

5. TRUE/FALSE

- _____ a. In soft tissue, the range of a 1 MeV electron is greater than that of a 1 MeV alpha particle.
- _____ b. ^{131}I is produced by spontaneous fission of ^{235}U , following neutron irradiation in a nuclear reactor. Therefore, it is totally useless for radiation therapy.
- _____ c. Bremsstrahlung radiation is emitted over a wide spectrum of energies, while characteristic x-rays have relatively discrete energies.
- _____ d. Wilhelm Conrad Röntgen won the first Nobel Prize awarded, the 1901 Physics Prize, for the discovery of “a new kind of penetrating ray,” which he called “x-rays.”
- _____ e. In radiation biology, the most important process by which photons interact with soft tissue is the photoelectric effect.
- _____ f. The mean free path of 62 keV x-rays in water is greater than the mean free path of 140 keV gamma rays in water.
- _____ g. When a 5 MeV alpha particle undergoes a single collision with a molecule, an average of 60 eV of energy is transferred. That is enough energy to ionize the molecule.
- _____ h. As the energy of a given type of charged particle increases, its range in soft tissue decreases.
- _____ i. Because they are components of antimatter, positrons have the same charge as electrons, but different mass.

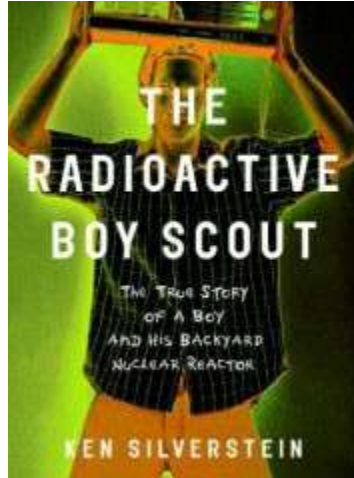
6. Rank the following forms of ionizing radiation in order of increasing LET in soft tissue. (Fill in the blanks: rank the lowest LET radiation number 1 and the highest number 6.)

- a. 500 keV positron _____
- b. 500 keV proton _____
- c. 15 MeV electron _____
- d. 500 keV alpha particle _____
- e. 140 keV gamma ray _____
- f. 5 MeV alpha particle _____

7. The difference between a 100 keV x-ray and a 100 keV gamma ray is:

- a. the x-ray has a lower velocity than the gamma ray.
- b. unless one knows the origin, there is no detectable difference.
- c. the x-ray originates from an orbital electron transition, while the gamma ray originates from the excited nucleus of an atom during radioactive decay.

- d. all of the above.
 - e. both (b) and (c) above.
8. If you studied all the old exams, you heard the story of the “radioactive Boy Scout,” who got busted by the police while trying to build a breeder reactor in his garage, extracting large quantities of thorium from Coleman lantern mantles and americium from smoke detectors.



(This is a true story!)

- Suppose he succeeded in building his reactor and it underwent a critical “meltdown,” causing him to absorb a lethal dose of radiation. In all likelihood,
- a. he would have glowed in the dark until he succumbed to radiation toxicity.
 - b. the radiation would have immediately induced spontaneous human combustion.
 - c. he would have preferred to absorb the same amount of energy by drinking one sip of hot coffee.
 - d. he would have been posthumously awarded the radiation biology merit badge.
9. Which of the following is considered a low LET radiation?
- a. a 15 MeV LINAC electron
 - b. a 62 keV tungsten characteristic x-ray
 - c. a 140 keV gamma ray
 - d. a 573 keV beta minus particle
 - e. all of the above
10. Which of the following is true of annihilation reactions?
- a. It occurs when positrons combine with electrons in matter at the end of their path.
 - b. Each event produces two 511 keV (0.511 MeV) photons.
 - c. Annihilation photons are emitted in opposite directions (~180°).
 - d. All of the above.

- e. None of the above.
11. When a radionuclide undergoes positron decay, which of the following **must** occur?
- a. emission of gamma rays
 - b. creation of a neutrino
 - c. emission of Auger electrons
 - d. internal conversion
 - e. emission of an alpha particle
12. Briefly define, identify, or describe.
- a. Marie Curie
 - b. Ionizing radiation
 - c. The atomic mode of energy loss that competes with x-ray emission
 - d. LET
 - e. Radioactive decay, or radioactivity
 - g. Half-value layer

INTRODUCTORY RADIATION BIOLOGY

Exam II, 2006

1. A radiation worker at a plutonium reprocessing plant in North Korea received a whole body dose of 35 rads from fast neutrons (Assume QF of fast neutrons is 10) and 15 rads from gamma-rays.
 - a. What is the total absorbed dose this worker received in units of rads and in units Gray (Gy)?
 - b. The equivalent dose (in rem units) this worker received from fast neutrons is _____.
 - c. The equivalent dose (in rem units) from the gamma-ray exposure is _____.
 - d. The total equivalent dose this worker received from both the gamma ray and neutron exposure (in rem units) is _____.
 - e. The total equivalent dose (in part d) in Sv units is _____.
2. Sketch examples of typical cell survival curves (including properly labeling both the X and Y axes) that depicts how the semi-log plot will appear when human cells are irradiated in the presence of oxygen (e.g., $pO_2 = 150$ mm Hg) under the following conditions.
 - a. With 150 KeV gamma-rays at a high dose rate.
 - b. With 1 MeV gamma-ray at a low dose rate.
 - c. With 4 MeV alpha particles at a high dose rate.
 - d. With 4 MeV alpha particles at a low dose rate.
3. Define and explain the "Oxygen Effect" and why it plays an important role of decreasing the sensitivity of tumors with high energy electron beams, relative to normal tissues.
4. Before you leave the MU Research Reactor (MURR) you must go through (and pause for 5 seconds) a whole body radiation "gate type" monitor. This monitor is located:
 - a. At exit at the front doors of MURR as you immediately go outside of the building.

- b. At the point where you exit the reactor containment, immediately outside of the airlock doors.
 - c. As you exit from the hallway leading to research laboratory facilities and enter into the lobby where the receptionist is located.
5. Outline the steps in the Nucleotide Excision Repair mechanism that is operable in mammalian cells after exposure to U.V. radiation. Identify the enzymes (or the functions they perform) involved at the corresponding steps.
6. Outline the important features or assumptions in the "linear-quadratic" model used to describe production of irreparable genetic mutations (i.e., irreparable DNA damage) as a function of radiation dose. Include in your discussion: a) differences between irradiation of cells with alpha particles *vs.* gamma-rays and b) the processes involved in producing radiation damage to DNA that results in a linear response and process that produces a quadratic dose response relationship. (Drawings or sketches will be helpful)

7. Briefly define or describe:

- a. sub-lethal damage
- b. D_0 and how it mathematically is used by radiation biologists to calculate/estimate "radiation sensitivity" of cells.
- c. The Roentgen Unit
- d. Single strand break
- e. Hypoxic cells
- f. Direct effect
- g. The main reason of a beam 1 MeV neutrons will penetrate further , on the average, into soft tissue compared to a beam of 1 MeV protons.
- h. Free radicals

8. True-False

- ___ a. The OER for human kidney cells irradiated with 4MeV alpha particles under a pO_2 of 100 mm Hg at a high dose rate will be higher than the OER of these cells irradiated under the same conditions with 1 MeV gamma-rays.
- ___ b. Molecular oxygen is a molecule that is considered to be a "free radical".
- ___ c. You would expect that a single atom of hydrogen (^1_1H) that has a zero charge (i.e., not the H molecule) would be expected to be a free radical.
- ___ d. T-T dimers are the primary radiation induced product produced in the DNA by the reaction of the OH free radicals (with the DNA) generated by the ionization of water molecules in the nucleus of cells.
- ___ e. The OER of anoxic cells are always 1.0.
- ___ f. In general, as the LET of radiation increases, the extrapolation number on cell survival curve plots decreases.
- ___ g. Cell survival curves from two different types of human cells (A and B) were obtained from experiments when cells were irradiated with fast neutrons. The D_{37} in Type A cells was found to be 120 rads and the D_{37} in Type B cells was found to be 50 rads. These results demonstrate that

Type B cells are more sensitive to the neutron radiation beam than are the Type A cells.

- ___ h. Fast neutrons will lose a smaller fraction of their kinetic energy, on the average, each time they collide with a carbon atom nucleus (i.e., $^{12}_6\text{C}$) compared when they collide with a hydrogen atom nucleus (i.e., ^1_1H).

Examination 3 – Radiation Biology – NSEI 7328

Nov. 09, 2006

Dr. Lattimer

For each of the following question provide the one best answer. Please note that although more than one answer may be partially right there is **one best answer**. 2.5 pts. each

1. Which of the following is least likely to be substantially injured by a dose of ionizing radiation?
 - a. DNA
 - b. Chromosome
 - c. Gene
 - d. Genome
 - e. Organelle

2. Considering the structure of DNA which of the following is true?
 - a. Composed of a single strand of sugar-phosphate polymer with a series of nitrogenous bases attached to it.
 - b. Composed of two strands of sugar-phosphate polymer with a row of nitrogenous base attaching them together
 - c. Composed of two strands of sugar-phosphate polymer with a double row of complimentary nitrogenous bases joining them
 - d. Composed of a single strand of sugar-phosphate polymer with a double row of nitrogenous bases attached to it.
 - e. Composed of a two strands of nitrogenous bases joined by multiple glucose phosphate bonds.

3. Which of the following represent the way in which the DNA is most commonly injured by ionizing radiation?
 - a. Damage by direct ionization of the molecular bonds of the DNA.
 - b. Damage by free radicals generated by the ionization of water
 - c. Damage by free radicals generated by the ionization of oxygen molecules
 - d. Damage by indirect ionization of DNA molecular bonds by recoil electrons
 - e. Damage by free radicals generated by the ionization of nitrogenous bases

4. Chromosomes are actually visible by light microscopy in which of the following phases of the cell cycle.
 - a. Mitosis
 - b. First Gap Phase
 - c. Null Gap Phase
 - d. Synthesis Phase
 - e. Second Gap Phase

5. During which phase of the Cell Cycle does the replication of the DNA occur?
- G₁
 - G₀
 - S
 - G₂
 - M
6. One of the effects of irradiation on a population of cycling cells is Mitotic Delay. At which point in the Cell Cycle does Mitotic Delay occur?
- M – G₀ interface
 - G₀ – G₁ interface
 - G₁ – S interface
 - S – G₂ interface
 - G₂ – M interface
7. Another effect of irradiation on a population of cycling cells is interphase death. At what point in the Cell Cycle does this happen for the major of cells experiencing interphase death.
- M – G₀ interface
 - G₀ – G₁ interface
 - G₁ – S interface
 - S – G₂ interface
 - G₂ – M interface
8. The third and perhaps most common type of radiation effect in most tissues is Mitotic Linked Death. At what point in the Cell Cycle does this radiation effect occur?
- M – G₀ interface
 - G₀ – G₁ interface
 - G₁ – S interface
 - S – G₂ interface
 - G₂ – M interface
9. Which of the following phases of the cell cycle often exhibits an increase in radiation sensitivity as it nears the end of that particular phase of the Cell Cycle?
- M Phase
 - G₀ Phase
 - G₁ Phase
 - S Phase
 - G₂ Phase

10. Which of the following effects of ionizing radiation on the DNA is most likely to result in permanent derangement of the DNA's structure for that cell?
- Nitrogenous base disruption
 - Single strand break
 - Double strand break
 - Multiple Single strand breaks
 - Multiple Double strand breaks
11. Which of the following types of DNA repair occurs in response to a double strand break that occur in mid to late S phase of the cell cycle?
- Base Excision Repair
 - Nucleotide Excision Repair
 - Nonhomologous End Joining Repair
 - Homologous Recombination Repair
 - Single strand Annealing Repair
12. The term Potentially Lethal Damage is used to refer to radiation injury that has which of the following characteristics?
- Radiation injury which will result in the death of the cell if the cell enters Mitosis
 - Radiation injury which will result in the cell's death if it tries to enter S phase
 - Radiation injury, which will result in the cell's death if condition, which enhance repair, are not present at the time of the repair attempt.
 - Radiation injury which will result in the cell's death if it is not repaired
 - Radiation injury which will result in the cell's death if the repair process is interrupted by some means such as hyperthermia
13. Sublethal Damage is used to refer to radiation injury that has which of the following characteristics?
- Radiation injury that is normally repaired by cellular repair mechanisms
 - Radiation injury that will not result in cell death even if it is not repaired
 - Radiation injury that results in non-lethal chromosomal aberrations
 - Radiation injury that does not induce apoptosis or mitotic linked death
 - Radiation injury that cannot be repaired but does not result in cell death
14. Which of the following is most likely to result in decreased repair of DNA damage by ionizing radiation?
- Splitting the total dose into two fraction separated by several hours.
 - Irradiation with Electrons
 - Irradiation with X-rays
 - Irradiation with Gamma Rays
 - Irradiation with Fast Neutrons

15. Decreasing the dose rate to approximately 0.5 cGy/hr will have which of the following effects on cell survival.
- The survival rate for hypoxic cells will decrease
 - The survival rate for oxic cells will decrease
 - Repair and regeneration will keep pace with cell damage and death
 - Non-repairable single hit killing will cease
 - The oxygen enhancement ratio will decrease
16. The radiation cell survival curve for photonic irradiation in mammals exhibits a shoulder that is more evident in some tissues than other but is generally there. The presence of this shoulder is generally taken to indicate the presence of which of the following processes?
- Reoxygenation
 - Repair
 - Repopulation
 - Recruitment
 - Reassortment
17. Highly differentiated cell generally have less reproductive (clonogenic) potential than do the less differentiated or non differentiated cells. Which of the follow is an example of a highly differentiated cell?
- Striated muscle cell
 - Intestinal crypt cell
 - Spermatogonia cell
 - Bone Marrow Stem Cell
 - All of the above
18. In Rubin and Casserette's classification of cells, the radiation sensitivity of a cell within the body is classified relative to it clonogenic activity and potential. Which of the following classifications indicates the most clonogenic potential?
- Vegetative intermitotic Cells
 - Differentiating intermitotic Cells
 - Multipotential Connective Tissue Cells
 - Reverting Post mitotic Cells
 - Fixed Postmitotic Cells
19. Which of the following is likely to result if the cell growth fraction is increased relative to the other determinates of cell population numbers and growth.
- The size of the cells in the population will increase.
 - The number of cells in the population will increase.
 - The number of cells in the population undergoing apoptosis will increase
 - The number of cells in the population undergoing mitosis will increase
 - The number of cells in the population which are hypoxic will increase.

20. Assay systems are used to determine the effects of radiation on cells, tissues, organs and organisms. Which of the following best describes the difference between clonogenic and functional assays?
- Clonogenic assays measure reproductive potential and functional assays measure the capacity to perform normal metabolic tasks.
 - Clonogenic assays measure reproductive potential and functional assays measure the integrity of the DNA
 - Clonogenic assays are performed *in vitro* and functional assays are performed *in vivo*.
 - Clonogenic assays are performed *in vivo* and functional assays are performed *in vitro*
 - Clonogenic assays require immortalized cells whereas functional assays do not.
21. One visible clinical effect of radiation exposure is erythema or reddening of the skin. This is an example of which of the following?
- Acute response in a late responding tissue
 - Chronic response in a late responding tissue
 - Acute response in an early responding tissue
 - Chronic response in an early responding tissue
 - Healing response in an early responding tissue
22. Which of the following is an example of a chronic response to radiation injury
- Edema
 - Moist desquamation
 - Dry desquamation
 - Fibrosis
 - Hemorrhage
23. One possible outcome following irradiation of a tissue or organ is replacement of the cells which were killed with cells of the same type. This is an example of which of the following?
- Reassortment
 - Reoxygenation
 - Repopulation
 - Repair
 - Recruitment
24. Field size is an important determinant of the clinical radiation injury when only a portion of the body is being irradiated – especially at the organ level. Why?
- Large field sizes irradiate more tissue than necessary
 - Large field sizes increase the Quality Factor of the radiation being used
 - Large field sizes reduce the dose by spreading it out over a larger area
 - Small field sizes reduce the dose by reducing the amount of scatter radiation.
 - Small field sizes increase the dose by concentrating the radiation in a smaller area.

25. Which of the following cells is apt to be the cell type most sensitive to ionizing radiation?
- Erythrocyte
 - Macrophage
 - Promyelocyte
 - Plasma cell
 - Small mature lymphocyte
26. The digestive system differs in its apparent sensitivity to radiation throughout its length. Which of the following regions of the digestive system displays the greatest sensitivity to ionizing radiation?
- The oral mucosa
 - The esophagus
 - The stomach
 - The small intestine
 - The Large intestine
27. Following an acute radiation dose of 2.5 Gray to the testicles which of the following would be the likely result.
- Temporary sterility
 - Permanent sterility
 - Severe mutations passed on to offspring
 - Temporary hormonal dysfunction
 - Permanent hormonal dysfunction
28. Which of the following tissues is generally considered to be the most susceptible to injury from and permanent dysfunction of following a single 10 gray dose of radiation?
- Heart
 - Lung
 - Liver
 - Bone
 - Brain
29. With regard to total body irradiation, which of the following statements is true?
- Death will occur greater than 50% of the time following a whole body dose of 3 Gray
 - A total body dose of radiation of 10 gray will result in the central nervous system syndrome
 - A total body radiation dose of 8 Gray is unsurvivable.
 - Except for very high doses the major terminal cause of death is systemic infection
 - Prodromal signs of diarrhea are due to loss of intestinal epithelium

30. Irradiation of an embryo at a dose of 1 gray is likely to result in which of the following?
- There is likely to be multiple clinical mutations evident when the baby is born.
 - The embryo will either die or develop normally.
 - The embryo will exhibit a delay in growth and any baby born will be small
 - The embryo will be unable to implant in the uterine wall due to radiation injury to the vasculature of the uterus.
 - The embryo will continue to develop but the baby will die at birth
31. Irradiation at a dose of 1.0 Gray to a fetus in the beginning of the third trimester (about the sixth month in humans) will likely have the most deleterious permanent effect on which of the following organs?
- The heart
 - The liver
 - The brain
 - The lungs
 - The intestines
32. Damaging effects on the body's immune system can occur at dose of 0.5 to 1.0 Gray. What would be the likely effect on the body's response to a pathogen if it were exposed to that pathogen 2-3 days before the irradiation?
- This would result in the body being unable to generate antibodies against the pathogen.
 - There would be little or no effect on antibody production
 - There would be a delay in the body's response to the pathogen
 - Antibody production would be markedly enhanced
 - The bone marrow would be destroyed so the body could not generate any cellular defense to augment the antibody response to the pathogen.
33. One potential effect of moderate radiation exposure is the long-term effect of carcinogenesis. Based on the process of mutation and subsequent transformation of the mutated cell into a cancer cell, which of the following cell types is most likely to develop a cancer after a moderate dose of radiation?
- Skeletal muscle cells
 - GI tract muscle cells
 - Endothelial cells
 - Secretory cells of the thyroid
 - Bone marrow cells
34. Cancer tissues and cells vary from normal cells in a variety of ways. Which of the following characteristics is most likely to protect the tumor cells from radiation injury?
- Their ability to invade surrounding tissue and recruit a blood supply
 - Their chaotic manifestation of different phenotypes
 - Their propensity for have hypoxic population within them
 - Their ability to undergo division without limit
 - Their short cell cycle times

35. When a tumor has a hypoxic cell population within it, it should be more able to recover from a radiation exposure. This is due to the hypoxia apparent ability to promote which of the following
- SLD repair
 - PLD repair
 - Repopulation
 - Recruitment
 - Redistribution
36. Tumor growth is mediated through a number of factors. The Cell Loss Fraction is one of these factors. Which of the following is **not** generally considered a means by which tumor cells are lost from the tumor cell population?
- Anoxic death
 - Non-viable replication
 - Immunologic attack by the immune system of the body
 - Shedding of cells into the systemic circulation
 - Chromosomal Zygoty
37. The process of apoptosis is frequently mediated through the function of so called "Checkpoint Genes" At which of the following points in the cell cycle do these checkpoint genes function?
- At the M-G₁ interface
 - During G₁ phase
 - At the G₁-S interface
 - During G₂ phase
 - S-G₂ interface
38. Fractionation is used as a major tool in the practice of radiation therapy for cancer. Which of the following is the major reason that fractionation is used in the treatment of cancer.
- Multiplies the difference in repair capabilities between tumor cells and normal late responding tissues
 - Enhances the rate of repopulation in normal tissues
 - Mitigates the effects of acute or transient hypoxia
 - Reduces the ability of tumor cells to repair radiation damage
 - Enhances the rate of reassortment

39. Under which of the following circumstances would you expect fractionation to have minimal benefit in enhancing tumor control over long-term normal tissue effects?
- When the cell cycle time of the tumor is longer than that of the early responding tissue in the radiation field.
 - When the cell cycle time of the tumor cells is shorter than that of the late responding tissues in the radiation field
 - When the cell cycle time of the tumor cells is shorter than that of the early responding tissues in the radiation field
 - When the cell cycle time of the tumor cells is longer than that of the late responding tissues in the radiation field.
 - When the cell cycle time of the tumor is the same as that of the early responding tissues in the radiation field.
40. Hyperthermia has long been investigated as a means of enhancing the rate of tumor control achieved with radiation therapy do to the synergistic effects of radiation and hyperthermia. Which of the following has been the greatest difficulty associated with making use of this synergy.
- The temperatures required result in thermal burns and necrosis when combined with radiation.
 - The difficulty in coordinating the administration of the hyperthermia and the radiation
 - Restricting the area of heating to the tumor only to minimize normal tissue effects
 - Difficulty in accurately measuring the heating of the tumor to determine the thermal dose.
 - Difficulty in actually achieving local hyperthermia in a living patient.

INTRODUCTORY RADIATION BIOLOGY
FINAL EXAM – 2006

1. A radiation worker received a whole body dose of 30 mrad from fast neutrons ($QF=20$) and 150 mrad from a 140 MeV gamma-ray source for the 2006 calendar year.
 - a. Calculate the **TOTAL** equivalent dose (in mrem units) this person received in 2006 (show work).
 - b. Calculate this worker's **TOTAL** equivalent dose in mSv units.

2. It has been shown in studies with the "A-bomb Survivor Cohort" (approx. 80,000 individuals that received whole body doses of radiation averaging 28 rads each) that the radiation exposure produced an increased number of cancers in that population. The overall percentage (including spontaneous and radiation induced) of the "A-Bomb Survivor Cohort" that died from all cancers by 1990 was about 20%. The percentage of these cancer deaths produced by the radiation, compared to the total number of cancer deaths in this population was estimated to be:
 - a. 1%
 - b. 5%
 - c. 30%
 - d. 50%

3. ^{131}I -iodide is ingested by a group of individuals exposed to radiation fallout shortly after explosion of a nuclear weapon test in North Korea. The organ expected to receive the largest radiation dose from this ^{131}I -iodide ingestion is the:
 - a. liver
 - b. thyroid gland
 - c. bone or skeleton
 - d. lung

4. Describe the meaning of "stochastic effects" of radiation exposure

5. Identify which of the following are considered to be good examples of "NON-stochastic effect" produced in the human population by ionizing radiation (more than one answer may be correct).
- Cancer induction
 - Induction of cataracts in the lens of the eye
 - Skin erythema
 - Decreased fertility
 - Hereditary effects
6. Of the four cancers - thyroid, female breast, leukemia, and lung cancers - identify which two pairs have higher "spontaneous" or background rates in the U.S. population than the other two.
- thyroid and leukemia are higher than lung and breast cancers
 - Thyroid and lung are higher than leukemia and breast cancers
 - Leukemia and lung are higher than thyroid and breast cancers
 - Lung and breast are higher than leukemia and thyroid
7. In a typical cross-section of 100,000 individuals in the U.S. population, the number "spontaneous" of deaths from **all** cancers is going to be approximately.
- 50,000
 - 20,000
 - 10,000
 - 5,000
8. If a group of 10,000 people in the U.S. population each received a whole body gamma-ray radiation dose of 10 rem, using the risk estimates (i.e., the number of cancer deaths per million persons per rem) obtained from the UNSCEAR and BEIR reports, it can be calculated that this would result in _____ cancer deaths. Show your assumption (i.e., risk estimates) and steps used in your calculation.
9. List three effects that may occur as a result of *in utero* radiation of the fetus at a dose of 50 rads during the first trimester of gestation.
10. Briefly define or describe:
- QF
 - Free radical
 - At least two sources of "natural" background radiation.

- d. Single strand break on the DNA
- e. Irreparable radiation induced damage on DNA
- f. The energy of UV light compared to ionizing radiation.

11. TRUE/FALSE

___ a. The QF of a beam of 1 MEV fast neutrons is expected to be higher than the QF for a beam of 250 KeV gamma rays.

___ b. Congenital malformations can be induced by *in utero* during the first trimester of pregnancy by ionizing radiation. There are NO congenital malformations induced by irradiation of the fetus that are unique, or different, from the spectrum of malformations found to occur "spontaneously" in the U.S. population.

___ c. It has been found that select populations of humans living for many generations in some specific areas around the world that have a high "natural" radiation background environment (e.g., 300-500 mrem/year) have **NO** statistically elevated levels of cancer compared with similar ("control") populations living in areas with normal background levels (i.e., 100mrem/year). Neither of these background levels include doses from radon.

___ d. Radiation absorbed doses (in rad units) to humans from fast neutrons are expected to produce radiation induced cancers at a higher rate (i.e., number of cancers/rads) than the corresponding absorbed doses (in rad units) from gamma-rays.

___ e. When considering cell survival curves, D_{37} will always be equal to or greater than D_0 .

___ f. Oxygen is considered a radioprotector.

___ g. Scientists can demonstrate that *in utero* doses of 1 rem to the human fetus during the first trimester of pregnancy will produce a statistically significant increase in the congenital malformation rate in new born babies.

___ h. If the extrapolation number on a cell survival curve is found to equal to 3, the radiation used to irradiate the cells was more likely to be 1M gamma-rays than 1 MeV alpha particles.

___ i. High LET radiation is more likely to produce single strand breaks on DNA molecules than Low LET radiation.

___ j. The data from the A-Bomb Survivor Cohort has been particularly valuable in demonstrating significant increases in radiation enhanced hereditary

(genetic) effects of ionizing radiation by showing increased levels of genetic defects that appear in the offspring of the A-Bomb survivors compared to the control population.

NSEI 7328 – Radiation Biology
Final Examination Questions: Dr. Lattimer

1. Which of the following represent the way in which the DNA is most commonly injured by ionizing radiation?
 - a. Damage by direct ionization of the molecular bonds of the DNA.
 - b. Damage by free radicals generated by the ionization of water
 - c. Damage by free radicals generated by the ionization of oxygen molecules
 - d. Damage by indirect ionization of DNA molecular bonds by recoil electrons
 - e. Damage by free radicals generated by the ionization of nitrogenous bases

2. One of the effects of irradiation on a population of cycling cells is Mitotic Delay. At which point in the Cell Cycle does Mitotic Delay occur?
 - a. M – G₀ interface
 - b. G₀ – G₁ interface
 - c. G₁ – S interface
 - d. S – G₂ interface
 - e. G₂ – M interface

3. Which of the following phases of the cell cycle often exhibits an increase in radiation sensitivity as it nears the end of that particular phase of the Cell Cycle?
 - a. M Phase
 - b. G₀ Phase
 - c. G₁ Phase
 - d. S Phase
 - e. G₂ Phase

4. Which of the following phases of the cell cycle often exhibits an increase in radiation sensitivity as it nears the end of that particular phase of the Cell Cycle?
 - a. M Phase
 - b. G₀ Phase
 - c. G₁ Phase
 - d. S Phase
 - e. G₂ Phase

5. Which of the following types of DNA repair occurs in response to a double strand break that occur in mid to late S phase of the cell cycle?
 - a. Base Excision Repair
 - b. Nucleotide Excision Repair
 - c. Nonhomologous End Joining Repair
 - d. Homologous Recombination Repair
 - e. Single strand Annealing Repair

6. Which of the following is most likely to result in decreased repair of DNA damage by ionizing radiation?
 - a. Splitting the total dose into two fraction separated by several hours.
 - b. Irradiation with Electrons
 - c. Irradiation with X-rays
 - d. Irradiation with Gamma Rays
 - e. Irradiation with Fast Neutrons

7. Which of the following is likely to result if the cell growth fraction is increased relative to the other determinates of cell population numbers and growth.
 - a. The size of the cells in the population will increase.
 - b. The number of cells in the population will increase.
 - c. The number of cells in the population undergoing apoptosis will increase
 - d. The number of cells in the population undergoing mitosis will increase
 - e. The number of cells in the population which are hypoxic will increase.

8. One visible clinical effect of radiation exposure is erythema or reddening of the skin. This is an example of which of the following?
 - a. Acute response in a late responding tissue
 - b. Chronic response in a late responding tissue
 - c. Acute response in an early responding tissue
 - d. Chronic response in an early responding tissue
 - e. Healing response in an early responding tissue

9. Field size is an important determinant of the clinical radiation injury when only a portion of the body is being irradiated – especially at the organ level. Why?
 - a. Large field sizes irradiate more tissue than necessary
 - b. Large field sizes increase the Quality Factor of the radiation being used
 - c. Large field sizes reduce the dose by spreading it out over a larger area
 - d. Small field sizes reduce the dose by reducing the amount of scatter radiation.
 - e. Small field sizes increase the dose by concentrating the radiation in a smaller area.

10. Which of the following tissues is generally considered to be the most susceptible to injury from and permanent dysfunction of following a single 10 gray dose of radiation?
 - a. Heart
 - b. Lung
 - c. Liver
 - d. Cortical Bone
 - e. Brain

11. With regard to total body irradiation, which of the following statement is true?

- a. Death will occur greater than 50% of the time following a whole body dose of 3 Gray
 - b. A total body dose of radiation of 10 gray will result in the central nervous system syndrome
 - c. A total body radiation dose of 8 Gray is unsurvivable.
 - d. Except for very high doses the major terminal cause of death is systemic infection
 - e. Prodromal signs of diarrhea are due to loss of intestinal epithelium
12. Damaging effects on the body's immune system can occur at dose of 0.05 to 1.0 Gray. What would be the likely effect on the body's response to a pathogen if it were exposed to that pathogen 2-3 days before the irradiation?
- a. This would result in the body being unable to generate antibodies against the pathogen.
 - b. There would be little or no effect on antibody production
 - c. There would be a delay in the body's response to the pathogen
 - d. Antibody production would be markedly enhanced
 - e. The bone marrow would be destroyed so the body could not generate any cellular defense to augment the antibody response to the pathogen.
13. When a tumor has a hypoxic cell population within it, it should be more able to recover from a radiation exposure. This is due to the hypoxia apparent ability to promote which of the following
- a. SLD repair
 - b. PLD repair
 - c. Repopulation
 - d. Recruitment
 - e. Redistribution
14. Tumor growth is mediated through a number of factors. The Cell Loss Fraction is one of these factors. Which of the following is **not** generally considered a means by which tumor cells are lost from the tumor cell population?
- a. Anoxic death
 - b. Non-viable replication
 - c. Immunologic attack by the immune system of the body
 - d. Shedding of cells into the systemic circulation
 - e. Chromosomal Zygoty
15. Hyperthermia has long been investigated as a means of enhancing the rate of tumor control achieved with radiation therapy do to the synergistic effects of radiation and hyperthermia. Which of the following has been the greatest difficulty associated with making use of this synergy.
- a. The temperatures required result in thermal burns and necrosis when combined with radiation.
 - b. The difficulty in coordinating the administration of the hyperthermia and the radiation

- c. Restricting the area of heating to the tumor only to minimize normal tissue effects
- d. Difficulty in accurately measuring the heating of the tumor to determine the thermal dose.
- e. Difficulty in actually achieving local hyperthermia in a living patient.

INTRODUCTORY RADIATION BIOLOGY 7328/4328

FINAL EXAM QUESTIONS 2006—Michael R. Lewis, Ph.D.

1. Rank the following ionizing radiations in order of increasing LET (*i.e.*, beginning with the lowest LET; *e.g.*, $a < b < c < d < e$, but please note that this may or may not be the correct answer!).
 - a. 500 keV alpha particle
 - b. 4 MeV positron
 - c. 500 keV beta minus particle
 - d. 62 keV x-ray
 - e. 8 MeV alpha particle

2. Oxygen-15 ($^{15}_8\text{O}$; $T_{1/2} = 2$ min) decays to $^{15}_7\text{N}$ (stable) with emission of a charged particle, no photon emissions from the nucleus, and a decay energy (Q) of 1.72 MeV.
 - a. Sketch a decay scheme that is consistent with this information.
 - b. True or False (circle one): ^{15}O decay can be imaged using a PET scanner.
 - c. True or False (circle one): ^{15}O is useful for radionuclide therapy.
 - d. Dr. Mike Welch at Washington University in St. Louis is a pioneer in the development of ^{15}O radiopharmaceuticals. Many years ago, before modern regulations existed, he used to produce ^{15}O -oxygen on the cyclotron at Wash U's "Hilltop" campus, drive 10 minutes to the School of Medicine, and study a rat after it breathed 2 mCi of ^{15}O -oxygen. Assuming it took another 6 minutes to prepare the rat, how many mCi of ^{15}O -oxygen did Dr. Welch have to make on the cyclotron to perform this study?

3. Briefly define or describe (no more than 1-2 sentences):
 - a. The type of radiation that Anger cameras or SPECT scanners detect
 - b. Ionizing radiation
 - c. Wilhelm Conrad Röntgen
 - d. LET
 - e. The most commonly used radionuclide for positron emission tomography (PET) imaging of cancer

TRUE/FALSE

4. _____ A 500 keV beta minus particle will have higher LET over its track and greater relative biological effectiveness (RBE) than a 500 keV alpha particle.
5. _____ ^{131}I is used to treat thyroid diseases like hyperthyroidism and well differentiated thyroid cancer.
6. _____ SPECT imaging is performed by rotating detectors around patients, while PET imaging is performed by surrounding patients with a circular array of detectors.

MULTIPLE CHOICE

6. If a patient shows high uptake of $^{99\text{m}}\text{Tc}$ -MDP in bone tumors, he or she is potentially a good candidate for therapy with
 - a. Na^{131}I (sodium iodide).
 - b. ^{153}Sm -EDTMP (QuadraMet™).
 - c. $^{201}\text{TlCl}$ (thallium chloride).
 - d. all of the above.
 - e. none of the above.
7. [^{18}F]Fluorodeoxyglucose (^{18}F -FDG) accumulates predominantly in tissues with high rates of glucose metabolism, such as
 - a. heart.
 - b. brain.
 - c. tumors.
 - d. all of the above.
 - e. none of the above.
8. The most biologically relevant mechanism by which ionizing photons interact with soft tissue (HINT: predominates in the energy range of 100 keV to 10 MeV) is
 - a. the photoelectric effect.
 - b. Compton scattering.
 - c. pair production.
 - d. positron annihilation.
 - e. spontaneous fission.