Symmetry in Nature (and Human Nature)
Stillness in Motion

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Symmetry — 2015

Key Idea #1

An object is *symmetrical* if it "remains unchanged," or maps precisely back onto itself, or is *invariant* when acted on by an (interesting) *motion* or *transformation*.

Product Design (Hubcap)

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Motion: Rotations by multiples of 1/5 of a full turn

Biology (Butterfly)

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Motion: Reflection across a line

Textiles (Peruvian Skirt)

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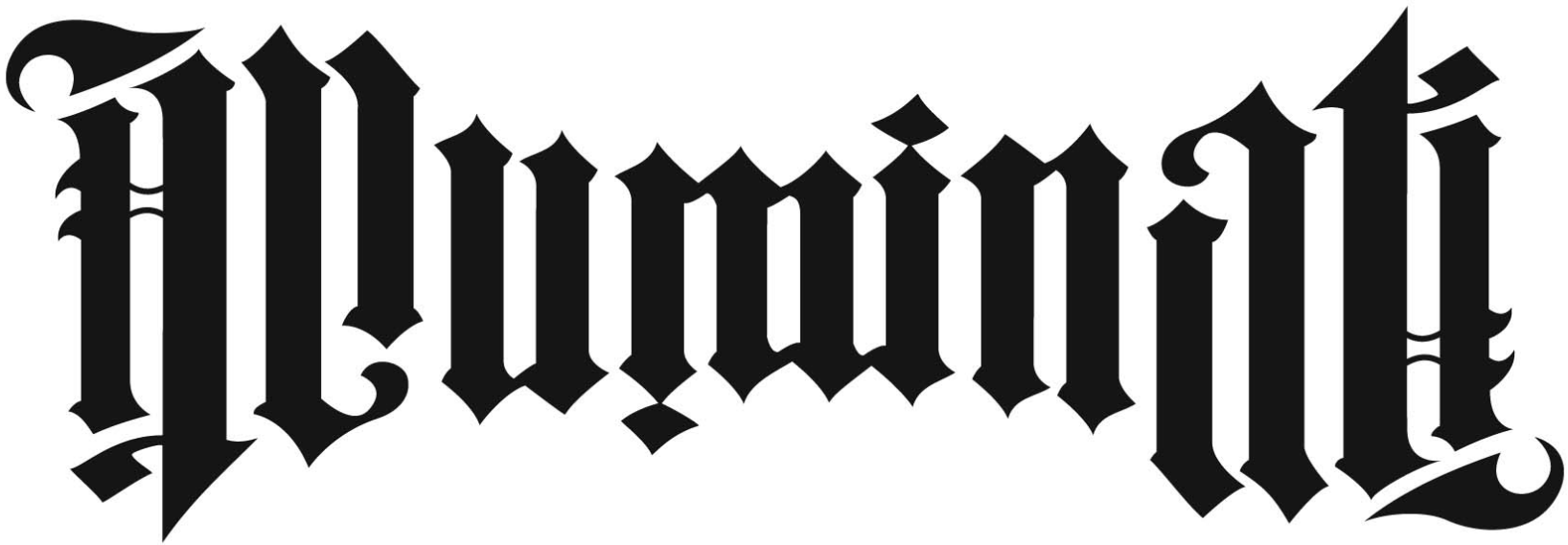
Motion: Reflection across a line

Literature (Ambigrams)



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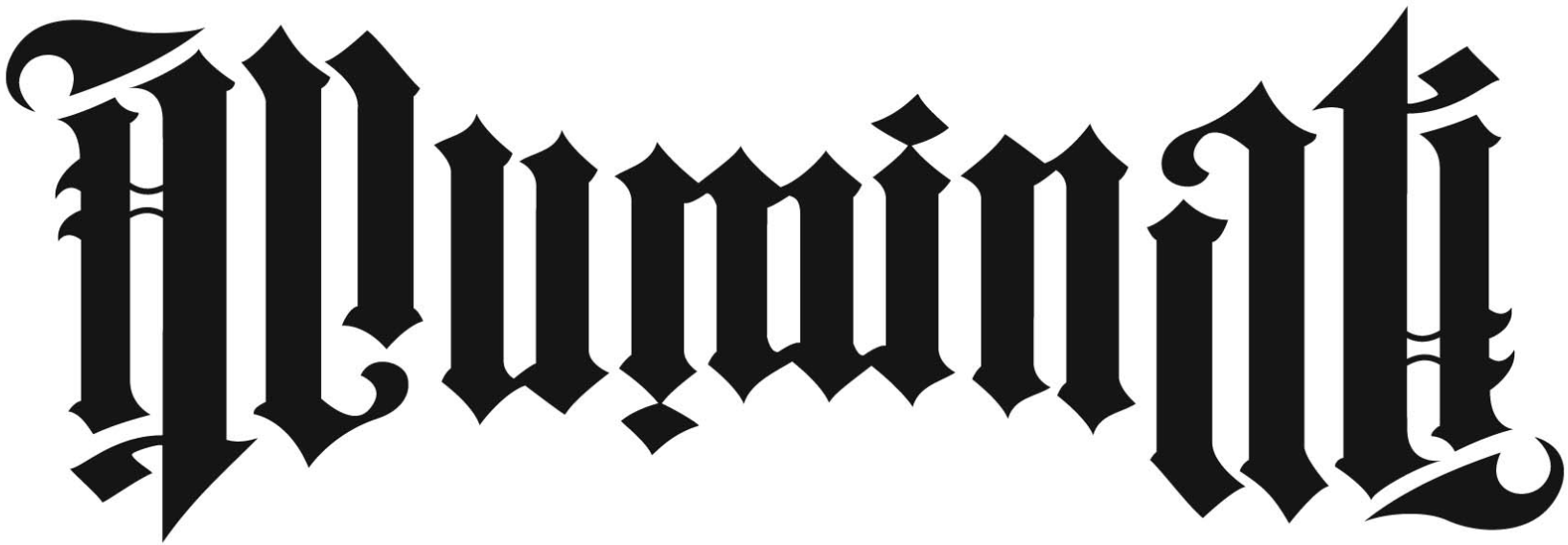


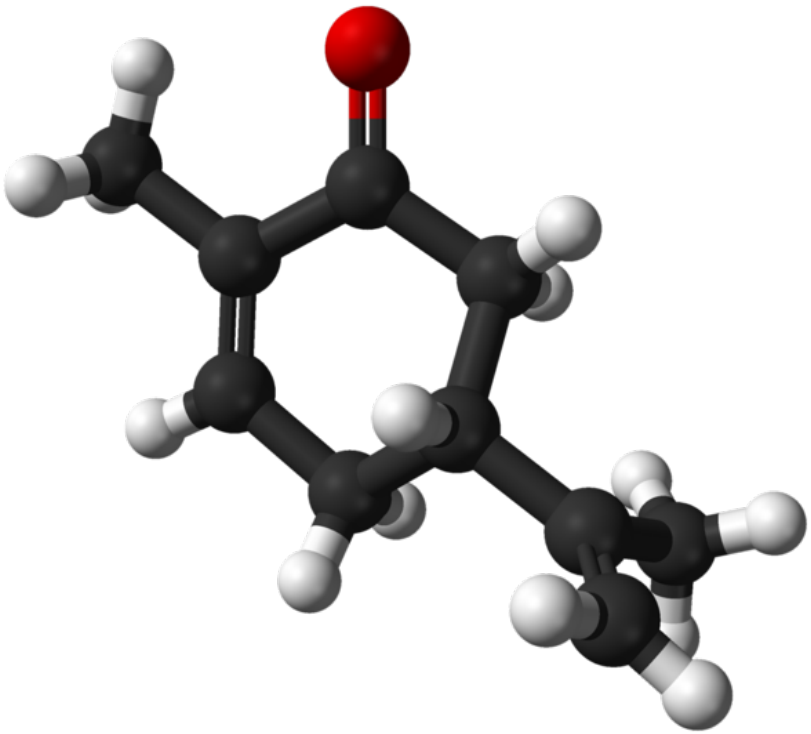
From Dan Brown's *Angels and Demons*
Motion: Half turn

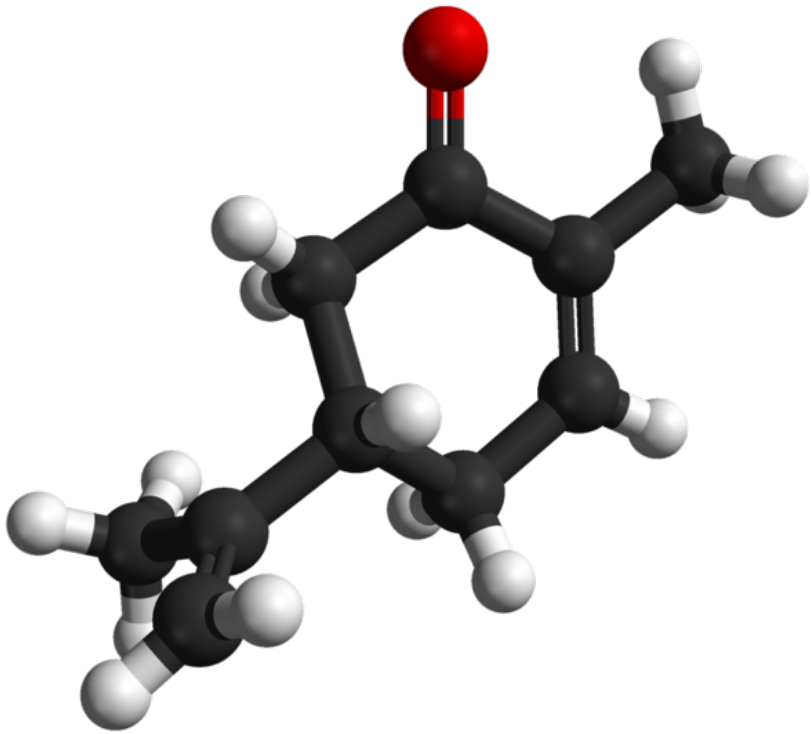
Ambigrams Activity

Solve the puzzles on the Ambigram handout

On your own: Try some online ambigram generators, such as `http://www.flipscript.com/ambigram-generator.aspx`

Chemistry (Carvone)





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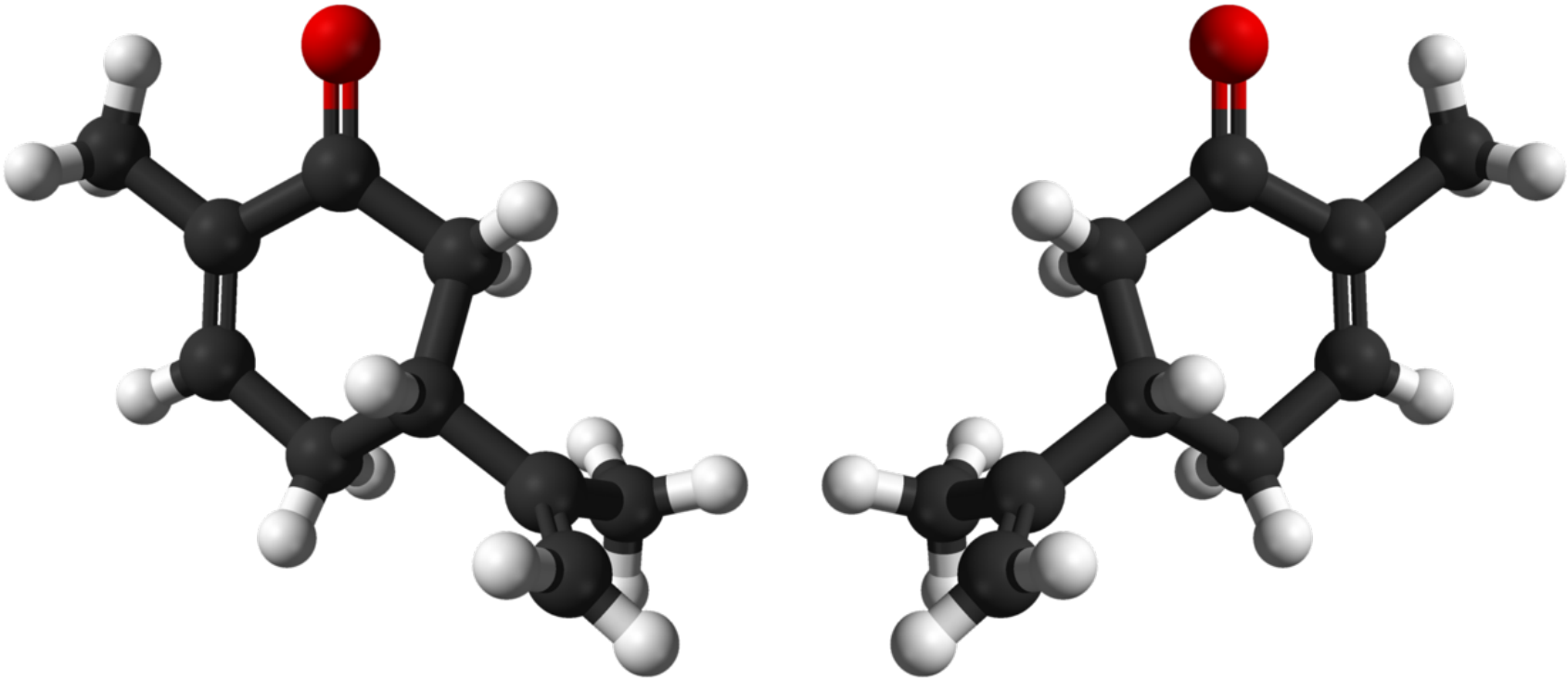
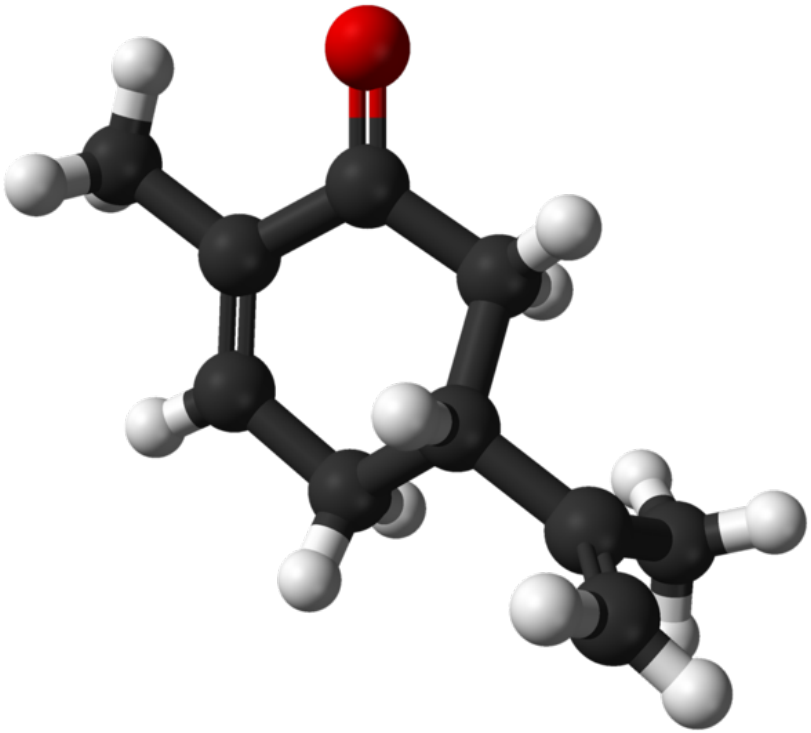
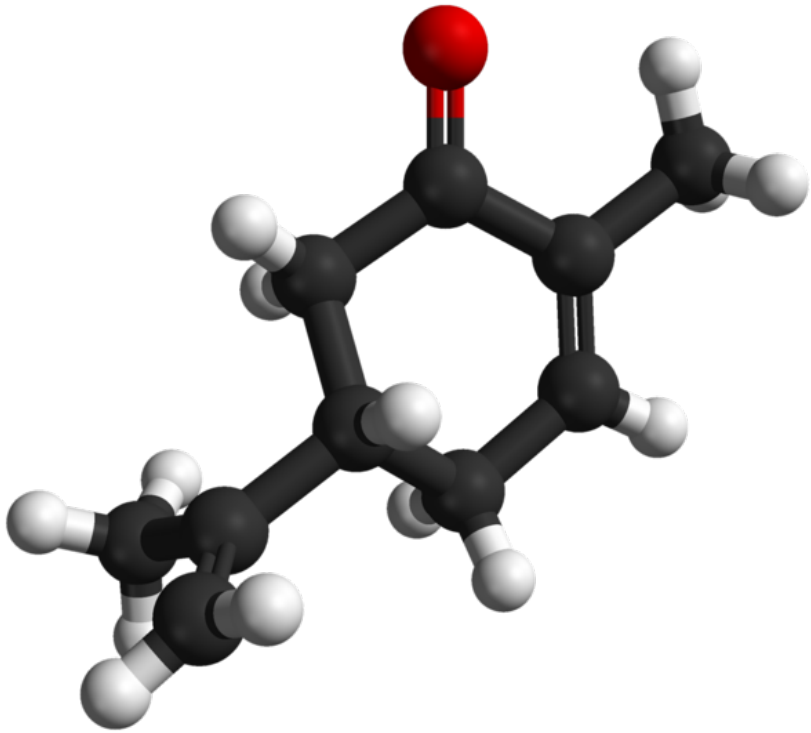


Motion: Reflection across a plane

Chemistry (Carvone)





Spearmint and Caraway

Other Examples of Enantiomers (Chiral Pairs)

Glucose and L-Glucose — the latter tastes sweet but cannot be metabolized

Thalidomide — only one version causes birth defects; the other is a sedative

DNA

Amino acids

Chirality Activity

Construct as many structures as you can with four multilink cubes

Identify symmetries of individual structures

Identify chiral pairs

Repeat with five cubes

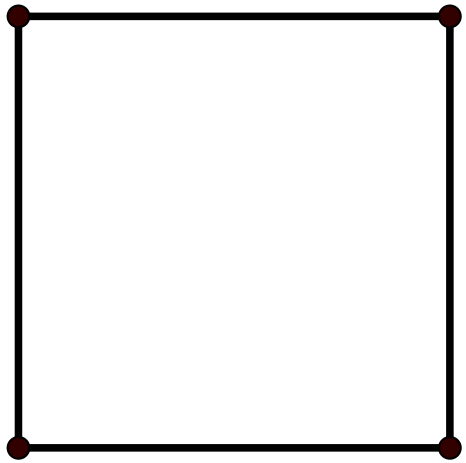
Dance (Square Dancing)

`http://www.squaredancecd.com/sdance.htm`

Try Basic Steps: Ladies' Chain Family: Four Ladies Chain Three Quarters

"Square Dance" Activity

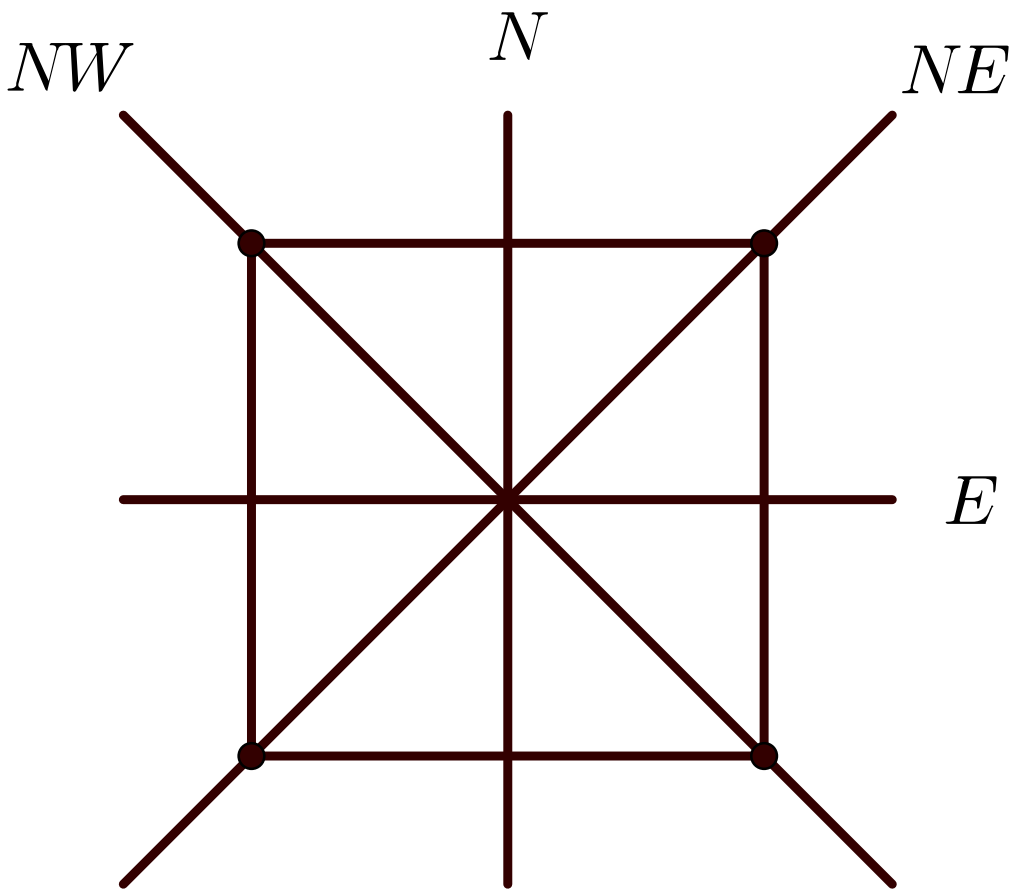
Four people stand at the corners of a square



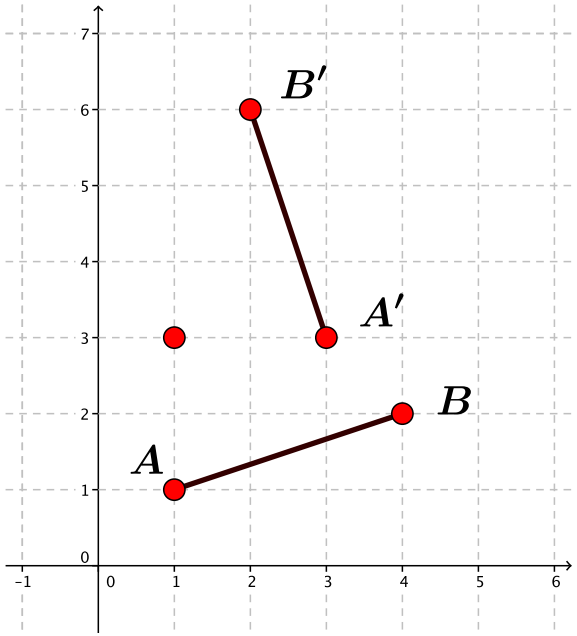
Determine seven moves (rotations and reflections) that move some or all of the individuals to different positions

Determine the net effect of carrying out two such moves, one after the other

"Square Dance" Activity



Math (Distance)



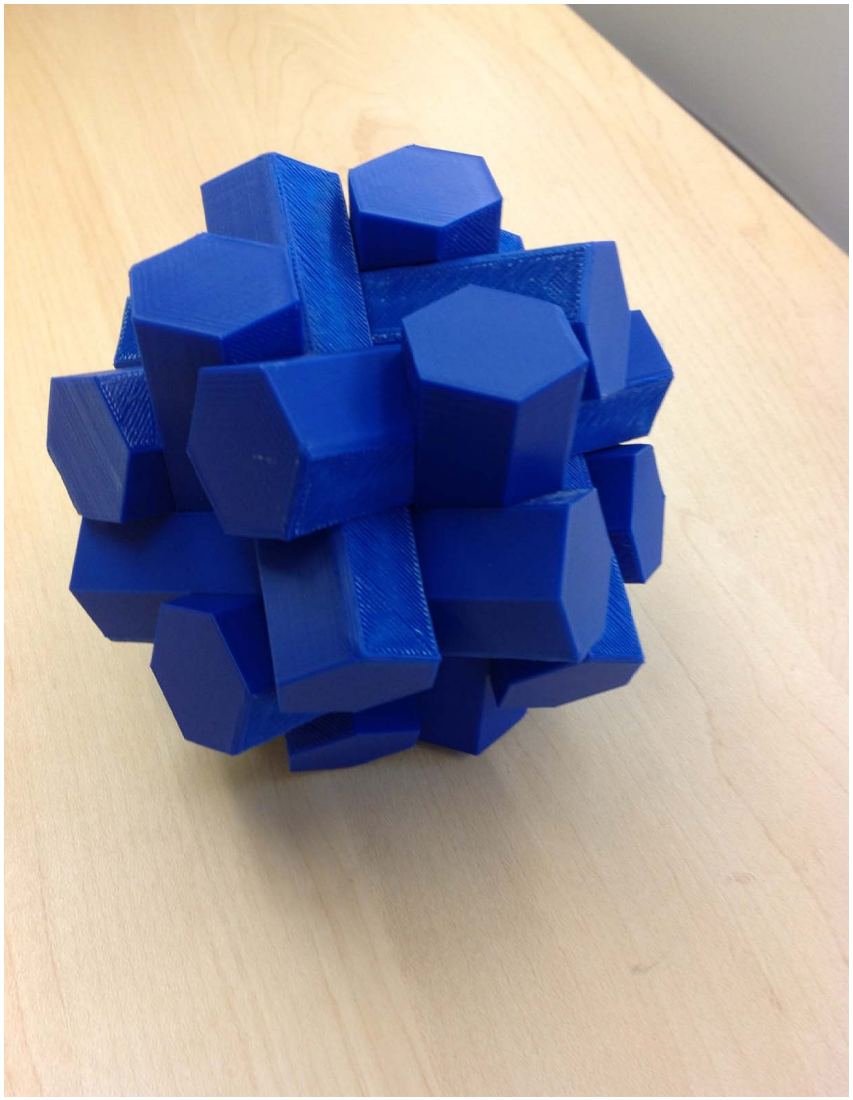
Motion: Rotation of segment AB about a point.
The coordinates of the endpoints change, but the distance formula yields the same length of the line segments:
$\sqrt{(4-1)^2+(2-1)^2} = \sqrt{(2-3)^2+(6-3)^2} = \sqrt{10}$.

Physics (Special Relativity)

Motion: Lorentz transformation of space-time coordinates (x, y, z, t)

Unchanged: Space-time distance
$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2 - (ct_2 - ct_1)^2}$

Puzzles



Motion: Various rotations by 1/3 turns, 1/4 turns (and others?)

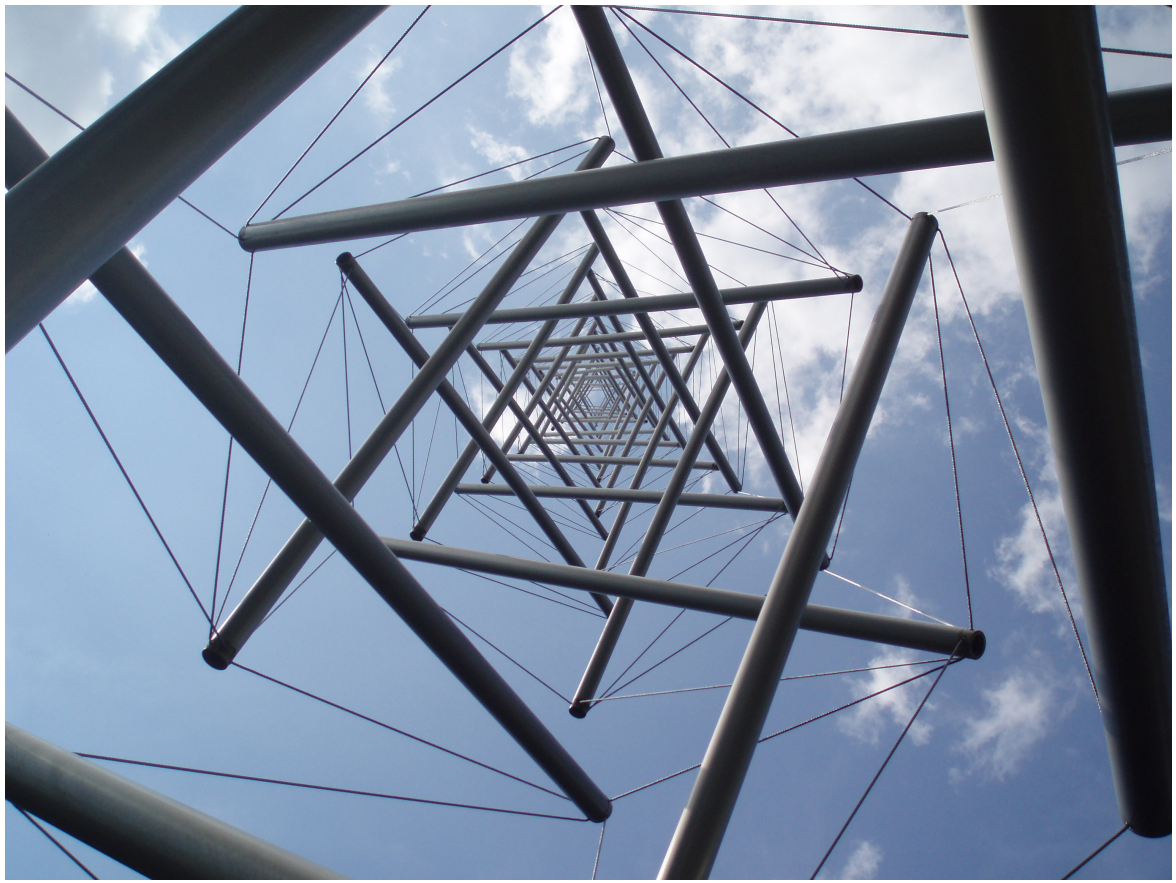
Puzzles

Pass around examples

Sculpture (Bathsheba)

Motion: Various rotations by multiples of 1/5 turns (and others?)

Sculpture (Snelson Tensegrities)



Motion: Various rotations by multiples of 1/3 turns

Geology (Giant's Causeway)

Motion: Various translations, rotations, reflections

Art (M.C. Escher)

Motion: Various translations, rotations, reflections

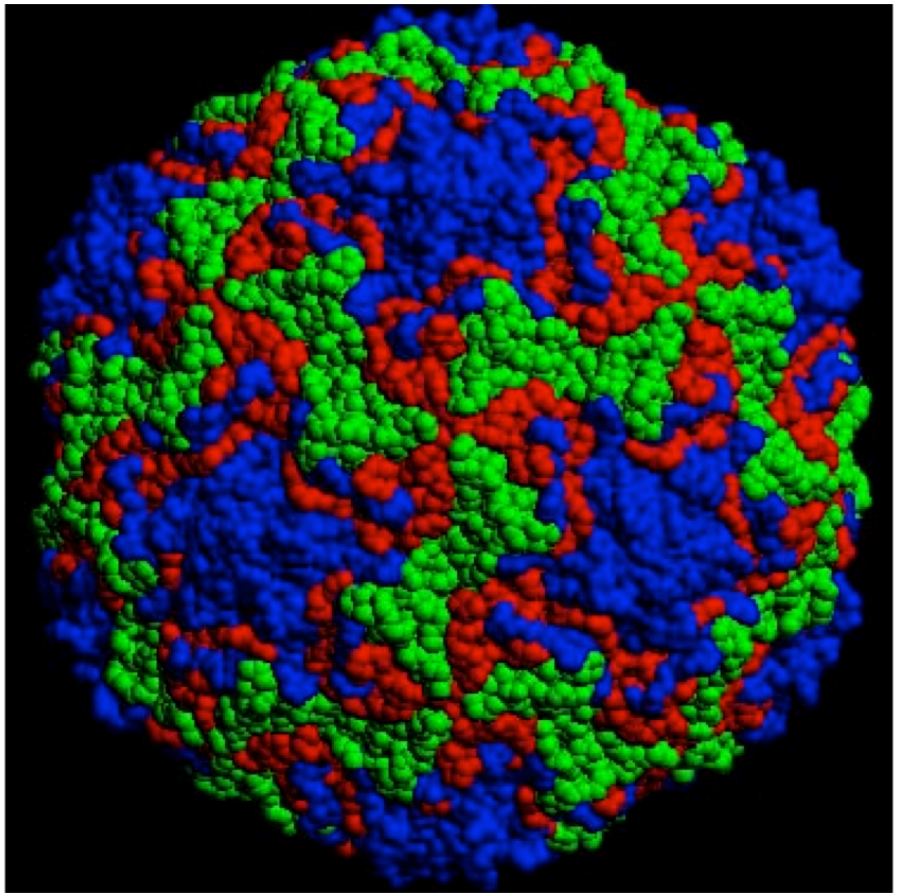
Pattern Analysis Activity

Identify the symmetries in various repeating patterns

Fractals (Sierpinski Triangle)

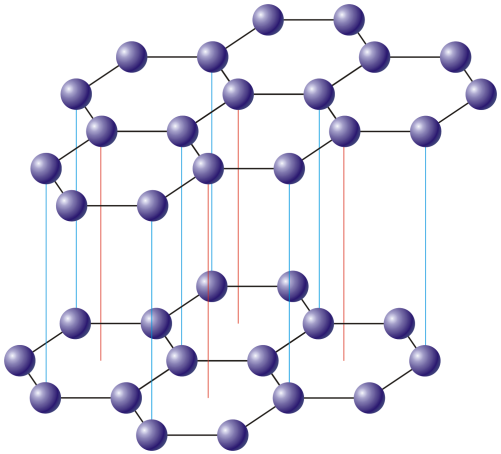
http://www.ms.uky.edu/~lee/visual05/povray/sierpinski2.mov
Motion: Scaling

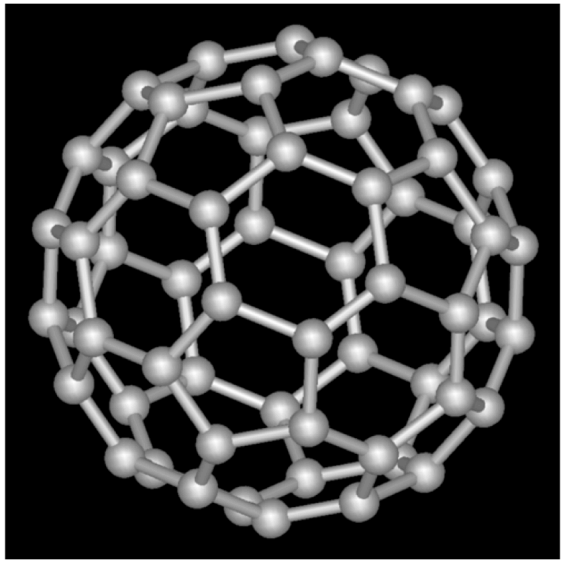
Biology (Cold Virus)

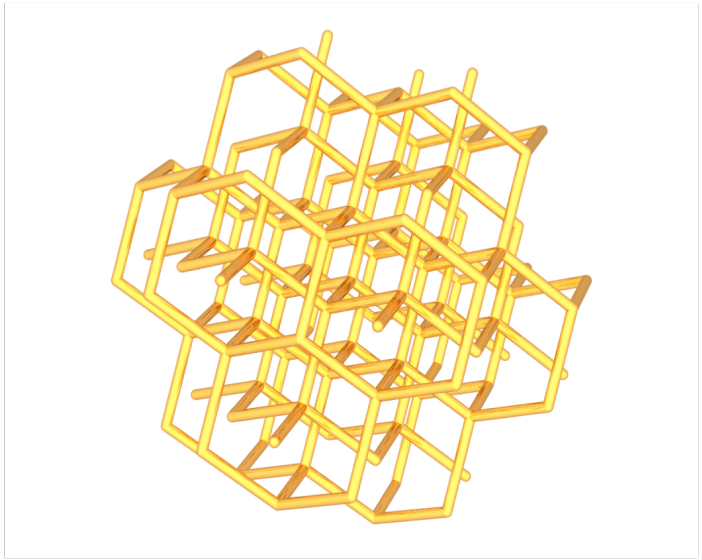


Motion: Various rotations

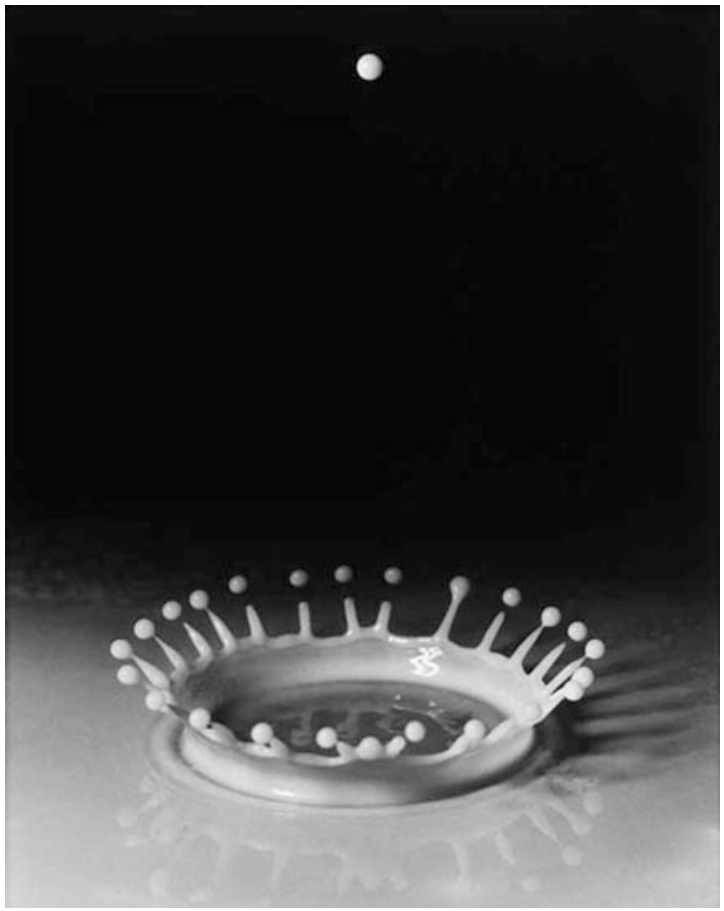
Chemistry (Carbon)







Liquid (Milk)



Motion: Rotation

Note: Symmetry breaking

Key Idea #2

We are tempted to *"complete"* a partially hidden object *using symmetry*

Architecture (Bahá'í Temple near New Delhi)

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Physics (Particles, Forces, and Laws)

Symmetry: A 'Key to Natures Secrets', by Steven Weinberg
`http://www.nybooks.com/articles/archives/2011/oct/27/symmetry-key-natures-secrets`
"At the same time, we did have a valuable key to nature's secrets. The laws of nature evidently obeyed certain principles of symmetry, whose consequences we could work out and compare with observation, even without a detailed theory of particles and forces. There were symmetries that dictated that certain distinct processes all go at the same rate, and that also dictated the existence of families of distinct particles that all have the same mass. Once we observed such equalities of rates or of masses, we could infer the existence of a symmetry, and this we thought would give us a clearer idea of the further observations that should be made, and of the sort of underlying theories that might or might not be possible. It was like having a spy in the enemy's high command."

Periodic Table of the Elements

Mendeleev organizes the known elements and correctly predicts some elements to fill the gaps in his table

Key Idea #3

We can *create* a symmetrical object by *repeatedly applying* a certain transformation or set of transformations

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We can *create* a symmetrical object by *repeatedly applying* a certain transformation or set of transformations

Unlike before when we start with an object and describe the symmetries, this time we start with the symmetries and create the object

Computer Aided Design (SketchUp)

SketchUp demo of ring of cloned columns

Kirigami

Cutting and folding symmetrical patterns

Art (Teach and Learn)

Object: A word
Motion: A single reflection
App: iOrnament

Art (Patterns)

Object: A motif
Motion: A set of translations, rotations, and/or reflections
App: iOrnament

Music

Object: A musical passage
Motion: Translation in pitch

Music

Object: A musical passage
Motion: Translation in pitch

Transposition

Music

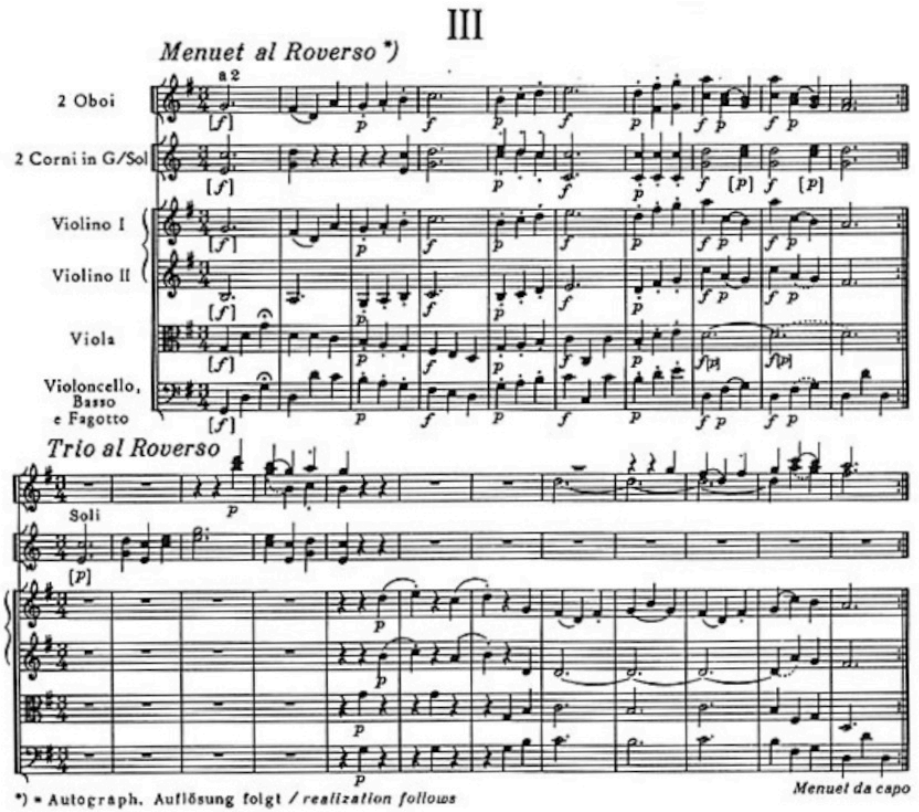
Object: A musical passage
Motion: Translation in time

Music

Object: A musical passage
Motion: Translation in time

Rounds

Music (Hayden)



Description by Scott Kim: Palindromic 3rd movement from Haydn's Symphony 47. The orchestra plays the first part twice forwards, twice backwards, the second part twice forwards, twice backwards, and finally the first part twice forwards, twice backwards.

Music/Video (Come into my World)

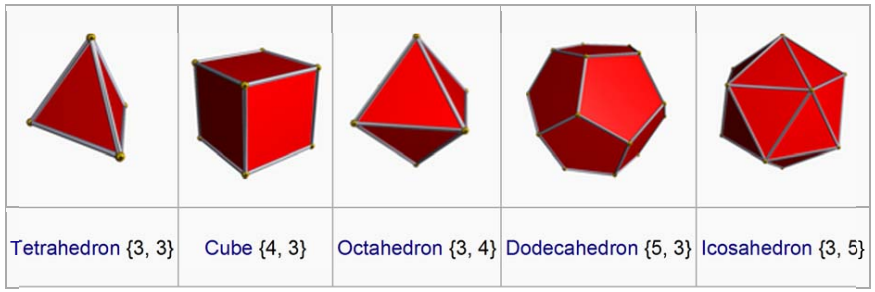
https://www.youtube.com/watch?v=63vqob-MljQ

Kaleidoscope

Make a human kaleidoscope with three “mirrors” and six people

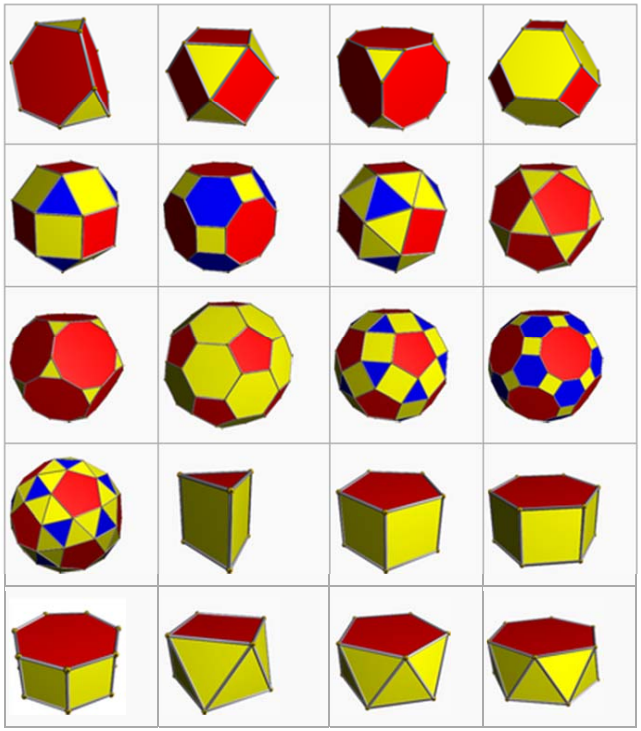
Polyhedra (Regular and Semiregular Solids)

Platonic (Regular) Convex Polyhedra



Tetrahedron {3, 3}	Cube {4, 3}	Octahedron {3, 4}	Dodecahedron {5, 3}	Icosahedron {3, 5}

Semiregular Convex Polyhedra



(Images from Wikipedia)

Tessellation and Polyhedra Activity

Build symmetrical patterns and objects

Try “unit origami”

Heighten your “symmetry awareness”