

What Is Information Geometry?

A New Mathematical Foundation for Minerals and Life

Mathematics is supposed to be the universal language of nature. Yet the math we use is built on assumptions that fail the moment we leave the smooth, infinite planes of Euclidean geometry. We call this failure “approximation” and patch it with limits, imaginary numbers, and continuous functions. But life does not approximate. Life builds. And the structures it builds prove that the universe does not run on calculus. It runs on compression.

This paper introduces Information Geometry: a constructive, computable framework of space, built not from projection or infinity, but from symmetry, compression, and recursive transformation. Information Geometry is not a metaphor for life—it is the geometry life already runs, proven in every folded protein and every organism built from a single cell. By formalizing it, we offer a new foundation that unites mathematics, mineralogy, and biology under a single, executable logic.

The Limits of Smoothness

Modern math depends on smoothness. Calculus, differential geometry, and topology assume every structure can be flattened locally and projected globally. These tools work beautifully when modeling continuous curves, but they produce contradictions when applied to discrete systems like crystals, proteins, or genomes.

Consider the irrational constants that haunt smooth math— π , e , ϕ . They are products of trying to describe compression failures in linear space. Or imaginary numbers, invented to patch the contradictions of coordinate-based rotation. These are not properties of the universe; they are symptoms of the tools used to describe it. Life shows us that reality is neither smooth nor infinite. It is discrete, symbolic, and constructible.

The Sphere as Axiom

Traditional geometry treats the sphere as an outcome—a special case of continuous curvature. Information Geometry inverts this: the sphere is the starting condition. Perfect symmetry. From this axiom, complexity emerges by breaking symmetry.

This reversal reframes every question about space. Instead of asking how to flatten a curve, we ask: how can symmetry be broken into stable, constructible forms? This is not just a philosophical shift. It is a practical one. Because from two nested spheres—an inner anchor and an outer shell of discrete points—we can generate every perfect solid in the infinite dimensions of space.

Generating Perfect Solids from Two Spheres

It takes only two nested spheres and a minimal rule set to produce the five Platonic solids:

- Place points symmetrically on the outer sphere—20 for a dodecahedron.
- Apply discrete symmetry operations—rotations, reflections, permutations.
- The tetrahedron, cube, octahedron, icosahedron, and dodecahedron emerge naturally.

No coordinates. No equations. No π . Just discrete, executable logic—a direct compression of space. This finite, symbolic process mirrors exactly what life does when building proteins: it assembles stable, functional structures from minimal information, guided by symmetry.

The Axioms of Information Geometry

We propose five axioms for this new foundation:

1. Geometry is Constructible. Only forms built by finite, discrete operations are admissible.
2. Symmetry is Primary. Geometry emerges by breaking symmetry, not by adding complexity.
3. Compression is Truth. The fewer rules needed to generate structure, the more fundamental it is.
4. Computability is Realism. If it cannot be computed, it cannot exist in the physical world.
5. Planes Are Emergent. Flatness is not a starting assumption; it arises under specific constraints.

These axioms reverse Euclid's worldview. They discard the infinite, flat space of orthogonal grids and replace it with finite, compressible, generative forms that can be executed as algorithms.

Life as Proof-of-Concept

Life does not describe geometry with equations. Life runs geometry as code. DNA spirals and proteins fold not through smooth functions, but through discrete steps constrained by local forces, symmetry, and topological recursion. The genetic code itself is a minimal symbolic system—four symbols, 20 codons—compressing astronomical possibilities into a searchable, constructible set of viable molecules.

Life's success proves that nature favors compression over projection, constructibility over approximation. Evolution has refined the code of life not to describe space, but to compute it efficiently.

Beyond Crystals: From Bravais to Fractals

Bravais lattices define crystals through periodic repetition on Euclidean grids. Quasicrystals shattered that framework by demonstrating perfect long-range order without periodicity, using “forbidden” symmetries like icosahedrons and dodecahedrons. But life goes even further: it constructs fractal crystals—recursive, non-repeating, yet coherent structures—encoding spatial information into every fold.

Life's structures bridge the gap between static minerals and dynamic intelligence. Recognizing this continuum shows that crystal logic, quasicrystal logic, and biological logic are all steps in the same progression of symmetry-breaking and compression.

Consequences of Information Geometry

Accepting this framework has radical implications:

- π is a failed compression. Describing a curve in linear terms requires an irrational constant; describing it by symmetry needs none.
- Calculus is an approximation. Limits cannot be computed. Constructible steps can.
- Imaginary numbers are artifacts. They patch failures of planar logic; real rotations in 3D need no imaginary dimension.

- Topology becomes compression. The fundamental question is not about boundaries, but about the minimal symbolic rules that generate form.
- Space is not continuous. It is a finite, constructible machine, running symbolic transformations.

The Code of Life Is the Code of Space

The genetic code is not a linear recipe; it is a spatial search engine. By encoding folding possibilities as a compressive, symbolic language, it finds functional structures in an impossibly vast combinatorial space. This is not random mutation wandering aimlessly. It is structured, probabilistic navigation, guided by the same logic that can generate perfect solids from nested spheres.