ASTR202 Laboratory on the
Evolution of Life and Intelligence

3 Exercise: The Cosmic Calendar

We have been studying the twisted evolutionary path life on Earth took to reach its present state. For us to communicate with another civilization, their species must have evolved to at least a similar level of advancement.

The table below lists 20 events illustrating the evolutionary timeline for life on Earth in millions (mya) or billions (bya) of years. The first column lists the time of the event; the second column gives a description of the event; and the third column gives a *crude* estimate of the probability of the event.

Table 1: **A Timeline for the Evolution of Life on Earth**

Time	Forms of Life	Probability
12 bya	Universe begins with a bang	1.0
10 bya	Galaxies form	1.0
4.6 bya	Solar System forms	1.0
4.0 bya	No life; shallow seas	1.0
3.8 bya	Origin of simple cells	0.5
3.5 bya	Origin of cyanobacteria	0.01
2.5 bya	Oxygen accumulates in atmosphere	1.0
1.7 bya	Protists amd greem algae	0.01
1.0 bya	Simple multicellular life (sponges, seaweeds)	0.5
700 mya	More invertebrates (flatworms, jellyfish)	0.7
520 mya	Early animals with hard parts in oceans	0.8
410 mya	Planets invade land	0.8
350 mya	Vertebrates invade land	0.8
300 mya	Coal forming forests, amphibeans, BIG insects	1.0
225 mya	Mass extinction (trilobites)	0.1
200 mya	Pangaea, first mammals, first reptiles	0.1
65 mya	Mass extinction (including dinosaurs)	0.1
30 mya	Small mammals, humanoids	0.001
2 mya	Early Man	0.1
0 mya	Us	0.5

1) Let us imagine we are able to speed-up evolution so that all of the events above occur in one calendar year. Preserving the relative spacing between the events in Table 1, indicate the dates of the year when the events took place.

2) On your evolutionary calendar, how long has it been since

1. The first oxygen-breathing organisms?
2. the death of the dinosaurs?
3. the emergence of Homo-Sapiens?

In many science fiction stories and films, alien life-forms look amazingly similar to those found on Earth. The evolutionary road that leads to the life-forms found on Earth today is frought with twists and turns and many forks in the road. This next question is designed to illustrate just how unlikely it is that life on another world (even an Earth-like one) would follow the same path.

3) Using the probabilities listed in the table, estimate the number of Earth-like planets you would need to survey before finding one with life-forms that have a similar evolutionary history to ours.

4) The number of Earth-like planets in our galaxy can be estimated from a modified form of the Drake equation:

$$N_E = R^* \times f_g \times f_p \times n_e \times L$$

where N_E = number of Earthlike planets in our galaxy

R^* = star formation rate ≈ 10
f_g = fraction of 'good' suns ≈ 0.12
f_p = fraction of 'good' suns with planets ≈ 0.3
n_e = number of Earth-like planets per 'good' sun ≈ 0.01
L = lifetime of planet ≈ 2 billion years

a) Use the above equation to estimate a value for N_e.

b) Based upon your answers to questions 3 and 4a, do you think it likely we will find another lifeform that looks humanoid in our galaxy?

c) If not, how many galaxies like ours would we need to search before we found another humanoid?