

Curriculum for the award of the Degree of

## **Master of Science in Biology**

options:

- **Biochemistry**
- **Animal Molecular Life Sciences**
- **Ecology and Evolution**
- **Plant and Microbial Sciences**

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## 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, Animal Molecular Life Sciences, Ecology and Evolution, Plant and Microbial Sciences**. The programme consists of 90 ECTS<sup>1</sup> 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.

The Regulation of 6 April 2020 for the award of the Bachelor of Science and Master of Science degrees establishes a limit on the duration of Bachelor's and Master's studies, as well as of the minor study programmes (see articles 10, 11a, 12a, 13 and 31) (<https://www3.unifr.ch/scimed/fr/rules/regulations>).

## 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

13 specializations are offered among the following four options:

- Biochemistry
- Animal Molecular Life Sciences
- Ecology and Evolution
- Plant and Microbial Sciences

Every option offers several specializations as shown in the attached table *MSc Biology specializations*. This table indicates which teaching units are obligatory, recommended or elective for every specialization.

## 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 his/her 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

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<sup>1</sup> ECTS: *European Credit Transfer System*. One ECTS corresponds to 30 hours of effective work of the student

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.

## 4 Master courses

For each option the University of Fribourg offers a number of obligatory, recommended, and elective<sup>2</sup> 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<sup>e</sup> 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 and attached table of the *Master in Biology specializations*) 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, 15 ECTS credits of Master's thesis-related courses/seminars, and 45 ECTS credits of Master's thesis project.

The mode of assessment of the courses is described in an appendix available at (<http://www3.unifr.ch/scimed/plans>).

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 table *MSc Biology specializations* (attached at the end of this document) provides an overview of the Master courses offered in the four options. "O" indicates a course that is obligatory for a given option. Most 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 and at the end of this document.

## 5 Master's 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 ECTS points. A detailed list of the activities required from students following a given option is given in section 11 (see below).

## 6 Master's thesis description and assessment

The Master's 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. 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 credits.

Each student must choose a research group and be accepted during the first semester of her/his Master studies. The group leader will be his/her supervisor for the Master thesis.

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<sup>2</sup> elective: student choice

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's 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's 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 may be granted provided the following two conditions have been met by the applicant:

- Satisfying the University admission requirements as defined in the *Règlement concernant l'admission à l'Université de Fribourg* (<https://www3.unifr.ch/apps/legal/fr/document/274904>),
- The student possesses a Bachelor of Science in Biology or in Biochemistry from the University of Fribourg or an academic degree judged equivalent by the Faculty of Science and Medicine.

For candidates with degrees that are not judged equivalent by the Faculty of Science and Medicine, the Commission for Students' Requests will decide on eligibility (*Commission des requêtes des étudiant-e-s*, Dean's Office, Faculty of Science and Medicine, ch. du Musée 8, CH-1700 Fribourg, Switzerland).

Based on the candidate's academic qualification, the Commission for Students' Requests can accept the application on the condition that additional requirements are fulfilled, provided they are of a minor scope and can be completed simultaneously with the Master studies. Otherwise, access is denied or applicants can be admitted to a "pre-master programme" and can begin the Master programme only after having fulfilled the requirements initially set for the pre-master. Final acceptance to the Master programme for a qualifying student depends on the successful completion of the additional requirements.

## 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 and Medicine has signed a formal commitment to restrain herself/himself from doing "plagiarism".

## **10 Regulations and Additional Information**

Detailed information about studying Biology can be found in the documents referenced on the web page <http://www3.unifr.ch/scimed/en/plans> which can also be obtained from the Office of the Department of Biology, chemin du Musée 10, CH-1700 Fribourg.

## 11 Detailed programmes of the options

### 11.1 Option Biochemistry

[Version 2020, validation packages: PV-SBL.0000059, PV-SBL.0000060]

#### 11.1.1 Study programme

Code		Semester, year	tot. h.	ECTS
<b>Obligatory courses</b>				
SBL.00413	Gene regulatory networks	AS	8	1
SBL.00415	Cell proliferation	SS	8	1
SBC.04201	Cell cycle control	AS	12	1.5
SBC.04202	Eucaryotic cell growth control	AS	12	1.5
SBC.04203	Genotyping (practical course)	AS	90	2.5
SBC.07108	Introduction to R	AS	3 days	1.5
SBC.07110	Introduction to UNIX and Bash	AS	5 days	2.5
SBC.07107	Bioinformatics (practical + in silico) <sup>3</sup>	AS	42	3
SBL.00501	Introduction to data analysis	AS	10	1
<b>Total ECTS credits in obligatory courses</b>				<b>15</b>

<sup>3</sup> SBC.07107 needs SBC.07110 as prerequisite

**Recommended and elective courses**

	- Courses listed in the <i>MSc Biology specialization</i> table or approved by the study advisor, among suitable courses within or outside the University of Fribourg.*	All		
SBL.00114	Experimental genetics	AS 1 <sup>st</sup>	8	1
SBL.00115	The RNA world	AS 1 <sup>st</sup>	12	1.5
SBL.00411	Signalling and transport	AS	8	1
SBL.00412	Introduction to protein structure and function §	AS	8	1
SBL.00414	Cell fate and tissue regeneration	AS/SS	8	1
SBL.00416	Biological rhythms	SS	8	1
SBL.00417	Evolution on the bench	SS	8	1
SBL.00418	Microbial metabolism and genetics	SS	8	1
SBL.00419	Advanced imaging	SS	8	1
SBC.07104	Introduction to protein structure and protein homology modelling #	SS	14	1.5
SBC.07105	Introduction to docking of small molecules to large macromolecules and molecular graphics #	SS	14	1.5
SBL.00216	Introduction to statistics with R – Model selection	Block in January	12	1
SBL.00127	BeFri research colloquium in cell and developmental biology I	SS	12	1.5
SBL.00128	BeFri research colloquium in cell and developmental biology II	SS	12	1.5
SBL.00129	BeFri research retreat in cell and developmental biology	SS	2 days	1
SBL.00123	Cellular and genetic networks	AS	28	3
SBL.00125	Light and fluorescence microscopy for life sciences	AS, block course	28	3
SBL.00322	Exploring protein functionality	AS	18	2
SBL.00318	Drugs and phytochemical analysis	SS	21	1.5
SBL.00420	Career profiling in life sciences	SS	8	1
SBL.00451	Introduction to mass spectrometry and proteomics	AS	8	1
SBL.00452	Advanced quantitative proteomics (incl. practical course)	SS	12	1
SBL.00453	Protein homeostasis: translation, quality control and degradation	SA	12	1
	- <i>English for Masters Students of Science I</i>	AS	–	3
	- <i>English for Masters Students of Science II</i>	SS	–	3
<b>Minimum ECTS credits in elective courses</b>				<b>15</b>

# Must be taken together

§ Recommended for SBC.07104 and SBC.07105

\* BENEFR I or other MSc programmes can be chosen upon approval by the study advisor.

**Thesis-related activities**

SBC.04402	Lab meetings	All	3x14	4.5
SBL.00403	Research seminars in molecular life sciences	3 sem.	3x14	4.5
SBL.00400	Seminars in biology	3 sem.	3x10	3x0.5
SBL.00404	Journal club in molecular life sciences	3 sem.	3x14	3
SME.03001*	Neurobiology seminars	3 sem.	3x5	3x0.5
SME.04001*				
SME.05001*				
<b>Total ECTS points in thesis-related activities</b>				<b>15</b>

\* If this course already has been taken in a bachelor programme, it is replaced by 0.5 ECTS of elective

SBL.05000	<b>Master thesis</b>		-	<b>45</b>
<b>TOTAL</b>				<b>90</b>

**11.2 Option Animal Molecular Life Sciences**

[Version 2020, validation packages: PV-SBL.0000061, PV-SBL.0000062]

11.2.1 Study programme

Code		Semester , year	tot. h.	ECT S
<b>Obligatory courses</b>				
SBL.00119	Molecular genetics of model organism development (BeFri lecture)	AS 1 <sup>st</sup>	28	3
SBL.00120	Topics in developmental biology	SS	28	3
SBL.00127	BeFri research colloquium in cell and developmental biology I	SS	12	1.5
SBL.00128	BeFri research colloquium in cell and developmental biology II	SS	12	1.5
SBL.00129	BeFri research retreat in cell and developmental biology	SS	2 days	1
SBL.00501	Introduction to data analysis	AS	10	1
SBC.07108	Introduction to R	AS	3 days	1.5
<b>Total ECTS credits in obligatory courses</b>				<b>12.5</b>

**Recommended and elective courses**

–	Courses listed in the <i>MSc Biology specialization</i> table or approved by the study advisor, among suitable courses within or outside the University of Fribourg.*	AS/SS		-
SBL.00114	Experimental genetics	AS 1 <sup>st</sup>	8	1
SBL.00115	The RNA world	AS 1 <sup>st</sup>	12	1.5
SBL.00130	Nuclear organization and chromosome dynamics	AS 1 <sup>st</sup>	8	1
SBL.00117	Neurogenetics	AS 1 <sup>st</sup>	28	3
SBL.00118	BeNeFri workshop “Frontiers in neurosciences”	AS, block course	18	1.5
SBL.00123	Cellular and genetic networks	AS	28	3
SBL.00124	Marine biology workshop **	AS, block course	40	4
SBL.00125	Light and fluorescence microscopy for life sciences	AS, block course	28	3
SBL.00126	Established and emerging organisms for marine science	SS, block course	10d	6
SBL.00216	Introduction to statistics with R – Model selection	Block in January	12	1
SBL.00411	Signalling and transport	AS	8	1
SBL.00412	Introduction to protein structure and function	AS	8	1
SBL.00413	Gene regulatory networks	AS	8	1
SBL.00414	Cell fate and tissue regeneration	AS/SS	8	1
SBL.00415	Cell proliferation	SS	8	1
SBL.00416	Biological rhythms	SS	8	1
SBL.00417	Evolution on the bench	SS	8	1
SBL.00418	Microbial metabolism and genetics	SS	8	1
SBL.00419	Advanced imaging	SS	8	1
SBL.00421	Oceanography and marine ecosystems	AS	8	1
SBL.00422	Molecular and cellular marine biology	SS	8	1
SBL.00426	Taxonomy and ecology of tunicates in Central Africa	SS	14 days	5
SBL.00427	Visual communication of data	SS	8	1
SBL.00428	Optogenetics and photopharmacology	SS	8	1
SBL.00429	Animal models of regeneration (Lecture with workshop)	SS	24	2
SBL.00420	Career profiling in life sciences	SS	8	1
	Systems biology of the brain	SS	2d	1.5
	Introductory course in laboratory animal science	SS	5 days	3
	<i>English for Masters Students of Science I</i>	AS	–	3
	<i>English for Masters Students of Science II</i>	SS	–	3
<b>Minimum ECTS credits in elective courses</b>				<b>17.5</b>

**Thesis-related activities**

SBL.00400	Seminars in biology	3 sem.	3x10	1.5
SBL.00403	Research seminars in molecular life sciences	3 sem	3x14	4.5
SME.05001 <sup>§</sup>	Neurobiology seminars	3 sem.	3x5	3x0.5
SME.06001				
SME.07001				
SBL.00401	Research group meetings	3 sem.	3x14	4.5
SBL.00404	Journal club in molecular life sciences	3 sem.	3x14	3
<b>Total ECTS credits in thesis-related activities</b>				<b>15</b>

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- \* BENEFRI or other MSc programmes can be chosen upon approval by the study advisor.
- \*\* This course is offered once every 2 years
- § If this course already has been taken in a bachelor programme, it is replaced by 0.5 ECTS of elective

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SBL.05000	<b>Master thesis</b>	-	<b>45</b>
<b>TOTAL</b>			<b>90</b>

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### 11.3 Option Ecology and Evolution

[Version 2020, validation packages: PV-SBL.0000063, PV-SBL.0000064]

#### 11.3.1 Study programme

Code		Semester, year	tot. h.	ECTS
<b>Obligatory courses</b>				
SBL.00201	Advanced topics in evolutionary genetics and ecology	AS 1 <sup>st</sup>	42	4
SBL.00202	Biological invasions and trophic interactions	AS 1 <sup>st</sup>	33	4
SBL.00203	Workshop in statistics and experimental design	SS 1 <sup>st</sup>	28	3
SBL.00205	Ecological field course	Block SS	80	5
SBL.00221	Biostatistics <sup>1</sup>	AS	18	2
SBL.00216	Introduction to statistics with R – Model selection	Block in Jan.	12	1
SBL.00410	Scientific writing	AS	28	3
SBL.00501	Introduction to data analysis	AS	10	1
SBC.07108	Introduction to R	AS	3	1.5
			days	
<b>Total ECTS credits in obligatory courses</b>				<b>24.5</b>
<b>Recommended and elective courses</b>				
Courses listed in the <i>MSc Biology specialization</i> table or approved by the study advisor, among suitable courses within or outside the University of Fribourg.*				
ULA.00376	Molecular methods in ecology and evolution (UniL)	AS, block course	–	4
SBL.00206	Evolutionary biology workshop “Guarda” ****	Block SS	56	4
SBL.00213	Ecological networks	SS	20	2
SBL.00219	The evolution of life histories and aging	SS	14	1.5
SBL.00417	Evolution on the bench	SS	8	1
SBL.00418	Microbial metabolism and genetics	SS	8	1
SBL.00419	Advanced imaging	SS	8	1
SBL.06002	Classical models in biology (lecture)	SS	28	3
SBL.06003	Classical models in biology (exercises) **	SS	14	1
XAF.00001	Tropical biology (field course, Tropical biology association) *** and ****	Block Summer	28	10
			days	
–	<i>English for Masters Students of Science I</i>	AS	–	3
–	<i>English for Masters Students of Science II</i>	SS	–	3
<b>Minimum ECTS credits in elective courses</b>				<b>5.5</b>
<b>Thesis-related activities</b>				
SBL.00400	Seminars in biology	3 sem.	3x10	3x0.5
SBL.00211	Seminars in ecology and evolution	3 sem.	3x14	1.5
SBL.00212	Research seminars in ecology and evolution	3 sem.	3x14	3
SBL.00401	Research group meetings	All	3x14	4.5
SBL.00402	Literature study/Journal club	All	3x14	4.5
<b>Total ECTS credits in thesis-related activities</b>				<b>15</b>

\* BENEFRI or other MSc programmes can be chosen upon approval by the study advisor.

- \*\* Cannot be taken without SBL.06002  
 \*\*\* This course can be used as a replacement for SBL.00205 (5 ECTS)  
 \*\*\*\* No guarantee that there will be space  
<sup>1</sup> Prerequisites SBL.00501, SBC.07108

SBL.05000	<b>Master thesis</b>	-	<b>45</b>
<b>TOTAL</b>			<b>90</b>

## 11.4 Option Plant and Microbial Sciences

[Version 2019, validation packages: PV-SBL.0000065, PV-SBL.0000066]

### 11.4.1 Study programme

Code		Semester, year	tot. h.	ECTS
<b>Obligatory courses</b>				
SBC.07110	Introduction to UNIX and Bash	AS	5 days	2.5
SBC.07107	Bioinformatics (practical + in silico) <sup>4</sup>	AS	42	3
SBL.00307	Symbiosis: how plants and microbes communicate	AS 1 <sup>st</sup>	12	1.5
SBL.00318	Drugs and phytochemical analysis	SS	21	1.5
SBL.00501	Introduction to data analysis	AS	10	1
SBC.07108	Introduction to R	AS	3 days	1.5
<b>Total ECTS credits in obligatory courses</b>				<b>11</b>
<b>Recommended and elective courses</b>				
Courses listed in the <i>MSc Biology specialization</i> table or approved by the study advisor, among suitable courses within or outside the University of Fribourg.*				
SBL.00125	Light and fluorescence microscopy for Life Sciences	AS, block course	28	3
SBL.00216	Introduction to statistics with R – Model selection	Block in Jan.	12	1
SBL.00308	Plant development: the life of a sessile organism	AS 1 <sup>st</sup>	12	1.5
SBL.00317	Molecular basis of innate immunity: theoretical and practical aspects	SS	28	3
SBL.00322	Exploring protein functionality	AS 1 <sup>st</sup>	18	2
SBL.00323	Plant biotechnology	SS 1 <sup>st</sup>	24	3
SBL.00411	Signalling and transport	AS	8	1
SBL.00412	Introduction to protein structure and function	AS	8	1
SBL.00418	Microbial metabolism and genetics	SS	8	1
SBL.00419	Advanced imaging	SS	8	1
SBL.00424	Microbiomes: from plants to humans	SS	14	1.5
SBL.00425	Metagenomic data analysis	SS	14	1
	<i>English for Masters Students of Science I</i>	AS	-	3
	<i>English for Masters Students of Science II</i>	SS	-	3
<b>Minimum ECTS credits in elective courses</b>				<b>19</b>

<sup>4</sup> SBC.07107 needs SBC.07110 as prerequisite

**Thesis-related activities**

SBL.00326	Current topics in plant and microbial sciences	All	3x14	6
SBL.00400	Seminars in biology	3 sem.	3x10	3x0.5
SBL.00401	Research group meetings	All	3x14	4.5
SBL.00410	Scientific writing	AS 1 <sup>st</sup>	28	3
<b><i>Total ECTS points in thesis-related activities</i></b>				<b>15</b>
<hr/>				
SBL.05000	<b>Master research and thesis</b>		-	<b>45</b>
<hr/>				
<b>TOTAL</b>				<b>90</b>

\* BENEFRI or other MSc programmes can be chosen upon approval by the study advisor.

## 12 Description of the teaching units

The lecture *Cell cycle control* (SBC.04201) covers specific aspects of cell cycle control mechanisms in eucaryotes.

The course *Eucaryotic cell growth control* (SBC.04202) covers the latest advances in our understanding on how nutrient signals are integrated to properly adjust cellular growth in eukaryotes.

The laboratory course *Genotyping* (SBC.04203) teaches students molecular methods how to distinguish between different alleles. In principle, this laboratory course is performed on tissue samples from mice.

The two courses *Introduction to protein structure and protein homology modelling* and *Introduction to docking of small molecules to large macromolecules and molecular graphics* (SBC.07104 and SBC.07105) 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 course *Bioinformatics (practical + in silico)* (SBC.07107) will allow the students to sequence a genome and analyse real genomic data. The goal is to identify potential mutations responsible for the phenotype.

*Introduction to R* (SBC.07108): This course introduces the basic usage of the statistical programming language R. The focus will be on data structures (vectors, matrices and data frames), import / export of data, basic plotting, writing of functions and scripts for reproducible data analysis. The course will be largely “hands-on” and does not require any prior knowledge on R. *Introduction to UNIX and BASH* (SBC.07110): The students will learn the basics of computing and programming, with an emphasis on UNIX operating system and command-line examples. They will learn BASH scripting using modern tools, including regular expressions.

The course *Signalling and transport* (SBL.00411) will focus on the plant signal transduction at first place. By comparing bacterial and plant signalling 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 explain 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* (SBL.00412) 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 SBC.07104 "Introduction to protein 3D structure and protein homology modelling" and SBC.07105 "Introduction to docking of small molecules to large macromolecules and molecular graphics". Prerequisite: course SBC.07003 "Introduction to

Bioinformatics and Genomics" or equivalent. Students are kindly requested to bring a personal laptop computer (Windows, MacOS, or Linux). This course SBL.00412 is recommended for those who intend to follow SBC.07104 and SBC.07105.

*Gene regulatory networks* (SBL.00413). Even though the human genome consists 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* (SBL.00414). 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* (SBL.00415) 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* (SBL.00416) 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. These 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* (SBL.00417) 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* (SBL.00418) 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* (SBL.00419) 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 Imaparis 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.

*Career Profiling in life sciences* (SBL.00420): After having completed their Master degree, students start applying for jobs. In this interactive course, we present the curricula of several people who are now active in the professional world. We chose different paths, from academia to industry and even less related fields. From this course you will also learn how to write a CV, how to write an application, and how to prepare for a job interview. 15-minute interviews will be held in front of the other participants or in private. We also provide information on where to look for jobs in Switzerland.

Block course SBL.00421, *Oceanography and marine ecosystems*: Oceans are home of a vast diversity of animal life forms from all animal phyla. Variable abiotic physical and chemical conditions as well as geographic location strongly impact the marine biosphere. This module will provide a comprehensive introduction into oceanography, diversity of marine biotopes and ecological interactions.

Block course SBL.00422, *Molecular and cellular marine biology*: All existing animal life forms originated from common marine ancestors. Thus, the largest diversity of life forms and corresponding evolutionary, physiological molecular and cellular adaptations can be found in marine environments. This module will provide an overview of specific examples of molecular, genetic and cellular biological processes in marine organisms SBL.00424 *Microbiomes: from plants to humans*. Students will be introduced to the concept of holobionts and metaorganisms. They will learn how microbiomes are assembled and structured in different host organisms, including plants, animals and humans. They will discover the functions these microbiomes fulfil for their hosts and how we can leverage on these microbiome-encoded functions to address current challenges, e.g. in plant and human health. SBL.0063 or an equivalent course on bacteriology has to be taken before.

The lecture with exercises SBL.00425 teaches *Metagenomics data analysis*. Students will learn the basic principles of metagenomics data analysis and their associated methods. The course will cover the targeted methods (16S, ITS) as well as the Whole Genome/Transcriptome Sequencing methods, both in prokaryotes and eukaryotes. Students will learn which kind of data could be extracted from metagenomics analysis and how to analyse and represent these data. BC.7106 or equivalent is a prerequisite to access this course.

The workshop *Taxonomy and ecology of tunicates in Central Africa* (SBL.00426) is given in the context of an international collaboration with the University of Douala, students participating in this two-week course will have the opportunity to sample and analyze tunicates from the coast of Cameroon. Tunicates are an evolutionarily critical yet understudied group of marine filter-feeders which are our closest invertebrate relatives. Cameroon has Africa's second highest biodiversity and is centrally located along the western coast of Africa, which has never been sampled for tunicates. This course will consist of two blocks. The first one will take place in Cameroon where students from Fribourg together with students from Douala will collaborate to

sample various locations along the Gulf of Guinea for tunicates. Students will learn how to collect, identify and preserve tunicates under the supervision of local and international experts. The second block will take place in Fribourg, where the same students will learn how to process the collected samples for genomic barcoding, mass-spectrometry processing and microplastic isolation. Students will thus learn a set of techniques highly relevant for monitoring the biodiversity and the environmental pollution that are applicable to other taxa, and participate in the very first census of tunicates in Central Africa.

The goal of the course *Visual communication of data* (SBL.00427) is to provide students with the theoretical background and practical skills needed to design and create efficient graphics that fairly present quantitative data. The course content includes an overview of classical and less classical graphic types available, guidelines on how to choose the best representation based on the type of data, tricks to emphasize specific messages without inducing bias, as well as major pitfalls to avoid. Practical exercises are carried out using Excel and other simple software.

*Optogenetics and photopharmacology* (SBL.00428) are two modern, fast-developing fields that use light-responsive molecules as tools for scientific research and hold promises for medical interventions. The lecture course will present ‘sensors’ used to monitor specific molecular events, as well as light-controlled molecules used to manipulate the activity of specific cells within a cellular network or the activity of specific signaling pathways within a cell. Richly illustrated with examples, the course covers the principles of these approaches, their main advantages and limitations, as well as current challenges for their application in translational medicine.

The lecture SBL.00429 *Animal models of regeneration* describes the processes of wound healing following injury. The ability to recreate a fully functional copy of the missing organ is a rare and fascinating phenomenon occurring in certain groups of animals. This course deals with conceptual models of regenerative principles in animals, as well as cellular and molecular mechanisms underlying efficient regeneration of body parts in various invertebrates and vertebrates. The course offers microscopic and molecular experiments aiming to assess regeneration in several model organisms. The techniques include animal procedures in hydra, tunicates and zebrafish embryos, live analysis of fin regeneration in adult zebrafish, collection and fixation of regenerating adult organs for molecular analysis, histological preparation, fluorescent visualization of specific tissues, microscopic imaging, and data interpretation.

The courses *Introduction to mass spectrometry and proteomics* and *Advanced quantitative proteomics* (SBL.00451 and SBL.00452) are each two days block courses at the end of respective semesters. The courses teach theoretical and practical principles of mass spectrometry (MS)-based proteomics. The first course SBL.00451 introduces principals of MS analysis of peptides and proteins. Current mass analysers and underlying physical principals are introduced in lectures. Hands-on analyses of mass spectra are performed in a practical course. The second course SBL.00452 introduces quantitative MS-based proteomics principles in lectures. In a practical course proteomics experiments are performed and data is analysed by current bioinformatics approaches. After both courses participants will be able to design and perform MS-based proteomics experiments and to analyse respective data. SBL.00451 is a prerequisite to take part in SBL.00452.

In the course *Protein homeostasis: translation, quality control and degradation* (SBL.00453), we discuss molecular mechanisms regulating protein homeostasis. In the first part, we highlight co-translational and post-translational quality control mechanisms that ensure the synthesis of functional proteins. Once a protein has been made, how is its half-life determined? In the second part, we therefore outline the cellular protein degradation pathways focusing on the ubiquitin-proteasome-system (UPS) and autophagosomal /lysosomal protein degradation.

The course *Molecular genetics of model organism development* (SBL.00119) 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* (SBL.00120) 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 bio-technical 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* (SBL.00115): 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. Other themes include the discovery and mechanism of RNAi interference, the importance of small and long non-coding RNAs, the implications of RNA technology, the evolution of RNA-based adaptive CRISPR immunity.

The lecture course *Experimental genetics* (SBL.00114) 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, and CRISPR technology for gene editing. 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 *Neurogenetics* (SBL.00117) 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 neuro-genetic 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* (SBL.00118) 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.

The course *Cellular and genetic networks* (SBL.00123) 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* (SBL.00124): 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* (SBL.00125): 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* (SBL.00126) 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 in the timetable (<http://www.unifr.ch/timetable>).

*Nuclear organization and chromosome dynamics* (SBL.00130): DNA associated processes, such transcription, replication, recombination, but also chromosome pairing during meiosis occur in the context of the highly organized cell nucleus. Several structural elements of the nucleus such as the nuclear lamina or special nuclear compartments are known to regulate these processes. Changes in the nuclear organization are accompanying development and differentiation processes and defects in the nuclear architecture are known to be responsible for several human diseases. This course will focus on the elements that are shaping the nuclear architecture and their role in the activity of the genome, such as transcription, replication and DNA recombination. Since meiotic nuclei are the home of a beautiful chromosome choreography and an intense nuclear reorganization, this course will also include an overview of the mechanisms underlying these processes. Understanding the molecular mechanisms underlying nuclear organization and chromosome dynamics is essential for human health and fertility. Key concepts of the lecture are nuclear architecture, chromatin domains, nuclear compartment, chromosome territories and pairing, recombination and genome stability.

*BeFri Research colloquium in cell and developmental biology I and II* (SBL.00127, SBL.00128) consist in half day meetings with 6 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 4 presentations for SBL.00127, and four presentations for SBL.00128. The meetings will alternatively be held in Fribourg and Bern. The two-day research retreat (SBL.00129) gives the opportunity to MSc students to present their projects or related topics.

The workshop *Systems Biology of the Brain* will give a wide overview of various aspects of the systems biology of the brain. Lectures will include large-scale approaches to understand genes, neurons and synaptic connections in the brain. We will provide a broad overview on the evolving fields and reveal solutions of data handling. Moreover various genetic model systems from simple invertebrates such as insects and nematodes to higher mammals will be presented. The

goal of the course consists in giving the students an overview into the emerging fields in neurosciences. Thus to provide all basic information of how novel techniques move the border of science and directly impact the approaches of how the complexity brain can be unveiled.

The *Introductory Course in Laboratory Animal Science* takes place in Lausanne in July ([www.unil.ch/resal/home.html](http://www.unil.ch/resal/home.html)). Summary: This education gives expertise and practical skills for a responsible and gentle handling of laboratory vertebrate animals. Theoretical and practical parts take about 20 hours each, and include the following topics: ethics and legislation, 3R concept, nutrition, transport, husbandry, breeding, transgenic techniques, observation of behaviour, anaesthesia and euthanasia, surgeries, treatments, collection of samples. This course is officially recognized by the Federation of Swiss Cantonal Veterinary Officers (VSKT) as requested by legislation (Swiss ordinance N° 455.171.2, October 1998) to get the accreditation to perform animal experimentation. This training module is relevant to all students working with vertebrate animals. Conditions for registration to this module: 1) The host laboratory must have permission to work with vertebrate animals. 2) Students must be announced to the cantonal veterinary office by the supervisor.

*Advanced topics in evolutionary genetics and ecology* (SBL.00201): the course will cover selected topics, including evolutionary demography, life history evolution, quantitative genetics, metapopulation 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* (SBL.00202) builds on knowledge of 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 *Workshop in statistics and experimental design* (SBL.00203) 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* (SBL.00205): 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"* (SBL.00206) is an extramural block course (1 week) involving Swiss and foreign graduate students, as well as invited professors. As part of groups centred on 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* (SBL.06002): 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 (SBL.06003).

*Ecological networks* (SBL.00213): 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* (SBL.00216): 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.

*The evolution of life history traits and aging* (SBL.00219) is an advanced course for students with a solid background in evolutionary ecology, evolutionary genetics and quantitative genetics with a strong interest in understanding Darwinian fitness and natural selection. The basic evolutionary problem the course addresses is how natural selection "designs" organisms to achieve optimal survival and reproductive success. The course will be strongly based on the book "The evolution of life histories", by Stephen C. Stearns, *Oxford University Press 1992*. The course requires proficiency in English and the willingness to actively engage in discussing, asking questions, reading, presenting material, etc. An understanding of basic statistics and mathematics (including calculus) is helpful.

The course *Biostatistics* (SBL.00221) is the follow-up of the Introduction to data analysis (SBL.00501) course. It aims at going into the topic data analysis in greater depth. The course introduces the fundamentals in statistics and experimental design. It covers topics from the fundamental concepts of statistics such as p-value, Type I and Type II error, multifactor ANOVA to multilinear regression, and an introduction to experimental design concepts such as replication, randomisation, nested and factorial design.

*Tropical ecology* (XAF.00001) is a project-oriented international summer field course in tropical Africa or Southeast Asia. It is organised by the Tropical Biology Association (<http://www.tropical-biology.org/>). This is a recommended and elective MSc course in Biology for the option Ecology and Evolution; it amounts to 28 days and counts of 10 ECTS points. This course can be used as a replacement for SBL.00205 (5 ECTS). The courses take place in summer / fall every year. Each year TBA runs month-long courses in tropical ecology and conservation for students at advanced undergraduate or early postgraduate level who have a keen interest, but little experience, in tropical biology. The TBA courses provide practical training and experience in the tropics with an emphasis on building skills and understanding. They provide a valuable foundation on which to build a career in conservation, research and sustainable natural resource management. TBA runs courses in collaboration with conservation and research institutions in Africa and Southeast Asia, ensuring they cover priority topics that are relevant. The Department of Biology can support 2 students per year to attend this course. The support from the Department of Biology consists of a financial contribution to the course and travel costs as well as a letter of support for students applying for admission to this field course. There is no guaranteed admission to this course. Students who are interested in attending a TBA course should please contact and make an appointment with Prof. Thomas Flatt ahead of time, i.e. before the official TBA application deadlines ([thomas.flatt@unifr.ch](mailto:thomas.flatt@unifr.ch)). Further information on TBA courses can be found at: <http://www.tropical-biology.org/> For application deadlines see the course website.

*Molecular methods in ecology and evolution* (ULA.00376) is a recommended or elective **external MSc course** held at the University of Lausanne (taught by Prof. Ian Sanders, Prof. Nicolas Salamin, Dr. Luca Fumagalli), taking place each year in the autumn semester. This labor- and time-intensive block course is for motivated MSc students in ecology and evolution who are interested in learning about how one can use molecular techniques to answer questions in evolution, population genetics and ecology. The course is split into a classroom part and a wet lab and dry lab part. It takes 8 days and lectures are interdispersed between lab classes. The first 4 days are class plus wet lab and the last 4 days are computer analyses and class. Class times can change if something does not work as expected in the lab. MSc students in ecology and evolution from Fribourg who would like to take this course should please contact Prof. Thomas Flatt ([thomas.flatt@unifr.ch](mailto:thomas.flatt@unifr.ch)) for further information ahead of time. MSc students in ecology and evolution from Fribourg are allowed to attend the class if there are open spots left. To ask if there are any free spots and to sign up for the course please send an e-mail in due to time to:

[biologie-etudiants@unil.ch](mailto:biologie-etudiants@unil.ch), and please put [thomas.flatt@unifr.ch](mailto:thomas.flatt@unifr.ch) in cc. Course page at UNIL: [https://applicationspub.unil.ch/interpub/noauth/php/Ud/ficheCours.php?v\\_ucid=284&v\\_semposs\\_elected=-1&v\\_langue=en&v\\_isinterne=&v\\_enstyid=72961](https://applicationspub.unil.ch/interpub/noauth/php/Ud/ficheCours.php?v_ucid=284&v_semposs_elected=-1&v_langue=en&v_isinterne=&v_enstyid=72961) The course *Symbiosis: how plants and microbes communicate* (SBL.00307) 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* (SBL.00308) 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 course *Molecular bases of innate immunity: theoretical and practical aspects* (SBL.00317) gives an overview about the basis of plant innate immunity, with a special focus on the molecular aspects. The lectures are combined with a practical course that introduces the students to the most common techniques applied in the field of plant-pathogen interactions, such as plant inoculation, disease resistance scoring, gene expression analysis, and quantification of antimicrobial secondary metabolites and proteins

The course *Drugs and phytochemical analysis* (SBL.00318) 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 data analysis, as well as a practical part on Gas Chromatography and Ultra High Performance Liquid Chromatography.

In the lecture *Exploring protein functionality* (SBL.00322) 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* (SBL.00323) 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.

The course *Current topics in plant and microbial sciences* (SBL.00326) comprises three different types of events: i) seminars with external speakers presenting recent work in the fields of plant and microbial sciences, ii) progress reports from master students, PhD students and postdocs, and iii) a journal club series where recent advances published in international journals are presented and discussed. In the course of the master thesis duration, students are expected to regularly attend and actively participate in the seminars and progress reports, to present their master project at least once and to discuss at least one paper in the journal club.

*Scientific writing* (SBL.00410): 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.

*Master thesis-related activities* in the option **Biochemistry** (SBL.00400, SBL.00403, SBL.00404, SBC.04402): 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 (SBL.00404) are meetings where researchers and students report and debate recently published articles. SBC.04402 are laboratory meetings where members of a research group expose and discuss their current work. SBL.00404

and SBC.04402 take place within the respective research groups. SBL.00403 are research seminars given in front of a larger audience by Master students, doctoral students and post-doctoral fellows.

*Master thesis-related activities* in the option **Animal Molecular Life Sciences**: (SBL.00400, SBL.00401, SBL.00403, SBL.00404): 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 (SBL.00404) are meetings where researchers and students report and debate recently published articles. SBL.00401 are laboratory meetings where members of a research group expose and discuss their current work. SBL.00401, SBL.00404 takes place within the respective research groups. SBL.00403 are research seminars given in front of a larger audience by Master students, doctoral students and post-doctoral fellows.

*Master thesis-related activities* in the option **Ecology and Evolution** (SBL.00400; SBL.00211, SBL.00212, SBL.00401, SBL.00402): 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.

*Master thesis-related activities* in the option **Plant and Microbial Sciences** (SBL.00400, SBL.00401): these courses consist of different activities comprising seminars and discussions where Master students, PhD students, and national and international speakers present their research.

The *Neurobiology seminars* (SME.03001, SME.04001, SME.05001, SME.06001, SME.07001) 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.

*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.

The block course *Introduction to data analysis* (SBL.00501) aims at teaching basic knowledge in data management and analysis using the Excel and R software. It is intended for all students starting their MSc in Biology and includes a short general introduction on administrative aspects. Specifically, the course introduces concepts such as dot-plot, box-plot, bar-graph, histogram, mean, standard deviation, population and samples, standard error, 95% C.I., logarithmic scale, pseudo-replication, and a short introduction to statistical testing (p-value, t-test, ANOVA, and linear regression).

During the *Master thesis* (SBL.05000) the student familiarizes herself/himself with modern techniques and executes a research project under the guidance of a group leader of the Department of Biology. 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. A 30-40-minute final presentation in English is mandatory. For the options "Biochemistry" and "Animal molecular life sciences", the Master thesis work can be accomplished in the Medicine section, upon approval by the Biology and BMS study advisors, and the hosting research group. The topic must include molecular techniques.

## Appendix

Master programme option			Anim.Mol. Life Sci.	Biochem.	Ecol. & Evolution	Pl. & Mic. Sciences	PERIODICITY	SEMESTER
Specialization	Title of the teaching unit	ECTS	Molecular and behavioural neuroscience Regeneration Developmental biology Marine biology	Cell cycle and growth control Biological rhythms Protein homeostasis	Theoretical and community ecology Applied ecology Evolutionary and population genetics	Crop health (interdisciplinary) Plant molecular biology Microbiology		
SBC.04201	Cell cycle control	1.5	E R R E	O O O	E E E	E E E	weekly	Fall
SBC.04202	Eucaryotic cell growth control	1.5	E R R E	O O O	E E E	E E E	weekly	Fall
SBC.04203	Genotyping (practical course)	2.5	E R R E	O O O	E E E	E E E	Block	Fall
SBC.07110	Introduction to UNIX and Bash	2.5	E E E R	O O O	E E O	O O O	Block	Fall
SBC.07107	Bioinformatics (practical + in silico) (requires SBC.07110)	3	E E E R	O O O	E E O	O O O	Block	Fall
SBC.07109	Programming with R	1	E E E E	E E E	E E E	E E E	Block	Fall
SBC.07104	Introduction to protein structure and protein homology modelling	1.5	E E E E	R O O	E E E	E O R	weekly	Spring
SBC.07105	Introduction to docking to large macromolecules...	1.5	E E E E	R O O	E E E	E O E	weekly	Spring
SBL.00114	Experimental genetics	1	R R O E	R E E	E E E	E E E	weekly	Fall
SBL.00115	The RNA world	1.5	R E O E	R R R	E E E	E E E	weekly	Fall
SBL.00130	Nuclear organization and chromosome dynamics	1	R R O E	O R E	E E E	E E E	weekly	Fall
SBL.00117	Neurogenetics	3	O O O R	E O E	E E E	E E E	weekly	Fall
SBL.00118	BENEFRI workshop "Frontiers in neurosciences"	1.5	O E R R	E R E	E E E	E E E	Block	Fall
SBL.00119	Molecular genetics of model organism development	3	O O O O	E R E	E E E	E E E	weekly	Fall
SBL.00120	Topics in developmental biology	3	O O O O	E E E	E E E	E E E	weekly	Spring
SBL.00127	BeFri colloquium in cell and developmental biology I	1.5	O O O O	R R R	E E E	E E E	Block	Spring
SBL.00128	BeFri colloquium in cell and developmental biology II	1.5	O O O O	R R R	E E E	E E E	Block	Spring
SBL.00129	BeFri research retreat in cell and developmental biology	1	O O O O	R R R	x x x	x x x	2 days	Spring
SBL.00123	Cellular and genetic networks (BeFri)	3	R R R R	R R R	E E E	E E E	weekly	Fall
SBL.00124	Marine biology workshop	4	E E E O	x x x	E E E	E E E	Block	Fall
SBL.00125	Light and fluorescence microscopy for Life Sciences	3	O R R R	R R R	E E E	R R R	Block	Fall
SBL.00126	Established and Emerging Organisms for Marine Science	6	E E E O	x x x	x x x	x x x	Block	Spring
SBL.00421	Oceanography and Marine Ecosystems	1	E E E O	E E E	E E E	E E E	Block	Fall
SBL.00422	Molecular and Cellular Marine Biology	1	E E E O	E E E	E E E	E E E	Block	Spring
CUSO	Introductory Course in Laboratory Animal Science (RESAL)	3	E R E E	E R E	E E E	E E E	Block	Spring
CUSO	Systems Biology of the brain	1.5	R E E E	E O E	E E E	E E E	Block	Spring
SBL.00201	Advanced topics in evolutionary genetics and ecology	4	E E E E	x x x	O O O	E E E	weekly	Fall
SBL.00202	Biological invasions and trophic interactions	4	E E E E	x x x	O O O	R E E	weekly	Fall
SBL.00203	Workshop in statistics and experimental design	3	x x x x	x x x	O O O	O E O	weekly	Spring
SBL.00205	Ecological field course	5	x x x x	x x x	O O O	E E E	Block	Spring
SBL.00206	Evolutionary biology workshop "Guarda"	4	x x x x	x x x	E E R	E E E	Block	Spring
SBL.00213	Ecological networks	2	E E E E	x x x	O R R	E E E	weekly	Spring
SBL.00221	Biostatistics	2	E E E E	E R R	O O O	E E E	weekly	Fall
SBL.00216	Introduction to statistics with R – Model selection	1	R R R R	R R O	O O O	O R O	Block	Fall
SBL.00219	The evolution of life histories and aging	1.5	E E E E	E E E	E E O	E E E	weekly	Spring
ULA.00376	Molecular methods in ecology and evolution	4	E E E R	x x x	E E R	E E E	Block	Fall
XAF.00001	Tropical biology (TBA field course)	10	E E E E	x x x	R R R	E E E	Block	Spring
SBL.00307	Symbiosis: how plants and microbes communicate	1.5	E E E E	x x x	E E E	O O O	weekly	Fall
SBL.00308	Plant development: the life of a sessile organism	1.5	E E E E	E E E	E E E	O O R	weekly	Fall
SBL.00317	Molecular bases of innate immunity: theoretical and practical aspects	3	E E E E	E E E	E E E	O R O	weekly	Spring
SBL.00318	Drugs and phytochemical analysis	1.5	E E E E	E E R	E E E	O O O	weekly	Spring
SBL.00326	Current topics in plant and microbial sciences	6	E E E E	E E E	E E E	O O O	weekly	Both
SBL.00322	Exploring protein functionality	2	E E E E	E R E	E E E	R O R	weekly	Fall
SBL.00323	Plant biotechnology	3	E E E E	E E E	E E E	O O R	weekly	Spring
SBL.00411	Signalling and Transport	1	R R E E	O R R	E E E	R O R	Block	Fall
SBL.00412	Introduction to protein structure and function	1	E E E E	O R O	E E E	R O R	Block	Fall
SBL.00413	Gene regulatory networks	1	R R E R	O O O	E E E	E E E	Block	Fall
SBL.00414	Cell fate and tissue regeneration	1	R O R E	O R R	E E E	E E E	Block	Fall
SBL.00415	Cell proliferation	1	O R R R	O O O	E E E	E E E	Block	Spring
SBL.00416	Biological rhythms	1	O O R R	R O O	E E E	E E E	Block	Spring
SBL.00417	Evolution on the bench	1	E E E O	R R R	E E R	E E R	Block	Spring
SBL.00418	Microbial metabolism and genetics	1	E E R R	R R R	E E E	R O R	Block	Spring
SBL.00419	Advanced imaging (Prerequisite SBL.00125)	1	O R R R	R R R	E E E	R R R	Block	Spring
SBL.00429	Animal models of regeneration (lecture with workshop)	2	E O E E	n n n	n n n	n n n	Block	Spring
SBL.00424	Microbiomes: from plants to humans (Prerequisite SBL.00063)	1.5	E E E E	E E E	E E E	O R O	weekly	Spring
SBL.00425	Metagenomic data analysis (Prerequisite SBC.007110)	1	E E E E	E E E	E E E	R O O	weekly	Spring
SBL.00426	Taxonomy and ecology of Tunicates in Central Africa	5	E E E E	n n n	E E E	n n n	Block	Spring
SBL.00427	Visual communication of data	1	O O O O	R R R	O O O	E E E	weekly	Spring
SBL.00428	Optogenetics and photopharmacology	1	R R R R	E E E	n n n	E E E	weekly	Spring
SBL.00429	Animal models of regeneration (lecture with workshop)	2	E O E E	n n n	n n n	n n n	Block	Spring
SBL.00451	Introduction to mass spectrometry and proteomics	1	E E E E	E E O	E E E	E E O	Block	Fall
SBL.00452	Advanced quantitative proteomics (prerequisite SBL.00451)	1	E E E E	E E O	E E E	E E O	Block	Spring
SBL.00453	Protein homeostasis: translation, quality control, degradation	1	E E E E	E E O	E E E	E E E	weekly	Fall
SBL.06002	Classical models in biology (lecture)	3	E E E E	x x x	O R R	E E E	weekly	Spring
SBL.06003	Classical models in biology (exercises)	1	E E E E	x x x	O R R	E E E	weekly	Spring
104.00002	English for Masters Students I	3	E E E E	E E E	E E E	E E E	weekly	Fall
UniFR	English for Masters Students II	3	E E E E	E E E	E E E	E E E	weekly	Spring
SBL.00400	Biology seminars	0.5	O O O O	O O O	O O O	O O O	weekly	Both
SBL.00420	Career profiling in life sciences	1	R R R R	R R R	E E E	E E E	weekly	Spring
SBL.00410	Scientific writing	3	E E E E	n n n	O O O	O O O	weekly	Fall
SBC.07108	Introduction to R	1.5	O O O O	O O O	O O O	O O O	Block	Fall
SBL.00501	Introduction to data analysis	1	O O O O	O O O	O O O	O O O	Block	Fall
SBL.05000	Master thesis	45	O O O O	O O O	O O O	O O O	Block	Both

x	Possible, if prerequisites are met
E	Elective
R	Recommended
O	Obligatory
n	not possible