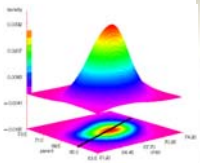
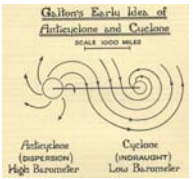
Galton's Greatest Graphical Discovery:

A short story of visual thinking from the *Milestones Project*

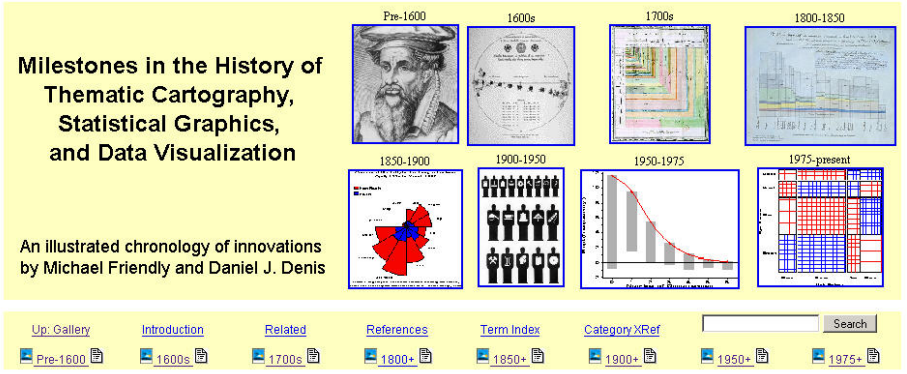
Michael Friendly

Psychology In-house Conference
April 30, 2007

(Slides at: www.math.yorku.ca/SCS/Papers/inhouse-2007-galton.pdf)

Milestones Project

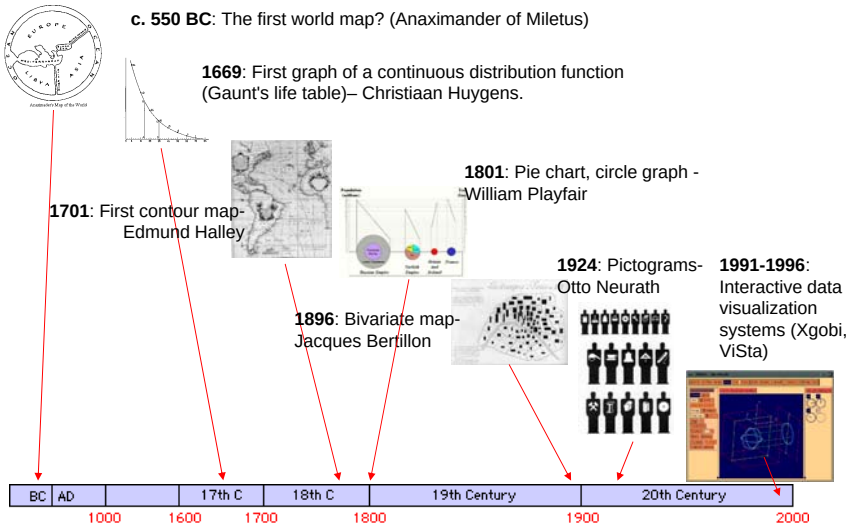
www.math.yorku.ca/SCS/Gallery/milestone



Project goals:
- Comprehensive catalog of developments in history of data visualization
- Tool to study themes, antecedents, influences, patterns, trends, etc.

Milestones: Content Overview

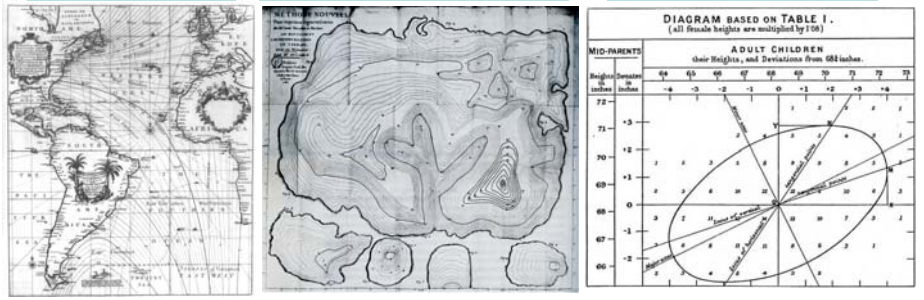
Every picture has a story – Rod Stewart



Background: Escaping flatland

3D maps & graphs from Halley to Galton

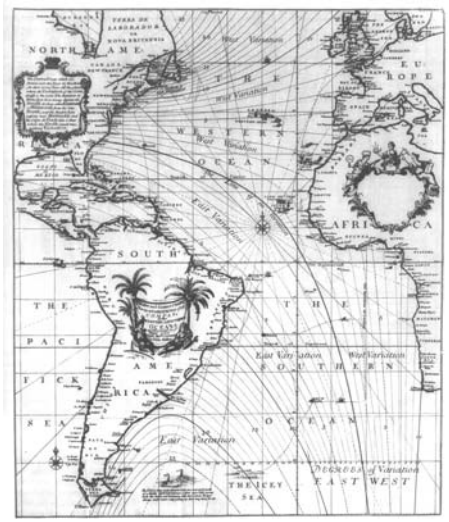
1701: Halley | **1782**: du Carla-Boniface | **1866**: Galton



Early 3D maps & graphs

1701: Halley's contour maps showing curves of equal value (an isogonic map: lines of equal magnetic declination for the world) -- possibly the first thematic contour map of a data-based variable.

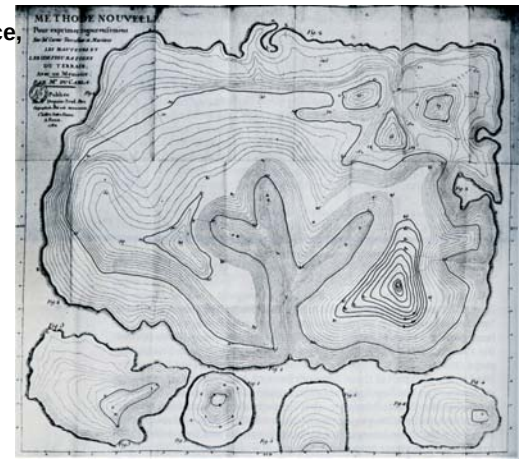
Visual ideas:
- curves showing equal value on a (lat, long) map.
- Interpolation from observed data
- Good use for oceans on maps



Early 3D maps & graphs

1782: **Marcellin du Carla-Boniface, France**
First topographical map, showing contours of equal elevation.

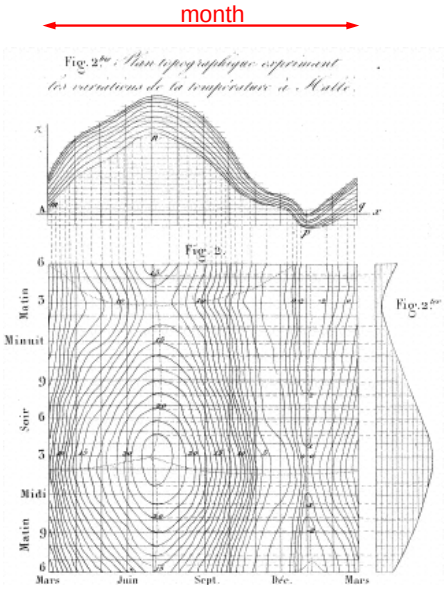
Visual ideas:
- Contours: horizontal slices of a landscape
- Spacing indicates slope



3D maps → Graphs

1843: Léon Lalanne, France
Contour diagram of a table: temperature ~ hour x month

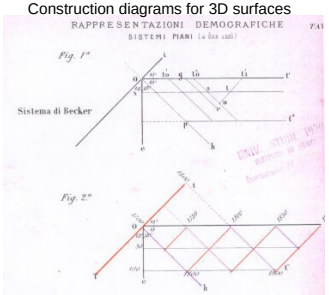
Visual ideas:
- Ordered table like a map
- 3D level curves
- 2D marginal projections
- multiple views: plan, elevation, section

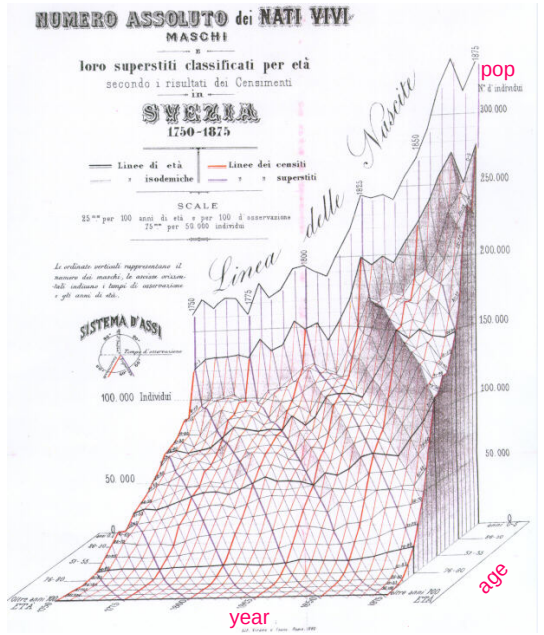


1879: Luigi Perozzo, Italy
Stereogram (3D population pyramid) modeled on actual data (Swedish census, 1750--1875)

Visual ideas:
- isometric projection
- 3D stereogram

Construction diagrams for 3D surfaces





Galton's discovery of the bivariate normal correlation surface (1886)

Table 9.1 One of Galton's correlation tables

Height of the mid-parent in inches	Height of the adult child													
	<61.7	62.2	63.2	64.2	65.2	66.2	67.2	68.2	69.2	70.2	71.2	72.2	73.2	>73.7
>73.0	—	—	—	—	—	—	—	—	—	—	—	1	3	—
72.5	—	—	—	—	—	—	—	1	2	1	2	7	2	4
71.5	—	—	—	—	1	3	4	3	5	10	4	9	2	2
70.5	1	—	1	—	1	1	3	12	18	14	7	4	3	3
69.5	—	—	1	16	4	17	27	20	33	25	20	11	4	5
68.5	1	—	7	11	16	25	31	34	48	21	18	4	3	—
67.5	—	3	5	14	15	36	38	28	38	19	11	4	—	—
66.5	—	3	3	5	2	17	17	14	13	4	—	—	—	—
65.5	1	—	9	5	7	11	11	7	7	5	2	1	—	—
64.5	1	1	4	4	1	5	5	—	2	—	—	—	—	—
<64.0	1	—	2	4	1	2	2	1	1	—	—	—	—	—
Totals	5	7	32	59	48	117	138	120	167	99	64	41	17	14
Medians	—	—	66.3	67.8	67.9	67.7	67.9	68.3	68.5	69.0	69.0	70.0	—	—

Source: Galton (1886), p. 68.

Visual smoothing → Insight

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70.5	1	—	1	—	1	1	3	12	18	14	7	4	3	3
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64.5	1	1	4	4	1	5	5	—	2	—	—	—	—	—
<64.0	1	—	2	4	1	2	2	1	1	—	—	—	—	—
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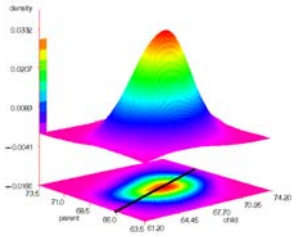
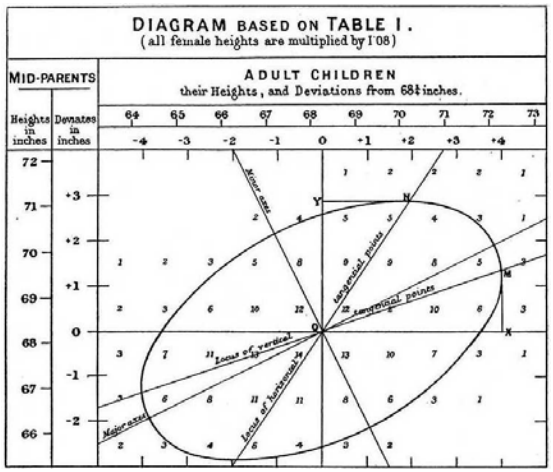
Source: Galton (1886), p. 68.

Visual insight → Theory

- Level curves are **ellipses**
- Regression lines are loci of conjugate **tangents**



… that Galton should have evolved all this … is to my mind one of the most note-worthy scientific discoveries arising from analysis of pure observation (Pearson 1920, p37)



Galton (1886, Pl X): Smoothed contours of heights of parents and children

Galton's discovery of weather patterns-

The most notable *purely graphic* discovery ever!

METEOROGRAPHICA,

OR

METHODS OF MAPPING THE WEATHER;

ILLUSTRATED BY UPWARDS OF 600 PRINTED AND LITHOGRAPHED DIAGRAMS

REFERRING TO

THE WEATHER OF A LARGE PART OF EUROPE,

During the Month of December 1861.

By FRANCIS GALTON, F.R.S.

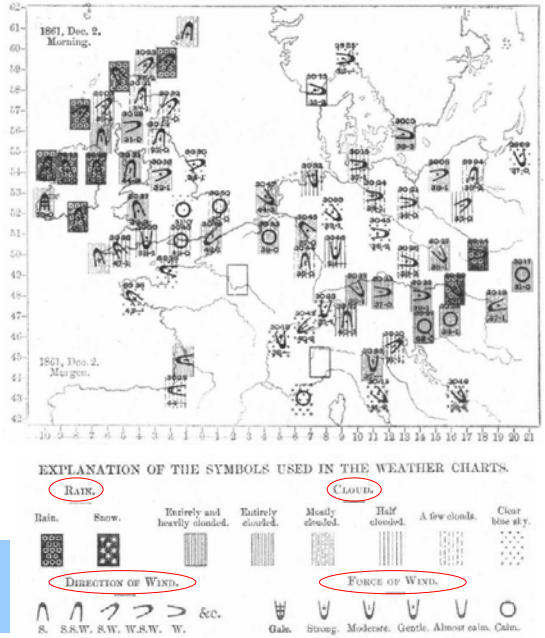
(Galton, 1863)

Method: All weather stations across Europe asked to record data 3x/day for all of Dec., 1861

Data: recordings of barometric pressure, wind dir/speed, rain, temp., cloud: 3x/day, 50 weather stations in Europe.

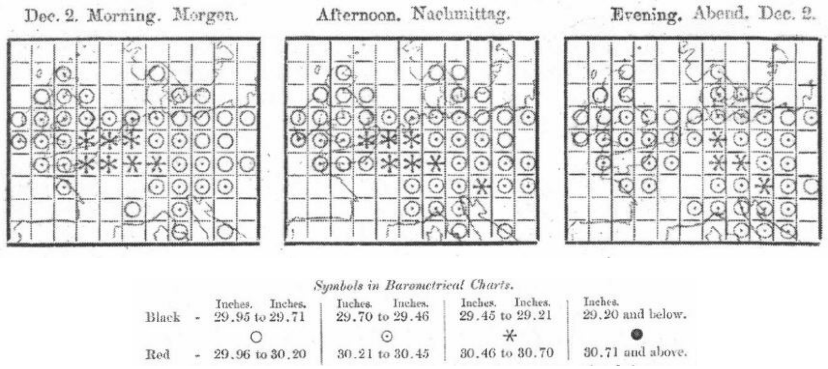
Graphic analysis: 3x31=93 maps, each with multivariate glyphs showing all variables

Visual ideas:
- Iconic symbols
- Multivariate glyphs (stamps!)



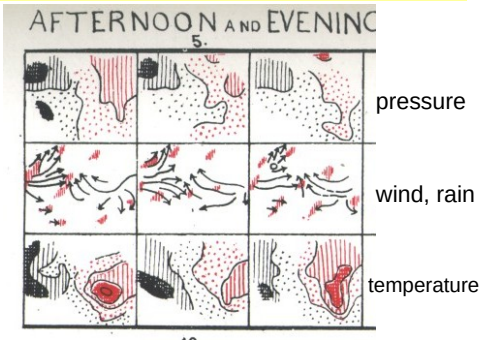
Visual abstraction → Patterns

How to see patterns of geographical variation over time?
- Iconic symbols on a geographical grid
- "Small multiples:" separate graphs laid out for direct comparison



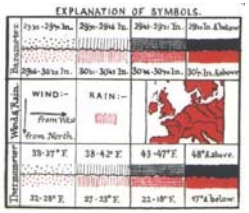
Visual abstraction → Patterns

What varies with what, over time and space?
- mini, abstract maps: vars x TOD
- iso-contours, shading to show equivalence
- arrows to show wind direction



AM noon PM

Data for Dec 5, 1861

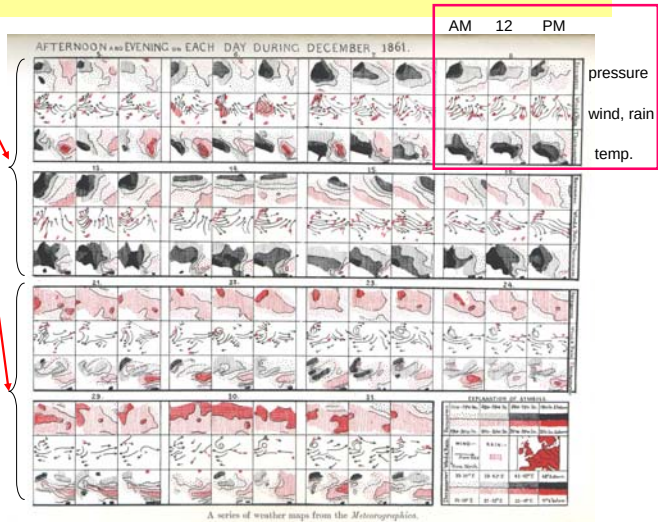


The large picture → Insight

Pattern:
Low pressure (black) in early Dec. → CCW wind
High pressure (red) in late Dec. → CW wind

Graphic: 3x3x31 grid, mapping {pressure, wind/ rain, temperature} x {AM, 12, PM} x day {1:31}

(try this with your software!)



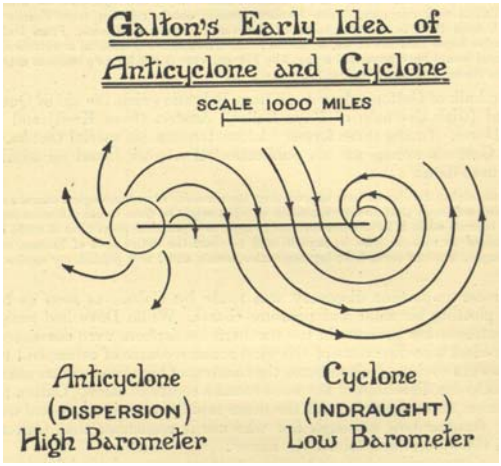
Visual insight → Theory

Visual insight from 93 (3x31) high-D graphs:
• Changes in wind dir w/ pressure over time
• → Winds revolve inwardly (CCW) in low pressure areas– as in a cyclone;
• → revolve outwardly (CW) in high pressure areas– "anti-cyclone"

Theory:

• Explained by Dove's 'Law of Gyration'

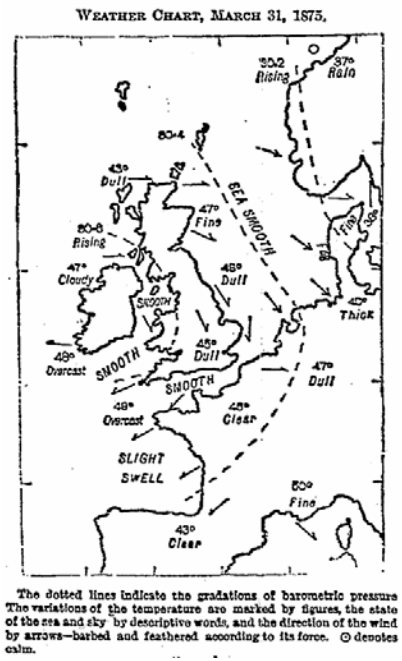
• Prediction: reversed pattern (CW/CCW) in southern hemisphere – confirmed!

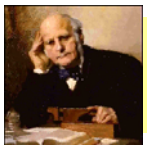


Theory → Practice

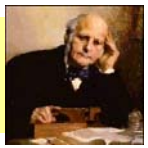
The first modern weather map, *London Times*, Apr. 1, 1875

Galton did for weathermen what Kepler did for Tycho Brahe. This is no small accomplishment. (Wainer 2005)





Conclusions



*You **do** need a weatherman to know which way the wind is blowing* – F. Galton

- When you look at your daily weather map, think of Francis Galton.
- His discoveries illustrate the value of:
  - Visual smoothing → patterns → insight → theory
  - Visual abstraction → patterns → insight → theory
- Modern data visualization has deep roots:
  - Cartography, statistics, data collection
  - Visual thinking, technology
- *Milestones Project* attempts to document them all comprehensively.