

# Symmetry – A Ubiquitous Concept in Nature and Science Part 1

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# Acknowledgements

**Marcus du Sautoy:** Symmetry, Reality's Riddle

**Ian Stewart:** Why Beauty is Truth – The History of Symmetry

**Mario Livio:** The Equation That Couldn't Be Solved

**Martin Gardner:** The New Ambidextrous Universe – Symmetry and Asymmetry

**Keshlan Govinder:** A Symmetric View of Life

**Stephen Strogatz:** Sync: How Order Emerges from Chaos in the Universe, Nature, and Daily Life



# Goals and Outline

- What is symmetry?
- Nature and architecture
- Design and art
- Music and literature
- Types of symmetries
- Symmetry in mathematical terms
- Group theory
- Symmetry in physics
- Symmetry in mathematics
- Symmetry in my research:
  - Lie point symmetries
  - Nonlinear waves and solitons

## What is Symmetry?

- Symmetry comes from the Greek sym and metria, meaning **the same measure**.
- Dictionary: **Exact correspondence** of form and constituent configuration on opposite sides of a dividing line or plane or about a center or an axis.
- **Invariance** under motions (flips, turns, translations) or mathematical operations (symmetries are transformations).
- Symmetry **preserves** distances, angles, sizes, shapes, etc.
- Symmetry creates **stability, harmony, and order**.
- Symmetry is associated with **beauty** and **visually pleasing** or **pleasant to listen to**.

# Nature

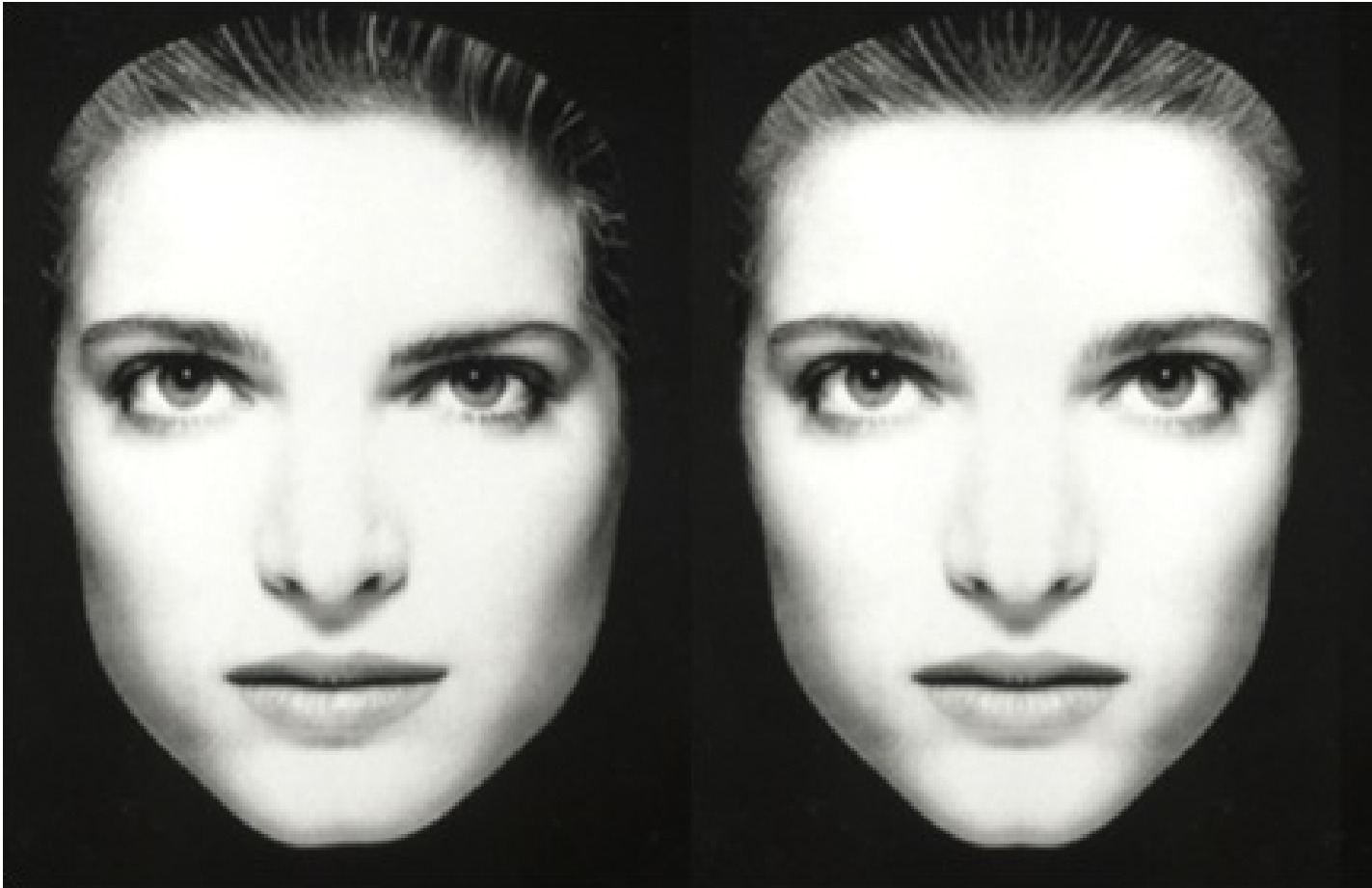




# Nature

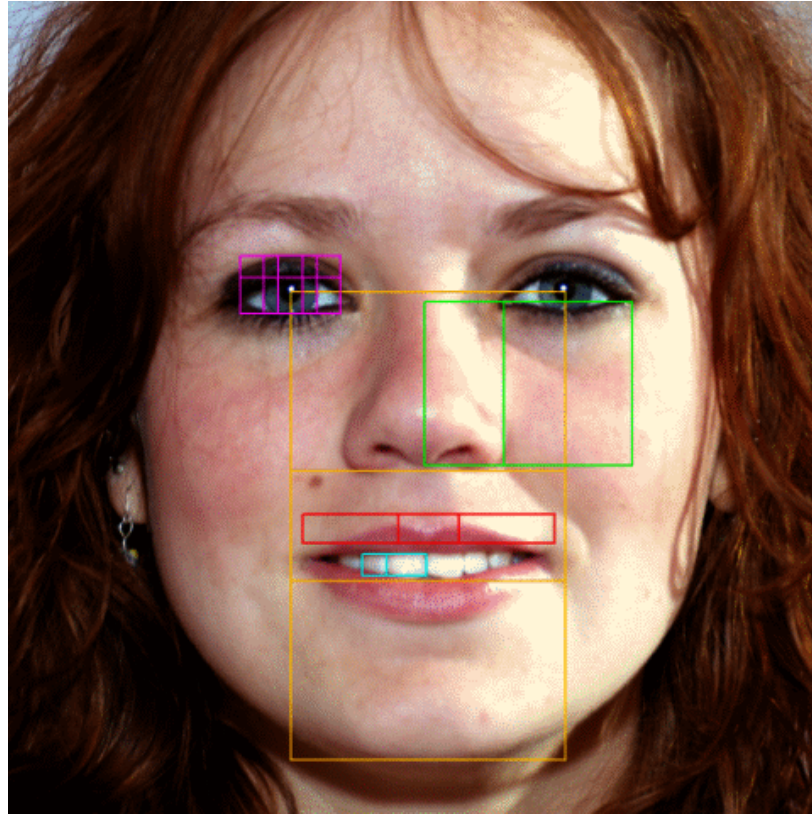


# Human Face



Symmetry and divine proportions

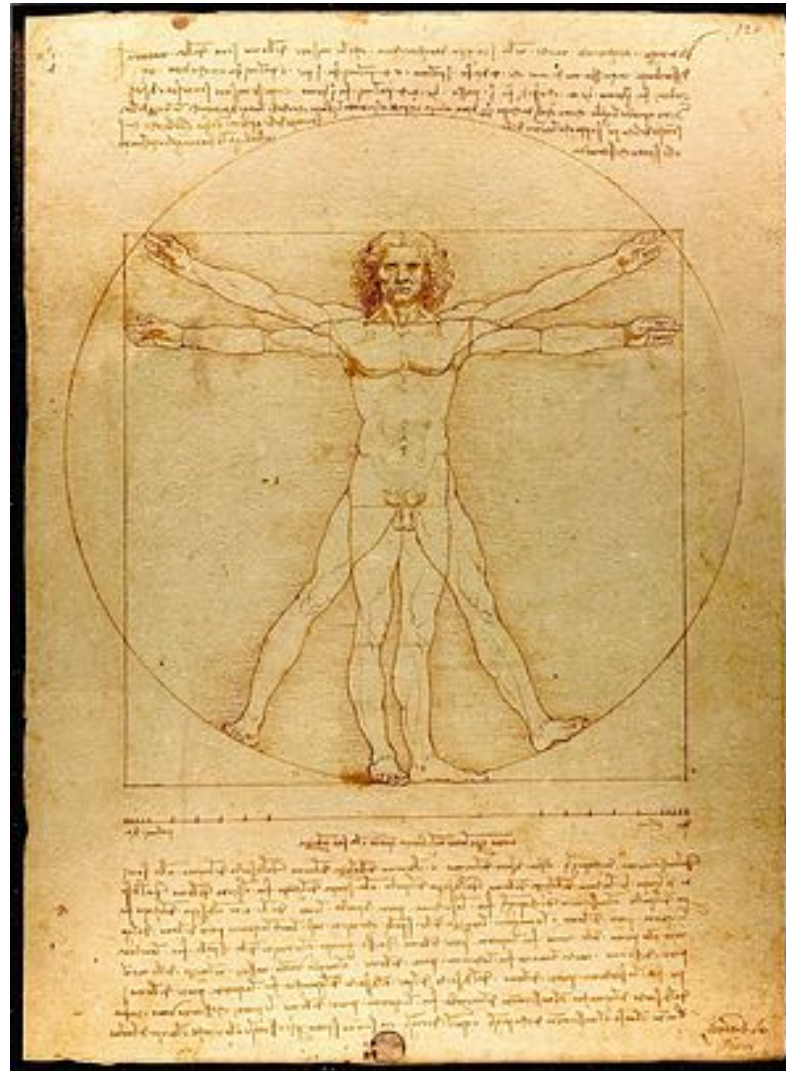
Golden Ratio:  $\frac{1+\sqrt{5}}{2} \approx 1.618$



- A “beautiful” person’s face is about 1.6 times longer than it is wide.
- The distance from the top of the nose to the center of the lips should be around 1.6 times the distance from the center of the lips to the chin.

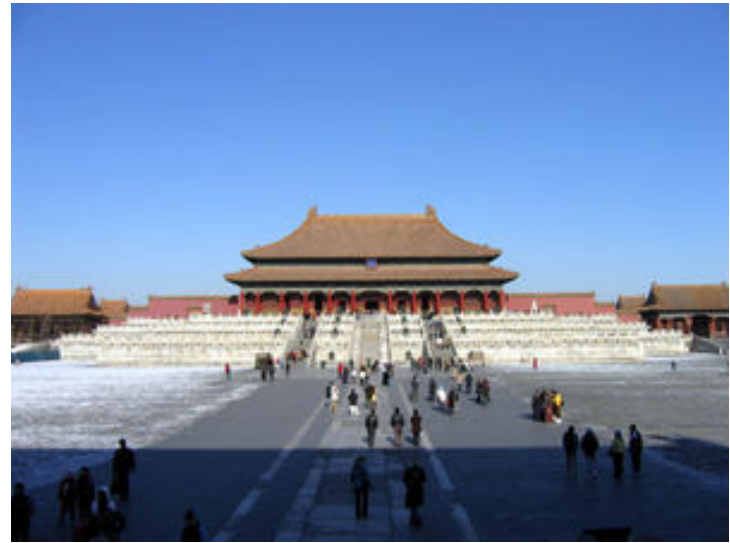
# Human Body

## Vitruvian Man – Leonardo da Vinci (c. 1490)



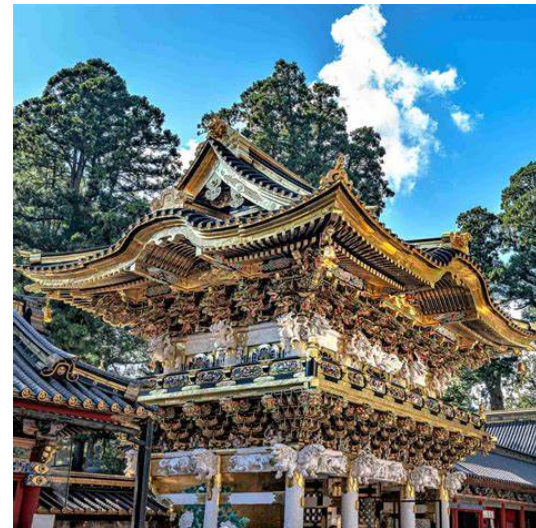


# Architecture





# Architecture





# Architecture: From Symmetry to Loss of Symmetry



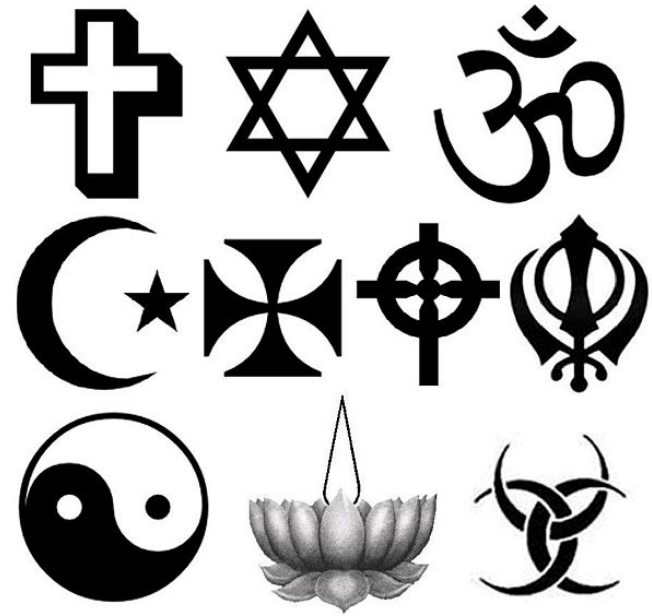


# Symmetric or Not?





# Symmetric or Not?

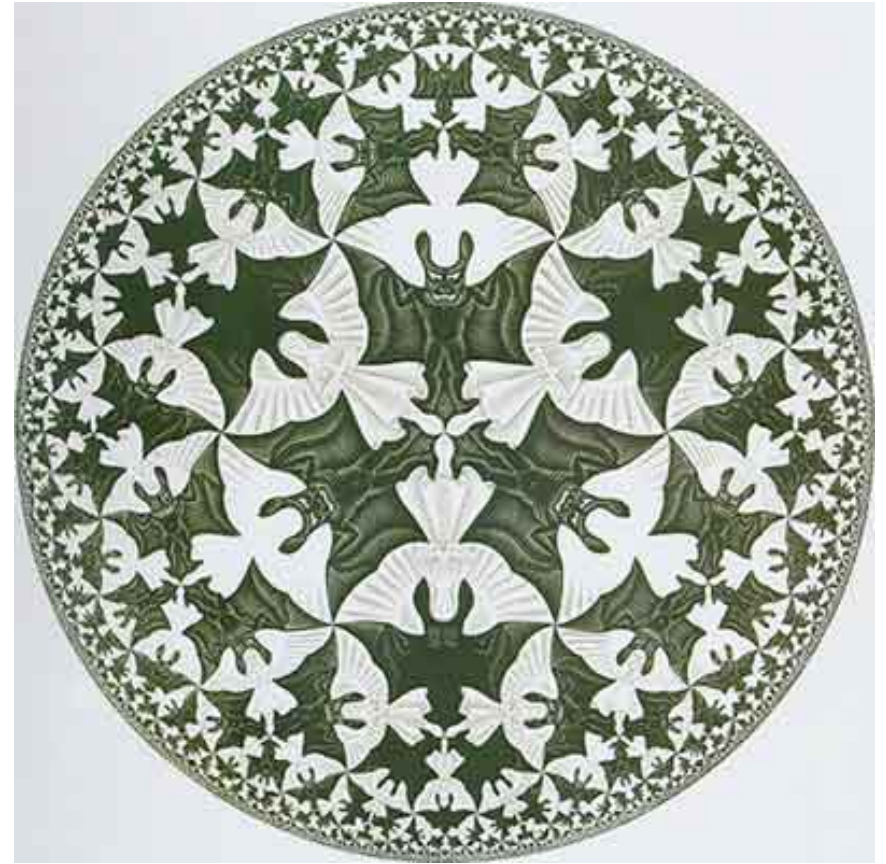




# Design and Art



# Artwork of Maurits Cornelis Escher





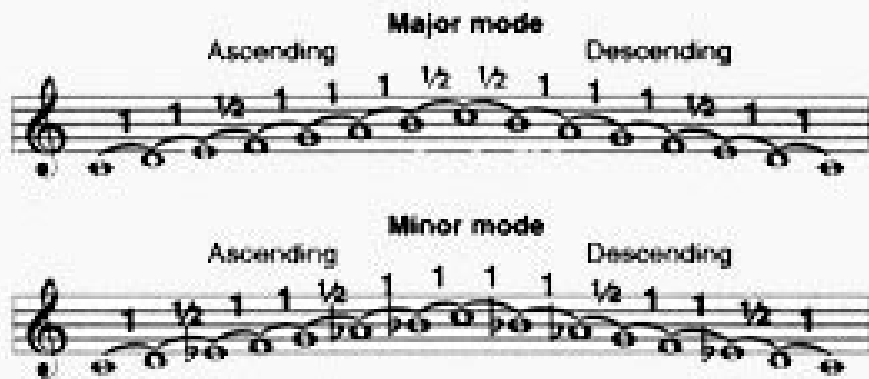
# Symmetries in Tiles in Alhambra



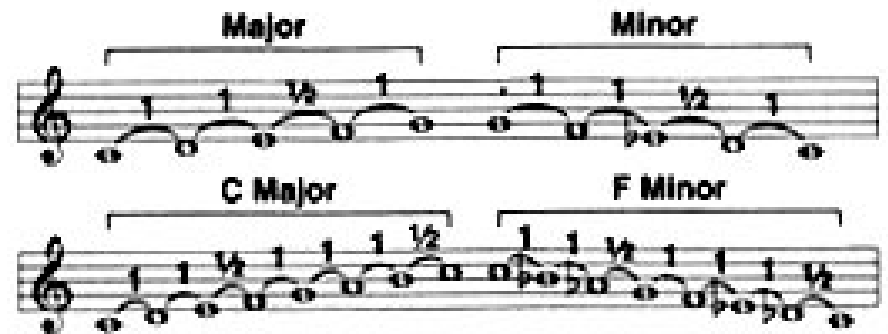
# Music

Fugues – Bach: [Play fugue.mp3](#)

**FIGURE 2.** *Intervals in the well-tempered system.*



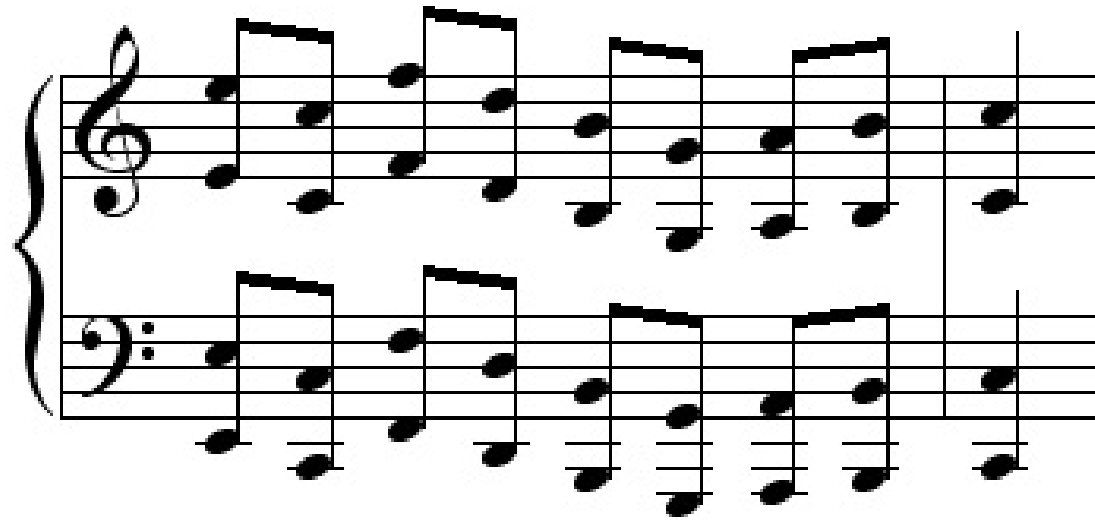
**FIGURE 4.** *Inversion of the major mode generates a minor mode of a different key.*



Arch form – **ABCBA** – Béla Bartók.



# Scales/chords – Mozart



# Literature

## Palindromes: Words and Sentences

dud, civic, madam

A man, a plan, a canal: Panama

Girl, bathing on Bikini, eyeing boy, finds boy eying bikini on bathing girl.

Palindrome Story – 2002 words long; published on Web on February 20th, 2002 or 20-02-2002.

Longest sentence: 17,826 words!

Y chromosome: 6 million of its 50 million DNA letters form palindromic sequences (with A, T, C and G).