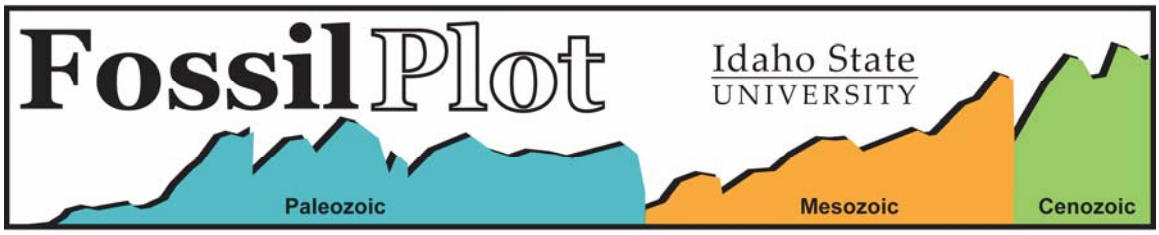

INTRODUCTION

Developing an understanding of the dynamic history of life on Earth is a primary goal of a course in paleontology. In the lectures, students learn the conceptual framework of organic evolution by studying the variety of body forms of living things. In the lab and field excursions, students learn to identify the major groups of organisms, many of which will serve a practical use in determining the age of rocks and the environmental conditions in which they were deposited. To connect the large-scale concepts of evolution presented in the lectures with the hands-on, practical teaching of the fossil groups, a new database approach will look at the specific evolution of fossil groups through the Phanerozoic. To facilitate this goal, students can use a new spreadsheet-based program for MSExcel called FOSSILPLOT.

The Sepkoski Compendium.—During the 1980s–1990s, paleontologist John J. Sepkoski Jr. (University of Chicago), compiled a database of marine genera and their fossil ranges. This work synthesized pre-existing systematic paleontology datasets (i.e., the *Treatise on Invertebrate Paleontology*), but in the digital spreadsheet format Sepkoski and others were able to statistically explore many significant patterns on the dynamic history of marine life. Following his death in 1999, the Sepkoski Compendium was published as a 560-page monograph (Sepkoski, 2002, *Bulletins of American Paleontology, v. 363*). This Excel application makes available and readily useable to students this primary database – the same one used by today's paleontologists – to examine various aspects of evolution.

Caveat. —Systematic paleontology is not a static scientific discipline! Since the publication of the Sepkoski Compendium, numerous refinements have been made to our understanding of the fossil record, including the phylogeny, taxonomy and stratigraphy of various taxa reported in the Compendium. Teachers and students using FOSSILPLOT should refer to Sepkoski, 2002 for methods in data acquisition and realize that some details in the Compendium are now obsolete.

WHAT'S IN FOSSILPLOT?

DATA WORKSHEETS

Compendium.—The Sepkoski Compendium raw data includes the stratigraphic ranges and taxonomy of 36,339 marine genera.

AbsDates.—Database that correlates relative time intervals (e.g., Periods, Epochs, and Ages) to absolute dates in millions of years (Ma).

&Data.—Generates range, diversity, speciation, and extinction graphs at the Epoch scale, using subsets of data copied from the Compendium worksheet.

&Age.—Generates a diversity graph at the Age scale, using subsets of data copied from the Compendium worksheet.

&O-S MX.—Generates diversity, speciation, and extinction graphs at a 2Ma interval for a total of 20Ma around the time of the End-Ordovician Mass Extinction.

&P-Tr MX.—Generates diversity, speciation, and extinction graphs at a 2Ma interval for a total of 20Ma around the time of the Permo-Triassic Mass Extinction.

&K-T MX.—Generates diversity, speciation, and extinction graphs at a 2Ma interval for a total of 20Ma around the time of the Cretaceous-Tertiary Mass Extinction.

GRAPH WORKSHEETS

@Range.—Presents the Phanerozoic range of selected genera, made by &Data.

@EpochDiv.—Presents the total diversity of selected genera by stratigraphic Epoch, made by &Data.

@EpochOr.—Presents the total number of genera that originated during each stratigraphic Epoch, made by &Data.

@EpochEx.—Presents the total number of genera that went extinct during each stratigraphic Epoch, made by &Data.

@EpochRates.—Presents the rates of origination and extinction of selected genera calculated over the duration of Epoch time intervals, made by &Data.

@EpochDOX.—Presents the total diversity, origination and extinction of selected genera by stratigraphic Epoch, made by &Data.

@EpochAbs.—Presents the total diversity, speciation and extinction of selected genera by stratigraphic Epoch but displayed on a linear absolute time x-axis, made by &Data.

@AgeDiv.—Presents the total diversity of selected genera by stratigraphic Age, made by &Age.

@MXs-DOX.—Presents the total diversity, origination and extinction of selected genera for 2Ma time-slices over a 20Ma interval centered on the End Ordovician, Permo-Triassic, and Cretaceous-Tertiary Mass Extinctions; made by &O-S MX, &P-Tr MX and &K-T MX. Background linear graph presents the total diversity of selected genera by stratigraphic Epoch but displayed on a linear absolute time x-axis; made by &Data.

@MXs-DOX-2.—Same as previous, with additional display of Age-scale diversity, from &Age.

HOW DO I MAKE GRAPHS?

1. *Select* the Compendium worksheet.

2. *Find* the grouping of genera that you wish to analyze. This group should usually be less than 4,000 rows long! Any more will result either in very slow computing time or a computer crash.

3. *Highlight* Columns A to P for the entire group of genera. Note: *do not* highlight all Columns of the row.

4. Select *Edit/Copy* (or shortcut Ctrl-C).

5. *Select* the &Data worksheet.

6. *Select* the field, **A8**.

7. Select *Edit/Paste* (or Ctrl-V). You now have the compendium data in place! Check the bottom rows of the data columns to make sure that *only* the group of genera you want to analyze are present.
   If you need to delete rows of data, highlight Columns A to P of the extra unwanted rows and hit the Delete key on your keyboard.

8. Check your graphs! &Data makes 6 complete graphs, and it is also a part of the data that produces @MXs-DOX. Be sure to update the title so that it is specific to the data presented (e.g., what genera are depicted?). Also, change the maximum value of the y-axis to match the scale of your data.

   You may also want to **Sort** your genera to produce a more useful @Range graph. Verify that the Source Data making @Range is complete (including all columns of Genus, FAD-begin, Lad-end, and Lad-end+).

   When looking at @Range, you may notice that the stratrigraphic ranges are plotted far to the left of the chart or some ranges at the right may be missing. To correct these problems use the following procedure (8a-h).

   a) When viewing the @Range graph, *right click* (with mouse) on the rainbow colored background.
   b) *Select* Source Data.
      {notice that the program switches your view to &Data, where you can see that Columns E, H, N and O are currently highlighted. You will need to reselect these 4 columns, but only including rows containing your genera} To do this…

c) With the mouse, *left click and hold* cell **E8** and *drag down* to highlight all rows containing data. *Release* the left mouse button.
d) *Hold down* the Ctrl key**.** Don't let it go until you've complete Step 8f!
e) With Ctrl key pressed, use the mouse to *left click and hold* cell **H8** and *drag down* to highlight all rows containing data. *Release* the left mouse button.
f) Repeat the process in Step e for Columns N and O (starting at cells N8 and O8, respectively). The Ctrl key must be held down the entire time!
g) Now, Columns E, H, N and O should be highlighted to include only the rows containing information on the genera you wish to plot. Be sure that these columns were highlighted in order (E, H, N, O).
h) Select OK in the Source Data window. Your stratigraphic ranges should now be evenly arranged across the @Range graph.

9. To make @AgeDiv graph, follow instructions 1–7 as above, except paste the Compendium selections into **&Age** worksheet (at instruction 5) *instead* of RangeData.

10. Similarly, to make @MXs-DOX graph, follow instructions 1–7 as above, except paste the Compendium selections into **&Data, &O-S MX, &P-Tr MX, and &K-T MX** worksheets at instruction 5.

GLOSSARY OF TERMS

Calculation Matrix.—In &Data worksheet, calculation fields that determine if genera have FADs, LADs or ranges within a given time interval. The result is presented as zeros and ones, and they are added up in the Summation Row.
FAD (First Appearance Datum).—The earliest (or stratigraphically lowest) occurrence of a taxon.
LAD (Last Appearance Datum).—The latest (or stratigraphically highest) occurrence of a taxon.
Range.—The stratigraphic interval (time) in which all representatives of a taxon are confined. The interval between the FAD and LAD.
Stratigraphic Hierarchy.—Eon>Era>Period>Epoch>Age
Summation Row.—In RangeData worksheet, the black row in Columns S to FH that adds up the contents of columns in the calculation matrix.
Taxonomic Hierarchy.—Kingdom>Phylum>Class>Order>Family>Genus>Species
Relative Time.—Periods, Epoch, and Ages used in this program. The following are the relative time interval abbreviations used in the diversity, speciation, and extinction graphs. Recall that for Epochs, Upper = Late, Lower = Early, and Middle = Middle.

Abbreviation	Period	Epoch
* Ng(Re)	Neogene	Recent
* Ng(Plei)	Neogene	Pleistocene
* Ng(Pli)	Neogene	Pliocene
* Ng(Mio)	Neogene	Miocene
* Pg(Oli)	Paleogene	Oligocene

* Pg(Eo)	Paleogene	Eocene
* Pg(Pal)	Paleogene	Paleocene
K(u)	Cretaceous	Upper Cretaceous
K(l)	Cretaceous	Lower Cretaceous
J(u)	Jurassic	Upper Jurassic
J(m)	Jurassic	Middle Jurassic
J(l)	Jurassic	Lower Jurassic
Tr(u)	Triassic	Upper Triassic
Tr(m)	Triassic	Middle Triassic
Tr(l)	Triassic	Lower Triassic
P(u)	Permian	Upper Permian
P(l)	Permian	Lower Permian
CPn	Carboniferous	Pennsylvanian
CMs	Carboniferous	Mississippian
D(u)	Devonian	Upper Devonian
D(m)	Devonian	Middle Devonian
D(l)	Devonian	Lower Devonian
S(u)	Silurian	Upper Silurian
S(m)	Silurian	Middle Silurian
S(l)	Silurian	Lower Silurian
O(u)	Ordovician	Upper Ordovician
O(m)	Ordovician	Middle Ordovician
O(l)	Ordovician	Lower Ordovician
Cm(u)	Cambrian	Upper Cambrian
Cm(m)	Cambrian	Middle Cambrian
Cm(l)	Cambrian	Lower Cambrian
† V	Ediacaran (=Vendian)	latest Neoproterozoic

Notes:

* Cenozoic nomenclature in FossilPlot uses Tertiary (T), Quaternary (Q), Paleogene (Pg) and Neogene (Ng) terminology for Periods. Graphic displays of data use the currently accepted priority of Pg and Ng in lieu of T and Q.

† Vendian (V) was originally part of the lower Cambrian in the Sepkoski database. According to the latest ICS Geologic Time Scale, the Vendian is now replaced by the Ediacaran and it is the last Period of the Neoproterozoic.

INFORMAL NOTES AND DATA SOURCES

(includes info on how each worksheet is organized)

Compendium Worksheet: Original database taken from Sepkoski, 2002 (Bulletins of American Paleontology, v. 363, p. 1–560). Note that I have added columns for the systematic taxonomy to be complete for each genus. The first column is a dummy number for re-organizing the sheet back to the original systematic order. FAD and F-stg are text fields for the period and Age to which the genus is resolved (same for LAD and L-stg). Column H and I (this column is hidden) are absolute time intervals in Ma, marked by a begin time and an end time for any particular Age. The beginning (base) of all Ages is 0.001Ma younger (above) the preceding Age ending (top). In other words, there is a miniscule gap between two adjacent time intervals (e.g., the Ordovician and Silurian, or the Givetian and Frasnian) to avoid a “doubling” of time intervals when making diversity curves. All absolute times are linked directly to the worksheet, AbsoluteDates. Since only the beginning of the FAD interval and the end of LAD interval is important, I have hidden columns I and M. Column O just replicates Column N, for graphing purposes on worksheet, RangeData. Column P gives generic length in Ma. The idea is that a student can simply copy Columns A to P for any genera and paste them into the left part of RangeData to produce graphs.

AbsoluteDates: The Relative Time Intervals used here are based on the Sepkoski 2002 publication. Absolute dates are based on Gradstein & Ogg, 2004, Lethaia 37: 175-181 and Okulitch, 1999, GSC Open File 3040, supplement to GEOLOG, 29(1). As explained before, each time interval has a beginning and end and no two adjacent time intervals overlap numerically. Age width gives the duration of each time interval. All absolute time references in this excel file are linked directly to the fields in this worksheet: change the values in AbsDates, and it changes those dates everywhere in the file. This is very good if/when absolute dates change, but it can also wreak havoc on your data if numbers change accidentally…they are very hard to troubleshoot!