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The Gothic Vision

Blueprints for technology in patterns of design.

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We see better when we recognize and can name (at least for our own purposes) the things we see. If you can tell a delphinium from a daylily, or a Titian from a Rubens, or a Honda Civic from a Lotus Elise, you see the world in sharper focus than someone who can't.

Gothic architecture--which emerged near Paris in the 1140s, became a powerful artistic force in most of Europe and remained so through the early 1500s--has been studied seriously since the 19th century. No other style of art in Western history has had such an intensely magnetic (sometimes passionate, sometimes hypnotic) appeal. You might imagine that every aspect of Gothic worth recognizing has already been recognized. Not true. Ideas from computer science sharpen our focus on Gothic architecture. They help us identify a fundamental design gesture that historians have seen in particular cases, but haven't described as the widespread, general phenomenon it is--because they lack the intellectual or ideational vocabulary.

Software has already played a role in research and writing on medieval architecture. The eminent Alain Erlande-Brandenburg's recent book on the cathedral of Reims (2007) is part of the new "Grand témoins de l'architecture" series. Each book is based on a fabulously detailed software model, which allows one to study the building of interest from unexpected viewpoints. Of course, the practice of architecture has been in the hands of the computer-aided design industry for years; historical essays illustrated by sophisticated computer-generated images are common. Yet the best such images approach nowhere within miles of the detail, precision, and beauty of engravings from the studios of such 19th-century master medievalists as Augustus Pugin, Robert Billings, and Eugène Viollet-le-Duc.

Allow me to discuss technology as a source not of tools but ideas. Computer science is useful in this case because software happens to resemble Gothic architecture in an unexpected way--"recursive structure" is important to each.

A structure is said to be recursive if the shape of the whole recurs in the shape of the parts. Imagine a circle, for example, formed of welded links that are circles themselves. Each circular link could itself be made of smaller circles, and in principle you might have an unbounded nest of circles made of circles made of circles. This sort of structure is surprisingly important in software, and in Gothic architecture.

The idea of recursive structure didn't originate with modern computing, but came into its own there. It first appeared as a powerful tool for organizing digital information in a software application designed in the late 1950s by H.L. Gelernter, in the course of his pioneering work on artificial intelligence. This application inspired a related one called Lisp, where recursive structure is the basic organizing principle not only for data but for the program itself. Years later the mathematician Benoit Mandelbrot developed his highly influential work on fractal curves as descriptions of nature based, partly, on the idea of recursive structure.

In architecture, the idea occurs in a much simpler way.

Many churches terminate in a chevet: As you enter such a church and walk towards the rear, you reach a

half-circular space called the apse. You might find separate chapels opening off (or "radiating from") the walkway or ambulatory that follows the outside perimeter of the apse.

The chevet at the Abbey of Saint-Denis (1144) is a recursive structure. Its half-circular perimeter is defined not by a simple curved line but by a series of scoops, each a radiating chapel--and itself (roughly) a half-circle. In other words, this chevet is a semi-circle of semi-circles.

Many chevets have approximately this shape--in which each chapel "becomes a paraphrase of the apse itself," as John Summerson puts it. But Saint-Denis realizes the idea in its purest form--appropriately; Gothic architecture first emerged at Saint-Denis in this very chevet, and nearby parts of the building.

The inside of the west or front façade at Reims Cathedral, probably designed in the 1220s, is one of the most celebrated compositions in medieval art. In a large pointed arch a rose window is lodged at the top like a helium balloon. Within this large arch, and below the rose, is a second, smaller arch with a smaller rose lodged at its top. Thus, another recursive structure: an arch with a rose and, nested within it, a smaller arch with a smaller rose.

The west wall at Reims seems perfectly natural and is, but its recursive structure solves a tricky problem. It's often difficult to design a satisfactory composition based on two of something. (Try arranging exactly two flowers in a vase in a non-ridiculous-looking fashion. It can't be done.) The large majority of Gothic west façades have one rose or none, but recursive structure allows Reims to have two, and the effect is spectacular.

The Gothic cathedral of Chartres, begun in 1194, established the classical or "high Gothic" style and is, as such, one of history's most beautiful, influential, and surprising buildings. Remarkably enough, the Gothic cathedral of Bourges, begun in 1195, is in many ways just as beautiful and surprising, although radically different. Bourges inspired its own small group of important buildings, including Beauvais Cathedral and the east end of Le Mans.

Many classical Gothic cathedrals have a lower level or story (the aisles and arcades), a medium level (the triforium), and an upper level (the clerestory). Entering at the front of Chartres, and finding yourself in the nave, you see the large windows of the clerestory along the upper level of the nave walls to your left and right; beneath them, the triforium is a dark, windowless band; below the triforium, aisles at ground level on each side, separated from the nave by arcades. The aisle ceilings are much lower than the nave.

At Bourges, this design undergoes a startling recursive revision. Imagine the nave cut in half down the middle, front to back. Pull the two halves apart. Insert a whole second church in the gap, telescoping upward from the newly opened slot (or popping out like a triumphant slice of Gothic toast). Now there is a second clerestory at the very top; below that, a second triforium; below that, a second set of arcades, left and right--each tremendously tall because each spans the whole vertical space from the bottom of the new triforium to the floor. The result is a space that builds in a jubilant crescendo towards the center, from the low outer aisles to the tall inner aisles to the enormous volume of the nave in the middle.

One of the most important aspects of mature Gothic design, and one that takes us right into the presence of the Gothic mind, is tracery--the thin, curvy, carved stone partitions that separate one window into many regions, or decorate blank wall surfaces. (The tracery within each window forms a structurally independent whole, separate from the window frame.) Tracery windows were a technical advance over earlier "composite windows," where a group of holes punched in stone panels yielded a set of related forms.

Tracery is central to Gothic because the medieval artist cared, above all, for design, not representation; his first goal was to create beautiful lines, surfaces, and volumes, not the painted or sculpted illusion of three-dimensional space. So medieval art is design art, and design begins with drawing--and tracery is pure drawing, abstract drawing representing nothing but itself; drawing in stone. Many later Gothic buildings use tracery not merely within windows and on wall surfaces but as a free-standing element of an architectural composition.

Recursion is basic to the art of tracery. Tracery was invented at Reims in around 1210 and used soon after at Amiens, the last (with Chartres and Reims) of the triumvirate on which the high Gothic style is based. To move from the characteristic tracery design of Reims to that of Amiens, simply add one level of recursion: at Reims, an arch

containing a foiled circle supported on two smaller arches; at Amiens, an arch containing a foiled circle supported on two smaller arches, each containing a still-smaller foiled circle supported on still-smaller arches.

Exactly the same transition connects the windows of the apse and those of the nave in the chapel of Saint-Germain-en-Laye, dating from the late 1230s.

Tracery recursion can go deeper, too. The great east window at Lincoln Cathedral dates from around 1275. (Most English medieval churches terminate not in curved chevets but in flat eastern walls--ideal places for spectacular windows.) Within a large arch is a circle supported between two smaller arches. Within each smaller arch, a circle supported between two still-smaller arches. Within each still-smaller arch, a circle supported between two even-smaller arches. The result is an enormous "eight-light window," with a row of eight lancets forming the bottom register.

As reconstructed by Edmund Sharpe in his still-unrivaled (and unreprinted) study of English tracery (1849), the great east window at the ruins of Tintern Abbey used a similar, although somewhat more venturesome, design, yielding again an eight-light window. (This is Wordsworth's Tintern Abbey, by the way.) At Le Mans Cathedral is another recursive eight-light window, which plays on recursion not only in the arrangement of each window and sub-window but in the decorative devices in the upper registers.

The celebrated Percy tomb (circa 1240) at Beverley Minster near York is another example of three-level recursion. The carved stone canopy of the tomb centers on a large ogee arch--two S-curves joined at a point on top. Within this ogee arch, three smaller ones; within each smaller arch, another even smaller.

Gothic architecture is often playful, and Gothic designers played with recursion. The chapel windows at Amiens, echoed in the apse windows at the Sainte-Chapelle, culminate in a pyramid of trefoils--a trefoil is a circle surrounded by three equally spaced part-circles, or (occasionally) just three plain circles arranged like a clover leaf, each touching the other two. (Sainte-Chapelle, which dates from the 1240s, was the royal chapel of King Louis IX of France, otherwise Saint Louis.)

The trefoil itself often occurs in recursive versions, where each lobe has two-thirds of a smaller trefoil inscribed inside--as, for example, on the façade of Strasbourg Cathedral. But in the Amiens and Sainte Chapelle windows, three simple trefoils are arranged not within a larger trefoil but in the shape of one--as if the large trefoil had been used as a temporary frame to rack up the small ones like billiard balls.

There is an even closer approach to this theme at Lichfield Cathedral, unsurprisingly--for Amiens inspired Sainte-Chapelle, which introduced the "spherical triangle," which was copied at Westminster Abbey, which inspired Lichfield. The sides of a spherical triangle are gracefully convex, as if they had been drawn on a sphere. The Sainte-Chapelle, Westminster Abbey, and Lichfield all have spherical-triangular windows, but the most beautiful are at Lichfield (ca. 1265), where the triangle frames a trefoil of trefoils.

Recursion is especially important to English tracery of the Perpendicular period. The Perpendicular style, which emerged at London and Gloucester in the 1330s, is "late Gothic" and unique to England--a style that combines dazzling virtuosity (on occasion) with a certain decorum and prickly restraint. The relation between recursion and Perpendicular design is a story in itself, but a window from the church of St. Mary Magdalen in Launceston, Cornwall, is a simple example. It is an arch with an elongated diamond in the center flanked by two other diamonds. Superimposed is a Y-shaped mullion that creates two smaller arches--each with an elongated diamond on top, flanked by two others.

Recursive structure occurs in rose windows, too--and helps us see a distinction we might otherwise miss. The great western rose at Reims, for example, is a 12-petaled flower containing an inner 12-petaled flower within a medium-sized 24-petaled flower. It's tempting to approach in the same way some of the older roses that predate tracery: The north rose at Laon, for example, is an 8-petaled flower surrounded by smaller 8-petaled flowers; the west rose at Chartres is a 12-petaled flower surrounded by (again) smaller 8-petaled flowers.

When we look at these roses from inside, it's impossible not to see a resemblance between their festive, abstract

flower shapes and recurring forms in the 20th-century cutouts of Henri Matisse. The resemblance is no fluke: the art of French Gothic glass is an art of color-design, of colored forms arranged on flat surfaces to represent stylized human beings and their paraphernalia, but with no attempt to suggest depth. French glass of the 12th and 13th centuries is as close to the 20th century fauves as Chartres is to Paris.

But these famous pre-tracery roses are not quite recursive: They are made of recurring forms, but the larger shapes do not contain the smaller ones; each smaller shape is distinct and set apart--which underlines a point that is often overlooked. It is difficult to accomplish, in the high-tech medium of tracery, an effect that is merely routine in any old 12th-century composite window: a design made of distinct shapes clearly separated by a neutral background--as in the north rose at Laon or the west at Chartres.

Tracery makes recursive compositions easy, but this older type of design becomes difficult. As tracery tended to displace the older-type window (among other things, tracery windows were cheaper) the loss to art was real. The composite roses at the top of each clerestory bay at Chartres, for example, might well be the most perfect roses ever designed. But by 1220 they were old-fashioned, technologically obsolete.

A final large-scale example: Some English Gothic churches have two transepts, a small eastern transept along with the main one. (Examples include Salisbury, Canterbury, Wells, Lincoln, Worcester and Southwell Cathedrals, as well as Beverley Minster.) The east end of a medieval church was ordinarily separated from the rest by a screen; the monks, canons, or other officiating priests wanted to chant the liturgy and celebrate mass in peace, shut off from nosy, noisy laymen. The extra transept turned the eastern part of the building into a priestly church in itself, with its own small transept.

This plan is inherently recursive: A large two-transept plan includes within it a smaller one-transept church. This recursive pattern yields the beautifully faceted, gem-like east end of Salisbury Cathedral. Salisbury's telescoping east end recalls the upward-telescoping structure of Bourges.

What do we gain by studying these many, varied instances of one basic design idea? The designers themselves had no idea of "recursive structure," at least not explicitly. But artists as a rule are too close to their own work to see any but the most obvious underlying themes or principles. A design impulse that appears in many forms in many artists' work is especially unlikely to be detected from the ground.

We need to soar years (or centuries) overhead and look at the era as a whole. When we do--when we notice such principles as recursive structure--the result is a clearer view of the spirit of the age, its artistic character, and the source of its vibrancy and integrity.

Recursive structure is by no means limited to Gothic. One of the most important developments in the whole range of post-Gothic architecture is Michelangelo's invention of the giant order, which vastly increased the expressive power of neo-classical design by introducing a kind of recursive structure. Tall columns or pilasters (the "giant order") span a deep vertical space containing stacked-up, shallower layers, each spanned by shorter columns or pilasters. And there is no neater demonstration of recursion than Brunelleschi's at Santo Spirito in Florence, where the domed, four-posted canopy over the altar at the crossing mirrors the domed crossing itself.

But the placid elegance of Santo Spirito gives us a hint about recursion's unique place in Gothic. As he mastered this radical new aesthetic vocabulary, the Gothic artist wanted his building to come alive, to throb with life. He wanted wave after wave of decoration to turn his building from a dead pile of stone to a live forest, with the sun screened through windows as colorful and intricate as a jungle canopy. Recursion is fundamental to Gothic art because it creates ordered profusion--profusion insofar as one can push the nest of form-within-form as deep as one likes; ordered and not chaotic insofar as the forms on each scale mirror the forms above and below. Recursion allows the Gothic artist to plant life in the smallest niche and tightest corner of his building, to push the level of decorative detail and aliveness to the finest scale his tools can reach.

We see recursion in Gothic buildings that are overgrown with sinuous, organic decoration built of abstract leaves, petals, and elegant compound curves, where large petals are built of smaller petals, which are built of smaller petals, which are built of still-smaller ones.

A Russian doll is recursive: open it and you find a smaller-scale copy inside. The Russian doll describes one of the most important gestures in Gothic (indeed, in medieval) architecture: an archway with a smaller archway nestled inside, and a smaller one within that.

The nest can be two dozen layers deep. The "recursive archway" occurs in a strikingly pure and beautiful form at Exeter Cathedral, where it dates from the late 1200s. But it is ubiquitous in Gothic; the great portals of the high Gothic triad of Chartres, Reims, and Amiens, set with extraordinary sculpture, are "recursive archways." So are countless other doorways and arcade elements. Simpler recursive archways occur in the Romanesque and Norman architecture that preceded Gothic.

Recursive tracery windows and archways are the basis of observations by Jean Bony and Erwin Panofsky. Like other medievalists, they are unfamiliar with the idea of recursion; are therefore forced back onto inadequate substitutes. But recursion helps sort their observations out.

Jean Bony comments on the clerestory windows at Saint-Denis. They are formally the same as the ones at Amiens which I have already described; but at Saint-Denis, the clerestory absorbs the triforium just below it. Instead of the dark windowless band of Chartres, this triforium has windows, and its rhythm (four beats to the measure) is created by the same vertical shafts that partition the clerestory windows.

In the triforium, moreover, each beat is split in two--yielding an eight light composition and three levels of recursion. Bony describes Saint-Denis as "composed of a series of similar forms progressively subdivided in increasing numbers and decreasing sizes."

Erwin Panofsky describes the same phenomenon as "this principle of progressive divisibility (or, to look at it the other way, multiplicability)"--a principle that "increasingly affected the entire edifice down to the smallest detail." This observation is far-reaching and important, but notice that "division" (Panofsky's word) suggests breaking into identical parts but doesn't apply to the nesting of one form within a larger version of itself. Panofsky's "principle of progressive divisiblity" is a fuzzy and roundabout way of saying "recursive structure."

Recursion allows us to connect Panofsky's observation with the west wall at Reims, the recursive trefoils of Strasbourg, and many other designs. It allows us to extend his observation to the nesting of small structures within larger ones. It allows us to connect it with Louis Grodecki's description of the Sainte Chapelle, where the shrine that once held sacred relics "was fashioned in the form of a tiny church." This shrine was intended for display on a canopied platform, itself shaped like a church, and the canopied platform stands at the front of the Chapelle, a full-sized church. Thus a church within a church within a church.

This is a common principle of Gothic art," Grodecki adds. Summerson cites a passage by Wilhelm Worringer (1927) that comes closer than any other to giving an accurate paraphrase of the idea of recursion and its importance:

Gothic man seeks to lose himself not only in the infinity of the great, but also in the infinity of the small. . . . Every individual detail is, in itself, a world of bewildering activity and infinity, a world which repeats in miniature, but with the same means, the expression of the whole. . . . The crown of a pinnacle is a cathedral in miniature, and anyone who has sunk himself in the ingenious chaos of a tracery can here experience on a small scale the same thrill in logical formalism as he experiences in the building system as a whole.

Gothic buildings are alive as the sea is with waves, wavelets, little wavelets, littler wavelets. If you look inside Wells Cathedral, the greatest triumph of English Gothic and (perhaps) of Gothic altogether, you find large vaults underpinning the ceilings, small vaults under the stone canopy of the bishop's
throne, smaller vaults under the canopies in the choir. Stone creatures scamper through carved foliage on the capitals of the nave piers, a magnificent branching canopy springs from the trunk-like central pillar of the chapter house, an intricate starburst (one star within a second within a third) clings to the ceiling of the sublime Lady Chapel--and a flock of statues roost in niches within the famously cliff-like front façade. In a chantry chapel in the nave the ceiling is carved with delicate outward-rippling fan vaults--and on the outside of this small enclosure, the carved stone cornice dissolves upwards into a lacy border, which dissipates gracefully into thin air.

And all this barely scratches the surface. There is far more detail than one can even see from any normal standpoint inside the building. The cathedral is like a shallow stretch of sea-water where you see, at first, only sand and water--until you become aware of innumerable tiny transparent fish whisking in and out, and small creatures crawling the bottom in an endless parade, an ordered profusion.

Ludwig Wittgenstein copied a verse from Longfellow into one of his notebooks:

In the elder days of art
,
Builders wrought with greatest care

Each minute and unseen part
,
For the gods are everywhere.

"This could serve me as a motto," he added. Replace "the gods are" with "the Lord is" and it could have served the builders of Wells, too. Wittgenstein himself greatly admired Ely Cathedral, where the sternly majestic Norman nave bursts into brilliant bloom in the Gothic lantern over the crossing. Here a tall, slender, light-flooded octagon emerges out of a larger, broader, ground-level octagon. The tall lantern is held so high on the shoulders of eight great, graceful arches that, from the ground, you can only catch a steeply foreshortened view inside.

The best Gothic buildings are alive as no other buildings ever have been or are likely to be. Recursive structure gives us a hint about how this amazing feat was accomplished.

In broader terms, recursion is as basic to art and nature as the noun phrase is to English. It is an idea that helps us parse and penetrate the world we see. Learning to understand images as we do language is one of the great unsolved problems of modern intellectual life. Computer science helps, because recursion helps.

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