Introduction to Mapping

In honor of the *Festival of Maps* that the City of Chicago will host in the coming year, this Yerkes Summer Institute is focused on mapping. Our goal is to examine some of the methods involved in creating maps, as well as to understand the ways in which mapping is broadly applied to different topics and circumstances. The term "mapping" is often paired with words like "exploration" or "discovery", but what kinds of things do you associate with maps? Do you think of modern science and technology, or are you more likely to think about road maps, or pirate treasure maps? Is mapping more about "X" marking the spot or mathematics? Can it be both?

"A map of the world that does not include Utopia is not worth even glancing at, for it leaves out the one country at which Humanity is always landing."

- Oscar Wilde

So what is a map? There are a lot of correct answers to that question, so it is important to establish what we mean when we say "map." The American Heritage Dictionary states simply that a map is "a representation, usually on a plane surface, of a region of the earth or heavens." This definition reflects the most conventional idea of a map, but it does not address the full potential of a map to encode and communicate information. At the most basic level, a map exists to efficiently communicate information about a set of locations. However, not all maps convey the same kind of information – there is a remarkable variety of specific purposes that different maps can serve. The most common maps that you encounter in daily life are designed to encode information such as political boundaries, geological features (mountains, lakes, rivers, etc.), and weather, but maps exist that contain data on topography (altitude), population, economic factors, and many other forms of information. Maps can also be used to encode scientific information, such as a CAT scan of your head (revealing the three-dimensional structure of your brain), or an astronomical map showing the position and velocity of stars in the center of the Milky Way (revealing the presence of a supermassive black hole).

When a map is constructed, several key attributes determine much of how that map may be used. We have already discussed one of these properties – the specific type of information that is encoded into a map. Another equally important property is that of **scale**. Scale refers to how much a map has been "shrunk" compared to the region or place that it is depicting. Large-scale maps fit information about a large area into a small space (such as a road map of the United States that fits information about our whole country onto a piece of paper that fits in your lap), and as a map begins to approach the size of the thing that it is

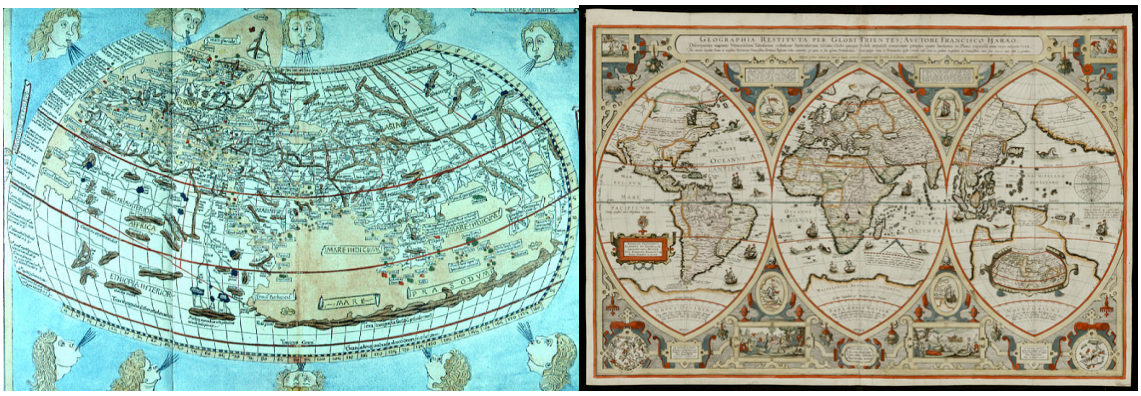
describing, its scale approaches one. There are pros and cons to any choice of scale for a map – can you think of some of the advantages/disadvantages to a map with a very large scale? How about one with a very small scale?

A Brief History of Maps: From Prehistory to the Present

The documented history of human map-making dates back more than 18,000 years to the primitive cave drawings near Lascaux, France (and similar finds in Spain have been dated at about 14,000 years old). It's no coincidence that the documented human pursuit of astronomy shares a similarly ancient history. The oldest maps known are, in fact, maps of the heavens and depict the constellations in the night sky. So it's rewarding to see that our work at Yerkes this summer provides a bridge between the past year, spent studying astronomy, and the upcoming *Festival of Maps*!

Cave drawing maps depicting constellations in the night sky.
Credit: BBC news (http://news.bbc.co.uk/2/hi/science/nature/871930.stm)

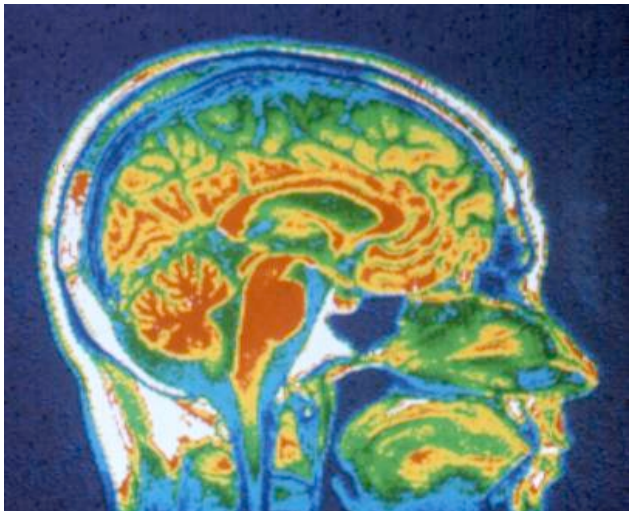
As a civilization, our mapping skills have come a long way over the years. Technological, mathematical, and scientific innovations have paved the way for much of this improvement. It is useful to focus on the history of maps in terms of the history of maps of the Earth. The Ancient Greeks developed the mathematics of geometry, and are credited with the first efforts to understand the shape and size of the Earth. Sometime around 350 BCE Aristotle observed that the Earth must be round rather than flat because you can see different constellations as you travel south – an effect that is only possible if the surface of the Earth is curved. In 240 BCE Eratosthenes even managed to measure the radius of the Earth with astonishing accuracy, and by the second century CE Ptolemy produced a map of the world known to him entitled *Geographica* (Ptolemy was well aware that his map covered only about ¼ of the entire world). An improved map of the world and measurement of the Earth's size was made by Indian astronomer and mathematician Aryabhata around 500 CE.



Left: Ptolemy's map of the world from 150 CE
(credit: http://academic.emporia.edu/aberjame/map/h_map/h_map.htm)
Right: A map of the world from 17th Century European cartographers
(credit: http://maps.bpl.org/pub/05/01/05_01_000219.MEDIUM.jpg)

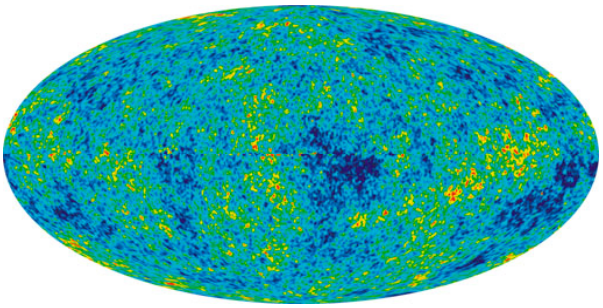
Developments in mapping the Earth improved dramatically from the Renaissance onwards as European explorers began to circumnavigate the globe. The first known maps of the entire world appeared around 150 CE, and maps became widespread with the appearance of the printing press in western society. However, despite the improved understanding of the basic shape and structure of the Earth, most parts of the world remained relatively unknown (that is, the maps contained errors) well into the 1900's when an entirely new technique was applied to map-making: aerial photography. In the years following World War II we entered what can be called the modern era of map-making. Modern maps of the Earth are based primarily on a good combination of satellite photography of the ground and other remote sensing techniques, such as Global Positioning Satellites (GPS) and sonar/radar. Some of these advanced technologies are also the cornerstone for navigating space shuttles into orbit around Earth.

So far we've tracked the history of the conventional map of the Earth, but maps now serve a great many other purposes in the modern world. The early maps were primarily used for navigating the globe without getting lost, and there are plenty of modern maps that serve the same purpose. From road maps, to maps of museums (e.g., the floor plan of the Adler Planetarium & Astronomy Museum), we rely on accurate representations of the places we are going. In the medical community doctors rely heavily on several mapping



Magnetic Resonance Imaging (MRI) map of a human brain, in profile. (credit: http://encarta.msn.com/media_461555006_761579758_1_1/Magnetic_Resonance_Imaging_Scan.html)

technologies to diagnose injury and illness. From the common "X-Ray", to magnetic resonance imaging (MRI), to the Computed Tomography (CT) scan, the ability to accurately map out the structure of the human body is the cornerstone of modern medicine. Furthermore, cutting-edge chemical (and biomedical) research employs scanning electron microscopes to explore the shape and behavior of molecules on tiny scales. In astronomy, a recent Nobel Prize in Physics was awarded for an advanced satellite experiment that mapped the cosmic microwave background (CMB) – a signal that originates from the universe when it was only a tiny fraction of its current age.



Map of the infant universe revealing tiny fluctuations in the Cosmic Microwave Background (CMB)
Image Credit WMAP
http://map.gsfc.nasa.gov/m_ig/060913/CMB_ILC_Map75.jpg

Chicago Note: Professor Stephan Meyer, Director PFC of KICP, is a member of the WMAP team and traveled to Stockholm for the Nobel Banquet last December. Pictured below.

Maps aren't limited to tools for getting yourself from one place to another across some terrain – the applications of accurate maps are widespread throughout modern society. During this year's Yerkes Summer Institute you will engage in three labs designed to explore the different ways in which maps can be created and to introduce you to the wide variety of applications towards which maps can be usefully applied. Have fun, learn lots, and good luck!

He had brought a large map representing the sea,
Without the least vestige of land:
And the crew were much pleased when they found it to be
A map they could all understand.
"What's the good of Mercator's North Poles and Equators,
Tropics, Zones, and Meridian Lines?"
So the Bellman would cry: and the crew would reply
"They are merely conventional signs!
Other maps are such shapes, with their islands and capes!
But we've got our brave Captain to thank"
(So the crew would protest) "that he's bought us the best—
A perfect and absolute blank!"

Lewis Carroll from The Hunting of the Snark