# Introduction to visualization

---

1. **Philosophy and key issues**
   **(T. Kuhn, The Structure of Scientific Revolutions)**

2. **The design of visualizations**
   **(Tufte, Envisioning Information)**

⇒ **3. The scientific illustration tradition**

⇒ **4. Scientific visualization techniques**

⇒ **5. Visualization software and systems**

# References


- H. Robin, *The Scientific Image*, 1994.
- Jacques Bertin, *The Semiology of Graphics*, 1967.
- John W. Tukey, *Exploratory Data Analysis,* 1977.
- Peter Keller and Mary Keller, *Visual Cues,* 1993.
- Richard Gallagher, *Computer Visualization*, 1995.
- William Schroeder et al., *The Visualization Toolkit*, 1996.
- Al Globus and E. Raible, *13 Ways to Say Nothing with Scientific Visualization*, 1992.

# Observation

- **hand-drawn**

  **1489 Da Vinci, The Human Spinal Column**

  **1543 Vesalius, On the Fabric of the Human Body**

  **1665 Hooke, Micrographia**

- **self-illustrating phenomena**

  **1782 Chladni, Discovery of the Theory of Pitch**

  **1935 Edgerton, Milk Splash**

  **1995 Hoehne, The Visible Human**

# Explanation

---

- **of procedures**

  **1704 Newton, Optics**

  **1586 Fontana, Moving the Obelisk**

  **1654 Guericke, The Magdeburg Spheres**

- **of theories**

  **1637 Descartes, Formation of a Rainbow**

  **1915 Wegener, Origin of Continents & Oceans**

  **1917 Thompson, Morphology of a Fish**

# Taxonomies

- **by data type**
  - **number of independent variables (domain)**
  - **number of dependent variables (range)**
  - **discrete vrs continuous domain**
  - **binary vrs multivalued vrs continuous range**
- **by visual metaphor**
  - **Bertin's *Semiology***
  - **Keller and Keller's *Visual Cues***

# Functions of one variable

- **1D -> 1D**
  - **graph**
- **1D -> 2D**
  - **parallel graphs**
  - **parametric line on the plane**
  - **animating arrow in the plane**
- **1D -> 3D**
  - **more parallel graphs**
  - **colored parametric line on the plane**
  - **parametric line in space**
  - **animating 3-vector**
  - **etc.**

# Functions of two variables

---

- **2D -> 1D**
  - grayscale image
  - elevation map
  - animating graph
- **2D -> 2D**
  - color image
  - grayscale + elevation map
  - vector field in the plane
  - parametric warp of the plane
  - animating parametric line in the plane
- **2D -> 3D**
  - 3-vector field in the plane
  - parametric surface in space
  - etc.

# Functions of three variables

- **3D -> 1D**
  - volume rendering
  - animating grayscale image
  - animating elevation map
- **3D -> 2D**
  - color volume rendering
  - animating elevation + color map
  - animating vector field in the plane
  - animating parametric warp of the plane
- **3D -> 3D**
  - vector field in space
  - parametric warp of space
  - animating 3-vector field in the plane
  - animating parametric surface in space
  - etc.

# Higher dimensions

- **domain**
  - multiples
  - animation
  - slices
  - level sets
  - projections
  - clipping
  - segmentation
- **range**
  - selection
  - multiple scalars -> texture attributes
  - multiple vectors -> shading frames
  - tensors -> geometric transformations
  - glyphs

# Discrete functions

- **1D -> 1D**
  - bar graph
- **1D -> 2D**
  - parallel bar graphs
  - scatterplot
  - array of arrows
- **2D -> 1D**
  - table of glyphs
  - chartmaps
  - cartograms
  - animating bar graph
- **2D -> 2D**
  - fancier glyphs
  - etc.

# Bertin's taxonomy

- **imposition**
  - diagrams
  - networks
  - maps
  - symbols

  ×

  - arrangement
  - rectilinear
  - circular
  - orthogonal
  - polar

- **retinal variables**
  - size
  - value
  - texture
  - color
  - orientation
  - shape

  ×

  - association
  - selection
  - order
  - quantity

# Keller and Keller's taxonomy

| <u>**Actions**</u> | × | <u>**Data**</u> |
|---|---|---|
| • identify | | • scalar |
| • locate | | • nominal |
| • distinguish | | • direction |
| • categorize | | • shape |
| • cluster | | • position |
| • rank | | • region |
| • compare | | • structure |
| • associate | | |
| • correlate | | |

# Other issues

- computational versus physical space
- displaying context and labeling
- displaying error bounds
- controlling error
- interaction
- things to avoid

# Interaction paradigms

---

- toolkit programming
  - SGI Inventor, ImageVision
- interpreted command line
  - Mathematica, matlab, tcl/tk
- flow chart
  - ConMan, AVS, SGI's Explorer, apE, Khoros, IBM's Data Explorer, PV-Wave, Wavefront's Data Visualizer, FIELDVIEW, VoxelView, etc.
- spreadsheet
  - Lotus 1-2-3, Excel, ASP, IISS, SI
- magic lenses
- RISC data analysis
  - simple analysis algorithms
  - real-time feedback

# Toolsmithing

---

## <u>Successful tools are...</u>

- **powerful**
  - **provides immediate value-added**
- **flexible**
  - **escape hatches for customization**
- **responsive**
  - **staying below the pain threshold**
- **easy to use**
  - **encourage extemporaneous experimention**

*A tool must be so <u>simple</u> full professor*
*can use it, and so <u>productive</u> that they will.*
- Fred Brooks