And this gets me now to our last why this matters, and I'm doing it on the backdrop of this beautiful periodic table.

So that's a lot of energy, by the way.

First you had to make these iron pipes, and now you've got to case-harden them or maybe you've got to put even more iron in.

Look at the other 900 C is really hot.

How much energy do we take to make stuff as simple as concrete?

It's just liquid stone.

Didn't you just grind some stones down or something and then pour it out?

Actually, if you think about concrete and other materials like steel, the use of them is skyrocketing.

This is how much we're making.

So look at this, the millions of tons.

Let's see.

There's steel, and there's cement.

Look at that.

There's the world population right there, and this runs out in 2009, 2010, '11, but it's continuing.

It's continuing because it's not just that the population is growing, it's that the places that the population is growing the most are also industrializing.

And that means building.

You go to some of these places and there's a new building.

Literally every block, there's a new building being built.

That takes this stuff.

That takes a lot of ovens at a lot of really high temperatures.

Just the cement alone is accounting for 7% of all CO_2 emissions, all CO_2 emissions on the planet, 7% of that goes into simply making this magic liquid stone, this powder.

And at the core of it, what is at the core of it?

It's chemistry.

It's clinker.

It's called the clinker.

What is a clinker?

It's this thing.

It's simply a calcium silicate group.

Making that is what takes all this energy.

It takes half of it at least, making that right.

And as always, the chemistry gives us the chance to get out of our constrained optimization.

And so you've got to make this mixture of different types of synthetic rock.

You've got to make mixtures of alite and belite.

They have different names.

And you might be able to make more belite, which takes less energy.

You can cool your oven down by 300 C to make belite compared to alite.

But then even though it's structurally OK, it takes 90 days to dry.

So you can't do that.

So you've got to spend the 300 extra Celsius to make more alite.

Why It's in the chemistry.

It's in the chemistry.

And understanding, what seems like not a very interesting-- cement, is it really that interesting?

You bet it is.

7% of all CO_2 emissions is just making this one material, and we're making a lot of it.

We're making a lot of it.

There's a 164 tower in Dubai that opened in 2010 that took a billion kilograms of this stuff.

Now, this makes a lot of CO_2, and I've talked about CO_2 throughout the semester.

And so one thing I wanted to leave you with was also some things that we're doing about it.

What do we do about CO_2?

So how is carbon capture and sequestration going?

Can we take it all out?

We put it in, can we take it out?

And so I'll share a couple of things.

So one of the problems with CO_2 capture is that if you don't do it right where you make it, then you have to transport it, and it turns out that's actually really hard to transport CO_2.

And there's a lot of problems that have happened over the years.

In the '80s, there was a leak that killed thousands of people.

There have been massive leaks in Canada in transporting this material.

So transporting is actually really hard to do.

There's metal pipe corrosion.

This is a great chemistry problem unsolved.

And then the next part of CO_2 sequestration is one is transporting it that's challenging, and the other is storing it.

What do you do with it?

Let's suppose we could capture it.

Well, then what?

And there's ideas around this.

So you could pump it maybe underground, geosequestration.

That's not a sure thing.

We don't know, we don't understand at those scales exactly how well we can in case this material and how long it lasts, so a lot of questions with that.

There's a whole line of thinking on putting it in the ocean.

Right?

Really?

So you want to fix the CO_2 problem by acidifying the oceans even faster?

OK.

Interesting.

So transport and sequestration is a big problem, but what about technologies where you simply sequester it right there where you make it, like clean coal.

You may have heard of clean coal, so clean coal.

So I'm going to look at a case study of a clean coal project in the US.

In 2005, I got really excited because eight companies joined, and it was called Future Gen, and the US government was going to put a lot of money into it.

They were going to capture 90% of the CO_2.

You get a little bit less efficiency.

Depending on how you think about it, it could be 30% less efficiency, I mean, less power out of the plant, but you sequester the CO_2.

And in 2009, construction was planned in Illinois.

In 2010, it was canceled.

In 2010, it was restarted.

In 2012, there was all sorts of discussions with the DOE that agreed to pay $1.1 billion.

It was all located, and then the companies dropped out and the DOE canceled projects.

So that was 10 years.

10 years and $200 million of taxpayer dollars and absolutely nothing has come out of it.

So one of the things I want to point out about this direction, I'm not saying that it's not a good direction to keep pursuing.

But the timescales are long.

So we need to be able to make decisions that can cover longer timescales.

That's a huge part of the challenge with this.

It's a policy challenge as much as it is a technical one.

And tying this back to the cement, there is some really interesting research that's going on in actually instead of-- OK, so you've got the CO_2.

It comes out when you make it because the ovens and you're burning stuff, but what if you could take that CO_2 and just put it into the thing you're making.

And by the way, if what you're making is a huge scale like cement, then maybe you can put a lot of it in, and maybe that could have a real global impact.

So there's a lot of interest in substantial global carbon uptake by cement carbonation.

So maybe you could get some of it in the cement.

I like this paper.

I'm pointing it out because they say that they used Fick's diffusion law.

They modeled the carbon uptake by applying Fick's diffusion law.

Yeah.

It actually matters.

Right?

You can do this too now.

And just a few weeks ago on CNN, this concrete, yes, concrete is going high tech.

Why?

Because this company has managed to figure out how to put a bunch of CO_2 into the concrete while they make it, and it doesn't change the mechanical integrity of the concrete.

And it's in there.

It's actually in there.

This is all chemistry.

This is all chemistry.

So this is, I think, another very interesting direction where technology can play a vital role in this particular global challenge.