MSc Bioinformatics

Course

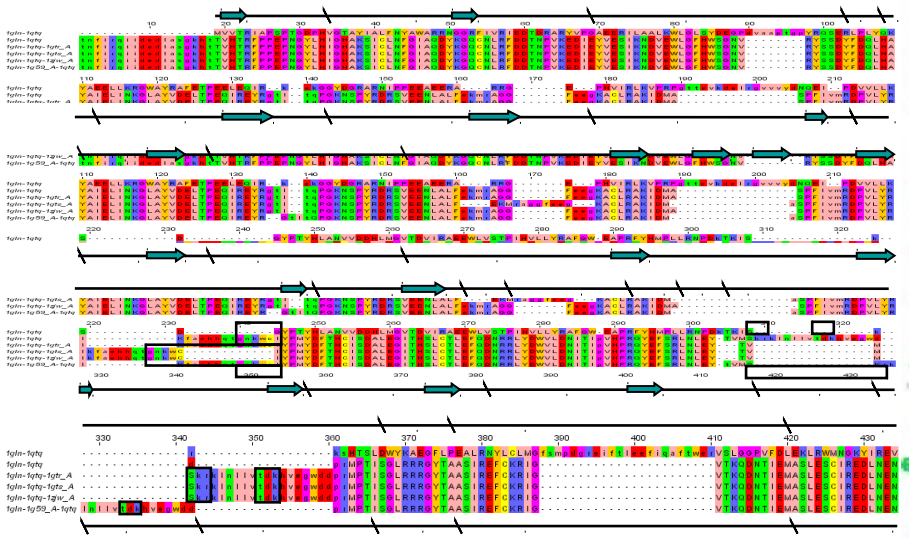
Fundamentals of Bioinformatics

Lecture 1: Introduction

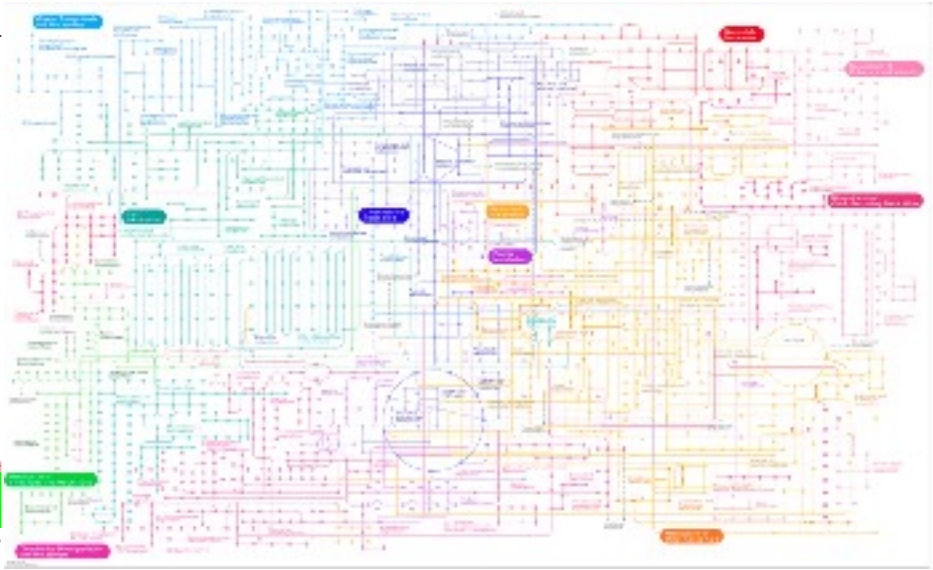
Centre for Integrative Bioinformatics VU (IBIVU)
Faculty of Exact Sciences / Faculty of Earth and Life Sciences
http://ibi.vu.nl, heringa@few.vu.nl, 87649 (Heringa), Room P1.28

MSc Bioinformatics & Systems Biology

- Major Bioinformatics



- Major Systems Biology



Overview of the BSB master

Year 1:

60 ec courses

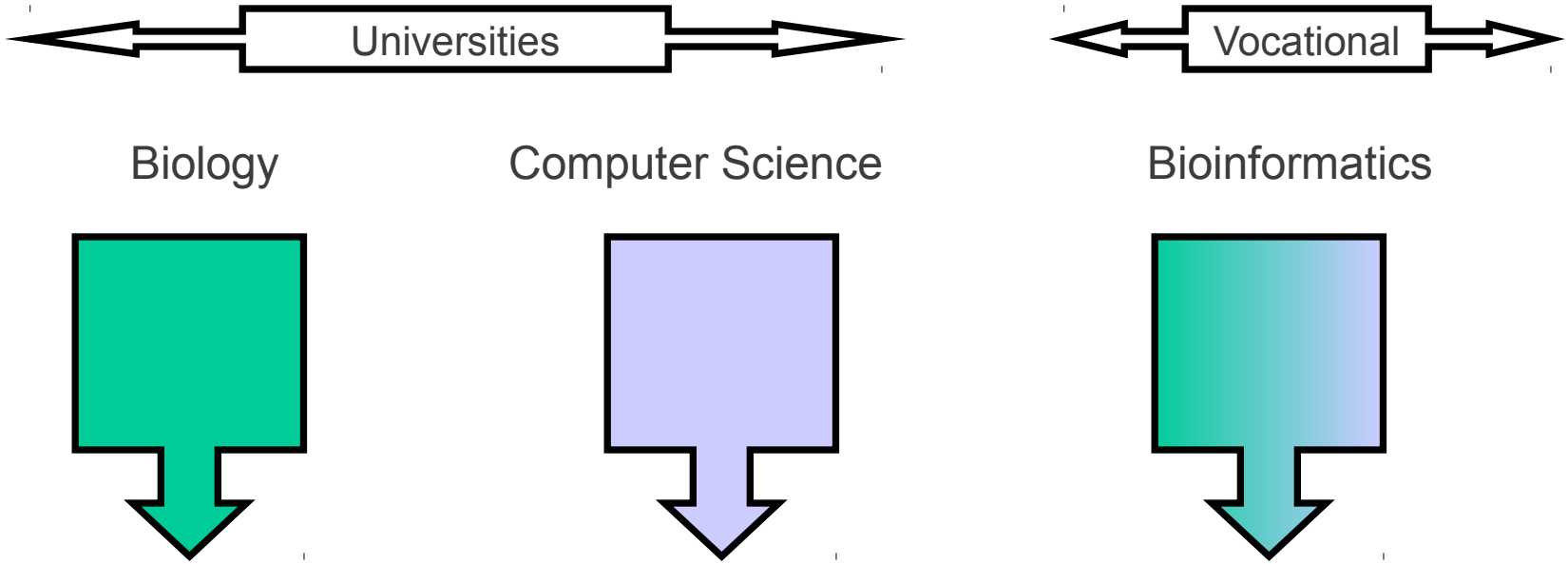
- 42 ec compulsory
- 18 ec optional (up to 12 ec deficiency mending)

Year 2:

Internships (major/minor)

- Total 60 ec

Who Comes In?



Master Bioinformatics

Learn to collaborate with people from different disciplines

"***Respectful collaboration of experts***"

Structure of the BSB master

Course work

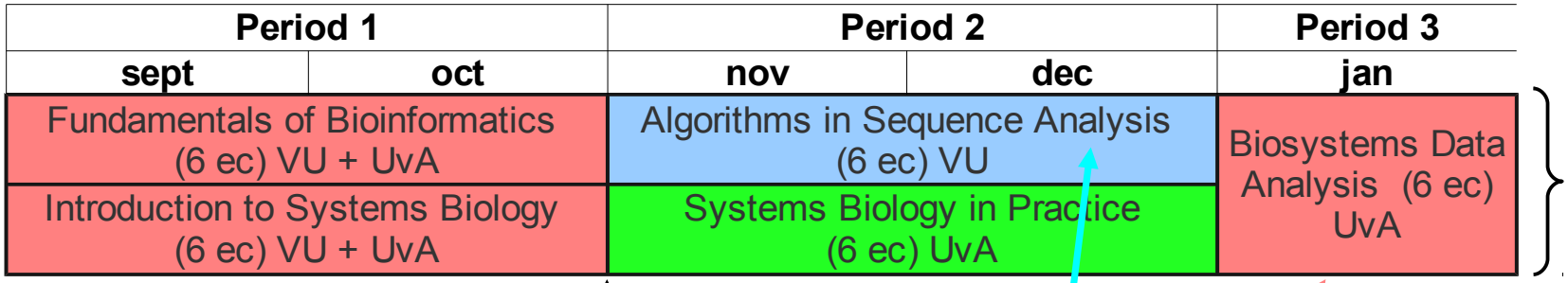
- 4 courses (24 ec) compulsory for both BI & SB
- 3 further courses (18 ec) compulsory for BI
- 3 further courses (18 ec) compulsory for SB

- 3 optional courses (18 ects) for both BI & SB

Internships

- Total 60 ec (Major 30-42 ec, Minor 18-30 ec)

Curriculum year 1



Joint start Bioinformatics & Systems Biology

Decision moment

Systems Biology

Bioinformatics

Joint subject BI & SB

Curriculum year 1

Period 1		Period 2		Period 3
sept	**oct**	**nov**	**dec**	**jan**
Fundamentals of Bioinformatics (6 ec) VU + UvA		Algorithms in Sequence Analysis (6 ec) VU		Biosystems Data Analysis (6 ec) UvA
Introduction to Systems Biology (6 ec) VU + UvA		Systems Biology in Practice (6 ec) UvA		

Period 4		Period 5		Period 6
feb	**mar**	**apr**	**may**	**jun**
Structural Bioinformatics (6 ec) VU		Bioinformatics for Translational Medicine (6 ec) VU		Proposal Writing (6 ec) VU # *or* Thesis Writing (6 ec) UvA # flexible*
Basic Models of Biological Networks (6 ec) VU		Advanced Modeling in Systems Biology (6ec) VU #		
		Programming in R (6ec) VU #		

(choose at least one of these two)

(flexible)

Curriculum year 1

Period 1		Period 2		Period 3	Period 4		Period 5		Period 6
sept	oct	nov	dec	jan	feb	mar	apr	may	jun
Bioinformatics and Systems Biology - Compulsory (24 + 18 ec)									
Fundamentals of Bioinformatics (6 ec) VU + UvA		Algorithms in Sequence Analysis (6 ec) VU		Biosystems Data Analysis (6 ec) UvA	Structural Bioinformatics (6 ec) VU		Bioinformatics for Translational Medicine (6 ec) VU		Proposal Writing (6 ec) VU # *or* Thesis Writing (6 ec) UvA # flexible*
Introduction to Systems Biology (6 ec) VU + UvA		Systems Biology in Practice (6 ec) UvA			Basic Models of Biological Networks (6 ec) VU		Advanced Modeling in Systems Biology (6ec) VU #		
							Programming in R (6ec) VU #		
Optional Recommended Courses									
Molecular Structures in Biology (6ec) UvA					Synthetic Biology and Biomedicine (6ec) VU/UvA				Molecular Microbial Physiology (6 ec) UvA
					Computational Biology (6ec) UvA				
							iGEM (18-30 ec)		
Preparatory Bachelor Courses (assigned to address deficiencies; max 12 ec)									
		Inleiding Programmeren (6ec) VU			Inleiding Programmeren (6ec) VU				
Calculus 1 (6ec) VU		Calculus 1 (3ec) VU							
		Physical Biology o/t Cell I (3 ec) VU			Moleculaire Celbiologie en Genetica (6ec) VU				
		Biochemie I (3ec) VU			Biochemie II (3ec) VU				
Optional Courses Other Masters (possibly in second year)									
Neural Networks (6 ec) VU		Stochastic Simulation (6 ec) UvA		Understanding Molecular Simulation (6ec) UvA	Scientific Computing (6 ec) UvA		Data Mining Techniques (6 ec) VU		Complex System Simulation (6ec) UvA
Evolutionary Computing (6 ec) VU		Computer Graphics (6 ec) VU							
Parallel Programming (6 ec) VU		Advanced Selforganisation (6ec) VU							
Principles of Neuroscience (6 ec) VU	Genomes and Gene Expression	Physical Biology o/t Cell II (3 ec) VU							
		Signal Transduction in Health and Disease (6ec) VU							

Key:

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

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

* schedule of *Proposal Writing* and of *Thesis Writing* is flexible and not limited to Period 6 in the first year

\# choose one out of *Advanced Modeling in Systems Biology* or *Programming in R*
And one out of *Proposal Writing* or *Thesis Writing*

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

Curriculum year 1

Period 1		Period 2		Period 3	Period 4		Period 5		Period 6
sept	oct	nov	dec	jan	feb	mar	apr	may	jun
Fundamentals of Bioinformatics (6 ec) VU + UvA		Algorithms in Sequence Analysis (6 ec) VU		Biosystems Data Analysis (6 ec) UvA	Structural Bioinformatics (6 ec) VU		Bioinformatics for Translational Medicine (6 ec) VU		Proposal Writing (6 ec) VU # *or* Thesis Writing (6 ec) UvA # flexible*
Introduction to Systems Biology (6 ec) VU + UvA		Systems Biology in Practice (6 ec) UvA			Basic Models of Biological Networks (6 ec) VU		Advanced Modeling in Systems Biology (6ec) VU #		
					Synthetic Biology and Biomedicine (6ec) VU/UvA		Programming in R (6ec) VU #		

- Thanks to collaboration (UvA & VU) the programme can be well planned and studied
- Optional courses can be scheduled appropriately

Further optional courses

Systems Biology

Bioinformatics

Computer Science

- Artificial Intelligence
- Genetic algorithms
- Neural Networks

Statistics

- Statistical Genetics
- Statistical Models

Biology

- Epigenetics
- Molecular physiology

Other interesting options

- Principles of Neuroscience
- Physical biology of the cell

Overview Year 2

- two internships
  - Minor: 18-30 ects
  - Major: 30-42 ects

- internship hosting:
  - Universities, Research institutes, Companies, Academic hospitals

Internships sites to date

- Netherlands, a.o.:
  - VU (FEW/ FALW)
  - VUmc
  - CMBI
  - UMCU
  - UvA
  - UU
  - TNO
  - MRC-Holland
  - LUMC
  - Philips
  - Organon (Merck)
  - Agendia
  - Keygene
  - Baseclear

International internship sites to date

- Stockholm Bioinformatics Centre
- European Bioinformatics Institute, Hinxton, UK
- Deutsche Krebs Forchungs Zentrum, Heidelberg
- European Molecular Biology Laboratory, Heidelberg
- INRIA Strasbourg
- Univerity of Luxembourg
- Sloan Kettering Foundation NYC, USA
- LONI laboratory UCLA, USA
- Oakland University, NZ
- RIKEN Tokyo, Japan
- Roswel Cancer Centre, Buffalo, USA
- UMC Mineapolis (Ann Arbour), USA

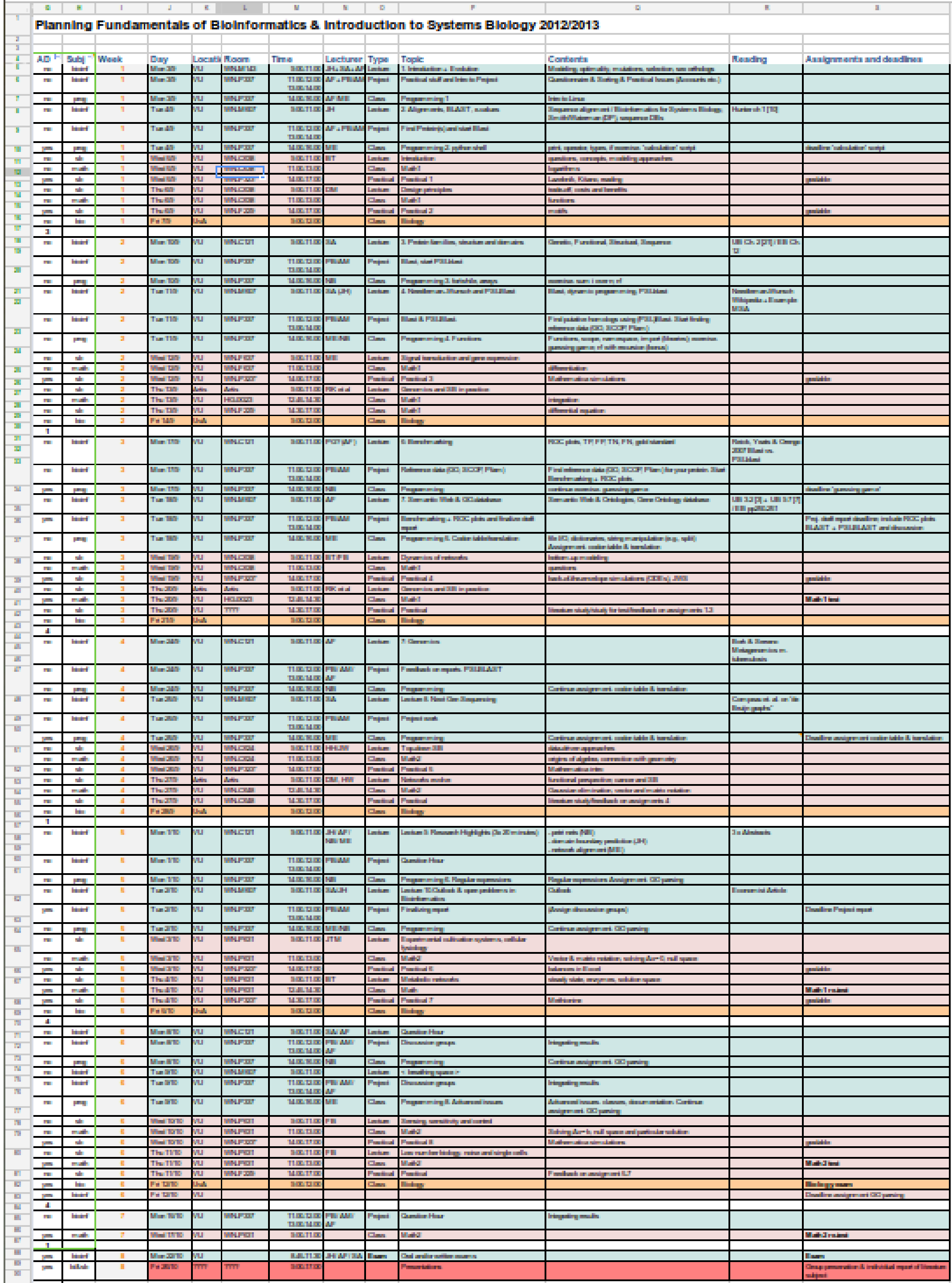
Fundamentals of Bioinformatics (FoB)

- Course coordinator: Dr Anton Feenstra

September + October

Two Courses:

- Fundamentals of Bioinformatics (Mondays & Tuesdays)
- Introduction to Systems Biology (Wednesdays & Thursdays)



FoB Lecture Schedule

	Date	Loc.	Room	Time	Lecturer	Type	Topic	Contents	Reading [#pages]
W1	03/09/12	VU	WN-M143	9h-11h	JH+ SA+ AF	Lecture	1a. Introduction 1b. Evolution	MSc Bioinformatics and Systems Biology mutations, selection, sex orthologs, introns, exons	
	04/09/12	VU	WN-M607	9h-11h	JH	Lecture	2. BLAST	BLAST, databases, e-values	Hunter ch 1 [10]
W2	10/09/12	VU	WN-C121	9h-11h	SA	Lecture	3. Domains	Genetic, Functional, Structural, Sequence	UB Ch. 2 [21] / EB Ch. 12
	11/09/12	VU	WN-M607	9h-11h	SA	Lecture	4. PSI-Blast	Blast, dynamic programming, PSI-blast	Needleman-Wunsch Wikipedia +Example MSA
W3	17/09/12	VU	WN-C121	9h-11h	AF	Lecture	5. Benchmarking	ROC plots, TP, FP, TN, FN, gold standard	Reick, Yeats & Orengo 2007 Blast vs. PSI-blast
	18/09/12	VU	WN-M607	9h-11h	PG	Lecture	6. Semantic Web & Ontologies	Semantic Web & Ontologies, Gene Ontology database	UB 3.2 [3] + UB 9.7 [7] / EB pp250-251
W4	24/09/12	VU	WN-C121	9h-11h	AF	Lecture	7. Genomics		Bork & Serrano Metagenomics m. tuberculosis
	25/09/12	VU	WN-M607	9h-11h	SA	Lecture	8. Next Gen Sequencing		Compeau et. al. on “de Bruijn graphs”
	26/09/12	*VU*	*WN-C624*	11h-13h		***Exam***	***Math1***	*(only when part of the math classes)*	
W5	01/10/12	VU	WN-C121	9h-11h	JH/ AF/ NB/ ME	Lecture	9. Research Highlights (3x 20 minutes)	- petri nets (NB) - domain boundary prediction (JH) - network alignment (ME)	3 x Abstracts
	02/10/12	VU	WN-M607	9h-11h	JH (AF/ SA)	Lecture	10. Outlook	NGS applications, unsolved problems in bioinformatics	Economist Article
W6	08/10/12	VU	WN-C121	9h-11h	SA/ AF/ JH	Lecture	**Question Hour**		
	09/10/12	VU	WN-M607	9h-11h		Lecture	< breathing space >		
	11/10/12	*VU*	*WN-P631*	*11h-13h*		***Exam***	***Math2***	*(only when part of the math classes)*	
	12/10/12	*UvA*		*9h-12h*		***Exam***	***Biology***	*(only when part of the bio classes)*	
W7	*17/10/12*	*VU*	*WN-P631*	*9h-11h*		***Exam***	***Math2 re-test***	*(only when part of the math classes)*	
W8	22/10/12	VU		8.45-11.30	JH/ AF/ SA	**Exam**	**Oral and/or written exams**		
	26/10/12	????	????	9h-17h		Presentations	**Presentations**	Group presenation & individual report of literature subject	

Acronym Lecturer
JH Jaap Heringa
AF Anton Feenstra
SA Sanne Abeln
PG Paul Groth
NB Nicola Bonzanni
ME Mohamed El-Kebir

Project/practical work

- Homology detection
  - BLAST vs. PSI-BLAST
- Benchmarking
  - Gene Ontology (GO), SCOP, Pfam

FoB Project Schedule

	Date	Loc.	Room	Time	Lecturer	Type	Topic	Contents	Deadlines and Assignments
W1	03/09/12	VU	WN-P337	11h-12h 13h-14h	AF+ PB/ AM	Project	Practical stuff and Intro to Project	Questionnaire & Sorting & Practical Issues (Accounts etc.)	
	04/09/12	VU	WN-P337	11h-12h 13h-14h	AF+ PB/ AM	Project	Find Protein(s) and start Blast		
W2	10/09/12	VU	WN-P337	11h-12h 13h-14h	PB	Project	Blast, start PSI-blast		
	11/09/12	VU	WN-P337	11h-12h 13h-14h	PB	Project	Blast & PSI-Blast.	Find putative homologs using (PSI-)Blast. Start finding reference data (GO, SCOP, Pfam)	
W3	17/09/12	VU	WN-P337	11h-12h 13h-14h	PB/ AM	Project	Reference data (GO, SCOP, Pfam)	Find reference data (GO, SCOP, Pfam) for your protein. Start Bench-marking + ROC plots.	
	18/09/12	VU	WN-P337	11h-12h 13h-14h	PB/ AM	Project	Benchmarking + ROC plots and finalize draft report		Proj. draft report deadline; include ROC plots BLAST + PSI-BLAST and discussion
W4	24/09/12	VU	WN-P337	11h-12h 13h-14h	PB/ AM/ AF	Project	Feedback on reports. PSI-BLAST		
	25/09/12	VU	WN-P337	11h-12h 13h-14h	PB/ AM	Project	Project work		
	26/09/12	*VU*	*WN-C624*	11h-13h		***Exam***	***Math1***	*(only when part of the math classes)*	*Math1 test*
W5	01/10/12	VU	WN-P337	11h-12h 13h-14h	PB/ AM/ AF	Project	**Question Hour**		
	02/10/12	VU	WN-P337	11h-12h 13h-14h	PB/ AM/ AF	Project	Finalizing report	(Assign discussion groups)	Deadline Project report
W6	08/10/12	VU	WN-P337	11h-12h 13h-14h	PB/ AM/ AF	Project	Discussion groups	Integrating results	
	09/10/12	VU	WN-P337	11h-12h 13h-14h	PB/ AM/ AF	Project	Discussion groups	Integrating results	
	11/10/12	*VU*	*WN-P631*	*11h-13h*		***Exam***	***Math2***	*(only when part of the math classes)*	*Math2 test*
	12/10/12	*UvA*		*9h-12h*		***Exam***	***Biology***	*(only when part of the bio classes)*	*Biology exam*
W7	15/10/12	VU	WN-P337	11h-12h 13h-14h	PB/ AM/ AF	Project	**Question Hour**	Integrating results	
	17/10/12	*VU*	*WN-P631*	*9h-11h*		***Exam***	***Math2***	*(only when part of the math classes)*	*Math2 re-test*
W8	22/10/12	VU		8.45-11.30	JH/ AF/ SA	**Exam**	**Oral and/or written exams**		Exam
	26/10/12	????	????	9h-17h		Presen-tations	**Presentations**		Group presenation & individual report of literature subject

Acronym Lecturer
AF Anton Feenstra
NB Nicola Bonzanni
PB Punto Bawono
ME Mohamed El-Kebir

Deficiencies worked on during September-October

Three defined areas:

- programming, mathematics, biology
- two out of three are addressed
- (working on all three is possible)
  - Mon/Tue: deficiency in programming (python)
    - 11-12h, 13-14h (rm P3.37) – FoB
  - Wed/Thu: deficiency in Mathematics
    - 11-13h – Introduction to Systems Biology
  - Fri: deficiency in Biology (UvA)

FoB Classes Schedule

	Day	Locati	Room	Time	Lectur	Type	Topic	Contents	Assignments and deadlines
W1	Mon 3/9	VU	WN-P337	14h-16h	AF/ME	Class	Programming 1	Intro to Linux	
	Tue 4/9	VU	WN-P337	14h-16h	ME	Class	Programming 2. python shell	print, operator, types, if exercise. 'calculation' script	deadline 'calculation' script
	Wed 5/9	VU	WN-C638	11h-13h		Class	Math1	logarithms	
	Thu 6/9	VU	WN-C638	11h-13h		Class	Math1	functions	
	Fri 7/9	UvA		9h-12h		Class	Biology		
W2	Mon 10/9	VU	WN-P337	14h-16h	NB	Class	Programming 3. for/while, arrays	exercise. sum i over n; n!	
	Tue 11/9	VU	WN-P337	14h-16h	ME/NB	Class	Programming 4. Functions	Functions, scope, namespace, import (libraries); exercise. guessing game; n! with recursion (bonus)	
	Wed 12/9	VU	WN-F637	11h-13h		Class	Math1	differentiation	
	Thu 13/9	VU	HG-0G23	12.45-14.30		Class	Math1	integration	
	Thu 13/9	VU	WN-F229	14.30-17h		Class	Math1	differential equation	
	Fri 14/9	UvA		9h-12h		Class	Biology		
W3	Mon 17/9	VU	WN-P337	14h-16h	NB	Class	Programming	continue exercise. guessing game	deadline 'guessing game'
	Tue 18/9	VU	WN-P337	14h-16h	ME	Class	Programming 5. Codon table/translation	file I/O, dictionaries, string manipulation (e.g., split) Assignment. codon table & translation	
	Wed 19/9	VU	WN-C638	11h-13h		Class	Math1	questions	
	Thu 20/9	VU	HG-0G23	12.45-14.30		Class	Math1		Math1 test
	Fri 21/9	UvA		9h-12h		Class	Biology		
W4	Mon 24/9	VU	WN-P337	14h-16h	NB	Class	Programming	Continue assignment. codon table & translation	
	Tue 25/9	VU	WN-P337	14h-16h	ME	Class	Programming	Continue assignment. codon table & translation	Deadline assignment codon table & translation
	Wed 26/9	VU	WN-C624	11h-13h		Class	Math2	origins of algebra, connection with geometry	
	Thu 27/9	VU	WN-C648	12.45-14.30		Class	Math2	Gaussian elimination, vector and matrix notation	
	Fri 28/9	UvA		9h-12h		Class	Biology		
W5	Mon 1/10	VU	WN-P337	14h-16h	NB	Class	Programming 6. Regular expressions	Regular expressions Assignment. GO parsing	
	Tue 2/10	VU	WN-P337	14h-16h	ME/NB	Class	Programming	Continue assignment. GO parsing	
	Wed 3/10	VU	WN-P631	11h-13h		Class	Math2	Vector & matrix notation, solving Ax=0, null space	
	Thu 4/10	VU	WN-P631	12.45-14.30		Class	Math		Math1 re-test
	Fri 5/10	UvA		9h-12h		Class	Biology		
W6	Mon 8/10	VU	WN-P337	14h-16h	NB	Class	Programming	Continue assignment. GO parsing	
	Tue 9/10	VU	WN-P337	14h-16h	ME	Class	Programming 8. Advanced issues	Advanced issues. classes, documentation. Continue assignment. GO parsing	
	Wed 10/10	VU	WN-P631	11h-13h		Class	Math2	Solving Ax=b, null space and particular solution	
	Thu 11/10	VU	WN-P631	11h-13h		Class	Math2		Math2 test
	Fri 12/10	UvA		9h-12h		Class	Biology		Biology exam
W7	Wed 17/10	VU	WN-P631	9h-11h		Class	Math2		Math2 re-test
W8	Mon 22/10	VU		8.45-11.30	JH/ AF/ SA	Exam	Oral and/or written exams		Exam
	Fri 26/10	????	????	9h-17h		Presentations	Presentations	Group presenation & individual report of literature subject	Group presenation & individual report of literature

FoB Programming Class Schedule

	Day	Locati	Room	Time	Lectur	Type	Topic	Contents	Assignments and deadlines
W1	Mon 3/9	VU	WN-P337	14h-16h	AF/ME	Class	Programming 1	Intro to Linux	
	Tue 4/9	VU	WN-P337	14h-16h	ME	Class	Programming 2. python shell	print, operator, types, if exercise. 'calculation' script	deadline 'calculation' script
W2	Mon 10/9	VU	WN-P337	14h-16h	NB	Class	Programming 3. for/while, arrays	exercise. sum i over n; n!	
	Tue 11/9	VU	WN-P337	14h-16h	ME/NB	Class	Programming 4. Functions	Functions, scope, namespace, import (libraries); exercise. guessing game; n! with recursion (bonus)	
W3	Mon 17/9	VU	WN-P337	14h-16h	NB	Class	Programming	continue exercise. guessing game	deadline 'guessing game'
	Tue 18/9	VU	WN-P337	14h-16h	ME	Class	Programming 5. Codon table/translation	file I/O, dictionaries, string manipulation (e.g., split) Assignment. codon table & translation	
W4	Mon 24/9	VU	WN-P337	14h-16h	NB	Class	Programming	Continue assignment. codon table & translation	
	Tue 25/9	VU	WN-P337	14h-16h	ME	Class	Programming	Continue assignment. codon table & translation	Deadline assignment codon table & translation
W5	Mon 1/10	VU	WN-P337	14h-16h	NB	Class	Programming 6. Regular expressions	Regular expressions Assignment. GO parsing	
	Tue 2/10	VU	WN-P337	14h-16h	ME/NB	Class	Programming	Continue assignment. GO parsing	
W6...	Mon 8/10	VU	WN-P337	14h-16h	NB	Class	Programming	Continue assignment. GO parsing	
	Tue 9/10	VU	WN-P337	14h-16h	ME	Class	Programming 8. Advanced issues	Advanced issues. classes, documentation. Continue assignment. GO parsing	
W8	Mon 22/10	VU		8.45-11.30	JH/ AF/ SA	Exam	Oral and/or written exams		Exam
	Fri 26/10	????	????	9h-17h		Presentations	Presentations	Group presenation & individual report of literature subject	Group presenation & individual report of literature

Some teachers in FoB

- Nicola Bonzanni – PhD (1/11/07)
- Anton Feenstra - UD (1/09/05)

  Course coordinator
- Mohammed El-Kebir – PhD (1/06/10)
- Sanne Abeln – UD (1/11/09)
- Jaap Heringa – HgI (1/10/02)
- Punto Bawono – PhD (1/06/11)
- Paul Groth – UD (Computer Science)







Deficiencies worked on during September-October

- Three defined areas: programming, mathematics, biology
- two out of three are addressed (working on all three is possible)
  - Mon/Tue: deficiency in programming (Perl)
  - 11-12am, 1-2pm (Rm P3.37) – Fundamentals of Bioinformatics
  - Wed/Thu: deficiency in Mathematics
  - 11-12am, 1-2pm – Introduction to Systems Biology
  - Fri: deficiency in Biology (UvA)

Project/practical work

Project: 14.00-16.00

- Practicals weeks 1-5
  - Intro
  - Find Protein(s), Pfam & GO terms
  - Find matching sequences (Blast) plus GO & Pfam entries
  - Find SCOP families
  - Scoring & Benchmarking
  - PSI-blast
- Project weeks 6-7
  - building on scripts & results from practicals
  - report, presentation

Some teachers in FoB

- Nicola Bonzanni – PhD (1/11/07)
- Anton Feenstra - UD (1/09/05)

  Course coordinator
- Mohammed El-Kebir – PhD (1/06/10)
- Sanne Abeln – UD (1/11/09)
- Jaap Heringa – Hgl (1/10/02)
- Punto Bawono – PhD (1/06/11)
- Andrew Gibson – PD AMC (Guest lecturer)







Examination and course marks

1. Written exam (40% weight)
   - General knowledge and overview
   - Questions about scientific papers
   - Discussion on scientific issue

3. Classes - deficiency (30% weight)
   - One out of two deficiencies (programming, math, bio) counts for course FoB, the other will count for the course ISB

4. Group (project) work (30% weight)
   - Progress, report, project presentation