

Print Me a Pill

By Barry P. Chaiken, MD, FHIMSS

During the first *Star Trek* series released in the mid 1960s, the creators introduced viewers to several magical devices—the Communicator, the Padd, the Replicator, and the Transporter. Although building the latter device requires the repeal of several laws of physics, the other three commonly exist today for the public to use. Smart phones are the Communicator of today allowing us to speak, text, or email to anyone around the world who might have a similar device. The Padd is my Nook—it even looks like it and makes the same sound when dropped on a desk—or your iPad or similar tablet device. Finally, the Replicator is nothing other than a three dimensional (3D) printer, a device just entering the world of consumer products. 3D printers are expected to cost only a few hundred dollars by 2015.

3D printing offers the opportunity to print pharmaceuticals specifically produced to meet the needs of individual patients.

According to Wikipedia:

3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. 3D printing is achieved using additive processes, where an object is created by laying down successive layers of material. 3D printing is considered distinct from traditional machining techniques (subtractive processes) which mostly rely on the removal of material by drilling, cutting, etc. (3D printing, 2012)

All 3D printing works from a digital file or blueprint that directs the building of the object. Some printers use tiny nozzles that deposit layers as thin as 0.1 mm in thickness from material contained in their “printer cartridges.” Other 3D printers use laser beams or tiny droplets of glue to fuse thin layers of plastic or material dust into solid objects. Currently, only certain materials—plastics, resins, and metals—can fill 3D printer cartridges, but scientists are working to allow other materials to be included in the 3D printing process.

Manufacturers use 3D printing to make prototype objects much more quickly and less expensively than previously possible. Once manufacturers complete a final design, 3D printers create the final mold that is used to manufacture the end product.

Replacement Parts

3D printers also work well in building hard-to-find replacement parts. In planning for long space flights, NASA tested a 3D printer on the In-

ternational Space Station, and recently announced its requirement for a high-resolution 3D printer to build replacement spacecraft parts during deep space missions.

Healthcare device companies utilize 3D printers in the manufacture of many specific products. Some dental labs print dental appliances customized to the needs of each patient. These include crowns, bridges, and temporaries, essentially printing new teeth. Other applications for 3D printing include the manufacture of ear molds for hearing aids and artificial hips for hip replacement surgery.

Future Applications

Bioprinting represents the next step in 3D printing. Instead of materials, living cells fill the cartridges of the 3D printer. Cell by cell and layer by layer, these bioprinters deposit specific living cells chosen to perform a particular function in a pattern that allows them to perform a designed task.

Patients requiring kidney replacement may have new kidneys printed from their own existing kidney cells or from stem cells coached to grow into kidney cells. The printing itself need not be exact, as nature takes over once the proper mix of cells and substrate exist together. For example:

...experimental blood vessels have been bioprinted using bioink spheroids comprised of an aggregate mix of endothelial, smooth muscle and fibroblast cells. Once placed in position by the bioprint head, and with no technological intervention, the endothelial cells migrate to



the inside of the bioprinted blood vessel, the smooth muscle cells move to the middle, and the fibroblasts migrate to the outside (Barnatt).

A bioprinter researcher describes the process as follows:

...it is no different to the cells in an embryo knowing how to configure into complicated organs. Nature has been evolving this amazing capability for millions of years. Once in the right places, appropriate cell types somehow just know what to do (Barnatt).

Companies expect to introduce bioprinted human structures by 2015. Futurists believe bioprinted organs will be commonplace in just a few decades and extend lifespans dramatically.

Personalized Medicine

In addition to organ replacement, 3D printing offers the opportunity to print pharmaceuticals specifically produced to meet the needs of individual patients. For example, diabetic patients with cardiovascular disease are often prescribed medications that mediate blood glucose, serum cholesterol, and blood pressure. Currently, patients follow drug regimens for each of their conditions, which require them to manage three or more medications. Limits on available drug doses restrict the ability of physicians to personalize drug treatment plans to address patient characteristics such as their genetics, body mass index (BMI), or other metabolic factors.

A 3D printer with cartridges loaded with the pharmaceuticals required by the patient could print a pill that contains exactly the right amount of each of a patient's medications, thereby customizing the drug treatment for the patient. Such customization of dosage reduces the number of pills required to be taken by patients from several to just one. This ensures that the medication dose "printed" in each pill delivers the desired effect with the least side effects.

If a drug dose needs to be changed, the 3D printer can adjust the medication in the next day's printing. This on-demand pill printing eliminates waste associated with monthly delivered drug supplies. Such customized printing ensures higher rates of therapeutic compliance due to the fewer number of medications to manage. This in turn leads to more effective treatment that improves outcomes and lowers costs.

Although much more work needs to be done in the area of personalized medicine to truly take advantage of such exacting drug "printing," the exponentially expanding availability of patient data and the evolution of semantic Web 3.0 analytics should accelerate this effort. In the meantime, 3D printing of drugs, body structures, or organs presents a promising technology to advance the capabilities and quality of health-care. ■

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REFERENCES

- 3D printing. (2012, April 24). In Wikipedia, The Free Encyclopedia. Accessed April 25, 2012, from http://en.wikipedia.org/w/index.php?title=3D_printing&oldid=488963324
- Barnatt C. (n.d.). Bioprinting. *Future Technologies* blog (<http://www.explainingthefuture.com/bioprinting.html>)
- Chaiken B. P. (2012). Big data drives big change. *Patient Safety and Quality Healthcare*, 9(1):8-9.
- Chaiken, B. P. (2011). Web 3.0 data-mining for comparative effectiveness and CDS. *Patient Safety and Quality Healthcare*, 8(5), 8-9.
- Chaiken, B. P. (2005). Personalized medicine: Just for you. *Patient Safety and Quality Healthcare*, 2(6), 16-17.
- Print me a Stradivarius. (2011, February 10). *The Economist*. Available at <http://www.economist.com/node/18114327>

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