TEACHER INSTRUCTIONS

Faunal Succession with Foraminifera

Developed by Hilary Clement Olson

Standards:

Elementary TEKS		Middle School TEKS		High School TEKS			NGSS	
3rd & 4th grade		7th grade		Biology	ESS	K-2-ESS1-1	MS-ESS1-4	HS-ESS1-5
1A	2B	1A	3A	1A 3A	1A 3B	K-2-ESS2-2	MS-ESS2-1	HS-ESS1-6
1D	3A	1D	3B	1B 3B	1F 3C	K-2-PS1-1	MS-ESS2-2	HS-ESS2-1
1E	3B	1G	3C	1F 3C	1G 4A	3-LS4-1	MS-ESS3-1	HS-ESS2-2
1F	3C	2A	4A	1H 4A	1H 7B	4-ESS1-1		HS-ESS2-7
2A	12D	2B	10A	2A 9A	2A 7C	5-ESS2-1		
				2B 9B	2B 7D			
					2C 7E			
					3A 7F			

Level: K-12, undergraduate, graduate

Objective: During this activity students will learn about the earliest concepts of determining geologic time with fossils. The various fossil flora and fauna in rocks can be used to correlate a suite of rock layers from one location to another based on relative age. Students will use the principle of faunal succession to organize a series of rock samples in stratigraphic order by applying the concepts of first appearance datum (FAD; evolutionary origin in time of a species) and last appearance datum (LAD; extinction point in time of a species). This case study relies on the concept of 'range' of a fossil when fossil distribution is looked at in stratigraphic order (from the oldest FAD, to the youngest LAD).

Background Information: The view of time related to the universe, Earth and humanity has changed throughout human history, depending on the various data available, and the social and religious beliefs of the time. In the eighteenth century, the intellectual climate of rationalism allowed educated individuals, like Scottish physician James Hutton, to recognize the cyclical nature of geologic processes and thus grasp the concept of deep time. Geologists estimate the Earth is 4.54 billion years old. This span of time has been subdivided and the units arranged into a geologic time scale. The study of historical geology, the rocks and fossils associated with the Earth's history, present the student with the nature of time within a geologic context.

The examination of fossils contributed to the construction of a relative geologic time scale, namely, one that is not tied to absolute ages. One of the important objectives of this activity is for participants to discover the concept of 'range' of a fossil when fossil distribution is looked at in stratigraphic order.

Time Requirements: 30-40 minutes

Teacher Preparation:

Materials:

1. Cards representing various fossil assemblages from a stratigraphic section (images after Jones, 1956); paper or laminated cards
2. Photomicrograph of fossil foraminifera from the Miocene of California as an example of what these fossils look like under a microscope
3. Optional: additional photographs or samples of foraminifera or other fossils to show students

Procedure:

Relative Dating and Fossils

1. Teacher introduces or reviews the first five basic principles of stratigraphy (Original Horizontality, Lateral Continuity, Superposition, Cross-Cutting Relationships, Inclusions) as the foundation of relative dating.
2. Teacher refers to the idea that there is a sixth principle involving the use of subtle changes of fossils through time, and then introduces the fossil record using hand specimens of fossils.
3. Teacher reviews basic concepts of evolution, First Appearance Datum and Last Appearance Datum (associated concept of biochronozone may also be introduced).
4. Teacher introduces the concept of microfossils and foraminifera (slides or sample vials of foraminifera can be purchased from a scientific supply company).

Faunal Succession Activity

5. Teacher gives student groups (of ~3 students) a set of cards representing faunal fossil assemblages from various sample locations. Starting with the information that sample J represents the youngest sample (i.e., from the top of the composite stratigraphic section), and sample E represents the oldest sample, students will arrange the cards in order from the oldest sample at the base and the youngest sample at the top. Students must adhere to the concepts of evolution, First Appearance Datum and Last Appearance Datum as they organize their faunal assemblage samples (cards) in a vertical stratigraphic section (oldest at the bottom and youngest at the top). For younger students, you may wish to use paper copies of the cards and they can use markers to color similar species.
6. Once students are finished organizing their cards, have students use blue painter's tape (or another easily removed tape) to connect the cards and then bring them to the front of the room to tape all the stratigraphic sections on a whiteboard or wall to compare. Another strategy is to have each student/group write their card order on a whiteboard to compare where the relationships were clear and where there may be ambiguity.

7. Teacher leads a discussion on the activity. A student worksheet with questions for reflection is available for more independent work.

Faunal Succession and William Smith

8. Teacher discusses the historical development of relative age dating using fossils by William Smith (1769-1839). A slide deck about William Smith and faunal succession is available.
9. Teacher explains the formal principle of faunal succession, developed by William Smith.

Solution:

Potential Answers Include:

Youngest to Oldest

(letters in parentheses show areas of ambiguity)

J – (C – D – G) – K – A – L – F – (B – I – H) – E

J – (C – D – G) – K – A – L – F – (H – I – B) – E

J – (C – G – D) – K – A – L – F – (B – I – H) - E

J – (C – G – D) – K – A – L – F – (H – I – B) - E

J – (G – D – C) – K – A – L – F – (B – I – H) – E

J – (G – D – C) – K – A – L – F – (H – I – B) – E

J – (D – G – C) – K – A – L – F – (B – I – H) – E

J – (D – G – C) – K – A – L – F – (H – I – B) – E

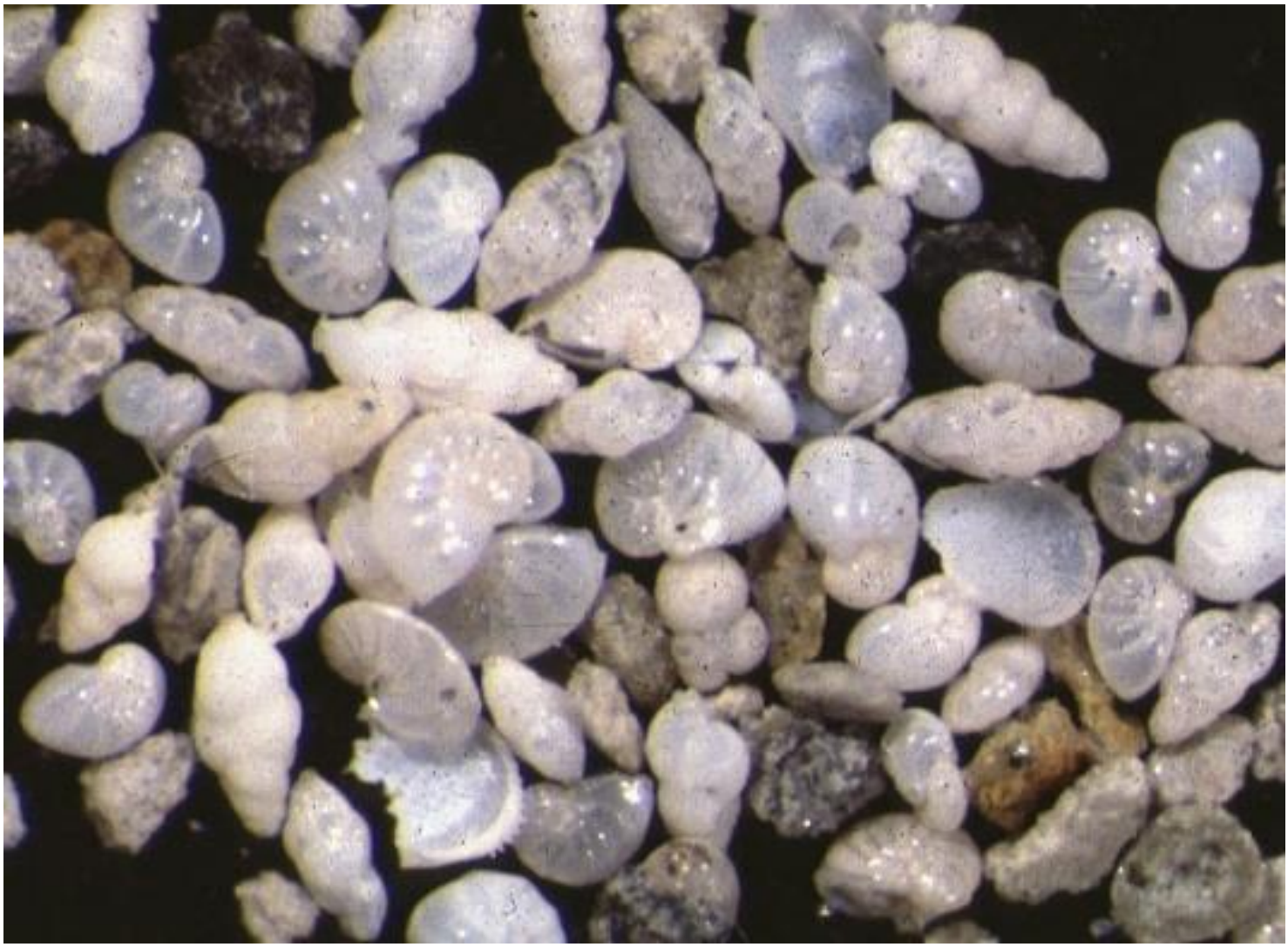
There is not only one answer. In fact, there are often multiple solutions that are applicable to a particular inquiry because of limited data. Additional strategies could involve collecting more samples to 'infill' between particular parts of the sequence, or trying to augment relative dating techniques by strategically running analysis to obtain absolute ages on particular samples if appropriate. The expense of this analysis could be justified because the samples would be targeted to address areas in the sequence not easily resolved using relative age dating techniques, like faunal succession.

Supporting Documents:

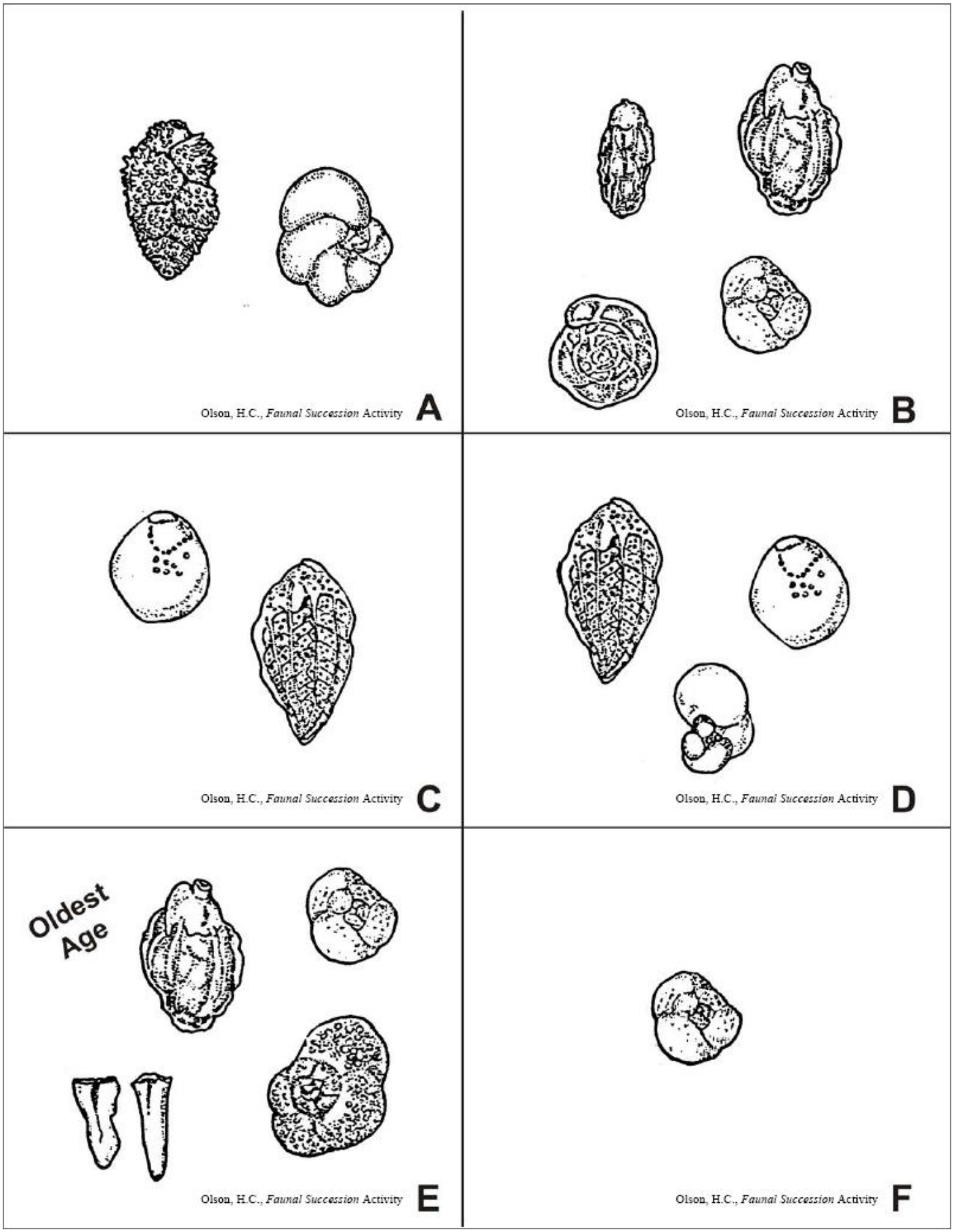
Teacher Resource Handout
Student Worksheet
Slide deck on William Smith and faunal succession

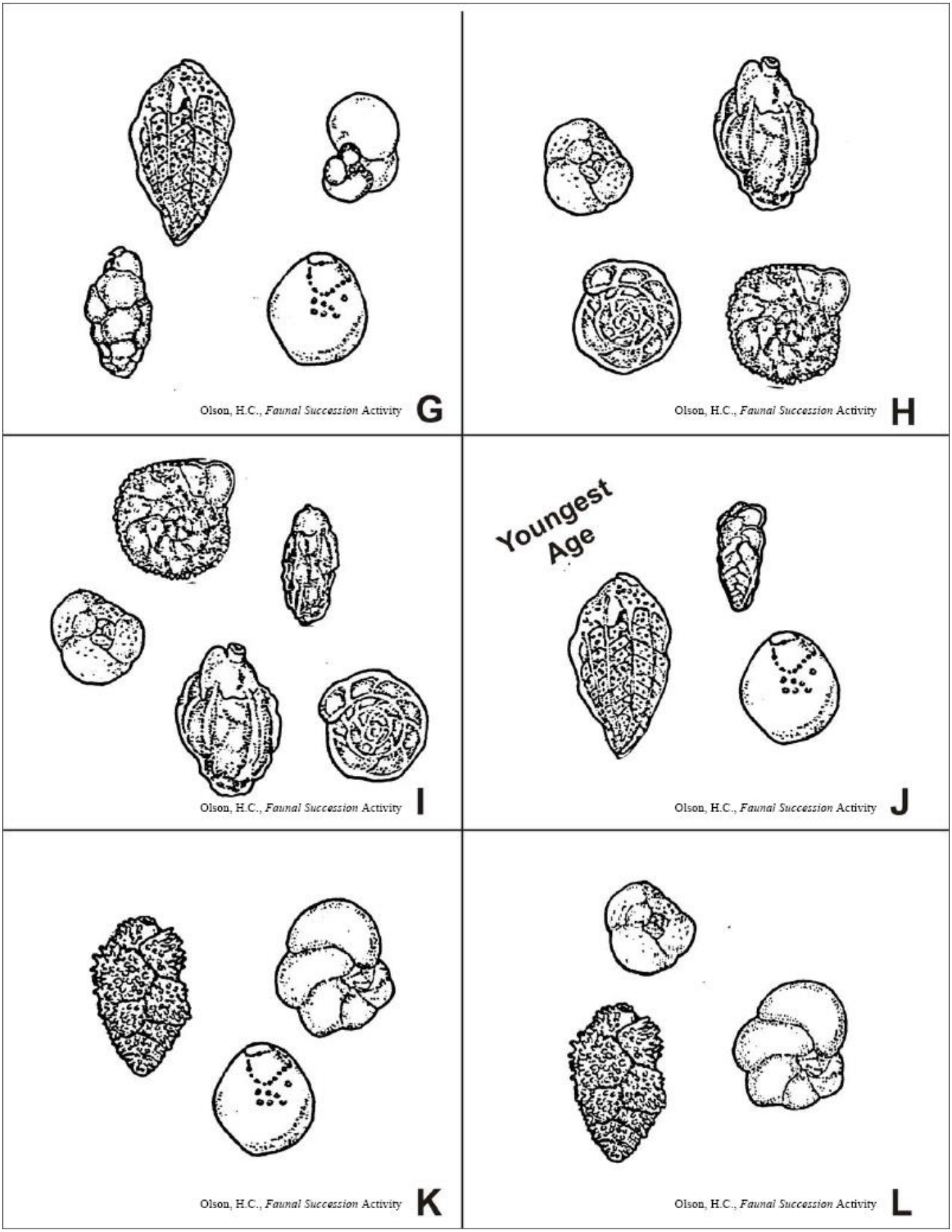
REFERENCES:

Jones, D.J., 1956, *Introduction to Microfossils*, Harper, 406p. (faunal succession cards)



Photomicrograph of fossil foraminifera from the Miocene (~23-5 million years ago) of California as an example of what these fossils look like under a microscope. Foraminifera in photo average .1-.3 mm in size. (photo by Hilary Olson)


Olson, H.C., *Faunal Succession* Activity A
Olson, H.C., *Faunal Succession* Activity B
Olson, H.C., *Faunal Succession* Activity C
Olson, H.C., *Faunal Succession* Activity D
Oldest Age
Olson, H.C., *Faunal Succession* Activity E
Olson, H.C., *Faunal Succession* Activity F


Olson, H.C., *Faunal Succession* Activity G
Olson, H.C., *Faunal Succession* Activity H
Olson, H.C., *Faunal Succession* Activity I
Youngest Age
Olson, H.C., *Faunal Succession* Activity J
Olson, H.C., *Faunal Succession* Activity K
Olson, H.C., *Faunal Succession* Activity L