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Like Nature Intended

Saul Griffith


Photo taken by Rebecca Pierik

Key Concepts
from Previous Chapters

1. Patent Research
2. Defining the Problem
2. Researching the Problem
8. Molding and Casting

If you think about it, nature can be a better manufacturer than humans. In fact, I'm disappointed with a lot of the things we mass produce. Take, for example, two manufactured products you commonly see: a plastic fork and a Styrofoam™ cup. Both take entire factories to produce, they function well for only one or two uses, and they last for hundreds or thousands of years in a landfill somewhere. This is not my idea of great design.

Nature, on the other hand, creates incredibly cool stuff right on the spot. A plant leaf, for instance, will hold together better than a lot of man-made materials. A plant can produce a leaf when it needs a new one. The plant doesn't have to make a thousand leaves and store them for later use. Nor does the plant need to go to a leaf supermarket to buy new leaves. The plant needs a leaf, so it gathers the raw materials from the soil, water, and air, and makes one right then and there—very simple. Elegant even. When the leaf degrades, it returns nutrients to the soil.

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My name is Saul Griffith, and I've been working for a few years on devising manufacturing systems that work more like Mother Nature. Recently, I designed a desktop machine that makes low-cost, high-quality eyeglasses for people in developing countries. The machine produces the glasses on demand, so there's no need for costly inventories or distribution systems.

I didn't grow up with the goal of making new and improved eyeglasses. I studied materials engineering at the University of South Wales in Sydney, Australia. Materials engineers specialize in knowing the structure and properties of different materials. We use this knowledge to envision new materials or new ways to use existing materials.

Engineers are always developing new materials or finding new ways to use materials already in existence. All materials fit into three categories: composite materials, natural materials, or synthetic materials. ***Composite materials*** are materials composed of at least two other materials. The properties of a composite are often more desirable than the properties of its individual components. For instance, fiberglass is made from glass and a plastic. The glass makes the plastic stronger and stiffer. Concrete, another composite, is made from sand, cement, and ground rock. ***Synthetic materials*** refer to materials that chemists design in a laboratory. When people talk about synthetics, they usually mean plastics. Plastics come in all varieties these days, from polyethylene sandwich bags to the polypropylene socks that keep your feet warm in the winter. Synthetics are remarkably versatile and show up in electronics, clothing, automobiles, and furniture—you name it. Do you own any rayon shirts or polar fleece jackets? These are made from synthetics. Of course, some products are made from ***natural materials*** such as leather, cotton, gold, and plant leaves.

Composite materials are made up of two or more different materials. The properties of a composite are more desirable than the properties of its individual components.

Synthetic materials, such as plastics, are created by chemists.

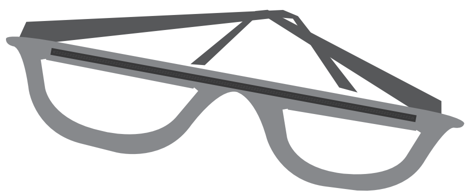
After I received my bachelor's degree, I began working on a project to build bridges out of glass composites. It was a worthwhile project, but I knew it would take a very long time to complete, so I began to look for other projects. I wanted to develop ideas and create designs that people could use every day.

I moved to the United States and enrolled at MIT as a doctoral student to work on a project developing electronic books. These electronic books would look and feel just like "real" books but would have pages that change on command, just like a computer screen. They would have enough memory to store a whole library, and they'd be cheap. That way people who didn't usually have access to books could have a whole library with just a single device!

In most developing countries, as well as in the United States, many schools can't afford to buy the books they need for their students. I wanted to change that, and I thought a new approach to manufacturing electronics might be a way to do it. I started designing a machine, something like a printing press, which "prints" transistors for computer chips onto large sheets of plastic.

When I presented my work to some visiting dignitaries from Kenya, they shocked me with their response. They told me that it would be nice if I found a way to get my electronic books to schools there. However, they cautioned, a quarter of the students wouldn't be able to read the books due to uncorrected eyesight problems.

Poor eyesight? I hadn't even thought of that! I know that glasses are expensive here, but I didn't realize that thousands of people all over the world suffer from poor vision and cannot afford eyeglasses at all. The World Health Organization estimates that as many as one billion people need glasses!



That's when I learned about a few students from Harvard Business School who were starting an interesting business venture—a company that produces low-cost eyeglasses for people in developing countries. They had done some research into the problem and found that only about half of the people who need glasses can afford them. These business students were looking for an engineer to help figure out how to develop a solution to this serious problem. I wanted to help and gladly joined their efforts.

The Problem with Inventory

Before trying to design less-expensive eyeglasses, I did some research into why eyeglasses cost so much in the first place. To make a lens, the lens material (usually a plastic called "acrylic") is poured into a metallic or glass mold that gives the lens the correct shape. The acrylic is cheap, but the molds cost a tremendous amount of money to make. Manufacturers must make thousands of different molds for every different possible lens shape, which adds to the expense. In the United States, eyeglass retailers buy thousands of lenses at a time and store them as inventory. In some cities, you can walk into an eyeglass store and get new glasses in about an hour. You just hand your prescription to the clerk who plucks the appropriate lenses out of a vast inventory. The clerk grinds the edges of the lenses to fit your frames, and, voila, you walk out with your glasses one hour later.

But in remote areas of developing countries, people cannot afford to create and maintain an inventory of thousands of lenses for a relatively small population. Given how many different combinations of vision problems people can have, an inventory of 6,000 lenses would be required to guarantee that the store had the right lenses for just 200 people. Buying and maintaining 6,000 different lenses is very expensive, and stores must pass some of that expense on to the customer, driving the price of eyeglasses higher.

After learning about all of these issues, I realized I needed to design a manufacturing system that could produce lenses at a very low cost. Additionally, the system would have to eliminate the need for large inventories.

This wasn't the first time a manufacturing engineer had faced the inventory problem. In the 1950s, Japanese automakers could not afford to buy land to house huge inventories of cars, so they retooled their factories to produce cars on demand. Instead of producing as many cars as possible and then trying to sell them, companies such as Toyota and Honda started producing cars only after buyers had purchased them. As a consequence, these companies did not have huge inventory costs, and they seldom faced the problem of making cars they couldn't sell. Since then, factories all over the world have tried to incorporate ***Just-In-Time*** manufacturing, as it came to be called, into their factory design.

But some systems, such as eyeglass manufacturing and distribution, have been slow to change. I researched old patents to see if I could find out if anyone had ever tried a different approach. My search led me to liquid-filled lenses patented as early as the 1850s. These lenses were made of two sheets of thin glass with liquid pumped between them. The glass and liquid combination worked on the same principles that modern glass lenses do. The lenses bend light passing through them so that the light hits the wearer's eye directly on the retina. This lens allows the viewer to focus on objects that normally appear fuzzy or distorted.

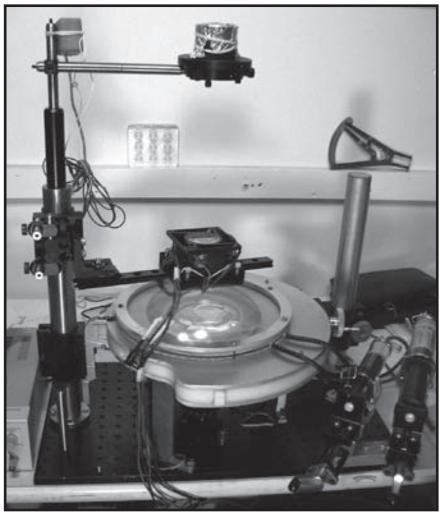
These liquid-filled glasses wouldn't work for my purposes. They didn't look good and they couldn't correct all vision problems. I wanted to make glasses that looked good and, more importantly, worked as well as any you could get in the United States.

But I couldn't shake the idea of the liquid-filled lenses that could be adjusted into different shapes. Soon after, I turned that idea on its head. I could create a liquid mold that could be shaped and reshaped to create a lens to match practically any prescription, eliminating the need for multiple molds and large inventories. Inspired, I eventually developed a machine that makes lenses of any size and shape in about three minutes.

Photo taken by Rebecca Pierik

I made these two lenses and the lenses in my own eyeglasses using my machine.

Liquid acrylic is poured into a mold made of two membranes. Then two syringes pump baby oil into the membranes, changing their shape. When a desired shape is reached, an ultraviolet light and fan cool the acrylic until it hardens.



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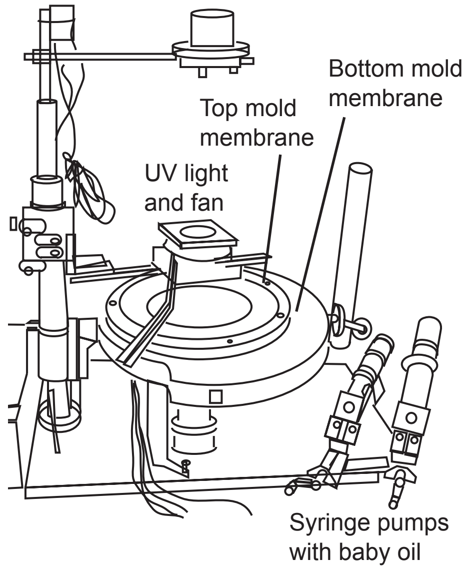


Taking Another Look at the Problem

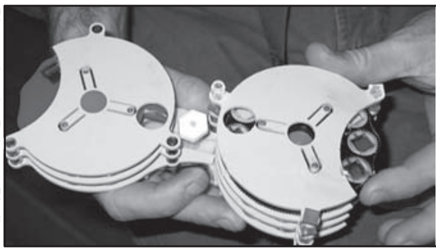
My new machine makes lenses quickly and the machine, or printer, is portable and inexpensive. People anywhere can afford to buy and use it. In addition, I've found frame suppliers that sell frames for under a dollar each. Problem solved. Right?

It's never that easy. Around the same time that I was building my lens-making device, one of my business partners was visiting India doing some more research into the issue. In the city of New Delhi, he found glassmakers who had had started a small business venture out of grinding lenses. The lenses worked relatively well, and they were cheap enough for most people to afford. Still, many people had uncorrected vision because they could not afford to have their eyes checked by an optometrist and they had no idea what kind of prescription they needed! After looking into this issue a little more, we realized that our eyeglass printer was only a partial solution.

So I began to develop a new system for diagnosing vision problems. Again, I started by researching the problems with the current system. I found that to get a prescription, you need an optometrist with five or more years of training or an expensive machine called an autorefractor. Not only do autorefractors cost a lot of money, they are also fragile and error-prone. For them to work, a patient must look at an electronic image a few inches away from his or her face. Most people have trouble focusing on such close-up images. As a result, these machines often misdiagnose a patient's eyesight.

To solve this problem, I've been developing a pair of diagnostic goggles. An electronic sensor superimposed on the goggles monitors the lens in the wearer's eye and adjusts the device's lens automatically to correct vision errors. To operate the goggles, patients must only hold the device and look through it. The goggles, once developed, should be cheap, easy to use, and they won't require an optometrist for basic prescriptions. I'm planning to test a new prototype this year.

Photo taken by Rebecca Pierik



This is the original prototype of the diagnostic goggles I'm developing. These goggles are cheap, and you don't have to be an optometrist to use them.

Money Makes the World Go Round

I've been getting a lot of attention for my various inventions, and I have to say, it makes me uncomfortable. My desktop eyeglass printer has shown up on CNN, ABC, and in countless newspapers and magazines. But it's not finished yet! I've made one machine that works perfectly about 80 percent of the time; I need to make about a thousand machines that work perfectly 99 percent of the time before trying to distribute them to developing countries. Basically, I need to *optimize* my lens manufacturing system. I'm still trying to get more funding to do that, but it's not easy.

Researchers get funding from the federal government, private companies, or from foundations that provide grants. But before these institutions give you money, you must convince them that the problem is worth solving. These organizations tend to want to spend their money on American problems. It's not easy to get funding to work on solutions for developing countries. Most people in the United States don't understand the need for low-cost eyeglasses because it's not a widespread problem here.

Other factors make communicating my solution even more difficult. Many countries restrict companies that want to bring in new technologies like low-cost eyeglasses or diagnostic goggles. Indonesia, for example, has a law that makes it illegal for foreigners to provide eyeglasses to citizens there. That's strange, isn't it? Not all nations have these laws, but many countries do have laws that seriously limit the number of people an invention can help.

Still, I can reach some countries, such as India and Honduras. As soon as I've got my system working well enough, I'm going to do my best to get the glasses distributed in those countries. In the meantime, I'm going to complete my Ph.D. and put the finishing touches on a comic book series I'm writing about how to make cool stuff like skateboards that can slide over ice or duct-tape T-shirts that enhance your muscles. After that, who knows? I'm sure I'll never be at a loss for neat things to invent. For an engineer like me, the natural world provides abundant inspiration.

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I'm writing a comic book series called *Howtoons* that explains how to make cool stuff.

What's the Story?

1. You could say that Saul's motives were consistent throughout his career, but his engineering goals changed. What were his motives? How did his engineering goals change as he told his story?

2. Saul Griffith starts the chapter with the idea that nature is a better manufacturer than humans. Explain what he means. Give an example that's not in the chapter.

3. What is "Just-In-Time" manufacturing, and what are its advantages?

4. List two kinds of composite materials, two kinds of synthetic materials, and two kinds of natural materials.

5. How did Saul research the eyeglass problem and develop possible solutions?

Connecting the Dots

6. Manufacturing systems don't just involve making a product. They also involve getting the product to the people who will use it. How does the inventory of New Balance Shoes in a sporting goods store compare to the inventory of lenses in an eyeglasses store?

7. Does Saul follow the steps of the design process in order? Which steps did he repeat? Which steps does Saul still need to complete?

What Do You Think?

8. Saul Griffith is clearly motivated by the desire to help people in developing countries, not just to make money. Yet he says that money is very important. What does he mean by this? Why is money so important in engineering?

9. Why might countries restrict companies that want to bring in new technologies such as low-cost eyeglasses or diagnostic goggles?