Solutions to HW 2

4.50) $t = \text{thalf} \times \left( \frac{\log_{10}(\text{current amount}/\text{original amount})}{\log_{10}(1/2)} \right)$

a) Rock from the lunar highlands: $t = 4.5 \text{ billion years} \times \left( \frac{\log_{10}(0.55)}{\log_{10}(1/2)} \right) = 3.88 \text{ Billion years}$

b) Rock from the lunar maria: $t = 4.5 \text{ billion years} \times \left( \frac{\log_{10}(0.63)}{\log_{10}(1/2)} \right) = 3.00 \text{ Billion years}$

The rock from the lunar maria is younger by 880 million years!

4.53) $\frac{\text{Total Power}}{4\pi R^2} = \frac{3 \times 10^{12}}{4\pi (6371000)^2} = 5.88 \times 10^{-3} \text{ watts/m}^2$

This is $5.88 \times 10^{-3}/400 = 0.001\%$ of the sun's power on the surface of the Earth.

Because we averaged the total internal radioactivity over the surface of the Earth our number appears very small. However, in reality it is not spread out evenly. Instead it forms “Hot Spots” at the positions of the upward convective cells (e.g., mid-Atlantic ridge), and these “Hot Spots” are what drives geological activity, such as plate tectonics.

(Note that the total heat flow – internal radioactivity + primordial heat left over from the formation of the Earth - is now estimated to be about an order of magnitude larger: 47 terawatts instead of 3 terawatts. However, the answer above does not change qualitatively – the internal heat flow is still orders of magnitude smaller than solar heating).

5.40) In order to breed a herd of cows that provide more milk I would isolate all cows that don’t meet my quota and breed the one’s that do. I would over time increase my quota such that I only ever let a portion of my herd reproduce. Over generations, I am artificially selecting cows with traits that I deem worthy to continue the species and all others eventually die without descendants.

This kind of breeding overtime will increase the milk production in my herd. If you think of me as nature and milk production as a characteristic that makes cows better suited to their environment, then
this is exactly natural selection. Those cows that produce more milk will survive to pass on their genes, whereas other cows will have no offspring, thus gradually changing the genetic makeup of the herd.

6.49) At t=1 hour there are $2^{60} \sim 10^{18}$ bacteria. If 1 out of every $10^6$ bacteria has a mutation then at one hour there are $10^{18}/10^6=10^{12}$ or one trillion mutated bacteria. Since they reproduce so quickly they will have ample opportunity to create a mutation with resistance to any new drug.