Milestones in the history of thematic cartography, statistical graphics, and data visualization*

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1 Introduction

> The only new thing in the world is the history you don't know.
>
> Harry S Truman, quoted by David McCulloch in *Truman*

The graphic portrayal of quantitative information has deep roots. These roots reach into histories of thematic cartography, statistical graphics, and data visualization, which are intertwined with each other. They also connect with the rise of statistical thinking up through the 19th century, and developments in technology into the 20th century. From above ground, we can see the current fruit; we must look below to see its pedigree and germination. There certainly *have* been many new things in the world of visualization; but unless you know its history, everything might seem novel.

A brief overview

The earliest seeds arose in geometric diagrams and in the making of maps to aid in navigation and exploration. By the 16th century, techniques and instruments for precise observation and measurement of physical quantities were well-developed— the beginnings of the husbandry of visualization. The 17th century saw great new growth in theory and the dawn of practice— the rise of analytic geometry, theories of errors of measurement, the birth of probability theory, and the beginnings of demographic statistics and "political arithmetic". Over the 18th and 19th centuries, numbers pertaining to people—social, moral, medical, and economic statistics began to be gathered in large and periodic series; moreover, the usefulness of these bodies of data for planning, for governmental response, and as a subject worth of study in its own right, began to be recognized.

This birth of statistical thinking was also accompanied by a rise in visual thinking: diagrams were used to illustrate mathematical proofs and functions; nomograms were developed to aid calculations; various graphic forms were invented to make the properties of empirical numbers– their trends, tendencies, and distributions— more easily communicated, or accessible to visual inspection. As well, the close relation of the numbers of the state (the origin of the word "statistics") and its geography gave rise to the visual representation of such data on maps, now called "thematic cartography".

Maps, diagrams and graphs have always been (and continue to be) hard to produce, still harder to publish. Initially they were hand drawn, piece-by-piece. Later they were etched on copper-plate and manually

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colored. Still later, lithography and photo-etching, and most recently, computer software was used, but graphic-makers have always had to struggle with the limitations of available technology— and still do today. Some note-worthy places in the history of visualization must therefore be reserved for those who contributed to the technology.

Most recently, advances in statistical computation and graphic display have provided tools for visualization of data unthinkable only a half century ago. Similarly, advances in human-computer interaction have created completely new paradigms for exploring graphical information in a dynamic way, with flexible user control.

While most of the recent contributions listed here relate to the visual display of statistical data, there has also been considerable interplay with advances in information visualization more generally, particularly for the display of large networks, hierarchies, data bases, text, and so forth, where problems of very-large scale data present continuing challenges.

Varieties of data visualization

Information visualization is the broadest term that could be taken to subsume all the developments described here. At this level, almost anything, if sufficiently organized, is information of a sort. Tables, graphs, maps and even text, whether static or dynamic, provide some means to see what lies within, determine the answer to a question, find relations, and perhaps apprehend things which could not be seen so readily in other forms.

In this sense, information visualization takes us back to the earliest scratches of forms on rocks, to the development of *pictoria* as mnemonic devices in illuminated manuscripts, and to the earliest use of diagrams in the history of science and mathematics.

But, as used today, the term *information visualization* is generally applied to the visual representation of large-scale collections of non-numerical information, such as files and lines of code in software systems [61], library and bibliographic databases, networks of relations on the internet, and so forth. In this document we avoid both the earliest, and most of the latest uses in this sense.

Another present field, called *scientific visualization*, is also under-represented here, but for reasons of lack of expertise rather than interest. This area is primarily concerned with the visualization of 3-D+ phenomena (architectural, meterological, medical, biological, etc.), where the emphasis is on realistic renderings of volumes, surfaces, illumination sources, and so forth, perhaps with a dynamic (time) component.

Instead, we focus on the slightly narrower domain of ***data visualization***, the science of visual representation of “data”, defined as information which has been abstracted in some schematic form, including attributes or variables for the units of information. This topic could be taken to subsume the two main focii: statistical graphics, and thematic cartography.

Both of these are concerned with the visual representation of quantitative and categorical data, but driven by different representational goals. Cartographic visualization is primarily concerned with representation constrained to a spatial domain; statistical graphics applies to any domain in which graphical methods are employed in the service of statistical analysis. There is a lot of overlap, but more importantly, they share common historical themes of intellectual, scientific, and technological development.

In addition, cartography and statistical graphics share the common goals of visual representation for exploration and discovery. These range from the simple mapping of locations (land mass, rivers, terrain), to spatial distributions of geographic characteristics (species, disease, ecosystems), to the wide variety of graphic methods used to portray patterns, trends, and indications.

Milestones Project

> The past only exists insofar as it is present in the records of today. And what those records are is determined by what questions we ask.
>
> Wheeler [286, p. 24]

There are many historical accounts of developments within the fields of probability [106], statistics [200, 212, 243], astronomy [221], cartography [282], which relate to, *inter alia*, some of the important developments contributing to modern data visualization. There are other, more specialized accounts, which focus on the early history of graphic recording [123, 124], statistical graphs [84, 85, 229, 254], fitting equations to empirical data [64], cartography [81, 146] and thematic mapping [225, 198], and so forth; Robinson [225, Ch. 2] presents an excellent overview of some of the important scientific, intellectual, and technical developments of the 15th–18th centuries leading to thematic cartography and statistical thinking.

But there are no accounts that span the entire development of visual thinking and the visual representation of data, and which collate the contributions of disparate disciplines. In as much as their histories are intertwined, so too should be any telling of the development of data visualization. Another reason for interweaving these accounts is that practitioners in these fields today tend to be highly specialized, and unaware of related developments in areas outside their domain, much less their history. Extending Wheeler [286], the records of history also exist insofar as they are collected, illustrated, and made coherent.

This listing is but an initial step in portraying the history of the visualization of data. We started with the developments listed by Beniger and Robyn [19] and incorporated additional listings from Hankins [110], Tufte [258, 259, 260], Heiser [118], and others (now too numerous to cite individually). In most cases, we cite original sources (where known) for the record; occasional secondary sources are included as well, where they appear to contribute to telling the story.

To convey a real sense of the accomplishments requires much more context— words, images, and, most usefully, interpretation. In this chronological listing, it has proved convenient to make divisions by epochs, and we provide some more detailed commentaries for each of these. The careful reader will be able to discern other themes, relations, and connections, not stated explicitly.

More importantly, we envisage this Milestones Project as the beginning of a contribution to historiography, on the subject of visualization. One goal is to provide a flexible, and useful multi-media resource, containing descriptions of events and developments, illustrative images, and links to related sources (web and in print) or more detailed commentaries. Another goal is to build a database which collects, catalogs, organizes, and illustrates these significant historical developments.

The present listing is simply chronological, but, as noted above, we provide some overview for each epoch. We have also begun coding the listings to be dynamically searchable by other criteria, for example by person, place, theme, content, and so forth. A parallel web version may be viewed on the Gallery of Data Visualization site at:

> Milestones web site: http://www.math.yorku.ca/SCS/Gallery/milestone/

In the listings below, PIC: refers to a web link (URL) to a portrait, while IMG: and FIG: refer to graphic images (FIG for a larger copy of an IMG). To allow more extensive treatments, with commentaries on some people, events, or topics, we use TXT: to refer to a link to related text.

These links should be active in the `.pdf` and web versions of this document. As a result, the web URLs do not appear in a printed copy, and the many portraits and images we have collected are implicit, rather than shown inline.

2 Pre-17th Century: Early maps and diagrams

> The earliest seeds of visualization arose in geometric diagrams, in tables of the positions of stars and other celestial bodies, and in the making of maps to aid in navigation and exploration. We list only a few of these here to provide some early context against which later developments can be viewed.
>
> In the 16th century, techniques and instruments for precise observation and measurement of physical quantities were well-developed. As well, we see initial ideas for capturing images directly, and recording mathematical functions in tables. These early steps comprise the beginnings of the husbandry of visualization.

c. 6200 BC 6200BCUnknown The oldest known map? (There are several claimants for this honor.)— unknown, Museum at Konya, Turkey.

IMG: Konya town map (280 x 160; 7K)
FIG: Konya town map (555 x 317; 24K)
TXT: Town map, with an errupting volcano (Hasan Daö?) and the Konya plain
TXT: An extended description of the most ancient maps

c. 550 BC 550BCMiletus The first world map? (No extant copies, but described in books II and IV of Herodotus' "Histories" [226]— Anaximander of Miletus (c.610BC–546BC), Turkey.
FIG: The first world map (325 x 326; 3K)
TXT: Anaximander biography

366–335 BC 335BCPeutinger The first route map ("carte routière"), showing the whole of the Roman world, a map from Vienna, through Italy, to Carthage; painted on parchment, 34 cm. high, by 7 m. in length. (Named the table of Peutinger, after a 16th century German collector.)— Italy. 06/21/05:YL
FIG: Peutinger map (1251 x 833; 330k)
TXT: Peutinger map background
TXT: Peutinger map images

240 BC 240BCEratosthenes Calculation of the diameter of the earth by measuring noontime shadows at sites 800 km. apart— Eratosthenes (of Cyrene) (276–194BC), Libya. 06/24/05:YL
TXT: Eratosthenes biography
TXT: Eratosthenes of Cyrene

170 BC 170BCparchment Invention of parchment. Parchment was superior to papyrus because it could be printed on both sides and folded.— Pergamon. 06/25/05:YL
TXT: History of parchment

134 BC 134BCHipparchus Measurement of the year with great accuracy and building of the first comprehensive star chart with 850 stars and a luminosity, or brightness, scale; discovery of the precision of the equinoxes— Hipparchus (of Rhodes) (190–120BC), Turkey. 06/24/05:YL
TXT: Astronomy
TXT: Hipparchus the Astronomer
TXT: Hipparchus biography

c. 105 105Lun Invention of paper, replacing (somewhat later) writing and other inscriptions on wood, cloth, stone, etc.—Tsai Lun, China 04/22/05
PIC: Tsai Lun portrait (180 x 180; 14K)
TXT: Tsai Lun, portrait and biography
TXT: Timeline of paper making

c. 150 150Ptolemy Map projections of a spherical earth and use of latitude and longitude to characterize position (first display of longitude)— Claudius Ptolemy (c. 85–c. 165), Alexandria, Egypt.
PIC: Ptolemy, portrait from ca. 1400 (90 x 109; 9K)
FIG: Ptolemy's world map, republished in 1482 (640 x 496; 40K)
TXT: Ptolemy world map description, with images
TXT: The world according to Ptolemy
TXT: Ptolemy's world map, description and high-res image
TXT: Ptolemy history

c. 950 950Unknown Earliest known attempt to show changing values graphically (positions of the sun, moon, and planets throughout the year)— Europe [84].
IMG: see [258, p. 28]
IMG: Planetary movements icon (222 x 124; 19K)
FIG: Planetary movements diagram (750 x 420; 92K)

c. 1280 1280Llull Triangular diagrams of paired comparisons for electoral systems (how to elect a Pope or Mother Superior, when all the candidates are voting)— Ramon Llull (1235–1316), Spain [159].

TXT: Llull portraits
TXT: Llull's writings on electoral systems

1305 1305Llull Mechanical diagrams of knowledge, as aids to reasoning (served as an inspiration to Leibnitz in the development of symbolic logic)— Ramon Llull (1235–1316), Spain.
FIG: Llull's tree of knowledge (329 x 467; 79K)
FIG: Llull's mechanical disks (518 x 354; 37K)

c. 1350 1350Oresme Proto-bar graph (of a theoretical function), and development of the logical relation between tabulating values, and graphing them (pre-dating Descartes). Oresme proposed the use of a graph for plotting a variable magnitude whose value depends on another, and, implicitly, the idea of a coordinate system— Nicole Oresme (Bishop of Lisieus) (1323–1382), France [192, 193]
PIC: Oresme portrait (268 x 326; 19K)
IMG: Oresme bar graph (225 x 117; 6K)
IMG: Page from Oresme (453 x 600; 19K)

1375 1375Cresques Catalan Atlas, an exquisitely beautiful visual cosmography, perpetual calendar, and thematic representation of the known world— Abraham Cresques (1325–1387), Majorca, Spain.
IMG: Carte de l'Europe, de l'Afrique du Nord et du Proche-Orient, BNF, ESP 30 (266 x 168; 48K)
IMG: Carte de l'Europe, de l'Afrique du Nord et du Proche-Orient, BNF, ESP 30 (747 x 508; 195K)
FIG: Catalan Atlas, detail: Europe, North Africa (747 x 508; 195K)
TXT: BNF description of Atlas catalan (BNF, ESP 30)
TXT: BNF listing of images from the Catalan Atlas
TXT: Detailed description of Catalan Atlas and Abraham Cresques (Henry-Davis)

c. 1450 1450Cusa Graphs of distance vs. speed, presumably of the theoretical relation — Nicolas of Cusa (1401–1464), Italy.
TXT: Cusa biography
TXT: Annotated links: Nicolas of Cusa on the Web

1453 1453Gutenberg Invention of moveable type printing press, and printing of the Mazarin bible (leads to a decline in the use of mixed text and graphics)— Johann Gutenberg (1387–1468), Germany.
PIC: Gutenberg portrait (124 x 114; 8K)
IMG: Gutenberg type sample (116 x 145; 5K)
FIG: Page from the Mazarin bible (375 x 952;196K)

c. 1500 1500Vinci Use of rectangular coordinates to analyze velocity of falling objects— Leonardo da Vinci (1452–1519), Florence, Italy [275].
PIC: da Vinci portrait (168 x 254; 10K)
TXT: biography of Leonardo da Vinci
IMG: The 'Arnovalley', the first known and dated work of Leonardo da Vinci (220 x 148; 13K)

1530 1530Gemma-Frisius Theoretical description of how longitude may be determined using difference of times by a clock and the associated observed change in star positions (not implemented)— Regnier Gemma-Frisius (1508–1555), Leuven [82].
PIC: Gemma Frisius portrait (90 x 109; 4K)
TXT: Frisius biography

1533 1533Gemma-Frisius Description of how to determine mapping locations by triangulation, from similar triangles, and with use of angles w.r.t meridians— Regnier Gemma-Frisius (1508–1555), Leuven [83].
PIC: Gemma Frisius at his desk surrounded by instruments and books (200 x 139; 30K) .
FIG: Image from Peter Apianius Cosmographia, edited by Gemma Frissius (383 x 503; 70K)
FIG: Gemma-Frisius Diagram of triangulation (272 x 400; 21K)
TXT: Frisius biography
TXT: Cosmographia web site

1545 1545Gemma-Frisius The first published illustration of a camera obscura, used to record an eclipse of the sun, on January 24, 1544.— Regnier Gemma-Frisius (1508–1555), Leuven [96].
IMG: Camera obscura (357 x 250; 40K)
FIG: Camera obscura (485 x 340; 90K)
TXT: Adventures in Cybersound: The Camera Obscura
TXT: Science, Optics and You - Timeline, 1000-1599

1550 1550Rheticus Trigonometric tables (published 1596 posthumously)— Georg Joachim Rheticus (1514–1574), Germany.
TXT: Rheticus biography

1556 1556Tartaglia Development of a method to fix position and survey land using compass-bearing and distance. (Tartaglia is better known for discovering a method to solve cubic equations) — Niccolo Fontana Tartaglia (1499–1557), Italy [249].
PIC: Tartaglia portrait (268 x 326; 19K)
TXT: Tartaglia biography

1562 1663Cardano *Liber de Ludo Alaea*, a practical guide to gambling, containing the first systematic computation of probabilities; written in 1562, but not published until 1663.— Gerolamo Cardano (1501–1576), Italy [35, 50]. 06/25/05:YL
TXT: Cardano (Galileo project)
TXT: Cardano biography

1569 1569Mercator Invention of cylindrical projection for portraying the globe on maps, to preserve straightness of rhumb lines— Gerardus Mercator (1512–1594), Belgium [230].
PIC: Mercator portrait (356 x 400; 34K)
FIG: Mercator's 1569 *Nova et Aucta Orbis Terrae* map (495 x 643; 145K)
TXT: Mercator biography, with related links
TXT: Mercator biography, with images

1570 1570Ortelius The first modern atlas, *Teatrum Orbis Terrarum*— Abraham Ortelius (Ortel) (1527–1598), Antwerp [194].
PIC: Ortelius portrait (160 x 217; 18K)
IMG: Map of the Netherlands, small (200 x 147; 32K)
FIG: Map of the Netherlands, medium (590 x 435; 255K)
FIG: Ortelius world map, from De Camp 1970 (700 x 874; 174K)
TXT: Overview of Ortelius and the Teatrum
TXT: Maps from Teatrum Orbis Terrarum

1572 1572Brahe Improvements in instruments for accurately measuring positions of stars and planets, providing the most accurate catalog on which later discoveries (e.g., Kepler's laws) would be based— Tycho Brahe (1546–1601), Denmark. 2/15/05
PIC: Tycho Brahe portrait (280 x 306; 27K)
FIG: Tycho Brahe's wall quadrant (290 x 450; 35K)
FIG: Parallax diagram (286 x 372; 31K)
TXT: Tycho Brahe "home page"
TXT: Galileo project summary of Brahe
TXT: Tycho Brahe biography

1581 1581Galilei Discovery of isosynchronous property of the pendulum (to be used for clocks and measurement)— Galileo Galilei (1564–1642), Italy.
TXT: Properties of the pendulum
TXT: Galileo's pendulum experiments §2: 26 items

3 1600-1699: Measurement and theory

Among the most important problems of the 17th century were those concerned with physical measurement— of time, distance, and space— for astronomy, surveying, map making, navigation and territorial expansion. This century saw great new growth in theory and the dawn of practice— the rise of analytic geometry, theories of errors of measurement and estimation, the birth of probability theory, and the beginnings of demographic statistics and "political arithmetic".

By the end of this century, the necessary elements were at hand— some real data of significant interest, some theory to make sense of them, and a few ideas for their visual representation. Perhaps more importantly, one can see this century as giving rise to the beginnings of visual thinking.

early 1600s 1600sUnknown Tables of empirical data, published tables of numbers begin to appear. "Die Tabellen-Statistik," as a branch of statistics devoted to the numerical description of facts— Germany.

1603 1603Nautonier Tables, and first world map showing lines of geomagnetism (isogons), used in work on finding longitude by means of magnetic variation. The tables give the world distribution of the variation, by latitude, along each of the meridians— Guillaume Le Nautonier (1557–1620), France [186, 161]. 2/15/05
PIC: Le Nautonier portrait ((156 x 199; 56K))
TXT: Biographical sketch
FIG: Le Nautonier's geomagentic map (566 x 381; 93K)
FIG: Modern re-creation of the magnetic equator after Le Nautonier (888 x 459; 16K)

1603 1603Scheiner The pantograph was invented for mechanically copying a figure on an enlarged or reduced scale— Christopher Scheiner (1575–1650), Italy.
PIC: Scheiner's portrait
FIG: Scheiner's pantograph (224 x 136; 4.5K)
TXT: Scheiner's sunspots, equatorial mount and pantograph

1610 1610Galilei The first astronomical pictures ever printed, from observations through a telescope, used to illustrate discoveries of craters on the moon, the 4 staelites of Jupiter and a vast number of stars never seen by unaided eyes— Galileo Galilei (1564–1642), Italy [88] 07/04/06:MF
FIG: Cover page from Sidereus Nuncius (500 x 672; 81K)
FIG: Page 9v: craters on the moon (226 x 366; 32K)
TXT: Works of Galileo: Starry Messenger

1614 1614Napier Invention of logarithms, and the first published tables of logarithms— John Napier (1550–1617), Scotland [185].
PIC: Napier portrait (268 x 326; 9.6K)
FIG: Two pages from Napier's table of logarithms (1330 x 1014; 352K)
FIG: Diagram of spherical triangles from [185] (500 x 760; 42K)
TXT: Biography of Napier
TXT: Text of *A Description of the Admirable Table of Logarithms* (with images)

1617 1617Snell First use of Frisius' method of trigonometric triangulation to produce locations of major cities in Holland; foundation of geodesy— Willebrord van Roijen Snell (Snellius) (1580–1626), Leiden [240].
PIC: Snellius portrait (200 x 257; 49K)
TXT: Snell, biographical sketch

1620–1628 1620Gunter Invention of a mechanical device, containing a logarithmic scale of equal parts and trigonomic functions which, with the aid of a pair of calipers, could be used as a slide rule. This device, called "Gunter's scale," or the "gunter" by seamen, was soon replaced by a true slide rule, containing

two parallel logarithmic scales— Edmund Gunter (1581–1626) and William Oughtred (1574–1660), England [9, 105].
TXT: Edmund Gunter - Biographical sketch
TXT: Edmund Gunter - Biography
TXT: William Oughtred - Biography
IMG: Gunter's log scale(398 x 39; 0.5K)
IMG: Oughtred's dual log scale (442 x 52; 1K)
FIG: Gunter's scale image (2200 x 176; 110K)

1623 1623Schickard The first known adding machine, a mechanical calculator called the "Calculating Clock." It could add and subtract up to six-digit numbers, based on the movement of six dented wheels geared through a "mutilated" wheel which with every full turn allowed the wheel located at the right to rotate 1/10th of a full turn—Wilhelm Schickard (1592–1635), Tubingen, Germany. 04/06/05
IMG: Schickard's calculating clock icon (133 x 114; 4.6K)
FIG: reproduction of Schickard's calculating clock (300 x 244; 34K)
TXT: Schickard biography
TXT: History of mechanical calculators - Part 1

1626 1626Scheiner Visual representations used to chart the changes in sunspots over time. Also, the first known use of the idea of "small multiples" to show a series of images in a coherent display— Christopher Scheiner (1575–1650), Italy [231].
IMG: Scheiner sunspot image (135 x 150; 4K)
FIG: Apparatus for recording sunspots (600 x 320; 68K)
TXT: A brief history of sunspots
FIG: Sunspot plate from Scheiner's "Tres Epistolae" (650 x 505; 250K)

1632 1632Galilei Statistical analysis of observations on location of Tycho Brahe's star of 1572, based on idea that the most probable hypothesis is the one having the smallest (least absolute value) deviations— Galileo Galilei (1564–1642), Italy [89] [106, §10.3].
PIC: Galileo portrait (190 x 187; 4K)
TXT: Galileo biography

1637 1637Fermat Coordinate system reintroduced in mathematics, analytic geometry; relationship established between graphed line and equation—Pierre de Fermat (1601–1665) and René Descartes (1596–1650), France [53].
PIC: Descartes portrait (200 x 248; 18K)
TXT: Biographical sketch - Rene Descartes
TXT: Biographical sketch - Pierre de Fermat

1644 1644Langren First visual representation of statistical data: variations in determination of longitude between Toledo and Rome— Michael F. van Langren (1600–1675), Spain [155].
IMG: Langren image (532 x 131; 11K)

1646 1646Kirscher Invention of the first projection lantern (the magic lantern). [Images were painted on glass and projected on walls. Kirscher, a Jesuit priest, was the last recorded ordained priest openly to concern himself with optics. Henceforth, the art of projecting images was classified as an entertainment and curtailed.]— Athanasius Kirscher (1602–1680), Germany [144].
PIC: Althanasius Kircher portrait (180 x 220; 39K)
IMG: a Sturm Lantern, 1676 (100 x 120; 1K)
TXT: Jesuits and the Sciences, 1660–1719
TXT: Jesuits and the Sciences, 1660–1719

1654 1654Pascal Initial statements of the theory of probability— Blaise Pascal (1623–1662) and Pierre de Fermat (1601–1665), France.
PIC: Pascal portrait (200 x 229; 41K)
TXT: Pascal biography, extract from [11]

1654 1654Petty The first large scale attempt at a scientific, economic survey (of the Irish estates confiscated by Oliver Cromwell), perhaps the first econometric study, leading to development of political arithmetic— William Petty (1623–1687), Ireland [204, 207].
PIC: William Petty portrait (200 x 240; 37K)
FIG: Map of William Petty's Down Survey (350 x 305; 26K)
TXT: Petty - Biographical profile, with links to works and resources
TXT: Political Arithmetick, by Sir William Petty

1657 1657Huygens First text on probability— Christiaan Huygens (1629–1695), Netherlands [131].
PIC: Huygens portrait (216 x 192; 9K)
TXT: Biographical blurb from [11]
TXT: English translation of De Ratiociniis in Ludo Aleae

1663 1663Wren Automatic recording device (the weather clock) producing a moving graph of temperature and wind direction (in polar coordinates)— Christopher Wren (1632–1723), England [20, 291].
PIC: Wren portrait (210 x 290; 10K)
PIC: Wren portrait (268 x 326; 16K)
TXT: Wren catalog entry from the Galileo Project
TXT: Wren biography (St. Andrews)

1662 1662Graunt Founding of demographic statistics: Development of the idea that vital statistics (records of christenings and burials in London) could be used to construct life tables. The average life expectancy in London was 27 years, with 65% dying by age 16— John Graunt (1620–1674), England, [103, 245].
PIC: Graunt portrait (526 x 762; 75K)
IMG: Title page of Graunt's Bills of Mortality (309 x 387; 5K)
FIG: Mortality table, from [204] (1000 x 795; 237K)
TXT: Text of Graunt's "Observations on the Bills of Mortailty"

1666 1666Talon First modern complete demographic census, a record of each individual by name of the 3215 inhabitants of New France— Jean Talon (1626–1694), Canada [101, p. 179],[138, p. xix].
TXT: Commentary on first Canadian census by Dan
TXT: The great intendant: A chronicle of Jean Talon in Canada (e-book)
TXT: Jean Talon biography from Statistics Canada

1669 1669Huygens First graph of a continuous distribution function, a graph of Gaunt's life table, and a demonstration of how to find the median remaining lifetime for a person of given age— Christiaan Huygens (1629–1695) (correspondence with his brother Lodewijk), Netherlands
IMG: see [106, Fig. 8.1.1].
IMG: Huygens graph (301 x 284; 1K)
TXT: Huygens - Biographical sketch

1671 1671Witt First attempt to determine scientifically what should be the purchase price of annuities, using mortality tables— Jan de Witt (1625–1672), Netherlands [290].
PIC: de Witt portrait (82 x 109; 5K)
TXT: de Witt biography
TXT: Death and Statistics, including an account of de Witt's method

1686 1686Halley Bivariate plot of a theoretical curve derived from observations (barometric pressure vs. altitude), graphical analysis based on empirical data— Edmond Halley (1656–1742), England [107].
PIC: Halley portrait (254 x 326; 21K)
FIG: Halley's graph of change in barometric pressure (914 x 773; 7K)

1686 1686aHalley First known weather map, showing prevailing winds on a geographical map of the Earth— Edmond Halley (1656–1742), England [107].
PIC: Halley portrait (254 x 326; 21K)

FIG: Halley's weather map, 1686 (512 x 196; 24K)
TXT: Halley - Biographical sketch

1687 1687Petty Use of statistics for international comparisons, e.g., London vs. Rome and London vs. Paris, compared in people, housing, hospitals, etc.— William Petty (1623–1687), England [205, 206].
PIC: Petty portrait (137 x 194; 3K)

1693 1693Halley First real mortality tables, containing the ages at death of a stable sample of individuals under stable conditions (from Breslau Bills of Mortality)— Edmond Halley (1656–1742), England [108].

1693 1693aHalley First use of areas of rectangles to display probabilities of independent binary events— Edmond Halley (1656–1742), England [108].
IMG: Halley's diagram (356 x 237; 1K) §3: 26 items

4 1700-1799: New graphic forms

The 18th century witnessed, and participated in, the initial germination of the seeds of visualization which had been planted earlier. Map-makers began to try to show more than just geographical position on a map. As a results, new graphic forms (isolines and contours) were invented, and thematic mapping of physical quantities took root. Towards the end of this century, we see the first attempts at the thematic mapping of geologic, economic, and medical data.

Abstract graphs, and graphs of functions were introduced, along with the early beginnings of statistical theory (measurement error) and systematic collection of empirical data. As other (economic and political) data began to be collected, some novel visual forms were invented to portray them, so the data could "speak to the eyes".

As well, several technological innovations provided necessary nutrients. These facilitated the reproduction of data images (color printing, lithography), and other developments eased the task of creating them. Yet, most of these new graphic forms appeared in publications with limited circulation, unlikely to attract wide attention.

1701 1701Halley Contour maps showing curves of equal value (an isogonic map, lines of equal magnetic declination for the world, possibly the first contour map of a data-based variable)— Edmond Halley (1656–1742), England [109, 252].
IMG: Halley isogonic map (400 x 468; 57K)
FIG: National maritime museum, Halley magnetic chart
TXT: Halley biography

1710 1710Blon Invention of three-color printing— Jacob Cristoph Le Blon (1667–1741), Germany.
TXT: Le Blon biography
TXT: Origins of the art of colour reproduction
TXT: Color reproduction

1711 1711Arbuthnot First test of statistical significance based on deviation between observed data and a null hypothesis (used to show that the guiding hand of a devine being could be discerned in the nearly constant ratio of male to female births in London over 1629–1710)— John Arbuthnot (1667–1735), England [6, 18].
PIC: Arbuthnot portrait (268 x 326; 14K)
TXT: Arbuthnot biography
FIG: Graph of the sex ratio from 1620–1710

1712 1712Hauksbee Literal line graph, inspired by observation of nature (section of hyperbola, formed by capillary action of colored water between two glass plates)— Francis Hauksbee (1666–1713), England [115].

1724 1724Cruquius Abstract line graph (of barometric observations), not analyzed— Nicolaus Samuel Cruquius (1678–1758), Netherlands [49].

1727 1727Schulze Experiments paving the way to the development of photography: Images obtained by action of light on a mixture of chalk, nitric acid, and silver salts— Johann Heinrich Schulze (1687–1744), Germany.
PIC: Schultze portrait (132 x 181; 7K)
TXT: Schulze biographical blurb

1736–1755 1736Newton Development of the use of polar coordinates for the representation of functions. Newton's *Method of Fluxions* was written about 1671, but not published until 1736. Jacob Bernoulli published a derivation of the idea in 1691. [238, p. 324] attributes the development of polar coordinates to Fontana, with no date.— Isaac Newton (1643–1727), England, and Gregorio Fontana (1735–1803) and Jacob Bernoulli (1654–1705) [238, p. 324]. 06/10/05:MF

1741 1741Sussmilch Beginnings of the study of population statistics (demography)— Johann Peter Süssmilch, Germany [117, 244].
TXT: French translation of "Die göttliche ordnung", 1741
IMG: Sussmilch portrait (191 x 264; 51K)
IMG: Image of a page from Sussmilch's book (421 x 341; 29K)

1748 1748Achenwall First use of the term "statistik." The word "statistics" was first used by Zimmerman in 1787. (For the earlier use of "statist", "statista" and other terms, see [136].)— Gottfied Achenwall (1719–1772), Germany [2, 295]. 06/16/05:YL
TXT: Achenwall biography

1750–1755 1750Mayer Beginnings of the estimation of m unknown quantities from n emipirical equations (where $n > m$), taking account of the possibility of errors in the observations (later supplanted by the method of least squares)— Johanes Tobias Mayer (1723–1762), Germany and Rogerius Josephus Boscovich (1711– 1787) [64, 165, 167].
TXT: Mayer biography
TXT: Boscovich biography

1752 1752Euler Introduction of a notation which gives a name and address to every possible point in 3D space, (x, y, z).— Leonhard Euler (1707–1783), Switzerland [62]. 06/24/05:YL
TXT: De'couverte d'un nouveau principe de mecanique
TXT: Euler biography:

1752 1752Buache Contour map— Phillippe Buache (1700–1733), France [31].
IMG: Buache contour map icon (116 x 90; 2K)
FIG: Buache's 1770 *Carte physique ou Geographie naturelle de la France* (483 x 386; 58K)

1753 1753Barbeu-Dubourg "Carte chronologique": An annotated time line of history (from Creation) on a 54-foot scroll, including names and descriptive events, grouped thematically, with symbols denoting character (martyr, tyrant, heretic, noble, upright, etc.) and profession (painter, theologian, musician, monk, etc.)— Jacques Barbeu-Dubourg (1709–1779), France [65, 277] .
FIG: Dubourg scroll, closed (690 x 595; 65K)
FIG: Dubourg scroll, opened ((466 x 487; 72K)

1758–1772 1758Mayer Diagrams developed to represent color systems. In 1758, Mayer developed a system of constructing and naming many of the possible colours. Lambert extended this with a 3D pyramid indicating "depth" (saturation).— Johanes Tobias Mayer (1723–1762), Moses Harris (1731–1785) and Johann Heinrich Lambert (1728–1777), Germany [153, 168, 112]. 06/14/05:YL
FIG: Johann Heinrich Lambert's color pyramid, from [153] (771 x 582; 510k)
FIG: Tobias Mayer's colour pyramid, from [168] (195 x 184; 596k)
FIG: Moses Harris' prismatic colour mixture system, from[112] (228 x 264; 596k)

1760 1760Lambert Curve-fitting and interpolation from empirical data points— Johann Heinrich Lambert (1728–1777), Germany [151].
PIC: Lambert portrait (192 x 248; 20K)
TXT: Lambert biography

1763 1763Bayes Graph of the beta density— Thomas Bayes (1702–1761), England [13].
PIC: Bayes portrait (304 x 326; 47K)
IMG: Bayes' Graph of the beta density (294 x 334; 4K)
TXT: Essay towards solving a problem in the doctrine of chances
TXT: Bayes biography
TXT: Bayes biography by D. R. Bellhouse

1765 1765Lambert Theory of measurement error as deviations from regular graphed line. (Lambert made the observation that "a diagram does incomparably better service here than a table."[254, p. 204]— Johann Heinrich Lambert (1728–1777), Germany [152, Vol. 1, pp. 424–488].

1765 1765Priestley Historical time line (life spans of 2,000 famous people, 1200 B.C. to 1750 A.D.), quantitative comparison by means of bars— Joseph Priestley (1733–1804), England [215].
PIC: Priestley portrait (216 x 192; 3K)
IMG: Priestley's specimen chart of biography (739 x 353; 69K)
TXT: Priestley biography

1767–1796 1767Lambert Repeated systematic application of graphical analysis (line graphs applied to empirical measurements) — Johann Heinrich Lambert (1728–1777), Germany.

1776 1776Monge Development of descriptive geometry, that leads to engineering drawing— Gaspard Monge (1746–1818), Beaune, France [250, 251]. 06/16/05:YL
PIC: Monge portrait (395 x 512; 85K)
FIG: Monge's system of multiple projections
TXT: Historical development of graphics
TXT: Monge's biography

1778 1778Charpentier Geological map (distribution of soils, minerals)— Johann Friedrich von Charpentier (1738–1805), Germany [37].
TXT: von Charpentier bio blurb (german)

1779 1779Lambert Graphical analysis of periodic variation (in soil temperature), and the first semi-graphic display combining tabular and graphical formats— Johann Heinrich Lambert (1728–1777), Germany [154, 110].
IMG: Lambert graphical table of temperatures (120 x 98; 9K)
FIG: Lambert graphical table of temperatures (381 x 310; 58K)
IMG: Lambert graph of solar warming vs. lattitude icon (120 x 95; 8K)
FIG: Lambert graph of solar warming vs. lattitude (494 x 392; 76K)

1782 1782Crome Statistical map of production in Europe, possibly the first economic and thematic map (shows geographic distribution of 56 commodities produced in Europe)— August Friedrich Wilhelm Crome, Germany [44].
PIC: Crome portrait (552 x 584; 31K)

1782 1782Carla-Boniface First topographical map— Marcellin du Carla-Boniface, France [36].
IMG: du Carla-Boniface topographical map icon (90 x 120; 13K)
FIG: du Carla-Boniface map (447 x 597; 149K)

1782 1782Fourcroy Use of geometric, proportional figures (squares) to compare demographic quantities by superposition, an early "tableau graphique"— Charles de Fourcroy, France [71].
IMG: de Fourcroy's proportional squares (346 x 408; 38K)

IMG: de Fourcroy's proportional squares (600 x 709; 94K)
TXT: Description of de Fourcroy, from Palsky

1785 1785Crome Superimposed squares to compare areas (of European states)— August Friedrich Wilhelm Crome, Germany [45, 191].
FIG: Crome's 1820 Verhaeltness Karte

1786 1786Playfair Bar chart, line graphs of economic data— William Playfair (1759–1823), England [210].
IMG: Playfair bar/line chart: price of wheat and wages (167 x 84; 8K)
FIG: Playfair bar/line chart: price of wheat and wages (504 x 267; 109K)
IMG: Playfair line graph: chart of national debt (70 x 120; 8K)
FIG: Playfair line graph: chart of national debt (390 x 669; 129K)

1787 1787Chladni Visualization of vibration patterns (by spreading a uniform layer of sand on a disk, and observing displacement when vibration is applied)— Ernest Florens Friedrich Chladni (1756–1827), Germany [40]. 06/16/05:YL
PIC: Chladni portrait
FIG: Chladni vibration patterns, from [40] (800 x 496; 158k)
TXT: Chladni biography
TXT: High frequency kink interaction

1794 1794Buxton Patenting and sale of printed graph paper, printed with a rectangular coordinate grid, attests to the growing use of Cartesian coordinates— Dr. Buxton, England

1795 1795Pouchet Multi-number graphical calculation (proto-nomogram: contours applied to multiplication table, later rectified by Lalanne [149])— Louis Ézéchiel Pouchet (1748–1809), France [213].
IMG: Pouchet chart icon (120 x 115; 10K)
FIG: Pouchet's chart of the multiplication table (589 x 567; 111K)

1796 1796Watt Automatic recording of bivariate data (pressure vs. volume in steam engine) "Watt Indicator," (invention kept secret until 1822)— James Watt (1736–1819) and John Southern, England.
IMG: Watt Indicator icon (76 x 120; 9K)
FIG: Watt Indicator photo (892 x 1419; 177K)
TXT: Watt biography

1798 1798Senefelder Invention of lithographic technique for printing of maps and diagrams ("At the time the effect of lithography ... was as great as has been the introduction [of the Xerox machine]" [225, p. 57]) (published in several translations, 1818–19)— Aloys Senefelder (1771–1834), Germany [234].
PIC: Senefelder portrait (200 x 248; 35K)
TXT: History of lithography and portrait
TXT: Senefelder biography

1798 1798Seaman First maps of the incidence of disease (yellow fever), using dots and circles to show individual occurrences in waterfront areas of New York— Valentine Seaman (1770–1817), USA [282, p. 103].
TXT: Origins of mortality mapping
FIG: Seaman's map (840 x 748; 53K)
TXT: Mapping disease: Seaman's maps §4: 33 items

5 1800-1849: Beginnings of modern data graphics

With the fertilization provided by the previous innovations of design and technique, the first half of the 19th century witnessed explosive growth in statistical graphics and thematic mapping, at a rate which would not be equalled until modern times.

In statistical graphics, all of the modern forms of data display were invented: bar and pie charts, histograms, line graphs and time-series plots, contour plots, and so forth. In thematic cartography, mapping progressed from single maps to comprehensive atlases, depicting data on a wide variety of topics (economic, social, moral, medical, physical, etc.), and introduced a wide range of novel forms of symbolism.

1800 1800Howard Use of coordinate paper in published research (graph of barometric variations)— Luke Howard (1772–1864), England [125].
PIC: Luke Howard portrait (170 x 207; 13K)
TXT: Luke Howard biography
TXT: Luke Howard: The man who named clouds

1800 1800Keith Idea for continuous log of automatically recorded time series graphs (of temperature and barometric pressure), also recording the maximum and minimum— Alexander Keith, England [143].

1801 1801Playfair Invention of the pie chart, and circle graph, used to show part-whole relations— William Playfair (1759–1823), England [211].
IMG: Playfair's 1805 *Statistical Representation of the U.S.A.* (265 x 286; 10K)
IMG: Playfair's diagram of population and taxes (474 x 336; 21K)
TXT: Oxford DNB article by Ian Spence (pdf)

1801 1801Smith The first large-scale geological map of England and Wales, setting the pattern for geological cartography, and founding *stratigraphic geology*. Recently called (hyperbolically) "the map that changed the world" [289]. (Smith's map was first drawn in 1801, but the final version was not published until 1815.)— William Smith (1769–1839), England[239, 182].
PIC: William Smith portrait (99 x 169; 4K)
FIG: Smith's 1815 map (244 x 250; 22K)
FIG: Smith's map, in zoomable sections
TXT: William "Strata" Smith on the Web
TXT: William Smith, from "The Rocky Road to Modern Paleontology and Biology"
TXT: William Smith (1769-1839), "The Father of English Geology"
TXT: William Smith, history
TXT: Transcript of pages from Smith's 1816–1824 *Strata Identified By Organized Fossils*

1809 1809Gauss Methods of determining an orbit from at least three observations; presentation of the least squares method— Johann Carl Friedrich Gauss (1777–1855), Germany [95]. 06/24/05:YL
TXT: Gauss biography

1811 1811Humboldt Charts using subdivided bar graphs, and superimposed squares, showing the relative size of Mexican territories and populations in the colonies — Alexander von Humboldt (1769–1859), Germany [128].
PIC: Humboldt portrait, young (761 x 945; 26K)
PIC: Humboldt portrait (200 x 254; 28K)
FIG: von Humboldt charts (578 x 768; 48K)
FIG: Cross-section diagram of the Chimborazo, 1805–07
TXT: Humboldt biography (French)
TXT: von Humboldt biography

1817 1817Humboldt First graph of isotherms, showing mean temperature around the world by latitude and longitude. Recognizing that temperature depends more on latitude and altitude, a subscripted graph shows the direct relation of temperature on these two variables— Alexander von Humboldt (1769–1859), Germany [129].
IMG: von Humboldt isotherm icon (120 x 87; 6K)
FIG: von Humboldt isotherm (492 x 357; 60K)
FIG: von Humboldt isotherms from Berghaus' 1849 Atlas (768 x 577; 79K)
FIG: von Humboldt isotherms, Annals de Chemie et de physique, 1817 (937 x 744; 616K)

1819 1819Dupin Cartogram, map with shadings from black to white (distribution and intensity of illiteracy in France), the first (unclassed) choropleth map, and perhaps the first modern statistical map. (This cartogram dates from 1826 [56, Plate 1, vol. 2] according to Robinson [225, p. 232], rather than 1819 according to Funkhouser [85])— Baron Pierre Charles Dupin (1784–1873), France [57].
PIC: Dupin portrait (393 x 512; 35K)
IMG: Dupin cartogram map of France (220 x 229; 34K)
FIG: Dupin cartogram map of France (1223 x 1270; 426K)
TXT: Dupin biography

1820s 1820sFaraday An increasing number of scientific publications begin to contain graphs and diagrams which describe, but do not analyze, natural phenomena (magnetic variation, weather, tides, etc.)— Michael Faraday (1791–1867), England.
IMG: Faraday diagram of a magnet with lines of force (294 x 373; 13K)
TXT: Michael Faraday's Lines of Force, by Dan Denis
TXT: Faraday biography with portraits

1821 1821Fourier Ogive or cumulative frequency curve, inhabitants of Paris by age groupings (shows the number of inhabitants of Paris per 10,000 in 1817 who were of a given age or over. The name "ogive" is due to Galton.)— Jean Baptiste Joseph Fourier (1768–1830), France [72].
PIC: Fourier portrait (268 x 326; 15K)
IMG: Fourier ogive (750 x 456; 12K)
TXT: Fourier biography

1822 1822Babbage Mechanical device for calculating mathematical tables (the Difference Engine) [The beginnings of computing as we know it today. The Difference Engine was steam-powered, and the size of a locomotive.] — Charles Babbage (1791–1871), England.
PIC: Babbage portrait (280 x 340; 4K)
IMG: Babbage Difference Engine (440 x 437; 31K)
TXT: Babbage biography

1825 1825Gompertz Gompertz curve, derived to describe expected mortality statistics for a population of organisms whose probability of death increases as a function of time— Benjamin Gompertz (1779–1865), England [102]. 06/16/05:YL
TXT: Gompertz bio
TXT: The Gompertz model

1827 1827Niepce First successful photograph produced (an 8-hour exposure). [A type of asphalt (bitumen of Judea) was coated on metal plates. After exposure it was washed in solvents, the light areas were shown by the bitumen, dark areas by bare metal. Exposed to iodine, the plate darkened in the shadowed areas.]— Joseph Nicephore Niépce, France.
PIC: Niepce portrait (75 x 100; 2K)
IMG: Niepce photo, *Point de vue du Gras* (206 x 148; 2K)
TXT: Catalog of Niepce heliographies
TXT: University of Texas exhibition: The first photo

1828 1828Quetelet Mortality curves drawn from empirical data (for Belgium and France)— Adolphe Quetelet (1796–1874), Belgium [216].
PIC: Quetelet portrait (268 x 326; 25K)
TXT: Quetelet biography
TXT: Quetelet biography
TXT: Quetelet web site

1830–1835 1830Faraday Graphical analysis of natural phenomena begins to appear on a regular basis in scientific publications, particularly in England. For example, in 1832, Faraday proposes pictorial representation of electric and magnetic lines of force.— Michael Faraday (1791–1867), England

PIC: Faraday portrait (203 x 176; 14K)
FIG: Faraday2019s iron filing diagrammes, the earliest ever made (300 x 390; 46K)
TXT: Faraday biography
TXT: Faraday bio, with images

1830 1830Montizon First simple dot map of population by department, 1 dot = 10,000 people— Frère de Montizon, France [181].
IMG: see [225, Fig. 49]
FIG: Dot map of population of France, 1830 (360 x 238; 53K)

1832 1832Herschel Fitting a smoothed curve to a scatterplot, advocacy of graph paper and graphical methods as standard tools of science. ["The process by which I propose to accomplish this is one essentially graphical; by which term I understand not a mere substitution of geometrical construction and measurement for numerical calculation, but one which has for its object to perform that which no system of calculation can possibly do, by bringing in the aid of the eye and hand to guide the judgment, in a case where judgment only, and not calculation, can be of any avail." (p. 178)] — John Frederick W. Herschel (1792–1871), England [120].
PIC: Herschel portrait (160 x 238; 11K)
TXT: Herschel images
TXT: Herschel biography

1833 1833Guerry The first comprehensive analysis of data on "moral statistics" (crimes, suicide, literacy, etc.) shown on thematic unclassed choropleth maps; bar charts (of crime, by age groupings and months)— André Michel Guerry (1802–1866), France [104].
TXT: Reference to English translation
FIG: Guerry's map of crimes against persons in France (1500 x 1595; 278K)
FIG: Guerry's map of crimes against property in France (1500 x 1603; 224K)
FIG: Guerry's map of "instruction" in France (1500 x 1556; 353K)
FIG: Guerry's map of suicides (1500 x 1592; 273K)

1833 1833aGuerry Graphical rank lists, with lines showing shifts in rank order between categories (rank of types of crime from one age group to the next)— André Michel Guerry (1802–1866), France [104].

1833 1833Scrope First classed depiction of population density on a world map (using three broad classes in a dasymetric map)— George Scrope (1797–1876), England [233].
TXT: Scrope biography

1833 1833Wheatstone Invention of the stereoscope, revealing the dependence of visual depth perception upon binocular vision, and allowing production of stereoscopic images— Charles Wheatstone (1802–1875), England. 06/25/05:YL
TXT: Stereoscopic photography
TXT: Wheatstone biography
TXT: Wheatstone uses paper tape to store data

1836 1836Angeville First broad and general application of principles of graphic representation to national industrial and population data— Adolphe d' Angeville (1796–1856), France [52, 51]
FIG: Population of France, Carte 1 (946 x 1213; 226K)
FIG: Taille, Carte 5 (413 x 518; 85K)
TXT: Angeville biography

1836 1836Parent-Duchatelet Extensive data tabulation, time series, and mapping of prostitutes in Paris— Alexandre Jean Baptiste Parent-Duchatelet (1790–1836), France [199].
FIG: Duchatelet's map showing the origins of prostitutes in Paris (729 x 557; 178K)
FIG: Duchatelet's map showing the distribution of prostitutes in Paris (650 x 509; 153K)
TXT: English translation of *On prostitution in the city of Paris*

1837 1837Harness First published flow maps, showing transportation by means of shaded lines, widths proportional to amount (passengers)— Henry Drury Harness (1804–1883), Ireland [111, 223].
IMG: see [225, Fig. 71]
PIC: Harness portrait (188 x 305; 35K)
FIG: Harness flow map of transportation of passengers in Ireland (1888 x 2923; 170K)

1838 1838Berghaus Physical atlas of the distribution of plants, animals, climate, etc., one of the most extensive and detailed thematic atlases; most of the maps contained tables, graphs, pictorial profiles of distributions over altitude, and other visual accompanyments— Heinrich Berghaus (1797–1884), Germany [22].
IMG: Berghaus map icon (149 x 120; 12K)
TXT: Berghaus map, high-res
FIG: World map showing the tradewinds (768 x 577; 88K)
FIG: Charts showing temperature throughout the world (768 x 577; 80K)
FIG: Full colour "ideal" geologic cross-section (768 x 351; 55K)
TXT: Berghaus biography

1839 1839Verhulst Development of the logistic curve, $y = k/(1 + Ce^{rt})$, to describe the growth of human populations— Pierre-François Verhulst (1804–1849), Belgium [217]. 06/16/05:YL
PIC: Verhulst portrait
TXT: Verhulst bio
TXT: Pierre-Francois Verhulst et la loi logistique de la population

1839 1839Daguerre Invention of the first practical photographic process, using coated plates of metal and glass— Louis Jacques Mandé Daguerre (1787–1851), France. 06/25/05:YL
FIG: Daguerre, Parisian Boulevard (560 x 394; 48K)
TXT: The Daguerrian Society (with comprehensive links and images)

1843 1843Lalanne Contour map of a 3D table, temperature x hour x month (published in 1845)— Léon Lalanne (1811–1892), France [148].
IMG: Lalanne contour diagram (98 x 120; 10K)
FIG: Lalanne contour diagram (322 x 394; 79K)
TXT: Lalanne biography

1843 1843aLalanne Use of polar coordinates in a graph(frequency of wind directions)— Léon Lalanne (1811–1892), France [148].
IMG: Lalanne windrose diagram (225 x 203; 24K)

1843 1843Pritchard Ethnographic maps showing distribution of ethnic groups throughout the world— James Cowles Pritchard (1786–1848) and Alexander Keith Johnston (1804–1871), UK [214], [139]
FIG: Ethnographical map of Africa (440 x 512; 26K)
FIG: Ethnographical map of Europe (512 x 431; 33K)
FIG: Ethnographical map of Europe (384 x 267; 21K)
TXT: Pritchard biography
TXT: Johnston bio and portrait (pdf)
TXT: Johnston biography

1844 1844Minard "Tableau-graphique" showing transportation of commercial traffic by variable-width (distance), divided bars (height ∼ amount), area ∼ cost of transport [An early form of the mosaic plot.]— Charles Joseph Minard (1781–1870), France [174]; see also: [51, 224].
IMG: Minard Tableau graphique (354 x 276; 20K)
TXT: Minard biography

1846 1846Lalanne Logarithmic grid (the first log-log plot, as a nomogram for showing products from the factors) [See also: Lalanne's ambitious *Universal Calculator* [147], combining logarithmic and trigonometric calculations (described by Tournès [256]).]— Léon Lalanne (1811–1892), France

[149].
IMG: Lalanne nomogram icon (120 x 118; 8K)
IMG: Lalanne nomogram image (221 x 206; 16K)
FIG: Lalanne's Universal Calculator (2317 x 2868; 529K)
TXT: l'Ecole des mines: Lalanne "compteur universel" and other calculating diagrams

1846 1846Quetelet Results of sampling from urns shown as symmetrical histograms, with limiting "curve of possibility" (later called the normal curve)— Adolphe Quetelet (1796–1874), Belgium [218].
FIG: Quetelet's graph of a binomial distribution, 999 trials (594 x 374; 34K) §5: 33 items

6 1850–1899: Golden Age of data graphics

By the mid-1800s, all the conditions for the rapid growth of visualization had been established. Official state statistical offices were established thoughout Europe, in recognition of the growing importance of numerical information for social planning, industrialization, commerce, and transportation. Statistical theory, initiated by Gauss and Laplace, and extended to the social realm by Quetelet, provided the means to make sense of large bodies of data.

What started as the "Age of Enthusiasm" [198] in graphics and thematic cartography, may also be called the "Golden Age", with unparalleled beauty and many innovations.

1851 1851Minard Map incorporating statistical diagrams: circles proportional to coal production (published in 1861)— Charles Joseph Minard (1781–1870), France [176].
FIG: Pie-map showing origin of meats consumed in Paris (341 x 349; 9.6K)

1852 1852Unknown Statistical graphics used in a lawsuit. (Reported by Ernst Engel at the 7th meetings of the International Statistical Congress, 1869, The Hague [85, p. 316])— Germany.

1853 1853ISI First international statistics conference (organized by Quetelet)— International Statistical Institute Belgium [220].
TXT: ISI History
TXT: ISI historical biography
TXT: Quetelet biography

1855 1855Snow Use of a dot map to display epidemiological data, leads to discovery of the source of a cholera epidemic— John Snow (1813–1858), England [241, 99].
PIC: Snow portrait (129 x 156; 11K)
IMG: Snow cholera map (160 x 143; 33K)
FIG: same, larger (700 x 671; 105K)
FIG: same, larger (764x852; 400K)
FIG: Cholera map (698 x 652; 510k)
TXT: John Snow UCLA web site, with zoomable images
TXT: John Snow MSU web site, online companion to a Snow biography

1857 1857ISI Discussion of standardization and classification of graphical methods at the Third International Statistical Congress— Vienna, Austria [133].
TXT: The debate on the standardization of statistical maps and diagrams (1857-1901), Cybergeo, No. 85

1857 1857aISI Exhibition display of graphs and cartograms. Third International Statistical Congress— Vienna, Austria [133].

1857 1857Nightingale Polar area charts, known as "coxcombs" (used in a campaign to improve sanitary conditions of army)— Florence Nightingale (1820–1910), England [190].

PIC: Nightingale portrait (106 x 134; 6K)
IMG: re-creation of a coxcomb (148 x 154; 1K)
IMG: Nightingale coxcomb (398 x 263; 10K)
TXT: Florence Nightingale's Statistical Diagrams
TXT: JSE article: A Dialogue with Florence Nightingale
TXT: Florence Nightingale by I. Bernard Cohen

1861 1861Galton The modern weather map, a chart showing area of similar air pressure and barometric changes by means of glyphs displayed on a map. These led to the discovery of the anti-cyclonic movement of wind around low-pressure areas— Francis Galton (1822–1911), UK [90, 91].
PIC: Portrait of Galton by Furse (198 x 200; 22K)
TXT: A comprehensive Galton web site, with many publications and images
TXT: Galton's 1861 "Meteorological charts", *Philosophical Magazine*
TXT: Galton's 1870 "Barometric predictions of weather", *Nature*
FIG: Galton's 1881 weather chart (470 x 593; 66K)

1861 1861Maxwell Invention of the trichromatic process for making color photographs, by taking three monochrome images through red, green and blue filters— James Clerk Maxwell (1831–1879), England.
PIC: Portrait of Maxwell (200 x 196; 22K)
TXT: Maxwell biography
TXT: Maxwell biography

1863 1863Jevons Semilogarithmic grid (showing percentage changes in commodities)— William Stanley Jevons (1835–1882), England [134, 135].
PIC: Jevons portrait (268 x 326; 13K)
FIG: Graphical method, from [135] (401 x 284; 39K)
FIG: Quantitative induction, from [135] (400 x 673; 95K)
TXT: Jevons Home page, by Bert Mosselmans
TXT: Jevons biography
TXT: Jevons in Sidney and the logic piano
TXT: Comprehensive bibliography

1868 1868Levasseur Statistical diagrams used in a school textbook— Émile Levasseur (1828–1911), France [156].
PIC: Levasseur portrait (404 x 543; 95K)
TXT: Link to bio blurb and texts

1869 1869Zeuner Three-dimensional population surface or "stereogram," with axonometric projection to show curves of various "slices" (sometimes known as a "Zeuner diagram)"— Gustav Zeuner (1828–1907), Germany [294].
TXT: Zeuner biography

1869 1869Minard Minard's flow map graphic of Napoleon's March on Moscow (called "the best graphic ever produced" by Tufte [258])— Charles Joseph Minard (1781–1870), France [175].
TXT: Web page for "Re-visions of Charles Joseph Minard"
IMG: Minard's March on Moscow graphic (569 x 273; 30K)

1869 1869Mendeleev The periodic table used to classify chemical elements according to their properties, and allowing the prediction of new elements that would be discovered later.— Dmitri Mendeleev (1834–1907), Russia. 06/16/05:YL
PIC: Mendeleev portrait (152 x 232; 13k)
PIC: Mendeleev portrait (152 x 232; 13k)
TXT: Mendeleev periodic table, and other pictorial representations
TXT: Mendeleev biography

1872 1872USCongress Congressional appropriation for graphical treatment of statistics— USA

1872 1872USCensus Use of statistical graphics by USA Government in census reports (cartograms of data from Ninth Census)— U.S. Bureau of the Census, USA [267].

1872 1872Schwabe Classification of statistical graphical treatments by form, with consideration of appropriate uses of color, graphical elements, limitations of perception. At the 8th ISI meetings, St. Petersburg.— Hermann Schwabe (1830–1875), Germany [232].

1872 1872Muybridge Recording of motion (of a running horse) by means of a set of glass-plate cameras, triggered by strings— Eadweard Muybridge (1830–1904), USA.
IMG: Galloping Horse, 1878 (370 x 227; 20K)
FIG: Galloping Horse, 1878 (635 x 391; 44K)
TXT: UCR Museum of Photography, animated Muybridge Gallery
TXT: Eadweard Muybridge's photography of motion
TXT: Muybridge photos, with timeline and bio
TXT: Muybridge's zoopraxiscope
TXT: Complete history of cinematography

1873 1873Gibbs Graphical methods applied to explain fundamental relations in thermodynamics; this includes diagrams of entropy vs. temperature (where work or heat is proportional to area), and the first use of trilinear coordinates (graphs of (x,y,z) where x+y+z=constant)— Josiah Willard Gibbs (1839–1903), USA [34, 97, 98].
PIC: Gibbs portrait (140 x 177; 6.3K)
TXT: Gibbs biography
FIG: Plot on trilinear graph paper by R. A. Fisher, ca. 1955 (540 x 425; 70K)
TXT: Gibbs, *Elementary principles in statistical mechanics*
TXT: Gibb's models

1874 1874Walker Age pyramid (bilateral histogram), bilateral frequency polygon, and the use of subdivided squares to show the division of population by two variables jointly (an early mosaic display) in the first true U.S. national statistical atlas— Francis Amasa Walker(Superintendent of U.S. Census) (1840–1897), USA [280].
TXT: History of US census atlases
TXT: Text of the Statistical Atlas of 1870
TXT: detailed Walker biography
PIC: Portrait (186 x 238; 7K)
PIC: Walker portrait (202 x 252; 52K)
IMG: Population pyramid (240 x 172; 10K)
IMG: Cover of the 1870 Statistical Atlas (113 x 150; 4K)
TXT: Detailed Walker biography

1874 1874Vauthier Population contour map (population density shown by contours), the first statistical use of a contour map— L. L. Vauthier, France [272].
IMG: Vauthier contour map (160 x 240; 4K)
FIG: Vauthier contour map (1405 x 2072; 767K)
FIG: Estuaire de la Seine en 1834 (650 x 315; 36K)

1874 1874Mayr Two-variable color map (showing the joint distribution of horses (red, vertical bars) and cattle (green, horizontal bars) in Bavaria, widths of bars $\sim$ animals/km^2)— Georg von Mayr (1841–1925), Germany [169, Fig. XIX]
IMG: see [278, p. 20].
PIC: von Mayr Portrait(223 x 248; 57k)

c. 1874 1874Galton Galton's first semi-graphic scatterplot and correlation diagram, of head size and height, from his notebook on *Special Peculiarities*— Francis Galton (1822–1911), England.

FIG: Galton correlation diagram, from [122] (631 x 898; 569K)
TXT: Comprehensive Galton site: biography, papers, images

1875 1875Lexis Lexis diagram, showing relations among age, calendar time, and life spans of individuals simultaneously (but the paternity of this diagram is in dispute [271])— Wilhelm Lexis (1837–1914), Germany [158].
PIC: Lexis portrait (378 x 538; 55K)
IMG: Lexis diagram (468 x 468; 6K)
TXT: Illustrated description of the Lexis diagram
TXT: The Lexis diagram, a misnomer
TXT: Visualisation using Lexis pencils

1875 1875Galton Galton's first illustration of the idea of correlation, using sizes of the seeds of mother and daughter plants— Francis Galton (1822–1911), England [201]. 06/21/05:YL
PIC: Galton portrait (268 x 326; 7k)
FIG: Galton's first correlation diagram
TXT: Comprehensive Galton website

1877 1877Mayr First use of proportional, divided square in the modern (mosaic) form for data representation— Georg von Mayr (1841–1925), Germany [170, S. 80].
PIC: von Mayr portrait (351 x 448; 14K)
IMG: von Mayr's Area diagram (194 x 190; 3K)

1877 1877aMayr First use of polar diagrams and star plots for data representation— Georg von Mayr (1841–1925), Germany [170, S. 78][196].
IMG: von Mayr's polar diagram (181 x 181; 2K)

1877 1877Bowditch Extensive statistical study of 24,500 children to improve school practice; early ideas of correlation and regression by quoting the "measure of stoutness", the ratio of annual increase in pounds weight to annual increase in inches height. Includes six charts, showing curvilinear regresions.— Henry Pickering Bowditch (1840–1911), Boston MA, USA [29],[281, p. 98–102] 06/21/05:YL
PIC: Bowditch portrait (325 x 435; 8.5k)
FIG: Early regression curves of height on weight for Boston schoolboys (507 x 514; 43K)
FIG: Early regression of heigh on weight for English schoolboys (500 x 504; 43K)

1878 1878Marey First attempt to survey, describe, and illustrate available graphic methods for experimental data— Etienne-Jules Marey (1830–1904), France [163].
PIC: Marey portrait (79 x 131; 1K)
PIC: Marey portrait (210 x 302; 10K)
TXT: Etienne Jules Marey - Movement in Light
TXT: Cinema firsts: Marey
TXT: Chronophotographical Projections

1878 1878Sylvester The term "graph" introduced, referring to diagrams showing analogies between the chemical bonds in molecules and graphical representations of mathematical invariants (also coined the term "matrix") — James Joseph Sylvester (1814–1897), UK [248].
IMG: Sylvester's diagram icon (85 x 120; 7K)
PIC: Sylvester portrait (339 x 335; 18K)
FIG: Sylvester's diagram image (421 x 594; 88K)
TXT: Sylvester biography

1879 1879Perozzo Stereogram (three-dimensional population pyramid) modeled on actual data (Swedish census, 1750–1875)— Luigi Perozzo, Italy [203].
IMG: Perozzo stereogram icon (160 x 195; 5K)
IMG: Perozzo stereogram image (613 x 727; 102K)
IMG: Perozzo ilustration of systems for 3D representation (392 x 625; 34K)

1879 1879Jevons Published instructions on how to use graph paper— William Stanley Jevons (1835–1882), England [135].
TXT: Biography

1879–1899 1879Cheysson *Album de Statistique Graphique*, an annual series over 20 years, using all known graphic forms (map-based pies and stars, mosaic, line graphs, bar charts, and, of course, numerous flow maps) to depict data relevant to planning (railways, canals, ports, tramways, etc.) [This series, under the direction of Émile Cheysson, is regarded as the epitome of the "Golden Age of Statistical Graphics"]— Émile Cheysson (1836–1910) and Ministere de Traveaux Publics, France [177, 198].
PIC: Cheysson portrait (295 x 378; 12K)

1880 1880Venn Representation of logical propositions and relations diagrammatically. [Actually, Liebnitz and, to some degree, Euler had used such diagrams previously.]— John Venn (1834–1923), England [273, 274]
PIC: Venn portrait (268 x 326; 9K)
IMG: Venn diagram (174 x 139; 0.9K)
TXT: A survey of Venn diagrams
TXT: Biography
TXT: Create your own Venn diagram

1882 1882Marey Invention of precursor of motion-picture camera, recording a series of photographs to study fight of birds, running and walking— Etienne-Jules Marey (1830–1904), France [162].
TXT: Expo-Marey: Movement in Light
IMG: Somersault icon (161 x 44; 2K)
IMG: Somersault image sequence (612 x 46; 8K)

1882 1882Bertillon Statistical reasoning employed to create a new system of bodily measurement, specifically for identifying criminals— Alphonse Bertillon (1853–1914), France.
PIC: Bertillon portrait (250 x 400; 24K)
TXT: Bertillon web site
PIC: Bertillon portrait (55 x 64; 3K)
IMG: Measuring the head with calipers (100 x 100; 5K)
FIG: Bertillon images (russian)
TXT: Science of criminal identification

1883 1883Unknown Patent issued on logarithmic paper (reported to the British Association for the Advancement of Science, in 1898). Also called "semi-log," "arith-log" paper and "ratio charts"— England.[85, p. 361]
TXT: Graphing on log paper

1883–1885 1885Lallemand Combination of many variables into multi-function nomograms, using 3D, juxtaposition of maps, parallel coordinate and hexagonal grids ("L'Abaque Triomphe")— Charles Lallemand (1857–1938), France [150]. 06/21/05:YL
FIG: Lallemand's "L'Abaque Triomphe" (516 x 424; 250K)
TXT: Graphic representations in three dimensions
TXT: Lallemand biography and portrait
TXT: Detailed biography (French)

1884 1884Mulhall Pictogram, used to represent data by icons proportional to a number— Michael George Mulhall (1836–1900), England [184].
IMG: pictogram icon (220 x 135; 17K)
FIG: Mulhall pictogram image (1676 x 1027; 56K)
FIG: Man, animal and machine pictogram (281 x 367; 66K)

1884 1884Hollerith Invention of the punched card for use in a machine to tabulate the USA Census (in 1890). Hollerith's company eventually became IBM— Herman Hollerith (1860–1929), USA.

IMG: Hollerith punched card machine: reader-sorter (374 x 300; 16K)
IMG: Hollerith punched card (270 x 117; 17K)
FIG: Hollerith tabulator machine for census bureau (474 x 402; 208K)
TXT: Comprehensive Hollerith biography

1884 1884Ocagne The first alignment diagrams, using sets of parallel axes, rather than axes at right angles; development of the essential ideas used in parallel coordinates plots. [Using the principle of duality from projective geometry, d'Ocagne [54] showed that a point on a graph with Cartesian coordinates transformed into a line on an alignment chart, that a line transformed into a point, and, finally, that a family of lines or a surface transformed into a single line [110].]— Maurice d' Ocagne (1862–1938), France [54, 55].
IMG: Traction of a locomotive in three coordinate systems (120 x 57; 5K)
FIG: Traction of a locomotive in three coordinate systems (703 x 335; 77K)
IMG: Diagram of parallel coordinates from [54, p. 6] (373 x 386; 13K)
TXT: Text of d'Ocagne's [54] book on parallel coordinates
TXT: D'Ocagne biography (French)

1884 1884Abbott A literary description of life in a two-dimensional world for people living in a 3D world. By analogy and extension, it suggests the possibile views of fourth and higher dimensions— Edwin A. Abbott (1838–1926), England [1].
PIC: Abbott portrait (84 x 110; 2K)
TXT: etext of Flatland
TXT: etext, with illustrations
TXT: Brief biography

1885 1885Galton Normal correlation surface and regression, the idea that in a bivariate normal distribution, contours of equal frequency formed concentric ellipses, with the regression line connecting points of vertical tangents— Francis Galton (1822–1911), England [92].
PIC: Galton portrait (268 x 326; 7K)
IMG: Galton diagram of bivariate normal distribution (745 x 631; 56K)
TXT: Galton biography
TXT: Comprehensive Galton web site
TXT: Karl Pearson's biography of Galton, online

1885 1885Levasseur Comprehensive review of all available statistical graphics presented to the Statistical Society of London, classified as figures, maps, and solids (3D), perhaps the first mature attempt at a systematic classification of graphical forms— Émile Levasseur (1828–1911), France [157]. 02/01/05
IMG: Area diagram comparing populations of countries to their colonies (402 x 662; 187K)
IMG: Circle diagram of Infant mortality by month in Brussels(368 x 407; 73K)
IMG: Population density in France in 1866 (266 x 287; 83K)
IMG: Four type of graphs illustrated by Levasseur (662 x 438; 123K)
TXT: Link to Levasseur's e-texts

1885 1885Marey Graphic representation of a train schedule showing rate of travel along the route from Paris to Lyon. (The method is attributed to the French engineer Ibry)— Etienne-Jules Marey (1830–1904), France [164],[258, p. 31]. 06/21/05:YL
PIC: Marey portrait (210 x 302; 10K)
IMG: Train schedule graphic

1888 1888Cheysson First anamorphic maps, using a deformation of spatial size to show a quantitative variable (e.g., the decrease in time to travel from Paris to various places in France over 200 years)— Émile Cheysson (1836–1910), France [198, Fig. 63-64]
PIC: Cheysson portrait (295 x 378; 12K)
TXT: Cheysson biography
TXT: Link to Cheysson's e-texts

1889 1889Booth Street maps of London, showing poverty and wealth by color coding, transforming existing methods of social survey and poverty mapping towards the end of the nineteenth century— Charles Booth (1840–1916), London, UK [27, 28]. 01/25/06:MF

PIC: Booth portrait (235 x 221; 10K)
FIG: Portion of Booth's poverty map (500 x 309; 54K)
FIG: Booth's poverty map, larger (974 x 824; 429K)
TXT: Charles Booth: Mapping London's Poverty, 1885-1903
TXT: Charles Booth and poverty mapping in late nineteenth century London
TXT: Charles Booth Online Archive at LSE
TXT: Booth's 1889 London Poverty Map (digitized, zoomable)

1892 1892Geddes Social data, diagrams, including regional survey, incorporated in museum— Patrick Geddes (1854–1932), Outlook Tower, Edinburgh.

PIC: Geddes portrait (273 x 283; 71K)
TXT: Patrick Geddes Exhibition
TXT: Geddes biography
TXT: Outlook Tower as an anamorphosis of the world

1895 1895Lumieres First movie, with the cinématographe, using the principle of intermittent movement of film (16 fps), but producing smooth projection (first public film screening on December 28, 1895 at the Cafe Grand)— Auguste Lumières and Louis Lumières, France.

PIC: Lumieres portrait (109 x 127; 7K)
TXT: Lumiere Biography
FIG: Images: Auguste et Louis Lumière, le cinématographe Lumière

1896 1896Bertillon Use of area rectangles on a map to display two variables and their product (population of arrondisements in Paris, percent foreigners; area = absolute number of foreigners)— Jacques Bertillon (1851–1922), France [23].

IMG: Bertillon map (479 x 352; 38K) ([198, Fig. 85])

1899 1899Galton Idea for "log-square" paper, ruled so that normal probability curve appears as a straight line— Francis Galton (1822–1911), England [93]. §6: 51 items

7 1900–1949: Modern Dark Ages

If the early 1800s were the "golden age" of statistical graphics and thematic cartography, the early 1900s could be called the "modern dark ages" of visualization [79].

There were few graphical innovations, and, by the mid-1930s, the enthusiasm for visualization which characterized the late 1800s had been supplanted by the rise of quantification and formal, often statistical, models in the social sciences. Numbers, parameter estimates, and, especially, standard errors were precise. Pictures were—well, just pictures: pretty or evocative, perhaps, but incapable of stating a "fact" to three or more decimals. Or so it seemed to statisticians.

But it is equally fair to view this as a time of necessary dormancy, application, and popularization, rather than one of innovation. In this period statistical graphics became "main stream." Graphical methods entered textbooks [202, 100, 114, 197, 141], the curriculum [43, 283], and standard use in government [8], commerce [94, 235] and science.

In this period graphical methods were used, perhaps for the first time, to provide new insights, discoveries, and theories in astronomy, physics, biology, and other sciences. As well, experimental comparisons of the efficacy of various graphics forms were begun, e.g., [59], and a number of practical aids to graphing were developed. In the latter part of this period, new ideas and methods for multi-dimensional data in statistics and psychology would provide the impetus to look beyond the 2D plane.

Graphic innovation was also awaiting new ideas and technology: the development of the machinery of modern statistical methodology, and the advent of the computational power which would support the next wave of developments in data visualization.

1901 1901ISI Attempt to formulate standards for graphical procedures at the International Statistical Congress; proposes that x,y scales be constructed so that the average behaviour corresponds to a curve of 45 degrees. Report not adopted, see [85, p. 321]; see also [127].— Jacques Bertillon (1851–1922) and Émile Cheysson (1836–1910) and M. Fontaine, Budapest, Hungary [127]. 06/16/05:YL
PIC: Cheysson portrait
TXT: Cheysson biography
TXT: Link to Cheysson's e-texts

1904 1904Maunder Use of the "butterfly diagram" to study the variation of sunspots over time, leading to the discovery that they were markedly reduced in frequency from 1645–1715 (the "Maunder minimum"). [Earlier work, started in 1843 by H. Schwabe, showed that sunspots exhibit an approximately twenty-two year cycle, with each eleven-year cycle of sunspots followed by a reversal of the direction of the sun's magnetic field]— Edward Walter Maunder (1851–1928), England
IMG: Maunder's butterfly diagram (250 x 150; 22K)
TXT: The butterfly diagram
TXT: The sunspot cycle

1905 1905Lorenz Lorenz curve (cumulative distribution by rank order, to facilitate study of concentrations, income distribution)— Max O. Lorenz (1880–1962), USA. [160].
TXT: Description of Lorenz Curve
IMG: Lorenz Curve (263 x 261; 6K)

c. 1910 1910Unknown Statistical diagrams begin to appear regularly in USA textbooks (graphs of temperature, population in texts of arithmetic, algebra)— USA

1910 1910Peddle Textbook in English devoted exclusively to statistical graphics— John Bailey Peddle, USA [202].

1911 1911Roesle First International Hygiene-Exhibition in Dresden, with 259 graphical-statistical figures of 35 national and international exhibitors and more than 5 million visitors. [Roesle also wrote publications which dealt with the structure of graphical-statistical displays [228].]— Emil Eugen Roesle (organizer) (1875–1962), Germany [227, 195].
PIC: Rosele portrait (283 x 417; 17K)
FIG: Trellis-like time series graphs of infant mortality (600 x 594; 116K)
FIG: Trellis-like time series graphs of tuberculosis (374 x 387; 33K)
FIG: 3D Histogram: *The course of death in Saxony* (891 x 643; 98K)

1911–1913 1911Hertzsprung The Hertzsprung-Russell diagram, a log-log plot of luminosity as a function of temperature for stars, used to explain the changes as a star evolves. It provided an entirely new way to look at stars, and laid the groundwork for modern stellar physics and evolution, developed independently by— Elnar Hertzsprung (1873–1967), Denmark [121] and Henry Norris Russell (1877–1957), USA. See [242] for a recent appraisal.
PIC: Russell portrait (439 x 638; 21K)
IMG: Hertzprung's first 1911 graphs (366 x 394; 23K)
IMG: early Hertzsprung-Russell diagram (689 x 546; 8K)
IMG: modern Hertzsprung-Russell diagram (283 x 335; 26K)
TXT: HR Diagram tutorial
TXT: Hertzsprung biography
TXT: Russell biography

1913 1913Hazen Arithmetic probability paper, ruled so that normal ogive appears as straight line— Allen Hazen (1869–1930), USA [116].
IMG: Probability paper (590 x 303; 8K)

1913 1913City Parade of statistical graphics, May 17, 1913, including large graphs on horse-drawn floats, and a photograph with people arranged in a bell-shaped curve— Employees of New York City, New York, USA [30].
FIG: Photograph of the Parade of Statistical Graphics (504 x 407; 57K)

1913 1913Moseley Discovery of the concept of atomic number, based largely on graphical analysis (a plot of serial numbers of the elements vs. square root of frequencies from X-ray spectra) The linear relations showed that the periodic table was explained by atomic number rather than, as had been supposed, atomic weight, and predicted the existence of several yet-undiscovered elements— Henry Gwyn Jeffreys Moseley (1887–1915), England [183].
TXT: Text of Moseley's article, with scanned graphs
IMG: Moseley graph image (345 x 543; 8K)
TXT: Henry Mosely biography
PIC: Moseley portrait (200 x 298; 14K)

1913–1914 1913Costelloe College course in statistical graphic methods, "The Graphic Method" (possibly the first)— Martin F. P. Costelloe, Iowa State College, USA.[43]

1914 1914Engineers Published standards for graphical presentation (by representatives from several scientific societies) — American Society of Mechanical Engineers (Joint Committee), USA [140].

1914 1914Brinton Pictogram of uniform size (combining concepts of the bar graph and pictogram of varying size)— Willard Cope Brinton, USA [30].

1915 1915Association Creation of a standing committee on graphics— American Statistical Association, USA.

1915–1925 1915Fisher Beginnings of the development of modern statistical theory (sampling distributions (1915), randomization, likelihood (1921), small sample theory, exact distributions, analysis of variance (1925), etc.)— Ronald Aylmer Fisher (1890–1962), UK [67, 68].
PIC: R. A. Fisher portrait (268 x 326; 3K)
TXT: Fisher biography, with other links and portraits
TXT: Collected papers of R. A. Fisher [21]

1916 1916Warne Correspondence course in graphical methods (20 lessons for $50, supplemented by a book of 100 specimen illustrations of bar, curve, and circle diagrams; entended title includes "There's an idea in every chart")— Frank Julian Warne (1874–1948), USA [283].

1917 1917Gantt Gantt chart, designed to show scheduled and actual progress of projects— Henry Laurence Gantt (1861–1919), Maryland, USA[94]. 06/16/05:YL
TXT: Gantt chart history

1918–1933 1918Cubberly Annual college course in statistical graphical methods— E. P. Cubberly, Stanford University, USA.

1919 1919Ayres Social statistical chartbook, containing a variety of graphic and semi-graphic displays in a USA Government report. [The image below is a fine early example of a semi-graphic display, showing four variables simultaneously.]— Leonard Porter Ayres (1879–1946), USA [8].
FIG: American Divisions in France, WWI, from [258] (467 x 429; 5K)

1920 1920Wright Invention of the path diagram to show relations among a network of endogenous and exogenous variables forming a system of structural equations— Sewall Wright (1889–1988), USA [292].
PIC: Sewall Wright portrait (216 x 405; 15K)
FIG: Wright's first path diagram (682 x 563; 42K)
TXT: Sewall Wright Papers, from the American Philosophical Society
TXT: Biographical memoirs

1920–1926 1920Haskell Numerous textbooks on graphics, describing principles of graphical presentation of numerical information (published at a rate of about two each year), e.g.,— A. C. Haskell[114], Karl G. Karsten, USA [141], A. R. Palmer, England [197].

1923 1923Zworykin Invention of the iconoscope television camera-tube— Vladimir Kosma Zworykin (1889–1982), Russia. 06/25/05:YL
TXT: Zworykin biography and invention (with images)

1924 1924Neurath Museum of Social Statistical Graphics and the ISOTYPE system (International System of Typographic Picture Education)— Otto Neurath (Director) (1882–1945), Social and Economic Museum, Vienna, Austria [188, 187].
PIC: Neurath portrait - small (104 x 150; 4K)
PIC: Neurath portrait - large (363 x 502; 29K)
IMG: Neurath Isotype image (215 x 300; 14K)
FIG: Births and deaths in Germany, from [188] (699 x 551; 43K)
FIG: Infant mortality and social position in Vienna, from [188] (500 x 320; 46K)
FIG: Number of men living in Europe, from [188] (551 x 451; 62K)
FIG: Isotype figure (400 x 229; 276k)
TXT: Neurath biography

1925 1925Shewhart Development of the control chart for statistical control of industrial processes— Walter A. Shewhart (1891–1967), USA[235].
PIC: Walter Shewhart portrait (82 x 109; 5K)
TXT: Collection of web sites on Shewhart

1926 1926Eells Experimental test of statistical graphical forms (pie vs. subdivided bar charts)— Walter C. Eells, USA [59].
IMG: Experimental stimuli (415 x 316; 96K)

1927–1932 1927Huhn Spate of articles on experimental tests of statistical graphical forms— R. von Huhn [126], F. E. Croxton [46, 47, 48], J. N. Washburne [284], USA.
FIG: Graphical image used by Washburne: Income (653 x 1120; 116K)
FIG: Graphical image used by Washburne: Population of Florence (647 x 295; 35K)

1928 1928Henderson Nomogram of chemical concentrations in blood, showing the relations among over 20 components— Lawrence Joseph Henderson (1878–1942), USA [119].
IMG: Henderson nomogram icon (120 x 59; 5K)
FIG: Henderson nomogram image (1305 x 642; 226K)
TXT: Henderson biography (pdf)

1928 1928Anderson Ideograph, a multivariate rectangular glyph, invented to display four variables and their relations (length and width of petals and sepals in iris flowers)—Edgar Anderson (1897–1969), USA [3, 145].
PIC: Portrait (150 x 200; 124k)
TXT: Brief biography

1929 1929Berger Electroencephalograph invented, to record electrical signals from the brain via galvanometers that measure electrical signals from electrodes on the scalp. EEGs were printed on multiple-pen, strip-chart recorders, with each channel showing the the amplitude from a given electrode.— Hans Berger (1873–1941), Austria. 06/16/05:YL
PIC: Berger portrait (125 x 190; 9K)
FIG: EEG machine (300x238; 23k)

1930 1930vonFoerster Table of historical events drawn on logarithmic paper— Heinz Von Foerster (1911–2002),Austria. 06/16/05:YL
FIG: Table of historical events drawn on logarithmic paper

TXT: von Foerster biography
TXT: von Foerster interview and logarithmic timeline
TXT: Tabular representation of logarithic timeline

1931 1931Martin "Log Square" paper ($\log y, \log x$, for relations which are linear in log scales)— F. C. Martin and D. H. Leavens, USA [166].

1933 1933Unknown Standard statistical symbols (Neurath's Isotype method) established by government decree (for schools, public posters, etc.)— Soviet Union [188].

1935–1950 1935Unknown Lapse of interest in statistical graphics, as concern with formal, "precise", and numerical methods gained ascendancy (the modern "dark ages" of statistical graphics)[79].

1937 1937Funkhouser First modern review of the early history of statistical graphics— H. Gray Funkhouser (1898–1984), USA [85].

1939 1939Bush Description of a memex, an associative information retrieval system which would help someone find information based in association and context rather than strict categorical indexing; conceptual creation of "hyperlink" and the "World Wide Web"— Vannevar Bush (1890–1974), USA. 06/25/05:YL
TXT: Bush biography (with links and images)
TXT: As We May Think (e-text):

1944 1944Aiken Harvard's Mark I, the first digital computer, put in service. Officially known as the "IBM Automatic Sequence Controlled Calculator" (ASCC), the Mark I was 50 feet long and weighed about 5 tons.— Howard H. Aiken (1900–1973) and Grace Hopper (1906–1992), USA.
PIC: Howard Aiken portrait (200 x 278; 33K)
IMG: The "Mark I" IBM ASCC (240 x 144; 38K)
TXT: Aiken biography
TXT: Howard Aiken's Harvard Mark I
TXT: History of Computing: Harvard Mark I

1944 1944Harmon Development of an electro-mechanical machine to aid in the rotation of multidimensional factor analysis solutions to "simple structure." This allowed an analyst to carry out by direct manipulation of dials what one did by plotting pairs of factors, and hand calculation of the rotation matrices in earlier times [(work carried out under the Adjutant General for development of the Armed Forces General Classification Test) [257]]— Harry Harmon, USA . §7: 37 items

8 1950–1974: Re-birth of data visualization

Still under the influence of the formal and numerical zeitgeist from the mid-1930s on, data visualization began to rise from dormancy in the mid 1960s, spurred largely by three significant developments:

- In the USA, John W. Tukey, in a landmark paper, "The Future of Data Analysis" [261], issued a call for the recognition of data analysis as a legitimate branch of statistics distinct from mathematical statistics; shortly, he began the invention of a wide variety of new, simple, and effective graphic displays, under the rubric of "Exploratory Data Analysis" (EDA). Tukey's stature as a statistician and the scope of his informal, robust, and graphical approach to data analysis were as influential as his graphical innovations. Although not published until 1977, chapters from Tukey's EDA book [264] were widely circulated as they began to appear in 1970–1972, and began to make graphical data analysis both interesting and respectable again.

- In France, Jacques Bertin published the monumental *Semiologie Graphique* [24]. To some, this appeared to do for graphics what Mendeleev had done for the organization of the chemical elements, that is, to organize the visual and perceptual elements of graphics according to the features and relations in data.
- But the skills of hand-drawn maps and graphics had withered during the dormant "modern dark ages" of graphics (though every figure in Tukey's EDA [264] was, by intention, hand-drawn). Computer processing of data had begun, and offered the possibility to construct old and new graphic forms by computer programs. True high-resolution graphics were developed, but would take a while to enter common use.

By the end of this period significant intersections and collaborations would begin: (a) computer science research (software tools, C language, UNIX, etc.) at Bell Laboratories [14] and elsewhere would combine forces with (b) developments in data analysis (EDA, psychometrics, etc.) and (c) display and input technology (pen plotters, graphic terminals, digitizer tablets, the mouse, etc.). These developments would provide new paradigms, languages and software packages for expressing and implementing statistical and data graphics. In turn, they would lead to an explosive growth in new visualization methods and techniques.

Other themes begin to emerge, mostly as initial suggestions: (a) various visual representations of multivariate data; (b) animations of a statistical process; (c) perceptually-based theory (or just informed ideas) related to how graphic attributes and relations might be rendered to better convey the data to the eyes.

1957 1957Anderson Circular glyphs, with rays to represent multivariate data— Edgar Anderson, USA [4].
FIG: Use of metroglyphs in a graph (672 x 532; 48K)
FIG: Diagramming variables in more than 3 dimensions (571 x 275; 39K)

1957 1957Backus Creation of Fortran, the Formula Translation language for the IBM 704 computer. This was the first high-level language for computing.— John Backus (1924–1998), USA. 06/25/05:YL
TXT: FORTRAN background
TXT: Backus biography and bibliography (with links and images)

1958 1958Phillips The "Phillips Curve," a scatterplot of inflation vs. unemployment over time shows a strong inverse relation, leading to important developments in macroeconomic theory— Alban William Housego Phillips (1914–1975), NZ [208].
FIG: The Phillips Curve (307 x 246; 4K)
FIG: The Phillips Curve (452 x 437; 19K)
TXT: Phillips biography

1962 1962Kruskal Beginnings of modern dynamic statistical graphics (a 1 minute movie of the iterative process of finding a multidimensional scaling solution)— Joseph B. Kruskal (1929–), Bell Labs, USA.

PIC: Photo of Joseph Kruskal (197 x 248; 45K)
TXT: ASA Video Library blurb for video "Multidimensional Scaling", with sample frames

1965 1965Tukey Beginnings of EDA: improvements on histogram in analysis of counts, tail values (hanging rootogram)— John W. Tukey (1915–2000), USA [262].
PIC: Photo of John W. Tukey (151 x 219; 4K)
TXT: Biography, tributes, images, bibliography of JWT
TXT: Tukey biography
IMG: Hanging rootogram for the fit of a Poisson distribution (427 x 319; 3K)

1966 1966Pickett Triangular glyphs to represent simultaneously four variables, using sides and orientation— R. Pickett and B. W. White, USA [209]

mid 1960s 1960sFisher Initial development of geographic information systems, combining spatially-referenced data, spatial models and map-based visualization. Example: Harvard Laboratory for Computer Graphics (and Spatial Analysis) develops SYMAP, producing isoline, choropleth and proximal maps on a line printer— Howard Fisher, USA [41, 255].
FIG: Early SYMAP image of Connecticut (763 x 768; 15K)
TXT: The GIS History Project
TXT: GIS Milestones

1967 1967Bertin Comprehensive theory of graphical symbols and modes of graphics representation— Jacques Bertin (1918–), France [24, 25]
PIC: Bertin portrait (156 x 240; 43K)
PIC: Bertin color portrait (180 x 223; 13K)
IMG: Bertin's seven visual variables (314 x 281; 9K)
IMG: The reorderable matrix (300 x 142; 2K)
TXT: 30 ans de semiologique graphique
TXT: Jacques Bertin, Semiologie Graphique web site
TXT: InfoVis interview with J. Bertin

1968 1968Bachi Systematic "graphical rational patterns" for statistical presentation— Roberto Bachi (1909–1995), Israel [10].
IMG: Bachi number patterns (371 x 253; 27K)
PIC: Bachi portrait (149 x 224; 251k)

1969 1969Tukey Graphical innovations for exploratory data analysis (stem-and-leaf, graphical lists, box-and-whisker plots, two-way and extended-fit plots, hanging and suspended rootograms)— John W. Tukey (1915–2000), USA [263].
IMG: Boxplot of leading digits of lottery numbers (640 x 495; 6K)

1969 1969Barnard Suggestion for displaying five variables by means of movements on a CRT— George Barnard, England [12]

1969 1969Fowlkes The first well-known *direct manipulation* interactive system in statistics: allowed users to interactively control a power transformation in realtime for probability plotting— E. B. Fowlkes, USA [73].

1971 1971Siegel Irregular polygon ("star plot") to represent multivariate data (with vertices at equally spaced intervals, distance from center proportional to the value of a variable) [but see Georg von Mayr in 1877 [170, S. 78] for first use]— J. H. Siegel, R. M. Goldwyn and Herman P. Friedman, USA [237]
FIG: Star plot of crime rates in US cities (504 x 505; 8K)
TXT: Star plot, description and example

1971 1971Biderman Proposal to use statistical graphics in social indicator reporting, particularly on television— Albert D. Biderman (1922–), USA [26].

1971 1971Gabriel Development of the biplot, a method for visualizing both the observations and variables in a multivariate data set in a single display. Observations are typically represented by points, variables by vectors, such that the position of a point along a vector represents the data value— Rubin Gabriel (1929–2003), USA [87]. 10/20/05:MF
FIG: Biplot representation of blood chemistry data (511 x 483; 17K)
FIG: Biplot representation of ratings of automobiles (489 x 397; 5.8K)
TXT: Description of PCA and biplot

1972 1972Andrews Form of Fourier series to generate plots of multivariate data— David F. Andrews, Canada [5].
IMG: Fourier function plot image (217 x 222; 3K)

1973 1973Chernoff Cartoons of human face to represent multivariate data— Herman Chernoff (1923–), USA [38].
IMG: Faces plot of automobile data, by origin (428 x 114; 3K)
TXT: Chernoff faces Java applet
TXT: Chernoff CV and portrait

1973 1973USBudget USA Government chartbook devoted exclusively to reporting social indicator statistics— U.S. Office of Management and Budget, USA [63].

1973–1976 1973Barabba Revival of statistical graphics innovation, use by U.S. Bureau of the Census— Vincent P. Barabba (1934–) (Director), USA.

1974 1974USCensus Color-coded bivariate matrix to represent two intervally measured variables in a single map (Urban Atlas series)[but see Georg von Mayr in 1874 [169, Fig. XIX] for first use]— U.S. Bureau of the Census, USA [268].
IMG: CDC map of incidence of stomach cancer (406 x 261; 60K)

1974 1974Wainer Comparative experimental test of histogram, hanging histogram and hanging rootogram— Howard Wainer, USA [276].

1974 1974Fishkeller Start of true interactive graphics in statistics; PRIM-9, the first system in statistics with 3-D data rotations provided dynamic tools for projecting, rotating, isolating and masking multidimensional data in up to nine dimensions— M. A. Fishkeller, Jerome H. Friedman and John W. Tukey (1915–2000), USA [69, 70] §8: 22 items

9 1975–present: High-D data visualization

It is harder to provide a succinct overview of the most recent developments in data visualization, because they are so varied, have occurred at an accelerated pace, and across a wider range of disciplines. It is also more difficult to highlight the most significant developments (and because we have focused on the earlier history), so there are presently areas and events unrepresented here.

With this disclaimer, a few major themes stand out:

- the development of a variety of highly interactive computer systems and more importantly,
- new paradigms of direct manipulation for visual data analysis (linking, brushing, selection, focusing, etc.)
- new methods for visualizing high-dimensional data (grand tour, scatterplot matrix, parallel coordinates plot, etc.);
- the invention of new graphical techniques for discrete and categorical data (fourfold display, sieve diagram, mosaic plot, etc.), and analogous extensions of older ones (diagnostic plots for generalized linear models, mosaic matrices, etc.) and,
- the application of visualization methods to an ever-expanding array of substantive problems and data structures.

These developments in visualization methods and techniques arguably depended on advances in theoretical and technological infrastructure. Some of these are: (a) large-scale software engineering; (b) extensions of classical linear statistical modeling to wider domains; (c) vastly increased computer processing speed and capacity, allowing computationally intensive methods and access to massive data problems.

In turn, the combination of these themes and advances now provides some solutions for earlier problems.

1975 1975Census Weekly chartbook (eventually computer-generated) to brief U.S. President, Vice President on economic and social matters— Bureau of the Census and Office of Management and Budget (at request of Vice President Nelson Rockefeller), USA
TXT: Measuring 50 years of economic change

1975 1975Fienberg "Four-Fold Circular Display" to represent 2×2 table— Stephen E. Fienberg, USA [66].
IMG: Fourfold display (258 x 254; 2K), from [75]
TXT: Friendly (1994) paper (.ps.gz format)
TXT: Fienberg CV and portrait

1975 1975Cleveland Enhancement of scatterplot with plots of three moving statistics (midmean and lower and upper semimidmean)— William S. Cleveland and Beat Kleiner, USA [42]
IMG: USA 1970 Draft Lottery Data, with median and quartile traces (563 x 448; 8K)
TXT: Cleveland bio and papers

1975 1975Chernoff Experiment showing random permutations of features used in Chernoff's faces affect error rate of classification by about 25 percent— Herman Chernoff (1923–) and M. H. Rizvi, USA [39].
TXT: Chernoff faces

1975 1975Ehrenberg Experimental tests of statistical graphics vs tables, findings favoring latter— A. S. C. Ehrenberg, England [60].
TXT: Summarising and presenting data- Rules for tables

1976 1976USCensus Monthly USA Government chartbook of economic and social trends (StatUS)— U.S. Bureau of the Census, USA [269]
TXT: US Bureau of Census home page

1977 1977Wainer "Cartesian rectangle" to represent 2 x 2 table, experimentally tested against other forms— Howard Wainer and Mark Reiser, USA [279]

1977 1977Association Ad Hoc Committee on Statistical Graphics, leading to the ASA Section on Statistical Graphics, later to the *Journal of Computational and Graphical Statistics*— American Statistical Association, USA

1978 1978Newton Original invention of linked brushing (highlighting of observations selected in one display in another display of the same data), although in a manner different from how we see it in today's systems— Carol Newton, USA [189].

1978 1978Becker *S*, a language and environment for statistical computation and graphics. *S* (later sold as a commercial package, *S-Plus*; more recently, a public-domain implementation, *R* is widely available), would become a *lingua franca* for statistical computation and graphics— Richard A. Becker and John M. Chambers, Bell Labs, USA [16, 15, 14].
IMG: Boxplot of the NJ Pick-it Lottery (160 x 124; 28K)
TXT: A Brief History of S (Postscript)
TXT: The R Project for Statistical Computing

1979 1979Monmonier Geographic correlation diagram, showing the bivariate relation between two spatially referenced variables using vectors to represent geographic covariation— Mark Monmonier, USA [178]
TXT: Monmonier bio

1981 1981Hartigan Mosaic display to represent frequencies in a multiway contingency table— John Hartigan and Beat Kleiner, USA [113]. See also:[78].
IMG: Mosaic display á la Hartigan and Kleiner (339 x 366; 3K)
TXT: A Brief History of the Mosaic Display (pdf)

1981 1981Furnas Fisheye view: an idea to provide focus and greater detail in areas of interest of a large amount of information, while retaining the surrounding context in much less detail— George W. Furnas, USA [86].
IMG: Fisheye view of central Washington, D.C. (207 x 207; 14K)
FIG: Fisheye view of central Washington, D.C. (512 x 512; 63K)
FIG: Fisheye view of central Washington, D.C. (512 x 512; 63K)
TXT: Nonlinear magnification home page[many references and links]
TXT: Furnas home page
TXT: Generalised fisheye views paper (pdf)

1981 1981Tukey The "draftsman display" for three-variables (leading soon to the "scatterplot matrix") and initial ideas for conditional plots and sectioning (leading later to "coplots" and "trellis displays")— Paul A. Tukey (1915–2000) and Paul A. Tukey, Bell Labs, USA[266].

1982 1982McDonald Another early version of brushing, invented independently of Newton, together with a system for 3-D rotations of data— John A. McDonald, USA [171].

1982 1982Monmonier Visibiltiy Base Map, a map of the United States where areas are adjusted to provide a readily readable platform for area symbols for smaller states, such as Delaware and Rhode Island, with compensating reductions in the size of larger states— Mark Monmonier, USA [180].
FIG: US Visibility Map (531 x 335; 5K)

1983 1983Riedwyl Sieve diagram, for representing frequencies in a two-way contingency table— Hans Riedwyl (1935–) and Michel Schüpbach, Switzerland [222]
IMG: Sieve diagram image (179 x 170; 2K)
TXT: Riedwyl bio and portrait
TXT: Sieve diagrams applet

1983 1983Tufte Esthetics and information integrity for graphics defined and illustrated (some concepts: "data-ink ratio", "lie factor")— Edward Tufte (1942–), USA [258, 259, 260]
PIC: Tufte portrait (190 x 218; 8.4K)
TXT: Graphics and web design according to Tufte's principles

1985 1985Asimov Grand tour, for viewing high-dimensional data sets via a structured progression of 2D projections— Daniel Asimov, USA [7].
TXT: Technical report, *The grand tour via geodesic interpolation of 2-frames* (pdf)

1985 1985Inselberg Parallel coordinates plots for high-dimensional data— Alfred Inselberg, USA [132].
TXT: Parallel coordinates– How it happened
TXT: Parallel coordinates visualisation applet
TXT: Java applet, allowing direct manipulation: The Parallel Coordinate Explorer
IMG: Representation of a six dimensional point in parallel coordinates (282 x 174; 2K)
FIG: Representation multivariate data in parallel coordinates (455 x 339; 9K)

1987 1987Becker Interactive statistical graphics, systematized: allowing brushing, linking, other forms of interaction— Richard A. Becker and William S. Cleveland, USA [17].
FIG: Figure 14 from "Brushing scatterplots" showing interactive labeling of brushed points (681 x 566; 76K)
TXT: ASA Video Library blurb for video "Dynamic Displays of Data"
TXT: Becker bio and portrait

1988 1988Buja First inclusion of grand tours in an interactive system that also has linked brushing, linked identification, visual inference from graphics, interactive scaling of plots, etc.— Andreas Buja, Daniel Asimov, Catherine Hurley and John A. McDonald, USA [32].
TXT: XGobi - multivariate visualization
TXT: Buja home page
TXT: Hurley home page

1988 1988Unwin Interactive graphics for multiple time series with direct manipulation (zoom, rescale, overlaying, etc.)— Antony Unwin and Graham Wills, UK [270].
IMG: DiamondFast image, overlaid time series, aligned and rescaled interactively (344 x 97; 19K), lynx trapping data
TXT: Unwin home page

1989 1989Wills Statistical graphics interactively linked to map displays— Graham Wills, J. Haslett, Antony Unwin and P. Craig, UK [288]; Mark Monmonier, USA [179]
IMG: REGARD image: largest annual oil flows into EU, 1977–1990 (476 x 359; 30K)

1989 1989Mihalisin Use of "nested dimensions" (related to trellis and mosaic displays) for the visualization of multidimensional data. Continuous variables are binned, and variables are allocated to the horizontal and vertical dimensions in a nested fashion— Ted Mihalisin, USA [172, 173].
FIG: TempleMVV image: 4 response variables vs. age, sex, education (912 x 585; 290K)
FIG: TempleMVV image: 4-way association (913 x 586; 527K)

1990 1990Tierney Lisp-Stat, an object-oriented environment for statistical computing and dynamic graphics— Luke Tierney, USA [253].
TXT: Lisp-Stat information
TXT: Tierney home page

1990 1990Hurley Grand tours combined with multivariate analysis— Catherine Hurley and Andreas Buja, USA [130]

1990 1990Tukey Textured dot strips to display empirical distributions— Paul A. Tukey and John W. Tukey (1915–2000), USA [265].

1990 1990Keiding Lexis pencil: display of multivariate data in the context of life-history— M. Keiding, UK [142]
IMG: Lexis pencil image (394 x 300; 39K)
FIG: Animated 3D lexis pencil, from Brian Francis (360 x 270; 135K)
TXT: Bertin, lexis, and the graphical representation of event histories

1990 1990Wegman Statistical theory and methods for parallel coordinates plots— Edward Wegman, USA [285].
FIG: Representation multivariate data in parallel coordinates (455 x 339; 9K)

1991 1991Friendly Mosaic display developed as a visual analysis tool for log-linear models (beginning general methods for visualizing categorical data)— Michael Friendly (1945–), Canada [80, 76].
TXT: Tutorial description of mosaic displays
TXT: Brief history of the mosaic display
IMG: Two-way mosaic of hair color and eye color (329 x 299; 4K)
IMG: Three-way mosaic of hair color, eye color, and sex (329 x 299; 4K)

1991 1991Shneiderman Treemaps, for space-constrained visualization of hierarchies, using nested rectangles (size proportional to some numerical measure of the node)— Ben Shneiderman, USA [236, 137].

FIG: TreeViz image of files on the HCIL server (636 x 429; 14K)
TXT: Treemaps description and images
TXT: Treemap homepage

1991–1996 1991Swayne A spate of development and public distribution of highly interactive systems for data analysis and visualization, e.g., XGobi, ViSta— Deborah Swayne, Di Cook, Andreas Buja [246, 33, 247], Forrest Young (1940–) [293], USA.
IMG: XGobi screen shot (901 x 682; 29K)
TXT: ViSta - The Visual Statistics System
TXT: XGobi and XGVis homepage

1992 1992Friendly Beginnings of the general extension of graphical methods to categorical (frequency) data— Michael Friendly (1945–), Canada [74, 77].

1994 1994Rao Table lens: Focus and context technique for viewing large tables; user can expand rows or columns to see the details, while keeping surrounding context— Ramana Rao and Stuart K. Card, Xerox Parc, USA [219].
IMG: Table lens screen shot (600 x 459; 58K)
TXT: The Table Lens: Merging Graphical ... (CHI, 1994) paaper
TXT: ACM SigChi paper: Exploring Large Tables with the Table Lens, Rao and Card
TXT: Interactive table lens demonstrations, from InXight
TXT: Information visualization and the next generation workspace (pdf)

1996 1996Dykes Cartographic Data Visualiser: a map visualization toolkit with graphical tools for viewing data, including a wide range of mapping options for exploratory spatial data analysis— Jason Dykes, UK [58].
TXT: CDV paper
IMG: CDV screen shot (432 x 300; 38K)
TXT: Dykes home page

1999 1999Wilkinson *Grammar of Graphics*: A comprehensive systematization of grammatical rules for data and graphs and graph algebras within an object-oriented, computational framework— Leland Wilkinson (1944–), USA [287].
FIG: Contour plot of death rate vs. birth rate (575 x 575; 24K)
FIG: 3D Contour map, Fig 8-11 (511 x 453; 48K)
FIG: Minard's March on Moscow graphic (561 x 267; 22K)
TXT: Wilkinson home page §9: 37 items

10 Related resources and web links

There are many other useful collections of historical information related to the milestones detailed here. We list below a few of the more useful ones encountered so far.

History of science

- Major Scientific & Medical Discoveries, Inventions & Events 1650-1800: A simple, but useful time line.
- Eighteenth-Century Resources – Science and Mathematics: part of a larger collection of Eighteenth-Century history resources.
- Media history time line pages: an illustrated chronology of media developments, with links to related time lines.
- Science time line: A detailed listing of important developments in the history of science, mathematics, and philosophy of science from the dawn of civilization, by David Lee.
- An Historical Timeline of Computer Graphics and Animation
- Timeline of knowledge representation: From a slightly quirky artificial intelligence perspective, the site lists hundreds of developments across many fields.
- GEsource thematic timeline of maps Part of a hub of internet resources related to geography and environmental studies.

History of cartography

- Henry Davis: Cartographic Images Home Page: Time charts of cartography, with a large collection of map images and descriptions, from ancient to late 19th century.
- The History of Cartography: An on-going project at the University of Wisconsin, producing a six-volume set, covering prehistoric and ancient cartography, through the 20th century.
- Historical Map Web Sites: A large list of links to historical maps on the web.
- Web Articles on the History of Cartography: Early maps, and the resources and activities associated with them, form the subject of over 100 'pages' on this site. All the worthwhile information about old maps can be found here, directly or indirectly.
- Map History / History of Cartography: All the worthwhile information about early, old, antique and antiquarian maps can be found here, or from here. The 100 pages of this site offer comment and guidance, and many, many links - selected for relevance and quality. Maintained by Tony Campbell, Map Librarian (retired), British Library, London.
- History and Milestones of GIS: A detailed timeline of history of maps and developments in GIS, from pre-200 AD to present.
- GiS TiMELINE, from the Centre for Advanced Spatial Analysis: An interactive, visual overview of key historical events in the development and growth of Geographical Information Systems from their conception in the 1960's to the present day.
- Places and Spaces, an exhibit on "cartography of the physical and abstract," uses illustrations of cartographic maps, concept maps and domain maps to explain how aspects of visual perception, data analysis, spatial layout and other aspects combine to create a visualization of spatially-referenced information.

History of probability and statistics

- The History of Mathematicians Archive: A large collection of biographical sketches of mathematicians and statisticians, with alphabetical and chronological indexes, and quite a few portraits.
- Materials for the history of statistics, University of York: A collection of portraits, biographies, original works, and images.
- UCLA History of Statistics pages: A collection of original articles and images from the history of statistics.
- History of Statistics Timeline: Dan Denis' collation of significant events in the history of statistics.

Information visualization

- Our Gallery of Data Visualization has a section on Historical Milestones, as well as many examples of the best and worst of statistical graphics.
- Keith Andrews' Information Visualization lecture notes provide many examples of recent advances in this field.
- The Numerical Aerospace Simulation maintains the comprehensive Annotated scientific visualization web site bibliography.
- InfoVis.net is an eclectic, bilingual (English, Spanish) web site on Information Visualization with a weekly newsletter by Juan C. Dürstfeler from UPF in Barcelona.

- Les fonds anciens de la bibliothèque de l'Ecole des mines de Paris has mounted a lovely exposition, Les graphiques scientifiques: prolégomènes à leur usage et à leur histoire of some of the history and usage of scientific graphics, under the direction of M. Henri Vérine. Several images linked here appear through the courtesy of Marie-Noelle Maisonneuve.

Milestones content totals: 265 items, 309 text links, 352 images, 295 bib refs. 265 items

11 Catgeory cross references

The milestones items have been classified into hierarchical categories as an aid to researchers wishing to examine this material by thematic groups. The categories of **Content** (Section 11.1) relate to the substance or subject matter of the milestone or innovation— what is was *about*. Some of the main category headings are Astronomy, Commerce, Education, and Social science. The categories of **Form** (Section 11.2) relate to the graphic or technological details of the milestone item— what it *consisted of*. Some of the main categories used here are graphic types or elements: Chart, Curve, Diagram, etc. The entries in the listing are the item keys, in the form *yearName*, from the chronological listing.

In this version of the cross-reference, a given item can appear at several levels in the hierarchy, representing broader or narrower categories.

11.1 Content

Astronomy 240BCEratosthenes, 134BCHipparchus, 950Unknown, 1375Cresques, 1530Gemma-Frisius, 1545Gemma-Frisius, 1572Brahe, 1626Scheiner, 1632Galilei, 1809Gauss, 1904Maunder, 1911Hertzsprung. C1

$>$ **Cosmography** 134BCHipparchus, 1375Cresques, 1530Gemma-Frisius, 1545Gemma-Frisius, 1572Brahe, 1632Galilei, 1911Hertzsprung. C11

$>$ **Planetary movement** 240BCEratosthenes, 950Unknown, 1809Gauss. C13

$>$ **Sunspot** 1626Scheiner, 1904Maunder. C15

Calculation 1550Rheticus, 1663Cardano, 1600sUnknown, 1614Napier, 1623Schickard, 1637Fermat, 1654Pascal, 1693aHalley, 1736Newton, 1750Mayer, 1760Lambert, 1765Lambert, 1767Lambert, 1795Pouchet, 1822Babbage, 1832Herschel, 1846Lalanne, 1846Quetelet, 1884Hollerith, 1885Galton, 1914Brinton, 1920Wright, 1944Harmon, 1957Anderson, 1965Tukey, 1966Pickett, 1969Tukey, 1969Fowlkes, 1972Andrews, 1974Wainer, 1975Ehrenberg, 1977Wainer, 1981Hartigan, 1981Tukey, 1983Riedwyl, 1987Becker, 1990Tukey, 1990Wegman, 1991Friendly, 1991Shneiderman, 1992Friendly, 1999Wilkinson. C2

Commerce 1654Petty, 1782Crome, 1786Playfair, 1836Angeville, 1851Minard, 1863Jevons, 1874Mayr, 1905Lorenz, 1925Shewhart, 1927Huhn, 1958Phillips, 1975Census, 1976USCensus, 1989Wills. C3

$>$ **External** 1782Crome, 1836Angeville, 1863Jevons. C31

$>$ **External** $>$ **General Economic Wealth** 1782Crome, 1836Angeville, 1863Jevons. C312

$>$ **Internal** 1654Petty, 1786Playfair, 1851Minard, 1874Mayr, 1905Lorenz, 1925Shewhart, 1927Huhn, 1958Phillips, 1975Census, 1976USCensus, 1989Wills. C32

$>$ **Internal** $>$ **Agriculture** 1786Playfair, 1851Minard, 1874Mayr, 1927Huhn, 1958Phillips. C321

$>$ **Internal** $>$ **Labour** 1786Playfair, 1905Lorenz, 1927Huhn, 1958Phillips. C323

1969Fowlkes, 1971Biderman, 1974Fishkeller, 1978Becker, 1985Asimov, 1985Inselberg, 1988Buja, 1988Unwin, 1989Wills, 1989Mihalisin, 1990Tierney, 1990Hurley, 1991Swayne, 1994Rao, 1996Dykes, 1999Wilkinson. C91

> **Computing** 1822Babbage, 1939Bush, 1944Aiken, 1944Harmon, 1957Backus, 1969Fowlkes, 1974Fishkeller, 1978Becker, 1991Swayne, 1994Rao, 1996Dykes, 1999Wilkinson. C93

> **Material** 170BCparchment, 105Lun, 1879Jevons, 1883Unknown, 1899Galton, 1913Hazen, 1931Martin. C94

> **Measurement** 1556Tartaglia, 1572Brahe, 1581Galilei, 1617Snell, 1620Gunter, 1686Halley, 1750Mayer, 1884Hollerith. C95

> **Motion** 1450Cusa, 1500Vinci, 1787Chladni, 1872Muybridge. C96

> **Photography** 1727Schulze, 1827Niepce, 1839Daguerre, 1861Maxwell, 1882Marey. C97

> **Printing** 1453Gutenberg, 1710Blon, 1798Senefelder, 1960sFisher. C98

> **Production** 1453Gutenberg, 1710Blon, 1833Wheatstone. C99

> **Projection** 1646Kirscher, 1776Monge, 1882Marey, 1895Lumieres, 1923Zworykin, 1962Kruskal, 1960sFisher, 1969Barnard, 1985Asimov, 1985Inselberg, 1988Buja, 1988Unwin, 1989Wills, 1989Mihalisin, 1990Tierney, 1990Hurley, 1991Swayne, 1994Rao, 1996Dykes. C9A

> **Recording** 1545Gemma-Frisius, 1663Wren, 1794Buxton, 1796Watt, 1800Howard, 1800Keith, 1833Wheatstone, 1872Muybridge, 1879Jevons, 1882Marey, 1929Berger, 1974Fishkeller. C9B

> **Reproduction/Copying** 1453Gutenberg, 1603Scheiner, 1710Blon. CA

Travel 1837Harness, 1844Minard, 1879Cheysson, 1885Marey, 1888Cheysson. CA1

> **Ferry** 1879Cheysson, 1885Marey. CA2

> **Rail** 1879Cheysson, 1885Marey, 1888Cheysson. CA3

> **Road** 1879Cheysson.

11.2 Form F1

Apparatus 170BCparchment, 105Lun, 1453Gutenberg, 1545Gemma-Frisius, 1581Galilei, 1603Scheiner, 1623Schickard, 1646Kirscher, 1663Wren, 1822Babbage, 1827Niepce, 1833Wheatstone, 1839Daguerre, 1872Muybridge, 1882Marey, 1882Bertillon, 1884Hollerith, 1895Lumieres, 1899Galton, 1923Zworykin, 1929Berger, 1939Bush, 1944Aiken, 1944Harmon, 1957Backus, 1960sFisher, 1971Biderman. F2

Chart 134BCHipparchus, 1857Nightingale, 1917Gantt, 1925Shewhart, 1969Tukey, 1975Census, 1975Ehrenberg, 1976USCensus, 1978Becker. F21

> **Box plot** 1969Tukey, 1975Census, 1976USCensus, 1978Becker. F23

> **Control chart** 1925Shewhart. F25

> **Coxcomb** 1857Nightingale. F28

> **Gantt chart** 1917Gantt. F29

> **Polar area chart** (See: Coxcomb) 1857Nightingale. F2C

> **Star chart** 134BCHipparchus.

> **Colour diagram** 1758Mayer. F56

> **Correlation diagram** 1874Galton, 1875Galton, 1979Monmonier. F57

> **Glyph** 1533Gemma-Frisius, 1928Anderson, 1957Anderson, 1966Pickett. F59

> **Glyph** > **Circular glyph** 1957Anderson. F591

> **Glyph** > **Multivariate rectangular glyph** 1928Anderson. F593

> **Glyph** > **Triangular glyph** 1533Gemma-Frisius, 1966Pickett. F594

> **Hertzsprung-Russell diagram** 1911Hertzsprung. F5A

> **International System of Typographic Picture Education** (See: Isotype) 1924Neurath, 1933Unknown. F5B

> **Isotype** 1924Neurath, 1933Unknown. F5C

> **Lexis diagram** 1875Lexis. F5D

> **Lexis pencil** 1875Lexis, 1990Keiding. F5E

> **Mechanical diagram** 1305Llull. F5F

> **Nomogram** 1795Pouchet, 1846Lalanne, 1885Lallemand, 1928Henderson. F5G

> **Nomogram** > **Multifunction nomogram** 1885Lallemand. F5G3

> **Path diagram** 1920Wright. F5H

> **Polar diagram** 1877aMayr. F5J

> **Proportional** 1782Fourcroy, 1851Minard, 1877Mayr. F5K

> **Proportional** > **Proportional circle** 1851Minard. F5K1

> **Proportional** > **Proportional divided square** 1877Mayr. F5K2

> **Rectangle** 1977Wainer, 1983Riedwyl, 1991Shneiderman. F5L

> **Square** 1782Fourcroy, 1785Crome, 1811Humboldt, 1874Walker, 1877Mayr. F5N

> **Square** > **Superimposed square** 1782Fourcroy, 1785Crome, 1811Humboldt. F5N1

> **Stereogram** 1869Zeuner, 1879Perozzo. F5O

> **Textured dot strip diagram** 1990Tukey. F5P

> **Treemap** 1991Shneiderman. F5Q

> **Triangular diagram** 1280Llull. F5R

> **Venn diagram** 1880Venn. F5S

> **Zeuner diagram** (See: Stereogram) 1869Zeuner. F5T

> **Coplot** 1981Tukey. FF4

> **Face plot** 1973Chernoff, 1975Chernoff. FF6

> **Fourier function plot** 1972Andrews. FF7

> **Frequency polygon** 1874Walker. FF8

> **Irregular polygon** (See: Star plot) 1971Siegel. FF9

> **Log-log plot** 1846Lalanne, 1911Hertzsprung. FFA

> **Logarithmic plot** (See: Log-log plot) 1846Lalanne, 1911Hertzsprung. FFB

> **Mosaic display** (See: Mosaic plot) 1844Minard, 1874Walker, 1879Cheysson, 1989Mihalisin, 1991Friendly. FFC

> **Mosaic plot** 1844Minard, 1874Walker, 1879Cheysson, 1989Mihalisin, 1991Friendly. FFD

> **Parallel coordinates plot** 1884Ocagne, 1990Wegman. FFE

> **Star plot** 1877aMayr, 1971Siegel. FFF

> **Stem-leaf plot** 1767Lambert, 1969Tukey. FFG

> **Trellis display** 1981Tukey, 1989Mihalisin. FFH

Table 1450Cusa, 1550Rheticus, 1600sUnknown, 1603Nautonier, 1614Napier, 1662Graunt, 1666Talon, 1669Huygens, 1671Witt, 1686Halley, 1693Halley, 1760Lambert, 1765Lambert, 1779Lambert, 1795Pouchet, 1822Babbage, 1828Quetelet, 1833aGuerry, 1836Parent-Duchatelet, 1838Berghaus, 1843Lalanne, 1869Mendeleev, 1913Moseley, 1930vonFoerster, 1975Fienberg, 1975Ehrenberg, 1977Wainer, 1983Riedwyl, 1994Rao, 1996Dykes. FG

> **2 x 2 table** 1975Fienberg, 1977Wainer. FG1

> **Contingency table** 1983Riedwyl. FG2

> **Empirical data table** 1600sUnknown. FG4

> **Logarithmic table** 1614Napier. FG5

> **Mathematical table** 1822Babbage. FG6

> **Multiplication table** 1795Pouchet. FG7

> **Periodic table** 1869Mendeleev, 1913Moseley. FG8

> **Trigonometric table** 1550Rheticus. FG9

> **Bivariate data** 1450Cusa, 1686Halley, 1796Watt, 1896Bertillon, 1975Fienberg, 1979Monmonier. FGB

> **Categorical data** 1983Riedwyl, 1991Friendly, 1992Friendly. FGC

> **Empirical data** 1600sUnknown, 1686Halley, 1760Lambert, 1767Lambert, 1828Quetelet. FGE

> **Multivariate data** 1928Anderson, 1957Anderson, 1966Pickett, 1969Barnard, 1971Siegel, 1972Andrews, 1973Chernoff, 1985Asimov, 1985Inselberg, 1987Becker, 1988Buja, 1989Mihalisin, 1990Hurley, 1990Keiding, 1990Wegman. FGG

> **Ordinal data** 1833aGuerry. FGI

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