BIOLOGY 201 – RADIOISOTOPE SAFETY
Summer 2008
WLS-107 (library)
3:45 – 5:25 pm

Tentative Schedule

	Dates	Lecture Number
July	14 M	1
	15 T	2
	16 W	no class
	17 Th	no class
	21 M	no class
	22 T	no class
	28 M	3
	29 T	4
	30 W	5
	31 Th	6
August	04 M	7
	05 T	8
	06 W	9
	07 Th	10
	11 M	11
	12 T	12
	13 W	13
	14 Th	14 (Exam)

TENTATIVE COURSE OUTLINE

LEARNING OBJECTIVE

The purpose of this course is to provide the students with a background knowledge of ionizing radiation, the basic concepts in radiation measurements, the proper safety procedures un the independent use of radioisotopes and to inform the student of current federal and state regulations, guidelines, and licensing procedures.

TENTATIVE OUTLINE OF TOPICS

Introduction

- Goals
- Description of course content
- Requirements

Radionuclides

- Nomenclature and general terminology
- Symbols and designations
- Basic structure of the atom
  - Bohr model
    - Isotopes, isobars, isotones
  - Nuclear binding energy
    - Mass defect
  - Orbital binding force

The Nature of Ionizing Radiation

- Types of radiation
  - Alpha (α) decay
  - Beta (β) decay
  - Electron capture
    - Characterisitc X-ray and electron transition
  - Positron decay
  - Gamma (γ) decay (isomeric transition)
  - Internal conversion
    - Auger electrons
  - X-radiation
  - Neutrons (?)
    - Slow, fast
  - Decay schemes
  - Quantitative description of radioactive decay
    - Disintegrations
    - Half life

Decay constants
Simple and mixed decay schemes

Interaction of ionizing radiation with matter

Distance
Interaction of heavy, charged particles (alpha, protons, deuterons)
Linear energy transfer (LET)
Specific ionization (SI)
Range/distance of penetration
Interaction of beta particles
With electrons
Elastic and inelastic collisions
With nuclei
Bremsstrahlung
Cerenkov radiation
Energy estimate and penetration
Interaction of positrons
Annihilation photons
Interaction of gamma and X-radiation
Photoelectric absorption
Compton scattering
Pair production
Photodisintegration
Photon attenuation
Attenuation coefficients
Interaction of neutrons

Quantities and Doses

Physical quantities
Curie (Ci) and fractions
Becquerel (Bq) and multiples
Other units
Absorbed doses
Roentgen (R)
Rad
Gray (Gy)
Rem
Sievert (Sv)
Relative biological effectiveness (RBE)

Source of Radioactive Nucleotides

Nature
Reactors

Types of reactions
Fission products
Accelerators

Measurements of Radioactivity

Detectors
A. Gas-filled
Ionization chambers and regions
Simple discharge
Saturation current
Proportional current
Limited proportionality
Geiger region
Spontaneous discharge
Counting Instruments
Simple ionization chambers
Proportional counters
Geiger counters
Problems and disadvantages
B. Neutron detectors
C. Scintillation Counting
a. Solid crystal detectors
- Crystal
- Photomultiplier tube
- Counting System
•Components:
Detector
High voltage supply
Preamplifier
Amplifier
Pulse rise and decay
Overloading: amplitude and rate
Pulse height analyzer
Integral sorting
Differential sorting
Multichannel sorting
Recording and display
Timers, rate meters
b. Spectrometry
Photopeaks
Photofractions
Compton region
X-ray escape peak
Backscatter peak
Annihilation peak

- Bremsstrahlung peak
- Sum peak
- Photopeak counting

- Sources of error
  - Background
  - Resolving time
  - Detector efficiency
  - Fractional emission of source
  - Geometry
  - Backscatter
  - Attenuation in window, air, sample, container, etc.
  - Self-absorption

- Liquid Scintillation Counting
  - Basic process
  - Solvents
  - Fluors
  - Counting systems
    - Detection and collection of light
    - Pulse height analyzer
    - Quenching
      - chemical , color, optical
    - Quench correction
      - Internal standardization
      - Channels ratio
      - External standards
      - Special index of sample
    - Double isotope counting
  - Semiconductor counting
  - Autoradiography
  - Other types of detectors
  - Standards
    - Absolute (primary)
    - Secondary
    - Tertiary

<u>Statistics of Radiation</u>

- Error
  - Determinate and indeterminate
  - Accuracy
  - Precision
  - Bias
  - Distribution of decay
  - Sigma value and confidence intervals

Biological Effects of Ionizing Radiation

- Absorbed dose
  - External source
  - Internal source
    - Effective half-life
    - Total dose
    - Gamma dose
    - Absorbed fraction
  - Acute effects
    - Hemopoietic, gastro-intestinal, central nervous system damage, secondary infections
  - Delayed effects
    - Cancer
    - Genetic damage
  - Mechanisms
    - Direct effects
    - Indirect effects
      - Radical formation and combination with O2, role of –SH groups
      - Nuclear vs. cytoplasmic sensitivity
    - Chromosomal aberrations
      - Large dose vs. low dose
    - Genetic fitness
  - Sources of low-level radiation
    - Natural
      - Cosmic
      - Terrestrial
        - External, internal
    - Medical or dental
    - Occupational
    - Power plants
    - Fallout (?)
    - Miscellaneous

Safety Regulations in Information

- Common Sense
- NRC guidelines
  - Title 10CFRpart20
  - Other NRC guidelines and updates
- State administrative codes
  - Wisconsin HFS-157
  - ICRP
  - Personnel monitoring
  - Work area monitoring
  - Exposure limits

ALARA Principle

Disposal

- Sanitary sewer
- Decay by storage
- Incineration
- Burial
- Expense, space, permits
- Special regulations of LSC and animal carcasses
- Mixed waste

Licensing

- Where, how, from whom?
  - Agreement states, non-agreement states
- What is a license; what dies it authorize; what does it oblige?
- Types of licenses
  - Exempt usage
  - General license
  - Specific license
    - Limited scope
    - Broad scope
      - Types A, B, C
  - Human (medical) uses
  - Amendments
  - Administration: committee and RSO
  - Compliance, penalties

Marquette University License Details

- Acquisition
- Bookkeeping
- Disposal
- Reporting
- Survey

Special Problems

- Loss of disposal sites
- Biohazards vs. radiation hazards
- Transportation
- Training and turnover of employees

Miscellaneous Topics

Sources of labeled compounds
Availability
Labeling service
The press and the public

List of References Sources

Cember J. Introduction to Health Physics. 2nd (1983) or 3rd (1996) edition. High level of technical difficulty.

Granier R, and Gambini D. Applied Radiobiology and Radiation Protection. High level of technical difficulty.

Turner JE. Atoms, Radiation, and Radiation Protection. High level of technical difficulty.

Hendee WR. Introduction to Health Physics. 2nd ed. 1973. Low to medium level of technical difficulty.

Chapman JM. The use of Radioactive Isotopes in the Life Sciences. 1981. Low level of technical difficulty.

Title 10CFR. Code of Federal Regulations, Part 19, 20, 30, 33, 35. Appears yearly. Source book for most regulations and licensing criteria. Mixed difficulty, but understandable for average science student if you read "federalese".

HFS 157. Wisconsin Department of Health and Family Services – Radiation Protection Section. Same level of technical difficulty as 10CFR. The major portion of this publication is identical to the contents of 10CFR, but the numbering is different and includes sections regulating the use of X-ray generating equipment.

Browne E, and Firestone RB. Table of Radioactive Isotopes. 1986. Source book for emission and decay properties of all known isotopes.

Publications of the International Commission on Radiological Protection. Intermittent publications for the past 40 years. Library has most, but not all.

Publications of the International Commission on Radiological Protection. Intermittent publication for the past 40 years. Library has most, but not all.

Websites

U.S. Federal:

www.NRC.gov
Click on Electronic Reading Room on top of screen
Click on basic references
Select statutes and regulations

State of Wisconsin:

www.legis.state.wi.us/rsb/code/hfs/hfs110.html
Click on 157