Introducing the Understanding Science Flowchart

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Overview: Students begin with a simple "warm up" activity that introduces them to the process of science. The class discusses whether or not they were "doing" science. Students then read a story about the geoscientist, Walter Alvarez, and identify phrases within the story that indicate that Alvarez was doing science. Students are introduced to the Science Flowchart and are asked to plot the scientific journey of Walter Alvarez. Students find that science is seldom a linear story, but instead involves unanswered questions, surprising leaps, reinterpretation of data, and the unexpected.

Lesson concepts:

- The process of science involves testing ideas about the natural world with data from the natural world.
- Scientific understanding improves as new evidence and perspectives emerge.
- The process of science is non-linear.
- The process of science involves observation, exploration, discovery, testing, communication, and application.
- Scientists test their ideas using multiple lines of evidence.
- Test results sometimes cause scientists to revise their hypotheses.
- Scientists are creative and curious.
- Scientists work together and share their ideas.

Grade span: 9–16

Materials:

- ***Asteroids and dinosaurs: Unexpected twists and an unfinished story*** (www.understandingscience.org/lessons/pdfs/alvarez_hs.pdf), a story about Walter Alvarez — one copy per student
- Copies of **simple Science Flowchart** (www.understandingscience.org/lessons/pdfs/simple_flow_handout.pdf) — one per student
- Copies of **complex Science Flowchart** (www.understandingscience.org/lessons/pdfs/complex_flow_handout.pdf) — one per student
- 3x5-inch cards
- Highlighters — one per student
- **Mystery tubes** (www.understandingscience.org/lessons/mystery_tubes.html) or **Mystery boxes** (http://www.indiana.edu/~ensiweb/lessons/mys.box.html) — see Teaching Tips

Time: One 90-minute class period

Grouping: Pairs and large group discussion

Teaching tips:

- There are several activities that can be used to introduce the nature and process of science. These include: **Mystery tubes**, **Mystery boxes**, or the **Checks lab** (http://www.indiana.edu/~ensiweb/lessons/chec.lab.html).
- There are several versions of the Walter Alvarez story that can be used for this lesson, depending upon student reading level and class time available. The simplest is a **two-page story appropriate for middle school students** (www.understandingscience.org/lessons/pdfs/alvarez_ms.pdf); the second is a more advanced **two-page story appropriate for high school** and above (www.understandingscience.org/lessons/pdfs/alvarez_hs.pdf); and the third is a **more complete story available online** (www.understandingscience.org/article/0_0_0/alvarez_01) appropriate for undergraduates.
- As there are two versions of the Science Flowchart, you may want to have a two-sided sheet—one side shows the simple version and the other the complex. Place the sheet in a plastic sleeve and cover the complex side with colored paper so that only the simple version is visible. Once the students are ready to see the complex version, they need only remove the colored piece of paper.

Procedure:

1) Have students respond to the question "What is science?" by writing their response on a 3x5-inch card. Cards should then be set aside.
2) Students participate in a warm-up activity such as **Mystery tubes**, **Mystery boxes**, or the **Checks lab**. At the close of the activity, students are asked: Were you doing science? Encourage discussion before proceeding.
3) Select the appropriate version of the Walter Alvarez story (see Teaching Tips) for your students, ask students to read *Asteroids and dinosaurs: Unexpected twists and an unfinished story*.
4) Discuss: *Was he doing science? How do you know?*
5) Advise students: *With a partner, go through and highlight all of the words or phrases that indicate Alvarez was doing science. For instance, you might begin by highlighting "looking for independent verification."*
6) Hand out the **simple version of the Science Flowchart** (see Teaching Tips). Explain to students that this is one way to depict the process of science. Discuss briefly their first impressions. Ask students to identify at least one thing that they highlighted in the Alvarez story that might fit in Explorations and Discovery. Repeat for Testing Ideas, Community Analysis and Feedback, and Benefits and Outcomes.
7) Suggest that they highlighted quite a number of phrases within the story and that obviously science is quite complex. Remove the Science Flowchart from its casing to reveal the more complex version, or pass out a copy of the **complex Science Flowchart** to each student. Go through each section with the students.
8) *Now let's return to the Walter Alvarez story. Let's go around the room and number all of the things that you highlighted. I will start. The first thing I saw was: "looking for independent verification." Put a number 1 in the margin of your story at that point. I will also put them up on the board as you list them for me. We will go in the order that they occur in the story.* Note: Continue around the room and number them on the board and on their sheets in order. The idea is to keep it in order so you might tell them that if someone missed something they highlighted, not to worry. Obviously not everyone highlighted the same things.
9) Ask students to place each of the numbers in the correct circle. You may want to start them off. For instance, you may put #1 down in Community Analysis and Feedback. Let students know that others might interpret that differently.
10) Once students have placed all of the numbers where they think they belong, have them connect the dots. The resulting pathway reflects the scientific journey of Walter Alvarez. Ask the students if all of the pathways were the same. Why not?

    Do you think that the pathway of all scientists would be the same? Why not?

Reflection: Discuss with your students how this differs from the Scientific Method that we tend to see in most textbooks?

Consider having students trace their pathways from the opening warm-up activity.

Extension (optional)**:** Ask students to return to their original definitions of science. Would they now make any changes? Discuss.