The Purposes of Visualization

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CS448B – Visualization

Winter 2004

Definition [www.oed.com]

1. **The action or fact of visualizing; the power or process of forming a mental picture or vision of something not actually present to the sight; a picture thus formed.**

   1883 Academy 14 July 31 Investigations into the phenomena of visualisation.

   1884 GURNEY & MYERS in 19th Cent. July 72 In the next stage of visualisation the percipient sees a face or figure projected or dejected, as it were, on some convenient surface.

   1894 Athenæum 10 Nov. 638/2 [The book had] a power of visualization that gave it a claim to real originality.

Definition [www.oed.com]

2. The action or process of rendering visible.

1936 ***Amer. Jrnl. Cancer*** **XXVII. 49 The hexagonal tube..offers distinct advantages with its flat sides permitting good visualization.**

1960 ***New Scientist*** **28 July 305/3 Echo sounding..is now being applied to the visualization of structures within the body.**

1973 ***Nature*** **17 Aug. 410/1 Direct visualization of biological material at this level would tell us much about the structure and mode of action of macromolecules.**

1982 ***Listener*** **23/30 Dec. 42/3 The cinematic visualisation of the script..belongs entirely to Welles and his technicians**

The Purpose of Data Visualization is to Convey Information to People

Why?

Answer a question
- "One image = One diagnosis"

Make decisions
- Support analysis and reasoning

To explore and discover; encourage creativity
- Look at things in a new way
- "The purpose of computing is insight, not numbers" [R. Hamming]

Communicate information to others
- Make a point
- Tell a story

Inspire
- Part of our cultural heritage

Functions of Visualizations

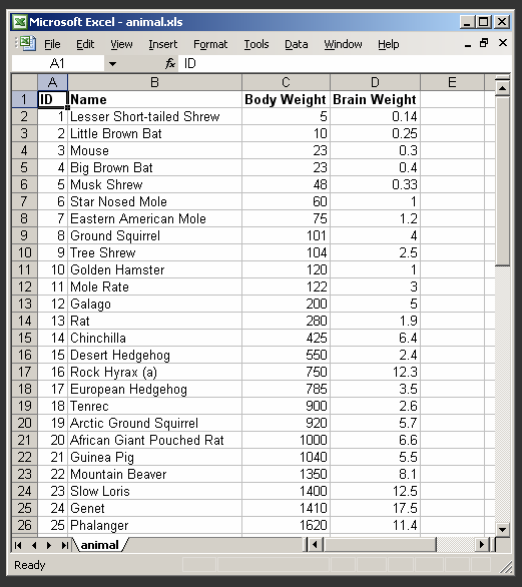
1. Recording information
   e.g. table of logarithms, blueprints and telescope images

2. Processing information
   Computer -> Display -> Person
   w/ feedback and interaction

3. Presenting information
   Display -> People
   Share, collaborate, revise, ...

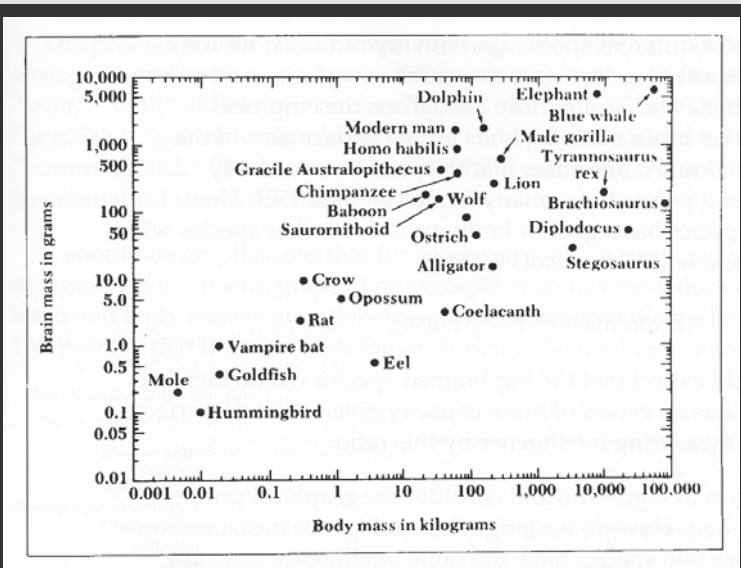
Power of Visualization

The Most Powerful Brain?



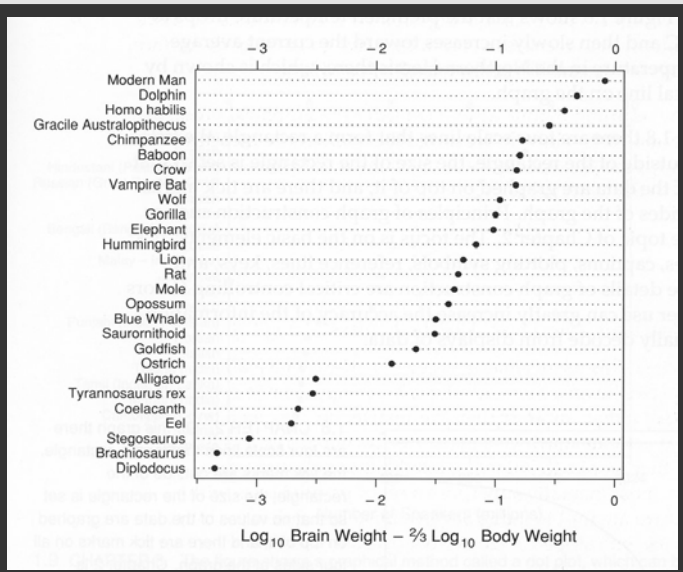
ID	Name	Body Weight	Brain Weight
1	Lesser Short-tailed Shrew	5	0.14
2	Little Brown Bat	10	0.25
3	Mouse	23	0.3
4	Big Brown Bat	23	0.4
5	Musk Shrew	48	0.33
6	Star Nosed Mole	60	1
7	Eastern American Mole	75	1.2
8	Ground Squirrel	101	4
9	Tree Shrew	104	2.5
10	Golden Hamster	120	1
11	Mole Rate	122	3
12	Galago	200	5
13	Rat	280	1.9
14	Chinchilla	425	6.4
15	Desert Hedgehog	550	2.4
16	Rock Hyrax (a)	750	12.3
17	European Hedgehog	785	3.5
18	Tenrec	900	2.6
19	Arctic Ground Squirrel	920	5.7
20	African Giant Pouched Rat	1000	6.6
21	Guinea Pig	1040	5.5
22	Mountain Beaver	1350	8.1
23	Slow Loris	1400	12.5
24	Genet	1410	17.5
25	Phalanger	1620	11.4

The Most Powerful Brain?



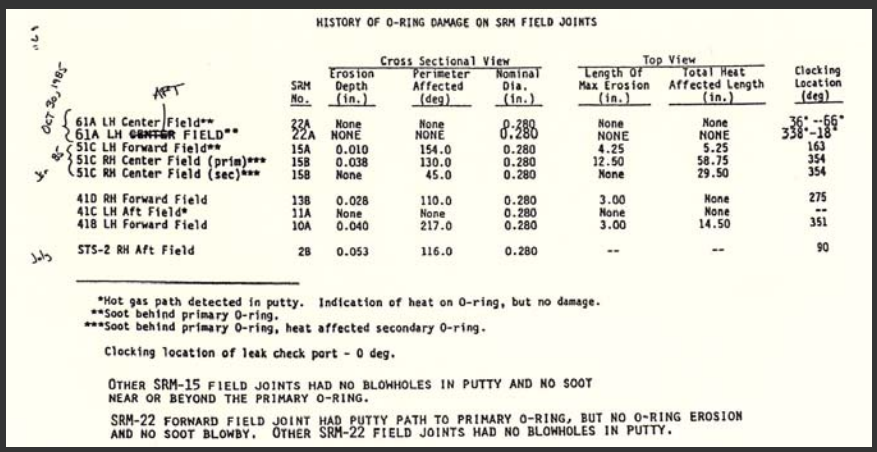
C. Sagan, The Dragons of Eden

The Most Powerful Brain?



W. Cleveland, The Elements of Graphing Data

Challenger Disaster



HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

	SRM No.	Cross Sectional View: Erosion Depth (in.)	Cross Sectional View: Perimeter Affected (deg)	Cross Sectional View: Nominal Dia. (in.)	Top View: Length Of Max Erosion (in.)	Top View: Total Heat Affected Length (in.)	Clocking Location (deg)
61A LH Center Field**	22A	None	None	0.280	None	None	36° -66°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338°-18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
41D RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275
41C LH Aft Field*	11A	None	None	0.280	None	None	--
41B LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351
STS-2 RH Aft Field	2B	0.053	116.0	0.280	--	--	90

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
**Soot behind primary O-ring.
***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

1 of 13 pages of material faxed to NASA by Morton Thiokol

Challenger Disaster

BLOW BY HISTORY

SRM-15 WORST BLOW-BY
- 2 CASE JOINTS (80°), (110°) ARC
- MUCH WORSE VISUALLY THAN SRM-22

SRM 22 BLOW-BY
- 2 CASE JOINTS (30-40°)

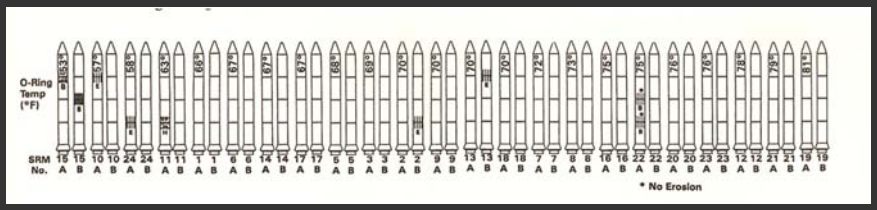
SRM-13A, 15, 16A, 18, 23A 24A
- NOZZLE BLOW-BY

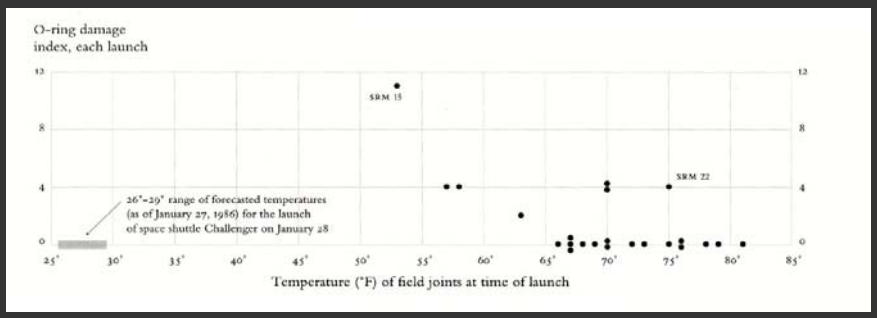
HISTORY OF O-RING TEMPERATURES (DEGREES - F)

MOTOR	MBT	AMB	O-RING	WIND
DM-1	68	36	47	10 MPH
DM-2	76	45	52	10 MPH
QM-3	72.5	40	48	10 MPH
QM-4	76	48	51	10 MPH
SRM-15	52	64	53	10 MPH
SRM-22	77	78	75	10 MPH
SRM-25	55	26	29 27	10 MPH 25 MPH

1 of 13 pages of material faxed to NASA by Morton Thiokol

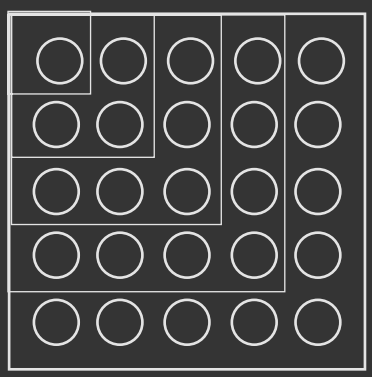
Challenger Disaster





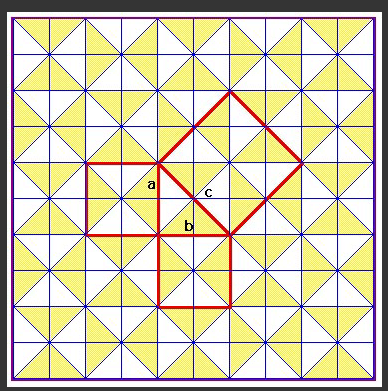
Redrawn by E. Tufte, p. 49 , Visual Explanations

Visual Thinking



Visual Proof:

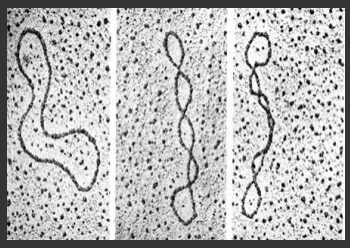
$1+3+5+7+9=5^2$

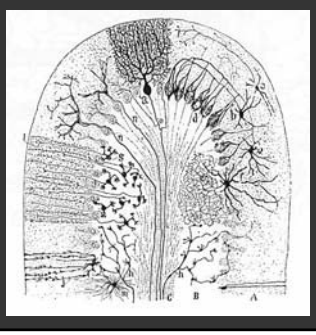


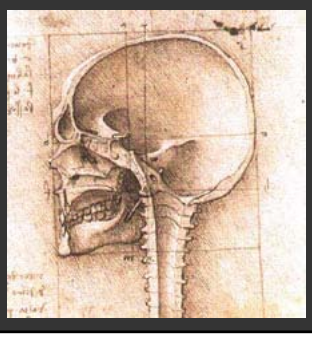
Pythagorean Theorem:

Chinese Proof by Dissection

Inspire

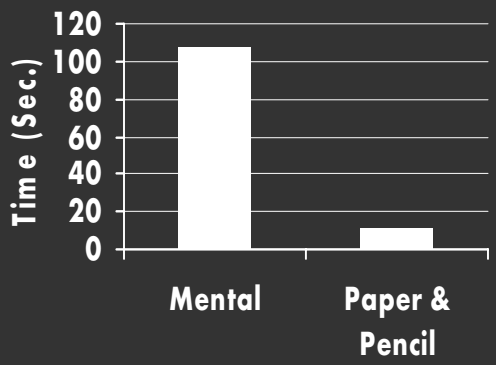






Long-Hand Multiplication

$$\begin{array}{r} 34 \\ \times\ 72 \\ \hline 68 \\ 2380 \\ \hline 2448 \end{array}$$



Amplifies Cognition/Perception

1. Expand working memory
2. Reduce search time
3. Pattern detection and recognition
4. Perceptual inference
5. Perceptual monitoring and controlling attention
6. Interaction is important for cognition

Card, Schneiderman, MacKinlay,
Readings in Information Visualization

Information-Seeking Mantra

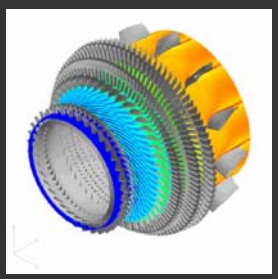
Overview first,
then zoom and filter,
details on demand

B. Schneiderman, The eyes have it: A task by data type taxonomy for information visualization, 1996

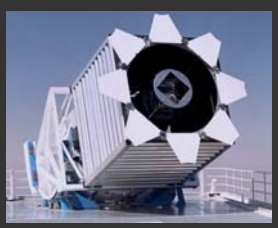
Challenges

More and more unseen data

Simulation and Instrumentation



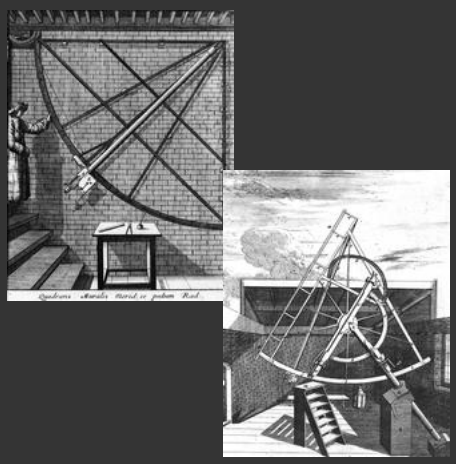
Ctr for Int. Turbulence Simulation
- **PW6000 Turbine**
- **93.8 million cell mesh**
- **5700 time steps, 30 iter/ts**
- **5970 hours on 1K proc**



Sloan Digital Sky Survey
- **Robotic telescope**
- **5x6 2048x2048 CCD sensors**
- **40 TB of imagery**
- **100 million object catalog**

Observation of Unseen Worlds

Hooke's Microscope



Flamsteed's Telescope

Challenges

More and more unseen data

Principles for designing effective visualizations

Challenges

More and more unseen data

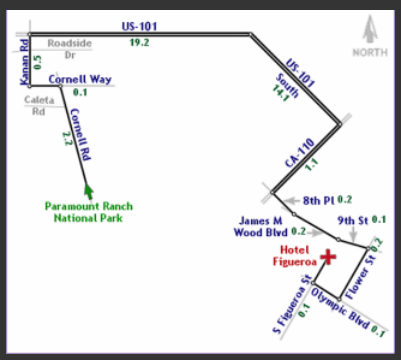
Principles for designing effective visualizations

Better tools to produce visualizations

Route Maps

Overlaid Route

Sketched Route

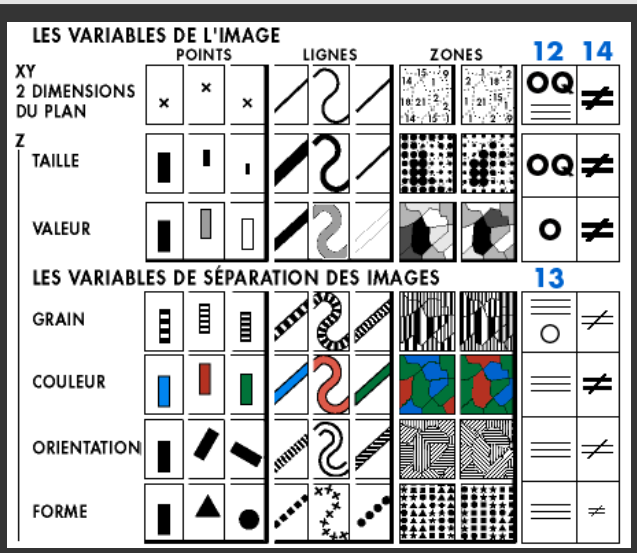


1. **Find cognitive and perceptual principles**
2. **Optimize the visualization according to these principles**

Agrawala and Stolte, Rendering Effective Route Maps, SIGGRAPH 2001

Topics

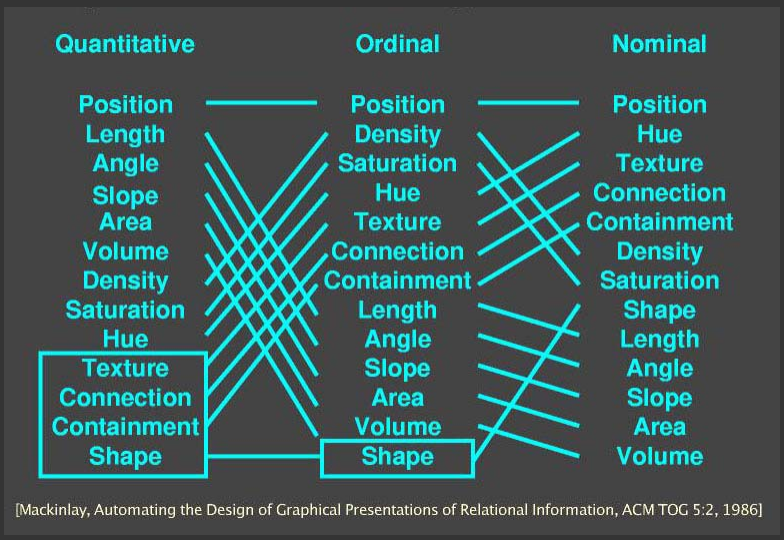
1. Data and Image Models



Bertin, The Semiology of Graphics

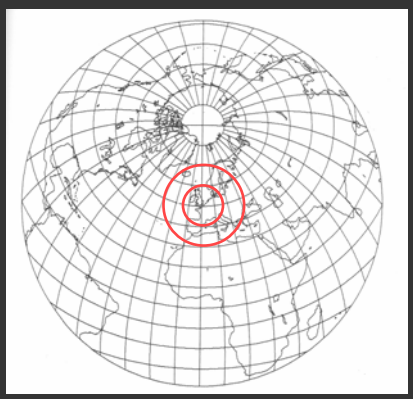
http://www.sciences-po.fr/cartographie/cartographie_html/5_page5theorie/graphique_bertin2001/index.html

2. Perception and Cognition



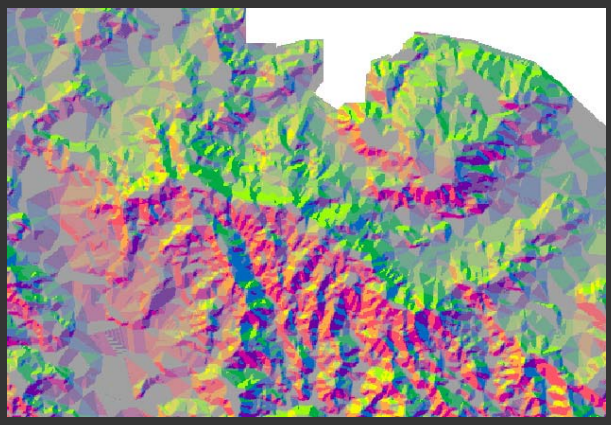
[Mackinlay, Automating the Design of Graphical Presentations of Relational Information, ACM TOG 5:2, 1986]

3. Spatial Encodings



Equiheading vs. Equidistance Projection

4. Color



From C. Brewer

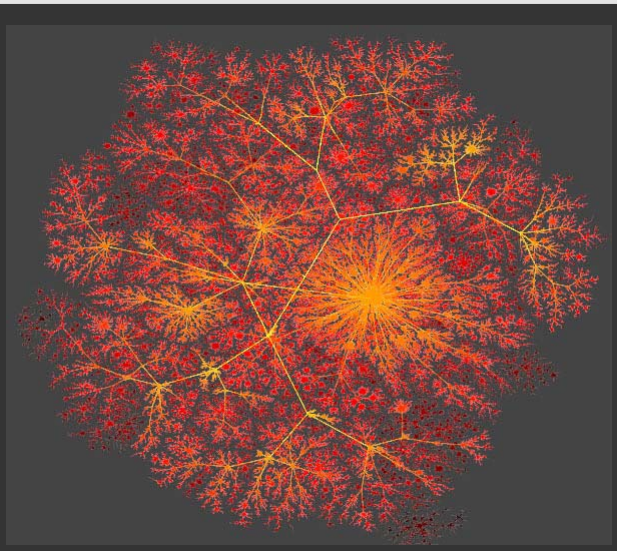
5. Interaction

Gibson's Experiment
Goal: Match 2 shapes
Active touch: 96%
Passive (rotation) 72%
Passive (imprint) 49%

From J. J. Gibson (1966)
The Senses Considered as a Perceptual System, p. 124

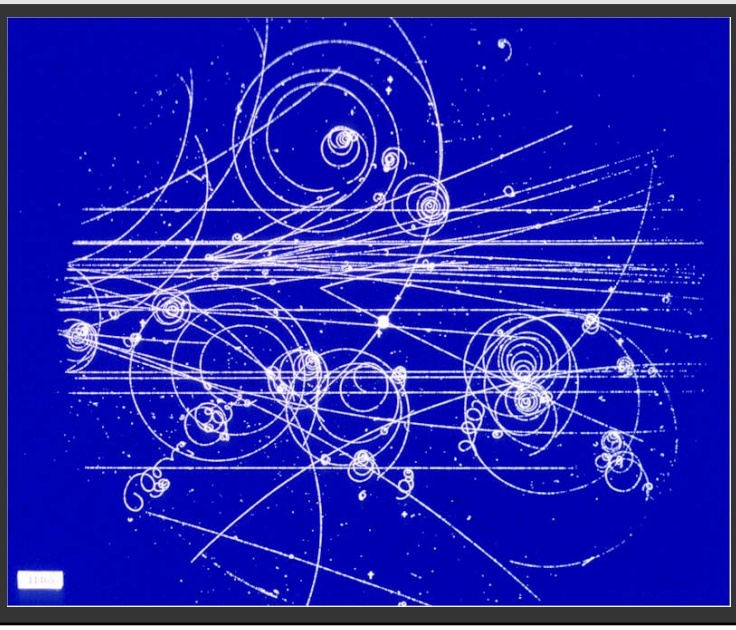
Thanks to David Kirsh for this example.

6. Drawing Trees and Graphs



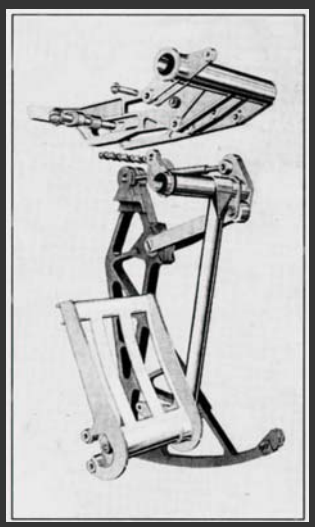
Internet colored by distance from a source host
www.lumeta.com

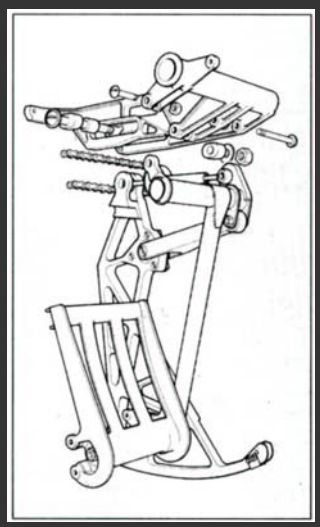
7. Self-Illustrating Phenomena



8. Conveying Shape

Good views
Lines
Shading
Texture

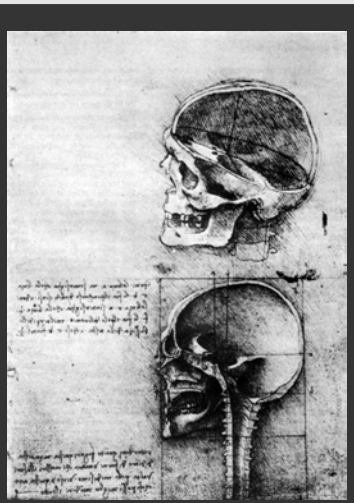




From Gooch[2]

9. Conveying Structure

Karl Heinz Hoehne's Voxel-Man
Images of the Visible Man



Leonardo's Notebooks

10. Motion and Animation

Outside-In, Geometry Computing Center