TOMSK POLYTECHNIC UNIVERSITY | ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

Director of Nuclear Science & Engineering School
_____ / Oleg Yu. Dolmatov
"25" 06 2020

Course Name: Radiobiological basics of radiotherapy

Field of Study: Nuclear Science and Technology

Programme name: Nuclear Science and Technology

Specialization: Nuclear medicine

Level of Study: Master Degree Programme

Year of admission: 2019

Semester, year: semester 2, year 1

ECTS: 2

Total Hours: 72

Contact Hours: 32

- **Lectures:** 16
- **Practical experience:** 16

Self-study: 40

Assessment: Exam

Division: Nuclear-Fuel Cycle

Director of Programme _____ / Vera V. Verkhoturova

Instructor _____ / Stanislav A. Vasilyev

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Radiobiological basics of radiotherapy

Course Overview

Course Objectives	The overall aim of the course is to develop professionally-centered competency in the field of experimental and theoretical studies in radiobiology contribute to the radiation therapy. The radiobiology is very fruitful in the generation of new ideas providing a conceptual basis for radiation therapy and in the identification of new treatment strategies developing of specific new approaches in radiation therapy. The learning aim of the course is to achieve the level of professionally-centered competency in the field of radiobiological bases of radiation therapy that is sufficient for practical use of radiobiological models and modern approaches to dosimetry for the safe modes of the radiation therapy planning. The development aim of the course is to evolve cognitive and research skills required conducting interdisciplinary research, self-study and continuous professional development.
Learning Outcomes	**Upon completion of the course, students will be able to demonstrate:** • knowledge of the basics and radiation therapy and radiation dose planning methods based on radiobiological data; • ability to apply radiation therapy methods and radiation dose planning based on radiobiological data for professional activities; • skills of selection and application of radiation therapy methods and radiation dose planning based on radiobiological data; • knowledge of the basic principles of setting and solution methods of innovative engineering and physical problems; • ability to set and solute the innovative engineering and physical problems; • knowledge of the approaches of projects realization in the field of medical physics and nuclear medicine, radiation therapy and radiation dose planning; • ability to realize the projects in the field of medical physics and nuclear medicine, radiation therapy and radiation dose planning; • skills of the innovative engineering and physical problems solution and of the projects realization in the field of medical physics and nuclear medicine, radiation therapy and radiation dose planning. **The results of the discipline development:** • formation of students' professionally-oriented competencies in the field of experimental and theoretical studies in the field of radiobiology, which are the basis of radiation therapy. • achievement of the level of professional-oriented competence in the field of radiobiological basics of radiation therapy, sufficient for practical use of radiobiological models and modern approaches to dosimetry for safe modes of radiation therapy planning. – development of cognitive and research skills required for interdisciplinary research, self-study and continuous professional development.
Course Outline	The course includes 4 sections, which are covered by learners within lectures and practical tutorials, as well as through self-study work.

	Teaching and Learning Strategies: • Interactive lectures • Mini-lectures (text, graphics, audio, video) • Demonstrations • Video presentations • Problem-based learning exercises (scenario examples) • Print-based Materials & Documentation • Group collaboration • Students presentations and reports • Testing. Students' knowledge and skills are assessed trough grading activities, among which testing is used. There are 4 tests planned for this course. Each test runs in a written form and includes 3 test questions and 1 test task to be solved. Performance of each test is scored with 20 points maximum. The course finishes with the examination, which runs orally. Learners shall provide oral answers to 4 exam questions included in the examination paper. Each correct answer is scored with 5 points. The maximum score for the examination which can be gained by learners for the exam is 20 points.
Course Structure	**Section 1. Radiation-induced damage and recovery of DNA, chromosomes and cell** **1.1** Review of interaction of radiation with matter, DNA damage and repair. Review of interaction of radiation with matter: types of radiation, mechanisms of radiation absorption, ionization density. Radiation injury to DNA: radiation chemistry of water, structure of DNA and radiation-induced lesions, double-strand breaks. Repair of DNA damage: excision repair, repair of double-strand breaks. **1.2** Radiation-induced chromosome damage and repair and survival curve theory. Radiation-induced chromosome damage and repair: chromosome biology and aberrations, linear-quadratic model. Survival curve theory: target theory, survival curve models, single-hit multitarget model, linear-quadratic model, cellular sensitivity, mechanisms of cell killing. **1.3** The processes of cell death and cellular recovery Cell death: concepts of cell death, apoptosis, reproductive cell death. Cellular recovery processes: types of radiation damage, potentially lethal and sublethal damage, fractionation effort, dose rate effects. **1.4** Cell cycle and cell kinetics. Cell Cycle: cell kinetics and cycle phases, radiosensitivity and cell cycle position, radiation effects on cell cycle. Cell kinetics: the cell cycle and quantitation of its constituent parts, the growth fraction and cell loss from tumors, autoradiography and flow cytometry, the growth kinetics of human tumors. **Section 2. The effects of radiation quality and chemical substances** **2.1** The effects of radiation quality and chemical substances Modifiers of radiation response – sensitizers and protectors: oxygen effect and other radiosensitizers, radioprotection. Relative biological effectiveness (RBE), oxygen enhancement ratio (OER), linear energy transfer (LET). Drug radiation interactions

	Section 3. Radiation-induced response in tumors and healthy tissues **3.1** Radiation injury to tissues and radiation pathology Radiation injury to tissues: tissue and organ anatomy, expression and measurement of damage. Radiation pathology – acute and late effects, acute and late responding normal tissues, pathogenesis of acute and late effects, different kinds of late responses, residual damage/radiation syndromes/clinical total body irradiation (TBI). Histopathology: general morphology of radiation injury, morphology of cell death, morphologic changes in irradiated tumors. **3.2** Tumor radiobiology and 4 R's of radiobiology Tumor radiobiology: basic tumor structure and physiology, importance of hypoxic cells in tumors and importance of reoxygenation. Time, dose, and fractionation: the 4 R's of radiobiology, volume effects, the basis of fractionation, dose-response relationships for early and late responding normal tissues, hyperfractionation and accelerated treatments, hypofractionation and high doses per fraction, α/β model. **Section 4. Radiation genetics** **4.1** Radiation genetics. Radiation genetics: radiation effects of fertility and mutagenesis: target cells for infertility, doses to result in temporary and permanent sterility, reverse-fractionation effect, mechanisms of mutation induction, relative risk vs. absolute risk, time course and latency period/risks of cancer induction in different sites. Molecular mechanisms of radiation genetics: molecular cloning techniques, gene analyses, oncogenes and tumor suppressor genes.
Facilities and Equipment	1. Room for lectures and practical experiences with multimedia equipment (projector, PC): 634050, Tomsk, Lenina Ave., building 10, room 125A.
Grading Policy	In accordance with TPU rating system we use: • Current assessment which is performed on a regular basis during the semester by scoring the quality of mastering of theoretical material and the results of practical activities (performance tests, perform tasks). Max score for current assessment is 80 points, min – 44 points. • Course final assessment (exam) is performed at the end of the semester. Max score for course final assessment is 20 points, min – 11 points. The final rating is determined by summing the points of the current assessment during the semester and exam (credit test) scores at the end of the semester. Maximum overall rating corresponds to 100 points, min pass score is 55.
Course Policy	Class attendance will be taken into consideration when evaluating students' participation in the course (students are expected to actively engage in class discussions about the assigned readings). Attendance is strictly controlled. All classes are obligatory to presence.
Teaching Aids and Resources	**Compulsory reading:** 1. Gopal B. Physics and Radiobiology of Nuclear Medicine / Gopal B. Saha. – 4th edn. - New York: Springer Science+Business Media, Inc., 2013. - 219 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-1-4614-4012-3 (дата обращения: 20.09.2020). Режим доступа: по подписке. 2. Joiner, M. Basic Clinical Radiobiology / M. Joiner, A. van der Kogel. - 4th edn. - London: Edward Arnold, – 2009. – 375 p. - Текст: электронный – URL: https://phyusdb.files.wordpress.com/2013/03/basic-clinical-

	radiobiology.pdf (дата обращения: 20.09.2020). – Режим доступа: свободный из сети интернет. 3. Beyzadeoglu M. Basic Radiation Oncology / M. Beyzadeoglu, G. Ozyigit, C. Ebruli. – Berlin: Springer-Verlag Heidelberg, 2010. – 575 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-642-11666-7 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. **Additional reading:** 1. Sourati, A. Acute Side Effects of Radiation Therapy. A Guide to Management / A. Sourati, A. Ameri, M. Malekzadeh. – Cham: Springer International Publishing, 2017. – 217 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-319-55950-6 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 2. Clinical Radiation Oncology / editors L. Gunderson, J. Tepper. - fourth edition. – Amsterdam : Elsevier, 2016. - Текст: электронный // ScienceDirect. – URL: https://www.sciencedirect.com/book/9780323240987/clinical-radiation-oncology (дата обращения: 20.09.2020). Режим доступа: по подписке.
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