Curriculum Guidelines
Bioinformatics and Computational Biology

Curriculum Task Force
ISCB Education Committee

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Introduction

- Provide curricular guidelines that others may reuse.

- Seek input from a variety of perspectives.

- Surveys conducted in 2011 and 2012.
Summary of 2011 Survey

- Surveyed the ISCB EduComm
- Surveyed the EMBnet community
- Received 41 responses from 20 countries (33% response rate)
Welch LR, Schwartz R, Lewitter F.

“A Report of the Curriculum Task Force of the ISCB Education Committee.”

2012 Surveys

• core facility directors (Fran Lewitter)

• career opportunities (Lonnie Welch)

• existing curricula (Russell Schwartz)
Survey of Core Facility Directors

• 29 core facility directors responded

• core facility directors were asked
  – what skills are needed for success in the field of bioinformatics
  – what skills are lacking in recently hired bioinformaticsians

• In general, these lists were very similar (i.e. skills needed are often lacking)
Survey of Career Opportunities

• Listings from the ISCB Members Job Board (http://www.iscb.org/iscb-careers)

• Sampled 75 of 130 job listings

• Items collected:
  – Geographic location (5 continents, 17 countries)
  – Job title
  – Duties
  – Skills
Job Duties

• Domain Specific Duties (Bioinformatics)
  – Data analysis
  – Software development
  – Project Support and Facility Support

• Domain Specific Duties (Biological Contexts)
  – NGS (next generation sequencing) data
  – Medicine
  – Regulatory genomics and systems biology
  – Others

• General Duties
Skills

- Computer science
- Biology
- Mathematics & Statistics
- Bioinformatics
- General
Preliminary Survey of Existing Curricula

• Criteria: To keep the survey manageable, we restricted it to programs that:
  – award a degree or certificate
  – have a name containing “computational biology,” “bioinformatics,” or some close variant

Potentially relevant programs excluded by these criteria included
  – tracks or options within traditional degree programs (e.g., Bioinformatics track of Ph.D. in Biology)
  – programs on related topics that do not include the keywords above, e.g., Quantitative Biology

• Numbers of programs identified by manual web search*:
  – Associate of Arts/Associate of Sciences: 2
  – Bachelor of Science/Bachelor of Arts/Bachelor of Technology: 72
  – Master of Science/Master of Research/Master of Biotechnology: 38
  – Doctor of Philosophy: 39
  – Non-degree certificate: 15

*we do not believe this to be an exhaustive count; see Challenges on the next slide
Solution: Create a Web-Based Repository with Program Self-Reporting

• We are currently working with ISCB staff to create a self-reporting web site for computational biology training programs

• Intended to serve a dual purpose:
  – platform for gathering comprehensive statistics on curricula
  – publicly accessible resource for prospective students and educators

• Curricular reporting is built on a controlled vocabulary of common requirements derived from manual survey of selected programs
  – must be specific enough to capture important program differences
  – must be general enough to allow aggregation across programs
### First Pass at a Controlled Vocabulary

<table>
<thead>
<tr>
<th>a. Computational Biology</th>
<th>d. Mathematics/Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.1. Computational molecular biology/Genetics</td>
<td>d.1. Probability</td>
</tr>
<tr>
<td>a.2. Computational structural biology</td>
<td>d.2. Statistics</td>
</tr>
<tr>
<td>a.3. Biological simulation</td>
<td>d.3. Biostatistics</td>
</tr>
<tr>
<td>a.4. Bioimage analysis</td>
<td>d.4. Mathematical biology</td>
</tr>
<tr>
<td>a.5. Computational Biology – General</td>
<td>d.5. Differential equations</td>
</tr>
<tr>
<td>a.6. Computational Biology – Other (please specify)</td>
<td>d.6. Linear algebra</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b. Computer Science</th>
<th>e. Other Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>b.1. Programming</td>
<td>e.1. Physics</td>
</tr>
<tr>
<td>b.2. Software engineering</td>
<td>e.2. Chemistry</td>
</tr>
<tr>
<td>b.3. Algorithms/Data Structures</td>
<td>e.3. Science – Other (please specify)</td>
</tr>
<tr>
<td>b.4. Databases</td>
<td>f. Non-Science Coursework</td>
</tr>
<tr>
<td>b.5. Artificial Intelligence</td>
<td>f.1. Ethics</td>
</tr>
<tr>
<td>b.6. Machine Learning</td>
<td>f.2. Entrepreneurship</td>
</tr>
<tr>
<td>b.7. Visualization</td>
<td>f.3. Writing/Communications</td>
</tr>
<tr>
<td>b.8. Computer Systems</td>
<td>f.4. Non-science – Other (please specify)</td>
</tr>
<tr>
<td>b.9. Computer Science – Other (please specify)</td>
<td>g. Other Requirements</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>c. Biology</th>
<th>g.1. Seminar</th>
</tr>
</thead>
<tbody>
<tr>
<td>c.1. Genetics</td>
<td>g.2. Research</td>
</tr>
<tr>
<td>c.2. Cell biology</td>
<td>g.3. Internship</td>
</tr>
<tr>
<td>c.3. Biochemistry</td>
<td>g.4. Capstone project</td>
</tr>
<tr>
<td>c.4. Biophysics</td>
<td>g.5. Teaching assistantship</td>
</tr>
<tr>
<td>c.5. Evolutionary biology</td>
<td>g.6. Other requirement not listed (please specify)</td>
</tr>
<tr>
<td>c.6. Biotechnology</td>
<td>h. Other Elective</td>
</tr>
<tr>
<td>c.7. Genomics</td>
<td>h.1. Elective (possibly restricted)</td>
</tr>
<tr>
<td>c.8. Systems biology</td>
<td></td>
</tr>
</tbody>
</table>
Types of Bioinformatics Training

• **Bioinformatics users**
  – access bioinformatics resources to perform job duties in specific application domains
  – For example, medical professionals

• **Bioinformatics scientists**
  – use computational methods to advance the scientific understanding of living systems

• **Bioinformatics engineers**
  – create novel computational methods needed for scientific discovery
Toward a Definition of Core Competencies

• set of desired proficiencies for each type of bioinformatics training

• provide guidance for bioinformatics educational programs

• synthesize the results of our surveys

• modeled after the ABET criteria for computer science programs

• terminology and concepts of Bloom’s Taxonomy used
WE INVITE YOUR PARTICIPATION

The ISCB Education Committee
Task Force on Bioinformatics Curriculum

Fran Lewitter - lewitter@wi.mit.edu
Russell Schwartz - russells@andrew.cmu.edu
Lonnie Welch - welch@ohio.edu
ISMB Birds of a Feather Session on Bioinformatics Curriculum

• At the ISMB meeting

• Monday:
  – 13:00-14:00
  – Room 4/5 of the Intl Conf Ctr
  – Bring your lunch
Discussion

- How may GOBLET partner with the Curriculum Task Force of the ISCB EduComm?
  - Overlapping areas?
  - Complimentary areas?