SACRED BOVINES

IS AN APPLE LIVING?

DOUGLAS ALLCHIN, DEPARTMENTAL EDITOR

It's a simple enough question, it seems: *Is an apple living?* First, define "life." Then apply the definition. Finally, arrive at a *definitive* answer. Isn't that clarity one of the great virtues of scientific knowledge?

But seasoned biologists know well that "life" is not easily defined. Like other scientific concepts, a single, apparently simple term hides substantial complexity. Others may realize that too, with just a little bit of reflection. For example, imagine using the question about apples to open the first day of a biology class and to spark a lively independent discussion among students:

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The answer is obvious. If an apple has been picked from the tree, it's no longer living.

Yes, I agree the answer is simple and obvious [another student weighs in]. *But you are wrong. Another apple tree might grow from it. So it's clearly living.*

Well, yes, the seeds may be living, but not the whole apple.

So, then, the fruit was not living when it was still on the tree?

No, I didn't say that. When it's on the tree, the fruit grows. When it falls off, it no longer has a source of nourishment. It can't survive without nourishment.

True [adds someone else]. *But it does continue to ripen. That shows that it's still active.*

Until someone eats it! Then it's dead! [Laughter.]

Or it begins to rot. Dead things rot.

Hey, not all of it rots. What about the seed? That is the link to the next generation. Where do you think apple trees come from? An apple can reproduce. That makes it living.

But a seed isn't active. It isn't growing. Can you really call it living before it sprouts?

Yes, unless you think you can create life out of something non-living.

Okay, so maybe the seed is living. But that doesn't mean that the whole apple is living. The fruit gets eaten by animals. It doesn't contribute to the new plant.

Not all of the seed contributes to the new plant either. Most of the seed is nourishment. You know, like the beans we planted in school when we were kids.

So maybe we can't even call the seed living—only the embryo inside it. Does the whole thing have to be living for you to call it alive?

I don't know. Wounded soldiers used to get gangrene. That's when a part of the body dies and starts decaying. But we don't call the whole body dead. The person is still living. So the non-living parts don't count. Like the fruit of the apple.

Can't we just look this up in a book somewhere? What does the text say? Let's google it.

Wait a minute. Sure, the apple tree is living. And the seed—or maybe the embryo—is the young living version of a new tree. But it makes no sense to ask if the apple is living. It's not an organism. It doesn't reproduce. It's just an apple.

Yeah. Like human hair. Hair grows. But it's not living.

It's not?

Naw. You don't feel it when it's cut, do you?

What about fingernails?

I heard fingernails keep growing even after you die. Creepy. Is that a sign that something's still living?

I'm confused. Doesn't something have to be, like, a plant or an animal to be living?

Well, of course. Just like I said earlier: when an apple comes off the tree, it's no longer part of the organism. It would be like severing an arm off a human. The arm by itself isn't alive.

That's gross.

But what if they can reattach them? I know this is gruesome, but do you remember that boy who lost his arms in a harvesting machine and the incredible surgery where they sewed them back on again? [Majeski, 1992]

Yeah, just like organs that get transplanted. Like my uncle's kidney replacement. Or livers or hearts, y'know? They're living. So maybe the apple is, too.

The organs are living. But they're not alive! C'mon, get real.

Give me a break. What do you mean, "living, but not alive"?

Hold on. It's perfectly possible for something to be living and not be an organism. My aunt works in a tissue culture facility. They grow cells in Petri dishes. They use them for skin grafts on patients with really bad burns. The cells grow. They reproduce. But they're not organisms, are they? Maybe an apple is like cells growing in the lab.

Is the apple fruit made of cells?

What's a cell? What are you talking about?

This question is really complex. I can't decide if the apple is living or not.

Excuse me. What's a cell?

You're right. I thought I knew what life was. Now I'm not so sure.

Can someone please tell me what a cell is?

Do we have to decide between living and non-living? Maybe the apple is partly both.

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That's ridiculous. It's can't be both. You're either living or you're not.

Who's to say? What is life, anyway? [All attention shifts back expectantly to the teacher.]

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What is life, indeed? What seems obvious at first, may not be. And that very awareness may be the core lesson here. A word—a concept—that is so familiar and apparently clear, when considered more fully, exhibits remarkable complexity. *The plain and simple may not be so plain and simple*. That realization is itself worthy of deep reflection, an occasion to pause and learn something significant about the nature of science.

Consider the moment when the inevitable comment arises: *OK, so we've had our discussion. Are you going to tell us the* real *answer now?* This question reflects a deep-seated assumption—this month's Sacred Bovine—that science *does* offer definitive answers to such "plain and simple" questions. For many people, the security of simplicity is what science and its authority are all about.

How fortunate, perhaps, that such a "plain and simple" question can also be engaging and, when posed to a group, elicit diverse background knowledge as relevant and allow multiple perspectives to be heard. Other examples that can tease open the complexity behind a definition of "living" versus "non-living" (even beyond those mentioned in the discussion above) are readily at hand: a bouquet of freshly cut flowers; dehydrated brine shrimp (the so called Sea-Monkeys®) and "water bears" (tardigrades—see Boothby et al., 2017, and St. Fleur, 2017) or other cases of cryptobiosis; viruses and prions; and even fossils or bones (they may not be alive now, but how can we be confident that they once were?). Veteran biology teachers will note how, exploring these examples, even "uninformed" introductory students can draw on intuitive concepts about life that are typically found profiled in the first chapter of many biology textbooks. The apple question discussion thus ultimately conveys what it is a standard first-day lesson while also, when properly framed, opening a deeper understanding of the nature of scientific knowledge.

What a powerful way to open the school year: to surprise students with the complexity hidden behind a commonly accepted notion, to open their minds to questioning, and to convey that the study of science is a gateway to such wonders.

Of course, such lessons about the complexity of scientific knowledge are not limited to the topic of defining life. Biological science is forever revealing unsuspected intricacies and apparent contradictions of nature. The moment we establish a "law" of nature, we seem to find exceptions. From Mendel's laws, we proceed next to *non-Mendelian* inheritance (Allchin, 2000). From the principles of natural selection in evolution, we shift to non-adaptive vestigial structures that provide evidence of history. From the presumed strict dichotomy of male and female, we delve into hermaphrodites, chromosomal hybrids, transgender identities, and other intersexual patterns (*Sacred Bovines*, Aug. 2006). From assumptions about "normal" development, we develop an appreciation of "monsters" (*Sacred Bovines*, Nov. 2007, Feb. 2008). From everyday notions about genes and species, we encounter problematic positions about genetically modified organisms (*Sacred Bovines*, Nov. 2014).

Such lessons about complexity have practical implications in the contexts of scientific literacy and decisions on current social issues. Complexity in concepts of life, for example, are relevant to the status of *in vitro* embryos; to decisions about death and dying; to abortion; to the legal status of tissue cultures; to patent applications. Complexity in the "biological" definitions of male and female could well inform ongoing and contentious debates about the status of transgender individuals and what the very term "transgender" means. Similarly, understanding that ecology and the science of climate change are not simple is foundational to addressing environmental policy in an informed way. Even the very expectation that scientific claims *should* be simply black and white shapes how people view appeals to science in matters of personal choice and public policy. When politicians and pundits bombard us with claims that appeal to the "plain facts"—as determined by and thus apparently justified by science—one should be wary. Many scientific issues and evidence-based conclusions are rarely as simple as advocates and ideologues would have us believe. To prepare students for a world of complex science, we need to first *teach* about that complexity.

Contrary to common understandings, science is not always about "plain and simple" facts. Biology, in particular, resounds with complexity. What better lesson might one offer on the first day of a biology class—to teach *about* science and to promote *the value of asking questions as a part of* science?

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