

Module Descriptions

TUM Masterstudiengang Radiation Biology

Mandatory Modules.....	3
STRB001: Human Anatomy and Physiology.....	4
STRB002: Principles of Radiation Protection.....	6
STRB003: Molecular Biology of the Cell.....	8
STRB004: Radiation Physics and Dosimetry.....	10
STRB005: Mechanisms of Radiation Effects on Cells and Tissues.....	12
STRB006: Molecular Radiation Biology.....	14
STRB007: Medical Applications of Radiation.....	16
STRB008: Research Management.....	18
STRB009: Practical: Radiation Protection.....	20
STRB010: Current Research Topics in Radiation Biology.....	22
Elective Modules.....	24
STRB011: Research Practical: Preclinical Research.....	25
STRB012: Research Practical: Medical Physics.....	27
STRB013: Clinical and Experimental Radiation Oncology.....	29
STRB014: Advanced Molecular Radiation Biology.....	32
STRB015: Medical Imaging in Radiation Research.....	34
Thesis.....	36
STRB016: Master's Thesis with Colloquium.....	37

Mandatory Modules

STRB001: Human Anatomy and Physiology

Module number: STRB001

School of Medicine

Module-level: Master

Duration: 1 semester

Frequency: only winter semester

Language: Englisch

ECTS: 6

Workload: 180 hours;

Attendance 75 hours,

- 60 hours of lectures divided into 30 hours of lectures about Anatomy and Pathology and 30 hours of lectures about Physiology and Pathophysiology
- 15 hours seminar

Self Study: 105 hours

Prerequisites: none

Learning Outcomes:

After successful completion of this module, students will be able

- To understand the organs of the human body and their functions
- To describe the physiological functions of the human body and their changes due to diseases
- To discuss occupational and medical radiological radiation exposure and its consequences
- To identify the consequences of radiation effects on the body as well as the organs and their functions
- To analyze the mechanisms of radiation effects and their both short-term (<6 months after radiation exposure) and long-term (>6 months after radiation exposure) pathophysiological consequences

Teaching and learning methods:

The module consists of lectures and accompanying seminars. In this context, the lectures teach the fundamentals of the major human organs and their functions, as well as the effects of radiation on these organs and functions. In the seminars, the anatomical, pathological and pathophysiological manifestations of certain diseases are discussed, starting from the clinical symptoms in their interrelationships to applying the taught basics in an exemplary manner.

Lecture content:

28.06.2022

- Fundamentals of general and special anatomy
- Fundamentals of topographic anatomy, including anatomy in imaging techniques
- Basics of general and special pathology
- Fundamentals of physiology and pathophysiology of organs and organ systems
- Radiation exposure and radiation effects on the human body
- Consequences and effects on functions of the human body

Course and examination results

Module grade: 100% written exam

The module examination consists of a written multiple-choice exam with 80 questions. There are 40 questions each on the topics of anatomy and pathology and 40 questions on the topics of physiology and pathophysiology. The questions are single-choice tasks with at least three answer choices in which students demonstrate an understanding of the changes in human anatomy caused by radiation exposure and the physiological functions of the human body. The exam is 120 min in duration.

Retake options: The exam may be repeated at the end of the semester.

Module Leader: Prof. Dr. rer. nat. Thomas Schmid

STRB002: Principles of Radiation Protection

Module number: STRB002

School of Medicine

Module level: Master

Duration: 1 semester

Frequency: only winter semester

Language: Englisch

ECTS: 6

Workload: 180 hours;

Attendance 60 hours,

- 45 hours lectures
- 15 hours seminar

Self Study: 120 hours

Prerequisites: none

Learning Outcomes:

Upon completion of this module, students will be able

- To recall the critical historical events of human radiation exposure and the lessons learned about acute and long-term side effects of radiation
- To compare the events and their consequences and describe their relevance to radiation protection today
- To understand the functions, areas of operation and duties of the various organizations concerned with radiation protection
- To discuss the regulations of occupational radiation protection as well as radiation protection of the normal population
- To analyze rules of radiation protection and their implementation in concrete situations
- To assess the consequences of natural and artificial radiation exposure on the human body and the environment

Teaching and learning methods

The module consists of lectures and a seminar. In the lectures, the basics of radiation protection (historical and current) and the effects of radiation in the environment and on the human body are taught in lectures. In the seminars, international examples of radiation protection are presented and discussed.

Content:

- Description of the studies and their results on which the evidence is based regarding the long-term effects observed in groups of people after radiation in medicine, through occupational activities, accidents, or in the survivors of atomic bomb explosions.
- Introduction to the history of radiation protection and the organizations concerned with optimizing radiation protection
- Introduction to the concepts (e.g., dose specifications, benefit/risk trade-offs) and regulatory requirements of radiation protection
- Radiation exposure from nuclear power plants during regular operation and accidents, the nuclear fuel cycle, final disposal; disposal of military nuclear hardware;
- methods and results of epidemiological studies on occupationally exposed persons
- Basics of radioecology: radioactive substances, dispersion, transfer to food, distribution in the body after incorporation, organ doses
- Natural radiation exposure, especially by radon: doses and effects
- Genetic radiation effects and developmental disorders after exposure in utero
- Introduction to cosmic radiation
- Risk communication

Course and examination results**Module grade: 100% written examination**

The module examination consists of a written exam in which students demonstrate competencies in the targeted Learning Outcomes through comprehension questions and discussion in 120 minutes. The questions and assignments may address, for example, the following topics:

- the effects of radiation events in the past
- the application of radiation protection regulations in a specific situation
- long-term health effects of radiation exposures from various sources and causes
- epidemiological studies of the long-term health effects of radiation exposure

Retake options: The exam may be repeated at the end of the semester.

Module leader: Prof. Dr. rer. nat. Thomas Schmid

STRB003: Molecular Biology of the Cell

Module number: STRB003

School of Medicine

Module level: Master

Duration: one semester

Frequency: Winter semester only

Language: Englisch

ECTS: 6

Workload: 180 hours;

60 hours attendance

- 30 hours lectures (2SWS)
- 30 hours laboratory practical (2 SWS)

Self-study 120 hours

Prerequisites: none.

Learning Outcomes:

After participating in the module courses, students will be able to

- to understand the molecular structure of the cell and the molecular function of the individual components of the cells
- to differentiate the corresponding cellular regulatory mechanisms
- to describe the structure and function of DNA as well as the molecular mechanisms of damage to DNA
- to distinguish the relevant repair mechanisms and assess the relevance of each repair process in the context of radiation
- to recognize the fields of application of the different methods of molecular biology, as well as to select their significance, and to assess their results
- to understand the concepts and relationships of an experimental analysis of radiation effects using molecular biology methods and apply these methods in the laboratory
- to classify scientific questions and research results on the molecular biology of the cell and to interpret the significance for radiation application and radiation research.

Teaching and learning methods

The courses consist of 30 hours of lectures and a common one-week laboratory practical to teach the basic methods of molecular radiation biology, both theoretically and practically. Theoretical principles will be taught through the lecture sessions. In the laboratory practical course, theoretically taught basics are to be built up in experiments, analyzed, and learned practically. Finally, the results are to be documented in writing and scientifically evaluated.

Content:

- the molecular organization of cells
- structure and function of the genome
- DNA replication, genetic recombination
- DNA repair
- cell membrane
- Cytoplasm, cytoskeleton, and organelles
- Nucleus, DNA / RNA
- Cell proliferation, cell division
- Intra- and intercellular signals
- Methods of molecular biology and their application in radiation research
- Basic principles of late radiation damage
- Mathematical modeling of carcinogenesis
- Biological dosimetry

Course and examination results

Module grade: Oral Examination 100%

The module examination consists of an oral exam in which students demonstrate knowledge of the molecular structure of the cell, molecular mechanisms, damage due to radiation effects, and repair mechanisms. The exam will last 20 minutes.

Retake options: The exam may be repeated at the end of the semester.

Module leader: PD Dr. Omid Azimzadeh / PD Dr. Simone Mörtl

STRB004: Radiation Physics and Dosimetry

Module number: STRB004

School of Medicine

Module level: Master

Duration: one semester

Frequency: Winter semester only

Language: Englisch

ECTS: 6

Workload: 180 hours;

Attendance 60 hours

- 30 hours of lectures (2 SWS)
- 15 hours seminar (1 SWS)
- 15 hours of laboratory practical (1 SWS)

Self-study 125 hours

Prerequisites: none

Learning Outcomes

After participating in the module courses, students will be able

- to explain the physical principles of the medical application of ionizing radiation from various sources
- to understand the interaction of radiation with matter and the resulting doses
- to apply the various methods of dose measurement
- to distinguish the concepts of physical-technical radiation planning in radiation therapy
- to understand the physical principles of various imaging techniques in medicine and illustrate differentiated applications of various techniques in diagnostics and therapy.

Content:

- Introduction to the basic principles of radiation physics in radiation biology and medical radiation applications.
- Generation of ionizing radiation, radioactivity, interactions of radiation with matter, dosimetry, radiation sources in clinical medicine and radiobiological research
- Physical principles of imaging techniques in medicine

- Physical principles of radiation therapy, including clinical treatment procedures and treatment devices; principles of radiation planning in radiation therapy

Teaching and learning methods

The module consists of lectures to teach the theoretical basics and a seminar in which the students present their competence in radiation physics and dosimetric problem-solving. In addition, the practical course on dosimetry demonstrates the planning and execution of experiments, and students practice presenting and analyzing the experimental results professionally.

Course and examination results

Module grade: Oral examination 100%

The examination performance will be in the form of an oral examination (20 minutes) covering the entire module. In this, it should be demonstrated that the applications of radiation physics in medical treatment are understood. In addition, the physical and clinical aspects of diagnostics and therapy should be reported, and questions about them should be answered. The module grade results solely from the oral examination.

Retake Options: The exam may be repeated at the end of the semester.

Module leader: Prof. Dr. J. Wilkens

STRB005: Mechanisms of Radiation Effects on Cells and Tissues

Module number: STRB005

School of Medicine

Module level: Master

Duration: 1 Semester

Frequency: nur im Sommersemester

Language: Englisch

ECTS: 8

Workload: 240 hours;

Attendance 105 hours, davon

- 45 hours Vorlesungen (3 SWS)
- 45 hours Laborpraktikum (3 SWS)
- 15 hours Übungen (1 SWS)

Self-study 135 hours

Prerequisites:

Modules 001, 002, 003, 004 of the TUM Master's program Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes

After participating in the module courses, students will be able

- to understand and analyze the chain of biological effects of radiation from the molecular changes occurring immediately after different radiation exposures to the effects of radiation in DNA, chromosomes, and cells
- to analyze the effects of ionizing radiation on the function of clonogenic cells and stem cells in vivo and in vitro.
- to understand the effects of radiation on the immune system
- to understand the pathogenesis of late radiation sequelae in healthy and diseased tissues and organs and be able to evaluate the clinical relevance of these changes based on medical findings
- to develop experimental models based on radiation biology principles to elucidate the pathogenesis of tissue radiation sequelae.

Content:

- The evolution of cellular radiation effects from structural changes in DNA and resulting structural chromosomal aberrations to cellular dysfunction

- the dose dependence of radiation-induced disturbances of cell proliferation and cell functions of cells in vitro as well as in stem cells and non-stem cells in vivo
- the dependence of the various cellular radiation damages on dose, dose rate, fractionation, microenvironment, and radiation quality, including underlying molecular and genetic mechanisms
- The role of the various cellular radiation effects in the development of the various early, late, and very delayed tissue radiation damage in the various organs
- the role of radiation effects on cells of the immune system

Teaching and learning methods

The module consists of lectures, exercises, and two laboratory practicals on cells in vitro. The exercises analyze and correctly evaluate the effects of ionizing radiation on the function of clonogenic cells and stem cells.

In practical course 1, "Cytogenetics," the formation of stable and unstable chromosomal aberrations in human lymphocytes after different doses of radiation, micronucleus formation, and their relation to the initiation and repair of DNA double-strand breaks are studied.

In practical 2 "Tumor Cells", different radiation consequences (such as loss of colony-forming ability, cell death, apoptosis, metabolic activity, proliferation behavior, DNA damage, changes in lymphocyte immunophenotype, and the like) will be investigated in different established tumor cell lines with different radiation sensitivities after different radiation doses and their dose-dependence will be compared. Students write detailed reports of both practicals on methods, results, and their critical comparison and conclusions.

Course and examination results

Module grade: 100% Examination Parcours

The module examination is an examination course consisting of a practical demonstration in the laboratory (50%) and an oral examination (50%). Both parts are equally weighted. With the practical demonstrations, the students are to prove that they can carry out experiments and explain the execution, evaluation, and knowledge acquisition in an accompanying manner. In the oral part of the exam, students are expected to answer comprehension questions about the molecular and cytogenetic consequences of radiation in irradiated cells and their dependence on dose, dose rate, and time. In addition, students will demonstrate their understanding of the role of these cellular radiation responses in the cellular pathogenesis of early and late radiation sequelae in tissues and organs. The exam will last a total of 60 minutes, 20 minutes of which will be devoted to the oral portion of the exam.

Retake Options: The exam may be repeated at the end of the semester.

Module leader: Prof. Dr. rer. nat. Thomas Schmid

STRB006: Molecular Radiation Biology

Module number: STRB006

School of Medicine

Module level: Master

Duration: 1 Semester

Frequency: summer semester only

Language: English

ECTS: 6

Workload: 180 hours;

Attendance 75 hours

- Lectures 45 hours (3 SWS)
- Practical 30 hours (2 SWS)

Self-study 105 hours

Prerequisites:

Modules 001, 002, 003, and 004 of the TUM Master's program Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes:

After participation in the module courses, students will be able

- to describe the molecular biological mechanisms of initiation of radiation-induced malignancies and evaluate their medical and societal relevance
- to analyze and interpret the molecular biological mechanisms of generation and repair of radiation-induced DNA damage
- to explain the molecular biological mechanisms of radiation-induced dysfunction
- to design, perform and evaluate molecular biology experiments to analyze specific radiation-induced processes in irradiated cells with the application of appropriate in vitro or in vivo models in each case

Content:

- Molecular biological mechanisms of initiation of the various radiation-induced malignancies.
- Molecular biological mechanisms of generation and repair of radiation-induced DNA damage and their consequences for function and proliferative capacity of irradiated cells

- The role of different molecular biological signaling chains on the function and structure of irradiated cells
- in vitro, in vivo, and silico models in molecular radiation research

Teaching and learning methods

The module consists of lectures and a whole-group laboratory practical, as well as seminars in which specific molecular biology changes are discussed in the group in a journal club-style based on presentations in which students present selected publications in molecular radiation biology.

Course and examination results

Module grade: Oral examination 100%

The module examination consists of an oral examination in which students demonstrate that they can analyze the molecular reactions triggered by radiation in the various cellular structures and describe the resulting functional changes in the cell in the context of complex regulatory processes. The examination will last 25 minutes.

Retake options: The exam may be repeated at the end of the semester.

Module leader: PD Dr. Omid Azimzadeh / PD Dr. Simone Mörtl

STRB007: Medical Applications of Radiation

Module number: STRB007

School of Medicine

Module level: Master

Duration: one semester

Frequency: Summer semester

Language: Englisch

ECTS: 5

Workload: 150 Hours;

Attendance 45 Hours,

- 45 Hours Vorlesung mit Demonstration (3 SWS)

Self-study: 105 Hours

Prerequisites: Modules 001, 002, 003, and 004 of the TUM Master's program Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes:

After participating in this module, students will be able

- to describe the medical measures in diagnostics and therapy in medicine
- to differentiate the radiation exposure in medical applications and the associated respective risk-benefit consideration
- to analyze and interpret uncertainties of risk assessment
- to explain diagnostic methods using X-ray, CT, and MRI as well as nuclear medical examinations and therapies, well as radiotherapeutic treatments
- to analyze the criteria of dose optimization in a medical application through examples

Teaching and learning methods

The module consists of lectures and demonstrations in the medical disciplines of clinical diagnosis and therapy (radiology, nuclear medicine, and radiation oncology) to illustrate the practical application of radiation.

Content:

- Introduction to the various procedures used in clinical radiology, including the associated radiation exposures in diagnosing and treating various diseases and the risk/benefit trade-offs in clinical radiation oncology.

- Demonstration of the function of equipment used in diagnostic radiology, nuclear medicine, and radiation therapy
- Diagnostic concepts of nuclear medicine using the tracer method and its application in oncological and non-oncological problems.
- Follow-up studies by medical measures of radiation-exposed patients: Results and significance for radiation protection

Course and examination results

Module grade: 100% Written examination

The module examination consists of a written test in which the students demonstrate their knowledge of radiation applications in diagnostics and therapy. Answering the questions requires own formulations. The exam lasts 120 min.

The module examination consists of a written multiple-choice exam with 75 questions. Twenty-five questions each are from the subject areas of radiology, nuclear medicine, and radiation oncology. The questions are single-choice tasks with at least three possible answers. Students demonstrate an understanding of radiation applications in diagnostics and therapy, their technical equipment, and the physical processes involved. The exam lasts 120 min.

Retake options: The exam may be repeated at the end of the semester.

Module leader: Dr. med. S. Pigorsch (RADONK), PD Dr. med. D. Pfeiffer (RAD),
Prof. Dr. med Christian Lohrmann (NUK)

STRB008: Research Management

Module number: STRB008

School of Medicine

Module level: Master

Duration: one semester

Frequency: Summer semester

Language: English

ECTS: 5

Workload: 150 hours

- 30 hours Seminar (2 SWS)

120 hours self-study

Prerequisites:

Modules 001, 002, 003, and 004 of the TUM Master's program Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes

After participating in this module of the master's program in Radiation Biology, students will be able to

- to independently identify and evaluate the scientific groundwork for a new research project
- to understand and independently prepare analyses of scientific data and their presentations
- to analyze the design of clinical trials and biological experiments
- to write and present scientific data orally and in writing in the English language

Teaching and learning methods

In a seminar, students learn skills of scientific work in the medical-biological research environment, including the associated handling of research data, literature research, project management, and time management, as well as writing scientific texts and presenting scientific results.

Content:

- Literature research
- hypothesis generation
- experimental design, selection of materials and methods
- scientific writing

- medical statistics
- presentation and discussion skills

Course and examination results

Course work: 100% Learning Portfolio

Students will submit a learning portfolio. The learning portfolio is contented with a bibliography, an abstract or poster, a presentation, and a description of medical statistical research findings. The learning portfolio is written in English.

Retake options: The examination may be repeated.

Module leader: Dr. Marco Vogel/Carmen Kessel

STRB009: Practical: Radiation Protection

Module number: STRB009

School of Medicine

Module level: Master

Duration: one semester

Frequency: Summer semester

Language: English

ECTS: 6

Workload: 180 Hours

Attendance 160 Hours

Self-study 20 Hours

Prerequisites:

Module 002 and Module 004 of the TUM Master's program Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes

After participating in the module courses, students will be able:

- to quantify and evaluate, in an evidence-based manner, the risks of radiation-induced adverse health effects in individuals exposed to radiation (both occupational exposures and unplanned exposures, e.g., accidental exposures) and their offspring
- to understand research approaches (both epidemiological studies and radiation biology experiments) to radiation risk
- to estimate and evaluate the risks posed by external radiation exposures as well as those resulting from released and incorporated radionuclides in various organs and tissues
- to implement and discuss the medical and organizational measures to protect the public in severe nuclear accidents.

Teaching and Learning methods:

The Radiation Protection group practicum lasts four weeks full-time. The practicum consists of four project-based learning phases in which students receive input and assignments and work through aspects of radiation protection one week at a time. The four focus areas revolve around 1) radiation accident scenarios, the medically necessary actions and associated practical exercises, as well as measurements, laboratory experiments, and simulations from the fields of 2) radioecology, 3) epidemiology and 4) radiation protection. In addition, excursions are offered to illustrate the practical relevance of radiation protection, e.g., for

sampling, e.g., measurements of environmental radioactivity, visits to nuclear facilities, and work in the metrological laboratory to measure environmental samples taken.

Content

- Issues and methods of radiation protection.
- Radiation epidemiological methods, cohorts, results: epidemiological studies on cohorts of radiation-exposed individuals (e.g., Hiroshima and Nagasaki, Marshall Islands, Kazakhstan, Mayak, Chernobyl)
- Follow-up studies of patients exposed to radiation through medical procedures: Results and significance for radiation protection
- Disaster management in the vicinity of nuclear facilities and medical care in the event of a disaster: ethical and social aspects of nuclear energy
- Radiation risk: scientific, ethical, and societal aspects

Course and examination results

Course work: 100% Presentation

The module examination consists of a group presentation within the practical course in which the students demonstrate that they can present an aspect of radiation protection, concisely, and comprehensibly with suitable media support. Groups will consist of a maximum of 4 students. The presentation should last 20 minutes, with each student having at least 5 minutes of speaking time.

Module leader: Prof. Dr. rer. nat. Thomas Schmid

STRB010: Current Research Topics in Radiation Biology

Module number: STRB010

School of Medicine

Module level: Master

Duration: one semester

Frequency: winter semester

Language: English

ECTS: 8

Workload: 240 Hours;

- 45 Hours seminar with presentations (3 SWS),
- Self-study 195 Hours

Prerequisites:

Modules 005, 006, 007, and 008 of the TUM Master's program in Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes

After participation in the module courses, students will be able

- to independently develop a complex research topic of their choosing in radiation biology and research and evaluate the literature on a topic of their choosing in radiation biology research; and
- to prepare scientific issues in the various areas of current research in radiation biology in the form of a presentation for a specific audience
- to discuss and evaluate scientific issues in the various areas of current research in radiation biology.

Content

- Lectures from current research in radiation biology are based on student interests.

Teaching and learning methods

The module consists of a seminar in which students prepare presentations (course work) with the help of input discussions with the lecturers, the topic of which they can choose from the current research questions in the field of radiation biology.

Course and examination results

Course work: Presentation 100%

The course performance consists of a presentation in which the students demonstrate that they can present a specific field of research or research results and their complex issues in the field of current radiobiological research in a clear, concise, and understandable manner with appropriate media support. The presentation should last 20 minutes, followed by 10 minutes of discussion in which students demonstrate that they can respond knowledgeably to questions and discussion points. The course performance will be graded as a pass.

Module leader:

Prof. Dr. Thomas. E. Schmid

Elective Modules

STRB011: Research Practical: Preclinical Research

Module number: STRB011

School of Medicine

Module level: Master

Duration: 1

Frequency: Winter semester

Language: English

ECTS: 6

Workload: 180 Hours

Attendance 160 Hours

Self-study 20 Hours

Prerequisites: none.

Learning Outcomes

After participation in the module courses, students will be able

- to carry out radiobiological research work under the supervision
- to apply the experimental techniques used
- to evaluate the results obtained during the research work in the laboratory
- to document the experiments in a laboratory notebook
- to describe the experimental techniques used
- to evaluate the experimental techniques and research work

Teaching and Learning methods

The research internship lasts four weeks. The students work full-time in a radiobiological scientific research group. There they are involved in a project that is currently being worked on and are expected to learn and apply all experimental techniques used in the project. During the respective internship and after completion, a written paper is prepared in which the methods used are critically described and discussed about the intended goals of the research project in which the student was involved.

Content

- Issues and methods of translational radiobiological research.

- Cell culture methods, transplantation, and measurement of tumor growth in experimental animals, precise irradiation of biological objects and tumors and organs in experimental animals, as well as their dosimetry
- Quantifying radiation consequences in the used biological objects, such as colony-forming ability or DNA breaks, tumor growth retardation and healing, and functional and morphometric quantification of early and late radiation consequences in tissues.
- Isolation of cells, DNA, and other cellular molecules from irradiated cells and tissues.
- histopathology
- Proteomics and other –omics

Course and examination results

Course work: 100% Bericht

In a report (8-10 pages consisting of abstract, introduction, methods, results, discussion, conclusion, and bibliography), taking into account relevant research literature on the research projects they have worked on, students demonstrate that they have understood the issues of the projects they have worked on and the research methods they have used and can understandably present them.

Module leader: Prof. Dr. Thomas E. Schmid

STRB012: Research Practical: Medical Physics

Module number: STRB012

School of Medicine

Module level: Master

Duration: 1

Frequency: Winter semester

Language: English

ECTS: 6

Workload: 180 Hours

Attendance 160 Hours

Self-study 20 Hours

Prerequisites:

Module 004 of the TUM Master's program Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes

After participating in the module courses, students will be able

- to understand methods of the ongoing physics research projects
- to apply measurement and experimental techniques of the ongoing physics research projects
- to evaluate the methods and objectives of the ongoing physics research projects

Teaching and Learning methods

The internship lasts four weeks. The student works full-time in a medical physics scientific research group. Depending on availability, the student will be involved in a research project currently in progress and will be expected to learn and apply the measurement or experimental techniques used in the project. During the respective internship and upon completion, a written paper is prepared in which the methods used are critically described and discussed concerning the intended goals of the research project in which the student was involved.

Content

- depending on the available research project: use of irradiation planning systems or other relevant software: data transfer of image data, evaluation of dose distributions, etc.

- depending on the available research project: measurements on clinical and/or preclinical irradiation equipment: use of different detector systems
- depending on the available research project: simulation calculations of radiation effects, dose calculation algorithms, evaluation of new techniques in the clinical or pre-clinical field, use of imaging techniques for patients and small animals, special problems of dosimetry

Course and examination results

Course work: 100% Report

In a report, taking into account relevant literature on the research projects they have worked on, students demonstrate that they have understood the issues of the projects they have worked on and the research methods they have used and can understandably present them.

Module leader: Prof. Dr. J. Wilkens/Dr. Stefan Bartzsch

STRB013: Clinical and Experimental Radiation Oncology

Module number: STRB013

School of Medicine

Module level: Master

Duration: 1

Frequency: Wintersemester

Language: English

ECTS: 8

Workload: 240 hours;

- 45 hours of lectures (3 SWS)
- 30 hours seminar (2 SWS)

240 hours self-study

Prerequisites:

Modules 005, 006, 007 of the TUM Master's program Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes

After participating in the module courses, students will be able

- to understand the clinical relationship between the biological effects of radiation on tumors as well as normal tissue
- to analyze the biological mechanisms that can lead to radiation sequelae in co-irradiated tissues weeks, months, or years after radiation therapy
- to describe the clinical manifestations and symptoms of early and late radiation sequelae in irradiated and adjacent organs and tissues
- to explain the relevant factors of radiation planning, such as the definition of the volume to be irradiated, anatomical dose distribution, dose, and fractionation concepts
- to recall the importance of the time factor as well as the different efficacy of dose and fractionation concepts on irradiated tumors and normal tissue
- to evaluate the different responses of the irradiated tumor and the co-irradiated healthy tissues and organs (normal tissues) to radiotherapy in individual patients
- to develop experimental strategies to analyze and evaluate the possible causes of individual radiation sensitivity of tumors and different healthy organs and tissues
- to discuss ways to improve radiation therapy, such as combination treatments of molecular biology or chemotherapeutic therapies with radiation therapy

- to design experimental projects that can test the developed hypotheses in appropriate in vitro and in vivo systems or experimental animals
- to defend the principles of evidence-based radiation oncology in a presentation on a specific clinical problem.

Content:

- The basics of clinical radiation oncology and the methods and goals of translational research in radiation oncology
- the biology of tumor stem cells in vivo and the effects of ionizing radiation on tumor stem cells
- Radiosensitivity of different tumors, curative and palliative radiotherapy, response to therapy, tumor cure, tumor regression, tumor recurrence, metastasis, the interaction of radiotherapy with chemotherapy
- the development of early and late radiation sequelae in the various critical organs, clinical manifestations, dose-volume relationships, pathogenesis, therapy, prognosis
- clinical problems in planning and follow-up radiotherapy of common and critical tumor diseases (mammary Ca, prostate Ca, head and neck tumors, tumors in children, etc.)
- Clinical concepts in radiation oncology as well as combination treatments
- Planning, executing, and evaluating animal experiments on radiation effects on transplanted tumors (xenograft, syngeneic, and orthotopic tumor models).
- Design, conduct, and evaluate animal studies on radiation effects on critical healthy organs: irradiation, clinical, pathological, and molecular biological responses, and interventional studies.
- Ethical and legal principles of animal welfare in research.
- Follow-up after radiotherapy, risk of secondary, therapy-induced malignancies.

Teaching and learning methods

The module consists of lectures and seminars. Lectures will cover in-depth knowledge of the treatment of common cancer entities in radiation therapy and the biological processes of radiation in clinical and experimental radiation oncology. Part of the seminars will take the form of prepared "clinic conferences" in which problems of treatment planning of real patients, in the form of clinic conferences, will be discussed anonymously. In the other part of the seminars, the problems of quantification and description of clinical or experimental data, as well as study design and ethical aspects, will be discussed based on selected results of translational experiments in vitro or in vivo.

Course and examination results

Module grade: Oral examination 100%

The module examination consists of an oral examination in which the student demonstrates knowledge of the relationships between the planned dose and the anatomical dose distribution and the responses of the irradiated tumors and the healthy organs and tissues partially located in the irradiated volume, as well as the criteria for optimizing radiation planning. In addition, the student's ability to develop experimental projects for quantitative testing of such hypotheses based on clinical findings and hypotheses for further improvement of radiation therapy will be assessed. The exam will last 30 min.

Retake options: Module exams may be repeated at the end of the semester.

Module leader

Prof. Dr. Thomas Schmid/Prof. Dr. S. E. Combs

STRB014: Advanced Molecular Radiation Biology

Module number: STRB014

School of Medicine

Module level: Master

Duration: 1

Frequency: Wintersemester

Language: English

ECTS: 8

Workload: 240 Hours;

Attendance 105 h

- 45 h lectures with seminars (3 SWS)
- 60 h practical/workshop (4 SWS)

Self-study 135 Hours

Prerequisites:

Modules 005, 006, 007 of the TUM Master's program Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes:

After participation in the module courses, students will be able

- To describe the molecular mechanisms of radiation-related health disorders
- with knowledge of these changes, to evaluate the design and results of studies on the molecular epidemiology of health disorders following exposure to low doses of radiation
- to evaluate the design and application of biomathematical models for risk analysis of low doses of radiation
- to independently evaluate the design of studies on the molecular biology of radiation-induced health disorders, and their results
- to develop new research approaches to molecular pathogenesis and individual sensitivity to radiation-induced early or late radiation sequelae of radiation therapy
- to present and discuss radiobiological effects at the molecular level understandably and descriptively using a professional and rhetorically confident manner.

Content:

- The knowledge of studies on the molecular biology of radiation-induced health disorders after low doses of radiation.

- The explanation of molecular pathogenesis and individual susceptibility to radiation-induced early or late radiation sequelae of radiation therapy
- Molecular epidemiological studies
- Different biomathematical models for risk analysis
- Molecular biology of heredity
- Ethical aspects of molecular biology radiation research

Teaching and learning methods

The module consists of a lecture on the contents of the module. In the associated practical course and workshop, students give presentations on current research and discuss with fellow students.

Course and examination results

Module grade: Oral Examination 100%

The module exam consists of an oral exam (30min) in which students are expected to recall and remember the Learning Outcomes without aids. The examination consists of comprehension questions on the entire Learning Outcomes of the module. In it, students demonstrate that they can identify and describe specific problems in the molecular pathogenesis of radiation sequelae following low and therapeutically applied doses of radiation and identify ways to resolve them. In addition, students demonstrate that they can explain and evaluate the methods used in the practical courses.

Retake options: Module exams may be repeated at the end of the semester.

Module leader: PD Dr. Omid Azimzadeh / PD Dr. Simone Mörtl

STRB015: Medical Imaging in Radiation Research

Module number: STRB015

School of Medicine

Module level: Master

Duration: 1

Frequency: Wintersemester

Language: English

ECTS: 8

Workload: 240 Hours;

- 45 Hours Lectures (3 SWS),
- 15 Hours Demonstrations/Practical (1 SWS)
- 15 Hours Seminar with presentations (1 SWS)
- Self-study 150 Hours

Prerequisites:

Modules 005, 006, 007 of the TUM Master's program Radiation Biology or equivalent modules of other Master's programs.

Learning Outcomes

After participating in the module courses, students will be able

- To understand the principles of different imaging techniques in research and medicine (especially oncology)
- To understand the technology and application of devices and tracers for imaging in cell and animal studies
- To analyze applications and methods of imaging for the diagnosis and therapy of tumor diseases (theranostics) before and after radiotherapy in research and medicine
- To Prepare scientific issues in the different fields of tumor imaging in the form of a lecture for a specific target audience
- To discuss and evaluate scientific issues in the different fields of tumor imaging

Content

- Fluorescence/radionuclide-based tumor imaging
- PET/Tracer development and application
- MSOT/ultrasound-based imaging
- Metabolic Imaging
- Immune Cell Imaging

- Dark Field (Lung) Imaging
- Theranostics (Nuclear Medicine)
- Imaging devices: SARRP and GULMAY
- Structural imaging with MRI
- MRI/CT anatomical imaging (spectral CT)
- AI applications for ultrasound

Teaching and learning methods

The module consists of lectures and demonstrations as well as a seminar. In the lectures, knowledge of the technical equipment and methods of imaging in radiobiological and medical research is taught. To illustrate the application in research practice, the lectures are accompanied by practical demonstrations. In the seminar, students prepare presentations (examination performance), the topic selected from the subject area of the module.

Course and examination results

Module grade: Presentation 100% with discussion and written paper

The module exam consists of a presentation in the second half of the semester, in which students demonstrate that they can present a specific field of research or research results and their complex issues in the field of imaging tumors after radiotherapy and the theranostic use of tumor-specific tracers in a clear, concise and understandable manner with appropriate media support. The presentation is expected to last 20 minutes, followed by 10 minutes of discussion in which students demonstrate that they can respond knowledgeably to questions and discussion points. In the supplementary written preparation of 3-5 pages, students demonstrate that they can also structure the complex issues in writing and summarize them to their essential core. The final grade results from the weighting of the individual parts, which is calculated as follows: Presentation 50%, discussion 30%, and written preparation 20%.

Module leader:

Gabriele Multhoff / Susanne Kossatz

STRB016: Master's Thesis with Colloquium

Module number: STRB016

School of Medicine

Module level: Master

Duration: 1

Frequency: summer semester

Language: English

ECTS: 30

Workload:

900 hours of self-study, of which 810 hours are spent preparing a master's dissertation and 90 hours are spent preparing for the examination and colloquium.

Prerequisites:

Modules 1 - 15 of the study program Radiation Biology at TUM

Learning Outcomes

After participating in the final module of the master's program in radiation biology, students will be able

- to develop their research project
- to carry out the research project
- to embed the experiments and results in the scientific context
- to produce a thesis based on their research work
- to defend the thesis in front of an examination board
- to discuss and prove the conclusions reached in comparison to the views expressed in the literature

Teaching and Learning methods

These projects cover all areas of radiobiological research and are proposed by collaborating researchers from all European countries. Based on the program developed in Module 7, students independently carry out their projects in the relevant laboratory under the supervision of the respective laboratory director. The TUM expert topic writer, in collaboration with the respective laboratory director or cooperating researcher, supervises the preparation of the Master's Thesis, which must be submitted six months after the official topic assignment by the examination board. A Master's Colloquium follows the Master's Thesis with a presentation and disputation of the thesis.

Content

- Develop and independently realize your research project
- Thesis based on own research work
- Defense of the thesis in front of the examination board

Course and examination results

Module grade:: 90% Master's Thesis, 10% Presentation (Master's colloquium)

The examination performance consists of submitting a Master's Thesis and a Master's Colloquium.

The thesis duration is six months from the official assignment of the topic by the examination board.

The master colloquium follows the passed master's thesis at the latest two months after the announcement of the result and lasts 60 minutes. The colloquium is used to test whether students can present the content of the master's thesis independently, precisely, and clearly. Students should show that they can present convincingly and professionally with rhetorical confidence and answer questions in the context of the topic and discuss it scientifically. Students will have a total of 30 minutes to present their thesis. This will be followed by a discussion that, based on the topic of the Master's Thesis, will cover the broader subject area of the Master's program in context to the topic of the Master's Thesis.

The Master's Thesis can be repeated once with a new topic.