

The logo for the Santa Fe Alliance for Science is centered in the upper half of the image. It consists of the words "SANTA FE" in a large, blue, sans-serif font, followed by "ALLIANCE FOR" in a smaller, grey, sans-serif font, and "SCIENCE" in the same large, blue, sans-serif font as "SANTA FE". The entire logo is set against a white rectangular background with a soft glow.

# SANTA FE ALLIANCE FOR SCIENCE

This video was created by volunteers from the Santa Fe Alliance for Science, a 501(c)(3) organization.

## **Our Mission**

We inspire the inner scientist in Santa Fe students by creating STEM learning and discovery opportunities through our network of volunteer scientists, engineers, and other STEM professionals.

**Learn more: [www.sfafs.org](http://www.sfafs.org)**

# Fibonacci and his numbers

Hubert van Hecke  
January 2021



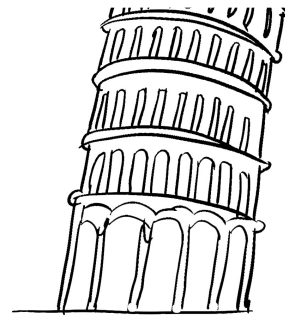
1170-1250



Leonardo of Pisa  
Fibonacci



Son of Bonacci



1172-1372

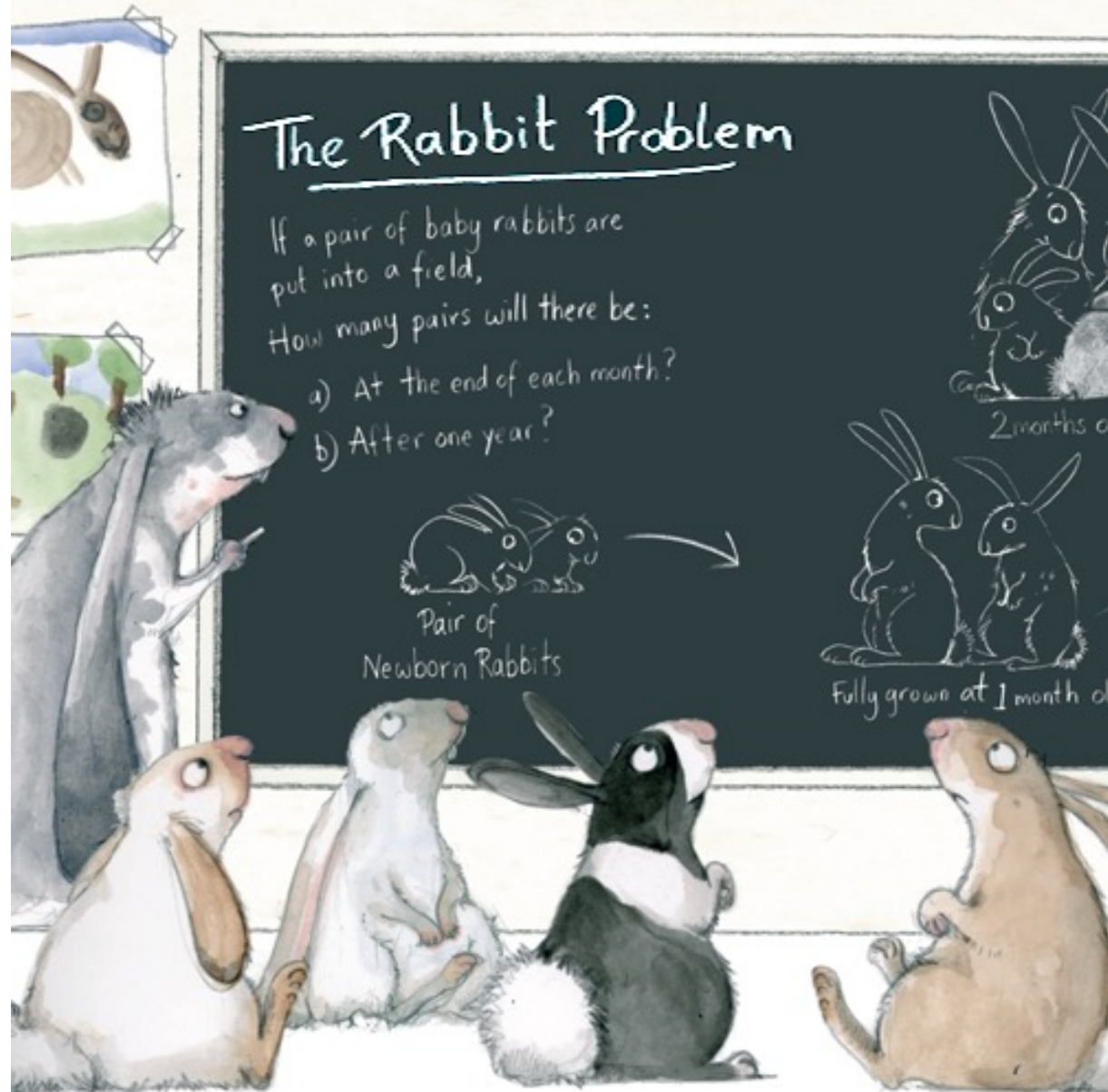
# Leaning tower of Pisa



If I put a pair of baby rabbits  
in a field,  
How many rabbits will there  
be in a year?

Rules:

- It takes one month to grow into an adult rabbit
- An adult pair will produce a pair of baby rabbits every month



■ Month

■ # of Pairs

 Mature


 Immature

1  1

1  1

■ Month

■ # of Pairs

 Mature

 Immature

1  1

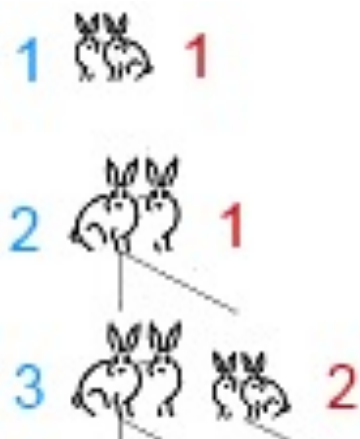
2  1

■ Month

■ # of Pairs

 Mature

 Immature



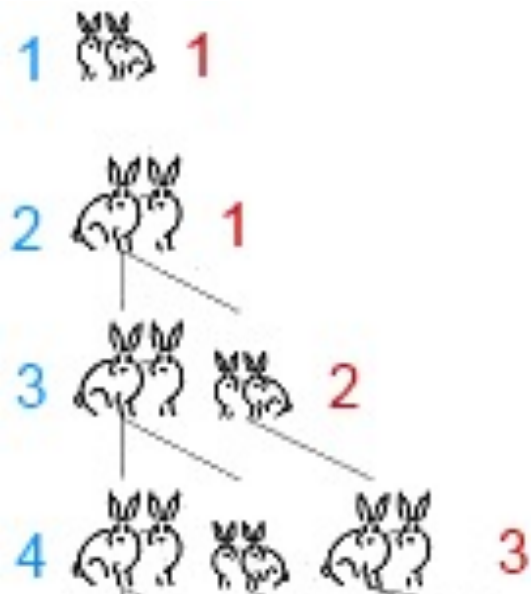


■ Month

■ # of Pairs

 Mature

 Immature

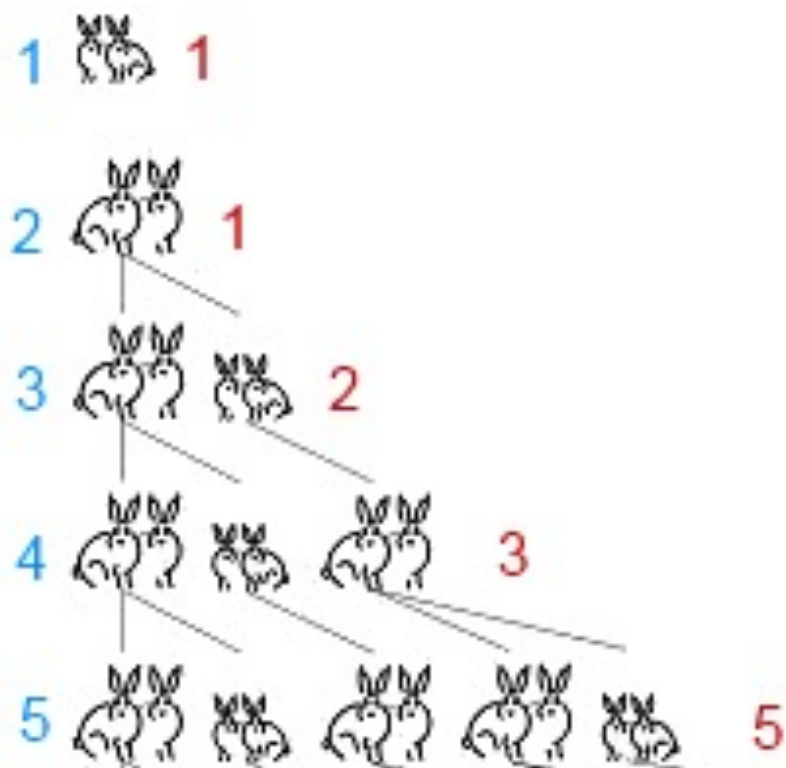


■ Month

■ # of Pairs

 Mature

 Immature

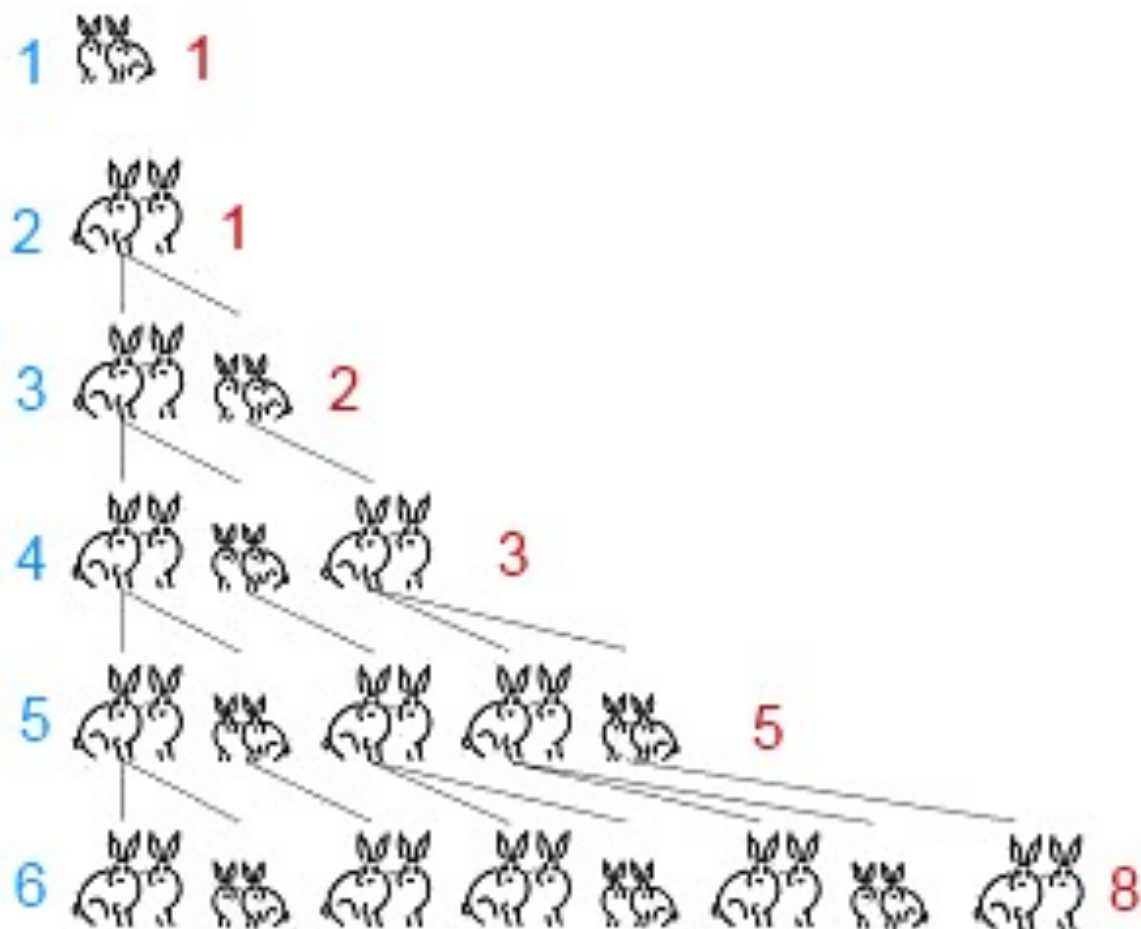


■ Month

■ # of Pairs

 Mature

 Immature



# Fibonacci number series

**1 1 2 3 5 8 13 21 34 ??**

# Fibonacci number series



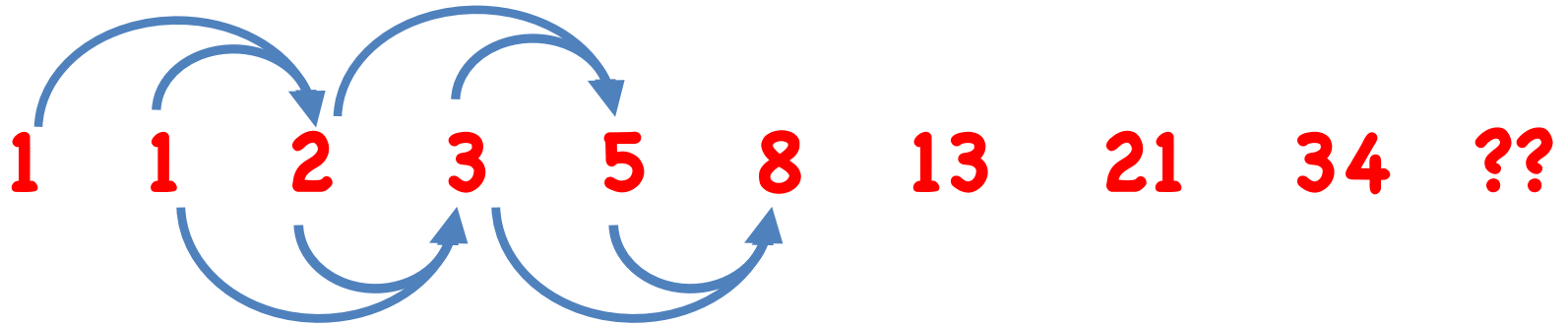
# Fibonacci number series



# Fibonacci number series

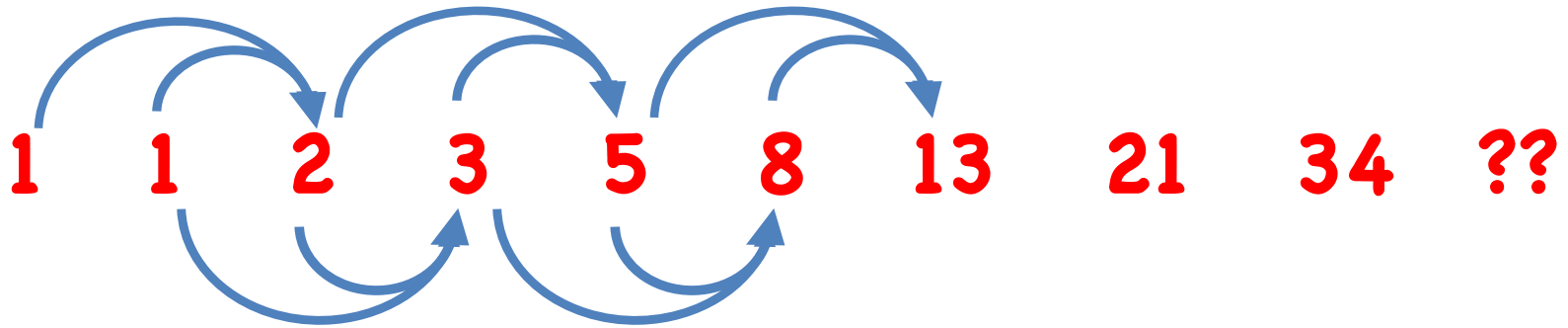


# Fibonacci number series



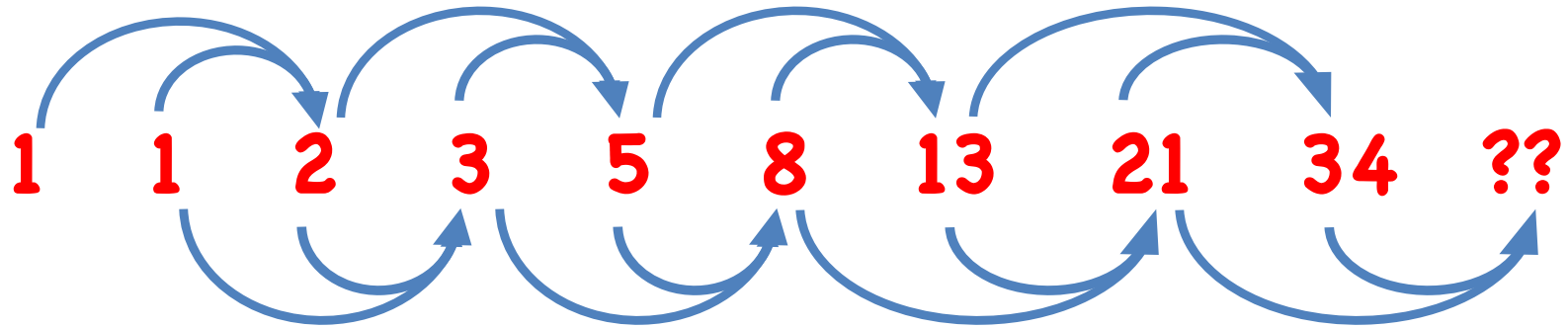


# Fibonacci number series



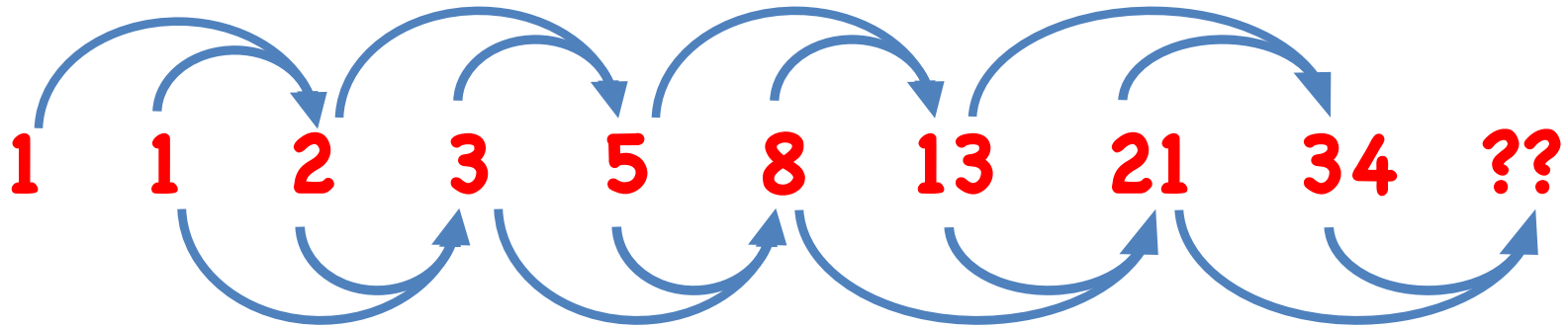
Every number is the sum of the previous two numbers

# Fibonacci number series



Every number is the sum of the previous two numbers

# Fibonacci number series



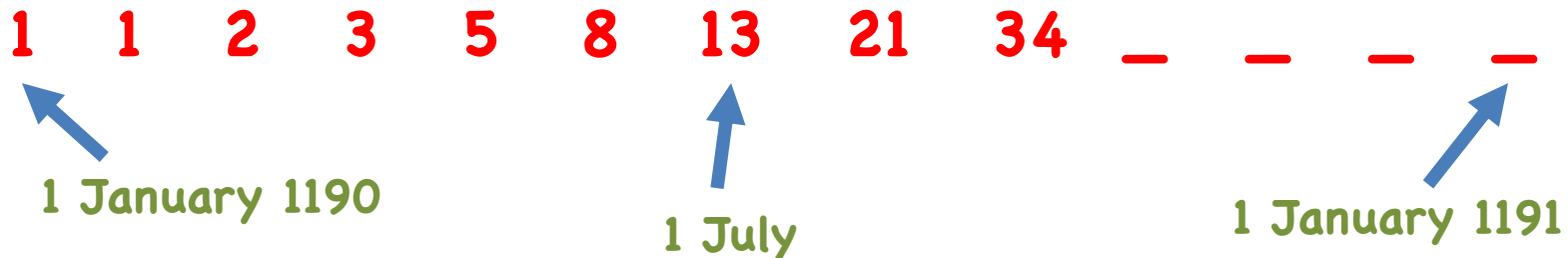
$$\begin{array}{r} 21 \\ 34 \\ \hline 55 \end{array} +$$

Every number is the sum of the previous two numbers

# Fibonacci number series



Every number is the sum of the previous two numbers



# Fibonacci number series



Every number is the sum of the previous two numbers

1 1 2 3 5 8 13 21 34 55 \_ \_ \_



1 January 1190



1 July



1 January 1191

# Fibonacci number series



Every number is the sum of the previous two numbers

1 1 2 3 5 8 13 21 34 55 89 \_ \_



1 January 1190



1 July

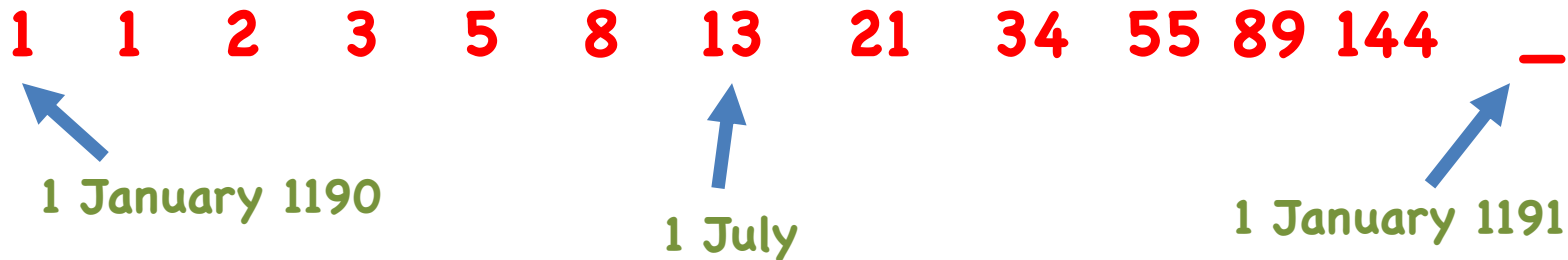


1 January 1191

# Fibonacci number series



Every number is the sum of the previous two numbers



# Fibonacci number series



Every number is the sum of the previous two numbers

1 1 2 3 5 8 13 21 34 55 89 144 233



1 January 1190

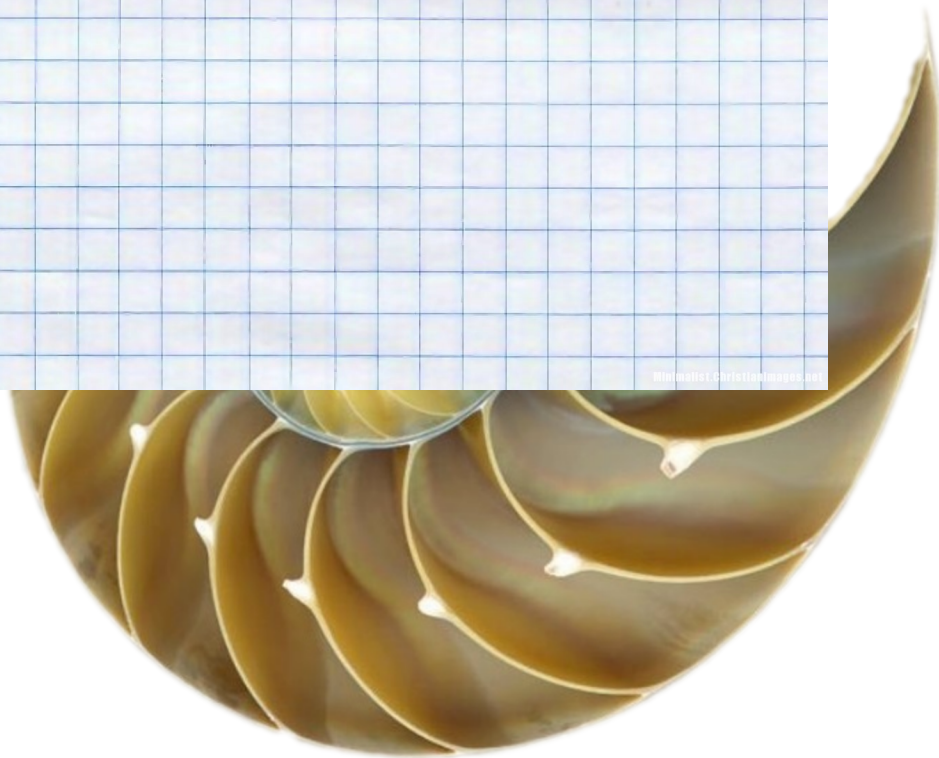
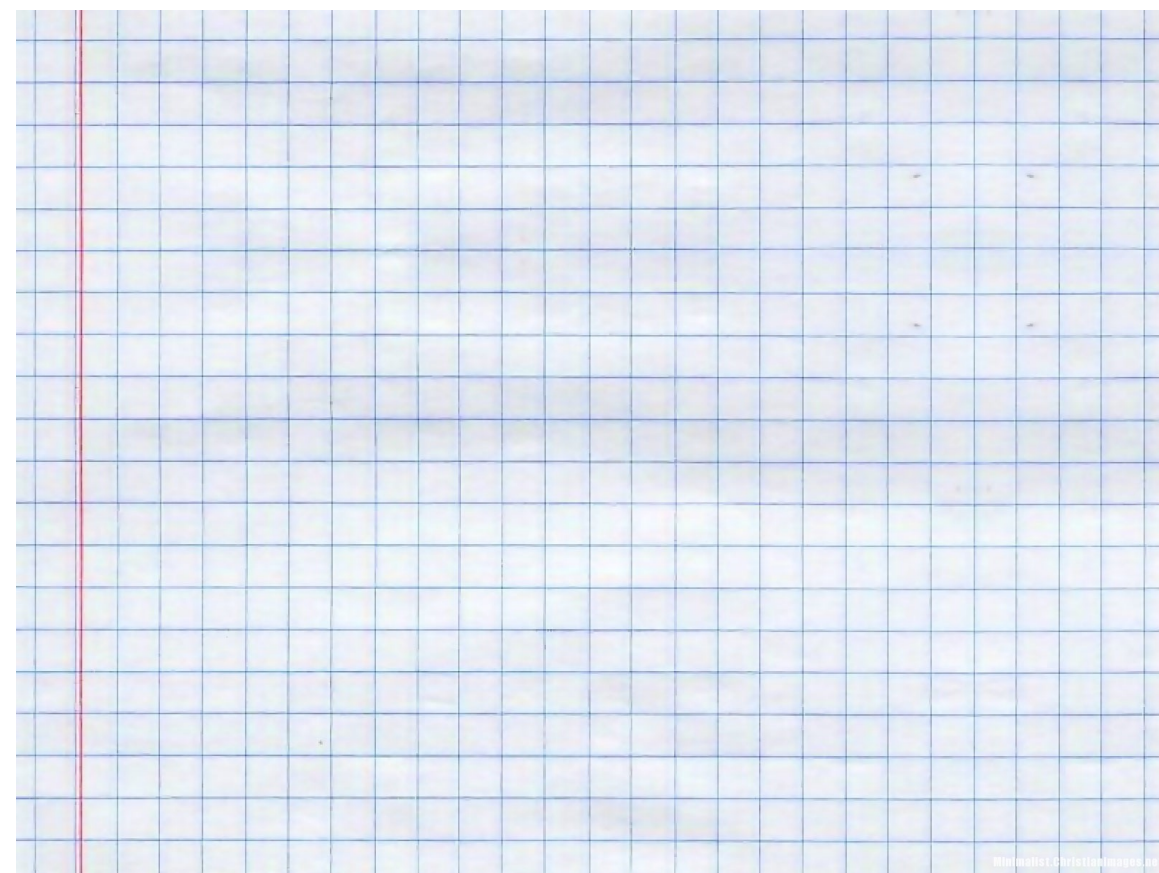


1 July



1 January 1191

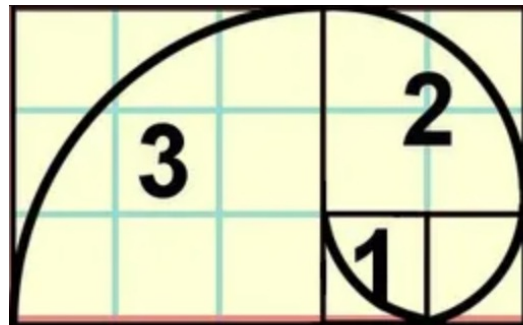


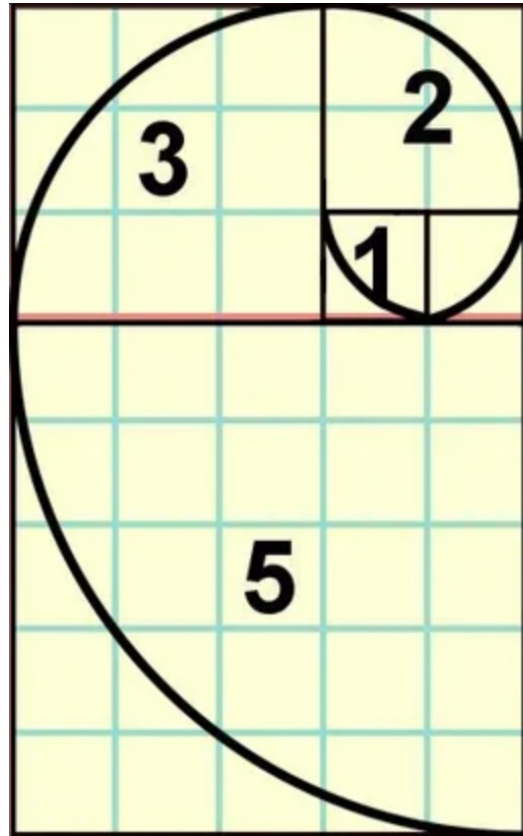


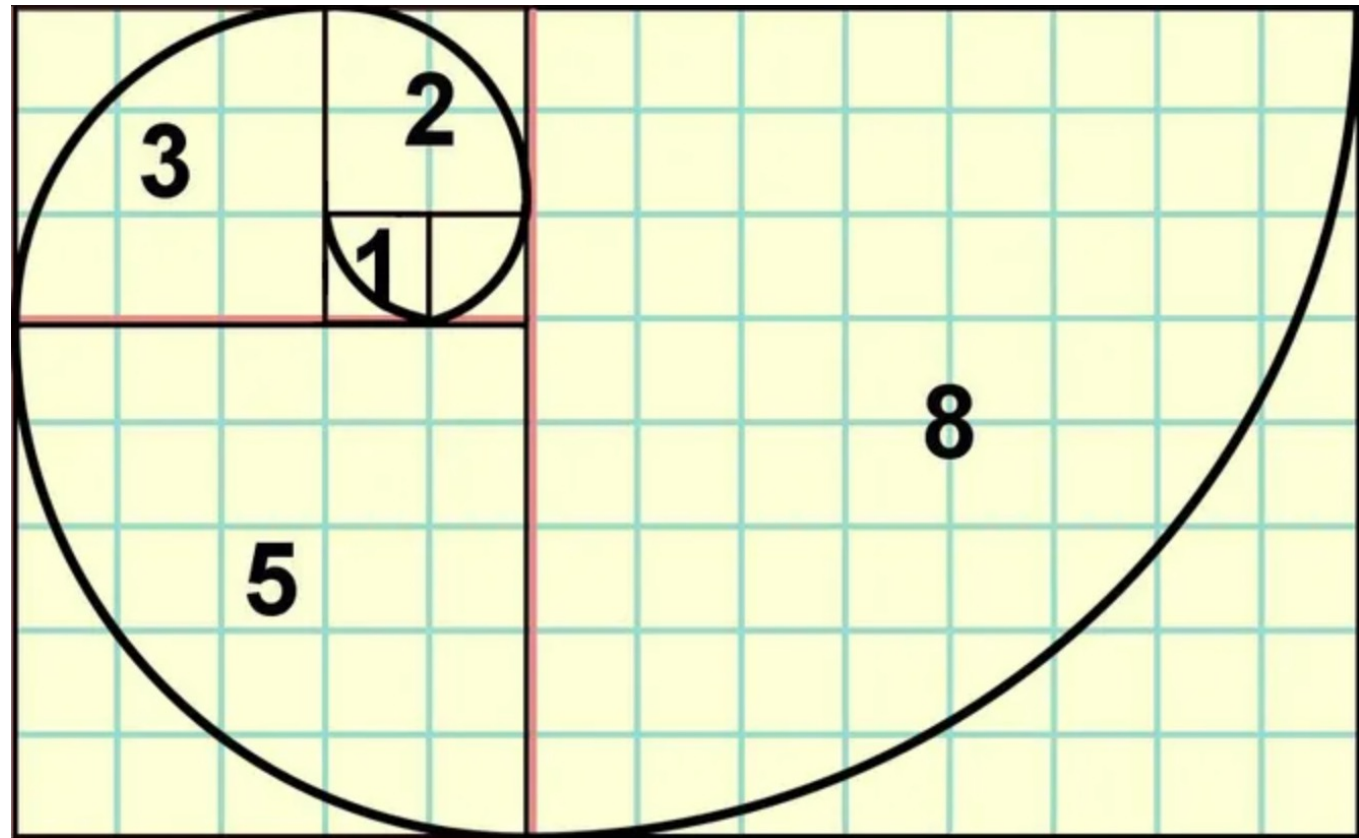


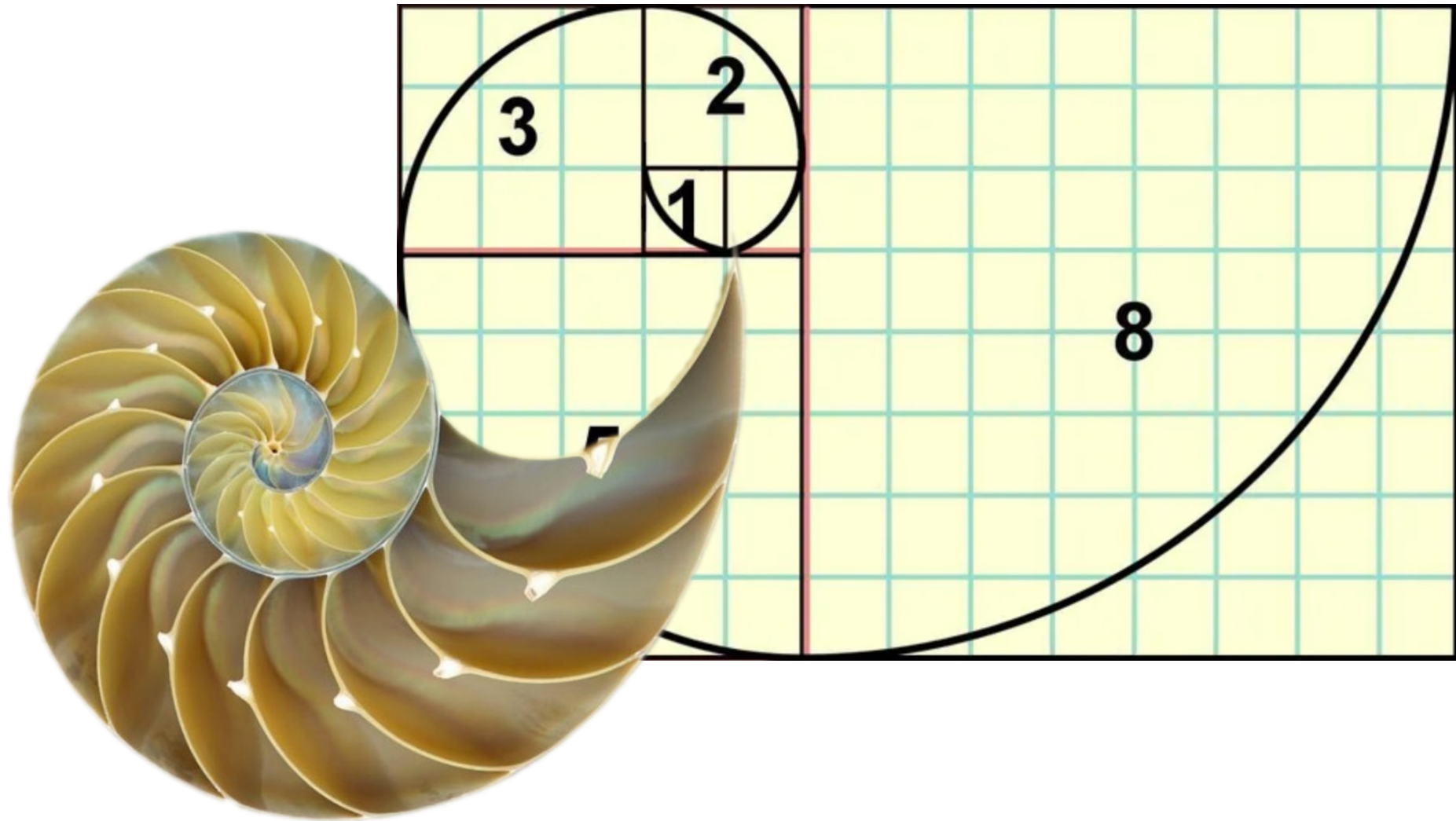














# Let's find Fibonacci numbers in Nature

First: the  
grocery  
store



1 1 2 3 5 8 13 21 34 55 ...

# Fibonacci numbers in Nature



pineapple

1 1 2 3 5 8 13 21 34 55 ...

# Pineapple

1 1 2 3 5 8 13 21 34 55 ...



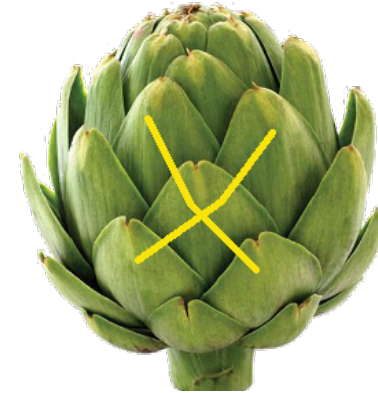
## Pineapple

1 1 2 3 5 8 13 21 34 55 ...



## Artichoke

1 1 2 3 5 8 13 21 34 55 ...



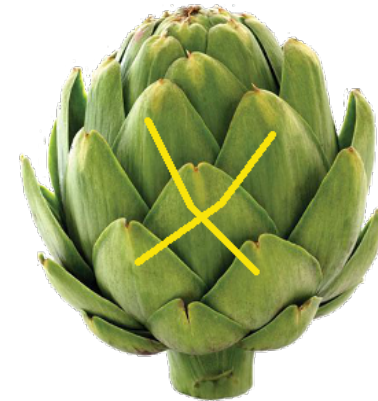
## Pineapple

1 1 2 3 5 8 13 21 34 55 ...



## Artichoke

1 1 2 3 5 8 13 21 34 55 ...



## Asparagus

1 1 2 3 5 8 13 21 34 55 ...



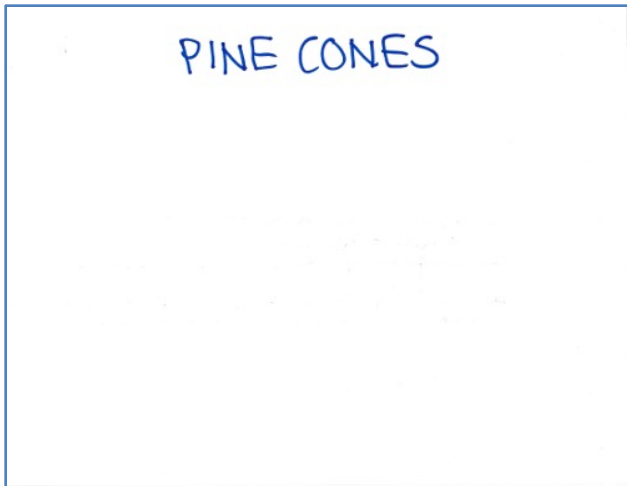
# Fibonacci numbers in Nature

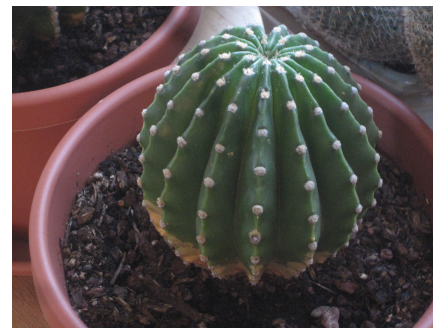
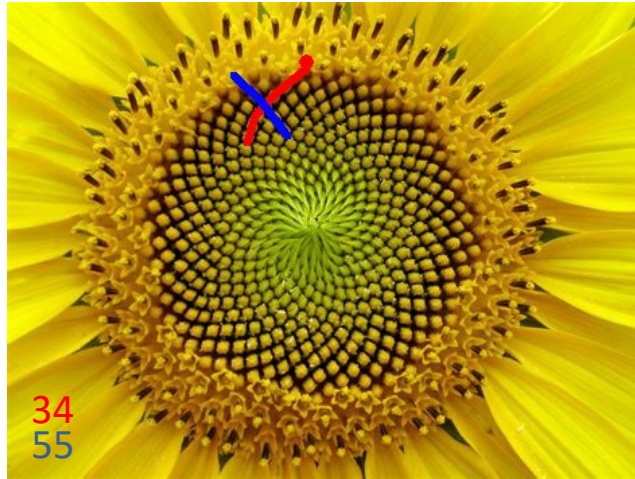
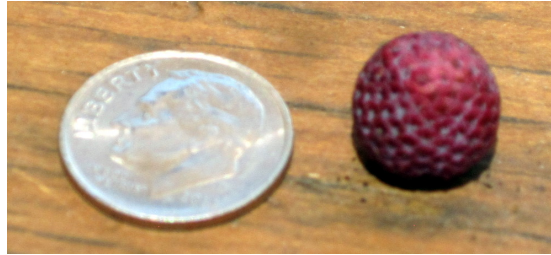


pinecones

1 1 2 3 5 8 13 21 34 55 ...

(switch to overhead camera)







**Part 2:  
Ratios  
Golden Ratio**

1 1 2 3 5 8 13 21 34 55 89 . . . .

Let's take the **ratio** between *adjacent* pairs of Fibonacci numbers

↙ *next to each other*



1 1 2 3 5 8 13 21 34 55 89 . . . .

Let's take the **ratio** between *adjacent* pairs of Fibonacci numbers

↙ *next to each other*

$$1/1 = 1$$



1 1 2 3 5 8 13 21 34 55 89 . . . .

Let's take the **ratio** between *adjacent* pairs of Fibonacci numbers

↙ *next to each other*

$$1/1 = 1$$

$$2/1 = 2$$



1 1 2 3 5 8 13 21 34 55 89 . . . .

Let's take the **ratio** between *adjacent* pairs of Fibonacci numbers

↙ *next to each other*

$$\begin{array}{l} 1/1 = 1 \\ 2/1 = 2 \\ 3/2 = 1.5 \end{array}$$



1 1 2 3 5 8 13 21 34 55 89 . . . .

Let's take the **ratio** between *adjacent* pairs of Fibonacci numbers

↙ *next to each other*

$$\begin{aligned} 1/1 &= 1 \\ 2/1 &= 2 \\ 3/2 &= 1.5 \\ 5/3 &= 1.667 \end{aligned}$$



1 1 2 3 5 8 13 21 34 55 89 . . . .

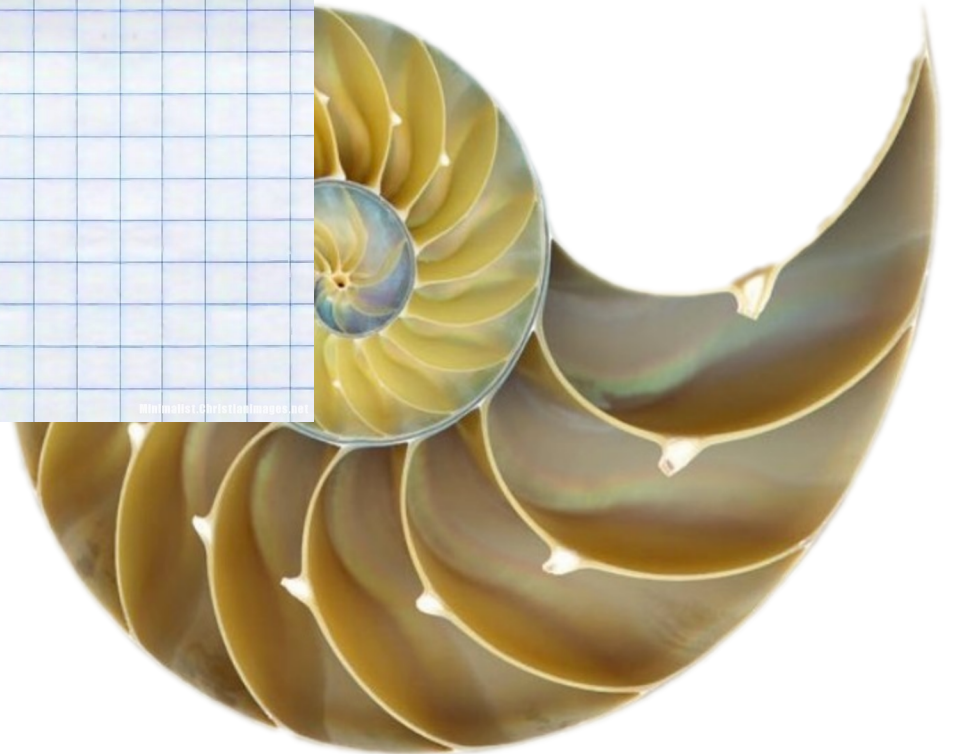
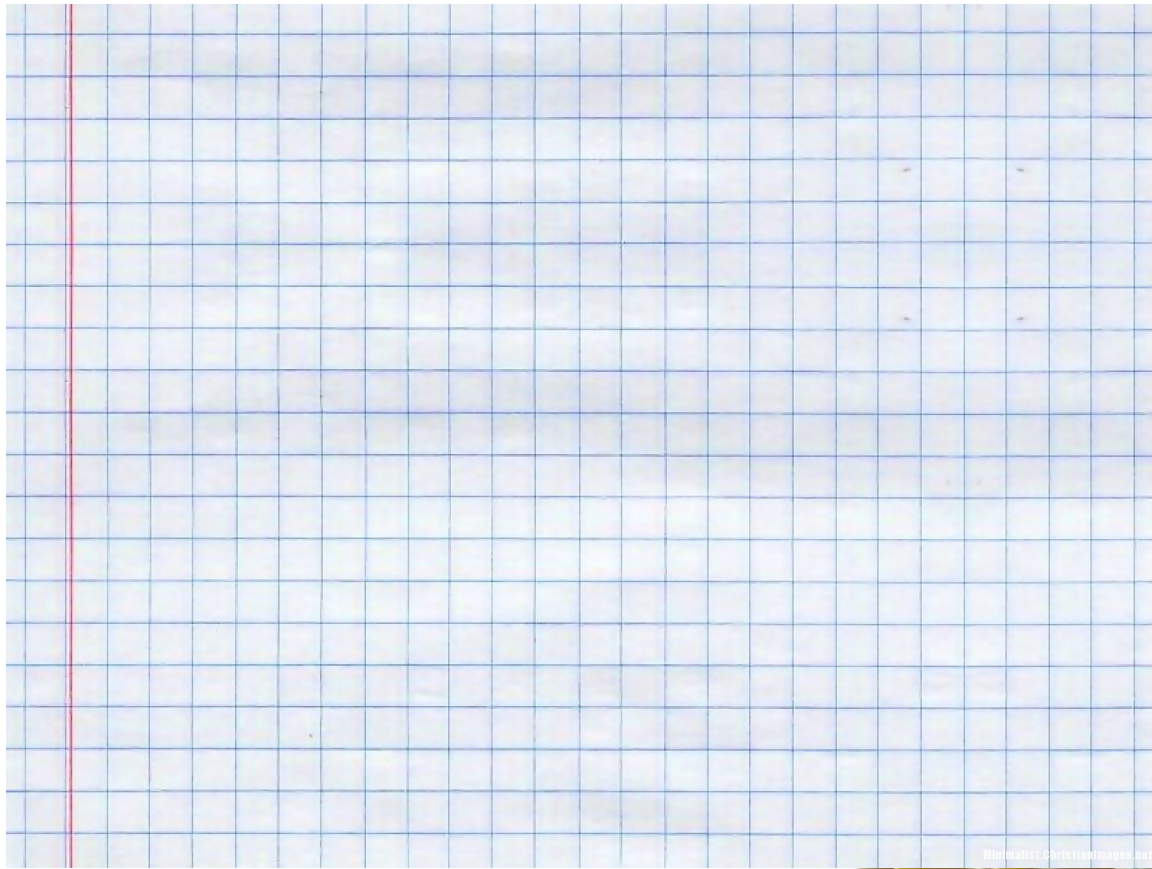
Let's take the **ratio** between *adjacent* pairs of Fibonacci numbers

↙ *next to each other*

$1/1 = 1$   
 $2/1 = 2$   
 $3/2 = 1.5$   
 $5/3 = 1.667$   
 $8/5 = 1.600$   
 $13/8 = 1.625$   
 $21/13 = 1.615$   
 $34/21 = 1.619$   
etc...

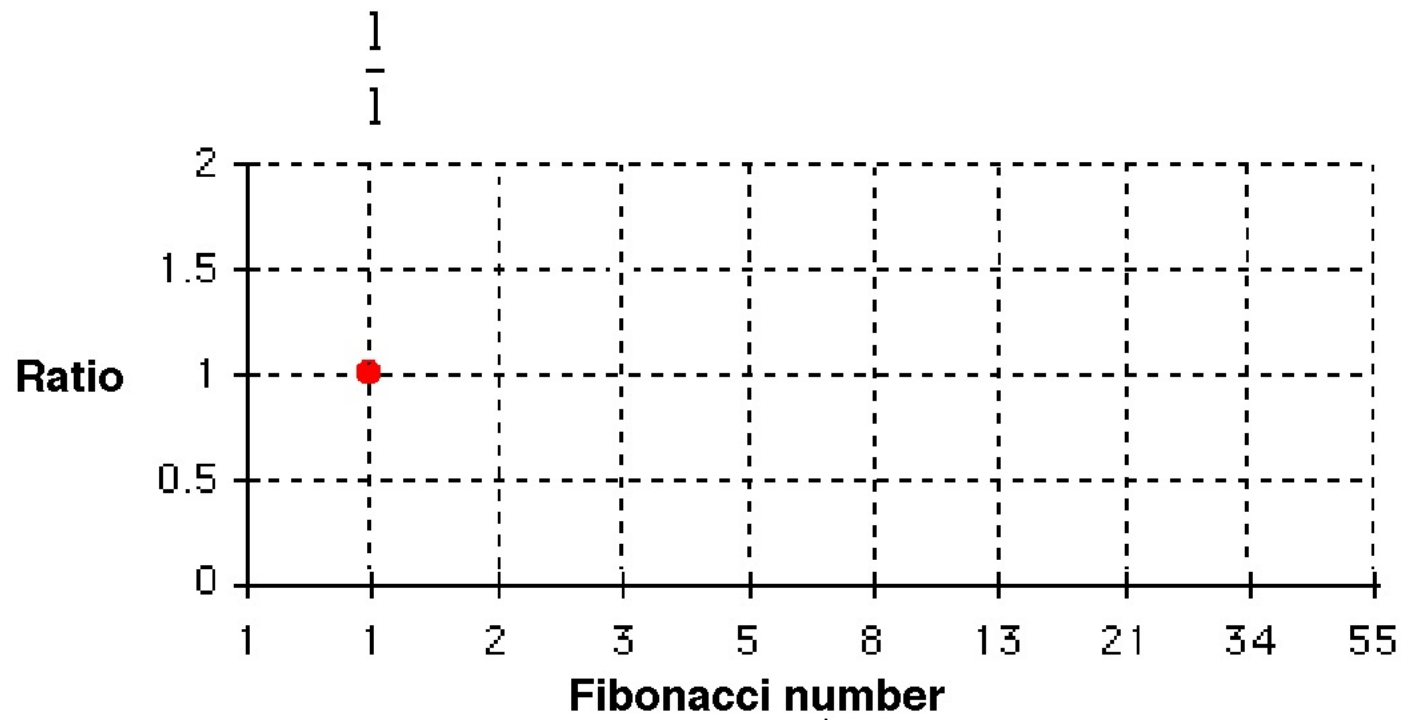


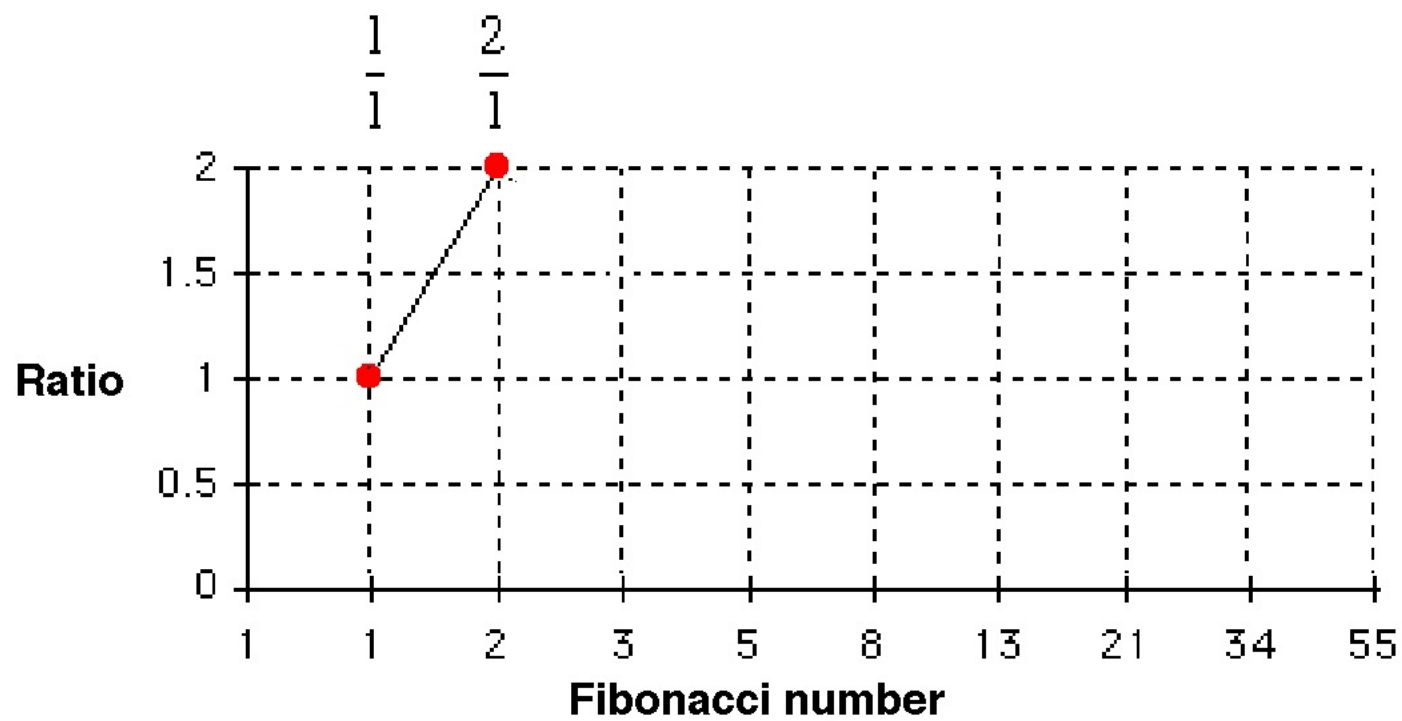
... so what do you think is the next number?

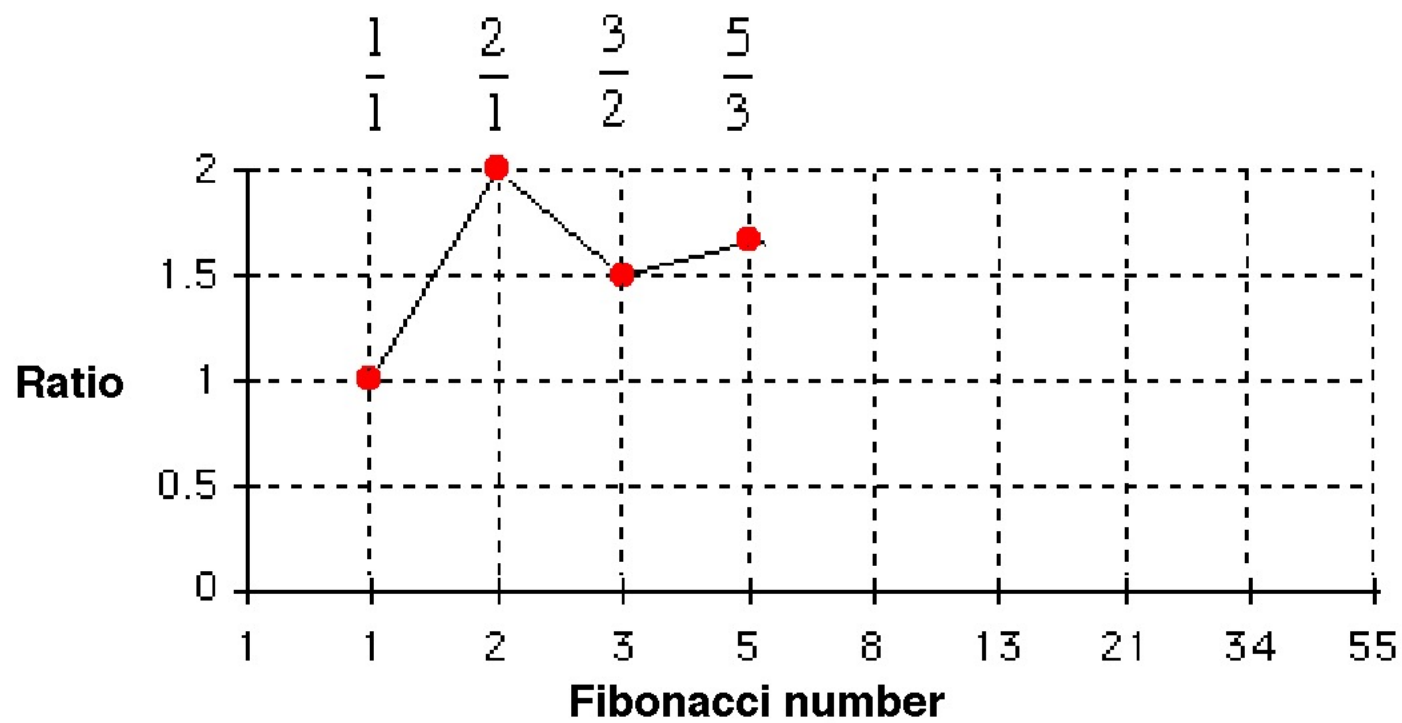


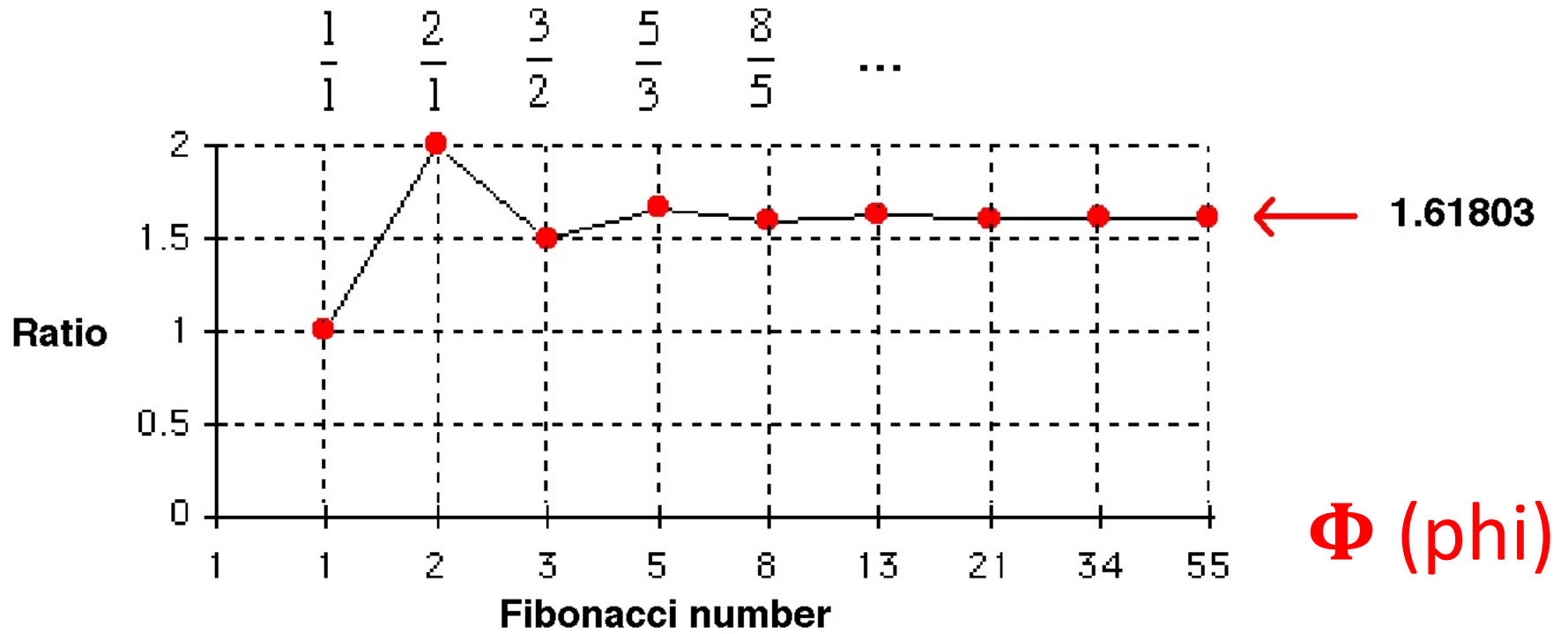
[www.walterchristianmagde.com](http://www.walterchristianmagde.com)

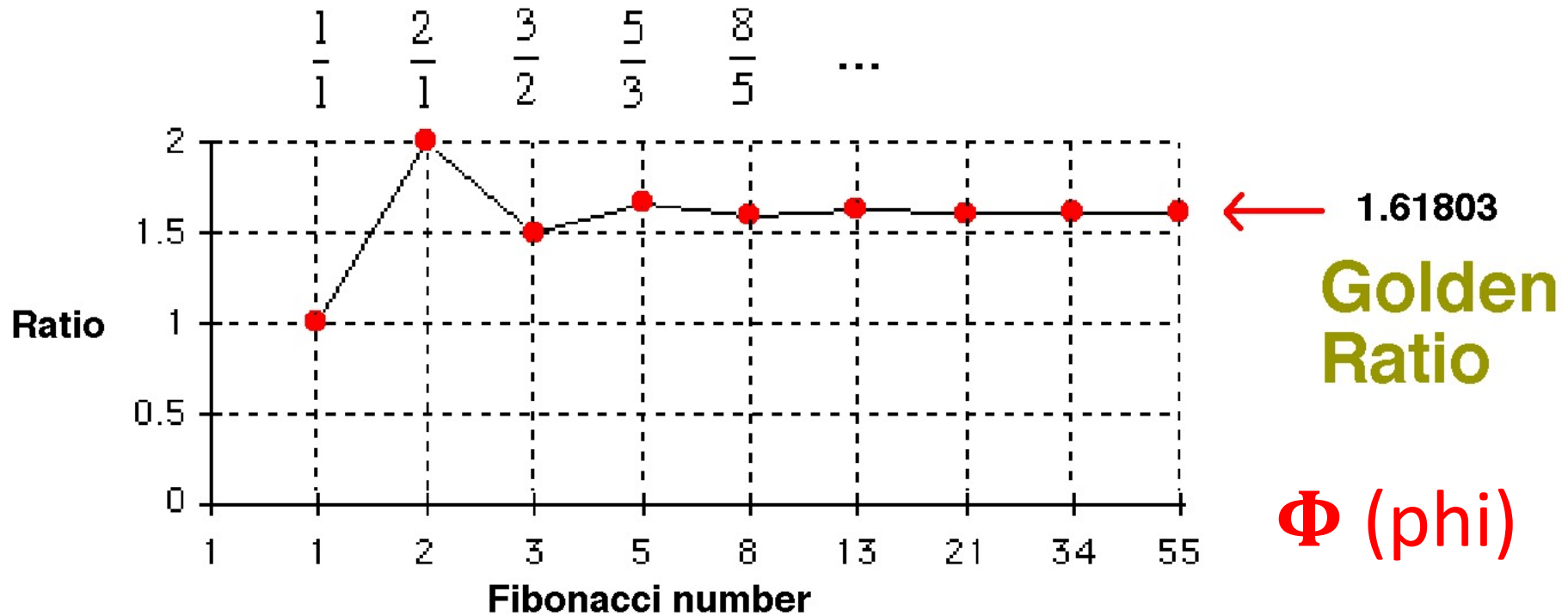










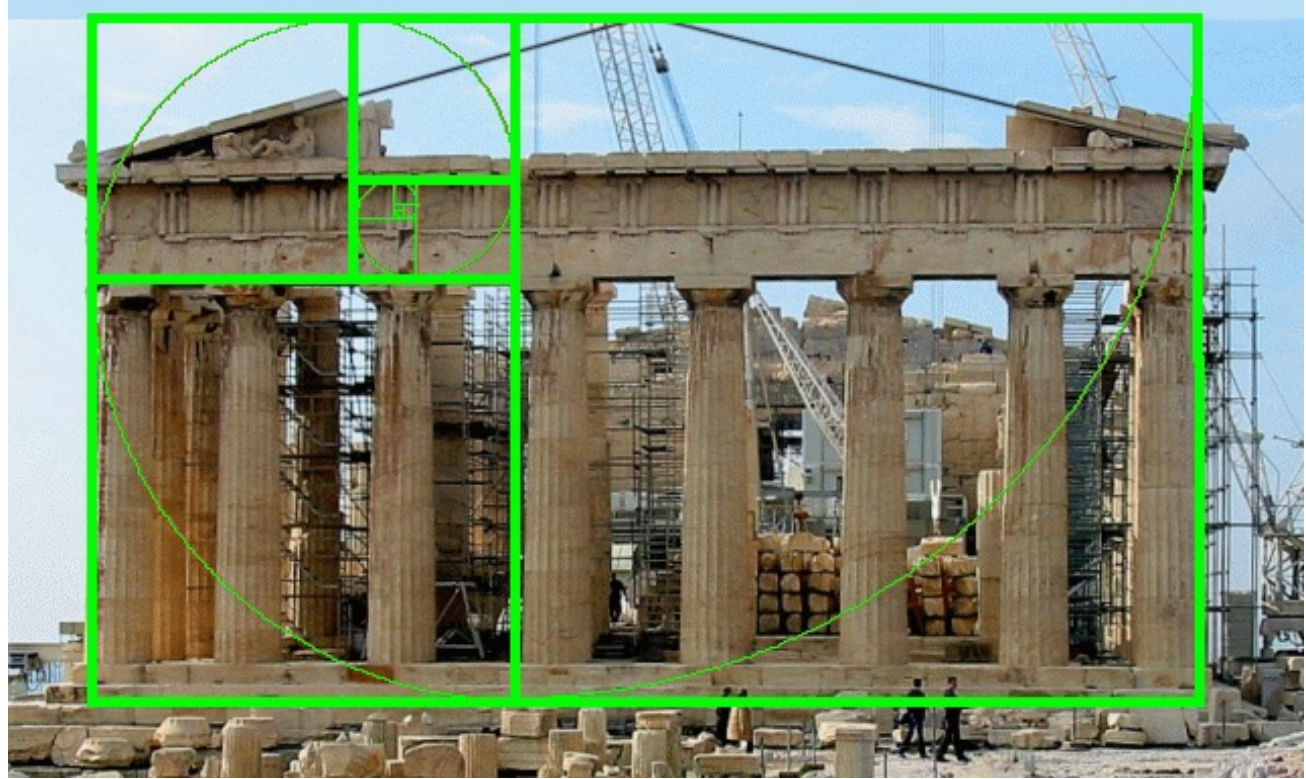


So why is this ratio interesting?

2000 years ago,  
The Greeks and  
the Romans

used this ratio  
to design some  
of their  
buildings.

They believed  
that this ratio  
led to **the most  
pleasing shapes**



The width of this temple  
divided by  
the height of this temple

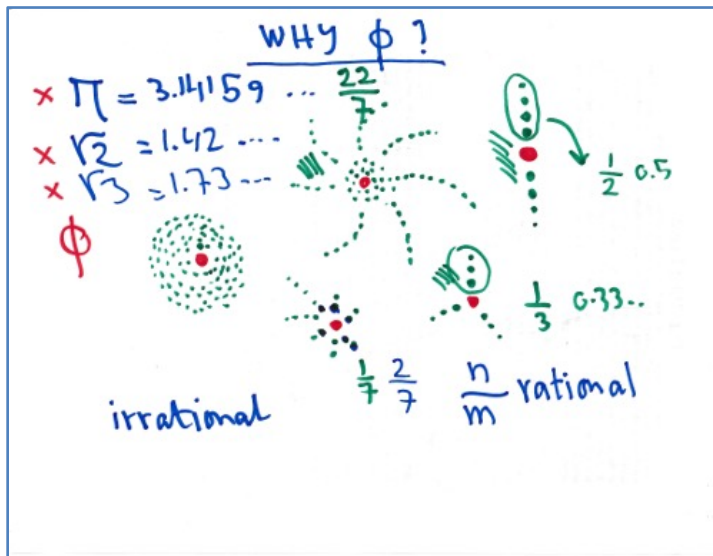
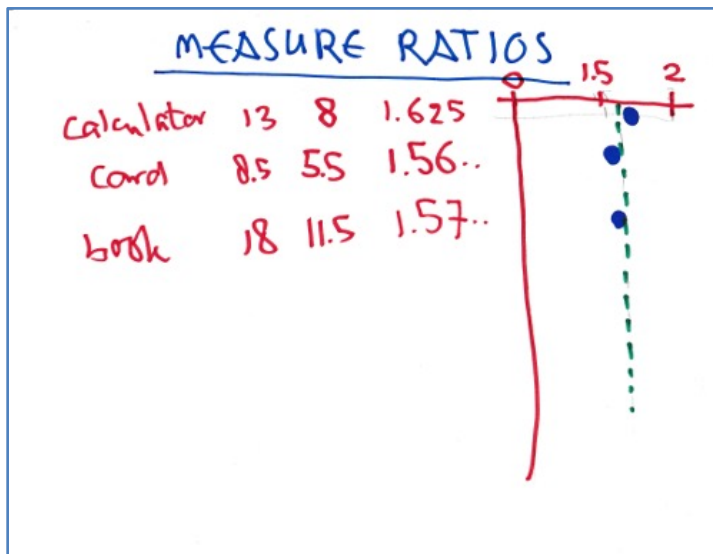
is equal to the **Golden Ratio**, 1.618

# ACTIVITY!

Get out a ruler, a meter stick or a tape measure



(switch to overhead camera)





# Part 3: Number systems



bottles of olive oil



sacks of grain






bales of hay






## ROMAN NUMERALS

1	I	11	XI	50	L
2	II	12	XII	60	LX
3	III				
4	IV	19			
5	V	20		100	C
6	VI	21		500	D
7	VII			1 000	M
8	VIII				
9	IX				
10	X				
					⋮

(switch to overhead camera)

BILL	How Many	price per	Total
			
			
			

BILL	How Many	price per	Total
	III	VI	XVIII
			
			

ROMAN NUMERALS

1	I	
2	II	50
3	III	60
4	IV	
5	V	
6	VI	100
7	VII	500
8	VIII	1000
9	IX	
10	X	

ROMAN NUMERALS

1	I		
2	II	XI	50 L
3	III	XII	60 LX
4	IV		
5	V		
6	VI		100 C
7	VII		500 D
8	VIII		1000 M
9	IX		
10	X		









(switch to overhead camera)

$$\begin{array}{r} 1 \text{ I} \\ 5 \text{ V} \\ 10 \text{ X} \\ 50 \text{ L} \\ 100 \text{ C} \end{array}$$

$$\begin{array}{r} 123 \\ \hline 10 \quad 10 \quad 1 \end{array}$$
 place-value system  
base-10

$$\begin{array}{r} \text{IV} \\ \text{XL} \\ 1 \text{ I} \\ 5 \text{ V} \\ 10 \text{ X} \\ 50 \text{ L} \\ 100 \text{ C} \end{array}$$

$$\begin{array}{r} 123 \times \\ \hline 100 \quad 10 \quad 1 \end{array}$$
 place-value system  
base-10

$$\begin{array}{r} 100 \\ \hline 100 \quad 10 \quad 1 \end{array}$$
 1 2 3 4 5 6 7 8 9  
 0

$$\begin{array}{r} * \\ 100 \\ \hline 100 \quad 10 \quad 1 \end{array}$$
 1 2 3 4 5 6 7 8 9  
 0

## OTHER NUMBER SYSTEMS

1 2 3

base 10

67

120 50 72 11 1 15 2 1

base -2

binary

0  
1  
2  
3

---

decimal base 10  
binary base 2  
hexadecimal - base 16



MONEY!

\$ 1.27



MONEY!

\$ 1.27



c x x

MONEY!

\$ 1.27



C X X V I I

(switch to overhead camera)

OTHER NUMBER SYSTEMS

$$\begin{array}{c} 1 \quad 2 \quad 3 \\ \hline \end{array}$$

base 10

$$\begin{array}{c} 1 \quad 2 \quad 3 \\ \hline \end{array}$$

base-2  
binary

---

decimal base 10  
binary base 2  
hexadecimal - base 16

OTHER NUMBER SYSTEMS

$$\begin{array}{c} \times 10 \\ \leftarrow \leftarrow \leftarrow \\ 1 \quad 2 \quad 3 \end{array}$$

base 10

$$\begin{array}{c} \times 2 \quad \times 2 \quad \times 2 \\ \leftarrow \leftarrow \leftarrow \\ 1 \quad 2 \quad 3 \end{array}$$

base-2  
binary

...	128	64	32	16	8	4	2	1
								1 ①
								1 0 ②
								1 1 ③
								1 0 0 ④
								1 0 1 ⑤
								1 1 0 ⑥
								1 1 1 ⑦
								1 0 0 0 ⑧


67



hexadecimal base-16

0123456789ABCDEF

MONEY!

MONEY!

\$1.27



CXXVII

←

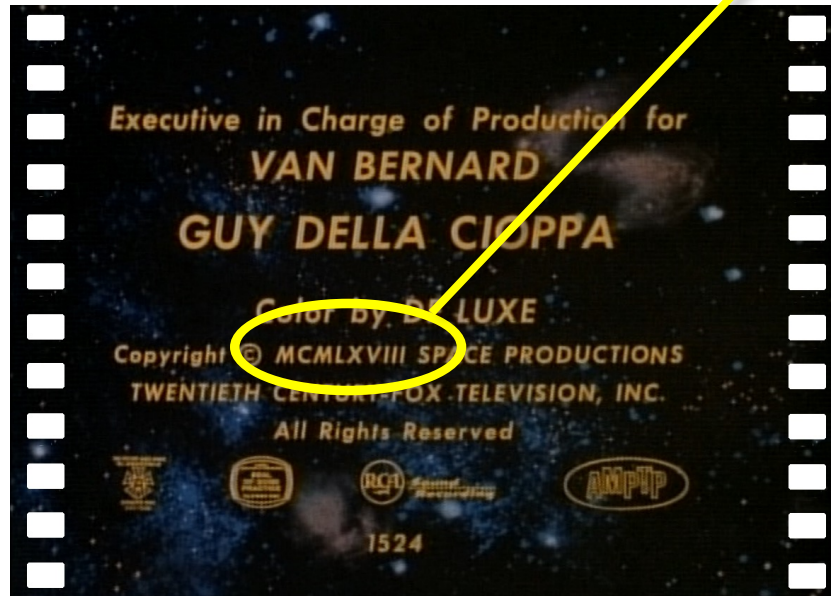
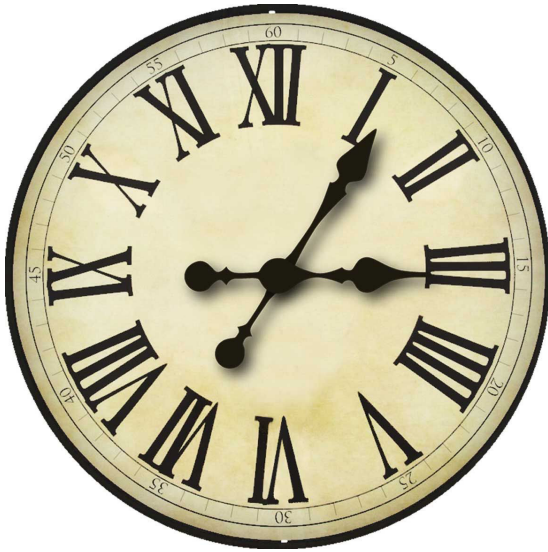
# Where can you find Roman numerals?



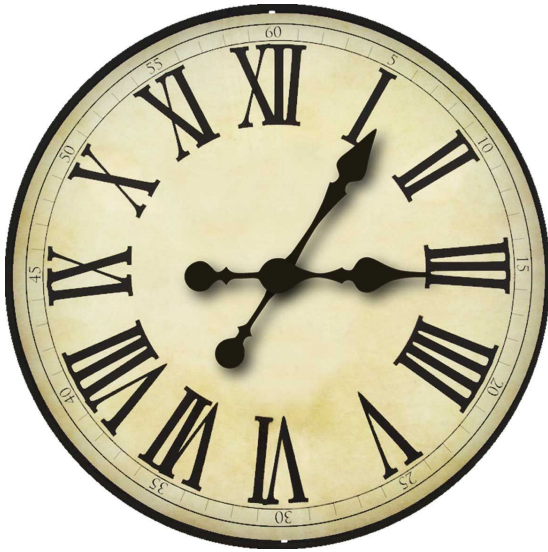
## Where can you find Roman numerals?



## Where can you find Roman numerals?



# Where can you find Roman numerals?



1000

1000

-100

50

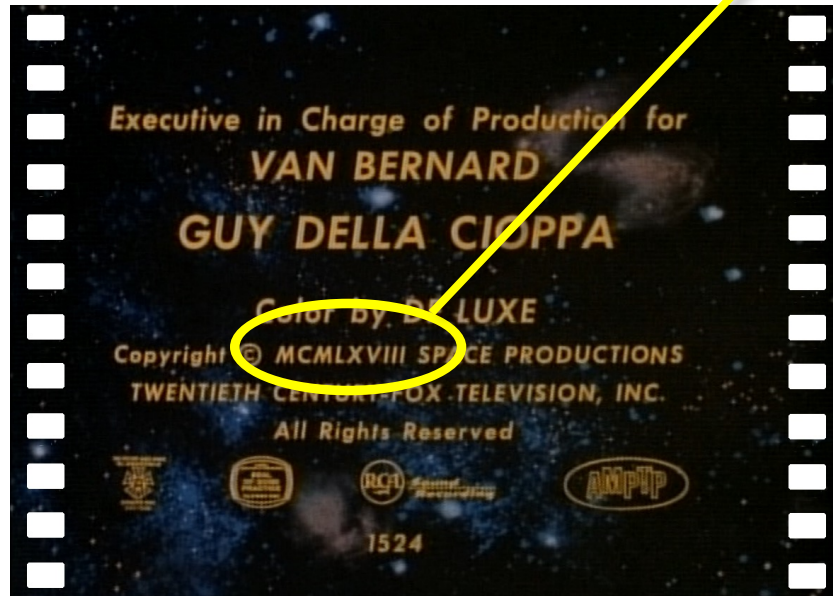
10

5

3

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1968



# Where can you find Roman numerals?



1000

1000

-100

50

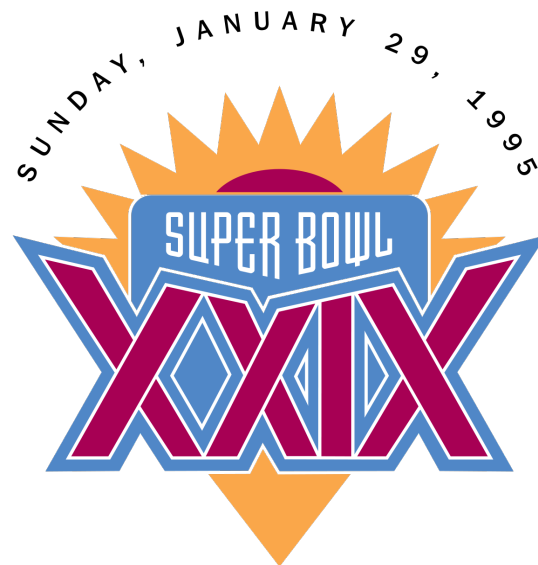
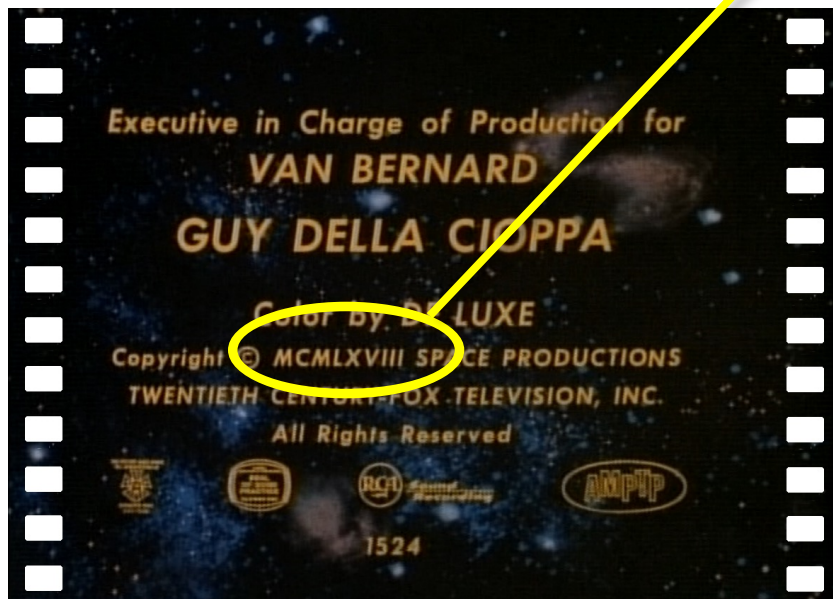
10

5

3

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1968



JOE ROBBIE STADIUM  
MIAMI, FLORIDA

MCMLXVIII

Roman

1968

Arabic

11110110000

Binary



$$\Phi \text{ (phi)} = 1.61803\dots$$



1 1 2 3 5 8 13 21 34 55 ...