The Professional Science Masters (PSM) in Bioinformatics at VCU

Gregory A. Buck
Director – Center for the Study of Biological Complexity
Professional Science Masters in Bioinformatics
Bioinformatics Training: Origins

President’s Bioinformatics Task Force: 1999:

How to respond to 21st Century Challenges in the Life Sciences?

- Develop training programs in bioinformatics
- Master’s level (later added BS and Ph.D.)
- Recruit faculty with integrative research programs
- Build infrastructure to support 21st century life sciences research

- VCU Life Sciences created: 2000
  - Vice Provost for Life Sciences created
  - A matrix academic organization (spans schools and departments)
  - Focus on integrative life sciences
  - Over 200 VCU faculty sign on

- Center for the Study of Biological Complexity established
  - Established in VCU Life Sciences: 2001
  - A matrix academic organization; ~100 faculty, 15 departments, 5 schools
  - Focus: 21st Century Systems Biology
  - Natural home for the newly forming Bioinformatics Programs!
Bioinformatics is central to 21st century biological research.
Why in the Center for the Study of Biological Complexity?

CSBC a *think tank* for VCU Life Sciences

- Focus on SYSTEMS (the whole is greater than the parts)
- ‘Omics’ hierarchy:
  - Genomics (all the genes)
  - Transcriptomics (all the RNAs)
  - Proteomics (all the proteins)
  - Interactomics (all the interactions)
- Spans all areas: small to big:
  - Molecules, cells
  - Tissues, organisms
  - Ecosystems, environments
- Key to all: Mathematics, Computer Science, Bioinformatics

An integrative backbone across VCU

External fellows in US and Europe
Center Resources include ‘omic’ hierarchy

‘Omics’ infrastructure
Nucleic Acids Research Facilities -- since 1986
-- five core services
  1. Gene synthesis
  2. RT PCR
  4. MicroArray analysis
  5. DNA sequencing
Center for High Performance Computing - CHiPC

**HPC Servers**
- Bioinformatics software/databases
- True high performance computing
  - Supercomputing clusters
  - Powerful SMP machines
  - High capacity data storage
  - Operators, programmers

**Bioinformatics Research Lab**
- Work stations
- Visualization Lab

**Instructional/Videoconferencing Lab**
- Instructor station
- 12 student stations
**Proteomics to interactomics....**

**Other Cores:**
Proteomics
   -- Mass spectrometry, 2D gels
Pharmacogenomics / Structural Biology
   -- Crystallography, molec. modeling
Molecular Interactions Core
   -- two hybrids, surface plasmon res.

Bioinformatics key to ‘omics’ technologies:

Therefore:
CSBC was the logical site for Bioinformatics
Time Line for Development of VCU Bioinformatics Programs

- VCU Life Sciences/ CSBC created 2000 - 2001
- Bioinformatics Subcommittee: 2000 - 2004
- Industry Survey
Industry Survey

Polled over a hundred private companies (CEOs, CSOs…)  
- Pharma  
- Large Biotech  
- Start up Biotech  
- Health industry

Asked: What qualities do you want in a new employee (bioinformatics)?  
- Not BS or Ph.D.: probably MS trained  
- Good team player  
- Good communication skills

Reinforced our intention to create PSM-based Masters Program.
Time Line for Development of VCU Bioinformatics Programs

– Departmental approvals: 2000-2001
– School approvals: 2001-2002
– Alfred P. Sloan Foundation Grant: 2002 – 2003

• Seeded development of PSM program
• Leveraged for additional two permanent faculty
• Focused development of Professional Science Masters
Time Line for Development of VCU Bioinformatics Programs

- Alfred P. Sloan Foundation Grant: 2002 - 2003
- University Undergraduate Course Committee: Spring 2003
- Univ. Graduate Council Course Committee in Spring, 2003.
- The Vice President’s Council (September 29, 2003)
- The President’s Council (October 7, 2003)
- Academic Affairs Subcom. / Univer. Council (October 30, 2003)
- University Council (November 6, 2003)
- Academic Affairs Subcommittee BOV (November 12, 2003)
- Board of Visitors approval: November 13, 2003
- State Council of Higher Education in Virginia (March 16, 2004)

First students enter: Fall, 2004
Almost five (5) years in development
Very comprehensive:
1. Bachelors of Science – 4 years
2. Masters Programs
   • Masters of Bioinformatics (PSM) – Sloan Foundation
   • Masters of Science (MS) – thesis masters
3. Compressed BS/Masters – five years (MS and PSM)
4. Three tracks: BS and Master’s programs
   • Biology/Genomics
   • Computational
   • Quantitative/Statistics
5. Ph.D. in Integrative Life Sciences:
   • Ph.D. in Bioinformatics...
The big challenge: How to teach this program?

New Faculty recruitment:

- Jeff Elhai: Biology (2001)
- Michael Miles: Pharm/Tox (2001)
- Clint Turbeville: Biology (2001)
- Darrell Mallonee: Micro (2001)
- Lambert Ngoka: Chemistry (2002)
- Ping Xu: Philip’s Institute (2003)
- Steve Fong: Chem E (2005)
- Ghislaine Meyer: Biology (2005)
- Sherry Baldwin: CSBC (2005)
- Maria Rivera: Biology (2006)
- Mark Reimers: Biostatistics (2007)
## New BNFO Courses:

<table>
<thead>
<tr>
<th>Course Number/Title</th>
<th>Coordinator</th>
<th>Date Launched</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNFO 292 Independent Study</td>
<td>Faculty</td>
<td>Fall, 2004</td>
</tr>
<tr>
<td>BNFO 301 Introductory Bioinformatics</td>
<td>Elhai</td>
<td>Spring, 2005</td>
</tr>
<tr>
<td>BNFO 420 Applications in Bioinformatics</td>
<td>Emery</td>
<td>Spring, 2006</td>
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<tr>
<td>BNFO 491 Special Topics in Bioinformatics</td>
<td>Faculty</td>
<td>Fall, 2004</td>
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<tr>
<td>BNFO 492 Independent Study in Bioinformatics</td>
<td>Faculty</td>
<td>Fall, 2004</td>
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<tr>
<td>BNFO 497 Research and Thesis in Bioinformatics</td>
<td>Kier (Chair BPC)</td>
<td>Fall, 2004</td>
</tr>
<tr>
<td>BNFO 505 Essentials of Statistics in Bioinformatics</td>
<td>Witten</td>
<td>Spring, 2005</td>
</tr>
<tr>
<td>BNFO 507 Essentials of Mol. Biology in Bioinformatics</td>
<td>Fawcett</td>
<td>Spring, 2005</td>
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<tr>
<td>BNFO 508 Introduction to Bioinformatics Research</td>
<td>Kier</td>
<td>Fall, 2004</td>
</tr>
<tr>
<td>BNFO 541 Mol. Biol. Bioinformatics Lab</td>
<td>Ozaki</td>
<td>Spring, 2005</td>
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<tr>
<td>BNFO 591 Special Topics in Bioinformatics</td>
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<td>Fall, 2004</td>
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<tr>
<td>BNFO 591 Business Principles for the Life Scientist/Pract</td>
<td>Baldwin</td>
<td>Spring, 2006</td>
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<tr>
<td>BNFO 592 Independent Study in Bioinformatics</td>
<td>Faculty</td>
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<tr>
<td>BNFO 601 Integrated Bioinformatics</td>
<td>Fawcett</td>
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<td>BNFO 620 Bioinformatics Practicum</td>
<td>Buck</td>
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<td>BNFO 640 Computational Methods in Bioinformatics</td>
<td>Gao</td>
<td>Fall, 2006</td>
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<tr>
<td>BNFO 650 Sequence Analysis in Biological Systems</td>
<td>Zhao</td>
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<td>BNFO 653 Survey of Bioinformatics</td>
<td>Xu</td>
<td>Spring, 2005</td>
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<td>BNFO 690 Seminars in Bioinformatics</td>
<td>Kier</td>
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<td>BNFO 691 Special Topics in Bioinformatics</td>
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<tr>
<td>BNFO 691 Special Topics in Bioinformatics-Networks Biology</td>
<td>Bonchev</td>
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<tr>
<td>BNFO 691 Special Topics in Bioinformatics-Modeling Biology</td>
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<td>BNFO 691 Special Topics in Bioinformatics</td>
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<tr>
<td>BNFO 692 Independent Study in Bioinformatics</td>
<td>Faculty</td>
<td>Fall, 2004</td>
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<tr>
<td>BNFO 697 Directed Research in Bioinformatics</td>
<td>Faculty</td>
<td>Fall, 2004</td>
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<tr>
<td>BNFO 700 Externship in Bioinformatics</td>
<td>Faculty</td>
<td>Summer, 2005</td>
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### Example MS/PSM curriculum:

#### Year 01

<table>
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<tr>
<th>Semester</th>
<th>Course Name</th>
<th>Credits</th>
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<tr>
<td>Fall</td>
<td>Bridge Coursework Topic 1</td>
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<tr>
<td></td>
<td>Bridge Coursework Topic 2</td>
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<td></td>
<td>BNFO 601 Integrated Biof</td>
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<tr>
<td></td>
<td>Track List A</td>
<td>3</td>
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<tr>
<td></td>
<td>BNFO 508 Intro Biof Research (MS)</td>
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<td></td>
<td>Track List A (PSM)</td>
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<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Name</th>
<th>Credits</th>
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<tr>
<td>Spring</td>
<td>Bridge Coursework Topic 1</td>
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<tr>
<td></td>
<td>Bridge Coursework Topic 2</td>
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<tr>
<td></td>
<td>Essentials of Topic 1</td>
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<tr>
<td></td>
<td>Essentials of Topic 2</td>
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<td>Track Lists A/B (MS)</td>
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<tr>
<td></td>
<td>Track List A (MS)</td>
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<td></td>
<td>BNFO Business Principles</td>
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<tr>
<td></td>
<td>BNFO 620 BNFO Practicum (MBf)</td>
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<tr>
<th></th>
<th>Totals</th>
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<td>14</td>
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<tr>
<td>MS</td>
<td>15</td>
<td>14</td>
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#### Year 02

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<tr>
<td>Summer</td>
<td>BNFO 700 Extern (MBf)</td>
<td>3</td>
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<tr>
<td></td>
<td>BNFO 697 Dir Res</td>
<td>6</td>
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<tr>
<td>Fall2</td>
<td>Track Lists A/B</td>
<td>3</td>
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<td></td>
<td>Cross-Trk Elective</td>
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<tr>
<td></td>
<td>Cross-Trk Elective</td>
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<tr>
<td></td>
<td>MICR 510 Scient Integ</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>BNFO 690 Seminars</td>
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<td></td>
<td>Cross-Trk Elective</td>
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<td>BNFO 697 Dir Dir Res</td>
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<table>
<thead>
<tr>
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<th>Totals</th>
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<tbody>
<tr>
<td>PSM</td>
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<td>14</td>
</tr>
<tr>
<td>MS</td>
<td>6</td>
<td>14</td>
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</table>

**Curriculum:** ~1.5 years

~35 credits

3 - 4 semesters

summer internship
<table>
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<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNFO 591 Business Principles for the Life Scientist and Practitioner</td>
<td>Baldwin</td>
<td>Spring, 2006</td>
<td>3</td>
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<tr>
<td>Goal: provide students a background in business principles</td>
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<tr>
<td>Business Plan</td>
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<tr>
<td>Financing</td>
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<tr>
<td>Intellectual Property</td>
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<tr>
<td>Confidentiality</td>
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<td></td>
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<tr>
<td>Marketing</td>
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<td></td>
<td></td>
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<tr>
<td>Strategic Planning</td>
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<td></td>
<td></td>
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<tr>
<td>Accounting</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Biotechnology industry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical trials</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>BNFO 620 Bioinformatics Practicum</td>
<td>Buck</td>
<td>Spring, 2005</td>
<td>3</td>
</tr>
<tr>
<td>Team projects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related to industrial questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How to apply for a job and interviewing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral communications and presentations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BNFO 700 Externship in Bioinformatics</td>
<td>Faculty</td>
<td>Summer, 2005</td>
<td>3–6</td>
</tr>
<tr>
<td>Facilitated projects with industrial partners</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 months, usually summer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students return and present results</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>BNFO 625 Business Principles: Project Management</td>
<td>Baldwin</td>
<td>Planned, 2008</td>
<td>2</td>
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<tr>
<td>BNFO 635 Cost Evaluations in Biotechnology (advanced)</td>
<td>TBD</td>
<td>Planned, 2009</td>
<td>2</td>
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</tbody>
</table>
PLUS Course: BNFO 591

Business Essentials for the Life Scientist and Practitioner

- First year (2006)
  - One credit
  - Evening course
  - 11 students (Bioinformatics and non-matriculated students)
  - Excellent feedback from students (increase credits)

- Second year (2007)
  - 3 credits
  - 17 students (Bioinformatics majors, biomedical science Ph.D students!)
Business Essentials for the Life Scientist and Practitioner

Focus on Biotechnology and Pharmaceutical Industry
Entrepreneurial slant
- From invention to innovation
- Startups and Incubators
- Business Plan
- Sources of Funding: family/angels/VCs/investors/IPO
- Costing ... and more

Business principles
- Intellectual property
- Confidentiality
- Accounting
- Strategic Planning
- Marketing concepts
- Regulatory compliance: GLP/GMP, etc.
- Clinical Trials

Team projects / presentations: market analysis of small, medium or large biotech company
Instructors

Sheryl Baldwin  Coordinator  VCU Life Sciences
George Kasper  Inventions/Innovation  VCU School of Business
David Lohr  Business Plan  Va Biotechnology Res. Park
Ivelina Metcheva  Intellectual Property  VCU Tech Transfer
Roxanne Spindle  Accounting/Cost Anal.  VCU School of Business
Van Wood  Global Marketing  VCU School of Business
Pam Kiecker  Marketing  VCU School of Business

Outside speakers (2007)

Evan Edwards  Intelliject (small successful startup)
Frank Gupton  Boehringer Ingelheim (large biotech)
Manfred Psiorz  Boehringer Ingelheim
Bill Welsted  Wyeth (large pharmaceutical)
Van Cline  Amgen (large pharmaceutical)
Mark Herzog  VABIO (regional biotechnology association)
James Skinner  VC Strategic Analyst (investor)
## Enrollment, Graduation and Placement in PSM

### Enrollment:
- **2004/2005** (first year): 2 students (1 graduated)
- **2005/2006**: 1 continuing; 3 new (1 graduate)
- **2006/2007**: 2 continuing; 6 new (1 will graduate)
- **2007/2008**: 7 continuing; 8 new (projected)

### Placement of Graduates:
- 1 in Ph.D. program
- 1 in industrial position
Challenges for the Professional Science Masters Program

Recruitment:

*students do not understand PSM Program; (not yet mainstream)*

Competition with traditional MS program:

*little understanding of PSM degrees (not yet mainstream)*

Teaching:

*finding faculty to teach additional courses/ mentor students*

Administration:

*Masters degrees get less ‘respect’ in the sciences*

*Limited appreciation of the value of the PSM degree*

Faculty:

*Tend to know, understand and support traditional thesis MS (real MS!)*

*Encourage students into thesis track (over PSM)*
Challenges for the Professional Science Masters Program

Recruitment:

Competition with traditional MS program:

Teaching:

Administration:

Faculty:

Sustainability:

Resources need to flow back to the program
Favor traditional MS and Ph.D. programs

Plus Courses:

Need Business School Faculty and Industry Support

Internships

Need industry support
Why will the PSM Programs Succeed?

Students like it!

when students understand the PSM, they tend to opt for it…

- finish in 18 - 24 months (or less)
- have work experience through internship
- business ready, through nano-MBA/PLUS courses
- have excellent job prospects

Students drive the program…their interest overcomes obstacles
Why will the PSM Programs Succeed?

Industry likes it!

Well – trained employees (MS)
Industrial experience
Employees come with knowledge of business principles
Can send their employees (part time or full time)
Cost - effective
Why will the PSM Programs Succeed?

Congress likes it (or should)!

- Produces well trained employees
- Increased focus on STEM (Science, Technology, Engineering, Math)
- Enhances country’s technological competitiveness
- Cost – effective
  - students or employers usually pay (instead of government)
  - no long Ph.D.
- May provide increased funding for creation of PSM programs (NSF)…
Conclusion: VCU PSM in Bioinformatics

1. Took a long time to launch (almost 5 years from the vision).
2. Launched in 2004 with state regulatory body approval.
3. Support from Alfred P. Sloan Foundation was seminal.
4. Program is rapidly growing, despite limited student, faculty, and administrator understanding.
5. Students and employers love the program when they understand it.
6. Students are prepared to be better, more productive employees.
7. Business Plus classes are very well received (even by non – PSM students).
8. Internships are highly valued by students and industry partners.
9. Good relationships with industry leaders is an asset (Advisory Board).
10. Should have positive impact on global competitiveness.
Thank you!