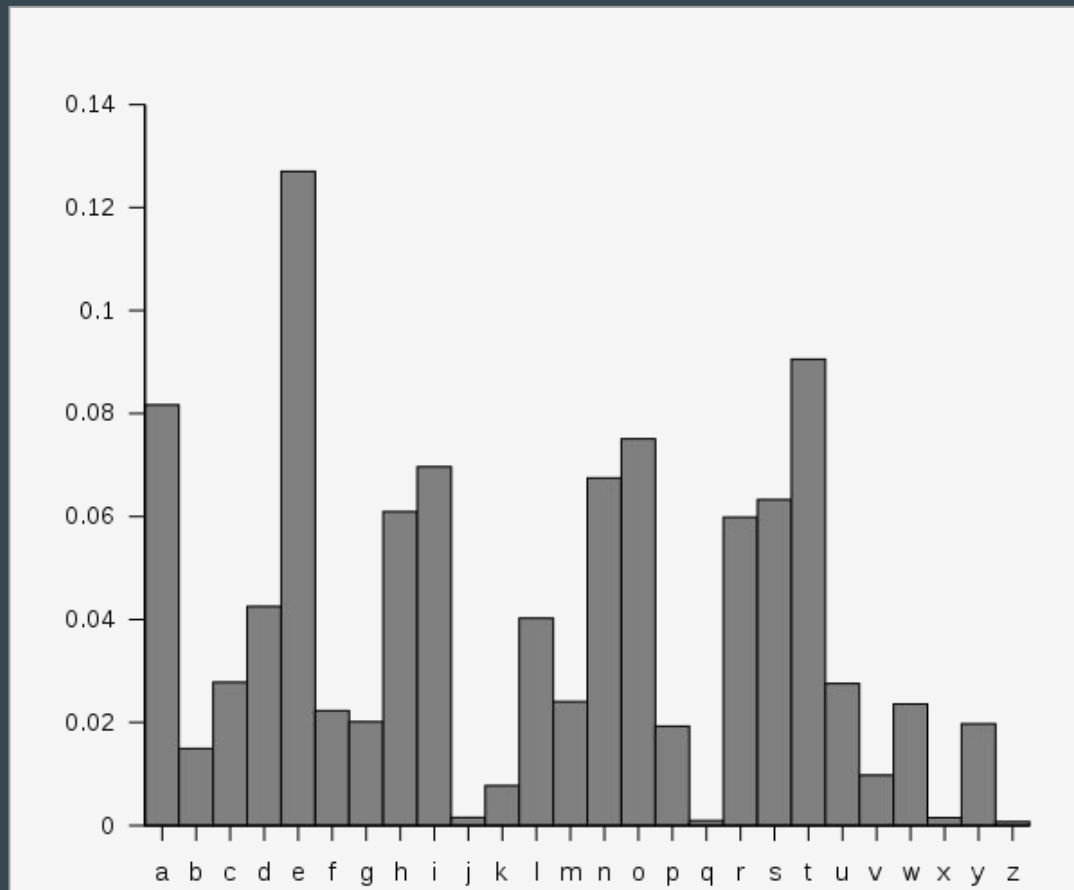
Plaintext:     ETTUBRUTE

Ciphertext:    HWWXEUXWH



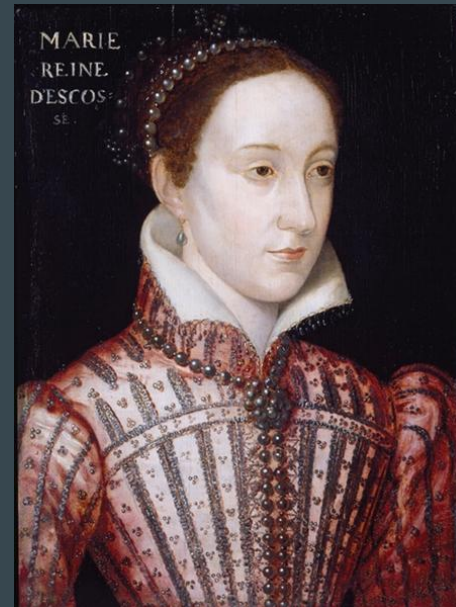
# 9th-10th century

Frequency analysis: Using frequently used letters to decipher the code.



# 15th century

- Use of **nulls** to confuse cryptanalysts.
- Used in Babington plot to assassinate Queen Elizabeth.
- Broken, led to the trial and execution of Mary, Queen of Scots



1586

## Vigenère Cipher

Blaise de Vigenère reinvents Giovan Battista Bellaso's cipher.

One letter is no longer encoded the same way every time.

Described as unbreakable by many, including Lewis Carroll.

# 1586

Example: Encrypting “Attack at dawn” using LEMON

Plaintext:           ATTACKATDAWN

Key:                   LEMONLEMONLE

Ciphertext:          LXFOPVEFRNHR

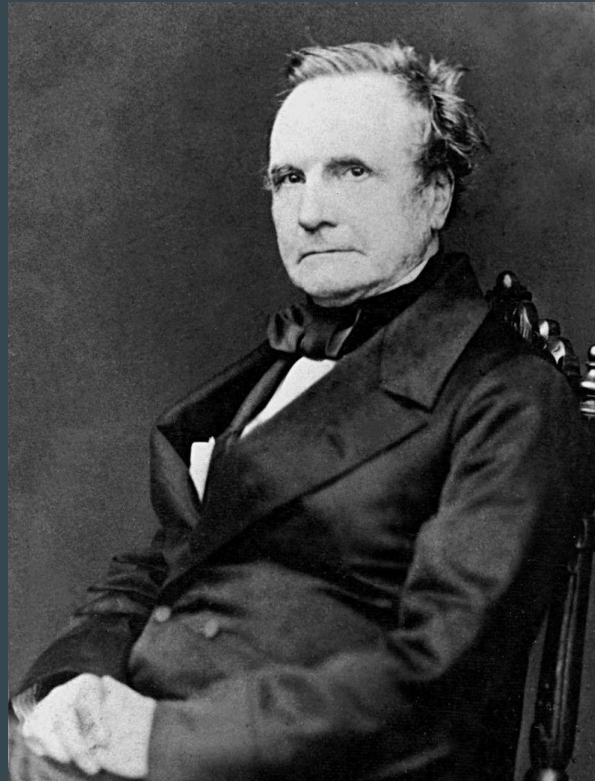
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A	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
B	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A
C	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B
D	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C
E	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S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



# 1854

- Charles Babbage found a solution to the Vigenère cipher.
- Analytical Engine
- “Father of the Computer” along with Ada Lovelace

You can see half  
his brain at the  
Science Museum  
in London!



The other half is  
at the Hunterian  
Museum in the  
Royal College of  
Surgeons in  
London.

# 1920s-1940's

- Enigma machines (Germany)
- Most notably used in WWII
- Polish Cipher Bureau started breaking Enigma messages.
- Alan Turing later improved the Polish methods.
- Bombe



← You can try a working enigma machine at the cryptologic museum at Fort Meade.

# Recurring Theme (until the 1970s)

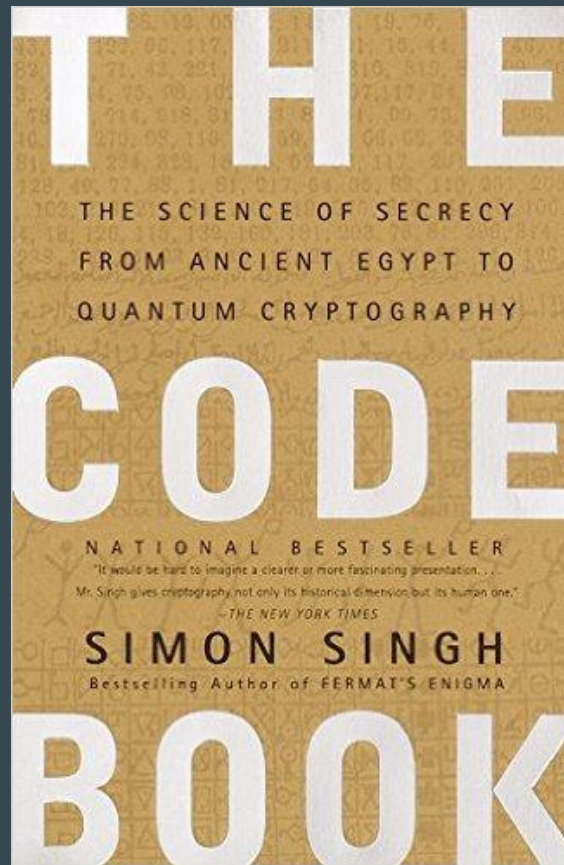
- Secret Code Invented.
- Typically called “unbreakable” by inventor.
- Used by spies, ambassadors, kings, generals for crucial tasks.
- Broken by enemy using cryptanalysis.

“Human ingenuity cannot concoct a cipher which human ingenuity cannot resolve.”

Edgar Allan Poe, 1841

If you want more history...

Read [The Code Book](#) (Simon Singh).



# This Course

## What you'll learn:

- Foundations and principles of the math behind crypto.
- Basic ingredients and components.
- Definitions, theorems and some proofs
- High-level applications and implementations

## What you will not learn:

- The most efficient and practical versions of components.
- Designing secure systems
- “Hacking” – breaking into systems.
- Viruses, worms, side-channel attacks etc.
- Everything important about crypto

# Resources

- Course Website: <http://tigerweb.towson.edu/nmcnew/m314s22/>
- CoCalc: <http://www.cocalc.com/>
- The textbook:

