Welcome to the Master’s Bioinformatics & Systems Biology

29th August 2014
Understanding the complexity of Life

Discovering the simplicity of Life

A joint master programme between the University of Amsterdam & VU University Amsterdam

Zuid-as
(South Campus)

Science Park
Teachers BI & SB:

Your teaching assistant for the next two months

Robbin Bouwmeester
Study Programme - Choice

Major
• Bioinformatics

Major
• Systems Biology
What is Bioinformatics?
From Gene to Function
It’s a networked world

Interesting systems are interconnected
  • in a non-linear way
  • with many components and connections
  • often at many levels
  • can be partially separated in space and time
From DNA to....

OH BRAD, THEY SAY THERE'S DNA IN MY BODY!

WHO CARES, DARLING, ...WHO CARES...

.....acctc ctgtgcaag acatgaaaca cccgatttac
nctgtggttc cccagatgg gtcctgtccc aggtgcacct
gcaggagtcg gcgcagagc tggggaagcc tccagagctc
aaaaaccccac tgggtacac aacctcacaca tgccccacggt
gccagaggcc aaatctttgt gacacacacct ccgccgtgccc
acggtgccca agcccaaat ctttgacac acctccccca
tgcacggtt ccagagccc caaatctttgt gacacacacct
cccggtgccc ccggtgccc gcacctgaac tcttgagggg
accgtaagtc tctctttccc ccccaaaacc caaggataacc
cttatgattt ccggacccc tcggtgaccc tgctggtgag
ctgacgtcag cacgagaagc cctnnngtcc agttcaagtg
gtacgacggt gcgtggaggg tgcataatgc caagacaag
ctgacgtgag gcagtaaa cagcagttc ctttggtcgc
gtcctctac gttcctacac cagctggccc taagcggcaaa
ggagtcacac gcaaggtct ccaacaaagc aaccaagtca
gctgaccctg ctgtgacac cgaagtgccc ccaacgcaag
cctcgcctgc agccgctgcc gggagagca atgggcaagc
tacaacca cgtcctgaat gctggtcagc gacggtctccc
tctcttctca agcaagctc accgtgccgt agagcaggtg
gcagcagggg acatcttct catgctccgt gatgcatgag
gctgtgccaca ccgcctacac gcagaagagc ctctc......
It’s the network stupid!
next generation sequencing
(baseclear)
mammaprint (agendia)

Models + Algorithms

Research & Bioinformatics

clinical trials (chdr)

Big data science
What is Systems Biology?

How does a radio work?

In what way does a biologist find out how a radio works?

A new kind of Biology

We like to understand the system.
What is Systems Biology?

Measured data

Dynamic (ODE) model

\[
\begin{align*}
\frac{d[DNA]}{dt} &= 0 \\
\frac{d[mRNA]}{dt} &= k_1[DNA] - k_2[mRNA] \\
\frac{d[TAL]}{dt} &= k_3[DNA] - k_4[mRNA] \\
\frac{d[Tyr]_{outside}}{dt} &= -\frac{k_{cat1}[AroP]_{outside}[Tyr]_{outside}}{K_m1+[Tyr]_{outside}} \\
\frac{d[Tyr]_{cell}}{dt} &= \frac{k_{cat1}[AroP]_{cell}[Tyr]_{outside}}{K_m1+[Tyr]_{outside}} - \frac{k_{cat2}[TAL]_{cell}[Tyr]_{cell}}{K_m2+[Tyr]_{cell}} \\
\frac{d[p-Coum]_{tot}}{dt} &= \frac{k_{cat2}[TAL]_{tot}[Tyr]_{cell}}{K_m2+[Tyr]_{cell}}
\end{align*}
\]
Bioinformatics or Systems Biology?

Bioinformatics
- IT, programming
- Labelling components
  - Structure/function prediction
  - Interaction prediction

Systems biology
- Quantitative processes through time
- Modelling
Study Programme: Overview

Courses (each course 6 ects)
- 4 courses (24 ects) compulsory for both majors
- 3 courses (18 ects) Bioinformatics major
- 3 courses (18 ects) Systems Biology major
- 3 optional courses (18 ects)

Internships
- Total 60 ects (major and minor internship)
## Study Programme - Year 1 first semester

<table>
<thead>
<tr>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>sept</td>
<td>oct</td>
<td>nov</td>
</tr>
</tbody>
</table>

### Bioinformatics and Systems Biology - Compulsory (24 + 18 ec)

<table>
<thead>
<tr>
<th>Fundamentals of Bioinformatics (6 ec) VU + UvA</th>
<th>Algorithms in Sequence Analysis (6 ec) VU</th>
<th>Biosystems Data Analysis (6 ec) UvA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Systems Biology (6 ec) VU + UvA</td>
<td>Systems Biology in Practice (6 ec) VU/UvA</td>
<td></td>
</tr>
</tbody>
</table>

---

**Joint start**

**Bioinformatics & Systems Biology**

---

**Decide about major**

Choose:
- Bioinformatics
- Systems Biology
- Both

---

**Joint compulsory course**

**Bioinformatics**

---

**Systems Biology**
First two months – Conversion Classes

<table>
<thead>
<tr>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>sept</td>
<td>oct</td>
<td>nov</td>
</tr>
</tbody>
</table>

**Bioinformatics and Systems Biology - Compulsory (24 + 18 ec)**

<table>
<thead>
<tr>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals of Bioinformatics (6 ec) VU + UvA</td>
<td>Algorithms in Sequence Analysis (6 ec) VU</td>
<td>Biosystems Data Analysis (6 ec) UvA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction to Systems Biology (6 ec) VU + UvA</td>
<td>Systems Biology in Practice (6 ec) VU/UvA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• Getting on a par - work on two deficiencies during first two months in special classes: biology, programming (bioinformatics major), mathematics (systems Biology)
# Study Programme - Year 1

<table>
<thead>
<tr>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>sept</td>
<td>oct</td>
<td>nov</td>
</tr>
</tbody>
</table>

**Bioinformatics and Systems Biology - Compulsory (24 + 18 ec)**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals of Bioinformatics (6 ec) VU + UvA</td>
<td>Algorithms in Sequence Analysis (6 ec) VU</td>
<td>Biosystems Data Analysis (6 ec) UvA</td>
<td></td>
</tr>
<tr>
<td>Introduction to Systems Biology (6 ec) VU + UvA</td>
<td>Systems Biology in Practice (6 ec) UvA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One out of Proposal Writing (6 ec) VU or Thesis Writing (6 ec) UvA. Both are individual work that can be flexibly planned (also in year 2).

**Period 4**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>sept</td>
<td>oct</td>
<td>nov</td>
<td>dec</td>
</tr>
</tbody>
</table>

**Period 5**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>feb</td>
<td>mar</td>
<td>apr</td>
<td>may</td>
</tr>
</tbody>
</table>

**Period 6**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Bioinformatics (6 ec) VU</td>
<td>Bioinformatics for Translational Medicine (6 ec) VU</td>
<td>Advanced Modeling in Systems Biology (6 ec) VU #</td>
</tr>
<tr>
<td>Basic Models of Biological Networks (6 ec) VU</td>
<td>Programming in R (6ec) VU #</td>
<td></td>
</tr>
</tbody>
</table>

are individual work that can be flexibly planned (also in year 2)

(choose at least one of these two)
**Study Programme - Year 1**

<table>
<thead>
<tr>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
<th>Period 4</th>
<th>Period 5</th>
<th>Period 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>sept</td>
<td>oct</td>
<td>nov</td>
<td>dec</td>
<td>jan</td>
<td>feb</td>
</tr>
<tr>
<td>Intro to Systems Biology (6 ec) VU + UvA</td>
<td>Algorithms in Sequence Analysis (6 ec) VU</td>
<td>Biosystems Data Analysis (6 ec) UvA</td>
<td>Structural Bioinformatics (6 ec) VU</td>
<td>Bioinformatics for Translational Medicine (6 ec) VU</td>
<td>Advanced Modeling in Systems Biology (6 ec) VU #</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioinformatics and Systems Biology - Compulsory (24 + 18 ec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fundamentals of Bioinformatics (6 ec) VU + UvA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction to Systems Biology (6 ec) VU + UvA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Optional Recommended Courses

<table>
<thead>
<tr>
<th>Molecular Structures in Biology (6ec) UvA</th>
<th>Synthetic Biology and Biomedicine (6ec) VU/UvA</th>
<th>Computational Biology (6ec) UvA</th>
<th>Molecular Microbial Physiology (6 ec) UvA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparatory Bachelor Courses (assigned to address deficiencies; max 12 ec)</td>
<td>Inleiding Programmeren (Python) (6ec) VU</td>
<td>Machine Learning (6 ec) VU</td>
<td></td>
</tr>
<tr>
<td>Probleemoplossen (3ec) VU</td>
<td>Probleemoplossen (3ec) VU</td>
<td>Lineaire algebra voor BWI en N (6ec) VU</td>
<td>Lineaire algebra I (6ec) VU</td>
</tr>
<tr>
<td></td>
<td>Calculus 1 (3ec) VU</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical Biology o/t Cell I (3 ec) VU</td>
<td>Moleculaire Celbiologie en Genetica (6ec) VU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biochemie I (3ec) VU</td>
<td>Biochemie II (3ec) VU</td>
<td></td>
</tr>
</tbody>
</table>

Optional Courses Other Masters (possibly in second year)

<table>
<thead>
<tr>
<th>Neural Networks (6 ec) VU</th>
<th>Stochastic Simulation (6 ec) UvA</th>
<th>Understanding Molecular Simulation (6ec) UvA</th>
<th>Scientific Computing (6 ec) UvA</th>
<th>Data Mining Techniques (6 ec) VU</th>
<th>Complex System Simulation (6ec) UvA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolutionary Computing (6 ec) VU</td>
<td>Computer Graphics (6 ec) VU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel Programming (6 ec) VU</td>
<td>Advanced Selforganisation (6ec) VU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principles of Neuroscience (6 ec) VU</td>
<td>Genomes and Gene Expression</td>
<td>Physical Biology o/t Cell II (3 ec) VU</td>
<td>Signal Transduction in Health and Disease (6ec) VU</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key:**

- **Compulsory**
  - First year:
    - 42 ects are compulsory:
      - 24 ects are compulsory for all students
      - 18 ects differentiate between the Bioinformatics and Systems Biology profiles
  - 18 ects are can be chosen freely.

- **Bioinformatics Profile**
- **Systems Biology Profile**
- **Recommended Optional Courses**
- **Supplementary Courses**
- **Optional Courses**

- **Optional Courses Other Masters (possibly in second year)**

- **Second year:**
  - 60 ects of projects:
    - major (max. 42 ects) must match profile (Bioinformatics or Systems Biology)
    - minor (min. 18 ects)

* Choose one out of Proposal Writing (6 ec – VU) or Thesis Writing (6 ec – UvA). Both are individual work that can be flexibly scheduled.
### Study Programme: Optional Courses

<table>
<thead>
<tr>
<th>Systems Biology</th>
<th>Bioinformatics</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Data mining techniques</td>
<td>- Genetic algorithms</td>
</tr>
<tr>
<td>- Genetic algorithms</td>
<td>- Neural Networks</td>
</tr>
</tbody>
</table>

Artificial Intelligence

- Data mining techniques
- Genetic algorithms
- Neural Networks

**Statistics**
- Statistical Genetics
- Statistical Models

**Biology**
- Epigenetics
- Molecular physiology

Other interesting options
- Principles of Neuroscience
- Physical biology of the cell
- Thanks to VU/UvA collaboration, programme can be conveniently planned in two years
- Wide choice of optional courses (that can really be taken)
- Possibility to study BI & SB combination
- Every student a Personal Education Plan (PEP)

### Study Programme - Year 1

<table>
<thead>
<tr>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
<th>Period 4</th>
<th>Period 5</th>
<th>Period 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>sept</td>
<td>oct</td>
<td>nov</td>
<td>dec</td>
<td>jan</td>
<td>feb</td>
</tr>
<tr>
<td>Bioinformatics and Systems Biology - Compulsory (24 + 18 ec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fundamentals of Bioinformatics (6 ec) VU + UvA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction to Systems Biology (6 ec) VU + UvA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algorithms in Sequence Analysis (6 ec) VU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systems Biology in Practice (6 ec) UvA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biosystems Data Analysis (6 ec) UvA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioinformatics for Translational Medicine (6 ec) VU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural Bioinformatics (6 ec) VU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Models of Biological Networks (6 ec) VU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming in R (6 ec) VU #</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced Modeling in Systems Biology (6 ec) VU #</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One out of Proposal Writing (6 ec) VU or Thesis Writing (6 ec) UvA. Both are individual work that can be flexibly planned *
By the end of September / early October

- Choose optional courses
- Make Personal Education Plan (PEP) together with
  - Huub (UvA)
  - Douwe (VU Systems Biology)
  - Sanne or Anton (VU Bioinformatics)
Study Outline – Next two months

- Fundamentals of Bioinformatics (FoB)
- Introduction to Systems Biology (ISB)
- Lectures
- Practicals (project/modeling)
- Conversion classes for Programming, Mathematics, Biology
- Last course day FoB: Presentations (followed by free beer...)
<table>
<thead>
<tr>
<th>Time</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00-11.00</td>
<td>Lecture FoB</td>
<td>Lecture FoB</td>
<td>Lecture ISB</td>
<td>Lecture ISB</td>
<td>Biology class (UvA)</td>
</tr>
<tr>
<td>11.00-13.00</td>
<td>Project FoB</td>
<td>Project FoB</td>
<td>Mathematics class</td>
<td>Mathematics class</td>
<td></td>
</tr>
<tr>
<td>13.30-14.00</td>
<td>Programming class</td>
<td>Programming class</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.00-15.30</td>
<td></td>
<td></td>
<td>Practical Modeling</td>
<td>Practical Modeling</td>
<td></td>
</tr>
<tr>
<td>15.30-17.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Study programme - Year 2

• Two internships (total 60 ects):
  • Minor: 18-30 ects (3-5 months)
  • Major: 30-42 ects (5-7 months)

• Major internship should match profile (BI or SB)

• Internship locations:
  • Company, University, Institution, Lab, Hospital (also abroad)
Where have our students been?

- Nederlands, among others:
  - VU (FEW/ FALW)
  - VUmc
  - CMBI
  - UMCU
  - UvA
  - UU
  - TNO
  - MRC-Holland
  - LUMC
  - Philips
  - DSM
  - Organon (MSD)
  - Agendia
  - Keygene
  - Baseclear
Where have our students been?

- Abroad:
  - Stockholm Bioinformatics Centre
  - European Bioinformatics Institute, Hinxton, UK
  - Deutsche Krebs Forchungs Zentrum, Heidelberg
  - European Molecular Biology Laboratory, Heidelberg
  - INRIA Strasbourg
  - Sloan Kettering Foundation NYC, USA
  - LONI laboratory UCLA, USA
  - Oakland University, NZ
  - RIKEN Tokyo, Japan
  - UMC Mineapolis (Ann Arbour), USA
  - Tuffts, Boston; Buffalo, Texas

Systems Biology: Special exchange programme CanSys with Luxembourg and Buffalo
Requirements

• Demonstrable experience in (Molecular) biology or Computer Science or Mathematics

• Enthusiasm for how life really works

• Wanting to learn various things

• No fear for technicalities
  o Desire to look under the hood
Why do this Master?

• Critical thinking – new field
  – Learn to develop and reason about methods
  – what + how + why (and why bother)

• Overview
  – Network biology

“This is how we do biology now.”
Why do this Master?

• Work on deficiencies (< 12 ects) during masters!
  • biology, programming (bioinformatics major), mathematics (systems Biology)

• Transferable skills
  • Modelling
  • Programming
  • Pattern recognition
  • Machine learning
Why studying BI & SB in Amsterdam?

- Master BI & SB title
  - Accredited programme!
  - Depth of “Study”

- Interdisciplinarity
  - Focus on networks
  - Tool creation as well as tool usage
  - Interdisciplinary programme, taylor-made courses
  - Students with different backgrounds
Why studying BI & SB in Amsterdam?

• Strong International Research Programme
  – Many partners (internships)
  – In the centre of ‘where it happens’

• Personal mentoring
  – At ‘South-campus’ or ‘Science Park’
  – Open-door policy by teachers
Where do our alumni go?

- 60% PhD (VU, VUMC, EBI, UU, CWI...)
- 40% Industry, UMCs
  - Biotechnology
  - But also
    - Finance
    - Bank
    - Insurance
- So far 100% of our students found a job immediately
  - Interdisciplinary programme = transferable skills
Any uncertainties or problems?

Ask us!

- Huub Hoefsloot
- Anton Feenstra
- Douwe Molenaar
Questions?

Bioinformatics and Systems Biology