

Stillness in Motion

The Essence of Symmetry

Carl Lee
University of Kentucky

Chellgren Presentation — October 2014

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)



Product Design (Hubcap)



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

Biology (Butterfly)



Biology (Butterfly)



Biology (Butterfly)



Motion: Reflection across a line

Textiles (Peruvian Skirt)



Textiles (Peruvian Skirt)



Motion: Reflection across a line

Literature (Ambigrams)

Wu-min-ah

Literature (Ambigrams)

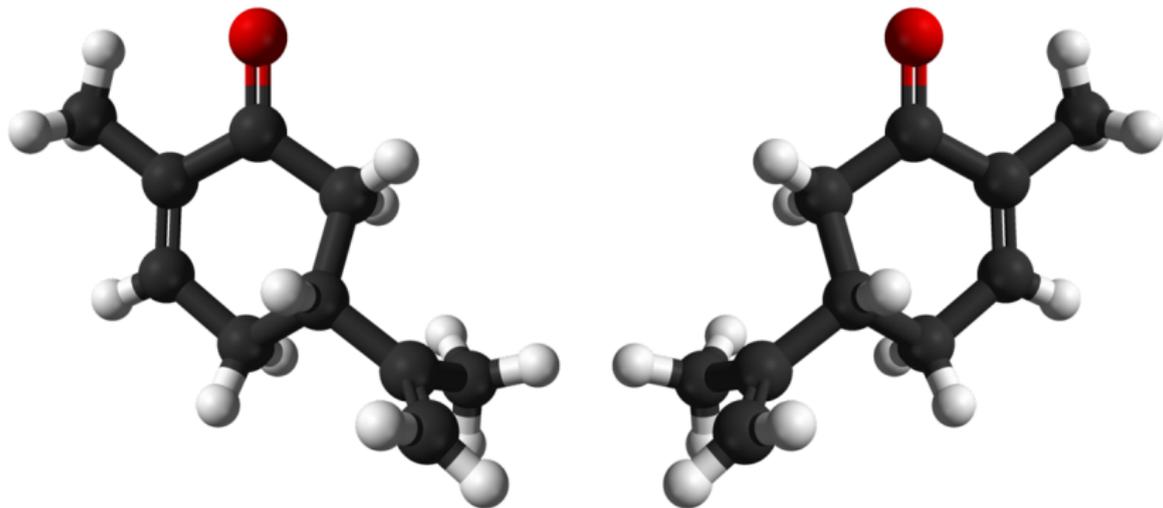
Worminall

From Dan Brown's *Angels and Demons*

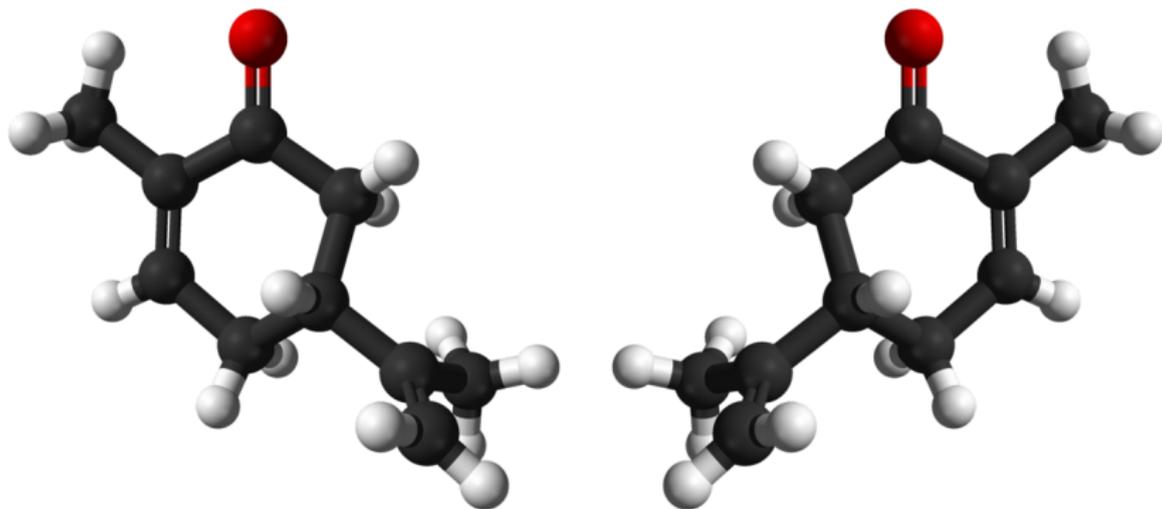
Motion: Half turn

Try the ambigrams puzzles on handout

Chemistry (Carvone)

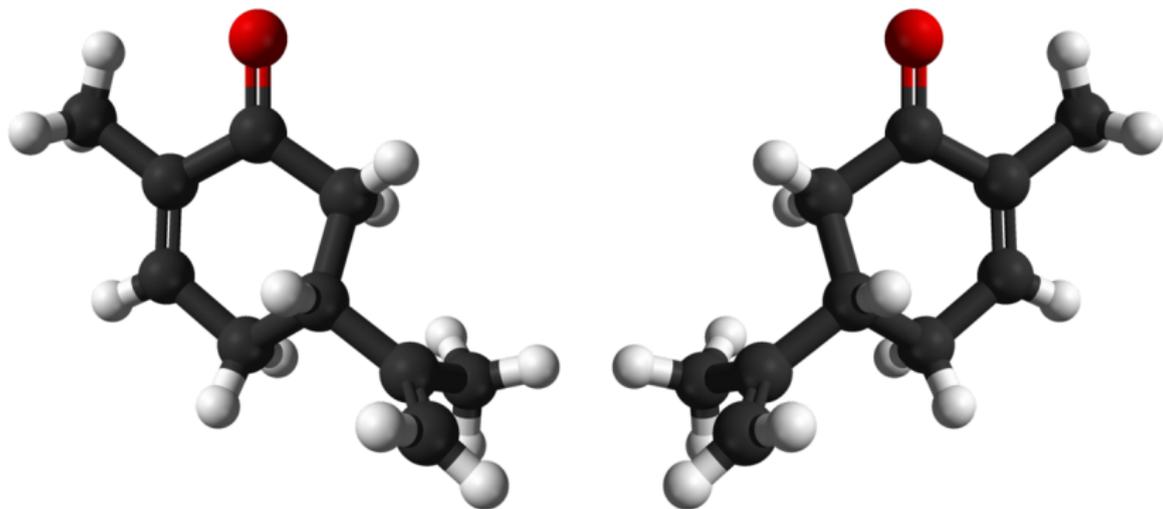


Chemistry (Carvone)



Motion: Reflection across a plane

Chemistry (Carvone)



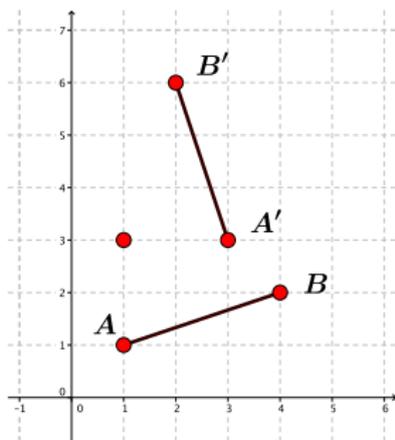
Spearmint and Caraway

Dance (Square Dancing)

<http://www.squaredancecd.com/sdance.htm>

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

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:

$$\sqrt{(4 - 1)^2 + (2 - 1)^2} = \sqrt{(2 - 3)^2 + (6 - 3)^2} = \sqrt{10}.$$

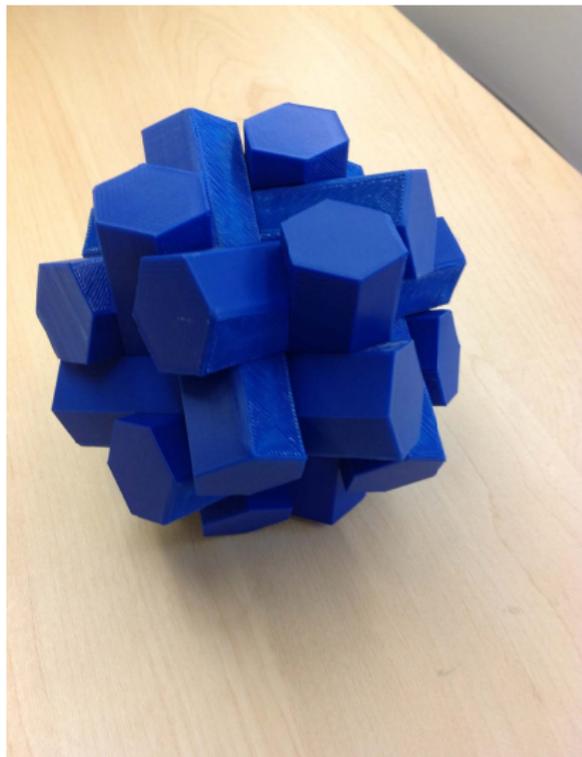
Physics (Special Relativity)

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



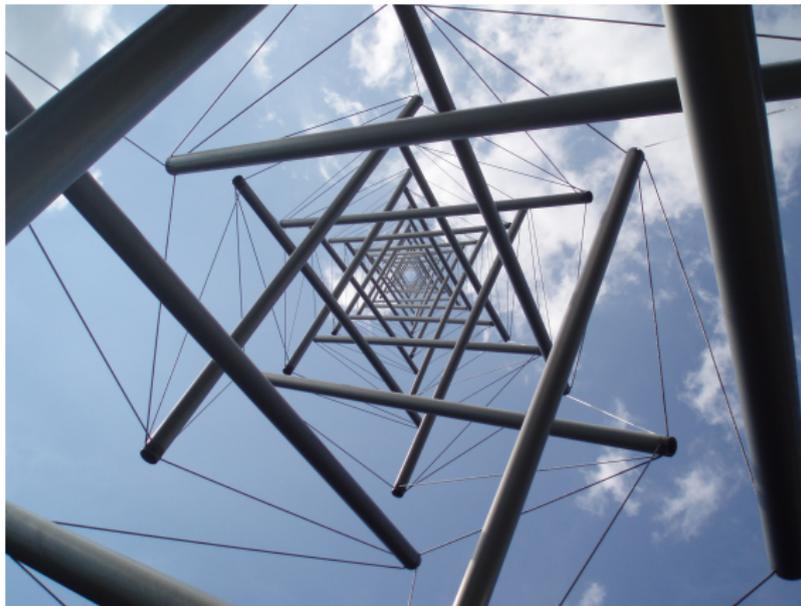
Motion: Various rotations by $1/3$ turns, $1/4$ turns (and others?)

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

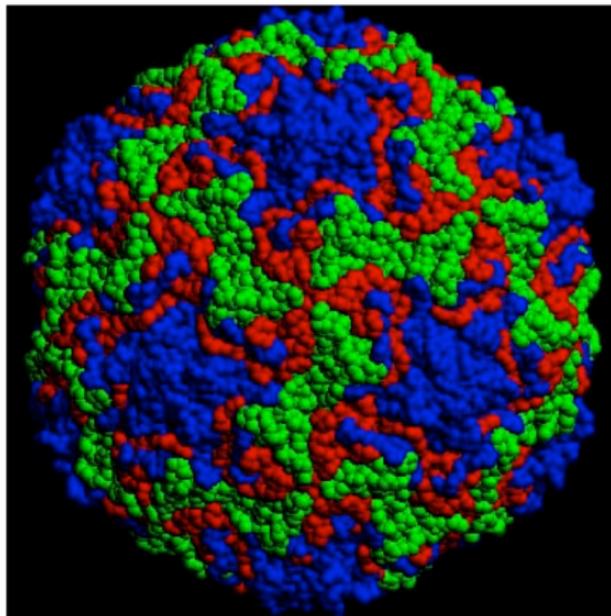
Fractals (Sierpinski Triangle)

http:

`//www.ms.uky.edu/~lee/visual05/povray/sierpinski2.mov`

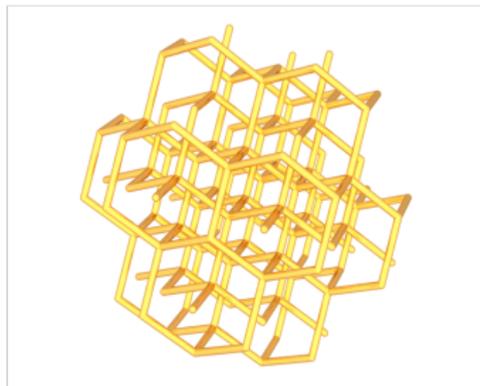
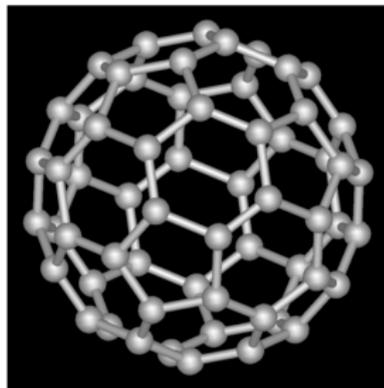
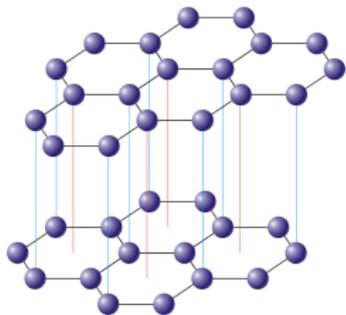
Motion: Scaling

Biology (Cold Virus)

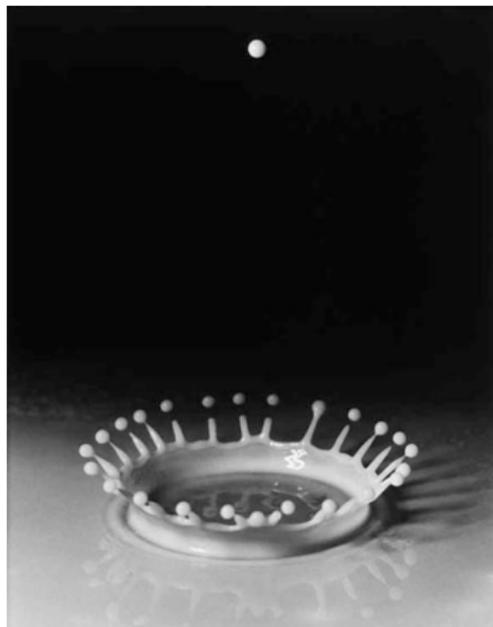


Motion: Various rotations

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)



Architecture (Bahá'í Temple near New Delhi)



Physics (Particles, Forces, and Laws)

Symmetry: A 'Key to Nature's 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.”

Key Idea #3

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

Computer Aided Design (SketchUp)

SketchUp demo of ring of cloned columns

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 (Rounds)

Object: A musical passage

Motion: Translation in time

Music (Hayden)

III
*Menuet al Rovverso *)*

2 Oboi
2 Corni in G/Sol
Violino I
Violino II
Viola
Violoncello,
Basso
e Fagotto

Trio al Rovverso

Soli

*) • Autograph. Auflösung folgt / realization follows *Menuet da capo*

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)

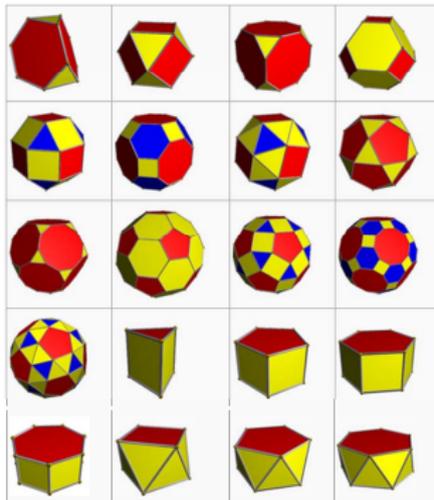
<https://www.youtube.com/watch?v=6Fe1Scu5fdw>

Polyhedra (Regular and Semiregular Solids)

Platonic (Regular) Convex Polyhedra



Semiregular Convex Polyhedra



(Images from Wikipedia)

Challenge

Build symmetrical objects next door after this talk

Heighten your “symmetry awareness”