

## Lesson Plan

### NOTE TO THE TEACHER

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**M**y experience studying science in school was that thousands of seemingly unrelated topics were taught to me, one after the other, with very little discussion of how they were connected or how they formed a coherent explanation of how the world works. One of my goals in this curriculum is to focus on a central theme of matter and how it interacts with other matter and with energy to explain what happens around us every day.

Understanding matter is the basis for all sciences, and if students don't have this background, they are limited in what they can understand in biology, earth sciences, and space sciences. These 10 lessons offer a strong foundation for all other science learning. For example, a thorough understanding of photosynthesis is dependent on students' understanding atoms, molecules, elements, chemical formulas, and chemical reactions.

This first lesson focuses on interaction, which is the most accessible concept for students out of matter, energy, and interactions. They see that they can predict the outcome of many interactions in the world because of their past observations. I hope that this serves two goals.

The first goal is that students see that they can (and should) apply their own observations to what we discuss in class. It's also meant to connect the often abstract study of science with concrete, recognizable phenomena relevant to students' lives. All of science is built on observing things happening in the world, and asking questions about how or why those things happened the way that they did. The Richard Feynman reading, "The Making of a Scientist," addresses this in a charming way.

The second, less direct goal is that students begin the study of science with confidence that they already understand a few things. Science strikes me as a field that presents itself as all-knowing, dropping a 40-pound textbook in your lap and expecting you to just memorize what the geniuses have figured out. This has made a lot of us feel pretty dumb in the past. In this curriculum, I want the students' first activity in science to be something that they could do with some confidence.

Connected to this, I hope that this curriculum offers a more humane view of the field—that science is just the (often flawed and limited) current understanding of how things work in our world. It’s unfinished, it’s often wrong, and it’s ongoing. At some point, it’s worth mentioning a few things that have been revised, like the belief that the Earth was the center of the universe or that smoking was good for your health. The revision to these beliefs is not to imply that “we’ve got it all figured out now,” but rather to ask the question, “What will we revise and understand better 100 years from now?”

### OBJECTIVES

- ✓ Students will understand that “matter, energy, and interactions” is the main theme in this class.
- ✓ Students will understand what an interaction is.
- ✓ Students will understand that they can connect their observations to scientific discussions in class.
- ✓ Students will understand that making observations and asking questions is key to the practice of science.

### MATERIALS

- Handout: What would happen if...?
- Reading: *The Making of a Scientist*
- Handout: Notes on Today’s Lesson
- Homework Assignment

## 1

In our experience, once the conversation warms up, students will suggest many different fields of study: Astronomy, anatomy, oceanography, geography, psychology, etc. Write all these fields of study on the board and then circling the general fields. You might also star Life Science, Earth Science and Astronomy since these are the high emphasis areas on the HSE Science test. An understanding of matter, energy and interactions supports learning in all of these fields.

## LESSON STEPS

**Review the fields of science, and the methodology of this curriculum.**

- 1 Introduce this unit on science by asking students what the different fields of science are. Start them off with one as an example and elicit the rest of them.
  - a. Chemistry
  - b. Biology
  - c. Earth Science
  - d. Astronomy
  - e. Physics

The HSE test expects students to know all five of these fields, but it’s impossible to cover all of these fields in one class. Instead, this class will focus on core ideas that are essential and common to all five fields.

**Introduce our central idea: Matter, Energy, and Interactions.**

- 2 What are the core ideas? MATTER, ENERGY, and how they INTERACT in any combination. It's fine if this seems confusing right now because we will return to this central idea every lesson. Let's start with INTERACTIONS. What is an interaction? Elicit a few ideas and write a definition on the board.

Offer a few examples, such as:

- Two people fall in love
- Lightning strikes a tree
- Two cars crash
- You take a pill and your headache goes away.

- 3 Ask students to work with a partner and think of three examples of interactions and write them down. Give them 2-3 minutes to do this and then ask several groups to share. Make a list on the board as students share their ideas.

- 4 Check off a few of the interactions that you will discuss in the coming science lessons, such as lightning hitting a tree.

**Introduce observations and questioning as central practices of science.**

- 5 Introduce the idea that science is based on OBSERVATIONS and QUESTIONS. Write these two terms on the board. Explain that everything we know about science comes from scientists making observations of the world and asking questions based on those observations. Say that everyone in the room has already made many observations, and that we will use those observations in our discussions of science.
- 6 For example, what would happen if you dropped a spoonful of sugar into water? Ask the students what happens. Point out that they already know what happens, but the next step is to ask questions about this. The first question is *Why does the sugar dissolve in water? Why doesn't it fall to the bottom like pieces of metal would?* Ask a few more questions, like *Can I mix an infinite amount of sugar into the water? Why not? Why does it dissolve at the beginning but not at the end? Why can't you see the sugar after it dissolves? Can you get the sugar back out? Would sugar dissolve in any liquid or only water?*

**VOCABULARY****• Interaction •**

Two or more things come together and have an effect on each other

**5**

Be explicit and make the point that observations include things we can see in the world with the naked eye, microscopes, telescopes, microphones, etc. and information we collect in experiments.

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Observing, asking questions and answering WHY is science. Many students will think that science is about memorizing information, rather than seeking explanations that make sense. We want to make it clear to our students that we want them to understand the “Why” behind the content.

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Richard Feynman was an American theoretical physicist who lectured and wrote books about physics for the general public. As a young man, he worked on the development of the atom bomb. He later won the Nobel Prize for Physics for creating a model of how light and matter interact. As an older man, he was part of a panel that investigated the Space Shuttle Challenger disaster. He’s actually the one who figured out what happened. There was a very dramatic moment during the hearing where he describes putting an O-Ring under pressure in a glass of ice water. There are a number of Feynman recordings on YouTube that would be interesting for teachers’ background knowledge. Feynman’s lectures on physics are accessible and available for free online. (This BBC interview contains the original recollections that became the reading for this class: <http://www.feynmanphysicslectures.com/bbc-horizon-interview/>)

- 7 Distribute **WHAT WOULD HAPPEN IF...?**. Ask students to work with a partner to use their previous experience to make notes on what would happen in each interaction. In the third column, students should write two questions about the interaction. Do one more example to get them started.
- 8 Stop students when the first few groups finish or when you think they’ve got the idea. Have two pairs of students to come together to compare answers. Address the whole class with any outstanding questions.

#### **In-class reading.**

- 9 (This can also be done as homework.) Distribute **THE MAKING OF A SCIENTIST**. Ask students to select a passage (or section) that stands out to them for any reason. They might select a passage they agree or disagree with, or a passage that they like or dislike. They should make a few notes in the margin about why they chose that passage. A passage might be one sentence, a few sentences, or a paragraph or two.
- 10 When most of the class is finished, have students share their passage with a partner. After a few minutes of discussion, come together as a whole class and hear a few examples. If it doesn’t come out naturally in the discussion, ask why Feynman was making a distinction between knowing the name of something versus observing/noticing things.

#### **Review the structure of the class: Quiz, Lesson, Summary.**

- 11 Congratulate the students on their good work on the first day of science, and tell them when their next science lesson will be. Review how you will be teaching science:
  - a. At the beginning of each lesson, there will be a cumulative quiz on the previous lesson. This is to help students review and reinforce the ideas. Explain that students who take tests or quizzes more frequently tend to remember the material better and also do better on future tests.
  - b. After the quiz, there will be a new lesson. Students will need to take notes during the lessons. Group and pair work is central to all lessons.
  - c. At the end of every lesson, you or the students will summarize the main ideas of the lesson.

**Summarize today's lesson.**

- 12** The first summary isn't going to be a formal summary—it's going to be notes. Ask students to work in pairs to make notes on what you talked about and did during today's lesson. Their list of notes doesn't have to be in complete sentences. It can include definitions of words, a note about an activity of question that was discussed, or anything else. It doesn't have to be in order. The idea is just to get down the most important ideas and concepts that were discussed in class today.
- 13** Collect ideas and record them on the board after they have had enough time to work on this.
- 14** Distribute your own version of notes. You can use "NOTES ON TODAY'S LESSON" as a model for your own teacher's version of class notes. Point out how similar they are (even if they aren't that similar).

 **HOMEWORK**

**Distribute the homework assignment.** Students should write a letter to you about their past experiences learning science. Ask students if their past experiences learning about science are mostly good, bad, or neutral. And ask them to think of at least one specific teacher or situation that they remember and describe it to you in the letter.

**Offer an example of your own to model how to do this.** (For example, the only thing I remember from my physics class in high school was being out in the hallways throwing balls around. I had no idea why we were doing that. A few years later, I enrolled in a physics class in college and I had a very hard time in that class. I had never heard of the words or concepts they were talking about, even though I supposedly had taken physics in high school.)

**Encourage students to be honest in their letters.** Students who may have it in their heads that they are just bad science students should have opportunities to re-examine that "truth." This assignment gives students and teachers an opportunity to start an individual conversation about past experiences in education and future goals in education and work.

**VOCABULARY**

Interactions • Observations • Summarize

11

Psychologists have shown that students learn more when they are given a series of brief quizzes that they do if they are just given one big exam at the end. Every time a memory is retrieved, it becomes stronger by being connected to new sensations and contexts. This has ramifications for how students should study. Students should test themselves as they read, looking away from the page to see what they remember or understand. One place to learn more is the American Radio Works' documentary, *The Science of Smart* (<http://www.americanradioworks.org/documentaries/the-science-of-smart/>).

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This is an opportunity to model notes that you expect your students to take in a science class. For students who are unfamiliar to the subject (or school in general), it is helpful to have models to refer to in subsequent classes when they are asked to take notes and write summaries. The summary model is a way to provide scaffolding for an activity that can be challenging for many students.

# What Would Happen If...?

Imagine the following interactions. What happens? Make some notes in the second column. Then ask questions about each interaction, such as “Why does the gasoline catch on fire but the water doesn’t? Can we explain the difference?”

INTERACTION	WHAT WOULD HAPPEN?	QUESTIONS
You drop a lit match into a gas tank full of gasoline.		
You drop a lit match into a glass of water.		
You stir one spoonful of sugar into a glass of water.		
You put small pieces of iron into a glass of water and leave them there for one month.		
You leave a bowl of ice cream in the sun.		
You pour oil into water.		
You pour blue ink into water.		

# Reading

As you read this article, choose a passage that stands out to you. Underline it. Why does it stand out to you? Write a few notes in the margin about why you choose it.

## The Making of a Scientist

by Richard Feynman

We used to go to the Catskill Mountains, a place where people from New York City would go in the summer. The fathers would all return to New York to work during the week and come back only for the weekend. On weekends, my father would take me for walks in the woods and he'd tell me about interesting things that were going on in the woods. When the other mothers saw this, they thought it was wonderful and that the other fathers should take their sons for walks. They tried to work on them but they didn't get anywhere at first. They wanted my father to take all the kids, but he didn't want to because he had a special relationship with me. So it ended up that the other fathers had to take their children for walks the next weekend.

The next Monday, when the fathers were all back at work, we kids were playing in a field. One kid says to me, "See that bird? What kind of bird is that?"

I said, "I haven't the slightest idea what kind of a bird it is."

He says, "It's a brown-throated thrush. Your father doesn't teach you anything!"

But it was the opposite. He had already taught me: "See that bird?" he says. "It's a Spencer's warbler." (I knew he didn't know the real name.) "Well, in Italian, it's a Chutto Lapittida. In Portuguese it's a Bom da Peida. In Chinese, it's a Chung-long-tah, and in Japanese, it's a Katano Tekeda. You can know the name of the bird in all the languages of the world, but when you're finished, you'll know absolutely nothing whatever about the bird. You'll only know about humans in different places, and what they call the bird. So let's look at the bird and see what it's doing—that's what counts." (I learned very early the difference between knowing the name of something and knowing something.)

He said, "For example, look: the bird pecks at its feathers all the time. See it walking around, pecking at its feathers?"

"Yeah."

He says, "Why do you think birds peck at their feathers?"

I said, "Well, maybe they mess up their feathers when they fly, so they're pecking them in order to straighten them out."

"All right," he says. "If that were the case, then they would peck a lot just after they've been flying. Then, after they've been on the ground a while, they wouldn't peck so much anymore—you know what I mean?"

"Yeah."

He says, "Let's look and see if they peck more just after they land."

It wasn't hard to tell: there was not much difference between the birds that had been walking around a bit and those that had just landed. So I said, "I give up. Why does a bird peck at its feathers?"

"Because there are lice bothering it," he says. "The lice eat flakes of protein that come off its feathers."

He continued, "Each louse has some waxy stuff on its legs, and little mites eat that. The mites don't digest it perfectly, so they emit from their rear ends a sugar-like material, in which bacteria grow."

Finally he says, "So you see, everywhere there's a source of food, there's some form of life that finds it."

Now, I knew that it may not have been exactly a louse, that it might not be exactly true that the louse's legs have mites. That story was probably incorrect in detail, but what he was telling me was right in principle.

Not having experience with many fathers, I didn't realize how remarkable he was. How did he learn the deep principles of science and the love of it, what's behind it, and why it's worth doing? I never really asked him, because I just assumed that those were things that fathers knew.

My father taught me to notice things. One day, I was playing with an "express wagon," a little wagon with a railing around it. It had a ball in it, and when I pulled the wagon, I noticed something about the way the ball moved. I went to my father and said, "Say, Pop, I noticed something. When I pull the wagon, the ball rolls to the back of the wagon. And when I'm pulling it along and I suddenly stop, the ball rolls to the front of the wagon. Why is that?"

"That, nobody knows," he said. "The general principle is that things which are moving tend to keep on moving, and things which are standing still tend to stand still, unless you push them hard. This tendency is called 'inertia,' but nobody knows why it's true." Now, that's a deep understanding. He didn't just give me the name.

He went on to say, "If you look from the side, you'll see that it's the back of the wagon that you're pulling against the ball, and the ball stands still. As a matter of fact, from the friction it starts to move forward a little bit in relation to the ground. It doesn't move back."

I ran back to the little wagon and set the ball up again and pulled the wagon. Looking sideways, I saw that indeed he was right. Relative to the sidewalk, it moved forward a little bit.

That's the way I was educated by my father, with those kinds of examples and discussions: no pressure—just lovely, interesting discussions. It has motivated me for the rest of my life, and makes me interested in all the sciences. (It just happens I do physics better.) I've been caught, so to speak—like someone who was given something wonderful when he was a child, and he's always looking for it again. I'm always looking, like a child, for the wonders I know I'm going to find—maybe not every time, but every once in a while.

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# Notes on Today's Lesson

- Different branches of science:
  - Biology
  - Chemistry
  - Physics
  - Earth science
  - Astronomy
  
- We don't have time to learn each field, so we'll focus on ideas that are common to all of them by studying "Matter, energy, and interactions."
  
- **Interaction** = two or more things come together and have an effect on each other. We used our past experiences to say what the result of certain interactions would be. We also asked questions about these interactions.
  
- Observations and questions are central to how science is done.
  
- Read "The Making of a Scientist," which gave an example of people making observations and asking questions.
  
- Structure of science lessons:
  1. Quiz
  2. New lesson (take notes)
  
- Summarize

# Homework

Dear Students,

Welcome to our science unit! I'm excited to work with you in this section—we are going to work hard to learn a lot, but we also will do a lot of fun activities in class together.

I know that not everyone has had good experiences learning science. It's helpful for me to understand how you feel about learning science as we start this part of the class. To help me, please write me a letter about your past experiences. You can be honest—if your experiences were good, bad, or forgettable, you can tell me.

I'd like you to include a paragraph on each of these topics:

- 1. How do you feel about learning science? (Excited, bored, scared, intimidated?) Why?**
- 2. Describe one teacher, class, or learning experience you've had related to science. Pick your most memorable memory—good or bad!**
- 3. Finally, what are your plans for after you pass the HSE test? Are you interested in attending college, and if so, what would you like to study? What kinds of jobs appeal to you?**

I look forward to reading your letters!

Warmly,

Your Science Teacher