Laetoli Trackway Puzzle

ENSI lesson by Larry Flammer @2008

Document Overview:
Using the Laetoli Footprints, students will explore how scientists use current patterns to understand the past.
Students will answer the questions:
What do the footprints tell us?
How do scientists find that out?
Students will measure and correlate their foot lengths and body heights and use that data to estimate the height of the Laetoli hominid.

Next Generation Science Standards:

HS-LS4-1.	**Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]
HS-LS4-4.	**Construct an explanation based on evidence for how natural selection leads to adaptation of populations.**[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

Objective:
- Understand that observations of present life can provide clues to life in the past.
- Understand how observations leads to scientific explanations and interpretations
- ancestor of humans and what information can be gathered from the fossil record.

Type of Activity: **Dry lab**
Duration: 1-2 Class periods
Teacher Tips: This lesson could be used during an introductory unit on the nature of science as an example of a non-experimental problem-solving process, the type of science ('historical science") done to help us understand past events that are not repeatable. It could also be easily inserted in the human evolution portion of an evolution unit.

Concepts: Geologic patterns, nature of science, evolutionary change, evidence in the present can reveal events of the past.

Description of Activity: Footprint diagrams were made from the trackway of *Australopithecus afarensis* ("Lucy's" species) at the Laetoli site in East Africa. They are topographic in nature, showing details of depth and superposition. Students are asked a series of probing questions, some requiring direct observation, others expecting inferences and analysis. This is an excellent example of an historical problem-solving exercise, using clues to derive a likely picture of a past event, very much like crime scene scientists must do. It's also open-ended, where students try to reach a "best explanation" based on the data and reasonable interpretations, with no "correct answer" available.

Materials: Overhead transparencies (or slides) of trackway and enlarged footprints for class discussion.

Activity:
PROCEDURE
1. Hand out (or show on your screen) the **Sample Laetoli Topographic Tracks**. Ask your students to describe what they see, giving several students an opportunity to respond without much (if any) comment. You may want to jot down short versions of each "observation" on the board or screen for later reference. Do this until at least 2-3 statements are made that are actually assumptions, not direct observations.

2. When they seem to run out of observations, ask them to look at the list, and say "are you sure you can actually see each of these things?" Out of this should come at least a few examples of inferences based on the observations, rather than directly observable items in the diagram. The idea here is that they become sensitized to what they actually see vs what they automatically infer or assume from their observations.

3. Turning to the inferences, ask "Why do you say that?" - getting them to point out specific features shown that might suggest what they inferred. Then ask another student "Could this suggest any other inference?" until you can get at least 2-3 other inferences. While doing this, look for examples of inference that could be attributed to prior experiences or biases on the part of each responding student. Experiences could include walking in sand; biases could include gender bias. All of this is to reinforce that, often, what we think we see we are actually assuming. This dialog should also reinforce the importance of distinguishing observations from inferences, and recognizing how inferences are influenced by personal experiences, opinions, and various biases. Finally, it's important that they recognize the importance of restricting inferences as close to the observed clues as

4. This should set the stage for handing out the **Laetoli Puzzle Worksheets**. This could be one worksheet for each group of 3-4, or each pair, or even one per student. Groups of 2-4 would probably be best, encouraging them to discuss elements of the introduction as they work with each prompt. The questions become increasingly challenging, but let them grapple with them, doing the best they can, but always tying inferences to the observed clues. As teams work on this, hand out to each team the two additional sheets: Enlarged Footprints 33 & 24, and Enlarged Footprints 35 & 26. These could be printed back to back on a single sheet, and/or placed in a protective plastic sleeve.

5. When all/most teams are done, or nearly done, open the class to a class-wide discussion - with different people in each team sharing out their responses, to see how much agreement or variety of responses they get, and the reasons why they answered as they did.

6. It would be interesting to see if there is any class consensus on their answers to some of the questions. It would also be instructive to point out that universal consensus on observations could be considered "evidence of reality" (recognizing that this is only diagrammatic representation - or picture - of the original tracks in Africa). In science, we would call such consensus a "scientific fact."

7. Other degrees of consensus, essentially on inferred assumptions, characterize the mental constructs that we call "ideas" or, more formally, if explanatory, testable and based on observations, "hypotheses." In a few cases, you should be sure to ask dissenters, "What would you need to know or see in order to go along with the majority?" And, to a majority person or two, "Could your interpretation be changed with new evidence? If so, what kind of evidence? What kinds of clues would you look for? Where?"

8.When completed, be sure to point out these footprints were found in hardened volcanic ash (called "tuff") in East Africa, and dated at about 3.6 million years in age, about the time that the prehistoric human called "Lucy" (Australopithecus afarensis) lived in the region, based on many fossils found for that time frame. When you do this, ask what the trackway suggests about how those early hominids walked (listen for "on two feet" or "bipedally"). You might also want to ask "How tall do you think they were? How could you find out? What other information would help?"

ASSESSMENT

Be sure to do a closing commentary, with students filling in key terms and ideas, or have them respond to "Tell me something new that you learned today." They should realize that good science can be done on past events by careful observation and analysis of surviving clues ("Evidence in the present can reveal events of the past.") They should see the distinction between observations and inferences, the role of experiences and biases in creating our inferences, the tentative nature of inferences and explanations, that a scientific fact is a critical observation confirmed by many critical viewers (and can even change with better viewing equipment), that a hypothesis is a tentative, testable explanation for something in nature.

Extension and Follow-up Activity:

1. You may want to engage the class (or interested students) in figuring out how tall the Laetoli walkers were. That's what the "Footsteps in Time" (http://www.indiana.edu/~ensiweb/lessons/footstep.html) lesson is all about, but it could be simplified here by getting them to hypothesize that tallness is directly proportional to foot length, measuring the feet and corresponding heights of classmates to get an approximate correlation (great graphing exercise, plotting a straight line through the cluster of plotted points of height vs foot length), calculating the actual foot lengths by applying the scale on the two trackways sheet - or doing a scaling calculation (comparing the 1:5 scale on the sheet with dimensions on a metric ruler, and this proportion to the approximate lengths of each foot).

2. The Checks Lab (http://www.indiana.edu/~ensiweb/lessons/chec.lab.html) , The Great Fossil Find (http://www.indiana.edu/~ensiweb/lessons/gr.fs.fd.html) , Crime Scene Scenario (http://www.indiana.edu/~ensiweb/lessons/crime.html) , and Crime Against Plants (http://www.indiana.edu/~ensiweb/lessons/plcr.les.html) provide similar experiences with "historical science," and could be used for reinforcement, or inserted later in the course in appropriate contexts.

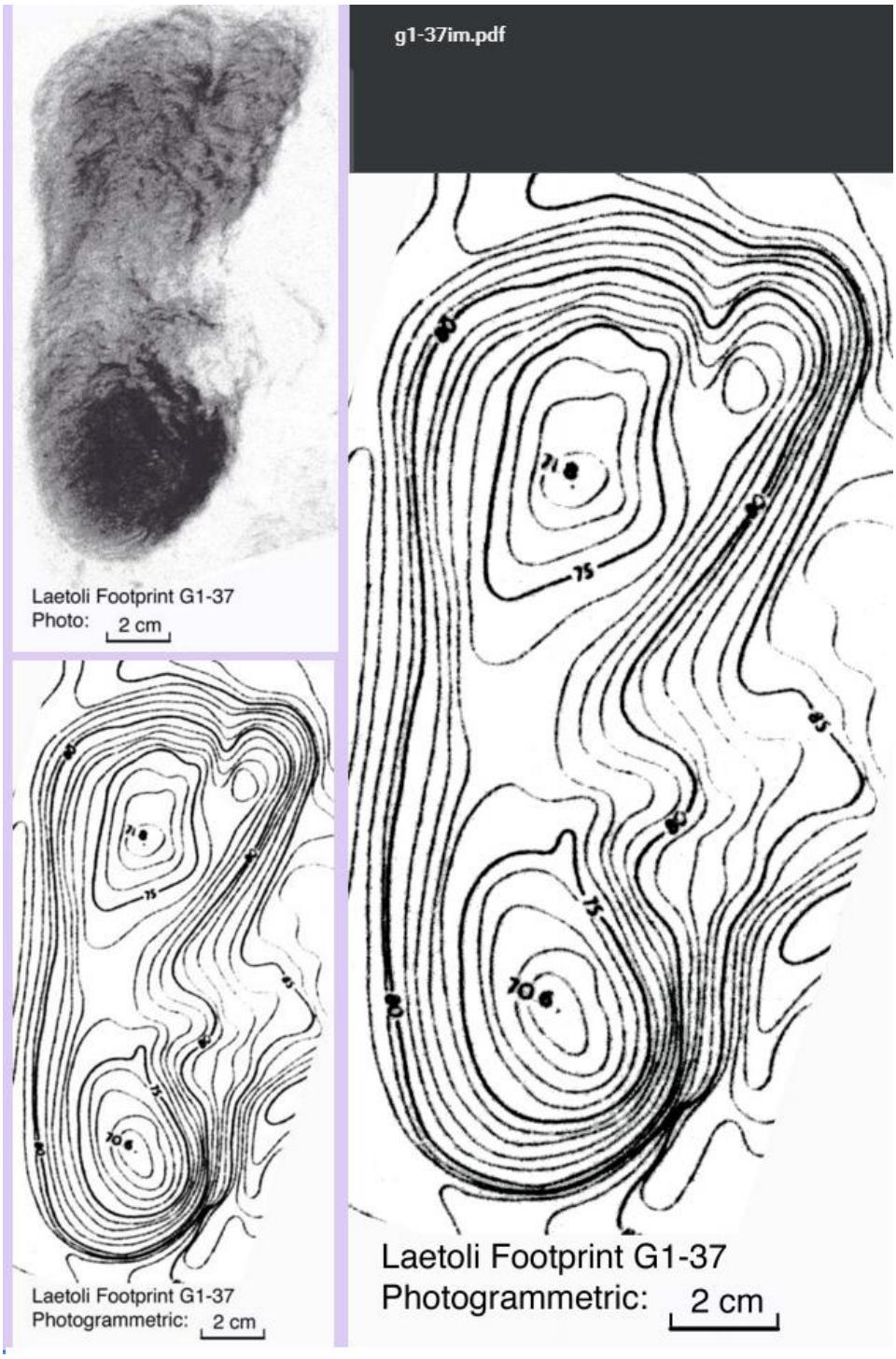
3. Video links:

Evolution Laetoli Footprints

https://www.youtube.com/watch?v=w1Lu4VggDH0

Laetoli Footprints: Protecting Traces of our Earliest Ancestors
https://www.youtube.com/watch?v=0EZi_EAyloQ

RESOURCE
The photogrammetric ("topographic") illustrations used here were adapted from a small portion of Fig. D.3 Site G 1/5th scale of the footprints in the southern part of the hominid trails, as a pocket insert published in Leakey, Mary D. & J.M. Harris (Ed). 1987. Laetoli: a Pliocene Site in Northern Tanzania. Clarend Press, Oxford.
ATTRIBUTION
Created 2004 by Larry Flammer, edited/revised by L. Flammer 9/30/08



This activity was modified by Dr. Aditya Kar, Associate Professor of Geology, Fort Valley State University

NAME_____ DATE_____ PERIOD_____

On a separate sheet, you will find a portion of the Laetoli trackway (with a scale) in which the footprint depths and contours are detailed at 1mm intervals. Of particular interest are two of the large tracks (G. 2/3-24 and G. 2/3-26). Study these tracks carefully, and answer the following questions.

1. In what major way are those larger tracks different from the smaller tracks above them (G.1-33 and G. 1-34), other than size?

2. What does that difference suggest about the number of people who made the lower set of tracks?

3. If two individuals made the larger tracks, which set was made first: larger or smaller? _____

4. Why did you say that?

5. What was the size (height) of the smaller individual (compared with the height of the individual who made the small tracks in the upper trail)? Smaller _____ Same Size _____ Larger_____

6. Were these tracks all made at the same time? _____ Why do you say that?

7. If they were all made at the same time, describe a likely scenario, knowing that the tracks were made in a damp layer of freshly fallen volcanic ash (now hardened into tuff):

a. How close was the G.1 individual to the G.2/3 individual?

b. Were their arms swinging, or did one individual have his/her arm around the shoulder of the other, or did they have their arms around each other's waist? (Walk alongside a partner on a dirt path or damp sand, and note how close your footprints are in those 3 different positions. Be sure to account for size differences.

c. Were the tracks traveling uphill, or downhill, or on a perfectly flat area (assuming the feature hasn't changed over time)?

d. Evidence? (see enlarged portions G.1-35 + G. 2/3-26 and G.1-35 + G. 2/3-24)

e. What sex were they?

f. Clues?

g. Who were these people?

h. Evidence?

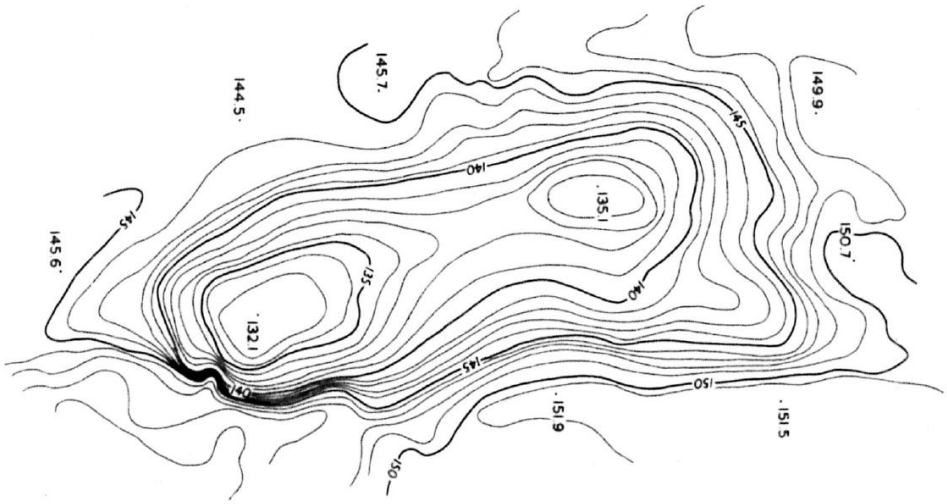
i. How were they related?

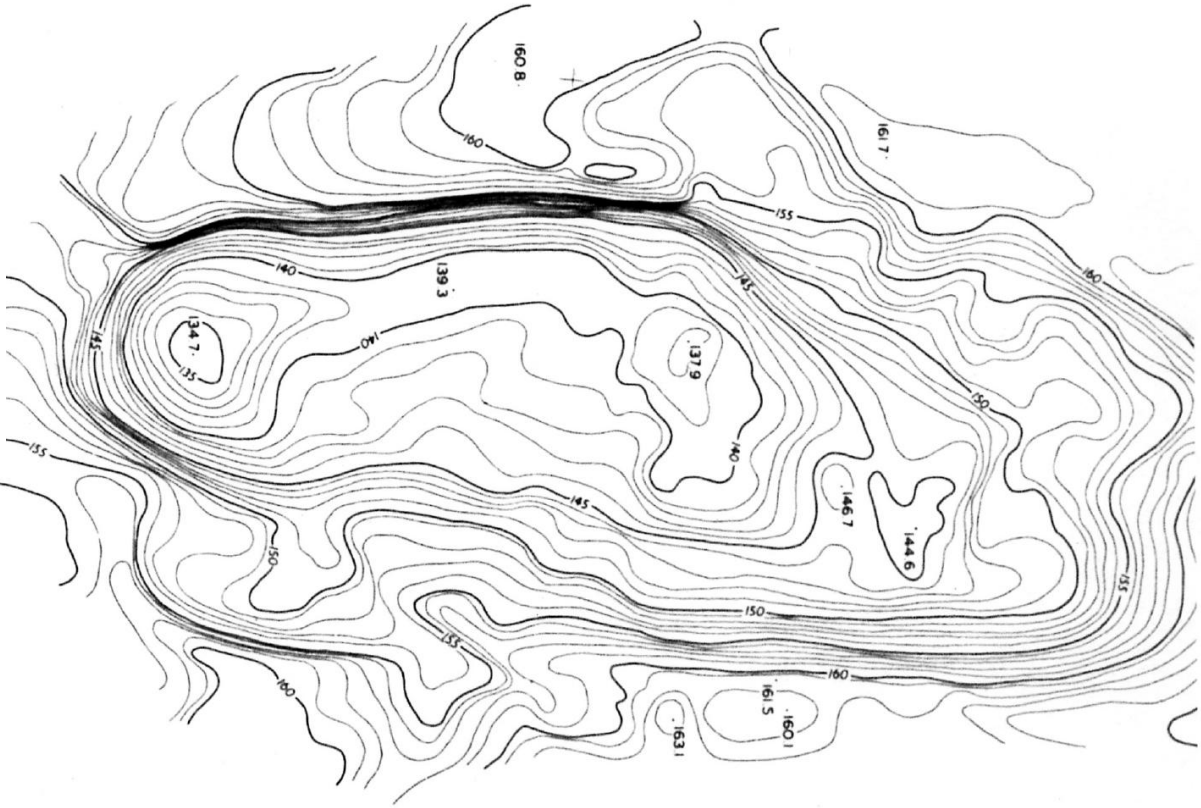
j. Clues?

FOOTPRINT SAMPLE

SAMPLE LAETOLI FOOTPRINT TOPOGRAPHIC MAP

G.1-33

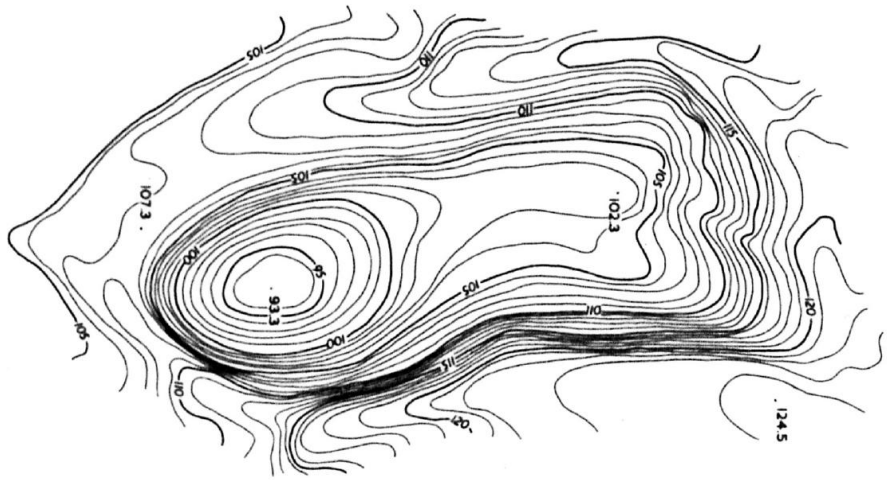


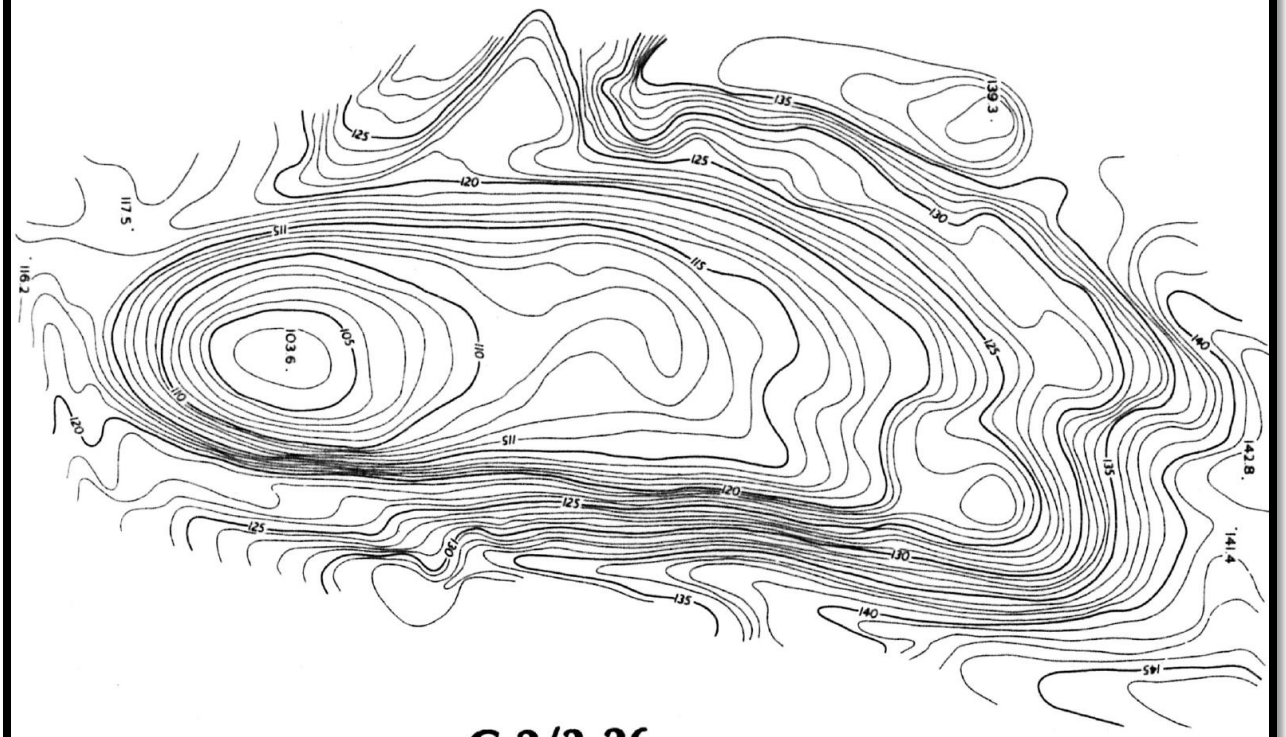


G.2/3-24

FOOTPRINT SAMPLE B

G.1-35





G.2/3-26