USC Jimmy Iovine and Andre Young Academy
Arts, Technology and the Business of Innovation

USC University of Southern California

ACAD 280: Designing Digital Experiences

QUANTITATIVE INFORMATION DESIGN

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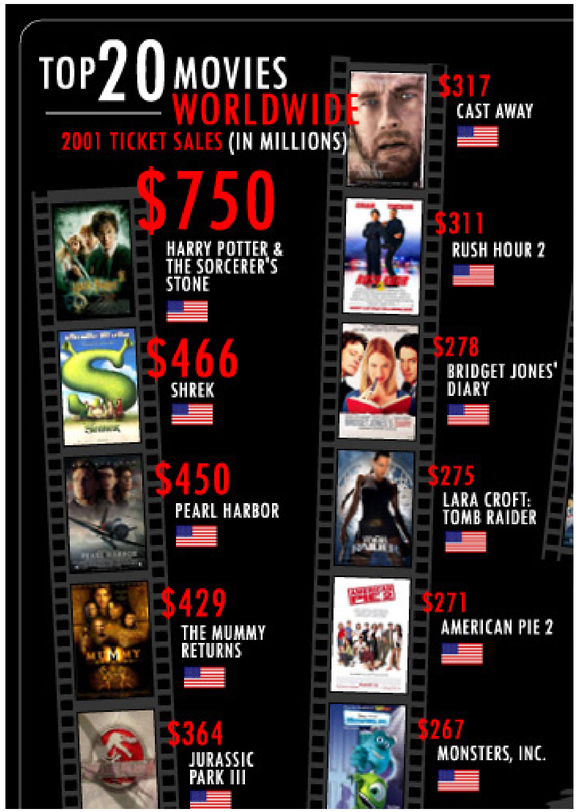
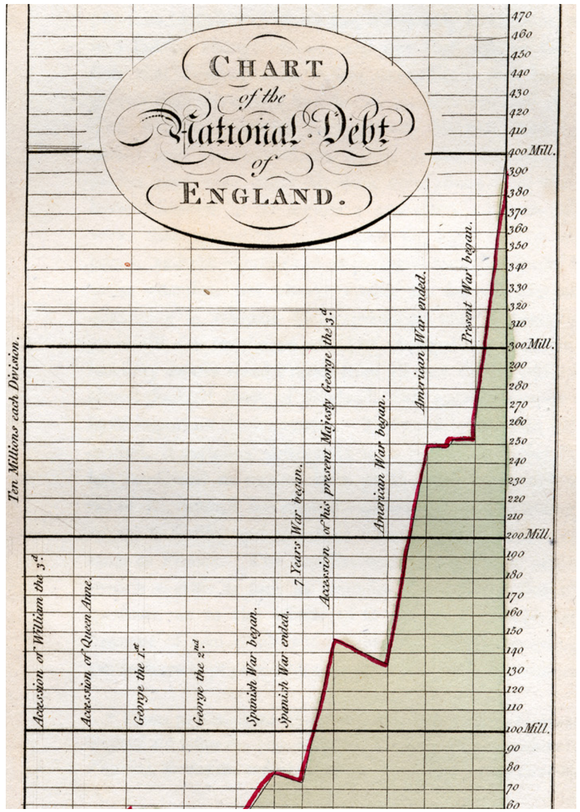
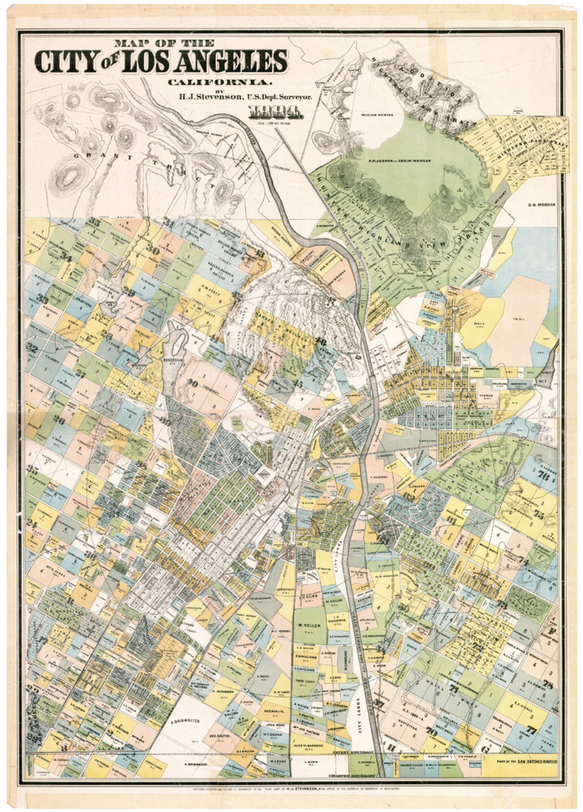
WHAT IS QUANTITATIVE INFORMATION DESIGN?



Information Design is the process of formatting information for quicker and more thorough understanding.



Quantitative Information Design is the process of transposing numeric data to visual forms.



Cartography is the practice of applying quantitative and qualitative data onto spatial maps.

Data Visualization is the practice of using computer software to render visual representations of data.

VISUAL VARIABLES

Comparisons:

Association: The marks can be perceived as similar.

Selection: The marks are perceived as different, forming families.

Order: The marks are perceived as ordered.

Quantity: The marks are perceived as proportional to each other.

Retinal Variables:

Size: Scale of graphic elements.

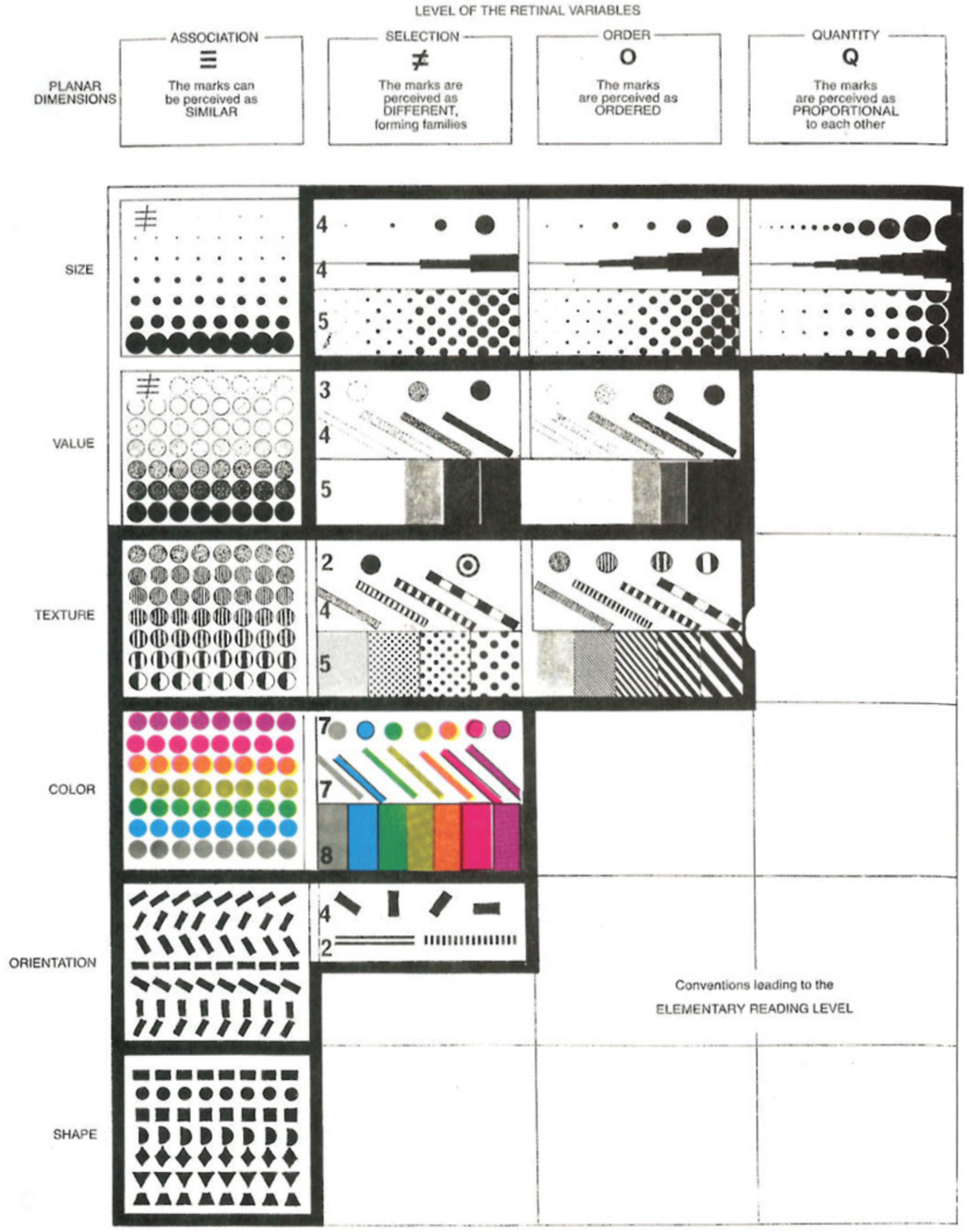
Value: Contrast between foreground and background.

Texture: Varying patterns used to distinguish elements.

Color: Varying hues used to distinguish elements.

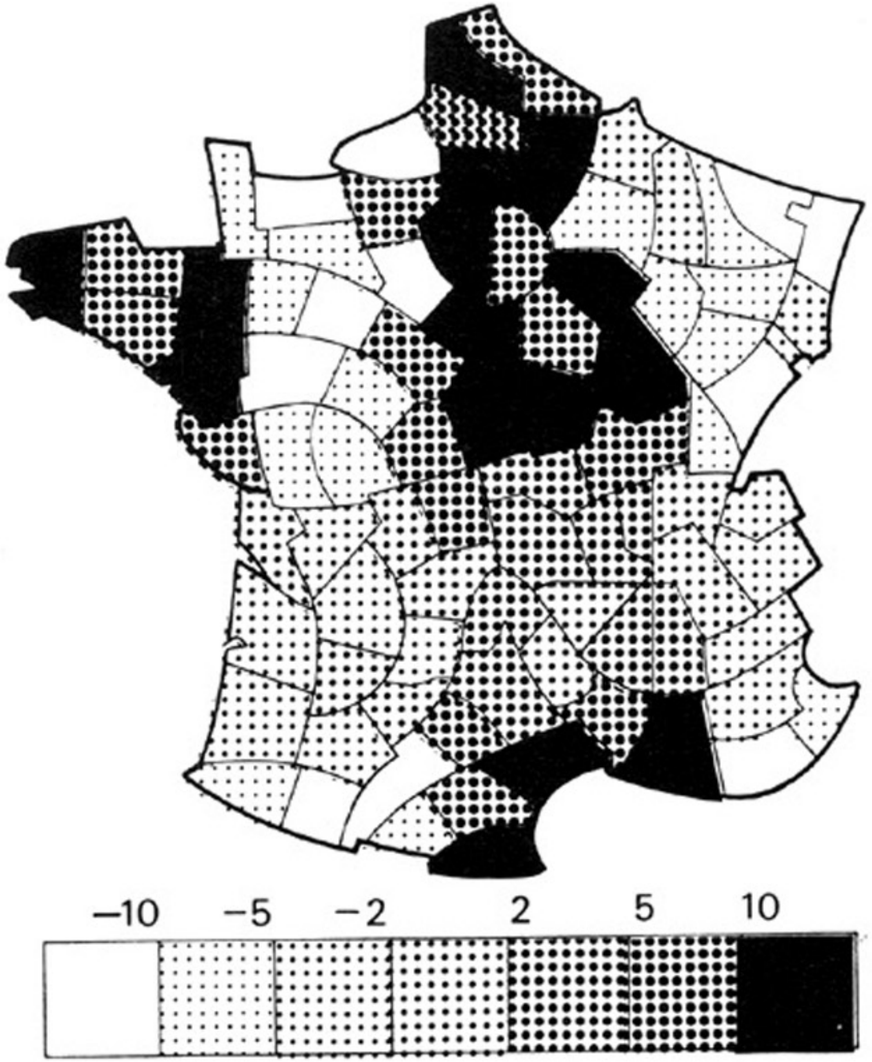
Orientation: Varying rotation of elements to create categories.

Shape: Varying shapes of elements to create categories.



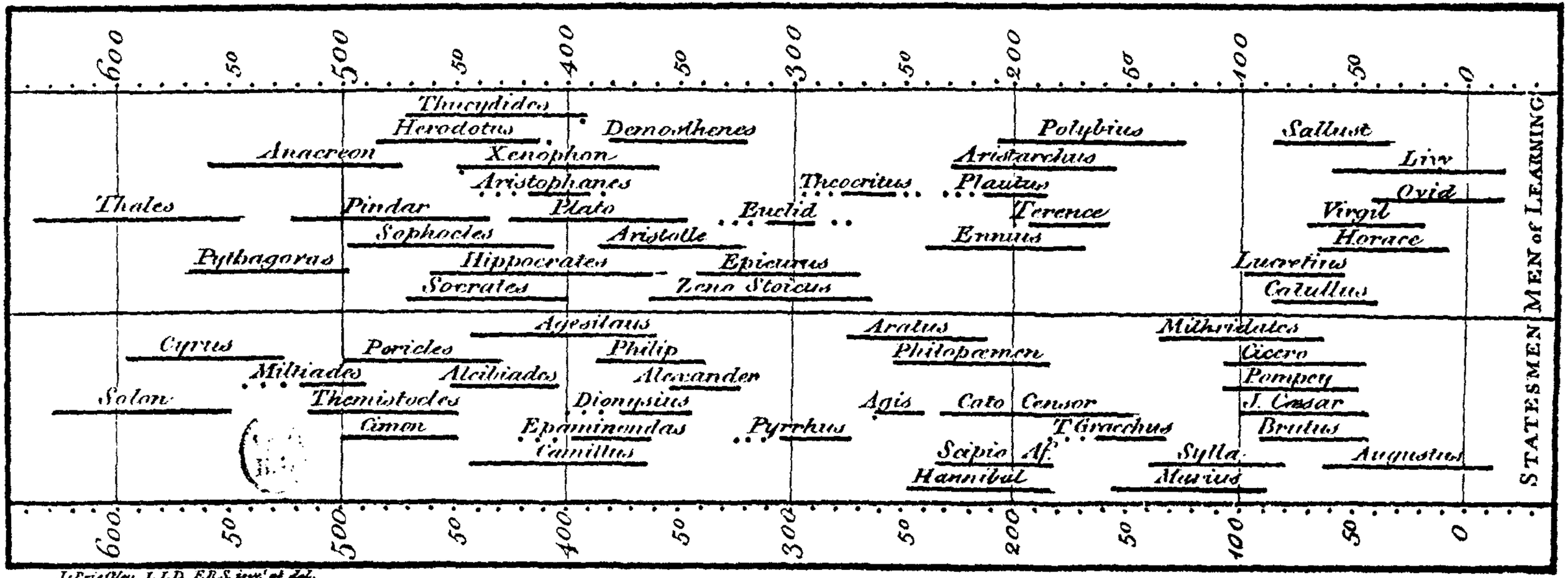
Semiology of Graphics, Jacques Bertin (1968)


11 5 1 −11 14 12 −2 −5 −12 9 18 −6 −2 −14 −15 −8 9 −9 11 8 −11 10 −8 −8 9 12 −6 −14 16 7 −4 5 −7 13 −12 10 −12 −7 12 13 7 −5 −6 8 6 −5 4 0 −3 1 5 3 1 −3 4 4 −2 0 −1 −3 −3 3 1 3 2 −4 −3 0 −1 4 −3 0 8 11 −4 −6 6 −4 −14 12 15 −10 −8 9 −11 −7 14


−10 −5 −2 2 5 10

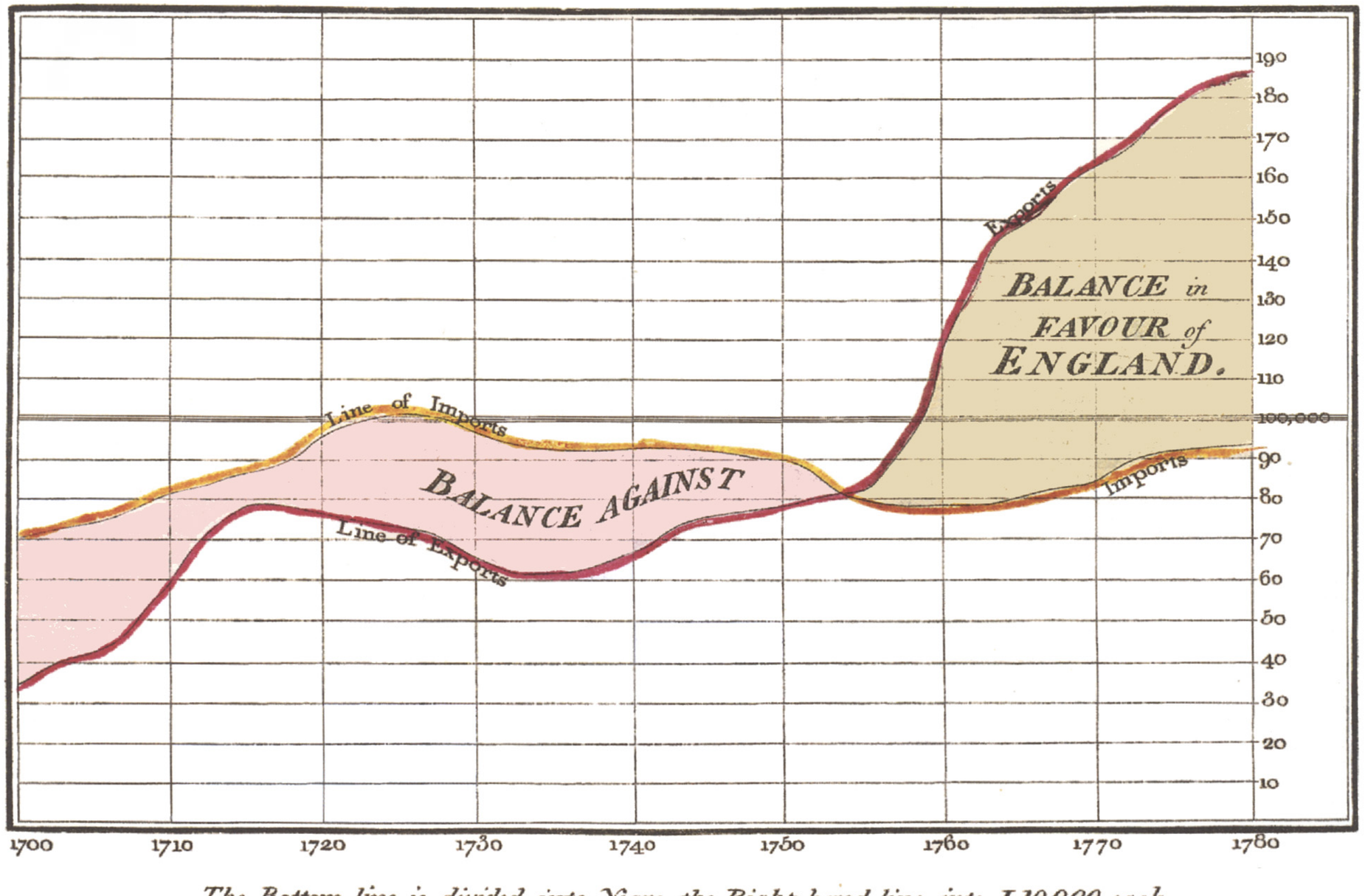
HISTORIC EXAMPLES

A Specimen of a Chart of Biography.



J. Priestley LL.D. F.R.S. inv.t et del.

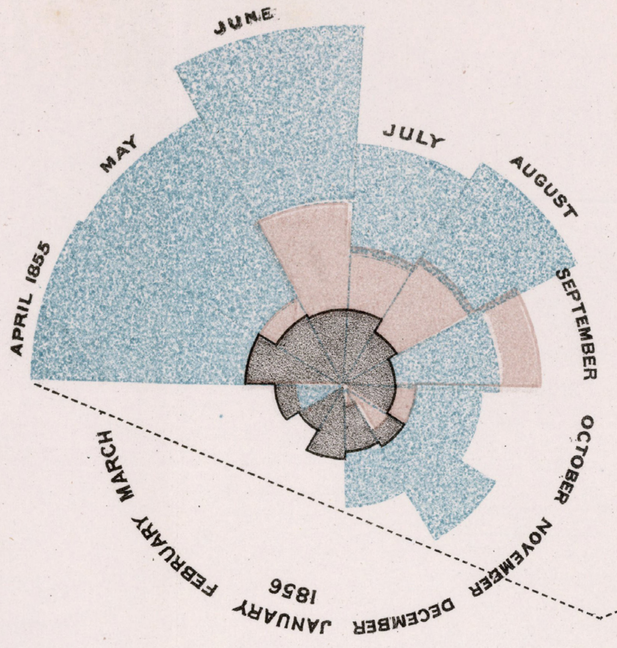
A Specimen of a Chart of Biography, Joseph Priestley (1765)



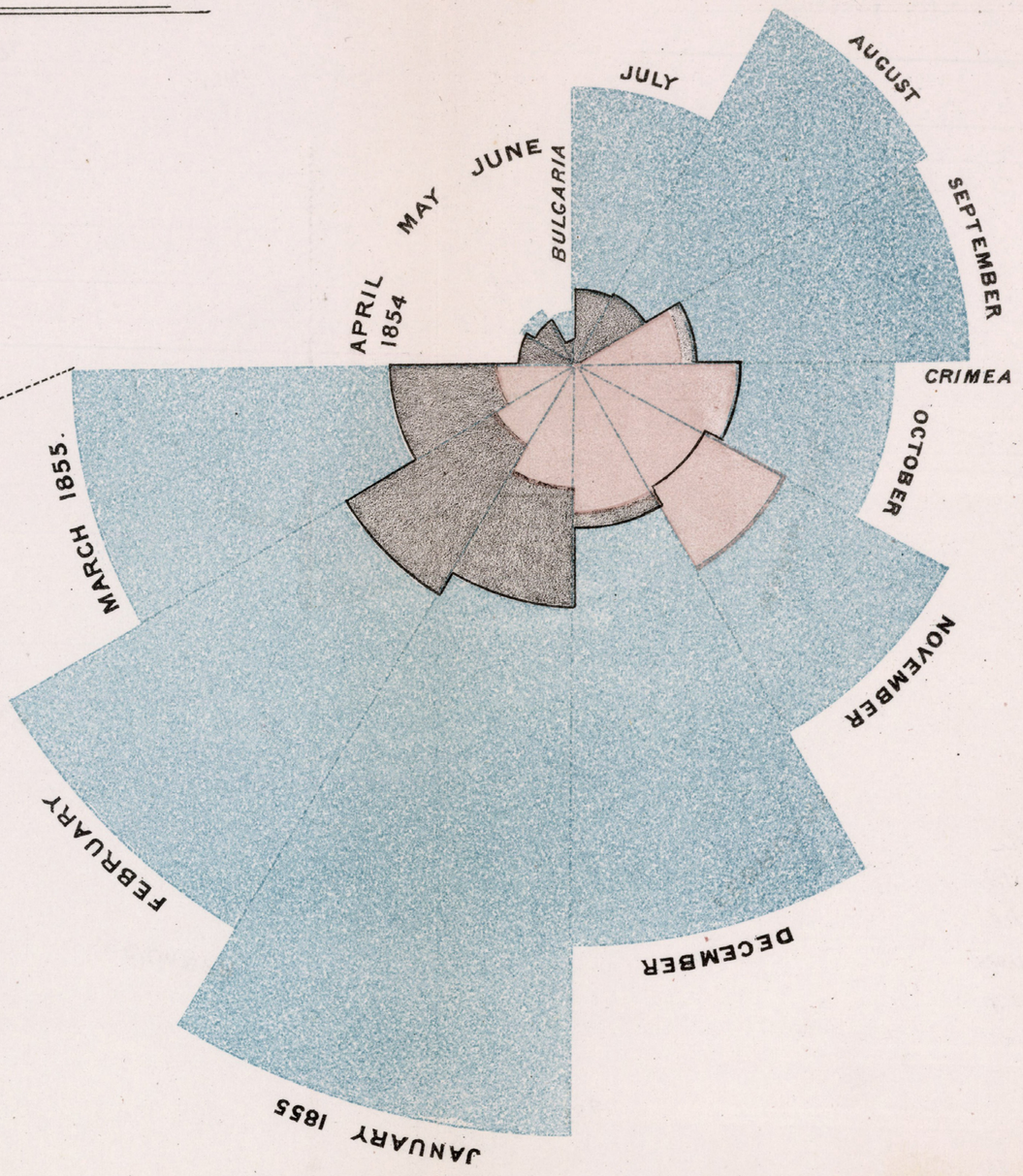
Exports and Imports to and from Denmark and Norway, William Playfair (1786)

DIAGRAM of the CAUSES of MORTALITY IN THE ARMY IN THE EAST.

2.
APRIL 1855 to MARCH 1856.



1.
APRIL 1854 to MARCH 1855.



The Areas of the blue, red, & black wedges are each measured from the centre as the common vertex.

The blue wedges measured from the centre of the circle represent area for area the deaths from Preventible or Mitigable Zymotic diseases; the red wedges measured from the centre the deaths from wounds; & the black wedges measured from the centre the deaths from all other causes.

The black line across the red triangle in Nov.r 1854 marks the boundary of the deaths from all other causes during the month.

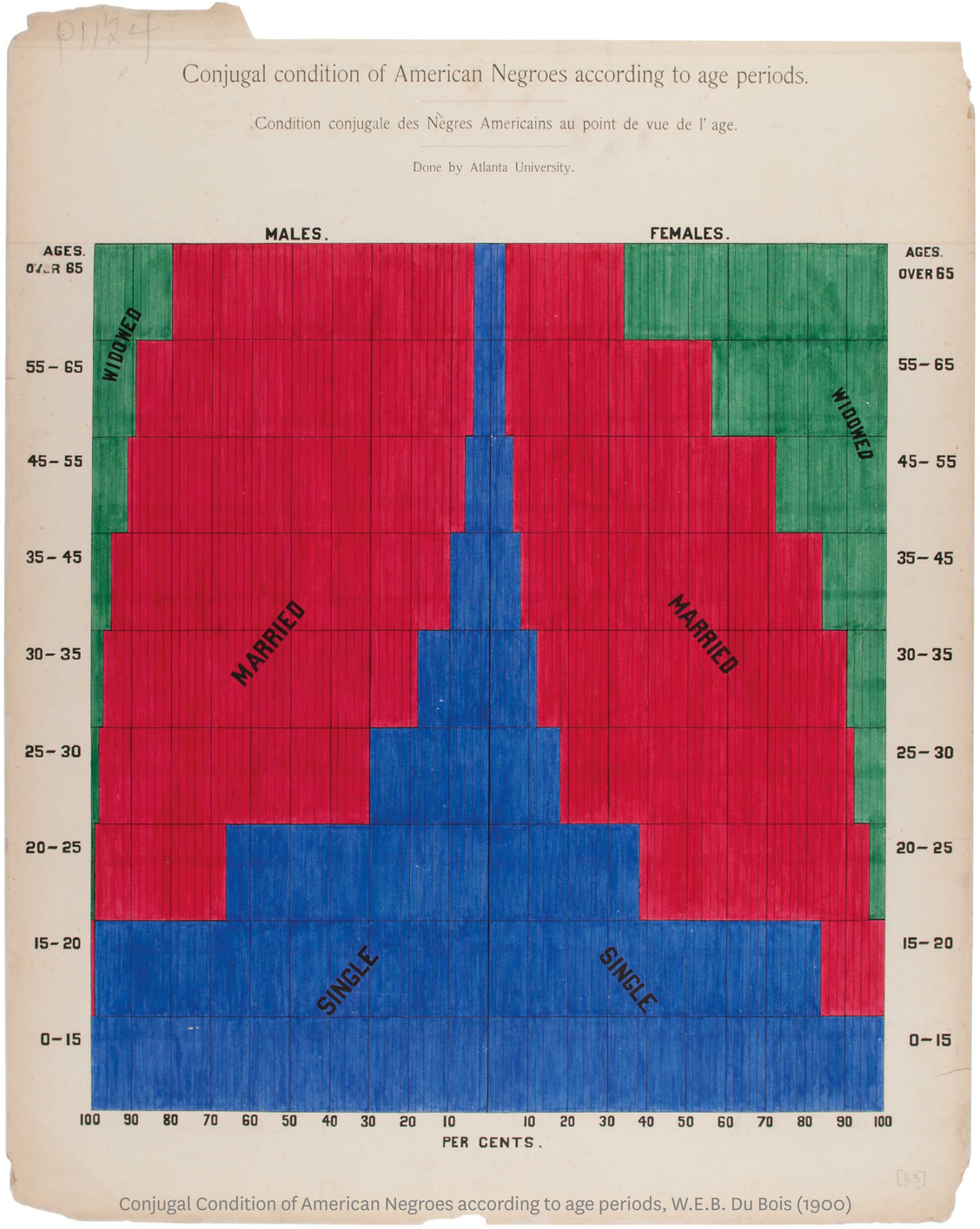
In October 1854, & April 1855, the black area coincides with the red; in January & February 1855, the blue coincides with the black.

The entire areas may be compared by following the blue, the red & the black lines enclosing them.

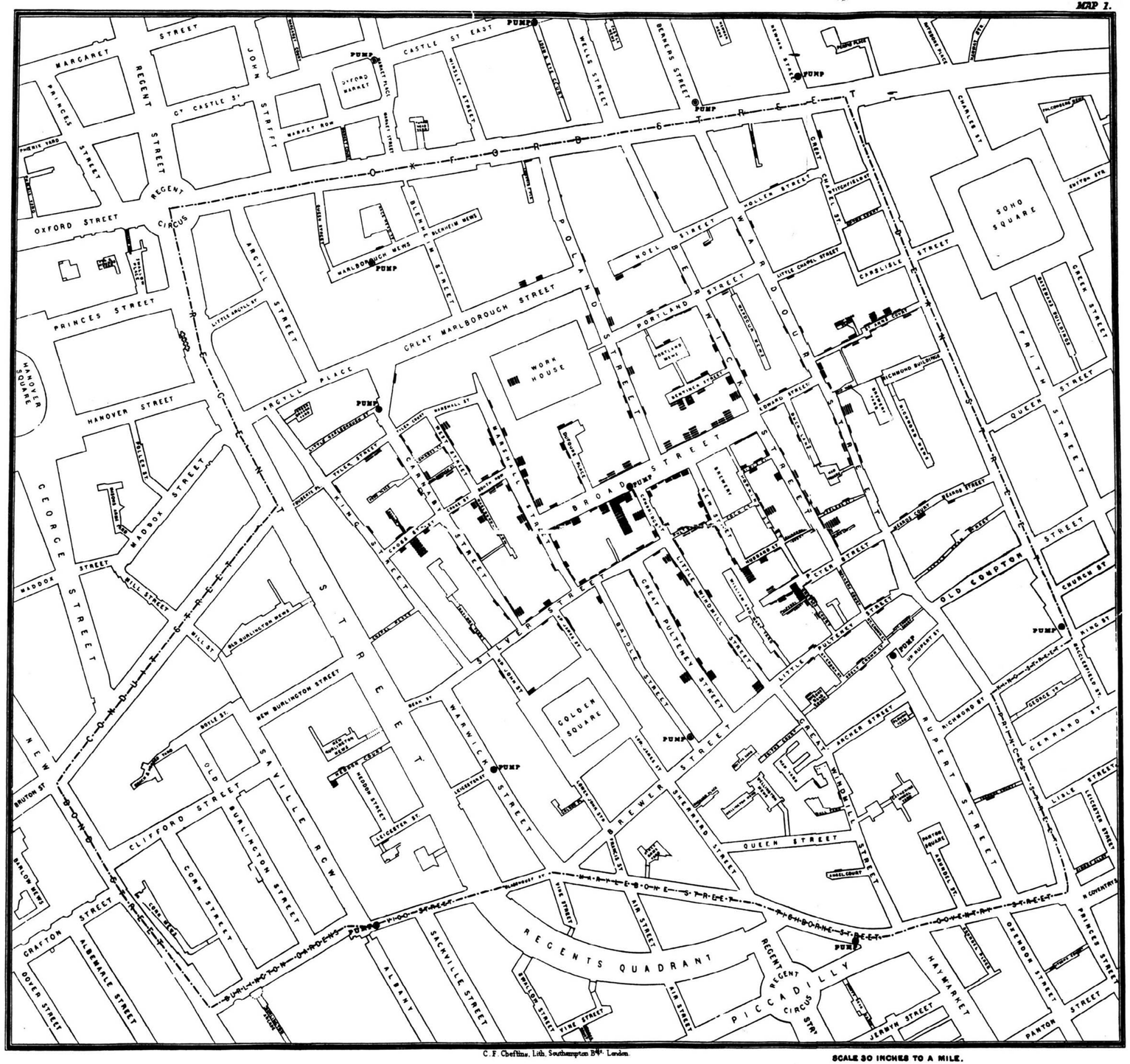
Diagram of the Causes of Mortality in the Army in the East, Florence Nightingale (1857)

Harrison & Sons, St. Martin's Lane.

City and Rural Population, W.E.B. Du Bois (1900)



Conjugal Condition of American Negroes according to age periods, W.E.B. Du Bois (1900)



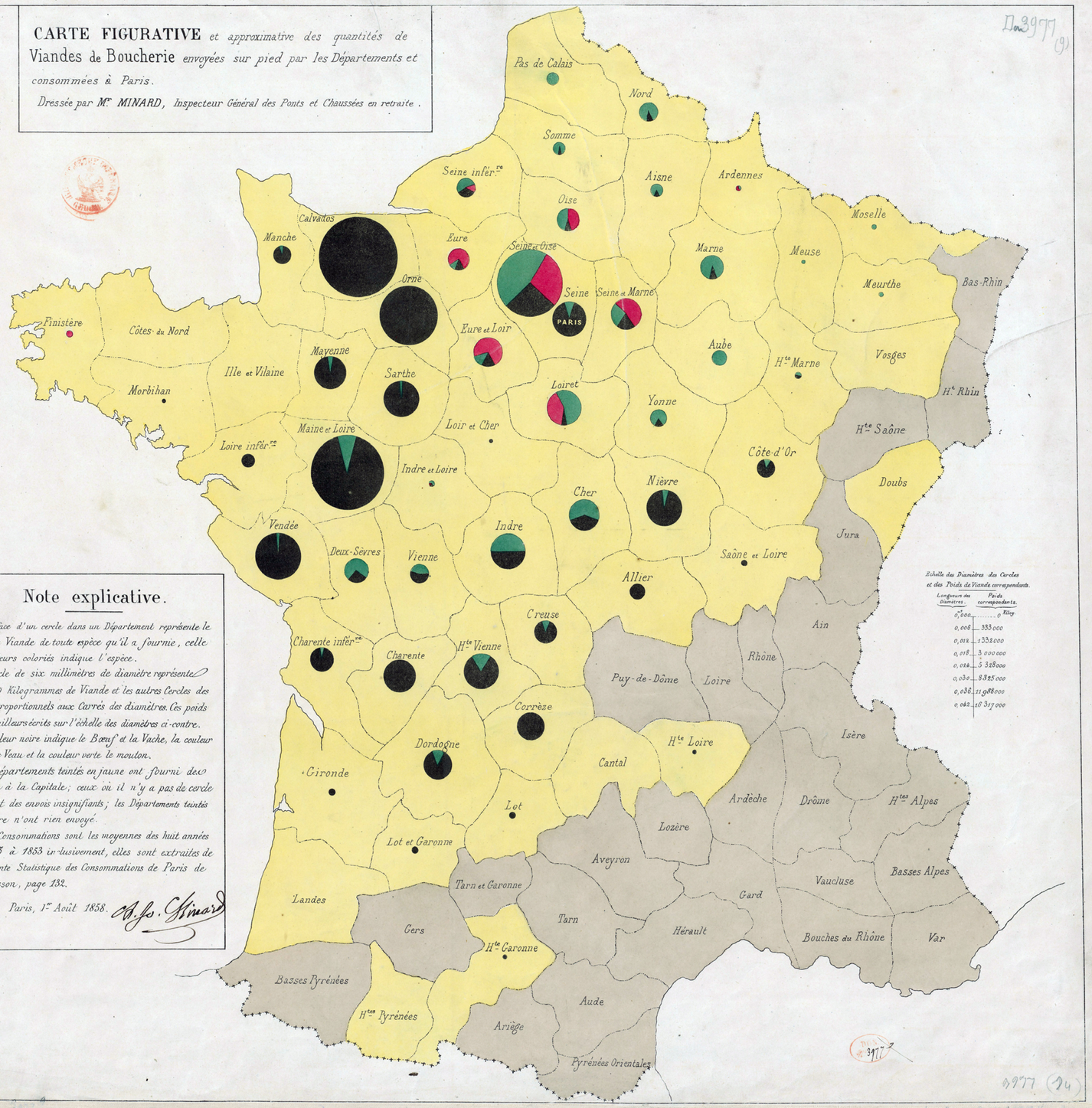
Broad Street Cholera Outbreak
John Snow (1854)


MARLBOROUGH MEWS
PUMP
NOEL
LITTLE CHAPEL STREET
CARLISLE
GREAT MARLBOROUGH STREET
PORTLAND STREET
PORTLAND MEWS
WARDOUR MEWS
ST ANNE COURT
RICHMOND BUILDINGS
RICHMOND MEWS
WORK HOUSE
ARGYLL PLACE
PUMP
LITTLE MARLBOROUGH ST
MARSHALL ST
TYLER STREET
MARSHALL STREET
DUFOURS PLACE
BENTINCK STREET
EDWARD STREET
BROAD STREET
PUMP
BREWERY
QUEEN STREET
FRITH STREET
CARNABY STREET
KING STREET
CROSS STREET
NEW STREET
HUSBAND ST
HEARDS COURT
HEARDS STREET
PETER STREET
OLD COMPTON STREET
SILVER STREET
GREAT PULTENEY STREET
LITTLE WINDMILL STREET
BRIDLE STREET
LITTLE PULTENEY STREET
UP JAMES ST
UP JOHN ST
UP RUPERT ST
PUMP
PUMP
OLD BURLINGTON MEWS
NEW BURLINGTON STREET
GOLDEN
GEORGE YD

MARLBOROUGH MEWS
PUMP
GREAT MARLBOROUGH STREET
ARGYLL PLACE
NOEL
BERWICK STREET
PORTLAND STREET
LITTLE CHAPEL STREET
CARLISLE
ST ANNE'S COURT
WORK HOUSE
PORTLAND MEWS
BENTINCK STREET
RICHMOND BUILDINGS
EDWARD STREET
DEAN STREET
FRITH STREET
QUEEN STREET
PUMP
MARSHALL ST
TYLER COURT
LITTLE MARLBOROUGH ST
TYLER STREET
CARNABY STREET
WEST STREET
MARSHALL STREET
DUFOURS PLACE
BROAD STREET
PUMP
BREWERY
KING STREET
CROSS STREET
CAMBRIDGE ST
NEW STREET
HUSBAND ST
PETER STREET
OLD COMPTON STREET
SILVER STREET
GREAT PULTENEY STREET
LITTLE WINDMILL STREET
BRIDLE STREET
LITTLE PULTENEY
PUMP
UP RUPERT ST
PUMP
KING STREET
OLD BURLINGTON MEWS
NEW BURLINGTON STREET
GOLDEN SQUARE

CARTE FIGURATIVE *et approximative des quantités de* Viandes de Boucherie *envoyées sur pied par les Départements et consommées à Paris.*

Dressée par Mr MINARD, *Inspecteur Général des Ponts et Chaussées en retraite.*



Note explicative.

La surface d'un cercle dans un Département représente le poids de Viande de toute espèce qu'il a fournie, celle des Secteurs coloriés indique l'espèce.

Un cercle de six millimètres de diamètre représente 333 000 Kilogrammes de Viande et les autres Cercles des poids proportionnels aux Carrés des diamètres. Ces poids sont d'ailleurs écrits sur l'échelle des diamètres ci-contre.

La couleur noire indique le Bœuf et la Vache, la couleur rouge le Veau et la couleur verte le mouton.

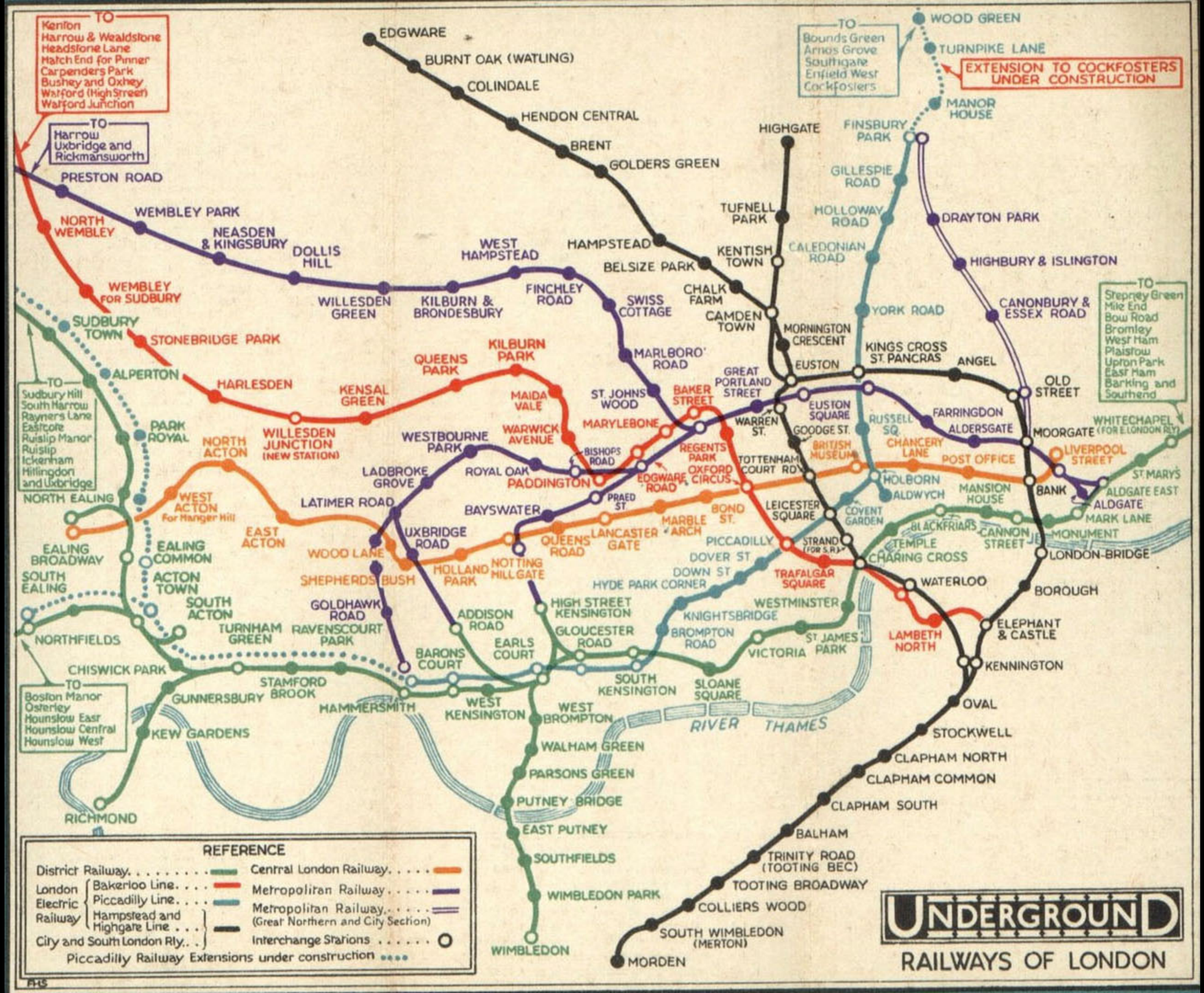
Les Départements teintés en jaune ont fourni des Bestiaux à la Capitale; ceux où il n'y a pas de cercle ont fait des envois insignifiants; les Départements teintés en bistre n'ont rien envoyé.

Ces Consommations sont les moyennes des huit années de 1845 à 1853 inclusivement, elles sont extraites de l'excellente Statistique des Consommations de Paris de Mr Husson, page 132.

Paris, 1er Août 1858. A.J.S. Minard

Echelle des Diamètres des Cercles et des Poids de Viande correspondants.

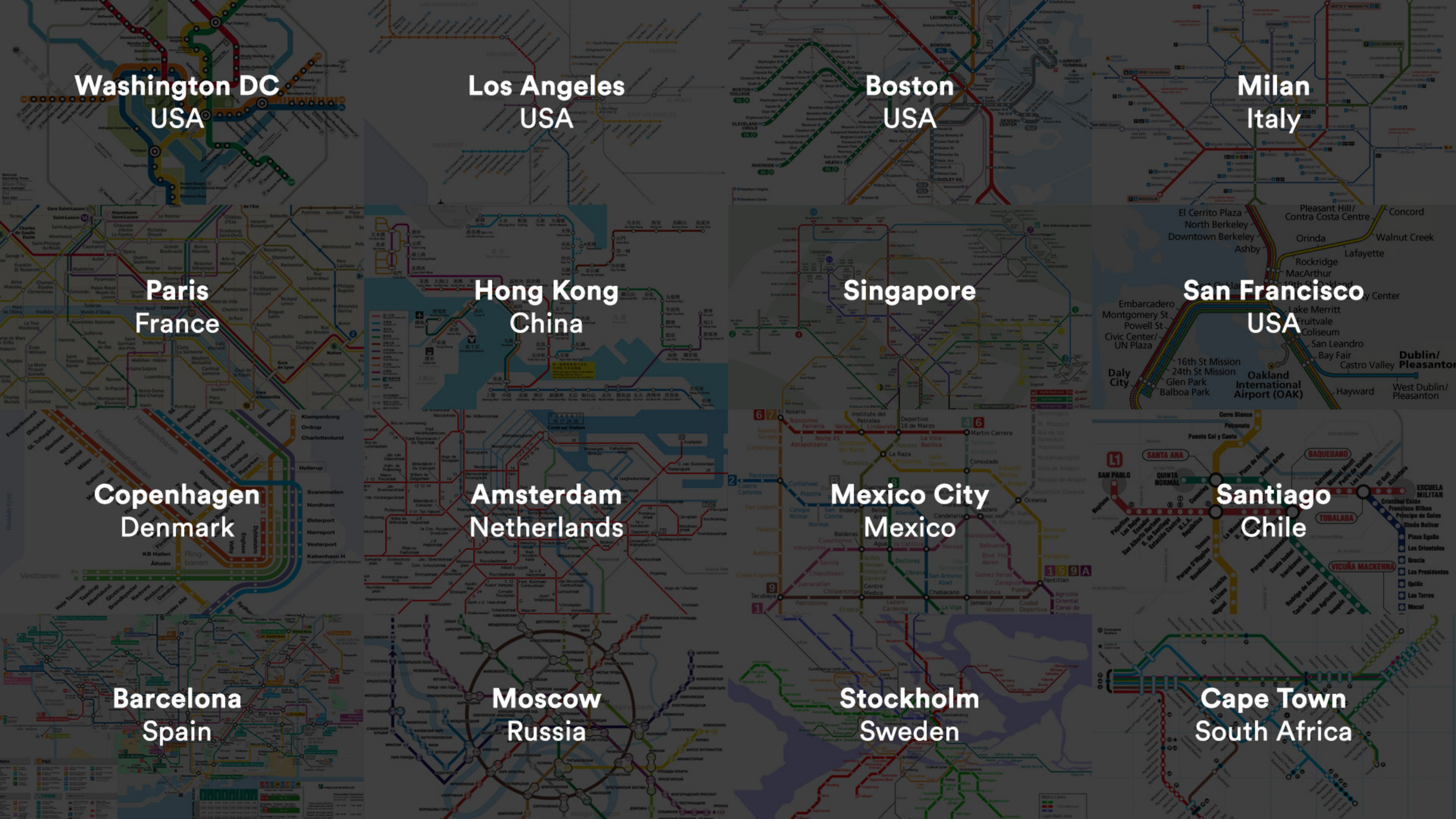
Longueurs des Diamètres.	Poids correspondants.
0m000	0 Kilog.
0,006	333 000
0,012	1 332 000
0,018	3 000 000
0,024	5 328 000
0,030	8 325 000
0,036	11 988 000
0,042	16 317 000



London Underground Map (1932)


WATFORD
RICKMANSWORTH
CROXLEY GREEN
MOOR PARK & SANDY LODGE
NORTHWOOD
PINNER
WATFORD JUNCTION
WATFORD (HIGH STREET)
BUSHEY AND OXHEY
CARPENDERS PARK
HATCH END for PINNER
HEADSTONE LANE
HARROW & WEALDSTONE
KENTON
STANMORE
CANONS PARK
KINGSBURY
NEASDEN
DOLLIS HILL
WILLESDEN GREEN
KILBURN & BRONDESBURY
WEST HAMPSTEAD
FINCHLEY ROAD
SWISS COTTAGE
MARLBORO ROAD
ST JOHNS WOOD
EDGWARE
BURNT OAK (WATLING)
COLINDALE
HENDON CENTRAL
BRENT
GOLDERS GREEN
HAMPSTEAD
BELSIZE PARK
CHALK FARM
HIGHGATE
TUFNELL PARK
KENTISH TOWN
CAMDEN TOWN
MORNINGTON CRESCENT
EUSTON
COCKFOSTERS
OPEN MIDSUMMER 1933
ENFIELD WEST
SOUTHGATE
ARNOS GROVE
BOUNDS GREEN
WOOD GREEN
TURNPIKE LANE
MANOR HOUSE
FINSBURY PARK
ARSENAL (HIGHBURY HILL)
DRAYTON PARK
HOLLOWAY ROAD
HIGHBURY & ISLINGTON
CALEDONIAN ROAD
CANONBURY & ESSEX ROAD
KINGS CROSS ST. PANCRAS
OLD STREET
ANGEL
FARRINGDON
ALDERSGATE
MOORGATE
LIVERPOOL STREET
RUSSELL SQUARE
CHANCERY LANE
POST OFFICE
HOLBORN
BANK
ALDWYCH
BRITISH MUSEUM
TOTTENHAM COURT ROAD
GREAT PORTLAND ST.
REGENTS PARK
EUSTON SQUARE
WARREN STREET
GOODGE STREET
MARYLEBONE
EDGWARE ROAD
BAKER STREET
PADDINGTON
PRAED STREET
WARWICK AVENUE
LATIMER ROAD
WESTBOURNE PARK
ROYAL OAK
LADBROKE GROVE
BISHOPS ROAD
BAYSWATER
NOTTING HILL GATE
LANCASTER GATE
BOND STREET
UXBRIDGE ROAD
HOLLAND PARK
QUEENS ROAD
MARBLE ARCH
OXFORD CIRCUS
PICCADILLY
DOVER STREET
HYDE PARK CORNER
KNIGHTSBRIDGE
BROMPTON ROAD
TRAFALGAR SQUARE
LEICESTER SQUARE
STRAND
COVENT GARDEN
MANSION HOUSE
MONUMENT
MARK LANE
ALDGATE
ALDGATE EAST
WHITECHAPEL
MILE END
SHOREDITCH
STEPNEY GREEN
BLACKFRIARS
CANNON STREET
TEMPLE
CHARING CROSS
WESTMINSTER
VICTORIA
WATERLOO
LAMBETH NORTH
LONDON BRIDGE
BOROUGH
ELEPHANT & CASTLE
KENNINGTON
OVAL
STOCKWELL
CLAPHAM NORTH
CLAPHAM COMMON
CLAPHAM SOUTH
BALHAM
TRINITY ROAD (TOOTING BEC)
TOOTING BROADWAY
COLLIERS WOOD
SOUTH WIMBLEDON (MERTON)
MORDEN
ST. JAMES PARK
SLOANE SQUARE
SOUTH KENSINGTON
WEST KENSINGTON
EARLS COURT
GLOUCESTER ROAD
HIGH STREET KENSINGTON
ADDISON ROAD
HAMMERSMITH
BARONS COURT
STAMFORD BROOK
GOLDHAWK ROAD
RAVENSCOURT PARK
TURNHAM GREEN
GUNNERSBURY
CHISWICK PARK
KEW GARDENS
RICHMOND
WEST BROMPTON
WALHAM GREEN
PARSONS GREEN
PUTNEY BRIDGE
EAST PUTNEY
SOUTHFIELDS
WIMBLEDON PARK
WIMBLEDON
NORTH HARROW
HARROW ON THE HILL
PRESTON ROAD
NORTHWICK PARK
NORTH WEMBLEY
WEMBLEY PARK
WEMBLEY for SUDBURY
STONEBRIDGE PARK
HARLESDEN
WILLESDEN JUNCTION
KENSAL GREEN
QUEENS PARK
KILBURN PARK
MAIDA VALE
WEST HARROW
RAYNERS LANE
RUISLIP MANOR
ICKENHAM
UXBRIDGE
HILLINGDON
RUISLIP
EASTCOTE
SOUTH HARROW
SUDBURY HILL
SUDBURY TOWN
ALPERTON
PARK ROYAL
NORTH EALING
EALING BROADWAY
WEST ACTON
EAST ACTON
NORTH ACTON
WOOD LANE
EALING COMMON
SHEPHERDS BUSH
ACTON TOWN
SOUTH ACTON
SOUTH EALING
NORTHFIELDS
BOSTON MANOR
OSTERLEY
HOUNSLOW EAST
HOUNSLOW CENTRAL
HOUNSLOW WEST
TO BOW ROAD BROMLEY WEST HAM PLAISTOW UPTON PARK EAST HAM BARKING UPNEY BECONTREE HEATHWAY DAGENHAM HORNCHURCH UPMINSTER & SOUTHEND
SHADWELL
WAPPING
ROTHERHITHE
SURREY DOCKS
NEW CROSS GATE
NEW CROSS
REFERENCE
DISTRICT RAILWAY
BAKERLOO LINE
PICCADILLY LINE
EDGWARE, HIGHGATE & MORDEN LINE
CENTRAL LONDON RLY.
METROPOLITAN RLY.
METROPOLITAN RLY. (GREAT NORTHERN & CITY SECTION)
EAST LONDON RAILWAY
INTERCHANGE STATIONS
UNDER CONSTRUCTION
UNDERGROUND
H.C. BECK


El Cerrito Plaza
North Berkeley
Downtown Berkeley
Ashby
Pleasant Hill/
Contra Costa Centre
Concord
Orinda
Walnut Creek
Lafayette
Rockridge
MacArthur
19th St/Oakland
12th St/Oakland City Center
West Oakland
Embarcadero
Montgomery St
Powell St
Civic Center/
UN Plaza
Lake Merritt
Fruitvale
Coliseum
San Leandro
Bay Fair
16th St Mission
24th St Mission
Glen Park
Balboa Park
Daly
City
Oakland
International
Airport (OAK)
Castro Valley
Dublin/
Pleasanton
Hayward
West Dublin/
Pleasanton
SAN PABLO
SANTA ANA
QUINTA
NORMAL
LOS HEROES
BAQUEDANO
TOBALABA
ESCUELA
MILITAR
VICUÑA MACKENNA
Cerro Blanco
Patronato
Puente Cal y Canto
Rosario
Instituto del
Petroleo
Deportivo
18 de Marzo
Martin Carrera
Pantitlan
Tacubaya
Hellerup
Svanemellen
Nordhavn
Østerport
Nørreport
Vesterport
København H
Vestbanen
Klampenborg
Ordrup
Charlottenlund


Washington DC
USA
Los Angeles
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Boston
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Milan
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France
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San Francisco
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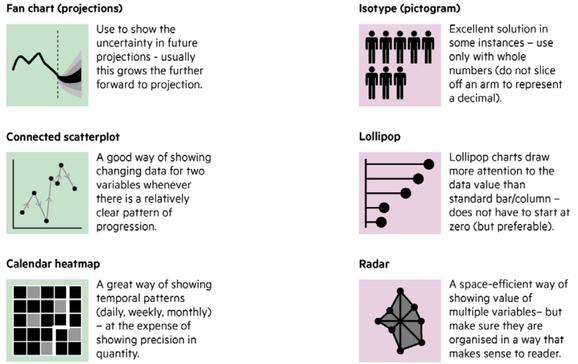
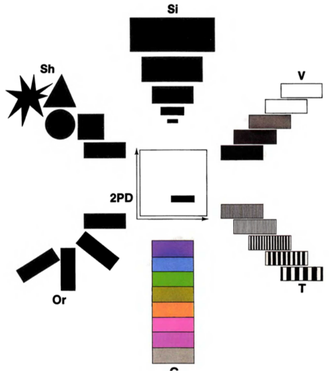
Copenhagen
Denmark
Amsterdam
Netherlands
Mexico City
Mexico
Santiago
Chile
Barcelona
Spain
Moscow
Russia
Stockholm
Sweden
Cape Town
South Africa

Race and Ethnicity Census, Erica Fischer (2010)

See Something or Say Something, Erica Fischer (2011)

STEPS TO CRAFTING A VISUALIZATION.





1) Review the subject matter and data properties. Further insight into the subject and thorough knowledge of how the data is stored and formatted will open your imagination to greater visualization opportunities.

2) Ask the right questions. A deeper understanding of the subject will provide you with a better perspective for posing questions against the data. Think of it as a hypothesis to make observations.

3) Choose the appropriate graph model. Once you have a proper question for your subject matter, you can choose the best graph model to help answer that question. This is the most effective perspective from which to make observations.

4) Define your retinal variables. With a graph model established, you will need to define the retinal variables that will apply to each data property. This includes placement, color, value, size, texture, orientation, and shape.

SELECTING THE APPROPRIATE GRAPH MODEL FOR YOUR QUESTION

Deviation

Emphasise variations (+/-) from a fixed reference point. Typically the reference point is zero but it can also be a target or a long-term average. Can also be used to show sentiment (positive/neutral/negative).

Example FT uses
Trade surplus/deficit, climate change

Diverging bar

A simple standard bar chart that can handle both negative and positive magnitude values.

Diverging stacked bar

Perfect for presenting survey results which involve sentiment (eg disagree/neutral/agree).

Spine

Splits a single value into two contrasting components (eg male/female).

Surplus/deficit filled line

The shaded area of these charts allows a balance to be shown – either against a baseline or between two series.

Correlation

Show the relationship between two or more variables. Be mindful that, unless you tell them otherwise, many readers will assume the relationships you show them to be causal (i.e. one causes the other).

Example FT uses
Inflation and unemployment, income and life expectancy

Scatterplot

The standard way to show the relationship between two continuous variables, each of which has its own axis.

Column + line timeline

A good way of showing the relationship between an amount (columns) and a rate (line).

Connected scatterplot

Usually used to show how the relationship between 2 variables has changed over time.

Bubble

Like a scatterplot, but adds additional detail by sizing the circles according to a third variable.

XY heatmap

A good way of showing the patterns between 2 categories of data, less effective at showing fine differences in amounts.

Ranking

Use where an item's position in an ordered list is more important than its absolute or relative value. Don't be afraid to highlight the points of interest.

Example FT uses
Wealth, deprivation, league tables, constituency election results

Ordered bar

Standard bar charts display the ranks of values much more easily when sorted into order.

Ordered column

See above.

Ordered proportional symbol

Use when there are big variations between values and/or seeing fine differences between data is not so important.

Dot strip plot

Dots placed in order on a strip are a space-efficient method of laying out ranks across multiple categories.

Slope

Perfect for showing how ranks have changed over time or vary between categories.

Lollipop

Lollipops draw more attention to the data value than standard bar/column and can also show rank and value effectively.

Bump

Effective for showing changing rankings across multiple dates. For large datasets, consider grouping lines using colour.

Distribution

Show values in a dataset and how often they occur. The shape (or 'skew') of a distribution can be a memorable way of highlighting the lack of uniformity or equality in the data.

Example FT uses
Income distribution, population (age/sex) distribution, revealing inequality

Histogram

The standard way to show a statistical distribution - keep the gaps between columns small to highlight the 'shape' of the data.

Dot plot

A simple way of showing the change or range (min/max) of data across multiple categories.

Dot strip plot

Good for showing individual values in a distribution, can be a problem when too many dots have the same value.

Barcode plot

Like dot strip plots, good for displaying all the data in a table, they work best when highlighting individual values.

Boxplot

Summarise multiple distributions by showing the median (centre) and range of the data

Violin plot

Similar to a box plot but more effective with complex distributions (data that cannot be summarised with simple average).

Population pyramid

A standard way for showing the age and sex breakdown of a population distribution; effectively, back to back histograms.

Cumulative curve

A good way of showing how unequal a distribution is: y axis is always cumulative frequency, x axis is always a measure.

Change over Time

Give emphasis to changing trends. These can be short (intra-day) movements or extended series traversing decades or centuries: Choosing the correct time period is important to provide suitable context for the reader.

Example FT uses
Share price movements, economic time series, sectoral changes in a market

Line

The standard way to show a changing time series. If data are irregular, consider markers to represent data points.

Column

Columns work well for showing change over time - but usually best with only one series of data at a time.

Column + line timeline

A good way of showing the relationship over time between an amount (columns) and a rate (line).

Slope

Good for showing changing data as long as the data can be simplified into 2 or 3 points without missing a key part of story.

Area chart

Use with care – these are good at showing changes to total, but seeing change in components can be very difficult.

Candlestick

Usually focused on day-to-day activity, these charts show opening/closing and high/low points of each day.

Fan chart (projections)

Use to show the uncertainty in future projections - usually this grows the further forward to projection.

Connected scatterplot

A good way of showing changing data for two variables whenever there is a relatively clear pattern of progression.

Magnitude

Show size comparisons. These can be relative (just being able to see larger/bigger) or absolute (need to see fine differences). Usually these show a 'counted' number (for example, barrels, dollars or people) rather than a calculated rate or per cent.

Example FT uses
Commodity production, market capitalisation, volumes in general

Column

The standard way to compare the size of things. Must always start at 0 on the axis.

Bar

See above. Good when the data are not time series and labels have long category names.

Paired column

As per standard column but allows for multiple series. Can become tricky to read with more than 2 series.

Paired bar

See above.

Marimekko

A good way of showing the size and proportion of data at the same time – as long as the data are not too complicated.

Proportional symbol

Use when there are big variations between values and/or seeing fine differences between data is not so important.

Isotype (pictogram)

Excellent solution in some instances – use only with whole numbers (do not slice off an arm to represent a decimal).

Lollipop

Lollipop charts draw more attention to the data value than standard bar/column – does not have to start at zero (but preferable).

Part-to-whole

Show how a single entity can be broken down into its component elements. If the reader's interest is solely in the size of the components, consider a magnitude-type chart instead.

Example FT uses
Fiscal budgets, company structures, national election results

Stacked column/bar

A simple way of showing part-to-whole relationships but can be difficult to read with more than a few components.

Marimekko

A good way of showing the size and proportion of data at the same time – as long as the data are not too complicated.

Pie

A common way of showing part-to-whole data – but be aware that it's difficult to accurately compare the size of the segments.

Donut

Similar to a pie chart – but the centre can be a good way of making space to include more information about the data (eg total).

Treemap

Use for hierarchical part-to-whole relationships; can be difficult to read when there are many small segments.

Voronoi

A way of turning points into areas – any point within each area is closer to the central point than any other centroid.

Arc

A hemicycle, often used for visualising parliamentary composition by number of seats.

Gridplot

Good for showing % information, they work best when used on whole numbers and work well in small multiple layout form.

Spatial

Aside from locator maps only used when precise locations or geographical patterns in data are more important to the reader than anything else.

Example FT uses
Population density, natural resource locations, natural disaster risk/impact, catchment areas, variation in election results

Basic choropleth (rate/ratio)

The standard approach for putting data on a map – should always be rates rather than totals and use a sensible base geography.

Proportional symbol (count/magnitude)

Use for totals rather than rates – be wary that small differences in data will be hard to see.

Flow map

For showing unambiguous movement across a map.

Contour map

For showing areas of equal value on a map. Can use deviation colour schemes for showing +/- values

Equalised cartogram

Converting each unit on a map to a regular and equally-sized shape – good for representing voting regions with equal value.

Scaled cartogram (value)

Stretching and shrinking a map so that each area is sized according to a particular value.

Dot density

Used to show the location of individual events/locations – make sure to annotate any patterns the reader should see.

Heat map

Grid-based data values mapped with an intensity colour scale. As choropleth map – but not snapped to an admin/political unit.

Flow

Show the reader volumes or intensity of movement between two or more states or conditions. These might be logical sequences or geographical locations.

Example FT uses
Movement of funds, trade, migrants, lawsuits, information; relationship graphs.

Sankey

Shows changes in flows from one condition to at least one other; good for tracing the eventual outcome of a complex process.

Waterfall

Designed to show the sequencing of data through a flow process, typically budgets. Can include +/- components.

Chord

A complex but powerful diagram which can illustrate 2-way flows (and net winner) in a matrix.

Network

Used for showing the strength and inter-connectedness of relationships of varying types.

Financial Times - Visual Vocabulary. https://github.com/ft-interactive/chart-doctor/tree/master/visual-vocabulary


QUESTIONS?