Growth and Decay Problems

1. Earth's population was 5,300,000,000 in 1990. It is projected to have 10,000,000,000 in the year 2050. Assuming this situation is exponential, in what year will the population of Earth reach 18,000,000,000? (Hint: Let the year 1990 be year 0.)

2. Iodine-131 is used in treating cancer of the thyroid gland. Because it has a short half-life of 8.14 days, the hospital cannot just keep some stored and get it when they need it. Instead, it must be ordered from a nuclear facility that produces it when it is needed. Suppose the hospital needs 100 mg of iodine-131 but they must take delivery two days before they use it. How much iodine-131 should actually be ordered so they will have 100 mg when they need it?

3. It is known that a certain kind of algae in the Dead Sea can double in population every two days. Assuming the population grows exponentially and we start with a population of 1,000,000, what is the population in a week?

4. The half-life of radium is 1590 years. If you start with 95 grams, then how much will you have in
   a. 20 years?
   b. 1000 years?

5. A bacteria culture starts with 500 bacteria and after 3 hours there are 8000.
   a. How many bacteria are there in 4 hours?
   b. How long will it take to reach 30,000 bacteria?

6. For an operation, a dog is anesthetized with sodium pentobarbital. It is eliminated exponentially from the blood stream; half is eliminated in 5 hours. For a short operation it is possible to use an amount of sodium pentobarbital that will make the dog unconscious but not kill it. Suppose 20 mg of sodium pentobarbital are required for each kg of body weight. What single dose would be required to anesthetize a dog for a half hour if the dog weighs 10 kg? This means you want to figure out what initial amount is needed to end up with the required minimum amount at the end of the half hour (when $t = 1/2$).