

Riddles as Metaphors: Illustrating the Role of Experimentation in Constructing a Scientific Theory

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Introduction

Science Defined

Consider the question “What is science?” Strangely, it’s hard to come up with a comprehensive definition – even for trained scientists (Williams, 2008)! It’s tempting to say that science is about “answers”, but what are the questions? One might say “Science is a systematic method of gathering knowledge” (such as suggested by MacMorris, 1989), but this leaves out the need for or quality of evidence to direct that system (that is, there have to be some rules about the system: are horoscopes not done “systematically”, at least to some extent?). It seemed like most participants of this mini-workshop at ABLE 2008 agreed that the concept of “science” can be slippery for these reasons.

To underscore how unfamiliar the nature of science is to the general population, I submit the controversy of including Intelligent Design (ID) in school curricula. At the time of this writing, the movie “Expelled: No Intelligence Allowed” (Frankowski *et al.*, 2008) had recently generated some discussion about what science *is* and what *it is not*. The movie attempts to paint “Big Science” (their term) as closed-minded towards scientists who subscribe to alternative beliefs, such as Intelligent Design as a theory of modern diversity. In the minds of its proponents, ID provides an alternative model to “Darwinism” (evolution through natural selection) to explain how life originated and became established on Earth. In the minds of many nonscientists, having alternative views is a necessary – even mandatory – position to take, saying it’s important to provide alternative views (as if this is a sports competition and we need to provide equal opportunity despite huge failings by one team).

The task we educators have is to relate in a meaningful way to the layperson how scientists apply disciplined thinking to try to understand the natural world. While it's perfectly acceptable to investigate alternative theories to explain a concept (for example, dealing with light as a particle or a wave), each path of investigation must be supported by a body of evidence, usually collected through experimentation. I'm tempted to bring up how particle physics and string theory are going head-to-head, but so far the latter isn't testable, and one might argue it therefore doesn't qualify as science! Alternative theories aren't "put into competition in a fair contest"; they have to have inherent merit as a medium for explanation. At no time should scientists claim to know "The Truth" about the world, but rather they should invoke a history of facts that can all be applied to a model of reality: a theory.

Carl Sagan once agreed with an (unfortunately anonymous) scientist who stated "I don't believe as a physicist that physics deals with the truth. I believe that it deals with successive approximations of the truth". (Sagan, 2006). Perhaps this is one of the most authentic ways to view science: as a way to gradually approach understanding all the nuances of the natural world while acknowledging that complete comprehension is impossible.

The Metaphor

We can only experience the world directly through our own senses, and our senses have been tuned through evolutionary pressures to allow us to make quick, efficient decisions. We therefore have to take pains to think in a disciplined manner. Seeing "prophetic phrases" in biblical texts appear to have predictive power (and are instead "postdictions", phrases that have coincidental meaning when one's mind tries to fit events in the past together as if there's a pattern). We are pattern seekers by nature – it's a survival instinct that served our primitive hunting ancestors well. Those patterns aren't necessarily causal, and so our reasoning is easily misled.

Science involves disciplined thinking. Often, we have to break down a complex system into smaller parts that can be studied and manipulated. The "parts" are often dealt with in experiments that propose a hypothetical explanation for causality in the natural world. Experimental results must be interpreted, and sometimes alternative interpretations are generated. Ambiguity between these interpretations can be addressed by further experimentation. The results of experiments are then used as components to a larger model of reality: a theory.

Riddles can be seen as having a similar composition. Each line of a riddle makes a suggestion, the answer for which is influenced by results from related lines. The final answer needs to accommodate *all* the lines, and thus is analogous to a theory – it is a model answer that relies upon work performed on multiple, simpler components.

The Exercise

Now we can use the metaphor as a demonstration. To a class of students, provide them with a riddle and solicit answers from them. For example, here's a Tolkien classic:

1. Alive without breath
As cold as death
Never thirsty
Always drinking
Dressed in armor
Never clinking

Students often come up with ideas like “rocks” or “a sponge”. I then point to each line, and ask them if each idea works. Starting with “wind”, we go through each line, and I'll put a check mark next to each if the students agree with a positive fit (Table 1). Note that interpreting the line is *encouraged*, just as we encourage interpretation of experimental results! I'll then do the same for all the other submissions (Table 2). The comparisons will stop if the class agrees that and one of the lines absolutely does not fit (such as if someone suggested “a rock” – it would take some liberal interpretation of being alive to include stones, although the phrase “the living rock” could be argued as evidence to include it. You'd then have to describe how they “drink”).

Table 1: A stanza-by-stanza interpretation of riddle #1 using “wind” as the answer.

Alive without breath	- Yes, wind can be lively. Some might be troubled by “without breath – wind is very much like breath to many authors!
As cold as death	- A North Wind can be considered quite cool, so sure!
Never thirsty	- Not having a nervous system or brain, we could say this also fits “wind”.
Always drinking	- Wind can dry up a puddle, thus “drinking” is permissible.
Dressed in armor	- It's hard to accept wind having armor. Perhaps wind blowing sleet fits (so, yes, with generous interpretation).
Never clinking	- A soft wind would be quiet, but a strong wind usually makes noise, particularly if it's hitting branches or chimes. This one can fit, but has to be worked at.

Table 2: A stanza-by-stanza interpretation of riddle #1 using “a sponge” as the answer.

Alive without breath	- From a biological standpoint, sponges are certainly alive.
As cold as death	- Although one might argue that they’re probably not very cold in the tropics, they’re not endothermic, and a live sponge and dead sponge probably don’t differ in temperature all that much.
Never thirsty	- Not having a brain, this works just like “wind” did.
Always drinking	- It constantly filters water, so this is a great fit!
Dressed in armor	- Well, some students might be familiar with living sponges, so they could agree the spicules give it some protection. Other students might be thinking of the collagen remains of processed sponges and argue that this doesn’t fit. You might have to mark it as tentative.
Never clinking	- Biological sponges don’t make sound, so this works!

In my experience, it takes a while for Tolkien’s answer to come out: “a fish”. Try it for yourself, and see if it’s better or worse than the other two example answers I proposed! Note that for “fish” to work, you have to be generous with the interpretation of “without breath” (they *do* consume oxygen) and armor (scales).

Table 3 provides some other opportunities for class. You can find many, many more online! Answers are provided in a later section of this paper.

Table 3: A stanza-by-stanza interpretation of a Tolkien riddle using “wind” as the answer.

<p>2. Pronounced as one letter, And written with three, Two letters there are, And two only in me. I’m double, I’m single, I’m black, blue, and gray, I’m read from both ends, And the same either way. What am I?</p>	<p>3. I am one simple word, but I mean different things One of my meanings brings great forceful swings. The other of me may have a curve, like the first But only one meaning can help quench a thirst. One of my meanings will often bring cheers, Either of them could hold a few beers.</p>
<p>4. A box without hinges, key, or lid, Yet a golden treasure inside is hid.</p>	<p>5. They follow and lead, and flee the light Without the sun, there would be none.</p>

Now let’s take a look at a couple riddles that often elicit alternative “right” answers.

6. Dies half its life
Lives the rest
Dances without music
Breathes without breath

This riddle often stirs students to answer “radioactivity”. As science students, they see “half life” and interpret it according to their past experiences, realizing it’s compatible with a radioactive element. The loss of activity can be equated to dying, and the dancing and breathing often equated

to radioactive emissions. Tolkien gave this the answer of “trees”, but this actually requires quite some interpretation – the trees don’t actually die half their life! The loss of leaves and quiescent lifestyle can be interpreted as a form of death, though. The dancing of leaves in the wind and act of oxygen release through photosynthesis seem to satisfy the audience most of the time. The take home message I try to leave my students with is that we’ve got two solutions that are imperfect, but (in my opinion, anyway) fit the clues or experiments equally well. How would you discriminate between them? Write more lines of poetry (do more experiments) that would include one and exclude the other!

Here’s a final exercise that I created from two different riddles by altering the original wording. My alterations are spelled out in the SOLUTIONS section at the end of this paper.

7. It cannot be seen
Cannot be felt
Cannot be heard
Cannot be smelt
It lies behind stars
Can cover hills
And empty holes it fills.

With a little time, students often come up with “nothing” and “darkness”. Once again, you’d have to be clear with your assumptions. Darkness covers hills only at night and darkness is banished if the hole is illuminated! Likewise, there are other stars behind most stars you look behind, so “nothing” isn’t a perfect fit, and oxygen is certainly a “something”, requiring interpretation of what it is that covers hills and fills holes. Students will probably be satisfied there’s no clear winner there.

Let’s add more poetry: we’ll perform experiments and the results give us the following that is *added* to the earlier riddle:

- It is better than the best
More evil than demons
The poor have it and the rich need it,
And if you eat it, you will die?

Now it’s not possible to use “darkness” as the solution – we’ve identified the best answer (theory) that accommodates the experimental evidence we’ve accumulated. That’s the way science works and why it won’t ever be completed. We can always add more evidence. In many cases, that extra work is consistent with the existing stanzas (previous experimentation), not altering our answer. However, the extra poetry on occasion will open new avenues. The creativity of scientists becomes their most valuable tool.

Note also that this exercise shows another facet of science. We can look at old work and reinterpret its meaning in new light. Disagreement between clever, disciplined minds is an asset, allowing valuable new avenues to creatively explore! I included in the next section a bonus riddle that has multiple “correct” solutions. I use it to tease my children (when they choose one answer, I’ll tell them they’re wrong and give an alternate. Hours of fun... for me, anyway!).

SOLUTIONS

1. “a fish” (Tolkien, 1937).
2. “I or eye” (*Puzzles and Riddles*, 2008).
3. “a pitcher” (baseball player, or vessel holding fluid) (*Braingle*, n.d.).
4. “the wind” (Tolkien, 1937).
5. “shadows” (*Debris*, 2007).
6. “trees” (official answer) or “radioactivity” (often submitted in class by students) (*WebRiddles.com*, n.d.).
7. These two parts come from two riddles from the same site (*Down the Rabbit Hole*, 2005). The first was modified to change the original “and under hills” to “can cover hills”. Its answer is “darkness”. The second is unambiguous for the answer “nothing”, which also fits the first riddle (which is why I changed it to “can cover hills” so that both answers fit). I also changed the traditional “What is better than the best” to “It is better than the best” for continuity. How’s that for full disclosure?
8. *Bonus riddle: (not shown above)*. “What’s black and white and red all over?”. The ambiguous answers can be “a newspaper”, “a zebra with a sunburn”, or “a skunk in a blender”. This is an example where you can challenge your class to “write more lines” to find out “the Truth”.

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