TECHNISCHE HOCHSCHULE DEGGENDORF

Module Guide
Life Science Informatics

Faculty Computer Science
Examination regulations 01.10.2019
Date: Wednesday 25.11.2020 11:27

LSI-01 Informatics and Biomedicine

Module code	LSI-01
Module coordination	Dr. Stefan Fischer
Course number and name	LSI-01-1 Informatics and Biomedicine
Lecturers	Prof. Dr. Gökçe Aydos Dr. Stefan Fischer
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

In LSI both students from biomedicine and informatics fields come together. Primary goal in this course is to learn the fundamentals of informatics and molecular biology to get everyone to an even level before the main courses start.

Biomedical research is currently using a variety of computer-based analyses to analyze genes that are predictive for the prognosis or therapy response of a disease ('personalized medicine'). After completing the Informatics and Biomedicine module, students will have obtained the following learning competencies:

Biomedicine:

Professional competences

After succesfully completing the module students will be:

- familiar with basic concepts of Anatomy, Physiology, Biochemistry, Metabolism, Cell Biology and Genetics
- able to basically describe and discuss the human body on anatomical, cellular and molecular level

Methodological competence

After succesfully completing the module students will be:

- aware of the relations of the above mentioned fields in context with the human body, health and disease

Social competence

After succesfully completing the module students will have:

- the capacity of discourse about the influence of molecular alterations on health and disease
- the ability to discuss medical issues with professionals and non-professionals

(Introduction to) Informatics:

After successful accomplishment of (Introduction to) Informatics the students can:

Professional competences

- explain how the data is stored as binary data
- name different computer classes
- compare different computer classes and select a computer class depending on requirements
- identify components in a computer case
- explain various software layers on a computer
- summarize the operating system tasks
- explain the Unix directory tree and guess which files can be found in select folders

Methodological competences

- guess the data size of different documents or files
- encode arbitrary information
- leverage the Unix shell for managing files and directories
- create shell scripts to solve basic automation tasks
- distinguish content, structure, and form in a text
- create a document LaTeX, HTML, Markdown, and RestructuredText
- recommend a document file format depending on requirements
- apply XML to structure information
- list different kinds of programming paradigms
- explain how software is built and used

- write algorithms for basic problems by combining variables, statements, etc
- list internet resources for self-studying

Social competences

- give constructive feedback to peers in context of peer-assessed exercises

Applicability in this and other Programs

Informatics I, Life Science I+II, Biomedical Data Analysis

Entrance Requirements

None

Learning Content

Biomedicine:

1 Introduction into Anatomy and Physiology
2 Introduction into Molecular Cell Biology
3 Basic metabolic events
4 Basic genetic mechanisms
5 Tissues/Cancer/Stem cells

(Introduction to) Informatics:

- Information & Data
  - bits and bytes
  - coding of information
  - data compression
- Hardware & Software
  - computer types
  - computer components
  - software components
- Jupyter notebooks as a computing interface
- Operating Systems
  - operating system landscape & Unix
  - files, paths, permissions
  - operating system components
- Shells
  - commands
  - programming

- LaTeX
  - content ? structure ? form
  - document structure
  - typography and graphics
- HTML
  - HTML components
  - XML
- lightweight mark-up languages
  - Markdown
  - restructuredText
- algorithms
  - from specification to implementation
  - compilers
- imperative Programming
  - programming paradigms
  - variables & statements & assignments
  - if-else statements, while loops

Teaching Methods

Seminar-like class (virtual/live/recorded) with Moodle blended learning tools (in iLearn).

Biomedicine:

This module consists of lectures, discussions and student tasks about biomedical topics. Students will get introduction into biomedical relevant topics which will be discussed or deepened via exercises to sharpen a life scientific view also on medical issues.

(Introduction to) Informatics:

No extra tools.

Recommended Literature

Biomedicine:

- Bruce Alberts, Alexander Johnson, Peter Walter, Julian Lewis, MartinRaff, Keith Roberts: Molecular Biology of the Cell (Englisch) GebundeneAusgabe ? 2. Dezember 2014; ISBN-13: 9780815344643; ISBN-10:0815344643
- Neil A. Campbell, [et al.]: Biology: A Global Approach, Global Edition, 11th Edition, Pearson 2018; ISBN-13: 9781292170435
- Stephen R. Bolsover [et al.]: Cell biology : a short course 2nd ed.; ISBN0-471-26393-1
- Erin C. Amerman, Human anatomy & physiology (English), Ebook, 2019, ISBN: 9781292260174

- Elaine Nicpon Marieb, Human anatomy & physiology (English), Ebook, ISBN: 9781292260938

(Introduction to) Informatics:

- Lecture notes Einführung in die Informatik by Till Tantau (in German)
- The Linux Command Line by William Shotts
- Software Carpenty lessons on Unix Shell, Python, Git, R, Automation and Make, Using Databases and SQL

LSI-02 Life Science I

Module code	LSI-02
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-02-1 Life Science I
Lecturer	Prof. Dr. Melanie Kappelmann-Fenzl
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The “Life Science I” module aims at providing an in depth understanding of the relevant aspects of molecular biology. In order to analyze biomedical data professionally, one needs a deep understanding of molecular biological and biochemical processes, which are conveyed within this module.

After completing the Life Science I module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- understand the genetic mechanisms of living organisms and the consequences of genetic alterations
- understand signaling pathways and their repercussions on cell systems
- gain deep knowledge about manipulating/ modifying living systems in the lab and understand the purpose and readout of genetic engineering

Methodological competence

After successfully completing the module, students will:

- be able to differentiate between genetics, transcriptomics and proteomics and have deep insights into their biomedical relevance
- be familiar with genetic engineering methods and experimental procedures and the significance of their results

Applicability in this and other Programs

Biomedical Data Analysis, Sequencing Technologies, Life Science II

Entrance Requirements

Advantageous: Basic knowledge in Molecular Biology

Learning Content

1 Molecular genetics
  1.1 How cells read the genome
  1.2 Control of gene expression
2 Cell Signaling
3 Genetic engineering

Teaching Methods

Seminar-like classes, application examples

The module consists of a lecture part with blended learning components, including exercises and interactive discussions on current topics and publications. The lecture part will prepare students' basic knowledge on biomedical objectives and the exercises as well as the interactive discussions will practice students’ critical thinking skills.

Excursion (3 days): Friedrich Alexander University Erlangen-Nürnberg, Institute of Biochemistry, Molecular Oncology, Genetical Engineering

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work:

- Bruce Alberts, Alexander Johnson, Peter Walter, Julian Lewis, Martin Raff, Keith Roberts: Molecular Biology of the Cell (Englisch) Gebundene Ausgabe – 2. Dezember 2014; ISBN-13: 9780815344643; ISBN-10: 0815344643
- Stephen R. Bolsover [et al.]: Cell biology : a short course 2nd ed.; ISBN 0-471-26393-1

LSI-03 Informatics I

Module code	LSI-03
Module coordination	Prof. Dr. Gökçe Aydos
Course number and name	LSI-03-1 Informatics I
Lecturer	Prof. Dr. Gökçe Aydos
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

After successful accomplishment the students can:

Professional competences

- summarize the challenges of biomedical text analysis
- list various scientific text resources and differentiate them
- outline the motivation behind ontologies for knowledge representation

Methodological competences

- implement shell scripts for automating information retrieval, text processing, and semantics processing

- breakdown given shell scripts into various components, tweak it for further purposes, and localize errors
- apply XPath expressions to extract data from XML files
- evaluate a shell script regarding performance considerations and suggest improvements
- apply regular expressions on text to extract relevant information
- find correlations between concepts (e.g., does caffeine lead to malignant hyperthermia?)
- implement Python programs which can solve simple text processing and automation problems

Social competences

- give constructive feedback to peers in context of peer-assessed exercises

Applicability in this and other Programs

Biomedical Data Analysis; Informatics II; Data management, Data analysis and Data mining, Bioinformatics: Algorithms and Data Structures; Data visualization

Entrance Requirements

Introduction to Informatics (in LSI-01)

Learning Content

- data and text processing using the shell
  - biomedical text resources
  - semantics
  - data retrieval
  - data extraction
  - task repetition
  - XML processing
  - text retrieval
  - text processing
  - pattern matching
  - regular expressions
  - tokens & entities & relations
  - semantics processing
  - classes
  - entity linking
  - performance considerations

- programming with Python
  - control structures
  - data structures
  - objects & algorithms

Teaching Methods

Seminar-like classes, interactive exercises during lecture

Recommended Literature

- Couto, Data and Text Processing for Health and Life Sciences
- Joyner, Introduction to Computing, 2016, ISBN: 1-260-08227-X

LSI-04 Biostatistics I

Module code	LSI-04
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-04-1 Biostatistics I
Lecturer	Dr. Meik Kunz
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The *Biostatistics I* module aims at providing an in depth understanding of the relevant aspects of statistics in terms of biomedical data analysis. In order to analyze biomedical data professionally, one needs in-depth biostatistical knowhow, which is conveyed within this module.

After completing the Biostatistics I module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- have learned how to use the free statistics language R and how to apply the language to biological data sets
- be able to use statistical methods such as descriptive statistics, parametric and non-parametric two-sample tests, chi-square tests, correlation analysis, linear regression analysis and ANOVA.

Methodological competence

After successfully completing the module, students will:

- be safe in dealing with R
- be able to use R for statistical testing of biomedical data
- be familiar with the Bioconductor R packages and their properties and contents

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on developing statistical data analysis.
- Working together with fellow-students in small groups on designing and developing biostatistical analysis methods on biomedical datasets.

Applicability in this and other Programs

Biomedical Data Analysis; Bioinformatics: Algorithms and Data Structures; Data visualization

Entrance Requirements

Advantageous: Basic knowledge in R and Statistics

Learning Content

1 Basics and Concepts in Biostatistics
2 DNA and RNA Analysis
3 Protein Analysis- Hidden Markov Models
4 Descriptive Statistics
5 Statistic Testing
6 Diagnostic Testing, Meta Analysis

Teaching Methods

Seminar-like classes, application examples

The module consists of a lecture part with blended learning components, including practical exercises. The lecture part will prepare students' basic knowledge on

biostatistical objectives and the practical exercises will practice students' gained knowledge in biostatistical analysis using the software R.

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work

- Motulsky, Harvey, M.D.: Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking, 2014;
- Andy Field: Discovering Statistics Using R; 2012; ISBN-13: 978-1446200469

LSI-05 Sequencing Technologies

Module code	LSI-05
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-05-1 Sequencing Technologies
Lecturer	Prof. Dr. Melanie Kappelmann-Fenzl
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	oral ex. 30 min.
Weight	5/90
Language of Instruction	English

Module Objective

The *Sequencing Technologies* module aims at providing an in depth understanding of the current Sequencing Technologies and their advantages and disadvantages. In order to analyze biomedical data professionally, one needs to understand the different experimental setups of commonly used NGS methods, which are conveyed within this module.

After completing the Sequencing Technologies module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- have learned how to prepare samples for NGS applications.
- know about common methods of NGS and understand their technology and are able to computationally handle NGS raw data.
- know about the advantages and disadvantages of each sequencing method.

Methodological competence

After successfully completing the module, students will:

- know about the impact of experimental procedures on sample quality.
- know which key data regarding quality and quantity are important for successful sequencing.

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on technical and methodical principals of Sequencing technologies
- Working together with fellow-students in small groups on designing and developing professional presentations of literature research results of different NGS applications.
- Team building by collaborative project work.

Applicability in this and other Programs

Biomedical Data Analysis; master seminar, master thesis

Entrance Requirements

Advantageous: Module LSI-01 *Introduction to Biomedicine*

Learning Content

1 Experimental setup for NGS applications
2 Sequencing instruments
3 Illumina Sequencers
4 PacBio sequencers
5 Minion sequencers
6 Sequencing data preparation
7 Sequencing data

Teaching Methods

Seminar-like classes, application examples

The module consists of a lecture part with blended learning components, including visualization of sequencing technologies. The lecture part will prepare students' basic knowledge on common NGS methods and their applications in research and medicine.

Guest lectures: Illumina, Dr. Silvio Scheel; Dr. Mohren and Dr. Hamberger, Pathology and Cytology, Deggendorf

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work:

- Jianping Xu: Next-Generation Sequencing: Current Technologies and Applications; 2014; ISBN-13: 978-1908230331

LSI-06 Biomedical Data Analysis

Module code	LSI-06
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-06-1 Biomedical Data Analysis
Lecturer	Prof. Dr. Melanie Kappelmann-Fenzl
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written student research project
Weight	5/90
Language of Instruction	English

Module Objective

This interdisciplinary module combines knowledge from the fields of informatics, statistics and molecular biology.

The *Biomedical Data Analysis* module shows the students the practical application of computer-aided biomedical data analysis and enables them to carry it out independently. This module is an interdisciplinary tutorial in which the students perform the NGS data analysis workflow by themselves under professional instruction.

After completing the Biomedical Data Analysis module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- have learned how to manage NGS data.
- be familiar with file formats and their usage in the different analysis approaches.
- know about common data analysis workflows and be able to interpret and visualize the achieved results.

Methodological competence

After successfully completing the module, students will:

- be able to perform quality control on sequencing data.
- be able to perform mapping procedures and understand the differences between various mapping algorithms.
- be able to create genome indices and know the relevance of a reference genome.
- be able to perform NGS data analysis in terms of RNA-Seq data.

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on performing biomedical data analysis.
- Working together with fellow-students in small groups on designing and developing NGS data analysis workflows.
- Team building by interactive working groups.

Applicability in this and other Programs

master seminar, master thesis

Entrance Requirements

Advantageous: Module LSI-01: *Introduction to Informatics and Biomedicine*, Basic knowledge in R, Basic knowledge in Statistics

Learning Content

1 NGS Data- File Formats
2 NGS-Open Sources
3 Reference Genome
4 Mapping
5 Data Analysis- Genomics
  5.1 Variant Calling
6 Data Analysis- Epigenetics
  6.1 ChIP-Seq
  6.2 Methyl-Seq

7 A practical approach: Data Analysis- Transcriptomics
  7.1 Count Table Generation
  7.2 Differential Expression Analysis
  7.3 Differential Exon Usage

Teaching Methods

Tutorial, practical exercises, application examples

The module consists of an interactive theoretical part with blended learning components. Within the tutorial the students use example NGS datasets to perform the biomedical data analysis workflow. In the practical part of the tutorial the students should learn to find solutions to problems independently by discussions and research work.

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work

- The Biostars Handbook: Bioinformatics Data Analysis Guide; 2019; https://www.biostarhandbook.com/

LSI-07 Life Science II

Module code	LSI-07
Module coordination	Dr. Stefan Fischer
Course number and name	LSI-07-1 Life Science II
Lecturers	Dr. Stefan Fischer Prof. Dr. Melanie Kappelmann-Fenzl
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The ?Life Science II? module builds on the knowledge from ?Life Science I? and aims at providing an in depth understanding of the relevant aspects of molecular based diseases with a special focus on molecular oncology. In order to understand the approaches of personalized medicine and targeted therapy the students should have a broad as well as profound knowledge about the ongoing biochemical processes resulting in disease development and progression.

The practice of medicine, especially in the disciplines of Pathology and human Genetics is increasingly reliant on Genomic technology. The aim of this module is to increase the knowledge and capability of the students using genetic data allowing them to engage confidently with the scientific concepts of Molecular Pathology and Genomic Medicine.

After completing the Life Science II module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- be able to explain how genetic variation is involved in human disease and the development of cancer.
- understand how genetic variation can be a major determinant of patient treatment.

Methodological competence

After successfully completing the module, students will:

- be able to intzerprete NGS data in the context of germline mutations that cause human genetic disease, and somatic mutations involved in cancer.
- be able to interprete NGS data in the context of gene expression analysis and understand the relevance of gene set enrichment analysis as well as gene ontology classifications

Social competence

After successfully completing the module, students will:

- be confident in critically evaluate molecular pathology & diagnostics.
- b e able to discuss molecular feature of different kind of diseases

Applicability in this and other Programs

Data vizualisation, master seminar, master thesis

Entrance Requirements

Recommended or advantageous:

Module LSI-02: *Life Science I*

Learning Content

Molecular basis of human disease

1 Molecular Pathology
2 Molecular Oncology

Teaching Methods

Seminar-like classes

The module consists of a lecture part with blended learning components, including interactive discussions on current topics and publications. The lecture part will prepare students' in-depth knowledge on the molecular basis of human disease.

Guest lecture: Prof. Dr. Michael Rehli, Dept. Internal Medicine III, University Hospital Regensburg

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work

- Bruce Alberts, Alexander Johnson, Peter Walter, Julian Lewis, MartinRaff, Keith Roberts: Molecular Biology of the Cell (Englisch) GebundeneAusgabe 2. Dezember 2014; ISBN-13: 9780815344643; ISBN-10:0815344643
- William B. Coleman, Gregory J. Tsongalis: Molecular Pathology: The Molecular Basis of Human Disease, 2nd edition, 2017, ISBN-13: 978-0128027615

LSI-08 Informatics II

Module code	LSI-08
Module coordination	Prof. Dr. Gökçe Aydos
Course number and name	LSI-08-1 Informatics II
Lecturer	Prof. Dr. Gökçe Aydos
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The *Informatics II* module builds on the knowledge from ?Informatics I? and aims at providing an in-depth understanding of the relevant aspects of computational science.

After completing the Informatics I module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- be confident in Python programming language and how to use it as a tool for data analysis.

- know how to use computation to help data tell a story.
- be familiar with fundamental principles and methods of visualization.
- know how to use tools widely used by data scientists, such as Jupyter Notebooks etc.

Methodological competence

After successfully completing the module, students will:

- be able to write Python scripts for biomedical approaches.
- know how to use different software tools and know about their application and function.

Applicability in this and other Programs

Data management, Data analysis and Data mining, Bioinformatics: Algorithms and Data Structures; Data visualization

Entrance Requirements

Recommended or advantageous:

Module LSI-01: *Introduction to Informatics*

Module LSI-03: *Informatics I*

Learning Content

1 Advanced Python programming language
2 Principles and methods of visualization.
3 Open access tools

Teaching Methods

Seminar-like classes, application examples

The module consists of a lecture part with blended learning components, including practical exercises. The lecture part will prepare students' basic knowledge on computational objectives and the practical exercises will practice students’ gained knowledge.

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

LSI-09 Biostatistics II

Module code	LSI-09
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-09-1 Biostatistics II
Lecturer	Dr. Meik Kunz
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The *Biostatistics II* module aims at providing an in depth understanding of the relevant aspects of statistics in terms of biomedical data analysis. In order to analyze biomedical data professionally, one needs in-depth biostatistical know-how, which is conveyed within this module.

After completing the Biostatistics II module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- be confident in advanced R programming.
- be able to identify different types of data, and how it can be collected.
- be able to recognize and design experiments.
- know how to summarize data numerically and graphically using R.
- understand the difference between point and interval estimation.
- be able to determine and perform correct statistical tests.
- know how to conclude and interpret the results from statistical tests.
- be familiar with inferential statistics including parametric and nonparametric methods.

Methodological competence

After successfully completing the module, students will:

- be able to write programming scripts in R.
- be able to use R for advanced statistical testing of biomedical data.
- be confident in data visualization in R.

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on developing statistical data analysis.
- Working together with fellow-students in small groups on designing and developing biostatistical analysis methods on biomedical datasets.

Applicability in this and other Programs

Bioinformatics: Algorithms and Data Structures; Data visualization, master seminar, master thesis

Entrance Requirements

Recommended or advantageous:

Module: LSI-04 *Biostatistics I*

Learning Content

1 Linear regression; Logistic regression
2 Survival analysis; Multivariate regression
3 Stepwise regression; SVM, GBM
4 Regularized regression I+II (Lasso, Ridge, Elastic net)
5 Dimension reduction I+II (PCA, MDS, t-SNE, SOM)
6 ClusteringI+II (kNN, k-means, ...)

Teaching Methods

Seminar-like classes, application examples

The module consists of a lecture part with blended learning components, including practical exercises. The lecture part will prepare students' basic knowledge on biostatistical objectives and the practical exercises will practice students’ gained knowledge in biostatistical analysis using the software R.

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work

- Motulsky, Harvey, M.D.: Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking, 2017;
- Andy Field: Discovering Statistics Using R; 2012; ISBN-13: 978-1446200469

LSI-10 Data Management, Data Analysis & Data Mining

Module code	LSI-10
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-10-1 Data Management, Data Analysis & Data Mining
Lecturers	Dr. Stefan Fischer Prof. Dr. Thomas Spittler
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

Within the *Data Management, Data Analysis & Data Mining* module the students will acquire fundamental knowledge of the techniques, opportunities and applications of data management, analysis and mining. The module provides an introduction to advanced data analysis techniques as a basis for analyzing NGS data.

After completing the Data Management, Data Analysis & Data Mining module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- be able to identify opportunities for applying data mining of NGS data.
- be familiar with the data mining possibilities and understand their relevance and differences.

Methodological competence

After successfully completing the module, students will:

- know how to manage and store NGS data.
- be able to select and apply appropriate data mining techniques.
- be able to interpret the results.

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on principals of NGS data management.

Applicability in this and other Programs

Bioinformatics: Algorithms and Data Structures; Data visualization, master seminar, master thesis

Entrance Requirements

Recommended or advantageous:

Module: LSI-03 *Informatics I*

Module: LSI-04 *Biostatistics I*

Learning Content

1 Goals and Principles of Data Management (Databases)
2 Goals and Principles of Data Analysis (GitHub etc.)
3 Goals and Principles of Data Mining
4 The Data Mining Process (Data Representation and Preprocessing)
5 Clustering
6 Classification
7 Association Analysis

Teaching Methods

Seminar-like classes, application examples

The module consists of a lecture part with blended learning components, including practical exercises. The lecture part will prepare students' basic knowledge on

biostatistical objectives and the practical exercises will practice students' gained knowledge in biostatistical analysis using the software R.

Guest lectures: Prof. Dr. Dominik Grimm- Machine learning

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work

- Tan, P.-N., Steinback, M.,Kumar, V. (2014). Introduction to Data Mining (2nd Edition). John Wiley & Sons.
- Bianchi V, Ceol A, Ogier AG, et al. Integrated Systems for NGS Data Management and Analysis: Open Issues and Available Solutions. Front Genet. 2016;7:75. Published 2016 May 6. doi:10.3389/fgene.2016.00075

LSI-11 Bioinformatics - Algorithms and Data Structures

Module code	LSI-11
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-11-1 Bioinformatics - Algorithms and Data Structures
Lecturers	Prof. Dr. Gökçe Aydos Prof. Dr. Melanie Kappelmann-Fenzl
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

Within the *Bioinformatics- Algorithms and Datastructure* module the students will acquire fundamental knowledge of the techniques, opportunities and applications of Bioinformatic Algorithms. The module provides an introduction to advanced data analysis techniques as a basis for analyzing NGS data.

After completing the Bioinformatics module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- understand essential algorithmic techniques and apply them to solve algorithmic problems.

Methodological competence

After successfully completing the module, students will:

- be able to implement programs that work in less than one second even on massive datasets.
- be able to test and debug code even without knowing the input on which it fails.
- be able to formulate real life computational problems as rigorous algorithmic problems.
- be able to prove correctness of an algorithm and analyze its running time.
- be able to synthesize their knowledge of algorithms and biology to build their own software for solving a biological challenge.

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on developing bioinformatical algorithms.
- Team work in small groups on designing and developing bioinformatical workflows.
- Team building by interactive project groups.

Applicability in this and other Programs

Bioinformatics: Algorithms and Data Structures; Data visualization, master seminar, master thesis

Entrance Requirements

Recommended or advantageous:

Module: LSI-03 *Informatics I*

Module: LSI-04 *Biostatistics I*

Learning Content

1 Algorithmic Design and Techniques
2 Data Structures Fundamentals
3 Graph Algorithms
4 NP-Complete Problems
5 String Processing and Pattern matching algorithms
6 Dynamic Programming: Applications in Machine learning and Genomics
7 Graph Algorithms in Genome Sequencing

8 Algorithms and Data Structures Capstone
9 Machine learning algorithms

Teaching Methods

Seminar-like classes, application examples

The module consists of a lecture part with blended learning components, including practical exercises. The lecture part will prepare students' basic knowledge on data structures and algorithms and the practical exercises will practice students’ gained knowledge in NGS data analysis using algorithms in R and Python.

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work:

- Phillip Compeau, Pavel Pevzner: Bioinformatics Algorithms: An Active Learning Approach, ISBN-13: 978-0990374633

LSI-12 Data Visualization

Module code	LSI-12
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-12-1 Data Visualization
Lecturers	Prof. Dr. Melanie Kappelmann-Fenzl Javier Valdes
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours virtual learning: 45 hours Total: 150 hours
Type of Examination	written student research project
Weight	5/90
Language of Instruction	English

Module Objective

Data Visualization is the graphic representation of a data analysis to achieve clear and effective communication of results and insights. Complex ideas are presented in charts and graphs with the goal of quickly and easily disseminating key, actionable information. Data visualization is an essential part of data science and analytics, especially when working with large, complicated data sets like sequencing data. The visualization tells a story, whether as a stand-along graph or combined with other graphs, charts and design elements in an infographic or dashboard.

After completing the Data Visualization module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- know the data visualization principles.
- be familiar with file formats and their usage in the different analysis approaches.
- know about common data analysis workflows and be able to interpret and visualize the achieved results.

Methodological competence

After successfully completing the module, students will:

- know how to use ggplot2 in R to create custom plots.
- be able to explore and check alignments with alignment viewers.
- be familiar with genome browsers.

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on developing R scripts for data analysis and data visualization.
- Working together with fellow-students in small groups on designing and developing biostatistical validation of biomedical datasets within R.

Applicability in this and other Programs

master seminar, master thesis

Entrance Requirements

Recommended or advantageous:

Basic Knowledge in R

Module: LSI-04 *Biostatistics I*

Learning Content

1 R Packages for data visualization
2 Alignment Viewers
3 Genome Browsers
4 Open access visualization tools

Teaching Methods

Tutorial, practical exercises, application examples

The module consists of an interactive theoretical part with blended learning components. Within the tutorial the students use example NGS datasets to perform the biomedical data visualization. In the practical part of the tutorial the students should learn to find various visualization tools, possibilities and methods and discuss their advantages and disadvantages to represent statisitical significance.

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work

- The Biostars Handbook: Bioinformatics Data Analysis Guide; 2019; https://www.biostarhandbook.com/

LSI-13 Master Thesis

Module code	LSI-13
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-13-1 Master Thesis LSI-13-2 Master Kolloquium LSI-13-3 Master Seminar
Lecturers	Prof. Dr. Gökçe Aydos Dr. Stefan Fischer Prof. Dr. Melanie Kappelmann-Fenzl
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	6
ECTS	30
Workload	Time of attendance: 90 hours self-study: 780 hours virtual learning: 30 hours Total: 900 hours
Type of Examination	master thesis
Weight	30/90
Language of Instruction	English

Module Objective

By producing a Master's Thesis the students should demonstrate their ability to apply the knowledge and skills acquired during the study course, in an independently written scientific work on complex tasks. They thus demonstrate that they have successfully completed their Master's levels studies and acquired the capacity for independent scientific work.

Entrance Requirements

According to the paragraph 8 of the Study and Examination Regulations, those students who have collected at least 40 ECTS credits may register for the Master's Thesis.

Learning Content

The Master's Thesis is a written report in a form of a scientific paper. It describes the scientific findings, as well as the way leading to these findings. It contains justifications for decisions regarding chosen methods for the thesis and discarded alternatives. The student’s own substantial contribution to the achieved results has to be evident. In addition, the student presents his work in a colloquium, in which the scientific quality and the scientific independence of his achievements are evaluated. The work on the Master’s Thesis is supervised by any of the instructors within the study course (professors or lecturers) or an external instructor. The Master’s Thesis can be written on any subject or topic related to the content of any of the modules of the study course. The students can suggest the topics for their Master’s Theses according to their research or practice preferences. The preparation time of a Master’s Thesis according to the regulations is 6 (six) months. However, an extension up to a maximum of 8 months from the subscription date is possible (§11 APO). As a general rule, the size of the thesis should not exceed 70 pages.

Teaching Methods

Students perform an independent supervised scientific research work.

Recommended Literature

Recommendations and instructions of writing a master's thesis (available through iLearn).