The Renaissance

Awakening from the intellectual slumbers of the Middle Ages.

Beginnings of Mechanization: The weight-driven clock

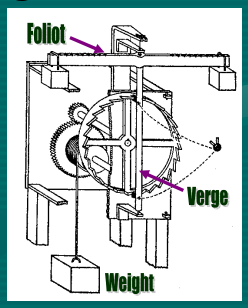
- Keeping time had importance in the monasteries.
  - Necessary to know the correct time for prayers, etc.
- Sun dials were hopeless in cloudy northern Europe.
- Water clocks froze in the winter.

The weight-driven clock

- A mechanical clock that moved by the force of a falling weight would work.
- Except:
  - Any falling object picks up speed as it falls.
  - Even if it is attached to a rope wound around an axis.
- Hence, a weight-driven clock would never keep correct time.

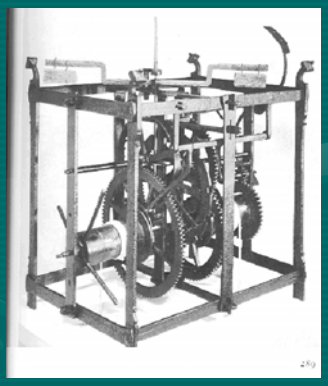
Solution: The verge and foliot

- A truly ingenious solution was an escapement mechanism to start and stop the falling weight over and over.
  - A metal rod (the *verge*) hangs vertically with two extending tabs set at the top and bottom of the verge slightly more than 90° apart, where they engage the teeth of a gear.
  - The foliot is a weighted bar that swings back and forth, pushed by the tabs as they strike the gear teeth.



A complex weight-driven clock

- Reconstruction of the 14th century Turret Clock from Dover Castle, with Verge and Foliot Escapement.

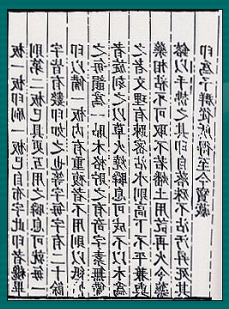


Books

- Humanism created a demand for books.
- Paper from Linen was readily available.
- But scribes were in great demand and could not keep up.

Printed Block Books

- A means of printing any written material mechanically would be in demand.
- Mechanical printing was known in China for at least 1000 years.
- But the method required making a woodcut of an entire page (in mirror image), then inking the woodcut, then applying it to a piece of paper.



Printing from Movable Type

- Some "block books" were printed in Europe in the 15th century.
- But the process was cumbersome, and error prone.
  - A single mistake on one page required that the entire page be re-carved.
- A method was needed to assemble a page, letter by letter.

Gutenberg's Printing Press

- Johann Gutenberg (1400-1468).
  - Goldsmith from Mainz, Germany.
  - Found a method of manufacturing individual letter slugs (that print the letter) of a uniform height so they could be lined up on a bed, inked, and a sheet of paper pressed against them to print a page.

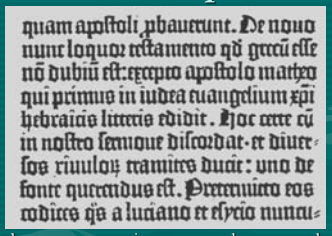
Gutenberg's matrix

- Gutenberg's trick was to use the same mould for all letter slugs, but placing a different letter impression on the end to make different letters.
- A molten lead alloy is poured into a matrix with the letter impression on the end, held together with a firm spring.
- The matrix adjusts to the width of the letters desired.
  - Wide for "M", narrow for "I", etc.

The Bed of the Press

- The desired letters for a page are then arranged and lined up on a flat bed, secured in place and inked.
- A sheet of paper is loaded into a frame held above the bed and then pressed onto the inked letters with a forceful screw press.

The finished product



quam apostoli pbauerunt. De nouo nunc loquor testamento qđ grecũ esse nõ dubiũ est: excepto apostolo matheo qui primus in iudea euangelium xpi hebraicis litteris edidit. Hoc ergo cũ in nostro sermone discordat: et diuersos riuulos trahimus duos: uno de fonte quærendus est. Preterea in eos codices qđ a luciano et hesycio nunc

- The printed page can contain any text whatsoever that can be written in Latin letters.
- When sufficient copies are made, the letter slugs are removed and sorted ready for another page to be composed.

A 16th century print shop

- Printing was immensely successful. In the 50 years from 1450 to 1500 more than 10 million volumes were printed.

Printing changed the world

- The character of education, general knowledge, the dissemination of information, and all the infrastructure of civilization changed dramatically with the invention of printing.

The Gutenberg Bible of 1455

- This is such a major event its date should be remembered.
- Therefore remember **1455**, the year of the printing of Gutenberg's 42-line Bible.
  - This is the third of the eight dates you must remember.

Influence of Printing on Science

- More texts available, to a wider audience.
- Publishing scientific discoveries became the norm.
- Interest in new knowledge (e.g., from exploration).

The woodcut

- Soon after the invention of printing with movable type, the woodcut was invented, providing a method of printing illustrations in a book.
- This was of major benefit to biology, where illustrations of animals and plants could be compared to the real things.
  - Especially the "Herbals," pharmaceutical texts on preparing medicines from wild growing herbs.
  - The illustration here is from Otto Brunfels' *Living Portraits of Plants*, 1530.

Comparative anatomy diagrams

- Illustrations, side-by-side, of the skeletons of different animals (here a human and a bird) showed relationships that would not have occurred to the ordinary observer.

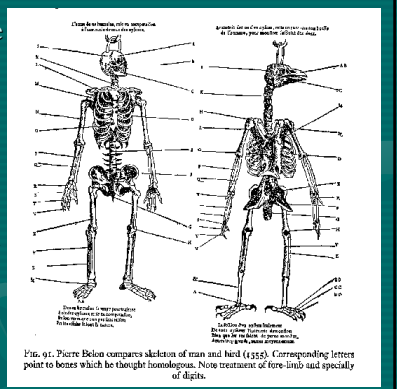
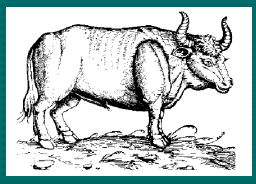


FIG. 91. Pierre Belon compares skeleton of man and bird (1555). Corresponding letters point to bones which he thought homologous. Note treatment of fore-limb and specially of digits.

Renaissance Illustrations of Previously "Unknown" Animals



A creature resembling a bull, but larger. And, a scaly "fish man."

The Revival of Learning

- Started with the 12th century translation project.
  - Translated works formed basis of curriculum at medieval universities.
- In the 15th century Byzantine manuscripts were imported into Western Europe.

Humanism

- Replaced theology in status.
- Relations of people in society.
- Activity: reworking Classical literature.
- Rebellion against Scholasticism.
- Worshipped remote past.

Early Humanism

- Manuel Chrysoloras came to Italy in 1397 from Byzantium.
  - Taught Greek in Italy.
- Sources dried up after 1453.

Ptolemy's *Geography* not known before 1406 when brought from Constantinople.

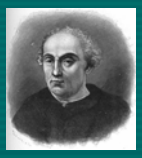
Printing of Ancient Scientific Classics

- Early printing was of very old texts:
  - Bible, theology, law, medicine
  - Few contemporary works
  - Few scientific works
- Need for Latin translations
  - Very few Western Europeans literate in Greek even into the 16th and 17th centuries.
  - Greek science had to be translated into Latin.
  - Among the first to be translated:
    - Euclid
    - Medical works: Hippocrates, Dioscorides, Galen, etc.

Scientific Atmosphere in Early Renaissance

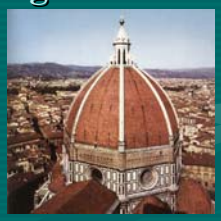
- Little interest in science among humanists
- Had to wait for translations from Greek
- Scholasticism gave way to Empiricism
  - Closer study of nature became the norm.

Perspective in Maps



- Paolo Toscanelli (1396-1482)
  - Brought Ptolemy's *Geography* to Italy

Engineering marvels



- Filippo Brunelleschi (1377-1446)
  - Renaissance Man
  - Built Dome of cathedral in Florence.

Perspective in Architecture

- Brunelleschi built churches with perspective tricks to make them grander
  - The Church of San Lorenzo in Florence looks longer than it is.
  - Popularised perspective in art and architecture.

Perspective in art

- Leone Battista Alberti (1404-1472)
  - Discovered mathematical laws of perspective.
- Albrecht Dürer of Nuremberg (1471-1528)
  - Used Alberti's analysis to portray the proportions of human body accurately by age and sex.

Leonardo da Vinci

- 1452-1519
- Genius in some areas, barely functioning in others
  - Small artistic output
  - Intense working style and attention to detail
  - Very secretive

Leonardo da Vinci

- Scientific interests:
  - Flying machine
  - Helicopter
  - Parachute
  - Designed parabolic compass
  - Designed guns, other engineering apparati

Leonardo da Vinci's Parabolic Compass

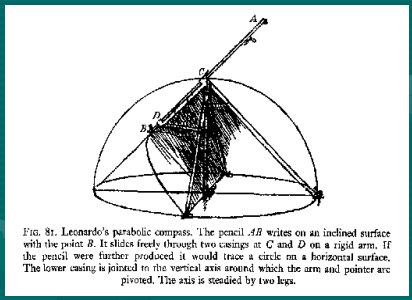
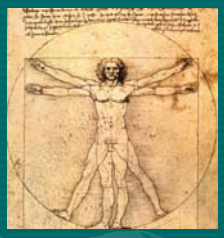


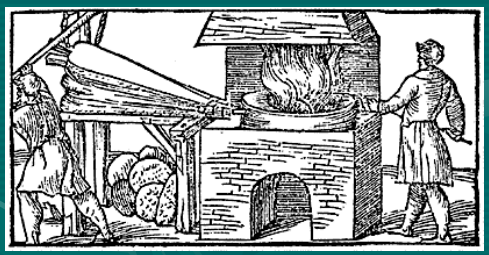
FIG. 81. Leonardo's parabolic compass. The pencil AB writes on an inclined surface with the point B. It slides freely through two casings at C and D on a rigid arm. If the pencil were further produced it would trace a circle on a horizontal surface. The lower casing is jointed to the vertical axis around which the arm and pointer are pivoted. The axis is steadied by two legs.

Leonardo da Vinci



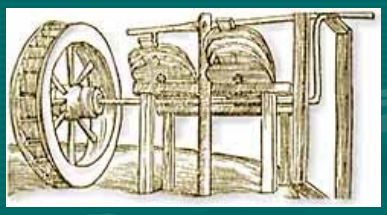
- Perspective and realism in art
  - Worked out principles of perspective
  - Studied physiology, embryology

Practical Arts in the 16th century



- Greatly advanced by the printing of technical manuals.

Practical Arts in the 16th century



- Waterwheel operating mechanical bellows for a blast furnace.
  - From Vanocchio Biringuccio (1460-1539), *Pirotechnia* (1540).

Practical Arts in the 16th century

- Agricola (1490-1555)
  - (George Bauer)
  - *De re Metallica* (1556)

Medicine

- Medicine followed the teachings and practices of the ancient authorities, Hippocrates, Galen, Avicenna.
- Renaissance physicians began to throw off blind adherence to authority in favour of direct observation and new theories.

An anatomy lesson

- An anatomy demonstration from the 15th century.
- The professor reads from the text, while the demonstrator (surgeon) displays the appropriate organs.

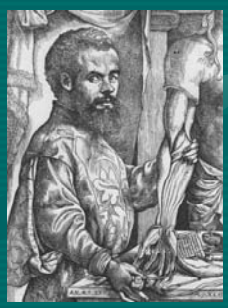
From Mondino's *Anathomia, 1493*

Paracelsus

- 1493-1541
- Actual name: Aureolus Philleppus Theophrastus Bombastus von Hohenheim
- Founded Iatrochemistry, i.e. medical chemistry
  - Curing diseases with specific drugs, instead of curing the body as a whole.

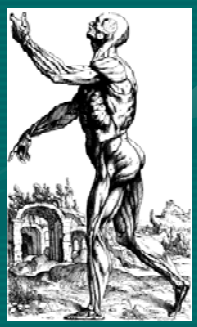
Andreas Vesalius

- 1514-1564
- Studied anatomy (i.e., Galen) in Paris, 1533-1536
  - In 1537 began teaching surgery in Padua.
  - Vesalius emphasized actual demonstrations of anatomy in the (new) anatomy theatre in Padua.



De Fabrica

- Published *On the Fabric of the Human Body*, in **1543.**
  - **Note this date. This is the fourth date to remember.**
- An illustrated anatomy text.
  - Raised biological observations to new level.
  - Artist for book probably from school of Titian.



Renaissance transportation: Overland

- Became more extensive as landlocked states developed.
  - Horses made individuals more mobile.
  - Farmers could get produce to market.
- Heavy loads, e.g. artillery, a problem.
  - Roads virtually non-existent.
- Wagons
  - 2-wheeled carts had limited capacity.
  - 4-wheeled wagons hard to manoeuvre, jolted.
  - Solutions: the movable forecarriage, suspension systems.

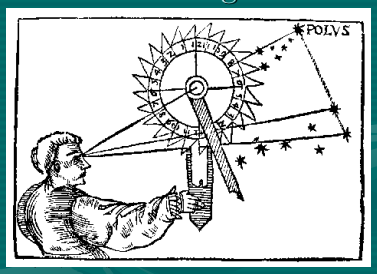
Shipbuilding in the Renaissance

- Existing styles:
  - Sewn planking in India and Arab countries
    - Better flexibility, allowed beaching.
  - Iron nails on a frame, used in Europe and China
    - Stronger for ocean travel
    - Larger construction
    - Problem of rust

The Age of Exploration

- Motivation
  - Ottoman Empire closed overland route to Orient after 1453.
  - But desire for Oriental spices was established.

The Problem of Navigation: Latitude:



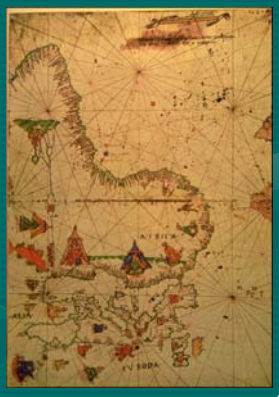
- Navigation by stars started around 1480 with quadrant
  - Only useful for latitude, hard to use at sea, impractical near equator, impossible below it.

The Problem of Navigation: Longitude

- Longitude virtually insoluble
  - Best method: **Dead Reckoning**

Portolan Charts

- For navigating at sea near enough to the cost to sight headlands.

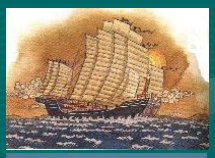


Map Making

- Ptolemy's *Geography*
  - With grid lines for longitude and latitude
  - Terra incognita (instead of the end ofthe earth).

Sails

- Square sails on European and Chinese ships
  - Suited large ships
  - Only allowed sailing with the wind
- Lateen (triangular) sails on Middle Eastern and African ships
  - Suited smaller boats and travel on calm waters.
  - Allowed sailing into the wind



The Caravel and the Carrack

- European innovation
- Square and Lateen sails on same ship
- Sternpost rudder
- Stable in high seas, manoeuvrable in adverse winds

Columbus

- Christopher Columbus, 1451-1506
  - Sailed for the new world in 1492
- Used caravels and carracks.

Destination: Japan

- Used Toscanelli's map, an updated version of Ptolemy's
  - Faults of map:
    - Asia too big by 105°
    - Degrees of longitude too small by 60%