

# BIOCHEMISTRY

MASTER OF SCIENCE



EBERHARD KARLS  
UNIVERSITÄT  
TÜBINGEN



## WELCOME

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Welcome to the University of Tübingen and welcome to its biochemistry institute, the IFIB (Interfaculty Institute of Biochemistry). Thank you for choosing this course and congratulations on passing the competitive selection process.

You are now at the second stage of your university education. A period to discover and develop your preferences in the field. And only one step away from your second major professional decision after deciding what to study. At the end of the Master, you will choose whether to continue along the academic track with a doctorate or whether to enter the job market. We strive to support you, as best we can, with this decision.

You are also no longer a beginner in the field and we believe the structure of the master's degree should strongly reflect this and support your further maturation towards becoming a full-fledged biochemist. In our course, this shows in the small number of obligatory elements and the large number of choices you can make. On the other hand, you have to invest more time making decisions and organizing yourself. It also shows in that a significant part of the degree will be dedicated to preparing you for future career decisions with seminars and transferable skill courses.

We are looking forward to working with you and wish you all the best for the start of your master's here in Tübingen.



Jakob Suckale, Coordinator

cover picture: albarst



Gerhard Groebe

## OVERVIEW

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The Tübingen *Master of Biochemistry* is a full-time 2-year program composed of 5 types of elements (see table below). Students have to earn a minimum of 120 credit points in total, each of which corresponds to approximately 30 hours of work including self study. All 4 elements are explained in detail later in the guide. *Advanced Biochemistry* and *Current Topics* are theoretical elements while *modules*, *labs*, and the master thesis are mixed theoretical and practical elements.

Elements of the Master	Credit points
<b>Advanced Biochemistry</b>	9
<b>Current Topics</b>	3
<b>3 Modules</b>	6+6+6
<b>4 Labs</b>	15+15+15+15
<b>Master Thesis</b>	30
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	120

The Tübingen *Master of Biochemistry* allows for a very flexible curriculum. You do not have to take all the elements in a specific order or at a specific time. Nevertheless, we recommend organizing your degree roughly according to the order above. The theoretical elements are a good starting point to gain an overview of the moving field of biochemistry and are thus well placed at the beginning. They may also serve as preparation for the laboratory work later on. *Modules* are designed to be a transition from theory to more practical work, since they contain both the background as well as the corresponding guided experiments. It also a good way of getting to know your peers. *Labs* require more organization from your part and are your stepping stone from predesigned modules to the more independent master thesis that concludes the *Master of Biochemistry*.

## A MASTER PLAN

This page shows you one possible and straightforward way to complete the *Master of Biochemistry*. Many variations on this theme are possible and depend on your individual preferences.

### Year 1 - Intro, Modules, First Labs

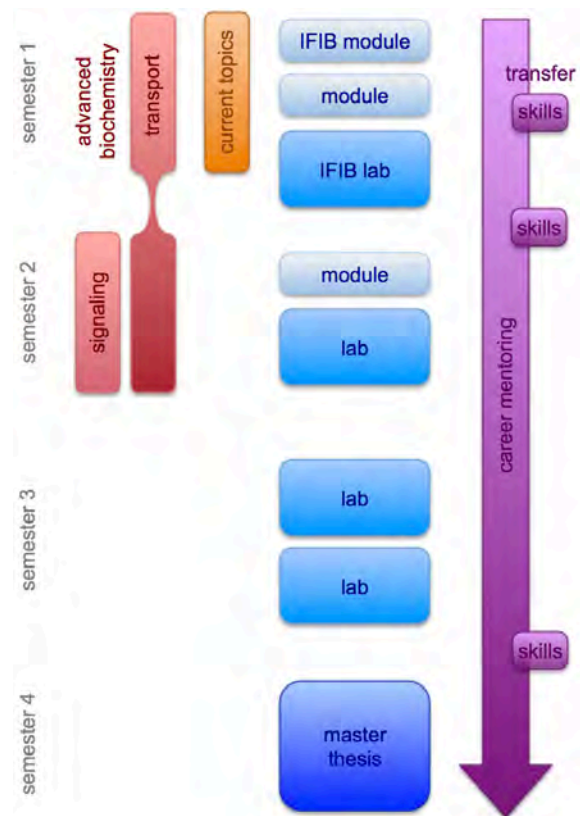
The 1<sup>st</sup> year kicks off with a joint lectures series by all the research group leaders of the institute. Departing from the basics you have acquired in your previous degree, this series takes you into the advanced topics of biochemistry and to the research frontier. In parallel, you will choose your first *modules* and your first *lab* placements.

In parallel to the lecture series, you will take a course on current topics, which includes a lecture series by guest speakers from outside the institute and abroad presenting their latest discoveries. In addition, you will most likely select a 3<sup>rd</sup> module and a 2<sup>nd</sup> lab placement.

### Year 2 - Modules, Labs & Master Project

As you enter the 2<sup>nd</sup> year, the elements of the program will become longer and more in-depth culminating in the master thesis at the end of the degree. You may decide to do one or more of the research placements outside the institute or abroad. We will support you with national and international placement using our contacts. At the end of the last semester, you will write up the data collected during your thesis and present the results to the faculty.

During the entire degree you will be able to acquire transferable skills ranging from numerical proficiency, IT, self-management and communication to interpersonal skills (purple track above). The IFIB faculty will support you in your future professional decision following your master in Tübingen and we hope that you will actively join our alumni network called *Mobbel*.



## VARIETY

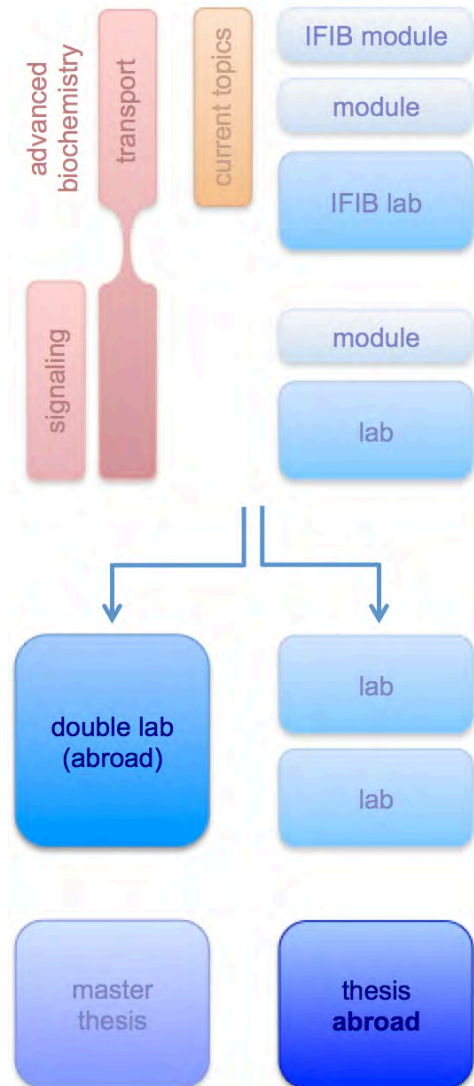
Here are a few ideas on how to adapt the template presented on the previous page to your personal preferences. Many variations are possible. Please discuss them with us.

In case you want to delve deeper into a special topic or in case you think one lab block is not enough to gain all the experience you want, you can fuse 2 *lab* blocks into 1 continuous element accounting for 2x15 credits. Do not chunk together more than 2 labs to make sure that you also see a variety of research topics.

If you want to do one of your *labs* abroad, a double lab may be useful. It takes time to organize a stint in another country. To go through all this work for a single lab element may not be efficient for you. Also, the receiving group leader may be more willing to accommodate you if you stay longer.

Another possibility to gain international experience is to do your master thesis abroad. This element of the master's degree is naturally longer, thus the ratio of preparation and lab time is better than for a single lab. On the other hand, it is an element that impacts on your final grade, so you need to be more carefully to select a good lab and a sure project.

In principle you can also take the *Advanced Biochemistry* lectures and the *current topics* during different semesters. Keep in mind though that the 1<sup>st</sup> part of the *transport* lectures is conceptually positioned before the 2<sup>nd</sup>. The same goes for *Current Topics*. We recommend starting them early.



## ADVANCED BIOCHEMISTRY

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The lecture series *Advanced Biochemistry*, nicknamed ABC, picks up where you left off with the basic lecture series of the bachelor degree and takes you farther into the advanced research topics. Reflecting this, the study material will be more papers and less textbooks, and the hypotheses will be more controversial and less established.

The series consists of 2 parts: transport and signaling. The transport series has 2 parts (fall + spring) while the signaling lectures are all in the spring semester.

*Advanced Biochemistry* is a relay of all the lecturers of the biochemistry institute. Every lecturer has a block of consecutive presentations and then hands over to a colleague. This will give you the chance to get to know the entire faculty of biochemistry and experience their distinct research angles.

### Element Overview

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Goals	Acquiring knowledge of the biochemistry governing cellular processes intra- and intercellular communication
Content	Extracellular matrix, cellular attachment, pathogen receptors, cellular uptake processes, endocytosis, endosomal escape mechanisms, targeting/transport in cells, organelle structure and maintenance, cytoskeleton, motor proteins, signaling pathways, hormones
Format	<ul style="list-style-type: none"><li>• Cellular transport processes (2 SWS in fall and 2 SWS in spring)</li><li>• Signal transduction (2 SWS in spring)</li></ul>
Duration	2 semesters in total (3x 1 semester series)
Recommended semester	<ul style="list-style-type: none"><li>• Cellular transport processes: 1<sup>st</sup> + 2<sup>nd</sup> semester</li><li>• Signal transduction (2 SWS in fall): 1<sup>st</sup> semester</li></ul>
Frequency	Each lecture is offered once per year
Participants	6-30
Evaluation	Oral examination with 2 professors or lecturers, at least one from the IFIB or biochemistry section of the ZMBP about both lectures, 45 min/student
Responsible	Dean of Studies in Biochemistry
Organizers	Professors / lecturers of the IFIB and the ZMBP
Work load	90 h = 6 SWS
Credit points	9 CP

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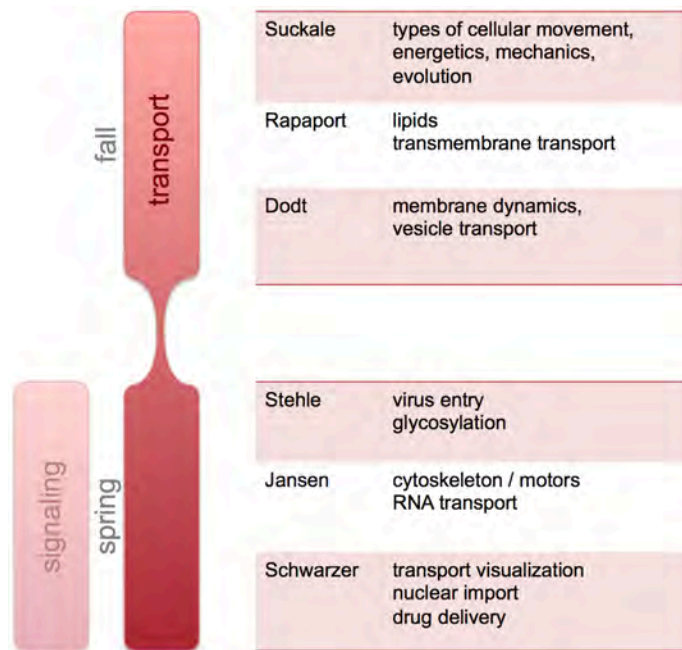
## Transport - Advanced Biochemistry

The approximate overview of topics is indicated in the table. Each lecturer is responsible for their block of presentations, typically taking place every Tuesday morning.

The biochemical basics of cellular transport processes will be reviewed before proceeding to the topical research questions and debates of the field.

Unless you have started in spring, we recommend to take the fall semester lectures first, as it is partly the basis for later lectures but the order can also be reversed.

Details regarding the individual lectures and teaching material will be made available and updated on the learning platform ILIAS.

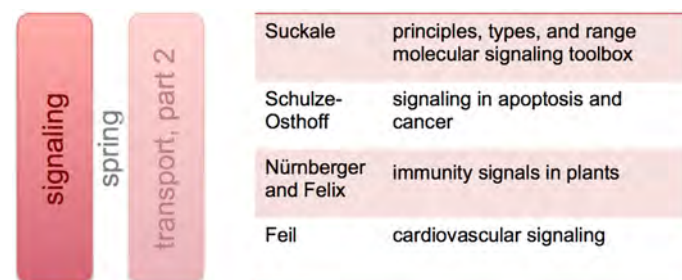


## Signaling - Advanced Biochemistry

In spring, in parallel to the 2<sup>nd</sup> part of the transport lectures, there is an additional series on the biochemistry of signaling processes.

In it you will get to know the remaining group leaders of the IFIB plus researchers from the next-door ZMBP, specializing in plant biochemistry, one of the strengths of Tübingen.

Signaling is a cutting edge field involved in most aspects of biochemistry. We chose the topic partly because of the specialties of the in-house group leaders and because of its central importance. Together with transport they both represent very active areas of biochemical research. We hope you will enjoy our lectures and are looking forward to your feedback.



## Examination

*Advanced Biochemistry* is one of the graded elements of the *Master of Biochemistry*. After you have completed the series, there will be an approximately 45 minute oral examination by 2 lecturers on general biochemistry, the lecture series, and 2 external speakers of your choosing.

See <http://www.ifib.uni-tuebingen.de/master/examinations.html>.

## CURRENT TOPICS IN BIOCHEMISTRY

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Biochemistry is a fast moving field, which is why we want to dedicate an entire element of the master's course to topical issues. Also, as master students you have already gained a lot of experience, so we want to approach the material in a more collegial and dynamic format rather than a typical frontal lecture.

Goals	Extracting and discussing relevant information from a scientific presentation Searching, interpreting and critically discussing published data Presentation and discussion skills
Content	Current findings, problems, and debates in biochemistry Modern experimental approaches
Format	Various interactive seminar formats, lectures by invited speakers
Duration	The students have to attend the seminar series once during their curriculum. The 20 lectures can be collected during the whole master program.
Recommended semester	Seminar: 1 <sup>st</sup> - 3 <sup>rd</sup> semester Lectures: starting in the 1 <sup>st</sup> semester
Frequency	10-12 invited speakers (typically Mondays) per term Current topic seminars every fall term
Evaluation	Invited speakers: attendance of 20 lectures (not graded) Seminar: participation and attendance during 1 term (not graded)
Responsible	Master coordinator
Work load	Speakers: 22.5 h = 20 lectures = 1.5 SWS Seminar: 30 h = 2 SWS
Credit points	3 CP

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## MODULES

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*Modules* are intended as both a transition from group practicals to independent research and as a way to connect with your class mates and build your network. In contrast, during the *Labs* you will rarely coincide with other master students. *Modules* last about a month and consist of about 75h of work plus preparation time. They typically consist of a theoretical part in the form of lectures and seminars and a practical part. Most are evaluated by a combination of a protocol and an oral examination. You will select a total of at least 3 *modules* and receive 6 credit points for each successfully completed module.

### IFIB Modules (at least 1 from this pool)

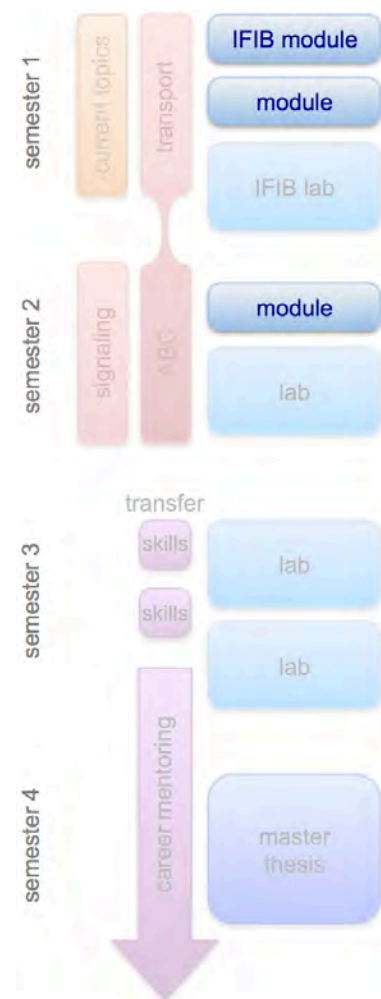
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- Cell biochemistry of organelles (Rapaport & Dodt)
- Cell signaling (Feil)
- Chemical biology (Schwarzer)
- Disease mechanisms (Suckale)
- Genetic engineering (Gust, Fuß)
- *In vivo* crystallography (Duszenko)
- Membrane organization & dynamics (Garcia-Sáez)
- Molecular oncology (Schulze-Osthoff)
- Plant-pathogen interactions (Nürnberger & Felix)
- Innate immunity animals/plants (Nürnberger & Felix)
- Post-transcriptional control / RNA (Jansen)
- Structural biology (Stehle)
- Science of cooking (Garcia, Suckale)

### Modules from Contributing Investigators

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- Imaging from probe dev't to in vivo application **NEW**
- Cell bio. w/ fluorescent fusion proteins (Rothbauer)
- Drug discovery technologies (Böckler, Exner)
- Immunology (Weber & colleagues)
- Microbial pathogens (Peschel, Götz & Wolz)
- Microscopy techniques (Liebig)
- Osteogenesis and wound closure (Ehnert, Nüssler)
- Pathobiochemistry (Weigert)



Apart from the requirement of at least 1 IFIB *module*, you are completely free to choose according to your personal preferences and aims. You could, for example, focus on clinically relevant topics like oncology, pharmacology and pathobiochemistry. Or you could hone your technical skills with bioinformatics, microscopy, and toxicology techniques. It's up to you. You can also take more than 3 modules if free places are available.

## Timing of Modules

In designing the master degree we had to choose between unavoidable trade-offs. On the one hand, a master with smoothly timed but compulsory elements. On the other hand, a master that gives you choice but where timing problems may occur. We favor the latter since it is important that you can develop your own personal profile and since we believe you are capable of organizing yourself at the master stage.



The screenshots above are from the *Master Calendar* (<http://tinyurl.com/mbioch-cal>) or go to the IFIB webpage under Master, subpage Links. Please refer to it when choosing your *modules*. You can also subscribe to it depending on your local calendar software. Some *modules* are offered both in fall and spring to allow you to minimize overlaps. Most of them have no additional requirements and finish within a 4 week window. Please check the module description below since a few *modules* deviate.

Let us know which *modules* you would like to have added and who may offer such a module. We will try our best to convince the group leader(s) in question to invest the time to develop a module.

A list of all the current *modules* follows below. Each module also has a page with details on the learning platform *ILIAS* (<https://ovidius.uni-tuebingen.de/ilias3/>) which you can access once formally signed up as a student.

## IFIB Module - Cell Biochemistry of Organelles

Goals	Experience in handling of cell cultures and yeast including principles of subcellular fractionation of organelles; design and evaluation of experiments for quantitative measurement of RNAi; experience in fluorescence microscopy of mitochondria and peroxisomes; critical presentation and discussion of data
Content	<u>Topics</u> : mitochondrial biogenesis and morphology; peroxisome dynamics and function <u>Methods</u> : subcellular fractionation, fluorescence microscopy, native gel electrophoresis, transfection of cell cultures, RNAi, quantitative RT-PCR, yeast genetics
Format	Lecture (0.5 SWS), seminar (0.5 SWS), practical course (4 SWS)
Frequency	Each spring term
Participants	4-12
Evaluation	Audited protocol (not graded) Oral presentation of the results and oral examination (=> grade)
Organizers	Doron Rapaport, Gabriele Dodt

## IFIB Module - Cell Biochemistry, Plant-Pathogen Interaction

Goals	Introduction into independent lab work and planning of experiments, team work (groups of 2), presentation of the experimental results in English
Content	Introduction into modern molecular methods of cell biochemistry with the model system of plant/pathogen interaction
Format	Practical course + seminar (6 SWS)
Frequency	Every term (e.g. Campus entry 2015 spring: <a href="http://bit.ly/1DNzomy">http://bit.ly/1DNzomy</a> )
Participants	Up to 2
Evaluation	Protocol (5-10 pages incl. introduction, methods, results & discussion) (50%) Colloquium (50% of final grade)
Organizers	Thorsten Nürnberger, Georg Felix, Birgit Kemmerling, Andrea Gust, Frederic Brunner

## IFIB Module - Cell Signaling

Goals	Understanding of selected signal transduction modules that are important for cardiovascular function in mammals Evaluation of the relevance of biochemical research to improve our understanding of human health and disease Getting experience in handling and analysis of mammalian cells and stem cells in particular Design and performance of well-controlled experiments; documentation and interpretation of data; critical presentation and discussion of data
Content	<u>Topics</u> : signal transduction in mammalian cells, with a focus on the cardiovascular system; visualization of signaling molecules in real time in living cells; cell death and survival; transgenic mice as models for human diseases; stem cell biology; regenerative medicine <u>Methods</u> : biochemical analysis of signaling proteins; live cell imaging (e.g. with FRET-based biosensors); analysis of gene expression (e.g. immunohistochemistry on mouse tissue sections); cell growth assays;

	generation of genetically-modified mice; Cre/lox recombination system; culture of mammalian cells, in particular stem cell culture and differentiation; iPS cell technology
Format	Lecture/seminar (0.5 SWS), final seminar (0.5 SWS) Practical course (4 SWS)
Frequency	Each spring term
Participants	4-12
Evaluation	Protocol (graded, 25%) Performance at work (graded, 25%) Oral examination (graded, 50%)
Organizers	Robert Feil, Martin Thunemann, Susanne Feil

### IFIB Module - Chemical Biology

Goals	Exercise in advanced solid-phase peptide chemistry. Handling and synthesis of building blocks for solid-phase peptide synthesis. Application of chemoselective reactions for protein engineering. Development of strategies for protein semisynthesis.
Content	<u>Topics:</u> posttranslational modifications of proteins, chemical labeling of proteins, protein chemistry <u>Methods:</u> solid-phase peptide synthesis, organic chemistry, protein semi-synthesis, methods for purification and analyses of semisynthetic proteins
Format	Lecture (1 SWS), seminar (0.5 SWS), practical course (4 SWS)
Frequency	Every term
Participants	2-6
Evaluation	Protocol (10-15 pages including introduction, results and discussion) 50% Oral examination (20 minutes) 50%
organizer	Dirk Schwarzer

### IFIB Module - Comparative Innate Immunity in Animals and Plants

Goals	To get an overview on the state of research and current research topics of plant molecular biology. To learn different presentation techniques to present in English
Content	Lecture concerning current topics of innate immunity in animals and plants. The seminar consolidates the topics covered in the lecture by using original publications.
Format	<u>Theory only:</u> lecture (2 SWS, fall term) + seminar (1 SWS, spring term)
Frequency	Each spring term (e.g. Campus entry spring '15: <a href="http://bit.ly/1EMSzRI">http://bit.ly/1EMSzRI</a> )
Participants	4-30
Evaluation	Oral examination (75%) Oral presentation within the seminar (25%)
Organizers	Thorsten Nürnberg, Georg Felix, Birgit Kemmerling, Andrea Gust, Frederic Brunner

## IFIB Module - Disease Mechanisms

Goals	Gain a basic biochemical understanding of human disease processes Summarize a disease mechanism with text and figures Review a scientific text and suggest improvements Discuss and debate a scientific topic
Content	<p>This course will explore the bewildering spectrum of molecular mechanisms that lead to disease in humans. We will look at problems caused by other species and by our own body, syndromes of dearth as well as plenty, damage done by the chemical as well as the physical, and diseases of development and degeneration.</p> <p>While we cover these mechanisms you will gain a basic biochemical understanding of the human body, its workings, and derailments. You will learn why certain common diseases arise and you will discover that in many cases it is far from clear why they do. You will see that diseases were in the past named and grouped according to their symptoms, some times placing diseases caused by very similar mechanisms confusingly far apart. You will see that knowing the mechanism of a disease is the crucial piece of information required before a treatment can be logically devised.</p> <p>As part of the course you will prepare a review with text, figures, and citations on a disease of your choosing. You will check somebody else's review and you will take part in a debate.</p>
Format	Seminars/discussion (5 SWS) + practical (2 SWS) + lab seminar (1 SWS)
Frequency	Each spring term
Participants	3-6
Evaluation	Written review & peer review (1/3 of final grade) Participation (1/3) Oral examination (1/3)
Organizers	Jakob Suckale

## IFIB Module - Membrane Organization & Dynamics

Goals	Understanding the principles of organization and dynamics of biological membranes; role of biochemical and biophysical research, with a focus on quantitative approaches, to improve our understanding of biological membranes; experience in preparation, handling and analysis of membrane model systems; design and performance of well-controlled experiments; documentation and interpretation of data; critical presentation and discussion of data
Content	<p><u>Topics</u>: principles of lipid membrane assembly and structure; heterogeneity in membrane composition and its relation to function; membrane fluidity; membrane shape and its determinants; dynamic processes in membranes, with a focus on shape changes, permeabilization, fusion and fission</p> <p><u>Methods</u>: preparation model membrane systems for microscopy experiments; imaging of dynamic processes in membranes; analysis of membrane fluidity and lateral organization; characterization of lipid phase diagrams; assays of membrane permeabilization at the single vesicle level, including kinetics, filling degree and pore size and stability; image processing and quantitative data analysis</p>
Format	Seminar (0.5 SWS), final seminar (0.5 SWS), practical course (4 SWS)
Frequency	Every term
Participants	4-8

Evaluation	Protocol (graded, 25%) Performance at work (graded, 10%) Seminar presentation (graded, 25%) Oral examination (graded, 40%)
Organizers	Ana J. García-Sáez

## IFIB Module - Modern Genetic Engineering

Goals	Overview of the most important methods of modern genetic engineering and their application in plants
Content	<u>Methods applied</u> : PCR mutagenesis, Gateway cloning, DNA sequencing, transient protein expression, transformation and PCR analysis, synthetic gene design <u>Methods discussed</u> : generation of genetically modified organisms, virus-induced gene silencing, amiRNA technology, TALEN, lambda-red
Format	Lectures (1 SWS), seminar (1 SWS), practical course (4 SWS)
Frequency	Beginning of spring term
Participants	0-6 (together with 10 BSc students)
Evaluation	Lab book (50% of final grade) Presentation of results (50% of final grade)
Organizers	Andrea Gust, Elisabeth Fuß

## IFIB Module - Molecular Oncology

Goals	Understanding of the major signaling pathways that promote carcinogenesis and therapy resistance Understanding of the major metabolic alterations in tumor cells Understanding of the concept of cancer stem cells Obtain insights in novel tumor therapies and conduct of clinical trials Design and performance of well-controlled experiments; documentation and interpretation of data; critical presentation and discussion of data
Content	<u>Topics</u> : Principles of tumor biology; oncogenes and tumor suppressor genes; cancer epigenetics; control of cell death and survival; apoptosis and senescence; induced pluripotent and cancer stem cells, tumor metabolism; translational oncology and personalized medicine; molecular targeted cancer therapies, tumor immunotherapies. <u>Methods</u> : biochemical analysis of signaling pathways; live cell imaging; immunocytochemistry; kinase assays; immunoprecipitation; flow cytometry; analysis of gene expression; assays for detection of apoptosis and senescence, cell cycle analysis; culture of mammalian cells, in particular stem cells; iPS cell technology
Format	Seminar (0.5 SWS), final seminar (0.5 SWS), practical course (4 SWS), lecture (2 SWS)
Frequency	Labs each spring term, lecture series in fall
Participants	4-12
Evaluation	Lab protocol (1/3 of final grade) Performance at work (1/3 of final grade) Lecture (Advanced Oncology) + written exam (1/3 of final grade)

Organizers	Klaus Schulze-Osthoff, Frank Essmann
Note	requires prior participation in the lecture and passing of the written exam

## IFIB Module - Posttranscriptional Control of Gene Expression

Goals	Experience in handling of RNA; design and evaluation of experiments for quantitative measurement of RNA and proteins; design of control experiments for quantitative measurements; critical presentation and discussion of data
Content	<u>Topics</u> : mRNA stability; translation and its control; RNA-binding proteins <u>Methods</u> : Northern blot; qRT-PCR; quantitative Western blot; RNP purification; ribosome binding assays
Format	Lecture (0.5 SWS), seminar (0.5 SWS), practical course (4 SWS)
Frequency	Every term
Participants	4-8/12 (spring/fall)
Evaluation	Audited protocol (not graded) Oral presentation of the results (not graded) Oral examination (=> grade)
organizer	Ralf-Peter Jansen

## IFIB Module - Structural Biology

Goals	Understand the general flow of a structural analysis, practice of different methods of crystallography (SIR, MAD, MR), identification of a protein by 3D-NMR, set-up and analysis of NMR structure calculation, evaluation of published data (significance, quality)
Content	<u>Topics</u> : Practical aspects of structure determination using modern X-ray crystallographic and NMR spectroscopic methods. Students will be trained to solve structures and interpret their validity. <u>Methods</u> : X-ray crystallography, NMR spectroscopy
Format	Lecture/seminar (1 SWS), practical course (4 SWS)
Frequency	Every term
Participants	4-8
Evaluation	Oral examination (⇒ grade)
Organizers	Thilo Stehle, Remco Sprangers, Silke Wiesner
note	Module requires the participation in a preparatory lecture series in fall

## IFIB Module – Science of Cooking

Goals	Understand the components of food and their positive and negative role. Why is food prepared and how? Acquire a basic knowledge of food related diseases. Quantitatively analyze the preparation of food and drink.
Content	History of science and cooking, food components, basic transformation processes during cooking: phase transitions, energy, temperature and heat transfer; elasticity and texture; diffusion and spherification; viscosity and polymers; emulsions and foams; baking and fermentation; applications in haute cuisine and food industry.

Format	Lectures (20h), Exercises (15h) and practical course (20h)
Frequency	Every spring term
Participants	0-2 (together with up to 6 BSc students)
Evaluation	Oral exam 60% Protocol 20% Project 15% Active participation 5%
Organizers	Ana J. García-Sáez, Jakob Suckale

### External Module - Modulating osteogenesis and wound closure *in vitro*

Goals	Experience in handling of cell cultures (isolation, expansion and differentiation of primary human osteoblasts) Design and evaluation of experiments for determining the effect of biological substances/epigenetic drugs on osteoblast growth and function Team work (groups of 2) Presentation and discussion of the experimental results in English
Content	<u>Topic</u> : Evaluating the effect of various biological substances/ epigenetic drugs on osteoblast growth and function (osteogenesis) <u>Methods</u> : Isolation and culture of primary human osteoblasts, viability tests, proliferation measurement, enzyme activity measurement, histological stainings (e.g. matrix mineralization), scratch assay for measuring wound closure
Format	Lecture/seminar (1 SWS), practical course (4 SWS)
Frequency	Each spring term
Participants	4-8
Evaluation	Written summary (2-5 pages) incl. materials, methods & results (30%) Performance at work (30% of final grade) Talk/poster presentation (40%)
Organizers	Dr. Sabrina Ehnert, Prof. Andreas Nüssler

### External Module - Cell Biochemistry with Fluorescent Fusion Proteins

Goals	One of the major challenges in cell biology is to understand cellular processes in response to external stimuli. The main goal is to localize cellular components and understand their interactions. Fluorescent fusion proteins are key factors to study the cellular distribution and dynamics of proteins in living cells using time lapse analysis and High-Content Analysis based on automated microscopy. To develop cellular models for compound or siRNA screening, fluorescent fusion proteins have to be generated and expression of fluorescent fusion proteins has to be validated in a number of disease relevant cell lines.
Content	In this course students will learn different aspects on how to generate fluorescent fusion proteins in appropriate vector systems (PCR, cloning, sequence analysis) as well as how to use them in various cellular and biochemical assays (cell proliferation, immunoprecipitation, Western blotting). You will learn cultivation of various human cell lines (sterile cell culture), different techniques to transfect/transduce human cell lines with expression vectors and how to analyze transfected cells on molecular and biochemical level. Students will have access to various imaging techniques including live



	cell analysis and immunofluorescence.
Format	Practical course (5 SWS) seminar (0.5 SWS)
Frequency	Each fall term
Participants	2-4
Evaluation	Oral presentation at the start (1/3 of grade) Audited protocol (1/3 of grade) Oral examination (1/3 of grade)
Organizers	Prof. Dr. Rothbauer

## External Module - Drug Discovery Technologies

Goals	Gaining basic knowledge and hands-on experience in the application of (bio-)chemical, biophysical, and computational techniques for drug discovery.
Content	<p>Students typically select one of 3 fields of research: (a) chemical biology / medicinal chemistry, (b) molecular biology &amp; biophysics, (c) computational biology &amp; <i>in silico</i> drug discovery.</p> <p>Tasks in these fields are: (a) synthesis and chemical characterization of tool compounds for studying biological processes; assay design &amp; development utilizing such new compounds; studying structure-activity relationships in lead development and optimization for elucidating key protein-ligand interactions and their cooperativity; (b) construction and expression of vectors for protein production; application of protein purification strategies; characterization of protein-ligand interactions with biophysical techniques including NMR, ITC, DSF, fluorescence polarization, etc.; implementation of compound screening strategies and use of automation for improving throughput; (c) modeling chemistry and biology at different levels of theory (QM, sQM, MM); studying the dynamic behavior of proteins and protein-ligand interactions; computational structure-based drug design; application of virtual screening techniques including pharmacophores and (high-throughput) docking.</p>
Format	Seminar (0.5 SWS), practical course (7.5 SWS)
Frequency	Once per year (seminar: during spring term; practical course: 3 weeks in August – October by individual arrangement must be scheduled at the start of each spring term)
Participants	Up to 6
Evaluation	Audited protocol (~10 pages summary of research results + lab book) 50% Oral presentation (~10 minutes) 50%
Organizers	Frank Böckler, Thomas Exner

## External Module – Imaging from probe development to in vivo application **NEW**

Goals	Participants will gain a solid theoretical and practical foundation in clinically relevant imaging techniques like positron emission tomography, magnetic resonance, and computer tomography.
Content	<p>The module deals with the radiochemistry of imaging probes and with their <i>in vivo</i> imaging. Participants will synthesize precursors for radiolabeling, learn how to radiolabel, and finally apply these imaging probes in small live laboratory animals. The module also involves detailed data analysis.</p> <p>Synthesis of precursors, radiolabeling of precursors, PET, MR, SPECT, CT and optical imaging, detailed data analysis of acquired data</p>
Format	Lectures (15h), practical lab work (40h), data analysis in seminars (4h),

	literature seminar (4h)
Frequency	Yearly
Participants	4-8
Evaluation	Practical evaluation, exam, literature seminar evaluation
Organizers	Florian Maier, Andreas Maurer

## External Module - Immunology

Goals	<p>Skills: practical skills (experimental planning and execution, data analysis, discussion), presentation, scientific writing</p> <p>Knowledge: theory of immunological methods, insights into aspects of innate and adaptive immunology</p>
Content	<p>Students will be acquainted with the <i>theoretical background</i> for the following immunology-related techniques in the introductory lecture block:</p> <ul style="list-style-type: none"> <li>- Characteristics of the main innate and adaptive immune cells</li> <li>- Working with blood- and skin-derived immune cells</li> <li>- Isolation and phenotyping of cell types</li> <li>- T-cell based assays and immune monitoring</li> <li>- Immunohistochemistry / Immunofluorescence / Immunoblot / ELISA</li> <li>- Flow cytometry (intracellular and surface stain; phospho-flow cytometry)</li> <li>- Immunological techniques in mice / immunological mouse models</li> </ul> <p>In the following 3.5 weeks, 1-2 students will be assigned to the following participating labs offering <i>insights into their ongoing research</i> and allowing first-hand <i>practical experience</i>. Preferences will be considered if possible.</p> <ul style="list-style-type: none"> <li>- T-cell assays and immune monitoring (C. Gouttefangeas, Immunology)</li> <li>- Peptide vaccination: from discovery to drugs (S. Stevanovic, Immunology)</li> <li>- Immune responses in the skin towards infection (B. Schitteck, Dermatology)</li> <li>- Immune responses in the context of cancer (H. Braumüller, Dermatology)</li> <li>- Innate Immunity (A. Weber, Immunology)</li> <li>- Dendritic cell immunity (S. Autenrieth, Internal Medicine)</li> </ul> <p>Upon completion of the practical period, students will be requested to:</p> <ul style="list-style-type: none"> <li>- present their lab project in a short Powerpoint presentation held during a 1-day colloquium in the final week (all students and PIs participate)</li> <li>- generate a report detailing their research topic, data and discussion.</li> </ul>
Format	Lectures (1 SWS), practical (8 SWS), colloquium (0.5 SWS)
Frequency	Each fall term
Participants	6-11
Evaluation	<p>Students present their lab project in a short Powerpoint presentation held during a 1-day colloquium in the final week (all students and lab supervisors participate) - 50% of the final grade</p> <p>Participants also generate a protocol/report detailing their research topic, data and discussion - 50% of the final grade</p>
Organizer	Alexander Weber
Requirements	Attendance of the Immunology lectures at the Department is recommended prior to completion of the module but not formally required. Students with prior knowledge or experience in immunology gained in Tübingen or elsewhere may be given preference should the module be oversubscribed.

## External Module - Pathobiochemistry

Goals	Experience in detection of phosphorylated proteins, design and evaluation of
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	experiments for detection of activated signal transduction, understanding and interpretation of pathobiochemical alterations and disease-related biomarkers in body fluids, critical presentation and discussion of data, presentation and discussion of scientific publications
Content	<p><u>Topics</u>: molecular mechanisms of metabolic regulation in health and disease, insulin resistance and diabetic late complications, diagnostic tools for detection of pathobiochemical alterations and disease-related biomarkers in body fluids</p> <p><u>Methods</u>: cell culture, transfection of cells, immunodetection of phosphorylated proteins, immunoprecipitation, point of care testing</p>
Format	lectures (2 SWS), seminar (0.5 SWS), practical course (2.5 SWS)
Frequency	Each fall term
Participants	4-8
Evaluation	<p>Protocol (not graded)</p> <p>Presentation of a recent scientific paper (graded, 30%)</p> <p>Oral examination (graded, 70%)</p>
Organizers	Cora Weigert, Rainer Lehmann, Andreas Peter, Erwin Schleicher, Harald Staiger, Susanne Ullrich

### External Module - Mechanisms of Microbial Pathogenicity

Goals	Knowledge of molecular and cellular mechanisms of microbial pathogenicity
Content	<p>Theory taught in lectures</p> <ul style="list-style-type: none"> <li>- How do bacteria survive in humans and cause infections?</li> <li>- How does our defense work and how is it circumvented by bacteria?</li> <li>- Which are the most topical and most urgent infectious diseases?</li> </ul> <p>Practical course</p> <ul style="list-style-type: none"> <li>- <i>Salmonella</i> mutagenesis</li> <li>- Functional analysis of the type 3 secretion system</li> <li>- Cell culture infection models of <i>Salmonella</i></li> <li>- Blue native gel electrophoresis</li> </ul>
Format	<p>Lectures (fall term every Friday 8-10 AM, 2 SWS)</p> <p>Seminar (Jan/Feb Monday 16:30)</p> <p>Practical (2-week block end of spring term)</p>
Frequency	Once per year (fall + spring)
Participants	Up to 4
Evaluation	<p>Exam following the lecture (1/3)</p> <p>Seminar grade (1/3)</p> <p>Presentation following the practical (1/3)</p>
Organizers	Prof. Christiane Wolz, Prof. Samuel Wagner, Dr. Weidenmaier, Dr. Jürgens, Dr. E. Bohn, Prof. Andreas Peschel, Prof. Fritz Götz
note	See also <i>W-Schiene: Mechanismen der Pathogenität von Mikroorganismen (4050)</i> , e.g. <a href="http://bit.ly/1bLV0ru">http://bit.ly/1bLV0ru</a> . As this module is currently being rearranged, the details are still in flux. Please confirm with the organizers before the start.

### External Module - Microscopic Imaging Techniques

Goals	Selection of an appropriate imaging technique and reliability to use it
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Evaluation of quality and validity of published data	
Content	Detailed theoretical and practical knowledge of microscopic techniques (wide field, fluorescence, life cell, confocal and electron microscopy) Sample preparation, selection of the conditions to get and process an image are taught and trained as well The seminar gives an insight into newly developed imaging techniques.
Format	Lecture/seminar (1.3 SWS), practical course (4.7 SWS)
Frequency	Each fall term
Participants	4-8
Evaluation	Written examination
Organizers	Christian Liebig, Matthias Flötenmeyer, Gaspar Jekely, Andrew Renault, Frank Schleifenbaum, York Stierhof

## LABS

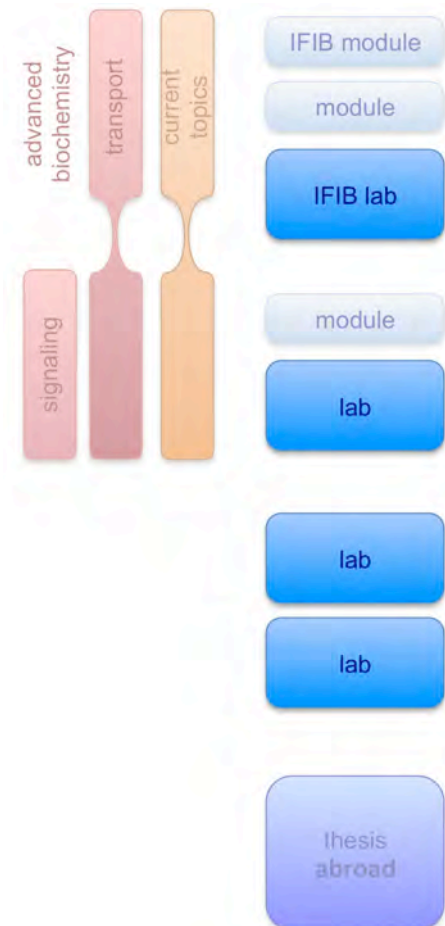
*Labs* are mini research projects in biochemistry. They will consist of about 2 months of lab work followed by a writing up or a final presentation depending on the group leader. You will arrange your own labs by contacting selected principal investigators. All investigators of the IFIB and external modules organizers automatically belong to this group. For all other labs please contact us first by filling in the lab form.

We are thinking of *labs* as a way for you to test yourself in different research areas of biochemistry. This will help you determine which specialty is most suited to your preferences and skills in a relatively short amount of time. After having explored different corners of biochemistry you will be in a better position to decide where to do a doctorate or in which area of industry to seek employment. For the same reason don't do more than 2 *labs* with the same group.

*Labs* often cannot be graded reliably because the results depend not only on your skills and work ethics but also on luck in the lab. Also, *labs* done abroad may shorten your effective working time at the bench and thus decrease your data output. This is why we have decided not to ask for these elements of the *Master of Biochemistry* to be graded. We believe this will give you more liberties to test with topics of modern biochemical research interest you.

In total, you will select 4 *labs*, one of which has to be in the IFIB. With 4x 15 CPs, or 60 points in total, the *labs* will be the largest part of your master. You can do 1 or more labs in other German laboratories or even abroad. If you want to spend more time on a topic, you can fuse to labs into one for a total of about 4 months.

When looking for a lab, keep in mind that at your stage you require good supervision to learn effectively. This can be harder to find in large, occasionally more impersonal groups. We are collecting your feedback on labs to build a database to help you profit from previous students' experience when looking for labs. This can be especially important for industry labs who are often inaccessible without personal contacts.



Goals	Study of published data in preparation for experimental work Practicing the flow from hypothesis via experimental design and controls to analysis of the results and interpretation within the context of current data Documentation, oral and written presentation of data
Duration	8 weeks
Evaluation	Audited protocol and oral presentation of the results and/or the theoretical background (all not graded)
Responsible	MSc biochemistry coordinator
Organizers	IFIB group leaders, module organizers, other labs after confirmation
Credit points	15 CP

## MASTER THESIS

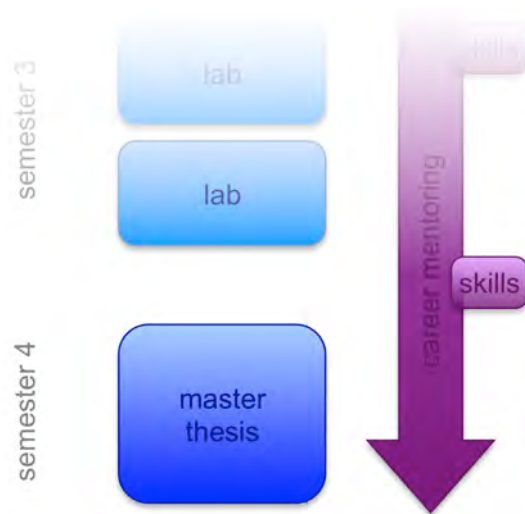
Your master thesis concludes the 2-year degree program with us. After having brushed up on the theoretical underpinnings in the lecture and *Current Topic* series, after having done more organized practicals in several *modules* and then in more self-organized laboratory placements, the master thesis will be your most independent and in-depth piece of research to date.

This is reflected in its setup. The longer time allotted, gives you more time to dig deeper into the topic of your choice. More than in the *labs* before, we expect you to actively develop your research plan before conducting experiments. The write up will also be more extensive and evaluated more thoroughly.

After doing several *labs*, you will have gained a good overview of several biochemical research areas. Carefully choose which thesis topic is most suited as it will influence future choices regarding a doctorate or your job search. The topic of the master thesis has to be clearly separate from any previous projects in the same lab, if any.

As with the *labs*, the master thesis can also be done abroad if you wish. As it needs to be formally graded and influences your final master grade, please consult us during your decision process. You will also need a 2<sup>nd</sup> supervisor in the IFIB.

We hope that the master thesis will bring you a step closer to becoming an independent and fully fledged biochemical researcher.



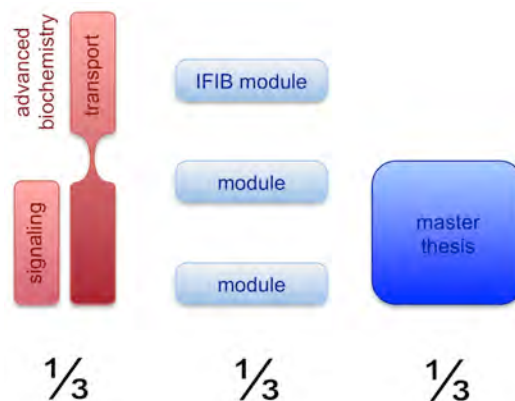
Goals	Survey published data to develop a novel hypothesis or find open questions Devise an experimental plan including suitable methods, controls, and timing Publication grade write up and conference level presentation of new data
Format	Seminar (3 SWS), practical work (37 SWS)
Duration	6 months
when?	4 <sup>th</sup> semester
prerequisite	3 modules, 4 lab projects
Evaluation	Oral presentation of results (not graded) Written thesis (⇒ graded by supervisor and if necessary a 2 <sup>nd</sup> referee)
Responsible	Head of the examination committee
organizers	IFIB group leaders, module organizers, other labs after confirmation
Credit points	30 CP

## FINAL GRADE

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As you progress from undergraduate studies via the master with us to a doctorate or employment outside academia, grades become less important and experimental skills, experience, contacts, and publications gain in weight. Nevertheless, the final grade of the *Masters in Biochemistry* will be of some influence.

The final grade is composed in equal part of the grades of the *Advanced Biochemistry* lecture series, your 3 best *modules*, and the master thesis. If you completed 4 modules, the best grades will be used automatically. It will thus be based in equal parts on the oral examination after the lectures, the mean grade of your *modules*, and the overall grade of your master thesis.



## LINKS

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We will use the **ILIAS** platform (<https://ovidius.uni-tuebingen.de/ilias3/>) as a principle way of organizing the courses and we hope that you will use your editing rights there to exchange information between each other and with us. There, you will find all elements of the current semester represented as ILIAS objects. In addition, there is a collection of frequently asked questions, useful links, and areas with content jointly generated by students and faculty.

Remember to regularly check our **calendar** for course changes and additional events: <http://tinyurl.com/mbioch-cal>.

Wondering where things are? Check the **map**: <http://tinyurl.com/mbioch-map>.

## PREPARATION

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If your bachelor was in a related discipline or if you just want to brush up a little to be able to start at full speed, we recommend the following **books**: Alberts, *Molecular Biology of the Cell*, 2014, <http://amzn.to/1K22W7r>, Berg,.. Stryer, *Biochemistry*, 2015, <http://amzn.to/1ExNQAt>.

Also, we would recommend to read current research **articles**. The following journals are usually a good choice: *eLife*, *PLoS Biology*, *Nature*, *Science*, or *Cell*.

To tune into the spoken scientific language, browse the following site for scientific **talks**: TED (not all biochemistry, <http://tinyurl.com/n3yndqv>), Nobel talks ([nobelprize.org/mediaplayer/](http://nobelprize.org/mediaplayer/)), HS talks (only the first minutes free, <http://tinyurl.com/m2uh8ds>).

And/or consider taking an **online course** on [edX.org](http://edX.org) or [Coursera.org](http://Coursera.org).