DNAZone Classroom Kit

Kit title	Origami Geometry
Appropriate grade level	High school (9-10 grade)
Abstract	Understanding the relationships and characteristics of geometric objects can be applied in wide variety of contexts. For example, an artist in creating a masterpiece based on the golden ratio, in medicine where different isomers can lead to different effects, and also in industries where one decides the most efficient use of the material. In this lesson, the students will build modular origami to represent isomers and to identify the symmetry elements in complex models. By doing so, the students will be able to model situations geometrically to solve problems and to enhance their understanding in the relationship of geometric objects.
Time	Two 40-minute class periods
PA Department of Education standards met with this kit	**Mathematics Standards** **2.9.11 H** Construct a geometric figure and its image using various transformations **2.9.11 I.** Model situations geometrically to formulate and solve problems **2.9.11 J.** Analyze figures in terms of the kinds of symmetries they have **Arts and Humanities Standards** **9.1.12 A.** Know and use the elements and principles of each art form to create works in the arts and humanities **9.1.12 B.** Recognize, know, use, and demonstrate variety of appropriate art elements and principles to produce, review, and revise original works in the arts **Science and Technology Standards** **3.1.12. B** Apply concepts of models as a method to predict and understand science and technology
Kit adapted from:	Easy Modular Spinner. http://www.origami-instructions.com/easy-origami-modular-spinner.html (accessed July 17. 2012). Garretson, Jennifer. Nature's Pentagrams. Geometry Activities. http://www.math.twsu.edu/history/activities/geometry-act.html#nature. Wichita State University. Modular Origami Diagrams. http://www.origami-resource-center.com/modular.html (accessed July 17, 2012).
Kit creation date	July 17. 2012

The Center for Nucleic Acids Science and Technology
4400 Fifth Avenue Pittsburgh, PA 15213
http://www.cmu.edu/cnast/

Origami Geometry Overview

Educational Objectives

1. Students can identify the different symmetry elements in a complex model
2. Students can construct geometric figures and apply various transformations
3. Students can understand the importance of different isomers
4. Students can relate the concepts learned for real life applications

Teacher Preparation Time

- Some time is required to master the modular origami so that help can be provided when students have trouble
- Allow time to go over the PowerPoint slides for the second part of the lesson
- Review the background information for symmetry and isomers
- Put apple slices in vinegar before class to keep them from browning

Class Time

1st period: 6 minutes for Donald Duck in Mathemagic Land
14 minutes for Nature's Pentagon Activity
10 minutes for Power Point Presentation
Total: 40 minutes in the first period

2nd period: 2 minutes for warm up in finding symmetry in Bucky Ball
20 minutes for the Box Geometric Transformation Activity
18 minutes for the Octahedral Isomer Activity
Total: 40 minutes in the second period

Materials Needed

Not included in the kit : one apple and five flower Petal
In Kit: Cardboard with graph paper attached
Thumbtacks
Piece of yarn
Protractor
Origami Papers

Required Student Knowledge

Geometric Transformations: translation, rotation, reflection, and the ability to identify symmetry

Questions or concerns?

Please visit our website at http://www.cmu.edu/cnast to learn more about CNAST's outreach program, DNAZone, or to find contact information.

Part I: Nature's Pentagrams; Golden Triangle

Objectives:

- To identify the symmetry found in nature
- To review algebra and geometry
- To transition into finding more complex symmetry elements
- To understand the importance of symmetry for real life applications

Background Information:

1. Golden Triangle
   a. Definition
      i. Known as sublime triangle
      ii. Isosceles triangle in which the smaller side is in golden ratio with adjacent side
      iii. Only triangle to have angle in 2:2:1 proportion
      iv. Angle A and B are both 72 degrees while angle C is 36 degrees
      v. Shape of triangles found in pentagons

   b. Golden Ratio
      i. In mathematics and arts, in golden ratio when two quantities equal
      ii. Many artists and architects have used golden ratio for they believed this proportion was aesthetically pleasing to the eye

Day 1: Teaching and Learning Activities- Introduction to Symmetry

Procedure	**Teaching-Learning Activities**	**Time** (min)	**Materials& Tips**
Introduction Motivation	**Warm up:** Start by showing the clip Donald Duck in Mathemagic Land until 13:15 http://www.youtube.com/watch?v=YRD4gb0p5RM	13	• Projector • Internet • Computer
Practice	**Nature's Pentagrams Activity:** Pass out the worksheets and have the students find the golden triangles found in nature after watching the clip	14	• Worksheet • Apple Slice • Five-petaled flower • Protractor
Presentation	**Lecture:** Start the lecture on symmetry, different geometrical transformation its applications and introduce symmetry elements. Have the students identify the symmetry elements in different gems and introduce modular origami and its relevance	13	• Projector • Power Point

Name:_____
Date:_____

Activity 1: Nature's Pentagrams

Reference: *http://www.math.twsu.edu/history/activities/geometry-act.html#nature*

Materials:

- Five petaled flower
- Apple
- Protractor

Procedures:

1. Open the kits and examine the following items in the kit
2. Cut the cross section of the apple (or this can be done before the class previously and be soaked in vinegar to preserve the apple)
3. Draw the tips from the star cross section or the tips of the five petaled flower and link all the tips together and it should form a pentagon
4. From the pentagon, you can see the triangles formed from the pentagon and measure the angles to see whether they are golden triangles
5. See how many golden triangles can be found

Figure 1. Cross section of the Apple

Figure 2. Five Petaled Flower

Discussions and Questions:

1. Draw the pentagons from the two materials in the space below and complete the angles found in each triangle. How many golden triangles did you find?

Part II: Modular Origami

Reference: http://www.origami-resource-center.com/modular.html

Purpose: The purpose of the second period of this lesson reiterates the concepts learned from the previous session by making 3D geometric models and applying symmetry operations as well as geometric transformations. Also different structural models are made to get a better understanding of isomers that was created from same number of units.

Background:
Geometric models are all around us whether it may be in architecture or the arts or in industries. Since ancient Greece, the concept of symmetry was applied for its aesthetic reasons. In psychology, it was said that we as human beings are innately attracted to symmetrical faces than those that are not. In this topic, the students will make modular origami in which several units are combined to make a three dimensional model. One will be an octahedral model in which the students will be given 4 units of one color and 2 of the other and inadvertently, some students will make the trans-isomer and the other the cis-isomer. The other activity will focus on making boxes with different number of colors as well, and symmetry elements will be applied as well as the geometric formations.

Procedure	**Teaching-Learning Activities & Tips**	**Time** (min)	**Materials**
Introduction Review	**Warm up :** Show the buckyball model and have the students point out the symmetry elements Explain to them that they can have the instructions to make these at home if they wish but due to the limited time in class they will make smaller models	2	• Buckyball model
Practice Production	**Geometric Transformations:** The students will make a box out of 4 units of one color and the 2 units of another and will make a box and apply geometric transformations	18	• Origami paper • Worksheet • Graph Paper
Practice Production	**Symmetry and Isomers:** The students will make an octahedral out of 4 units of one color and 2 units of another and will indicate the symmetry elements as well as point what shape they have in terms of molecular geometry. They will also compare their model with their partners to see if they have different isomers	20	• Origami paper • Worksheet

Day 2: Teaching and Learning Activities- Review and pH Activities

Name_____
Date_____

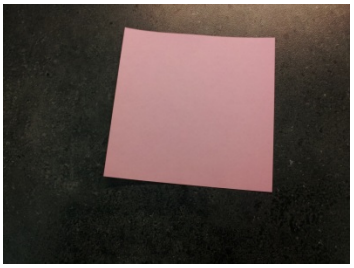
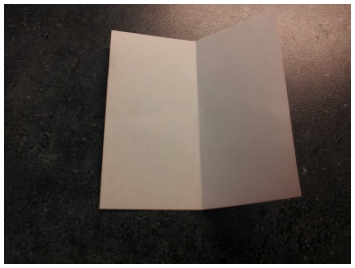
Geometric Transformations

Materials:

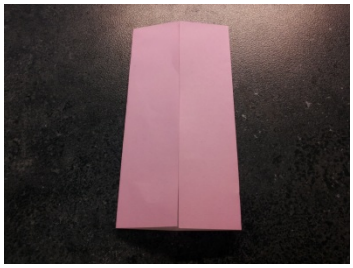
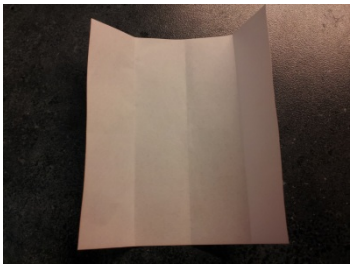
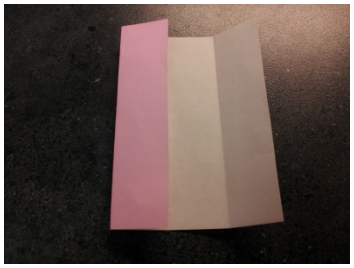
- 6 origami paper total, 2 of one color and 4 of another color
- Graphing paper

Instructions:

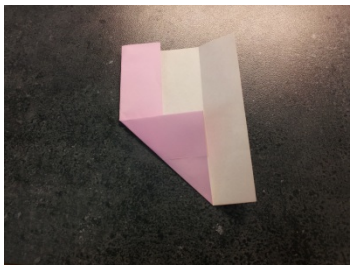
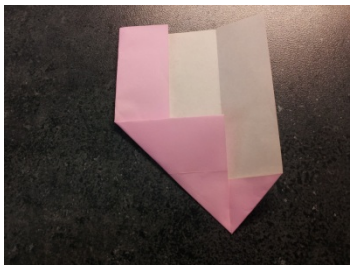
Folding Instructions for the Sonobe Unit

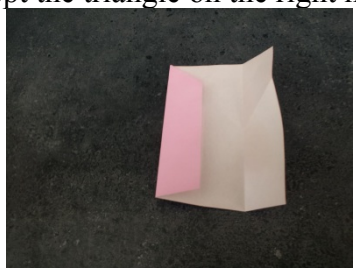
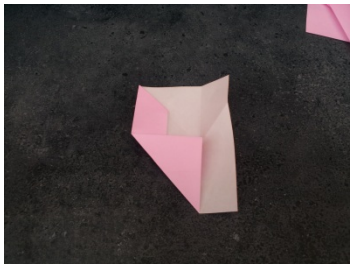
1. Choose four origami papers of one color and two origami papers of another color
2. Let's start with one of them
3. Fold the origami paper in half and make sure the colored side is on the bottom
4. Unfold and you will see the crease made in the center

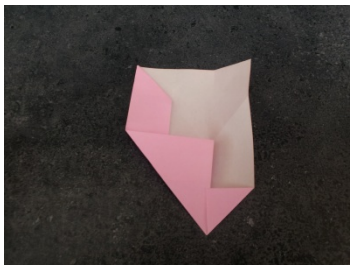
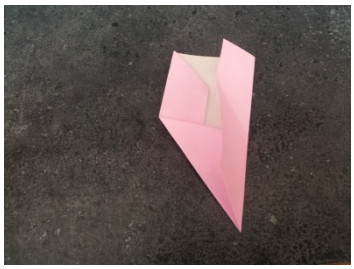
5. Fold the two halves until the crease line
6. Unfold and you should see four sections
7. Then only fold the leftmost until the crease line in the center

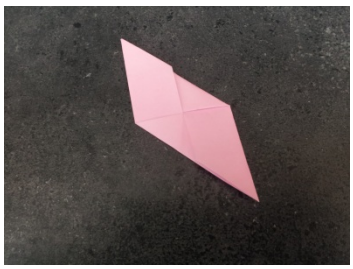

8. Fold the leftmost corner until the crease line as shown
9. Fold the rightmost corner until the crease line as shown
10. Unfold everything except the triangle on the right most corn

11. Fold the rightmost part until the crease line
12. Rotate the paper 180 degrees to the left
13. And fold the left most corner as done previously to the crease line

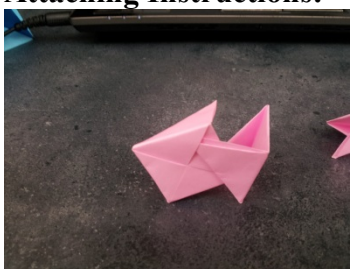

14. Fold the right most lower corner until the crease line
15. Then fold the entire right flap over towards the crease line in the middle as shown
16. The upper most corner will go in the left flap as shown

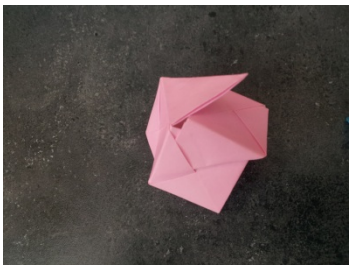


17. This is the finished Sonobe unit
18. Flip it over and fold it half way on each side

19. Follow the same steps for all the other colors so that 6 total units are made.

Attaching Instructions:





1. Use the flaps to push in the flaps to the openings in the cross of the box
2. Push it through and attach
3. Do the same for all the other units making sure that no flaps are inside the box but are all attached in the outside


4. Attach it all the way through until all the units are attached
5. Finished Product

Questions

1. How many of one color and the other color do you see in each side? Write them below

2. Do you see any symmetry elements in your box? If so which ones are they?

3. Place your box on the graphing paper and write down the initial x y and z coordinates. Write down the matrix operations when you apply 1) Translation by (5,5,0) 2) Rotation by 90degrees and 3) Reflection by 180 degrees

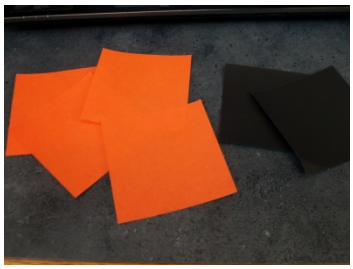
Name:_____
Date:_____

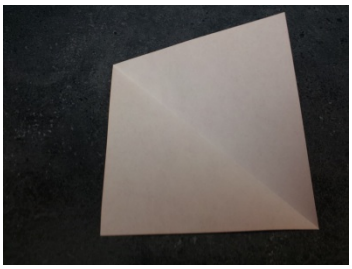
Activity 2: Symmetry and Isomers

Reference: http://www.origami-instructions.com/easy-origami-modular-spinner.html

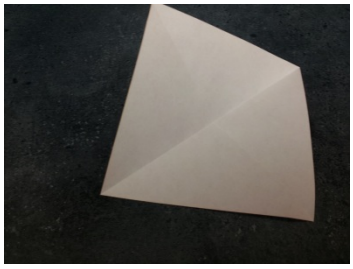
Purpose: This activity is intended to compare different isomers. As explained in the Power Point slide, even a slight difference in the structure can drastically change its effects.

Instructions:

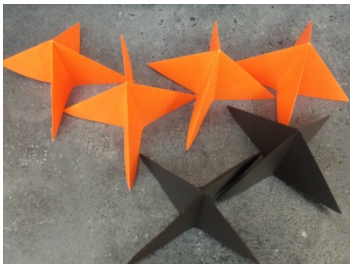




1. Choose four of one color and two of another color
2. From the six chosen choose one to start with and fold it diagonally in half as shown
3. Unfold



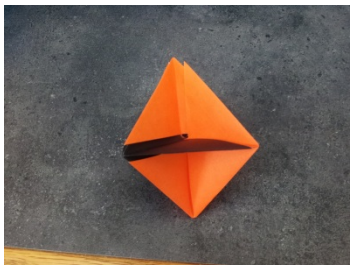
4. Do the same to the other side and so when unfolded, you see an "X" crease line
5. Flip it over and pinch the two sides as shown
6. Push it down to make the crease more visible

7. Crease the opposite side as well so that it makes the shape above
8. Do the same for all the other units

Connecting Instructions:





1. The four flaps have to connect in the other flaps in such a way where the two have to go "in" the other flap and the other two have to go "over" the other flap
2. See the diagram carefully to see which flap goes where
3. When connected together the model will look something like this
   (Please ask the instructor for assistance if you're having trouble with this part)

Questions

1. How many of one color and the other color do you see in each side? Write them below

2. Do you see any symmetry elements? If so which ones are they?

3. Which isomer do you have? Trans or Cis? How do you know?