

# Domed Architecture: Image of the Universe

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Writing in the first century BC, the Roman architect Vitruvius, in his *Ten Books of Architecture*, defined the role of the architect and the education, skills and personal qualities which the architect should possess. Last but not least in his list, Vitruvius specified that it is essential for all architects to 'be acquainted with astronomy and the theory of the heavens'—and nowhere is knowledge of astronomy more significant in architecture than in the history of the construction, development and symbolism of the dome<sup>1</sup>.

## Origins

The precise sources of domed architecture are untraceable to a single point of origin, in time or location. Primitive constructions or shelters, based on the use of flexible materials tied at the top, have been found in early civilisations, and are still in use in primitive societies today. Underlying symbolic meaning cannot be argued for these simple structures, although it is on such a format that the tradition of the ancestral hut arose, which in turn provided the basis of the spiritual tradition and symbolic importance of the dome. More than a functional type of vaulting, the cosmic symbolism of the dome as basically imitative of natural eye observation of the flat earth surmounted by the 'dome of heaven' is of very ancient origin and is fundamental to its usage in ancient classical-pagan, Judaeo-Christian and Islamic architecture. Cosmic symbolism of the dome was not only of prime importance in Christian architecture of the eastern Mediterranean, but also had roots in classical architecture in Egypt, Greece and Rome, was revived during the Renaissance and remains significant up to the present day.

The point at which the dome, irrespective of the material used, assumed special symbolic significance is hard to determine. Architectural works dealing with domes tend to emphasise its construction and development and the variety of its forms, ranging from shallow to hemispherical to 'beehive' or 'onion' domes which may be placed on or over cylindrical, square or more complex buildings<sup>2</sup>. Materials used were also significant as early wooden domes came to be replaced by structures of brick and masonry. Since these developments largely took place in earthquake areas, where masonry would be less suitable than wood, it is reasonable to assume that the desire for domes was motivated by some more significant reason (not simply for utilitarian or environmental reasons like deforestation or fire proofing). Constructional developments appear to have been sought as result, not as the cause, of the spiritual associations<sup>3</sup>. Development of the dome was surely dependent on technical progress and organisation which provided materials and enabled craftsmen and architects to achieve the desired constructions but cultural reasons, relating to the symbolic values of the shape of the dome, must have provided the impetus. The form clearly did not originate in stone, which is in itself shapeless, but in more pliable materials so the key issue is what provided the motivation behind such a difficult process. Whether for divine, royal or celestial traditions, the ideology must surely predate the domical masonry vault, and in this way the original transient hut, where a dome is used to enclose a small living area, over time took on a ceremonial function as the ancestral or lordly home, a place of audience or the eternal stone memorial or dwelling house for the dead<sup>4</sup>.

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<sup>1</sup> Vitruvius (1960 ed.) *The Ten Books on Architecture*, transl. M. H. Morgan, New York: Dover, p. 6, see also book 9, pp. 249-277 which is entirely devoted to astronomy, including information on the zodiac and planets, sun and moon and even southern constellations. Reference is made to ancient astronomers such as Aristarchus (p. 263), Thales, Anaxagoras and Pythagoras (p. 269). The word 'universe' is defined as 'the general assemblage of all nature, and it also means the heaven that is made up of the constellations and the courses of the stars' (XI, i).

<sup>2</sup> For summary definitions of types of domes and their construction, see Harold Osborne (ed.) (1993) *The Oxford Companion to Art*, Oxford: Clarendon, 1993, pp. 320-322; Bannister Fletcher (1975 ed.) *A History of Architecture*, London: Athlone, p. 269f., 378f., 823, 842.

<sup>3</sup> The opposite scenario whereby having achieved the construction of masonry dome, the architects and their secular or ecclesiastical patrons then hunted around for some form of symbolic attribute for it, seems far less likely. See also *Encyclopedia of World Art*, 'Cosmology,' vol. 3, pp. 836-864.

<sup>4</sup> The earliest stone domed structures of which evidence survives seem to be those in the Neolithic settlement of Choirokoitia in southern Cyprus, dating from the sixth millennium BC (George Phylactopoulos (1974) *History of the Hellenic World: Prehistory and Protohistory*, London: Heinemann, pp. 85-87). Traces of corbel vaulting show that some 47 houses had dome like roofs, 6-10 metres in diameter and constructed in brick. Comparisons may be made with modern native constructions, still made according to ancient tradition but of less durable materials.

## The ancient, classical vision

In the architecture of ancient Greece, the use of the dome is clearly more than a functional vaulting device, its symbolic meaning dating back to early Greek tholos tombs<sup>5</sup>. One of the best known early examples is the Tomb of Agamemnon (also known as the Treasury of Atreus) of the second millennium BC at Mycenae in the Peloponnese (Figure 1)<sup>6</sup>. The particular form of tombs and memorials derives from the ancient association with the dead and the symbolism of the circle (which generates the dome) as eternity. The addition of metal 'rosettes' which studded the pointed vault suggest stars, and the emphasis on circular cosmology and associations with the dead are reinforced by contemporary references in Homer and Hesiod<sup>7</sup>. As Baldwin Smith demonstrates, most early civilisations had rooted domical ideologies, which originated in the use of pliable materials but came to be imitated in masonry for ideological reasons<sup>8</sup>. While classical Greek architecture, based on the post and lintel system, did not lend itself to domed structures, circular buildings were also popular in classical Greek times, exemplified by the Tholos at Delphi (c 400). Little is known about the roofing of these structures, although records of destruction by burning suggest wooden roofing. Whether this was domed or conical is unknown, but the cosmological significance becomes clear as we recall that Delphi was considered to be the centre of the universe - 'the omphalos' (navel of the earth). Greek writers speculated on the shape of the earth from the sixth century BC onwards, and writers like Thales of Miletus and Anaximander considered the universe to be circular (either a disc or sphere) while Pythagoras maintained that the world must possess the most perfect form of a sphere<sup>9</sup>. The writings of Plato and Aristotle, however, provided the foundation for later Greek cosmology and were of enormous influence in medieval and Renaissance Europe as we shall see<sup>10</sup>. Interestingly, numismatics can also provide further evidence where early circular or domed structures are no longer extant. One such example is the celestial baldachin over the great altar of Zeus at Pergamon, depicted on a coin of Septimus Severus, now in the British Museum (Figure 2)<sup>11</sup>. The domical shape of the baldachin above the altar of the supreme sky god would clearly have had celestial meaning and such examples confirm the special symbolism attached to the dome even in Greece where the standard form for religious structures was the rectangular temple. The description in Euripides' *Ion* of a temporary tent structure for a festival, richly embroidered with stars reinforces the astronomical allusions of the form<sup>12</sup>.

In ancient Egypt, the perception of the universe was made clear and recorded by visual images based on the flat earth concept with the sky goddess Nut covering the earth in a 'dome like' manner. The motif was regularly depicted in detailed cosmographical maps, such as the papyrus (c. 1000 BC) now in the British Museum (Figure 3). The long-limbed goddess Nut (twin sister of the earth god, Geb) represents the celestial vault stretching from horizon to horizon as the stars twinkle above

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<sup>5</sup> The word  $2\cong 8\cong H$  signifies the dome or cupola of a circular building, hence the building itself. Phylactopoulos, *Hellenic World*, p. 315.

<sup>6</sup> **Editor's Note:** all of the figures cited in this paper may be found on the CD-ROM accompanying this book; they are labeled "shrimp!N," where N = 1, 2, 3, ... , 34; the details for the figures may be found in the "List of Illustrations" at the end of the text for this paper.

<sup>7</sup> See for example, Homer, *Iliad* (7th century BC) XVIII, 483-489 (London: Heinemann, Loeb, 1985 ed. pp. 323-325) which identifies the circular courses of the heavenly bodies, compare *Odyssey*, V, 270-74 (London: Heinemann, Loeb, 1974 ed. p. 189). Hesiod *Theogony*, 104-210, deals with the origins of sky, earth and oceans, describing earth as a disk covered by starry heaven (London: Heinemann, Loeb, 1964 ed. pp. 85-95).

<sup>8</sup> E. Baldwin Smith (1950) *The Dome: A Study in the History of Ideas*, Princeton: Princeton University Press, p. 6f.

<sup>9</sup> See W. K. C. Guthrie (1962) *History of Greek Philosophy*, Cambridge: Cambridge University Press, vol. I, especially pp. 89-100, 132-37, 282-300 for presocratic cosmology in general.

<sup>10</sup> Plato's key cosmological text is the *Timaeus* (the only platonic text known during the medieval period) for which see Francis M. Cornford (1937) *Plato's Cosmology*. London: Routledge and Kegan Paul. Aristotle also insisted the shape of the heaven must be spherical in his *De Caelo*, II, iv (London: Heinemann, Loeb, 1960 ed. p. 155f.).

<sup>11</sup> Baldwin Smith, *The Dome*, pp. 7, 69 and Figure 106. Smith traced this to the importance of the ancestral hut as a special gathering place, and linked with the idea of kingship.

<sup>12</sup> Euripides, *Ion*, 1141f. (London: Heinemann, Loeb, 1980 ed. pp. 112-133), cited also by Karl Lehmann (1945) 'The Dome of Heaven', *Art Bulletin*, 28, pp. 1-27, p. 11 (reprinted in W. E. Kleinbauer (1971) *Modern Perspectives in Western Art History*, New York: Holt, Rinehart and Winston, pp. 227-70).

her<sup>13</sup>. The identification of the arch form with the apparent curve of heaven (reinforced by the apparent circular motion of the sun, moon and planets) also relates to the ceremonial importance of the King's dwelling or meeting place.

### Roman domes

The Greek background is important for establishing the spiritual significance and importance of the domical form. By contrast with the Greek post and lintel system, the Romans based their architecture on arcuated structures and were able to span enormous spaces with the use of concrete and arches, but a similar symbolism prevailed<sup>14</sup>. The most important example of domed vault in Roman architecture is of course the Pantheon in Rome (AD 126, Figure 4) one of the best preserved monument of antiquity. The proportions are exceptional since the height is the same as the radius of the dome which is placed on a circular cylindrical building, supported by the immense walls. Here we are left in no doubt about the cosmic overtones since the contemporary Dio Cassius records quite clearly that the very name of the Pantheon, derived from the fact that 'because of its vaulted roof, it resembles the heavens'. and the twelve classical gods of ancient mythology related to the planets in Greek or Roman terminology<sup>15</sup>. Hence, even at the time of the Pantheon constructional developments are to be viewed as the result rather than the cause of the spiritual meaning of the dome. Meaning first, rather than mere solutions to constructional problems seem to have inspired such monuments.

Additional evidence for cosmological meaning is to be found in Roman secular buildings such as the Tower of the Winds in Athens, built by the astronomer Andronikos (c. 48 BC) where the symmetrical building has a clear astronomical relation with points of the compass but it is not known whether the interior was domed. Also in Greece, the Rotunda in Salonica (built in 300 and converted to the Christian Church of St George in c 400) relates in design to the Pantheon in Rome, with its hemispherical dome concealed from the outside. In Rome itself, a main cupola decoration in the Golden House of Nero (Domus Aurea) has an eight cornered canopy surrounding a central circle with Jupiter depicted on clouds (as shown in a valuable eighteenth century drawing), and cosmic overtones are clear in other vaults from the same building with astronomically decorated cupolas<sup>16</sup>. Nero was fully aware of the astronomical implications of the dome and even had a banqueting hall with a domical heaven which 'went round day and night like the world'<sup>17</sup>. Dio Cassius also confirms the astronomical implications of temporary awnings with heavenly representations in Nero's time and Hadrian's villa at Tivoli similarly provides evidence for astronomical decorations in domed ceilings<sup>18</sup>.

### Biblical views and Christian architecture

Roman building techniques were imitated in the near and middle east, and the dome was frequently used in pagan design. For example, as described in the *Life of Porphyry*, a dome covered the temple of the sky god, Marneion at Gaza 130 AD<sup>19</sup>.

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<sup>13</sup> See example in James George Frazer (1996 edition) *The Illustrated Golden Bough: A Study in Magic and Religion*, New York: Labyrinth, p. 217. [Compare Hesiod's description of how 'Heaven came and lay about Earth, spreading himself full upon her' (*Theogony*, 176-78, ed. cit. pp. 91-92).] Pyramid and rectangular forms were more popular in Egypt for ceremonial buildings, however, Egyptian rulers are frequently depicted under celestial domed tent coverings, associated with the concept of the heavens.

<sup>14</sup> E. Baldwin Smith (1956) *Architectural Symbolism of Imperial Rome and the Middle Ages*, Princeton: Princeton University Press. The celestial canopy or baldachin is placed over the monarch or ruler as an indication of importance, a concept which links with imperial, and secular architecture (especially pp. 12-13).

<sup>15</sup> The construction is interesting since hollow pots and light weight concrete/tufa rock was used in order to reduce the immense forces of the dome. It is buttressed by walls which partly conceal the dome from the outside. See Dio Cassius, *Roman History*, vol. 6, LIII, 27 (London: Heinemann, Loeb, 1917 ed. pp. 263-65), cf Virgil, *Aeneid*, 6, 750f. 'the vault of heaven.' and Martial, *Epigrams* 8, 36, 11-12 ('par domus est caelo'), cited by Lehmann, p. 1.

<sup>16</sup> Lehmann, *Dome of Heaven*, p. 12 and fig 27; also Nicole Dacos (1969) *La Découverte de la Domus Aurea et la Formation des Grottesques à la Renaissance*, London: Warburg Institute. Cf also Plutarch's description of Alexander the Great's tent of heaven, *Life of Alexander* 37, 4 (London: Heinemann, Loeb, 1919, vol. 7, p. 337).

<sup>17</sup> Baldwin Smith, *Architectural Symbolism*, p. 123; Baldwin Smith also cites Varro (*Rerum Rusticarum*, III, 2, 4), and Cato (*Notes on Civil Law*) for the Roman conception of the domed heavens.

<sup>18</sup> Dio Cassius, *Roman History* LXIII, 2, and other examples described by Lehmann, *Dome of heaven*, especially pp. 6-11. The circular Temple of Vesta (first century AD) is a good example of the circular concept but details of the original ceiling are unknown.

<sup>19</sup> Baldwin Smith, *The Dome*, p. 14ff.

However, in the eastern Mediterranean, the concept of the dome of heaven and its transference to ecclesiastical architecture was of prime importance. In the Judæo-Christian tradition, the links between cosmology and theology are clear from Genesis 1. According to the Old Testament, God is viewed as the architect or creator of the physical universe who 'sitteth upon the circle of the earth' and 'stretcheth out the heavens as a curtain and spreadeth them out as a tent to dwell in' (Isaiah 40:22, cf Psalm 104 and Jeremiah 10:12). This clearly provides the basis for the view of the flat earth covered by heaven's dome, and Jerusalem was regarded as the centre of the flat-earth system (Ezekiel 5:5). This view of the universe with heaven above and hell beneath the earth's surface is very much reinforced through out the Old and New Testaments. Cosmological concepts were reflected in art and architecture and, with the expansion of Christianity, such concepts carried over into church construction and decoration, underpinning much of the architecture of the eastern Mediterranean during the early Christian and Byzantine period<sup>20</sup>.

Early examples are found in mausolea and martyria rather than in the large churches where the Roman basilican type was generally adopted. The circular plan, with its connotations of perfection, symmetry and eternity was more commonly used for edifices relating to death or commemoration<sup>21</sup>. Examples of circular, domed pagan mausolea are to be found as well as Christian monuments, including evidence of the early use of wooden domes in the native tradition in Syria and Palestine, which are comparable with Roman and Hellenistic examples<sup>22</sup>. Precise shapes varied from hemispheric, shallow, onion, pinecone, cosmic egg or 'heavenly bowl' (reminiscent of the 'bowl of night' alluded to in Fitzgerald's translation of the *Rubaiyat of Omar Khayyam*). The actual word for dome derives from *domus* used in Greek and Latin at first to signify house or dwelling, and later with the precise meaning of roof or cupola. From this, in time, was derived the word dome which in Christian terms came to signify the ceremonial meeting place or cathedral (in Italian, *duomo*; *Dom* in German). Similarly, the Syrian *qubāb* or the Arabic word for house, *kubba* or *qobba*, came to mean dome.

Little remains of very early Christian domed structures, although Baldwin Smith has carefully traced evidence for wooden domes (previously thought only to have been conical) and which were often painted in blue and gold to signify the dome of heaven. The type is shown on an early ivory at the John Rylands Library Manchester which clearly demonstrates the celestial overtones<sup>23</sup>. Wooden domes had no necessity for massive supports and buttresses and their design also apparently related to ship building traditions with girders and ribs, although (naturally) inverted. In the earthquake zones of the eastern Mediterranean constructions in wood was less difficult and dangerous than working in masonry with constant danger of collapse with any slight disturbance, but there was clearly great motivation, inspired by the significance of the symbolic meaning, to produce more durable construction. Influenced by Roman methods of vaulting many churches were built with official approval and assistance and Smith firmly establishes evidence for the use of the dome as an important tradition in Syria and the Holy land. Further impetus was gained as Christianity became the official religion of the Roman empire (in 313) and the Emperor Constantine created his new capital at Byzantium, renamed Constantinople (330). At the same time, the Holy Sepulchre at Jerusalem (326-335), the supposed tomb of Christ on the hill of Golgotha and the place where the relics of the Holy Cross were found (although now thoroughly restored and renovated) was first built as a circular memorial type erected by Constantine as memorial tomb of Christ, and likely to have possessed a wooden dome with stars. The 'omphalos' is represented on the floor of the church, as a twelfth century carved representation of a human navel. Crusader seals show that the Holy Sepulchre seems to have had a dome until 1169, which was unlikely to have been masonry because of insufficient

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<sup>20</sup> The shape of the Holy Tabernacle (Exodus 25-27) was rectangular with curved roof, and twice as long as it was wide, the earth being held to be the same shape (see A. Koestler (1984 ed) *The Sleepwalkers: A History of Man's Changing Vision of the Universe*, Harmondsworth: Penguin, pp. 92-93). Similarly, the proportions of the Temple of Solomon were founded on the same concept (I Kings 6) and even in the sixteenth century, the Sistine Chapel in Rome was built to the same proportions in imitation (see A. Chastel et al (1986) *The Sistine Chapel. Michelangelo Rediscovered*, London: Muller Blond and White, pp. 12 and 40).

<sup>21</sup> As alluded to in the writings of the early Church Fathers, especially St. Augustine, whose writings exerted enormous influence and who was clearly aware of the platonic symbolism of the circle in relation to cosmic order: 'the circle, because of its equality surpasses all other plane figures' (*On the Magnitude of the Soul*, chapters 7-12, especially pp. 75-80). John of Damascus alluded to Heaven as a dome (in his chapter 'Concerning heaven' in his *Exposition of the Orthodox Faith*). See also Louis Hautecoeur (1954) *Mystique et Architecture: Symbolisme du Cercle et de la Cupole*, Paris: Picard, pp. 145-292.

<sup>22</sup> Baldwin Smith, *The Dome*, especially p. 4 f; and A. Grabar (1946) *Martyrium, Recherches sur le culte des reliques et l'art Chrétien antique*, Paris.

<sup>23</sup> Baldwin Smith, *The Dome*, Figure 114. Smith also looks at the development of brick domes in Syria, clearly built with the aim of making them more durable, and concludes (p. 131) that there were a large number and a very solid tradition of domed churches in the Holy Land.

buttressing<sup>24</sup>. The idea of the dome or baldachin as relating to the ancestral hut and ideas of kingship was transferred to Christ as King of Kings.

### Early Christian and Byzantine

During the Early Christian and Byzantine period, Christian architecture was used to heighten theological concepts, particularly at a time when many were poorly educated or unable to think abstractly. Ecclesiastical authorities therefore used architecture to produce the vision of heaven on earth as the richly decorated churches of the period clearly demonstrate. A good example still remaining, and with obvious celestial overtones is the Mausoleum of Galla Placidia at Ravenna, Italy (Figure 5). Here the heavenly dome is clearly signified by stars, conveying the idea that a heavenly starred vault over a tomb is visible proof of the heavenly home of the departed soul. The idea of an other worldly cosmic paradise is also emphasised by the surrounding depiction of the sylvan paradise with animals and the fountain of life. A similar example from about the same time is the dome mosaic of the fifth century martyrium at Casaranello, Italy (Figure 6) which also shows obvious celestial overtones<sup>25</sup>. The difficulty of placing a circular dome on the square crossing of a cruciform church, which leads to a tent like formation, shows the determination of the builders of the monument, almost like trying to square the circle. At S. Vitale in Ravenna, the constructional problem of surmounting the octagonal church with a dome was solved by the use of lightweight hollow pots as the basis for the dome in order to alleviate the immense stress. Christ is depicted seated on the sphere of the universe in the semi dome of the apse.

By the sixth century, the order of the universe had been codified in terms of a hierarchical ascending and descending order, drawing a relation between the celestial and terrestrial order. The Syrian religious writer Pseudo-Dionysius the Areopagite in his *On the Celestial Hierarchy* and *On the Ecclesiastical Hierarchy* determined the order of the universe in relation to the order of the Church on Earth and his writings in turn closely underpinned Christian church iconography. The church became a microcosmos of the macrocosmos, a mystical temple which served as a replica of the comprehensible universe<sup>26</sup>. The direct influence of the cosmological view of the universe on art and architectural tradition can specifically be demonstrated by the *Christian Topography* of Cosmas Indicopleustes, an Alexandrian monk active in the sixth century. His work provides the fullest account of the world as cosmic house and is important for the way in which it summarises the thought of the scriptures and early church fathers. The *Christian Topography* is particularly significant since, unlike the writings of Pseudo-Dionysius and other, it is illustrated with diagrams<sup>27</sup> and that of the universe (Figure 7) clearly demonstrates the idea of the heavens as a dome, with the hierarchy of the heavens labelled in Greek. The scheme relates closely to Cosmas' drawing of the *Last Judgment* in the same manuscript (Figure 8) at which time the Good will ascend to heaven while the condemned sink beneath the earth's (flat) surface. Aware but dismissive of ancient theories of the spherical universe, the diagram relates specifically to ecclesiastical iconography and architecture. Another diagram of the universe clearly forms the foundation for the Christian basilican church, surmounted, this time, by a celestial barrel vault of heaven, rather like an old fashioned travelling trunk, as Kuhn describes it (Figure 9). As demonstrated in such early manuscripts, the perception of the macrocosmos, although sometimes confused, is key to Byzantine church iconography and architecture. Relating to the fundamental concept of the organization of the universe with an 'up for heaven' and 'down for hell' approach, curved and domed vaults (often star-covered) recur frequently in Early Christian and Byzantine architecture from Ravenna to Constantinople.

The sacred and celestial aspects of the dome were increasingly refined during the Byzantine era as an integral part of the decorative programmes of the typical Byzantine cross in square Church. The prime example of this is of course S. Sophia in Constantinople, built under Justinian in 532-37 (Figure 10), with its massive dome spanning 32.6 metres (107 feet) which rests

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<sup>24</sup> See Baldwin Smith, *The Dome*, figs. 218-227. Other examples of wooden dome include Antioch (327 and 526-88); the martyrium of Gregory of Nazianzus (374), and the martyrium at Nyssa in Cappadocia (379) (*ibid.* p. 29ff.).

<sup>25</sup> See Hauteceur, *Mystique et Architecture*, pp. 205-210. Similar examples are to be found in the catacombs in Rome where domed vaults contain depictions of Christ as caring Shepherd in paradisaical settings, partly derived from pagan Roman traditions (cf Virgil, *Eclogues* 2, 28f and 5, 60 f.).

<sup>26</sup> See Arthur O. Lovejoy (1936) *The Great Chain of Being*, Cambridge: Harvard University Press.

<sup>27</sup> Cosmas Indicopleustes (1968) *Topography Chrétienne*, ed. W. Wolska-Conus. Paris: du Cerf (other editions by E. O. Windstedt 1909 and J. W. McCrindle 1897). Also D. V. Ainalov (1961) *The Hellenistic Origins of Byzantine Art*, New Brunswick: Rutgers University Press, p. 33f). Cosmas' writings were not official doctrine but clearly typical (Koestler, *Sleepwalkers*, pp. 92-94; Thomas S. Kuhn, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*, Cambridge: Harvard University Press, p. 108)

on pendentives derived from a dome almost exactly the same size as the Pantheon. The great height of the dome, rising 54.8 metres (180 feet) above the ground adds to its celestial qualities and the organisation of the interior spatial design is clearly not for utility, privacy or comfort but to dramatise and spiritualise. As a contemporary, Procopius, described it, the dome was 'overlaid with pure gold and rests with apparently little support', seeming to 'float on the air.' The huge spherical dome (*sphairoeides tholos*) appears 'as if suspended by a chain from Heaven'<sup>28</sup> and was in continuous use until 1453 apart from a period of adaptation as a Latin Cathedral by crusaders 1204-61. Used as mosque until 1930, it is now a museum. As with most Byzantine church architecture, the exterior of S. Sophia is less impressive than the interior, the prime aim being to create an other worldly effect for those entering the building.<sup>29</sup>

Byzantine mosaic schemes of decoration reflect the religious, political and social order, according to the hierarchical levels of existence as exemplified in the writings of Pseudo-Dionysius, which related the Christian world view to the ordering of the Church on earth. Such writings underlie the whole ethos of the iconological programmes of Byzantine mosaic decoration and demonstrate the conscious search for a solution in accordance with liturgical needs and aesthetic ideals. The use of the cupola or dome is invariably part of any formal Byzantine scheme and, as Demus expresses it, represents 'the image of the changeless and celestial world set over against the varying earthly sphere of the ground plan.'<sup>30</sup> Classical schemes of mid-Byzantine architecture represent an image of the universe where celestial and terrestrial regions are carefully defined in an ordered hierarchy. It is essentially a hanging architecture as vaults appear to depend from above, with the dome symbolising heaven and other areas represented in descending hierarchical order down to the earthly zone of the lower parts. Figures of saints and angels take their place in the hierarchy, the Virgin Mary often occupying the conch of the apse as the bridge between heaven and earth. The mosaic schemes also closely correspond to the liturgical cycle and the calendar of the Christian year as the flow of events circle around the centre in a recurring circle. Unlike Western Romanesque or Gothic architecture with the core emphasis from west to east along the main axis, the domed centralised church appears to have no single emphasised direction but an eternal motion related to that of the heavens<sup>31</sup>. Particularly in the mid Byzantine period (9th-12th century) the dome was reserved for subjects with cosmic overtones such as the *Ascension*, *Pentecost* or the *Pantocrator* or all Ruler, often depicted with a rich gold mosaic background, symbolising infinity rather than an attempt to depict real space. In classic schemes of mid-Byzantine mosaic decoration, such as at Hosios Loukas (begun 1020) and Daphne (1080) in mainland Greece (Figure 11) such schemes are strictly adhered to, as the very shape of the vaults as a celestial form are designed to act as visible proof of the existence of the heavenly realm above<sup>32</sup>.

Soon afterwards, the Italo-Byzantine church of St Mark's was built in Venice (1063-85) and clearly reflects the art of Byzantium. Stylistically owing to both eastern and western traditions, the mosaic decoration dates mainly from the twelfth century, and emphasises even more graphically the cosmic significance of its multiple domes. The mosaicists of St Mark's were faced with the problem of filling no less than five main cupolas and a wide range of subjects with specific cosmological and astronomical significance were included. The Pantocrator in the main dome has clear astronomical references in its concentric rings of stars (Figure 12), as also the depiction of Christ Emmanuel in the eastern dome. The north dome with St

<sup>28</sup> Procopius, *Buildings*, vol. 7, I, i, 27-66 (London: Heinemann, Loeb, 1971 ed. pp. 13-29, especially p. 21, 25).

<sup>29</sup> See also the description by Photius, Patriarch of Constantinople in the ninth century (Cyril Mango (1958) *The Homilies of Photius*, Cambridge: Harvard University Press) and R Cormack (1981) 'Interpreting the Mosaics of S. Sophia,' *Art History*, 4, pp. 131-49.

<sup>30</sup> Otto Demus, *Byzantine Mosaic Decoration: Aspects of Monumental Art in Byzantium*, London: Routledge and Kegan Paul. Although published in 1948, there are few better texts to provide an understanding of Byzantine iconography. Also Richard Krautheimer (1965) *Early Christian and Byzantine Art*, Harmondsworth: Penguin, who analyses the cross in square church as image of the Universe (pp. 201-213) and provides further references for the symbolism (n. 18 on p. 344), its acceptance and practice in church building, by citing the Patriarch Germanos in c. 700: '... Finally, the dome represented heaven' (p. 213).

<sup>31</sup> Demus, *Byzantine Mosaic Decoration*, pp. 14 -17. The tradition continued in the Greek Orthodox Church beyond the mid-Byzantine period, and examples are to be found in the sixteenth century (such as the starred background to the Christ in Glory, Monastery of Roussanou, Meteora) and even to the present day in the starred domes of the Mitropoli (Cathedral Church) in Athens, founded 1842.

<sup>32</sup> From the depiction of the Pantocrator in the dome to the rich gold mosaic backgrounds, the cosmic allusions are clear at Hosios Lukas and Daphne (See Demus, *Byzantine Mosaic Decoration*, especially pp. 56-58 and 60-61 and figs. 42 and 43a). Cosmological allusions of the Pantocrator as ruler of the universe may be reinforced by inscriptions, such as that surrounding the bust of Christ in the Palatine chapel, Palermo (12th century) 'the heavens are my throne, the earth my footstool says the Lord, Pantocrator' (? \*, ≡ΛΔ∇<≡H\_μ≡4\_2Δ≡≡H\_0\_\*,\_(0\_ΛB≡B≡\*4≡<\_9T<\_B≡\*T<\_μ≡Λ\_8,(4\_5ΛΔ4≡H\_Α∇<9≡6Δ∇9≡Δ,\_cited by Lehmann, 1) taken from Isaiah 66:1 which continues 'where is the house that ye build unto me?' (cf Matthew 5:34-35).

John centres on an abstract design with inscriptions with astronomical references to the points of the compass, and such astronomical devices may well have had special significance for the Venetians as a seafaring nation reliant on the stars for navigation<sup>33</sup>. In the south and west domes, the *Ascension* and *Pentecost* are depicted (subjects normally reserved for the dome because of the heavenly allusions). Coupled with historic scenes from the life of Christ, the life of the Church and the *Last Judgment* in the westernmost vault, the entire scheme symbolises the past, the present and the future. Even more dramatically inspired by cosmic phenomena are the mosaics of the atrium with the creation cycle, based on Genesis I (Figure 13 and detail Figure 14). The iconography of the scenes in the Creation cupola have their origin in late antique cosmological representations, based on the close connections in medieval thinking between paradise, the world and the dome of heaven. The appropriateness of the subject to its position in the dome can hardly be doubted as a clear interpretation is provided in sequential narrative of the days of creation, from the separation of light and dark, to the creation of the sun, moon and stars<sup>34</sup>. The whole effect of St Mark's is visionary, to convey the idea to the worshipper of entering into the heavenly realm which transcends the earthly reality.

In the same way, the Byzantine tradition permeated not only the Italian mainland, but also a number of areas in Eastern Europe, developing its special characteristics and ceasing to be merely 'colonial' art. Space does not allow detailed investigation of such types, but the fourteenth-century Holy Spirit Cathedral in the monastery town of Sergiev Posad, near Moscow, serves as a clear example of the wide dissemination of the cosmic associations of the dome, heightened by the eight and ten pointed star symbols on the multiple blue domes (Figure 15).

It seems curious that the circular form and the celestial symbolism of the dome was somewhat lost in the medieval west, although the orientation of the great Romanesque and Gothic cathedrals (with the altar in the east) did have astronomical overtones, as did the concept of the soaring heights of Gothic spires and pinnacles, pointing to heaven. One area in the west where the domical tradition appears to continue is in the great curved tympana of the medieval cathedrals where the *Last Judgment*, the end of the universe, was frequently depicted. The *Last Judgment* remains the one scene in Christian iconography where Heaven, Earth and Hell, the three parts of the medieval universe, would naturally be depicted together and this was normally portrayed on (or just inside) the west front of a church, to face the setting sun and as a disciplinary reminder to the congregation on exit. The astronomical orientation also links with the relation between the birth of Christ at the winter solstice and the analogies between Christ and the pagan sun-god which may well have been pursued in the early days in order to gain converts, and which are well known<sup>35</sup>. Many examples of cathedral sculpture show a relationship to the perception of the layered domed universe, as well as specific astronomical symbols which reinforce the idea, as at Autun (Figure 16)<sup>36</sup>. Amongst all the debate on the medieval cosmos in the west, Romanesque and Gothic architecture was thus not devoid of astronomical significance in its painted and sculptural decoration<sup>37</sup>. However, it was not until the fifteenth century that the centralised architectural plan was regarded in western Europe as the most suitable for expression of God's divine order. The acceptance of the circular domed Greek cross as the ideal for churches belongs to the Renaissance revival of Greek thought, precipitated by the influx of Greek writers, architects and thinkers into Italy following the fall of Constantinople in 1453. However, before considering the revival of the dome during the renaissance, a brief consideration of the importance of the rise of Islam in the east and the development of the domed mosque appears significant in order to demonstrate the universality of

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<sup>33</sup> See Otto Demus (1988) *The Mosaic Decoration of San Marco, Venice*, Chicago: Chicago University Press. In the north dome 'A D A M' stands for the four cardinal points in Greek and 'A A O O' the same in Latin, *ibid.* p. 93

<sup>34</sup> *Ibid.*, chapter 20. Other domes in the atrium appear to depict abstract symbolic 'orbits' (plates 51, 53 and 56).

<sup>35</sup> See, for example, Malachi 4:2 for the Messiah as sun; and H. Rahner (1963) *Greek Myths and Christian Mystery*, London: Burns and Oates, for Christological astronomical symbolism.

<sup>36</sup> See Hauteceur, *Mystique et Architecture*, pp. 264-270 for examples of circular churches or 'rotunda' in the west. An unusual and interesting example of a circular Romanesque Church is the Round Church in Cambridge, England (early 12th century), but it is not domed. Examples of semicircular tympana are numerous; painted examples of the *Last Judgment* also abound, such as that by Giotto c. 1305 (with angels rolling back the scrolls of Heaven, next to a ceiling studded with stars) or Rogier van der Weyden, 1445 with Christ seated on a dome shaped 'arc en ciel'.

<sup>37</sup> For summary of western medieval thought and its basis on Aristotelian cosmology, see Koestler, *Sleepwalkers* and Kuhn, *Copernican Revolution*. More recent comment includes Edward Grant (1997) 'The medieval cosmos: its structure and operation,' *Journal of the History of Astronomy*, vol. 28, no. 91, 147-167; Bruce S. Eastwood (1997) 'Astronomy in Christian Latin Europe, c. 500 - c. 1150,' *Journal of the History of Astronomy*, vol. 28, no. 92, pp. 235-258.

the concept.

### Islam and the development of the domed mosque

As mentioned above, from the time of the Roman empire domed architecture was swiftly adopted as a standard form in the western Mediterranean and, after the death of the Prophet Muhammad (632) it was very much taken over in Syria and also by the Arabs as a distinctive feature of their architecture. Soon after the first flourishing of Byzantine art, the dome thus also became, in its immense variant forms, a keystone for Islamic architecture. It is questionable whether the tradition derived from early Christian and Byzantine architectural cosmology or from the heritage of the nomadic people who largely made up the Islamic world. The importance of the tent or canopy for nomadic peoples and the perception of the heavens as such is provided by records of huge dome shaped tents, and in the Qur'an itself, the word 'canopy' is frequently used as descriptive of the sky or heavens (XXXI 32; LII, 5; LXXIX, 28) and the firmament is clearly perceived as 'round' (LXXXVI, 11 - with eternal and circular movement). In the simple religious ceremonies of the pre-Islamic Arabs, the symbol of the divinity was sometimes placed in a tent referred to as a 'qubba' or dome<sup>38</sup>.

Descriptions of the creation are common in the Qur'an and recur in many places (for example, Sura VI, 1-3, Sura VII, 54 and Sura XIII, 1-4, XVI, 12f., XLI, 9-12). Of particular interest are references to the Heavenly zodiac and stars (Sura XV, 16; XXV, 61, XXXVII; 5-8, LV, 7; LXXXV, 1, 9) above the flat earth (XV, 19). The relation of this view to the construction of houses of worship, mosques, seems clear from the specific reference to God raising the heavens 'without any pillars' that can be seen (Sura XIII, 2). The blue vault of heaven is all that is visible and hence the domed mosque appears also to relate to the physical concept of the universe<sup>39</sup>.

The prophet Muhammad left Mecca to found the Islamic state in 622, and by 750 Arab Muslim armies stretched from the borders of France to the Indus. Following the Muslim conquest of former Roman and Byzantine provinces Christian art was known or seen by the conquering Umayyad dynasty. Completed in 691, the Dome of the Rock in Jerusalem (Figure 17) is the earliest remaining monument of Islamic architecture, associated with Muhammad's ascent into Heaven from the Rock. Domes were by this time a well known means of honouring a holy place and, with a centrally planned dome of 20 metres (height 25 metres) and gilded on the outside, the design follows the ancient practices of the Eastern Christian Empire. Particularly notable is the way the inner and outer dome rise out of the octagon. Like most Islamic art, the mosaic decoration is largely vegetal and abstract, but does include star motifs<sup>40</sup>. The inner dome carried the painted and gilded decoration of the interior and until the nineteenth century several inscriptions survived, facing the four cardinal points<sup>41</sup>. The inscription of dome on square or octagon had a mystical significance, as also seen in the Great Mosque of Damascus (706) and other examples, often achieved with the assistance of itinerant Byzantine architects. Depictions of trees, vegetation and actual cities relate to the setting of the Muslim paradise and the depiction of the 'fullness of the universe.'

In secular buildings, also, the depiction of idealised and paradisaical scenes related to the connotation of well-being. Baths in particular became a common feature, and luxurious complexes were created. The zodiacal design on the interior of the dome at Qusayr Amra in Syria (eighth century) is one such example which supports the idea of astronomical influence in the overall design and heighten the idea of cosmic well-being (Figure 18). The chief constellations in the northern hemisphere are depicted on the dome together with the signs of the zodiac (Ursa major, Ursa minor, Andromeda and Cassiopeia have been identified). Cresswell draws attention to this as 'the earliest attempt to portray the vault of heaven on a hemispherical surface.'<sup>42</sup> Less accurate and more abstracted star-like designs which occur on the interiors of early Islamic mosques are to be

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<sup>38</sup> Richard Ettinghausen and Oleg Grabar (1987) *The Art and Architecture of Islam*, Harmondsworth: Penguin, p. 18. All quotations and references to the Qur'an are taken from the bilingual edition: *The Holy Qur'an*, translation and commentary by A. Yusuf Ali, Durban: Islamic Centre International (1st ed. 1946).

<sup>39</sup> Qur'an, ed. cit. p. 602, n. 1800. The Arab astronomical tradition is particularly significant. The Arabs, like the Venetians, would have had particular interest in the stars for navigation, but in the desert rather than at sea.

<sup>40</sup> Ettinghausen and Grabar, *Art and Architecture of Islam*, p. 28f. and Figure 9; also K. A. C. Cresswell, *A Short Account of Early Muslim Architecture*, Aldershot: Scolar Press, 1989 (first published, Penguin 1959) p. 20 f.

<sup>41</sup> Cresswell, *Early Muslim Architecture*, p. 33. All mosques are of course orientated toward Mecca, the sacred direction known as the qibla, indicated by the mihrab or prayer-niche.

<sup>42</sup> *Ibid.* pp. 60-61 and 111-12. The original design for the city of Baghdad (founded 762) was perfectly circular, and of planned cosmic significance, conceived as the navel of the universe with the mosque of the green Dome at the very centre (pp. 76-79). (See also David A.



found, for example, at Cordova (961/76) and the Great Mosque at Isfahan (1088 - part of a complex of 476 vaults, mostly domes). The architectural element of the dome and its decoration were clearly less for architectural or structural purposes, nor simply aesthetic reasons, but regulated by abstract principles<sup>43</sup>.

These and other examples serve to show how Christian and Islamic domed architecture was related to pagan structures. Just as in the ancient Greek and Roman and in the Early Christian and Byzantine tradition, Islamic architects were inspired to build mosques with similar symbolic and imposing domes (often decorated and gilded) pointing to a common and deep-rooted belief in the symbolism which led to its adoption<sup>44</sup>. The tradition was well established by the time that Constantinople fell to the Ottoman Empire in 1453 and modern examples of domed mosques, mounted by the crescent and with other astronomical allusions to the heavens abound in the Middle East, as shown by modern examples from Saudi Arabia and Oman (figs. 19, 20). The Regent's Park Mosque in London, built c. 1970 (Figure 21) also stands out as a prime example. The interior of the dome, painted a rich deep blue with star shaped medallions of blue stained glass, preserves the tradition and recalls once more Fitzgerald's allusion in the Rubaiyat to 'that inverted bowl we call the sky' (quatrain 52)<sup>45</sup>.

### The Renaissance revival of domed architecture

While the Byzantine and Islamic traditions secured a role for domed architecture, it was not until the Renaissance revival of classical thought that the dome again became the dominant style of architecture in western Europe<sup>46</sup>. The revival of the dome in the Renaissance period was inextricably linked to the revival of classical ideas, and very much based on its derivation from the circle as the most perfect form, according to neoplatonic thought. Alberti's *De Re Aedificatoria* (c. 1450) was the first architectural treatise of the Renaissance and written in imitation of Vitruvius<sup>47</sup>. Book 7 in particular elaborates on sacred architecture and the building and decoration of the ideal church, and the discussion begins with a eulogy on the perfection of the circular form (as derived from nature). An emphasis is laid on the dome and its relation with the sky as Alberti cites ancient authors such as the poet Ennius, on 'the vast vault of the heavens' (Book 3, chapter 14). Cosmic significance might also be suggested by actual painted representation of the sky as described in antiquity by Varro which Alberti found highly pleasing (Book 7, chapter 11). Alberti also provided evidence that the design of the ancient circus was based on the heavens, with the number of entrance gates, turning posts and orientation generally corresponding to astronomical features such as the number of planets (Book 8, chapter 8). Alberti thus seems to have been aware that a cosmic interpretation of the dome had been common in antiquity and kept alive in the eastern Church, and his works in turn exerted an enormous influence on architects of the Italian Renaissance.<sup>48</sup>

The eleventh century octagonal Baptistery of Florence has a conical ceiling decorated with the *Last Judgment* in hierarchical tiers with Christ as Saviour seated on the arc of heaven, and creation scenes with starry backgrounds. This seems to have provided the inspiration for the choice of a domed octagon for the new adjacent cathedral, begun in 1294 and intended to be as large and impressive as possible. However, the projected dome proved impossible to construct and the task of spanning the 140 foot opening had still not been solved by the early fifteenth century. The problem was solved by Filippo Brunelleschi

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King (1995) 'The Orientation of Medieval Islamic religious Architecture and Cities,' *Journal of the History of Astronomy*, vol. 26, no. 84, pp. 253-273.)

<sup>43</sup> *Ibid.*, figs. 114 and 274. Decorative arts of the period also frequently included cosmic images, constellations and planets (p. 329).

<sup>44</sup> Baldwin Smith, *The Dome*, p. 43 f

<sup>45</sup> For alternative translation, see Robert Graves and Omar Ali-Shah (1967) *Rubaiyat of Omar Khayyam*, London: Cassell 1967. For modern Islamic architecture, see Renata Holod and Hasan-Uddin Khan (1998) *The Mosque and the Modern World: Architects, Patrons and Designs since the 1950s*, London: Thames and Hudson.

<sup>46</sup> The best single volume guide to Renaissance architecture is probably Peter Murray (1986) *The Architecture of the Italian Renaissance*, London: Thames and Hudson. For Renaissance Cosmology, see also S. K. Heniger (1977) *The Cosmographical Glass: Renaissance Diagrams of the Universe*, San Marino California: Huntington.

<sup>47</sup> Leon Battista Alberti (1988 ed.) *On the Art of Building in Ten Books*, transl. Joseph Rykwert, Neil Leach and Robert Tavernor, Cambridge: MIT Press.

<sup>48</sup> Alberti, *On Building*, ed. cit. especially pp. 84, 222, 278f. The actual construction of arched vaults and domes is dealt with in Book 3, chapters 13 and 14, ed. cit. pp. 81-87. See also Rudolf Wittkower (1973 ed.) *Architectural Principles in the Age of Humanism*, London: Academy, especially pp. 3, 9ff.

(1377-1446) following a visit to Rome specifically to look at ancient building design and construction, and there can be little doubt that it was his special study of the Roman ruins and methods which enabled him to solve the constructional problems and devise the means for the completion of the long-awaited dome in 1420-34 (Figure 22) A pointed dome was adopted rather than perfect hemisphere, the basic formation being a pointed arch rotated around a central point, and the interior was eventually decorated with the appropriately cosmic scene of the *Last Judgment*, painted later by Vasari (1571-74) and Zuccari (1578-79)<sup>49</sup>. The same theme occurs on the interior of the dome of Pisa cathedral, while that of the inner (conical) Romanesque dome at the Baptistery at Pisa remains unadorned.

Given additional impetus by the influx of Greek thinkers after the fall of Constantinople in 1453, interest escalated in the revival of ancient ideas which eventually contributed to the High Renaissance in the sixteenth century and the achievements of artists like Leonardo da Vinci and Michelangelo. The revival of Platonic philosophy through the work of neoplatonists like Marsilio Ficino (1433-99) should not be underestimated in its influence on the perfect circular form, for, as Wittkower expresses it, 'the full renaissance conception of the perfect church was rooted in Plato's cosmology.'<sup>50</sup> The shape of the Cosmos is described in *Timaeus*, as the perfect circular form<sup>51</sup> and Renaissance Church building continued to imitate this. Later works by Brunelleschi and others clearly adhere to the concept of the domed perfect circular form, as exemplified by the Pazzi chapel (1429-46) built in classical and harmonious proportions, and according to the ancient proportions of the 'Golden Section.'<sup>52</sup> Direct awareness of the astronomical implications of the dome is made clear by Brunelleschi's design in the Old Sacristy of S. Lorenzo, where the cosmic allusions in the dome are heightened by specific depictions of the constellations at a given time. The smaller dome is entirely decorated with astronomical symbols (Figure 23). The constellations are reproduced in black and white on a blue background while the meridians, equator, ecliptic, stars, sun and moon are in gold. Almost like a planetarium, the dome depicts the northern celestial hemisphere as it would have been seen on 4th or 5th July 1442. Various hypotheses have been suggested for the selection of this date, possibly the welcoming of the sovereign of Jerusalem or celebration of the crusade against Murad II, in the aftermath of the Council of Florence 1439<sup>53</sup>.

The Old Sacristy is balanced literally and symbolically by the New Sacristy, also known as the Medici Chapel (1521-34), with sculptures by Michelangelo to commemorate the Medici dukes. Frescoes in the Old Sacristy at S. Lorenzo provide a clear indication of the astronomical meaning, while Michelangelo's sculptural schemes in the 'New Sacristy' or Medici chapel are based on less overt references to cosmological meaning. The massive dome is derived from classical examples and recalls the Pantheon (especially with the raised lantern giving the impression of an oculus open to the sky), while the sculptural features have clear cosmological allusions. As Tolnay points out,<sup>54</sup> the whole chapel was intended to be an abbreviated image of the universe, arranged in hierarchical layers of the different regions referred to specifically in platonic schemes (Figure 24), and heightened by the domed structure (for which frescoes had been intended). Reclining figures of Day and Night (the latter clearly signified by the wearing of a crescent moon and stars in her hair), Dawn and Dusk, while referring to Plato's theory of opposites, explore the meaning of time and space in neoplatonic terms. Michelangelo's contemporary biographer, Ascanio Condivi, noted that the monument symbolized time and its passage, while Tolnay has provided a neoplatonic interpretation in terms of the order of the universe, with an underworld symbolised by the river gods planned for the lower tiers, an earthly

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<sup>49</sup> Alberti, in the prologue to his treatise *On Painting* described the Duomo as 'so great a structure rising above the heavens (*sopra e cieli*) broad enough to cover with its shade all the people of Tuscany.' The scheme for the frescoes was devised by Vincenzo Borghini, who frequently refers to the dome as 'il cielo della chiesa' (Letter from Vincenzo Borghini to Giorgio Vasari, from C. Guasti, *La Cupola di Santa Maria De Fiore*, Florence 1847).

<sup>50</sup> Wittkower, *Architectural Principles*, p. 23.

<sup>51</sup> Plato, *Timaeus*, 33B: 'He wrought it into a round in the shape of a sphere, equidistant in all directions from the centre to the extremities, which of all shape is the most perfect and the most self-similar' (London: Heinemann, Loeb, 1981 ed. p. 63).

<sup>52</sup> Murray, *Architecture of the Italian Renaissance*, pp. 87, 131.

<sup>53</sup> The Old Sacristy was painted by Giuliano d'Arrigo (1367-1446); the adviser was Paolo Toscanelli. See Licia Bertani (1998) *San Lorenzo: The Medici Chapels*, Florence: Scala; and Gioia Mori (1987) *Arte e Astrologia*, Florence: Giunti Barbera, pp. 24-26, which includes other examples (not domes) of astronomical decoration of the Renaissance.

<sup>54</sup> Charles de Tolnay (1943-60) *Michelangelo*, 5 vols. Princeton: Princeton University Press, vol. 3, pp. 3-83, especially p. 63ff. and summarised in Charles de Tolnay (1981) *Michelangelo: Sculptor, Painter, Architect*, Princeton: Princeton University Press, p. 39f.. The idea is linked to the platonic doctrine of rebirth of the soul, as in Plato's *Phaedo*.

sphere symbolised by time and matter, and the world above, symbolised by the luminous celestial dome. The soul moves through the three levels in order to release become released from the flesh (in neoplatonic terms) Detailed interpretations vary<sup>55</sup> but there seems little doubt that the contrast is made between the earthly world below (dominated by matter and the passing of time) and the luminous other world above as souls ascends towards the brightness above, in the dome - recalling the neoplatonic idea of stars as the souls of the departed.

### Michelangelo in Rome

Of course Michelangelo's greatest works are those in St Peter's, whose dome was finally constructed according to his design. The project to design the new domed St Peter's had however been ongoing for some time (lasting altogether from 1506-1626) and many artists and architects had shown interest in such projects. Leonardo da Vinci had demonstrated a clear interest in astronomy, alongside a particular fascination for domed architecture as evidenced by his numerous drawings and schemes for centralised domed churches<sup>56</sup>. Derived from the form of the Greek cross, or similar plans with symmetrical affinity to the circle (and not necessarily designed for execution), the ideal domed church was an important theme in his drawings, and it seems that general taste for domes prompted him to undertake thorough investigation. Prior to Michelangelo's appointment as architect for St Peter's in Rome in 1546, the scheme involved many architects from its commencement under Bramante in 1506. For Bramante, the significance of the dome with its neoplatonic perfection and celestial symbolism can hardly be overestimated, as evidenced by his plan for the small but perfect Renaissance circular domed church known as the Tempietto in S. Pietro in Montorio (1502-10, Figure 25)<sup>57</sup>. Constructed on concentric circles and cylinders, with a hemispherical dome, it was inspired by antique sources (such as the small round temple of Vesta). By contrast, the building history of St Peter's is complex. Bramante's scheme, like the Tempietto, derived from ancient Roman and antique Christian sources and Michelangelo finally returned to a similar concept thirty years later. By the time of Michelangelo's death in 1564, the drum had been completed up to the springing of the dome, and the original plans for a pure hemisphere had been altered to a slightly pointed form (for constructional reasons to reduce thrust)<sup>58</sup>. St Peter's was thus finally completed during the period of the Counter Reformation when the Catholic Church was seen at its most powerful. The dome is surmounted by a globe to represent the Church's global authority and dominates the central city of Roman Catholicism to represent the height of the power of the Catholic Church and the power of the Church of the Counter Reformation over the world (Figure 26).

At this point it is appropriate to digress slightly in order to consider the decoration of the Sistine Chapel at St Peter's, since evidence for cosmological meaning in Michelangelo's works has also been argued particularly with reference to the Sistine Chapel frescoes. Although the flat earth view of the universe had lost favour long before the Renaissance (made clear by Dante's writings, with which Michelangelo well was versed), the use of vaults and domes to emphasise cosmological meaning continued. The Sistine chapel provides a particular case study since although rectangular it was known to have been built to the same dimensions as Solomon's Temple, as already mentioned above. Furthermore, although not a dome, the curved vault of the Sistine was originally decorated with stars, and Michelangelo's replacement scheme for the ceiling (1508-1512) was also decidedly cosmic, with its well known depictions of the creation (*Separation from Light and Dark, Creation of Sun, Moon and Stars, and Creation of the Planets*) (Figure 27). Once again, astronomical phenomena provided the inspiration for the decoration of the curved vault. In addition, the *Last Judgment* over the altar wall has also been argued as having clear cosmic overtones. Taken in conjunction with the creation scenes on the ceiling, Michelangelo's vision of the *Last Judgment*, the end of the universe and time, reinforces the overall main cosmic theme of the chapel: the beginning and the end. Although now

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<sup>55</sup> See also Linda Murray (1984) *Michelangelo: His Life, Work and Times*, London: Thames and Hudson, p. 106f; Herbert von Einem (1976 ed.) *Michelangelo*, London: Methuen, pp. 95-109; Erwin Panofsky (1972 ed.) 'The neoplatonic movement and Michelangelo' in *Studies in Iconology: Humanistic Themes in the Art of the Renaissance*, New York: Harper and Row, pp. 171-230, especially p. 204; and William E. Wallace (1994) *Michelangelo at San Lorenzo: The genius as entrepreneur*, Cambridge: Cambridge University Press, chapter 2, pp. 75-121.

<sup>56</sup> See Leonardo da Vinci, (1970 ed. by Jean Paul Richter) *Notebooks*, 2 vols. New York: Dover, vol. 2, plates LXXXIV-XCII, and Section XV 'Astronomy' pp. 135-172 for discussion on the earth's place in the universe; the sun, moon and stars in an obviously ptolemaic system based on a spherical earth; and the shape, movement and luminosity of heavenly bodies. Even though Leonardo observed 'il sole no si muove' ('the sun does not move' *ibid.*, p. 152, no. 886), the significance of domed architecture was clearly not lost on him.

<sup>57</sup> Wittkower, *Architectural Principles*, p. 24; Murray, *Italian Architecture*, especially pp. 118-120.

<sup>58</sup> Raphael, Peruzzi and the Sangallos (father and son) all worked on the project after Bramante's death. The dome was completed on heroic scale to Michelangelo's designs by Giacomo della Porta and Domenico Fontana (1585-90).

more commonly perceived in terms of the big bang and gravitational collapse rather than Creation and Last Judgment, the Sistine Chapel is an expression of these key issues which have concerned humankind since time immemorial.

Looking briefly at the end or altar wall, it is also important to consider the fresco of the *Last Judgment* in the context of earlier depictions of the subject, to trace any possible links with contemporary views of the universe. As the key scene in Christian iconography where the entire universe (Heaven, Earth and Hell) is depicted in one image, the *Last Judgment* traditionally corresponded to the prevailing view of the universe (as exemplified by the layered compositions mentioned above). Michelangelo's vision (Figure 28) changes dramatically as it is dominated by a unique circular as opposed to stratified composition. Coupled with the depiction of Christ as beardless sun god Apollo type, it is possible to argue that this might have had some relation with Copernicus' heliocentric view of the universe (Figure 29). This argument has been fully explored elsewhere but suffice it to say that strong evidence exists to demonstrate papal interest in Copernicus' theory at exactly the time of the commission, and it can convincingly be argued that Copernican ideas (reinforced by the common ground shared between the Catholic revival of the traditional Christian analogy between the deity and the sun, the neoplatonic cult of sun-symbolism and literary theories in Dante) strongly influenced the iconography of Michelangelo's *Last Judgment*<sup>59</sup>.

### **Borromini and Kepler**

The addition of Bernini's colonnades enclosing the foreground space (1655-57) completed the scheme for St Peter's in the early seventeenth century and, architecturally, there seemed little else to be accomplished. Yet the seventeenth century saw some remarkable developments in domed architecture, which have not really been adequately explained. While the significance of the 'dome of heaven' in Byzantine and Renaissance architecture has more frequently been emphasised and evidence clearly shows that domes were inspired by the view of the universe, less discussion seems to have taken place about post-renaissance developments during the baroque period. Following on perhaps from the argued influence of Copernicus on Michelangelo, could it be coincidence that the dramatic introduction of true elliptical domes occurs at about the same time as Kepler revolutionised the perception of the universe and its mechanics, and might the radical changes and transition to the use of oval domes in the Baroque period have any relation to Kepler's elliptical orbits?

Interest in the perfect circular form in the Renaissance derived from platonic thought and concepts of natural perfection, a tradition continued by Palladio into the seventeenth century, yet the vocabulary of architecture, including domed architecture, altered radically during the 'Age of Enlightenment' in the seventeenth century. The use of the elliptical dome is a key feature of Baroque architecture, yet explanations for the notable preference of architects like Borromini for elliptical rather than perfectly circular or hemispherical domes appear incomplete. The inspiration of developments in astronomy in the seventeenth century challenged many classical and humanist precepts, such as the perfection of the circular form, and it is worth considering whether the predilection for the form of the ellipse by architects like Borromini might have anything relationship with Kepler's view of the structure of the universe. In his architectural schemes like S. Carlo alle Quattro Fontane (Figure 30, 1638-41) Borromini was accused of overthrowing the classical rules of architecture - an artistic anarchist who replaced the accepted vocabulary with innovation and disorder<sup>60</sup>. Yet mathematical precision underlies his apparently extravagant schemes, and seventeenth century scientific developments, especially the enormous changes in world view, cosmology and astronomy, might well have had a direct effect on his work.

While a certain form of oval dome was not unknown in the sixteenth century (the earliest examples being S. Andrea in Via Flaminia, 1554 and S. Anna dei Palafrenieri, 1572 by Vignola, and Volterra's S. Giacomo, 1590) these were often simply based on the domed square type with the circular dome elongated along one axis<sup>61</sup>. By contrast, the use by Borromini of the elliptical dome in churches like S. Carlo alle Quattro Fontane (1638-41) and by Bernini at S. Andrea al Quirinale (1658-70) are striking in their mathematical basis. Not simply rectangles with rounded corners, the construction at S. Carlo for example is

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<sup>59</sup> Valerie Shrimplin (1990) 'sun-symbolism and Cosmology in Michelangelo's *Last Judgment*,' *Sixteenth Century Journal*, 21 (4), 607-643, 1990 (summary of PhD thesis, 1991). A developed version is to be published in full as *Sun-symbolism and Cosmology in Michelangelo's Last Judgment*, Kirksville, Missouri: Thomas Jefferson Press, forthcoming 1999. It is quite easy to trace a direct connection between Michelangelo and Copernicus, through Johannes Widmanstadt (a member of Copernicus' chapter of Varmia) who in 1533 explained Copernicus theory to a group at the Vatican including the papal patron of the fresco and at least two personal friends of Michelangelo, just three months before he began work on the design for the *Last Judgment*.

<sup>60</sup> Anthony Blunt (1979) *Borromini*, London: Allen Lane.

<sup>61</sup> Murray, *Architecture of the Italian Renaissance*, p. 198; also Blunt, *Borromini*, p. 68.

based on a specific and measurable mathematical schema. Following on the work of Copernicus and Tycho Brahe, and in an attempt to explain anomalies in their hypotheses, in his early work, the *Mysterium Cosmographica* (1596) Kepler looked to the concept of the perfect regular nested solids as the basis for the disposition of the planets, as derived from Plato's *Timaeus*<sup>62</sup>. By the early seventeenth century, Kepler had started to question the ancient basis of astronomy founded on circular orbits and began to consider the ellipse as the basis for his view of the universe and its mechanics. He had realised that the universe did not work on perfect circular motion but rather that the orbits of the planets were elliptical, with the sun placed at one of the foci, as explained in his famous laws<sup>63</sup>. These views might well have had far reaching influence on the cosmological symbolism of spiritual architecture, and particularly the work of Borromini, well known as a conscious innovator. While the seventeenth century marks the beginning of the divisions and subsequent 'warfare' between science and theology, the prevalence of elliptical domes at this time does seem to suggest a positive link. In addition, as with the evidence for a link with the papal patron in the case of Michelangelo and Copernicus, it is interesting to note that Borromini's patron from the time of his arrival in Rome was Cardinal Barberini, who was elected Pope Urban VIII in 1623. As Koestler points out in discussion of the acceptance of the new heliocentric astronomy, 'Galileo himself enjoyed the active support of a galaxy of Cardinals, including the future Urban VIII' who wrote a letter to Galileo expressing sincere admiration<sup>64</sup>. As far as the new astronomy was concerned, Urban VIII showed a clear interest until his *volte face* in the 1530s, by which time the fashion for elliptical domes in the Baroque had taken secure hold.

It has been suggested, by Blunt, that the oval form of church in the sixteenth century was also influenced by liturgical requirements following the Council of Trent, but a relationship with the changing view of the universe (in terms of Kepler's orbits) also seems likely. Borromini's elliptical domes had a far more secure mathematical and geometrical foundation—possibly with a shared source with Kepler in Plato's *Timaeus* (54E-55C). Clearly, the ellipse had scarcely been considered as an architectural form before the seventeenth century and examples are very hard to find<sup>65</sup>. Borromini however, takes it as an overriding motif and the idea of the elliptical dome as a possible allusion to contemporary astronomical theory is reinforced by evidence of interest in astronomical symbolism appearing in much of Borromini's work. Short of the discovery of handwritten notes by the artist, it is difficult to prove Borromini's interests in Galileo, Kepler, or astronomy in general, but various works by the artist do lend weight to the hypothesis. For example, the drawings for the Oratory of S. Filippo Neri, S. Giovanni in Laterano and the Collegio di Propagande Fide include numerous star motifs and at S. Ivo della Sapienza, Rome (Figure 31, 1542), the six point starred decoration completely dominates. Borromini's letter to Cardinal Camillo Pamphili about the designs for his villa also provides useful evidence for Borromini's interest in mathematics and astronomy<sup>66</sup>.

Particularly significant is the startling inclusion of the motif of the icosahedron on the Filomarino altar in SS Apostoli, Naples (begun 1635) which relates directly to Kepler's theory of the solids as expressed in his *Mysterium Cosmographica*, 1596. The curious inclusion of the two icosahedra on the top of the altarpiece were pointed out by Blunt as being related to Plato's solids of the universe in *Timaeus* but no connection was made by Blunt with Kepler's theory of the solids so the inclusion here of icosahedra appears to signify an interest in forms to which hitherto little attention had been given<sup>67</sup>. In addition, Borromini's fitting of the octagonal floor design into the overall hexagonal plan in S. Ivo is curious to say the least, especially in the solution found of a border or dividing line, which also recalls Kepler's approach to polygonal forms. Although it is difficult conclusively to prove a direct connection between Keplerian theory and the Baroque architecture with elliptical domes, of

<sup>62</sup> Kuhn, *Copernican Revolution*, pp 217-219, Koestler, *Sleepwalkers*, 249-255. See Plato, *Timaeus*, 53D-55C, ed. cit. pp. 127-133.

<sup>63</sup> For a concise summary of Kepler's first two Laws (in his treatise on *Motion of Mars*, 1609) and third Law (in *Harmony of the World*, 1619) see Kuhn, *Copernican Revolution*, pp. 212-217.

<sup>64</sup> Koestler, *Sleepwalkers*, pp. 362, 437 and 448. Blunt, *Borromini*, p. 22f. and 47 where Blunt argues the influence of Galileo on Borromini.

<sup>65</sup> See *Timaeus*, ed. cit. pp. 132-33 and Blunt, *Borromini*, p. 48. Borromini's elliptical forms predate Bernini's (elliptical domes and the piazza of St Peter's). A notable exception, of course is the Colosseum in Rome and the reason for its oval form has not really been explained, other than to give prominence to one side for the placing of emperor and retinue; it may have had a covering canopy.

<sup>66</sup> See Blunt, *Borromini*, fig 69, 111 and 136-38, and p. 50 for the letter to Cardinal Pamphili.

<sup>67</sup> Blunt, *Borromini*, pp. 108-110. For additional background: Torgil Magnuson (1982) *Rome in the Age of Bernini*, Stockholm: Almqvist and Wiksell; J. V. Field (1988) *Kepler's Geometrical Cosmology*, London: Athlone. See also Martin Kemp (1990) *The Science of Art: Optical Themes in Western Art from Brunelleschi to Seurat*, New Haven: Yale, p. 63f..

Borromini and other architects of the period, evidence does suggest the matter is worthy of further investigation<sup>68</sup>.

### Sir Christopher Wren as architect-astronomer

At the same time as Bernini and Borromini were changing the face of Rome, the rebuilding of London was also taking place since the redesign of St Paul's Cathedral was already underway before the Great Fire of London in 1666 made total rebuilding necessary. Sir Christopher Wren had been consulted about St Paul's which was in danger of collapsing and proposed replacing the tower by a dome. The process was interrupted by fire of London 5 September 1666 which made total rebuilding necessary and the massive dome dominates the London skyline, along with other domed Wren churches built during the same period. While it had first been decided to improve the medieval cathedral with a tower and spire, Wren opted for a domed structure. This may well have been influenced by Wren's knowledge of the late sixteenth century architecture of Palladio (such as the Villa Rotunda) or by his actual meeting with Bernini in Paris in 1665-66 (suggesting an emulation of St Peter's) but could also be partly the result of his astronomical knowledge relating to the celestial implications of domed structures. Clearly, well before the time of the Baroque no one seriously believed the earth to be flat, yet the idea of the dome of heaven persisted in church architecture. Sir Christopher Wren was elected as Professor of Astronomy at Oxford in 1661, long before he was famed as an architect and generally utilised a simple mathematical basis for his art<sup>69</sup>. Although the concept of the flat earth had been superseded and was not accepted by educated persons, let alone professors of astronomy, the celestial implications remained and appeared to have acted as inspiration for the final design of the dome of St Paul's (1675), reinforced by the mosaic decoration (some of which was added later, such as the creation cycles), which can hardly be doubted by anyone able to visit it (Figure 32). Bearing in mind that Wren was first a mathematician and astronomer and afterwards an architect, and that he was also the architect for the Greenwich Observatory and Hospital, lying on the meridian, the astronomical implications seem clear. Domed architecture continued to be reserved for schemes of special significance.

### Post age of enlightenment

As art and science drew apart during the age of enlightenment, the increasing separation between science and religion became sometimes confrontational<sup>70</sup>. This is generally a post seventeenth-century phenomenon as cosmology and astronomy became separate scientific disciplines from theology and philosophy. Based on advanced physics and mathematics, astronomy and cosmology became much less influential on religious architecture and the usage of domes also became less exclusively associated with this type. The developments of the industrial revolution, led to an increasing amount of secular architecture and the eighteenth and nineteenth centuries saw the flourishing of state and large scale domestic architecture, but by this time, and in spite of developments in astronomy, the dome had become so ingrained as a symbol of power and authority that its usage remained reserved for key buildings, in increasing variation - such as the Radcliffe Camera, Oxford by James Gibbs (1737), the Bank of England by Sir John Soane (1798), or the 'oriental' Brighton Pavilion, by Nash (1815-21), influenced perhaps by the Taj Mahal, as royal domed mausoleum imitative of the heavenly paradise (1659). Numerous examples are to be found, yet (with the possible exception of Étienne Louis Boullée's design for a monument to Newton, 1784)<sup>71</sup> it becomes more difficult to demonstrate the cosmic associations. However, poetic allusions confirm a revival of the romantic associations of the dome in the nineteenth and twentieth centuries<sup>72</sup>. The dome still appeared to be ingrained on the human consciousness as a powerful cosmic shape, in spite of increase in astronomical knowledge.

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<sup>68</sup>See also Eugenio Battisti (1967) 'Il Simbolismo in Borromini' in *Studie sul Borromini*, Rome: Accademia Nazionale di San Luca, pp. 231-281, especially 275-281. It seems likely that the prevalence of elliptical domes in German Baroque architecture at a later date might similarly have been influenced by Kepler.

<sup>69</sup>For Wren as astronomer, see Kerry Downes (1971) *Christopher Wren*, London: Allen Lane, pp. 36-37 (and p. 163 for his knowledge of S. Sofia); Kerry Downes (1988) *Sir Christopher Wren: The design of St Paul's Cathedral*, London: Trefoil; Bryan Little (1975) *Sir Christopher Wren: A Historical Biography*, London: Robert Hall, p. 28f.

<sup>70</sup>Andrew Dickson White, (1960 ed.) *A History of the Warfare Between Science and Theology in Christendom*, New York: Dover.

<sup>71</sup>See Kemp, *Science of Art*, p. 229 for the intention of the Newton monument to engulf the spectator in the starred sphere, as if floating in space.

<sup>72</sup>For dome symbolism in the romantic poets see G. Wilson Knight (1997), *The Starlit Dome: Studies in the Poetry of Vision*, London: Oxford University Press (examples are to be found in Percy Bysshe Shelley's *The Cloud*, 1819 with its 'blue dome of air', and Samuel Taylor Coleridge's 'stately pleasure dome' of Kubla Khan in Xanadu). The image surprisingly continues to be found in twentieth century poetry, such as Robert Frost's 'the inner dome of heaven' (*Birches*, 1916) and G. K. Chesterton 'under the Sky's dome' (*The House of Christmas*).

Although far easier to construct architecturally on a small scale, the use of the dome in domestic architecture remains virtually unknown but the challenge of large scale construction for grandiose schemes increased, if anything, particularly with the possibilities afforded by new materials becoming available such as iron or steel frameworks. Steel frames and concrete shells made thick masonry walls redundant and increasingly wide spans can be built without any specific needs for vaults and domes. The significance of the dome remains however, and the same materials meant that huge spans can be more easily achieved. The 30 metre span of the cast iron dome of the United States Capitol, Washington D C (1793-1867) has clearly been used for a building of special significance, while, also in Washington, the Jefferson Memorial (1934-43) seems to have come full circle to the ancient idea of the cosmic memorial.

### Twentieth century

In twentieth century thinking (although followers of Freud may well have something to say about the shape of the dome and the female form) celestial allusions may still be inferred demonstrating how ingrained is the concept in the human consciousness, in spite of scientific and astronomical developments. As a method of embracing large spaces and large numbers of participants, the dome can hardly be bettered, and has consequently become used for large gatherings of a different type, such as sports stadia, where the possibilities are exploited on a massive scale, such as stadia by Nervi, the geodesic dome built in Montreal for Expo 67, the Olympic stadium in Rome 1960, or the Georgia dome in Atlanta. The ceiling of the main 1,200 seat auditorium Congress and exhibition hall Salamanca 1992 by Navarro is constructed as a stepped dome with a glazed central oculus that seems to float above the space, since its pendentives have no visible connections with the corners of the room, and the architect himself has confirmed the symbolism where 'the lightness of the roof accentuates rather than negates its primary historical role as the parallel of the sheltering sky vault and finally to an abstracted recollection of the dome of the cathedral in the city centre.'<sup>73</sup>

In astronomical terms, the 'dome' is still used as the most convenient structural method for the reproduction of the night sky and observatories and planetariums continue to be domical in spite of current knowledge of the shape (or otherwise) of the universe. There is no 'earthly' reason why a planetarium or observatory should be dome shaped in terms of current knowledge of the structure of the universe, yet still the shape persists in spite of all that is known about the boundlessness of space above us. The recent re-modelling of the London planetarium is a case in point and material supplied by the architects confirms the approach to the overall structure (Figure 33). Last but not least it comes as no surprise that a dome has been selected as the structure to commemorate the new millennium in London. The spectacular structure of the millennium dome (364m in diameter, Figure 34), to be completed in time for 31 December 1999, is not a dome in the true sense, since it is not freestanding and self-supporting, but supported by a system of cables. The original design for the structure by the Richard Rogers Partnership, built to house a celebration of the achievements of the past 2000 years, was planned as separate pavilions but this was abandoned in favour of a domed structure, a particularly dramatic sight when illuminated at night, almost like a space craft. The architect Michael Davies is a keen astronomer and it appears significant that at the turn of the millennium architects should once more turn to the dome with its immense richness and symbolism to mark the new era, at the meridian in Greenwich. Even without a direct analogy of the dome as imitation of dome of heaven over flat earth, it is remarkable that at such a significant occasion, we have turned to architecture to find a fitting tribute for the cosmological event of the new millennium, concerned with time, space and eternity.<sup>74</sup>

Consciousness of dome symbolism on the part of architects is not always easy to prove. Since the time of the Renaissance, different astronomical systems have come under consideration as the accepted view or perception of the universe has developed from the flat earth to geocentric, heliocentric, galacto-centric and finally a-centric in our own century. In matters of construction, materials and symbolism, the dome has provided an endless source of fascination, as tangible images and constructions were used to elucidate theoretical concepts as well as artistic interpretations of theological, philosophical or scientific theory. Without necessarily claiming that every dome is cosmic, and without overemphasising the aesthetic and

<sup>73</sup> James Steele (1997) *Architecture Today*, London: Phaidon Press, p. 59 and figs 27, 28.

<sup>74</sup> Kenneth Powell (1997) 'Constructing the Dome: Mike Davies profiled' in *Architects' Journal*, 27 November; and Barrie Evans (1997) 'The Dome Experience', *Architects' Journal*, 27 November, pp. 29-36. Much controversy surrounds the construction of the millennium dome, which features almost daily in the London press. However, the appropriateness of the chosen dome shape as an ideal architectural form has provoked surprisingly little comment.

symbolic functions of architecture at the expense of the structural and utilitarian, it may reasonably be argued that the body of evidence suggests the cosmological/astronomical as a major source of interdisciplinary inspiration for the forms thus created. As Paul Klee expressed it, 'art does not reproduce the visible, rather it makes visible.'

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January 22, 2010

Elizabeth Martin  
Administrative Secretary, Magdalen College, Oxford

Dear Ms Martin –

I am pleased and honored to supply a reference for Dr Valerie Shrimplin. I have known her both professionally and personally, and worked with her, for more than a decade.

Dr Shrimplin has done a fine job carrying on a demanding full-time position, and in parallel continuing her research in art history. As her CV shows, she has done remarkably well in both. She has worked in a cross-disciplinary area of art history that has been largely neglected, studying the influence of astronomical knowledge and phenomena on major areas of art and architecture. Astronomical phenomena are largely taken for granted, and it comes as a surprise when someone like Dr Shrimplin demonstrates how important and pervasive they are in human culture. Her presentations at the series of international conferences on the “Inspiration of Astronomical Phenomena”, and her subsequent publications, have been noteworthy. Indeed she was the prime organizer of the fourth in the conference series (Magdalen College, 2003) and is on the local committee for the seventh (Bath, 2010).

The theme of her proposed work (“The Beginning and the End: Images of the universe”) is a bold one, combining a basic expression of human culture with the seemingly unending growth of astronomical knowledge. Her talks and papers so far show she is on the right track. I fully support her need to spend some months focused solely on this project, and there is probably no better place for her than Magdalen College with its atmosphere of scholarship and inquiry. I feel both she and the College would profit greatly from this opportunity.

I am quite willing to supply any further comments as you may wish.

Sincerely yours,  
(Dr) Rolf M. Sinclair

N. B. Because I may well not be known to Magdalen College, I am appending a short CV to introduce myself.

Rolf M Sinclair  
A Brief CV

Rolf Sinclair obtained degrees in theoretical and experimental physics from the California Institute of Technology (1949) and Rice University (1951, 1954). He then took up research positions in nuclear physics at the Westinghouse Laboratories (1953-56), the University of Hamburg (1956-57), and the École Normale Supérieure (Paris) (1957-58). He then joined the US Controlled Thermonuclear Program at the Princeton University Plasma Physics Laboratory (1958-69). He spent a year (1965-66) on leave at the United Kingdom Atomic Energy Authority Laboratory at Culham, England. He then joined the US National Science Foundation (1969-98) with the responsibility for the direction of atomic, molecular, and plasma physics. While at NSF he returned to research part-time at Princeton (1972-73) and spent a year (1988-89) on leave at the Los Alamos National Laboratory. He was detailed to the US Antarctic Program as the NSF Representative at the Amundsen-Scott South Pole Station (1995 and 1996), and served as the NSF Representative at two solar eclipse expeditions (Canada, 1979, and India, 1980). He retired from NSF in 1998, and since 1999 has been a Senior Scientific Advisor to the Centro de Estudios Científicos, Valdivia, Chile.

Dr. Sinclair has carried out for several decades a study of the astronomical practices of the Pre-Columbian Pueblo cultures of the US Southwest, and in parallel the broader influences of astronomical phenomena on human culture worldwide. He helped found and continues to help organize a series of international conferences on the cultural influences of astronomical phenomena, eight of which have been held or planned so far in Europe, the US, and China.

He has published upward of 60 scientific papers in various sub-fields of physics, and a dozen or so in different aspects of archaeoastronomy and of the effects of astronomical phenomena on human culture and expression. He has edited several books in these fields.