NEW DIMENSIONS

3-D printing is capturing the imaginations of everyone from engineers and doctors to artists and home DIY-ers. We take a look at what's fit to print.

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THERE'S A NEW headline about 3-D printing almost every day: a new material! A new printer! A new application! It all sounds cool, but it can be hard to understand what's really going on.

It all began in the 1980s when engineer Chuck Hull patented the stereolithography process. Early printers used a liquid photo polymer similar to the substance that attaches orthodontics or dental fillings. When hit with a thin beam of UV radiation (that little blue light your dentist probably uses), the liquid plastic hardened to a solid.

At first, 3-D printing was great for prototyping, quickly producing items without needing any of the expensive tools of traditional manufacturing. (Hull apparently got his idea while working for a company that applied plastic veneers and needed to produce plastic objects faster to refine its application technology.) But it only made sense for models. "The very early materials were extremely brittle; if you dropped them on the floor they would shatter, and if you got them exposed to moisture they would weaken," recalls Tim Gornet, manager of operations of the Rapid Prototyping Center at the University of Louisville in Kentucky, who's been 3-D printing since 1987.

Early adopters included automakers and aerospace companies, who could suddenly test parts without the time and expense of factory runs. The medical community was equally keen on the technology. As early as the 1990s, surgeons scanned patients' bodies, 3-D printed models of their organs, and mapped each cut on the replicas before even entering the operating room.

Better materials and newer processes such as laser sintering (in which thin layers of powdered plastic or metal, fused by a laser beam, are gradually built up to form shapes) produced more durable results that could be used for actual parts, not just prototypes. Soon, 3-D printing was disrupting manufacturing—it was being used to produce final parts in small volumes that were expensive or difficult to make using traditional methods.

It's still slow—it takes hours to print items, compared to tens of seconds to injection-mold them—but it allows engineers to completely overhaul designs and cuts down on certain manufacturing inefficiencies. A single duct on an airplane, for example, once required mounting brackets and other add-ons that had to be produced separately. Now, "they're combining all these pieces into one using 3-D printing," says Gornet. "They're building parts that can't be manufactured any other way."

Today, high-end machines can print a variety of plastics, metals and even ceramics, with the range of possible applications expanding all the time. (Gornet's team, for example, is developing a material that can withstand higher temperatures.) Most can be used and recycled just like any other object, and some can be printed from recycled material; researchers are developing filaments for 3-D printers made from old milk jugs and plastic potato chip bags.

The latest 3-D printed items can even hold up inside the human body. Unlike early prints that couldn't withstand moisture, bone grafts and dental crowns can be custom-printed from ceramics and porcelain, implanted and used for years. And one of the hottest new 3-D printing materials is actually a very old one: human cells, with which scientists hope to eventually print entire organs. (Given that they've just started printing blood vessels, it will take much more research before they can move on to hearts or livers, which have whole networks of arteries and veins.)

Some of the most exciting projects are not duplicating existing structures, but creating totally new ones. Amateur designers and professional artists alike are letting their imaginations run wild on 3-D-printed custom-fit shoes, intricate jewelry and abstract background scenery for opera and theater. On the online marketplace Shapeways—like Etsy for 3-D printed items—anyone can submit a design, set a price and have it manufactured in one of the company's 3-D printing centers in New York, opening the technology to anyone with an Internet connection.

In the future, 3-D hobbyists will see cheaper (but better) desktop machines and software that can produce models from 2-D photos instead of scans. Meanwhile, researchers will continue trying to develop the holy grail of higher-end machines: one that can print anything on demand using multiple materials, such as an entire smartphone made from plastic, metal circuitry and glass.

It may take a while—researchers at MIT just recently announced they had managed to print glass—but in an industry whose ethos seems to be "if you can dream it, you can print it," it can't be *too* far off.

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