1. Guns and Sails

2. Modernity
   - Key late medieval innovations:
     - the mechanical clock
     - cast iron
     - gunpowder & firearms
     - the compass
     - the caravel

3. Materials
   - Key materials of traditional society
     - Wood
     - Ceramics
     - Stone
     - Fibers
     - Leather
     - Metals

4. Advantages of wood
   - is easily cut and worked
   - can be shaped in other ways (bent, turned, drilled, planed)
   - is strong in compression (stronger than many metals, by weight)
   - is common, easily gathered & prepared for use

5. Disadvantages of wood
   - does not hold an edge
   - is weak in tension
   - can often be easily penetrated
   - wears easily
   - is easily destroyed by fire and water
   - cannot be cast or molded

6. The Metals
   - Copper & copper alloys (brass & bronze)
   - Precious metals (gold & silver)
   - Base metals (lead, tin)
   - Iron—the most important

7. Basic types of iron:
   - Wrought iron
     - <0.1% carbon (almost pure iron, some slag)
     - ductile, tough, the classic form of all iron
   - Steel
     - between 0.2% C & 1.5% C
- hard, moderately ductile, moderately tough
- **Cast iron**
  - >2% carbon (usually not more than 5%)
  - moldable, brittle

8  Cast Iron
- One of the key innovations of the Middle Ages
- Product of the blast furnace
- Much larger scale production
- Used for castings and --as “pig iron”--source of wrought (malleable) iron

9  Guns & gunpowder
- New form of warfare: one of the key changes of the late Middle Ages
- Very slow to develop
- Originated in China, made its way west through Islamic countries

10  Gunpowder consists of a mixture of:
- charcoal
- sulfur
- saltpeter (potassium nitrate)
  - Derived from “nitrogenous earths”
  - Required considerable skill to produce and purify
Gunpowder manufacture a highly skilled and prized industry

11  Consequence of gunpowder warfare
- Advantages no longer in cavalry, but more in artillery
- Fortifications need to be improved
- Power now requires capital rather than land
- Power and influence begins to flow from landed classes to the cities and monied classes

12  Sails & Navigation
- Key changes in ships
- Key changes in navigational tools and techniques
  - Compass
  - Astrolabe
  - Charts

13  Older ship forms:
- Mediterranean 2- and 3-masted ship
- Northern longship

14  The Caravel
- Combines qualities of roundship and long ship
- Vastly improves ocean-going capability of Europeans
More expensive and complex than older ships--requires combining capital
   Exploited first by Portuguese

15 ☑ The Caravel

16 ☑ The Expansion of Europe
   - Guns & ships combine to foster European expansion, both eastward and westward

17 ☑ Question:
   - Which seems more important to promoting European expansion, new ships or new weapons? Why?