

**BIOSYSTEMS
ENGINEERING & SOIL SCIENCE**

UTIA INSTITUTE OF
AGRICULTURE
THE UNIVERSITY OF TENNESSEE

Backyard STEM: Environmental Science Activities for K12

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Biosystems Engineering & Soil Science



Today's Schedule

Morning session

- Introductions
- Overview:
 - Our goals for this training
 - Why Environmental Science?
- Activities!

12:00 Lunch (provided)

Afternoon session

- More activities!
- Wrap-up discussion and surveys

Introductions!

- Name?
- School and grade level(s)?
- Favorite number? (And why?)

Backyard STEM



- Curriculum and training program
- Goals:
 - Provide ready-to-go environmental science curriculum that includes fun, hands on, experiential activities
 - Train educators to lead these activities

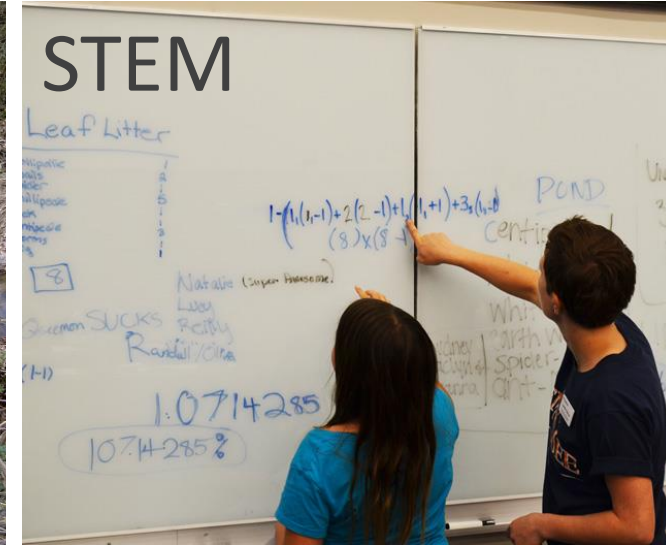


Why Environmental Science?

Stewardship



STEM



Experiential



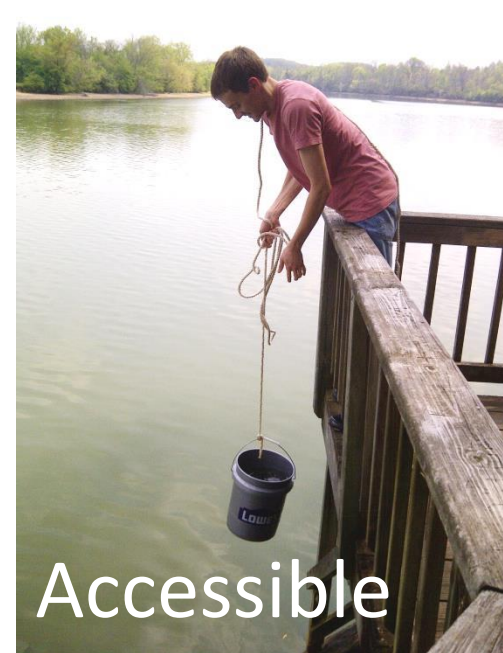
Hands On



FUN!



Accessible



Backyard STEM curriculum

- Focus on environmental science
- Follow the experiential learning model
- Some our own ideas, some adapted from various sources

The Color of Soil Student Handout

Words to Explore
Hue
Value
Chroma
Well-drained
Poorly-drained

Did you know?
Near the ocean, green sands sometime form, due to a mineral called glauconite.

What's coloring my soil?
Draw a line between the soil component and the color that it adds to soils:

| | |
|-----------------------|------------|
| Iron oxide minerals | Black |
| Iron sulfide minerals | Red |
| Calcium minerals | Dark Brown |
| Low oxygen | Gray |
| Organic matter | White |

Munsell Soil Color
Soil scientist use a Munsell Color Chart to describe soil colors. The Munsell colors use three parts:

Hue is the color: red, yellow, green etc. On the chart, hue is listed as red (R) or yellow-red (YR) or yellow (Y)

Value is the lightness and darkness of the color. It ranges from 0 (black) to 10 (white).

Chroma is the saturation of the color. Brighter colors have higher numbers.

Now put it together!
Soil color is written like this: **5YR 6 / 8**
Hue Value Chroma

Answer this!
Is a 5R 6/6 more yellow or red? _____
What is the chroma of 5YR 2/4? _____
Which one of these is darker: 5YR 2/4 or 5YR 8/4? _____

IN THE WORLD? Student Handout
Can you guess where in the world these soils come from? Write the name of the country on the soil profile to the correct part of the world below.

CLUE 1: These long roots are "home on the range."
CLUE 2: Did a gaucho lose his spur?
CLUE 3: The topsoil is deep, dark and fertile.

CLUE 1: Brrrr! It's icy way down here!
CLUE 2: Is that a woolly mammoth tusk?
CLUE 3: Lots of dark brown plant compost is slowly decaying.

Siberian Permafrost
South Pacific Volcano

Credits: Jennifer DeBruyn
The 4-H Name & Emblem is protected under 18 USC 707.

Activities are adapted for a 4-H framework:

- Hands on, interactive
- Most fit in a class time frame (30-40 min)
- Are portable and affordable: require minimal, inexpensive or no supplies
- Adaptable: include variations and extensions

<https://ag.tennessee.edu/watersheds/Pages/BackyardSTEM.aspx>

Backyard STEM training

- Annual in-service training in each region
 - Launch 6 new activities each year
 - Get feedback from agents

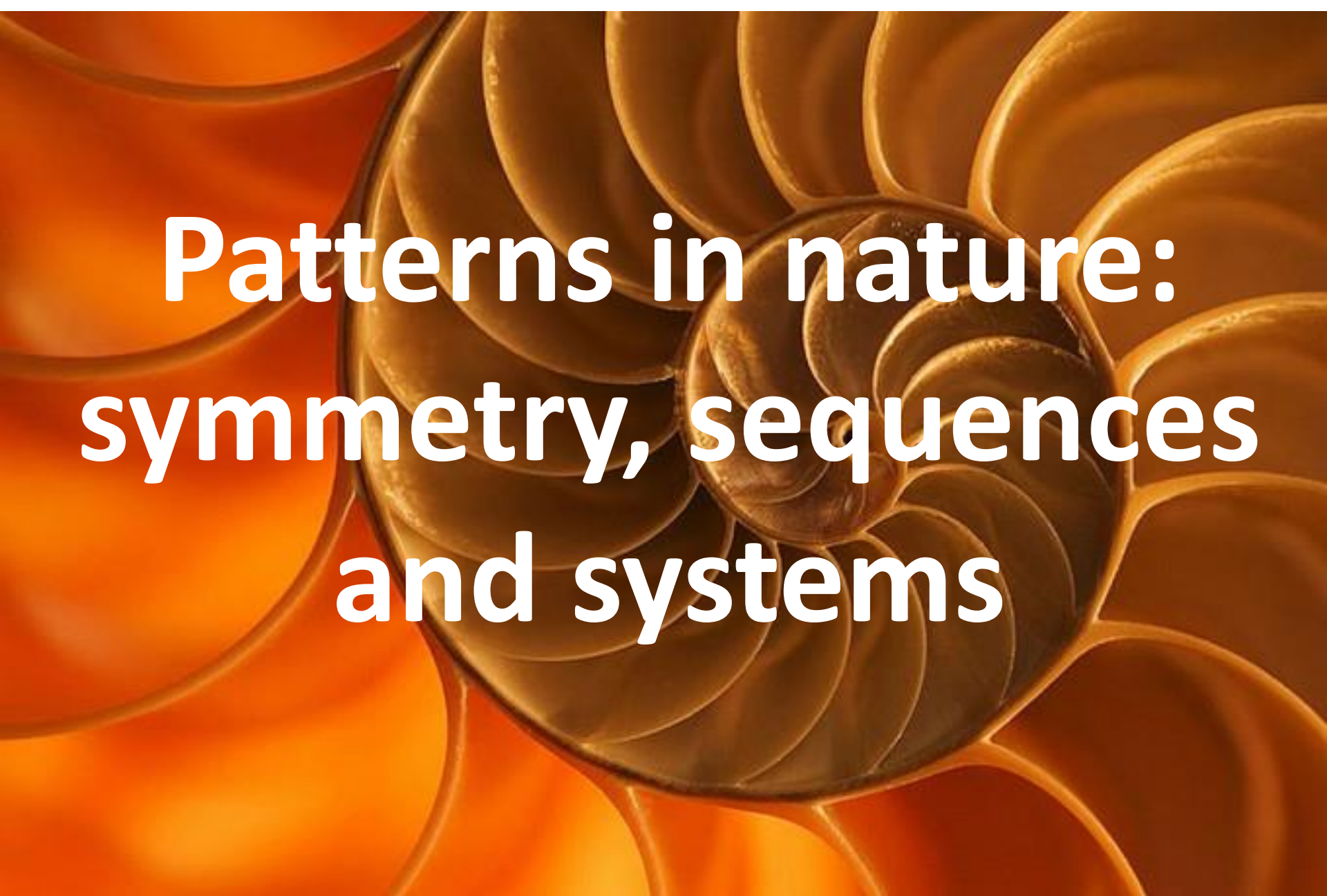


Important feedback



- Do you think you could use this activity with your 4-Hers?
- Do you see any challenges in implementing this activity?
- Any ideas for variations or extensions?

This year's theme...



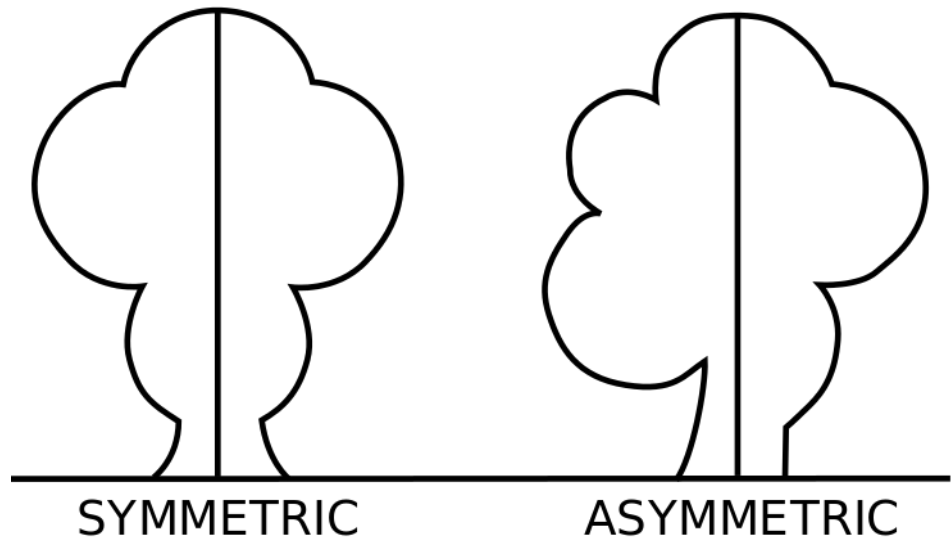
**Patterns in nature:
symmetry, sequences
and systems**

Nature's Patterns

Symmetry in nature

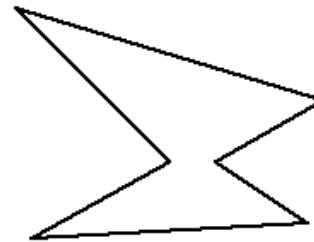
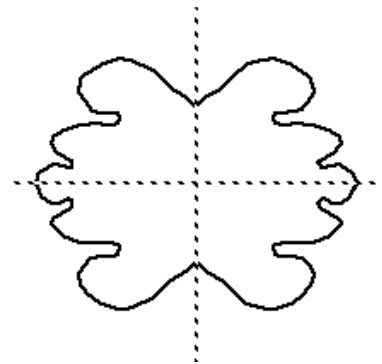
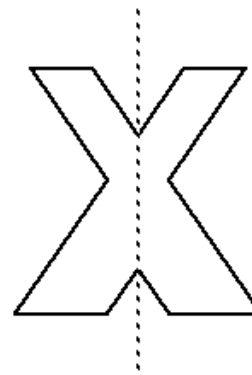
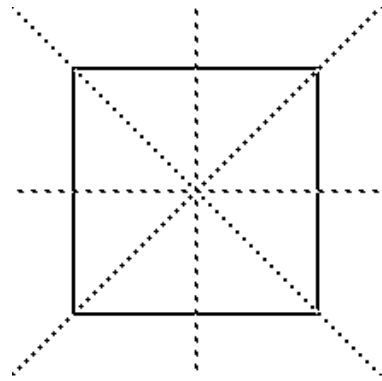
What is symmetry?

- In mathematics, if an object has symmetry, it is invariant (i.e. does not change) to various transformations
 - Reflection
 - Rotation



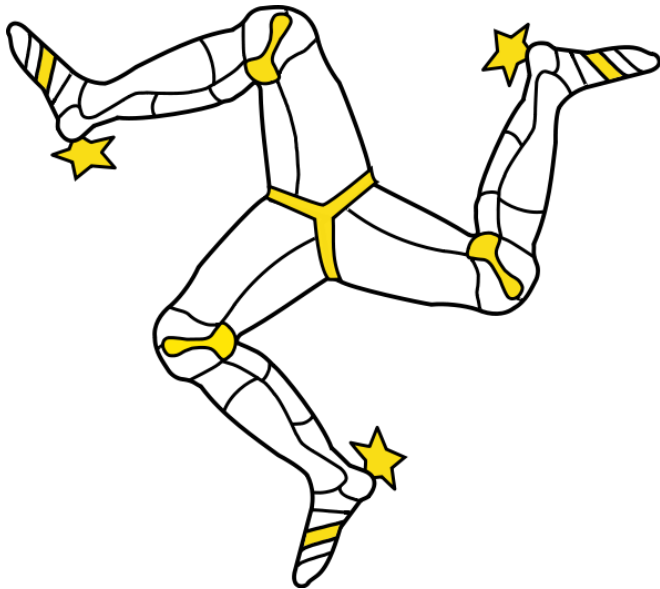
Reflection Symmetry

- An object has reflectional symmetry (line or mirror symmetry) if there is a line going through it which divides it into two pieces which are mirror images of each other

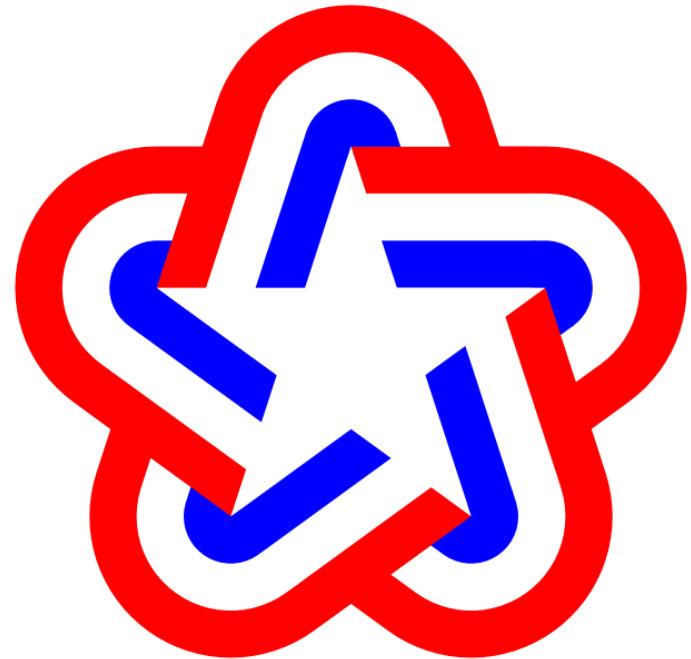


Rotational Symmetry

- An object has rotational symmetry if the object can be rotated about a fixed point without changing the overall shape



3 fold symmetry



5 fold symmetry

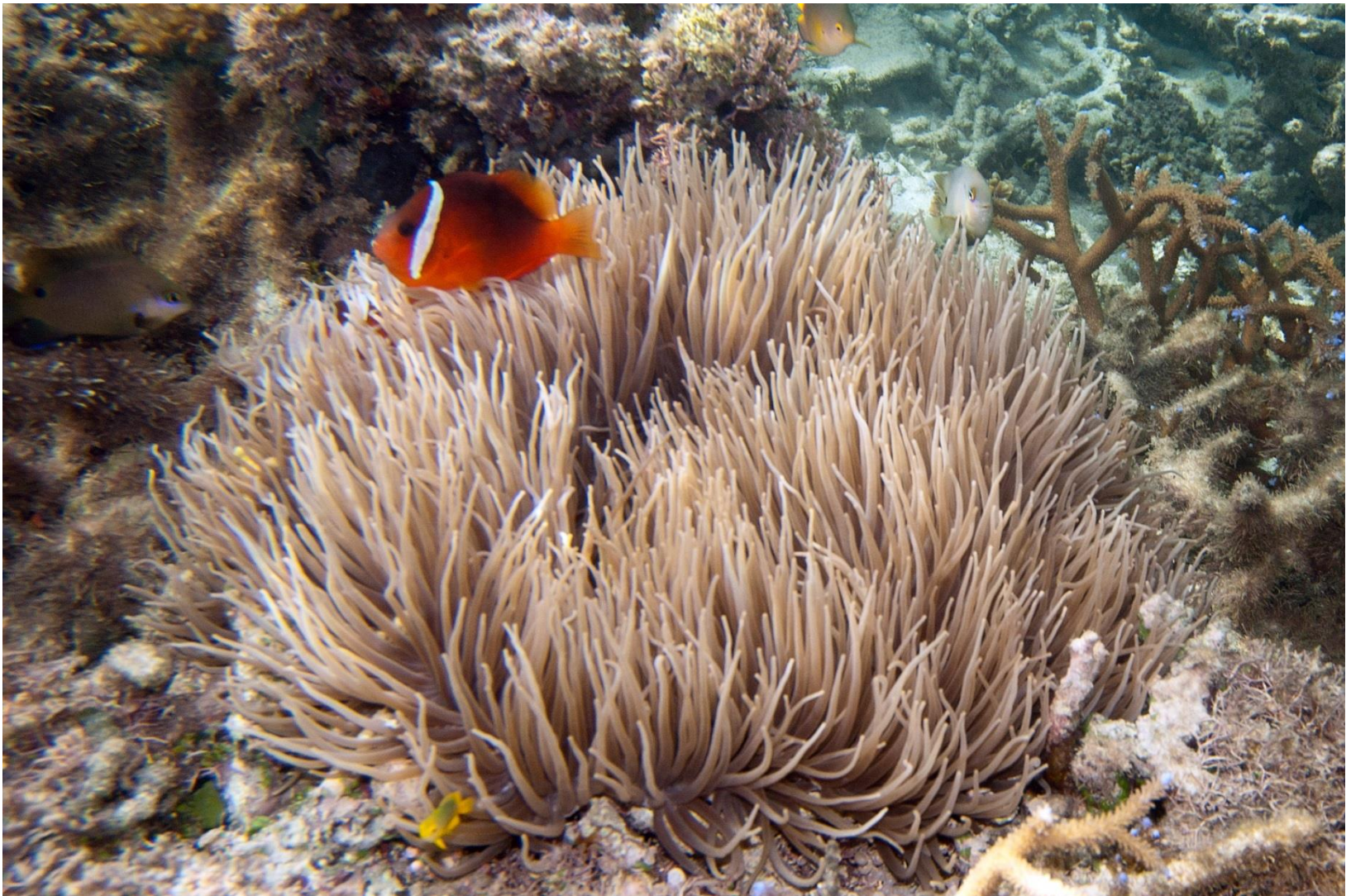
Symmetry in Nature

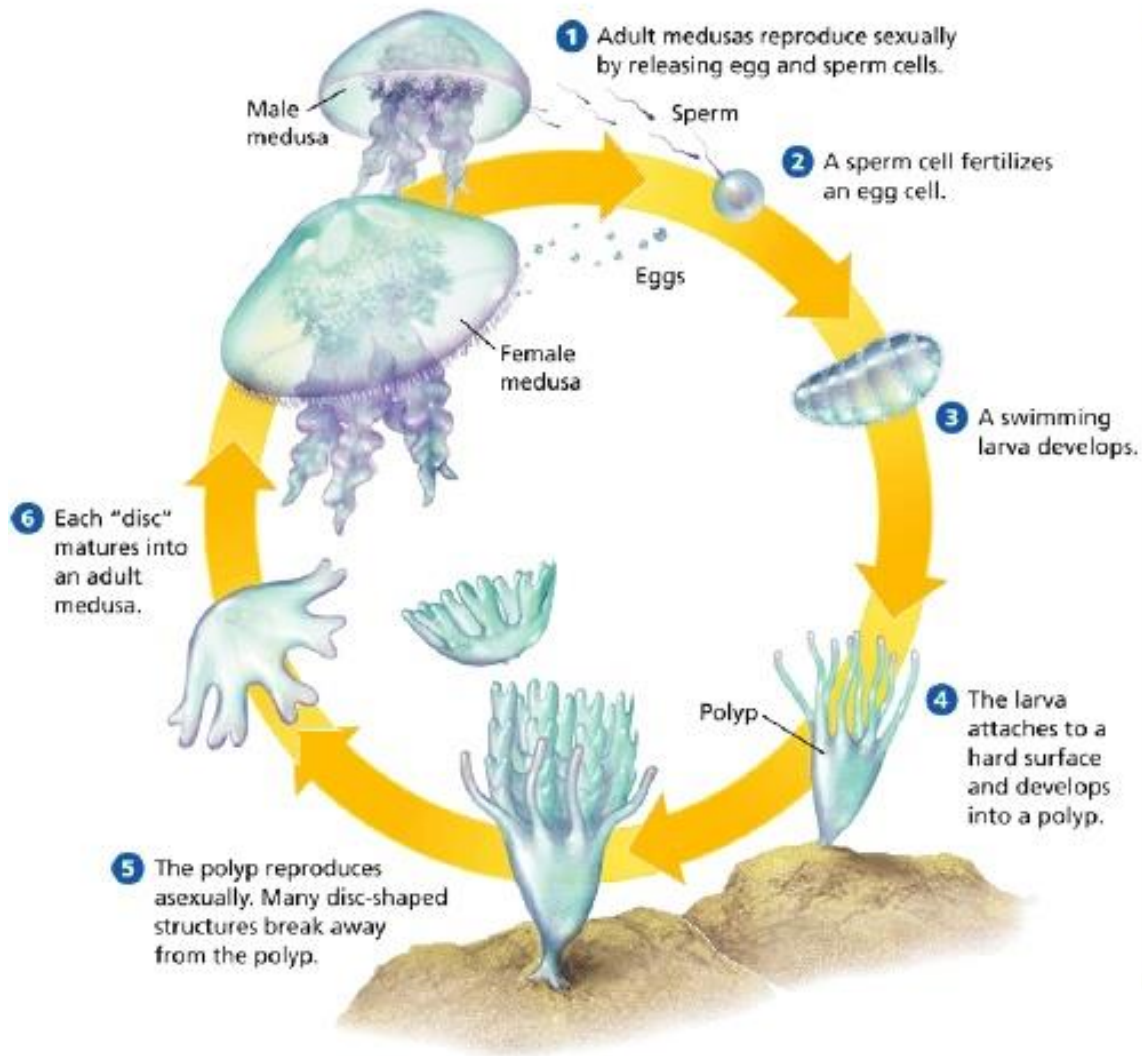
- In biology, we use slightly different terms:
 - Reflectional symmetry = bilateral symmetry
 - Rotational symmetry = radial symmetry

Can you identify the symmetry?

- Think about the object's general SHAPE (ignore color and texture)
- To identify bilateral symmetry, hold a small mirror across the object.
 - When you look at the reflected image, does it look the same as the ORIGINAL?
 - Try multiple planes (i.e. rotate the mirror) – can you find more than one plane of symmetry?
- To identify rotational symmetry, put the picture of the object on the foam board and push a pin or thumbtack through the center. Rotate the picture around the pin – does it look the same from multiple angles?
- If an object doesn't have bilateral or rotational symmetry, it is asymmetric.
- Put your picture in the correct category.
 - Note – it may belong to two categories!

What do the animals/plants in each category have in common?





- The life cycle of a moon jelly has both a polyp and a medusa stage.

Optional Extension 1: Symmetry scavenger hunt

- Have students go out into the school yard or forest to collect items from nature that are bilaterally, radially and a-symmetric.
- Challenge them to find at least one item from each category.
- Have them share what they found with the class.



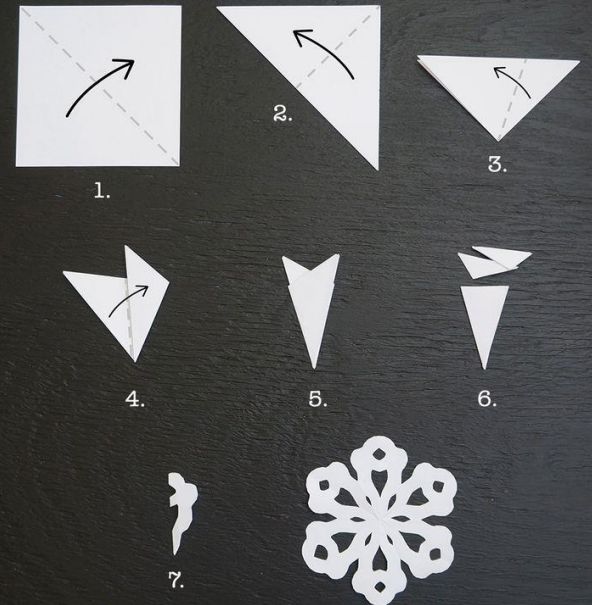
Optional Extension 2: Symmetry Art Projects

- Bilateral symmetry: butterfly decoration



- Radial symmetry: paper snowflakes

How to Make Paper Snowflakes



www.craftiments.com



Nature's Secret Code

Fibonacci sequences, spirals and the
golden ratio

A bit of history...

- Fibonacci (1175-1240) was a 13th century Italian mathematician (Real name: Leonardo of Pisa)
- Popularized the Hindu-Arabic numeral system in the West (uses digits 0-9 and decimals instead of roman numerals)
- Most well know for describing a series of numbers that became known as the **Fibonacci sequence** or **Fibonacci numbers**



Just for fun: *Blockhead* by Joseph D'Agness



Part I: Fibonacci sequence

$$F_n = F_{n-1} + F_{n-2}$$

Start with $F_1 = 1$ and $F_2 = 1$

1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144....

The diagram illustrates the recursive nature of the Fibonacci sequence. It shows the first few terms: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144.... Below the first two terms (1 and 1), a green bracket is drawn, with the equation $1+1=2$ written below it. A second green bracket is drawn under the first three terms (1, 1, and 2), with the equation $1+2=3$ written below it. A third green bracket is drawn under the first four terms (1, 1, 2, and 3), with the equation $2+3=5$ written below it. This visualizes how each term in the sequence is the sum of the two preceding terms.

Examples in nature?

- Our hands
- Flower petals, seeds, leaves etc.

1



2



3



5



8



13



21



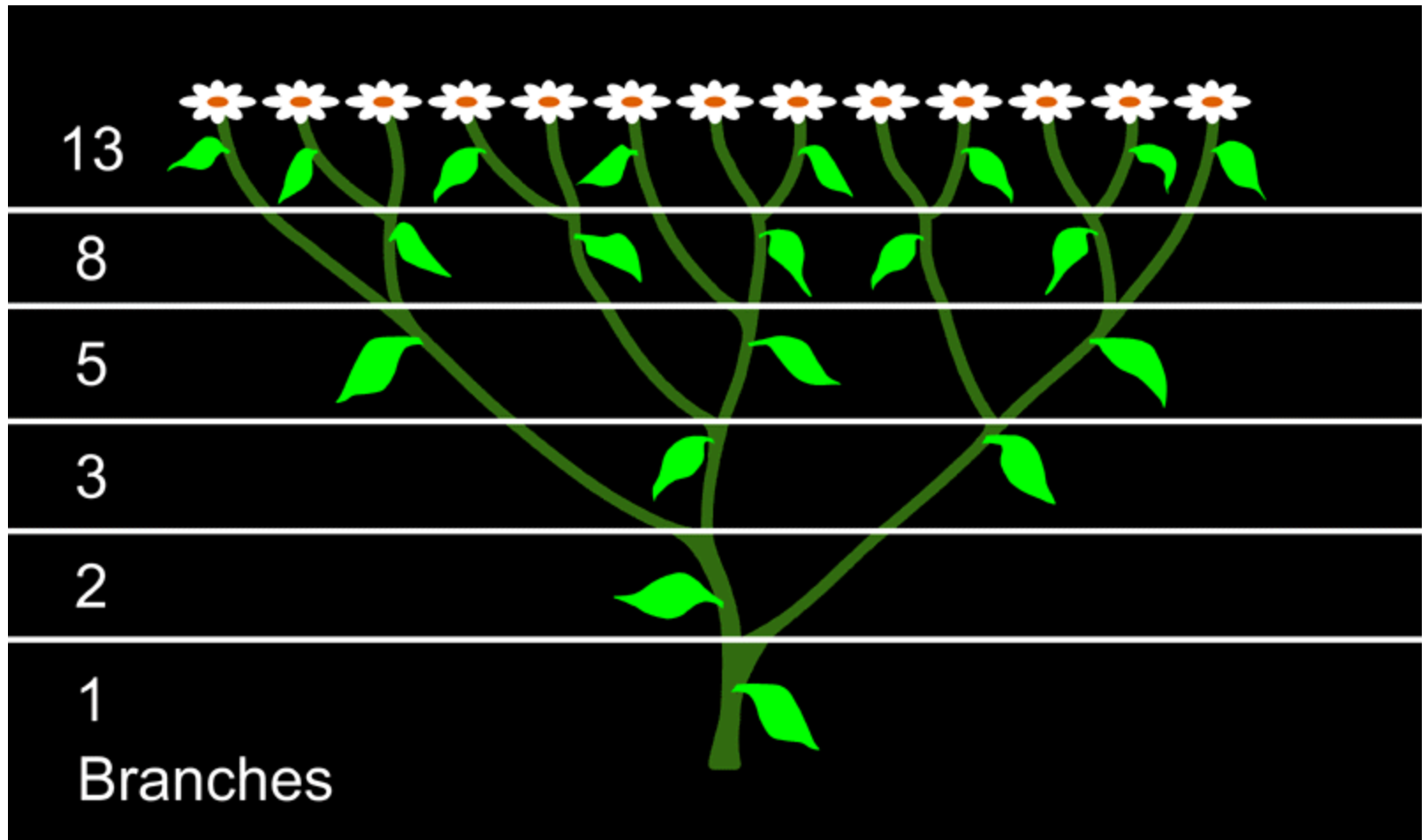
34



Examples in nature?

- Find examples of the Fibonacci in nature
 - Indoors – bring in flowers, pinecones, leaves, shells, pineapples etc. OR pictures of these items
 - Outdoors – have students go on a scavenger hunt for items that have a Fibonacci number
- Classify items by what number they have. Can we find at least one thing for each number?

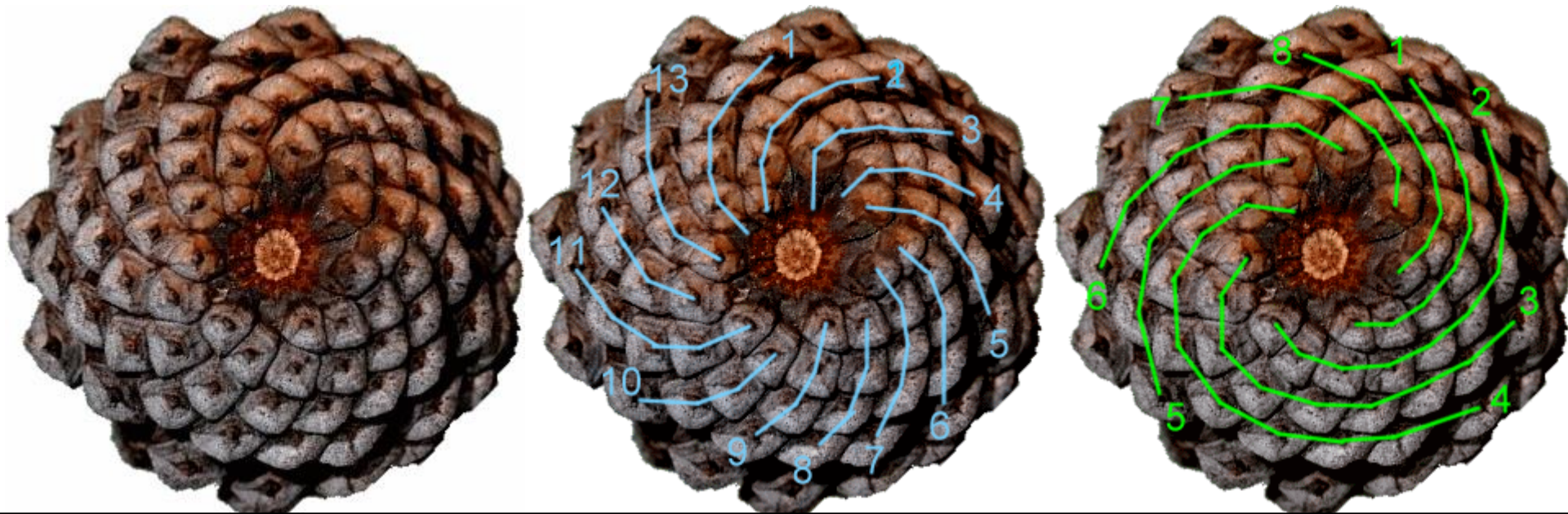
1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233...



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

Part II: Fibonacci spirals

- Sunflower seeds, pinecones, pineapples etc. have seeds arrange in a spiral. If you look closely, you can see one spiral going left and one going right.
- Count the number of items in each spiral (or each branch of the spiral.) How many do you get?



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

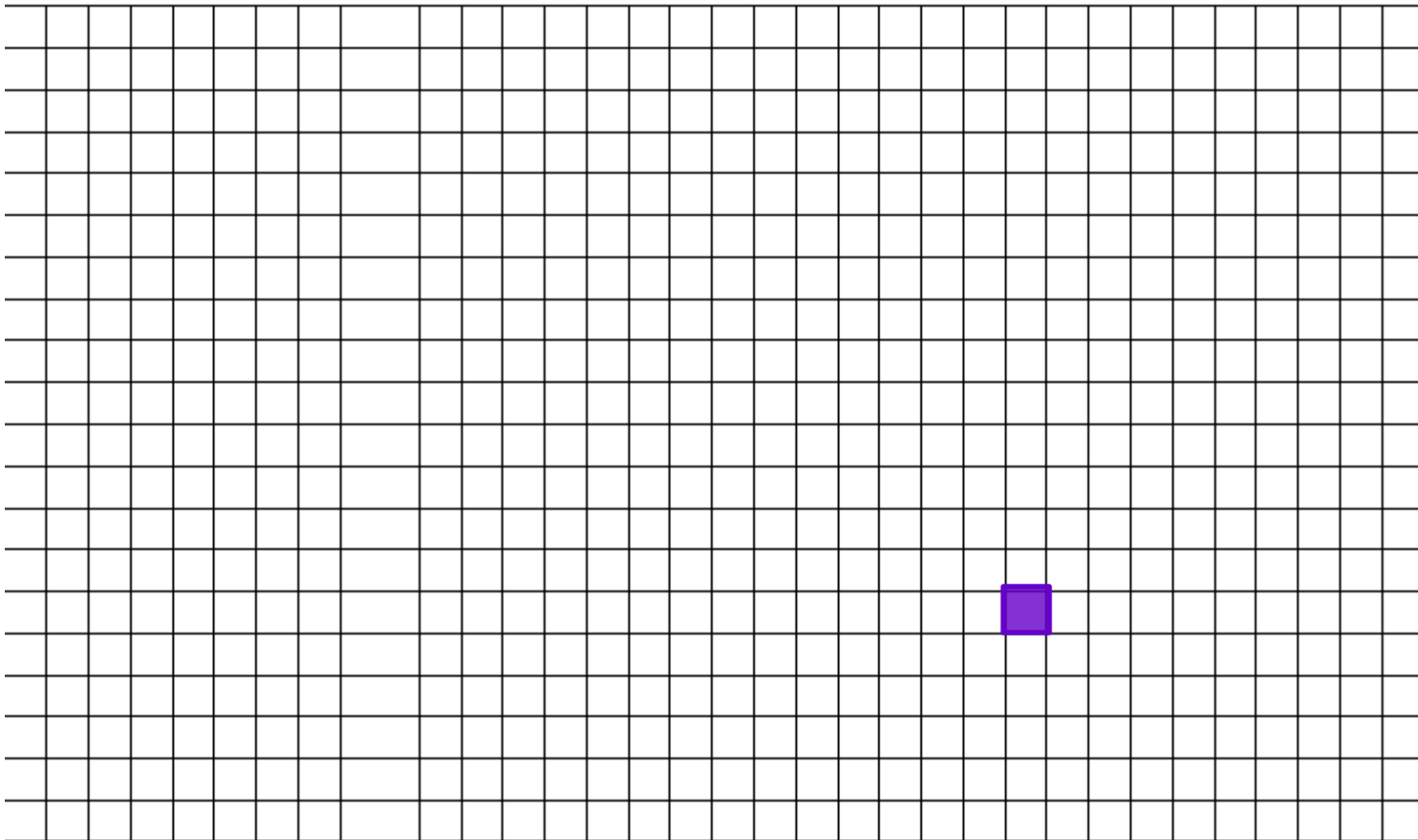


Similar 3 spirals in the pineapple, which are adjacent numbers in the fibonacci series 5 8 13

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

Part II: Draw a Fibonacci Spiral

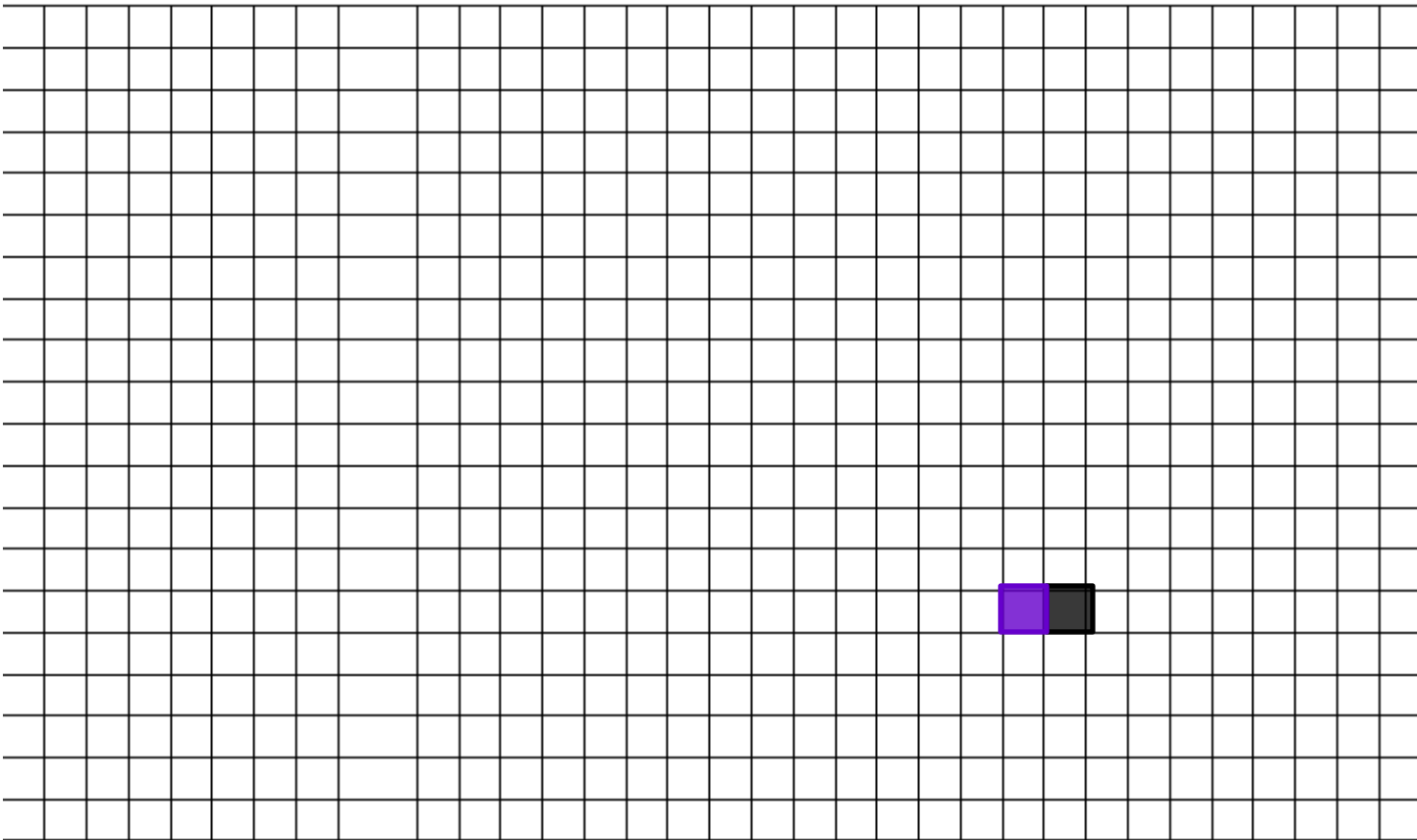
- Pick a square in the middle of the lower quadrant, outline this square.



To maximize space:
6th from the bottom;
10th from the right

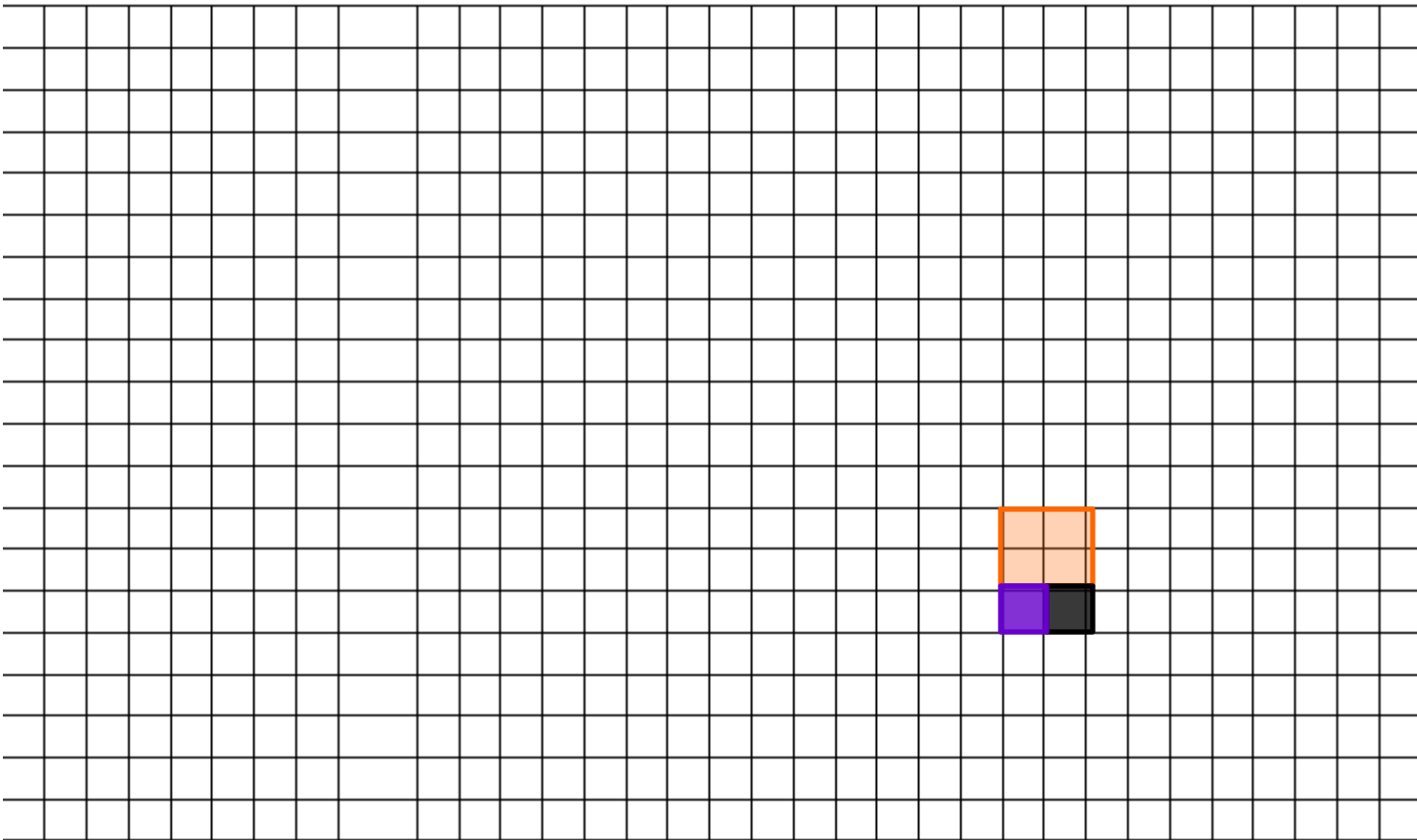
Draw a Fibonacci Spiral

- Move one square to the right, and outline this square.



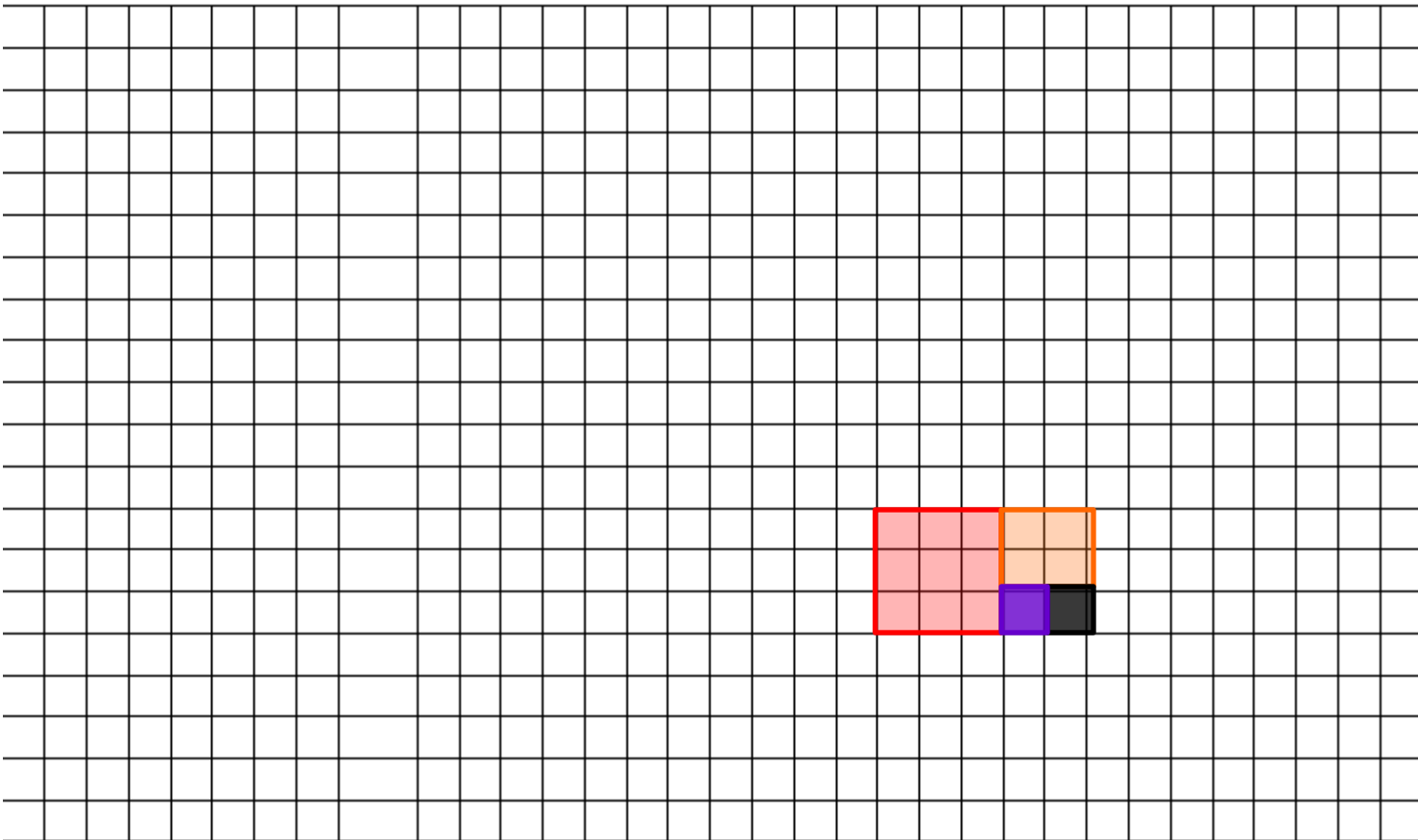
Draw a Fibonacci Spiral

- Directly above those two squares, outline a 2x2 square.



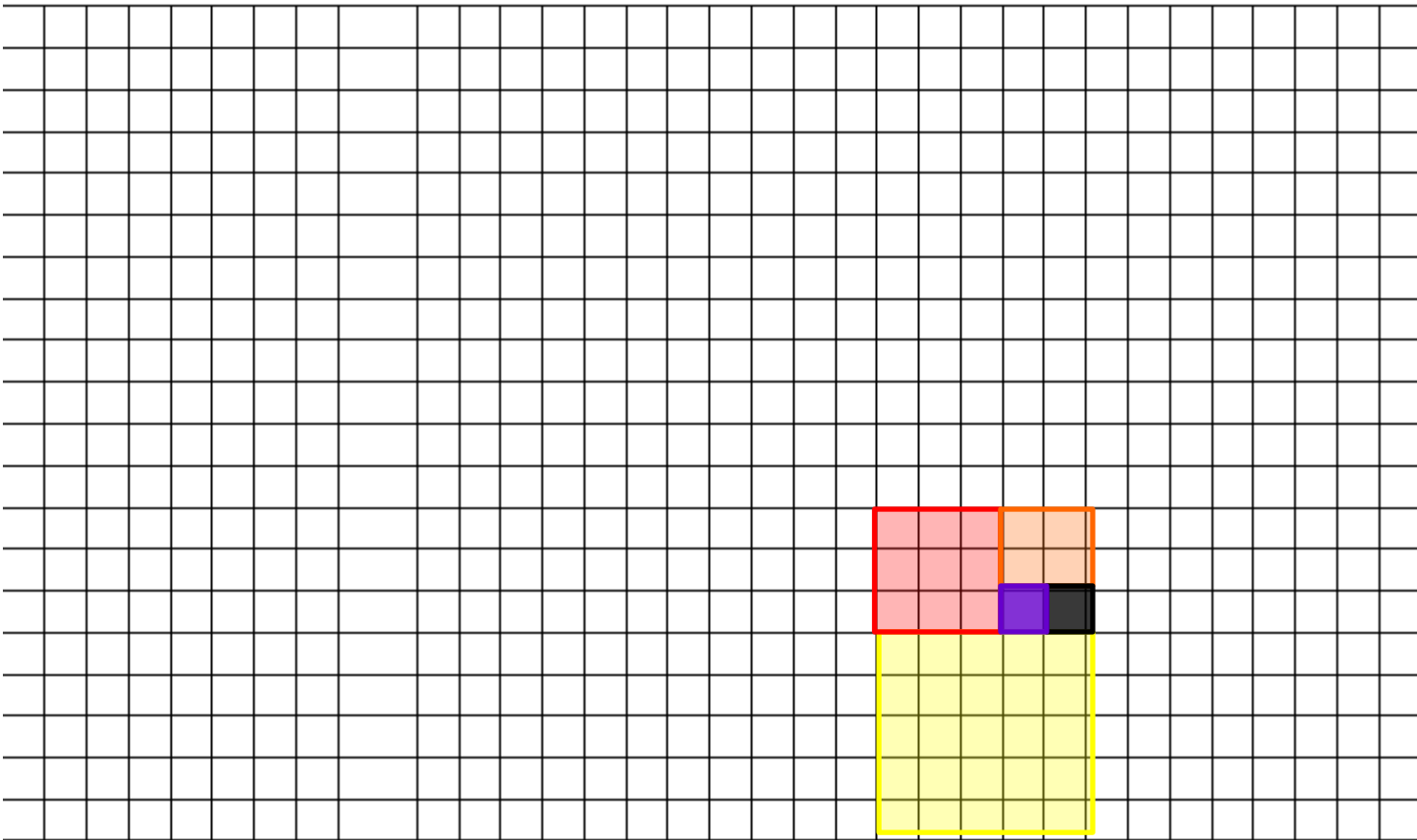
Draw a Fibonacci Spiral

- Directly to the left of those squares, outline a 3x3 square



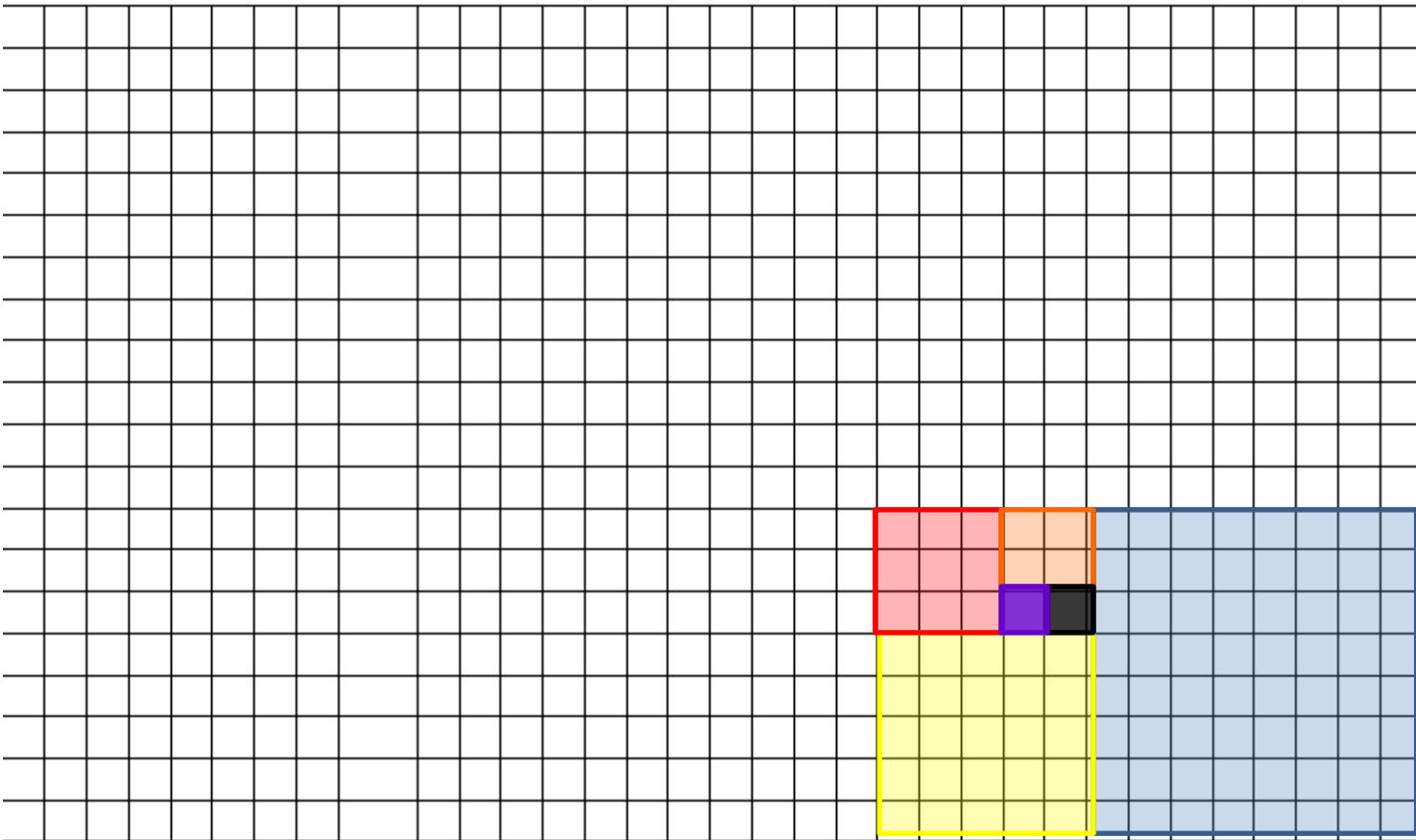
Draw a Fibonacci Spiral

- Directly below, outline a 5x5 square. Continue moving around counter clockwise making an 8x8 square, then 13x13, then 21x21 until you run out of paper.



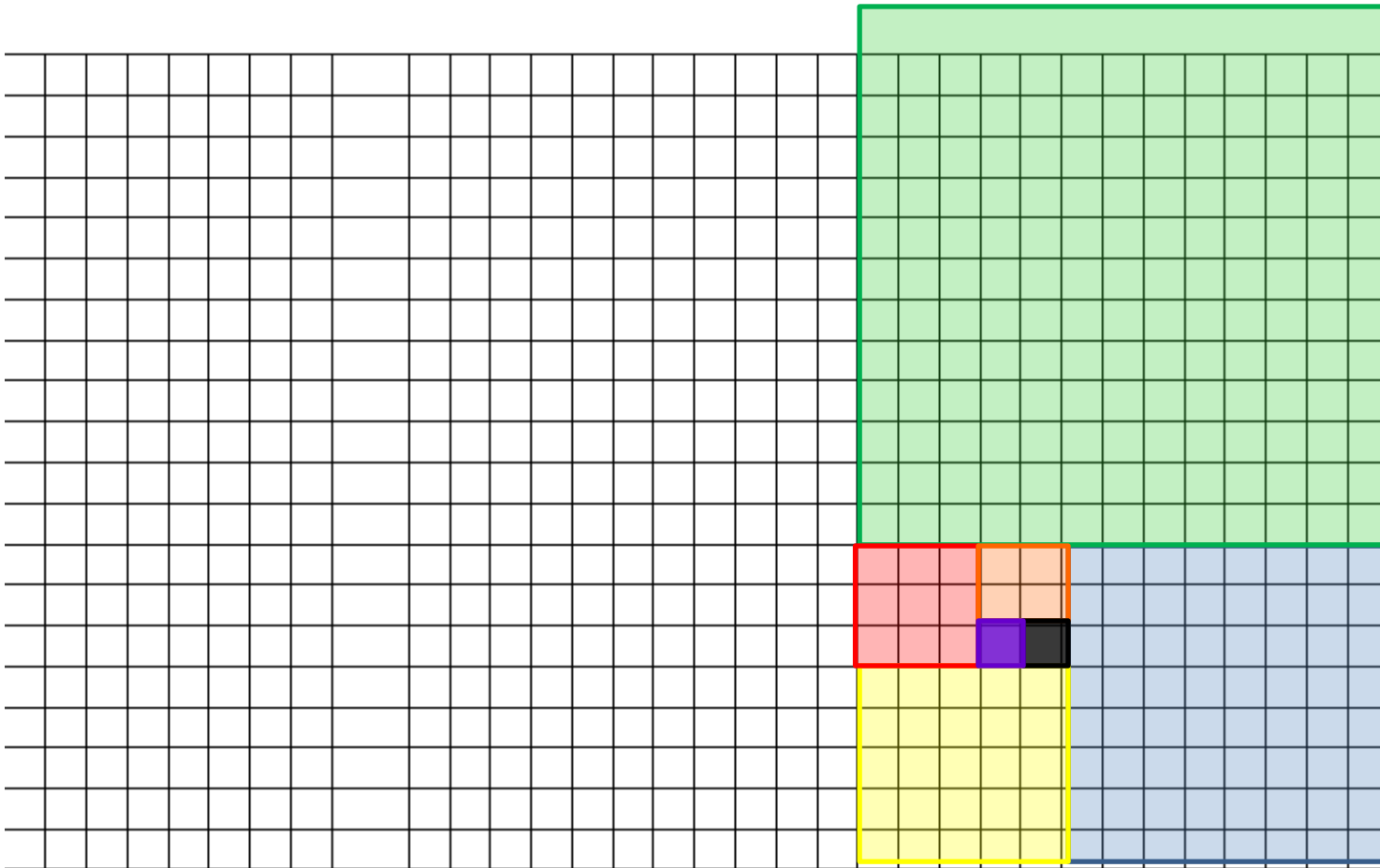
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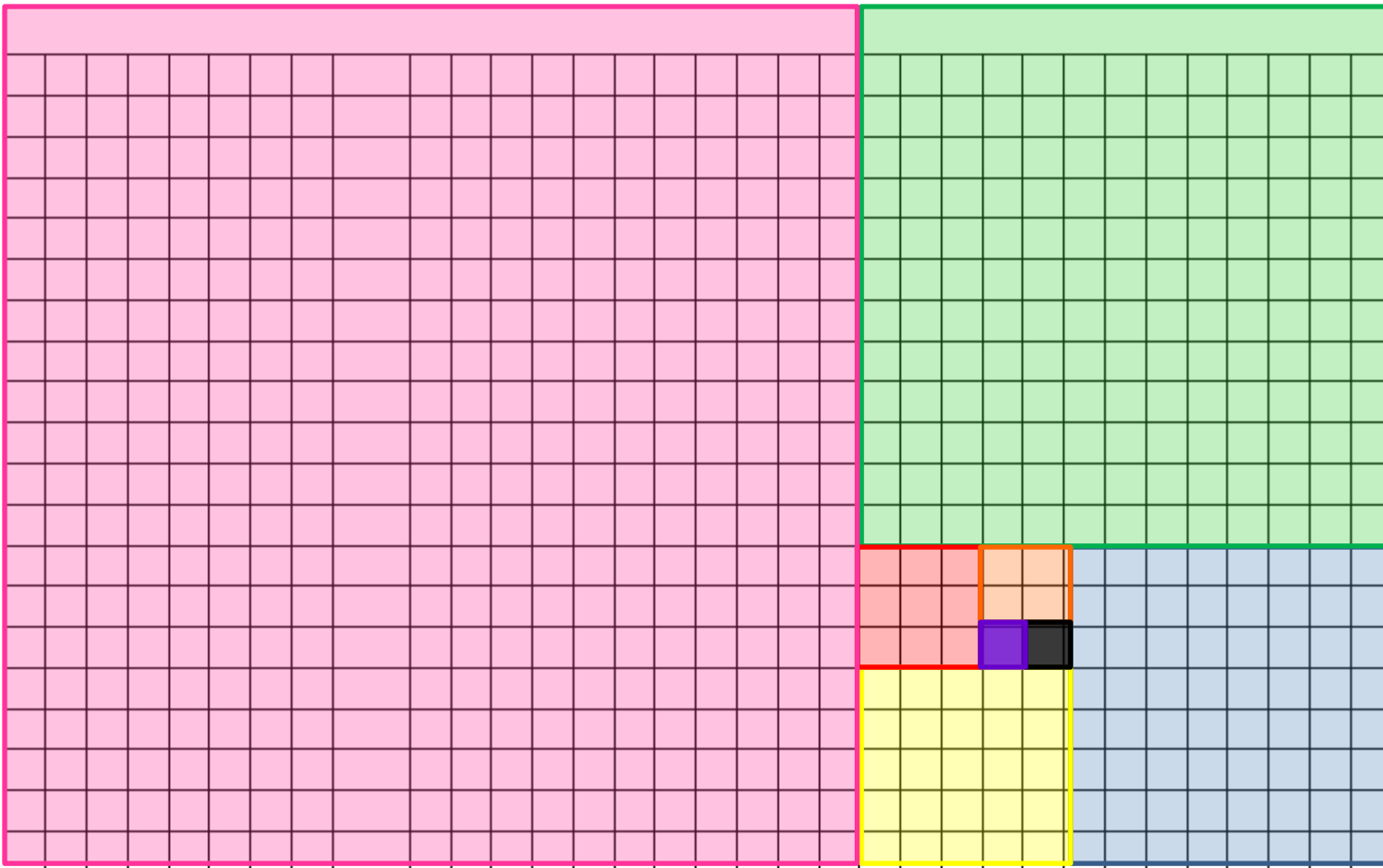
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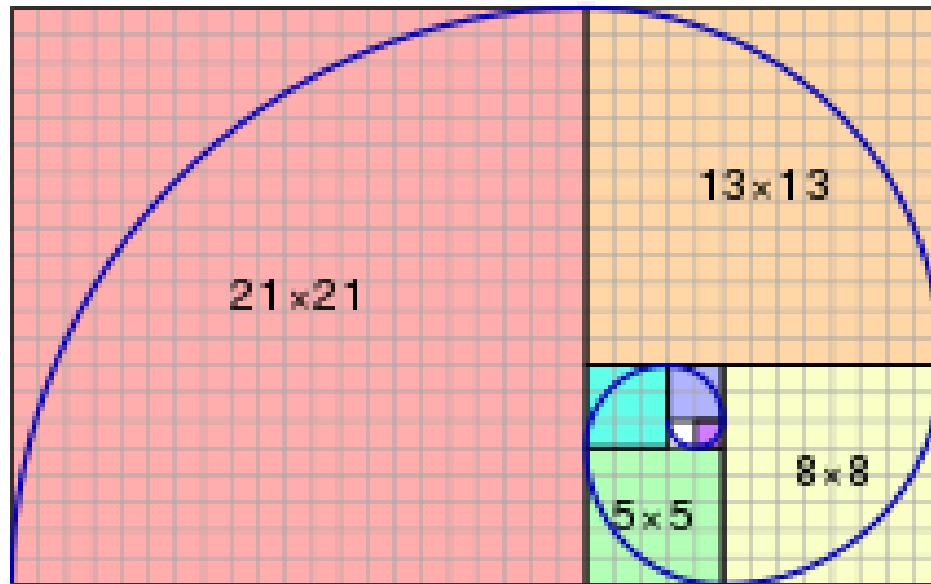
Draw a Fibonacci Spiral

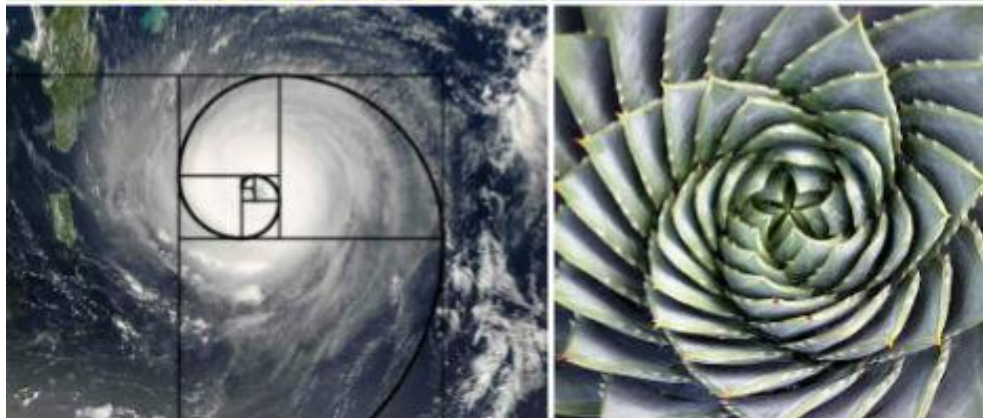
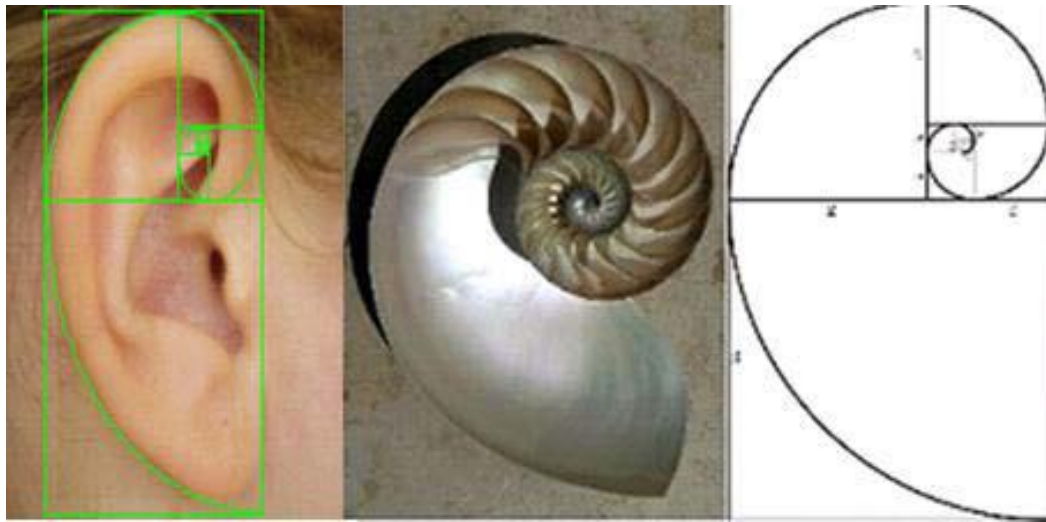
- Directly below, outline a 5x5 square. Continue moving around counter clockwise making an 8x8 square, then 13x13, then 21x21 until you run out of paper.



Draw a Fibonacci Spiral

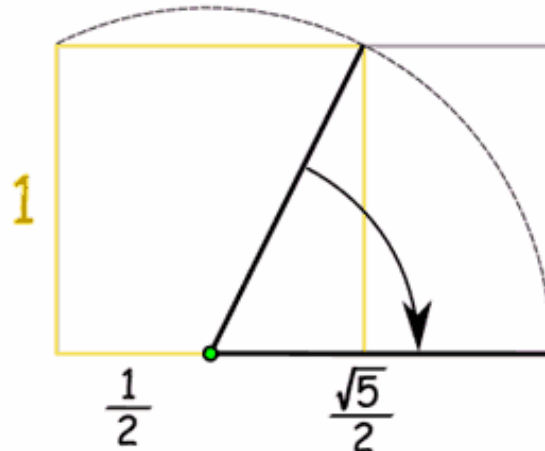
- When all your boxes are outline start connecting the corners. On your first square, draw a line from upper left to lower right. On the second square, from lower left to upper right. On the 2x2 square, from lower right to upper left. Etc.





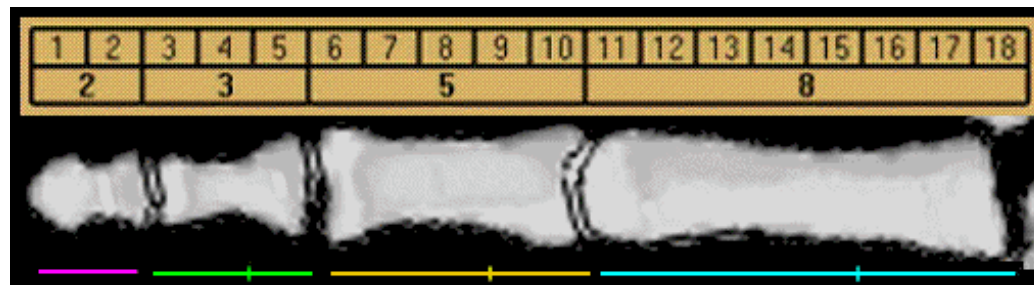
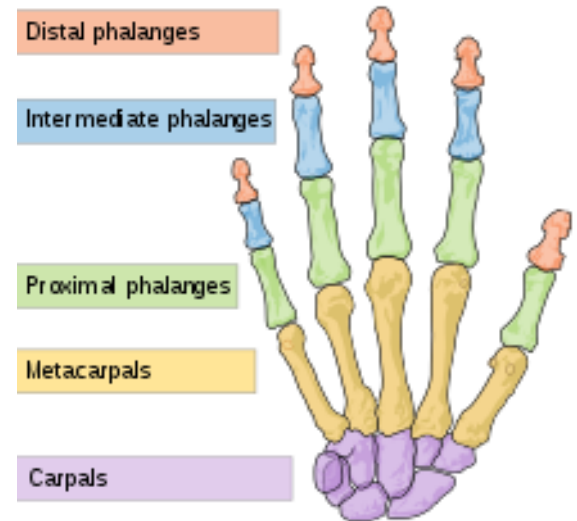
Part III: The Golden Ratio

- Divide each number in the Fibonacci sequence by the previous number.
 - 1/1, 2/1, 3/2, etc.
- See a pattern? Try calculating the decimal expansions
 - 1, 2, 1.66666, etc.
- If you do enough, you'll see that the numbers converge around 1.618 – this is an irrational number $(\sqrt{5} + 1)/2$, called **phi** (or ϕ).
 - Phi, or the “Golden Ratio” comes up in nature again and again...
 - Other names: **golden section, golden mean, golden number, divine proportion, divine section** and **golden proportion**

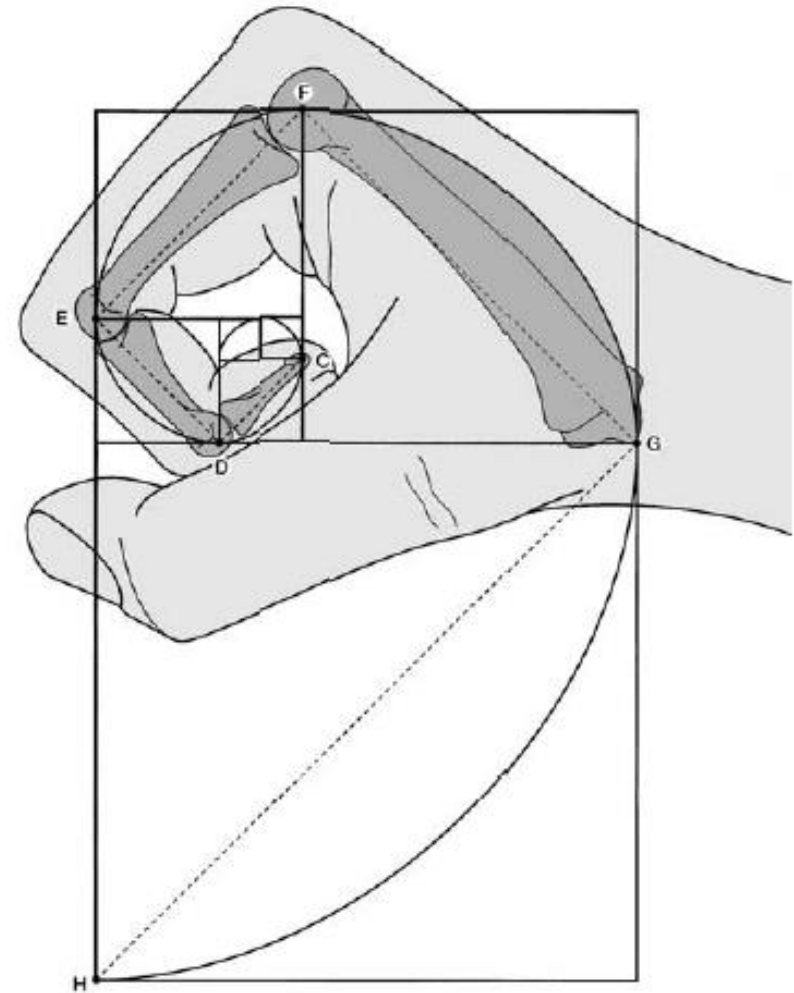
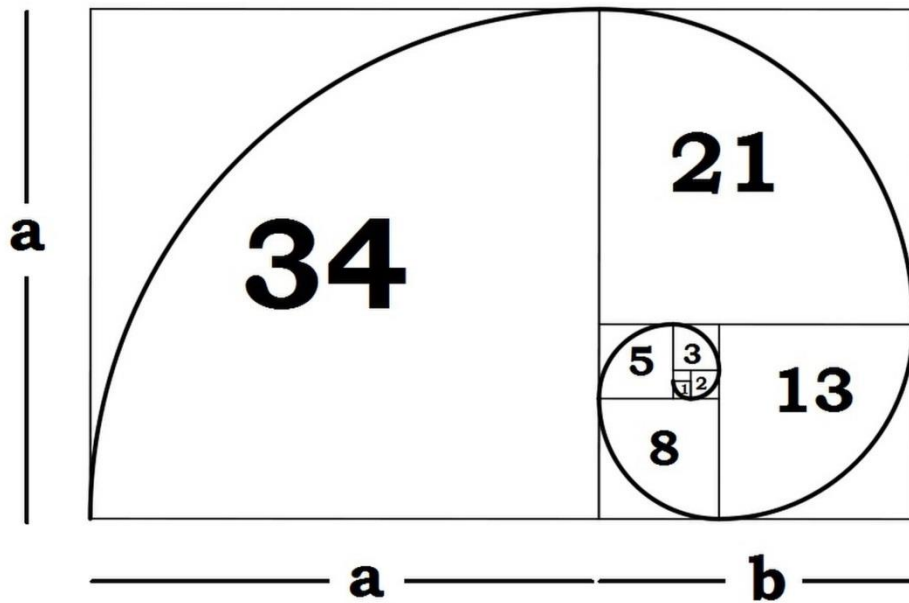


Golden Ratio and the Human Body

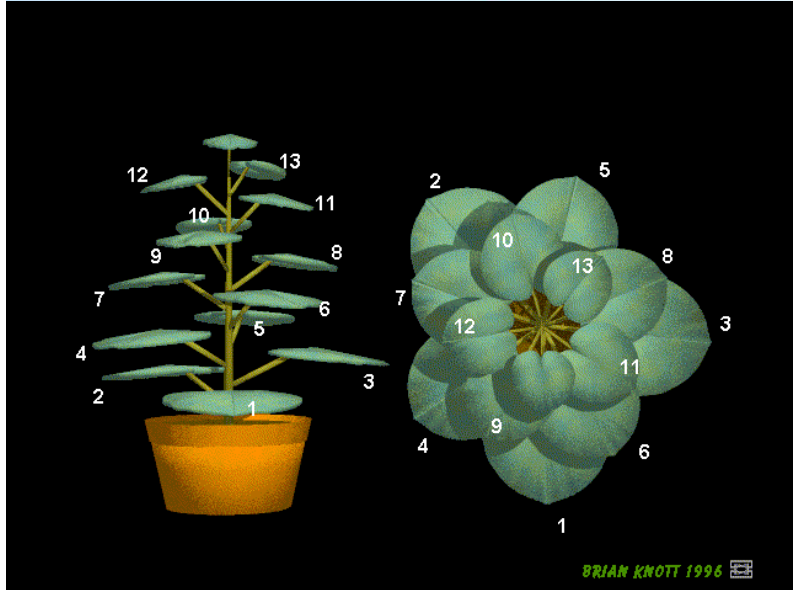
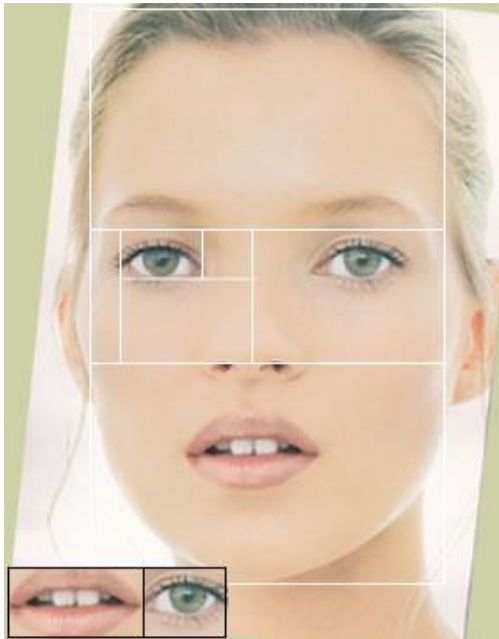
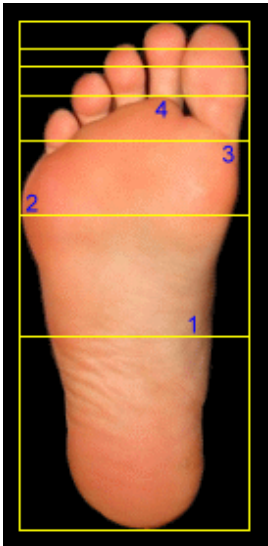
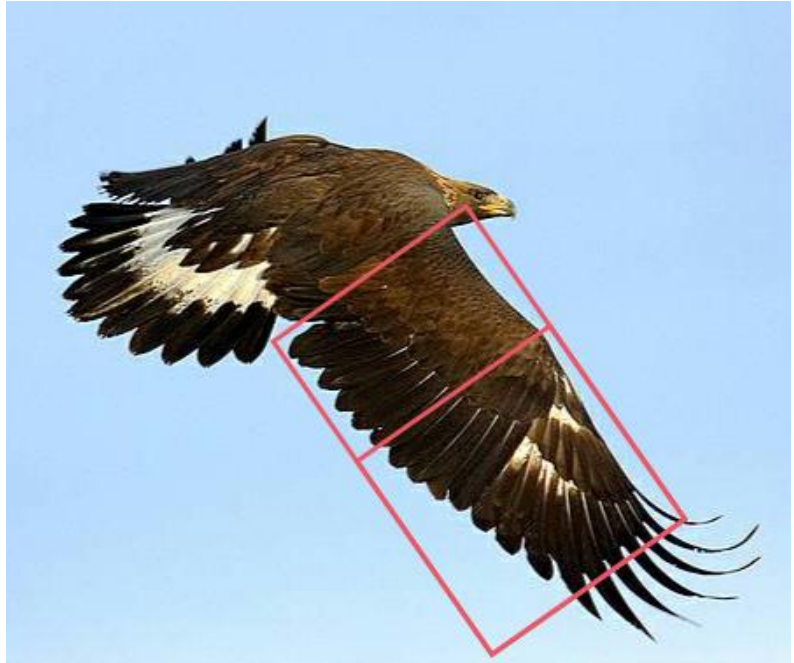
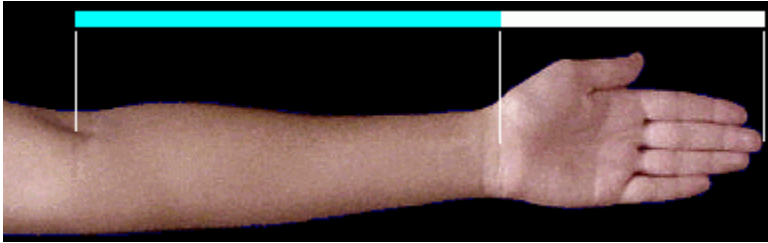
- The Golden Ratio is everywhere in nature, including YOU!
- Try this out:
 - Measure the length of the bone at the end of your index figure (distal phalanges) from the tip of your finger to the middle of the first knuckle
 - Measure the second bone (intermediate phalanges) between first and second knuckle.
 - Measure the third bone (proximal phalanges).
 - Measure the hand bone (metacarpal) between the knuckle and the wrist
 - What numbers do you get? Calculate the ratio between the numbers?



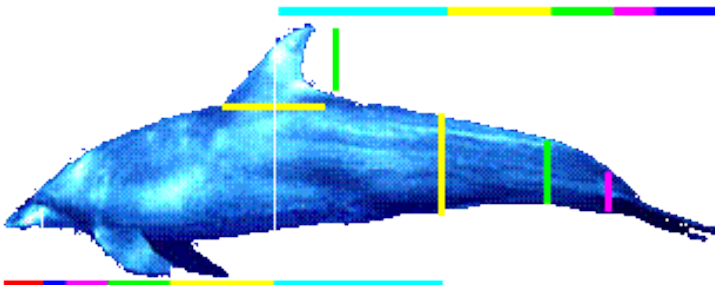
Remember our Fibonacci spiral?



Other examples of the Golden Ratio



BRIAN KNOTT 1996



Why do these patterns exist?

- Humans have recognized these patterns and proportions for centuries
 - Considered the most aesthetically pleasing
- Optimize packing (e.g. for seeds)
- Optimize light exposure (e.g. for leaves)



<https://www.youtube.com/watch?v=2pbEarwdusc>

Spider Web Design Challenge

Spin your best web!

Introduction

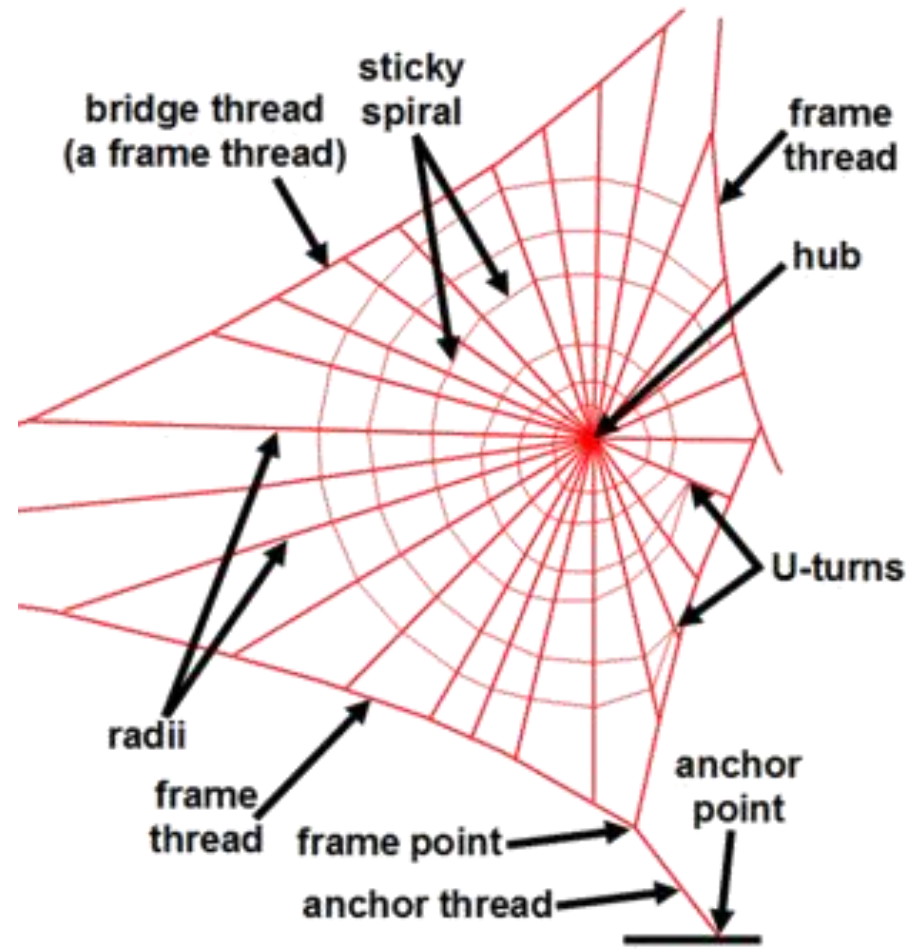
- Why do spiders spin webs?



- <https://animals.howstuffworks.com/arachnids/spider5.htm>
- <https://www.youtube.com/watch?v=zNtSAQHNONo>

Basic spider web structure

- Bridge thread
- Frame threads
- Radius threads
- Auxillary spiral
- Sticky spiral



Design Challenge!

- Materials:
 - Dental floss
 - Dixie cups
 - Tape
 - Scissors
 - Weights (dominoes, magnets, blocks, washers, pennies etc.)
- Work in teams of 3-4
- Design a spider web that can hold the most “flies”
- Rules:
 - Must start with a planning drawing (even if it doesn’t work)
 - Use paper cups as anchor points – anchors must be around the outside (not middle of structure)
 - Must be at least 12” wide (in one direction)
 - The web itself must only be built of floss – no other materials allowed
 - Flies must sit on the web (not the anchor cups)
 - Structure must stand on its own (can’t hold it during test)