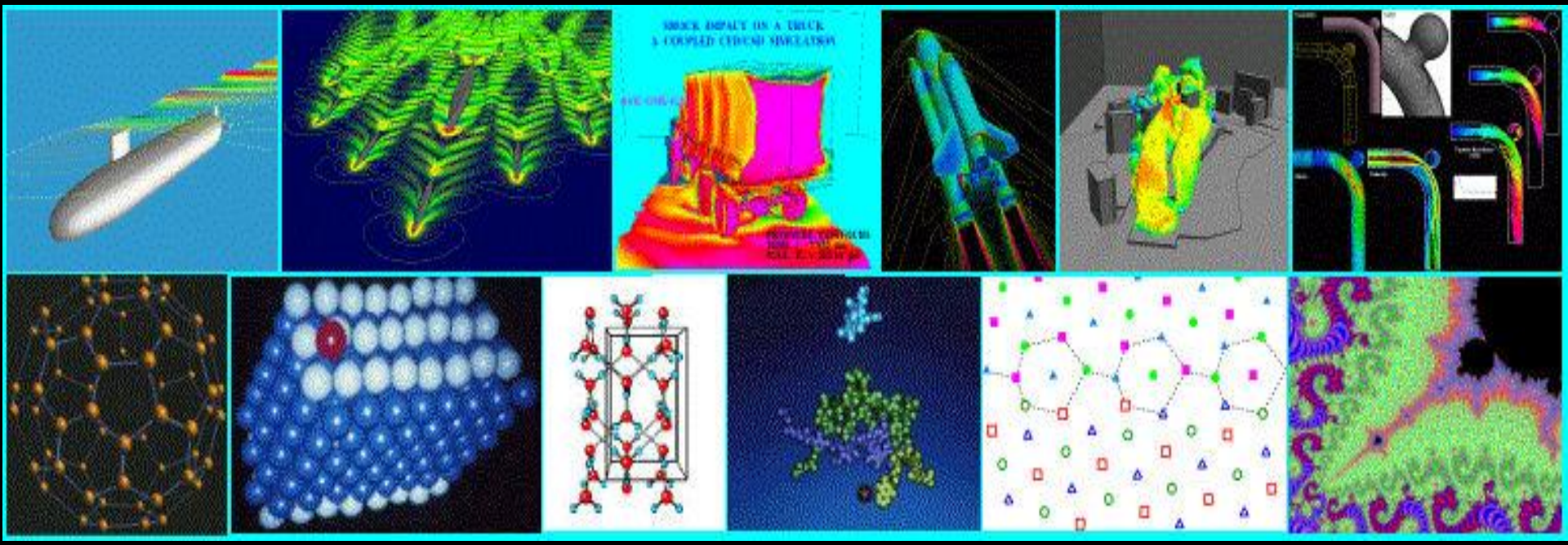
Computing for Scientists

Introduction

(Aug. 31, 2010)



Jie Zhang

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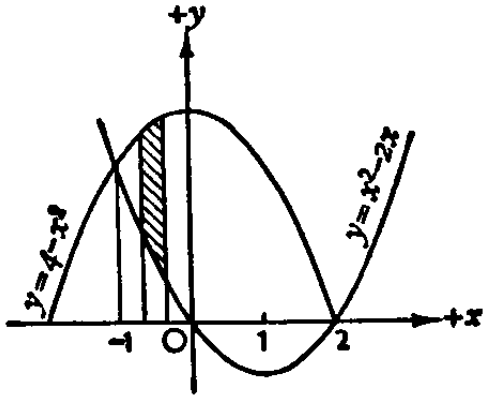
CDS 130 - 003
Fall, 2010

Why Computing for Scientists?

Sciences are driven by

Experiment
(~ before 1600)



Math
(~ After 1600)

Computing
(~ After 2000)

The goal is to gain insight

Why Computing for Scientists?

- **"Experimental science is the queen of sciences"**
  – Roger Bacon (1214 ?- 1294?, English Philosopher)

- **"Math is the queen of sciences"**
  – Carl Friedrich Gauss (1777 – 1855, German Mathematician)

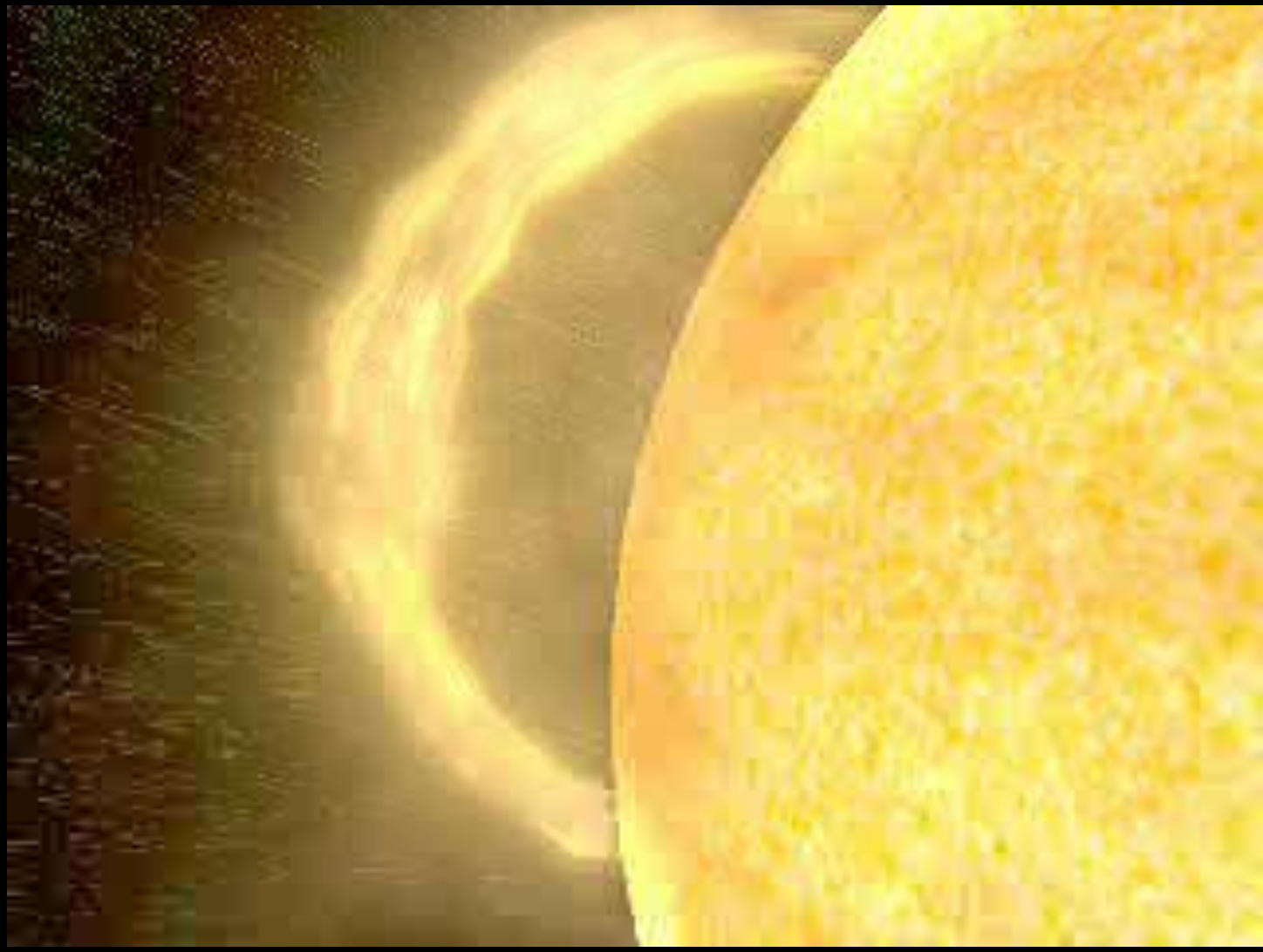
- **"The purpose of computing is insight, not numbers"**
  – Richard Wesley Hamming (1915 – 1998, American Mathematician)

You and Me

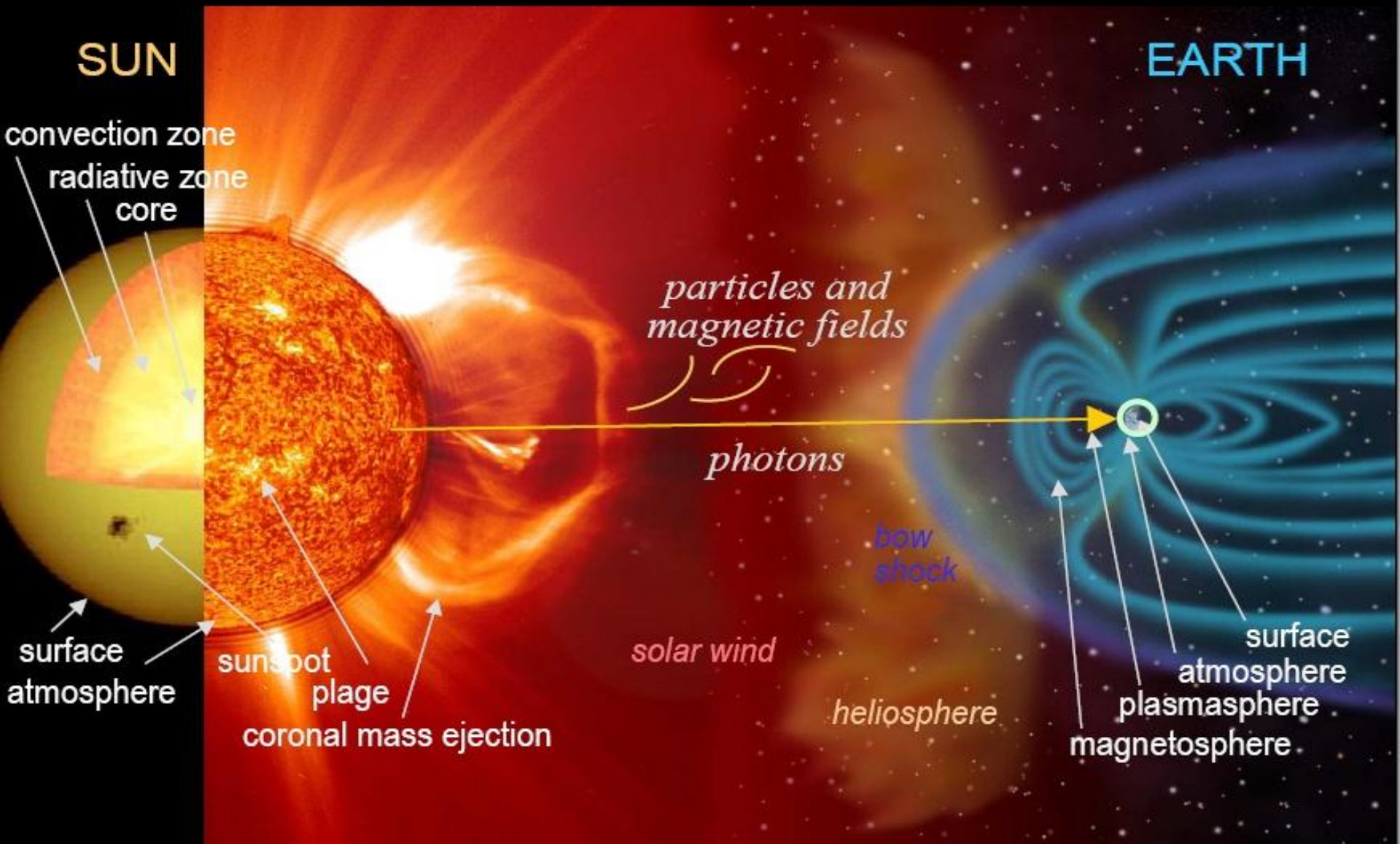
Space Weather: the Process

It starts from an eruption from the Sun.

Prediction depends on how it propagates

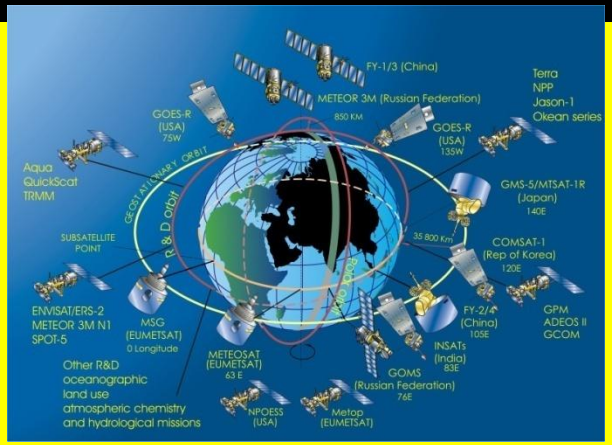


Space Weather: the Systems



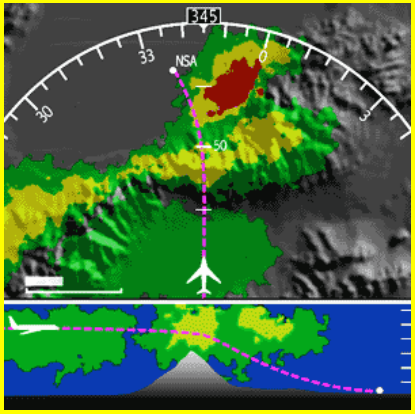
Space Weather: effects

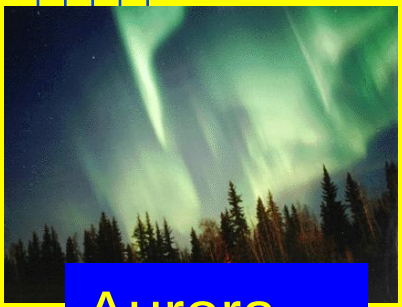
Human Space Exploration



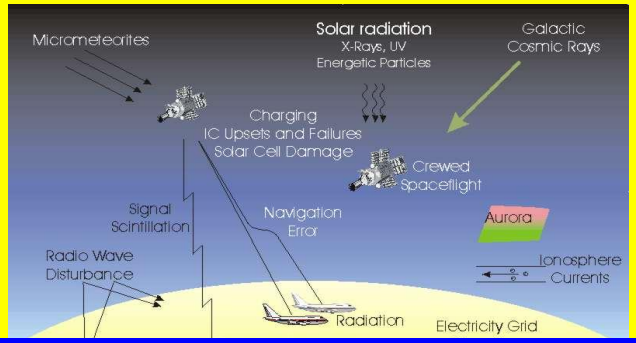
Satellite Operation

Aviation



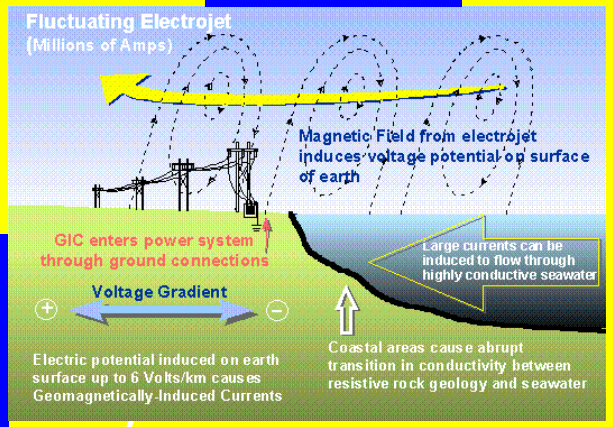


Aurora

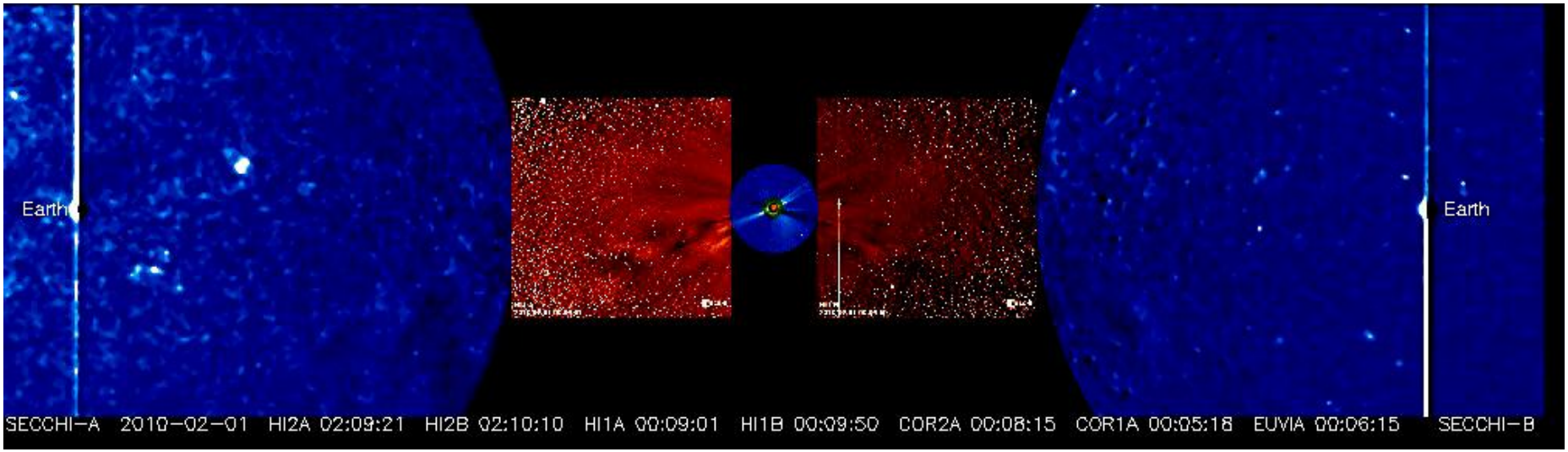


Communication and Navigation

Power



STEREO Mission



SDO Mission

Syllabus

http://solar.gmu.edu/teaching/2010_CDS130/

http://blackboard.gmu.edu/

Content

- **Computer fundamentals** - Binary representation of data, data storage, logic tables and circuits.
- **Measurements** - Sensors, sensor limits, calibration, analog to digital converters, signal-to-noise, precision, *accuracy*, and bias.
- **Basic Data Structures** – tables, spreadsheets, arrays
- **Data analysis** - statistical analysis, data fitting
- **Visualization** – Data representation types, creating visualizations, creating and visualizing images
- **On-line information systems** – scientific databases, SQL, queries, data storage, data and information quality, literature searches
- **Data Ethics**
- **Scientific simulation**
- **Effective scientific publications and collaborations**
- **The future of scientific computing**

Text Book

- None - no suitable textbook exists for this course.

- Class Notes, Assignments
  - http://solar.gmu.edu/teaching/2010_CDS130/ClassNotes.html

- Online Content
  - http://solar.gmu.edu/teaching/2010_CDS130/Resources.html

Assignments

- Homework
  - Weekly homework.
  - Homework will be multiple choice and short answer
  - Submission through GMU Blackboard

- Project
  - One comprehensive project, with multiple-phase assignment
  - Software tool: **Excel, Matlab**

- Prerequisite
  - Analytic Geometry and Calculus (Math 113)

Grading

- Homework (25%)
- Projects (20%)
- One mid-term (25%)
- One final (25%)
- Class Participation (5%)

Contact

- **Instructors:** **Prof. Jie Zhang**
- **Contact Info:** jzhang7@gmu.edu (e-mail)
  1-703-993-1998 (phone)
- **Office Hour:** 10:30 AM to 11:30 AM, Thursday
  or by appointment
- **Office:** Room 351, Research Bldg 1

- **Teaching Assistant: Dr. Joseph Marr**
- **Contact info:** jmarr2@gmu.edu (e-mail)

Honor Code

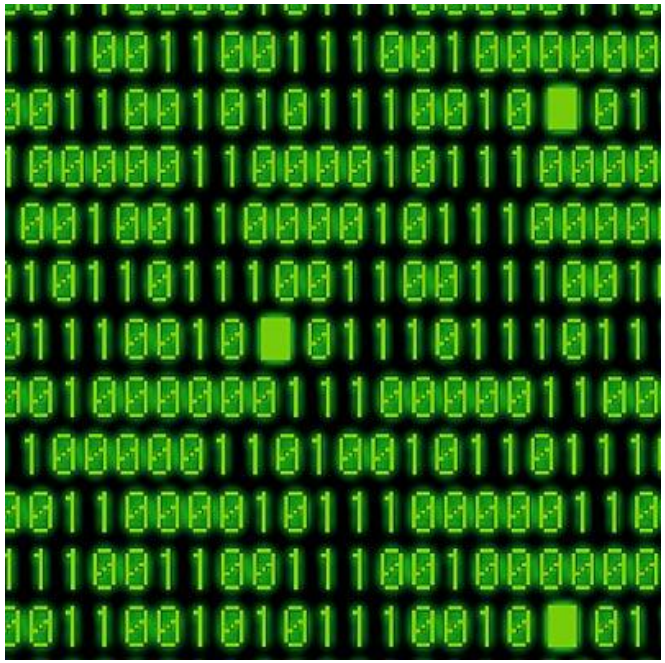
As in any class, you are allowed to study with other students. However, tests and homework assignments must be completed on your own unless stated specifically in the assignment guidelines. In some assignments, you will be directed toward on-line sources for papers, data and code. If these data, code, or papers are used for a project, then you MUST cite where it came from. Specifically, you may not copy any text, computer code, image, data or any other material from the Internet or any other source and represent it as your own. Any material that is taken in whole or in part from any other source (including web-pages) that is not properly cited will be treated as a violation of Mason's academic honor code and will be submitted to the honor committee for adjudication, as will other violations of the honor code.

Topics

Computer Fundamental

There are only 10 types of people in this world: those who understand binary and those who do not

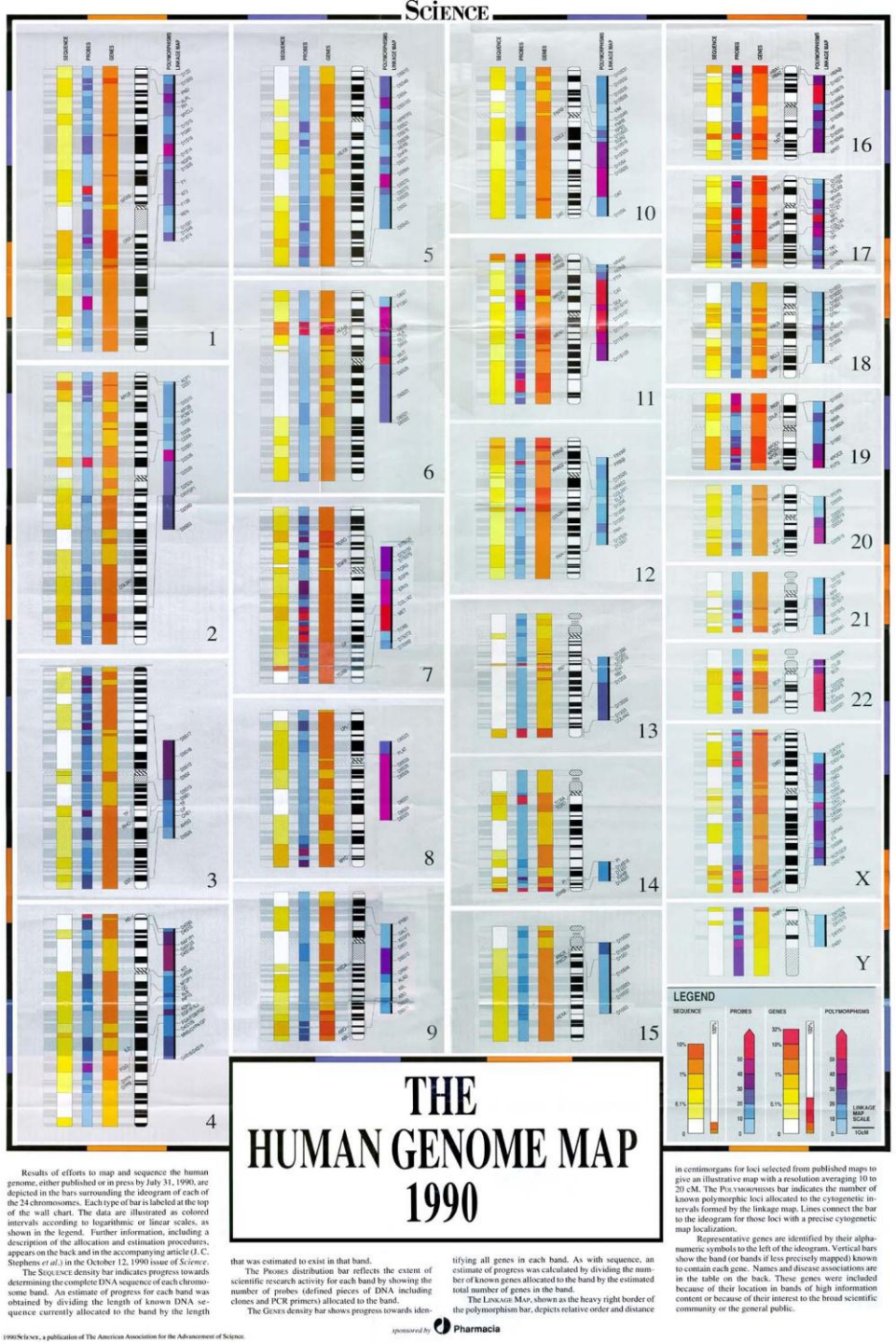
- Binary Representation
- How to store binary data
- How to process binary data



Measurements

How to obtain scientific data and encode them into binary data?

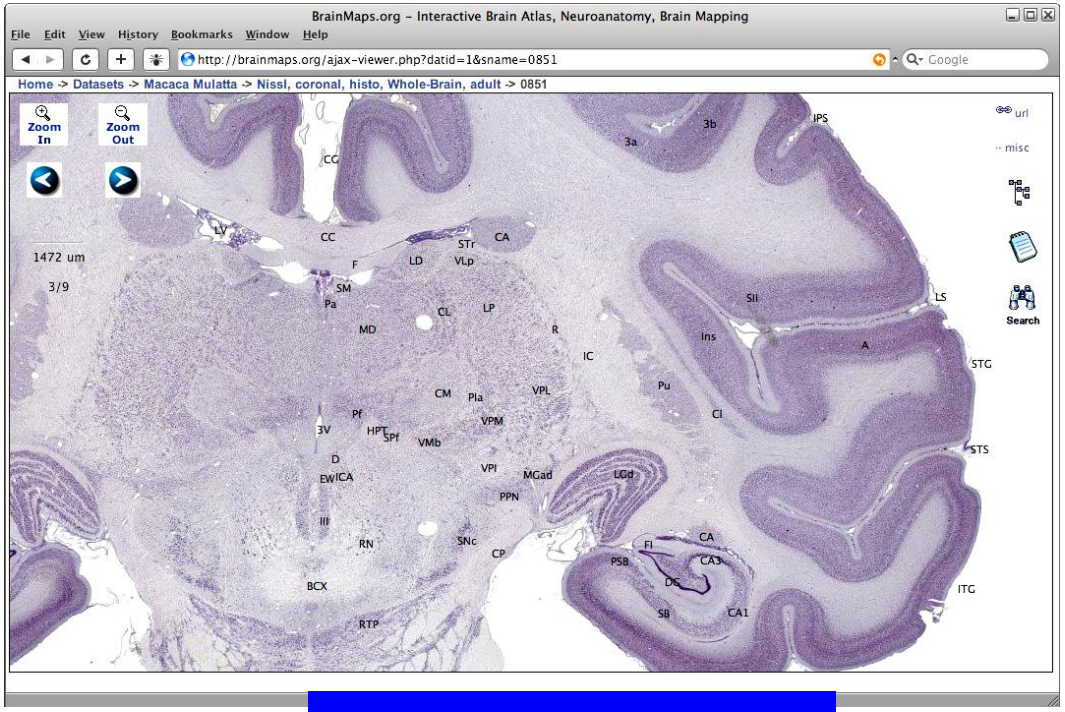
- Sensors
- Analog to digital converters
- Signal to noise



Basic Data Structure

How are scientific data organized in computer for the convenience of computing?

- Tables
- Spreadsheets
- Arrays

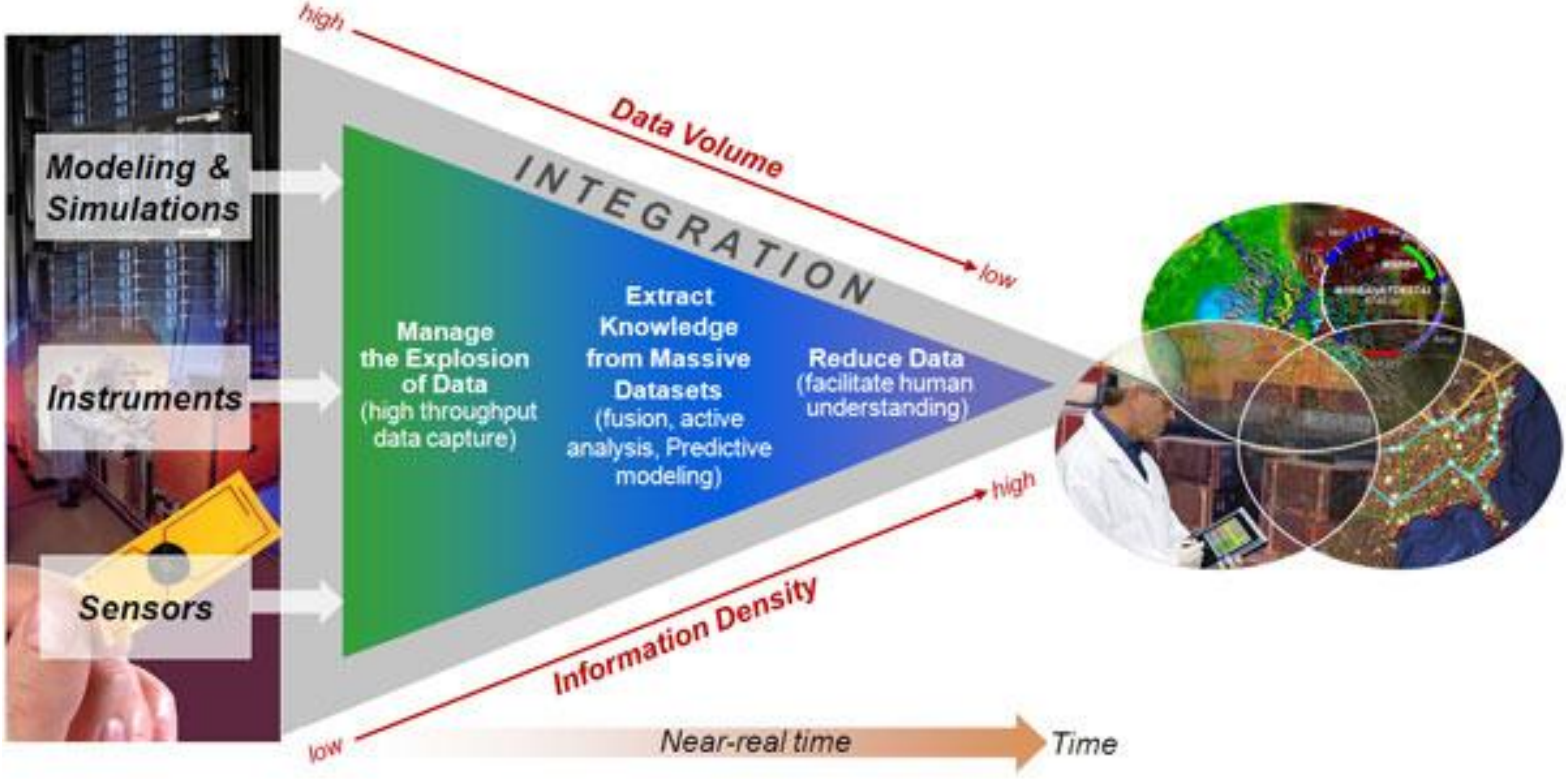


Interactive Brain Map
http://brainmaps.org/

Data Analysis

How to convert data into information, and information into knowledge?

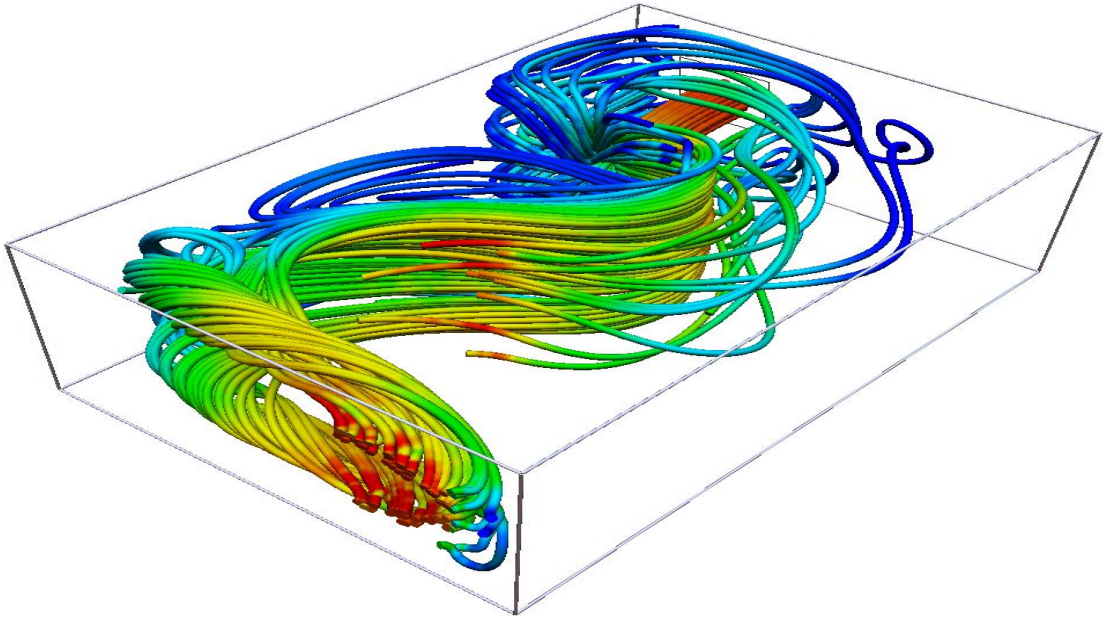
- Statistical analysis
- Data fitting



Visualization

A Picture Is Worth a Thousand Words

- Data Representation
- Creating Visualization



Stream Tubes

Cave Painting

Online Information Systems

The new face of science : data flood

- Scientific database
- Data Query, SQL
- Literature searches

Data Ethics

Ethical use of data, code, publication

Scientific Simulation

A good simulation, be it a religious myth or scientific theory, gives us a sense of mastery over experience
- Heinz R Pagels

- Mathematic model
- Iteration
- Simulation

•Galactic Collision Simulation:
http://www.youtube.com/watch?v=Lru7Fod1Evg&feature=player_embedded
•E-Cell Simulation:
http://www.youtube.com/watch?v=l5s_29xR28w

Scientific Presentation and Collaboration

Future of Scientific Computing

The End