Nature by numbers (Cristóbal Vila)

This section is meant to be a complement to the animation, in order to better understand the theoretical basis that you can find behind the sequences. It was also, more or less, the appearance of the screenplay in the days that I was planning this project.

The animation begins by presenting a series of numbers. This is a very famous and recognized sequence since many centuries ago in the Western World thanks to Leonardo of Pisa, a thirteenth century Italian mathematician, also called Fibonacci. So it is known as Fibonacci Sequence, even although it had been described much earlier

0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610 987 1597 2584 4181

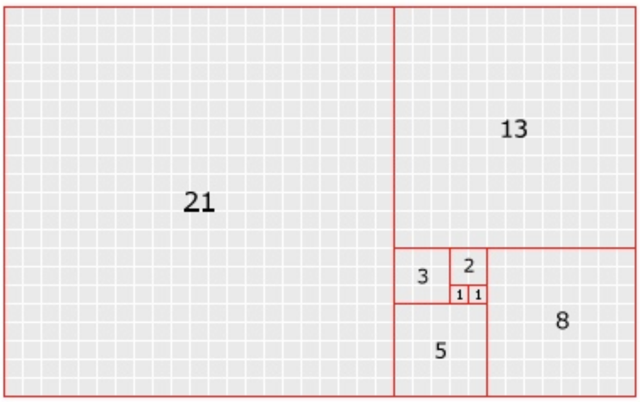
by Indian mathematicians.

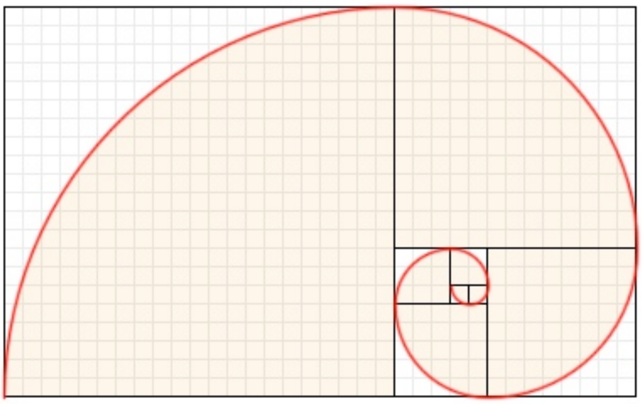
This is an infinite sequence of natural numbers where the first value is **0**, the next is **1** and, from there, each amount is obtained by **adding the previous two**.

0+1=**1**
0 1+1=**2**
0 1 1+2=**3**
0 1 1 2+3=**5**
0 1 1 2 3+5=**8**
0 1 1 2 3 5+8=**13**
etc

The values of this sequence have been appearing in numerous applications, but one of the most recognized is the Fibonacci Spiral, which has always been used as an approximation to the Golden Spiral (a type of logarithmic spiral) because it is easier to represent with help of a simple drawing compass.

This is the next thing to be shown on the animation, appearing just after the first





values on the succession: the process of building one of these spirals.

We will create first a few squares that correspond to each value on the sequence: 1x1 - 1x1 - 2x2 - 3x3 - 5x5 - 8x8, etc. And they are arranged in the way how we see in the diagram at left.

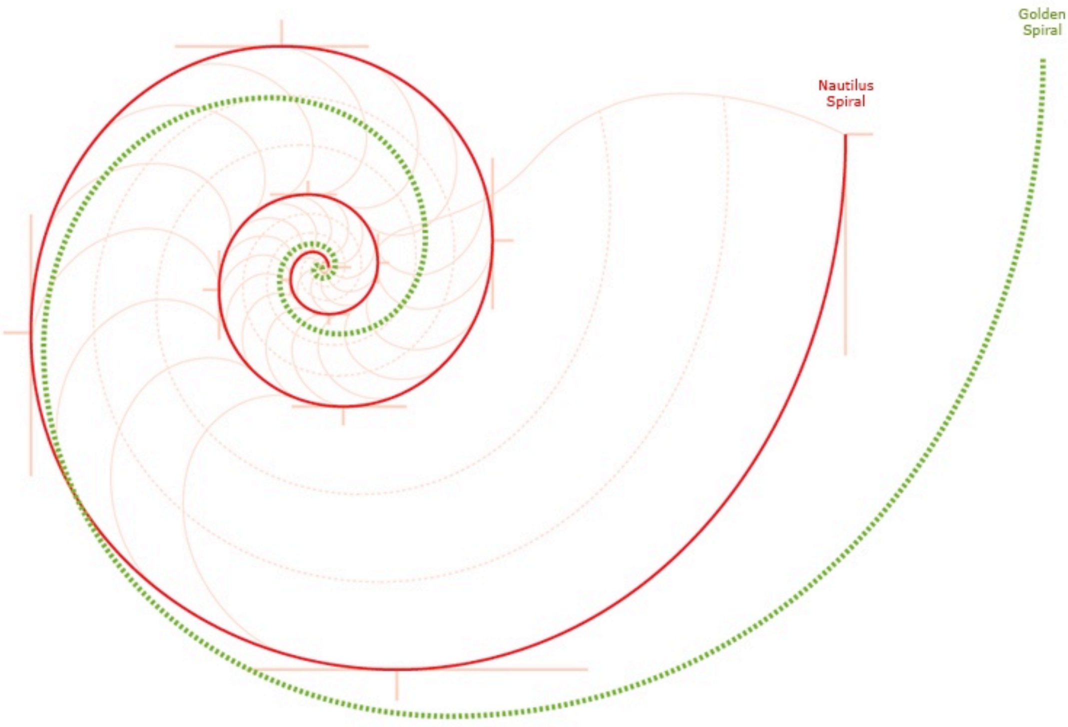
Then we draw a quarter circle arc (90°) within each little square and we can easily see how it builds step by step the Fibonacci Spiral, looking at right graphic.

I have introduced a small optical correction in the animation in order to get the resulting curve more like a true Golden Spiral (more harmonious and balanced), as explained on this plate. It's something similar to what happens when we try to approach to an ellipse by drawing an oval using circular segments: the result is not the same as a true ellipse. And it shows.

IMPORTANT NOTE: while watching the animation conveys the idea that the Fibonacci spiral (or the Golden Spiral, it doesn't matter) is on the origin of the shape of a Nautilus, this isn't absolutely right.

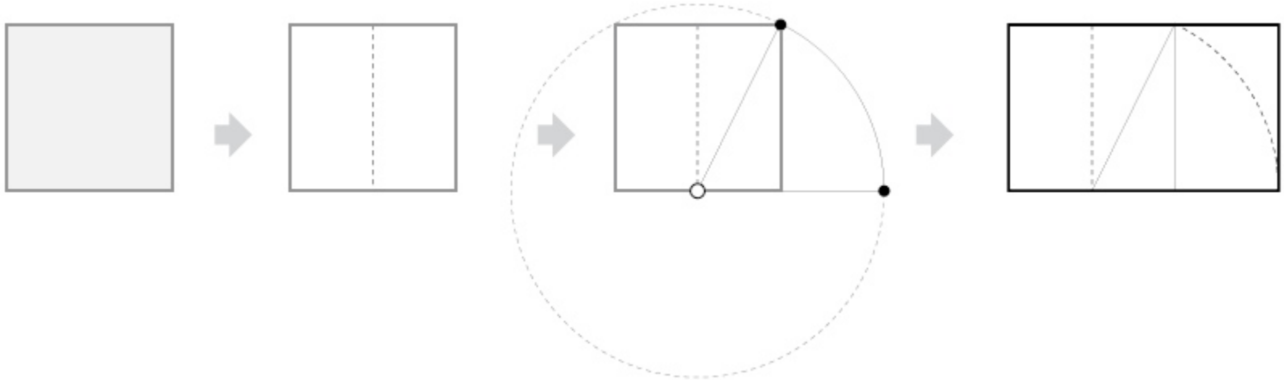
It's funny because if you perform this search at Google Images: “spiral + nautilus” you will see how many images suggest that this shell is really based on the construction system described above.

But this isn't correct, as it's outlined on this other page.

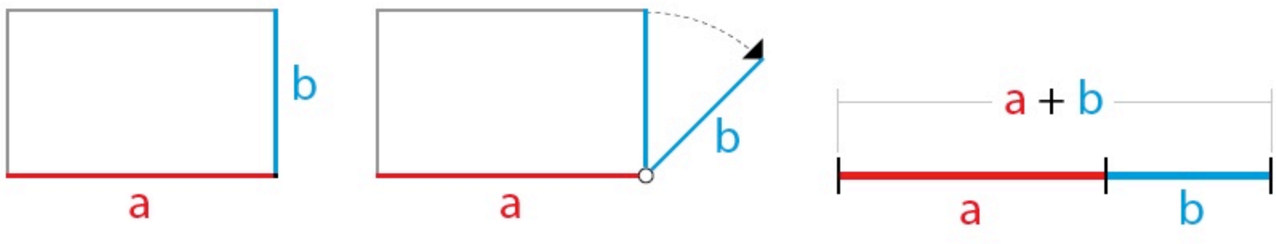


The truth is that this is something I discovered when I had completely finished the screenplay for this project and I was too lazy to change. Therefore I must confess that I did a kind of cheat with this animation. Or you could explain in a more "genteel" way, saying that I have taken an artistic license ;-)

Once it has appeared the Nautilus we advance to the second part of the animation. It introduces the concept of Golden Ratio by constructing a Golden Rectangle. We start from a simple square to get that and use a classic method that requires only a ruler and drawing compass. See the complete process on the following series of illustrations:



This is very special rectangle known since ancient times. It fulfills this ratio, also known as the Golden Ratio or Divine Proportion: the ratio of the sum of the quantities (**a+b**) to the larger quantity (**a**) is equal to the ratio of the larger quantity (**a**) to the smaller one (**b**).



$$\frac{a}{b} = \frac{a+b}{a} = \varphi \text{ (Phi)} = \mathbf{1.61803399...}$$

The result of this ratio (ie the division of a by b) is an irrational number known as **Phi** —not to be confused with Pi— and an approximate value of **1.61803399...**

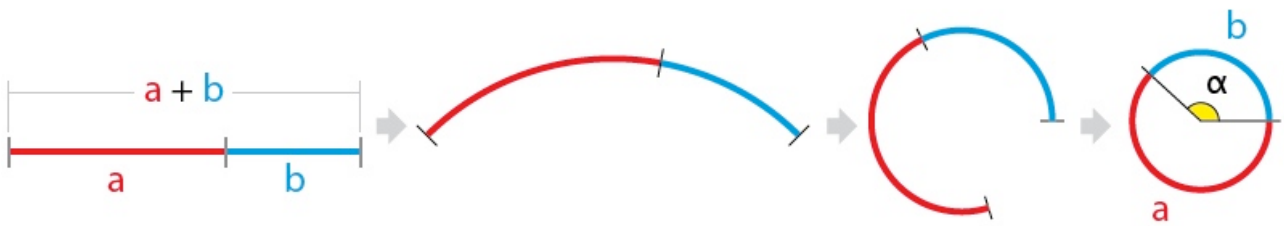
Formerly was not conceived as a true "unit" but as a simple relationship of proportionality between two segments. And we find in many works created by the mankind in art and architecture, from the Babylonian and Assyrian civilizations to our days, passing through ancient Greece or the Renaissance.

JUST A CURIOSITY: it isn't evident on the animation, but there is a deep connection between the Fibonacci Sequence and Golden Ratio.

You have an example at right (we will see another one): if we divide each value in the Fibonacci Series by the previous, the result **tends to Phi**. The higher the value, the greater the approximation (consider that Phi, like any irrational number, has infinite decimals).

1/1	= 1
2/1	= 2
3/2	= 1.5
5/3	= 1.66666666666
8/5	= 1.6
13/8	= 1.625
21/13	= 1.61538461538
34/21	= 1.61904761905
55/34	= 1.61764705882
89/55	= 1.61818181818
—	
Phi	**= 1.6180339887...**

We are going one step further on the animation by introducing a new concept, maybe less known but equally important, the Golden Angle. That is, the angular proportional relationship between two circular segments:

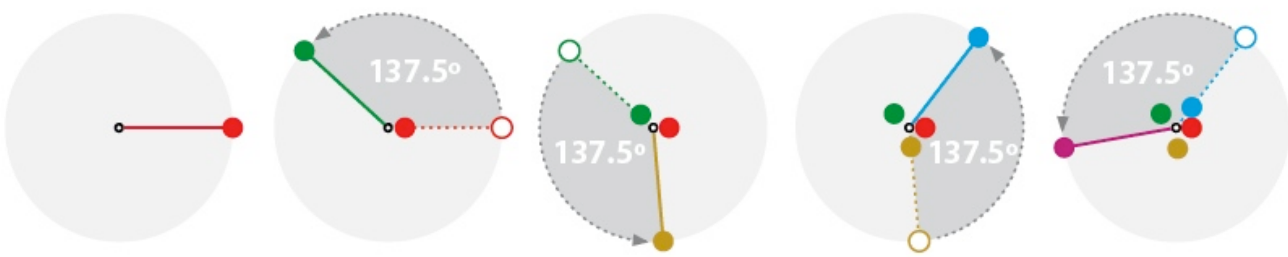


$$\frac{a}{b} = \frac{a+b}{a} = \varphi \text{ (Phi)} = 1.61803399\ldots \rightarrow \alpha = 137.507764^\circ\ldots \quad \sim 137.5^\circ$$

These two circular segments are accomplishing too with the same golden proportionality, but on this case the value of the angle formed by the smallest of them is another irrational number, we can simplify and round it as **137.5 º**

And this value is deeply present in nature. This is the next concept we see on the animation: how to configure the structure formed by the **sunflower seeds**.

Look at the figures below:



— We add a first red seed.

— Turn 137.5º

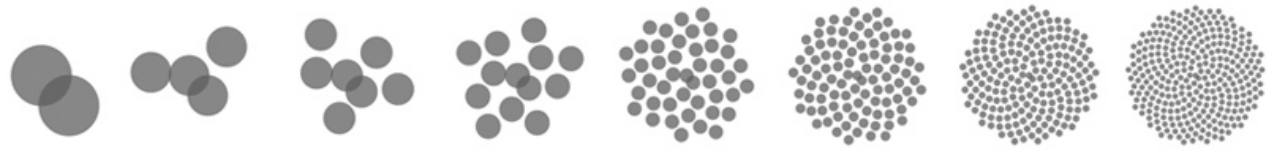
— Add a second green color seed and make the previous traveling to the center.

— Turn other 137.5º

— Add a third ocher seed and make the previous traveling to the center, to stay side by side with the first one.

— Turn other 137.5º…

…and so on, seed after seed, we will obtain gradually a kind of distributions like the ones you have in the following figures.



This leads to the characteristic structure in which all seeds are arranged into a sunflower, which is as compact as possible. We have always said: nature is wise :-)

....etc (For more information visit www.etereaestudios.com)