Questions

How do scientists know which questions have reasonable answers and which do not? How do frameworks affect our use of imagination or creativity? If you take someone else's invention, change the way it works, and start selling it as your own invention, can you give it the same name or should you change the name?

Materials Needed

For this activity, you will need the following materials:

- a set of objects and associated observational data
- a pencil (do not use ink)
- the ability to read and follow directions

Points To Remember

Unless otherwise explicitly instructed, your responses must not contain personal opinions. All of your responses must be in the form of complete sentences; the fewer sentences the better. Spelling and grammar must be correct. Effective communication is essential for both learning and doing science.

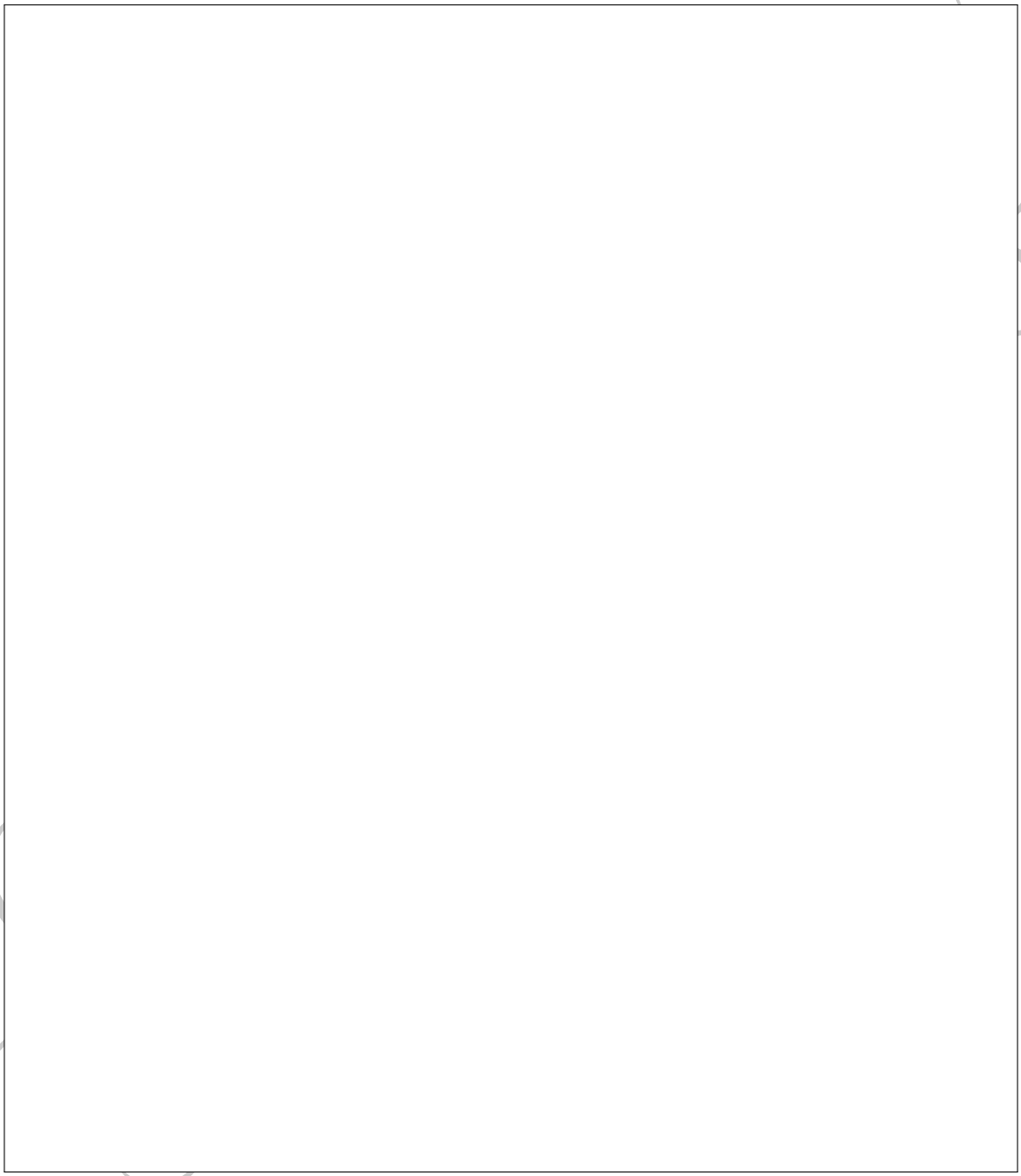
Don't ask instructors for answers to questions posed in activities; you won't get them. You may ask questions regarding the clarity of the instructions or the soundness of your reasoning. If you encounter a word you are not familiar with, don't ask the instructor about it. Look it up first in your glossary and then a dictionary or some other source if necessary. Ensure that all definitions are unanimously agreed upon before proceeding. There are, of course, sound reasons for these policies. See the instructor if you have questions, but do not complain about these policies. They are not negotiable.

1 A Process

You should have already read the definition of a *framework* in your glossary. If you have not, do it right now before proceeding. This definition is rather wordy, so let's see how it works in practice.

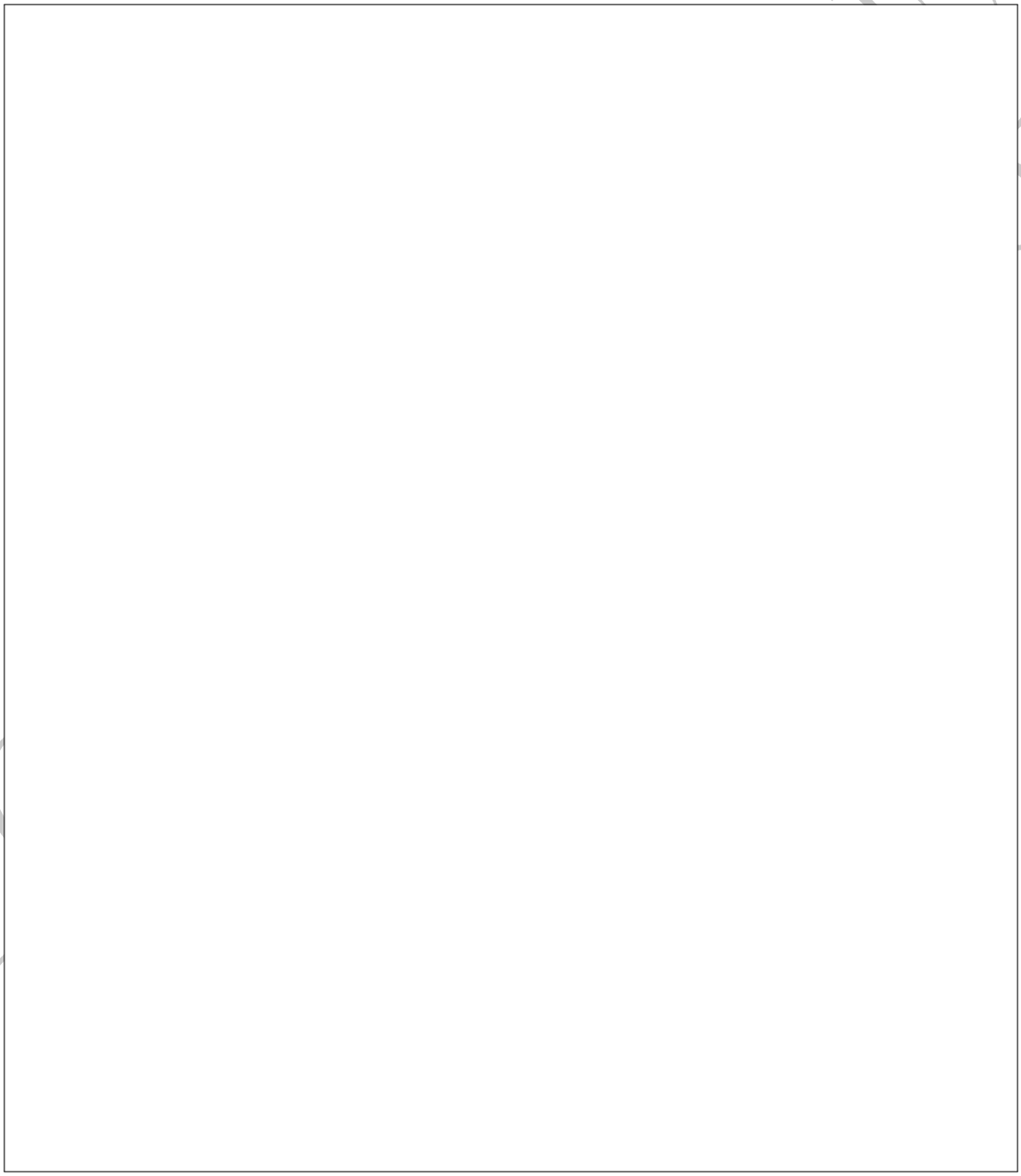
1.1 Where To Begin?

You have been given a set of items. Your task is to figure out what the items are used for, how to use them, and anything else you can figure out about them. Just like in the real world, you have to develop a strategy to figure all this out. Begin by listing all the questions you think you need to know about the items. List your questions in the space provided.



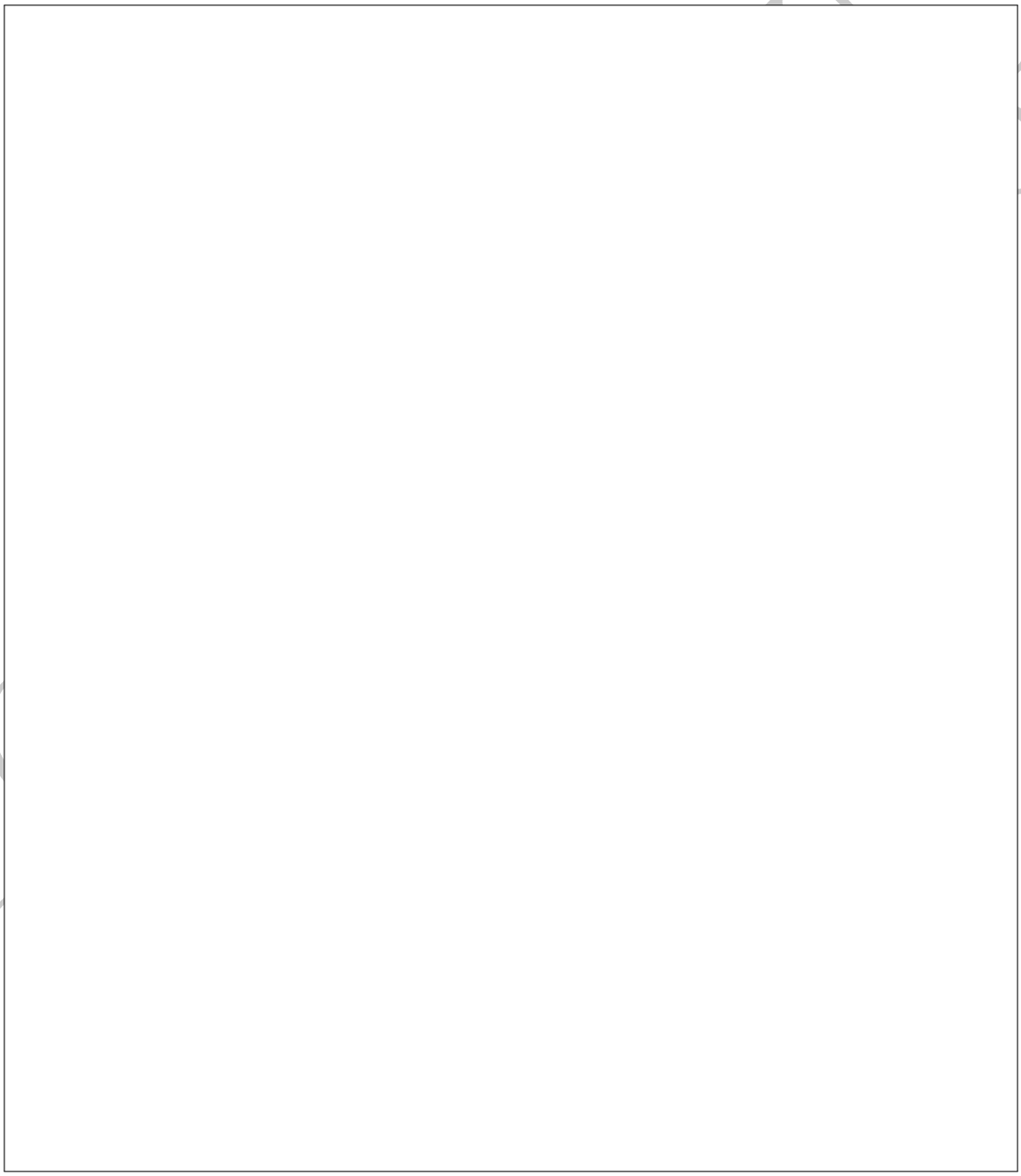
1.2 Figuring It Out

Now you get to set about answering all of the questions you listed above. If you were watching a natural phenomenon take place, you could simply observe and write down what you see. You can't do that here, however, but you can do the next best thing. You can make some initial assumptions about the items and proceed to figure things out based on those assumptions. Don't worry if you need to modify some or all of those assumptions. This is difficult! This will take some time! The end result should be a set of statements (not questions!) that tell someone (anyone?) what the items are and how to use them. These statements must be agreed upon by **everyone in your group**.



1.3 Collaboration

Scientists rarely work alone. We often collaborate with other scientists. One of the most important reasons for this is to check up on each other. We make sure our collaborators don't overlook something simple that causes their (or our) observations to be incorrect. If we're observing a phenomenon for the first time, it's impossible to know whether our observations are correct or incorrect unless we check against other scientists' observations. As you might expect, one comparison is not enough; repeated comparisons are almost always needed. Take some time now to collaborate with other groups and come to a unanimous consensus on the set of statements you derived above. You may need to modify one or more of your own statements. Don't worry about the concepts of "right" or "wrong" because you have absolutely no way of knowing which you are at this point. The end result must be a set of statements upon which **every group** must agree.



——— CHECKPOINT ———

1.4 Now you have a framework!

The **set of statements you derived** constitutes a *framework* that, among other things, defines how you would teach someone else (from another class, for example) to use the items for their intended purpose. Frameworks let you do much more though. A framework may also be called a *paradigm* (pronounced to rhyme with "time"). We will continue to use *framework* in this course.

2 Accommodating People

2.1 Let's be fair and balanced.

1. If necessary, modify your framework so that it is as fair and balanced as possible.

2. If necessary, modify your framework so that it is as liberal as possible and does not offend someone who identifies as "liberal." If no changes are necessary, explicitly say so.

3. If necessary, modify your framework so that it is as conservative as possible and does not offend someone who identifies as "conservative." If no changes are necessary, explicitly say so.

CHECKPOINT

2.2 Frameworks let you make predictions.

4. Try to predict how to use the items if they are initially arranged or set up in a certain particular way. Comment on how well you can do this.

5. Swap data sets with another group and see if your framework correctly accommodates the other group's data set. If it does not, what must you do?

2.3 Prediction versus Discovery

6. Do you perceive a difference between a *prediction* and a *discovery*? If so, articulate it.

Your instructor will provide you with some materials and further instructions that will hopefully make the difference between a *prediction* and a *discovery* clearer to you.

2.4 Frameworks let you experiment.

Experiments are situations in which you have some degree of control over the environment in which the phenomenon takes place. Suppose you have a hunch, based on your framework, where some of the items may be placed relative to each other at the end of the setup you imagined in the previous question. Now, experiments must have predictable outcomes. Carry out your experiment by setting up a situation where your test can be carried out and observe what happens.

7. Did you observe the predicted outcome?

2.5 Frameworks don't limit us.

It's very important that you understand that a framework doesn't limit your imagination. For example, you could ask, "What would happen if some of the items were upside down?" You could also ask, "What would happen if some of the items were glued to the tabletop?" Are these questions addressed by your framework?

8. What constraints does your framework put on the questions you dream up about the materials you were given?

2.6 Frameworks limit us.

Scientists must be creative when attempting to explain natural phenomena. In fact, a creative scientist is more likely to find a correct explanation for a natural phenomenon than an unimaginative scientist. Scientists must also be rational. Just because you can imagine an explanation doesn't mean that explanation is possible or consistent with your framework. All explanations must be consistent with the framework within which the explanations lie.

9. Consider the question, "What would happen if you were to eat one of the items?" Although your framework doesn't prohibit you from asking this question, why should asking this question probably be avoided?

2.7 A Matter of Ethics

10. If you take someone else's invention, change the way it works, and start selling it as your own invention, can you give it the same name or should you change the name?

3 Inquiry

3.1 Discussion Questions

11. Was collaboration with other research groups beneficial or detrimental? Does avoiding collaboration have significant consequences? Defend your response.

12. Was modifying your framework beneficial or detrimental? Does not modifying it have significant consequences? Defend your response.

13. At any time during this activity, were you able to *prove* that your framework in its present form is correct?

STUDENT NOTE: Recall that once something is *proven*, it need never be investigated again because the outcome is certain to never change.

14. Reread this activity and replace every occurrence of the word *framework* with *theory*.

STUDENT NOTE: At this point you should thoroughly understand the problem with the word *theory*. When non-scientists use this word, they use it as a substitute for the word *hypothesis*. When scientists use this word, they use it as a synonym for the word *framework*.

15. In Nature, there are frameworks too. From where did Nature get the frameworks that govern natural phenomena? Did they not have to originate somewhere?

STUDENT NOTE: You won't get very far by tracing the origin of the frameworks. Don't ask, "Well from where did the instructor get the frameworks?" Don't ask, "From where the the person who gave them to the instructor get them?" This approach is futile! You'll end up in an infinite regression. "The frameworks have just always been there, they're there now, and they'll be there a hundred million years from now and that's just the way it is." is not the answer either. The answer is also not the same as that tracing the origin of all scientific information back to an attempt to explain an observation. Think carefully about frameworks in general. This is a difficult question, but not so difficult as to be unanswerable! The answer just may not be obvious to you.

What could be done to make this activity more interesting? Please be honest.