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Celestial Vaults in English Gothic Architecture

Many of the vaults in English Gothic cathedrals and churches are catechisms of cosmologies and celestial vaults. Matter was seen as originating in light, and expanding through reflection and refraction in geometrical terms, in increasing lengths of straight lines and curved lines, to form volumes. The tierceron and lierne ribs at Lincoln Cathedral, for example, and later lierne and net vaults at Bristol Cathedral and St. Mary Redcliffe, for example, display the geometries that can be found in medieval cosmologies such as the *De Luce* and *De Lineis, Angulis et Figuris* of Robert Grosseteste in the thirteenth century. The vaulting of the nave of Lincoln Cathedral (Figure 1) between 1235 and 1245, during the bishopric of Grosseteste, introduces basic vocabulary elements continued in later vaulting, and can be seen as a catechism of Grosseteste's cosmologies.

In the *De Lineis*, *Angulis et Figuris*, or *On Lines, Angles and Figures* of Grosseteste, written around 1230, the *virtus* or strength from the natural agent, light, is more active and more unified if it is along a shorter line, because it is closer to the recipient, the passive agent, and it is less active along a longer line, because of the greater distance from the recipient. A light is brighter if it is closer to the eye, for example. Shorter lines contain a more condensed *virtus*; in architecture they are more structurally sound, and exert greater force on an adjoining member. In the vaulting at Lincoln Cathedral, the ribs are divided into the long longitudinal ridge pole, the transverse ribs which cross the vault, the tierceron ribs which connect the ridge pole to the springer but do not provide structural support for the vault, and the lierne ribs, the shortest of the ribs which connect the transverse or tierceron ribs, do not reach the springers of the vault on the sides, and provide no structural support.

The hierarchy of ribs in the vault corresponds to the hierarchy of lines described by Grosseteste, with different degrees of *virtus*, and different con-

centrations of *species* or visual form. The *virtus* in *De Lineis* proceeds immediately from the natural agent along either a straight line or a bent line. The action of the *virtus* is greater along a straight line, as was established by Aristotle in Book V of the *Physics*, where a straight line is the shortest path between two points, and in Book V of the *Metaphysics*, where the straight line is more unified than the bent line. Nature always takes the shorter of two possible paths, according to Grosseteste, because the *virtus* is greater. The straight and bent lines, the latter formed by the lierne ribs, are present in the vaulting of the cathedral, and in the tracery of the stained glass.

In *De Lineis*, the *virtus* is weaker along the reflected or incident line, as, for example, light is weaker when it is reflected. In the *De anima* of Aristotle, both light and sound are weaker when they are reflected. Light is strongest in reflection when it is reflected from smooth surfaces like mirrors, and weakest when it is reflected from rough surfaces, as then the *species* is more dissipated, less concentrated. The *virtus* is greater in a reflection of light from a concave surface, because then the rays of light converge at a point, forming a cone of light. Lines emanating from a concave surface and converging at a point, in the form of a cone, can be seen in the vaulting at Lincoln Cathedral: the ribs of the vault begin at the ridge pole and converge at the top of the springer shaft, forming a convex surface in a cone which is formed by the severies between the ribs, or the surface of the vault which the ribs define. The corbel at the top of the springer shaft can be seen as a point of convergence, a nodal point, at which the *virtus* is greatest and the *species* the most concentrated, as it is intended in the architecture, as the corbel is the most important visual point in the divisions of the bays longitudinally in elevation and vaulting, and the most important visual point in connecting the vaulting to the elevations.

In Grosseteste's *De Luce*, or *On Light*, written between 1225 and 1228, as light extends matter in all directions equally into the form of a sphere through infinite multiplication, the further out the parts of matter are, the closer to the surface of the sphere, the more extended and rarefied they are. There is a hierarchy of rarefaction in matter, as there is a hierarchy of rarefaction in the architectural forms in the cathedral. This can be seen in particular in the vaulting systems and the tracery in the stained glass, where the density at the center gives way to thinner and less dense membrification toward the outer edges. In the vaulting, the density of the cluster of ribs at the corbel gives way to more spread out membrification toward the ridge pole at the center of the vault. In each case the membrification can be seen to be ra-

refied toward a circumference, as matter is rarefied toward the sphere of the cosmos by the autodiffusion of *lux*.

In the architecture of Lincoln Cathedral, the rectilinear geometries of the elevation are contrasted with the curvilinear geometries of the vault, in the nave, transepts, and choir. The elevations are of the earthly, material world, the sublunary spheres, and the vault is of the celestial world, in the nine circular spheres, so the geometries correspond to the representational role of the architecture as a microcosm of the structure of the cosmos. The hierarchy of the architecture represents the contrast between the sensible world and the intelligible world, and between the physical world and the spiritual world, body and soul. The hierarchy corresponds to the trivium and quadrivium of Scholasticism: curvilinear forms represent the higher arts of the triune spirit, grammar, rhetoric, and logic, which involve the *virtus intellectiva* or *nous poietikos*, higher forms of reasoning, while rectilinear forms represent the lower arts of the material world, mathematics, geometry, music and astronomy, which involve only *ratio* or discursive reason, what Grosseteste calls *virtus cogitativa*.

Bristol Cathedral, the Cathedral Church of the Holy and Undivided Trinity, or St. Augustine's Abbey, was founded by Robert Fitzharding in 1140, as a foundation of Augustinian canons, and made a cathedral by Henry VIII in 1542. The nave and west front of the cathedral were built by George Edmund Street between 1868 and 1888. The chapter house, with its blind arcades of intersecting arches and diapering, survives from the Norman building circa 1165. The north choir aisle, Eastern Lady chapel, and choir or chancel are the earliest parts of the Gothic cathedral, from between 1298 and 1330, and it is these parts of the cathedral which represent the originality of the cathedral in architectural terms and which reflect the international importance of medieval Bristol, one of the wealthiest cities in England and its most important port.

The vault of the choir or chancel of Bristol Cathedral (Figure 2), built under Abbot Knowle, between 1300 and 1330, is close to the Lincoln-style tierceron vault, with tiercerons rising from conoid springers towards a ridge pole, and shorter tiercerons intersecting transverse ridge ribs in front of the window heads, as in Lincoln nave. As in the Eastern Lady Chapel at Bristol, the tiercerons are intersected before they reach the ridge pole by liernes forming diamonds, and the ridge pole is eliminated, or reduced to an imaginary line running down the center of a series of diamonds formed by the liernes. Lierne diamonds are also placed between the transverse ribs and the

shorter tiercerons in front of the window heads. There are bosses on the joints and the dark ribs contrast with the white severies, as in the Eastern Lady Chapel, but in the choir vault the diamonds are in addition cusped on the inside, increasing the density of the surface texture, and the Curvilinear content of the vocabulary elements, turning the lierne lozenges into tracery motifs. The cusping of the liernes originated in this vault, and was soon taken up in the vaults of the choirs of Wells Cathedral and Tewkesbury Abbey, and at St. Mary Redcliffe.

The lierne vault in Bristol choir does not have a structural appearance, as it did in the undercroft of St. Stephen's Chapel, for example. The liernes of the vault have an organic structural quality, like a crustaceous skeletal form, but not a functionally structural quality in relation to the building; it is thus an "intelligible organism," and the line is blurred between the sensible form, *species sensibilis*, the visual form of the vault, and intelligible form, *species apprehensibilis*, the conceptual organization of the vault, in Grosseteste's terms. The architectural forms play a structural role as a catechism, of the structure of matter and the relation between the material and spiritual, but the vault is not a physical structure. The bays of the vault can be read as individual or as doubled, corresponding to the elevation bays, thus producing an oscillation of reading, as in the Lincoln nave vault. The vaults of the Eastern Lady Chapel and choir are the products of the same building campaign, the Eastern Lady Chapel being completed first.

The nave at Bristol was begun by Abbot Edmund Knowle in around 1306, and construction continued until the fifteenth century. The nave was completed to its medieval design by George Edmund Street in the nineteenth century. The nave is dominated by large quatrefoil bundle piers, with Purbeck shafts at the corners contrasting with the light stone, topped with gilded foliate capitals. The vault (Figure 3) is a Lincoln-style tierceron vault, with eleven tiercerons per bay in conoid springers rising from the thick bundle columns below. As it is a hall church, the vault rises from the arcade which separates the nave and aisles, so the shafts in the piers are the responds. The tiercerons rise towards the ridge pole, except for the pair of short tiercerons in each bay, in this case in front of the heads of the pointed arches of the arcade, which meet at a short transverse ridge rib, or lierne, as at Lincoln. The nave aisle vaulting continues the vaulting of the choir aisles, with the vault ribs springing from flat transverse lintels supported by thick transverse flying arches, with stonework arabesques in the spandrels, as in the choir, in the spirit of the Decorated Curvilinear style.

Vaulting in the crossing and north and south transepts of Bristol Cathedral (Figure 4 and 5) dates from between 1460 and 1480, under Abbot William Hunt. The crossing (Figure 6) features a centralized lierne star vault pattern, with tiercerons springing from the corners and a pattern of cusped lierne diamonds around the center, creating an effect similar to the vaulting in the North Porch of St. Mary Redcliffe, suggesting an intelligible structure underlying organic form, a *species apprehensibilis* in relation to the perceived forms of nature. The vaulting in the south transept of Bristol Cathedral presents an elongated version of the crossing vaulting, with tiercerons converging on a series of intersecting lierne diamonds along an imaginary ridge line, with cusping and large bosses at the intersections of the ribs. The two-dimensional pattern of ribs on the vault surface suggests a three-dimensional geometrical structure, where the interiors of the lierne diamonds suggest voids or folds behind the continuous surfaces created by the fanning tiercerons. It is easy to imagine by looking at the vaulting pattern how three-dimensional form and space can be constructed from the regular geometric progression from point to line to surface to solid, as suggested in classical philosophy and practiced by medieval architects, and that matter itself unfolds from an intelligible geometrical structure. The vaulting pattern in the north transept presents a series of much more complex geometrical patterns, which lose any sense of three-dimensional spatial construct and can be read only as two-dimensional surface pattern. The vault is a quadripartite vault with lierne diamonds along the imaginary ridge line and elongated lierne diamonds extended towards the corners of each bay, with cusping and excessively large bosses. The geometry is artificial in relation to the space in which it is placed; the geometry in the north transept vaulting aspires to the complexity of the vaulting patterns at nearby St. Mary Redcliffe, but also fails to suggest the entangled organic forms of nature which the vaulting in the nave of the parish church enacts.

The Lady Chapel of Ely Cathedral, the largest Lady Chapel in England, was constructed between 1321 and 1349. It was initiated by Alan of Walsingham, much of its design is by John Ramsey, and much of it was executed under Bishop Simon de Montacute. Treasurer John of Wisbech acted as supervisor of construction, and it was complete by the time of his death in 1349. The vault of the Lady Chapel (Figure 7), with a span of forty-six feet, is the widest medieval vault in England. It is a variation of the Decorated "lierne star" vault, with liernes forming a series of hexagons along the ridge pole. Without the lierne patterns it is a conventional Lincoln-style tierceron

vault, with eleven tiercerons per bay in each conoid springer, the first three on each side connecting to a transverse ridge rib between the bays of the vault, connecting the window heads. The next tierceron on each side forms a transverse diagonal arced rib across the vault, and the central tierceron forms an arced transverse rib.

While the bays of the vault contradict the bays of the elevation, the lierne pattern serves to dissolve the distinction between the bays of the vault, and the vaulting conoids give way to a continuous surface pattern, with forty-eight compartments per bay, as in the nave vault at Tewkesbury Abbey. The painted bosses, which are comparatively small, are currently the only trace of color left on the stone vault. The entire Lady Chapel would have originally been filled with color—the arcade, the vault, and the stained glass windows, none of which remains. The vaulting pattern represents a crystalline organic intelligible form emerging from the conoid clusters of rays, as light is rarefied into matter in a catechism of the processes of nature as described by geometry. The dissolution of the distinction between bays in the vault, and of the structural relation to the elevations, reveals the mannerist tendency to negate the structural articulation of the form, to create a disjunction between form and function, a tendency initiated at Lincoln Cathedral.

St. Mary Redcliffe, begun in the 1290s by Simon de Burton, Mayor of Bristol, is the only cathedral-like parish church in England. The vault (Figure 8) in the North Porch dates from 1325. Like the wooden vault in the crossing at Ely Cathedral, it is a centralized tierceron vault, though hexagonal rather than octagonal, and stone. Four tiercerons spring from each bay between the window heads, but none of them reach the central boss. They all connect to one of six transverse ridge rib segments; the inner joints are connected by a lierne hexagon around the central boss. The bosses are large gilded foliate bosses, contrasting with the grey stone. The two tiercerons on each side of the severies of each bay meet the transverse rib which runs from the window head across the vault, through the hexagon in the center, resulting in three continuous transverse ridge ribs. The surface of the vault is a series of folds creating flat surfaces, with a palimpsest of patterns overlaid.

The vault looks like a snowflake, or a pattern in a kaleidoscope, merging the structure of the building with the surface texture of the ribbing, and merging the intelligible form of the architecture, the structure as understood in the mind, called by Grosseteste the *species apprehensibilis*, with the visible form of the architecture, the *species sensibilis*, as perceived by the senses, in the same way that the *species apprehensibilis* of natural forms is con-

nected to the *species sensibilis*. In order to perceive a form in nature, it must first be understood by the mind, and in that way the laws of nature are revealed. In order to perceive a form in architecture, it must first be understood by the mind, and in that way the secrets of architecture are revealed. In this way the architecture accommodates the intellectual ascension and comprehension of the spectator, as a model for understanding nature, and the archetypal intelligence of the world.

Large bundled responds in between bays support thick transverse ribs in the vaulting of the transepts (Figure 9) from the early fourteenth century, dividing the vault into bays corresponding to the elevations, with three tiercerons springing towards the center of the vault bay on each side of the transverse ribs. The short tiercerons connect to a pattern of liernes in the center of each bay, consisting of a square divided into four quadrants in the center, and diamonds on each of the four sides of the square, tangent to the walls and the transverse arches. The interior of each diamond and square is lined with cusping, the ribs are painted, and all the joints are covered by gilded foliate bosses. The vault in the transept at St. Mary Redcliffe represents the first Curvilinear style vault, achieving a new level of decorative pattern in vaulting, and detachment from structural exigency of vocabulary elements. The regular Euclidean geometries of the vault suggest a cosmology such as the *Timaeus* of Plato, where matter, as it is formed from the autodiffusion of light in Grosseteste's terms, in geometry and mathematics, has as well a geometrical atomic substructure of archetypal forms. Similar archetypal geometries can be found in the vaulting of the choir.

The nave vault (Figure 10) of St. Mary Redcliffe was begun in 1337 and completed in 1342. The vault pattern, fifty-four feet above the floor, is a more complex and distorted version of the transept vault begun earlier. The nave vault is composed of a series of springer clusters in each bay of the vault, between the window heads of the clerestory, with seven tiercerons per bay. The arches of the clerestory windows are extremely wide, so the tierceron clusters of each bay, spreading out like fingers across the surface of the vault, are easily distinguished. Liernes interrupt the tiercerons above the window heads, but not in the springer conoids. While the bays of the transept vault at St. Mary Redcliffe are clearly divided by pronounced transverse arches, the presence of the springers is minimized, and the square bays are filled out with the diamond and square lierne patterns; the vault reads as a series of centralized square bays, distinct from each other; the presence of a ridge line is minimized as well.

The nave vault is dominated by the presence of the tierceron springers and the longitudinal ridge line—it is only imaginary, but it is reinforced by zigzagging lines of liernes running parallel to it. This is the first in a series of vaults in the Curvilinear style dominated by zigzagging liernes running parallel to the ridge line. The tiercerons in each bay extend to form transverse ribs and diagonal transverse ribs which run to the window heads and responds in the next bays over, forming a crossing pattern of diamonds longitudinally, which is extended by the zigzagging liernes running parallel to the ridge line and more liernes added to form diamonds above the window heads. The vocabulary is the same as in the transept vault—painted ribs with cusping and gilded bosses against white severies—but the pattern leaves the regular geometrical organization of the transept vault, and begins to suggest the irrational forms of nature. The line between the sensible form, *species sensibilis*, and intelligible form, *species apprehensibilis*, is blurred.

The ribs undulate and fold across an uneven vault surface, suggesting topographical lines, and they are unevenly clustered and thorny, with the cusping, suggesting natural growth. There are similar instances in the architecture of Lincoln Cathedral where the patterns suggest topography and charts of the vectors of the *virtus* of natural forces, corresponding to the treatises on natural philosophy of Robert Grosseteste, such as the astronomical treatises, *Computus I*, *Calendarium*, *Computus Correctorius*, and *Computus Minor*; the treatise on light, *De Luce*; treatises on the heavenly bodies, *De Generatione Stellarum*, *De Motu Corporali* and *De Motu Supercaelestium*; treatises on meterological phenomena, *De Impressionibus Elementorum*, *De Iride*, *De Colore*, and *De Calore Solis*; and the cosmology *De Lineis*. Perhaps the vaulting pattern in the nave, along with the vaulting pattern in the North Porch, reflects the growing influence of natural philosophy, and the attempts to understand natural phenomena through geometry and mathematics and other rational means, and the desire on the part of the church to evoke the wonders of divine creation and the infinity of divine intelligence, with the stretched canopy of the vault simulating the starry vault of the heavens.

The visual effect of the vaulting is like that of a billowing tent being stretched to the corners and bays of the walls, structured by the geometries. It seems to be a skeletal and structural variation of the effect found in the Byzantine building, such as the Baptistry of the Orthodox in Ravenna, or the Hagia Sophia, designed to represent the vaulting of the heavens, and complete the metaphorical role of the building as a microcosm of the cosmos. In the terms of contemporary science, the severies of the vaulting might be seen

as an epigenetic landscape. In Complexity Theory, organisms undergo structural changes in morphogenesis, in increasing complexity to avoid torpor or entropy. In morphogenesis, the organism can undergo changes as a result of influences on it from its environment, in epigenesis. In Topology Theory, an epigenetic landscape, in the form of waves, fields, or fronts, is the result of the action of the environment on unstable, structureless forms.

The relief features of the folds or fields of an epigenetic landscape, as in waves or dunes, for example, are the product of a complex network of interactions underneath the surface, in the form of vectors, nodal points, and directional movements. The undulating folds of the severies in the vaulting can be seen as a topological field, an epigenetic landscape. Robert Grosseteste also described the fields and forms found in nature, such as hills, valleys, clouds, etc., as the product of underlying geometrical and mathematical forces. These are described in his treatise *De natura locorum*, an extension of the treatise *De Lineis, Angulis, et Figuris*. *De natura locorum* attempts to apply the mathematics and geometry which are understood to be the underlying structure of light as it diffuses into matter in *De Lineis*, to natural phenomena. The relation between surfaces in natural forms and geometry is on display in the vaulting of the nave, as an *edificium* of the structure of matter and the celestial vaults.

The vaulting of the choir of St. Mary Redcliffe (Figure 11) dates from around 1450. It is a more regularized and geometrical version of the nave vault, also fifty-four feet high, with the same conoid tierceron springer vaults, cusping and gilded bosses, but the longitudinal zigzagging liernes are replaced by three parallel ridge poles and transverse liernes forming a series of lierne squares down the center of the vault, with lierne diamonds placed between the bays tangent to the window heads. The difference between the vaults exemplifies the difference between the Curvilinear and the Perpendicular styles, where the irregular curvilinear lines are replaced by the more austere horizontal and vertical lines. The choir vaulting suggests none of the irrationality of natural forms or the organization of topographical lines represented in the nave vault; it is more superficially decorative: the vaulting pattern has no relation to the structure of the vault, and presents itself as a two-dimensional organization of Euclidean geometries, as if to evoke the polyhedral atomic structures of matter as described in the *Timaeus* of Plato, a cosmology of the universe and description of matter in geometrical terms which was not attempted again until the *De Lineis* of Robert Grosseteste.