# the botany of desire

Based on the book by Michael Pollan

## patterns in nature (beauty)

People have long seen beauty in the geometric shapes and patterns found in tulips and other flowers. In this lesson, students will observe and categorize these shapes, and discuss how tulips, by appealing to our desire for beauty, have spread themselves around the world.

# patterns in nature (beauty)

## overview

When we hear the word beauty, often the first thing that comes to mind is something in nature: a sunset, a cloud formation, a mountain range, or the ripples on water coursing through a mountain stream. But perhaps nothing has come to epitomize beauty in nature more than flowers. *The Botany of Desire* argues that people have a desire to experience beauty, and that by being especially good at satisfying this desire, one flower, the tulip, has spread itself around the world.

In this lesson, we'll explore how people perceive beauty more deeply by observing geometric shapes in plants and flowers; by studying different kinds of patterns in nature; and by using natural forms as an inspiration to create art.

Students will use computer-generated images of fractals and tessellations to create objects possessing the characteristics they deem beautiful.

As a culmination, students will participate in a hands-on simulation that demonstrates how human preferences for "beauty" and the mechanisms of natural selection have led to an increased frequency of particular traits expressed in the gene pool of a species.

*Everyday roles and values are suddenly, thrillingly, suspended, and astounding new possibilities arise.*

– Michael Pollan,
*The Botany of Desire*

## objectives

Students will:

- Explore the history of beauty as it relates to the tulip.
- Create an object they deem beautiful using computer generated fractals, tessellations, origami, or molecule builders.
- Create a beautiful flower using food coloring with carnations or by manipulating pH in hydrangeas.
- Establish criteria for determining "beauty."
- Use those criteria to defend their belief that an object is or is not beautiful.
- Generate questions as a result of reading about and/or observing patterns/order/chaos in nature.
- Examine the theory of natural selection through observation of the interaction of bees and flowers.

## grade level: Grades 5-12

## subject areas:

**Art, Physical Science, Life Science, Biology and Chemistry**

## National Visual Arts Education Standards

**Visual Arts National Content Standard 1 Understanding and applying media, techniques, and processes**

**Achievement Standard Grades 5-8**

- Students select media, techniques, and processes; analyze what makes them effective or not effective in communicating ideas; and reflect upon the effectiveness of their choices.
- Students intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas.

**Achievement Standard Grades 9-12**

- Students apply media, techniques, and processes with sufficient skill, confidence, and sensitivity that their intentions are carried out in their artworks.
- Students conceive and create works of visual art that demonstrate an understanding of how the communication of their ideas relates to the media, techniques, and processes they use.

## National Science Education Standards

**Science National Content Standard 1: Science as Inquiry**

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

**Science National Content Standard 2: Physical Science**

- Structure and properties of matter

**Science National Content Standard 5: Science and Technology**

- Abilities of technological design
- Understandings about science and technology

**Science National Content Standard 7: History and Nature of Science**

**As a result of activities in grades 5-12, all students should develop understanding of:**

- Science as a human endeavor
- Nature of science
- History of science

## materials needed

- Apples
- A variety of natural objects that exhibit patterns, form, or beauty in nature. The collection can include any or all of the following:
    - segment of a wasp nest or honeycomb
    - a spiral shell
    - ammonite galena
    - halite or fluorite
    - sweetgum balls
    - echinoderms
    - starfish
    - pine frond
    - pine cones
    - leaf edges
    - Romanesco broccoli
    - nautilus
    - millipede
    - snake skin
    - butterfly wings
    - zebra skin
    - sunflower (and/or other seeds)
- Construction paper
- Scissors
- Hand lenses
- Pen or Pencil
- Notepad
- Stopwatch
- Clips from the film *The Botany of Desire* (available online)

## estimated time needed

120+ minutes

# background

All forms of life are constructed of nine basic designs. The nine designs are listed below and are often combined as composite forms that can include all nine or just a few.

1. the sphere and spheroid
2. the circle and ellipse
3. the cube
4. the cylinder
5. the spiral
6. the undulate
7. the pyramid and triangle
8. the lattice
9. the frond

Identifying the world's shapes can be a fascinating exercise. For example, conifer trees, such as the spruce and the balsam fir, illustrate how objects in nature can combine all of the forms.

- The tree itself is a pyramid (7).
- Its root system and boughs are arranged in dendritic patterns and fronds (9).
- Roots and boughs spread outward from a cylinder of the trunk (4).
- Around the trunk the branches rise in a spiral (5). (Spirals are common in nature as seen in the vine of a morning glory flower, in the scales of flowers and cones, and in the way leaves and needles wind around twigs and branches.)
- A close examination of a pine tree's needles reveals an undulate (6). In general, leaves have the undulated (i.e., toothed, notched, or wave edged) pattern.
- The tree's resin ducts, like the minerals Halite (salt) and Galena (lead ore), are cubes (3).
- Its needles, like twigs and human fingers, are cylinders (4).
- Leaf and wood fibers are lattices (8).
- The cells in the wood and needles (like those in blood) are spheres or spheroids (1).
- Finally, if the sun shines just right, the shadow of a tree forms a rough circle or ellipse (2).

When you look at any living thing as a whole, it is made of many geometric shapes or patterns – the composite. We don't need to know scientific names, economic value, or botanical details to appreciate a tree. We can appreciate the tree simply because it is beautiful in many ways.

*"Beauty is truth;*
*Truth beauty.*
*That's all on earth*
*ye know.*
*And all ye need to know."*

-John Keats

*Note to Teachers: To view the movie clips referenced in these steps, please go to this lesson plan's page on The Botany of Desire website at* **http://www.pbs.org/thebotanyofdesire/lesson-plan-beauty.php** *and choose the clip from the video player.*

# Part 1: Patterns and Beauty in Nature

The following steps (1 - 4) include clips from the film *The Botany of Desire*, available online, as well as discussion questions.

1. View *Clip 1* and discuss with your class. Have your students share their thoughts on Michael Pollan's observations. In particular, pose the question: What aesthetic tastes do bees and humans have in common?
2. View *Clip 2* and discuss the following questions with your class. What is your opinion of tulips compared to other flowers? Are they more or less beautiful?
3. View *Clip 3* and discuss the following questions with your class. Are there rational explanations for "beauty?" How obsessed with beauty are Americans? Do other cultures have obsessions with beauty?
4. View *Clip 4* and discuss the following questions with your class. What is the practical purpose of flowers? From an economic standpoint, how important is the idea of beauty to people today? Did we learn a lesson from "Tulipmania?"
5. Have your students explore the *Perceiving Beauty* interactive on the website: http://www.pbs.org/thebotanyofdesire/perceiving-beauty.php. The interactive experience prompts users to detect traits (such as symmetry, color, vibrancy, and health) that appeal to users' perceptions of beauty. Provide the following questions for your students to consider as they explore the interactive:
   - Think about your own personal opinion of beauty. Which traits do you think influence how you perceive beauty?
   - Do you find beauty in things that are more complex or more simplistic? Or both?
   - What are the likely evolutionary advantages to possessing traits that are considered beautiful?

   After reviewing the interactive and answering the questions, encourage your students to reflect on the experience and write a summary paragraph about what they learned about their perceptions of beauty.
6. Provide examples of as many different beautiful patterns/forms as possible and place them on tables or on a media screen for your students to see. If possible, include a variety of living things (including bugs!) and place them in Petri dishes to be examined with stereoscopes and microscopes [Note: An alternative is to take students on a treasure hunt asking them to collect/provide examples from nature according to the following shapes: (1) the sphere and spheroid, (2) the circle and ellipse, (3) the cube, (4) the cylinder, (5) the spiral, (6) the undulate, (7) the pyramid and triangle, (8) the lattice, (9) the frond.]

7. As a class, first arrange the objects according to similarities/differences in form. (Depending on the objects, it may make more sense to examine their coloring patterns or markings, as opposed to their overall shapes.). Ask students how easy or difficult it was to arrange the objects.
8. As a class, arrange the objects according to beauty. This should prove to be more difficult to reach a classroom consensus because of differing perceptions of beauty. At minimum, try to establish consensus on the objects that belong on the extreme ends of a "beauty continuum." Are there certain forms that tend to be placed on either end of the continuum? If there is strong disagreement on the objects' beauty, have students discuss the reasons for the lack of consensus.
9. Share *your* choice for most beautiful with your students and why it is your favorite.
10. Have students organize the objects based on their personal preferences of beauty. Using the table template provided as a reproducible, students should arrange the objects in their preferred order, from most beautiful to least beautiful. Students should also designate the objects' primary categories of beauty based on the following: *Health, Symmetry, Vibrancy, and Complexity.* Additionally, students should identify the objects' more striking qualities that elevate or minimize their beauty.
11. As a class, have students share their arrangements. Do common themes emerge? Was it color, shape, form, or geometric pattern that was found to be the most beautiful? Have your students reflect on how their findings compare with others.

# Part 2: Generating Patterns and Beauty with Technology

1. *Note to Teachers:* Familiarize yourself with the concepts of fractal and tessellation generators by visiting the website resources below. This will prepare you for the discussion with your students.
2. As a way to introduce the beautiful patterns found in nature and to prompt a discussion with your students on how they occur, introduce and discuss online fractal and tessellation generators.
3. Have your students explore the websites below, observing and creating basic fractals and tessellations. Have them consider the questions below as they review the sites:
    - What are the most beautiful representations of fractals and tessellations in nature?
    - How and why does nature fold things? (See Ha-ori leaf folding or Miura folding patterns.)
    - How might I use unusual shapes to break the rules of traditional geometry?
    - What is the shape of a beautiful fractal or tessellation or origami object?
    - What role does the concept of "the infinite" have in art?
    - What variables might I manipulate in order to create a desired, symmetry, color, or form?
    - How might I incorporate bumps, curves, folds, spikes, and curls into a piece of artwork to achieve my definition of beauty?

- What are the most beautiful sorts of fractals? (Graftals, Mandelbrots, L-systems, IFS theory fractals, Von Koch curves or Sierpinski triangles?)

4. Have your students create original pieces of work that they consider beautiful, incorporating the knowledge they have gained by exploring the basics of fractals and tessellations and answering the questions.
5. Have your students present their works to the class. Encourage them to share their reasons for creating what they chose to create and the process they employed.

**Patterns in Nature**
http://www.math.smith.edu/phyllo//

**Visual Math**
http://www.miqel.com/fractals_math_patterns/visual-math-phi-golden.html

**Fractal Generators**
http://polymer.bu.edu/java/java/anthill/Anthill.html
http://www.utopiansky.com/labratory/fractals/
http://www.wackerart.de/gold_fractal_2.html

**Tessellation Generators**
http://www.shodor.org/interactivate/activities/Tessellate/?version=1.6.0_05&browser=MSIE&vendor=Sun_Microsystems_Inc.&flash=10.0.22

**Molecule Builders**
http://www.molecular-networks.com/tmp/corina000O8VpqE.html
http://www.weditor.com/~users/ilyar/3dmolbuilder/index.html

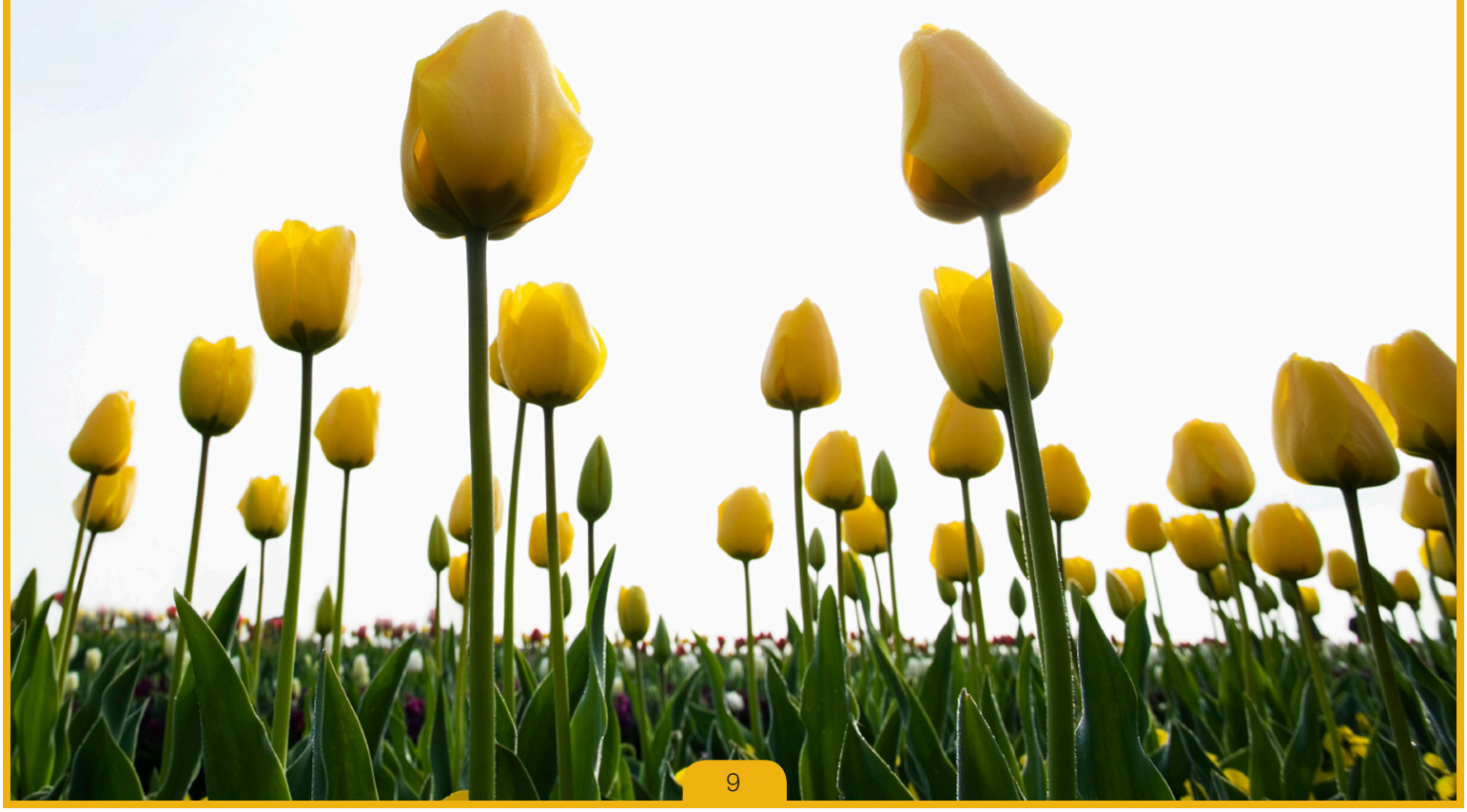
# Part 3: Natural Selection

In Charles Darwin's theory of evolution, one of the most important ideas is that of natural selection. In the face of environmental challenges, plants and animals with characteristics that help them meet those challenges are more likely to survive and reproduce than others. Those characteristics are the outward and frequently beautiful expressions of the genes a plant or animal carries deep inside its cells. As the surviving plants and animals reproduce, so do their genes, giving rise to ever-greater proportions of plants and animals that exhibit the desirable traits.

In the case of flowers, one characteristic that helps insure survival is the ability to attract bees – the insects flowers rely on to bring their pollen to other flowers, which enables them to reproduce. Bees prefer landing on certain kinds of flowers – usually the ones whose colors and shapes we would describe as most beautiful, although our opinion does not matter here. The display is tailored to its intended audience – the bee.

So through the process of natural selection, the flowers that bees find beautiful are more likely to catch the bee's attention, survive, and reproduce. Human beings have perhaps an even greater effect on flower survival, by selecting a few very lucky kinds of flowers – like the tulip - for breeding, cultivation, and distribution all over the world.

1. Have your students find a spot at school or home where bees forage.
2. Have them record the number of times a bee(s) visit a particular flower(s) in a specified period of time (3 minutes).
3. Have them compile and represent the results of these observations in a bar graph.
4. Your students should consider and try to answer the following questions:
    - Which flowers do bees find beautiful? Which ones do they prefer?
    - Which flowers are more likely to be pollinated?
    - Which flowers will most likely be more widely distributed in future seasons?
    - How is this bee and flower observation related to natural selection?
    - How is human preference for and selection of "beauty" in flowers the same as and different from the bees preference and selection of flowers?
    - Have your students present their findings to the class.



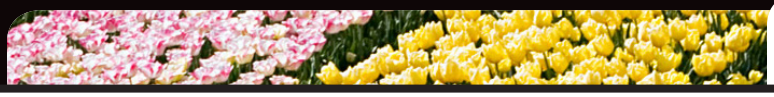
# Assessment

Have your students present their objects (flowers, digital tessellations, and/or fractals) to the class and describe why they consider them to be beautiful. Discuss with them how human preferences for "beauty" in flowers have favored increases in populations of some species of flowers over others over time.

# Extensions & Adaptations

- Provide additional opportunities for your students to see patterns in the field by using hand lenses to examine flower parts.
- When in the field, explore and discuss the following questions:
    - What are the most common shapes or forms that make up the living world?
    - Is nature chaotic or orderly? Give examples to support your opinion.
    - What investigation can be done to support your opinion?
    - How are patterns created in nature?
- Choose a natural object that shows a pattern.
    - Have your students use the pattern(s) as an inspiration for creating a piece of art.
- Investigate the science behind hybridization and how it is utilized to create botanical beauty.
- Have your students attempt to alter a flower's appearance by either manipulating its pH, or "dyeing" it with food coloring. One sample of step-by-step instructions that walk you through experiments for floral dyeing, can be found here: http://pbskids.org/zoom/activities/sci/coloringflowers.html





reproducible

# Basis for Beauty

As a class, you have evaluated the beauty of a number of objects relative to one another. Now it's time to organize the objects based on your personal preferences of beauty. In the table below, please arrange the objects in your preferred order, from most beautiful to least beautiful. Designate their primary categories of beauty based on the following: *Health, Symmetry, Vibrancy,* and *Complexity*. Additionally, identify the objects' more striking qualities that elevate or minimize their beauty.

| | Object | Category (Health, et al) | Striking Qualities |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |