

# Positron Emission Tomography (PET)- Computed Tomography (CT) Curriculum

*Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3917 and the Society of Nuclear Medicine Technologist Section, 1850 Samuel Morse Drive, Reston, VA 20190.*

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# Introduction

The Society of Nuclear Medicine Technologist Section (SNMTS) and the American Society of Radiologic Technologists (ASRT) convened a consensus conference to discuss the personnel issues involved in performing fusion imaging. Conference participants included technologists, physicians and educators, as well as representatives from state regulatory agencies, companies that manufacture hybrid imaging equipment and supply radiopharmaceuticals, educational accreditation agencies, certification bodies and professional associations.

The goal of the conference was to develop specific recommendations for the education and regulation of personnel who operate hybrid imaging equipment. Conference participants, by offering these recommendations in the form of consensus statements, hoped to ensure safe, high-quality care for all patients who undergo fusion imaging examinations.

A consensus statement addressing personnel qualified to operate PET-CT equipment states:

*Any registered radiographer with the credential R.T.(R), registered radiation therapist with the credential R.T.(T), or registered certified nuclear medicine technologist with the credentials R.T.(N) or CNMT may operate PET-CT equipment after obtaining appropriate additional education or training and demonstrating competency.*

Participants recommended that multiple pathways be created to educate or train registered/certified nuclear medicine technologists, radiographers, CT technologists and radiation therapists to operate PET-CT equipment. Conference participants acknowledged that each individual will require varying amounts of additional education, depending upon his or her background, skills and experience.

The primary responsibility of an individual operating any type of medical imaging equipment is to obtain the best image quality while delivering the smallest radiation dose possible. For hybrid imaging examinations such as PET-CT, the technologist must be competent in every aspect of the examination, not just one component of it, in order to maximize quality and minimize dose. Quality patient care hinges upon the qualifications of the person performing the procedure.

A PET/CT Project Group meeting was convened by the ASRT and SNMTS to identify the skills and knowledge required for technologists performing PET-CT studies and to recommend educational pathways for technologists to transition to PET-CT. This document is a reflection of the outcomes of this meeting.

The document is divided into three sections: foundations, content specifications for basic nuclear medicine and computed tomography and PET for dual modality imaging, followed by a table representing a gap analysis of content.

The foundations section represents an inventory of pre-existing knowledge and skills gained through an entry-level radiography or nuclear medicine educational experience and reinforced through professional practice. The content in the foundations section is intended to aid

technologists in career planning and program managers in the development of preassessment tools for candidate selection into a fusion imaging educational program.

The basic nuclear medicine and computed tomography and PET for dual modality imaging sections are representative of the skill and knowledge elements applied to this form of fusion imaging.

The skill and knowledge elements are carried over to the gap analysis. Check marks indicate elements associated with PET-CT fusion imaging that are present in existing curriculum documents and/or found in existing educational programs of the specialties indicated. Elements that are not checked for a given specialty are intended as a guide for the development of educational pathways for technologists to transition to PET-CT fusion imaging. The following is a list of participants who contributed to the fusion imaging initiative, with their organizational affiliations.

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# Foundations

## **Computers in Radiologic Sciences**

Content is designed to introduce knowledge in computing and information processing. Computer applications in the radiologic sciences related to image capture, display, storage and distribution are presented.

## **Contrast Media**

Content is designed to impart an understanding of contrast media used during common diagnostic procedures. Topics include an overview of the chemical makeup and physical properties of select contrast agents, selection of contrast agents for specific exams, patient risk factors, premedication strategies, indicators/symptoms of a patient contrast media reaction and recommendations for care and treatment of patients experiencing reaction to a given contrast agent.

## **Ethics and Law in the Radiologic Sciences**

Content is designed to provide a fundamental background in ethics. The historical and philosophical basis of ethics, as well as the elements of ethical behavior, will be discussed. The student will examine a variety of ethical issues and dilemmas found in clinical practice.

An introduction to legal terminology, concepts and principles also will be presented. Topics include misconduct, malpractice, legal and professional standards and the ASRT scope of practice. The importance of proper documentation and informed consent is emphasized.

## **Human Diversity**

Content is designed to promote better understanding of patients, patients' families and professional peers through comparison of diverse populations based on their value systems, cultural and ethnic influences, communication styles, socioeconomic influences, health risks and life stages. Content will include the study of factors that influence relationships with patients and professional peers. Understanding human diversity assists the student in providing better patient care.

## **Human Structure and Function**

Content is designed to establish a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems will be described and discussed.

## **Image Analysis**

Content is designed to provide a basis for analyzing patient images. Included are the importance of minimum imaging standards, discussion of a problem-solving technique for image evaluation and the factors that can affect image quality. Actual images will be included for analysis.

**Imaging and Processing**

Content is designed to establish a knowledge base in factors that govern and influence the production and recording of images. Film and electronic imaging with related accessories will be emphasized. Class demonstrations/labs are used to demonstrate application of theory.

**Medical Terminology**

Content is designed to provide an introduction to the origins of medical terminology. A word-building system will be introduced, and abbreviations and symbols will be discussed. Also introduced will be an orientation to the understanding of patient exam orders and interpretation of diagnostic reports. Related terminology is addressed.

**Patient Care in Radiologic Sciences**

Content is designed to provide the basic concepts of patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures will be described, as well as infection control procedures utilizing standard precautions. The role of the technologist in patient education will be identified.

**Pharmacology and Drug Administration**

Content is designed to provide basic concepts of pharmacology. The theory and practice of basic techniques of venipuncture and the administration of diagnostic contrast agents and/or intravenous medications is included. The appropriate delivery of patient care during these procedures is emphasized.

**Radiation Biology**

Content is designed to provide an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

**Radiation Production and Characteristics**

Content is designed to establish a basic knowledge of atomic structure and terminology. Also presented are the nature and characteristics of radiation, x-ray production and the fundamentals of photon interactions with matter.

**Radiation Protection**

Content is designed to present an overview of the principles of radiation protection including the responsibilities of the technologist for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

**Sectional Anatomy**

Content is designed to study normal sectional anatomy via diagrams and diagnostic images.

# Content Specifications for Basic Nuclear Medicine and PET for Dual Modality Imaging

*Please note that italics represent content specification for PET.*

## **I. Radiation Protection**

- A. Personal protection and monitoring
  - 1. Basic concepts
  - 2. Personnel protection, source shielding
  - 3. Personnel monitoring devices, extremity monitoring
  - 4. Nuclear Regulatory Commission (NRC) regulation
  
- B. Area / facilities monitoring
  - 1. Basic concepts
  - 2. Survey equipment and techniques
  - 3. NRC regulations
  
- C. Packaging and storage of radioactive materials
  - 1. Inspection of incoming and outgoing materials
  - 2. Storage of radiopharmaceuticals
  - 3. Documentation
  - 4. Accountability
  
- D. Radioactive decontamination
  - 1. Area
  - 2. Personnel
  - 3. Patients
  
- E. Disposal of radioactive waste
  - 1. Release to environment
  - 2. Decay in storage
  - 3. Incineration
  - 4. Transfer to authorized recipient
  
- F. Medical events
  - 1. Definitions
  - 2. Regulations for reporting and notification

## **II. Radionuclides and Radiopharmaceuticals**

- A. Physical properties of radioactive materials
  - 1. Types of emissions (decays)
  - 2. Energies
  - 3. Decay rate and half-life (physical half-life)
  - 4. Radiopharmaceutical quality control
  - 5. Clearance from the body (biological half-life)
  - 6. Kinetics of distribution in the body

- B. Dosage determination
  - 1. Calculation of radiopharmaceutical/pharmaceutical doses
  - 2. Calculation of pediatric dose
  - 3. Volume determination
  - 4. Units – calculations and conversions
  - 5. *Dose determination according to scan mode and crystal type*
  
- C. Dosage preparation and administration
  - 1. Verify correct radiopharmaceutical for exam
  - 2. Preparation for administration
  - 3. Assay in dose calibrator
  - 4. Proper radiopharmaceutical labeling
  - 5. *Administration technique*
  - 6. *Administration records*
  - 7. *Residual dose measurements*
  - 8. Dose charting
  
- D. PET radiopharmaceutical principles
  - 1. *Positron decay*
  - 2. *Positron energy and effect on resolution*
  - 3. *Coincidence events*
  - 4. *Bremsstrahlung radiation*
  - 5. *Decay factors*
  - 6. *Exposure rates*
  - 7. *Half-value layer(HVL) – lead and concrete*
  - 8. *Branching fraction*
  
- E. Radiation safety with positron decay
  - 1. *Hot cells*
  - 2. *Facility monitoring considerations*
  - 3. *Personnel monitoring considerations*
  - 4. *Exposure from patients*
  
- F. Radionuclide production
  - 1. *Cyclotron*
    - a. *Basic concept*
    - b. *Targets*
    - c. *Large and small volume*
    - d. *Liquid or gas*
  
- G. Synthesis of radiopharmaceuticals
  - 1. *Basic chemistry*
  - 2. *Synthesis modules*
  
- H. Rubidium generators

1. *Regulations*
2. *Quality control*
3. *Dose assay*
4. *Dose administration*
5. *Storage*
6. *Disposal*

### III. Instrumentation / Quality Control

- A. Survey meter
  1. Operating principles
  2. Quality control consistent with NRC regulations
  3. Source selection
  4. Interpretation of QC results
  
- B. Dose calibrator
  1. Operating principles
  2. Types of quality checks
  3. Frequency of quality checks
  4. Source selection
  5. Interpretation of results
  
- C. Scintillation detector systems
  1. Principles of scintillation detection
  2. Properties of detector materials
    - a. Material types
    - b. Atomic number
    - c. Delay time
    - d. Conversion efficiency
  3. *PET detector materials*
    - a. *Sodium iodide (NaI)*
    - b. *Bismuth germinate (BGO)*
    - c. *Lutetium oxyorthosilicate (LSO)*
    - d. *Gadolinium oxyorthosilicate (GSO)*
      - 1) *System types*
        - a) *Terminology*
          - (1) *Aperture size*
          - (2) *Field of view*
          - (3) *Overlap*
          - (4) *Bed positions*
        - b) *Dedicated PET*
          - (1) *Full ring tomograph*
          - (2) *Partial ring tomograph*
          - (3) *Panel detector*
        - c) *PET-CT combined*
        - d) *Gamma PET camera*
      - 2) *Quality control*

- a) *Normalization*
- b) *Blank scan*
- c) *Gains (singles)*
- d) *Cross-calibration*
- 3) *System performance*
  - a) *Scatter fraction*
  - b) *Noise equivalent count rate*
  - c) *National Electrical Manufacturers Association (NEMA) standards and testing*

D. *Theory of operation*

1. *Principles of coincidence detection*

- a. *True coincidence*
- b. *Lines of response (LOR)*
- c. *Randoms*
- d. *Scatter*
- e. *Delayed event*
- f. *Coincidence window and timing*

2. *Image formation and reconstruction*

- a. *Sinograms*
  - 1) *2-D*
  - 2) *3-D*
  - 3) *Fourier rebinding*
  - 4) *Single slice rebinding*
    - a) *Filtered back projection (FBP)*
    - b) *Iterative reconstruction*
      - (1) *Ordered subset expectation maximization (OSEM)*
      - (2) *Maximum likelihood expectation maximization (MLEM)*
  - c) *Image filters*
  - d) *Matrix selection*
- b. *Data processing and corrections*
  - 1) *Normalization corrections*
  - 2) *Decay corrections*
  - 3) *Dead time corrections*
  - 4) *Arc corrections*
  - 5) *Randoms corrections*
  - 6) *Scatter corrections*
  - 7) *Attenuation corrections*
    - a) *Calculated (mathematical)*
    - b) *Measured*
      - (1) *Patients with and without activity*
    - c) *Segmentation*
    - d) *CT*
    - e) *No corrections*

#### IV. Diagnostic Procedures

- A. Radiopharmaceutical characteristics
  - 1. *Half-life of PET radioisotopes and radiopharmaceuticals*
  - 2. *Method of localization*
    - a. *FDG kinetics*
    - b. *Target organs*
    - c. *Radiopharmaceutical biodistribution and normal variants*
  - 3. *Dose considerations*
  
- B. Administration of radiopharmaceuticals
  - 1. *Routes*
  - 2. *Intravenous injection techniques*
  - 3. *Factors affecting biodistribution*
    - a. *Cardiology*
      - 1) *Glucose level*
      - 2) *Insulin level*
    - b. *Neurology*
      - 1) *Stimulation*
      - 2) *Surgical variants*
      - 3) *Radiation treatment*
      - 4) *Insulin/glucose levels*
      - 5) *Psychotropic drugs*
      - 6) *Ictal vs. inter-ictal state*
    - c. *Oncology*
      - 1) *Insulin/glucose levels*
      - 2) *Exercise*
      - 3) *Chemotherapy*
      - 4) *Radiation therapy*
      - 5) *Surgery or biopsy*
      - 6) *Hemopoietins*
      - 7) *Muscle tension*
      - 8) *Hydration*
      - 9) *Inflammatory disease*
      - 10) *Room temperature*
  
- C. Administration of pharmaceuticals
  - 1. *Use case for administering pharmaceuticals*
    - a. *Basic concepts*
      - 1) *Indications*
      - 2) *Contraindications*
      - 3) *Adverse reactions*
      - 4) *Medication interactions*
        - a) *Dosing and route of administration*
  - 2. *Pharmaceuticals*
    - a. *Cardiology*
      - 1) *Dobutamine*

- 2) *Adenosine*
  - 3) *Dipyridamole*
  - 4) *Glucose*
  - 5) *Insulin*
  - 6) *Hyperinsulinemic-euglycemic clamp*
  - b. *Neurology*
    - 1) *Sedatives*
    - 2) *Antiseizure*
  - c. *Oncology*
    - 1) *Diuretics*
    - 2) *IV and oral hydration*
    - 3) *Sedative drugs (Valium)*
    - 4) *Insulin*
- D. Gated procedures
- 1. Equipment
  - 2. ECG lead placement
  - 3. Sources of error
    - a. Patient arrhythmia
    - b. Equipment error
    - c. User error
- E. *Acquisition modes*
- 1. *2-D*
  - 2. *3-D*
  - 3. *Emission*
  - 4. *Transmission*
  - 5. *Single bed positron*
  - 6. *Dynamic imaging*
  - 7. *Whole-body imaging*
- F. *Imaging procedures*
- 1. *Cardiology*
    - a. *Patient preparation*
    - b. *History and assessment*
    - c. *Indications and contraindications*
    - d. *Exercise*
    - e. *Uptake time*
    - f. *Patient positioning*
    - g. *Imaging indications*
      - 1) *Rest and stress perfusion*
      - 2) *Myocardial viability*
        - a) *Artifacts*
  - 2. *Neurology*
    - a. *Patient preparation*
    - b. *History and assessment*

- c. *Indications and contraindications*
  - d. *Uptake time*
  - e. *Patient positioning*
  - f. *Imaging indications*
    - 1) *Epileptic seizures*
    - 2) *Dementia*
    - 3) *Tumor*
    - 4) *Movement disorders*
3. *Oncology*
- a. *Patient preparation*
  - b. *History and assessment*
  - c. *Indications and contraindications*
  - d. *Uptake time*
  - e. *Patient positioning*
  - f. *Fiducial marker use and placement*
  - g. *Imaging techniques*
  - h. *Imaging indications*
    - 1) *Colon cancer*
    - 2) *Head/neck cancer*
    - 3) *Esophageal cancer*
    - 4) *Lung cancer*
    - 5) *Breast cancer*
    - 6) *Melanoma*
    - 7) *Lymphoma*
    - 8) *Thyroid cancer*
    - 9) *Ovarian cancer*
    - 10) *Sarcoma*
    - 11) *Other indications*

G. *Image artifacts*

- 1. *Normal variants of radiopharmaceutical distribution*
- 2. *Physiologic artifacts*
  - a. *Muscle tension*
  - b. *Organ movement*
  - c. *Active tension*
  - d. *Patient motion*
  - e. *Injection sites/tubing*
  - f. *Urinary catheter lines*
  - g. *Metal*
  - h. *Misalignment of emission and transmission*

H. *Computerized data processing*

- 1. *Quantitative analysis*
  - a. *Region of interest (ROI)*
  - b. *Time activity curves (TAC)*
  - c. *Standard uptake values (SUV)*

- 1) *Calculations*
      - 2) *Sources of error*
    - d. *Metabolic flow rate measurement and analysis*
    - e. *R to L count profiles and histogram*
    - f. *Cardiac polar map*
  - 2. *Image reconstruction variants*
- I. *Image fusion / image registration*
  - 1. *Basic principles*
    - a. *Interactive registration*
    - b. *Landmark based registration*
    - c. *Surface matching*
    - d. *Automatic imaging registration*
    - e. *Registration by maximization of mutual information*
    - f. *Elastic registration to Talairach Atlas*
  - 2. *Fiducial markers*
- J. *Image display, manipulation, recording and archiving*
  - 1. *Display*
    - a. *Cathode ray tube (CRT)*
  - 2. *Recording*
    - a. *Film*
      - 1) *Multiformat camera*
      - 2) *Laser camera*
    - b. *Archiving*
      - 1) *Tapes*
      - 2) *Disks*
      - 3) *Laser and optical disks*
- K. *Patient scheduling*
  - 1. *Proper procedure sequencing*
  - 2. *Awareness of current Medicare regulations*
  - 3. *Women age 12 – 55 years scheduling preference within 10 days of onset of last menses.*

# Content Specification for Basic CT and PET for Dual Modality Imaging

## I. Patient Care

- A. Venipuncture
  - 1. Site selection
  - 2. Pathology
  - 3. Use of current line
  - 4. Injection techniques (manual/automatic)
  - 5. Associated problems
    - a. Air embolism
    - b. Extravasation
  
- B. Contrast media agents
  - 1. Oral
  - 2. IV – ionic/nonionic
  - 3. Rectal
  - 4. Intrathecal
  - 5. Catheters
  - 6. Types/indication/chemical makeup etc.
  - 7. Routes – dose calculations (adult vs. pediatric)
  - 8. Iodinated contrast materials
    - a. Procedures requiring the use of iodinated contrast
    - b. Contrast used for intrathecal injections
      - 1) Aqueous contrast
      - 2) Patient management to reduce the incidence and severity of adverse reactions
    - c. Instructions given to diabetic patients receiving antihyperglycemic agents (Metformin) (Glucophage)
  - 9. Characteristics of iodinated contrast materials
    - a. Water solubility and hydrophilicity
    - b. Osmolality
      - 1) High osmolar contrast media (HOCM)
        - a) Molecular structure
      - 2) Low osmolar contrast media (LOCM)
        - a) Molecular structure
        - b) Advantages of LOCM
        - c) Disadvantages of LOCM
    - c. Viscosity
    - d. Calcium binding
    - e. Iodine concentration
  - 10. Adverse reactions
    - a. Recognition
    - b. Treatment
    - c. Documentation

11. Strategies for dealing with patients with a known history of allergic reaction and at risk for adverse contrast reaction.
  - a. Steroid premedication for intravascular contrast media and substitution of barium based contrast instead of iodinated oral contrast
    - 1) Indications for steroid premedication
    - 2) Contraindications for steroid premedication
    - 3) Dosage
      - a) Non-emergency cases
    - 4) Two-dose regimen
  - b. Emergency cases
12. Patient counseling and recommended follow-up care for patients undergoing a procedure requiring the use of contrast media
  - a. Following iodinated contrast media procedures
  - b. Following an adverse reaction to administered contrast agent

## **II. Patient Assessment**

- A. History
  1. Indications
  2. Risk factors for adverse contrast reaction
    - a. Allergies
    - b. Abnormal lab values
      - 1) Blood urea nitrogen (BUN)
      - 2) Creatinine
      - 3) Eosinophil values
      - 4) Prothrombin time (PT) and partial thromboplastin time (PTT), (International Normalized Ratio, or INR value)
      - 5) Platelet count
    - c. Diabetes (Glucophage/Glucoavance)
    - d. Multiple myeloma
    - e. Pheochromocytoma
    - f. Hemoglobin sickle cell disease
    - g. Congestive heart failure
    - h. Grave's disease
    - i. Symptomatic asthmatics
- B. Current medications

## **III. Radiation Protection**

- A. Technical factors affecting patient dose
- B. CT dose index/Multiple scan average dose (CTDI/MSAD)
- C. Conventional/spiral (single or multi-detector row)
- D. Pediatric dose reduction

E. Pregnant patients

#### **IV. Computers**

A. General definition

B. Associated terminology

C. General purpose

D. Special purpose

E. Analog

F. Digital

G. Hardware

1. Input devices

2. Central processing unit (CPU)

3. Memory

4. Output devices

H. Software

#### **V. The CT Computer**

A. Hardware

B. Data acquisition system

C. Software

D. Algorithms

E. Postprocessing techniques

F. Keyboard orientation

G. Peripheral devices orientation

H. Image display, manipulation, recording and archiving

1. Display

a. Cathode ray tube (CRT)

2. Manipulation

a. Image reformation

b. Image smoothing

c. Edge enhancement

d. Gray-scale manipulation

- e. Three-dimensional processing
- f. Stereotaxis
- g. Radiation oncology treatment planning
- 3. Recording
  - a. Film
    - 1) Multiformat cameras
    - 2) Laser cameras
  - b. Archiving
    - 1) Laser and optical disks
- 4. Image reconstruction
  - a. CT computer
    - 1) Minicomputer and microprocessors
    - 2) Array processors
  - b. Reconstruction algorithms
    - 1) Filtered back-projection (convolution)
    - 2) Fourier reconstruction
    - 3) 3-D
    - 4) Interpolation

## **VI. Image Quality in CT**

- A. Definition
- B. Determinants
  - 1. Artifacts
  - 2. Contrast resolution
  - 3. Distortion
  - 4. Noise
  - 5. Spatial resolution
- C. Influencing factors
  - 1. Film contrast
  - 2. Focal spot size
  - 3. Geometry
  - 4. Image receptor
  - 5. Motion
  - 6. Subject contrast
  - 7. Viewing conditions
- D. Measurements
  - 1. Contrast transfer and response function
  - 2. Line spread function
  - 3. Point spread function
  - 4. Modulation transfer function
  - 5. Full width at half maximum
  - 6. Edge response function

- E. Quality control programs in CT
  - 1. Definition of QC
  - 2. Principles
    - a. Regular performance
    - b. Prompt interpretation of results
    - c. Accurate and timely record keeping
  - 3. Common QC tests
    - a. Choosing techniques
    - b. Determining frequency of performance
    - c. Establishing acceptable limits from test results
    - d. Types
      - 1) CT number calibration
      - 2) Standard deviation of CT number in water
      - 3) High-contrast resolution
      - 4) Low-contrast resolution
      - 5) Accuracy of distance measuring device
      - 6) Distortion of video monitor
      - 7) Hard copy output distortion
      - 8) CT number flatness
      - 9) Hard copy output
      - 10) Localization device accuracy
      - 11) CT couch indexing
      - 12) CT couch backlash
      - 13) Light field accuracy
      - 14) Slice width
      - 15) CT number vs. patient position
      - 16) CT number vs. patient size
      - 17) CT number vs. algorithm selection
      - 18) CT number vs. slice width
      - 19) Radiation leakage and scatter
      - 20) kVp wave form

## **VII. Computed Tomography Process**

- A. Data acquisition
  - 1. Methods
    - a. Slice-by-slice
    - b. Volumetric
  - 2. Elements
    - a. Beam geometry
      - 1) Pencil-beam
      - 2) Fan
      - 3) Spiral
      - 4) Cone
  - 3. Data acquisition system (DAS)
    - a. Components
      - 1) Tube-type and characteristics

- 2) Detectors – types
- 3) Filters
- 4) Collimators
- 5) Analog-to-digital converter (ADC)
- 6) Gantry controls
  - a) Laser centering
  - b) Gantry tilt – table controls
- 7) Computer and array processor
- 8) Conventional – spiral
- 9) Maintenance – QC/QA
- b. Functions
  - 1) Measurement of transmitted beam
  - 2) Encoding measurements into binary data
  - 3) Logarithmic conversion of data
  - 4) Transmission of data to computer
4. Data acquisition process
  - a. Scanning/raw data/image data
    - 1) Rays
    - 2) Views
    - 3) Profiles
      - a) Pixels
      - b) Matrices
      - c) Voxels
    - 4) Sampling
      - a) Angular
      - b) Ray
  - b. Attenuation
    - 1) Lambert-Beer law
    - 2) Linear attenuation coefficients
    - 3) CT/Hounsfield numbers

## **VIII. Spiral Computed Tomography**

### **A. Definition**

- ### **B. Differences between conventional single slice, multislice, spiral and electron beam CT**
1. Advantages
  2. Disadvantages
  3. Comparison of patient radiation doses and effects of slice thickness

### **C. Scanner design**

1. High-voltage and low-voltage scanners
2. Slip-ring cylinders and slip-ring disk scanners

### **D. Composite and wire brush scanners**

## **IX. Physics/Instrumentation (System Operation and Components)**

- A. Selectable scan factors
  - 1. Matrix size (pixel size)
  - 2. Slice thickness (voxel size)
  - 3. Scan field of view (SFOV)
  - 4. Display field of view (DFOV/RFOV)
  - 5. CT numbers (Hounsfield units)
  - 6. Window width
  - 7. Window level
  - 8. kVp/mAs
  - 9. Algorithm
  - 10. Scan time and rotational arc
  - 11. Radiographic tube output
  - 12. Region of interest (ROI)
  - 13. Magnification
  - 14. Focal spot size and tube geometry
  
- B. Data management
  - 1. Display
  - 2. Transmission/PACS
  - 3. Archival methods
  - 4. DICOM
  
- C. Image quality
  - 1. Densities
  - 2. Contrast and spatial resolution
  - 3. Noise/artifacts recognition and reduction
  
- X. CT, Applied Terminology**
  - A. Pixel
  
  - B. Matrix
  
  - C. Voxel
  
  - D. X, y, z coordinates
  
  - E. Scan field of view (SFOV)
  
  - F. Display field of view (DFOV)
  
  - G. Linear attenuation coefficient
  
  - H. CT/Hounsfield number
  
  - I. Partial volume averaging

- J. Window width (WW) and window level (WL)
- K. Spatial resolution
- L. Contrast resolution
- M. Noise aliasing
- N. Digital imaging
- O. Annotation
- P. Scanogram
- Q. Region of interest (ROI)
- R. Standard vs. volumetric data acquisition
- S. Half-scan, full-scan, overscan
- T. Interscan delay
- U. Rays and views
- V. Sampling (angular and ray)

## **XI. Cross-sectional Anatomy (Multiplane) With Pathologic Correlation**

### **XII. Procedures Protocol**

- A. Indicators for specific protocols
- B. Contraindications for specific protocol
- C. Indications for contrast media
  - 1. Types of contrast media
- D. Contraindications to the use of contrast media
- E. Informed consent requirements
- F. Patient preparation and postprocedure instructions
- G. Charting
- H. Protocol parameters
  - 1. Range

2. Azimuth
3. Anatomical landmarks
4. Patient position
5. Scout image parameters
6. Scan field of view
7. Mode
8. Algorithm
9. Gantry angle
10. Technical factor selection
11. Table indexing
12. Z-axis selection
13. Window level
14. Window width
15. Matrix size
16. Image annotation parameters
17. Imaging planes
18. Spiral application
19. Filming format
20. Image archiving
21. Identification of possible pathology
22. Charting and documentation requirements

### **XIII. Procedures (CT)**

- A. Head
- B. Neck
- C. Spine
- D. Thorax
- E. Abdomen
- F. Pelvis
- G. Radiation therapy treatment planning (RPT)
- H. Interventional procedures
  1. Biopsies
  2. Drainage procedures

## Content Specifications Gap Analysis for Basic Nuclear Medicine for Dual Modality Imaging

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
<b>I. Radiation Protection</b>				
A. Personal protection and monitoring				
1. Basic concepts	✓	✓	✓	✓
2. Personnel protection, source shielding	✓	✓	✓	✓
3. Source shielding			✓	✓
4. Personnel monitoring devices, extremity monitoring	✓	✓	✓	✓
5. NRC regulations	✓	✓	✓	✓
B. Area / facilities monitoring				
1. Basic concepts	✓	✓	✓	✓
2. Survey equipment and techniques	✓	✓	✓	✓
3. NRC regulations	✓	✓	✓	✓
C. Packaging and storage of radioactive materials				
1. Inspection of incoming and outgoing materials			✓	✓
2. Storage of radiopharmaceuticals			✓	✓
D. Radioactive decontamination				
1. Area			✓	✓
2. Personnel			✓	✓
3. Patient			✓	✓
E. Disposal of radioactive waste				
1. Release to environment			✓	✓
2. Decay in storage			✓	✓
3. Incineration				✓
4. Transfer to authorized recipient			✓	✓
F. Medical events				
1. Definitions			✓	✓
2. Regulation for reporting and notification			✓	✓
<b>II. Radionuclide and Radiopharmaceuticals</b>				
A. Physical properties of radioactive materials				
1. Types of emissions	✓	✓	✓	✓
2. Energies	✓	✓	✓	✓

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
3. Decay rate and half-life	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4. Radiopharmaceutical quality control				<input checked="" type="checkbox"/>
<b>B. Dosage determination</b>				
1. Calculation of radiopharmaceutical/ pharmaceutical doses				<input checked="" type="checkbox"/>
2. Calculation of pediatric dose				<input checked="" type="checkbox"/>
3. Volume determination				<input checked="" type="checkbox"/>
4. Units – calculations and conversions	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5. <i>Dose determination according to scan mode and equipment type</i>				<input checked="" type="checkbox"/>
<b>C. Dosage preparation and administration</b>				
1. Verifying correct radiopharmaceutical for exam				<input checked="" type="checkbox"/>
2. Preparation for administration				<input checked="" type="checkbox"/>
3. Assay in dose calibrator				<input checked="" type="checkbox"/>
4. Proper radiopharmaceutical labeling				<input checked="" type="checkbox"/>
5. <i>Administration technique</i>				<input checked="" type="checkbox"/>
6. <i>Administration records</i>				<input checked="" type="checkbox"/>
7. <i>Residual dose measurements</i>				<input checked="" type="checkbox"/>
<b>D. PET radiopharmaceutical principles</b>				
1. <i>Positron decay</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2. <i>Positron energy and effect on resolution</i>				<input checked="" type="checkbox"/>
3. <i>Annihilation reaction</i>				<input checked="" type="checkbox"/>
4. <i>Bremsstrahlung radiation</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5. <i>Decay factors</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
6. <i>Exposure rates</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
7. <i>Half-value layer (lead and concrete)</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
8. <i>Branching fraction</i>				<input checked="" type="checkbox"/>
<b>E. Radiation safety with positron decay</b>				
1. <i>Hot cells</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2. <i>Facility monitoring considerations</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3. <i>Personnel monitoring considerations</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4. <i>Exposure from patients</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<b>F. Radionuclide production</b>				
1. <i>Cyclotron</i>				<input checked="" type="checkbox"/>

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
a. <i>Basic concept</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
b. <i>Targets</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
c. <i>Large and small volume</i>				<input checked="" type="checkbox"/>
d. <i>Liquid or gas</i>				<input checked="" type="checkbox"/>
G. <b>Synthesis of radiopharmaceuticals</b>				
1. <i>Basic chemistry</i>				<input checked="" type="checkbox"/>
2. <i>Synthesis modules</i>				<input checked="" type="checkbox"/>
H. <b>Rubidium generators</b>				
1. <i>Regulations</i>				<input checked="" type="checkbox"/>
2. <i>Quality control</i>				<input checked="" type="checkbox"/>
3. <i>Dose assay</i>				<input checked="" type="checkbox"/>
4. <i>Dose administration</i>				<input checked="" type="checkbox"/>
5. <i>Storage</i>				<input checked="" type="checkbox"/>
6. <i>Disposal</i>				<input checked="" type="checkbox"/>
<b>III. Instrumentation / Quality Control</b>				
A. <b>Survey meter</b>				
1. <i>Operating principles</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2. <i>Quality control consistent with NRC regulations</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3. <i>Source selection</i>				<input checked="" type="checkbox"/>
4. <i>Interpretation of QC results</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
B. <b>Dose calibrator</b>				
1. <i>Operating principles</i>				<input checked="" type="checkbox"/>
2. <i>Types of quality checks</i>				<input checked="" type="checkbox"/>
3. <i>Frequency of quality checks</i>				<input checked="" type="checkbox"/>
4. <i>Source selection</i>				<input checked="" type="checkbox"/>
5. <i>Interpretation of results</i>				<input checked="" type="checkbox"/>
C. <b>Scintillation detector systems</b>				
1. <i>Principles of scintillation detection</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2. <i>Properties of detector materials</i>				
a. <i>Material types</i>				<input checked="" type="checkbox"/>
b. <i>Atomic numbers</i>				<input checked="" type="checkbox"/>
c. <i>Decay time</i>				<input checked="" type="checkbox"/>
d. <i>Conversion efficiency</i>				<input checked="" type="checkbox"/>
3. <i>PET detector materials</i>				<input checked="" type="checkbox"/>

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
a. <i>NaI</i>				<input checked="" type="checkbox"/>
b. <i>BGO</i>				<input checked="" type="checkbox"/>
c. <i>LSO</i>				<input checked="" type="checkbox"/>
d. <i>GSO</i>				<input checked="" type="checkbox"/>
1) <i>System types</i>				<input checked="" type="checkbox"/>
a) <i>Terminology</i>				
(1) <i>Aperture size</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
(2) <i>Field of view</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
(3) <i>Overlap</i>				<input checked="" type="checkbox"/>
(4) <i>Bed position</i>				<input checked="" type="checkbox"/>
b) <i>Dedicated PET</i>				<input checked="" type="checkbox"/>
(1) <i>Full ring tomograph</i>				<input checked="" type="checkbox"/>
(2) <i>Partial ring tomograph</i>				<input checked="" type="checkbox"/>
(3) <i>Panel detector</i>				<input checked="" type="checkbox"/>
c) <i>PET-CT combined</i>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
d) <i>Gamma PET camera</i>				<input checked="" type="checkbox"/>
2) <i>Quality control</i>				<input checked="" type="checkbox"/>
a) <i>Normalization</i>				<input checked="" type="checkbox"/>
b) <i>Blank scan</i>				<input checked="" type="checkbox"/>
c) <i>Gains (singles)</i>				<input checked="" type="checkbox"/>
d) <i>Cross-calibration</i>				<input checked="" type="checkbox"/>
3) <i>System performance</i>				<input checked="" type="checkbox"/>
a) <i>Scatter fraction</i>				<input checked="" type="checkbox"/>
b) <i>Noise equivalent count rate</i>				<input checked="" type="checkbox"/>
c) <i>NEMA standards and testing</i>				<input checked="" type="checkbox"/>
D. <i>Theory of operation</i>				
1. <i>Principles of coincidence detection</i>				<input checked="" type="checkbox"/>
a. <i>True coincidence</i>				<input checked="" type="checkbox"/>
b. <i>Lines of response (LOR)</i>				<input checked="" type="checkbox"/>
c. <i>Randoms</i>				<input checked="" type="checkbox"/>
d. <i>Scatter</i>				<input checked="" type="checkbox"/>
e. <i>Delayed event</i>				<input checked="" type="checkbox"/>

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
f. <i>Coincidence window and timing</i>				<input checked="" type="checkbox"/>
2. <i>Image formation and reconstruction</i>				<input checked="" type="checkbox"/>
a. <i>Sinograms</i>				<input checked="" type="checkbox"/>
1) <i>2-D</i>				<input checked="" type="checkbox"/>
2) <i>3-D</i>				<input checked="" type="checkbox"/>
3) <i>Fourier rebinning</i>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
4) <i>Single slice rebinning</i>				<input checked="" type="checkbox"/>
a) <i>Filtered back projection (FBP)</i>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
b) <i>Iterative reconstruction</i>				<input checked="" type="checkbox"/>
(1) <i>Ordered subset expectation maximization (OSEM)</i>				<input type="checkbox"/>
(2) <i>Maximum likelihood expectation maximization (MLEM)</i>				<input checked="" type="checkbox"/>
c) <i>Image filters</i>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
d) <i>Matrix selection</i>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
b. <i>Data processing and corrections</i>				<input checked="" type="checkbox"/>
1) <i>Normalization corrections</i>				<input checked="" type="checkbox"/>
2) <i>Decay corrections</i>				<input checked="" type="checkbox"/>
3) <i>Dead time corrections</i>				<input checked="" type="checkbox"/>
4) <i>Arc corrections</i>				<input checked="" type="checkbox"/>
5) <i>Randoms corrections</i>				<input checked="" type="checkbox"/>
6) <i>Scatter corrections</i>				<input checked="" type="checkbox"/>
7) <i>Attenuation corrections</i>				<input checked="" type="checkbox"/>
a) <i>Calculated (mathematical)</i>				<input checked="" type="checkbox"/>
b) <i>Measured</i>				<input checked="" type="checkbox"/>
(1) <i>Patients without activity</i>				<input checked="" type="checkbox"/>
(2) <i>Patients with activity</i>				<input checked="" type="checkbox"/>
c) <i>Segmentation</i>				<input checked="" type="checkbox"/>
d) <i>CT</i>				<input checked="" type="checkbox"/>
e) <i>No corrections</i>				<input checked="" type="checkbox"/>
<b>IV. Diagnostic Procedures</b>				
A. <b>Radiopharmaceutical characteristics</b>				
1. <i>Half-life of PET radioisotopes</i>				<input checked="" type="checkbox"/>

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
2. <i>Method of localization</i>				<input checked="" type="checkbox"/>
a. <i>FDG kinetics</i>				<input checked="" type="checkbox"/>
b. <i>Target organs</i>				<input checked="" type="checkbox"/>
c. <i>Radiopharmaceutical biodistribution and normal variants</i>				<input checked="" type="checkbox"/>
3. <i>Dose considerations</i>				<input checked="" type="checkbox"/>
<b>B. Administration of radiopharmaceuticals</b>				
1. <i>Routes</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2. <i>Intravenous injection techniques</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
3. <i>Factors affecting biodistribution</i>				<input checked="" type="checkbox"/>
a. <i>Cardiology</i>				<input checked="" type="checkbox"/>
1) <i>Glucose level</i>				<input checked="" type="checkbox"/>
2) <i>Insulin level</i>				<input checked="" type="checkbox"/>
b. <i>Neurology</i>				<input checked="" type="checkbox"/>
1) <i>Stimulation</i>				<input checked="" type="checkbox"/>
2) <i>Surgical variants</i>				<input checked="" type="checkbox"/>
3) <i>Radiation treatment</i>				<input checked="" type="checkbox"/>
4) <i>Insulin/glucose levels</i>				<input checked="" type="checkbox"/>
5) <i>Psychotropic drugs</i>				<input checked="" type="checkbox"/>
6) <i>Ictal vs. inter-ictal state</i>				<input checked="" type="checkbox"/>
c. <i>Oncology</i>				<input checked="" type="checkbox"/>
1) <i>Insulin/glucose levels</i>				<input checked="" type="checkbox"/>
2) <i>Exercise</i>				<input checked="" type="checkbox"/>
3) <i>Chemotherapy</i>				<input checked="" type="checkbox"/>
4) <i>Radiation therapy</i>				<input checked="" type="checkbox"/>
5) <i>Surgery or biopsy</i>				<input checked="" type="checkbox"/>
6) <i>Hemopoietins</i>				<input checked="" type="checkbox"/>
7) <i>Muscle tension</i>				<input checked="" type="checkbox"/>
8) <i>Hydration</i>				<input checked="" type="checkbox"/>
9) <i>Inflammatory disease</i>				<input checked="" type="checkbox"/>
10) <i>Room temperature</i>				<input checked="" type="checkbox"/>
<b>C. Administration of pharmaceuticals</b>				
1. <i>Use case for administering pharmaceuticals</i>				

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
a. <i>Basic concepts</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
1) <i>Indications</i>				<input checked="" type="checkbox"/>
2) <i>Contraindications</i>				<input checked="" type="checkbox"/>
3) <i>Adverse reactions</i>				<input checked="" type="checkbox"/>
4) <i>Medication interactions</i>				<input checked="" type="checkbox"/>
a) <i>Dosing and route of administration</i>				<input checked="" type="checkbox"/>
2. <i>Pharmaceuticals</i>				
a. <i>Cardiology</i>				
1) <i>Dobutamine</i>				<input checked="" type="checkbox"/>
2) <i>Adenosine</i>				<input checked="" type="checkbox"/>
3) <i>Dipyridamole</i>				<input checked="" type="checkbox"/>
4) <i>Glucose</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5) <i>Insulin</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
6) <i>Hyperinsulinemic-euglycemic clamp</i>				<input checked="" type="checkbox"/>
b. <i>Neurology</i>				<input checked="" type="checkbox"/>
1) <i>Sedatives</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2) <i>Antiseizure</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
c. <i>Oncology</i>				
1) <i>Diuretics</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2) <i>IV and oral hydration</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3) <i>Sedative drugs (Valium)</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4) <i>Insulin</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
D. <i>Gated procedures</i>				
1. <i>Equipment</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2. <i>ECG lead placement</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3. <i>Sources of error</i>				<input checked="" type="checkbox"/>
a. <i>Patient arrhythmia</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
b. <i>Equipment error</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
c. <i>User error</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
E. <i>Acquisition modes</i>				
1. <i>2-D</i>				<input checked="" type="checkbox"/>
2. <i>3-D</i>				<input checked="" type="checkbox"/>
3. <i>Emission</i>				<input checked="" type="checkbox"/>

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
4. <i>Transmission</i>				<input checked="" type="checkbox"/>
5. <i>Single bed positron</i>				<input checked="" type="checkbox"/>
6. <i>Dynamic imaging</i>				<input checked="" type="checkbox"/>
7. <i>Whole-body imaging</i>				<input checked="" type="checkbox"/>
F. <i>Imaging procedures</i>				
1. <i>Cardiology</i>				<input checked="" type="checkbox"/>
a. <i>Patient preparation</i>				<input checked="" type="checkbox"/>
b. <i>History and assessment</i>				<input checked="" type="checkbox"/>
c. <i>Indications and contraindications</i>				<input checked="" type="checkbox"/>
d. <i>Exercise</i>				<input checked="" type="checkbox"/>
e. <i>Uptake time</i>				<input checked="" type="checkbox"/>
f. <i>Patient positioning</i>				<input checked="" type="checkbox"/>
g. <i>Imaging indications</i>				<input checked="" type="checkbox"/>
1) <i>Rest and stress perfusion</i>				<input checked="" type="checkbox"/>
2) <i>Myocardial viability</i>				<input checked="" type="checkbox"/>
a) <i>Artifacts</i>				<input checked="" type="checkbox"/>
2. <i>Neurology</i>				
a. <i>Patient preparation</i>				<input checked="" type="checkbox"/>
b. <i>History and assessment</i>				<input checked="" type="checkbox"/>
c. <i>Indications and contraindications</i>				<input checked="" type="checkbox"/>
d. <i>Uptake time</i>				<input checked="" type="checkbox"/>
e. <i>Patient positioning</i>				<input checked="" type="checkbox"/>
f. <i>Imaging indications</i>				<input checked="" type="checkbox"/>
1) <i>Epileptic seizures</i>				<input checked="" type="checkbox"/>
2) <i>Dementia</i>				<input checked="" type="checkbox"/>
3) <i>Tumor</i>				<input checked="" type="checkbox"/>
4) <i>Movement disorders</i>				<input checked="" type="checkbox"/>
3. <i>Oncology</i>				
a. <i>Patient preparation</i>				<input checked="" type="checkbox"/>
b. <i>History and assessment</i>				<input checked="" type="checkbox"/>
c. <i>Indications and contraindications</i>				<input checked="" type="checkbox"/>
d. <i>Uptake time</i>				<input checked="" type="checkbox"/>
e. <i>Patient positioning</i>				<input checked="" type="checkbox"/>

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
f. <i>Fiducial marker use and placement</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
g. <i>Imaging techniques</i>				<input checked="" type="checkbox"/>
h. <i>Imaging indications</i>				<input checked="" type="checkbox"/>
1) <i>Colon cancer</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2) <i>Head/neck cancer</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3) <i>Esophageal cancer</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4) <i>Lung cancer</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5) <i>Breast cancer</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
6) <i>Melanoma</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
7) <i>Lymphoma</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
8) <i>Thyroid cancer</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
9) <i>Ovarian cancer</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
10) <i>Sarcoma</i>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
11) <i>Other indications</i>				<input checked="" type="checkbox"/>
<b>G. Image artifacts</b>				
1. <i>Normal variants of radiopharmaceutical distribution</i>				<input checked="" type="checkbox"/>
2. <i>Physiologic artifacts</i>				<input checked="" type="checkbox"/>
a. <i>Muscle tension</i>				<input checked="" type="checkbox"/>
b. <i>Organ movement</i>				<input checked="" type="checkbox"/>
c. <i>Active tension</i>				<input checked="" type="checkbox"/>
d. <i>Patient motion</i>				<input checked="" type="checkbox"/>
e. <i>Injection sites/tubing</i>				<input checked="" type="checkbox"/>
f. <i>Urinary catheter lines</i>				<input checked="" type="checkbox"/>
g. <i>Metal</i>				<input checked="" type="checkbox"/>
h. <i>Misalignment of emission and transmission</i>				<input checked="" type="checkbox"/>
<b>H. Computerized data processing</b>				
1. <i>Quantitative analysis</i>				<input checked="" type="checkbox"/>
a. <i>Region of interest (ROI)</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
b. <i>Time activity curves (TAC)</i>				<input checked="" type="checkbox"/>
c. <i>Standard uptake values (SUV)</i>				<input checked="" type="checkbox"/>
1) <i>Calculations</i>				<input checked="" type="checkbox"/>
2) <i>Sources of error</i>				<input checked="" type="checkbox"/>

<b>Content Specification for Basic Nuclear Medicine and PET for Dual Modality Imaging</b> <i>(Please note that italics represent content specification for PET.)</i>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
d. <i>Metabolic flow rate measurement and analysis</i>				<input checked="" type="checkbox"/>
e. <i>R to L count profiles and histogram</i>				<input checked="" type="checkbox"/>
f. <i>Cardiac polar map</i>				<input checked="" type="checkbox"/>
2. <i>Image reconstruction variants</i>				<input checked="" type="checkbox"/>
I. <i>Image fusion / image registration</i>				
1. <i>Basic principles</i>				<input checked="" type="checkbox"/>
2. <i>Fiducial markers</i>				<input checked="" type="checkbox"/>
J. <i>Image display, manipulation, recording and archiving</i>				<input checked="" type="checkbox"/>
1. <i>Display</i>				
a. <i>Cathode ray tube (CRT)</i>				<input checked="" type="checkbox"/>
2. <i>Recording</i>				<input checked="" type="checkbox"/>
a. <i>Film</i>				<input checked="" type="checkbox"/>
1) <i>Multiformat camera</i>				<input checked="" type="checkbox"/>
2) <i>Laser camera</i>				<input checked="" type="checkbox"/>
b. <i>Archiving</i>				<input checked="" type="checkbox"/>
1) <i>Tapes</i>				<input checked="" type="checkbox"/>
2) <i>Disks</i>				<input checked="" type="checkbox"/>
3) <i>Laser and optical disks</i>				<input checked="" type="checkbox"/>
K. <i>Patient scheduling</i>				
1. <i>Proper procedure sequencing</i>				<input checked="" type="checkbox"/>
2. <i>Awareness of current Medicare regulations</i>				<input checked="" type="checkbox"/>
3. <i>Women age 12-55 years scheduling preference within 10 days of onset of last menses</i>				

## Content Specification Gap Analysis for Basic CT and PET for Dual Modality Imaging

Content Specification for Basic CT and PET for Dual Modality Imaging	RT	CT	RTT	NM
<b>I. Patient Care</b>				
A. Venipuncture				
1. Site selection	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2. Pathology	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3. Use of current line	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4. Injection techniques (manual/automatic)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5. Associated problems	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
a. Air embolism	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
b. Extravasation	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
B. Contrast media agents				
1. Oral	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
2. IV – ionic/nonionic	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
3. Rectal	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
4. Intrathecal	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5. Catheters	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
6. Types/indication/chemical makeup, etc.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
7. Routes – dose calculations (adult vs. pediatric)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
8. Iodinated contrast materials				
a. Procedures requiring the use of iodinated contrast	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
b. Contrast used for intrathecal injections	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
1) Aqueous contrast	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
2) Patient management to reduce the rate and severity of adverse reactions	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
c. Instructions given to diabetic patients receiving antihyperglycemic agents (Metformin) (Glucophage)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
9. Characteristics of iodinated contrast materials				
a. Water solubility and hydrophilicity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
b. Osmolality	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
1) High osmolar contrast media (HOCM)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
a) Molecular structure	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
2) Low osmolar contrast media (LOCM)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
a) Molecular structure	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
b) Advantages of LOCM	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
c) Disadvantages of LOCM	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
c. Viscosity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
d. Calcium binding	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
10. Adverse reactions				
a. Recognition	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
b. Treatment	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
c. Documentation	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
11. Strategies for dealing with patients with a known history of or at higher risk for adverse reaction				
a. Steroid premedication for intravascular contrast media and substitution of barium based contrast instead of iodinated oral contrast	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
1) Indications for steroid premedication	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
2) Contraindications for steroid premedication	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
3) Dosage	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
a) Non-emergency cases	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
4) Two-dose regimen	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
b. Emergency cases	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
12. Patient counseling and recommended follow-up care for patients undergoing a procedure requiring the use of contrast media				
a. Following iodinated contrast media procedures	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
b. Following an adverse reaction to administered contrast agent	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
<b>II. Patient Assessment</b>				
A. History				
1. Indications	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
2. Risk factors for adverse contrast reactions	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
a. Allergies	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
b. Abnormal lab values				
1) BUN	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
2) Creatinine	✓	✓	✓	✓
3) Eosinophil values	✓	✓	✓	✓
4) PT and PTT (INR value)	✓	✓	✓	✓
5) Platelet count	✓	✓	✓	✓
c. Diabetes (Glucophage/Glucoavance)	✓	✓	✓	
d. Multiple myeloma			✓	✓
e. Pheochromocytoma			✓	✓
f. Hgb. sickle cell disease			✓	
g. Congestive heart failure	✓	✓	✓	✓
h. Grave's disease	✓	✓	✓	✓
i. Symptomatic asthmatics	✓	✓	✓	✓
B. Current meds	✓	✓	✓	✓
<b>III. Radiation Protection</b>				
A. Technical factors affecting patient dose	✓	✓	✓	✓
B. CTDI/MSAD (CT dose index/multiple scan average dose)		✓		
C. Conventional/spiral (single or multi-detector row)		✓		
D. Pediatric dose reduction		✓		✓
E. Pregnant patients	✓	✓	✓	✓
<b>IV. Computers</b>				
A. General definition	✓	✓	✓	✓
B. Associated terminology	✓	✓	✓	✓
C. General purpose	✓	✓	✓	✓
D. Special purpose	✓	✓	✓	✓
E. Analog	✓	✓	✓	✓
F. Digital	✓	✓	✓	✓
G. Hardware				
1. Input devices	✓	✓	✓	✓
2. Central processing unit (CPU)	✓	✓	✓	✓
3. Memory	✓	✓	✓	✓
4. Output devices	✓	✓	✓	✓
H. Software	✓	✓	✓	✓
<b>V. The CT Computer</b>				
A. Hardware		✓		
B. Data acquisition system		✓		

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
C. Software		✓		
D. Algorithms		✓		
E. Postprocessing techniques		✓		
F. Keyboard orientation		✓		
G. Peripheral devices orientation		✓		
H. Image display, manipulation, recording and archiving				
1. Display		✓		
a. Cathode ray tube (CRT)		✓		
2. Manipulation		✓		
a. Image reformation		✓		
b. Image smoothing		✓		
c. Edge enhancement		✓		
d. Gray-scale manipulation		✓		
e. Three-dimensional processing		✓		
f. Stereotaxis		✓		
g. Radiation oncology treatment planning		✓		
3. Recording		✓		
a. Film		✓		
1) Multiformat cameras		✓		
2) Laser cameras		✓		
b. Archiving		✓		
1) Laser and optical		✓		
4. Image reconstruction		✓		
a. CT computer		✓		
1) Minicomputer and microprocessors		✓		
2) Array processors		✓		
b. Reconstruction algorithms		✓		
1) Filtered back-projection (convolution)		✓		
2) Fourier reconstruction		✓		
3) 3-D		✓		
4) Interpolation		✓		
<b>VI. Image Quality in CT</b>				

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
A. Definition		<input checked="" type="checkbox"/>		
B. Determinants				
1. Artifacts		<input checked="" type="checkbox"/>		
2. Contrast resolution		<input checked="" type="checkbox"/>		
3. Distortion		<input checked="" type="checkbox"/>		
4. Noise		<input checked="" type="checkbox"/>		
5. Spatial resolution		<input checked="" type="checkbox"/>		
C. Influencing factors				
1. Film contrast		<input checked="" type="checkbox"/>		
2. Focal spot size		<input checked="" type="checkbox"/>		
3. Geometry		<input checked="" type="checkbox"/>		
4. Image receptor		<input checked="" type="checkbox"/>		
5. Motion		<input checked="" type="checkbox"/>		
6. Subject contrast		<input checked="" type="checkbox"/>		
7. Viewing conditions		<input checked="" type="checkbox"/>		
D. Measurements				
1. Contrast transfer and response function		<input checked="" type="checkbox"/>		
2. Line spread function		<input checked="" type="checkbox"/>		
3. Point spread function		<input checked="" type="checkbox"/>		
4. Modulation transfer function		<input checked="" type="checkbox"/>		
5. Full width at half maximum		<input checked="" type="checkbox"/>		
6. Edge response function		<input checked="" type="checkbox"/>		
E. Quality control programs in CT				
1. Definition of QC		<input checked="" type="checkbox"/>		
2. Principles		<input checked="" type="checkbox"/>		
a. Regular performance		<input checked="" type="checkbox"/>		
b. Prompt interpretation of results		<input checked="" type="checkbox"/>		
c. Accurate and timely record keeping		<input checked="" type="checkbox"/>		
3. Common QC tests		<input checked="" type="checkbox"/>		
a. Choosing techniques		<input checked="" type="checkbox"/>		
b. Determining frequency of performance		<input checked="" type="checkbox"/>		
c. Establishing acceptable limits from test results		<input checked="" type="checkbox"/>		
d. Types		<input checked="" type="checkbox"/>		

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
1) CT number calibration		<input checked="" type="checkbox"/>		
2) Standard deviation of CT number in water		<input checked="" type="checkbox"/>		
3) High-contrast resolution		<input checked="" type="checkbox"/>		
4) Low-contrast resolution		<input checked="" type="checkbox"/>		
5) Accuracy of distance measuring device		<input checked="" type="checkbox"/>		
6) Distortion of video monitor		<input checked="" type="checkbox"/>		
7) Hard copy output distortion		<input checked="" type="checkbox"/>		
8) CT number flatness		<input checked="" type="checkbox"/>		
9) Hard copy output		<input checked="" type="checkbox"/>		
10) Localization device accuracy		<input checked="" type="checkbox"/>		
11) CT couch indexing		<input checked="" type="checkbox"/>		
12) CT couch backlash		<input checked="" type="checkbox"/>		
13) Light field accuracy		<input checked="" type="checkbox"/>		
14) Slice width		<input checked="" type="checkbox"/>		
15) CT number vs. patient position		<input checked="" type="checkbox"/>		
16) CT number vs. patient size		<input checked="" type="checkbox"/>		
17) CT number vs. algorithm selection		<input checked="" type="checkbox"/>		
18) CT number vs. slice width		<input checked="" type="checkbox"/>		
19) Radiation leakage and scatter		<input checked="" type="checkbox"/>		
20) kVp wave form		<input checked="" type="checkbox"/>		
<b>VII. Computed Tomography Process</b>				
A. Data acquisition				
1. Methods		<input checked="" type="checkbox"/>		
a. Slice-by-slice		<input checked="" type="checkbox"/>		
b. Volumetric		<input checked="" type="checkbox"/>		
2. Elements		<input checked="" type="checkbox"/>		
a. Beam geometry		<input checked="" type="checkbox"/>		
1) Pencil-beam		<input checked="" type="checkbox"/>		
2) Fan		<input checked="" type="checkbox"/>		
3) Spiral		<input checked="" type="checkbox"/>		
4) Cone		<input checked="" type="checkbox"/>		
3. Data acquisition system (DAS)		<input checked="" type="checkbox"/>		
a. Components		<input checked="" type="checkbox"/>		

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
1) Tube – type and characteristics		✓		
2) Detectors – types		✓		
3) Filters		✓		
4) Collimators		✓		
5) Analog-to-digital converter (ADC)		✓		
6) Gantry controls		✓	✓	
a) Laser centering		✓	✓	
b) Gantry tilt – table control		✓	✓	
7) Computer and array processor	✓	✓	✓	
8) Conventional – spiral	✓	✓	✓	
9) Maintenance – QC/QA		✓	✓	
b. Functions		✓		
1) Measurement of transmitted beam		✓		
2) Encoding measurements into binary data		✓		
3) Logarithmic conversion of data		✓		
4) Transmission of data to computer		✓		
4. Data acquisition process		✓		
a. Scanning/raw data/image data		✓		
1) Rays		✓		
2) Views		✓		
3) Profiles		✓		
a) Pixels		✓		
b) Matrices		✓		
c) Voxels		✓		
4) Sampling		✓		
a) Angular		✓		
b) Ray		✓		
b. Attenuation		✓		
1) Lambert-Beer law		✓		
2) Linear attenuation coefficients		✓		
3) CT/Hounsfield numbers		✓		
<b>VIII. Spiral Computed Tomography</b>				

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
A. Definition		✓		
B. Differences between conventional single slice, multislice, spiral and electron beam CT				
1. Advantages		✓		
2. Disadvantages		✓		
3. Comparison of patient radiation doses and effects of slice thickness		✓		
C. Scanner designs				
1. High-voltage and low-voltage scanners		✓		
2. Slip-ring cylinders and slid-ring disk scanners		✓		
D. Composite and wire brush scanners		✓		
<b>IX. Physics/Instrumentations (System Operation and Components)</b>				
A. Selectable scan factors				
1. Matrix size (pixel size)	✓	✓	✓	✓
2. Slice thickness (voxel size)	✓	✓	✓	✓
3. Scan field of view (SFOV)		✓		✓
4. Display field of view (DFOV/RFOV)		✓		✓
5. CT numbers (Hounsfield units)	✓	✓	✓	✓
6. Window width	✓	✓	✓	✓
7. Window level	✓	✓	✓	✓
8. kVp/mAs	✓	✓	✓	✓
9. Algorithm				✓
10. Scan time and rotational arc				✓
11. Radiographic tube output				✓
12. Region of interest (ROI)				✓
13. Magnification				✓
14. Focal spot size and tube geometry				✓
B. Data management				
1. Display	✓	✓	✓	
2. Transmission/PACS	✓	✓	✓	✓
3. Archival methods	✓	✓	✓	
4. DICOM	✓	✓	✓	
C. Image quality				
1. Densities	✓	✓	✓	

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
2. Contrast and spatial resolution	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
3. Noise/artifacts recognition and reduction	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>X. CT, Applied Terminology</b>				
A. Pixel		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
B. Matrix		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
C. Voxel		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
D. X, y, z coordinates		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
E. Scan field of view (SFOV)		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
F. Display field of view (DFOV)		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
G. Linear attenuation coefficient		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
H. CT/Hounsfield units		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
I. Partial volume averaging		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
J. Window width (WW) and window level (WL)		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
K. Spatial resolution		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
L. Contrast resolution		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
M. Noise aliasing		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
N. Digital imaging		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
O. Annotation		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
P. Scanogram		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
Q. Region of interest (ROI)		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
R. Standard vs. volumetric data acquisition		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
S. Half-scan, full-scan, overscan		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
T. Interscan delay		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
U. Rays and views		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
V. Sampling (angular and ray)		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
<b>XI. Cross-sectional Anatomy (Multiplane) with Pathologic Correlation</b>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<b>XII. Procedure Protocol</b>				
A. Indicators for specific protocol		<input checked="" type="checkbox"/>		
B. Contraindications for specific protocol		<input checked="" type="checkbox"/>		
C. Indications for contrast media				
1. Types of contrast media		<input checked="" type="checkbox"/>		
D. Contraindications for contrast media	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
E. Informed consent requirements	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
F. Patient preparation and postprocedure instructions		<input checked="" type="checkbox"/>		
G. Charting	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
H. Protocol parameters				
1. Range		<input checked="" type="checkbox"/>		
2. Azimuth		<input checked="" type="checkbox"/>		
3. Anatomical landmarks		<input checked="" type="checkbox"/>		
4. Patient position		<input checked="" type="checkbox"/>		
5. Scout image parameters		<input checked="" type="checkbox"/>		
6. Scan field of view		<input checked="" type="checkbox"/>		
7. Mode		<input checked="" type="checkbox"/>		
8. Algorithm		<input checked="" type="checkbox"/>		
9. Gantry angle		<input checked="" type="checkbox"/>		
10. Technical factor selection		<input checked="" type="checkbox"/>		
11. Table indexing		<input checked="" type="checkbox"/>		
12. Z-axis selection		<input checked="" type="checkbox"/>		
13. Window level		<input checked="" type="checkbox"/>		
14. Window width		<input checked="" type="checkbox"/>		
15. Matrix size		<input checked="" type="checkbox"/>		
16. Image annotation parameters		<input checked="" type="checkbox"/>		
17. Imaging planes		<input checked="" type="checkbox"/>		
18. Spiral application		<input checked="" type="checkbox"/>		
19. Filming format		<input checked="" type="checkbox"/>		
20. Image archiving		<input checked="" type="checkbox"/>		
21. Identification of possible pathology		<input checked="" type="checkbox"/>		
22. Charting and documentation requirements		<input checked="" type="checkbox"/>		
<b>XIII. Procedures (CT)</b>				
A. Head		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
B. Neck		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
C. Spine		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
D. Thorax		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
E. Abdomen		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
F. Pelvis		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
G. Radiation therapy treatment planning (RTP)		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	

<b>Content Specification for Basic CT and PET for Dual Modality Imaging</b>	<b>RT</b>	<b>CT</b>	<b>RTT</b>	<b>NM</b>
H. Interventional procedures				
1. Biopsies			✓	
2. Drainage procedures			✓	

## Foundations Content Objectives

Foundations represent an inventory of pre-existing knowledge and skills gained through an entry-level radiography educational program and reinforced through professional practice.

### Computers in Radiologic Sciences

Content is designed to introduce knowledge in computing and information processing. Computer applications in the radiologic sciences related to image capture, display, storage and distribution are presented.

#### Objectives

1. Identify various types of computers.
2. Define analog to digital conversion and digital signal processor.
3. Identify various terms related to computer fundamentals and components.
4. Describe major functions of the central processing unit (CPU).
5. Differentiate the various input and output devices.
6. Give examples of various types of memory.
7. Describe computer care and preventive maintenance.
8. Explain the following computing applications as they relate to radiology: radiologic information systems (RIS), hospital information systems (HIS) and picture archiving and communication systems (PACS).
9. Define digital imaging and communications in medicine (DICOM).
10. Discuss the impact of the Internet on the distribution of health information.

### Contrast Media

Content is designed to impart an understanding of contrast media used during common diagnostic procedures. Topics include an overview of the chemical makeup and physical properties of select contrast agents, selection of contrast agents for given exams, patient risk factors, premedication strategies, indicators/symptoms of a patient contrast media reaction and recommendations for care and treatment of patients experiencing reaction to a given contrast agent.

#### Objectives

1. Discuss the rationale for the use of contrast media.
2. Differentiate between negative and positive contrast agents.
3. Identify the physical properties of various contrast agents.
4. Describe the structural differences and characteristics of low and high osmolar injectable contrast media.
5. Identify the desired contrast agent employed for select exams.
6. Discuss the resources used to identify patients at risk of reacting to the contrast media.
7. Identify patient indicators for altering the selection of contrast media used to perform a given procedure.
8. Recite the patient preparation necessary for various contrast and special studies.
9. Identify the strategies employed when faced with patients with a known history of a previous allergic reaction.

10. Recognize the indicators/symptoms associated with a patient experiencing a mild, moderate or severe reaction to contrast media.
11. Discuss the strategies for treating patients experiencing an adverse reaction to contrast media.
12. Discuss patient counseling and recommended follow-up care for patients undergoing a procedure requiring the use of contrast media.

### **Ethics and Law in the Radiologic Sciences**

Content is designed to provide a fundamental background in ethics. The historical and philosophical basis of ethics, as well as the elements of ethical behavior, will be discussed. The student will examine a variety of ethical issues and dilemmas found in clinical practice.

An introduction to legal terminology, concepts and principles also will be presented. Topics include misconduct, malpractice, legal and professional standards and the ASRT scope of practice. The importance of proper documentation and informed consent is emphasized.

### **Objectives**

1. Describe specialized standards of behavior for the healing arts as a continuum, with historical and philosophical roots in the earliest periods of human history.
2. List the major milestones in the development of codes of behavior and ethical standards in the healing arts.
3. Explain ethics as a branch of philosophy and the moral, social and cultural basis of the development of an ethic.
4. Describe the moral, social and cultural basis of ethics.
5. Apply medical/professional ethics in the context of a broader societal ethic.
6. Explain the role of ethical behavior in health care delivery.
7. Differentiate between empathetic rapport and sympathetic involvement in relationships with patients and relate these to ethical conduct.
8. Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
9. List legal/professional standards and their relationship to practice in health professions.
10. Identify specific situations and conditions that give rise to ethical dilemmas in health care.
11. Discuss the *U.S. Genome Project* relative to the cause of genetically induced disease.
12. Explore the ethical issues of genetic screening.
13. Explain the genetic counseling responsibility of health care providers.
14. Employ a basic system of examination, clarification, determination of alternatives and decision-making in addressing ethical questions.
15. Explain select concepts embodied in principles of patients' rights, the doctrine of informed (patient) consent and other issues related to patients' rights.
16. Explain the legal implications of professional liability, malpractice, professional negligence/carelessness and other legal doctrines applicable to professional practice.
17. Describe the importance of accurate, complete, correct methods of documentation as a legal/ethical imperative.
18. Explore theoretical situations and questions relating to the ethics of care and health care delivery.
19. Explain specific legal terms, principles and laws.

20. Outline the elements necessary for a valid malpractice claim.
21. Define specific legal doctrines to include vicarious liability, *respondeat superior*, and *res ipsa loquitur*.
22. Describe the scope of practice for radiography, the elements that comprise it and responsibilities of the radiographer.
23. Differentiate between professional and legal standards and describe how each relates to the radiography profession.
24. Describe institutional and professional liability protection typically available to the technologist.
25. Describe the elements and implications of informed consent.
26. Identify standards for disclosure relative to informed consent.
27. Describe how consent forms are utilized relative to specific patient procedures.

### **Human Diversity**

Content is designed to promote better understanding of patients, the patients' families and professional peers through comparison of diverse populations based on their value systems, cultural and ethnic influences, communication styles, socioeconomic influences, health risks and life stages. Content will include the study of factors that influence relationships with patients and professional peers. Understanding human diversity assists the student in providing better patient care.

### **Objectives**

1. Explain the development of a personal value system.
2. Discuss the interrelationship between personal, community and societal values.
3. Explain the influence a person's value system has on his or her behavior.
4. Discuss the development of personal and professional values.
5. Describe how professional values influence patient care.
6. Examine Kohlberg's theory on how an individual's morality influences his or her behavior.
7. Differentiate between culture and ethnicity.
8. Explain how a person's cultural beliefs toward illness affect his or her recovery.
9. Explain the origins of medical ethnocentrism.
10. Discuss the societal factors that influence the quality of health care.
11. Compare alternative/complementary medicine to the traditional Western model.
12. Describe the culture of poverty and its effect on health care.
13. Discuss family dynamics in a cultural, social, ethnic and lifestyle context.

### **Human Structure and Function**

Content is designed to establish a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems will be described and discussed.

### **Objectives**

1. Identify the location of structures using directional and orientation terms.
2. Indicate where various planes lie in relation to the body.
3. Identify the structural limits, functions and contents of each of the body cavities.
4. Explain the terms atom, ion, atomic number and atomic weight.
5. Describe the nature of chemical bonds and compare the different types of chemical bonds.

6. Apply the pH scale to differentiate between acid and base substances.
7. Differentiate between polar and nonpolar compounds, and relate these to water solubility.
8. List different types of carbohydrates and give examples of each type.
9. Differentiate between the different types of lipids and determine common characteristics.
10. Describe the structure and functions of proteins.
11. Describe the structure of deoxyribonucleic acid (DNA) and the law of complementary base pairing.
12. Describe the structure of ribonucleic acid (RNA) and name the different types of RNA.
13. Characterize the structure of the cell membrane and the cytoskeleton.
14. Compare endocytosis and exocytosis.
15. Identify the structure and function of cilia and flagella.
16. Diagram the replication of DNA.
17. Diagram the phases of the cell cycle.
18. Describe genetic transcription and the post-transcriptional modifications that change pre-mRNA into mRNA.
19. List the functions of mRNA, tRNA and rRNA.
20. List the functions of the rough endoplasmic reticulum and Golgi apparatus in post-translational modifications of secretory proteins.
21. Outline the sequence of events that occur in the synthesis packaging and exocytosis of secretory proteins.
22. Differentiate between the stages of meiosis and mitosis and identify the stages of each reproductive process.
23. Define the following: anabolism, catabolism and metabolism.
24. Characterize the role of enzymes in metabolism.
25. Describe carbohydrate metabolism.
26. Describe lipid metabolism.
27. Describe the Krebs cycle in general terms and its functional significance.
28. Express the significance of ketone.
29. List the factors that affect the basal metabolic rate.
30. Diagram the germinal layers of the embryo.
31. Classify tissue types, describe the functional characteristics of each and give examples of their location within the human body.
32. Identify and locate the bones of the human skeleton.
33. Identify bony processes and depressions found on the human skeleton.
34. Describe articulations of the axial and appendicular skeleton.
35. Differentiate the primary and secondary curves of the spine.
36. Describe sesamoid bones and locate examples on radiographs.
37. Summarize the functions of the skeletal system.
38. Label different types of articulations.
39. Compare the types, locations and movements permitted by the different types of articulations.
40. Examine the organization of muscle at the gross and microscopic levels.
41. Differentiate between the structures of each type of muscle tissue.
42. State the function of each type of muscle tissue.
43. Name and locate the major muscles of the skeleton.
44. Differentiate between the structure and function of different types of nerve cells.

45. State the structure of the brain and the relationship of its component parts.
46. Describe the brain functions.
47. List the meninges and describe the function of each.
48. Outline the formation, circulation and function of cerebrospinal fluid.
49. Describe the structure and function of the spinal cord.
50. Determine the distribution and function of cranial and spinal nerves.
51. Summarize the structure and function of components making up the autonomic nervous system.
52. Describe the structures and functions of the components making up the human eye and ear.
53. List the component body parts involved in the senses of smell and taste.
54. List the somatic senses.
55. Define endocrine.
56. Describe the characteristics and functions of the components making up the endocrine system.
57. Identify the location and describe the structure of each component of the endocrine system.
58. Identify the major hormone(s) secreted by each component of the endocrine system.
59. Describe the hard and soft palates.
60. Differentiate between deciduous and permanent teeth in terms of age for eruption and number.
61. Differentiate between the types of teeth in terms of number, location within the jaws and their function.
62. Label the component parts of a tooth.
63. Describe the structure and function of the tongue.
64. Identify the structure, function and locations of the salivary glands.
65. Recite and label the primary organs of the digestive system.
66. Describe the function(s) of each primary organ of the digestive system.
67. Differentiate between the layers of tissue that comprise the esophagus, stomach, small intestine, large intestine and rectum.
68. Differentiate between peritoneum, omentum and mesentery.
69. List and label the accessory organs of the digestive system, and describe their function.
70. Identify the secretions of accessory organs of the digestive system and the function of each.
71. Explain the purpose of digestion.
72. List the digestive processes that occur in the body.
73. Describe the composition and characteristics of blood.
74. List the types of blood cells and state their functions.
75. Differentiate between blood plasma and serum.
76. Outline the clotting mechanism.
77. List the blood types.
78. Explain the term Rh factor.
79. Explain the antigen/antibody relationship and its use in blood typing.
80. Label the parts of the human heart.
81. Describe the flow of blood through the body and identify the main vessels.
82. Describe the structure and function of arteries, veins and capillaries.
83. Differentiate between arterial blood in systemic circulation and arterial blood in pulmonary circulation.
84. Differentiate between normal and common abnormal electrocardiogram (ECG) tracings.

85. Summarize the structure, distribution and function of lymphatic vessels.
86. Outline the major pathways of lymphatic circulation.
87. Identify the location of major lymph node clusters.
88. Differentiate between nonspecific defenses and specific immunity.
89. Explain antibody production and function.
90. List the different types and functions of T- and B-cells and explain their functions.
91. Label the components of the respiratory system.
92. Describe the physiology and regulation of respiration.
93. Label the parts of the kidneys, ureters, bladder and urethra.
94. Describe the function of each organ of the urinary system.
95. Describe the composition and formation of urine.
96. Explain micturition.
97. Label the anatomy of the male and female reproductive organs.
98. Analyze the function of each of the male and female reproductive organs.
99. Demonstrate the use of topographical landmarks to locate internal structures.
100. Identify major anatomical structures found within sectional images.

### **Image Analysis**

Content is designed to provide a basis for analyzing patient images. Included are the importance of minimum imaging standards, discussion of a problem-solving technique for image evaluation and the factors that can affect image quality. Actual images will be included for analysis.

### **Objectives**

1. Discuss the elements of a diagnostic image.
2. Identify the steps in the decision-making process used in image analysis.
3. Describe an effective image analysis method.
4. Describe the role of the technologist in image analysis.
5. Apply the process for evaluating images for adequate density, contrast, recorded detail and acceptable limits of distortion.
6. Explain how the technologist determines that the adequate level of penetration has been applied to produce the desired level of contrast.
7. List the parameters for evaluating visibility of detail on the image.
8. Discuss the method for evaluating image distortion.
9. Summarize the importance of proper positioning.
10. Discuss the impact of patient preparation on resulting images.
11. Analyze images to determine the appropriate use of beam restriction.
12. Identify common equipment malfunctions that affect image quality.
13. Determine the corrective actions necessary to correct for common equipment malfunctions.
14. Differentiate between technical factor problems, procedural factor problems and equipment malfunctions.
15. Critique images for appropriate technical and procedural factors, and recommend corrective actions if necessary.

## **Imaging and Processing**

Content is designed to establish a knowledge base in factors that govern and influence the production and recording of images. Film and electronic imaging with related accessories will be emphasized. Class demonstrations/labs are used to demonstrate application of theory.

### **Objectives**

1. Discuss practical considerations in setting standards for acceptable image quality.
2. Assess image density.
3. Distinguish between acceptable and unacceptable image densities.
4. Analyze the relationships of factors that control and affect image density.
5. Differentiate between subject contrast and image receptor contrast.
6. Compare long-scale and short-scale contrast images.
7. Analyze the relationships of factors that control and affect image contrast.
8. Critique recorded detail on various images.
9. Differentiate between umbra and focal spot blur.
10. Analyze the relationships of factors affecting recorded detail.
11. Define distortion.
12. Differentiate between shape and size distortion.
13. Explain beam filtration.
14. Describe the change in the half-value layer (HVL) when additional filtration is added to the beam.
15. Summarize the relationships of factors affecting scattered and secondary radiation.
16. Evaluate the effects of scattered radiation on the image.
17. Articulate the advantages and disadvantages of grid use.
18. Evaluate grid artifacts.
19. Explain the use of standardized radiographic technique charts.
20. Apply mAs reciprocity to clinical simulations.
21. Explain latent image formation.
22. Discuss photostimulable phosphor plates as image receptors.
23. Discuss how an image is retrieved from a photostimulable phosphor.
24. Identify types of image artifacts and analyze the artifacts to determine the cause.

## **Medical Terminology**

Content is designed to provide an introduction to the origins of medical terminology. A word-building system will be introduced, and abbreviations and symbols will be discussed. Also introduced will be an orientation to the understanding of patient exam orders and interpretation of diagnostic reports. Related terminology is addressed.

### **Objectives**

1. Apply the word-building process.
2. Interpret medical abbreviations and symbols.
3. Critique orders, requests and diagnostic reports.
4. Define radiation science terms.
5. Translate medical terms, abbreviations and symbols into common language from a medical report.

## **Patient Care in Radiologic Sciences**

Content is designed to provide the basic concepts of patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures will be described, as well as infection control procedures utilizing standard precautions. The role of the technologist in patient education will be identified.

### **Objectives**

1. Identify the responsibilities of the health care facility and members of the health care team.
2. List the general responsibilities of the imaging professional.
3. Explain select perceptions of death and dying from patient and technologist viewpoints.
4. Describe ethical, emotional, personal and physical aspects of death.
5. List the stages of dying and describe the characteristics of each stage.
6. Identify the support mechanisms available to the terminally ill.
7. Identify methods for determining the correct patient for a given procedure.
8. Explain the use of various communication devices and systems.
9. Explain specific aspects of a diagnostic/therapeutic procedure to the patient.
10. Demonstrate correct principles of body mechanics applicable to patient care.
11. Demonstrate techniques for specific types of patient transfer.
12. Demonstrate select procedures for turning patients with various health conditions.
13. Describe select immobilization techniques for various types of procedures and patient conditions.
14. Describe specific patient safety measures and concerns.
15. Explain the purpose, legal considerations and procedures for reporting an accident or incident.
16. Describe methods for evaluation of patient status.
17. List the information to be collected prior to patient examination.
18. Describe vital signs used to assess patient condition.
19. Convert a Fahrenheit measurement to the Celsius equivalent.
20. State the normal temperature values for the oral and rectal routes of measurement.
21. Describe the method of monitoring respiration and state the normal values expected.
22. Identify the normal values for blood pressure for males and females.
23. Identify the seven major sites for monitoring the pulse and indicate the normal values.
24. Assess patient vital signs.
25. List the normal ranges for specific laboratory studies.
26. Define terms related to infection control.
27. Describe the importance of Standard Precautions and Isolation Procedures.
28. Explain sources and modes of transmission of infection and disease.
29. List institutional/departmental procedures for infection control.
30. Describe methods for the prevention of infection to the health worker and patient.
31. Identify symptoms related to specific emergency situations.
32. Describe the emergency medical code system for the institution and the role of the student during a medical emergency.
33. Explain the special considerations necessary when performing procedures on an infant or a child.
34. Explain the special considerations necessary when performing procedures on a geriatric patient.

35. Describe the symptoms and precautions taken for a patient with a head injury.
36. Describe the symptoms and precautions taken for a patient with a spinal injury.
37. Explain the types, immobilization devices and positioning for upper and lower extremity fractures.
38. Describe the symptoms and precautions taken for a patient with massive wounds.
39. Describe the classifications and medical interventions for burns.
40. Describe the symptoms and medical interventions for a patient having a contrast agent reaction.
41. Explain the role of the technologist in patient education.
42. Identify specific types of tubes, lines, catheters and collection devices.
43. Explain the purpose, precautions and care of tubes, lines, catheters and collection devices.
44. Outline the steps in the operation and maintenance of suction and oxygen equipment and demonstrate their use.
45. Demonstrate competency in cardiopulmonary resuscitation (CPR).
46. Demonstrate the use of specific medical emergency equipment and supplies.
47. Demonstrate select first aid techniques.
48. Describe the special problems faced in performing procedures on a patient with tracheotomy and specific tubes, drains and catheters.

### **Pharmacology**

Content is designed to provide basic concepts of pharmacology. The theory and practice of basic techniques of venipuncture and the administration of diagnostic contrast agents and/or intravenous medications is included. The appropriate delivery of patient care during these procedures is emphasized.

### **Objectives**

1. Identify key drug laws impacting consumer safety.
2. Identify the five schedules of controlled substances and cite a drug example of each.
3. Identify the role of the U.S. Food and Drug Administration and the U.S. Drug Enforcement Administration in the regulation and control of consumer drugs.
4. Implement strategies for health care workers involved in dispensing medications to comply with the restrictions of drug laws.
5. Interpret common abbreviations and symbols used for medication orders.
6. Translate drug measurements across measurement systems.
7. Differentiate among drug names (generic, chemical, trade, official).
8. Explain the restrictions of drug sales implied by the designation of: over the counter, legend drug and controlled substance.
9. Describe the biological processing of drugs in the body.
10. List common variables affecting drug action within the body.
11. Describe common unexpected responses to drugs.
12. Accurately perform calculations for drug dose delivery.
13. Describe dose modifiers for pediatric and geriatric patients.
14. Describe various forms of drug preparations and supplies.
15. Incorporate the principles of responsible drug administration in the patient care setting to prevent medication error.
16. Describe administration routes and techniques for select medications.

17. Describe the principles associated with a controlled clinical drug trial.
18. Distinguish between single-blind and double-blind drug trials.

### **Radiation Biology**

Content is designed to provide an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

#### **Objectives**

1. Describe the characteristics of a molecule.
2. Describe principles of cellular biology.
3. Identify sources of electromagnetic and particulate ionizing radiations.
4. Discuss directly and indirectly ionizing radiations.
5. Identify sources of radiation exposure.
6. Describe radiation-induced chemical reactions and potential biologic damage.
7. Evaluate factors influencing radiobiologic/biophysical events at the cellular and subcellular level.
8. Identify methods to measure radiation response.
9. Describe physical, chemical and biologic factors influencing radiation response of cells and tissues.
10. Explain factors influencing radiosensitivity.
11. Recognize the clinical significance of LD<sub>50/30</sub> and LD<sub>30</sub>.
12. Examine effects of limited vs. total body exposure.
13. Relate short-term and long-term effects as a consequence of high and low radiation doses.
14. Differentiate between somatic and genetic radiation effects as well as discuss specific diseases or syndromes associated with them.
15. Discuss stochastic and nonstochastic (deterministic) effects.
16. Discuss risk estimates for radiation-induced malignancies.

### **Radiation Production and Characteristics**

Content is designed to establish a basic knowledge of atomic structure and terminology. Also presented are the nature and characteristics of radiation, x-ray production and the fundamentals of photon interactions with matter.

#### **Objectives**

1. Describe Bohr's theory of atomic structure.
2. Discuss the characteristics and function of a proton, neutron and electron.
3. Discuss the energy levels of the atom.
4. Explain the processes of ionization and excitation.
5. Define the terms relating to atomic nomenclature.
6. Describe the electromagnetic spectrum.
7. Define and describe wavelength and frequency and how they are related to velocity.
8. Explain the relationship of energy and frequency.
9. Explain the wave-particle duality phenomenon.
10. Identify the properties of x-rays.

11. Describe charged and uncharged forms of particulate radiation.
12. Describe radioactivity and radioactive decay in terms of alpha, beta and gamma emission.
13. State the principles of x-ray production.
14. Compare the production of bremsstrahlung and characteristic radiations.
15. Discuss various photon interactions with matter in terms of description of the interaction, relation to atomic number, photon energy and part density, and their applications in diagnostic radiology.
16. Discuss relationships of wavelength and frequency to beam characteristics.
17. Discuss the clinical significance of the photoelectric and modified scattering interactions in diagnostic imaging.

### **Radiation Protection**

Content is designed to present an overview of the principles of radiation protection including the responsibilities of the technologist for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

### **Objectives**

1. Identify and justify the need to minimize unproductive radiation exposure of humans.
2. Distinguish between somatic and genetic radiation effects.
3. Differentiate between the stochastic and nonstochastic (deterministic) effects of radiation exposure.
4. Explain the objectives of a radiation protection program.
5. Define radiation and radioactivity units of measurement.
6. Identify dose equivalent limits (DEL) for occupational and nonoccupational radiation exposure.
7. Describe the as low as reasonably achievable (ALARA) concept.
8. Identify the basis for occupational exposure limits.
9. Distinguish between perceived risk and comparable risk.
10. Describe the concept of negligible individual risk level (NIRL).
11. Describe the theory and operation of radiation detection devices.
12. Distinguish between controlled and noncontrolled areas and list acceptable exposure levels.
13. Describe the function of federal, state and local regulations governing radiation protection practices.
14. Describe the requirements for and responsibilities of a radiation safety officer.
15. Express the need and importance of personnel monitoring for radiation workers.
16. Identify dose equivalent limits for the embryo and fetus in occupationally exposed women.
17. Distinguish between primary and secondary radiation barriers.
18. Identify emergency procedures to be followed during failures of x-ray equipment.
19. Demonstrate how time, distance and shielding can be manipulated to keep radiation exposures to a minimum.
20. Explain the relationship of exposure factors to patient dosage.

## **Sectional Anatomy**

Content is designed to study normal sectional anatomy via diagrams and diagnostic images.

### **Objectives**

1. Differentiate between sagittal, coronal and axial planes of the body.
2. Review the principles of imaging for imaging modalities using relevant terminology.
3. Compare the imaging modalities for application to radiation therapy.
4. Identify normal anatomical structures on sectional images.
5. Identify topographic anatomy used to locate underlying internal structures.