Degrading Dialogue
(Achilles & The Tortoise)

(The characters Achilles and the Tortoise are taken from Douglas Hofstadter's Goedel, Escher, Back: an Eternal Golden Braid.)

Achilles (a Greek warrior, fleetest of foot of all mortals)
comes across a Tortoise in a forest. The Tortoise is
smashing a plastic box with a hammer.

Achilles: Good afternoon, Tortoise. What on earth are you doing?

Tortoise: I am finished with this plastic packaging, so I am returning it to the earth.

Achilles: But all you are doing is hitting it with a hammer.

Tortoise: Actually, if you must know, I am degrading it.

Achilles: Degrading it? Well, hitting something with a hammer *is* rather insulting…

Tortoise: No, no. It just means that I'm breaking it down. You've heard of things being "biodegradable," right?

Achilles: Yes…

Tortoise: Well, biodegrading is just one *kind* of degrading, you know. Things can degrade in different ways. I am choosing to degrade this plastic… (heaves the hammer over his head, and brings it down one more time on the box)… in *this* way.

Achilles: Now wait, but that's hardly the same thing.

Tortoise: Why? I mean, suppose I break it down small enough…

Achilles: You'll never do it with a hammer.

Tortoise: Well, I could use a grinder of some sort.

Achilles: That wouldn't… look. You know what plastic *is*, right? It is made up of these big long molecules called polymers. Even if you use the hammer to separate it into little chunks, it's still made of these big long polymer molecules.

Tortoise: Aha, well now I've got you! I happen to know that there are things you can add to the plastic, that can break those polymer molecules!

Achilles: Something you can add *now*?

Tortoise: No, no. You have to add it when you are making the plastic. But work with me for a moment, ok?

Achilles: OK.

Tortoise: So when they make this plastic box, they can add things that make it sensitive to natural things in the environment. Like light. Leave it out in the sun, and the sun will actually act like scissors, snipping those long molecules into shorter bits. This makes the plastic very brittle, and eventually it will just fall apart on its own. That is called photodegradation. It's another kind of degradation.

Achilles: You wouldn't even have to hit it with a hammer?

Tortoise: No! Eventually, it would just crumble away naturally with erosion. You can also add things to the plastic so that water will do the same thing: scissor the molecules so that the plastic becomes brittle. That's called hydrolytic degradation. And, you can add chemicals to the plastic so that it will react with oxygen to become brittle. And that is called…

Achilles: Oxydolic-degradation?

Tortoise: Close. Oxidative degradation.

Achilles: But so what? It is brittle and it crumbles. And in the end you get plastic dust. Plastic powder. But it still isn't dirt. It's plastic sand.

Tortoise: So what? Same difference.

Achilles: It is *not* the same!

Tortoise: Why? When you are walking on the beach and stepping in a fine powdered sand, who cares if it is itsy-bitsy pieces of rock or itsy-bitsy pieces of plastic? Sand is sand. It's part of the earth. It's…

Achilles: Don't say it!

Tortoise: … it's natural!

Achilles: It is not natural. It's still plastic, no matter how small the pieces.

Tortoise: Why does it make a difference?

Achilles: Well, for one thing, it doesn't just end up on the beaches for you to walk on. It ends up building up in the oceans. I read somewhere[1] that marine animals eat these microscopic bits of plastic, and you can see it building up in their digestive systems.

Tortoise: Well, is it toxic?

Achilles: As far as we know, it's not toxic…

Tortoise: Aha!

Achilles: …but it can attract toxic materials. There was a study[2] that showed that degraded plastic residues can attract and hold toxins like PCB and DDT up to one million times normal levels. The PCB's and DDT's are already in the environment, but are usually so diluted that they are not a significant risk. However, plastic residues concentrate these chemicals, until they can build up to toxic levels.

Tortoise: OK, fine. But tell me how biodegradation is any different. Doesn't "biodegradable" just mean that something is broken into teeny-tiny bits by microbes and fungus and stuff, instead of by light or water?

Achilles: Well, no. When something biodegrades, the molecules are converted into a form that can actually be used by the cells of living organisms.

Tortoise: (blank stare) I don't know what that means.

Achilles: OK, let's start at the beginning again, then. These polymers I told you about, these long molecules?

Tortoise: Yes?

Achilles: They are long chains that are made up of carbon atoms. Cells *like* carbon atoms. They use carbon atoms to make energy.

Tortoise: Really? How?

Achilles: There is a biochemical process involving the participation of three metabolically interrelated processes… look, it's all very complicated, I'll lend you something to read[3] about it some time.

Tortoise: Ok.

Achilles: Anyway, when the carbon atoms are in the long chain, they can't get inside the cells to be used for energy. Even when the polymers are broken down very short, they have to be in a particular form that can be brought inside the cells so that the cells can use them. When something is broken down into small pieces by biodegradation, it always is able to pass into the cells of the organism to get used. When something is broken down into small pieces by other types of degradation… who knows? The cells might be able to use it, they might not.

Tortoise: So you are saying, these other ways of degrading plastic *might* be the same as biodegradation, we just aren't sure…

Achilles: I'm saying that these other ways of degrading plastic might be the same as biodegradation under some circumstances, depending on the plastic and depending on the method, but even *that* we don't know for sure yet. It's a big question-mark.

Tortoise: If I just make sure that I hit the plastic really *hard* with the hammer…

Achilles: No! It's not enough. Whether the cells can get the carbon from the molecule depends on the chemical structure of the original polymer, not just on how small the pieces are. That's why it's better to use plastic that is made from plants instead of oil, because the chemical structure of those polymers is much easier for cells to work with.

Tortoise: So if the plastic is made from plant polymers, and then I hit it with the hammer…

Achilles: Hitting it with a hammer can help make biodegradation faster. But it doesn't biodegrade until the organisms actually use their own enzymes and stuff to break down the polymer so that the cells can use the carbon. That is biodegradation.

Tortoise: And anything that breaks down polymers in a way where the pieces *can't* be used by living cells?

Achilles: Anything that does that is not biodegradation. Which means it can build up inside organisms and attract toxins and who knows what else.

Tortoise: So the moral of the story is…

Achilles: The moral of the story is, biodegradation really matters, not just degradation!

Tortoise: … and hitting things with hammers always helps!

Achilles: (rolls his eyes)

NOTES:

1) Ramani Narayan, "Biodegradability…" *Bioplastics Magazine*, Jan. 2009. Narayan is a professor from the Department of Chemical Engineering and Materials Science at Michigan State University.

2) www.algalita.org/pelagic_plastic.html

3) Ramani Narayan, "Biodegradability…" *Bioplastics Magazine*, Jan. 2009. Narayan is a professor from the Department of Chemical Engineering and Materials Science at Michigan State University.

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