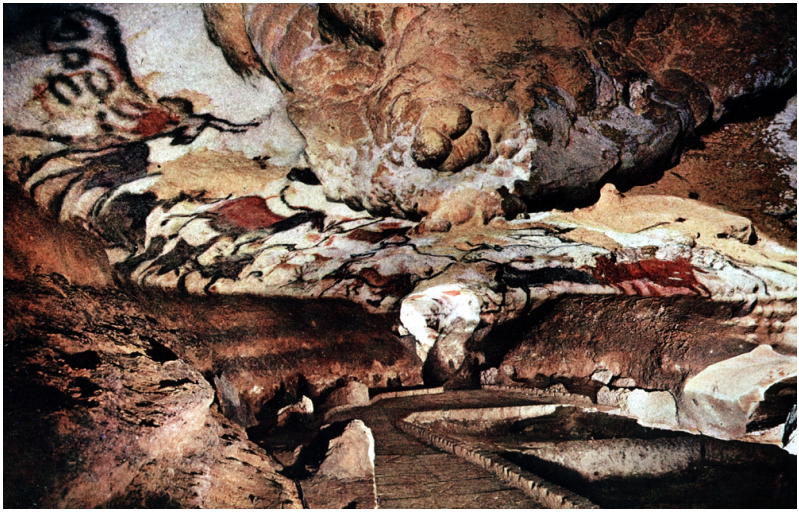
Statistics 120
A Graphical Tour

Early Uses of Graphical Representation

- The oldest known uses of graphical representation are probably cave paintings found in a variety of caves in Southern Europe (E.g. Lascaux, Altamira, Chauvet).
- Some of the paintings found in these caves date back over 30,000 years.
- Many of the paintings show stylised pictures of animals and may have been associated with hunting rituals.



The Great Hall of the Bulls, Lascaux Cave.

The Path to Abstraction

- Cave paintings are largely representational, and show limited abstraction.
- The first step toward modern graphical displays came with the use of graphic images as maps.
- The earliest known map is Babylonian and was found at Nuzi near Kirkuk in Iraq.
- It dates from the dynasty of Sargon of Akkad, about 2400 – 2200 BC.

The Earliest Known Map.

Maps

- Map making was common across a variety of cultures; Chinese, Greek, Egyptian …
- For the most part, maps were strictly representational; showing the shape and location of landmasses.
- The best “world map” was created by Claudius Ptolemy in Alexandria in about 100 AD.
- Ptolemy’s work was unsurpassed until the 16th century.

A 15th Century Copy of the Ptolemy World Map.

Diagrams

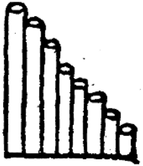
- Early scholars made use of diagrams but there was no systematic body of knowlege about visual representations.
- Amazingly modern looking diagrams can be found in the manuscripts of Nicholas Oresme (1323–1381, France).
- Oresme discovered the idea of plotting a variable magnitude which depends on another variable.

difformis vniformiter variatio reddit vnifor-
miter difformiter difformem. ¶ Latitudo vni-
formiter difformis ē illa q̄ inter excessus graduū
eq̄ distātiū ſuat eādē ꝓportōē: alia tñ ē ꝓ-
portōe eq̄litatis. Nā si inter excessus graduū
inter se eq̄ distantiū ſuarent ꝓportōē eq̄lita-
tis iā eēt latitudo vniformiter difformis ut pz ex
diffinitionibus membrorum secūde diuisiois
Rursus si nulla proporcio seruat̄ tunc nulla
posset attendi vniformitas in latitudine tali et
sic non esset vniformiter difformis ē difformis
¶ Latitudo difformiter difformiter difformis
ē illa q̄ inter excessus graduū eque distantiū
non seruat eandem proportionem sicut in se-
cunda parte patebit. Notandum tamen est
q̄ sicut in supradictis diffinitōib[9] ubi loqtur
de excessu graduum inter se eque distantium
debz accipi distancia scd̄m partes latitudinis
extēsiue et nō intēsiue sicut ut loquunt̄ de diē dif-
finitōes d distātia s̄dum situali n̄ aūt graduali

scip. et fiat ad ĩn

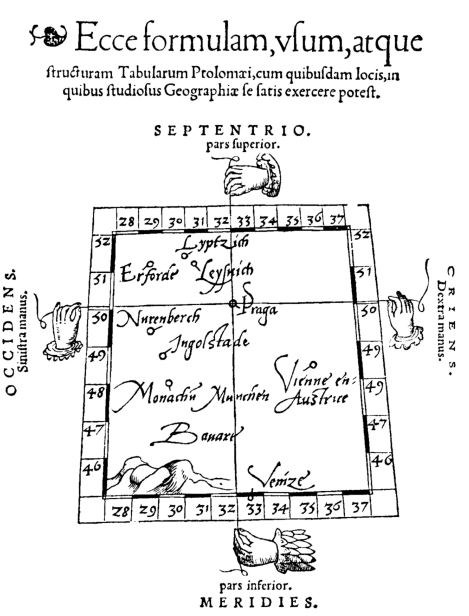
Difformiter difformis

Df. df. difformis



Coordinates

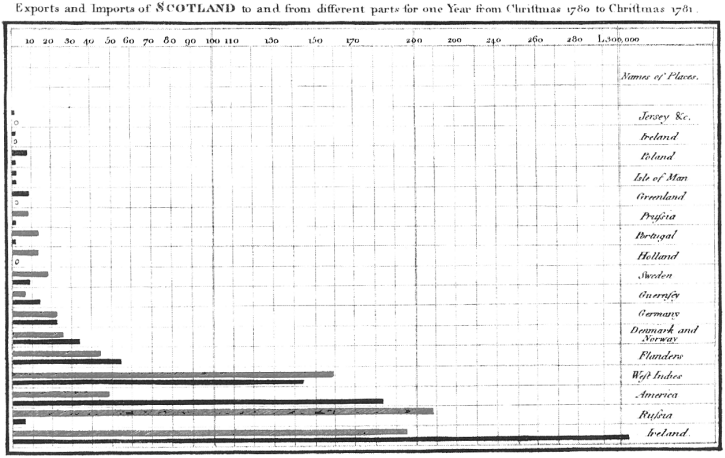
- By the 16th century the idea of coordinate pairs was becoming commonplace.
- The 1546 edition of *Cosmographia* by Petrus Apianus contained a diagram which showed how city locations correspond to latitude and longitude values.
- René Descartes (1596–1650, France) formalised the use of coordinate pairs in analytic geometry.
- We now refer to (x, y) coordinate pairs as *Cartesian coordinates*.



Location described by latitude and longitude.

Data Graphics

- Although Descartes had provided the machinery required to produce statistical graphs it took nearly a century for such graphs to become commonplace.
- The German mathematician Johann Heinrich Lambert (1728–1777) and the English political economist William Playfair (1759–1823) created many modern graphical designs.
- The invention of lithography in 1798 made it possible for these designs to reach a large number of people.



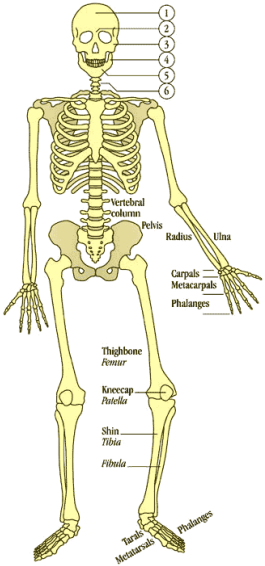
A Playfair Barchart.

Some Types of Graph

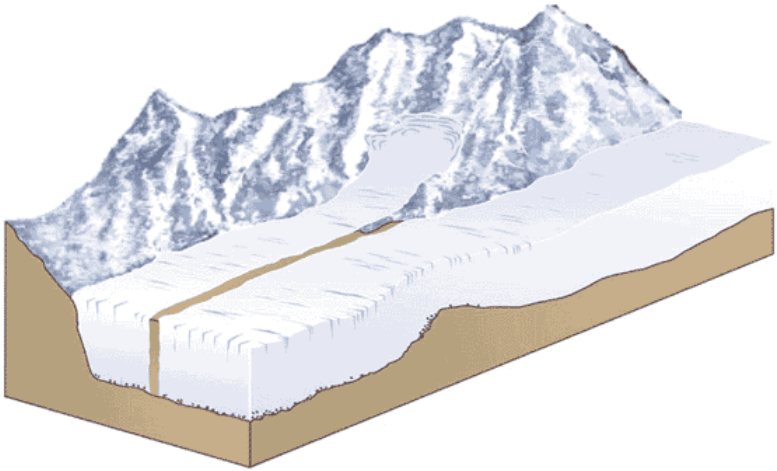
- Illustrative diagrams
- Organisational diagrams
- Maps and plans
- Statistical graphs
  - Bar charts, dot charts, pie charts
  - Histograms, density plots, boxplots
  - Function plots, Scatter plots

Illustrative Diagrams

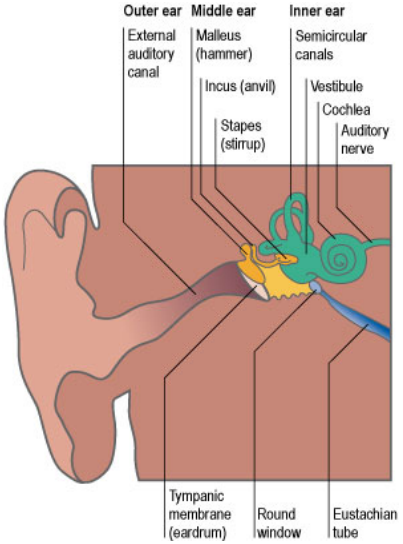
- These graphically portray an object, usually in a simplified or schematic form.
- A common use is to show a complex object broken down into its component parts.
- The images presented trade off *realism* and *abstraction*.



The Human Skeleton



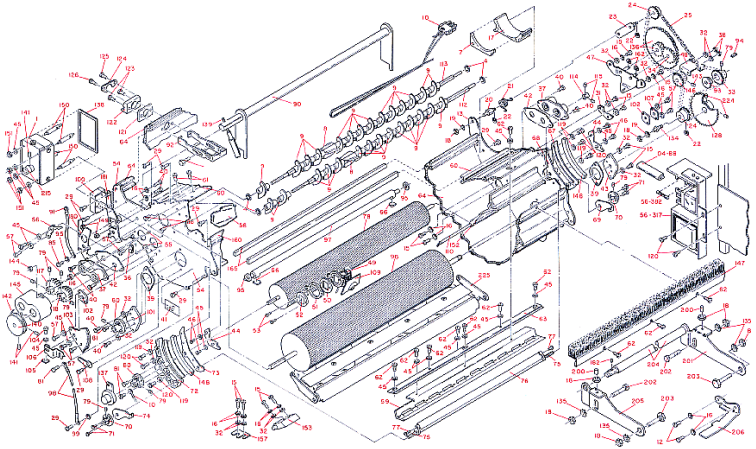
Illustrative Cross-section of a Glacier.



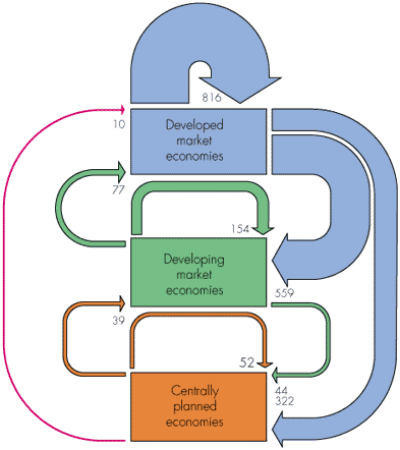
The Human Ear

Organisational Diagrams

- These diagrams emphasise the relationships between objects, or the parts of a single object.
- The objects represented can be concrete or may be quite abstract.
- The boundary between illustrative and organisational diagrams is not always clear.



IBM Series III Copier/Duplicator (1976)

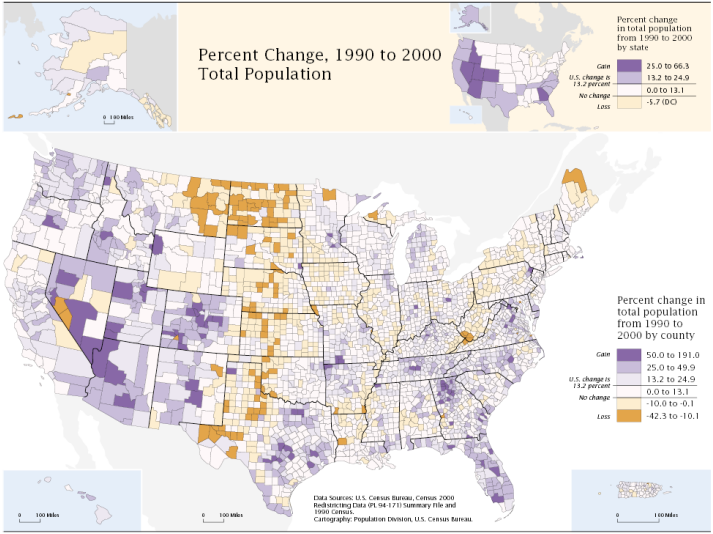


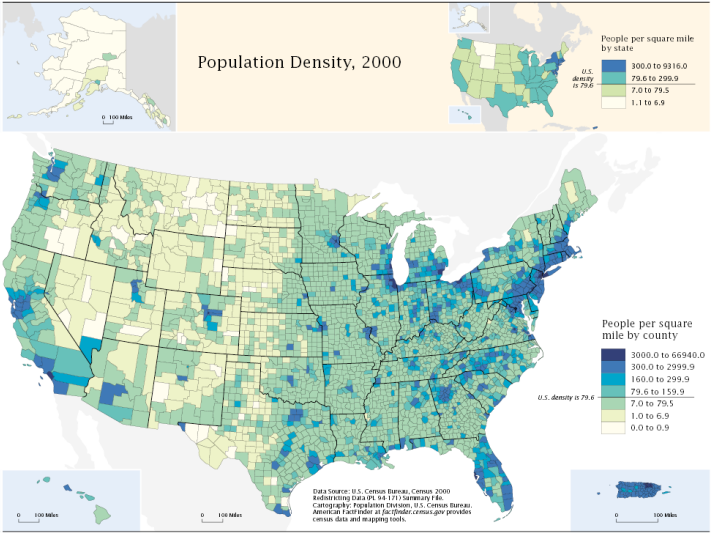
Volumes of Trade
From an FAO Document

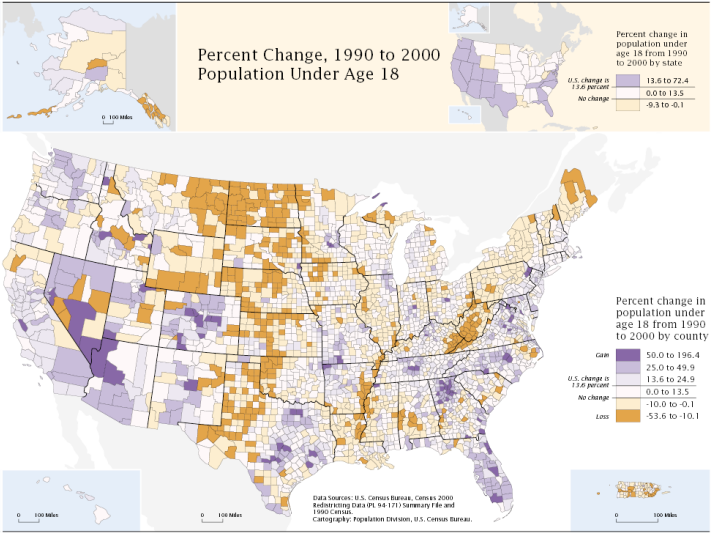
Maps and Plans

- Some maps are simple representations of spatial locations.
- Other maps include additional numeric information encoded in some graphical fashion.

A map of a golf course.

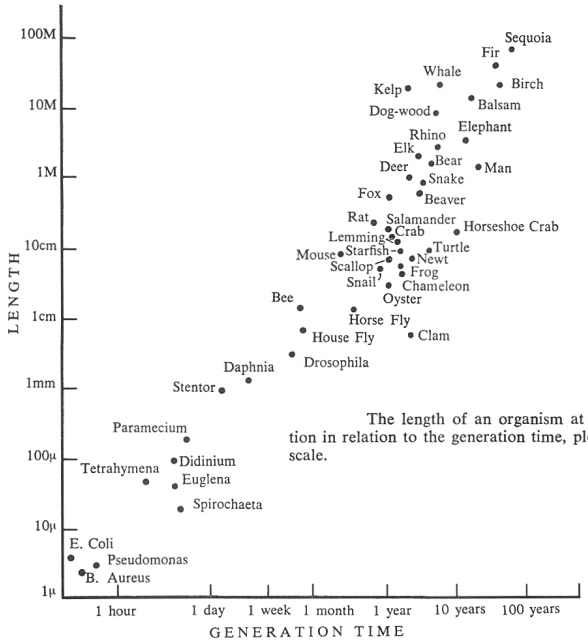

Percent Change, 1990 to 2000
Total Population
Percent change in total population from 1990 to 2000 by state
Gain
U.S. change is 13.2 percent
No change
Loss
25.0 to 66.3
13.2 to 24.9
0.0 to 13.1
-5.7 (DC)
Percent change in total population from 1990 to 2000 by county
Gain
U.S. change is 13.2 percent
No change
Loss
50.0 to 191.0
25.0 to 49.9
13.2 to 24.9
0.0 to 13.1
-10.0 to -0.1
-42.3 to -10.1
0 100 Miles
0 100 Miles
0 160 Miles
Data Sources: U.S. Census Bureau, Census 2000 Redistricting Data (PL 94-171) Summary File and 1990 Census.
Cartography: Population Division, U.S. Census Bureau.


Population Density, 2000
People per square mile by state
U.S. density is 79.6
300.0 to 9316.0
79.6 to 299.9
7.0 to 79.5
1.1 to 6.9
0 100 Miles
People per square mile by county
3000.0 to 66940.0
300.0 to 2999.9
160.0 to 299.9
79.6 to 159.9
7.0 to 79.5
1.0 to 6.9
0.0 to 0.9
U.S. density is 79.6
Data Source: U.S. Census Bureau, Census 2000 Redistricting Data (PL 94-171) Summary File.
Cartography: Population Division, U.S. Census Bureau.
American FactFinder at factfinder.census.gov provides census data and mapping tools.
0 100 Miles
0 100 Miles
0 100 Miles


Percent Change, 1990 to 2000
Population Under Age 18
0 100 Miles
Percent change in population under age 18 from 1990 to 2000 by state
U.S. change is 13.6 percent
13.6 to 72.4
0.0 to 13.5
No change
-9.3 to -0.1
Percent change in population under age 18 from 1990 to 2000 by county
Gain
50.0 to 196.4
25.0 to 49.9
U.S. change is 13.6 percent
13.6 to 24.9
0.0 to 13.5
No change
-10.0 to -0.1
Loss
-53.6 to -10.1
0 100 Miles
0 100 Miles
0 100 Miles
Data Sources: U.S. Census Bureau, Census 2000 Redistricting Data (PL 94-171) Summary File and 1990 Census.
Cartography: Population Division, U.S. Census Bureau.

Statistical Graphs

- Statistical graphs represent a quantum jump in abstraction over the other plots we have seen.
- Even the choropleth population maps we have seen retain a representational component (the map).
- William Playfair's great achievement was to introduce entirely abstract forms of graphical data display.
- The use of abstract graphs is now so ingrained in our culture that we hardly notice them.



The length of an organism at the time of reproduction in relation to the generation time, plotted on a logarithmic scale.

Data to Theory

This graph says

$$\log(\text{Size}) = a + b \times \log(\text{Generation Time}),$$

or

$$\text{Size} = A\exp(\text{Generation Time}).$$

The Importance of Data Graphs

- Seeing that a set of observations follows a particular pattern will often allow us to move from the specific to the general.
- It is ability of graphs to suggest theories or to provoke questions which makes them so important.