



**American College of Veterinary Radiology
Radiation Oncology Board Certification Examination Program**

**1. Radiation and Tumor Biology
Examination Content Outline**

1. DNA and Chromosome Structure, and Repair: 10

- A. Describe the structure of DNA and chromosomes.
- B. Describe DNA replication and control.
- C. Describe DNA binding domains, transcription and translation.
- D. Describe single nucleotide polymorphisms.
- E. Describe proto-oncogenes, oncogenes and tumor suppressor genes.
- F. Define genomic instability.
- G. Describe the difference and significance of somatic and germline mutations.
- H. Describe and understand commonly known mutations that are associated with cancer, including hereditary syndromes.
- I. Describe chromosomal mutations (e.g., translocation, deletion, inversion, single strand break, double strand break) and their significance in cancer.
- J. Describe DNA/chromosomal repair pathways (e.g., nucleotide excision repair, base excision repair, mismatch repair, homologous and non-homologous end joining) and resultant disease processes when these pathways do not function correctly.
- K. Describe internal tandem duplication.
- L. Describe epigenetics as it relates to gene regulation, tumorigenesis and therapy.
- M. Interpret indirect methods of assessing DNA damage and repair. (e.g. Comet assay, gamma H2AX assays).

2. Cellular Signaling and Molecular Pathways: 10 items

- A. Describe autocrine and paracrine signaling.
- B. Explain the role of phosphorylation in cell signaling.
- C. Explain and apply knowledge of common signaling pathways in human and veterinary cancer (e.g., Kit signaling, EGF family of receptors and signaling pathways, FGF family and signaling, TGF- β superfamily and signaling, MAPK signaling pathway, Wnt pathway, Hedgehog pathway, JAK-STAT cytokine pathways).
- D. Explain pathways that regulate apoptosis and their potential dysfunction in cancer and therapeutic implications.

3. Radiosensitivity/Radiobiology: 60 items

- A. Describe the cell cycle's response to radiation exposure.
- B. Describe radiation carcinogenesis.

- C. Describe and explain radiation syndromes associated with accidental exposure.
- D. Describe the indirect and direct actions of radiation.
- E. Draw and interpret cell survival curves for different types of radiation, tissues and for different models of radiation response such as the linear quadratic model and the multitarget model.
- F. Calculate plating efficiency and surviving fraction.
- G. Describe and calculate the oxygen enhancement ratio.
- H. Describe potentially lethal damage repair and sublethal damage repair.
- I. Describe the dose-rate effect and the inverse dose-rate effect for different radiation modalities.
- J. Describe the principles of low dose and high dose rate brachytherapy.
- K. Explain the principles of radiosensitizers and radioprotectors.
- L. Describe and recognize relative biological effectiveness (RBE) and describe factors that affect it.
- M. Describe and recognize linear energy transfer (LET) and describe factors that affect it.
- N. Describe radiation therapeutic index and how it relates to tumor control probability (TCP) and normal tissue complications (NTCP).
- O. Describe the radiobiology of early and late effects as well as consequential late effects.
- P. Explain functional subunits and how it relates to tolerance doses.
- Q. Describe Casarett's classification of tissue radiosensitivity (I-IV).
- R. Describe Michalowski's H- and F- type populations.
- S. Describe endothelial and vascular responses to radiation therapy.
- T. Describe growth factors in the pathophysiology of radiation-induced tissue changes.
- U. Describe and explain the 4 R's (5 R's) of radiobiology.
- V. Define the nominal standard dose.
- W. Explain mechanisms of action and theory of boron neutron capture therapy.
- X. Explain mechanisms of action and theory of intraoperative radiation therapy.
- Y. Explain mechanisms of action and theory of hyperthermia.
- Z. Calculate and compare Biological Effective Dose (BED) for different radiation dose fractionation protocols for different tissues and understand the limitations of its use.
- AA. Calculate alpha/beta ratios from cell survival curves.
- BB. Describe effective and equivalent dose.
- CC. Describe stochastic and deterministic effects of radiation.
- DD. Recognize radiation-induced cancer in humans and animals.
- EE. Apply occupational exposure limits and define the roles of regulatory agencies.
- FF. Draw and interpret isoeffect curves.
- GG. Explain significance of time, dose and fractionation.

4. Cell Cycle and Cell Death: 10 items

- A. Describe the cell cycle, its regulation, dysregulation and its significance in malignant transformation, tumorigenesis and tumor progression.
- B. Describe mechanisms of cell injury and death following irradiation; including, but not limited to:
 - 1. abscopal effect.
 - 2. bystander effect.
 - 3. apoptosis.
 - 4. mitotic cell death
 - 5. necrosis.
 - 6. autophagy.
 - 7. senescence.

- C. Interpret apoptosis assays

5. Tumor Growth, Angiogenesis, Metastasis, and Microenvironment: 10 items

- A. Describe carcinogenesis via initiation, promotion, progression.
- B. Describe tumor growth and Gompertzian growth for solid tumors.
- C. Explain the Warburg Effect.
- D. Describe angiogenesis and theoretical mechanisms of action and targets of antiangiogenic drugs.
- E. Describe the principles of the seed and soil hypothesis of metastasis versus anatomic patterns of metastasis.
- F. Describe the steps in the metastatic cascade.
- G. Explain selective pressure for metastasis.
- H. Explain epithelial-to-mesenchymal transition and mesenchymal-to-epithelial transition.
- I. Explain the cancer stem cell theory including the rationale behind targeting cancer stem cells for therapy.
- J. Describe models of tumor heterogeneity.
- K. Describe tumor hypoxia including acute and chronic hypoxia and its causes and effects.
- L. Describe pathways and genes affected by hypoxia including HIF-1alpha.
- M. Describe methods for measuring tumor hypoxia.
- N. Describe basics of tumor immunology including immune editing.