Well, I got to show you this spider because-- and if you're interested, Professor Bueller does some wonderful work on spider silk-- because I think this is a great example of something that nature can do that gives us a sense of how far away we are.

Like I said, we're very proud of this, and we want to do more.

And so we take our two mers, and we mix them together, and we make branches, and maybe we're going to try to add a third.

Meanwhile, nature has had a lot more flexibility and a lot more time.

What can it do?

Well, here's spider silk.

Now, this is a spider.

Spider is an incredible polymer synthesis machine.

It's an incredible polymer synthesis machine.

And here it is weaving a web, and I love this-- [MUSIC PLAYING]

--because I think it's so cool.

OK, there's music, I guess.

I forgot about that, and there it is.

Now watch.

Out of here, this is the back of the spider.

There it is right there.

It's making protein.

That's called spider silk, but these are proteins.

These are polymers.

It is doing condensation polymerization right there, and then there's all sorts of structural stuff that it does.

Right?

It's got a specialized hook.

It knows how to step.

It creates-- look at that.

There's a branch place where it knows to put it.

Right?

It's already created the glue.

So not only is it putting this spider silk out there, but it can put other types of polymer depending on what it needs.

Does it need something really sticky, less sticky?

Right?

And so there it is weaving its web, and it's generating this polymer on the fly.

It's doing condensation polymerization.

Now a couple properties about spider silk.

OK, so here we go.

Let's see.

So spider silk, this is just one example of what nature can do.

It's five times stronger than steel.

Remember the mechanical strength chart, nothing was stronger than steel.

Spider silk is five times stronger.

Just to give you sense, the example, I found that I like.

If you had a spider silk that was a pencil width, and you made a strand, it would stop a Boeing 747 in midair.

That's how strong it is.

Oh, it keeps strength-- here's another thing-- below 40 degrees C. We can't do that.

Just take a rubber ball and put it at that low of a temperature and try to bounce it.

It's going to shatter.

Right?

Spider silk can keep that strength and not break.

Its elastic, so it's got-- throughout all of this, it's got an elastic property of 4x, so it can be stretched to four times its original strength.

Compare that with nitrile.

Nitrile rubber could also go to very, very high elastic elongation.

All right?

So if you go back to nitrile-- here it is in the table.

We're very happy with this, but this only had two monomers to play with.

Right?

We played with two monomers, and we got to here, and look at the sacrifice in the strength.

Look at how much we had to sacrifice strength.

Spiders don't have to do that.

Here's the last one.

Fully recycles-- now the thing is that this is actually kind of incredible.

Spider webs get dusty.

They lose their stickiness.

So many spiders know this and just simply have to weave a new web every day, but they don't leave the old web there.

They actually eat it, and they fully recycle it, fully.

Right?

They eat the web, fully recycle it, process it, have this condensation polymerization work, and make a new one the next day.

All right?

So we don't come close to this spider.

We don't even come anywhere near it in terms of where we are.

Even though I gave you all these wonderful things that we're doing with engineering, we still have so far that we could go if we could just figure out how nature works.

OK?

And this gets me to what we do, and so I've got my "why this matters" now.

And so a spider eats its web, fully recycles it, spins a new web the next day.

Here's what we do with our polymers.

I already talked about the oceans.

Here's what we do on land.

These are tires.

Now, tires are very difficult to recycle.

Why?

Because they're too vulcanized.

They've got too much cross-link.

Remember, if the cross-link density is too strong, which you need to make a tire, then you can't recycle it.

And in fact, what happens is-- and there's a tire mound.

Here's it is from a satellite picture.

Those are tires.

Those are tire mounds.

Here's what happens when one catches fire.

Here's what happens when many catch fire.

All right?

It's actually a very hard fire to control once they catch.

But we don't really know how to recycle them well yet.

What can we do?

On the science and engineering side, the fact of the matter is there is a lot of work to do, but there are promising directions.

So I wanted to leave you with a little bit of that, and I'm not going to go into great detail.

I just want to show you, and there's references here you can look.

This was published a couple of years ago in Nature.

One direction is in self-healing polymers.

This is a very exciting direction.

What can we do?

Well, we can go away from this whole single-use idea and make stuff last longer.

All right?

So that would be beneficial.

Maybe not if it ends up in the ocean, but in terms of just how long we can use these materials.

So one direction is, well, you've got these polymer networks, and you incorporate little gels, little beads in here, but the beads don't open up until a crack comes along.

So they're sensitive to a crack.

And when they feel a crack in the material, they open up, and they pour a healing liquid that then solidifies.

That's a self-healing kind of approach.

You could do that at different scales, all the way down to the strand.

You can do that on larger scales.

And here's a whole system where there's actually this healing material being flowed through a polymer structure, just like arteries in our body.

Again, always there to try to heal the material.

Right?

Another direction is in fully recovering.

And again, I don't want to go into full detail here.

You can look up some of this stuff.

This was published last year.

Can we take the polymer and chemically decompose it all the way back to the monomer?

Can we go back to where we started?

Can we do what the spider does?

Right?

The answer is no, not today.

But if we could, that would open up a whole lot of doors for recycling that are closed today.

Can we do this in a way that is efficient?

Right?

And then, another direction of work that I think is very important is in making thermosets so heavily cross-linked so you get all the hardness and all the properties you need of the polymer that's heavily cross-linked, but easily breakable in the cross link.

And there is good work going on in this direction.

Can we make degradable thermosets?

That's another really important direction.

And last, we should be encouraging people, if you can't do any of this, at least take the polymer out of the landfill and make something with it.

And there are projects-- you can look at here, Waste Management Journal, in making bricks out of polymers, incorporating them into construction materials.

Right?

These are important directions, and we need a lot more hopefully in the very near term.