UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG

Curriculum for the award of the Degree of

Master of Science in Biology

options:

- **Biochemistry**
- **Neuro- and Developmental Biology**
- **Ecology and Evolution**
- **Plant-Microbe Interactions**

Accepted by the Faculty of Science on March 21, 2005
Revised version from May 30, 2016

FACULTÉ DES SCIENCES
MATHEMATISCH-NATURWISSENSCHAFTLICHE FAKULTÄT

Contents

Master of Science (MSc)

1 Introduction

The University of Fribourg offers a multidisciplinary study programme leading to the degree of Master of Science in Biology, with the four options **Biochemistry**, Neuro- and **Developmental Biology**, **Ecology and Evolution**, **Plant-Microbe Interactions**. The programme consists of 90 ECTS[1] credits and corresponds to 18 months of full-time study. English is the official language for all activities. However, the students may choose the language of the examinations (English, French or German).

A special emphasis is placed on the development of the student's scientific capabilities (independent thinking, problem-solving skills, critical evaluation of data, oral and written communication skills, ability to work in a team). The student will deepen her/his knowledge of a selected area of biological sciences and acquire techniques needed in basic research as well as in practical applications such as biomedical and pharmacological research, biotechnology, public health, crop protection, sustainable agriculture, environmental protection, wildlife management, etc. Courses are accompanied by discussions, student presentations and writing exercises in order to stimulate an active participation of students. Students are integrated in one of the research teams and have the opportunity to experience all aspects of the daily life of a research scientist. They will obtain extensive experience with academic research in biology and learn to plan, carry out, analyse and present research. The Master also paves the way to a potential PhD and an academic career in biology and related fields.

2 Overview

The programme consists of three modules:

- Master courses: 30 ECTS credits
- Master thesis-related activities: 15 ECTS credits
- Master thesis: 45 ECTS credits

Four options (specialisations) are offered:

- Biochemistry
- Neuro- and Developmental Biology
- Ecology and Evolution
- Plant-Microbe Interactions

3 Acquired skills

The aim of the studies leading to the award of an MSc in Biology is to deepen knowledge and perfect competence in the chosen field and at the same time develop skills in scientific English. Thus, at the end of the course, a student will have shown that he/she can apply their knowledge to accomplish a research project and will have learned how to work independently and how to integrate into an interdisciplinary research team. The award of the degree requires creative and self-critical talents as well as the ability to communicate ideas and work both in English and in the student's native language.

[1] ECTS: *European Credit Transfer System*. One ECTS corresponds to 30 hours of effective work of the student

4 Master courses

For each option the University of Fribourg offers a number of obligatory and elective[2] Master courses. Elective courses can also be chosen among Master level courses at the Universities of Berne and Neuchâtel (BENEFRI convention) or among activities of the "III[e] Cycle Romand en Sciences Biologiques". An individual programme of elective courses according to the study programme is established by each student. The study advisor of the student's Master option may help in case of difficulties. An elective course not listed in the study programme of the four options (list below) may also be taken. In this case, the student must consult the study advisor. Completing the Master programme requires a minimum of 30 ECTS credits for Master courses.

The mode of assessment of the courses is described in an appendix available at http://www.unifr.ch/science/plans/e.

Courses are evaluated with a grade between 6 (best mark) and 1 (worst mark) or with passed/failed, based on an oral or a written examination, or some other performance of the student. Although students are allowed to attend Master courses before admission to a Master programme, it is not possible to acquire any ECTS credits.

The following table provides an overview of the Master courses offered in the four options. "O" indicates a course that is obligatory for a given option. All other courses listed in the table can be taken as elective (E); "R" indicates a course recommended for a given option. A detailed course programme for each option is described below.

Code	Course	ECTS	BC[1]	N&D[2]	E&E[3]	PMI[4]
BC.4201	Cell cycle control	1.5	O	E	E	E
BC.4202	Eucaryotic cell growth control	1.5	O	E	E	E
BC.4203	Genotyping (practical course)	2.5	O	-	-	-
BC.7107	Bioinformatics (practical + in silico)	3	O	E	E	E
BC.7104	Introduction to protein structure and protein homology modelling	1.5	R	E	E	E
BC.7105	Introduction to docking of small molecules to large macromolecules and molecular graphics	1.5	R	E	E	E
BL.0114	Experimental genetics	1	E	O	E	E
BL.0115	The RNA world	1.5	R	O	E	E
BL.0116	DNA damage response pathways	1	R	O	E	E
BL.0117	Neurogenetics	3	E	O	E	E
BL.0118	BENEFRI workshop "Frontiers in neurosciences"	1.5	E	R	E	E
BL.0119	Molecular genetics of model organism development	3	E	O	E	E
BL.0120	Topics in developmental biology	3	E	O	E	E
BL.0121	A BeFri colloquium on development I (ABCD I)	1.5	E	O	E	E
BL.0122	A BeFri colloquium on development II (ABCD II)	2.5	E	O	E	E
BL.0123	Cellular and genetic networks (BeFri)	3	E	E	E	E
BL.0124	Marine biology workshop	4	-	R	-	-
BL.0125	Light and fluorescence microscopy for Life Sciences	3	R	R	E	R
BL.0126	Established and Emerging Organisms for Marine Science	6	-	R	-	-

[2] elective: student choice

BL.0201	Advanced topics in evolutionary genetics and ecology	4	E	E	O	E
BL.0202	Biological invasions and trophic interactions	4	E	E	O	E
BL.0203	Workshop in statistics and experimental design	3	E	E	O	E
BL.0205	Ecological field course	5	E	E	O	E
BL.0206	Evolutionary biology workshop “Guarda”	4	E	E	R	E
BL.0213	Ecological networks	2	E	E	R	E
BL.0214	Speciation	2	E	E	R	E
BL.0216	Introduction to statistics with R – Model selection	1	E	E	R	E
BL.0217	Geographic Information System for ecology, evolution and conservation	1.5	E	E	R	E
LA_BL.0207	Molecular genetics for ecologists	4	E	E	R	E
AF_BL.0210	Tropical biology (TBA field course)	10	E	E	R	E
BL.0307	Symbiosis: how plants and microbes communicate	1.5	E	E	E	O
BL.0308	Plant development: the life of a sessile organism	1.5	E	E	E	O
BL.0317	Molecular bases of innate immunity: theoretical and practical aspects	3	E	E	E	O
BL.0318	Drugs and phytochemical analysis	1.5	R	E	E	O
BL.0322	Exploring protein functionality	2	E	E	E	E
BL.0323	Plant biotechnology	3	E	E	E	O
BL.0411	Signalling and transport	1	O	E	E	O
BL.0412	Introduction to protein structure and function [§]	1	O	E	E	O
BL.0413	Gene regulatory networks	1	O	E	E	E
BL.0414	Cell fate and tissue regeneration	1	O	R	E	E
BL.0415	Cell proliferation	1	O	R	E	E
BL.0416	Biological rhythms	1	O	R	E	E
BL.0417	Evolution on the bench	1	O	E	O	E
BL.0418	Microbial metabolism and genetics	1	O	E	E	O
BL.0419	Advanced imaging	1	O	E	E	E
BL.6002	Classical models in biology (lecture)	3	E	E	O	O
BL.6003	Classical models in biology (exercises) [6]	1	E	E	R	E
–	*English for Masters Students of Science I*	3	E	R	R	R
–	*English for Masters Students of Science II*	3	E	R	R	R
BL.0410	Scientific writing	3	–	O	O	O

[1] option Biochemistry
[2] option Neuro- and Developmental Biology
[3] option Ecology and Evolution
[4] option Plant-Microbe Interactions.
[5] Must be taken and examined together.
[6] Cannot be taken without BL.6002.

5 Master thesis-related activities

As members of a research team the Master students take part in various activities such as research group meetings, seminars, literature study/Journal club etc. Students are expected to participate in those activities throughout the duration of the study. The credits for these activities amount to 15 ETCS points. A detailed list of the activities required from students following a given option is given in section 9 (see below).

6 Master thesis description and assessment

The Master thesis is a scientific project carried out by a student under the supervision of a group leader within a research group of the Department of Biology or the Division of Biochemistry. The details vary with the option and research group, but in general the student is expected to establish a research strategy, plan the project, carry out the research, analyse the results, present them in a formal seminar, and write them up in the form of a scientific paper. The written report

in the form of a scientific paper, the oral presentation of the work and the practical work will be the objects of the final assessment of the Master thesis. A Master thesis is evaluated with a grade and corresponds to 45 ECTS points.

Each student should have chosen and have been accepted by her/his thesis supervisor at the latest by the 4th week (option Biochemistry) or 8th week (all other options) of the first semester of her/his Master studies.

To facilitate this choice, students are encouraged to familiarise themselves with the research carried out in the different research groups either before starting their studies or during the first weeks of their Master study, e.g., by taking part in their research group meetings. The student informs the student advisor of her/his choice.

If a thesis is evaluated as insufficient (less than 4.0), the student has the option to begin a new Master thesis in another research group. In this case, the student has to continue to attend and participate to the Master thesis-related activities.

7 Validation

The teaching units of the Master programme can only be examined after the student has completed all requirements for her/his Bachelor degree.

The **Validation Package MScBL1** comprises the Master courses and the Master thesis-related activities. **Validation Package MScBL2** comprises the Master thesis.

With the validation of the **MScBL1 and MScBL2** packages the student obtains the degree of Master of Science in Biology, option Biochemistry, Neuro- and Developmental Biology, Ecology and Evolution or Plant-Microbe Interactions.

8 Conditions of admission

The acceptance to a Master programme in Biology requires fulfilling the following conditions:

- being registered at the University of Fribourg (as defined in the "Règlement concernant l'admission à l'Université de Fribourg / Zulassungsreglement der Universität Freibourg)
- having completed the requirements for a Bachelor of Science in Biology or in Biochemistry at the University of Fribourg, or a similar degree acknowledged by the Faculty of Science.

The Faculty of Science establishes a list of recognized degrees. Candidates that hold a degree mentioned on this list are automatically accepted. Candidates holding a title not listed can be admitted by a decision of the Faculty of Science upon submission of an application to the *Committee of student requests* (*Commission des requêtes des étudiant-es*) of the Faculty of Science (address: Committee of student request, Dean's Office, Faculty of Science, Musée 8, CH-1700 Fribourg, Switzerland). The Faculty may also request that a candidate takes additional courses or other complements. If the imposed courses amount to less than about 30 ECTS, the student may attend them during any of the 3 semesters of the Master programme. If the imposed courses amount to more than about 30 ECTS, the student will only be able to begin her/his studies once the prescribed conditions have been met.

9 Ethics and science

Ethical principles are an integral part of a scientific education. Accepted international conventions must be respected during research and while documenting all scientific work whether it be a project, a lecture, a thesis, or a report. In particular, every external source of information (articles, lectures, web pages, etc.) must be correctly cited. Every student of the Faculty of Science has signed a formal commitment to restrain herself/himself from doing "plagiarism".

10 Detailed programmes of the options

10.1 Option Biochemistry

[Version 2012, validation packages: MSc1-BL.0404, MSc2-BL.5000]

10.1.1 Study programme

Code		Semester, year	tot. h.	ECTS
Obligatory courses				
BL.0411	Signalling and transport	AS	8	1
BL.0412	Introduction to protein structure and function §	AS	8	1
BL.0413	Gene regulatory networks	AS	8	1
BL.0414	Cell fate and tissue regeneration	AS	8	1
BL.0415	Cell proliferation	SS	8	1
BL.0416	Biological rhythms	SS	8	1
BL.0417	Evolution on the bench	SS	8	1
BL.0418	Microbial metabolism and genetics	SS	8	1
BL.0419	Advanced imaging	SS	8	1
BC.4201	Cell cycle control	AS	12	1.5
BC.4202	Eucaryotic cell growth control	AS	12	1.5
BC.4203	Genotyping (practical course)	AS	90	2.5
BC.7107	Bioinformatics (practical + in silico)	AS	42	3
Total ECTS credits in obligatory courses				**17.5**
Elective courses				
–	Courses chosen from the table in section 1.4, or from the programs of other Master options, or, with approval of the study advisor, other suitable courses given within or outside the University of Fribourg.*	All		
BC.7104	Introduction to protein structure and protein homology modelling #	SS	14	1.5
BC.7105	Introduction to docking of small molecules to large macromolecules and molecular graphics #	SS	14	1.5
BL.0115	The RNA world	AS	12	1.5
BL.0116	DNA damage response pathways	AS	8	1
BL.0125	Light and fluorescence microscopy for Life Sciences	AS, block course	28	3
BL.0318	Drugs and phytochemical analysis	SS	21	1.5
–	*English for Masters Students of Science I*	AS	–	3
–	*English for Masters Students of Science II*	SS	–	3
Minimum ECTS credits in elective courses				**12.5**

\# Must be taken together
§ Recommended for BC.7104 and BC.7105
* BENEFRI or other MSc programmes can be chosen upon approval by the study advisor.

Thesis-related activities				
BC.4402	Lab meetings	All	3x14	3x1.5
BL.0111	Research seminars and seminars in zoology	3 sem	3x14	3x1
BL.0400	Seminars in biology	3 sem	3x10	3x0.5
BL.0402	Literature study/Journal club	3 sem	3x14	4.5
ME.3001 ME.4001 ME.5001	Neurobiology seminars	3 sem	3x5	3x0.5
Total ECTS points in thesis-related activities				**15**
BL.5000	**Master thesis**		**–**	**45**
TOTAL				**90**

10.1.2 Description of the courses of the option Biochemistry

The lecture *Cell cycle control* (BC.4201) covers specific aspects of cell cycle control mechanisms in eucaryotes.

The course *Eucaryotic cell growth control* (BC.4202) covers the latest advances in our understanding on how nutrient signals are integrated to properly adjust cellular growth in eukaryotes.

The laboratory course *Genotyping* (BC.4203) teaches students molecular methods how to distinguish between different alleles. In principle, this laboratory course is performed on tissue samples from mice.
The course *Bioinformatics (practical + in silico)* (BC.7107) will allow the students to sequence a genome and analyse real genomic data. The goal is to identify potential mutations responsible for the phenotype.

The two courses *Introduction to protein structure and protein homology modelling* and *Introduction to docking of small molecules to large macromolecules and molecular graphics* (BC.7104 and BC.7105) describe the methodologies for 3D protein structure modelling (ab initio and by homology), as well as how to dock small molecules or large macromolecules to proteins. They also describe basic methods for producing nice molecular graphics for publications.

The *Seminars in biology* (BL.0400) and *Neurobiology seminars* (ME.3001, ME.4001 and ME.5001) are given by invited speakers and give an overview on recent developments. Students will have to attend and document their participation by submitting in writing what they think are relevant questions or criticisms after each seminar. This usually requires that they read a small review or some publication abstracts on the presented topic beforehand.

The course *Signalling and transport* (BL.0411) will focus on the plant signal transduction at first place. By comparing bacterial and plant signaling pathways over membranes, students will learn functional differences between the cytokinin receptor and bacterial sensor histidine kinases. As a side effect they will be also taught how structural models can be visualized. Using the example of the ethylene-sensing pathway it will be illustrated how evolution has 'modernized' plant histidine kinases. By comparing typical mammalian signal transduction pathways, such as G-protein coupled receptors or Toll-like innate immune receptors, with leucine-rich repeat (LRR) receptor(-like) kinases, such as BRI1, it will explained how plants differently sense steroid hormones over membranes. This course will compare eukaryotic signal transduction in plant, bacterial and mammalian systems, and is thus also recommended for “non-plant” Master students.

The course *Introduction to protein structure and function* (BL.0412) will focus on the properties and functions of proteins and how to detect those using bioinformatics tools and databases. Due to its lateral chain properties, each amino acid of a peptide will adopt a specific orientation or fold driven by a series of non-covalent interactions such as ionic interactions, Van de Waals forces, hydrogen bonds and hydrophobic packing. These conformations are necessary for the proteins to perform their biological function. Based on the primary structure of a protein (the amino acid sequence), bioinformatics tools aim at predicting several possible secondary structure conformations such as alpha helices, beta sheets, coils, turns, signal peptides and localisation signals, transmembrane regions and their topologies, protein domains and motifs, metal binding sites, post translational modifications, to cite a few. Going further would reach the 3D modelling subject covered by another course. This course should be seen as an introduction to the courses BC.7104 "Introduction to protein 3D structure and protein homology modelling" and BC.7105 "Introduction to docking of small molecules to large macromolecules and molecular graphics". Prerequisite: course BC.7003 "Introduction to Bioinformatics and Genomics" or equivalent. Students are kindly requested to bring a personal laptop computer (Windows, MacOS, or Linux). This course BL.0412 is recommended for those who intend to follow BC.7104 and BC.7105.

Gene regulatory networks (BL.0413). Even though the human genome consist of over 30’000 genes, each cell only expresses a defined subset of genes. Gene regulation at a global scale or whole genome scale is not dependent on a single transcription factor, but rather on complex gene regulatory networks. In the context of development, cell-cycle and function of differentiated cells different gene regulatory networks are at the core of what makes cells different from each other. Studies from bacteria, unicellular as well as complex, multicellular organisms are important for our understanding of how gene regulation occurs on a genome level. This lecture we will be dedicated on a specific subject in current research given by an expert in the area of gene regulatory networks.

Lecture course *Cell fate and tissue regeneration* (BL.0414). Tissues rely on stem cells for homeostasis and repair. Recent research shows that the fate and lineage potential of stem cells can change depending on whether a stem cell exists within its resident niche and responds to normal tissue homeostasis, whether it is mobilized to repair a wound, or whether it is taken from its niche and challenged to *de novo* tissue morphogenesis after transplantation. This course offers teaching in basics of stem cell biology, pluripotency and induced pluripotency. The particular focus will be given to the molecular control of mammalian stem cell fate decisions. It will be discussed how different populations of naturally lineage-restricted stem cells and committed progenitors can display remarkable plasticity and reversibility and reacquire long-term self-renewing capacities and multi-lineage differentiation potential during physiological and regenerative conditions. Finally, it will be also discussed what are the implications of cellular plasticity for regenerative medicine, as exemplified by cardiac and skeletal muscle differentiation.

The course *Cell proliferation* (BL.0415) covers a wide range of issues related to the regulation of cell proliferation in eukaryotic cells. These include fundamental aspects of cell cycle control and their coordination with environmental cues that are mediated by signal transduction pathways. Lectures will provide detailed information on both the recent conceptual and technical advances in the field of cell proliferation control.

The course *Biological rhythms* (BL.0416) focuses on the properties and functions of the circadian clock and other biological rhythms. The circadian clock is a cellular property defined by a set of clock genes that establish an auto-regulatory transcriptional/translational feedback-loop. This cellular clocks interact with each other via neuronal, hormonal and biochemical pathways to establish a coherent systemic hierarchy of physiological functions. This organizes body functions such as sleep, and feeding in a temporal manner. Prerequisite: Basic understanding of biochemistry and physiology.

In the course *Evolution on the bench* (BL.0417) we will discuss the main processes and factors

determining the rate of evolution of microorganisms and cell lines. We will compare the time scales of these processes to the time scales of experiments frequently carried out in cell biology and microbiology, and realize that evolution is in integral part of almost any such experiment. The goal of this course is then to develop an intuition for the expected evolutionary change over the course of your own experiments and to discuss how evolution may help or limit discovery and how the speed of evolution can be manipulated in the laboratory.

The course *Microbial genetics and metabolism* (BL.0418) treats various aspects of microbial genetics with the focus on bacteria, fungi, and oomycetes. It deals with fundamental aspects of microbial genetics and applied aspects related to disease or beneficial mutualistic interactions. Furthermore, important examples of metabolic pathways will be discussed in the context of microbial life and interactions with the biotic and/or abiotic environment.

Fluorescence light microscopy is a core technique to visualize biological processes in fixed and living tissue. With new development in microscope design and image acquisition progress was also made in digital image analysis. The aim of the course *Advanced imaging* (BL.0419) is to give the students a theoretical background in digital image analysis and to train students to use state of the art software tools. In a first module the students obtain theoretical knowledge about principles of digital image analysis and learn about ethical aspect in image manipulation. In a second module students are taught in workshops to use image analysis open source software ImageJ/Fiji and commercial software Bitplane Imaris and Huygens Deconvolution. In self-directed teaching tutorials student acquire basic image analysis skills (File formats, Metadata, Contrast adjustment, Background correction, Filtering). In workshops advanced techniques are learned such as image segmentation, 3D rendering, deconvolution, and co-localization. An introduction in batch processing and macro language will complete the session. The course will give practical guidelines that will help students with imaging projects in their line of research.During the *Master thesis* (BL.5000) the student familiarizes herself/himself with modern techniques and executes a research project under the guidance of a qualified investigator within a research group of the Biochemistry Unit or, upon approval by the study advisor, within another research group of the Department of Medicine or of Biology. Generally, the lab work starts during the first weeks of the MSc studies and extends over 3 semesters. This work requires designing and carrying a research strategy, keeping a clear lab journal and data analysis. The results will be written in the form of a scientific article.

Master thesis-related activities (BL.0400, BL.0111, BL.0402): these consist of different activities comprising seminars with national and international speakers presenting their research and seminars organized by the different groups in relation to their research activities. Literature study/Journal Club are meetings where researchers and students report and debate recently published articles. Research group meetings allow members of a research group to expose and discuss their current work.

10.2 Option Neuro- and Developmental Biology

[Version 2008, validation packages: MSc1-BL.0104, MSc2-BL.5000]

10.2.1 Study programme

Code		Semester, year	tot. h.	ECTS
Obligatory courses				
BL.0114	Experimental genetics	AS 1st	8	1
BL.0115	The RNA world	AS 1st	12	1.5
BL.0116	DNA damage response pathways	AS 1st	8	1
BL.0117	Neurogenetics	AS 1st	28	3
BL.0119	Molecular genetics of model organism development (BeFri lecture)	AS 1st	28	3
BL.0120	Topics in developmental biology	SS	28	3
BL.0121	A BeFri colloquium on development I (ABCD I) (BeFri)	SS	12	1.5
BL.0122	A BeFri colloquium on development II (ABCD II) (BeFri)	SS	20	2.5
BL.0410	Scientific writing	AS 1st	28	3
Total ECTS credits in obligatory courses				**19.5**
Elective courses				
–	Courses chosen from the table in section 1.4 or from BeFri, BeNeFri or other MSc programmes	AS/SS		-
BL.0118	BENEFRI workshop “Frontiers in neurosciences”	AS, block course	18	1.5
BL.0123	Cellular and genetic networks	AS	28	3
BL.0124	Marine biology workshop *	AS, block course	40	4
BL.0125	Light and fluorescence microscopy for Life Sciences	AS, block course	28	3
BL.0126	Established and Emerging Organisms for Marine Science	SS, block course	10d	6
–	*English for Masters Students of Science I*	AS	–	3
–	*English for Masters Students of Science II*	SS	–	3
BL.0411	Signalling and transport	AS	8	1
BL.0412	Introduction to protein structure and function	AS	8	1
BL.0413	Gene regulatory networks	AS	8	1
BL.0414	Cell fate and tissue regeneration	AS	8	1
BL.0415	Cell proliferation	SS	8	1
BL.0416	Biological rhythms	SS	8	1
BL.0417	Evolution on the bench	SS	8	1
BL.0418	Microbial metabolism and genetics	SS	8	1
BL.0419	Advanced imaging	SS	8	1
Minimum ECTS credits in elective courses				**10.5**

Thesis-related activities				
BL.0400	Seminars in biology	3 sem	3x10	3x0.5
BL.0111	Research seminars and seminars in zoology	3 sem	3x14	3x1
ME.5001§ ME.6001 ME.7001	Neurobiology seminars	3 sem	3x5	3x0.5
BL.0401	Research group meetings	3 sem	3x14	4.5
BL.0402	Literature study/Journal club	3 sem	3x14	4.5
Total ECTS credits in thesis-related activities				**15**

* This course is offered once every 2 years

§ If this course has been taken in a bachelor programme, it is replaced by 0.5 ECTS of elective courses.

BL.5000	**Master thesis**	**-**	**45**
TOTAL			**90**

10.2.2 Description of the courses of the option Neuro- and Developmental Biology

The course *Molecular genetics of model organism development* (BL.0119) is an introduction into some of the most popular model systems used for the study of development. These include *Xenopus*, Mouse, *C. elegans*, *Drosophila* and Zebrafish. The value of different technical approaches will be discussed. Further emphasis will be on presenting key experiments and the most recent findings for each system. Topics may vary from year to year but are likely to include transcriptional, translational, post-translational and epigenetic control of gene expression.

The course *"Topics in Developmental Biology"* (BL.0120) reviews specific topics in developmental biology, a central organizing discipline in biology that relates cell and molecular biology, anatomy, ecology, evolution and medicine to each other. The course provides the basic conceptual background of the anatomical, experimental, genetic, cellular, molecular and biotechnical approaches to modern developmental biology. Current topics are among others: limb formation, metamorphosis, aging, regeneration, germ line formation and sex determination, fertilization and implications of developmental biology on human medicine.

The RNA world (BL.0115): The flow of genetic information goes from DNA to RNA, and from RNA to proteins. Then how could the first proteins be made if they are needed for transcription and translation? The hypothesis of the RNA world suggests that catalytic RNAs (ribozymes) may have preceded proteins. This lecture will briefly describe the origins of life and emphasize the importance of ribozymes, their mode of action and their roles in today's world. The mechanism of RNAi interference, the importance of non-coding RNAs and the implications of RNA technology will be discussed.

The lecture course *Experimental genetics* (BL.0114) gives the theoretical background of the main techniques used in modern genetics. Students will learn how to localise genes using deletions, polymorphisms, recombination frequencies and the candidate gene approach. Furthermore, this course presents the design of forward genetic screens, reverse genetics, how to construct strains and the use of sequence databases. This lecture is intended for students who are interested in pursuing their education on genetic model organisms such as *S. cerevisiae*, *Drosophila*, *C. elegans*, Zebrafish and *Arabidopsis*.

The course *DNA damage response pathways* (BL.0116) will focus on the elements of the DNA damage-induced responses, as components of the cell cycle control machinery or the repairing process. It will mainly describe the signalling network of these responses in the nematode *C. elegans*, as well as in yeast and humans and the important links to cancer and other genetic abnormalities. Since double-strand breaks occur not only following genotoxic stress, but also during meiotic prophase, the course will also include mechanisms underlying the meiotic recombination process.

The course *Neurogenetics* (BL.0117) consists of an introduction into developmental genetics of *Drosophila* followed by a comprehensive coverage of neurogenetics, the key discipline of developmental neurobiology. The neurogenetic part begins with an overview of modern genetic and neurobiological methods in *Drosophila* and then focuses on the major highlights of neurogenetic research in *Drosophila*, *C. elegans* and vertebrates. Topics include: early neurogenesis, nervous system regionalization, tissue specification, axonal pathfinding, neuromuscular specificity, biological rhythms, learning and memory, mechanosensation, and olfaction. The topics are covered by an up-to-date script. This lecture is also accessible to MSc students from Berne

The BENEFRI workshop *Frontiers in Neurosciences* (BL.0118) is intended to make students familiar with current frontiers in neurobiological research. The course is given by national and international experts working in very diverse fields of neuroscience. Previous block courses included topics such as brain mapping, hypothalamus, motor systems, neurogenetic model systems, neuroinformatics, olfaction, sensory systems, synaptic function, and visual cortex.

ABCD; A BeFri Colloquium on Development I and *II* (Bl.0121, BL.0122) consist in monthly meetings during both terms with 2 presentations by PhD students or junior post-docs of participating groups from the Universities of Fribourg and Bern. MSc students are requested to attend the meetings, to participate to discussions and to provide a short summary of each presentation. The meetings will alternatively be held in Fribourg and Bern. During the Spring term, a two-day retreat gives the opportunity to MSc students to present their projects or related topics.

The course *Cellular and genetic networks* (BL.0123) describes how genes and cells function in a complex web of networks to regulate any biological system. Opposite to the reductionist approach to understand life sciences, the systems level approach is much needed and has been emphasized in recent years. In this course, we will cover the cutting-edge topics including transcriptional regulatory networks, neuronal networks, interactions between environment and cellular metabolisms, as well as mathematical modelling. The goal of this course is to learn and discuss how to approach systems-level biological problems by integrating different experimental methods.

Marine biology workshop (BL.0124): The scientific themes will cover an initial general introduction to the marine environment and its diverse ecosystems followed by theoretical and practical introductions to plankton, oceanic nekton, intertidal organisms, and subtidal benthic animals. In subsequent practical comparative work, the morphology and diversity of major invertebrate phyla, including sponges, cnidarians, arthropods, echinoderms and tunicates, and of teleost fish will be explored. Experimental benchwork will focus on fundamental aspects of developmental biology and neurobiology of marine animals. Developmental processes such as fertilization, cell lineage, cell differentiation, organogenesis and larval development will be analysed in representative marine organisms (echinoderms, ascidians, annelids). Comparative neurobiological experiments will elucidate major sense organ types, central nervous system organization and behavioural control systems in marine organisms. Developmental evolutionary (EvoDevo) aspects will be emphasized in both experimental areas by demonstrations and theoretical presentations. Independent practical work and literature reports by the participating students will be encouraged. This two weeks course will be credited with 4 ECTS.

Light and fluorescence microscopy for Life Sciences (BL.0125): Fluorescence microscopy has become one of the core techniques in biological research. Its applications range from the study of the expression of specific molecular markers with high spatial resolution in single cells to the probing of cell functions in living organisms. Constant progress in microscope design and in fluorescent probe development has led to a large choice of applications based on the principles of fluorescence microscopy. This course will aim at giving an understanding of key concepts of the main techniques used in life sciences. It will also insist on practical issues essential for a productive use of these techniques in biological and biomedical research.

The practical course, *Established and Emerging Organisms for Marine Science* (BL.0126) presents modern experimental and scientific approaches to study marine organisms. The location is Roscoff Biological Station in Brittany, France. Students will be actively involved in practical laboratory work. They also participate in discussions and debates on selected topics from published scientific articles. The number of participants is limited. Please contact the responsible professor, as indicated on Gestens.

Scientific writing (BL.0410): In a first part consisting of a few lectures the student will be introduced to the art of writing scientific articles. In a second part, she/he will practice writing a publication.

Teaching units BL.0411 to BL.0419 are described in the option "Biochemistry", see page 8.

English for Masters Students of Science I: this elective course aims to help Master's students in scientific disciplines develop the English language skills relevant to their studies and future careers. The emphasis will be placed on oral presentation skills, academic writing, strategies for reading comprehension and analysis of texts, and academic listening skills. Target level is B2-C2.

English for Masters Students of Science II: this elective course is a follow-up to English for Masters Students of Science I. As such, it will focus more heavily on issues surrounding the writing and oral defence of the Master's thesis. Target level is B2-C2.

Master thesis-related activities (BL.0400; BL.0111, BL.0401, BL.0402): these consist of different activities comprising seminars with national and international speakers presenting their research and seminars organized by the different groups in relation to their research activities. Literature study/Journal Club are meetings where researchers and students report and debate recently published articles. Research group meetings allow members of a research group to expose and discuss their current work.

During the *Master thesis* (BL.5000) the student familiarizes herself/himself with modern techniques and executes a research project under the guidance of a group leader within a research group of the domain Neuro- and Developmental Biology or, upon approval by the study advisor within a research group of the Department of Medicine. This work requires designing and carrying a research strategy, keeping a clear lab journal and data analysis. The Master thesis also includes a report written like a scientific article (summary, introduction, methods, results, discussion).

10.3 Option Ecology and Evolution

[Version 2008, validation packages: MSc1-BL.0203, MSc2-BL.5000]

10.3.1 Study programme

Code		Semester, year	tot. h.	ECTS
Obligatory courses				
BL.0201	Advanced topics in evolutionary genetics and ecology	AS 1st	42	4
BL.0202	Biological invasions and trophic interactions	AS 1st	33	4
BL.0203	Workshop in statistics and experimental design	SS 1st	28	3
BL.0205	Ecological field course	Block SS	80	5
BL.6002	Classical models in biology (lecture)	SS	28	3
BL.0410	Scientific writing	AS	28	3
BL.0417	Evolution on the bench	SS	8	1
Total ECTS credits in obligatory courses				**23**
Elective courses				
LA_BL.0207	Molecular genetics for ecologists (Uni Lausanne)**	AS, block course	–	4
BL.0206	Evolutionary biology workshop “Guarda” ***	Block SS	56	4
BL.0213	Ecological networks	SS	20	2
BL.0214	Speciation	SS	12	2
BL.0216	Introduction to statistics with R – Model selection	Block in January	12	1
BL.0217	Geographic Information System for ecology, evolution and conservation	AS	14	1.5
BL.0411	Signalling and transport	AS	8	1
BL.0412	Introduction to protein structure and function	AS	8	1
BL.0413	Gene regulatory networks	AS	8	1
BL.0414	Cell fate and tissue regeneration	AS	8	1
BL.0415	Cell proliferation	SS	8	1
BL.0416	Biological rhythms	SS	8	1
BL.0418	Microbial metabolism and genetics	SS	8	1
BL.0419	Advanced imaging	SS	8	1
BL.6003	Classical models in biology (exercises) *	SS	14	1
AF_BL.0210	Tropical biology (field course, Tropical biology association) ** and ***	Block Summer	28 days	10
–	*English for Masters Students of Science I*	AS	–	3
–	*English for Masters Students of Science II*	SS	–	3
–	Other elective courses from the table in section 1.4 or from BENEFRI or other Master programmes	AS/SS		
Minimum ECTS credits in elective courses				**8**

Thesis-related activities				
BL.0400	Seminars in biology	3 sem	3x10	3x0.5
BL.0211	Seminars in ecology and evolution	3 sem	3x14	1.5
BL.0212	Research seminars in ecology and evolution	3 sem	3x14	3
BL.0401	Research group meetings	All	3x14	4.5
BL.0402	Literature study/Journal club	All	3x14	4.5
	Total ECTS credits in thesis-related activities			**15**

* Cannot be taken without BL.6002
** This course can be used as a replacement for BL.0205 (5 ECTS)
*** No guarantee that there will be space

BL.5000	**Master research and thesis**	**-**	**45**
TOTAL			**90**

10.3.2 Description of the courses of the option Ecology and Evolution

Advanced topics in evolutionary genetics and ecology (BL.0201): the course will cover selected topics, including evolutionary demography, life history evolution, quantitative genetics, meta-population genetics, and genetic analysis of adaptation. It will be largely based on original literature and analysis of data.

The course *Biological invasions and trophic interactions* (BL.0202) builds on knowledge in population biology and plant-insect interactions. We will discuss both ecological and evolutionary explanation of plant invasions and review recent theory and practical applications for their control. The topic will also be highlighted in the context of future climate change conditions.

In the W*orkshop in statistics and experimental design* (BL.0203) students will learn basic and advanced techniques in statistical data analysis and they will perform exercises with data from ecological experiments. In addition, they will propose various experimental designs and discuss their advantages and disadvantages.

Ecological field course (BL.0205): a project-oriented field course taking place at a research field station. With the support of the teachers, the students learn to develop their own research projects, carry them out, and present and write up the results.

Evolutionary biology workshop "Guarda" (BL.0206) is an extramural block course (1 week) involving Swiss and foreign graduate students, as well as invited professors. In groups centered on a common scientific interest, and in interaction with the teachers, the students design research projects, and write and present grant proposals. The goal is to learn to discuss science, develop criticism and arguments, interact in a scientific team, and write research proposals.

Classical models in biology (BL.6002): the use of simple models to describe the behaviour of biological phenomena has been of great help for their understanding and has often driven researchers to new ideas. Here we will show how to go from the phenomenon to a model and what can be learned using this process. The lecture is illustrated with exercises (BL.6003).

Ecological networks (BL.0213): The course will give an introduction to graph theory and to the historical development of the research on ecological networks. It will tackle key studies on the structure and dynamics of ecological networks, with a special focus on food webs.

Introduction to statistics with R – Model selection **(**BL.0216): Many of us are interested in questions like "which factors influence a certain biological phenomenon?", but are unsure which statistical test to apply. The purpose of the course is to understand which test is appropriate for your data. I'll cover the standard statistical tests and explain in easy-to-understand terms how to use the R software to analyse your data. We cover linear and non-linear regression, t-tests, anova, ancova, multiple regression and other model- fitting techniques. This course provides a short introduction into the R environment, model fitting and then tackles in more depth the

problem of model selection (the task of selecting "good" models from a set of candidate models). The open source software R (http://www.r-project.org) has revolutionized the statistical data analysis for most bioscience disciplines. The R environment is completely free and runs on all common operating systems.

Geographic Information System (GIS) for ecology, evolution and conservation (BL.0217). A Geographic Information System (GIS) is a system made to manipulate spatial or geographical data. In biology, GIS information can have wide applications from the design of natural reserves optimising species conservation to the study of species evolution. Following the multiplication of biological data available in online databases, GIS is now an attractive tool for biologists. During this course, the students will receive the theoretical knowledge of the use of GIS for biological analyses. In addition, they will learn how to manipulate spatial objects and conduct spatial analyses in practical sessions.

Speciation (BL.0214): The course will give an introduction into current concepts and methods used to study the process of speciation, i.e. the origin of biological diversity. It will explore theoretical aspects, experimental evidence from speciation genetics, and evidence from nature.

Tropical ecology (AF_BL.0210) is a project-oriented international field course in tropical Africa, organised by the Tropical Biology Association.

The course with laboratory work *Molecular genetics for ecologists* (LA_BL.0207) is an intensive, practical course on molecular methods.

Scientific writing (BL.0410): In a first part consisting of a few lectures the student will be introduced to the art of writing scientific articles. In a second part, she/he will practice writing a publication.

Teaching units BL.0411 to BL.0419 are described in the option "Biochemistry", see page 8.

English for Masters Students of Science I: this elective course aims to help Master's students in scientific disciplines develop the English language skills relevant to their studies and future careers. The emphasis will be placed on oral presentation skills, academic writing, strategies for reading comprehension and analysis of texts, and academic listening skills. Target level is B2-C2.

English for Masters Students of Science II: this elective course is a follow-up to *English for Masters Students of Science I*. As such, it will focus more heavily on issues surrounding the writing and oral defence of the Master's thesis. Target level is B2-C2.

Master thesis-related activities (BL.0400; BL.0211, BL.0212, BL.0401, BL.0402): these courses consist of different activities comprising seminars where national and international speakers present their research, Literature study/Journal Club where researchers and students report and debate recently published articles, and research group meetings where the members of the research group expose and discuss their current work.

During the *Master thesis* (BL.5000) the student familiarizes herself/himself with modern techniques and executes a research project under the guidance of a group leader within a research group of the unit Ecology and Evolution. This work requires designing and carrying a research strategy, keeping a clear lab journal and data analysis. The results will be written in the form of a scientific article.

10.4 Option Plant-Microbe Interactions

[Version 2012, validation packages: MSc1-BL.0305, MSc2-BL.5000]

10.4.1 Study programme

Code		Semester, year	tot. h.	ECTS
Obligatory courses				
BL.0307	Symbiosis: how plants and microbes communicate	AS 1st	12	1.5
BL.0308	Plant development: the life of a sessile organism	AS 1st	12	1.5
BL.0317	Molecular basis of innate immunity: theoretical and practical aspects	SS	28	3
BL.0318	Drugs and phytochemical analysis	SS	21	1.5
BL.0323	Plant biotechnology	SS 1st	24	3
BL.0325	Current topics in plant biology	All	3x14	3
BL.0411	Signalling and transport	AS	8	1
BL.0412	Introduction to protein structure and function	AS	8	1
BL.0418	Microbial metabolism and genetics	SS	8	1
BL.6002	Classical models in biology (lecture)	SS	28	3
Total ECTS credits in obligatory courses				**19.5**
Elective courses				
BC.7104	Introduction to protein structure and protein homology modelling	SS	14	1.5
BC.7105	Introduction to docking of small molecules to large macromolecules and molecular graphics	SS	14	1.5
–	Elective courses chosen from the table in section 1.4 or from BENEFRI or other Master programmes	AS/SS		–
–	*English for Masters Students of Science I*	AS	–	3
–	*English for Masters Students of Science II*	SS	–	3
BL.0322	Exploring protein functionality	AS 1st	18	2
BL.0413	Gene regulatory networks	AS	8	1
BL.0414	Cell fate and tissue regeneration	AS	8	1
BL.0415	Cell proliferation	SS	8	1
BL.0416	Biological rhythms	SS	8	1
BL.0417	Evolution on the bench	SS	8	1
BL.0419	Advanced imaging	SS	8	1
Minimum ECTS credits in elective courses				**10.5**
Thesis-related activities				
BL.0324	Progress seminars for MSc students in plant biology	AS/SS	3x14	1.5
BL.0400	Seminars in biology	3 sem	3x10	3x0.5
BL.0401	Research group meetings	All	3x14	4.5
BL.0402	Literature study/Journal club	All	3x14	4.5
BL.0410	Scientific writing	AS 1st	28	3
Total ECTS points in thesis-related activities				**15**
BL.5000	**Master research and thesis**		**-**	**45**
TOTAL				**90**

10.4.2 Description of the courses in the option Plant-Microbe Interactions

The course *Symbiosis: how plants and microbes communicate* (BL.0307) deals with the mutual recognition between the plant and the microbial partner, and with the coordination of their development. In general, the course consists of short introductory lectures followed by critical examination of the recent literature on the topic. The goal is to show how scientific knowledge is generated and interpreted.

The course *Plant development: the life of a sessile organism* (BL.0308) describes central issues of developmental programmes involved in embryogenesis, root, shoot, and flower development. The emphasis will be on hormonal control of morphogenesis and pattern formation, and on the determinants of organ identity.

The lecture *Recent highlights in plant biology* (BL.0316) articles will be discussed that highlight recent advances in plant biology in selected areas. For each article, the historical background and the methodological aspects will be underlined. The goal is to provide students an opportunity to familiarize with and gain insight into the contemporary workings of basic research.

In the course *Molecular bases of innate immunity: theoretical and practical aspects* (BL.0317), a series of articles will be read, presented and discussed by the participants. The selected articles are major contributions that have shaped our current concepts on the defence of plants to pathogens.

The course *Drugs and phytochemical analysis* (BL.0318) is a theoretical and practical introduction to the accurate quantification of compounds such as vitamins, drugs and nutrients from complex matrices (cell samples, plant extracts, food, beverage and drugs). It covers extraction methods, the use of internal standards, techniques of purification and chromatography, detection procedures and the analysis of data. The course includes a practical part on Gas Chromatography and Ultra High Performance Liquid Chromatography.

In the lecture *Exploring protein functionality* (BL.0319) we aim at exploring state-of-the-art tools needed to conduct a timely investigation of protein functionality using transporter proteins as example. Beside a critical evaluation on these technical tools given the teacher and the students (via a presentation of technical publications), the course will also offer a practical part that deals with database mining.

In the lecture *Plant biotechnology* (BL.0323) your memory of the basic methods and associated problems of plant transformation will be refreshed. This is followed by an introduction of new methods and technology related to genome engineering. Finally, we will have a look at selected examples of plant biotechnology in commercial applications as well as basic science.

Classical models in biology (BL.6002): the use of simple models to describe the behaviour of biological phenomena has been of great help for their understanding and has often driven researchers to new ideas. Here we will show how to go from the phenomenon to a model and what can be learned using this process.

Scientific writing (BL.0410): In a first part consisting of a few lectures the student will be introduced to the art of writing scientific articles. In a second part, she/he will practice writing a publication.

Teaching units BL.0411 to BL.0419 are described in the option "Biochemistry", see page 8.

English for Masters Students of Science I: this elective course aims to help Master's students in scientific disciplines develop the English language skills relevant to their studies and future careers. The emphasis will be placed on oral presentation skills, academic writing, strategies for reading comprehension and analysis of texts, and academic listening skills. Target level is B2-C2.

English for Masters Students of Science II: this elective course is a follow-up to *English for Master's students of science I*. As such, it will focus more heavily on issues surrounding the writing and oral defence of the Master's thesis. Target level is B2-C2.

Master thesis-related activities (BL.0400, BL.0324, BL.0325, BL.0401, BL.0402): these course consist of different activities comprising seminars where Master students (BL.0324), national and international speakers present their research, Journal club where researchers and students report and debate recently published articles, and research group meetings where the members of the research group expose and discuss their current work.

During the *Master thesis* (BL.5000) the student familiarizes herself/himself with modern techniques and executes a research project under the guidance of a group leader within a research group of the unit Plant-Microbe Interactions or, upon approval by the study advisor within another research group. This work requires designing and carrying a research strategy, keeping a clear lab journal and data analysis. The results will be written in the form of a scientific article.