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Using Squeak to graphically model symmetries in **NATURE**

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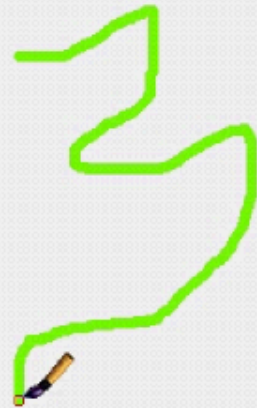
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Squeak is:

- 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)

then 'Keep' the object

Navigator

NEW Share < PREV NEXT > PUBLISH IT! Newer? Tell! FIND Escape Browser Undo QUIT

Supplies



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



This leaf has a **line of symmetry**

Create a script

Select the Viewer handle



Sketch1

Sketch1

Search

basic

- Sketch1 make sound croak
- Sketch1 forward by 5
- Sketch1 turn by 5
- Sketch1's x 383
- Sketch1's y 518
- Sketch1's heading 2

tests

- Sketch1's color sees
- Sketch1's isOverColor color
- Sketch1's isUnderMouse false
- Sketch1's obstructs false
- Sketch1's overlaps Sketch1
- Sketch1's overlaps any Sketch1

Sketch

Search

category

- basic
- scripts
- color & border
- geometry
- motion
- pen use
- tests
- drag & drop
- scripting
- observation
- miscellaneous
- graphics

croak

155

419

0

graphics

- Sketch's graphic
- Sketch's baseGraphic
- Sketch look like dot
- Sketch restoreBaseGraphic
- Sketch's rotationStyle rotate

Sketch emptyScript

drag & drop

Sketch

Search 0

scripts

- Sketch emptyScript

graphics

- Sketch's graphic
- Sketch's baseGraphic
- Sketch look like dot
- Sketch restoreBaseGraphic
- Sketch's rotationStyle rotate

Sketch script1 normal

You've created a script - yea!
But it's empty - aw!

Sketch

Search 0

scripts

- Sketch script1
- Sketch emptyScript

graphics

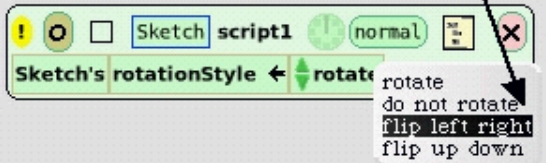
- Sketch's graphic

'Program' the script to do reflection symmetry

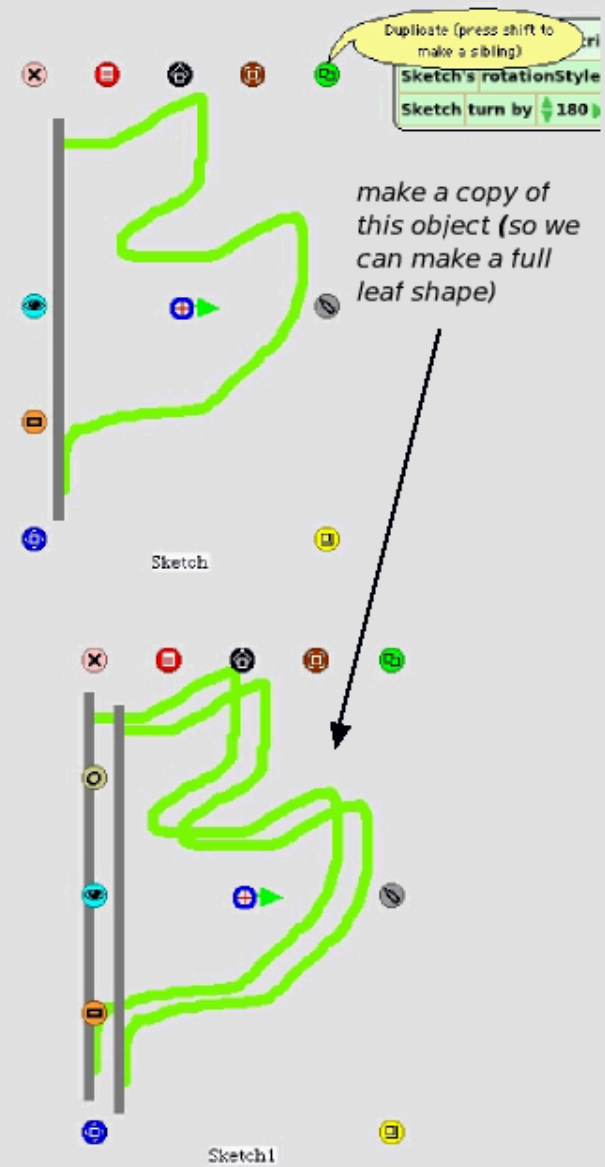
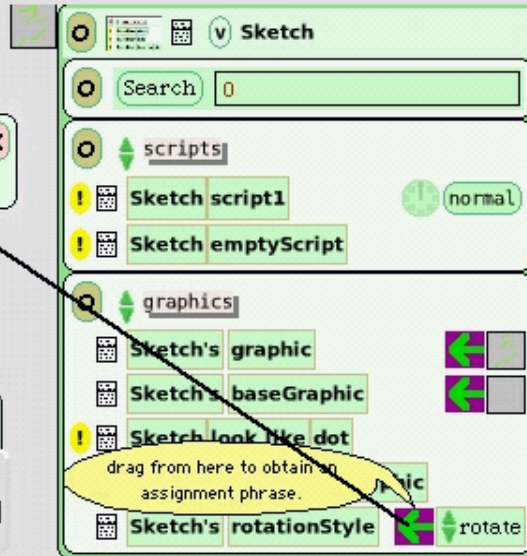
drag & drop 'rotationStyle' into script



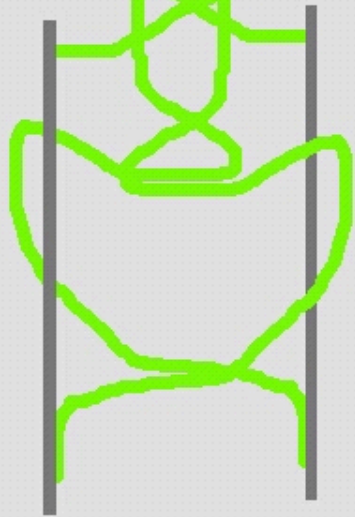
change style to be 'flip left right'



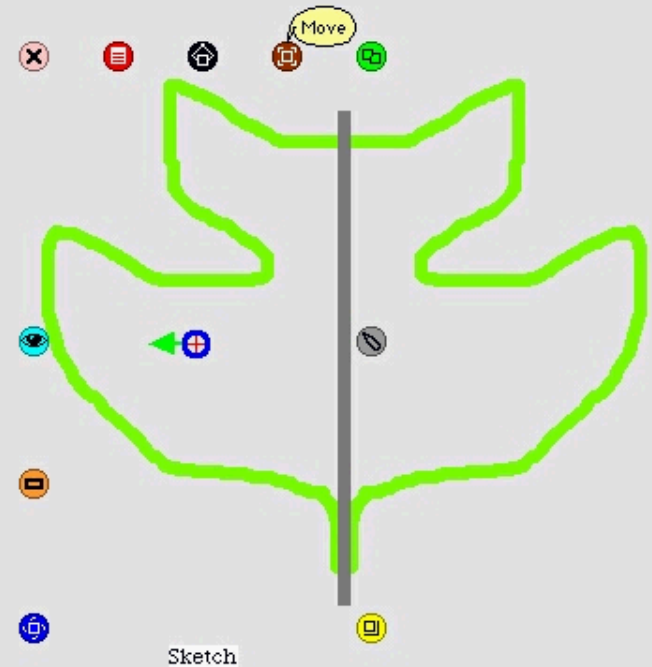
drag & drop a 'turn by' into the script from the 'basic' category



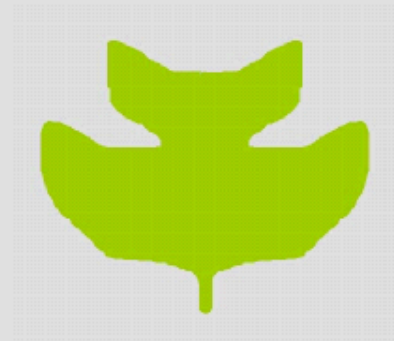
Run the script!



Then move it over to
make our complete
tuliptree leaf shape

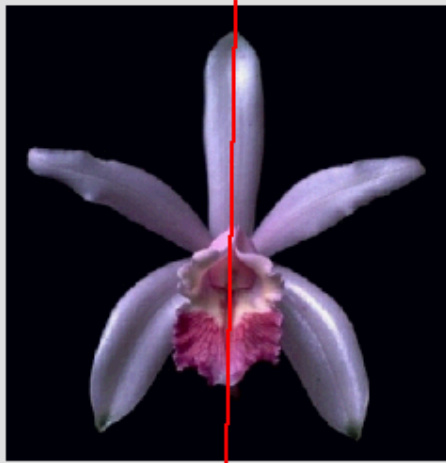


How'd we do?

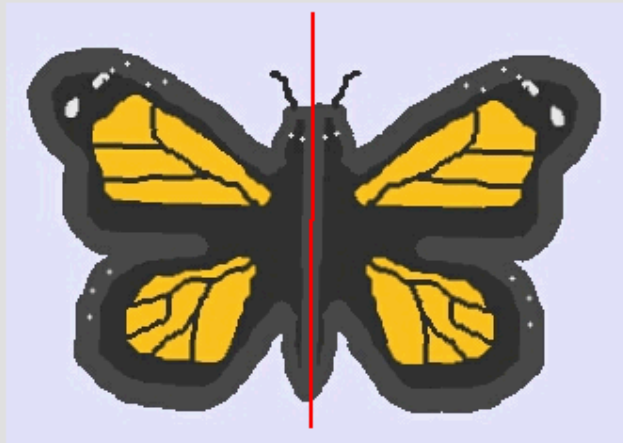


Well, we can always
erase or repaint it in
Squeak!

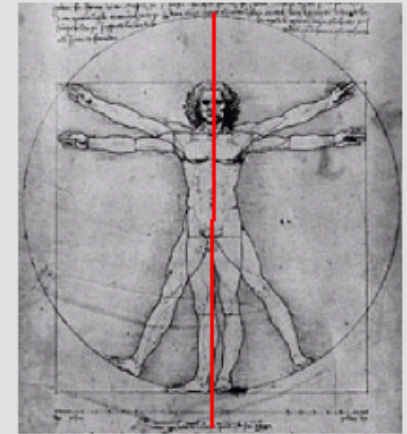
A **Line Symmetry** occurs when two halves of a figure mirror each other across a line. In 3-D, this is called **Bilateral Symmetry** (halves are mirrored across a plane).



Common in: flowers(*orchid*) & leaves

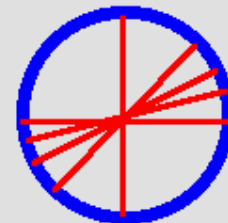
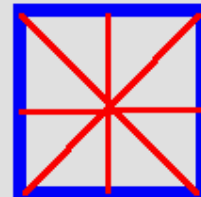
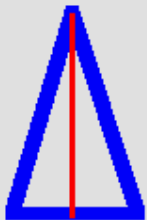


insects (*monarch*)



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



6-fold symmetry



8-fold symmetry

Many flowers have **rotation symmetry**

Add

Add

Clear

```
Script Editor clearScript normal
Sketch2's heading ← 0
Sketch2 clear all pen trails
Sketch3's heading ← 0
Sketch3 clear all pen trails
```

```
Sketch2 script1 mouseDown
Sketch2 stamp
Sketch2's heading increase by 60
```

```
Sketch3 script10 normal
Sketch3 stamp
Sketch3's heading increase by 45
```

Other examples of **rotation symmetry**



clover



Royal Catchfly wildflower



snow crystals

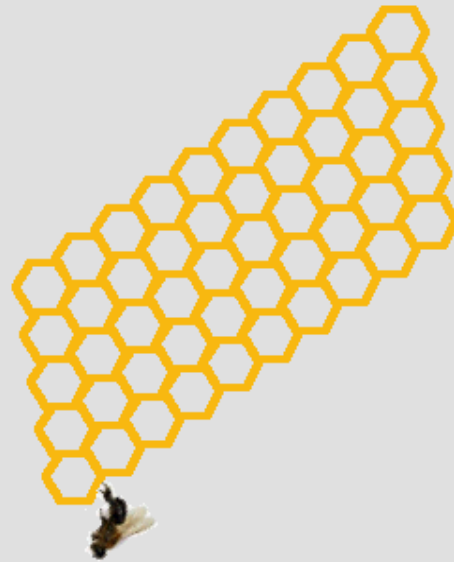
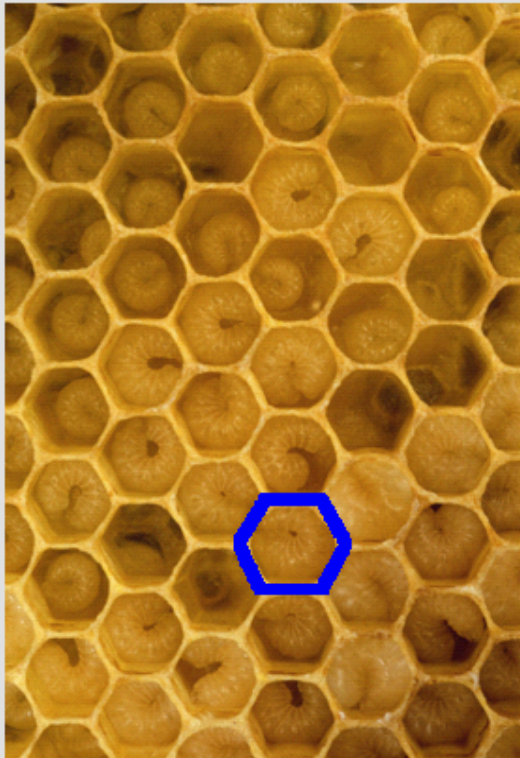


jellyfish

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

bee script1 normal

```
Test bee's num1 < 7
  bee forward by 15
  bee turn by 60
  Yes
  bee's penDown ← true
  bee's num1 increase by 1
  Test bee's num2 < 9
    bee's penDown ← false
    bee's num2 increase by 1
    Yes
    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
    No
    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
```

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
```

Button1 script1 mouseDown

```
bee start script script1
```

Glide Reflection symmetry

(=translate + reflect)

Sketch walk normal

Sketch stamp

Sketch's leftfoot increase by 1

Sketch's heading ← 90

Sketch forward by 110

Test Sketch's leftfoot isDivisibleBy: 2

Yes Sketch's heading ← 0

No Sketch's heading ← 180

Sketch turn by 180

Sketch's rotationStyle ← flip up down

Sketch forward by 50

Sketch stamp

Sketch clearFeet normal

Sketch clear all pen trails

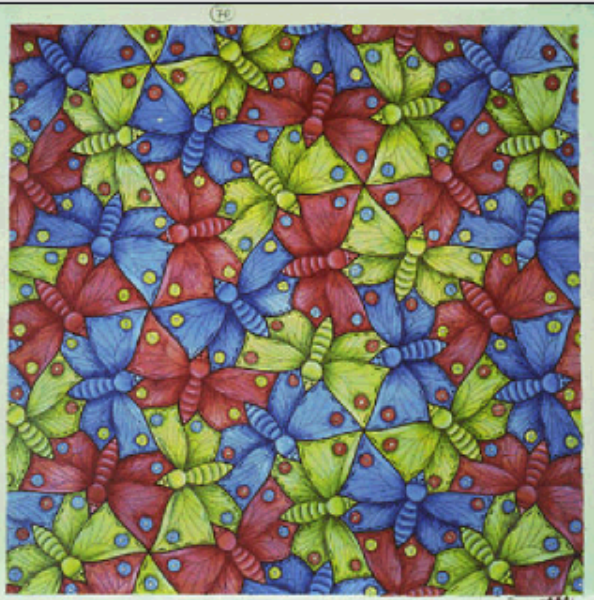
Be careful where those feet are stepping while in nature!

start walking

clear feet

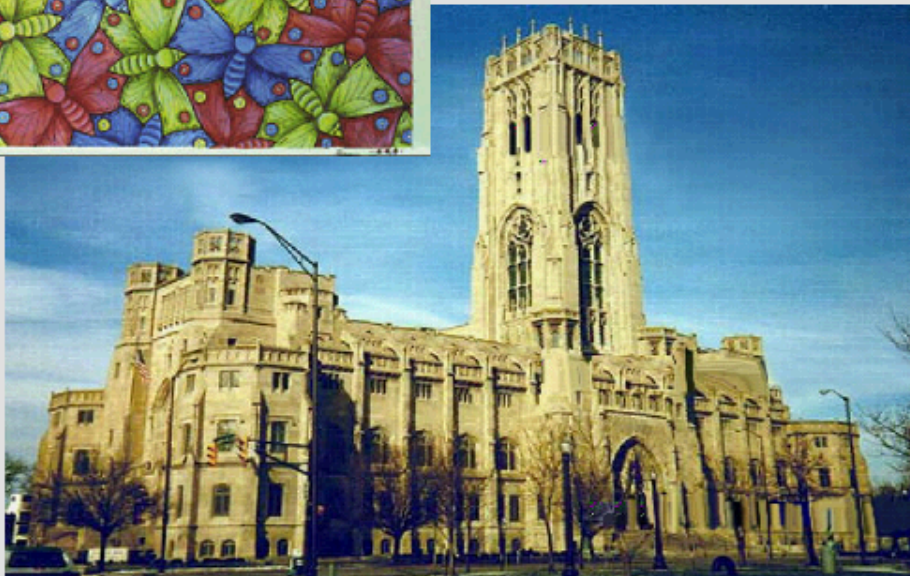


Symmetries are found in places other than nature



Escher

**Art,
Architecture,
Music**

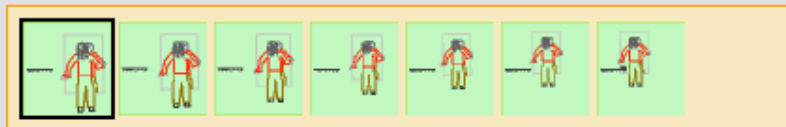


Crab Canon Bach
J S Bach

Musical score for Crab Canon by J.S. Bach, showing multiple staves of music and a keyboard diagram below. The score is written in 4/4 time and features a complex, interlocking melodic structure. The keyboard diagram shows the notes used in the piece, which are primarily in the right hand.

Scottish Rite Cathedral,
Indianapolis

Squeak lets you make animations



! Sketch1 script1 normal [] [X]

Sketch1's rotationStyle ← flip up down

Sketch1 turn by 180 ▶

! Holder grow normal [] [X]

Holder's cursor increase by 1 ▶▶

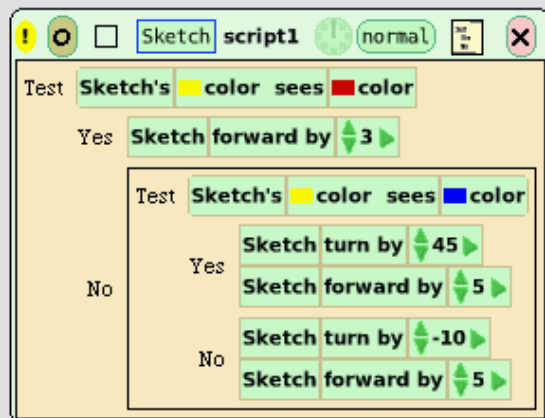
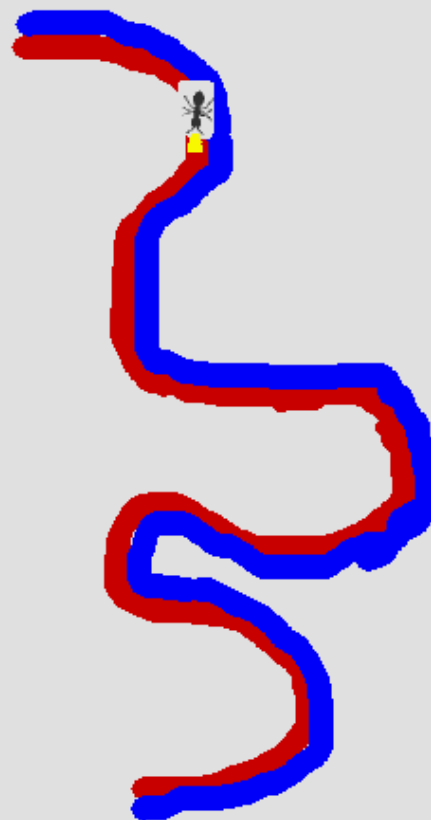
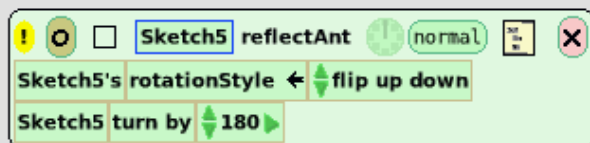
Playfield1 look like Holder's playerAtCursor

Step Frame



"Smart objects" in Squeak

An ant following food trails



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

Squeak World

Project
A project is the "hyper-document" in Squeak. Projects are created, projects are published (saved) and projects are shared and exchanged. In word processing, we create documents; in Squeak we create projects.

Painting Supplies
A collection of painting tools and colors is found here to create objects. Use these tools to make paintings that become scriptable objects.

Viewer
The viewer shows categories of properties and instructions for the object, represented by tiles. Clicking the yellow exclamation point in the viewer will run that particular instruction one time (holding the exclamation point will repeat the action). Values of properties such as "x," "y" and "heading" are also shown in the object's viewer. There are several categories in the viewer. Clicking on the green arrowheads next to any category (i.e., "basic") will toggle between the categories. Adding panes to the viewer will reveal additional categories.

Sketch
Any painted object, before it is named, is a sketch. It is good practice to name your sketches after painting and keeping them.

Handles
The colored icons surrounding an object. Each of these allow for different manipulation and change to that object. Each handle is also supplied with balloon help to inform you of its function.

Navigator Tab
When opened it contains options for navigating, collaborating, publishing (saving), painting, sound, and creating new projects.

Script
Objects can be sent messages and instructions by combining tiles and running them inside of a "Scriptor". Before a script is created for an object, the "Scripts" category in the viewer only contains an "empty script". It is good practice to name your scripts as you create them. Scripts can be dismissed or hidden by clicking on the tan circle to the right of the exclamation point.

Stop Step Go Buttons (All Scripts tool)
The set of Stop Step Go Buttons will run (and stop) all scripts in a project. The Stop Step Go Buttons (tool) will also show *all* scripts in a project. All scripts can be viewed by clicking the small blue button next to "Go". This will expand the buttons into the "All Scripts Tool".

Supplies Tab
When opened it contains an assortment of objects and tools for object creation, deletion, scripting, and script control.

Watcher
Watchers (simple and detailed) can be found in an object's viewer by clicking on the small menu to the left of its property. A watcher can be added to a project to track a particular property of an object.

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

