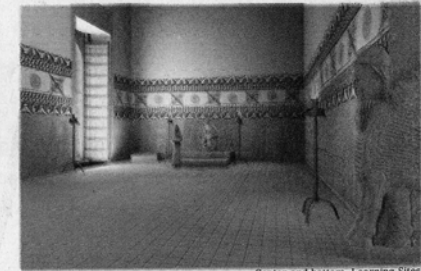
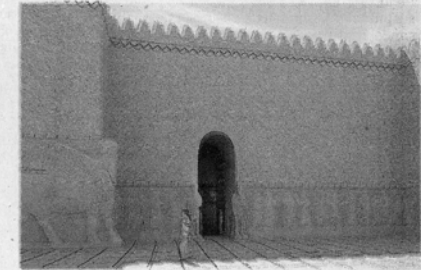
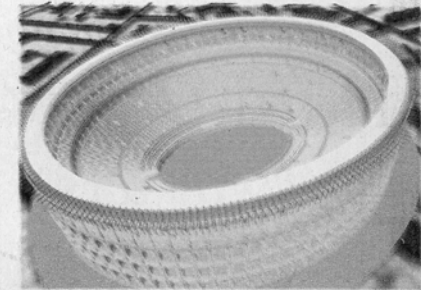


Above and top right, University of California, Cultural Virtual Reality Laboratory



Center and bottom, Learning Sites

**RETHOUGHT IN A DAY** A series of 3-D simulations of the Colosseum in Rome led researchers to question whether spectators could easily navigate its upper hallways.

**MORPHING MARVELS** Simulated reconstructions, from top: the Roman Colosseum; the Great Northern Courtyard of the Northwest Palace of Ashur-Nasir-Pal II, in Nimrud in ancient Assyria, now in Iraq; the throne room of the Northwest Palace.

# Virtually Rebuilt, a Ruin Yields Secrets

By SAM LUBELL

**E**VERYONE knows that the Roman Colosseum is an architectural marvel. Built so that thousands of people could be ushered in and out in minutes, it is a testament to the genius of Roman engineering. Or is it?

By reconstructing the building with three-dimensional computer modeling and then virtually "walking through" it, researchers have discovered that in some sections the building may have had all the efficiency of a railroad-style apartment on the Bowery. The model reveals dark, narrow upper hallways that probably hemmed in spectators, slowing their movement to a crawl.

Such three-dimensional modeling is turning some of archaeology's once-established truths on their heads. Because 3-D software can take into account the building materials and the laws of physics, it enables scholars to address construction techniques in ways sometimes overlooked when they are working with two-dimensional drawings.

"Now we have a tool that will really test assumptions," said Dean Abernathy, a doctoral student who helped reconstruct the Colosseum at the Cultural Virtual Reality Lab at the University of California at Los Angeles. "It creates a lot of excitement in the field."

The U.C.L.A. lab ([www.cvrilab.org](http://www.cvrilab.org)) creates models of architectural sites around the world. Since 1996 it has been working on a project called Rome Reborn, which seeks to rebuild much of the ancient metropolis.

Researchers at the lab recreated the Colosseum using a program called MultiGen Creator, which allows users to pan, zoom, walk or even fly through a simulation of a site. Graphics software like 3D Studio MAX and Lightscape, the same kind of programs used by digital movie studios, helps make

the replicas particularly lifelike, with sharp colors and intricate stonework.

The Colosseum, a vast four-story oval arena, was built from around A.D. 70 to 80 under the rule of the Emperor Vespasian and then Titus. It once held as many as 50,000 spectators. Earthquakes and the ravages of time have destroyed much of the building, but an impressive amount, including most of its facade, still stands.

Mr. Abernathy confronted the issue of the third-level hallways when he was working on the reconstruction. His model drew on the findings of a team of experts on Roman architecture assembled by U.C.L.A. who had studied similar amphitheaters, drawings of the Colosseum and records of the building's construction and expansion. The team also examined what was left of the upper hallways, an area that had previously been all but closed to researchers.

Bernard Frischer, a classics professor at U.C.L.A. and director of the Cultural Virtual Reality Lab, said that researchers have generally held that the entire Colosseum was a masterpiece of circulation, with people able to enter and leave in as little as 10 minutes. After touring the virtual Colosseum, now he is not so sure.

"Most scholars just never focused on the problem of circulation throughout the building," he said. "They assumed that each of the floors was going to look like the bottom," which is spacious and well lit. "Only once we had to reconstruct the building did an idea like that pop into our heads."

Such reconstructions have challenged traditional thinking about other sites as well.

Analysis of U.C.L.A. models suggests that the Roman Senate may have been poorly ventilated and lighted and had inferior acoustics. The models also raised some new questions about the Temple of Saturn, whose design may have been altered centuries after its construction.

Colleges have developed sophisticated devices to enhance the experience of touring the models. At U.C.L.A., researchers view models at the university's visualization portal, a screen 24 feet wide by 9 feet high that offers 160-degree views, with special goggles producing a three-dimensional effect.

At Brown University, archaeologists can view the results of their digs in a room called the CAVE, for Computer-Automated Virtual Environment. Surrounded by three-dimensional images on screens on the walls and the floor, scholars navigate by wearing shuttered goggles and sensors that ex-

### Computer renderings challenge traditional thinking about ancient architectural wonders.

change data with a computer system. A "wand" with an internal track ball like that of a mouse moves them wherever they direct it.

Other virtual-reality projects allow users to move around the room physically, with their movements tracked by overhead 3-D magnetic or infrared devices.

Samuel Paley, a classics professor at the State University at Buffalo, and members of the virtual reality lab there have worked with Learning Sites ([www.learningsites.com](http://www.learningsites.com)), a design company based in Williamstown, Mass., that specializes in archaeological visualizations, to produce virtual models of several Assyrian palaces. The simulations can be viewed on a supercomputer at the university's center for computational research.

Moving through a simulation of the northwest palace of Ashur-Nasir-Pal II of Assyria,

an ancient site in modern-day Iraq, he caught a glimpse of three leaf bas-relief sculptures in a row. The sculptures, which depicted a ritual involving the king, courtiers and protective gods, could be viewed as a single, isolated tableau only from his position on the threshold of the throne room — as was evidently the intention of the palace's designers.

When Professor Paley described his finding at a lecture, "the room went absolutely silent," he said. "I think people realized right then that this is a useful technology that helps them see things in a different way."

Donald Sanders, president of Learning Sites, said that more than 70 university programs across the country were now using computer-generated virtual reality models, compared with only a handful five years ago.

"This is the future," Professor Paley said.

But the future is not cheap. More than \$25,000 has gone into the Colosseum project so far, researchers at U.C.L.A. said. Microsoft, which incorporated the Colosseum graphics into its Encarta 2002 interactive learning software, helped cover some of the project's costs through a licensing agreement with the university. The Andrew Mellon Foundation supplied \$127,000 to cover the Roman Forum project.

Some experts hesitate to rely on such modeling, saying that it can gloss over the realities of the past.

Kenneth Kolson, deputy director of the division of research programs for the National Endowment for the Humanities, said that virtual images conveyed a "false sense of integrity and purity."

"Those images, especially the stunningly seductive ones," he added, "convey as much or more about our own values and cultural aspirations as about the ancients."

Even Professor Frischer and other schol-

ars who have embraced interactive 3-D modeling caution that their reconstructions can never be accepted as fact, partly because new information is always surfacing.

"We're working the stuff out," said Mark Wilson Jones, a member of the U.C.L.A. committee of Roman architecture experts and a lecturer in architecture at the University of Bath in England. "Nothing's ever final." One advantage of using digital models, scholars say, is that they can easily be updated with new findings.

Fikret Yegul, a professor of architectural history at the University of California at Santa Barbara, acknowledges that computer modeling can shed new light on the past. "It just brings greater depth to our understanding," he said.

Still, he questions some of the theories of the team of experts assembled by U.C.L.A. "V.R. models can never be seen as the last word," he said. "They are only another perspective."

Some researchers reject the technique because they are wary of changing the way they work or of ceding control to computer programmers. And some are unconvinced that the technique accomplishes anything beyond creating pretty computer models. "There are a lot of archaeologists who look at this as glorified coloring book stuff," said Dr. Sanders of Learning Sites.

"There are always people hesitant to move from their own set ways of doing things," he said. He offered a historical example.

"It wasn't so long ago that there was a technology coming into popular use," Dr. Sanders said. "The equipment used to create it was very expensive, yet the images you got were something that you could never get without it. Within a generation it became indispensable to archaeology."

"That's exactly how photography got started."