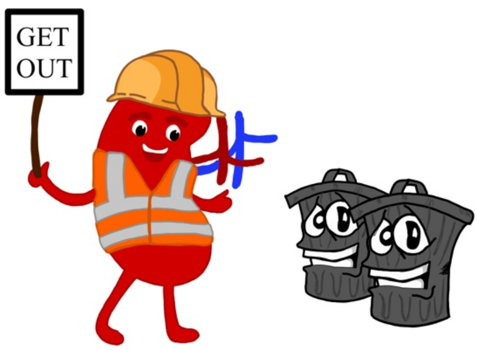
Plumber Cracks or DIY?

Reinventing Vascular Access and Allowing Better Blood Flow for Hemodialysis

By Grace Garcia

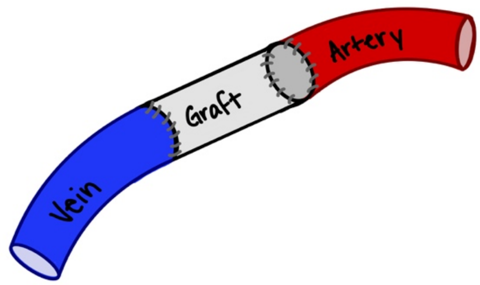
Picture this, you are a father of three daughters. These girls all have long hair and take showers in the same bathroom every day. Your oldest daughter comes to you and tells you that



their shower is clogged, and water won't go down the drain. You go to check out the drain and it is filled with hair, obstructing the flow of water, causing it to pool up in the bathtub. Now you must fish out all that hair clogging the drain so it will work again. Think about it, would you rather pay a plumber to continually fix this issue, or would you go buy a really good hair catcher to cover the drain, avoiding future clogs? Keep this story in the back of your mind, but now let's talk about science.

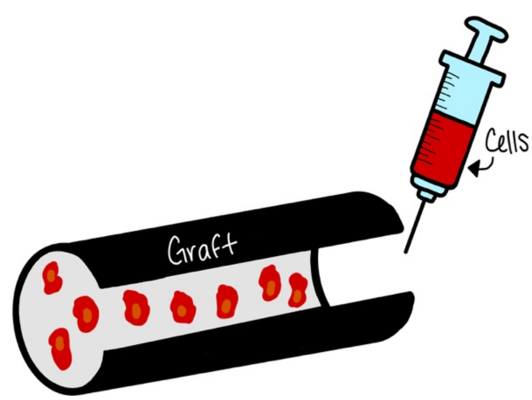
In the human body, your kidneys work to filter out blood and waste. The waste exits your body through urine. Every time you use the restroom, your kidneys have already put in work to filter waste out of your body. For a very large population, about 15%, of individuals in the US, their kidneys slowly lose function over time, often leading to a disease called chronic kidney disease. If this disease advances to its end stages, it becomes classified as end stage renal disease, or kidney failure. Patients with this disease only have two options for treatment: kidney transplant or hemodialysis. While kidney transplants are the best option, there is a shortage of available kidneys for transplant. This leaves hemodialysis as the only answer. Hemodialysis is a treatment that helps your kidneys function regularly, by regulating waste and water in your blood. This machine works by taking your blood, cleaning it, and returning it to your body. This is often only a temporary fix until a kidney becomes available for transplant (sadly, transplant waiting lists are incredibly long and many people end up on hemodialysis for the remainder of their lives).

Hemodialysis requires access to the arteries and veins of your body. The machine that performs hemodialysis works by removing blood from an artery in your arm, running it through a filter, and returning it back to your body through your veins. Typically, your veins and arteries run separately through your body and only come together in the form of small vessels called capillaries. Capillaries are thin blood vessels that work to carry essentials, like oxygen and nutrients, to all of the tissues and organs in the body. In order to gain access to these blood vessels, surgery is required to begin hemodialysis. Currently, there are a couple forms of synthetic access; arteriovenous fistulas (AVFs) and arteriovenous grafts (AVGs). Arteriovenous means relating to an artery or vein. Fistulas are a synthetic, surgically created connection between two hollow or tubular organs, like veins and arteries. AVFs are less common than AVGs because they require specific sized veins and arteries, leaving many patients unqualified. AVGs are human-made tubular grafts, like the one above, that are sutured into an artery on one side and a vein on the other.



As with almost everything that is human-made, there are problems associated with AVGs. On the good side, AVGs are typically made of materials that are deemed "biocompatible" (meaning not harmful to living tissues); but despite their biocompatibility, nothing will function as good as your normal blood vessels. For example, normal blood vessels in your body typically only clot in response to injury, to help stop the bleeding—but the grafts are constantly being poked and prodded by the needles which causes the blood to continually clog up at the site of access. Often, these blood clots cause the graft to fail because it reduces the normal blood flow, no longer allowing the hemodialysis machine to function properly. Remember the clogged drain from earlier? The same idea applies here—the blood can no longer flow properly, just like the drain can no longer drain properly. This means that a patient originally being treated for a failing kidney must now shift focus and find alternative ways to access their bloodstream. This causes said patient more stress, hospital time, and money, without any progress toward addressing the original problem—their failing kidneys.

What are scientists doing to fix this problem? How can we create a human-made graft that avoids blood clots and functions similarly to the blood vessels in your body? Current research is being performed to use human cells to attach them to the inside lining of these human-made grafts to mimic the structure of a natural blood vessel in the body. Why would we want this? Think about how many injuries you have experienced, all the way down to a simple paper cut or scrape of a knee. Yes, these injuries are often frustrating, but eventually they heal. If we had grafts that had our own cells lined on the inside, then the regenerative properties of the cells would allow the pokes and prods of the hemodialysis to heal more quickly, avoiding the blood clots. Lining grafts with human cells is accomplished by injecting cells into the graft and allowing them to coat the lining of the graft (as show in the diagram above). Other necessary biomolecules will also be injected to help mimic the molecules normally found in the blood vessels of your body. The hope is that the graft will capture the injected cells and be coated



entirely, preventing other molecules from attaching to the graft—this would prevent those pesky blood clots from attaching to the graft, so blood can flow properly through the vessels.

Remember the thought-experiment with the shower drain hair catcher at the outset of this article? The drain catcher represents a preventative solution that would enable you to avoid having to repeatedly fix a problem by paying someone else. Cell-lined grafts are a similar concept—except instead of catching hair to prevent a drain clog, they prevent vessel damage, blood clots, and repeated medical interventions for people who are incurring enough trauma.