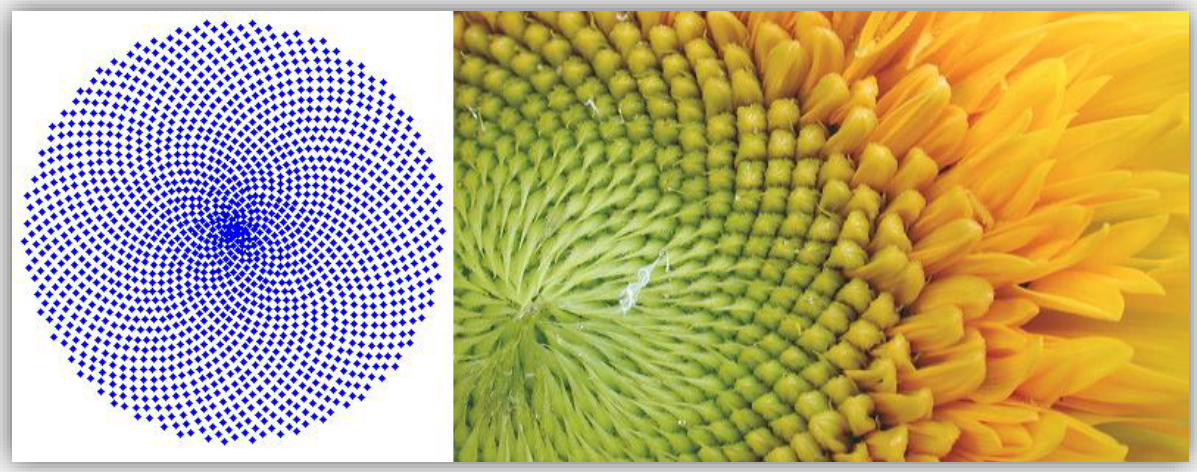
Phyllotaxis

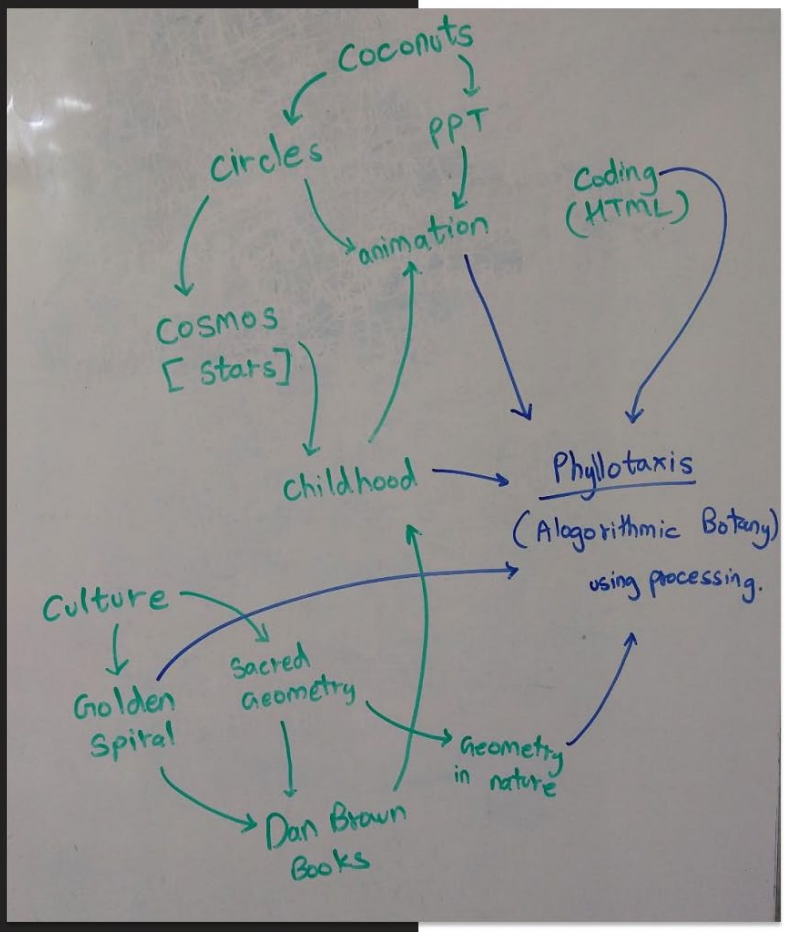
By Aditya Sadavarte

The term *phyllotaxis* was coined by Charles Bonnet to describe the arrangement of leaves on a plant. The Phyllotactic spirals form a distinctive class of patterns in nature that can be characterized by the **Fibonacci sequence** and the **Golden Ratio**.

I have used ***p5.js*** to mimic the phyllotactic arrangement of sunflower seeds. But before writing a code, I had to do some research on **Algorithmic Botany**. While researching, I came across a set of equations that determine the pattern and realized that the **golden angle** *(137.5 degrees)* plays a major role.



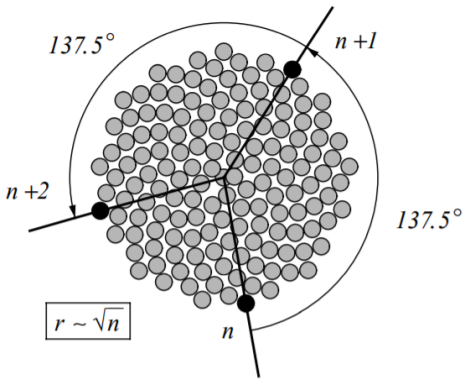
Mapping my journey to Phyllotaxis



I've always found the **golden ratio** in Dan Brown's books and **geometry in nature** to be quite fascinating. I could connect it to the ***childhood*** umbrella as it was a part of my actual childhood.

I was also able to map phyllotaxis to the ***Culture*** umbrella as it is a Golden spiral afterall.

To connect it to the ***Cosmic*** umbrella and ***circles***, I decided to mimic the *sunflower seeds* as tiny circles.




```
#define a 137.5  /* divergence angle */
#include D       /* disk shape specification */

ω  :  A(0)
p1 :  A(n) :  * → +(a)[f(n^0.5)~D]A(n+1)
```

Figure 4.1: Pattern of florets in a sunflower head, according to Vogel's formula

4.1 The planar model

Vogel's formula

In order to describe the pattern of florets (or seeds) in a sunflower head, Vogel [154] proposed the formula

$$\phi = n * 137.5°, \qquad r = c\sqrt{n}, \tag{4.1}$$

where:

- n is the ordering number of a floret, counting outward from the center. This is the reverse of floret age in a real plant.
- ϕ is the angle between a reference direction and the position vector of the n^{th} floret in a polar coordinate system originating at the center of the capitulum. It follows that the *divergence angle* between the position vectors of any two successive florets is constant, $\alpha = 137.5°$.
- r is the distance between the center of the capitulum and the center of the n^{th} floret, given a constant scaling parameter c.

Source: *The 'Algorithmic Beauty of Plants' originally printed by Springer-Verlag in 1990*

To get the phyllotactic pattern as the output, I have used the following two equations in my code:

$$a = n * 137.5° \qquad r = c\sqrt{n}$$

Here, **a** *is the angle/direction of dots,* ***r*** *is radius,* ***c*** *is the number for scaling the pattern and* ***n*** *is the number of dots.*

In order to find the X and Y coordinates, I have used *Polar to cartesian coordinate transformation*:

$$x = r * \cos(a) \qquad y = r * \sin(a)$$

Experimenting with Colour Combinations

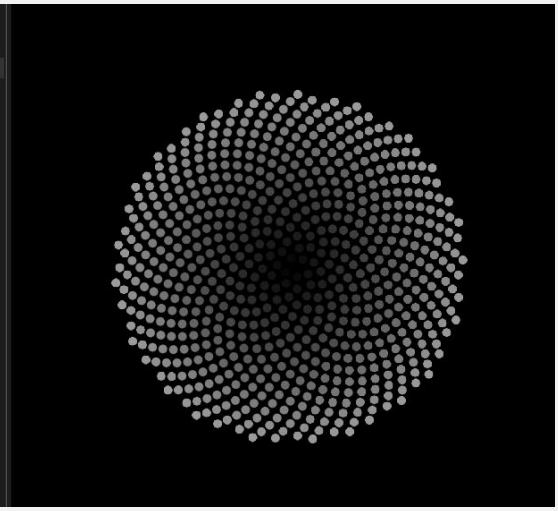
```
var n = 0;
var c = 6;

function setup() {
  createCanvas(500, 500);
  background(0);
  angleMode(DEGREES);
  colorMode(RGB);
}

function draw(){
  var a = n * 137.5;
  var r = c * sqrt(n);

  var x = r * cos(a) + width/2;
  var y = r * sin(a) + height/2;

  fill(r%256, r%256, r%256);
  noStroke();
  ellipse(x,y,8,8);
  n++;
}
```



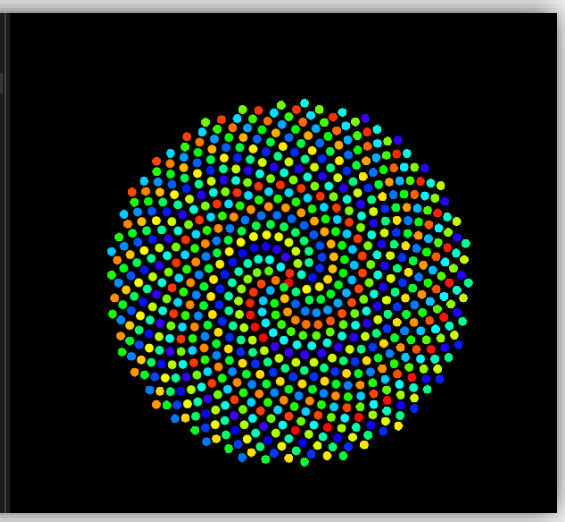
```
var n = 0;
var c = 6;

function setup() {
  createCanvas(500, 500);
  background(0);
  angleMode(DEGREES);
  colorMode(HSB);
}

function draw(){
  var a = n * 137.5;
  var r = c * sqrt(n);

  var x = r * cos(a) + width/2;
  var y = r * sin(a) + height/2;

  fill((a - r) % 255, 255, 255);
  noStroke();
  ellipse(x,y,8,8);
  n++;
}
```



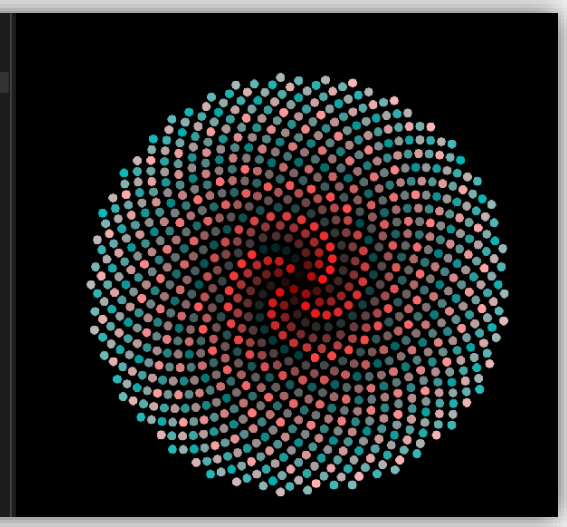
```
var n = 0;
var c = 6;

function setup() {
  createCanvas(500, 500);
  background(0);
  angleMode(DEGREES);
  colorMode(RGB);
}

function draw(){
  var a = n * 137.5;
  var r = c * sqrt(n);

  var x = r * cos(a) + width/2;
  var y = r * sin(a) + height/2;

  fill(a%256, r%256, r%256);
  noStroke();
  ellipse(x,y,8,8);
  n++;
}
```



Experimenting with Changes in the angle

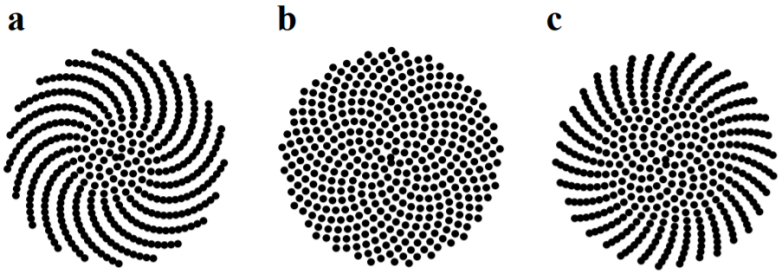


Figure 4.2: Generating phyllotactic patterns on a disk. These three patterns differ only by the value of the divergence angle α, equal to (a) 137.3°, (b) 137.5° (the correct value), and (c) 137.6°.

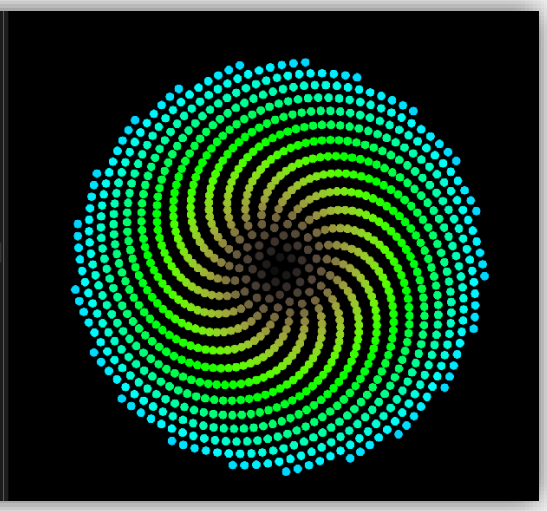
```
var n = 0;
var c = 6;

function setup() {
  createCanvas(500, 500);
  background(0);
  angleMode(DEGREES);
  colorMode(HSB);
}

function draw(){
  var a = n * 137.3;
  var r = c * sqrt(n);

  var x = r * cos(a) + width/2;
  var y = r * sin(a) + height/2;

  fill(r%256, r%256, r%256);
  noStroke();
  ellipse(x,y,8,8);
  n++;
}
```



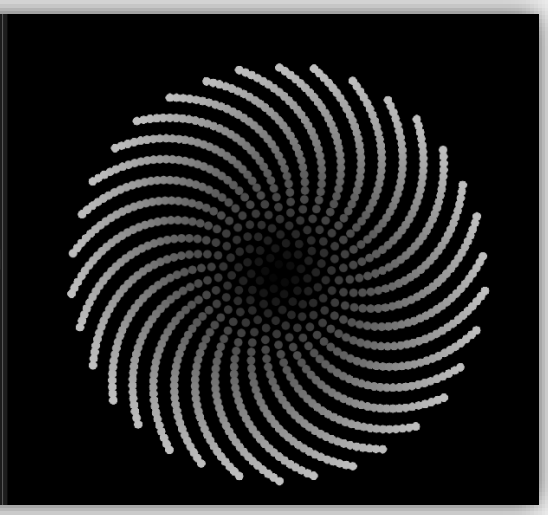
```
var n = 0;
var c = 6;

function setup() {
  createCanvas(500, 500);
  background(0);
  angleMode(DEGREES);
  colorMode(RGB);
}

function draw(){
  var a = n * 137.6;
  var r = c * sqrt(n);

  var x = r * cos(a) + width/2;
  var y = r * sin(a) + height/2;

  fill(r%256, r%256, r%256);
  noStroke();
  ellipse(x,y,8,8);
  n++;
}
```



Citation

Videos

https://youtu.be/D1GHPaaM9JQ

https://youtu.be/svq3-Yoioao

https://youtu.be/MQMJ0xWSMWE

https://youtu.be/Vzeyj3DCWGw

https://youtu.be/EaFLM8ildWc

Websites

http://algorithmicbotany.org/

http://algorithmicbotany.org/papers/abop/abop-ch4.pdf

https://www.reddit.com/r/proceduralgeneration/comments/68nzwn/algorithmic_botany/

Software Used

https://editor.p5js.org/