

Printing Pizza ... in Space

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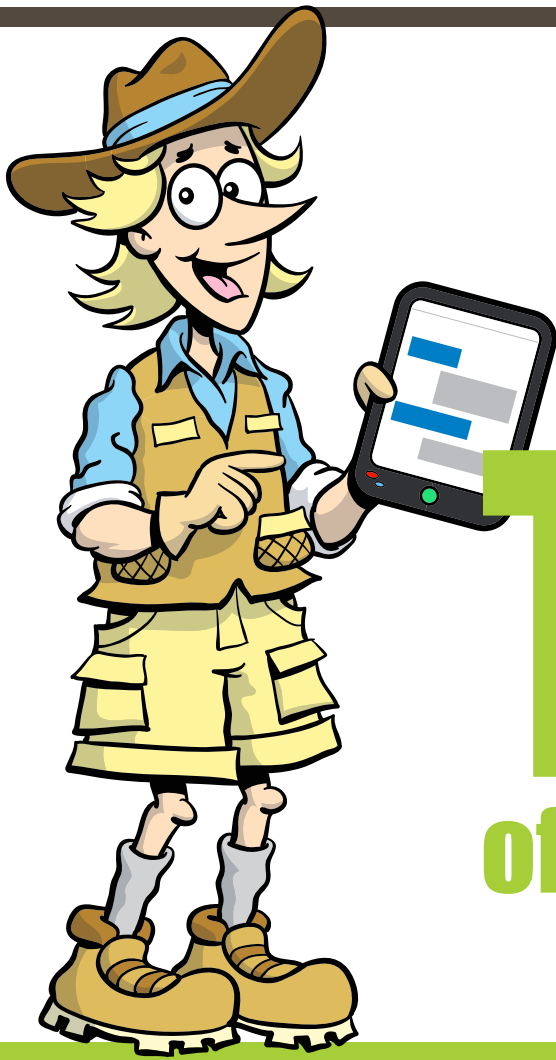
ADVENTURES IN SCIENCE

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3D printers
are producing:
dino bones
action figures
robo arms
human skin
cool guitars
& much,
much more



making the
FUTURE



Hi! I'm Dr. Dig, and I am so excited about being here with O and Aarti! What brought me here, you ask? Aarti's text message about ODYSSEY doing an issue on 3D printing! I am an archaeologist and just love being in the field. But one of my chief concerns is how to excavate in a way that will have minimal impact on the site and the finds. My friend Steve Murray has been researching the latest and greatest tech advances in archaeology. Imagine how thrilled I was when he agreed to share his "onsite" insights with all of you!

Tools of the Trade

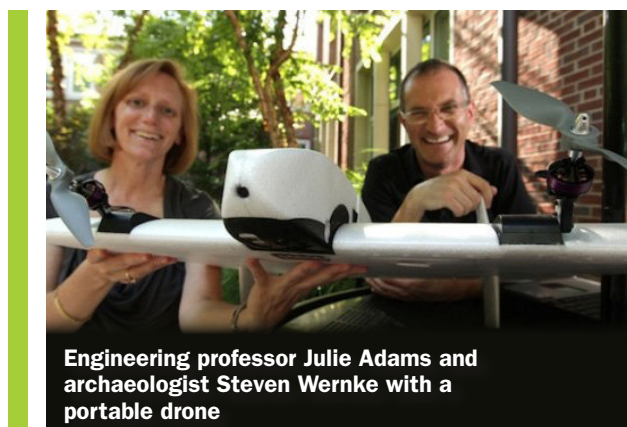
The tech transformation in archaeology

by Steve Murray



Dr. Hiram Bingham excavated the Inca city of Machu Picchu, in Peru, about a century ago. His expedition teams worked the site with shovel and machete and carried away up to 40,000 artifacts.

Archaeology isn't done that way today. Twenty-first-century diggers take to the field with the latest technologies, as modern tools transform how we explore—and protect—the past. These aren't Bingham's excavations anymore.



Engineering professor Julie Adams and archaeologist Steven Wernke with a portable drone

Flying Above the Fray

The first task of archaeologists is to map the site they intend to explore. Multispectral satellite data, airplane surveys, and Google Earth images are a great start, but many scientists want more detailed planning information. How do they get it? They call in the drones.

Drones are portable “eyes in the sky”: small, unmanned aircraft that can fly over an area at low level and bring back information about prospective dig sites. Equipped with global positioning systems (GPS) and the right sensors, drones can map topographic features as small as half an inch, using preprogrammed flight paths.

As drone systems grow more capable, less expensive, and easier to use, they're also growing

more essential to archaeologists. Fit one with a camera and you're an instant explorer!

And drones can be small. To get the high-resolution photos he needed in Peru, for example, Vanderbilt University archaeologist and historical anthropologist Dr. Steven Wernke used a drone that fit in a backpack.

Technology in the sky can now map the most rugged places on Earth. But surveying isn't the same as exploring. For most archaeologists, walking the ground is still vital to their work. As long as that ground is walked gently.

Do Not Disturb

Modern archaeologists understand the importance of low-impact digging. After all, other archaeologists, with their own ideas and tools, may also want to excavate there someday. They also appreciate the scientific value of “context,” or the need to collect exact information about where and how artifacts were discovered. New devices help to establish context, even as the archaeologist starts to dig.

Smartphones and tablets are becoming important archaeological assistants because apps can reproduce many functions of more complex equipment. Phones and tablets with GPS and digital cameras are also useful for both documenting and analyzing dig sites. Digital photographs, for example, can be connected together using geographic information system (GIS) software to document an entire excavation



Theodolite



This 3D print of a human skull is displayed at a museum in Germany.

as a computer database. And a smartphone app, Theodolite, can digitally record the position, altitude, bearing, and range of an artifact or dig site landmark. Not a bad capability for the field!

Recently, a young fossil hunter took digital site recording to a whole new level. Aki Watanabe, a student at the American Museum of Natural History's Richard Gilder Graduate School, used Google Glass to take both video and audio notes of his explorations in the Gobi Desert. Archaeologists may be taking these head-worn helpers along on future excavations, too.

Handle with Care

Archaeologists call it the Principle of Reversibility: Avoid doing things that can't be undone. Too often, however, a scientist must break off and destroy a small piece of an artifact to learn more about it. This happens, for example, when a piece must be burned or dissolved to find out its chemical components. No wonder archaeologists are now embracing new

tech tools to help them examine artifacts without damaging them.

Jillian Huntley, a graduate student at the University of New England, Australia, wanted to find out the source of paint pigments in an ancient aboriginal rock art site. She couldn't break off rock pieces for testing because the art was a cultural treasure, so she reached for her PXRF unit. Portable x-ray fluorescence (PXRF) uses low-level x-rays to determine the chemical properties of a material. The tool has been valuable in the laboratory for a long time, but it's become a "hot" technology because it's now available as a handheld device. PXRF is fast becoming popular in the field.

When scientists want to study the inner parts of an artifact without physically opening it, they often turn to computerized tomography (CT). CT scanning makes x-ray images of an object that can then be explored as a three-dimensional computer model. Archaeologists can examine it from different angles and digitally peel away its layers to see how it was

put together. Archaeologists at the British Museum recently used CT scanning to digitally unwrap an Egyptian mummy. Computer views revealed its age, state of health, and even the cause of death without anyone touching the real mummy.

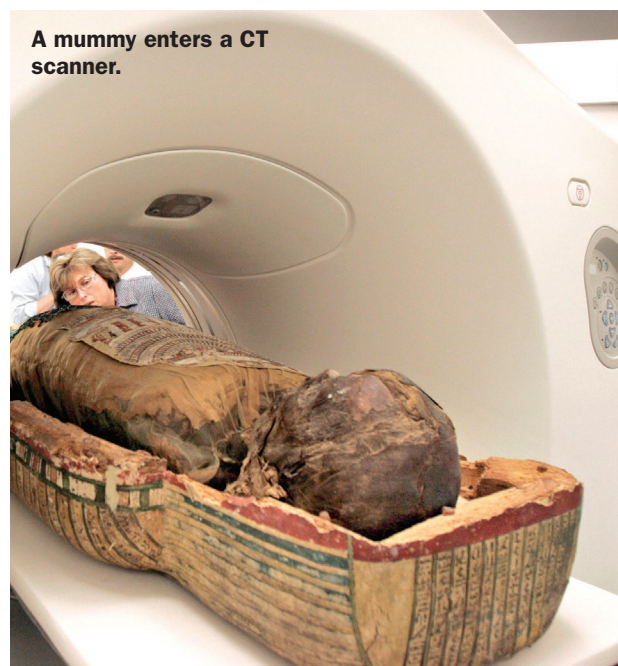
Share the Wealth

Archaeology isn't finished until it's shared, but hard-found artifacts can be too rare, fragile, or valuable to be handled. This is where 3D printing intersects with research science.

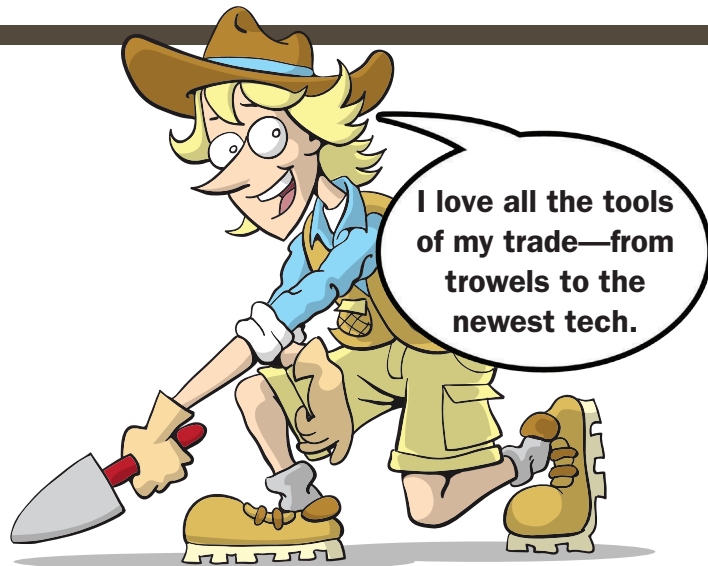
Home printers and 3D printers are similar in one way: They both require a computer program to guide them over a surface. A conventional printer is two-dimensional, because it places ink on flat paper. A 3D printer, however, places materials horizontally *and* vertically. Materials are layered higher and higher until a solid object is formed.

Archaeologists use 3D printing to physically reconstruct almost anything that can be modeled by digital data. These replicas can be shared with other archaeologists, museums, and the public.

It also looks like 3D technology is coming full-circle in archaeology. A private company is using 3D printing to manufacture a drone for archaeologists, while another company is starting a project to build a 3D printer specialized for archaeological work.



A mummy enters a CT scanner.



Twenty-First Century Science

Things are moving quickly. Archaeologists increasingly rely on new technologies because they make their work faster and more effective. But is this a total transformation? Will future archaeologists just sit behind computer screens, operating sensors or staring at data?

"Not at all," claims Dr. Dominique Rissolo, executive director of the Waitt Institute. "An archaeologist is, fundamentally, a *field* scientist. There's nothing like being at a site, using all your senses. Your 'gears' turn differently. Tech won't replace digging, but new tools have certainly changed the game."

So the trowel *isn't* getting tossed from the toolbox. Technology is making the toolbox bigger.

Steve Murray, PhD, is a science writer. He's also a former research engineer and Navy flyer.