Graphic History of Architecture

John Hansbridge
EGYPT

THE ARCHAIC PERIOD

Dynasty I II
ca. 3200 B.C. 2980

THE OLD KINGDOM

III IV V VI
2780 2680 2565 2420

First Intermediate Period

THE MIDDLE KINGDOM

IX XII
2258 2134 1991 1786

Second Intermediate Period

Union of Upper and Lower Egypt
Capital: Memphis

The Age of the Pyramids
Capital: Thebes

The Feudal Age
Invasion of the Hyksos from Asia

MAP OF EGYPT AND WESTERN ASIA

Miles

500
### INTRODUCTION

#### THE NEW KINGDOM

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<td>1314</td>
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The Egyptian Empire in Asia and Nubia
Capital: Thebes

#### THE LATE PERIOD

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<td>671-663</td>
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Assyrian invasion
Domination of Persia

#### THE PTOLEMAIC PERIOD

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Egypt a Roman province

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Egypt was a narrow strip of highly productive soil, 8 to 12 miles wide, along the banks of the Nile, about one-fifth of the area of England and Wales. From pre-dynastic times sun-dried mud bricks were used for houses, but these have not survived: timber was scarce and hence arches were built without centering. There was however an abundance of limestone, sandstone and granite. The planning of irrigation canals and fields, necessitated by the annual inundations of the Nile, demanded a system of geometry (Gk land measuring). Believing in a life after death, the Egyptians thought that the body should be preserved in a lasting tomb; this became a geometric construction of great solidity and permanence.

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**Measurement**  
**The Right Angle**  
**The 'Egyptian Triangle'**

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Method of orientating the pyramids

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Temples constructed with columns, beams and massive, battered external walls
EGYPT

Pit graves in desert cemeteries: sand heap A surrounded by circle of stones B over grave C

Pit graves transformed into tombs by brick lining and flat wooden or arched brick roofs

Walls of sun-dried brick

Beginning of stone masonry

THE STEP PYRAMID, Saqqara, Dynasty III: Section looking west
Built by Imhotep, architect to King Zoser.

1 Begun as a mastaba-tomb. 2-5 Then successively enlarged, in limestone. Set within a complex of buildings (p. 18)

THE PYRAMID OF MEDUM, Dynasties III-IV
Section looking west, reconstructed
1 Centre core. 2 Successive layers added, at about 75°, each of local stone and cased with limestone.
3 Enlargement of the pyramid. 4 Steps filled in with a facing of limestone. 5 The tomb chamber

Stones on sledges, pulled up long earth ramps

The Rocker; pulleys were unknown

Suggested methods of hauling and lifting stones
Built of local stone on a core of rock
Constructed of some 2,300,000 stone blocks,
each weighing approximately 2 1/2 tons. It is probable that for a period of twenty years 100,000 men were levied annually, during the three months' inundation of the Nile (July to October), for transporting stone.
Also about 4,000 permanent skilled masons and attendant labourers were employed
EGYPT

THE OLD KINGDOM
Dynasties III-VI, 2780-2258 B.C.
The Age of the Pyramids

The Step Pyramid, Saqqara, set within a complex of buildings of local stone faced with limestone

Built by Imhotep for King Zoser, (reconstructed) Dynasty III

The great Pyramid of Cheops, Giza, Dynasty IV

Funerary Temple of Mentuhotep I, Deir-el-Bahari (reconstructed), Dynasty XI

Pyramid of Sahura

Pyramid of Neferirkara

Pyramids of Abu Sir (reconstructed), Dynasty V

THE MIDDLE KINGDOM
Dynasties XI-XII, 2134-1786
COMPARATIVE BUILDINGS & PLANS

THE NEW KINGDOM
Dynasties XVIII-XX, 1570-1085 B.C.
The Age of the great Temples

Mortuary Temple of Amon, Deir-el-Bahari (reconstructed), Dynasty XVIII
Designed by Senmut and built for Queen Hatshepsut

The Great Temple of Amon, Karnak, Dynasties XVIII-XXXI (Foundations Dynasty XI)

The Temple of Amon, Luxor, Dynasties XVIII-XIX
Begun by Amenhotep III and added to by Rameses II

The Temple of Seti I, Abydos, Dynasty XIX

Great Temple, Abu Simbel, Nubia, Dynasty XIX. Built for Rameses II

THE PTOLEMAIC PERIOD
332-30 B.C.
Revival of Temples

The Temple of Horus, Edfu, 237-212 B.C.
Begun by Ptolemy III

The Temple of Hathor, Dendera, 1st cent. B.C.

St Paul’s, London

Plans and buildings in black drawn to the same scale
A garden shrine from a painting in a tomb, Thebes, Dynasty XIX

Temple of Amenhotep III, Island of Elephantine, Dynasty XVIII (Destroyed A.D. 1822)

1 Avenue of sphinxes
2 Pylons (Gk: a gateway)
3 Open courtyard with colonnade
4 Hypostyle hall (Gk: resting on pillars), beyond which only the king and priests might enter
5 The sanctuary
6 Hall and store rooms
GREAT TEMPLE OF AMON, KARNAK

Built of sandstone
Begun Dynasty XII
1-4 Dynasty XVIII 5 Dynasty XIX
6 Ptolemaic period
7 Temple of Rameses III, Dynasty XX
8 Temple of Khonsu, Dynasties XX-XXI

Section

Hypostyle hall, a-a
hall filled with sand and roof-slabs lowered into position

clerestory windows
EGYPT

Valley Temple built of granite: Pyramid of Cephren, Giza.
Dynasty IV

Rock-hewn tomb, Beni-Hasan,
Dynasty VII

Column & Beam

PROTO-DORIC COLUMNS

LOTUS COLUMNS

Palm Columns

Gorge cornice roll moulding bundle of reeds

Brick arch, el 'Asaseef, Thebes

Vault of damp mud bricks laid in slanted courses without centering
COLUMN  BEAM  &  ARCH

Mortuary Chapel of Ne-user-ra, Abusir
Dynasty V

Temple of Luxor
Dynasty XIX

open flowers in nave

Dynasty XIX

The Great Temple of Amon, Karnak; Hypostyle Hall,
closed buds in aisles

Dynasty XIX

PAPYRUS COLUMNS

Temple of Hathor, Denderah,
Ptolemaic

Temple of Isis, Philae
Ptolemaic

HATHOR-HEADED COLUMNS

Corbelled-stone pyramidal tomb, Abydos,

Temple-tomb Deir-el-Bahari
Corbelled-stone arches,

Temple of Seti I, Abydos
Dynasty XIX

Corbelled-stone pyramidal tomb, Abydos,

Dynasty XI
SUMERIAN CITY KINGDOMS

Civilization in Western Asia began with city kingdoms in the rich alluvial plain between the lower Tigris and the Euphrates, an area about that of Wales (Map p. 14). Tower-temples or ziggurats were the centre of city life. There was no stone and little timber but clay was moulded into sun-dried brick. Buildings were faced with kiln-baked bricks, sparingly owing to lack of fuel.

ASSYRIA

Assyria was set on a high tableland of lime-stone, harder rock & alabaster, but the Assyrians continued to use sun-dried and kiln-baked bricks. Palaces of warrior-kings were built on large platforms of brick 30-50 feet high. Lower courses of walls were faced with slabs of alabaster 9-12 feet high and carved with bas-reliefs or covered with plaster and painted with bright colour. The arch was constructed for gateways, vaults and drains.

SECOND BABYLONIAN EMPIRE

Nebuchadnezzar (604-561 B.C.) rebuilt Babylon to a regular plan described in The Histories by Herodotus (484-406 B.C.). Buildings were of kiln-baked brick and bitumen.

PERSIAN EMPIRE

Palaces were built at the capital city of Susa, at Pasargadae and Persepolis, being constructed of stone which was abundant in Persia; whilst raised platforms and glazed coloured bricks were adapted from the Assyrians; also influences from Babylon, Syria and Egypt.

SECOND PERSIAN—SASSANID—EMPIRE

The capital city at Ctesiphon. Buildings were erected of kiln-baked brick, vaults and the earliest domes being built over square compartments, developed by the Byzantines.
INTRODUCTION - ASSYRIA

Both the platform, about 50 ft high and 25 acres in extent, and the palace built of sun-dried brick and faced with kiln-baked brick built without centering.

Palace of Sargon II, Khorsabad (restored) 772-705 B.C.
THE CITY OF BABYLON
(reconstructed),
as rebuilt by Nebuchadnezzar,
604-561 B.C., during the Second Babylonian Empire.
Described in *The Histories* of Herodotus.
THE PALACES OF PERSEPOLIS
(reconstructed),

Built by Darius (521-485 B.C.) and Xerxes (485-465 B.C.)

Built on a platform 1500 ft by 1000 ft in area, and 40 ft above the plain, part solid rock, part large blocks of stone, without mortar, held by metal cramps. Buildings constructed of sun-dried brick and faced with glazed bricks. Columns of stone and flat roofs of cedar wood.

'Hall of the Hundred Columns'

Assyrian pavilion motifs adopted by the Persians.
Bricks were laid to form a base A; against an end wall B wedge-shaped bricks were fixed with mortar C. To ensure adherence these were often laid in sloping courses D. An arch was constructed with little or no centering to complete the vault E. To facilitate work and to reduce pressure, vaults (and domes) had a high oval profile F. When completed vaults were often re-inforced by a second or more courses of brick G. Sassanid Persian buildings, vaults and domes were constructed of kiln-baked bricks laid with a mortar of lime and sand.

The Persians built domes with little or no centering. A dome is an arched construction both vertically & horizontally: each ring of brick or stone once closed in cannot fall if it rests adequately on the ring below.

The Persians were the first to erect circular domes on square plans with four angular corbelled semi-domes.
Domes - Second Persian Empire

The Palace of Chosroes, Ctesiphon, 6th cent. A.D.

The Palace, Firouzabad (exterior restored), c. A.D. 450
GREEK

AEGEAN

Minoan—Crete

1500

Mycenaeans

1184

775/6
First
Olympiad

1184

650

Archaic period

Establishment of Greek city-states
along the Mediterranean and Black Sea

1000

835

Homer

582

Pythagoras

510

Dorians c.2000
Achaeans c.1550
Ionians c.1100

The Greek invasions

Greek colonisation 8th-6th centuries B.C.
The Aegean Period. 1 No records survive of the Minoan sea-kings of Crete except remains of palaces, e.g. Cnossus. 2 The Mycenaeans built massive citadels with Cyclopean masonry and domed tholos tombs on the mainland. The Aegean civilization fell before the Homeric Greeks.

The Hellenic Period. The Greeks called themselves Hellenes (Hellas was called Graecia by the Romans). They formed numerous small city states in which primitive houses surrounded a citadel and later a temple built on an acropolis or upper city. National unity was achieved by pan-Hellenic festivals held at Olympia, Delphi, Argos and Corinth every few years.

The Hellenistic Period began with the Empire created by Alexander the Great when many new cities were founded with monumental buildings.

The Greek temple developed from the Mycenaean megaron built of sun-dried brick, stone and timber to house a deity and to be looked at from outside, not to contain a congregation within. The arch was known to the Greeks, but they based their temples on the column & beam. These developed from the 6th-4th centuries B.C., each with its own ratios of proportions established by experience. Columns were often placed closer than necessary to support the entablature in order to create a repetitive rhythm of solids and voids. Optical refinements displaying an appearance of vitality and strength have been measured in a number of them. Many architects wrote treatises about their buildings, cited by Vitruvius (1st cent. B.C.) who classified their plans and proportions.
The Palace of King Minos (restored), c. 1800-1600 B.C.

1. The King and Queen's apartments
2. Great staircase
3. Hall of the Colonnade
4. Hall of the Double Axes
5. Queen's Megaron or Hall
6. Construction: A timber framework B sun-dried brick or rubble masonry C gypsum slabs or D plaster painted with frescoes E plinth and floor of gypsum or limestone F ceiling beams
7. Cypress columns

'TIRYNS of the Great Hall' (Homer)
(restored) c. 1400-1200 B.C.
on a limestone ridge above the plain of Argos, wide ascribed to the framework, sun-dried bricks and columns of wood

1. Main gateway
2. Greater propylaeum
3. Lesser propylaeum
4. The men's Megaron or Great Hall
5. The women's Hall

The great wall from 24 to 27 ft. Cycl. The palace built of timber bricks and columns of wood
MYCENAE (restored), c. 1350 B.C.
The citadel palace of Agamemnon,
Cyclopean walls of boulders weighing 5 to 6 tons were eased into alignment on pebbles.

Lion Gate, Mycenae, c. 1200 B.C.

MYCENAE, The Treasury of Atreus, 1330-1300 B.C. One of some 40 beehive or tholos tombs on the Greek mainland. Built of horizontal overlapping courses of lime-stone or corbelling without centering. The door-way flanked by 2 green sandstone half-columns with a relieving triangle above.
Stone beams of great span are liable to fracture, therefore columns were placed close together.

**Timber to Stone Antae or Pilasters**

**Timber** construction, c.620 B.C.
Doric temple of Apollo, Thermum. Wooden entablature and columns

**Marble** construction, c.477-438 B.C.
The Parthenon, Athens.
The Heraeum, Olympia, c.649 B.C.
Walls sun-dried brick. Stone replaced wood columns as they decayed. Gable roof with terracotta tiles

Temple of Apollo, Syracuse, c.575 B.C.
Monolithic stone columns

Sanctuary of Thermum, Aetolia
Megaron A, c.2000-1500 B.C.
Small stones carry walls of wood and clay, roof thatched with reeds

Megaron B, c.1000-800 B.C.
House or Temple. 18 posts formed the first known Greek peripteral temple scheme

The Temple of Apollo, c.600 B.C.
built over Megaron B.
Columns and entablature of wood

Temple F, Selinus, c.560 B.C.
Stone screens join the columns

Archaic Temple of Artemis, Ephesus, c.560 B.C. Burnt down and rebuilt, 356 B.C.
Designed by Chersiphron of Cnossus and his son Metagenes who wrote a work on the temple, now lost, cited by Vitruvius.
Appearance conjectural, columns of marble, walls of limestone faced with marble.
The Parthenon, Athens, c. 447–432 B.C.
Ictinus and Callicrates architects, Pheidias master sculptor; built of white marble

Temple of Aphaia, Aegina, c. 490 B.C.

Temple of Zeus Olympius, Agrigentum, c. 480 B.C.
Built of coarse stone faced with marble dust cement; position of figures conjectural

The Doric Temple of Athena Alea, Tegea, c. 353 B.C.
Designed by the sculptor Scopas, the interior had 14 Corinthian engaged columns

Doric temple of Apollo Epicuriius, Bassae, c. 430 B.C.
By Ictinus, architect of the Parthenon, Athens. The Corinthian order used for the first time
Built of fine-grained, brittle grey limestone; details in marble, roof of thin marble slabs.

Ionic temple of Athena Polias, Priene, c. 334 B.C.
By Pythios, architect and sculptor of the Mausoleum, Halicarnassus, who wrote a book on the temple, since lost.
All the measurements are in multiples of the Ionic foot, i.e. 11.587 inches.
GREEK & ROMAN

GREEK

The Theseion, Athens

Temple of Demeter, Paestum

Temple of Aphaia, Aegina

Roman

Theatre of Marcellus, Rome

Thermae of Diocletian, Rome

Capital, angle column

IONIC

Cyprus, c. 6th cent. B.C.

Neandria, c. 6th cent. B.C.

Greek Temple on the Ilissus, Athens

Greek

Delos, c. 6th cent. B.C.

Ionic and Corinthian;
24 flutes separated by fillets

A method of setting out a volute

20 flutes separated by sharp ‘arises’

18.8" = 11 modules

23.7" = 15 M 18 Parts

14.8.3" = 16 M 14 P

lower 1/2 diameter = 1 module
THE FIVE ORDERS

CORINTHIAN

Egypt, Dynasty XIX

TOWER OF THE WINDS, EPIDAurus, c. 334 B.C.

The Tholos, Epidaurus, c. 360 B.C.

COMPOSITE

27° 0' 17" M 2P

46° 0' 28" P

N = 2° + 8'

TUSCAN

16 M

ARCH OF SEVERUS, ROME

Roman

Temple Fortuna Virilis, Rome

Ilissus, Athens

Erechtheum, Athens

The Olympicum, Athens, c. 174 B.C.

Temple Fortuna Virilis, Capitals taken to Rome, 86 B.C.

GreeK

Choragic Monument, Athens

The Tholos, Epidaurus, c. 334 B.C.

Roman

The Pantheon, Rome

Roman

Arch of Severus, Rome

Roman

Vitruvius (IV, 7)

From

The Five Orders of Architecture
by Vignola
(A.D. 1509-73)
GREEK

Classification of column arrangement according to Vitruvius (111, 2)

distyle in antis
prostyle tetrastyle

peripteral hexastyle (surrounded by columns)

peripteral octastyle
dipteral octastyle (2 rows of columns)
dipteral decastyle
THE TEMPLE OF APHAIA,
AEGINA, c.490 B.C.

Built of soft, yellow local sandstone, coated with a thin layer of stucco and coloured. Sculpture and tiles on pediments of Parian marble, other tiles of terracotta.
Between the Greeks' defeat of the Persians in 479 B.C. and the Peloponnesian War (431-404 B.C.), Athens rose to her zenith; under the leadership of Pericles, buildings were erected on the Acropolis:
1. The Parthenon
2. The Propylaea
3. The Erechtheum (restored)

THE PROPYLAEA, entrance to the Acropolis, 437-432 B.C. Mnesicles, architect. Built of marble

THE PARTHENON, 447-432 B.C. Doric temple dedicated to Athena. Ictinus and Callicrates, architects; Phidias, master sculptor. Optical refinements p. 38
Possible architect Mnesicles. The caryatids and column capitals may have been designed by Callimachus, inventor of the Corinthian capital. Built on 4 levels, irregular in plan to preserve places sacred to Athens; built of white marble
GREEK CITY

AEGEAN

Section of the 9 superimposed 'cities' of TROY
II Prehistoric citadel, c.2600-2300 B.C.
VI Homeric Troy, 1900 B.C.; sacked c.1200 B.C.

Plan of selected buildings, Troy
II Prehistoric citadel  VI Homeric Troy

HELLENIC

Little is known of Greek city planning before Hippodamus laid out his native city
MILETUS
c.479 or 466 B.C.

and 'discovered the method of dividing up cities' (Aristotle Politics)
The Telesterion or Hall of the Mysteries, Eleusis

The Plan of selected buildings

Plans showing additions to a palace, Larissa (restored)

Megaron, c.500 B.C.

Peristyle, c.450 B.C.

A house or temple, c.8th cent. B.C. after a terracotta model from Argive Heraeum
PLANS, BUILDINGS AND HOUSES

HELLENISTIC

City state of PRIENE,
c. 350 B.C.;
about 5000 inhabitants

Agora or market place, Priene
(restored)

Dynamic planning
Upper citadel,
PERGAMUM,
c. 241-159 B.C.

The Bouleuterion
or Council Hall,
Miletus (restored),
c. 175-164 B.C.

House, Priene, c. 350 B.C.
Built of stone and sun-dried bricks (restored)

House,
Built of stone
(restored) 
Introduction of the Peristyle

Delos,
c. 250 B.C.
Entasis (Gr: distension) designed to counteract the illusion of the outline of a column curving inwards.

Exaggerated diagram of the rising curvature of the stylobate and inward inclination of the columns.

Angle columns look thinner seen dark against light and are thickened by 1\(\frac{1}{2}\) in.

OPTICAL CORRECTIONS, THE PARTHENON, ATHENS

Proportions of height, thickness & distance apart of columns according to Vitruvius (III, 3).
The Tholos, Epidaurus, c. 360 B.C.
by the sculptor-architect Polycleitus the Younger;
built of sandstone and marble

The Choragic Monument of Lysicrates,
Athens, c. 334 B.C.
Podium of limestone,
upper part white marble,
Corinthian order used externally for the first time

The Tower of the Winds, Athens,
c. 50 B.C. Clock-tower built of marble
Early Rome, with its Republican magistrates, town-council (senatus) and town-meetings (comitia), by a series of systematic conquests created an Empire round the Mediterranean consisting of different nationalities accepted as allies. The Roman Empire became a fusion of the practical Western idea of one universal society in which all men might live in conformity with Roman law and the Oriental conception of an Emperor-God with a throne-altar demanding a common worship and loyalty. This union between the West and the East was a continual source of weakness and led to the ultimate division of the Empire. The Romans built roads and bridges for swift communication, military camps with a simple set plan (later incorporated in many city-plans) for speed of construction, and government and civic buildings, which were both useful and symbolic of Roman law and order.
During the Republic kiln-baked bricks and stone blocks with or without mortar were used in building. The invention of concrete revolutionised construction in the Empire. Concrete was used with a facing for protection and a surface finish, & there is a sharp distinction between the art of the engineer constructing arches, vaults and domes and the applied art of decoration with columns and pilasters, marbles and mosaics.

The Romans invented all possible variations in the plans of buildings which were copied by later architects. *The Ten Books on Architecture* by Marcus Vitruvius Pollio, a Roman architect and engineer who lived in the 1st century B.C. was widely read in the Renaissance and later.
THE FORUMS.
ROME (restored)

V Nerva, c.A.D. 97. VI Trajan, A.D. 100-117.

TEMPLES: 1 Saturn, 44 B.C. 2 Concord, 7 B.C. 3 Venus Genetrix, 49 B.C.
7 Castor and Pollux, A.D. 6. 8 Peace, A.D. 67-79. 9 Vespasian, A.D. 94. 10 Trajan, A.D. 100-117.

BASILICAS: 14 Aemilia, c.179 B.C. 15 Julia, 46 B.C. 16 Trajan, A.D. 100-117.
17 Constantine, A.D. 310-313.

The Thermae of Caracalla, Rome, c. A.D. 212-217

Stands on a platform 20 ft high containing store-rooms, furnaces, hypocausts and hot-air ducts; room for more than 1600 bathers

1. Main entrance
2. Apodyteria—undressing rooms
3. Tepidarium—tepid bath
4. Calidarium—hot-air bath
5. Warm baths
6. Hot baths
7. Frigidarium—open-air cold bath
8. Palaestra, peristyles
9. Lecture halls and libraries

The Pantheon, Rome, A.D. 120-124

Palaces of the Emperors on the Palatine Hill, Rome, A.D. 3-212

1. Palace of Augustus, 21 B.C.-A.D. 14
2. Palace of Domitian, A.D. 81-96
   a. Triclinium or Banqueting Hall.
   b. Peristyle.
   c. Temple of household gods.
   d. Basilica or Hall of Justice.
   e. Tablinum or Throne Room
The Romans developed the arch as a constructive principle and added the Greek column and entablature as decoration.

Wooden centering supported on piles P or on the impost I.

Ribs of baked brick set on wooden centering to receive concrete.

Methods of constructing stone and concrete vaults.
Arches supported on piers: Aqueduct, Pont du Gard, Nîmes, c.A.D. 150

Construction of arches on piers with non-constructional facing of columns and entablature

Arch and dome of the Pantheon, Rome, A.D. 120-24
ROMAN

BRICKS
kiln-baked of varying sizes
used from c.300 B.C.

Opus incertum
from c.200 B.C.

Opus reticulatum
Concrete walls faced

CONCRETE
used by the Romans from the 2nd century B.C., consisting of sand, gravel, pebbles, chippings of stone, mixed with a cement of lime and water and spread over a temporary wooden or permanent brick centering, to solidify into the required shape—arch, vault or dome. The dead weight rested upon supporting walls or piers without exerting an outward thrust. Pozzolana, a volcanic rock found near Rome, made a concrete of great hardness and durability. Concrete surfaces were faced with stucco, brick or marble for protection and finish.

MASONRY

The Romans copied the Greek technique, building courses of dressed blocks, held by through stones laid dry without mortar or with iron cramps and dowels set in molten lead. The space between the courses was left empty or filled with undressed stones, earth or concrete.
MATERIALS & METHODS

Opus testaceum with brick from c. 78 B.C.

Cross-vault built of brick ribs and filled in with concrete Villa Sette Bassi, near Rome, c. A.D. 123-134

Concrete dome with a framework of brick ribs Temple of Minerva Medica, Rome, c. A.D. 260

Method of fixing marble facing A marble slab B plinth C cement D iron clamps

Concrete dome with a framework of Temple of Minerva Medica, Rome, c. A.D. 260

The Basilica, Shakka, c. A.D. 175-200 Syria: buildings of dressed stone continued in the period of Early Christian architecture in the 5th to 7th centuries.

The Pretorium, Musmiyeh, c. A.D. 180

65
The Pantheon, Rome, A.D. 120-24. Erected by Hadrian

Concealed brick arches link together 8 massive brick piers supporting the dome.

The Temple of Vesta, Tivoli (restored), 27 B.C.-A.D. 14
The Colosseum, Rome, A.D. 70-82

The Temple of Venus, Baalbek (restored), c.A.D. 245
Temple of Bacchus, c.a.D. 120-200

Temple of Jupiter, from c.a.D. 10

Court, c.a.D. 200

34°

TEMPLES, BAALBEK, SYRIA (restored), c.1st-2nd centuries A.D.; built of hard local sandstone

Temple of Bacchus: interior
The early Greek theatre consisted of an auditorium (simply a hill slope with stone seats), a semi-circular orchestra where the chorus sang and danced, and a wooden stage from which a single actor would hold a dialogue with the chorus. The number of actors was raised to two or three by Aeschylus (525-456 B.C.) and Sophocles (495-406 B.C.), who also introduced painted scenery and a dressing hut or skene. In the 4th century B.C. a wooden skene A was erected with a proscenium B having a row of columns, usually Doric, 8-12 ft from the skene wall supporting a stage of planks called the logeion or speaking-place C. Three doors in the skene wall were for entrances and exits of actors. At the two ends of the proscenium were the parodoi or open passage-ways D.
The Theatre, Orange (restored), c.A.D. 50. Designed to seat 7000. Stage 5 ft high, 23 ft deep. Built up on stone and concrete piers.

A Semi-circular cavea or auditorium
B Proscenium replaced by a frons scaenae
C Covered passages—vomitoria

Introduction of a stage curtain

Plan of a Roman theatre based on 4 equilateral triangles in a circle (Vitruvius v, 6)

A Renaissance adaptation of a Roman theatre. The Teatro Olympico, Vicenza, Italy, designed by Palladio and completed by Scamozzi, A.D. 1584.
Triumphal Arches with one opening

Arch of Augustus, Susa, Piedmont, c. A.D. 8

Arch of Titus, Rome, A.D. 70

Earliest use of the Composite order.

Town gateway with four archways

The Porte S. André, Augustomonum (Autun).

An arcade gallery with Ionic pilasters creates an antiphonal response with the rise and fall of the large and small arches below

Tomb of the Julii, Provence, S. Remy, c. 30 B.C.-A.D. 14

Trajan's Column, Rome, A.D. 114.
The Library, Ephesus (restored), C.A.D. 115. Lower storey Composite and upper storey Corinthian order, both having smooth shafts.

EARLY CHRISTIAN

S. Stephano Rotondo
Rome (restored),
A.D. 470

S. Apollinare in Classe, Ravenna,
A.D. 534-539

Basilian church
of S. Peter, Rome
(restored),
A.D. 330.
Pulled down in
the 15th century

Syria,
5th-6th centuries:
churches built of large
stone blocks and
timber roofs

Church, Roueiha (restored),
c. 6th century A.D.

Visigothic before the Moslem invasion, with horse-shoe arch:
S. Juan de Baños, Cerrato, Spain, c.a.D. 500-713

S. Costanza,
Rome,
A.D. 330

Baptistery of
Constantine,
Rome,
A.D. 430-440
COMPARATIVE PLANS

plans and sections in black to the same scale

S. Prassede, Rome, 822
S. Clemente, Rome, rebuilt 1084-1108 over a 4th-century church

Carolingian: S. Riquier, nr Abbeville, France (restored as in 800)

Early Christian-Romanesque: S. Miniato, Florence, A.D. 1013

Oratory, Germigny-des-Prés, France, A.D. 806

S. Maria de Naranco Asturia, Spain, A.D. 824-840
S. Miguel de Escalada, León, A.D. 913

Mozarabic, 'Arabized Spanish':
S. Vicente de Cardona, Catalonia, c. 1024-1040

Spanish-Romanesque:
TIMBER ROOFS

Rafters tend to push walls outwards

A beam supports rafters at AA and a post at B

Scientific tie-beam construction: king-post or suspensory tie B holds up the tie-beam AA

Tie-beams lengthened by scarf-joints and iron bolts

Basilica of Ulpia, Rome, c. A.D. 98-112: a part of Trajan’s Forum built by the Hellenistic architect, Apollodorus of Damascus
CHRISTIAN CHURCHES

Basilican church of S. Paolo fuori le Mura, Rome, a.d. 320; burnt down in 1832 and rebuilt to the original design.

Columns supporting a flat entablature:
S. Maria Maggiore, Rome, a.d. 432

Columns supporting semi-circular arches:
S. Apollinare in Classe, Ravenna, a.d. 534-539

Aisles in two storeys:
S. Agnese fuori le Mura, Rome, a.d. 625-638
The Minerva Medica, Rome, c.A.D. 260

The Pantheon, Rome, A.D. 120-124

S. George, Salonika, c.A.D. 400

S. Vitale, Ravenna, A.D. 526-547

SS. Sergius and Bacchus, Constantinople, A.D. 527-553

S. Sophia, Constantinople, A.D. 532-537

PERSIA:
detail of Palace, Feruz-abad, A.D. 450

SYRIA:
S. George, Ezra, c.A.D. 510
COMPARATIVE PLANS

plans and sections in black to the same scale

Carolingian cathedral,
Aix-la-Chapelle,
A.D. 796-804

Holy Apostles,
Salonika,
A.D. 1200

S. Mark, Venice, A.D. 1042-1085

S. Basil,
Moscow,
A.D. 1554-1560

S. Irene, Constantinople,
A.D. 740

Church, Daphni, nr Athens,
c. 11th century A.D.

S. Saviour
Pantepoptes,
Constantinople,
early 12th century

S. Sophia, Salonika,
c. 6th century A.D.

S. Front, Perigueux, France, A.D. 1120
BYZANTINE

Pendentives

Dome and pendentives parts of one hemisphere

The dome a hemisphere set above pendentives

To build an arch centering is necessary,

but a dome can be built in successive rings of horizontal arches without centering

S. Sophia, Salonika, c. A.D. 495

Domes on pendentives built with bricks not radiating from centre

Little Cathedral, Athens, A.D. 1250

Dome with drum: cross-in-square plan
S. Sophia ( Hagia Sophia = divine wisdom), Constantinople, A.D. 532-537 (plan p. 74)

Built for Justinian by two Greek architects, Anthemius of Tralles and Isodorus of Miletus. Built of brick; the dome probably erected without centering, with bricks about 24-27 inches square and 2 inches thick laid in deep mortar and covered with \( \frac{1}{4} \) inch lead; the dome supported on 4 piers, the thrust being taken by 2 semi-domes and 4 massive buttresses; the interior lined throughout in coloured marbles and mosaics.
ROMANESQUE
plans and elevations to the same scale

ITALY
S. Miniato, Florence, 1062

FRANCE
Pisa Cathedral, 1063-1272
S. Riquier, nr Abbeville (restored), c. 799
S. Philibert, Tournus, c. 950-1120 & later

GERMANY
Abbey-aux-Hommes (S. Etienne), Caen, 1066-1077
S. Cyriakus, Gernrode, 961 and later
Speyer Cathedral, 1031-61 & 12th century

SPAIN
Ripoll Abbey, Catalonia, 1020-1032
Santiago de Compostela, c. 1075-1121: pilgrimage church similar in plan to Tours, Limoges, Conques and Toulouse
S. Ambrogio, Milan, c. 1140

Campanile.
Pisa, 1174;
belfry 1350

Baptistery,
Pisa, 1153-1278, Gothic additions 14th century

Cluny Abbey III
(restored), 1088-1131
(elevation reversed to show the apse)

GERMANY

Angoulême Cathedral, 1105-1128 and later

Worms Cathedral, 1105-1128 and later

Maria Laach Abbey, 1093-1156

ENGLAND (Norman)
tower c. 1465

Durham Cathedral, 1093-1133

Peterborough Cathedral, 1177-1190

Façade 1233

1170-1175

1170-1175

1240-1290

GERMANY
ROMANESQUE

S. Savin-sur-Gartempe, c. 1060-1115

S. Sernin, Toulouse, 1080-1096

S. Madelaine, Vézelay, c. 1104-1132

centering of mounded earth

timber centering

groin stones

1,2 joint moulds

1a, 2b plans
Durham Cathedral: nave 1093-1133

- Groins
- Square bays
- Ribbed vault with level crowns, transverse ribs stilted as at A
- Domical vault, semi-circular diagonal and transverse ribs
- Gothic ribbed vault with pointed arches which can be made any height for any span

Insert blocks to remove centering.

Oblong bay: the lines of the groins 'wave' on plan, and need specially shaped groin stones.
GOTHIC

**English Architectural Periods**

- **Norman**: late 11th & 12th centuries
- **Early English**: 13th century
- **Decorated**: 14th century
- **Perpendicular**: 15th century

**French Architectural Periods**

- **Gothique à Lancettes**: 12th century
- **Rayonnant**: 13th century
- **Flamboyant**: 14th, 15th & early 16th centuries

**Single-nave Churches**

- Albi
- Avignon
- Arles

**Other Locations**

- Edinburgh
- Carlisle
- Arbroth
- Ripon
- York
- Conway
- Chester
- Harlech
- Lincoln
- Gloucester
- Oxford
- Winchester
- Exeter

**Brick Gothic**

- Lübeck
- Chorin

**'Hall' Churches**

- Bremen
- Münster

**Château-Chinon**

- London
- Bruges
- Antwerp
- Cologne
- Marburg
- Limburg
- Annaberg
- Prague
- Würzburg
- Nuremberg
- Augsburg
- Munich
- Salzburg
- Rome
- Venice
- Genoa
- Bologna
- Pisa
- Florence
- Siena
- Perugia
- Assisi
- Naples
- Palermo
- Messina

**The retreat of the Moors**

- Santiago
- León
- Burgos
- Barcelona
- Avila
- Segovia
- Toledo
- Valencia

- Palermo
- Monreale

- C. 1212
- C. 1230
- C. 1475

- 100 miles
# INTRODUCTION

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The enlargement of S. Denis, 1144 (p. 89) inaugurated a lyrical form of construction in which pointed arches, high stone vaults and flying buttresses were fused into an organic whole, and which reached a crescendo in the cathedrals built in the Ile de France (pp. 100-101). Gothic, or the ‘style Ogivale’ (Fr.: pointed) was known as ‘Opus Modernum’ or ‘Opus Francigenum’ (French work); the term ‘Gothic’, i.e. barbarian, was first used by the Humanists of the Renaissance. Few plans survive by the lay master-masons, who designed their buildings with ‘a good wit of geometry’ and who directed the quarry-men, stone-cutters, smiths, carpenters & workmen. In England (pp. 102-105), France (pp. 106-107), Italy (pp. 108-109) and Germany (pp. 110-111) castles, parish churches, guild-halls and houses followed the same pattern of pointed arches, pinnacles, spires & high-pitched roofs. South of the Alps in Italy Gothic was neutralised by the Roman tradition and ceased with the advent of the Renaissance in the 15th century.
GOTHIC

plans and elevations to the same scale

Amiens Cathedral, 1220-1288

FRANCE

Notre Dame, Paris, 1163-1235

Marienkirche, Lübeck, 1251-1310

GERMANY

Salisbury Cathedral, 1220-1258

York Cathedral, 1261-1324

ENGLAND
THE PARTS OF A CATHEDRAL

Laon Cathedral, c. 1235

Notre Dame, Paris, c. 1200-1250

Rheims Cathedral, c. 1255-1290

Wells Cathedral, c. 1220-1242

Peterborough Cathedral, c. 1235

THE WEST FRONT
ENGLAND, STONE VAULTING

Introduction of liernes or small ribs with shorter web courses
Winchester Cathedral nave, 1371-1460
Norwich Cathedral nave, 1463-1472

Fan vaults: all ribs of equal span and the web carved from the same stone
King's College Chapel, Cambridge, 1446-1515
Henry VII's Chapel, Westminster Abbey, 1502-1512

Courses parallel and not parallel with the ridge
Plan and projection of ribs
Method of laying the web
GOTHIC

S. Elizabeth, Marburg, c.1233-1283: one of the many 'Hall' churches in North Germany, having the nave and aisles of equal height.

Chorin Abbey, c.1273-1334: west front

Freiburg Cathedral, c.1268-1288: west front
The Turks take Constantinople
& block trade with the Orient: this leads to maritime discoveries

Spain united 1497 1519—Charles V 1556—Philip II of Spain 1598
Italy Florence: the Renaissance Rome: temporal power of the Popes Venice: trade lost
France Franco-Spanish rivalry in Italy 1515—Francis I—1547 Italian influence
Holland 1485—Henry VII 1509—Henry VIII 1547 1558—Elizabeth I 1603
England 1483—Martin Luther 1546 Protocols (hence Protestants) against the Roman Church leads to the Reformation

1499—S. Ignatius Loyola—1556 founded the Society of Jesus

1568 Revolt of the Netherlands
1545-63 Internal Reformation of the Roman Church at the Council of Trent
1545-63, aided by Protestant Catholic Greek Moslem

The Medieval universe, haunted by the law and order of the Roman Empire

The Renaissance (Florence) High Renaissance (Rome) Mannerism

Renaissance churches were centralized and designed on the drawing-board.
They were inspired by classical architecture, as interpreted by Vitruvius (above all, by Roman temples, arches, domes & the Five Orders (pp.116-117)), & obeyed the canon

of the Divine Proportions (pp.118-119).
The increasingly dramatic movements of High Renaissance and Mannerist buildings became, especially in the 'theatrical' churches of the Counter-Reformation, an interplay of forces. (This required the drawing of
INTRODUCTION

Conflicts for colonies and overseas trade

The architecture of each European country was a reaction to that of Italy, modified by its own native characteristics. France (pp.130-133), Germany & Austria (pp.134-135), Spain (pp.136-137), England (pp.138-159).

This Baroque style was finally resolved into the lighter curves of the Rococo.

The New Astronomy...the Motions of Mars

Prague, 1609

three-dimensional elevations and curved details by means of projective geometry, which had been developed by the new science of dynamics.)

This Baroque style was finally resolved into the lighter curves of the Rococo.

THE BAROQUE

Baroque

1700

1750

Rococo
Florence Cathedral: Brunelleschi (1377-1446)
(pp. 109, 124)

S. Andrea, Mantua, 1472-1512
Alberti (1404-72)
(pp. 120, 122)

Pope Julius II (1503-13) had the old basilican church pulled down (p. 70), and successive plans were made for the new church:
1 Bramante (1444-1514)
1506
2 Raphael (1483-1520)
1515-20
3 Sangallo the Younger (1485-1546)
1539
4 Michelangelo (1474-1564)
1546-64 also designed the dome, completed 1585-90 by Giacomo della Porta (1541-1604) and Domenico Fontana (1543-1607);
5 side cupolas added 1564, by Vignola (1507-73)
6 Carlo Maderna (1556-1629) lengthened nave to form a Latin cross & added the façade 1606-12

St Peter’s, Rome, 1506-1612 (pp. 93, 124)
The Gesù, Rome, 1568-75
Vignola (1507-73)
(pp. 120, 122)

S. Maria della Salute, Venice, 1632
Longhena (1604-75)

The Escorial, near Madrid, 1559-84

Juan de Herrera (c. 1530-97)
(p. 138)

The Dome of the Invalides, Paris, 1693-1706
J. H. Mansart (1646-1708)
(pp. 125, 131)

St Paul's Cathedral, London, 1675-1710
Sir Christopher Wren (1631-1723)
(pp. 144-145)

Vierzehnheiligen, S. Germany, 1744-72
Neumann (1687-1753)
(p. 137)

Karlskirch, Vienna, 1716-29
J. B. Fischer von Erlach (1656-1725)
Sources of Italian architectural theory:

1. The study of Roman buildings.
2. The Platonic-Aristotelian description of God and the Universe as a perfect circle.
3. The Pythagorean, and Medieval, idea of Man as the microcosm of the Universe (the macrocosm).
4. The linking of Geometry and Music, two of the Seven Liberal Arts:
   'Geometry makes visible the musical consonances' (Boethius, De Musica, c.500).

In Florence Cosimo de Medici (1389-1462) founded the Platonic Academy.

Plato gives an account of the creation and geometrical form of the universe. He represents the four basic elements and the cosmos as:

these ‘Platonic’ bodies are the 5 regular solids. The elements of the cosmos, as well as its soul-substance & its motion, were created proportionate to musical ratios based on Pythagoras (582-507 B.C.) He regarded numbers as the elements of all things and the whole heaven as a numerical scale' (Aristotle), & found that tones could be measured by striking cords proportionate in length.

Plato gives the ‘Harmonic’ scale as:

which contain the musical consonances 1:2, 2:3, 3:4.

For Renaissance architect-theorists, churches based upon these axioms, would be microcosms of the universe of God:

'...the little temples we make ought to resemble this very great one' (Palladio).
In Baroque churches musical ratios were resolved into an orchestration of visual forces comparable to the fugue, & measured by the eye and the mind of the beholder.

Michelangelo stated that a figure should be made 'pyramidal, serpent-like and multiplied by one, two and three', and wrote in a letter: '...the architectural members derive from human members'.

1475 — Michelangelo — 1564
1508 — Andrea Palladio (pp. 128-9) — 1580
1598 — Giovanni Lorenzo Bernini — 1680
1599 — Francesco Borromini — 1667
1624 — Guarino Guarini — 1683

mathematician & architect, mostly at Turin
**RENAISSANCE - BAROQUE**

Baptistery, S. Miniato, S. Maria Novella, Florence, *c. 1456*

*Alberti (1404-72)*

The Gesù, Rome, 1568-75

*Vignola (1507-73)*

(p. 122)

Arrangement & permutations of columns & pilasters to compose a visual 'overture'

Roman arches

and temples

S. Andrea, Mantua, *1470*  
S. Francesco della Vigna, Venice,  
Il Redentore, Venice, *1576-92*

*Alberti (p. 122) 1562  Andrea Palladio (1508-1580)*
ITALY, CHURCH FACADES

SS. Martina e Luca, Rome, 1635-50
Pietro da Cortona (1596-1669)

S. Agnese in Piazza Navona, Rome, 1653-55
Francesco Borromini (1599-1667)

S. Maria della Pace, Rome, 1656-57
Pietro da Cortona (1596-1669)

S. Susanna, Rome, 1597-1603
Carlo Maderna (1556-1629)

S. Carlo, Rome, 1665-7
Borromini (p. 123)

S. Gregorio, Messina, 1660
Guarini (1624-1683)
ITALY, CHURCHES

S. Carlo alle Quattro Fontane,
Rome, 1638-41
(Façade 1662-67, p.121)
Borromini (1599-1667)

S. Lorenzo, Turin, 1668-87 Guarini (1624-83)
RENAISSANCE - BAROQUE

The Pantheon, Rome, A.D. 120-124

Florence Cathedral: Rome, 1420-34
Brunelleschi (1377-1446)
(pp. 91, 109, 116)

St Peter's, Rome, 1506-1625
(pp. 91, 116)

Circular temples, Vitruvius (iv, 9)

Tempietto, S. Pietro in Montorio, Rome, 1502-10
Bramante (1444-1514)

Dome 1564-90
Michelangelo (1475-1564)

c. chains
ITALY, DOMES

S. Ivo della Sapienza, Rome, 1642-50, 
Borromini (1599-1667)

St Paul's Cathedral, London, 
1675-1710

Wren (1631-1723)

(pp. 146-7)

The Dome of the Invalides, Paris, 
1693-1706 Jules 
Hardouin-Mansart 
(1646-1708)

(p.131)

Sanctuary, Vallinotto, near Turin, 1738-9
Bernard Vittone (1704/5-70)
Palazzo Medici-Riccardi, Florence, 1430
Michelozzo (1397-1473)

Palazzo del Te, Mantua, 1526-35
Guido Romano (1492-1549)
rusticated masonry after Serlio

Palazzo Rucellai, Cancelleria, Rome, 1451
House of Raphael, 1495-1505
Rome c. 1512
Alberti (1404-72)
Bramante (1444-1514)

Palazzo Thiene, Vicenza, 1556-58
Andrea Palladio (1508-1580)

The Capitol, Rome, 1546-1644
Michelangelo (1475-1564)
The 'Colossal' Order
ITALY, PALACES

Collegio Propaganda Fide, Rome 1646-66
Borromini (1599-1667)

Palazzo Carignano, Turin, c.1678-80
Guarini (1624-1683)

Cycloidal curves
Pascal (1623-1662)

Palazzo Farnese, Caprarola, 1559-1564
Giacomo Barozzi da Vignola (1507-1573)
The Italian campaigns of the French Kings, Charles VIII (1483-98), Louis XII (1498-1515) and Francis I (1515-47), failed in their aims; instead France was invaded by the ideas and the arts of the Italian Renaissance.
Church of the Invalides, Paris, 1680-91
Jules Hardouin Mansart (1646-1708)

Panthéon (St Généviève), Paris, 1764-90
Jacques-Germain Soufflot (1713-80)
RENAISSANCE - BAROQUE

A. Central pavilion, 1570-1592
  Philibert de l'Orme (c. 1515-1570)

B. 1600-09
  Jacques du Cerceau
  (c. 1550-1614)
  (Remodelled 1860-65)

C. Course du Vieux Louvre, begun 1546
  Pierre Lescot (c. 1510-78)

Château de Maisons, 1642-46
  François Mansart (1598-1666)

Palais des Tuileries,
  1564-1680
  (Destroyed 1871)

Palais du Louvre,
  Paris, 1546-1878

Château de Chambord,
  1519-1547

Leonardo da Vinci

Paris, 1546-1878
FRANCE, CHÂTEAU TO PALACE

Palais de Versailles
A. Small château, 1624-26
De Brosse (1562-1626)
B. Enlarged 1669-83
for Louis XIV (1643-1715)
Louis Le Vau (1612-70)
decoration, Le Brun
(1619-90); gardens
Le Nôtre (1613-1700)

C. Galerie des Glaces, & Façade
1679-82 J. H. Mansart
(1646-1708)

D. East front, 1667-70
Claude Perrault (1613-88),
Louis Le Vau (1612-88) &
Charles Le Brun (1619-90)

First project and
final project made by Bernini (1598-1680)
in Paris, 1665 for the East Front of the Louvre
RENAISSANCE-BAROQUE

The Gesù, Rome, 1668-83: fresco and stucco figures on nave vault, 1674-79, ‘Adoration of the Name of Jesus’
Giovanni Battista Gaulli (1639-1709)

S. Andrea in Valle, Rome, 1591-1623: fresco in dome, ‘The Virgin in Glory’
Giovanni Lanfranco (1582-1647)

Italian Baroque churches
Vaults, domes and apses were frequently ‘opened out’ to heaven by means of sotto in su (Italian: ‘from below upwards’), illusionist paintings, and often reinforced by three-dimensional figures

Die Wies, Southern Germany, 1745-54
Dominikus Zimmerman (1685-1766)

In Southern Germany and Austria, many Jesuit Baroque churches were built in the style of the Gesù (p. 122). The Thirty Years’ War (1618-48) was followed by a resurgence of church-building in which all the arts—architecture, sculpture, painting and music—were fused into Rococo.
Vierzehnheiligen, Southern Germany, 1744-72

Balthasar Neumann (1687-1753), architect, mathematican, military engineer, town-planner, designer of fountains, bell-caster; possessed Guarini's *dell' Architettura Civile*, 1737 (p.123)

jets of water describe parabolic curves

parabolic, forward tilted, three-dimensional arches
RENAISSANCE - BAROQUE

I. ‘Plateresque’ (platero = silversmith), from the use of extravagant decoration 1492-1556

Cathedral, Granada, 'designed in the Roman manner' as a memorial to the conquest of the Spanish Moors in 1492 (c.1495-1563)

Portals of Pardon, 1536 Silóé

begun 1528

II. Herreran style or 'Estilo desornamentado' (plain style), 1556-1650: adaptation of the design of the Italian High Renaissance by Juan de Herrera (c.1530-97)

The Escorial 1574-82 (p. 115), Doric Church, first designed by Juan Bautista de Toledo (d.1567), philosopher and mathematician, who worked under Michelangelo; redesigned by Juan de Herrera (c.1530-97) built in yellow-grey granite, in 2:3 ratios
III ‘Churrigueresque’, named after José de Churriguera (1665-1723)

Cathedral, Santiago de Compostella: west façade, known as ‘El Obradoiro’, c.1738

Fernando de Casas y Novoa (fl. 1711-94)

Charterhouse sacristy, Granada, 1713-47.

Designed by Francisco Hurtado (1669-1725), begun 1730 by Luis de Arévalo (1727-64), stonemason; plasterwork by Luis Cabello
Pre-Fire Design for a domed crossing, 'in a Latine style'
Old St Paul's, destroyed in the Great Fire, 1666
The Pantheon Design, c. 1668-69
Centralized designs 'after a Roman manner', remote from 'the Gothick rudeness of ye old Design'.
The chapter 'thought the model not enough of a cathedral fashion', and a longitudinal plan, based on the Latin Cross, was adopted.
Greek Cross Design, c. 1672
The Great Model, 1673
The Warrant Design, before 1675

Projects for St Paul's Cathedral, London, by Sir Christopher Wren
St Paul's Cathedral, London, c.1675-1711
Sir Christopher Wren (1632-1723)
Vaulting of brick, walls of ashlar stone with rubble filling, façades of Portland stone

outer dome of timber covered with sheet lead, on a brick cone 18" thick, also with an inner brick dome 18" thick

St Peter's, Rome: dome Bramante (1444-1514) (from Serlio)

The mathematician Robert Hooke wrote that Wren used the 'catenary line'

Vaulting of brick, walls of ashlar stone with rubble filling, façades of Portland stone

Study for dome

Section of nave
Sir Christopher Wren (1632-1723).
Early scientific pursuits: optics, hyperbolic lenses & a treatise on cycloids.
Newton in the *Principia* described Wren as 'one of the greatest geometers of our times'.
Professor of Astronomy, London 1657 and Oxford 1661.
First architectural works 1662.
Studied buildings in and around Paris 1665; met F. Mansart, Le Vau, Bernini and probably Guarini.

St Bride, Fleet Street, 1670-84; spire, 1701-3
St Mary-le-Bow, Cheapside, 1670-83
The fire of London lasted from 2-5 September 1666. On 11 September Wren submitted a plan for rebuilding the City of London.

Though this plan was later abandoned, of the 87 churches destroyed 52 were redesigned by Wren as preaching halls for Protestant services.
Sir John Soane (1753-1837) Visited Italy 1778-1780

Kedleston Hall, Derbyshire, 1767-70
designed by James Paine (1725-89);
south front & interior by
Robert Adam (1728-92).
Studied in Italy 1754-58

Bank Stock Office, Bank of England,
1792-93 (demolished 1927)

Pitzhanger Place, Middlesex,
1800-1803

26, Grosvenor Square, London,
1773-74 Adam (demolished 1862)
ENGLAND, STONE, BRICK & IRON

London's 'Metropolitan Improvements', 1812-1835
John Nash (1752-1835)

A The Quadrant, Regent Street 1818
Cast-iron columns

B Carlton House Terrace, 1827 Cast-iron Doric columns

Cotton mill, Manchester, 1801. Cast-iron columns & beams
James Watt (1736-1819) & Matthew Boulton (1728-1809)

First iron bridge: Coalbrookdale, Shropshire, 1775-79
Thomas Farnoth Pritchard (d.1777)

Cast-iron Bridge, Sunderland, 1793-96

St Katherines Dock, London, 1828: Telford

Cast-iron rib-and-truss Bridge, Craigellachie, 1815: Telford

Suspension Bridge, Menai Straits, 1819-26
William Telford (1751-1834)
INDUSTRIAL REVOLUTION

Gauss Faraday Clerk constant Marie Curie
(1777-1855) (1791-1879) (1831-1934)
first 1879 18,600

dynamo electromiles radio-
1834 magnetism per activity,
1864 second radium
1887

Capitol, Washington Houses of Parliament,
London 1840-65

Menai suspension bridge, 1819-21

Crystal Palace, London, 1851

timber stone brick cast iron wrought iron

Portland cement reinforced concrete

Parthenon, Athens
Pantheon, Rome
Beauvais Cathedral
St Peter's, Rome
St Paul's, London

Eiffel Tower, Paris, 1889

19 TH & 20 TH CENTURIES
22 churches and chapels built by Augustus Welby Northmore Pugin (1812-52) from frontispiece to *An Apology for the Revival of Christian Architecture*, 1843

British Museum, London, 1824-47
Sir Robert Smirke (1789-1867)

Clifton Suspension Bridge, Bristol, designed 1829-31; begun 1836
Isambard Kingdom Brunel (1806-59)

Sir Charles Barry (1795-1860), assisted by Pugin


John Ruskin (1819-1900), *The Seven Lamps of Architecture*, 1849
The Stones of Venice, 1851

The Red House, Kent, 1859
Philip Webb (1831-1915) for William Morris (1834-96)

The Crystal Palace, Sydenham, London, 1851-54
Paxton; water towers, Brunel (Moved from Hyde Park, p. 163)
School of Art, Glasgow, 1896  Art Nouveau
Charles Rennie Mackintosh (1868-1928)

Village College, Impington, Cambridgeshire, 1936
Walter Gropius (1883-1969) (pp.174-5)
& Edwin Maxwell Fry (1890-

House, Rutland, 1901
Charles Annesley Voysey (1857-1941)

Heal & Son Store, London, 1910-14
Smith & Brewer

Peter Jones Store, London, 1936-39
William Crabtree

Royal Festival Hall, London, 1951
Robert Hogg Matthew (1906-)

Projected Roman Cathedral,
Sir Edwin Lutyens
(1869-1944)

Catholic Liverpool, 1929-41 succeeded 1962
by the design of
Frederick Gibberd (1908-)

F. R. S. Yorke (1908-62)
& Marcel Breuer (1902-):
born Hungary, U.S.A. 1937

The Forth Bridge, 1882-1890 Sir Benjamin Baker & Sir John Fowler

Auditorium insulated by foyers
CAST IRON is the direct result of smelting iron ore in a blast furnace with coke. The liquid ore solidifies on cooling & can be given the desired shape by being poured into moulds. The process was first carried out c.1710 by Benjamin Darby (1677-1717). Cast iron is brittle & reacts to bending stress. Used primarily for vertical columns.

WROUGHT IRON is obtained by oxidizing white-hot cast iron. It is puddled (purified) from an excess of carbon & impurities in a 'reverberatory' furnace, introduced by Henry Cort c.1760s. Ductile and malleable, wrought-iron can be pulled out into wire or rolled into beams.

STEEL is made from cast-iron, the carbon being burnt out by a blast of air through the molten metal in a 'Converter', invented by Sir Henry Bessemer in 1856. Steel has equal strength in compression and tension.

THE BEAM & TRUSS

- Compression boom
- Tension boom
- Compression or strut
- Tension or tie
- Bolt and rivets

CAST IRON, WROUGHT IRON, STEEL

The Crystal Palace, Hyde Park, London, 1851
Sir Joseph Paxton (1803-1865)

Constructed in 17 weeks in cast-iron with pre-fabricated standardized parts and based on multiples of 24 feet standard glass size 49" by 10"

The Fair Building, Chicago, U.S.A., 1893
William Le Baron Jenny (1832-1907)

The Eiffel Tower, Paris, 1887-89. Constructed of wrought-iron
Gustave Eiffel (1832-1923)

Galerie des Machines, International Exhibition, Paris, 1889: three-hinged steel arch Dutert; engineer Cottamin
Casa Battló ('House of the bones'), Barcelona, 1903-07 Gaudi

Parc Güell, Barcelona, 1900-14 Gaudí

tilted helicoid columns

Model of plan with weights hung proportional to the loads to be carried

Project for Güell Colony chapel, nr Barcelona 1898-1914 Gaudí

Antoni Gaudi (1852-1926): born Reus, near Tarragona; worked & died in Barcelona. 'Gaudi
SPAIN, MODERNISMO, GAUDÍ

Casa Milá
(The Quarry),
Barcelona,
1905-10
Gaudí

Sagrada Familia,
Barcelona, 1883.
Unfinished at
Gaudí's death,
1926;
work continues

is the constructor of 1900, the professional builder in stone, iron and brick. Le Corbusier
19th & 20th Centuries

Colonial or Georgian period: The Revolution
influence of Wren, Gibbs, Chambers & the Palladians

The Governor's House, Virginia, 1705 (rebuilt 1932)

St Michael, Charleston, South Carolina, 1761

Washington Monument, Baltimore, 1829 Robert Mills (1781-1855)

The Bank of Philadelphia, 1798-99
Benjamin Latrobe (1764-1820): born England; U.S.A. 1796

Redwood Library, Newport, Rhode Island, 1750 Peter Harrison (1716-75): born England; U.S.A. 1740

The “bank of Philadelphia, 1798-99
Benjamin Latrobe (1764-1820): born England; U.S.A. 1796

Westover, Virginia, c.1730 1761

State House, Boston, 1793-98
Charles Bulfinch (1763-1844)

St Michael, Charleston, South Carolina, 1761

State House, Richmond, Virginia, 1785-96 Jefferson

First design

Redwood Library, Newport, Rhode Island, 1750 Peter Harrison (1716-75): born England; U.S.A. 1740

Temple, Nimes

Trinity Church, New York, 1846 Richard Upjohn (1802-1878)

Thomas Jefferson (1743-1826); studied Roman buildings in Europe 1784-89

University of Virginia, Charlottesville, 1822-26

Mauricello, Charlottesville 1770-1809

the Pantheon, Rome

Thomas Jefferson (1743-1826); studied Roman buildings in Europe 1784-89

First design
U. S. A.

Revivals

Civil War 1861-1865

The Chicago School 1883- (pp. 168-9)

Crane Library, Quincy, Massachusetts, 1883

Trinity Church, Boston, 1872-77

Henry Hobson Richardson (1838-1886): studied in Paris

Exchange, Philadelphia 1832-4

William Strickland (1788-1845), pupil of Latrobe

The Capitol, Washington:

central block, 1792-1828,
William Thornton (1759-1828) & others.
Wings & dome (cast-iron), 1851-65
Thomas Ustick Walter (1804-1887)

The Capitol, Washington:

central block, 1792-1828,
William Thornton (1759-1828) & others.
Wings & dome (cast-iron), 1851-65
Thomas Ustick Walter (1804-1887)

James Bogardus (1809-1874)

Cast Iron Buildings, their Construction and Advantage
New York, 1858

Coliseum in cast-iron: suspended roof

Transportation Building, Chicago Exposition, 1893

Louis H. Sullivan (1856-1924):
Paris 1874. Frank Lloyd Wright worked with Sullivan 1888-93

Brooklyn Bridge, 1869-1883

John Roebling (1806-69) & W. A. Roebling (1837-1926)
Unity Temple, Oak Park, Illinois, 1906. Reinforced concrete
Influence on De Stijl, Holland (p.182)

Larkin Administration Building, Buffalo, 1904. Brick

Robie House, Chicago, Illinois, 1909

Willetts House, Highland Park, Illinois, 1902

Japanese house based on the standardized shape of mats 6 by 3 feet

Millard House, Pasadena, California, 1923

Frank Lloyd Wright (1867-1959), born Wisconsin, worked with Louis Sullivan 1888-93.
He innovated designs for an ‘organic’ architecture, kaleidoscopic in its variety
19 TH & 20 TH CENTURIES

Development of the curtain wall

Fagus Factory, Alfeld-an-der-Leine, 1911

Walter Gropius (1883-): assistant to Behrens, 1907-11 (p. 173); director of the Bauhaus,

Chrome-plated steel columns, slabs of travertine and glass

German Pavilion, International Exhibition, Barcelona, 1929

Ludwig Mies van der Rohe (1886-): born Aachen, Germany; worked with Behrens 1908-11,

A. Minerals & Metals Research Building, 1942-43

B. School of Architecture and Design, 1952

Illinois Institute of Technology, Chicago, 1940

The site divided into 24 foot modules

Chapel, 1952
Project: the ‘Total Theatre’, 1927

Bauhaus Buildings, Dessau, 1926.

Weimar 1919-25, at Dessau 1925-8; worked in England 1934-37 (p.161), U.S.A. 1937

Project: Convention Hall, Chicago, 1953

Two 26-Storey blocks of flats: No. 860, Lake Shore Drive, Chicago, 1951

director of the Bauhaus, Dessau, 1930-33; to U.S.A., 1937. His dictum: ‘less is more’
Peri Luigi Nervi (1891-), born Lombardy, engineer in reinforced concrete, follows "both
Corrugated roof composed of prefabricated units 13 3/8" long 1 1/8" thick joined at A by concrete poured in situ.

Exhibition Hall, Turin, 1948-50
Nerzi developed prefabricated units of ferro-cemento (iron-concrete), speedily assembled on a light scaffolding.

Palazzetto dello Sport, Rome, 1956-57
Arch. Annibale Vitelozzi, eng. Nerzi

the intuitive & mathematical paths'. Author of Construction, Science or Art?, Rome, 1945
T. W. A. Terminal, Kennedy Air Port, New York, 1956-62

Eero Saarinen (1910-61), born Finland, went to U.S.A. in 1923

Union Dome, Baton Rouge, Louisiana, 1958-59. 321 hexagonal steel panels, each folded with tubes & rods

Kaiser Aluminium Dome, Hawaii, 1957. Erected in 22 hours

Geodesic Domes from 1948

Richard Buckminster Fuller (1895- ), 'comprehensive designer'
Dulles International Jet Air Port,
Washington, 1960-63
Sauarineu
suspended roof, concrete slabs laid on cables

‘Key project’ for Ellis Island, New York Harbour, 1959-61, one of the last projects made by Frank Lloyd Wright (1867-1959)