What is a Map?

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Compare the following examples:

- Polynesian stick chart, Marshall islands. Can you imagine using such a map so naturally that you think: "this and no other way a map has to look like?"
- compare with an english 19th century map M. Maury, the physical geography of the sea
- USGS Topographic map. At first it may look familiar, but if you look close, you will find a lot of unfamiliar elements and scales.

What is found on a map?

- Frame
- Title
- North Arrow
- Grids / Graticules- Geographic features (others - political, cultural, thematic …)
- Scales
- Legend / Symbology (symbols for colors, lines, points…)
- Contours
- Information about map projection
- Annotation

Which way is up?

Maps are based on arbitrary conventions

- Medieval OT (Orbis Terrarum) maps
- Peutinger map (based on a Roman map)
- A map of New England, 17th century
- Joaquín Torres García's "América Invertida"

Introduction to Geographic Information Systems (GIS)

"everything is related to everything else, but near things are more related than distant things."

Waldo Tobler's 1st law of geography, in 1970. "A Computer Movie Simulating Urban Growth in the Detroit Region." *Economic Geography*

- But what do *near* and *distant* mean? Distance can be measured in meters, time, similarity, number of interactions, phone calls…

Example:

Dr. John Snow, deaths from Cholera during the Golden Square outbreak, 1854

- What constitutes "data" on this map? How does proximity matter?

GIS Concepts

GIS is a framework for spatial computation. Geographic information systems capture, store, manipulate, analyze, manage, and visualize spatial or geographic data. GIS systems are used to:

- create maps
- query and manage geographic data.
- conduct spatial analysis (e.g. how many buildings are affected by sea-level rise in Boston?)

GIS data consists of the geometry of geographic features (point, line, polygon, raster) and arbitrary data attached to each of these features.

- geographic data is organised as a stack of layers.
- Each layer uses a specific coordinate system.
- Layers are rendered using map projections and symbolic mappings (colors, shapes, size etc.)

Coordinate systems

in QGIS: CRS (Coordinate Reference System)

Geodetic datum

- Specifies location on the globe (abstracted as an ellipsoid)
- Can be of local or global scope
- Coordinates are typically meridians & parallels, i.e. longitude, latitude in degrees (-180,180,-90,90)
- Most used standard: WGS 84 (world geodetic system, revision from 1984)

Projected coordinate system

- specifies location on a plane
- cartesian or polar
- geography is transformed onto this plane using some algorithm / transformation

Map Projections Three main families:

- cylindrical (projection onto cylinder)
- planar (projection onto plane)
- conic (onto cone)

Review many map projections at radical cartography

Map distortion Map projections were designed to preserve certain properties, while distorting others.

- **equal area** - areas are shown in true size
- **conformal** - angles are locally preserved, a circle remains a circle
- **equidistance** - distance along certain directions (meridians)
- **azimuthal** - preserves directions from a fixed point to all others
- **compromise** - visual balance, mostly for world maps.

Exercise: Load the world map layer, set and compare the following projections in QGIS

- WGS 84 datum, no projection
- WGS 84 World Mercator
- Robinson
- Polyconic
- Transversal Mercator

Question: how does scale affect the usefulness or uselessness of a projection?

GIS Features

Vector

Point, line, polygon layers

Raster

Images (rgb), data grids (integer or floating point): e.g. digital elevation models (DEM)

Exercise

Get together in groups of 2-3. Create a map that juxtaposes two different geospatial data sets (e.g. pumps and cholera), in order to tell a story.

Example GIS resources:

City of Boston - different spatial open data sets: https://data.boston.gov/group/geospatial

State of Massachusetts - various map layers and elevation model: https://www.mass.gov/service-details/massgis-data-layers

US Census - TIGER data layers (census, roads, coastlines, administrative units …): https://www.census.gov/geo/maps-data/data/tiger.html

Global - Natural Earth data: https://www.naturalearthdata.com/downloads/

Addendum - Install QGIS 3.4

- Go to the site `https://qgis.org` and download the latest (version 3.x) of QGIS.

- It is recommended to use the latest python 3.6 version from python.org, no later (3.7) version!
- When you run the installer, the newer Mac OS versions will try to prevent you from installing it. Do not run by double click, but use the context menu to open it, this will let you execute the installer.
- QGIS is open source software under active and rapid development, so expect frequent feature changes and some bugs. I recommend running QGIS from the terminal / commandline: on a mac, go to `/Applications/QGIS3.app/Contents/MacOS/` then run by executing `./QGIS`