Using Squeak to graphically model symmetries in NATURE

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Squeak is:

- a **free** computer program that runs on Windows, Macs, Linux

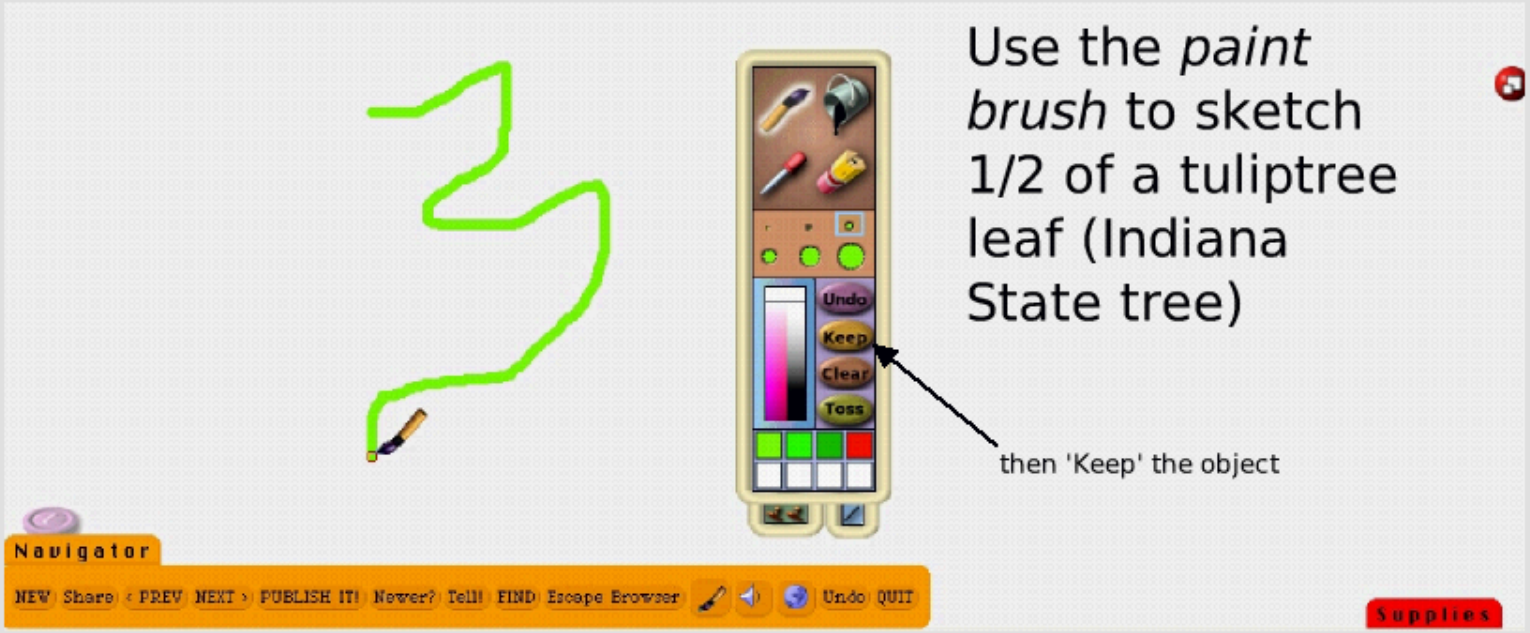
- downloadable from **http://www.squeakland.org**

- a painting, modeling, simulation, animation environment

- **FUN!!**

An object is said to be **symmetrical** if one can subject it to a certain **operation** and it appears exactly the same after the operation as before.
Any such operation is called a **symmetry** of the object.

Modeling the Indiana state tree (leaf)

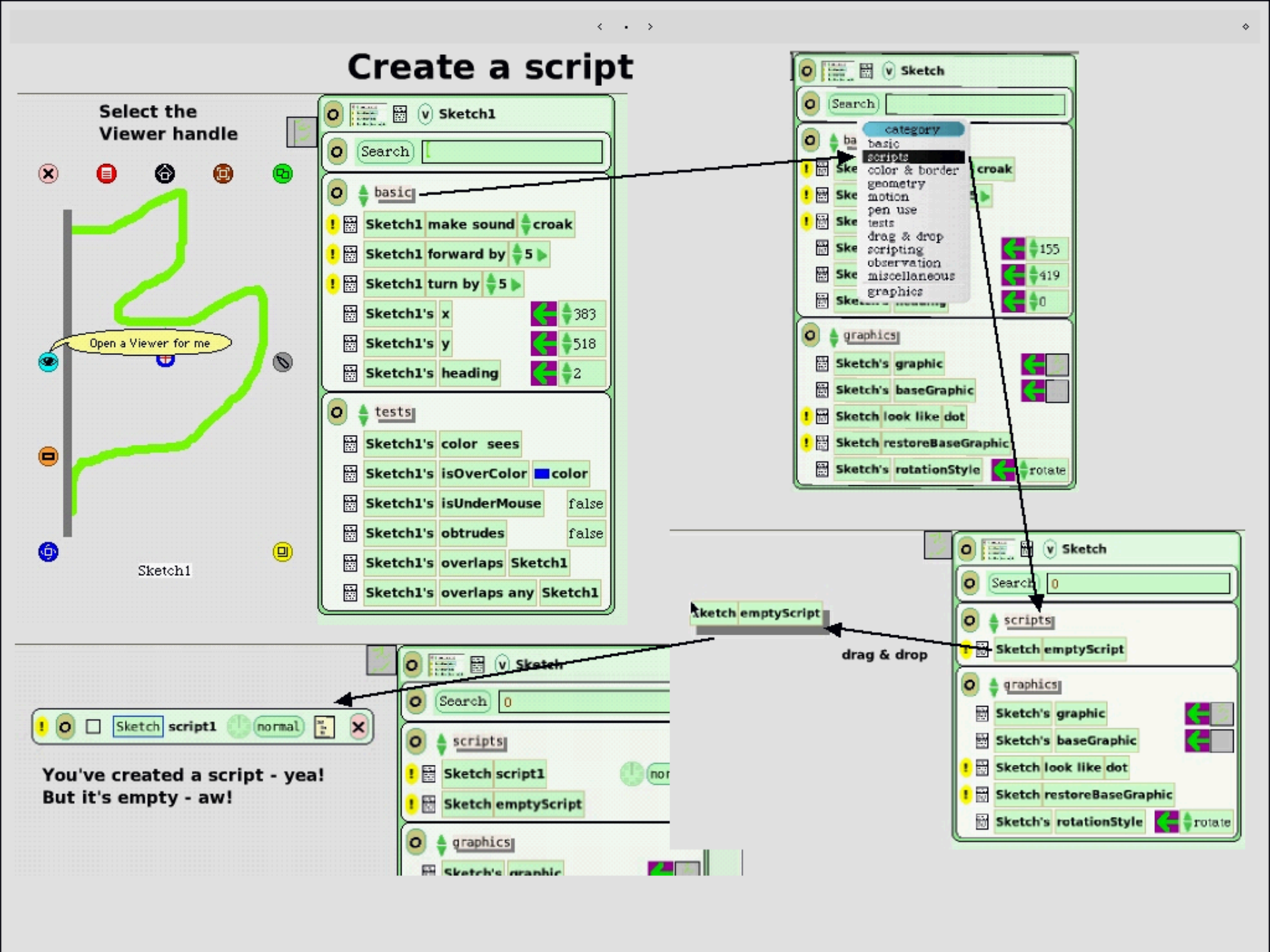


Use the *paint brush* to sketch 1/2 of a tuliptree leaf (Indiana State tree)

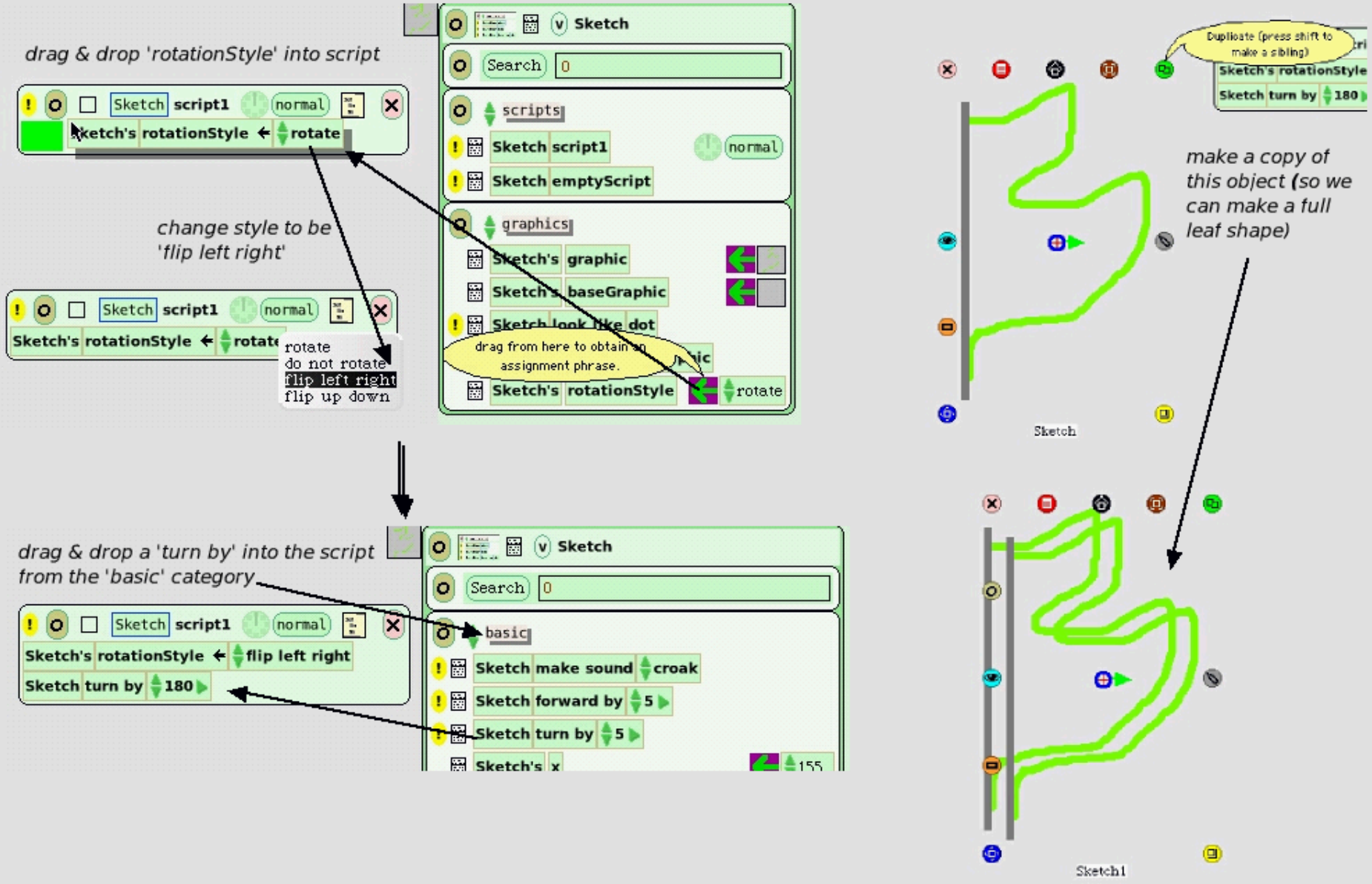
A painted object has *handles* (the circular symbols on an object's border)

This leaf has a **line of symmetry**

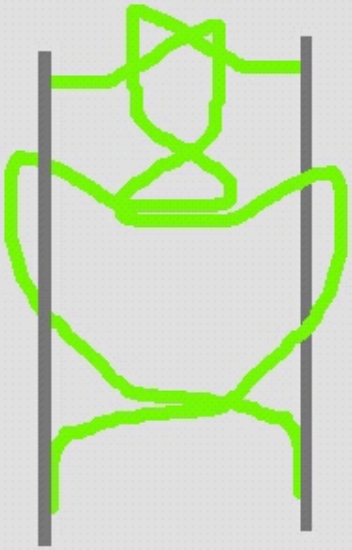
Create a script



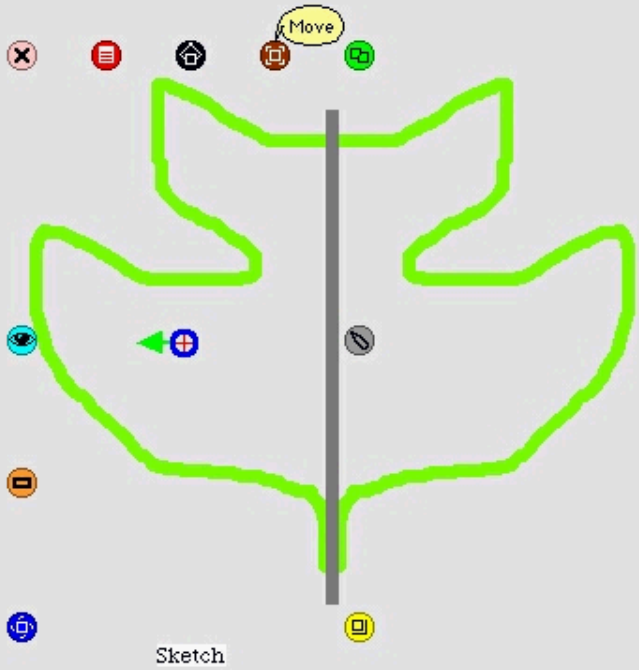
'Program' the script to do reflection symmetry



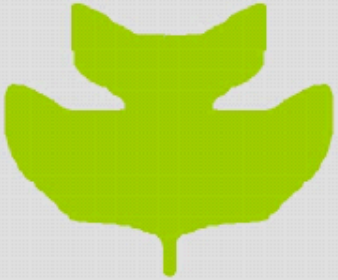
Run the script!



Then move it over to make our complete tuliptree leaf shape



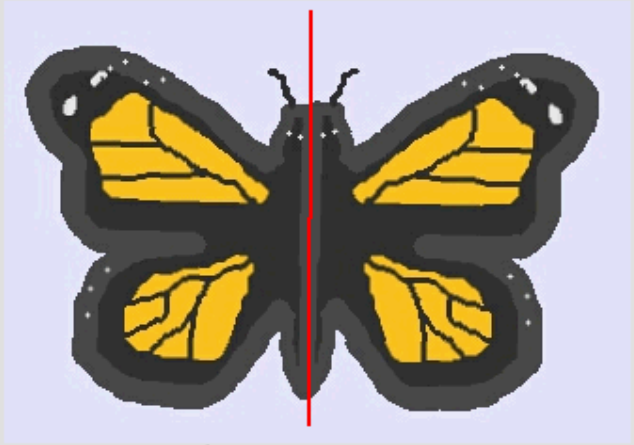
How'd we do?



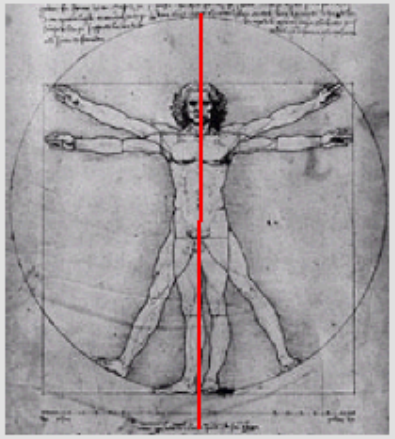
Well, we can always erase or repaint it in Squeak!

A **Line Symmetry** occurs when two halves of a figure mirror each other across a line. In 3-D, this is called **Bilateral Symmetry** (halves are mirrored across a plane).

Common in: flowers*(orchid)* & leaves

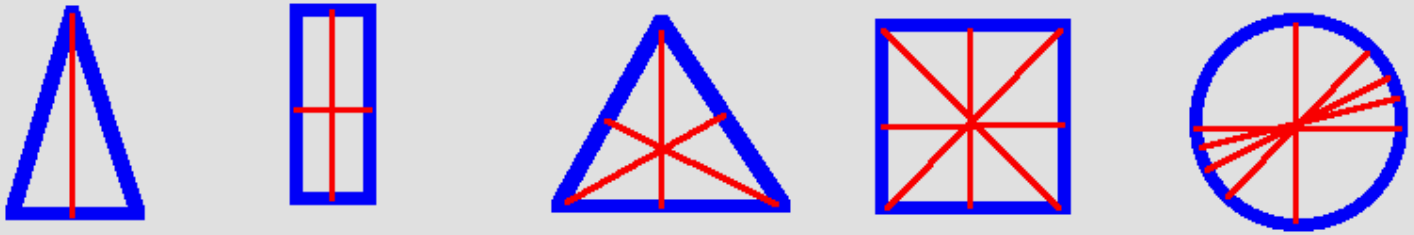


insects *(monarch)*



mammals

In some sense, the degree of symmetry is measured by the number of lines of symmetry:



infinite symmetry?

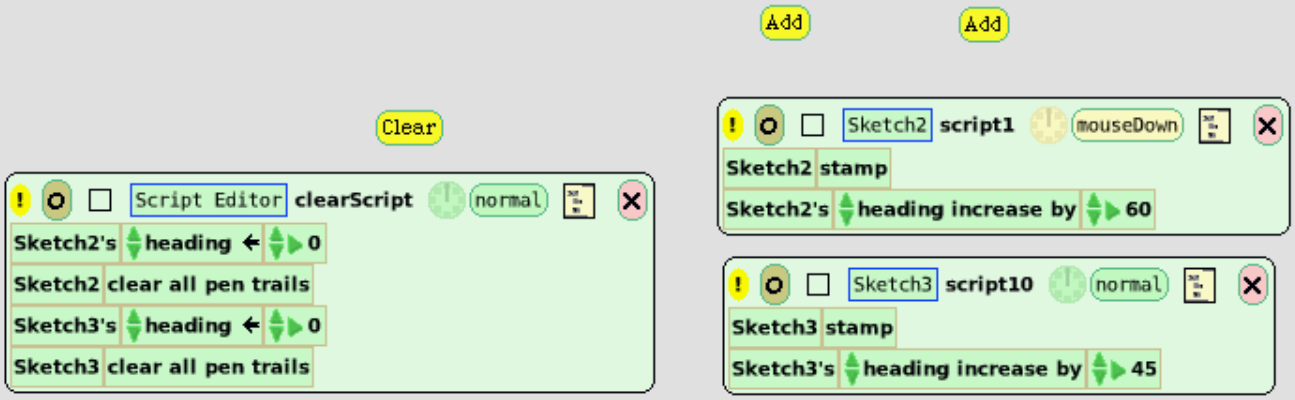
Other symmetries in 2-D: in addition to line symmetry (or **reflection**), there is also **rotation**, **translation**, and **glide reflection**

tiare

Many flowers have **rotation symmetry**

6-fold symmetry

8-fold symmetry



Other examples of **rotation symmetry**

clover

Royal Catchfly wildflower

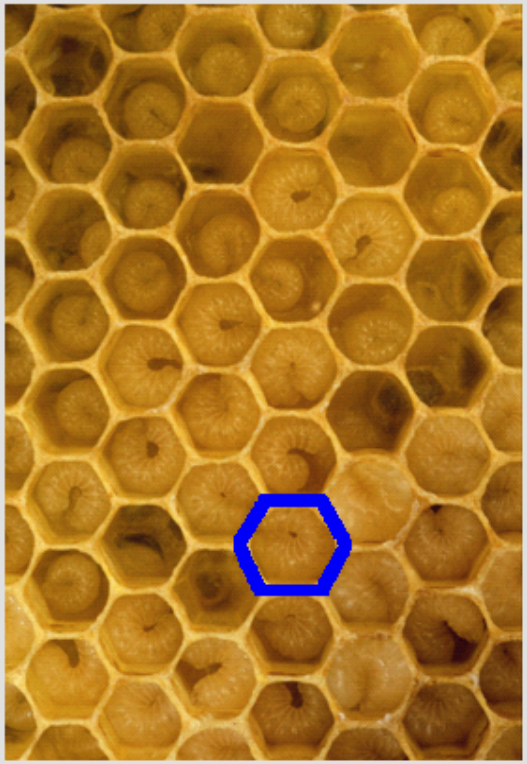
snow crystals

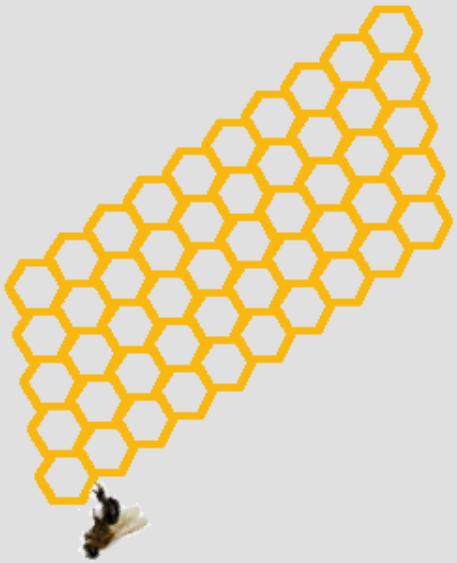
jellyfish

Can something have both rotation symmetry and reflection symmetry?

Can you think of more examples of rotation symmetry in nature?

Example of **translation symmetry**





Clear Start

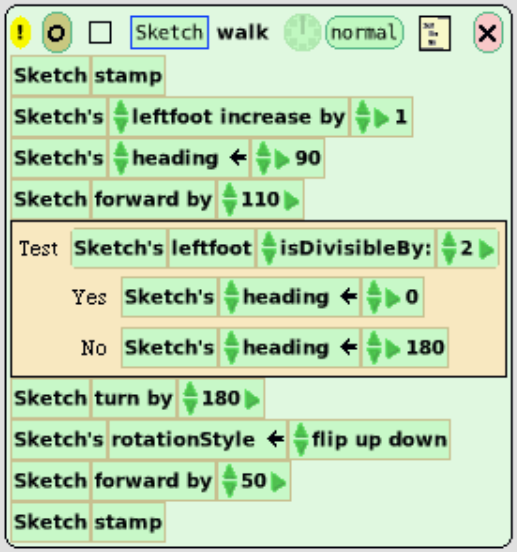
```
! O ☐ Button script1 mouseDown
bee's num2 ← 0
bee's x ← 375
bee's num3 ← 0
bee's num1 ← 0.0
bee's heading ← 90
bee's y ← 500
bee clear all pen trails
```

```
! O ☐ Button1 script1 mouseDown
bee start script script1
```

```
! O ☐ bee script1 normal
Test bee's num1 < 7
  Yes
    bee forward by 15
    bee turn by 60
    bee's penDown ← true
    bee's num1 increase by 1
    Test bee's num2 < 9
      Yes
        bee's penDown ← false
        bee's num2 increase by 1
        bee's x increase by 21
        bee's y increase by 15
        bee's num1 ← 0.0
      No
        bee's penDown ← false
        bee's num2 ← 0
        bee's num1 ← 0.0
        bee's x decrease by 185
        bee's y decrease by 160
        bee's num3 increase by 1
Test bee's num3 > 4
  Yes
    bee stop script script1
  No
```

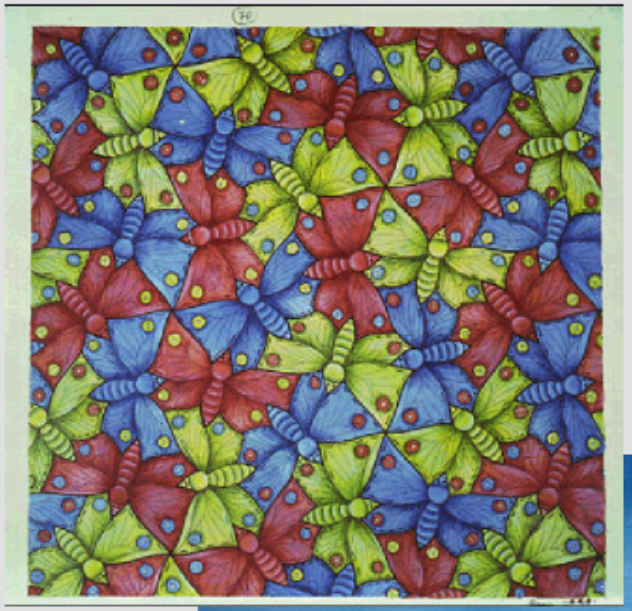
Glide Reflection symmetry

(=translate + reflect)



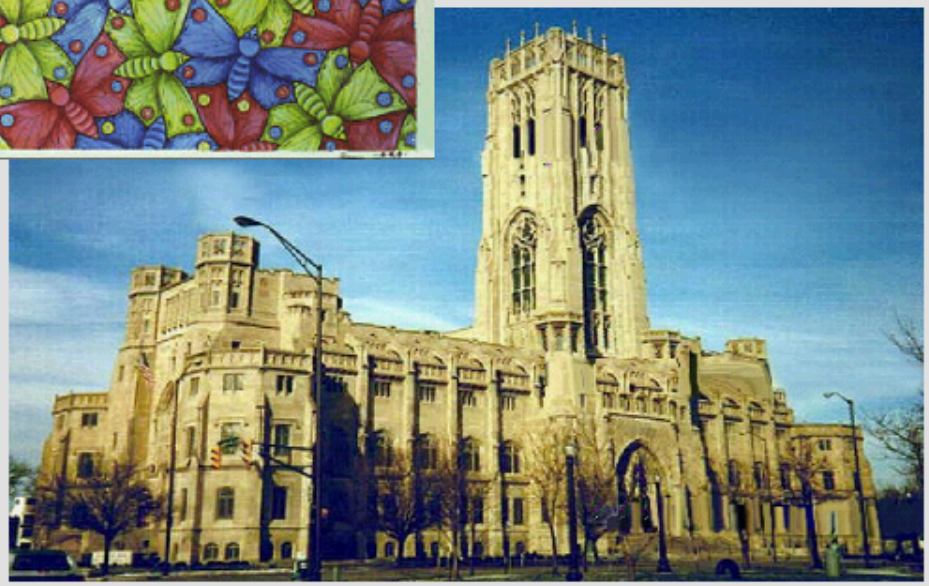
Be careful where those feet are stepping while in nature!

Symmetries are found in places other than nature

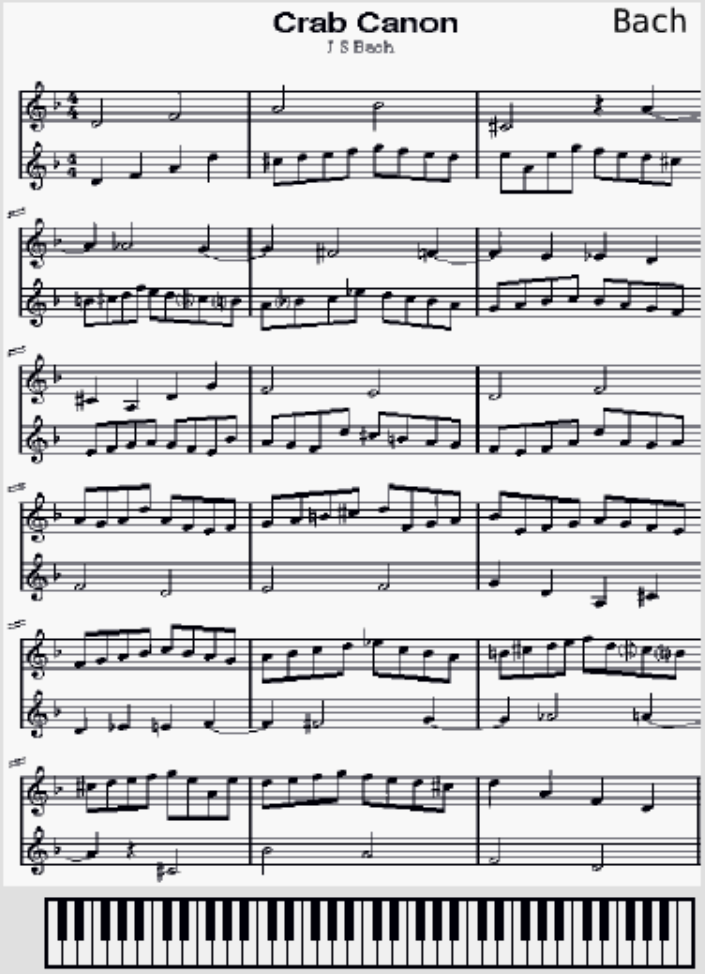


Escher

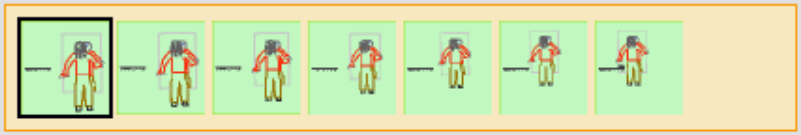
Art,
Architecture,
Music

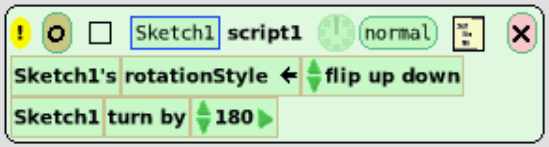


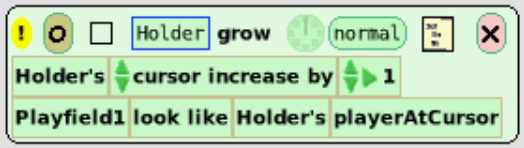
Scottish Rite Cathedral, Indianapolis



Squeak lets you make animations



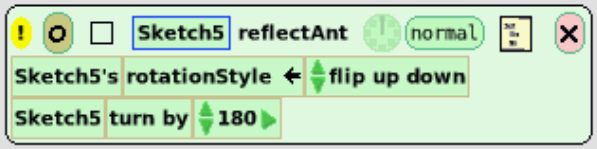


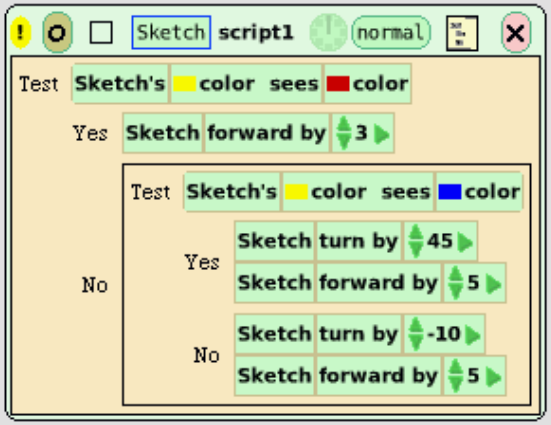


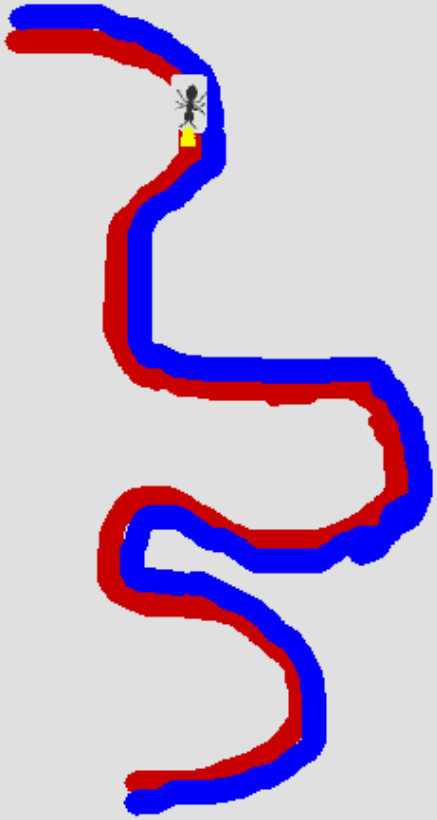
Step Frame

"Smart objects" in Squeak

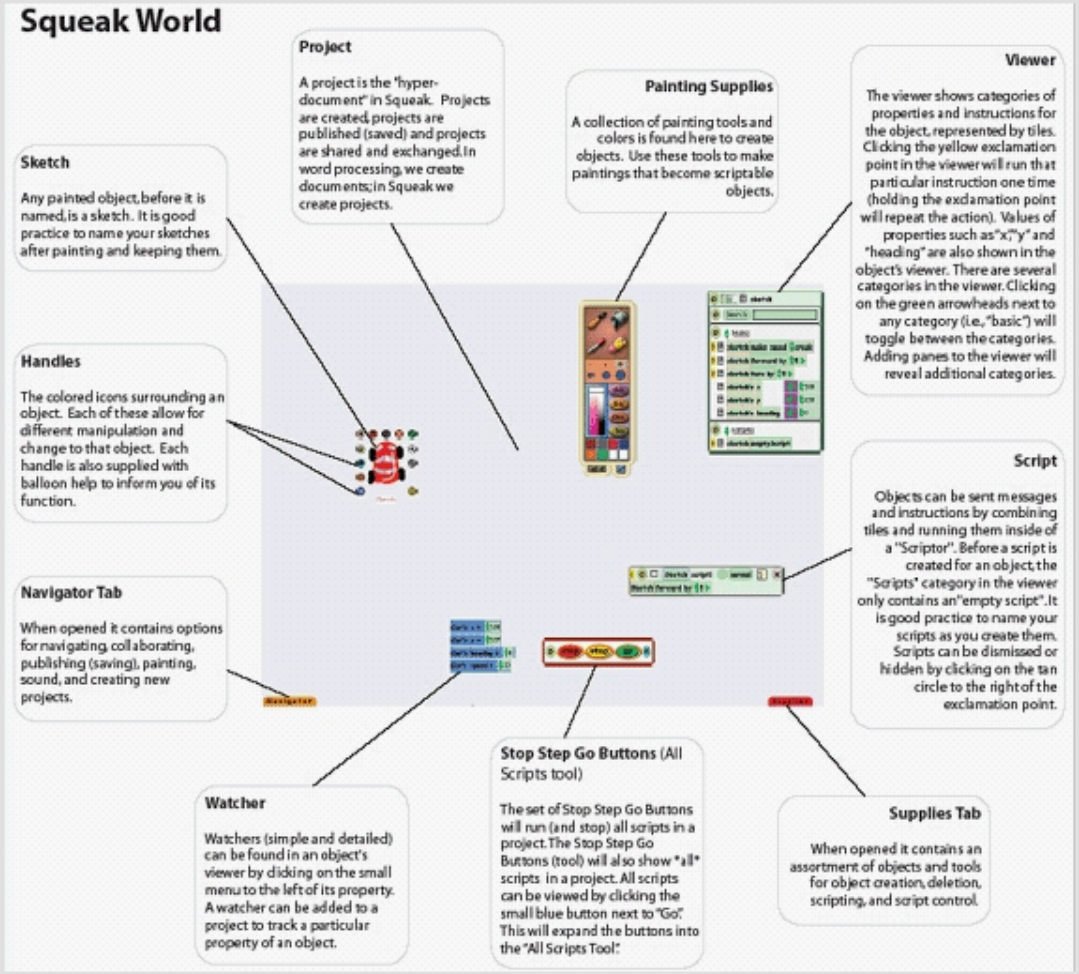
An ant following food trails







Visit **squeakland.org** for tutorials, documentation, and much more!



What about other shapes in nature that are not symmetric - can we model those?