Cardinal Health
Nuclear Pharmacy Services
7000 Cardinal Place
Dublin, OH 43017
614.757.5000 main
800.234.8701 toll free

cardinalhealth.com

CardinalHealth

January 21, 2013

U.S. Nuclear Regulatory Commission
Region III – Division of Nuclear Materials Safety
2443 Warrenville Rd, Suite 210
Lisle, IL 60532-4352

Re: Amendment Request for Radioactive Materials License 34-29200-01MD, Cardinal Health Nuclear Pharmacy Services, Dublin, OH.

Radioactive Materials Licensing:

Cardinal Health 414, LLC (Nuclear Pharmacy Services, hereafter Cardinal Health) requests an amendment to the above referenced license to update the reference to our Authorized User (AU) and Authorized Nuclear Pharmacist (ANP) didactic training program. The proposed update will include the option for recognition of any online or accredited college or university School of Pharmacy curriculum for nuclear pharmacist didactic training. The current license amendment number 40, conditions 12.B.(1) and 25.B. refer to our correspondence dated December 18, 2006, February 8, 2007 and May 3, 2012 concerning the Cardinal Health training program for Authorized Nuclear Pharmacist (ANP) or Authorized Users (AU).

Cardinal Health has evaluated other accredited ANP training programs for didactic content consistent with regulatory requirements and the company objectives in planning for future business needs. We find that these programs also require on-site or remote participation with the experience to meet the requirements of 10 CFR 35.55 and 10 CFR 32.72(b)(2)(i) or (4). The AU-ANP correspondence courses are available on the campus or via the internet by either recognized expert training resources such as Nuclear Education Online (NEO, http://www.nuclearonline.org/index.asp) and/or using qualified instructors at an accredited college or university School of Pharmacy, along with ANP's acting as a proctor on site.

Please see the enclosed Cardinal Health course syllabus in **Attachment A** to update the Cardinal Health ANP-AU program. Examples of our collaborative efforts to review and accept equivalent didactic training from other ANP-AU college or university School of Pharmacy programs is enclosed in **Attachment B**.

If you have any questions regarding this request, please contact Dan Hill at 614.757.5074.

Sincerely,

Willie Regits, Ph D.
Corporate Radiation Safety Officer
Director, Health Physics
Nuclear Pharmacy Services

/dh

Enclosure: Attachment A: Cardinal Health AU-ANP Course Syllabus
Attachment B: University School of Pharmacy Syllabus SAMPLE

Original + 1 copy

cc: Consolidated NRC File (3)
Ligi Mathews, RSO, Loc. 2231
Joseph Zuehl, RSO, loc. 011
John Alexander, RSO, Loc. 2
Dan Burton, RSO, Loc. 10
Mathew Svejk, RSO, Loc. 13
Christie Holland, RSO, Loc. 16
Sharon Jackson, RSO, Loc. 25
Asma Abassi, RSO, Loc. 28
Earl Robertson, RSO, Loc. 30
Jay Simmons, RSO, Loc. 88
Brian Porter, RSO, Loc. 109
Dane Dishman, RSO, Loc. 120
John A. Miller, RSO, Loc. 128
Bruce Jorgensen, RSO, Loc. 172
Sarah Pekarek, RSO, Loc. 182
Mark Peters, RSO, Loc. 200
Nate Johnson, RSO, Loc. 201
Doug Sopp, RSO, Loc. 3341
Mark Rotman, RSO, Loc. 3306
Cliff McClendon, RSO, Loc. 5045
Michael Chee, Loc. 7232 (1199)

ATTACHMENT A

Cardinal Health
Authorized Nuclear Pharmacist / Authorized User
Training Program Syllabus

THE OHIO STATE UNIVERSITY
College of Pharmacy
University Medical Center

And

CARDINAL HEALTH 414, LLC
NUCLEAR PHARMACY SERVICES

Authorized User/Authorized Nuclear Pharmacist
DIDACTIC EDUCATION PROGRAM

Syllabus
Rev 1/13

Defining the Role of the Authorized User/Authorized Nuclear Pharmacist

Properly trained authorized users (AU) (the authorized nuclear pharmacist (ANP) is in a regulation defined class of authorized users who possesses a valid board of pharmacy license) play the key role in the completion of the many tasks involved with the practice of nuclear materials manufacturing and nuclear pharmacy. The AU is specially trained to handle radioactive materials (RAM) in the operation of a nuclear manufacturing facility or nuclear pharmacy. Additionally, they are required by regulatory agencies for the handling of RAM. In the PET manufacturing facility, regulatory compliance requires that all RAM is handled by or under the supervision of an AU. In the nuclear pharmacy, all handling of radiopharmaceuticals must be handled by or under the supervision of an ANP. The AU completes a variety of job functions in the handling of RAM, including the supervision of non-authorized users, nuclear pharmacy technicians and other handlers of RAM. In order to properly function in the role of an AU, the individual must demonstrate working knowledge of the terms, rules, regulations and safe practice of nuclear manufacturing/pharmacy including the proper techniques in the handling, ordering, storage, preparation, testing, distribution or dispensing, and disposal of RAM.

Program Description

The goal of this education program is to provide didactic training for the AU leading to a demonstration of knowledge in radiation physics and instrumentation, math associated with radiation, radiation protection including regulatory requirements, and radiation biology. The AU working in a pharmacy additionally is provided training in procedures associated with the calculation and measurement of radiation pharmaceuticals and radiopharmaceutical dosages, and in other areas that would complete administrative and customer service tasks. The AU will learn the scope of duties and activities in accordance with applicable rules and regulations. This training should be supplemented with previous learning experience involving an orientation to the practice of nuclear materials. The AU education program provides an opportunity to gain knowledge and understanding of the authorized user's work under the supervision of a licensed authorized user.

Regulations require that any person to be named as an AU on a license must undergo didactic training and handling experience commensurate with the level of responsibility. For the Authorized Nuclear Pharmacist (ANP) or Authorized User NPT (AU) the NRC requires 200 hours of didactic training. For the manufacturing AU, the number of hours is usually not specified, though 120 hours is seen as adequate. This AU education program is designed to help prepare authorized users for inclusion on a radioactive materials license. The preceptor is responsible for guiding all authorized user trainees through the modules of the distance education portion of the program. The distance education portion is 200 hours of didactic training designed to be completed over a six (6) week period. The onsite portion of the authorized user training is designed to complement and complete the distance education portion offered by Cardinal Health Nuclear Pharmacy Services preceptor authorized nuclear pharmacy practitioners located around the country.

The onsite portion of the program is for authorized users in nuclear pharmacies. During the four weeks between the distance learning and onsite portions, students spend a day with their Cardinal Health sales consultant and spend a day in the nuclear medicine department of a hospital or clinic.

The onsite portion is a three (3) week intensive training on radiopharmaceuticals, including their production, uses and dosages. This portion of the program provides an additional 105 hours for a total of 305 didactic hours for authorized users in nuclear pharmacies.

This program, whether just the distance learning (for those working in nuclear manufacturing facilities) or the full nuclear pharmacy AU preparation, will not make a person an AU (ANP). This merely fulfills the regulatory requirements for didactic training set forth by the various regulatory agencies. Additional experience with the handling of RAM also is required. For the nuclear pharmacy AU candidate, this is a minimum of 500 hours of experience handling RAM of the type and activity associated with the normal practice of nuclear pharmacy (under the supervision of a preceptor if an ANP candidate). For the nuclear manufacturing candidate, this is minimum 120 hours. Each must be under the supervision of an already named AU (ANP). Even so, this only qualifies the person as an AU (ANP) in the eyes of a regulatory agency. The true AU constantly strives to improve technique in the handling of RAM so as to maintain exposure to radiation ALARA (As Low As Reasonably Achievable).

Program Objectives

The six-week distance education training consisting of both didactic and laboratory experience will assure mastery of the self-study material and provide hands-on experience with the primary components of the job function of the authorized user.

1. Demonstration of appropriate knowledge and understanding of the principles involved with radiation physics, radioactive decay, and the math pertaining to radiation physics and radioactive decay, including statistics used in counting of radioactive decay.
2. Demonstration of appropriate knowledge and understanding of the principles in the shielding of radioactivity, dosimetry, and other principles of radiation protection.
3. Demonstration of appropriate knowledge and understanding of the principles involved with the instrumentation associated with the measurement of radiation and radiation fields.
4. Demonstration of appropriate knowledge and understanding of radiation biology and the effects of radiation on living tissue, especially in humans.
5. Demonstration of appropriate knowledge and understanding of the various regulations that relate to possession and transportation of radioactive materials.
6. Demonstration of appropriate knowledge and understanding of the policies and procedures of the appropriate Cardinal Health Radiation Safety Manual (Nuclear Pharmacy Services or PET Manufacturing Services) and how these policies relate to compliance with regulatory requirements.

7. (AU for a nuclear pharmacy only) Demonstration of appropriate knowledge and understanding of the chemistry of byproduct material for medical use, including imaging techniques and current radiopharmaceutical technology.
8. (AU for nuclear manufacturing facility only) Demonstration of appropriate knowledge and understanding of the principles of radiation physics and radiation detection instrumentation that is unique to a nuclear manufacturing facility, including neutron physics.

The three-week onsite training consisting of both didactic and laboratory experience will assure mastery of the self-study material and provide hands-on experience with the primary components of the job function of the authorized user.

1. To demonstrate knowledge of the current practice of nuclear medicine and nuclear pharmacy
2. To describe the use and operation of radionuclide generators
3. To explain technetium, indium, and iodide chemistry
4. To evaluate clinical application of radiopharmaceuticals
5. To explain the mechanism of localization, biodistribution, and radiation dosimetry of technetium, iodide, and indium radiopharmaceuticals
6. To perform mathematical calculations involved in nuclear pharmacy
7. To interpret the regulations involving radiopharmaceutical preparation and distribution

Based on these objectives, experiential training and demonstration of competencies will include a total of either six (6) weeks of training and evaluation for nuclear manufacturing, or nine (9) weeks of training and evaluation for nuclear pharmacies.

Instructors

Richard Green, R.Ph., BCNP
Director Radiopharmacy Practice
Nuclear Pharmacy Services
Cardinal Health
614-757-3174
E-mail richard.green@cardinalhealth.com

George H. Hinkle, M.S., R.Ph., BCNP, FASHP, FAPhA

Director, Learning Management
Cardinal Health
614-553-3264
E-mail: george.hinkel@cardinalhealth.com

Paul Knapp, R.Ph., MBA, BCNP
Program Manager Clinical Support
Nuclear Pharmacy Services
Cardinal Health
614-757-6713
E-mail paul.knapp@cardinalhealth.com

Janet Robertson, R.Ph., BCNP
Program Manager Pharmacy Practice
Nuclear Pharmacy Services
Cardinal Health
614-652-1870
E-mail janet.robertson01@cardinalhealth.com

Willie Regits, Ph.D.
Director Health Physics
Nuclear Pharmacy Services
Cardinal Health
614-757-3147
E-mail willie.regits@cardinalhealth.com

Dan Hill
Health Physicist
Nuclear Pharmacy Services
Cardinal Health
614-757-5074
E-mail dan.hill01@cardinalhealth.com

Vai Paye
Senior Health Physicist
Manager, Health Physics
Nuclear Pharmacy Services
Cardinal Health
614-757-2646
E-mail vai.paye@cardinalhealth.com

Evan Western
Health Physicist
Nuclear Pharmacy Services
Cardinal Health
614-553-4555
Email: evan.western@cardinalhealth.com

Randy Kuhner
Health and Safety Specialist
Nuclear Pharmacy Services
Cardinal Health
614-757-5651
E-mail randy.kuhner@cardinalhealth.com

The Distance Learning Portion

In an effort to both strengthen your candidate, and to give you an opportunity to gauge their ability to perform in a nuclear pharmacy or nuclear manufacturing environment, a four-week pre-training period has been added prior to the initiation of the current six week distance-based authorized user didactic program. This four-week period is meant to expose the candidate to as many shifts and facility duties as possible, in order for everyone involved to be aware of the expectations and potential performance issues specific to each employment situation prior to the individual's probationary period ending.

The four-week period is meant to give the local team the chance to have the candidate shadow the preceptor or another designated authorized user through as many shifts and duties as possible. Ideally, the candidate will complete all required training and documentation and then be able to work one week of opening shifts, one week of mid-day shifts and one week of closing shifts. In addition, the candidate should be given some experience with on-call duties as well as weekend shifts. Of course, the specifics of each locations operations will dictate different experiences, but the goal is to have the candidate experience as much of the location's normal workload as possible. If no significant difficulties are experienced, the candidate can then begin the six week distance-based authorized user program.

It has been decided that the four-week pre-training period will not be made a mandatory part of the authorized user training program, but it is highly recommended. To stress this point, any deviations from the four-week period will require the approval of the applicable Vice President of Operations or PET, the notification of Q&R and the development of a candidate specific plan to ensure both their successful completion of the didactic training and that there will be an opportunity for the local team to expose the candidate to the full nuclear pharmacy/nuclear manufacturing experience prior to the Dublin-based portion of the authorized user program.

The distance learning portion of the class is a computer based set of Adobe Acrobat documents, homework exercises, and laboratory experiments. All are provided electronically to the students. Although they are in a self study format, there is a minimum progression of modules that should be performed in order to successfully pass the exams (see the schedule). The schedule is an example only. Some students may proceed at a faster pace, and it is possible holidays may occur during the schedule. These specifics will be discussed at the first conference call (during week 0). The preceptor must allow the student time to complete this work.

Computer hours are now listed as required weekly hours and are the average time a student would probably need to complete weekly modules. This is the minimum amount of computer time the preceptor must give the student for completion of that week's modules. This time can be scheduled at the discretion of the preceptor, but must be during the student's regular shift. Homework, laboratory work and study time are not included. Time for study and homework are managed by the preceptor. This may be

done in the facility during normal working hours, at the discretion of the preceptor. It is understood that some study and/or homework may need to be done after the student's regular shift. **However, it is up to the student and preceptor working together to determine when during the week these modules are to be completed. All other time is mentored by the preceptor, and it is up to the preceptor to determine whether the student needs extra time for study and homework.**

Three lists of suggested tasks (one for each exam) to be completed prior to the end of each week is included on the class CD. The goal is to allow students to realize where the information being learned is useful in their daily pharmacy activities. Preceptors should meet with students periodically to review and check off each task once the student has performed them.

The exams typically include multiple choice type questions (usually worth 2 points each) and other questions that include calculations or require exposition (usually worth 5 points each). A minimum score of 70 is required to pass an exam. A candidate is allowed one (1) make up exam. All three exams must be passed in order for a candidate to successfully pass the distance learning portion. Exams are closed note and closed book except for a single sheet that contains commonly used formulas (this sheet is supplied), and are proctored by the preceptor. In order to ensure security of the exams, they will be either be emailed to the proctor 15 minutes prior to the start of the exam or administered through a learning management system electronically. Students have a four hour timeframe to complete the exam. The learning management system will lock the student out of the exam after the four hour mark. Students faxing their exams to Q&R must submit completed exams electronically or fax before the four hour mark, otherwise the exam will be voided and will count as a fail. Homework and laboratory experiments are not collected or graded, but will be discussed at the conference calls, and exam questions frequently reflect homework and experimental results. Exams typically occur every other week.

Preparation for Onsite Portion

During the approximately four weeks between the distance and onsite portions, those training to become authorized users in a nuclear pharmacy will spend a day in a nuclear medicine department at a hospital or clinic, and spend a day with their Cardinal Health sales consultant.

The purpose of the hospital or clinic visit is to introduce students to the daily practice of nuclear medicine, to increase awareness and appreciation of the needs of a nuclear medicine department, and to enhance communication with the nuclear medicine professional.

Time also will be spent with students' pharmacy field sales consultants to learn the role of sales. This assignment educates the new AU in the duties, responsibilities and resources of Cardinal Health sales consultants. It also enhances communication and increases appreciation of the interactions between the sales consultants, the pharmacy, and the customer.

Onsite Class Portion

The onsite portion of the didactic training is designed for the AU in the nuclear pharmacy. This is three (3) weeks of intensive training on radiopharmaceuticals, including their production, uses and dosages. Students attend class daily from 8 a.m. to 5 p.m., Monday through Friday. Additional time outside of class will be necessary in order to complete homework assignments and prepare for exams. The course format consists of lectures utilizing handouts, audiovisuals, demonstrations, and discussions including problem-solving sessions, supervised laboratory practice and homework assignments. In order to receive credit, students must attend all class sessions and score a minimum of 70% on each of the following four scored activities: 3 clinical exams and the homework assignments/clinical case presentation component. In addition, two laboratory practical exams must be completed on a pass/fail basis. Only one clinical exam retake, and one laboratory practical exam retake, are permitted during the duration of the onsite course.

Authorized Nuclear Pharmacist candidates (and NPT AU candidates if needed) will receive 50 contact hours (5 CEUs) of pharmacy continuing education after successful completion of the onsite portion. Statement of credit will be issued on the day of completion of the program. Cardinal Health 414, LLC (Nuclear Pharmacy Services), a business unit of Cardinal Health, Inc. is accredited by the Accreditation Council for Pharmacy Education (ACPE) as a provider of continuing pharmacy education.

Description of Modules for Distance Learning Portion

The hours listed for the distance courses reflect the average minimum time necessary for completion of the module, and does not include study time or homework time. Most students will take longer for completion. Hours are minimum needed per week for completion of the required modules for that week. The letters following each module refer to the category of training as outlined by the NRC (see last page).

Distance learning Week 0:

Introductory Conference Call: B
Introduction to the distance learning portion of the class; description and reasons for program; logistics of program; requirements for passing.

Distance learning Week 1: Minimum hours 15 hours

Math, Physics and Chemistry Review: C
Review of basic concepts from mathematics, including scientific notation, units and unit conversions, exponents and logarithms, significant figures, and solving equations, as they relate to radioactive materials and radiation in general; basic concepts in physics, including force, work and energy, and charge; concepts from chemistry, including atomic structure and the structure of matter itself.

Radioactivity: A
Basic concepts of radiation and radioactivity; types and mechanisms of radioactive decay; decay products and decay series; examples of common radionuclides.

Half-Life and Decay: C
Radioactive decay and half-life; why some elements undergo radioactive decay and the units used to measure it; half-life and the decay constant in the radioactive decay law. Experiments with half-life and radioactive decay.

Statistics: C
Radiation counting and probability statistics. Experiments with counting.

Basic Cyclotron Theory and FDG Synthesis Overview: A
Specific to the cyclotron students, basic cyclotron and FDG synthesis overview

Conference Call: B
Conference call to go over the week's modules, homework and laboratory work.

Distance learning Week 2: Minimum 15 hours

Nuclear Interactions: A
Interactions of radiation, both charged particles, and uncharged radiation, with matter; charged particle interactions, including ionization and excitation; uncharged interactions,

including the photoelectric effect, pair production and Compton scattering; stopping power, linear energy transfer and attenuation coefficients.

Shielding: A
Attenuation, HVL, TVL and buildup. Experiments with shielding.

Dosimetry: B
Review of dosimetry, the measurement of ionizing radiation doses, and the different dosimetric quantities involved in monitoring radiation exposure; differences between exposure, absorbed dose, and dose equivalent for external exposure; internal exposure and monitoring intake of radiation; Annual Limit on Intake (ALI), Derived Air Concentrations (DAC) and Effluent Limits.

Safe Handling: B
Safe use of radioactive material; ALARA concept and the principles behind it; how to minimize external and internal exposure by applying the ALARA principle. Experiments with safe handling.

Neutron Physics: A
Specific to the cyclotron students, Neutron physics and shielding concepts

Conference Call: B
Conference call to go over the week's modules, homework and laboratory work.

Distance learning Week 3: Minimum 15 hours

Instrumentation: A
Different methods of detecting radiation.

Gas Filled Detectors & Resolving Time: A
Gas-filled radiation detectors, including Geiger-Mueller (GM) detectors and ion chambers.

Scintillation Detectors: A
Scintillation detectors, such as the bioassay probe and the detectors for the single-channel and multi-channel analyzers.

Efficiency, LLD, MDA, Resolving Time: A, C
Efficiency, lower limit of detection, and minimum detectable activity of a radiation detector. Experiments with efficiency, LLD and MDA.

MCA, E Resolution, & ROI: A
Multi-channel analyzers; concepts of efficiency, lower limit of detection, and minimum detectable activity of a radiation detector in more depth. Experiments with MCA.

PET Safe Handling: B

Specific to the cyclotron students, safe handling of radioactive material in a manufacturing site and common tasks that may incur exposure, ways to reduce exposure

Conference Call: B
Conference call to go over the week's modules, homework and laboratory work.

Distance learning Week 4: Minimum 15 hours

Hoods & Air Sampling: A
Fume hoods, glove boxes, and air monitoring in the nuclear pharmacy. Experiments with hoods & air sampling.

PET Hoods & Air Monitoring: A
Specific to the cyclotron students, fume hoods, hot and mini cells, air monitoring, peak stripping.

Survey Meters: A
Survey meters used throughout Cardinal Health. Experiments with survey meters.

SCA & Bioassay: A
Single channel analyzer (SCA) and the bioassay procedure. A more detailed bioassay procedure is made during the second half of ANP training. Experiments with SCA and bioassay.

Emergency Procedures: B
Potential emergencies that can happen at a Cardinal Health facility and the responses to those emergencies. Experiments with emergencies.

Conference Call: B
Conference call to go over the week's modules, homework and laboratory work.

Distance learning Week 5: Minimum 15 hours

Radiation Biology: E

Sources
Sources of radiation, how they vary geographically, and where most radiation exposure comes from.

Historical Background
Discovery of radiation and the history of radiation protection.

Exposure Defs
Definitions used in radiation biology; LET, range, RBE; acute and chronic dose; dose fractionation; cell survival curves.

Cell Structure and Function
Human cell structure and functions of various components of a cell; processes by which a cell is produced and replicated.

Radiation Damage in Living Tissue
How radiation affects human tissue on the cellular and genetic levels.
Effects of Radiation (Defs)
Definitions of the effects of radiation on human tissue.
Genetic Effects
Genetic effects of radiation, why they occur, and some examples of genetic effects.
Non-stochastic Effects
Non-stochastic effects, such as acute radiation syndrome types, effects on various organs, and treatment; several case studies including Goiania, Brazil and Chernobyl.
Stochastic Effects
Somatic and stochastic effects in detail.
Study Groups
Study groups which have provided information regarding the effects of radiation on living tissue; studies ranging from laboratory animals to survivors of actual radiation events such as the Chernobyl incident.

Conference Call: B
Conference call to go over the week's modules, homework and laboratory work.

Distance learning Week 6: Minimum 15 hours

Radiation Biology: E
Low Dose Studies
Different low dose studies; results and conclusions of these studies, and their advantages and disadvantages.
In Utero Effects
In utero effects of ionizing radiation.
Risk Assessment
Risk models, including Linear No Threshold (LNT), Linear Threshold, and Linear Quadratic; genetic and cancer risk assessments; perspective of risks.

DOT Regulations: B
Regulations of the DOT and how they apply to Cardinal Health facilities.

Radioactive Materials Regulations: B
Nuclear Regulatory Commission (NRC) rules that govern the use of radioactive material.

Using the Cardinal Health Radiation Safety Manual: B

Conference Call: B
Conference call to go over the week's modules, homework and laboratory work.

Description of Modules for Onsite Portion

The hours listed for the onsite courses reflect the minimum time necessary for completion of the topic, and do not reflect homework or study time.

Instrumentation Review (HP): A, C – 10 hours
Review and hands on experience using survey meters, SCA, MCA, performing bioassay and routine surveys.

Human Resources Presentation: B – 1 hour
Supervisory and other HR aspects of managing a radiation safety program. Rules, regulations and boundaries when safety is involved in people management.

Health and Safety Program Overview : B – 2 hours
Overview of requirements under OSHA's health and safety regulations; topics include Bloodborne Pathogen Standard and its requirements, occupational exposure to bloodborne pathogens and exposure reduction techniques; review of chemical hazards and the Hazard Communication Standard with an emphasis on hierarchies of exposure control; generation of medical waste in the nuclear pharmacy and an understanding of medical waste regulations; review of the Cardinal Health NPS distance learning computer based training that includes training modules for all major required training subjects: radiation safety, general health and safety and bloodborne pathogens, and DOT training; review of major emergency scenarios and action plans; understanding the Driver's Safety Program and its requirements. Students will participate in Health and Safety program scenarios in order to emphasize required programmatic elements for health and safety in the nuclear pharmacy.

Incident Response (HP): B – 2 hours
Practice at responding to emergencies involving radioactive materials and proper procedures to follow.

USP <797> Changing the Face of Nuclear Pharmacy: B – 1 hour
Defining who USP is; outlining the contents of chapter <797> 2004; bridging the gap between the inherent conflicts between radiation safety requirements in the practice of Nuclear Pharmacy and the literal read of USP <797>; introduction of augmented and new SOPs to be implemented towards achieving compliance with 2004 <797> regulations;

Pharmaceutical Event Reporting: B – 1 hour
Defining required prescribed pharmaceutical events; highlights of "best practice" recommendations to avoid events; reviewing and recommending appropriate reporting guidelines.

Production of Radioisotopes: A – 4 hours
Discussion of how short lived radioactive materials for medical use are produced, including accelerator production, nuclear reactors and radionuclide generator systems;

concepts of radionuclidic contaminants, licensing, available manufacturers and logistics; extensive discussion of Mo-99 generators including kinetics, carrier, expected yield and disposal.

Gamma Cameras and Sealed Sources: A – 1 hour
Review of general operational characteristics of a scintilization gamma camera and how the ANP can assist the NMT in maintaining its correct function; scintilization event, detector crystals and efficiencies, PM tubes, collimators, quality control testing, flood fields, resolution and sensitivity, bar phantoms; introduction to sealed sources encountered in Nuclear Medicine & Radiopharmacy including their uses and licensing.

Radiopharmaceutical Chemistry: D – 4 hours
Facts, concepts and theories regarding the chemistry involved with radiopharmaceuticals. Manufacturer's kits and available isotope forms, radiopharmaceutical labeling reactions, bifunctional chelates, chemical stability.

Quality Control: C, D – 4 hours
Quality control and quality assurance testing methods for manufacturer provided and custom compounded radiopharmaceuticals; thin layer chromatography and other QC method concepts.

Brain Imaging: D – 1 hour
Physiology and anatomy of the nervous system; current standard of practice for nuclear medicine studies of the nervous system; current, past and possible future radiopharmaceuticals for use in the imaging of nervous system's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Cardiology: D – 2 hours
Physiology and anatomy of the heart and cardiovascular system; current standard of practice for nuclear medicine studies of the heart and cardiovascular system; current, past and possible future radiopharmaceuticals for use in the imaging of heart and cardiovascular system's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Parathyroid: D – 1 hour
Physiology and anatomy of the parathyroid glands; current standard of practice for nuclear medicine studies of the parathyroid glands; current, past and possible future radiopharmaceuticals for use in the imaging of parathyroid's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Scintimammography: D – 1.5 hours
Physiology and anatomy of the breast; current standard of practice for nuclear medicine studies of the breast; current, past and possible future radiopharmaceuticals for use in

the imaging of breast's morphology and dynamic functions; concepts regarding drug l localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Skeletal Imaging: D – 1.5 hours
Physiology and anatomy of the skeletal system; current standard of practice for nuclear medicine studies of the skeletal system; current, past and possible future radiopharmaceuticals for use in the imaging of skeletal system's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Bone Pain: D – 1 hour
Discussion of cancer related bone pain complications; current standard of practice for nuclear medicine palliative treatment of bone pain; current, past and possible future radiopharmaceuticals for use in the treatment of bone pain; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Liver / Spleen: D – 1 hour
Physiology and anatomy of the liver and spleen; current standard of practice for nuclear medicine studies of the liver and spleen; current, past and possible future radiopharmaceuticals for use in the imaging of liver and spleen's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Lymphoscintigraphy: D – 1 hour
Physiology and anatomy of the lymphatic system; current standard of practice for nuclear medicine studies of the lymphatic system; concept of the "sentinel node"; current, past and possible future radiopharmaceuticals for use in the imaging of lymphatic system's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Hepatobiliary: D – 2 hours
Physiology and anatomy of the hepatobiliary system; current standard of practice for nuclear medicine studies of the hepatobiliary system; current, past and possible future radiopharmaceuticals for use in the imaging of hepatobiliary system's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Pulmonary: D – 1.5 hours
Physiology and anatomy of the pulmonary system; current standard of practice for nuclear medicine studies of the pulmonary system; current, past and possible future radiopharmaceuticals for use in the imaging of pulmonary system's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Renal: D – 1.5 hours
Physiology and anatomy of the renal system and urinary tract; current standard of practice for nuclear medicine studies of the renal system; current, past and possible future radiopharmaceuticals for use in the imaging of renal system's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Radiation Fields: A, B – 2 hours
In depth discussion of radiation protection tools and techniques to keep extremity doses as low as reasonably achievable; application of the use of time, distance, shielding, reduction of activity handled and common sense to achieve ALARA; discussions of shielding within LAF, dose calibrator, remote handling devices, syringe shields of various design and materials, vial shields, contamination prevention and control. Includes direct hands on practice with the correct use of syringe shields and vials shields.

Dose Calibrator Lab: A, C – 2 hours
Review of the use of dose calibrators in a radiopharmacy including their function, and license requirements for maintenance and testing, including: daily constancy, accuracy, linearity, geometrical variation; laboratory session during which testing is performed.

Thyroid: D – 4 hours
Physiology and anatomy of the thyroid gland; current standard of practice for nuclear medicine studies of the thyroid gland; current, past and possible future radiopharmaceuticals for use in the imaging of thyroid gland's morphology and dynamic functions; concepts regarding drug localization, metabolism and elimination; compounding, safety, logistical and manufacturer issues.

Thyroid Lab: D – 2 hours
Hands on application of the concepts and methods of thyroid scintigraphy; specific focus on thyroid bioassay procedures and thyroid burden calculations; use of thyroid phantoms, sealed sources and counting equipment; practical problem solving utilizing the above required.

Miscellaneous Radiopharmaceuticals and GI Imaging: D – 3 hours
Comprehensive overview of current, past and possible future miscellaneous radiopharmaceuticals; specific discussions of; ^{51}Cr blood volume studies, radioiodinated human serum albumin, ^{57}Co & ^{58}Co Schilling's Test, gastric emptying studies, gastro-intestinal bleeding studies, Meckel's Diverticulum studies, ^{13}C & ^{14}C H. Pylori assessment, Dacryocystography, ^{131}I Norcholesterol adrenocortical imaging, ^{32}P intracavity and IV uses, testicular imaging, radioiodinated mIBG and others. Current, past and possible future radiopharmaceuticals for use in miscellaneous nuclear medicine studies. Concepts regarding drug localization, metabolism and elimination, compounding, safety, logistical and manufacturer issues.

Gallium Imaging: D – 1 hour
Overview of Gallium uptake and distribution concepts. Current standard of practice for nuclear medicine studies of suspected tumors utilizing ^{67}Ga. Concepts regarding ^{67}Ga metabolism and elimination. Safety, logistical and manufacturer issues.

Monoclonal Antibodies: D – 3 hours
Comprehensive overview of current, past and possible future monoclonal antibody based radiopharmaceuticals, and current standard of practice for nuclear medicine studies involving their uses. Discussion of the current state and possible future of radioimmune therapy. Concepts regarding drug localization, metabolism and elimination. Compounding, safety, logistical and manufacturer issues.

Peptides: D – 1 hour
Comprehensive overview of current, past and possible future peptide based radiopharmaceuticals, and current standard of practice for nuclear medicine studies involving their uses. Concepts regarding drug localization, metabolism and elimination. Compounding, safety, logistical and manufacturer issues.

Lactating Women: D – 1 hour
Concepts and complications in dealing with lactation when a nuclear medicine study is medically necessary; current standard of practice for nuclear medicine studies when administration to a lactating female is performed; concepts regarding drug localization, metabolism and elimination; specific focus on excretion of tracers in breast milk, and possible impact on nursing infants; compounding, safety, logistical and manufacturer issues.

Pediatrics: D – 1.5 hours
Concepts and complications in dealing with pediatric patients when a nuclear medicine study is medically necessary; current standard of practice for nuclear medicine studies when administered to child; concepts regarding drug localization, metabolism and elimination; specific focus on reduction of tracer dosages and pediatric specific biodistribution issues; compounding, safety, logistical and manufacturer issues.

Altered Biodistribution: D – 1.5 hours
Concepts, causes and complications of altered biodistribution of radioactive imaging and therapeutic agents; current standard of practice for responses to altered biodistribution occurrences; concepts regarding normal and altered drug localization, metabolism and elimination; specific focus on drug interactions and disease states that cause altered biodistribution.

Brachytherapy: D – 1 hour
Overview of brachetherapy implants; specific focus on applicable disease states, available isotopes, dosimetry and implantation procedures; current, past and possible future uses, isotopes and configurations; handling, safety, logistical and manufacturer issues.

PET: A, D – 1 hour
Overview of positron emission tomography (PET); specific focus on applicable disease states, available isotopes, dosages and imaging protocols; additional focus on production and distribution; current, past and possible future uses and isotopes; handling, safety, logistical and manufacturer issues.

Kit Compounding Lab and Classroom Applied Practical: C – 4 hours
Hands on training and experience with various class topics, including: instrumentation, sealed sources, radiation safety procedures & record keeping, isotope handling & storage, ALARA, kit compounding, DOT procedures and contamination control; practical exam stresses the above as applied to pharmacy practice, and physics calculations.

Pharmacy Practice Policy & Procedure Manual (P4M) Review: D – 1 hour
Comprehensive review of policies, procedures and rational contained within the Cardinal Health Pharmacy Practice Policy & Procedure (P4M) Manual.

10 CFR 35.55 requires 200 hours didactic training in

A Radiation physics and instrumentation
B Radiation protection
C Mathematics pertaining to the use and measurement of radioactivity
D Chemistry of byproduct material for medical use; and
E Radiation Biology

At least 200 hours is completed by the candidates' from their assigned work place or home locations. This includes a mixture of reading modules, homework completion, and experimental discovery in the pharmacy under the supervision of a qualified preceptor. These assignments are designed to emphasize certain key topics covered in the modules and homework. The successful completion includes a passing grade of at least 80% for three exams of maximum length 4 hours, for a total of at least **200 hours**. All exams are proctored by a preceptor.

Item **D** is covered in the last three weeks in Dublin, OH, which also encompasses practical use of radiation instrumentation and some radiation protection. The last three weeks in Dublin account for 105 hours total which includes three exams of maximum length two hours for a total of **105 hours** in Dublin. Total hours between the two forums is **305 hours**.

ATTACHMENT B

Accredited College or University
School of Pharmacy

SAMPLE

Authorized Nuclear Pharmacist / Authorized User
Training Program Syllabus

November 28, 2012
Nuclear Pharmacy Certificate Program: Current Content

DISTANCE EDUCATION PROGRAM

I. Physics and Overview
   a. 4 DVD series
   b. Dr. Stanley M. Shaw
   c. Topics covered:
      i. Units of energy
      ii. Atomic structure
      iii. Nuclides
      iv. Radioactive decay and half-life
      v. Modes of radioactive decay
         1. Alpha
         2. Beta
         3. Beta-gamma
         4. Gamma (isomeric transition)
         5. Positron
         6. Electron capture
      vi. Ideal radionuclide for imaging
      vii. Interaction of ionizing radiation with matter
         1. Alpha
         2. Beta
         3. Gamma
         4. Photoelectric effect
         5. Compton effect
         6. Pair production
      viii. Radiation detection methods
         1. Gas filled detectors
         2. External scintillation detectors
         3. Nuclear medicine detection systems

II. Radiation Protection
   a. 2 DVD series
   b. Dr. Paul Ziemer
   c. Topics covered:
      i. Goals of radiation safety
      ii. Terminology and units
         1. Activity
         2. Exposure and exposure rate

3. Source strength
4. Absorbed dose and absorbed dose rate
5. Exposure and absorbed dose
6. Dose equivalent and dose equivalent rate

iii. Protection from external exposure
1. Time
2. Distance
3. Shielding
4. External protection from beta emitters
5. Alpha particle considerations

iv. Radiation survey instruments
1. GM survey meter
2. Sodium iodide scintillation detectors

v. Personnel monitoring
1. Dosimetry

vi. Contamination control and internal dose protection
1. Preventing contamination
2. Decontamination
3. Laboratory monitoring
4. Labeling requirements for containers
5. Survey of shipments received
6. Leak testing of sealed sources
7. Internal dose considerations

vii. Radioactive waste management
1. Long lived wastes
2. Short lived wastes
3. Recordkeeping

viii. Shipping requirments: packaging and labeling
1. Types of shipping containers
2. Container labeling

ix. 10 CFR part 20 – standards for protection against radiation
1. NRC
2. Radiation protection philosophy
3. Occupational dose limits
4. Determining internal exposures
5. Caution signs and labels
6. Labeling containers
7. Exceptions to posting requirements

x. 10 CFR part 19 – notices, instructions and reports to workers
1. posting of notices
2. instructions to workers
3. notifications and reports
4. inspections
    a. presence of representatives of licensee and workerd
    b. consultations with workers

III. Instrumentation
- a. 1 DVD
- b. Kara Weatherman
- c. Topics covered:
    - i. GM Survey meters
        1. Review of GM region of gas filled detector
        2. Review of equipment
        3. Survey meter calibration
        4. Daily operational checks
        5. Recordkeeping
    - ii. Dose calibrators
        1. Review of operation
        2. Quality control
            - a. Constancy
            - b. Accuracy
            - c. Linearity
            - d. Geometry
    - iii. SCA / MCA
        1. Photon detection
        2. Information obtained
        3. Efficiency
        4. Calibration
            - a. % variance
        5. Window selection

IV. Radiopharmaceuticals
- a. 4 DVDs
- b. Kara Weatherman
- c. Topics covered:
    - i. Imaging techniques
        1. Xray
        2. CT
        3. MRI
        4. Ultrasound
        5. Nuclear medicine
    - ii. Nuclear medicine imaging
        1. Gamma cameras
    - iii. Radionuclide production methods
        1. Reactor produced radionuclides
        2. Accelerator produced radionuclides
        3. In-house generator production
        4. Production issues
    - iv. Package inserts
    - v. Dosage forms
        1. IV
        2. Oral
        3. Inhalation

4. Intrathecal

vi. Radiopharmaceuticals
    1. Brain imaging
        a. Anatomy
        b. Blood flow
            i. Sodium pertechnetate
            ii. Tc-99m DTPA
            iii. Tc-99m Glucoheptonate
        c. Perfusion agents
            i. Tc-99m Ceretec
            ii. Tc-99m Neurolite
    2. Thyroid imaging
        a. Anatomy and physiology
        b. Agents
            i. I-123 sodium iodide
            ii. I-131 sodium iodide
            iii. Tc-99m sodium pertechnetate
    3. Lung imaging
        a. Anatomy and physiology
        b. Perfusion imaging
            i. Tc-99m MAA
        c. Ventilation imaging
            i. Xe-133
            ii. Tc-99m DTPA aerosol
    4. Cardiac imaging
        a. Agents
            i. Tl-201
            ii. Tc-99m Sestamibi
            iii. Tc-99m Tetrofosmin
            iv. Tc-99m labeled red blood cells
                1. UltraTag
                2. PYP
    5. Bone imaging
        a. Anatomy and physiology
        b. Agents
            i. Tc-99m MDP
            ii. Tc-99m HDP
        c. Imaging
    6. Liver-spleen –bone marrow imaging
        a. Anatomy and physiology
        b. Tc-99m sulfur colloid
    7. Hepatobiliary imaging
        a. Anatomy and physiology
        b. Agents
            i. Tc-99m Hepatolite
            ii. Tc-99m Choletec

8. Gastric imaging
    a. Anatomy and physiology
    b. Gastric emptying / reflux
        i. Tc-99m Sulfur colloid
    c. Meckles diverticulum
        i. Tc-99m sodium pertechnetate
    d. GI bleeding
        i. Tc-99m labeled red blood cells
9. Renal imaging
    a. Anatomy and physiology
    b. Renal function
        i. Tc-99m DTPA
        ii. Tc-99m MAG-3
    c. Renal morphology
        i. Tc-99m DMSA
        ii. Tc-99m Glucoheptonate
10. Infection imaging
    a. Wbc labeling procedure
        i. Tc-99m labeling
        ii. In-111 labeling
    b. Ga-67
11. Tumor imaging
    a. Agents
        i. Tl-201
        ii. Tc-99m sestamibi
        iii. Tc-99m tetrofosmin
        iv. Ga-67
        v. Monoclonal antibodies
        vi. Peptides
        vii. I-123 / I-131 MIBG

vii. Therapeutic radiopharmaceuticals
1. Therapeutic considerations
2. Taking therapy orders
3. Therapeutic agents
    a. Thyroid therapy
        i. I-131 sodium iodide
    b. Bone pain palliation
        i. Sr-89
        ii. Sm-153
    c. P-32
        i. P-32 chromic
        ii. P-32 sodium
    d. Non-Hodgkins lymphoma treatment
        i. Y-90 Zevalin

V. Review of Math
a. 1 DVD

b. Kara Weatherman
c. Topics covered
    i. The metric system
    ii. Units
        1. Curies
        2. Becquerel
    iii. Converting between units
    iv. Radioactive decay
        1. Decay law
        2. Half-life
        3. Decay constant

VI. Radionuclide Generators
a. 1 DVD
b. C Anne Smith
c. Topics covered
    i. History – generator development
    ii. Characteristics of an ideal generator
    iii. Mo-99 / Tc-99m generator
        1. Separation
        2. Eluting the generator
        3. Generator yield
    iv. Generator eluate
        1. Quality control tests
            a. Radionuclidic purity
            b. Radiochemical purity
            c. Chemical purity
            d. pH testing
    v. Generator kinetics
        1. Mo-99 decay scheme
        2. Calculating generator yield

VII. Kit preparation
a. 1 DVD
b. Kara Weatherman
c. Topics covered
    i. Radiopharmaceutical kit components
        1. Ligand
        2. Reducing agents
        3. Stabilizers
    ii. Prepping a radiopharmaceutical kit

VIII. Quality control testing of radiopharmaceuticals
a. 1 DVD
b. C Anne Smith
c. Topics covered
    i. Quality control test types
        1. Biological purity tests
            a. Sterility

b. Bacterial endotoxin
2. Radionuclidic purity tests
3. Radiochemical purity tests
4. Chemical purity tests
5. Microscopic inspection
6. Cell viability

ii. Equipment needed
iii. General QC procedures
1. Kit preparation qc steps
a. Package insert information
2. Biologic purity testing
3. Aseptic technique
4. Sterility testing
5. Pyrogen testing
6. Radionuclidic purity testing
7. Chemical purity testing
8. Radiochemical purity testing
a. Impurities
i. "free Tc-99m"
ii. HR Tc-99m
iii. Other chemical species
b. Solubility
c. Improving testing procedures
d. Understanding QC results
i. Calculating RCP
ii. Common RCP values
9. Microscopic inspection
a. Tc-99m sulfur colloid
b. Tc-99m MAA
10. Cell viability

IX. Problems Associated with Radiopharmaceutical Formulations
a. 1 DVD
b. James Ponto
c. Topics covered
i. Common problems
1. Carrier Tc-99
2. Excessive radioactivity
3. Aluminum ion
4. Stannous ion
5. pH
6. Mixing order
7. Reagent concentration
8. Blood volume
9. Tc-99m volume
10. Leukocyte labeling
11. Concentration effects

12. Heating effects
13. Incubation
14. Delays in radiolableing
15. Particle size and number
16. Commercial source differences
17. Oxidation / decomposition
    a. Peroxide production
    b. Radiolytic production
    c. Effect of radioactivity on stability
    d. Eluate age
    e. Addition of air
18. Preservatives
19. Anticoagulants
20. Age of blood
21. Encapsulation
22. Volatility
23. Radionuclidic contamination effects

X. Health Physics and Recordkeeping
   a. 1 DVD
   b. Brigette McGhee
   c. Topics covered
      i. RAM license
      ii. Health physics tests
         1. Tests performed daily
            a. Survey meter battery check
            b. Survey meter constancy
            c. Dose calibrator constancy / accuracy
            d. Well counter constancy
            e. Area wipes and surveys
            f. Other license specific / pharmacy specific tests
         2. Tests done weekly
            a. Bioassay
            b. Air monitoring
            c. Vehicle monitoring
            d. Other license specific / pharmacy specific tests
         3. Tests performed quarterly
            a. Dose calibrator linearity
            b. Well counter efficiency
            c. Sealed source inventory
            d. Air flow check (I-131)
            e. Other license specific / pharmacy specific tests
         4. Tests performed semi-annually
            a. Leak tests – sealed sources
         5. Tests performed annually
            a. Survey meter calibration
            b. Hood certification

c. Dose calibrator accuracy
6. Other tests
a. Dose calibrator geometry

iii. Recordkeeping

XI. Radiation Biology

a. 3 DVDs
b. Dr. Stanley M Shaw
c. Topics covered
i. General concepts
ii. Energy transfer and distribution patterns
1. Alpha
2. Beta
3. Gamma
4. Distribution patterns in a unit of mass
iii. Units of energy transfer
1. Roentgen
2. Radiation absorbed dose (RAD)
3. Radiation Equivalent Man (REM)
iv. Specific ionization
1. Linear energy transfer (LET)
v. Energy transfer
1. Direct effects
2. Indirect effects
3. Basic mechanisms
vi. Aqueous radiation chemistry
1. Production of free radicals
2. Interaction of free radicals
3. Factors influencing free radical reactions
vii. Characteristics of free radicals from water
1. Hydroxyl
2. Hydrogen
3. Hydroperoxyl
4. Irradiation of organic compounds in water
viii. Biologic response
1. Maximum permissible dose
2. Single hit concept
3. Multi hit concept
4. Relationship of dose response to MPD
ix. Target theory
1. Single hit model
2. Multi hit model
3. Survival fraction curves
x. Structural changes in macromolecules
1. Proteins
2. DNA
xi. Effects of radiation on cells

1. History
2. Effects of radiation on cell cycle
3. Cell cycle and radiosensitivity
    a. Differentiation of cells
4. Oxygen and cell radiosensitivity
    a. Dose fractionation

xii. Radiation effects on intact human system
1. Factors influencing radiation effects
    a. LET
    b. Area of exposure
    c. Dose rate
    d. Dose fractionation
    e. Age
    f. Species
2. System effects
    a. Hematopoetic system
    b. GI tract
    c. Skin
    d. Reproductive organs
    e. Other tissues
        i. Eye
        ii. Ear
        iii. Circulatory system
        iv. Radiation resistant tissues
            1. Respiratory tract
            2. Nervous system
            3. Bone
            4. Muscle

xiii. Medical radiation doses
1. Acute whole body exposure to gamma radiation
2. Diagnostic medical doses
3. Occupational radiation doses
4. Dose to embryo and fetus
    a. Influence of gestation time
    b. Preventative actions

XII. Late Effects of Ionizing Radiation
a. 1 DVD
b. William Widmer
c. Topics covered
    i. Assessing risk of late effects
    ii. Mechanism of late somatic effects
    iii. Cancer induction
        1. Skin cancer
        2. Lung cancer
        3. Bone cancer
        4. Liver cancer

5. Leukemia
6. Thyroid cancer

iv. Mechanism of radiation carcinogenesis
1. Mutation theory
2. Oncogene theory
3. Multi-event concept
4. Latent period for radiation induced cancers
5. Assessing risk
a. Linear quadratic
b. Linear

v. Life span shortening
vi. Cataractogenesis
vii. Organ fibrosis degeneration and atrophy

XIII. Radiation Safety in Pregnant and Breastfeeding Patients
a. 1 DVD
b. Jim Ponto
c. Topics covered
i. Regulatory oversight
ii. Review of normal fetal / embryo development
iii. Types of radiation effects on embryo / fetus
1. Death
2. Congenital abnormalities
3. Later childhood leukemias

iv. Relationship to gestational age
1. Pre-implantation
2. Organogenesis
3. 2^{nd} / 3^{rd} trimester

v. Dose-effect relationships
vi. Childhood leukemia
vii. Comparison of risks during pregnanacy
viii. Fetal dosimetry from nuclear medicine procedures
ix. Pregnancy testing

XIV. Adverse Reactions to Radiopharmaceuticals
a. 1 DVD
b. Jim Ponto
c. Topics covered
i. Definition
ii. Types of adverse reactions to radiopharmaceuticals
1. Allergic / hypersensitivity
a. Type I – IV
2. Anaphylactoid / idiosyncratic
3. Pyrogenic / aseptic meningitis
4. Mechanical
5. Concentration reactions
6. Vasovagal reactions
7. Radiation effects

iii. Reporting systems
    1. Statistics
    2. Severity
    3. Reported adverse reactions to radiopharmaceuticals
iv. Specific cases with radiopharmaceuticals
    1. Iodine containing radiopharmaceuticals
    2. Colloid radiopharmaceuticals
    3. Bone radiopharmaceuticals
    4. Lung perfusion radiopharmaceuticals
    5. Tc-99m DTPA for cisternography
    6. Monoclonal antibodies
    7. Radiation effects

XV. Radiopharmaceutical Updates
- a. 3 DVD
- b. Richard Kowalsky
- c. Topics covered
    - i. Brain imaging
        1. Tc-99m Ceretec
        2. Tc-99m ECD
    - ii. Kidney imaging
        1. MAG-3
        2. Captopril renograms
    - iii. Cardiac imaging
        1. Perfusion imaging
            - a. Stress-rest protocols
        2. Ventriculography
            - a. First pass
            - b. ECG gated equilibrium studies
        3. Interventional agents
            - a. Adenosine / dipyridamole
            - b. Dobutamine
    - iv. Bone pain palliation
        1. Strontium-89 chloride
    - v. Somatostatin receptor imaging
        1. In-111 Pentetreotide
    - vi. Monoclonal antibodies
        1. Review of immune system
        2. Antibody production and modification
        3. Agents
            - a. In-111 capromab

XVI. Clinical Uses of PET
- a. 1 DVD
- b. Laurie Ponto
- c. Topics covered
    - i. Clinical availability
    - ii. Special characteristics of PET radiopharmaceuticals

iii. Agents
    1. F-18 FDG
        a. Mechanism of action
        b. FDG uptake patterns
            i. Normal sites of uptake
            ii. Pharmacokinetics
        c. General patient preparation for imaging
            i. Fasting
            ii. Diabetic patients
            iii. Cardiac imaging
            iv. Tumor imaging
        d. Clinical uses
            i. Heart disease
            ii. Neurological disorders
                1. Epilepsy
                2. Alzheimer's disease
                3. Pick's disease
                4. Traumatic brain injury
                5. Cancer
            iii. Whole body tumor imaging
                1. Lung cancer
                2. Colon cancer
                3. Lymphomas
                4. Breast cancer
                5. Melanoma
                6. Thyroid cancer
                7. Areas where PET is not useful
                    a. Prostate cancer
                    b. Neuroendocrine tumors

XVII. Blood Pool Imaging
- a. 1 DVD
- b. Ron Callahan
- c. Topics covered
    - i. Clinical indications for blood pool imaging
        1. Cardiac
        2. Gastrointestinal
        3. Mechanism of localization
    - ii. Blood pool imaging agents
        1. Ideal properties
        2. Currently available
            - a. In vivo
            - b. In vitro
            - c. Modified in-vivo
            - d. Human serum albumin
            - e. Disadvantages of currently available agents
        3. Methods of radiolabeling RBC with Tc-99m

a. In vivo
b. Modified in-vivo
c. In vitro

iii. Pharmacokinetics of Tc-99m RBC
1. Bi-exponential whole body clearance

iv. Factors affecting labeling of RBC
1. Temperature
2. Volume of blood
3. Hematocrit
4. Sn++ dose
5. Tc-99m activity

v. Drug interactions with labeling RBC
1. Heparin / anticoagulants
2. Iodinated contrast media
3. Blood transfusion
4. Dipyridamole

vi. Comparison of labeling methods
1. In-vivo
a. Advantages
b. Disadvantages
2. Modified in-vivo
a. Advantages
b. Disadvantages
3. In-vitro
a. Advantages
b. Disadvantages

vii. New developments

XVIII. Nuclear Pharmacy Regulations
a. Introduction to regulations
b. Regulatory agencies
i. Food and Drug administration
ii. Nuclear Regulatory commission
c. NRC Regulations
i. Part 19: Notices, instructions and reports to workers
ii. Part 20: Standards for Protection against radiation
iii. Part 30: Rules of general applicability to domestic licensing of byproduct material
iv. Part 32: Specific domestic licenses to manufacture or transfer certain items containing byproduct material
v. Part 35: Medical use of byproduct material

XIX. Radiopharmaceutical Chemistry
a. 4 DVDs
b. Mark Green
c. Topics covered
i. Comparison of diagnostic imaging techniques
ii. Radionuclides used for radiopharmaceutical labeling

iii. Tracer principle
    1. Specific activity calculations
    2. Comparison of pharmaceuticals used in diagnostic imaging
iv. Myocardial perfusion imaging
    1. Ischemia vs. infarction
    2. Coronary flow reserve
    3. Principles of perfusion imaging
        a. Absolute / relative blood flow
        b. Freely diffusible tracer
        c. 1st pass extraction efficiency
v. Counting statistics in image analysis
vi. Evaluation of diagnostic tests
    1. Sensitivity, specificity
    2. Accuracy
    3. Positive / negative predictive value
vii. Inorganic radiopharmaceutical chemistry
    1. Periodic table
    2. Ligand
    3. Coordination chemistry
    4. Geometry
    5. Thermodynamic stability
    6. Kinetic stability
    7. Gallium, indium and thallium chemistry
    8. Bifunctional chelates
    9. Technetium chemistry
    10. PET
        a. PET camera / PET imaging
        b. FDG
        c. Radionuclide production
        d. Quality control of PET
        e. Clinical application

ON CAMPUS – HANDS ON LABORATORY MATERIALS / EXERCISES

I. Math and isotope review
    a. Review of decay equation
    b. Use of decay factors
    c. Unit conversions
    d. Commonly used isotopes in nuclear medicine (half life emphasis)
    e. Lab work
        i. Radioactive decay calculations
        ii. Use of decay factors
        iii. Conversion between Curie and Becquerel units

II. Survey meter review
   a. Operation
   b. Reading a survey meter
   c. Battery check and constancy test
   d. Troubleshooting
      i. Perform surveys
      ii. Demonstrate appropriate survey technique
      iii. Perform battery check and constancy check
      iv. Demonstrate various problems with (broken) survey meters

III. Protection from Ionizing Radiation
   a. Time distance shielding
   b. Inverse square law
   c. Specific gamma constant
   d. Radiation intensity
   e. Alpha vs. beta vs. gamma – shielding
   f. Calculating appropriate shielding
   g. Lab work
      i. Determine effect of distance and shielding on alpha, beta and gamma sources
      ii. Determine the best shielding material for use with different isotopes

IV. Gamma Scintillation
   a. SCA vs. MCA
   b. Components of a scintillation detector
      i. Crystal
      ii. Photocathode
      iii. Photomultiplier tube
      iv. Pulse height analyzer
   c. Calibration of a scintillation detector
   d. Calculation of efficiency
   e. Daily constancy testing
   f. Calculating percent variance
   g. Source comparisons
      i. Co-57
      ii. Ba-133
      iii. Cs-137
   h. Lab work
      i. Calibrate SCA
      ii. Calculate efficiency of SCA
      iii. Troubleshoot issues with SCA
      iv. Perform daily constancy test to assure calibration
      v. Calculate daily percent variance

V. Contamination and Decontamination
   a. Contamination risk
   b. Regulatory requirements
   c. Area surveys
      i. Area map
      ii. How to survey
      iii. Action levels
   d. Area wipes
      i. Area map
      ii. How to perform wipe test
      iii. Action levels
   e. Fixed vs. Removable contamination
   f. Decontamination
      i. Fixed
         1. Shield with lead
         2. Decontaminate by decay
      ii. Removable
         1. Methods of cleaning
   g. Lab work
      i. Survey and wipe contaminated lab station to identify areas of contamination
      ii. Identify areas as fixed / removable
      iii. Decontaminate areas
      iv. Documentation

VI. Aseptic technique and personnel validation
   a. USP 797
   b. Pharmacy modifications for compliance
   c. Sterility and pyrogenicity
   d. Personnel validation testing
   e. Lab work
      i. Perform personnel validation test using aseptic technique kit
      ii. Design a pharmacy layout while maintaining USP 797 compliance

VII. Dose calibration
   a. Function of dose calibrator
   b. Components of dose calibrator
      i. Well
      ii. Digital display
   c. Quality control tests
      i. Constancy
      ii. Accuracy
      iii. Linearity
      iv. Geometry
   d. Lab work
      i. Introduction to dose calibrator keypad

1. How to enter isotopes
2. How to enter calibration numbers
3. Converting between curies and Becquerel units
4. Dose calibrator power check
5. Entering calibration date and time
6. Background correction

ii. Perform dose calibrator constancy tests
1. Perform daily constancy (compared to 1 week of previous data)
2. Evaluate constancy test (data supplied to student to identify errors)
3. Perform accuracy calculations for current activity
4. Perform accuracy test
5. Determine accuracy percent variance
6. Calibrate Calicheck for use in linearity testing
7. Evaluate linearity test (time decay) using data supplied to student and identify any errors
8. Evaluate linearity test (Calicheck) using data supplied to student and identify any errors
9. Perform volume geometry test

VIII. Radionuclide generators
a. Introduction to generator (manufacturers, how column works, etc)
b. Wet (Covidien) and dry (Lantheus) generators
c. Elution of both types of generators
d. Calculating generator yield
i. Generator decay equation
ii. Generator decay factors
iii. Estimating yield
e. Quality control of generator eluate
i. Radionuclidic purity
1. Mo-99 as radionuclidic impurity in Tc-99m elution
2. How to perform Moly assay
3. Determining Moly assay at time of elution
4. Determining Moly assay at time of administration
ii. Radiochemcial purity
1. HR Tc-99m in Tc-99m elution
2. Formation of HR Tc-99m
3. Determining radiochemical purity
iii. Chemical purity
1. Alumina breakthrough in Tc-99m elution
2. Determining chemical purity with colormetric testing
f. Lab work
i. Evaluation of wet and dry generators
1. View column
2. Elute non-radioactive generators

ii. Perform quality control tests
    1. Mo-99 assay
        a. Perform Mo-99 assay using CRC15R dose calibrator Moly assay feature
        b. Perform Mo-99 assay using direct measurement (Mo-99 reading and Tc-99m reading – no automatic feature)
        c. Calculate radionuclidic purity of generator elution
    2. Radiochemical purity
        a. Perform ITLC chromatography to determine HR Tc-99m
        b. Calculate HR Tc-99m in elution sample
    3. Radiochemical purity
        a. Perform alumina testing of elution sample using standard alumina testing kit

IX. Introduction to Kit Preparation
- a. Kit components (ligand, reducing agents, etc)
- b. Kit activities (package insert values compared to current practice levels)
- c. How to prepare a radiopharmaceutical kit
- d. Lab work
    i. Review calculations for compounding kits
        1. Volume of Tc-99m eluate needed to achieve particular activity
        2. Total volume of kit to achieve desired kit concentration
        3. Volume of saline needed to adjust final concentration
        4. "hot and cold" kit concentration
        5. Calculating volume of dose based on kit concentration
        6. Prepare kits based on calculations performed

X. Dose Drawing Skills
- a. Appropriate way to hold kits and syringe shields when drawing doses
- b. Accuracy and precision when drawing doses
- c. Lab work
    i. Practice drawing non-radioactive material to particular volume using radiation safety tools
    ii. Practice drawing radioactive materials repeatedly with same volume to determine precision and accuracy of drawing skills

XI. White blood cell labeling
- a. Rationale for WBC labeling
- b. WBC labeling procedure
    i. Blood collection
        1. Anticoagulant
        2. Needle selection
    ii. Blood separation
        1. Sed rate

2. Hespan
3. Separation layers

iii. Preparation for labeling with radioactivity
1. Removal of plasma
2. Removal of RBC
a. Cell lysis

iv. Radiolabeling
1. In-111 labeling
2. Tc-99m HMPAO labeling

v. Post labeling clean-up of final product / preparation of final product
1. Removal of unlabeled radioactivity
2. Return of cells to physiologic state
3. Dispensing of final product

c. Comparison between In-111 and Tc-99m labeled WBC
d. Lab work
i. Complete labeling procedure using pig blood sample and Tc-99m HMPAO

XII. Quality Control Procedures
a. Basic principles of instant thin layer chromatography
b. Solid and mobile supports
c. QC of various radiopharmaceutical products
d. Lab work
i. Perform quality control on various radiopharmaceutical kits
ii. Evaluate separation of components using radiochromatograph scanner
iii. Evaluate separation of components using SCA counting
iv. Evaluate problems and issues with QC testing

XIII. Beta Emitters
a. Principles of beta emitters
b. Reading beta emitters on using dose calibrators
c. Geometry differences when using beta emitters
d. Use and safety of Y-90 containing radiopharmaceuticals
e. Lab work
i. Evaluate the effect of container on dose calibrator reading of beta emitters
ii. Evaluate the effect of volume on dose calibrator reading of beta emitters
iii. Determine appropriate dose calibrator setting to accurately read Y-90 on a given dose calibrator

XIV. Iodine compounding
a. Clinical use of iodine for therapeutic applications
b. Availability of I-131 for therapy capsules
i. Manufacturer direct order
ii. Custom compounding
c. Compounding of therapy capsules

i. Manual compounding
ii. Capsule compounding machines

d. Lab work
i. Calculate appropriate volume of I-131 for desired therapeutic dose (using Tc-99m as substitute for I-131 for safety purposes)
ii. Compound desired therapy capsule manually
iii. Compound desired therapy capsule using compounding machine
iv. Determine acceptability of final doses (both manual and compounding machine) for dispensing for patient use

XV. Iodine instrumentation
a. Characteristics of I-131 that require special handling
b. Regulatory oversight for I-131 use
c. Regulatory requirements
i. Bioassay
ii. Air monitoring

d. Lab work
i. Calibrate SCA for I-131 / Ba-133
ii. Determine efficiency of SCA
iii. Perform bioassay on self
1. Count neck
2. Count background
3. Calculate uCi I-131 in gland
4. Determine LLD and MDA for SCA being used
iv. Perform air monitoring calculations given a set of data collected from air monitoring sampling

XVI. Shipping and receiving of radioactive materials
a. NRC/DOT regulations pertaining to shipping
i. Package types
ii. Labeling
iii. Receipt of packages
iv. Shipping of packages

b. Lab work
i. Perform receipt procedure on incoming package
1. Identify errors (10 – 15 intentionally introduced by faculty) found during receipt process
2. Document procedure
ii. Perform shipping procedure for several unit dose radiopharmaceuticals
1. Wipe individual unit doses to determine acceptability for shipping
2. Cap and seal all unit doses
3. Place in appropriate shipping container
4. Perform survey of container to determine shipping category (WI, YII, YIII)
5. Label box with appropriately filled out placards

6. Wipe box for final shipment
7. Complete DOT approved shipping papers (including all calculations required to determine shipping activity)

c. Waste handling
   i. Regulations for handling radioactive waste
   ii. Radioactive vs. biohazard issues
   iii. Disposal requirements
   iv. Lab work
      1. Open returned box (from customer) and appropriately segregate waste
      2. "close" full waste bin using appropriate documentation and hold for decay
      3. prepare fully decayed bin for final disposal

XVII. Exams, quizzes and homework
   a. Homework
      i. Each night – students are assigned a problem solving homework assignment related to a topic or topics discussed that day
      ii. Students work on assignment when back at hotel
         1. Can work in group format to discuss answers
      iii. 30 minute discussion period at beginning of each day
   b. Exams and quizzes
      i. Students have 3 exams during week, each covering 2 days worth of material
      ii. Quizzes are open book, scenario based and are done in evenings to allow for group discussion of topics and collaboration on final answer
         1. Each student must answer all questions individually, but are allowed to discuss issues, etc prior to doing so.

Proposed Revision - 2013

NPCP Proposed revised content – revision roll-out: first quarter, 2013

BASICS OF NUCLEAR PHARMACY PRACTICE

I. Physics and Overview
   a. Stan Shaw / Kara Weatherman
   b. Hour breakdown: Radiation physics and instrumentation
      Mathematics
      Radiation protection

II. Radiation protection (includes time distance shielding, inverse square, etc, radiation dosimetry)
   a. Stan Shaw
   b. Hour breakdown: Radiation protection
      Mathematics

III. Radiation safety in pregnant and breastfeeding patients
   a. Jim Ponto
   b. ~ 1 hours
   c. Hour breakdown: Radiation protection
      Radiation biology
   d. Notes: Taping in August, 2012

IV. Review of Math and isotopes
   a. Kara Weatherman
   b. Hour breakdown: Mathematics

V. Statistics related to the use of radioactive material
   a. Kara Weatherman
   b. Hour breakdown: Mathematics

VI. Instrumentation (survey meter, dose calibrator, SCA/MCA, laminar flow, capsule compounding machine, fume hood and glove box, air monitoring)
   a. Kara Weatherman
   b. Hour breakdown: Radiation physics and instrumentation

RADIOPHARMACEUTICALS

VII. Generator
   a. Kara Weatherman
   b. Hour breakdown: RP chemistry (generator elution, quality control)
      Mathematics (generator yield)

VIII. Radiopharmaceutical chemistry – Introduction to kit preparation
   a. Ross Weatherman
   b. Hour breakdown: Radiopharmaceutical chemistry

IX. Radiopharmaceutical chemistry – Tc, In, Ga, Tl,, Iodine
   a. Vivian Loveless
   b. Hour breakdown: RP chemistry

X. Kit Preparation (discuss basics of kit prep plus each individual kit and how prepped – also dispensing concerns with non-kit products)
   a. Kara Weatherman
   b. Hour breakdown: Math
      Radiation physics and instrumentation

XI. Problems associated with RP formation
   a. Jim Ponto
   b. Hour breakdown: RP chemistry

XII. Basics of quality control
   a. Ross Weatherman
   b. Hour breakdown: RP chemistry
   c. Notes

XIII. Principles of quality control (discuss each kit and how QC is done)
   a. Kara Weatherman
   b.
   c. Hour breakdown: Radiation physics and instrumentation
      (method of counting samples)
      Math (calculations)
      RP chemistry (solubility, separation, etc)

REGULATORY

XIV. Nuclear pharmacy regulations (10 CFR Part 19,20,30,31,32,35), DOT regs
   a. Stan Shaw / Kara Weatherman
   b. Hour breakdown: Radiation protection

XV. Health physics and recordkeeping
   a. Still to be taped
   b. Hour breakdown: Radiation physics and instrumentation
      Radiation protection

XVI. Regulatory oversight of nuclear pharmacy practice – case examples
   a. Still to be taped
   b. Hour breakdown: Radiation protection
      Regulatory

XVII. Regulatory oversight on nuclear medicine practice – case examples
   a. NEW – Mack Richard
   b. Hour breakdown: Radiation protection

XVIII. USP <797> : Sterile product compounding – background regarding chapter requirements
   a. Eric Kastango
   b. Hour breakdown: Regulatory

XIX. USP <797> as applied to nuclear medicine and nuclear pharmacy
   a. Neil Petry
   b. Hour breakdown: Health physics and instrumentation

RADIATION BIOLOGY

XX. Radiation biology
   a. Stan Shaw
   b. Hour breakdown: Radiation biology

XXI. Late effects of ionizing radiation
   a. Stan Shaw
   b. Hour breakdown: Radiation biology

XXII. Low level radiation effects
   a. NEW – Stan Shaw
   b. Hour breakdown: Radiation biology

RADIOPHARMACY MANAGEMENT

XXIII. Shipping and receiving of radiopharmaceuticals
   a. Kara Weatherman
   b. Hour breakdown: Radiation physics and instrumentation
      Radiation protection

XXIV. Waste management
   a. Kara Weatherman
   b. Hour breakdown: Radiation physics and instrumentation
      Radiation protection

XXV. Inventory management
   a. Stephanie Hoffman
   b. Hour breakdown: Math

CLINICAL RADIOPHARMACEUTICAL USES

XXVI. Mechanisms of Radiopharmaceutical Localization
- a. Jim Ponto
- b. Hour breakdown: Clinical uses
- c. Notes:

XXVII. Clinical applications of radiopharmaceuticals
- a. Kara Weatherman
- b. Hour breakdown: Radiation biology
  RP chemistry

XXVIII. White blood cell labeling
- a. Jessica Turner / Kara Weatherman
- b. Hour breakdown: Clinical uses

XXIX. Blood pool imaging
- a. Ron Callahan
- b. Hour breakdown: Clinical uses

XXX. Therapeutic applications of radioisotopes
- a. Jessica Turner / Kara Weatherman
- b. Hour breakdown: Clinical uses

XXXI. Adverse reactions to radiopharmaceuticals
- a. Jim Ponto
- b. Hour breakdown: Clinical uses

XXXII. Drug interactions involving radiopharmaceuticals
- a. Kara Weatherman
- b. Hour breakdown: Clinical uses

XXXIII. Pediatric dosing
- a. Jim Ponto
- b. Hour breakdown: Clinical uses

POSITRON EMISSION TOMOGRAPHY

XXXIV. Introduction to PET radiopharmaceuticals
- a. Laurie Ponto
- b. Hour breakdown: Radiation physics and instrumentation
  Radiation protection
  RP chemistry

XXXV. Clinical uses of PET - FDG
- a. Laurie Ponto
- b. Hour breakdown: Radiation physics and instrumentation
  Radiation protection

RP chemistry
Clinical use

XXXVI. Clinical uses of PET – Cardiac applications
a. Laurie Ponto
b. Hour breakdown: Radiation physics and instrumentation
Radiation protection

XXXVII. Clinical uses of PET – Brain imaging
a. Laurie Ponto
b. Hour breakdown: Radiation physics and instrumentation
Radiation protection

XXXVIII. Clinical uses of PET - Oncology
a. Laurie Ponto
b. Hour breakdown: Radiation physics and instrumentation
Radiation protection

XXXIX. PET regulations
a. Needs to be taped
b. Hour breakdown Radiation protection

ON-CAMPUS MATERIAL

- on campus material will not change significantly from previous documents

CERTIFIED MAIL

Cardinal Health
Nuclear Pharmacy Services
7000 Cardinal Place
Dublin, OH 43017

7012 1010 0002 8212 8599

CardinalHealth

Priority Mail
ComBasPrice

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ZIP 43017 $ 011.09⁰
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US Nuclear Regulatory Commission
Region III-Division of Nuclear
Material Safety
2443 Warrenville Rd, Suite 210
Lisle, IL 60532-4352

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