The goal of radiation therapy is to deliver a therapeutic dose of radiation to target tissues while minimizing the risks of normal tissue complications. Until recently, the quality of a radiation treatment plan has been judged by physical quantities, i.e., dose and dose-volume parameters, thought to correlate with biological response rather than by estimates of the biological outcome itself. Developments in our understanding of advantages and limitations of existing dose-response models begin to allow the incorporation of biological concepts and outcome date into a routine treatment planning process. Any use of dose-response (outcome) models that involves feedback from a model during the treatment planning process is referred here as biologically based treatment planning, which aims to design dose distributions that would produce the desired balance between tumor cure and normal tissue injury based on the knowledge of biological properties of the particular tumor and surrounding normal tissues. Such a multidimensional problem is most appropriately addressed in the framework of inverse treatment planning presently employed for the optimization of IMRT plans and will rely on models to describe relationships between dose distributions and biological outcomes. The feedback may be either passive/automated in the case of inverse treatment planning, or with active participation from the planner in the case of forward treatment planning. Treatment planning tools that use biologically-related models for plan optimization and/or evaluation are being introduced for clinical use. A variety of dose response models and quantities along with a series of organ-specific model parameters are included in these tools. However, due to factors such as the limitations of models and available model parameters, the incomplete understanding of dose responses, and the inadequate clinical data, the use of biologically-based treatment planning system represents a paradigm shift and can be potentially dangerous. There will be a steep learning curve for most planners.

This presentation will (1) briefly review dose-response modeling, (2) discuss advantages, strategies, limitations for using biophysical models and model parameters in clinical treatment planning, (3) point out dosimetrical differences between biologically based and physical dose (dose-volume) based treatment plan optimization and evaluation, and (4) provide general QA methodology for biologically-based models in treatment planning process.

Learning Objectives:

- Understand advantages and limitations for using biologically-related models for treatment planning;
- Understand differences between the use of biologically-based and dose-volume based treatment plan optimization and evaluation;
- Understand general QA methodology of a biologically based planning system.