Course Plan: Radiobiology (2 Credits)

Course Information

Course Title: Radiobiology
Level: M.Sc. In Medical Physics
Credits: 2 Credit Hours
Format: 2 Hours Lecture per Week

Course Description

This course provides a comprehensive introduction to the biological effects of ionizing radiation on living systems, from molecular damage to whole-body responses. Based on the foundational textbook by Eric J. Hall and Amato J. Giaccia, the curriculum covers the physical, chemical, and physiological bases of radiation cytotoxicity, mutagenesis, and carcinogenesis, with strong emphasis on clinical applications in radiation oncology and radiology .

Overall Learning Objectives

Upon successful completion of this course, students will be able to:

1. **Describe** the physical and chemical mechanisms of radiation absorption at the molecular level.
2. **Explain** DNA damage and repair pathways, chromosomal aberrations, and cell survival kinetics.
3. **Analyze** factors affecting radiosensitivity, including cell cycle, oxygen effect, LET, and RBE.
4. **Apply** radiobiological principles to clinical fractionation schedules and treatment planning.
5. **Evaluate** acute and late effects of radiation on normal tissues and tumors.

6. **Interpret** dose-response relationships for radiation carcinogenesis and heritable effects.
7. **Discuss** the role of radiosensitizers, radioprotectors, and alternative radiation modalities in modern therapy.
8. **Critically assess** published radiobiological literature and clinical trial data.

Expectations (What You Will Be Able to Do After This Course)

Area	Specific Outcomes
Clinical Application	Explain the rationale behind fractionation schemes (e.g., 2 Gy per fraction) to clinicians and patients.
Problem-Solving	Calculate cell survival using linear-quadratic (LQ) model for different fractionati regimens.
Risk Assessment	Estimate cancer risk and hereditary effects from occupational or patient radiati exposures.
Treatment Optimization	Recommend strategies to exploit tumor hypoxia and reoxygenation in radiotherapy.
Research Literacy	Read and interpret cell survival curves, dose-response graphs, and experimenta radiobiology papers.
Safety Competency	Apply radiobiological principles to radiation protection and ALARA practices.

Weekly Course Schedule (15 Weeks + Exams)

Week	Topic	Key Content
1	Introduction & Radiation Absorption	Course overview, physics and chemistry of radiation absorption, direct and indirect effects, free radicals
2	DNA Damage and Chromosomal Aberrations	DNA strand breaks (SSB, DSB), types of chromosomal aberrations, repair mechanisms (HR, NHEJ)
3	Cell Survival Curves	Historical development, in vitro vs in vivo survival curves, linear-quadratic (LQ) model, α/β ratio
4	Radiosensitivity and Cell Cycle	Variation in radiosensitivity across cell cycle phases (G2/M most sensitive, S phase resistant), cell synchronization
5	Repair of Radiation Damage	Sublethal and potentially lethal damage repair, dose-rate effect (protraction vs fractionation), repair kinetics
6	Oxygen Effect and Reoxygenation	Oxygen enhancement ratio (OER), mechanisms of oxygen effect, tumor hypoxia, reoxygenation during fractionated RT
7	LET and RBE	Linear Energy Transfer (LET), Relative Biological Effectiveness (RBE), RBE-LET relationship, clinical implications for particle therapy
8	**Midterm Exam**	Comprehensive review of weeks 1–7
9	Acute Radiation Syndrome	Total-body irradiation effects, LD50/60, bone marrow, GI, and CNS syndromes, medical management
10	Radiation Carcinogenesis & Heritable Effects	Mechanisms of radiation-induced cancer, dose-response models, heritable genetic effects, risk estimation
11	Effects on Embryo, Fetus & Lens	Teratogenic effects, critical periods, radiation cataractogenesis, threshold doses
12	Cancer Biology & Tumor Systems	Oncogenes, tumor-suppressor genes, apoptosis, tumor growth kinetics, model tumor systems
13	Time, Dose, and Fractionation	4 R's of radiobiology (Repair, Reoxygenation, Redistribution, Repopulation), clinical fractionation schedules, BED and EQD2 calculations

Week	Topic	Key Content
14	Radiosensitizers, Bioreductive Drugs & Radioprotectors	Mechanisms and clinical use of hypoxic cell sensitizers, bioreductive drugs, chemical radioprotectors (e.g., amifostine)
15	Alternative Modalities & Emerging Topics	Particle therapy (protons, carbon), FLASH-RT, BNCT, combination with immunotherapy, molecular imaging
16	**Final Exam**	Comprehensive coverage of all topics

Assessment (Proposed)

Component	Weight
Homework / Problem Sets	10%
Quizzes	10%
Midterm Exam	30%
Final Exam	40%
Participation / Discussion	10%
Total	**100%**

Alternative: Some programs include an oral presentation (30%) and written report (30%) for graduate-level emphasis .

Primary Textbook

Hall, E. J., & Giaccia, A. J. *Radiobiology for the Radiologist*. 8th edition (or current edition). Lippincott Williams & Wilkins .

Note: The 8th edition includes new chapters on Radiological Terrorism, Molecular Imaging, and Retreatment after Radiotherapy .

Recommended Prerequisites

- One year each of **Biology**, **Physics**, and **Organic Chemistry** (or instructor approval)
- Elementary algebra and graph interpretation skills

Teaching Methods

- **Lectures** with PowerPoint presentations and board work
- **Problem-solving sessions** (survival curve calculations, BED/EQD2 examples)
- **Case-based discussions** linking biology to clinical scenarios
- **Paper discussions** (optional for graduate-level depth)

Final Takeaway

By the end of this course, you will master the biological principles that underpin modern radiation therapy and radiology, enabling you to think critically about treatment prescriptions, radiation risks, and emerging therapeutic strategies. You will speak the language of radiobiology fluently, bridging the gap between physics, biology, and clinical practice.