Class 2: Thinking Spatially

Guiding Question:

How do our bodies, cultures, and experiences shape the way we understand and navigate space?

- Spatial thinking is our ability to understand, reason about, and mentally manipulate spatial relationships
- Multiple factors influence how we create our framework for thinking spatially
  - Embodied spatial knowledge
  - Situated spatial knowledge
  - Learned spatial knowledge
- Our brains have the same hardware for mapping space, but everyone's cognitive map looks different
- We need to think spatially because human survival and cooperation have long depended on understanding and navigating spaces beyond our immediate perception
- Because of the way our species works, we have always needed to be able to externalize this knowledge

Class 3: What are maps

Guiding Question:

If maps are made through choices, what does that mean for how we should read and trust them?

- Maps play many functions in society
- Today, maps are usually framed as technical tools- precise, objective, measured.
- This idea that maps are scientific representations of space has become dominant, especially in the Western tradition. That framing solidified during the Scientific Revolution

Class 4: Mapping to Claim and Administer

Guiding Question:

How does measuring and recording land turn space into something that can be controlled?

- Harley argues that we should "deconstruct" maps:
  - Maps are arguments, not mirrors
  - Power shapes maps
  - Cartographic choices are ideological
  - Silences are as important as what is shown
  - The mapmakers' authority is constructed
- You can ask the following questions to begin to "deconstruct" a map:
  - What do you see first? What does this say about what is important to the map?
  - What is this map for?
  - Who made it?
  - What's on the map?
  - What's missing?
  - Who is this map for?

    - What is this map trying to convince you of?
- Measurement is the process of assigning standardized values to the world using physical tools and shared conventions.
- Measuring space has never been just a technical act
- Babylonian Land Survey (1900 BCE)
    - Babylon became a major power in the 18th century BCE under Hammurabi, ruling in the Tigris-Euphrates valley.
    - Before this time, land was controlled by temples and palaces.
    - Hammurabi's Code, written around 1750 BCE introduced detailed property laws
    - In the Old Babylonian period, private landholding expanded.
    - Standard Babylonian surveying tools: the measuring rope and unit rod. These were revered symbols of fairness and justice in ancient Babylon and were often seen in the hands of goddesses and kings.
    - The Old Babylonian cadastral survey Si.427 shows the boundaries of a small parcel of land
        - Pythagorean Triple: Through Si.427, we now know ancient Babylonians used them to make accurate land measurements as far back as 1900 BCE.
- Reconstruction of Pei Xiu maps (original ~250 CE)
    - After the fall of the Han Dynasty in 220 CE, China entered a period of fragmentation and political instability (Three Kingdoms period)
    - Pei Xiu introduced Six Principles of Cartography
        - Establish a consistent scale
        - Fix directions (N/S/E/W)
        - Measure distance along roads
        - Adjust for terrain (slopes/rivers)
        - These were designed for standardization and accuracy
    - Pei Xiu anchored his maps in the Yu Gong, a canonical Confucian text describing how legendary rulers organized territory after natural chaos.
- Roman Centuriation (Starting 5th century BCE)
    - Rome started as an agrarian society where land distribution was crucial to stability.
    - The Roman Republic used land grants as rewards for military service, integrating conquered territories into the state.
    - During the 5th and 4th centuries BCE, as Rome expanded into central Italy, conquered lands were confiscated and distributed among Roman citizens or used for state purposes (ager publicus).
    - The Romans used a precise grid-based system (centuriation) to divide land into organized parcels.

Class 5: Mapping to Orient and Order

Guiding Question:

How can the structure of maps help people orient themselves within a larger spiritual or moral order?

- Babylonian World Map (6th century BCE)
    - Center: Babylon, positioned as the civilized heart of the world.
    - Edges: Triangles labeled with mysterious regions.
    - Known places, like Egypt, are omitted
- T-O Maps (Medieval Europe)
    - T-O maps reflected the biblical story of Noah's sons:
        - Shem: Associated with Asia, the largest section of the map, representing the spiritual and historical primacy of the East. Asia was considered the birthplace of humanity and the location of key biblical events.
        - Ham: Linked to Africa, often depicted as a smaller segment. Africa was sometimes viewed through a Eurocentric and theological lens that tied it to the "curse of Ham."
        - Japheth: Represented Europe, seen as the home of Christendom and central to the medieval audience's worldview.
    - Jerusalem at the center, East at the top
    - The antipodes (theoretical landmasses on the other side of the globe) were thought to exist but were deemed uninhabited or unreachable.
- Hereford Mappa Mundi (1457)
    - The largest surviving medieval mappa mundi
    - Contains the T-O framework
- Hunt Lennox Globe (1504)
    - Unlike symbolic medieval maps, it aimed to represent new geographic knowledge
    - Still includes mythical elements– famously inscribed "HIC SVNT DRACONES" ("here be dragons").

Class 6: Mapping to Center

Guiding Question:

How can the structure of maps help people orient themselves within a political/cultural order?

- Selection of the Prime Meridian (0 degrees longitude) was a reflection of British imperial dominance and technological power
- Da Ming Hunyi Tu "Amalgamated Map of the Ming Empire" (c. 1389, Ming Dynasty)
    - Created in the early decades of the Ming Dynasty after overthrowing the Mongol-led Yuan.
    - The Mongols were not ethnically Han Chinese and came from the Central Asian steppe. The traditional Confucian civil service exam system was suspended or diminished, weakening the scholar-official class that had long legitimized dynastic rule.
    - The map is massive (over 6 feet wide) and painted on silk. It combines geographic information from earlier Chinese sources.
    - The map includes distant regions such as Korea, Japan, India, Central Asia, Mecca, and parts of Africa
    - Rivers and mountains are stylized but given prominence.
- Kangnido (Korean Map of the World, 1402)

    - Produced in early Chosŏn dynasty Korea (founded 1392)
    - Unlike Da Ming Hunyi Tu, Kangnido incorporated wider knowledge, blending Chinese, Korean, and Islamic sources.
    - Korea was part of the Ming tributary system and tied into the larger Confucian world order.
    - At the same time, Korea maintained strong connections with other regions beyond China.
- Spatial structure is the way a map arranges space so that placement, size, and orientation give meaning

Class 7: From Theory to Practice

- Classical geographic thought played a huge role in developing the principles and practices of the Western cartographic practice.
- Conceptual tool 1: Space could and should be structured according to geometric principles.
    - Greeks believed the universe had a rational structure. If you could describe it mathematically, you were uncovering the truth of nature itself.
    - Anaximander started this
        - Idea that space has order and a rational structure
        - Explains the world through reasoned principles, observation, and logical argument.
        - Because earth is equally distant from everything else in space, it has no reason to move in any one direction.
        - A cylinder made sense because it could stand, with flat surfaces above and below.
    - Pythagoreans: Numbers and ratios revealed the hidden harmony of reality. Mathematics was a way to access ultimate truth.
        - The sphere was seen as the perfect, most harmonious shape (fits with their idea of cosmic harmony).
    - Conceptual tool 2: The geometric ordering of space can be measured mathematically
        - Moves from philosophical abstraction (space has a rational structure) to measurement (we can quantify it)
        - Eratosthenes calculated the Earth's circumference using astronomical observations and geometry.
    - Conceptual tool 3: Geography must balance abstract models with practical knowledge of places and peoples
        - In *Geographica* Book 2, Strabo criticizes Eratosthenes and Hipparchus for being too focused on mathematical precision and abstract geography.
        - Romans accepted the Greek idea of a spherical Earth and the notion that space is ordered by geometry.
            - The Roman Empire needed geography to serve infrastructure, military conquest, taxation, and land division.
            - They didn't invent new theories of space but they turned existing ones into tools of administration and control.

Class 8: Ptolemy's Legacy

- Key idea: Ptolemy systematized and formalized Greek philosophical thinking about space. This set the stage for the development of the scientific Western cartographic tradition.
- What we know so far
    - Maps are not neutral- they are shaped by culture and power.
    - Maps serve different functions in different societies- meaning there is not one "accurate" way to make a map
        - Babylonians: Measurement and land division tied to law and justice.
        - Romans: Survey grids and centuriation to administer conquered land
        - Chinese & Koreans: Large-scale maps embedded in Confucian world order.
        - Medieval Europeans: Symbolic maps tying geography to biblical and moral order.
- For most of human history, maps were not primarily about scientific objectivity, they were about meaning and function
- Claudius Ptolemaeus (c. 100–170 CE) was a Greco-Roman scholar based in Alexandria, Egypt– a major hub of learning in the Roman Empire.
- Ptolemy introduced a coordinated worldview
    - Earth is fully legible as a numerical, mappable, gridded object.
- The Mathematical Grid
    - Ptolemy applied a standardized system of latitude and longitude to every place on Earth.
    - Latitude was measured from the equator; longitude from a prime meridian passing through the Fortunate Isles.
    - This made space measurable, navigable, and expressible in consistent terms across the known world.
- Map Projections
    - Ptolemy addressed the cartographic challenge of representing a spherical Earth on flat paper.
    - He proposed several projections, balancing geometric fidelity with practical usefulness:
        - Simple conic projection for regional maps
        - Modified perspective projection for world maps
- Gazetteer of Coordinates
    - Geographia Books 2–7 contained over 8,000 place names with coordinates.
- Guide to Mapmaking
    - Offered practical instructions on drawing maps from coordinate lists.
    - Included details on spacing, scaling, and projections.
    - Differentiated between local and global mapping: regional maps were to be more detailed and accurate; world maps more schematic and general.
    - It was effectively the first comprehensive manual for scientific cartography.
- After the fall of the Roman empire, Ptolemy's work was "lost" in Latin Europe for almost 1000 years, but thrived in the Islamic world.

Class 9: Scientific Cartography

- Ptolemy introduced the idea of universal measured geography
    - Treating the earth as a measurable object using geometry, coordinates, and standardized measurements
    - A map corresponds to physical locations in the real world
    - Societies have been measuring space for a long time, but not as a standardized coordinated worldview
- Measured geography is not the only way to "know" space
- The fact that Ptolemy's measured geography was "rediscovered" in the Renaissance (so it hadn't been used in 1000 years in Latin Europe) clearly indicates that the way we think about space isn't inherent, it is culturally and politically and socially informed.
- How did measured geography come to be the "right" way to think about space
    - Epistemological shifts from religion to science
        - In the beginning of the Renaissance most scholars didn't see science as competing with religion.
        - This changed slowly as new discoveries and methods sometimes conflicted with traditional authorities, and over time truth came to be grounded more in observation, measurement, and rational systems than in religious authority
    - Technological change
        - Telescope
        - Printing press
    - Practical and political demands
        - Age of exploration
        - Trade
        - Rise of the nation state
- Components of scientific cartography include
    - Use of coordinate systems (latitude and longitude can locate any point on earth)
    - Geometric projection (systematic methods to represent the curved surface on a flat map)
    - Measurement and scale (maps correspond to real, measurable distances using a consistent scale)
    - Standardization and reproducibility (maps follow formal conventions)
    - Separation of subject and object (the mapmaker is an objective observer)
    - Emphasis on universality (seeks to map the entire world using a single framework)
    - Functional utility (cartography becomes a tool of empire, science, and governance)
- Maps from this time often merged religious and scientific cartographic traditions

Class 10: State Cartography

- In medieval Europe, power was exercised over people, not over land.
- Monarchs began to shift from identifying with peoples to identifying with territories
    - e.g., France's king changed title from *rex Francorum* to *rex Franciae*.
- This happened for many reasons
    - State centralization (monarchs consolidated power)
    - Fiscal and bureaucratic needs (land became the basis for taxation)

    - Written law replaced obligations
    - The emergence of private property.
- The transformation into territorial states took off in the 15th and 16th century
    - This created a demand for scientific cartography, Ptolemaic techniques became influential because they matched the needs of emerging territorial states
- By the mid-16th century, monarchies across Europe had formalized cartography.
    - Not all of Europe was made up of growing territorial nation states (for instance, the Holy Roman Empire), but France, Spain, Portugal, England were
- "State" cartography is a way of conceptualizing how nations used cartography to grow their power
    - Much of it was about administering the state, which is now made up of a bounded territory
- Nationwide surveys were the cornerstone of state cartography
    - Were used to grow the power of the state
    - Holy Roman Empire, Italy, Ottoman Empire weren't undertaking these types of surveys
    - They were for bounded territorial states.

Class 11: Lines on Paper

Class 11: Lines on Paper

Main idea: The map precedes the territory

- Straight borders show that "natural frontiers" (mountains, rivers) were often less practical for states.
    - Political theorists and geographers in the 18th–19th centuries often argued that states should follow natural borders, imagining a kind of organic fit between landscape and sovereignty.
- Before the rise of the territorial state, maps were largely ineffective at displaying power relations, because these relations were built on non-spatial authority (lords, religion, etc.)
- Scientific cartography produced the conditions necessary to clearly define states as territory
    - These ideas developed together. Scientific cartography got popular because it could do this but also it allowed this idea to become a reality
- The result of this in Europe was a balancing act between existing power structures and defining territories
    - In the late medieval and early modern period, monarchs and rulers were consolidating authority, reducing the autonomy of feudal lords and cities.
        - In the medieval period, space was understood as a patchwork of unique places
        - Moving into the early modern period cities, estates, and landmarks still mattered, but they came to be understood as located within a larger bounded space rather than as autonomous centers.
    - Cartographers began to draw neat borders around realms before such borders existed in practice. These visual depictions made bounded authority thinkable and legitimate
    - Over time, rulers and states acted to make the map real: fortifying frontiers, conducting cadastral surveys, negotiating border treaties, and eliminating overlapping jurisdictions.
- The "New World" offered a "blank state" (spaces without places) unconstrained by existing systems of power
    - Because of this, it offered an opportunity to fully idealize new spatial thinking
    - Space exists everywhere, even where nothing is built or known yet.

    - In the absence of recognized power structures, claiming authority with cartography was even easier
        - Case Study 1: The Treaty of Tordesillas (1494)
            - Spain and Portugal divided the world with a single vertical line across the Atlantic. No one knew how wide the Americas were, but that didn't matter
            - Mapping created a claim to whatever was there
            - This line was drawn by Pope Alexander VI through the papal bull Inter Caetera, giving Spain control over lands west of the line and Portugal control over those to the east.
                - The Pope's authority to define this division came from his position as the leader of the Catholic Church, which had significant influence over European monarchies. Spain and Portugal, as dominant Catholic powers, accepted the papal decree to avoid conflict.
        - Case Study 2: Top-down Western Expansion
            - Influenced by Enlightenment geometry, Thomas Jefferson believed that surveying land into squares could shape both the land and society.
            - He saw the square as democratic
            - Congress mandated a rectilinear system of townships (6 x 6 miles) subdivided into sections.
            - Surveyors laid down principal meridians and baselines, extending the grid across the continent.
            - This was top-down governance from Washington
            - The grid preceded the frontier

Class 12: Mapping Society

- Key idea: Social cartography turned social problems into spatial problems. Once mapped, poverty, disease, and immorality looked like spatial "disease" — diagnosable, moralized, and curable through spatial reform.
- In the 1800s, cities were growing at a rate that dramatically outpaced their infrastructural growth
    - These areas became "illegible" to middle- and upper-class observers, reformers, and officials
- There was an increasing view of the city as an organism
    - Poverty, disease, and vice were read as symptoms of urban sickness
    - Space is seen as the CAUSE of these issues, not an OUTCOME
- Space as container vs. Space as cause
    - Container view: space holds poverty/disease, but they come from outside causes.
    - Causal view: the arrangement of space itself produces poverty/disease.
- Sanitary Map of Leeds
    - the heart of Edwin Chadwick's landmark study demonstrating the correlation between poverty and disease, "Report on the Sanitary Conditions of the Labouring Population of Great Britain."
    - By the inspection of a map of Leeds, which Mr. Baker has prepared at my request, to show the localities of epidemic diseases, it will be perceived that they similarly fall on the uncleansed and close [sic] streets and wards occupied by the labouring classes; and that the track of the cholera is nearly identical with the tract of fever. It will also be observed that in the badly cleansed and

badly drained wards to the right of the map, the proportional mortality is nearly double that which prevails in the better conditioned districts to the left.

- Diagnosis
  - Highest disease in "uncleansed" wards with poor drainage, no paving, inadequate sewerage.
- Moralization
  - Brown shading on map associates filth with moral failure.
- Cure
  - Sanitary/environmental reform: improve drainage, sewerage, paving.
  - Redesign housing to improve air, light, and circulation.

- Booth Poverty Maps
  - In the 1880s there was fierce debate in Britain about how widespread poverty really was. Some politicians and elites believed poverty was the fault of "idleness" or "vice." Others argued it was structural. Booth — a wealthy Liverpool shipowner — thought existing statistics were unreliable and misleading. He wanted to measure poverty with the same rigor as a census.
  - Diagnosis
    - Streets shaded by "class," from yellow/red (wealthy) to black (vicious, semi-criminal).
  - Moralization
    - Color ramp (vicious, semi-criminal to wealthy)
  - Cure
    - Officials and reformers used them to justify clearance and rehousing projects
- Chinatown Vice Maps
  - In 1885, the **San Francisco Board of Supervisors' Special Committee on the Condition of the Chinese Quarter** published an investigative report that included a detailed color-coded map of Chinatown. The committee hired inspectors and surveyors to catalog "dens of vice."
  - Diagnosis
    - Color-coded vices
      - Pink = gambling dens
      - Yellow = opium dens
      - Blue/green = prostitution by ethnicity
      - Red = temples/joss house
    - District shown as congested, filthy
    - Report: Chinatown as a "slumbering pest" and menace to the city's welfare
  - Moralization
    - Vice and disease explicitly racialized: residents of the "Mongolian race" depicted as inherently unclean, immoral, and dangerous.
  - Cure
    - Exclusionary policies like sidewalk and laundry ordinances, cubic air ordinance, Chinese Exclusion Act
- Alternatives to spatial disease
  - Moral Reformers
    - Saw poverty and disease as consequences of individual vice, alcohol abuse, or moral weakness.
    - Solutions: religious conversion, temperance campaigns, philanthropy, and moral

education.

- Social Critics
    - Socialists and radicals argued that urban issues came from capitalism— low wages, labor exploitation, and class inequality.
    - Solutions: labor reform, unionization, and broader systemic change.

- Social Work & Settlement Reformers
    - Viewed urban problems as social and educational rather than purely spatial or moral.
    - Solutions: settlement houses, health clinics, schools, vocational training, and neighborhood programs (e.g., Jane Addams' Hull House, Octavia Hill's housing management in London).

Class 13: Mapping Exclusion

- Scientific cartography created legibility
    - Flattened complex, lived space into standardized space
    - Made land, people, and resources "visible" in ways states and institutions could act on.
    - Once distinctions are on a map, they look objective and become enforceable.
- The spatial logic of borders (deciding who is in and who is out) is not confined to the edges of states, but is reproduced inside them to regulate land, rights, and belonging
    - Borders are "dispersed a little bit everywhere"
- Reservations in the US & Canada
    - Native peoples were confined to small, often resource-poor lands, severed from ancestral territories.
    - Reservation boundaries restricted sovereignty and mobility, enabling settler expansion onto seized land.
- Bantustans (South Africa, apartheid era)
    - In the 1930s, the Home Owners' Loan Corporation (HOLC) created "residential security maps" for cities across the U.S.
    - Neighborhoods were graded A–D: "A" (green) = "best," "D" (red) = "hazardous."
    - Minority, especially Black, neighborhoods were almost automatically shaded red, regardless of resident income or housing quality.
    - These maps were used by banks and federal agencies to deny mortgages and insurance, blocking Black families from homeownership and wealth accumulation.
- Redlining (U.S. cities, 1930s onward)
    - Federal maps shaded minority neighborhoods in red, marking them as too "risky" for loans or investment.
    - This systematically denied Black families mortgages, producing racial wealth gaps that persist today.
- Restrictive zoning covenants

    - Beginning in the early 20th century, many neighborhoods adopted racially restrictive covenants that barred Black and nonwhite residents from buying or renting homes.
    - In Chapel Hill, deeds often stipulated that Black residents could only live in the neighborhood as domestic servants or caretakers.
    - After covenants were ruled unenforceable (Shelley v. Kraemer, 1948), exclusion shifted to "neutral" zoning ordinances.
    - Rules like single-family zoning, minimum lot sizes, and owner-occupancy clauses drove up housing costs and kept lower-income families — disproportionately Black — out.
    - These lines on planning maps became durable barriers to integration, ensuring segregation and inequality through technical, legalistic means rather than explicit racial language.

Class 14: Persuasive Cartography

- Persuasive or propaganda maps are often criticized by cartographers for making their arguments too explicitly, even though all maps inevitably make arguments about the world.
- This claim of neutrality became cartography's identity. But between WWI and WWII, a new, openly rhetorical style appeared in Germany and Italy.
- Geopolitical Mapping (1920s–30s)
    - New cartographic language: arrows, blocs, shading.
    - Grundsignaturen (1935): style guide for arrows, circles, shading, dashed lines.
    - Meant explicitly to argue that political borders should be redrawn to match the natural borders of the nation as revealed by geography
- Germany's Geopolitik
    - Versailles humiliation: lost colonies, cramped, "deprived of Lebensraum."
    - Haushofer's theories: states as organisms, blocs, eastward expansion.
- Italy's Geopolitica
    - "Mutilated victory" narrative after WWI. Italy entered WWI on the Allied side, promised territorial rewards.
    - Nationalist obsession with Mare Nostrum ("Our Sea").
        - *Mare Nostrum* (Latin for *"Our Sea"*) was a Roman phrase.
        - It symbolized complete control and the heart of Roman imperial power.
        - After Italy's unification in 1861, nationalists began to look to Rome's empire as a model for modern greatness.
        - Mario Morandi's L'equilibrio politico mediterraneo (1939): Italy at the pivot, arrows into Libya, Balkans, across Mediterranean.
        - North Africa as the 4th shore
        - "Incognita Islamica" = colonial fantasy of Africa as undefined frontier.
- Transition: As nationalism radicalized into fascism, the maps themselves became more extreme.
    - Nazi Propaganda Maps
    - The New Europe is Unbeatable (1941/42): fortress Europe shaded as a solid bloc; Britain isolated; USSR looming.

    - Used same geopolitical visual grammar (blocs, arrows, shading), but amplified for mass audiences.
- Transition: By 1943, propaganda maps targeted occupied peoples directly.
    - Dutch/French Pamphlets (1943)
    - Two-sided propaganda map.
    - Side 1 (1918): Germany strangled by British blockade.
    - Side 2 (1942): Britain strangled by German U-boats.
    - Before/after symmetry = history reversed, roles flipped.
    - Function: sap morale in occupied Netherlands and France, persuade that Britain was doomed.

Propaganda Maps:

- Deliberate distortion
- Use of symbolism
- Selective emphasis
- Emotions (color, labels, captions)
- Simplification
- Integration of narrative

Day 16: The Digital Turn

- Digital maps are fundamentally changing what a map is
- Google Maps
    - Rapid integration of satellite imagery (whole world viewable).
    - Adoption of participatory strategy (APIs, Map Maker, mashups).
    - Exclusive data streams (Street View, proprietary datasets).
    - Mobile mapping (always with you, centered on you).
- How have maps changed:
    - Ownership
    - Temporality
    - Knowledge
    - Egocentricity
    - Labor
    - Access
- Classical critical cartography
    - Maps are not neutral science but texts that must be "read" for silences, omissions, rhetoric.
    - Critiques maps as ideological tools of power
    - Three classic lenses:
        - Sovereignty: Maps as tools of state control used to produce governable territory
        - Hegemony: Maps as power/knowledge which normalize worldviews
        - Acculturation: Maps as cultural technologies (to adopt a map is to adopt its categories)

- How might digital mapping shift the concerns of critical cartography?
- Maps as Corporate Services
    - Google Maps, Apple Maps, Bing Maps
    - Business model:
        - Location-based advertising
        - Logistics integration
        - Surveillance capitalism (Android phones feeding GPS traces back to Google)
    - Implication: Maps are no longer about representing the world, but about monetizing location as a service.
- Open Street Map
    - Founded in 2004, open, wiki-style global mapping project

Day 17: Algorithms and Control

- Algorithms have always been a part of digital cartography
    - 20th-century digital cartography used rule-based algorithms to automate human decisions:
        - Label placement
        - Map generalization
        - Data classification
    - These systems improved efficiency, but all interpretive control remained with human cartographers
    - The rise of machine learning and AI represents a shift from human-guided to machine-driven mapmaking.
- Modern digital mapping has led to an increase in AI-driven algorithms
    - Machine learning is used to:
        - Extract roads and features from satellite imagery
        - Detect real-time traffic
        - Personalize map views based on individual behavior
        - Predict future actions and optimize for engagement or monetization
        - Design maps
- Algorithms now "govern" space
    - Maps no longer just represent geography; they govern how space is navigated and accessed.
    - Platforms like Google Maps shape urban mobility, visibility of businesses, and delivery logistics.
    - Routing algorithms determine traffic flows, which roads get overloaded, and which communities are bypassed.
- What are potential problems with this?
    - Feedback loops and algorithmic entrenchment
        - Predictive systems often create self-reinforcing feedback loops.
    - Bias in training data

        - AI systems reflect the limitations of the data they are trained on.
    - Invisible labor and global extraction
        - AI cartography relies on extensive invisible labor
        - Image annotation (often done in the Global South)
        - Manual correction by users
        - Behavior tracking and data harvesting from users
    - Environmental and infrastructure costs
- Autonomous AI?
    - MapGPT allows non-experts to create maps by describing their needs in natural language
    - Integrates multiple AI algorithms to automate mapmaking
    - Impacts of AI on Map-Making:
        - Lowers the expertise barrier
        - Loss of reflexivity
        - Homogenization of cartographic practices

Day 18: Spatial Data

- Reference maps: show locations and features for orientation (roads, rivers, basemaps)
- Thematic maps: highlight a particular variable or pattern (population, disease rates, cartograms)
- Cartometric maps: designed for measurement and precise analysis (surveys, cadastral parcels)
- All maps are made of spatial data
- Map types (reference, thematic, cartometric) use spatial data differently
- Spatial data: data that has a location component (tied to a place on Earth)
    - Not all spatial data is usable spatial data
    - Not all spatial data is used as spatial data
- Vector: points, lines, polygons (discrete objects)
- Raster: grid of cells with values (continuous fields)
- Slippy maps: interactive web maps (Google Maps, OSM, Apple Maps) that let you pan and zoom smoothly
    - Built on a tiling system: world divided into small squares (usually 256×256 pixels)
    - Raster tiles: pre-drawn images, fast but fixed style
    - Vector tiles: vector data chunks, rendered on your device, flexible styling and smooth zoom
    - Underlying storage: large vector databases of roads, buildings, POIs

Day 19: Seeing from Above

- Remote sensing emerged to meet military demands for global, fast, image-based intelligence.
- WWII marked a significant transformation in American cartography
    - Civilian and military mapping efforts were fully integrated; universities, scientists, and private companies were pulled into the war effort.

- During WWII, aerial photography and photogrammetry advanced rapidly, setting the stage for modern remote sensing.
- CORONA Program
  - 1960–1972
  - Officially, the satellites were described as scientific research or weather satellites, sometimes framed as "Discoverer" launches. This was the cover story used to mask their true purpose.
  - In reality, they were the first large-scale orbital reconnaissance program, designed to spy on the Soviet Union, China, and other regions during the Cold War.
- Early reconnaissance satellites carried actual cameras that capture visible-light images (like photographs) of specific targets.
- Passive optical remote sensing measures reflected and emitted electromagnetic radiation from the Earth
- When energy from the sun hits the earth, it can be reflected, absorbed (and re-emitted), transmitted, or scattered
- Sensors measure how much energy was reflected at different wavelengths at stores them as digital numbers
- Most satellites capture data for multiple bands (different wavelengths)
- These bands can be combined to analyze analyze different phenomena
- Spatial resolution determines the pixel size
- Spectral resolution determines the ability of a sensor to detect small differences in wavelength
- Radiometric resolution defines the ability of a sensor to detect small differences in energy magnitude

Day 20: Seeing from the Ground

- Surveying
  - One of the oldest forms of spatial data collection, based on direct ground measurement.
  - Traditional tools: chains, compasses, plane tables, theodolites.
  - Modern instruments: total stations (electronic distance + angle), GPS/GNSS (precise positions, control networks).
- Ground-Based Sensors
  - Instruments fixed at or near the surface that automatically record environmental conditions.
  - Weather stations: temperature, precipitation, wind, humidity.
  - Air-quality monitors: particulate matter, ozone, NO_2, CO_2.
  - Hydrological gauges: river discharge, groundwater levels, soil moisture.
  - Noise and traffic counters: sensors monitoring sound or vehicle flow.
  - Provide continuous, real-time data tied to specific locations.
- Human-Scale Data (Socio-Demographic & Administrative Records)
  - Data collected about people and households through surveys, censuses, and institutions.
  - Census: population counts, housing characteristics, economic data.
  - Health records: disease incidence, vital statistics, hospital data.
  - Household and travel surveys: behaviors, commuting, expenditures.
  - Administrative data: school enrollments, tax rolls, voter registration.
  - Essential for understanding social, economic, and health conditions at specific places.
- Modern Data Collection: What's Changed
  - Millions now collect usable geospatial data with phones
  - OpenStreetMap: Editing roads, paths, buildings

    - Disaster response: Mapping after earthquakes, floods
    - Citizen science:
        - iNaturalist (biodiversity)
        - PurpleAir (air quality)
        - eBird (bird sightings)
    - Community mapping:
        - Indigenous territories
        - Pollution zones
        - Accessibility infrastructure
    - Often more current, specific, and socially relevant than official data
    - Tension: Authoritative vs. Participatory Data
        - Authoritative data: institutional, formal standards
        - Participatory data: community-created, modern tools
        - Institutions often distrust crowdsourced data
- Common metadata standards:
    - FGDC CSDGM (U.S.)
    - ISO 19115 (International)
    - INSPIRE (EU)
    - These ensure:
        - Trust
        - Discoverability
        - Interoperability
    - Participatory data:
        - Often lacks metadata
        - Metadata is informal (e.g., tags in OpenStreetMap)
        - Stored in inconsistent formats

Day 22: Seeing from the Ground

- Geographic coordinate systems locate places using the curved surface of the earth
    - Coordinates are represented in degrees, which are angular measurements
- The geoid is a model of Earth's shape based on gravity. It's the surface where gravity is equal everywhere ("mean sea level" extended globally).
    - A geoid is still too irregular to easily put a coordinate grid on. So we approximate Earth with a smooth mathematical shape: an ellipsoid (slightly flattened sphere).
- A datum defines how an ellipsoid is placed on/within the geoid and fixes it to real-world points.
    - There's many ways to fit an ellipsoid to a geoid, this is called a datum
    - Datums are supported by networks of surveyed benchmarks.
    - Different datums "fit" the Earth differently.
- A geographic coordinate system is an:

    - ellipsoid
    - datum
    - coordinate system
    - The result is a location in degrees.
- Projected coordinate systems are what we need to put the earth on a flat surface
    - Coordinates are represented in linear units (feet, meters, etc.)
    - A developable surface is a surface that can be flattened to a plane without introducing distortion from compression or stretching.
    - There are three developable surfaces: planes, cones, and cylinders.
    - Whenever coordinates are transformed from 3-dimensional angular to 2-dimensional planar coordinates, spatial relationships are distorted, as compared to their relationships (measurements) on the Earth's surface.
        - Angle
        - Area
        - Distance
        - Direction
- Conformal Projections: Preserve local shapes and angles but distort area and distance. Useful when accurate representation of shapes is more important than preserving true sizes.
    - Examples: Mercator, Lambert Conformal Conic
- Equal-Area Projections: Preserve the relative size (area) of landmasses and features but distort shape and sometimes direction. Ideal for maps that require accurate comparisons of area.
    - Examples: Albers Equal-Area, Mollweide
- Equidistant Projections: Preserve distances from specific points or along specific lines but distort area and shape. Best for maps where accurate distance measurement is essential.
    - Examples: Azimuthal Equidistant, Equirectangular
- Azimuthal Projections: Preserve direction from a central point but distort other properties like area and shape.
    - Examples: Stereographic, Polar Azimuthal
- Compromise Projections: Provide a visually balanced map by minimizing distortions of shape, area, and distance, without preserving any one property perfectly.
    - Examples: Robinson, Winkel Tripel
- Projections play a huge role in forming our geographic imaginary, or how we think about space.
    - We know that every projection has distortion, and seeing the same projection over and over again means that we internalize those distortions
    - Case Study: Mercator Projection
        - The Mercator projection was designed for long-distance ship navigation where navigators could follow a straight line
        - This introduced huge distortions in size as you move further from the equator.
        - This wasn't a problem for shipfaring because you don't have your ship on land.
        - What did become a problem was when the Mercator map became the de facto world map
        - This was due, in part, to the dominance of Cartesian logic

Day 23: GIS

- We've talked about the growth of digital mapping (using computers to create and display maps)
    - End-product focused
    - Optimized for end users
- GIS is not just about the end product (a map), but the data infrastructure and analysis tools behind them
    - GIS was developed as a general system to capture, store, manage, retrieve, analyze, and communicate geographic information for decision-making
- Computers entered geography in the 1950s and 1960s
    - Growing interest in experimenting with computers for geographic work
    - Early uses were focused on automation
        - Digitizing boundaries and census tracts
        - Printing line maps using mainframe line printers
        - Developing algorithms for line simplification, lettering, and symbol placement
        - "Computer-assisted" cartography
        - SYMAP
- A problem in Canada
    - In the early 1960s, the Canadian government launched the Canada Land Inventory (CLI) to guide land-use planning across the country.
    - Traditional cartography (hand-drawn overlay maps) couldn't handle this.
        - Too many variables
        - Paper overlays were logistically challenging
    - The CLI inventory was meant to create standardized, legible data bases, while the task of the CGIS computer system was to facilitate ways of visualizing in digital maps much faster than human manual ones.
- Throughout history, maps have been used to visually analyze space
    - Ex. John Snow maps
    - This analysis has largely been visual– looking for spatial patterns between things across space
- Spatial analysis extracts or creates new information from spatial data
- Developments in computer cartography and GIS were happening right around where geography, as a discipline, was becoming more quantitative
    - Geography had been largely descriptive and regional through the early 20th century.
    - By mid-century, pressure to make geography a more "scientific" discipline (like economics or physics).
    - Influence from logical positivism: knowledge should be based on measurable facts, models, and laws.
    - Emphasis on quantitative methods: statistics, mathematics, and models.
    - Search for spatial laws
- GIS rapidly changed from a government/academic interest to a marketable product
    - GIS's logic (storing, querying, overlaying geographic data) was clearly useful across many domains
- Critical turn
    - Scholars (Pickles, Sheppard, Cloud, others) argued GIS is not neutral, it is socially and politically shaped.
    - Key critiques:
        - GIS assumes space is continuous, measurable, and objective.
        - Prioritizes quantitative, state, and corporate data; marginalizes local, Indigenous, and experiential knowledge.
        - Reinforces surveillance and technocratic decision-making

Class 24: Spatial Analysis

- Spatial analysis is how we answer spatial questions
    - Location
        - Where is it?
        - Why is it here or there?
        - How much of it is here or there?
    - Distribution
        - Is it distributed locally or globally?
        - Is it spatially clustered or dispersed?
        - Where are the boundaries?
    - Association
        - What else is near it?
        - What else occurs with it?
        - What is absent in its presence?
    - Interaction
        - Is it linked to something else?
        - What is the nature of this association?
        - How much interaction occurs between the locations?
    - Change
        - Has it always been here?
        - How has it changed over time and space?
        - What causes its diffusion or contraction?
- The basic types of spatial analysis are:
    - Queries
    - Overlay analysis
    - Proximity analysis
    - Surface analysis
    - Statistical (pattern) analysis

Mapping Otherwise

- Counter-mapping- Appropriating the "language" of scientific cartography to make marginalized perspectives legible.
- Counter-cartography- A broad practice of questioning the assumptions of what a map is and how mapping produces knowledge.
- Peluso- "Whose Woods Are These" (Indonesia, 1995)
    - Introduced the term counter-mapping
    - Worked with Dayak communities in West Kalimantan resisting state forest concessions
    - State maps classified land as "production forest" under national control.
    - Communities created sketch maps to prove long-term occupation and resource management
    - Local maps became evidence in disputes with logging companies and provincial officials
    - "Strategic legibility" – using the language of mapping
- Sovereignty Mapping

    - The Waorani in Ecuador collaborated with the organization Digital Democracy to create participatory maps that combined GPS points, hand-drawn sketches, and oral histories to document their territory.
    - Community members decided what to include and how to represent it
    - Their maps became key evidence in a 2019 Ecuadorian court ruling that protected Waorani land from oil concessions
- Nunavut Atlas
    - Collaboration between Inuit hunters, elders, and cartographers
    - The Nunavut Atlas helped document Inuit land use and occupancy across the eastern Arctic
    - Provided spatial evidence for the 1993 Nunavut Land Claims Agreement which legally transferred about two million square kilometers of land to Inuit ownership and self-government.
    - Proof of "land-tenure"
- Toxic Wastes and Race (United Church of Christ, 1987)
    - First national study linking hazardous-waste sites to race and income.
    - Overlaid EPA facility data with U.S. Census demographics.
    - Found race to be the strongest predictor of exposure.
    - Politically radical use of "objective" data visualization
    - Coined "environmental racism," spurred the EJ movement
- Anti-Eviction Mapping Project (San Francisco, 2013–present)
    - Grassroots network of tenants, artists, and data scientists.
    - Maps eviction notices, rent spikes, and displacement alongside oral histories.
    - Visualizes gentrification as a spatial process of inequality.
    - Used in housing-policy advocacy and public hearings.
- San Francisco Emotion Map (Christian Nold, 2007)
    - Participants wore GSR (skin-conductance) sensors while walking the city.
    - Data recorded physiological arousal linked to location.
    - Combined with participant notes to map emotional intensity.
    - Re-centers bodily affect as geographic data.
    - Still uses spatial base maps but shifts focus to sensation and movement.
- Red Line Archive and Labyrinth (Walis Johnson, Brooklyn, 2017)
    - Public-art and walking project commissioned by WalkingLab.
    - Installed a maze of red ribbon at the Weeksville Heritage Center, echoing 1930s redlining maps.
    - Participants walked the ribbon path with Johnson, discussing race, housing, and memory.
    - Re-enacted and re-claimed the geography of exclusion as communal performance.
    - Connects to Katherine McKittrick's concept of "Black geographies"—spaces defined through but resisting anti-Blackness.
- Kate McLean's "Smell Maps" (2010s) asked residents to draw scent patterns of neighborhoods.
    - These experiments reject accuracy and scale as map criteria.
    - Mapping becomes sensory ethnography or how space feels, smells, and affects bodies.
    - Pushes the boundary of what counts as "data" or "cartographic."

Cartographic Design

- Two main types of maps:
  - Reference Maps → Focus on location, navigation, and general features.
  - Thematic Maps → Use symbols to convey spatial patterns and data variations.
- What makes a good map?
  - Only important things are included (Selection)
  - There is appropriate geographic context (Basemap)
  - It is easy to interpret the features on the map (Scale, Generalization, Symbology)
  - Important things stand out (Intellectual and Visual Hierarchy)
  - The map is “nice” to look at (Layout and Design Principles)
- Feature selection
  - Every feature on the map should be important
- Basemaps provide geographic reference and orientation
  - Showing familiar features like land, water, roads, and buildings
  - Giving a sense of location, scale, and extent
  - Helping readers interpret where the thematic data sits in space
- Map generalization is the strategic removal of detail to aid cartographic understanding
  - **Selection** reduces the number of features by deleting features that are small or insignificant.
  - **Simplification** reduces unnecessary details by simplifying or abstrating shapes.
  - **Smoothing** refines and smooths geometries to make them more aesthetically pleasing.
  - **Aggregation** combines close features of the same type to a cluster.
- Maps use symbols or visual variables to represent geographic features/ spatial patterns
  - Maps translate real-world features into symbols for clarity and communication.
  - Symbols should be easily recognizable and consistent with user expectations.
  - Two main types of maps:
    - Reference Maps → Focus on location, navigation, and general features.
    - Thematic Maps → Use symbols to convey spatial patterns and data variations.
- Reference Maps Use Standardized Symbols for Clear Communication
  - Reference maps provide a consistent visual language for navigation and geographic understanding.
  - Symbols in reference maps are often standardized to enhance usability and quick recognition.
  - Reference maps use widely accepted semiotic principles to ensure clear interpretation.
  - The human brain is wired to recognize and categorize visual stimuli quickly.
    - Top-Down Processing: When we see a familiar symbol, our prior knowledge helps us interpret it almost instantly.
    - Bottom-Up Processing: When encountering a new or unfamiliar symbol, we analyze its shape, color, and context before assigning meaning.
    - Cognitive Load Theory suggests that overly complex symbols or cluttered maps slow down interpretation.
  - Semiotics (study of signs and symbols) helps explain how people "read" and interpret map symbols.

        - Iconic Symbols (Pictorial or Replicative)
            - Symbols that look like what they represent
            - Tree icon for forest, blue waves for water
        - Functional Symbols
            - Directly symbolize the function or purpose of a place
            - Campground- tent icon, skier for ski resort
            - Airplane for airport
        - Conceptual Symbols represent abstract ideas
            - Dollar sign for bank
        - Conventional symbols are learned over time
            - Cross for hospitals
            - Red lines for highways
- Thematic maps use visual variables to represent data
    - Our brains are wired to interpret visual variables in a certain way
        - Value
            - The retina has cells (rods and cones) that respond to different intensities of color (light to dark)
            - Their firing rate changes gradually as intensity increases or decreases.
            - This gives us a built-in continuum from "dim" to "bright."
        - Size
            - The retina encodes how much space an object takes up in your field of vision.
            - Bigger object = larger retinal image = automatically interpreted as *more*.
            - Humans have an innate ability to compare quantities without counting.
- Visual variables allow effective symbolization of data
    - Six primary visual variables:
        - Size: Represents magnitude or quantity (e.g., larger circles for higher population).
        - Shape: Differentiates categories (e.g., squares vs. circles for different land uses).
        - Orientation: Shows directional relationships (e.g., wind patterns).
        - Texture: Represents variations across an area (e.g., hatching for density).
        - Hue (Color): Used for categorical distinctions (e.g., different political parties).
        - Color Value (Lightness): Represents ordered data (e.g., darker shades for higher values).
- Matching visual variables to data type ensures clarity
    - Nominal Data (Categories) : Best represented by hue, shape, or texture.
    - Ordinal Data (Ranked Order): Best represented by size, value, or texture.
    - Interval/Ratio Data (Numerical) : Best represented by size or color value.
    - Using the wrong visual variable can mislead map readers and obscure patterns
- Reference maps follow established color conventions to ensure clarity and consistency
    - Reference maps provide a consistent visual language for navigation and geographic understanding.
    - Symbols in reference maps are often standardized to enhance usability and quick recognition.
    - Common color conventions in reference maps

            - Blue: Water (rivers, lakes, oceans).
            - Green: Vegetation, forests, parks.
            - Yellow/Tan: Urban or built-up areas.
            - Brown: Elevation, terrain (contour lines, deserts).
            - Red & Black: Infrastructure (roads, railways, political boundaries).
- Thematic maps use color to represent data, not just features.
    - Three major color schemes in thematic maps
        - Sequential color schemes→ Used for ordered data (low → high values).
            - Example: Population density (light yellow → dark green).
            - Light colors represent low values, dark colors represent high values.
        - Diverging Color Schemes → Used for data with a meaningful midpoint.
            - Example: Temperature change (blue for cooling, red for warming).
            - Neutral color (white, gray) at the center.
        - Qualitative Color Schemes → Used for categorical data with no numerical order.
            - Example: Land cover (forests, agriculture, water, urban).
            - Distinct hues to separate categories.
- We group data into classes since our eyes can only interpret a few colors effectively, and because many datasets are skewed rather than evenly distributed.
    - Natural Breaks
    - Equal Interval
    - Quantile
- You should match your classification decision to your data distribution
- The best map layouts follow general cognitive principles
    - Scanning Patterns
        - People don't look at everything evenly
        - In Western culture, we scan left to right, top down
        - Layout should place important information where eyes go naturally
    - Visual hierarchy and figure-ground
        - The eye is drawn to bright, high-contrast features
        - Thematic data must be the "figure", basemaps/supporting elements should be the "ground"
        - Titles, legends, etc. should support, not compete
    - Balance
        - The brain prefers visual harmony, layouts feel "wrong" when one part is heavier
    - Simplicity
        - Include the minimum amount of information to effectively demonstrate your point to minimize cognitive load
- Visual hierarchy means important things stand out (intellectual hierarchy)
    - Thematic symbols, and labels directly related to the theme
    - The title, subtitle, and legend
    - Base map information (boundaries, roads, place-names, etc.)

    - Scale bar and north arrow
    - Data source information
    - Frame and neat lines
- Visual hierarchy is achieved using contrast, Gestalt principles, and map layout
    - Contrast is the perceptual comparison of one portion of a visual image to another, the greater the difference, the stronger the contrast and generally the higher in the visual hierarchy an object or component will rise.
    - Gestalt is a theory of perception that describes the manner in which humans perceive the components of an image and organize them into broader structures or interpretations.
    - Map layout is how map features are organized on a map
        - In a map, each element has weight due to size, position, color, detail, shape and other characteristics. A well-balanced map layout does not appear to tip left or right and it doesn't look bottom or top heavy.
        - The compartmentalized map layout places each of the main components of a map page into a separate, often boxed, compartment
        - The fluid or more free-flowing layout eschews sharp divisions between map elements
- Major map components
    - data (or map) frame
    - map legend
    - map title
    - north arrow
    - map scale bar
    - metadata (or map citation)
    - border (or neatline)
    - inset (or locator) map
- Labeling/Text
    - Use clear, readable fonts
    - Create a visual hierarchy with size and style
    - Place labels to be easily associated with their features without overlapping