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USE WITH CAUTION!

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Adapt & Verify for Your Classroom!



The Art of Mathematics

Where Watercolor Meets Number Theory

A cross-curricular exploration of the Golden Ratio, Fibonacci Sequence, natural science, and artistic composition for art and mathematics educators.

Biology

Watercolor

Photography

Mathematics

Composition

PROFESSIONAL DEVELOPMENT RESOURCE FOR EDUCATORS



The Golden Ratio = 1.618033988...

0 · 1 · 1 · 2 · 3 · 5 · 8 · 13 · 21 · 34 · 55

The Fibonacci Sequence

Bridging Two Worlds

Art and mathematics share a profound, often hidden relationship — this guide helps educators reveal it.

ART STUDENTS

- Use proportion and balance intuitively
- Often intimidated by formal mathematics
- Discover math through visual patterns
- Learn abstract concepts through making
- Connect formulas to beauty and elegance



MATH STUDENTS

- Understand ratios and sequences readily
- Often see math as abstract and irrelevant
- Discover art's geometric foundations
- Apply formulas to real visual outcomes
- Connect numbers to nature and beauty

The Fibonacci Sequence

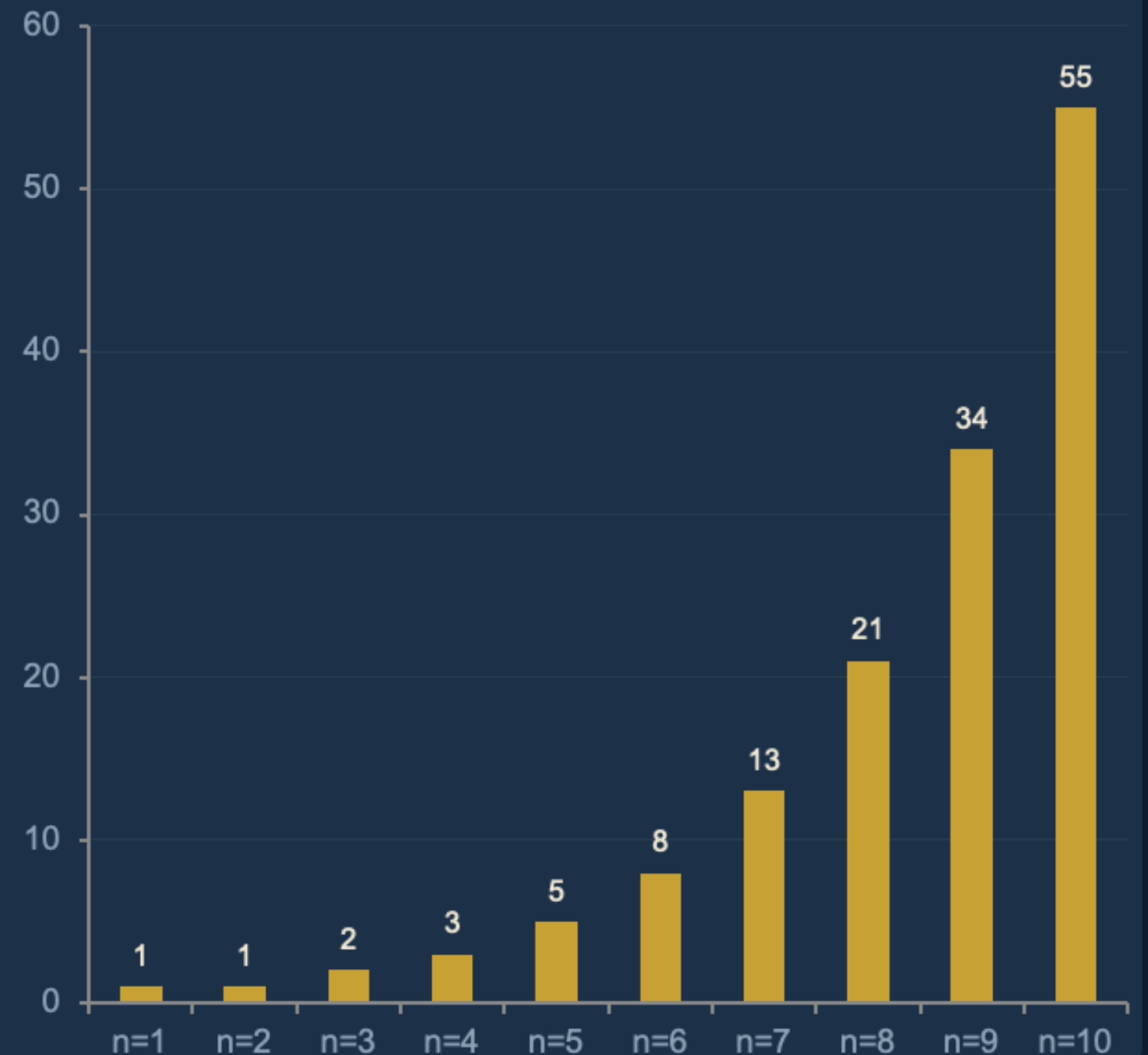
Each number equals the sum of the two preceding numbers — and together they encode nature's own blueprint.

0	1	1	2	3
5	8	13	21	34

$$F(n) = F(n-1) + F(n-2)$$

with $F(0) = 0$ and $F(1) = 1$

Exponential Growth of Fibonacci Numbers

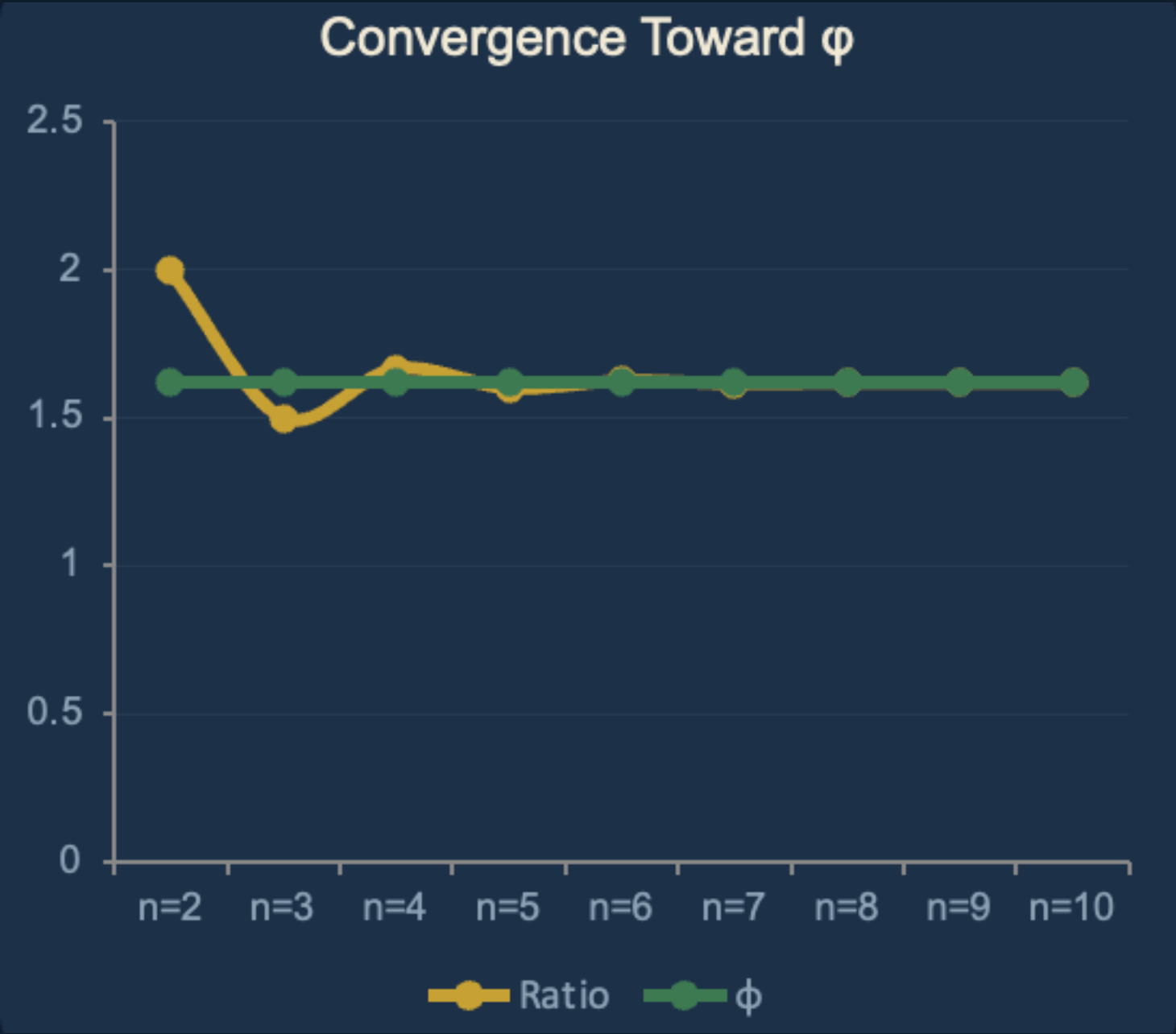


From Fibonacci to ϕ

Consecutive Fibonacci ratios converge — with remarkable precision — toward the Golden Ratio.

As n grows, the ratio $F(n+1) / F(n)$ approaches $\phi = 1.618033...$

n	F(n)	F(n+1)	F(n+1) / F(n)
1	1	1	1.0000
2	1	2	2.0000
3	2	3	1.5000
4	3	5	1.6667
5	5	8	1.6000
6	8	13	1.6250
7	13	21	1.6154
8	21	34	1.6190
9	34	55	1.6176
10	55	89	1.6182 ←
∞	→	→	$\phi = 1.6180...$



After just 10 terms, the ratio is accurate to 4 decimal places. This is why artists and architects have trusted it for centuries.

What Is the Golden Ratio?

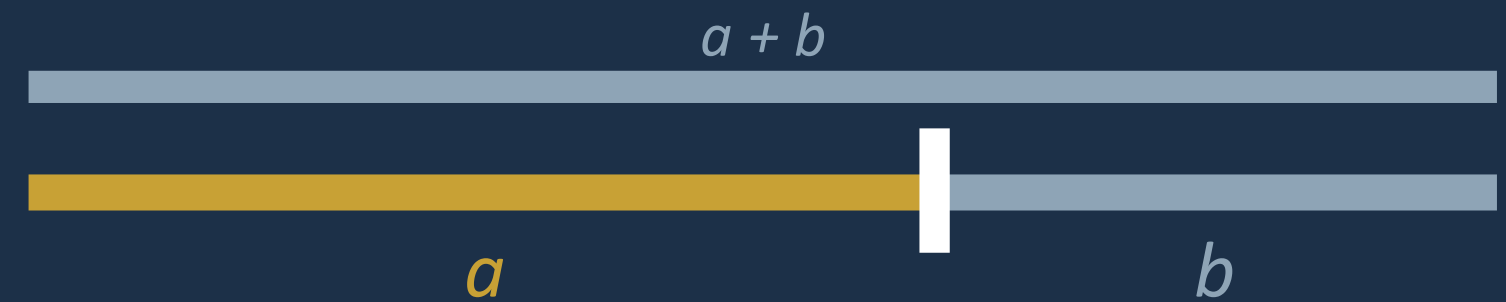
The Golden Ratio (ϕ , "phi") describes a special proportion in which a line divided into two parts has the ratio of the whole to the longer part equal to the ratio of the longer part to the shorter.

$$\phi = (1 + \sqrt{5}) / 2$$

$$\phi \approx 1.6180339887...$$

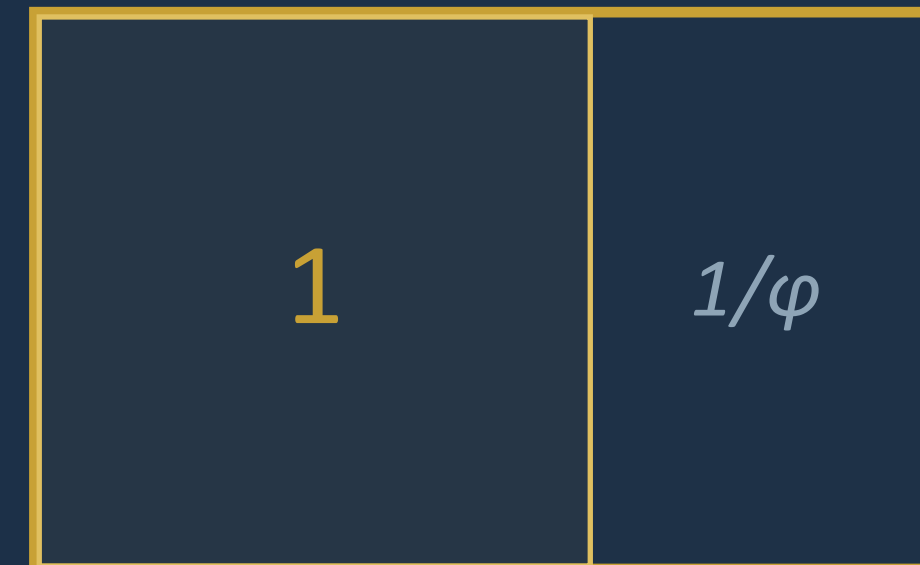
Key Properties:

- $a / b = (a + b) / a = \phi$ (the defining equation)
- $\phi^2 = \phi + 1 = 2.618...$
- $1 / \phi = \phi - 1 = 0.618...$
- ϕ is the only number where $\phi - 1/\phi = 1$



$$a / b = (a + b) / a = \phi$$

$$\phi \approx 1.618$$



Golden Rectangle (ratio $\phi : 1$)

Nature's Blueprint: Flora

Fibonacci numbers are encoded into the growth patterns of plants everywhere you look.

Sunflowers

- Seeds arranged in interlocking spirals
- 34 clockwise spirals, 55 counter-clockwise
- Ratio $55/34 \approx 1.617 \approx \phi$
- Maximizes packing efficiency — nature's optimization

Pinecones & Pineapples

- Pinecone scales: 8 spirals one way, 13 the other
- Pineapple rows: 8, 13, and 21
- Always consecutive Fibonacci numbers
- The spiral direction reverses at each level

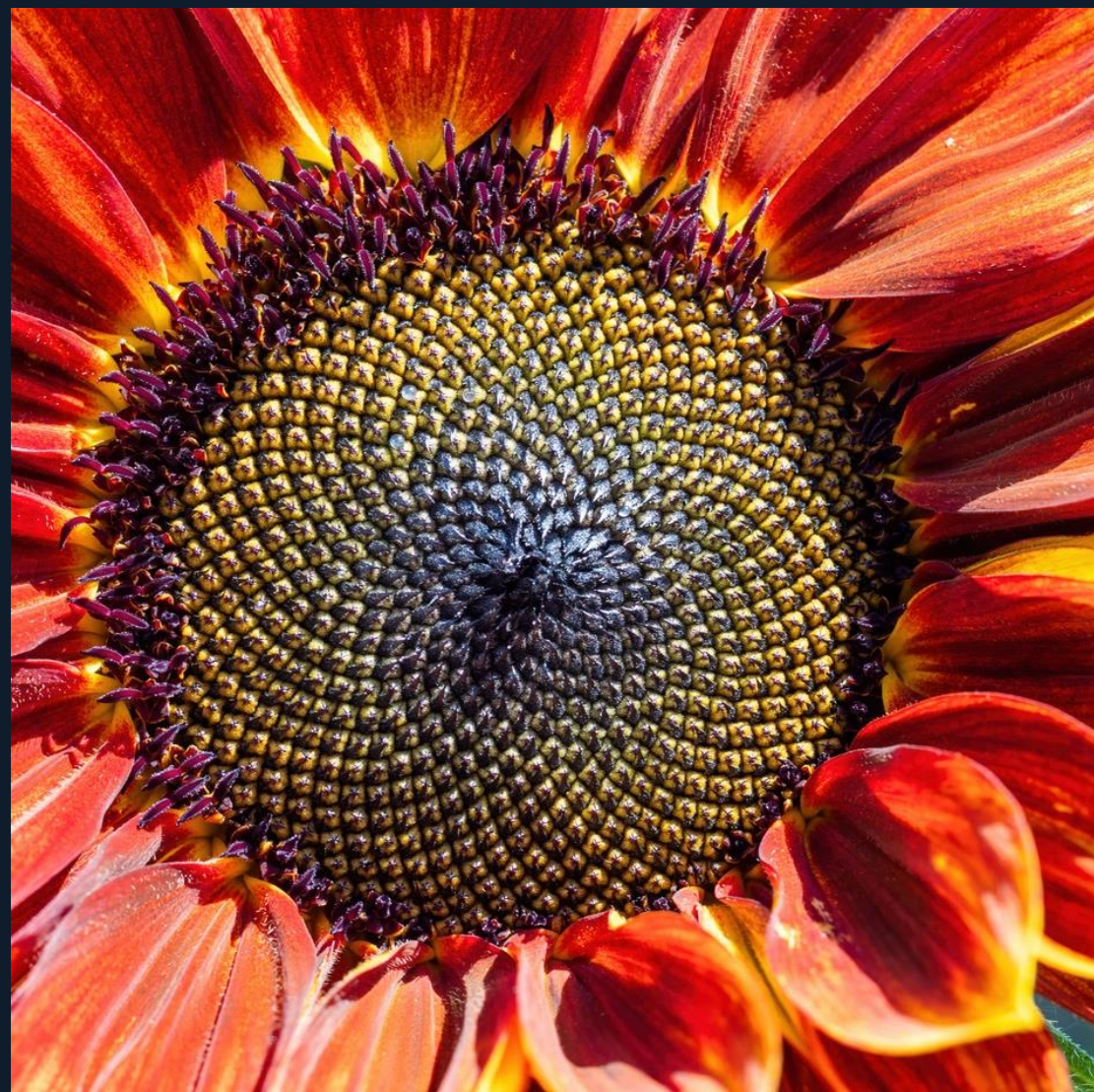
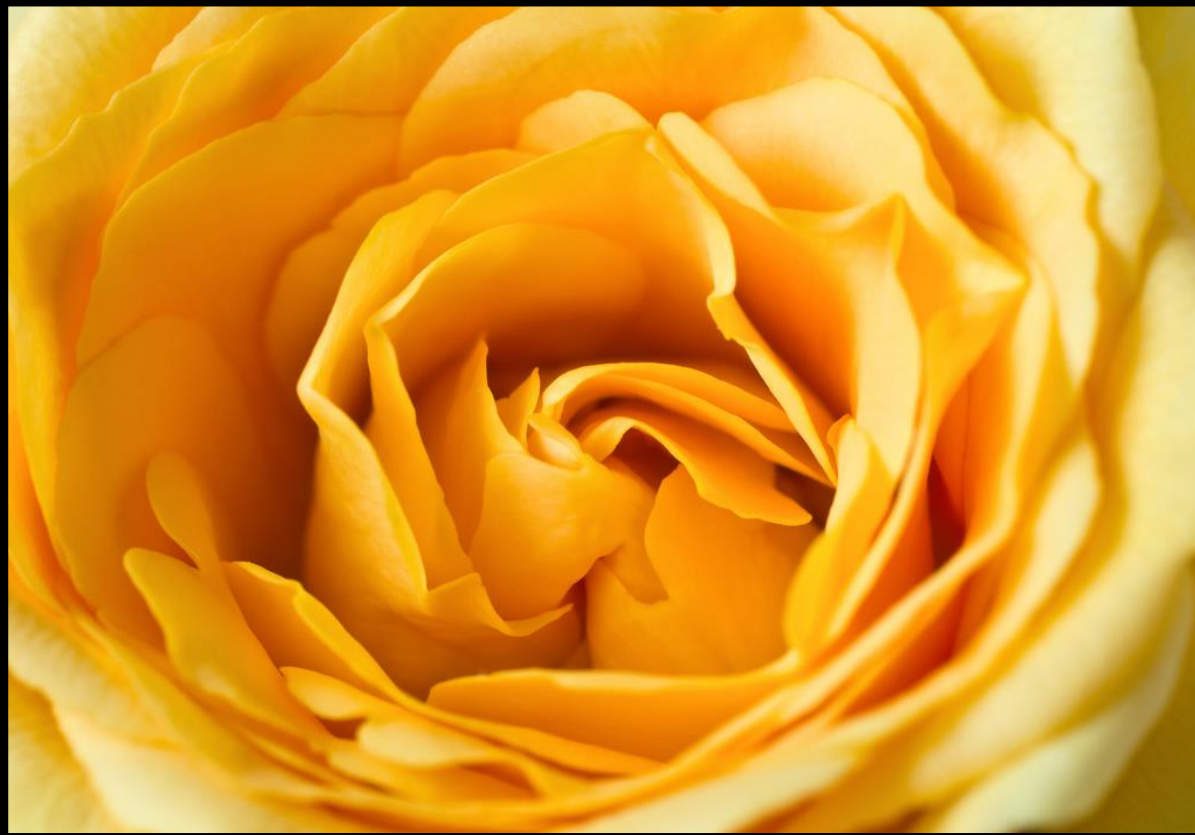
Flower Petals

- Lilies & irises: 3 petals
- Buttercups: 5 petals
- Delphiniums: 8 petals
- Corn marigolds: 13 petals | Asters: 21

Ferns & Romanesco

- Fern fiddleheads spiral logarithmically
- Romanesco broccoli shows perfect ϕ -spiral
- Each floret is a smaller self-similar copy
- This self-similarity is a fractal: math made visible

The Golden Angle: leaves and seeds are spaced exactly 137.5° apart — ϕ expressed in degrees



Nature's Blueprint: The Human Body

From fingertip to crown, the Golden Ratio appears throughout our own proportions.

Golden Proportions in the Human Form:

Total height to navel height

height $\div$ navel = φ

Navel to floor vs. navel to crown

lower $\div$ upper = φ

Forearm to hand length

forearm $\div$ hand = φ

Finger joints (each segment)

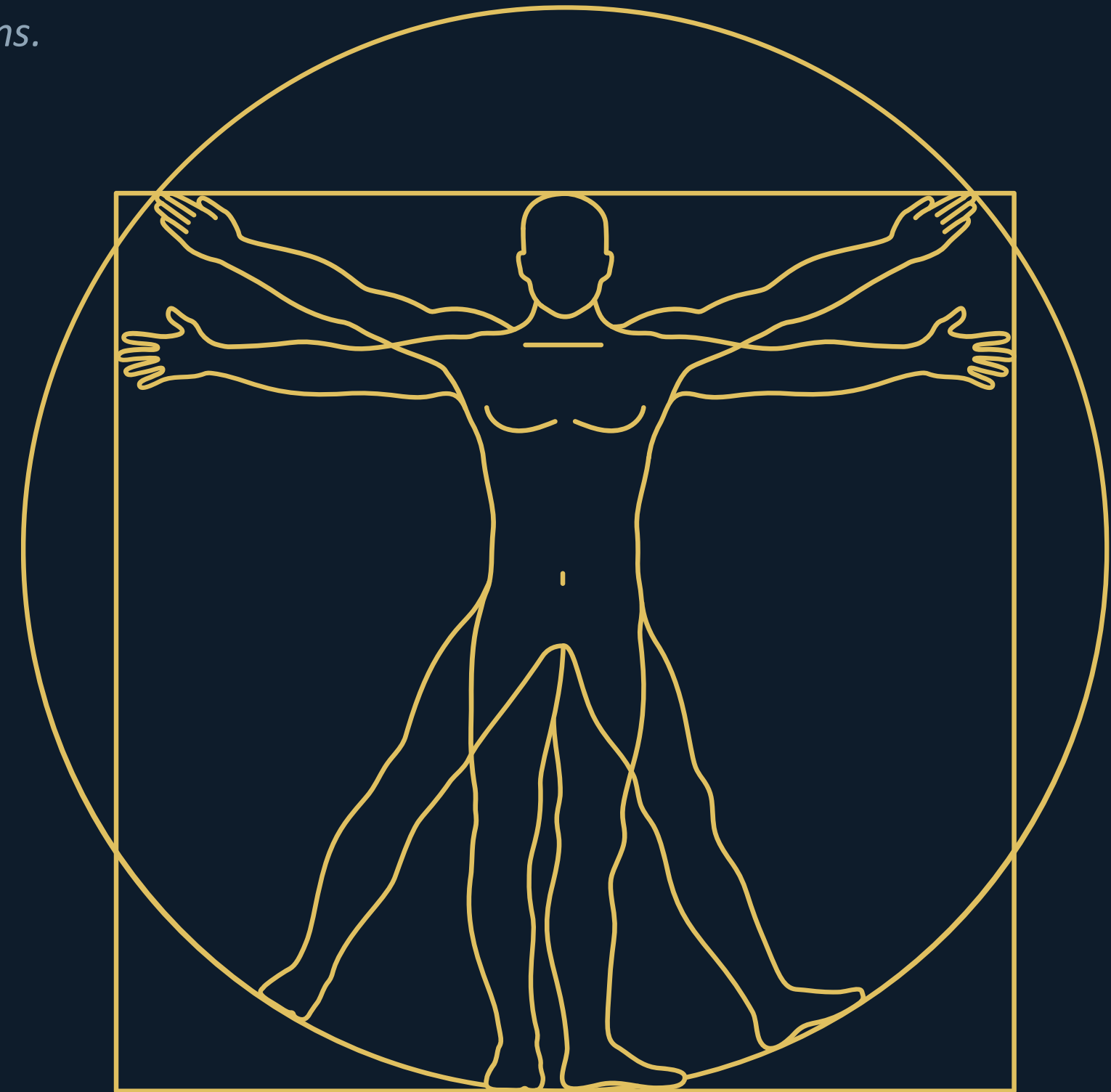
each $\div$ next = φ

Tooth width proportions

used in dental esthetics

DNA molecule geometry

34 Å long $\times$ 21 Å wide per turn



"The human body was first to display in itself the proportions of the divine ratio." — Fra Luca Pacioli, 1509

Constructing the Golden Rectangle

A compass and ruler are all that's needed — a powerful classroom construction activity.

Construction Steps:

- 1 Draw a unit square (1×1).
- 2 Find the midpoint of the base.
- 3 Draw a diagonal from midpoint to upper-opposite corner.
- 4 Use this diagonal as the radius of an arc.
- 5 Extend the base of the square to meet the arc.
- 6 Complete the rectangle — this is the Golden Rectangle.



Fibonacci Rectangle (8 × 5)

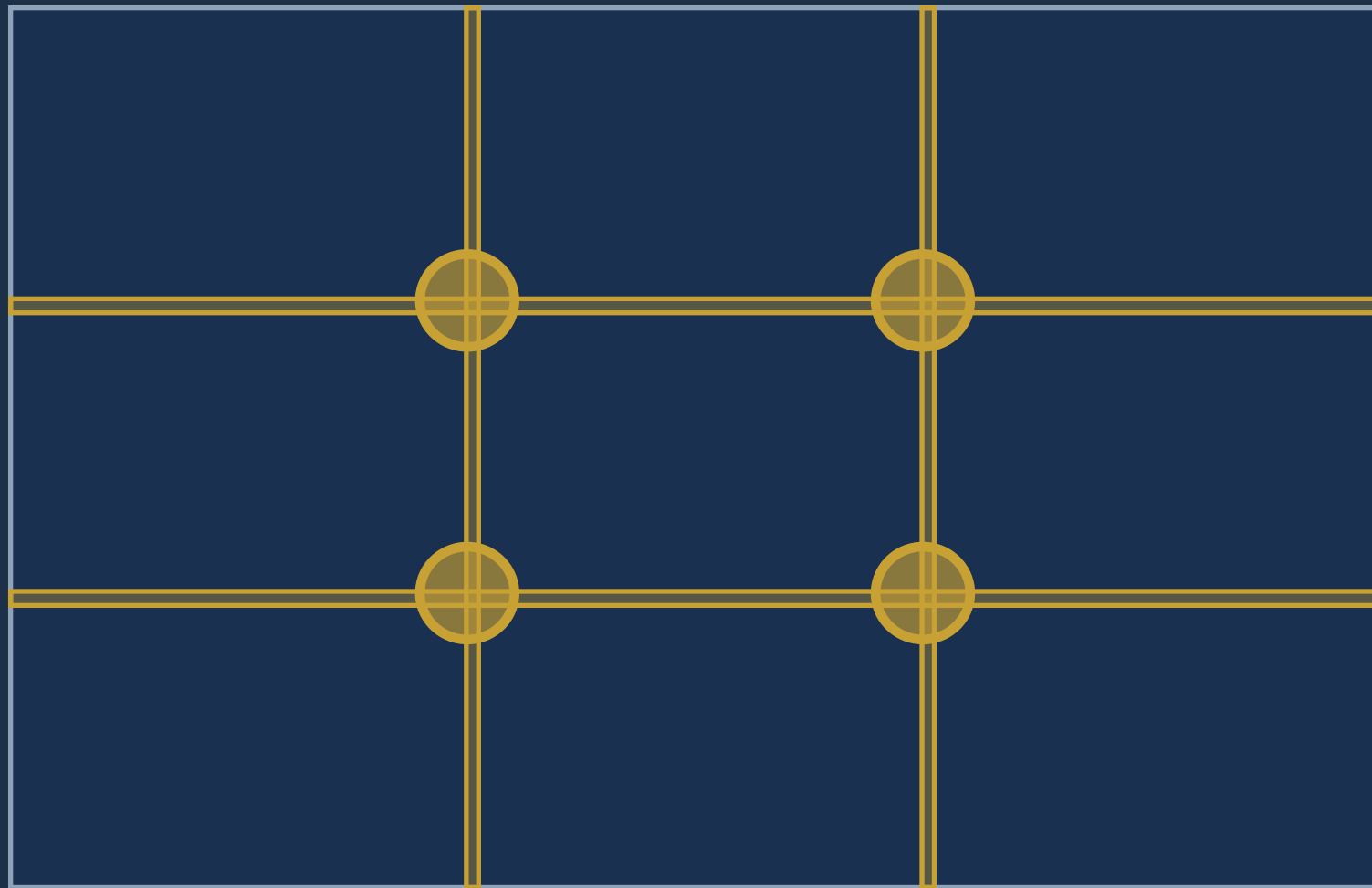
The Infinite Spiral

Each square, when removed, leaves a smaller golden rectangle. This nesting continues infinitely. Draw a quarter-circle arc through each square and you create the logarithmic spiral — found in nautilus shells, galaxies, and breaking waves.

Composition: Photography & the Golden Mean

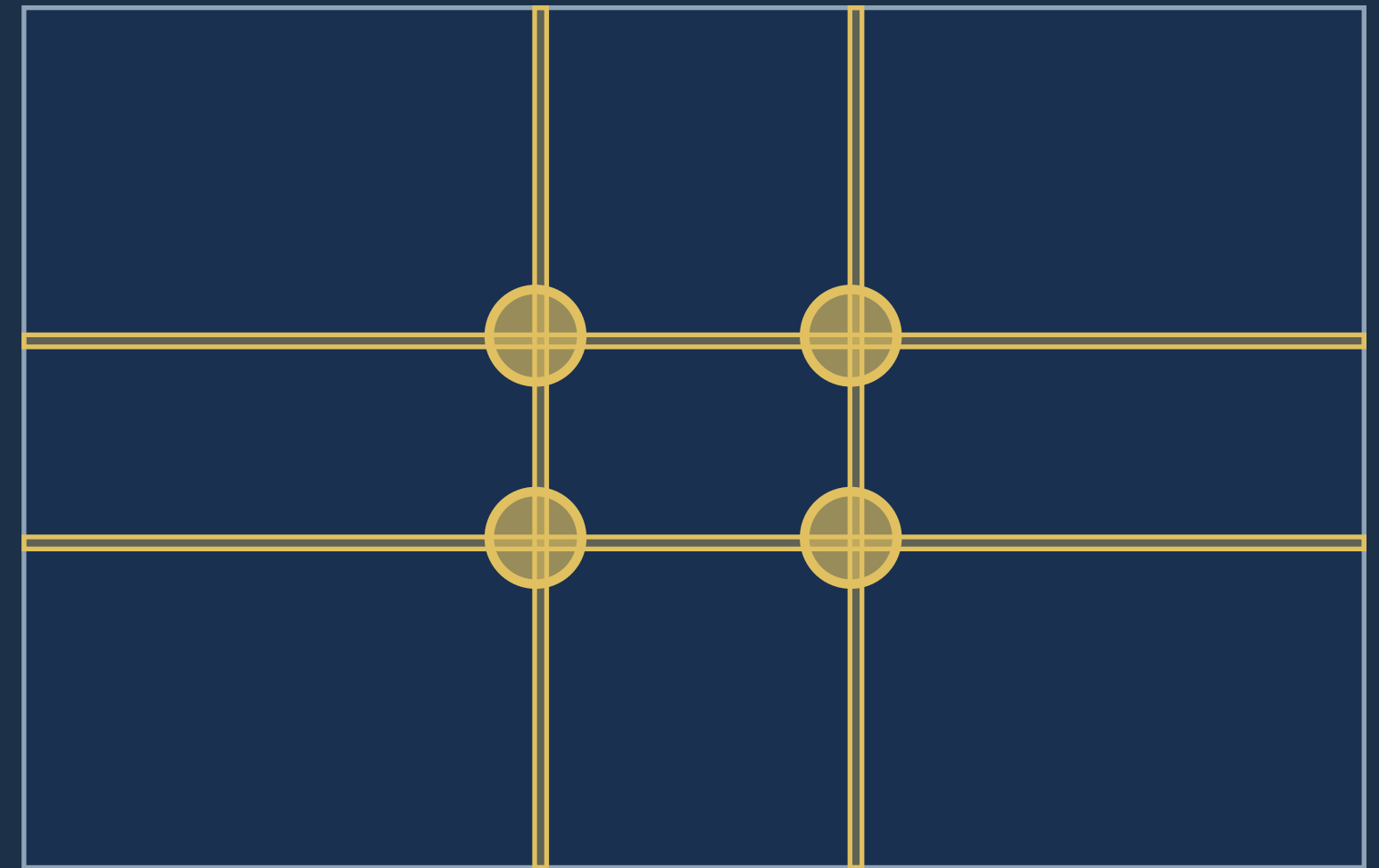
Professional photographers use mathematical grids to guide the eye and create powerful images.

Rule of Thirds



Grid divides image into 9 equal parts.
Key subjects placed on intersections.

The Phi Grid (ϕ)



Divides image using ϕ proportions — not equal thirds.
Feels more naturally balanced to the human eye.

Classroom Tip: Students can create cardboard viewfinders with rule-of-thirds and phi-grid overlays to practice compositional analysis in their own photographs.

Composition: The Art of Still Life

Still life painting is the perfect laboratory for teaching mathematical proportion in a hands-on context.

The Golden Mean

- Place primary subject at ϕ intersection
- Secondary elements complete the ratio
- Avoid centering — tension creates interest
- Use diagonals to guide the eye

Mathematical Balance

- Visual weight, not symmetry
- Larger objects need smaller counterparts
- Dark values balance large light areas
- Negative space is a compositional element

Proportion & Scale

- Objects sized by golden-ratio relationships
- Foreground objects: Fibonacci multiples larger
- Use calipers to verify proportional spacing
- Overlap objects to create depth

Activity Idea: Photograph a still life setup, then overlay the ϕ -grid in photo editing software. Have students compare perceived beauty with mathematical placement.

The 60–30–10 Rule: 60% dominant color · 30% secondary · 10% accent — a Fibonacci-like proportion found in interior design, fashion, and classical painting.

Watercolor & Mathematical Proportion

Mathematics is embedded in every decision a watercolor painter makes — from canvas format to color mixing.

Canvas Format & Proportion

Golden Rectangle Format

Choose a canvas in ϕ :1 ratio (e.g., 13"×8") for natural harmony.

Standard Paper Sizes

Many watercolor formats approximate ϕ : 22"×15" (Imperial) $\approx$ 1.47.

Dividing the Picture Plane

Use the ϕ -grid to place your horizon, focal point, and key elements.

Matting Math

Mats in golden ratio proportions feel more elegant than equal borders.

Scaling & Thumbnails

Thumbnail sketches preserve proportions when enlarged using grid or ratio.

Color Temperature & Value Scales

The 7-Step Value Scale

Create a mathematically even grayscale from white to black — a key skill.

Warm-Cool Ratio

Classical theory: 60% cool + 40% warm, or inverse — always unequal.

Color Mixing Ratios

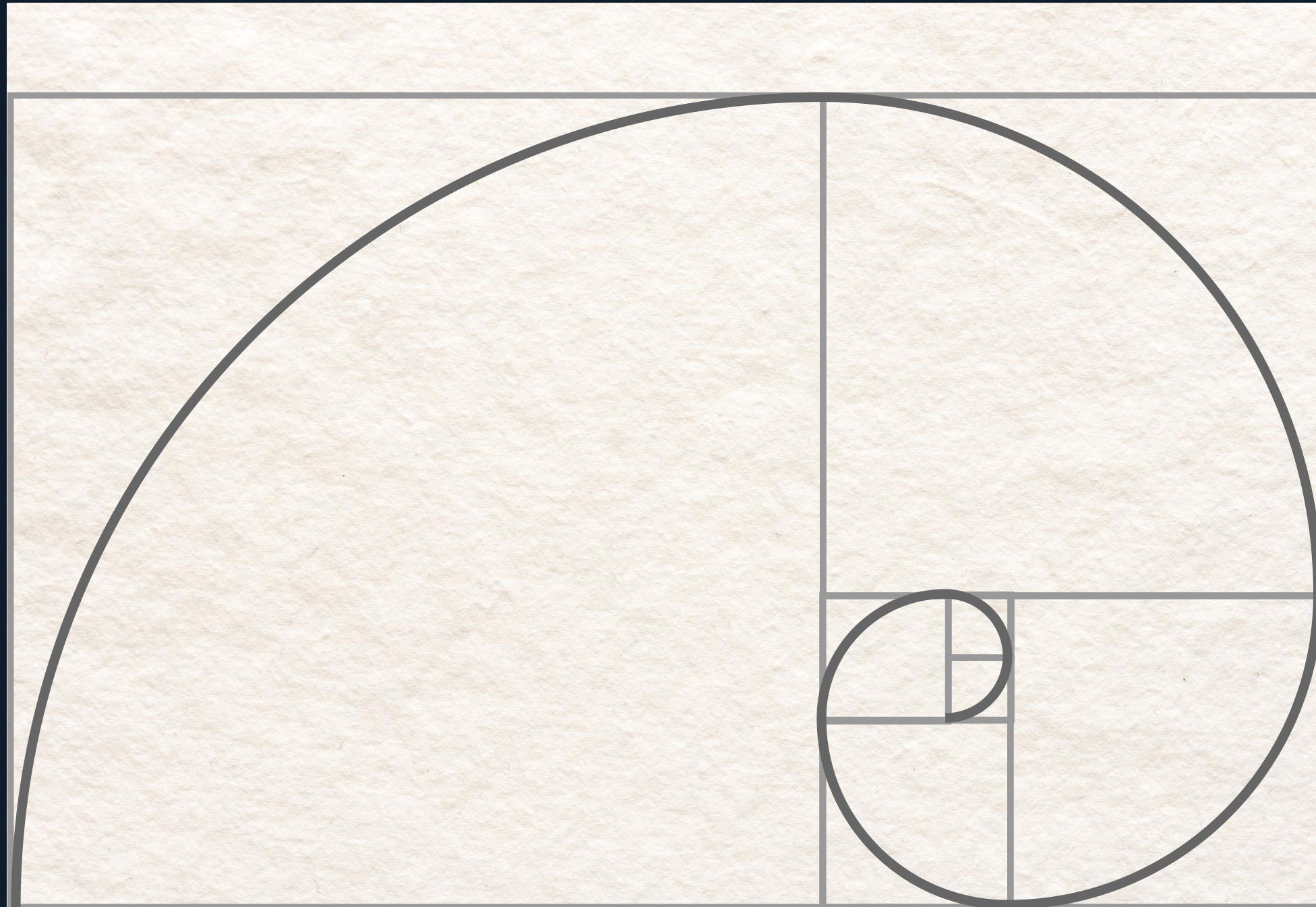
2:1, 3:1 ratios control color temperature shifts predictably.

Fibonacci Color Harmony

Hue relationships at 3, 5, 8 positions on the color wheel.

Transparent vs. Opaque Wash

Glazing dilution ratios (1:5, 1:10) create precise value steps.



The golden ratio requires:
long side $\div$ short side = ϕ =
1.618

Keep the 10" width, trim the height:

$$10 \div \phi = 10 \div 1.618 = 6.18"$$

*Trim your 8" height down to $6\frac{3}{16}"$
(6.1875" — within $1/100"$ of exact)*

*You'll remove about $1\frac{7}{8}"$ from one
long edge.*

Resulting sheet:

$$6\frac{3}{16}" \times 10" \rightarrow \text{ratio} = 1.617$$

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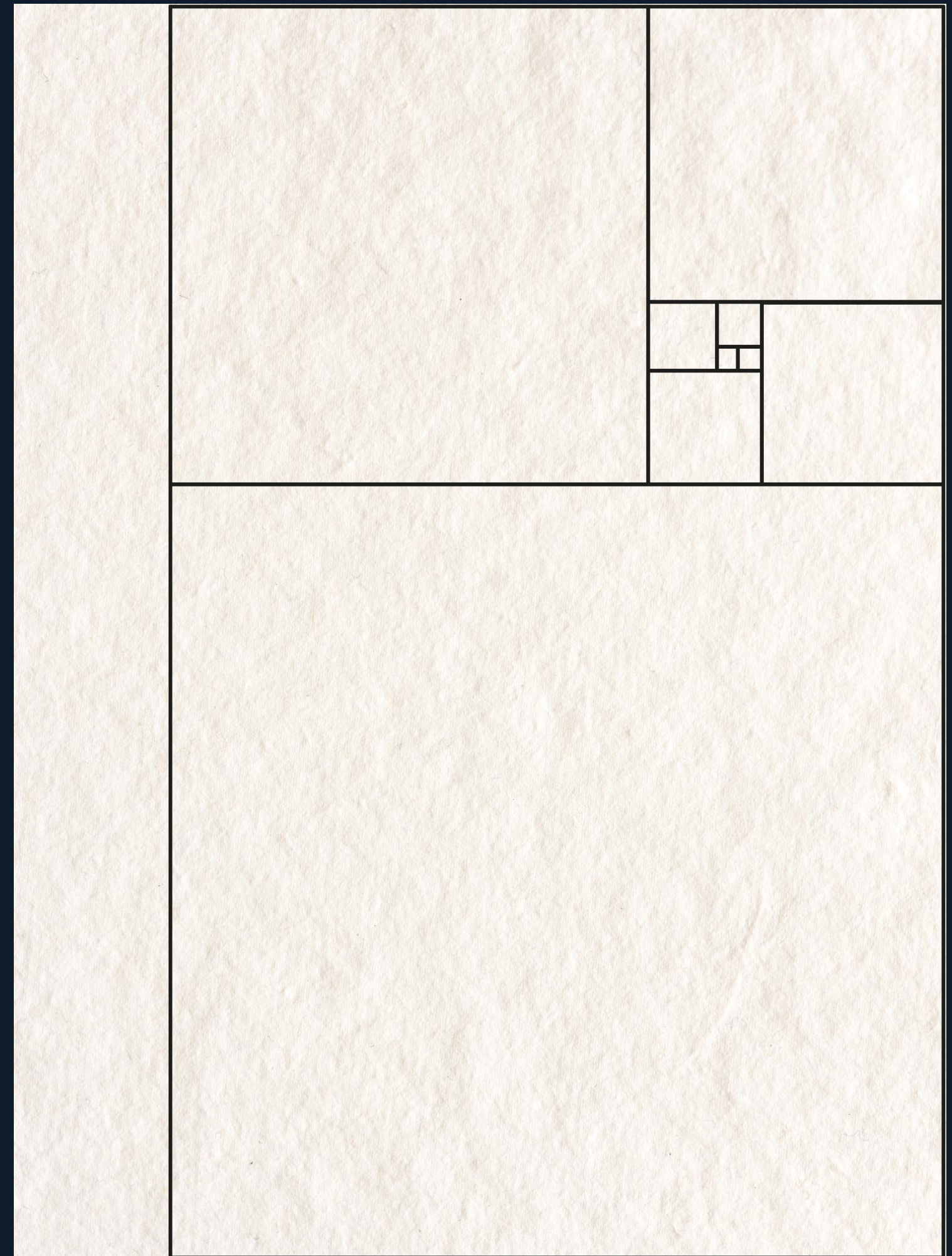
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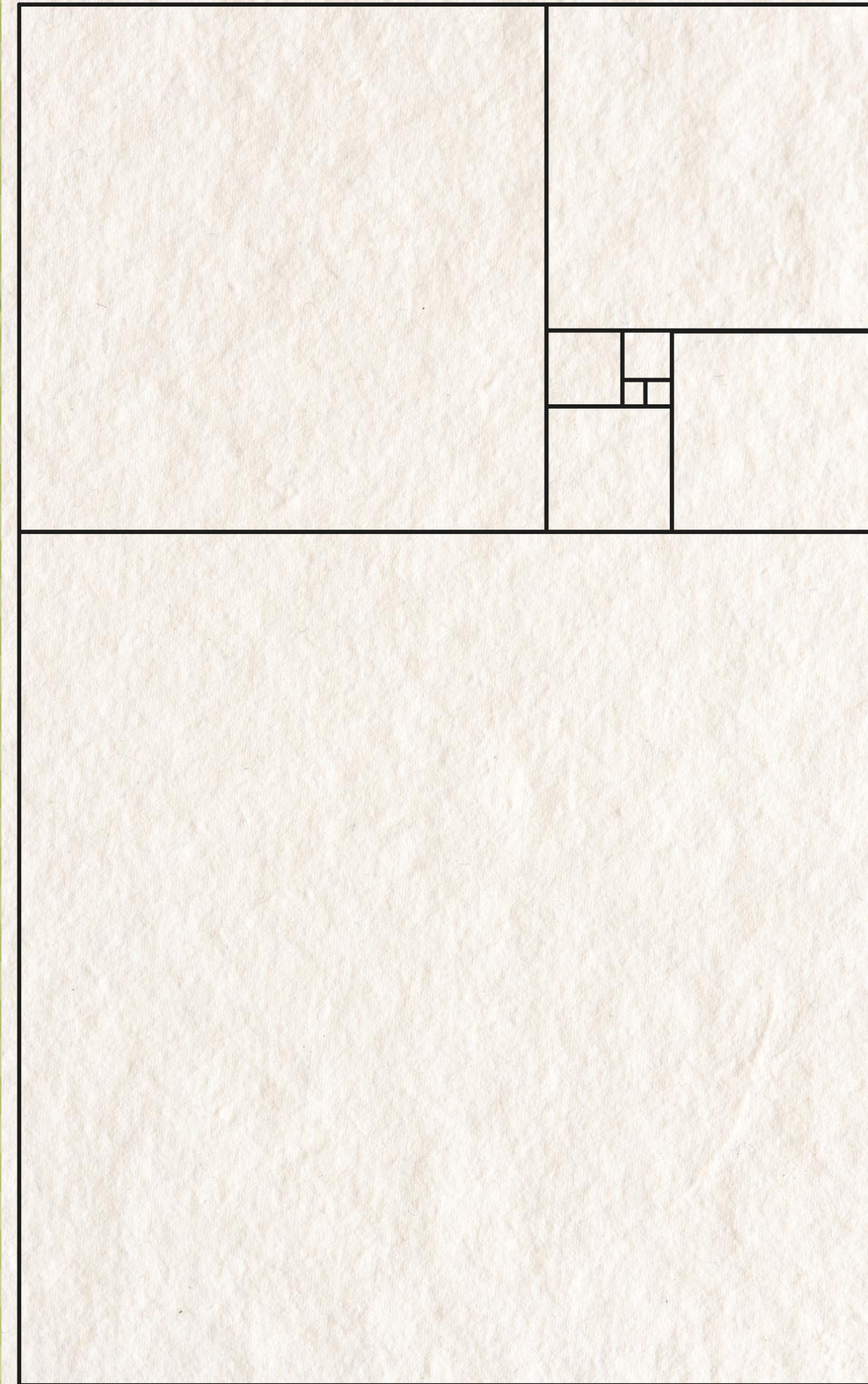
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Better YET!

**Lay out your Grid and tape
down the outside edges
with paper-safe tape**



Tools of the Artist-Mathematician

Physical tools transform abstract mathematics into tangible creative decisions.

Golden Ratio Calipers

Purpose-built calipers with ϕ built into their geometry. Whatever distance measured on the outer arms, the inner arm automatically reads $1/\phi$ of that distance — ideal for checking proportions in life drawing, still life, and painting.

Use for: Figure drawing, proportioning still life objects, verifying canvas division, checking perspective ratios.

Proportion Wheel

Two rotating discs showing any ratio. Enter an original dimension on one scale and read the proportional enlargement or reduction on the other. Essential for scaling reference photos to canvas without distortion.

Use for: Scaling thumbnails to final size, maintaining ϕ ratio when choosing canvas dimensions.

Viewfinder & L-Frames

Two L-shaped cards form an adjustable frame. Students use these to isolate compositions, practice applying the rule of thirds and phi-grid before committing to paper. Inexpensive — made from cardboard in class.

Use for: Composition practice, identifying natural ϕ proportions in the environment.

Compass & Straightedge

The classical mathematical tools for constructing golden rectangles, pentagons, and Fibonacci spirals with full geometric precision. Constructing ϕ from a unit square requires only these two tools.

Use for: Classroom construction of the golden rectangle; demonstrating geometric proof of ϕ .

Classroom Activity: Fibonacci Spiral Watercolor

A step-by-step project that produces beautiful art while teaching sequence, ratio, and geometric construction.

Project Sequence (1–2 class periods)

- 1

Introduce the Sequence

Present Fibonacci on the board. Students calculate 15 terms individually, then verify with a partner. Discuss the ratio $F(n+1)/F(n)$ and demonstrate its approach to ϕ .
- 2

Construct the Fibonacci Rectangle

Using compass and ruler, students draw the nested squares (1,1,2,3,5,8) on watercolor paper. Label each square. Calculate actual ratios of adjacent squares.
- 3

Draw the Logarithmic Spiral

In each square, draw a quarter-circle arc from corner to corner. The combined arcs create the ϕ -spiral. Students may use a compass or freehand for organic variation.
- 4

Apply Watercolor

Each Fibonacci square receives one hue family (warm→cool or light→dark progression). Students mix paint to fill each rectangle in a mathematically even gradient.
- 5

Reflect & Measure

After drying, students measure color proportions, calculate the actual ϕ -ratio from their paintings, and write a brief reflection connecting art decisions to mathematical principles.

Materials

- Watercolor paper (140 lb, cold press)
- Compass and ruler
- Watercolor paints (limited palette)
- Round brushes (#4, #8, #12)
- Mixing palette
- Pencil and eraser

Differentiation

- Advanced: research the irrational nature of ϕ
- Core: focus on construction and painting
- Support: provide pre-drawn Fibonacci grid

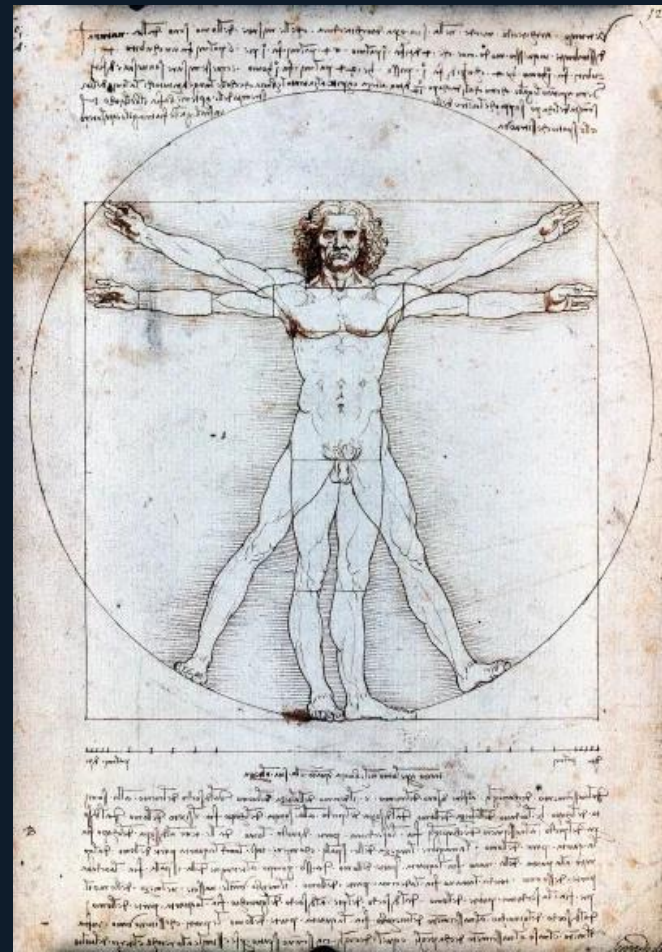
Great Artists & Mathematical Beauty

The world's most celebrated artists were also mathematicians — and knew it.

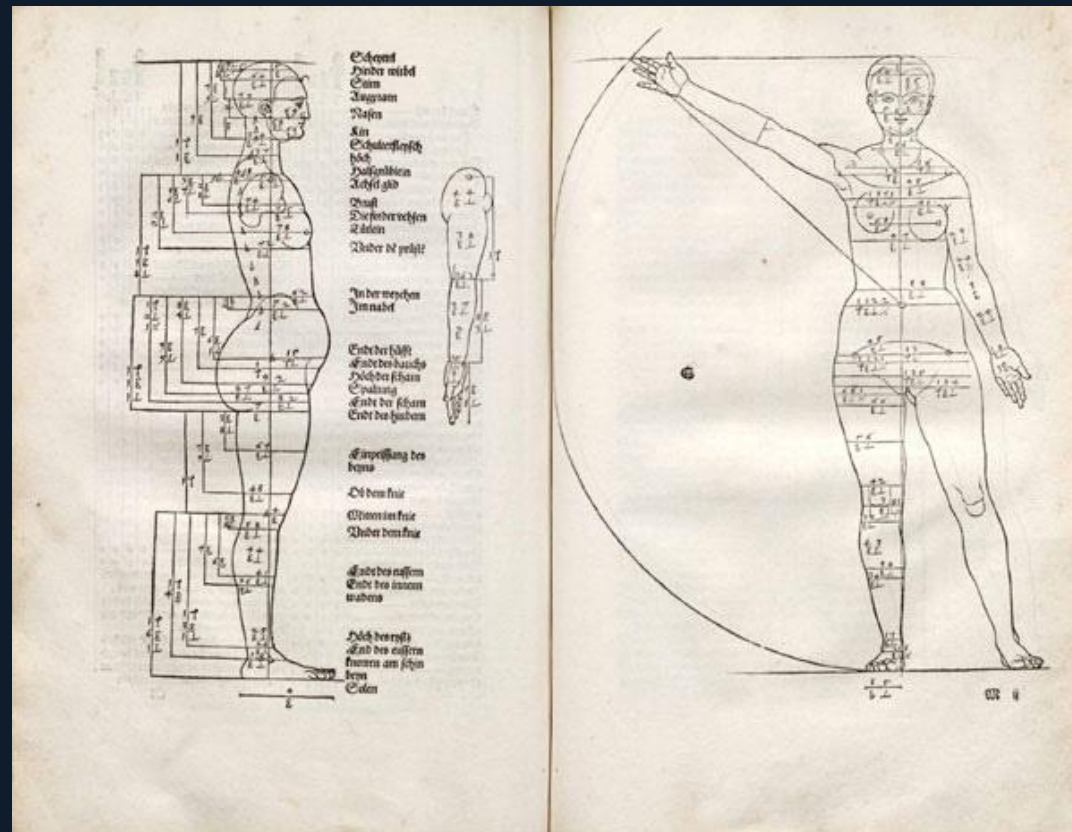
Leonardo da Vinci

1452–1519

- Illustrated Pacioli's De Divina Proportione (1509)
- Vitruvian Man encodes human ϕ proportions
- The Last Supper: composition based on golden mean
- Wrote: "Let no one who is not a mathematician read me"



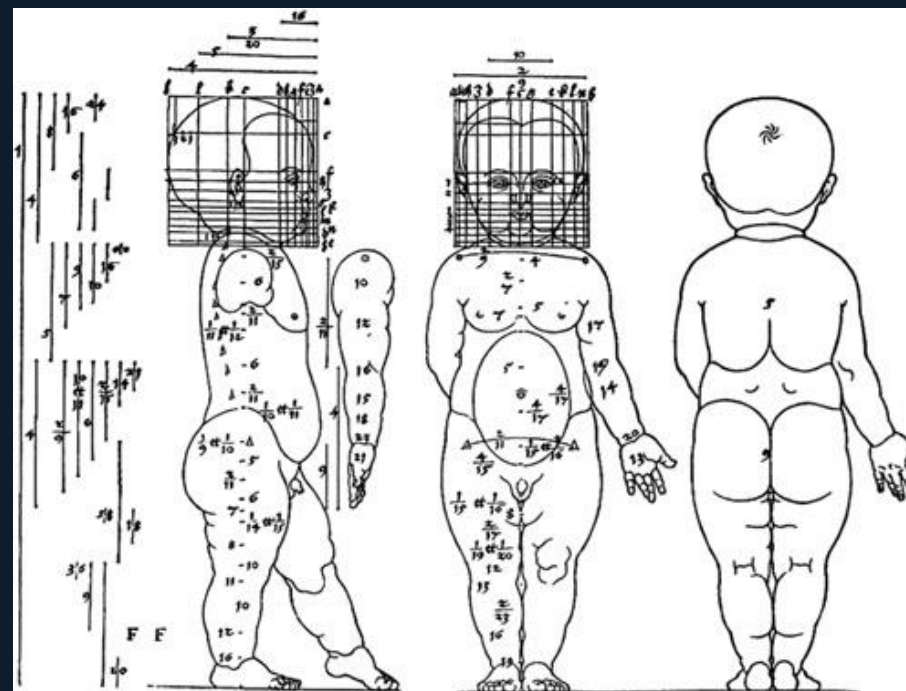
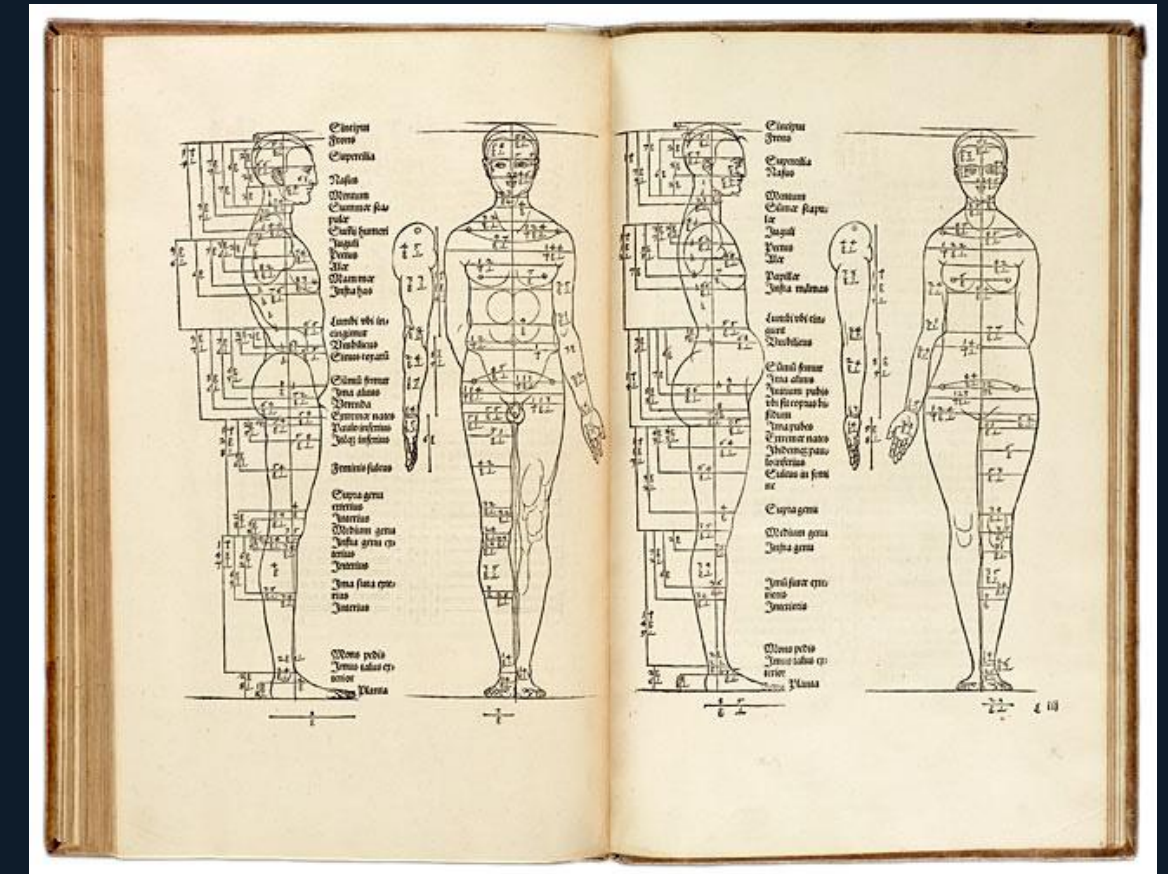
Great Artists & Mathematical Beauty



Albrecht Dürer

1471–1528

- Published Treatise on Human Proportion (4 volumes)
- Applied ϕ systematically to figure drawing
- Developed compass-and-ruler construction methods
- Influenced German Renaissance through geometric art



Great Artists & Mathematical Beauty

The world's most celebrated artists were also mathematicians — and knew it.



Katsushika Hokusai

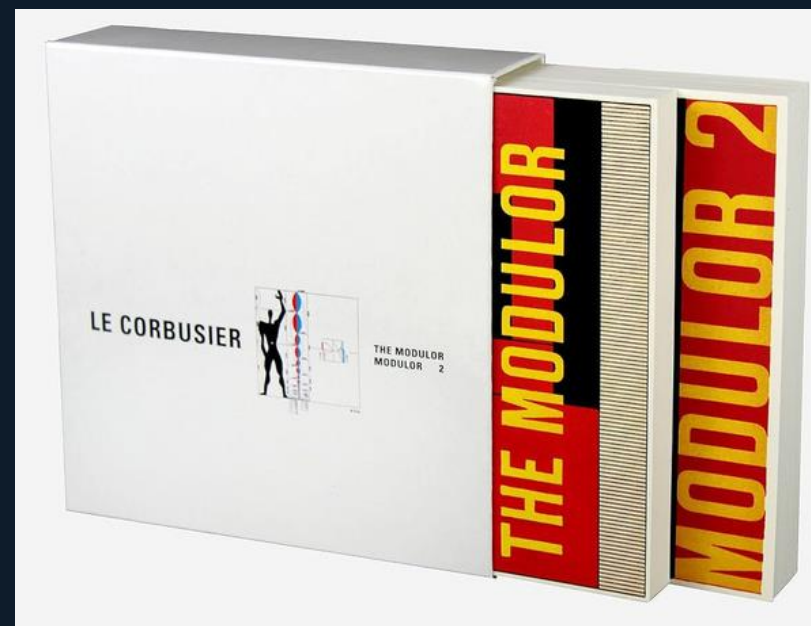
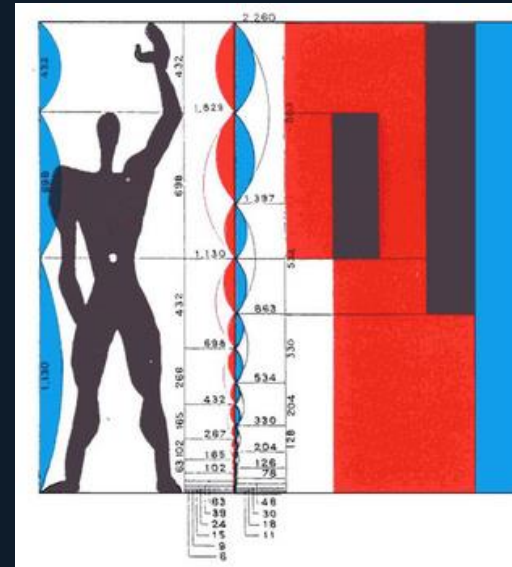
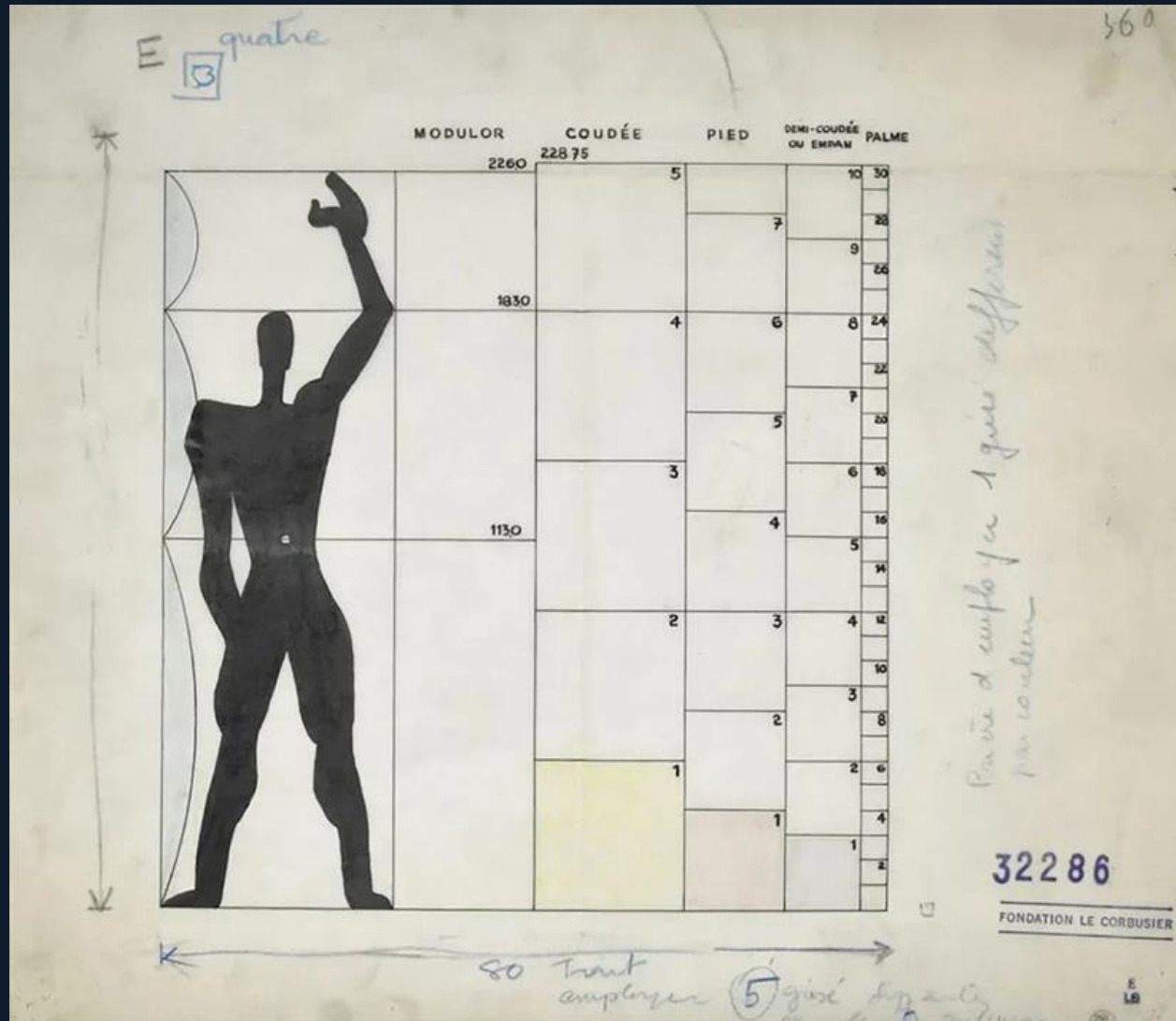
1760–1849

- The Great Wave: phi spiral in the composition
- Mt. Fuji placed at golden-ratio position
- Known to study Dutch mathematical geometry
- His 36 Views explore mathematical perspective



Great Artists & Mathematical Beauty

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Le Corbusier

1887–1965

- Developed the Modulor: ϕ -based human proportions
- Applied golden ratio to architecture and urban design
- Published *Le Modulor* (1948) — mathematics + art + body
- Defined human-centered design through number

Great Artists & Mathematical Beauty

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Salvador Dalí

1904–1989

- "Sacrament of the Last Supper" on a ϕ -ratio canvas
- Incorporated dodecahedron (ϕ -based solid) in the work
- Collaborated with mathematician René Thom
- Called the golden ratio "the most beautiful number"



Cross-Curricular Teaching Strategies

Practical guidance for art educators building mathematical literacy — and math educators building visual fluency.

FOR ART EDUCATORS

Start with beauty, then reveal the math

Show stunning works first — ask why they feel right. Introduce ϕ as the answer.

Use physical calipers daily

Have students measure their own drawings for ϕ proportions throughout the year.

Build the construction

Every student constructs a golden rectangle with compass — it's memorable and precise.

Require mathematical notation

Insist students write the ratios they find. Connect art vocabulary to math vocabulary.

Invite the math teacher

Co-teach one lesson: the artist sets up; the mathematician explains the formula.

FOR MATHEMATICS EDUCATORS

Use the Fibonacci sequence as a hook

Its visual beauty is instantly motivating — even for reluctant math learners.

Prove ϕ from the sequence

Walk students through the limit proof: $\lim F(n+1)/F(n)$ as $n \rightarrow \infty$.

Assign watercolor as a math product

Require students to submit painted golden rectangles as a ratio assignment.

Visit the art room

Ask the art teacher to show works with ϕ proportions — connect classrooms physically.

Photograph and measure nature

Field assignment: photograph 10 natural examples, measure and calculate ratios.

Resources for Further Exploration

Essential Reading

The Golden Ratio — Mario Livio (2002)

The Divine Proportion — Luca Pacioli (1509)

Drawing on the Right Side of the Brain — Betty Edwards

Math and Art: An Introduction — Sasho Kalajdzievski

The Power of Limits — György Doczi

Classroom Tools

Golden ratio calipers (search "golden mean gauge")

Free phi-grid camera apps (iOS & Android)

Desmos graphing calculator (desmos.com)

NCTM Illuminations (illuminations.nctm.org)

Khan Academy: Fibonacci & golden ratio lessons

Suggested Projects

Fibonacci spiral watercolor (see Slide 13)

Photo field study: ϕ in nature (biology cross-over)

Still life with proportion analysis

Body proportion study with calipers (art + biology)

Architecture site visit with measurement assignment

"A mathematician, like a painter or poet, is a maker of patterns. If his patterns are more permanent than theirs, it is because they are made with ideas."

— G.H. Hardy, *A Mathematician's Apology*