

# **Lewis and Clark, the Scientific Method, and the Learning Cycle**

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## **Introduction**

In this lesson undergraduate students in an earth science course read and reflect on journal entries of Meriwether Lewis and colleagues in order to understand scientific methods and basic principles of science. The instructor first sets the stage by describing the historical background of the expedition, then using the journal entries, the students relive the expedition as they choose which fork that would take them to the Great Falls of the Missouri River which is located in the state of Montana.

Objective expressed as a standard from the National Science Education Standards (1996):

- Students (will) develop understanding of the nature of scientific knowledge (p. 200).

Science as a way of knowing proceeds as scientists use empirical standards, logical arguments, and skepticism to make explanations of the natural world. Scientific explanations must be consistent with experimental and observational evidence, must be logical, be open to criticism, and must respect the rules of evidence. Scientific knowledge is tentative, that is, it is subject to change as new evidence becomes available (pp. 200-201).

Background Knowledge

As reported in the journal writings of the explorers, on June 2, 1805, the Lewis and Clark expedition, following the Missouri River west toward the Rocky Mountains, arrive at the junction of two rivers. The natives of the area had told the explorers that they would soon arrive at a series of falls and rapids (the Great Falls of the Missouri River) but had not given them any information about which fork in the river to follow. Lewis and Clark decide the only option is to investigate both rivers in the hope of finding evidence that would allow them to predict which is the Missouri River. Two teams of men are sent to spend the day investigating the rivers. When the teams reconvene they share their data and agree on which one of the rivers is the Missouri. However, Lewis and Clark are not so sure. They realize that a mistake might have severe consequences for their exploration and decide to conduct some further investigation. Clark and Lewis each lead a team. Clark takes three days to explore the South Fork; Lewis spends five days on a North Fork expedition. Using this additional data, the group makes a decision. And the rest, they say, is history.

The investigations of the Lewis and Clark team follow five basic principles of science (for example, see Evolution and the Nature of Science Institutes (ENSI) website, <http://www.indiana.edu/~ensiweb/>).

- Tentative - Scientific explanations are tentative and can and do change. Early attempts to determine the age of Earth were based upon erroneous assumptions and estimated the age of the planet to be a few million years old. With the advent of radiometric dating methods scientists calculated that Earth formed approximately 4.6 billion years ago.
- Observations - Scientific explanations are based on empirical observations or experiments. For example, the direction and rate of flow of groundwater in cave

systems can be established by injecting non-toxic colored dyes at one location and then monitoring flow at several points downslope from the source. The data obtained from such analyses should be reproducible by others.

- Predictable - Scientific explanations should be predictable and testable with successful hypotheses. The daily weather forecast is a common example of the use this rule. Meteorologists use their knowledge of how air and moisture circulate through the atmosphere to predict short-term changes in weather patterns.
- Technology - Scientific explanations may be limited by available technology and new technologies can lead to new fields of inquiry. For example, prior to the invention of the telescope, knowledge about Earth's position in space was based upon observations made with the naked eye. Astronomers such as Galileo used some of the first telescopes to identify perturbations in planetary orbits that would result in the hypothesis that the Sun, not Earth, is the center of the solar system.
- Natural Causes - A valid scientific hypothesis offers a well-defined natural cause or mechanism to explain the occurrence of a natural event. For example, scientists who study earthquakes recognize a clear relationship between the amount of movement on fractures in Earth's crust and the size of earthquakes.

### Teacher

The teacher of this lesson was a professor of geology. The setting was an earth science course, typically a survey course that fulfills the general studies requirement and is taken by non-science majors. This lesson could easily be taught by science teachers in middle or high schools.

## Student

The students in the earth science class are usually college freshmen. Most of these students do not plan on majoring in science; many of these students have not declared a major area of study. This lesson is also appropriate for middle or high school students. In this lesson, the students will work together in groups of three to four. The teacher could form groups ahead of time or, when needed, the students could make informal groups to discuss the material.

## Materials

Copies of the journal writings of the explorers should be made available to the student groups. The teacher should have a map of the Rocky Mountain region as it was known in the late 1700's. See website <http://www.pbs.org/lewisandclark/index.html> for some suggestions.

## Safety Procedures

There are no safety issues in this lesson.

## **Lesson Body**

### **Engagement**

Show the students a map of the Rocky Mountain region as it was known to the explorers of the late 1700's/early 1800's. Set up the scenario of the Lewis and Clark expedition by reading the following:

*Instructor: It is June 1805. The Lewis & Clark expedition followed the Missouri River west toward the Rocky Mountains. The natives of the area had told the explorers that they would arrive at a series of falls and rapids (the Great Falls of the Missouri River) and soon after reach the mountains. However, before they were to find the falls they were*

*confronted by a fork in the river and were forced to make a decision about which route to follow. The passages you will read are taken from the journals of different members of the Corps of Discovery. In your handout, corps members are identified by bold lettering, their journal entries are in italics, their original spelling and grammar are preserved. As you read the passages, keep in mind that the expedition team is proceeding on foot or canoe. They must rely on the accuracy and completeness of their observations, their prior experiences to interpret these observations, and the absence of modern technologies (like a camera, satellite photographs, cell phones, the Internet) to assist them. So, put yourselves back in time as a member of the Corps of Discovery as you wrestle with the important decision of which fork of the river is the Missouri.*

### **Exploration (1)**

Suggest that students work together in groups of three or four and designate persons to record and to report in each group. Distribute part one of handout.

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### **HANDOUT - Part One**

June 1805: The Lewis & Clark expedition followed the Missouri River west toward the Rocky Mountains. On June 2 the expedition arrives at the junction of two rivers (Fig. 1). The natives of the area had told the explorers that they would arrive at a series of falls and rapids (the Great Falls of the Missouri River) and soon after will reach the mountains. However, before they were to find the falls they had to determine which river to follow. The passages below are taken from the journals of different members of the Corps of Discovery. Read their comments and answer the questions that are included. Corps members are identified by bold lettering, their journal entries are in italics, their original spelling and grammar are preserved.

June 02, 1805:

**Joseph Whitehouse** *we Came 18 miles & Camped at a fork of the river. we could not determine which was the Missourie.*

June 03, 1805

**Meriwether Lewis** *An interesting question was now to be determined; which of these rivers was the Missouri . . . which they had discribed to us as approaching very near to the Columbia river. to mistake the stream at this period of the season, two months of the traveling season having now elapsed, and to ascend such stream to the rocky Mountain or perhaps much further before we could inform ourselves whether it did approach the Columbia or not, and then be obliged to return and take the other stream would not only loose us the whole of this season but would probably so dishearten the party that it might defeat the expedition altogether. ...an investigation of both streams was the first thing to be done; ... accordingly we dispatched two light canoes with three men in each up those streams; we also sent out several small parties by land with instructions to penetrate the country as far as they conveniently can permitting themselves time to return this evening and indeavour if possible to discover the distant bearing of those rivers by ascending the rising grounds.*

*. . . the air & character of this river is so precisely that of the missouri below that the party with very few exceptions have already pronounced the N. fork to be the Missouri; myself and Capt. C. not quite so precipitate have not yet decided but if we were to give our opinions I believe we should be in the minority, certain it is that the North fork gives the colouring matter and character which is retained from hence to the gulph of Mexico. ... convinced I am that if it penetrated the Rocky Mountains to any great distance it's waters would be clearer unless it should run an immense distance indeed after leaving those mountains through these level plains in order to acquire it's turbid hue. ... thus have our cogitating faculties been busily employed all day.*

June 03, 1805

**John Ordway** *we formed a Camp on the point in the junction of the two rivers, & two canoes & 3 men were dispatched up each river to examine and find it possable which is the most probable branch. the left fork which is the largest we are doubtful of. the Indians do not mention any river falling in on the right in this part of the Missourie Missourie. ... Capt Clark measured each river & found the one to the Right hand 186 yards wide of water, & the left hand fork 372 yards wide and rapid. the right hand fork falling the other at a Stand, and clear the right fork and the river which fall into it is couloured & a little muddy. . . our officers are not Satisfied in their minds which River will be best to for us to take.*

Lewis & Clark decided the only option was to investigate both rivers in the hope of finding evidence that would allow them to predict which was the Missouri River. Two teams of three men each are sent to spend the day investigating each river.

1. What observations could they have made to help in their decision?

At this point all members of the expedition agreed on which one of the rivers was the Missouri.

2. Which river do you think they chose? Support your choice with evidence gleaned from the journals.

A. South Fork

B. North Fork

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**Explanation (1)**

After a few minutes the instructor calls the groups to attention. Ask the groups, by show of hands, to choose either the South Fork or the North Fork. Have groups share with the class their justifications for their choices. Accept all explanations for the choices. Do not reveal the choice eventually made by the Corps of Discovery.

**Exploration (2)**

Tell the class: The team that investigated the North Fork reported that the waters flowed “*in the same boiling and rolling manner which had uniformly characterized the Missouri throughout its whole course so far*”. At this point all members of the expedition agreed on which one of the rivers was the Missouri. Which river do you think they chose? However, Lewis & Clark themselves were not so sure. They realized that a mistake might have severe consequences for their exploration and decided to do some further investigation. The next day, Clark and Lewis each led teams of men up the South and North Forks respectively. Clark took three days and traveled 40 miles upstream; Lewis spent five days on his reconnaissance, which reached sixty miles upstream. You will read several more passages from the explorers’ journals to inform your group’s decision.

3. What additional observations could they make to aid in their decision?

## HANDOUT - Part Two

June 04, 1805

**Patrick Gass** *Captain Lewis with six men went up the North Branch, to see if they could find any certain marks to determine whether that was the Missouri or not; and Captain Clarke myself and four others went up the South branch, for the same purpose with regard to that branch.*

**Joseph Whitehouse** *Capt. Lewis & 6 men Set out to go up the Right hand fork. Capt. Clark & 5 more Set out to go up the left hand fork. they intend to go about one day & a halves walk up the rivers & See what discoveries they can make.*

Clark took three days and traveled 40 miles upstream; Lewis spent five days on his reconnaissance, which reached over sixty miles upstream on the north fork.

June 05, 1805

**Patrick Gass** *Some light showers of rain fell in the night, and the morning was cloudy. ... we set out along the plains again, and discovered the mountain South of us covered with snow, that had fallen last night. When we had gone about 11 miles we saw a large mountain to the West of us also covered with snow.*

June 06, 1805

**Meriwether Lewis** *I now became well convinced that this branch of the Missouri had it's direction too much to the North for our rout to the Pacific, ...*

June 08, 1805

**Meriwether Lewis** *The whole of my party to a man except myself were fully persuaded that this river was the Missouri, but being fully of opinion that it was neither the main stream, nor that which it would be advisable for us to take, I determined to give it a name and in honour of Miss Maria Wood. called it Maria's River. it is true that the hue of the waters of this turbulent and troubled stream but illy comport with the pure celestial virtues and amiable qualifications of that lovely fair one; but on the other hand it is a noble river; one destined to become in my opinion an object of contention between the two great powers of America and Great Britin with respect to the adjustment of the Northwestwardly boundary of the former; . . .*

June 08, 1805

**Patrick Gass** *... the water of the South river, or branch, became almost of the colour of claret, ... The water of the other branch has the appearance of milk when contrasted with the water of this branch in its present state. ... The officers concluded that the south*



*branch was the most proper to ascend, which they think is the Missouri. The other they called Maria's river.*

June 09, 1805

**Meriwether Lewis** *The Indian information also argued strongly in favour of the South fork. they informed us that the water of the Missouri was nearly transparent at the great falls, this is the case with the water of the South fork;*

*Those ideas as they occurred to me I indevoured to impress on the minds of the party all of whom except Capt. C. being still firm in the belief that the N. Fork was the Missouri and that which we ought to take; they said very cheefully that they were ready to follow us any wher[e] we thought proper to direct but that they still thought that the other was the river and that they were affraid that the South fork would soon termineate in the mountains and leave us at a great distance from the Columbia. ... finding them so determined in this beleif, and wishing that if we were in an error to be able to detect it and rectify it as soon as possible it was agreed between Capt. C. and myself that one of us should set out with a small party by land up the South fork and continue our rout up it untill we found the falls or reached the snowy Mountains by which means we should be enabled to determine this question prety accurately*

4. What additional observations did they make to aid in their decision?

5. Which river do you think they chose? Support your choice with evidence gleaned from the journals.

A. South Fork

B. North Fork

### **Explanation (2)**

After a few minutes the instructor calls the groups to attention. Ask the groups, by show of hands, to choose either the South Fork or the North Fork. Have groups share with the class their justifications for their choices. Accept all explanations for the choices.

Display these additional journal entries on a screen and read them to the class.

June 12, 1805

**Joseph Whitehouse** . . . *proceeded on up the South fork which we Still call the Missouri R. ... Several Rattle Snakes has been Seen by the party to day. . .*

June 13, 1805

**Meriwether Lewis** . . . *my ears were saluted with the agreeable sound of a fall of water and advancing a little further I saw the spray arise above the plain like a column of smoke which would frequently dispear again in an instant caused I presume by the wind which blew pretty hard from the S.W. I did not however loose my direction to this point which soon began to make a roaring too tremendous to be mistaken for any cause short of the great falls of the Missouri. ... to gaze on this sublimely grand specticle ... formes the grandest sight I ever beheld, . . .*

On June 11, the Lewis & Clark expedition ascended the South Fork and two days later, Lewis roving ahead of the rest of the expedition, encountered the Great Falls of the Missouri, confirming that they had made the right decision.

### **Elaboration**

Ask the students what skills/methods the Corps of Discovery used to help them choose their course. Lead the discussion to include observing, measuring, recording data, inferring, hypothesizing, and predicting. Be sure to discuss examples of where each of these was employed by the expedition. Point out to the students that, in addition to scientific skills used by the Corps, these explorers operated like scientists, respecting five basic tenants of science. List on the screen, five basic principles of science.

- Scientific explanations are tentative.
- Scientific explanations are based on empirical observations or experiments.
- Scientific explanations should be predictable.
- Scientific explanations are limited by technology.
- Scientific explanations offer well-defined natural causes to explain natural phenomena.

Briefly, elaborate on these tenants with an example of a scientific finding/experiment illustrating each one. See background knowledge for suggestions.

## **Evaluation**

Throughout the lesson the instructor should monitor the students' and groups' answers for completeness and accuracy. The questions in Handout Part Three will probe each student's comprehension and application of scientific methodologies and basic tenants of science. These papers will be completed individually and will be reviewed by the instructor. Suggested/acceptable answers are provided.

## **Closure**

Wrap up the lesson with a brief review of scientific methodologies, to include observing, measuring, recording data, inferring, hypothesizing, and predicting; and basic tenants of science. Pass out Part Three of the handout and instruct each student to hand it in for grading.

## **HANDOUT - Part Three**

Name: \_\_\_\_\_

Return this sheet for grading.

A. Describe one example of how you use the scientific method in your daily life to make simple decisions. Identify a hypothesis and at least one observation you could make to test the hypothesis.

B. Which of the five basic principles of science (listed below) were followed by Lewis and Clark?

•Scientific explanations are tentative

Was used/Was not used (circle where appropriate; explain your answer)

- Scientific explanations are based on empirical observations or experiments  
Was used/Was not used (circle where appropriate; explain your answer)

- Scientific explanations should be predictable  
Was used/Was not used (circle where appropriate; explain your answer)

- Scientific explanations are limited by technology  
Was used/Was not used (circle where appropriate; explain your answer)

- Scientific explanations offer well-defined natural causes to explain natural phenomena  
Was used/Was not used (circle where appropriate; explain your answer)

## ANSWERS TO HANDOUT QUESTIONS

### 1. What observations could they have made to help in their decision?

Their findings were:

- South fork: wider (372 yards), shallower, faster flowing, clearer
- North fork: narrower (220 yards), deeper, muddier

At this point all members of the expedition agreed on which one of the rivers was the Missouri.

### 2. Which river do you think they chose? The North Fork.

The team that investigated the North Fork reported that the waters flowed “*in the same boiling and rolling manner which had uniformly characterized the Missouri throughout its whole course so far*”.

### 3/4. What additional observations could they have made to aid in their decision?

Neither Lewis or Clark saw the falls predicted by the local inhabitants. Lewis considered that the course of the North Fork (the Marias River) was too far to the north to hold any hope that it would lead them through the Rocky Mountains to the west.

**5. Which river do you think they chose?** The South Fork. The clear, rocky stream bed of the South Fork was consistent with what they expected to see for a river draining from the steeper terrain of the mountains.

**A. Describe one example of how you use the scientific method in your daily life to make simple decisions. Identify a hypothesis and at least one observation you could make to test the hypothesis.**

Answers will vary.

**B. Which of the five basic principles of science (listed below) were followed by Lewis and Clark?**

•Scientific explanations are tentative

**Was used**/Was not used (circle where appropriate; explain your answer)

L & C were prepared to change their ideas on which stream to follow based on data collected.

•Scientific explanations are based on empirical observations or experiments

**Was used**/Was not used (circle where appropriate; explain your answer)

Yes. L & C collected data on stream characteristics (width, depth, etc.)

•Scientific explanations should be predictable

**Was used**/Was not used (circle where appropriate; explain your answer)

Simple prediction: If they chose the correct stream to follow they should find the falls up ahead.

•Scientific explanations are limited by technology

**Was used**/Was not used (circle where appropriate; explain your answer)

Clearly today we could use much greater technology than L & C. They were limited by the technology they could transport on their expedition.

•Scientific explanations offer well-defined natural causes to explain natural phenomena

**Was used**/Was not used (circle where appropriate; explain your answer)

Yes. Natural phenomena in this case was stream flow. L & C chose course on the basis of the clarity of the stream.

*About the authors...*

**David McConnell** teaches geology courses and **Katharine Owens** teaches science methods courses at The University of Akron. Together these faculty collaborate on projects to incorporate inquiry-based teaching methods into undergraduate science courses, especially those taught to preservice teachers.

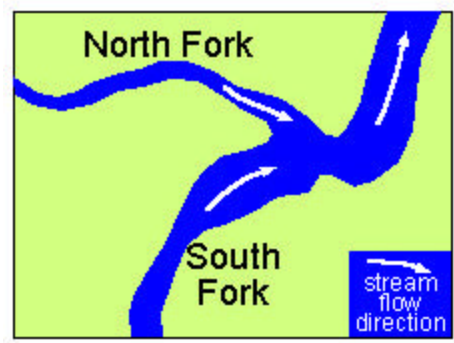


Figure 1. The map above illustrates the relative positions of the two forks in the Missouri River. Remember that the expedition is traveling upstream. The North Fork is sometimes referred to as the “right branch” and the South Fork as the “left branch”.