Educating problem-solving skills for Bioinformatics research

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What skills are we looking for?

Technical Skills:

- Languages: Java, SQL, PL\SQL, C,C++, HTML , PHP, JavaScript, JSP, VB(.Net), XML.
- Operating Systems: Windows 3.x/95/2000/XP/Vista, UNIX, LINUX (Red Hat Linux 9).
- Tools: Eclipse, Toad, MS-Office softwares, MS Visual Studio, Dreamweaver.
- Servers: Weblogic, WebSphere, JBoss

Technical Skills:

- **Computer Languages & Technologies**: **Core Java**, **J2EE**, **Swings**, **Struts**, **Servlets**, **EJBs**, **JSP**, PL/SQL, XML, IBM Portlets, **JSR 168 Portlets**, Hibernate, Collections Framework, **JDBC**, RMI, Tiles, **AJAX**, UML, **Teamsite**, **LDAP**, Siteminder.
  - **Application Servers**: **WebSphere** Application Server (**WAS**), **ColdFusion**, WebSphere Portal Server (**WPS5.1**), Oracle9ias Application Server and BEA Weblogic Application Server.
  - **Web Servers**: Tomcat & Apache Web Server.
  - **Databases**: **Oracle8i** & **9i**, Microsoft Access.
  - **Web Designing & Tools**: **HTML**, DHTML (Dynamic), **JavaScript**, Extensible Stylesheet Language Family (XSL), Cascading Style Sheets (**CSS**), Document Object Model (DOM), Macromedia Dreamweaver.
  - **Job Schedulers**: **Appworx 5.1** & Autosys.
  - **Load Runner**: **Mercury** Load Runner, JUnit.
  - **Version Control Tools**: Microsoft Visual Source Safe, Rational Clearcase & Teamsite.

- **Software Tools**: WebSphere Studio Application Developer (**WSAD**), Rational Application Developer (**RADv6**), **TOAD8.6** (for Oracle), Lotus Notes, SSH Client, **Remedy**, Rational Rose, Edit Plus 2, Textpad & JAD Decomplier

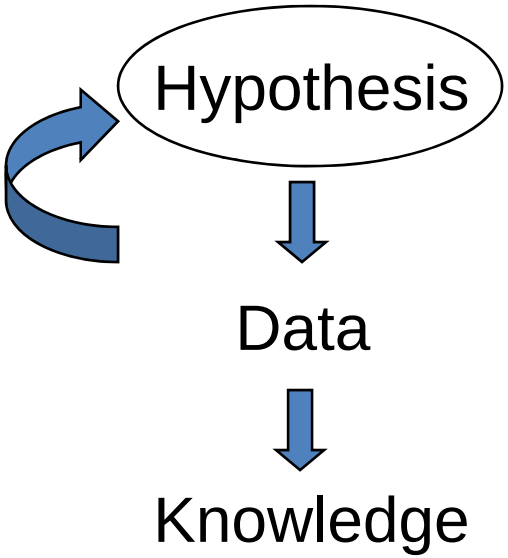
What is missing?
technique skills vs. problem solving skills

- Information technology
  - Programming-driven
  - Many inexperienced users
  - Robust, user-friendly, scalable, modular
  - General models
  - Challenge: engineering
- Scientific computing
  - Problem-driven
  - A few experienced users
  - Accurate, efficient,
  - Specific (often novel) models
  - Challenge: problem solving

Domain knowledge is not a hurdle (at least in bioinformatics): teaching a computer scientist biology is usually easier than teaching a biologist computer science.

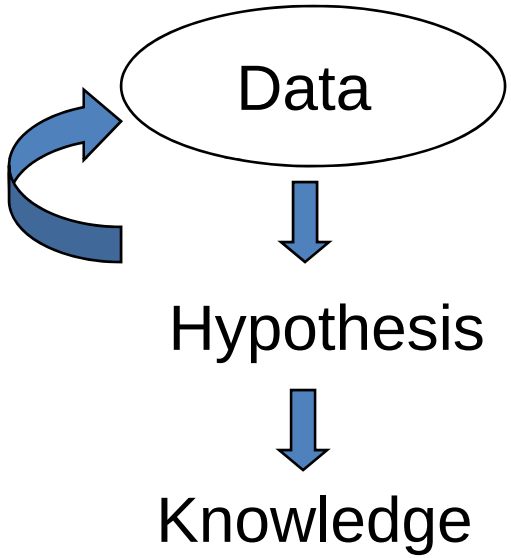
Genome science: a revolution in biology

- Classical Biology



Hypothesis driven approach

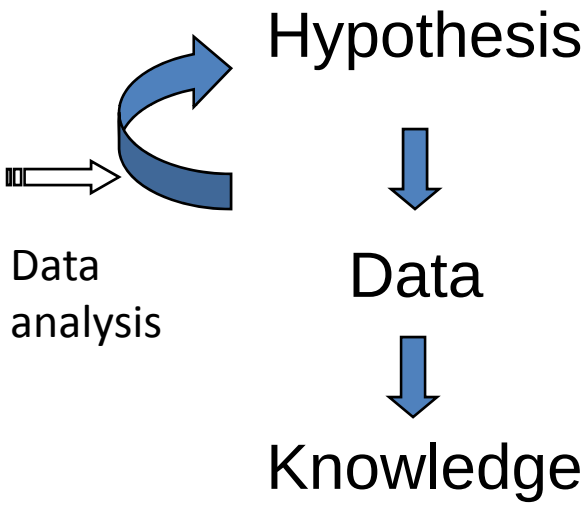
- Genome Science



Data driven approach

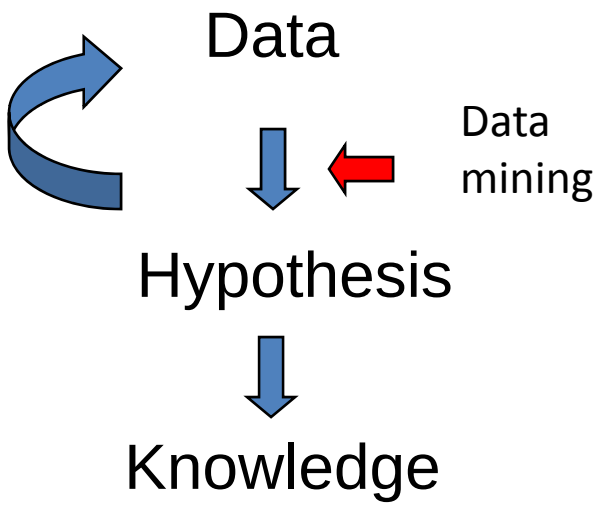
Bioinformatics: in the driving seat

- Classical Biology



Hypothesis driven approach

- Genome Science



Data driven approach

Problem solving skills for bioinformatics research

- Key: computational thinking about the data
  - High dimension & large amount
  - Objective: generating hypothesis
- Examples
  - Data visualization
  - Simulation
  - Data mining: rule discovery, classification, clustering, etc
  - Statistics: hypothesis testing, etc
  - Modeling: probabilistic modeling, etc

Data visualization

- What plot?
  - Scatter plot, bar plot, distribution, heat map
- Data representation
  - Vector, binning (density), ratio (log ratio)
- High dimension data
- Inhomogeneous data
  - Data integration
- Applying domain knowledge

Computational thinking vs. quantitative (mathematical) thinking

- Data-centered vs. hypothesis centered
- Statistics
  - Hypothesis tests
    - Model-based
    - Parametric vs. non-parametric
  - Permutation tests: simulation
- Modeling
  - Theoretical (i.e. mathematical) models
    - analytic solutions
  - Simulated models
    - Numerical solutions
  - Probabilistic models
    - NN, HMM, BN, etc.

Genome science: key advancements

- High throughput biotechnologies
  - Genome sequencing techniques
  - DNA microarray
  - Mass spectrometry
- Large-scale experiments
  - HGP, HapMap
  - Omics / Systems Biology
- Massive data generation, storage, exchange and analysis
  - Bioinformatics