This is a great time for me to tell you about my why this matters.

And, of course, the sp2 carbon atom matters because of drinking water, of course.

And, you know, this is a well-- in a district in India where more than 50% of the wells exceed the WHO limits for arsenic by around a factor of 5.

1.8 billion people in the world drink fecally contaminated water on a daily basis.

600 million people boil their water in the world.

Boiling doesn't help with arsenic, though, arsenic just stays in the boiled water.

It kills bacteria, but it doesn't help with toxic-- toxic elements.

If you look at the world as a whole, and you look at sort of where there are water-- water crisis, where the water crisis is at this level, it's a little over 3 and 1/2 billion people.

And in those countries, almost 185 or so countries, where this is a serious problem, if you look at the cost of disease, and the cause of death in those countries, 70% to 80% of all disease and almost 30% of all death can be attributed to the water quality.

Right.

So when I talk about water as a problem, I really mean it's a serious problem.

It's a problem of life or death.

Now, this is-- to get fresh drinking water, if you look at the planet, and you say, well, where is the water on this planet?

Where is the water on this planet?

I like this picture because we consume water volumetrically, not in an area, right?

We use water as a volume, and this is the water we have on this precious planet as a volume.

This bubble here is all of the ocean water.

It's about 70-- it's about 97% of all the water.

That bubble there is freshwater that is inaccessible.

It's frozen.

And this one here, you can't really see it, there is another dot there.

That's less than 1% of the world's water.

That is our drinking water ecosystem that is what we are destroying.

And-- so what-- OK.

So there's a lot of things we can try to do about this.

One of the things we can try to do is to see if we can tap into this in a way that's more affordable and more efficient.

Because there's a lot of water here, right, and use that.

But the problem is, if you look at the cost of desalination today as opposed to the cost-- that's desalination.

If you look at the cost as opposed to just digging water out of a well, like the one I just showed you in India, it's over a factor of 10.

Still.

And, in fact, one of the big issues with desalination isn't just the total cost or the operating costs, but the capital cost.

How do you build this plant in the first place?

And so it takes too much money.

If you look at the thing that's at the heart of desalination, it's a filter, right.

It's a filter.

And I talked about this in my last, why this matters, when I talk about separations, and I promised that in my next why does this matter, I'd talk about water.

Right.

Which is what I'm doing.

If you look at a desal plant, this is one of the world's largest, this is a plant called the Hadera plant in Israel, and you look at what their costs are that-- remember, the costs digits-- half of that cost-- almost half of the cost isn't just energy.

And almost all of that energy is in pushing salt water through a filter.

Through a membrane.

That's called a reverse osmosis membrane, because you're going against the osmotic pressure.

And if you look at the membrane itself-- this is a picture of it, it's actually a very small layer on top of this active layer that does all the work-- it's not a very good design.

In fact, membranes for desalination are pretty bad.

Right.

They kind of do everything worse than they should, except that they work, which is good, and they're cheap, $1.00 a square foot.

But, see, they're very-- they take much more energy than you need.

They foul up very easily.

And then that means stuff gets kind of, you know, stuck in them.

And then you can't take it-- you can't clean them because these polyamide membranes, which are the same polymer used in these membranes for 50 years, haven't changed, the material.

Those polyamide membranes are destroyed by chlorine.

So even in a desal plant-- in a desal plant, if you have drinking water in your feed stream, drinking water has six parts per million chlorine.

That's not much.

They still will go through the cost to remove it.

They will remove it from the feed.

Why?

Because if you leave that little amount of chlorine in the feed, these membranes get destroyed.

By the way, there's 40,000 of these membranes in this plant.

Each one is 2 meters long and 40 square meters of area.

So-- so these are so delicate that you can't really clean them well.

And that's part of what the cost of a plant involves.

That's part of what the cost of a plant involves.

Now, this would be like a plant, right, you have sea water coming in and, you know-- and then you've got your membrane module that's taking the salt out of the water.

And then the product water.

But because this filter is so delicate-- there's the picture-- because that filter is so delicate, you actually have to add a whole lot more to the plant.

So much of a desal plant is built around essentially protecting this membrane.

So that's cost.

That's cost.

Right.

A better membrane could change this.

But like I said, the membrane-- oh, there it is.

You can't Snapchat on that.

Snapchat?

What is it that people do today?

Not Snapchat.

Yeah, Snapchat.

Yeah.

OK.

Thank you.

You can't Snapchat on that.

That's what I meant.

I know it's not My Space, but I don't know-- but, anyway, this is like even-- you know, when I look at-- at membranes today as a material scientist and materials chemists, all of your membranes, I think, that's what it looks like.

Why?

Doesn't have to be the case.

We can do so much better.

And so-- OK.

Energy costs goes into pretreatment, secondary treatment, and this is where this comes back.

This beautiful material that we have now understood more than we did before.

Because, remember, before I showed you graphene and I showed you-- no, I showed you benzene.

And we talked about it as a Lewis resonant structure, remember?

Right.

A Lewis resonant structure to help explain how it looked.

You know, gra-- graphene does not have alternating bonds.

Remember, that's what we talked about before.

It's a Lewis resonant structure.

So it lowers its energy by having two sets of structures that have sort of alternating bonds.

We talked about it in the context of benzene.

But, see, now you know so much more.

You know so much more.

Because, now, you know why graphene is so special.

You know why graphene is so special.

It actually is the hybridization.

It's the hybridization.

Because on top, and on the bottom, of a single atom of a single sheet of graphene, you've got pi bonding all the way.

Those pi bands are going across the whole surface.

And those electrons are critical.

Those electrons that occupy those [INAUDIBLE]

are critical to the very special properties that graphene has.

So you now know the secret.

It's sp2 hybridization.

And, you know, this has allowed us-- this has-- you might tell I'm kind of passionate about this problem.

Partly impassioned passion about a lot of problems but, also, we happen to work on this, and we have been developing this.

This is like the ultimate membrane.

I can soak this in chlorine overnight.

I can put it in negative pH solutions.

I can heat it up.

It doesn't degrade.

And we have figured out how to poke holes in it at just the right size, or to stitch it together so that maybe you can filter particles by the flow in between these sheets.

Right.

And this material, as a membrane, is so promising that we've actually started to commercialize it as of the last year.

And I think this is really going to make a big difference in a lot of areas.

Why?

Because of sp2 hybridization.

That is why.

That is why this is such a special material.

OK.

That's my why this matters.