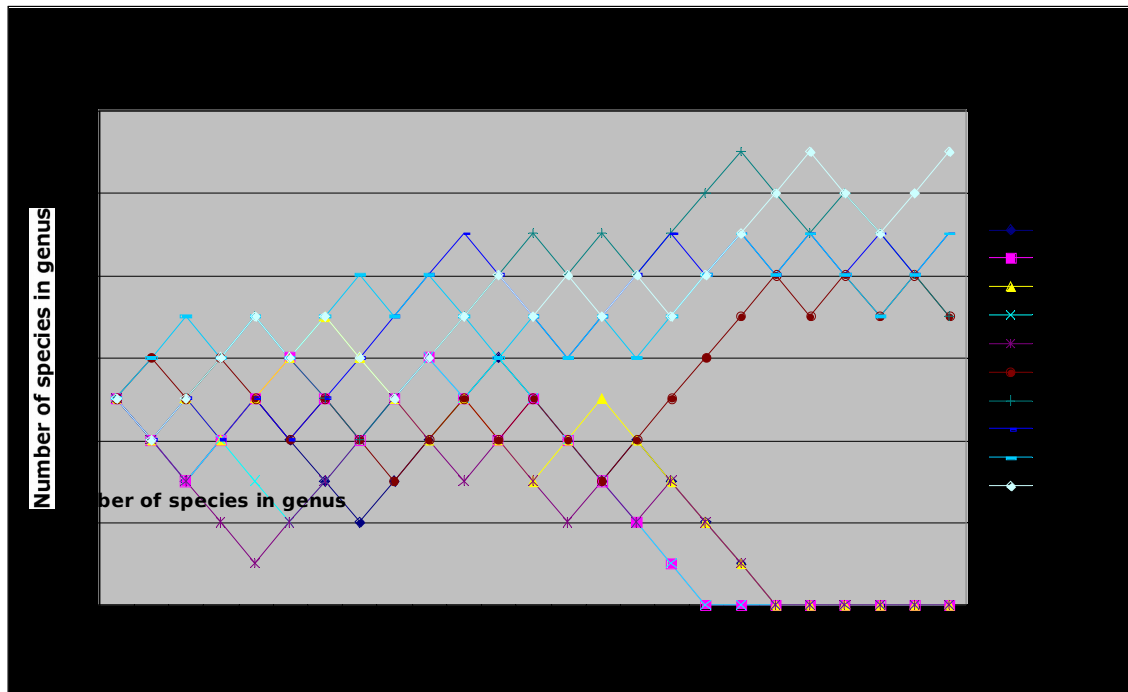


1) A simple way to model the evolution of life is to consider the random evolution of different genera. In the example shown, each genus (of 10) starts with 5 species. At each time step, there is a 45% chance the number of species increases by one as a new species evolves, and a 55% chance the number decreases by one as a species goes extinct.

The simulation below shows how 10 genera evolve over 25 time steps. Here, 4 genera have become extinct by the end, but one genus has more than doubled to 11 species.



a) Use an excel spreadsheet, or a computer program, to simulate this process as shown. If you use excel, you can use the `RAND( )` function that returns a random number between 0 and 1, and the `IF (condition, true, false)` that returns the value given in “true” if “condition” is true, and returns the value given in “false” if “condition” is false.

b) Experiment with the results to see how many steps are needed for 90% of the genera to become extinct. Present the results as a spreadsheet (or output) like that shown following, as well as a graph, aka 'plot'.

Sample 'output' for random evolution model:

time	number of species in each genus									
1	5	5	5	5	5	5	5	5	5	5
2	4	6	6	4	4	6	4	6	6	6
3	3	7	5	5	5	5	5	7	7	5
4	4	8	6	6	6	6	6	6	8	6
5	3	9	5	7	7	5	7	7	9	7
6	2	10	4	6	6	4	8	6	10	8
7	1	9	3	5	7	3	7	7	9	9
8	2	8	2	4	8	2	8	8	8	10
9	1	7	3	5	9	3	7	9	9	11
10	2	6	2	6	8	4	8	8	8	10
11	3	5	1	5	9	3	9	7	7	11
12	2	4	2	6	10	2	10	8	6	12
13	1	3	1	7	9	1	11	9	5	13
14	0	2	0	8	10	0	12	10	6	14
15	0	1	0	7	9	0	13	11	7	15
16	0	2	0	8	8	0	12	12	8	16
17	0	1	0	9	7	0	11	11	7	15
18	0	2	0	10	6	0	10	12	6	16
19	0	3	0	11	7	0	9	13	7	15
20	0	4	0	10	8	0	8	12	8	16
21	0	5	0	9	9	0	7	11	9	17
22	0	4	0	8	8	0	8	10	8	16
23	0	3	0	7	7	0	7	11	9	17
24	0	4	0	8	8	0	6	10	10	18
25	0	5	0	9	9	0	7	9	9	17

2) At about 540 Ma (m.y. ago) the Cambrian Period opened the Paleozoic Era with an 'Explosion' of life.

a) Characterize the proliferation and explain why it's called an 'explosion'.

b) Why did this explosion occurring after nearly 3.5 billion years of life on Earth trouble Charles Darwin in his view of evolution?

c.) Of three possible causes: biological, environmental or artifact of preservation, explain which seems most plausible to you and why? (Ward & Brownlee, Chapter 7)

3) The Permian extinction ~250 Ma (m.y. ago), called the 'Great Dying', closed the curtain on the Paleozoic Era.

a) What new analysis did Clapham and Payne (article. class webpage under Evolution, or for a good summary find the 4/30/12 NY Times, Science Times, Permian Extinction) undertake to shed light on what caused 95% of all species to become extinct?

b) From their analysis what did they conclude caused the Permian extinction event? What does the genera count across the Permo-Triassic boundary suggest (e.g. HP, fig. 17-7)?

4) Read “A new view of the tree of life” (see Hug et al., 2016; also Yong, *Atlantic Monthly*, 2016), the latest version after 20+ years. Why now? What data provides the tree layout? What does this depiction suggest about complex life (Eukaryotes) on Earth?

5) View the 2014 Carl Sagan Lecture, Fall AGU meeting by Dawn Sumner, *Microbial communities: Tracing growth processes from Antarctic lakes to early Earth to other planets*: <http://planets.agu.org/lectures.php>

a) Why is the development of O<sub>2</sub> regarded as a critical event in Earth history?

b) Which characteristics of martian sediments indicate life? But which would inhibit life?

6) The advance from prokaryote cell to eukaryote, with a nucleus, represents one of the “hard steps” in life's evolution on Earth. Summarize in a sentence the breakthrough hypothesis proposed by Lynn Margulis (published under Lynn Sagan, References).

7.) Read “Signatures of a Shadow Biosphere” 2009, by Davies et al.. How would “weird life” be recognized? Identify one or two key elements.