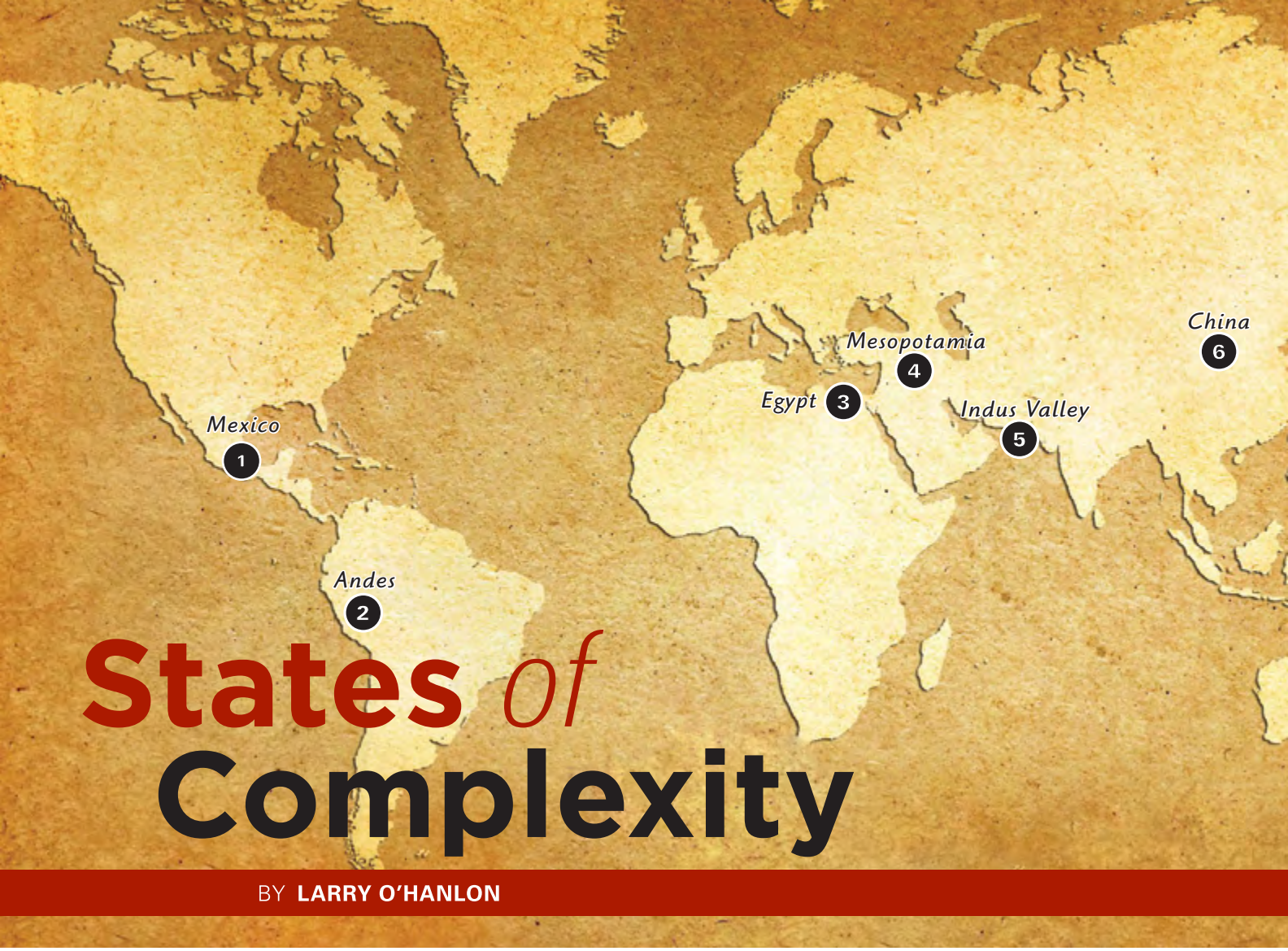


States of Complexity

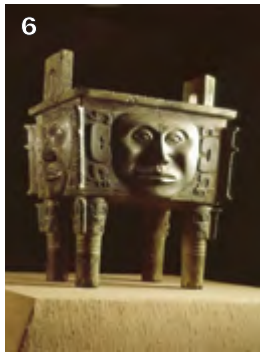
BY **LARRY O'HANLON**

BETWEEN TWO AND SIX THOUSAND YEARS AGO something unprecedented began happening in about six separate places around the world: The people of small chiefdoms in places like the Nile Valley, Mesopotamia, the Peruvian Andes, Mexico, China, and the Indus Valley began uniting to form the first large centralized states. It's not known what triggered these transformations. There were no scribes yet to record the transition from villages to states and, until very recently, there wasn't enough information about these first complex civilizations to make detailed comparisons.

Archaeologists do know these transformations occurred in fits and starts, with some changes taking place incrementally, others shifting suddenly and dramatically. Villages grew larger. One chief in a region began to amass the accoutrements of his elevated stature, living in larger huts and, later, elaborate palaces tended by servants. He or his successors appointed bureaucrats to manage his affairs – a tax man to collect tariffs, a bookkeeper to record transactions, or a security guard to protect accumulated wealth, perhaps. People from neighboring villages began traveling to the palace to conduct business. A market located near the palace was sanctioned as the primary locus for the region's trade. A religious structure of some size was built nearby. Families and villages began to specialize in the provision of certain goods and, in turn, were increasingly reliant on the specialties of others.

In some cases, there were phases of disintegration and collapse followed by the rapid emergence of new structures. The typically brutal exercise of military power and the resulting dominance over neighboring chiefs led to larger territories falling under one chief's jurisdiction, with military outposts and garrisons established to maintain control of the region, its labor, and its resources. New construction projects brought hundreds or thousands of people into forced toil. Droughts, disease, or food scarcity caused people to die or move in large numbers.

In these ways, a new political, economic, and social order emerged. The before-and-after contrast was striking. "The rise of the state is a key point in the evolution of human society, perhaps the most important shift for *Homo sapiens* since the advent of language in the Paleolithic until the present day," said Santa Fe Institute President Jerry Sabloff. "We want to see if there is an underlying explanation for the rise of the state through time and space. We also want to see why states did not arise."



1. Mexico, Maya Relief
Stone relief depicting a Maya ruler-deity, 9th Century CE (IMAGE: JERRY SABLOFF)

2. Andes, Face Spout Vessel
Ceramic stirrup spout vessel (100-900 CE) from the Pre-Columbian Moche, a stratified agrarian and fishing society in coastal regions of northern Peru. This vessel depicts a Moche ruler in a turban-like headdress and earrings. (IMAGE: ALBUM/ART RESOURCE, NY)

3. Egypt, Wall Painting
Replica of a fresco from the tomb of sculptors Nebamun and Ipuky (Thebes, 1411-1375 BCE) depicting goldsmiths at work. Egyptian tomb scenes often show craft specialization and typically depict trades supervised in life by the tomb's owners. (IMAGE: ART ARCHIVE/GIANNI DAGLI ORTI/ART RESOURCE, NY)

4. Mesopotamia, Uruk Ruins
Ruins at Warka, Iraq, site of Uruk, one of the first large cities. By 2800 BCE at least 40,000 people lived inside Uruk's walls. Newly emerging socio-political factors and the intensification of pre-existing systems of economic production might have contributed to its rapid growth. (IMAGE: NIK WHEELER/CORBIS)

5. Indus Valley, Figure
Seated soapstone figure dubbed by archeologists as the "priest-king," discovered in the ruins of Mohenjo-daro (2600-1900 BCE), one of the world's earliest major urban settlements. Indus Valley settlements exhibit evidence for a high degree of urban planning, including the first-known city sanitation systems. (IMAGE: ROBERT HARDING IMAGES/MASTERFILE)

6. China, Bronze Ding
Bronze, four-legged food vessel, called a ding, from the late Shang dynasty (1100-300 BCE). Dings were used for preparation and storage of ritual food offerings for ancestors of elites and were associated with dominion over the land, implicitly symbolizing a ding owner's power. (IMAGE: ART ARCHIVE/ART RESOURCE, NY)

Society Simulator

Sabloff is leading SFI's "Emergence of Complex Societies" project, supported by the John Templeton Foundation. He and a team of SFI researchers are working on the richest in-depth side-by-side analyses of the organization of archaic states to date. Drawing from many fields and a new wealth of archaeological data, the SFI team is collecting in a single database all the information they can find relating to the economics, trade, agriculture, climate, demographics, environment, disease, and other factors that make, or fail to make, a state. They will plug this data into mathematical models they are developing, then pose questions of their simulations to help them understand the critical, common themes that led to the emergence of the first states.

Artist's depiction, central Maya village at Dos Pilas, Guatemala, showing increasing complexity.

1. Rulers' palaces were often used to conduct the administrative business of the state.

2. A central temple served as a focal point and gathering place for religious and political activities associated with the growing state.

3. The state's central plaza hosted large ceremonial gatherings for people of the region.

4. Residences of elites indicate a stratified class structure.

5. Large urban centers are likely to have been the first to install elaborate ball courts.

6. Commoners specializing in skills needed to maintain the lifestyle of the elite often took up residence in the urban center.

Human societies, of course, have evolved and have become more complex throughout prehistory and history, aided by innovations that have opened doors to later steps – from the first tools and spoken languages of small family groups; to the agriculture and animal husbandry of villages and chiefdoms; to written languages, specialized trades, markets, and militaries of cities and states; and finally to today's nations, global financial markets, international corporations, and transgovernmental organizations such as the World Bank and the United Nations. All are significant milestones in the complexity of human society, but few are as great a leap as the emergence of the state.

"As cultures evolve they not only change things, but change the way they change things," said Sander van der Leeuw, an SFI External Professor and director of the School of Human Evolution and Social Change at Arizona State University. "There are so many actors and variables involved that you can't solve, from a linear perspective, how societies organize themselves."

The only way to approach something that complex and changing is through the simplifying language of mathematics, van der Leeuw said.

The Impetus of Competition

The current general understanding of the rise of early states is that they emerge from competing chiefdoms. That is, they arise from smaller groups that are competing for resources, labor, and other essentials in a given landscape. It's in such competitive environments that the next step happens, and one of these groups becomes central to the others.

"There's a lot of discussion among scholars about the importance of conflict in such situations," said Sabloff. "But it is, in effect, the increasing organization of one of the competing groups that gives it the ability to out-compete, if you will, the other chiefdoms." The winning edge is most likely a mixture of military skill, and the ability to mobilize significant wealth and get different groups to cooperate, he said. There is a lot of debate in archaeology about the details, of course.

VILLAGE, YEORGOS LAMPATHAKIS/NATIONAL GEOGRAPHIC STOCK

"Current archaeological research points to an interplay of factors, such as ability in warfare, control of trade and tribute, and then the buildup of administration to effectively control areas that might have been taken over by military conquest," Sabloff explained. "So it's the competition that gives rise to the state administration that allows it not only to be successful in taking over areas and other people, but then securing them and efficiently getting tribute in the form of material goods, raw materials, and labor."

Eventually there develops something that meets the modern definition of a state: A large population with a strong centralized government, a range of socioeconomic classes, a diverse economy, and, as the earliest states develop, substantial cities.

"The complex adaptive systems we are studying are the political, economic, and social systems and their interaction with both the physical environment and the cultural environment surrounding them," said Sabloff.

Archaeologist Henry Wright of the University of Michigan, an SFI Science Board member and External Professor and a member of the project team, has written that states tend to exhibit the delegation of administrative authority along with a degree of interdependency, and they both are necessary for managing multiple urban centers.

"What distinguishes states from pre-state polities is the specialization of administrative tasks within the central control apparatus, such that the performance of one is dependant on others," said Wright. "The idea of indivisible chiefly authority grounded in concepts of sacred status is replaced by ideas about the delegation of authority based on competence."

What prevents the successful state from fissioning, then, as its administrative span of control grows and as layers of hierarchy are added, is the interdependence that arises among individuals performing specialized roles – along with a willingness to promote individuals as a reward or to remove them when needed to prevent rebellions. "Any polity with three or more stable levels of control hierarchy must have developed such a strategy," he said, "or it would have broken apart into warring factions."

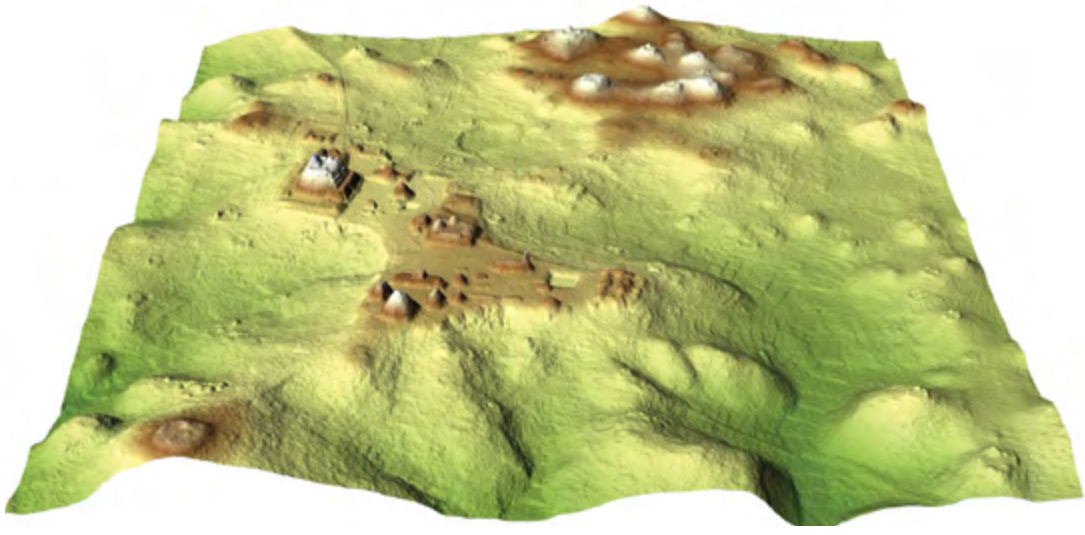
Deluge of Data

To uncover the underlying patterns of the earliest states, researchers can't work in a vacuum. They need data. and it just so happens that this is the golden age of archaeological data.

"The reasons we're in a much better position today than we might have been even five or ten years ago is that there are many more archaeologists, lots more field research and analyses, and a number of new efficient techniques, particularly in the realm of remote sensing – satellite imagery, aerial photography, and the like," said Sabloff. "We also have more sophisticated analytic techniques and more sophisticated complex adaptive modeling methods to tackle this problem in better ways than have been done before."

Combined with more than a century of traditional on-the-ground archaeological surveys and more recent groundbreaking work to assemble this information in modern geographical information systems, the data available today allow for unprecedented advances in theory building and theory testing, said Wright.

The next step is translating that data about individual digs into something that can be compared between ancient states around the globe. But just how do you, for instance, turn satellite photos, pot sherds, and burial sites of diverse cultures into comparable data?



3-D image of the site of Caracol (1200 BCE-950 CE) in Belize, one of the great cities of the ancient Maya. The image is generated using LIDAR, for light detection and ranging, an airborne remote-sensing technology that can penetrate jungle cover, yielding 3-D images of the ground below.

"It's hard," said anthropologist and SFI Omidyar Fellow Laura Fortunato, the associate project lead. "You can't directly compare some cultural practices. All you have is what's left in the ground." For that reason, the team will start with available indicators such as estimated population sizes, nutrition and disease information from bones, and estimates on the levels of inequality in societies based on what people are buried with after they die, she said.

After the mathematical models are up and running, the simulation itself becomes a laboratory for experiments in which the researchers can, in effect, "play God" by running histories of artificial societies. By adjusting variables such as population size and available labor, agricultural capacity, environmental stability, the number and directions of trade routes, and types and amounts of resources flowing into the system, for example, researchers can run simulations to see which of the system's features impact other features, and under which conditions

3-D MAP, UNIVERSITY OF CENTRAL FLORIDA CARACOL ARCHAEOLOGICAL PROJECT, WWW.CARACOL.ORG

World's first paycheck? Clay bowl found in Farrukhabad (Middle Uruk period, 4000-3200 BCE). After a period of labor, workers may have received rationed amounts of grain or other compensation, measured in standard-sized vessels.

states emerge. They can even run parallel simulations, isolating variables to try to find the subtle differences that matter most.

"We are in a very fortunate position to explore a whole range of evolutionary hypotheses, so we can play around with, let's say, varying strengths of different evolutionary processes," said Anne Kandler, an assistant professor in the School of Mathematical Sciences at City University London and an SFI Omidyar Fellow alum. "We can bundle them together. We can look at them separately, and that gives us some information about what each process does individually, as well as what we need to do in order to get complex systems going, to achieve the rise of complex societies."

The outputs from the model will be mathematical statements, of course, but they can be interpreted in terms that give insights into societies. One such output drawing on network theory, for example, could be which persistent social network structures could lead to long-term stability and which to relatively fast-changing structural features of the society, said Kandler.

Just as critical will be examining places in the world that seemed to possess all the necessary attributes for state formation but mysteriously did not incubate states.

"All the reasons for ancient states were present in California, but we didn't see a state emerge," said modeler and SFI Postdoctoral Fellow Eric Rupley. "Why not in Hungary? Why not in the American Southwest? This needs to be looked at from the reverse. It will give us unique insights."

It's also expected that models dealing with different variables – like population or wealth – might distill results that seem contradictory. But anomalous results are a good thing, said Rupley, because they can be used to improve the models or focus future research.

Global Villagers

"It's cool because we'll be working with such big datasets," said Rupley, "and we have the ability to integrate such different expertise."

"We have a unique team here of both faculty and postdocs, interns and external faculty, to contribute to the project," said Sabloff. SFI is suited to assemble such a team, he said. "At SFI we model everything from metabolic networks to cities. Human societies are at the most complex end of the scale."

Scholars on the transdisciplinary project include anthropologists Laura Fortunato, Paula Sabloff, Charles Perreault, and Paul Hooper; archaeologists Jerry Sabloff, Eric Rupley, and Scott Ortman; mathematician and modeler Anne Kandler; and physicist Murray Gell-Mann. External Professors on the team include archaeologists Henry Wright, Sander van der Leeuw, Tim Kohler of Washington State University, and Peter Peregrine of Lawrence University, whose *Outline of Archaeological Traditions* database and *Encyclopedia of Prehistory* are among the most cited cross-cultural, cross-history comparisons of emerging societies to date.

Ultimately, studying the emergence of states should have practical benefits, including insights into our modern society. "It took humans well near two million years to master matter," said van der Leeuw, regarding humanity's tool-making prowess. Then it wasn't until the late 18th century that fossil fuels freed us of energy constraints and led to an explosion of invention over the last 200 years, he said.

Now, with critical societal and environmental challenges, and with the Internet and modern transportation and trade essentially immersing us all in one massive, hyper-connected worldwide society, we might be able to pose new questions. What does this unprecedented level of connectedness imply for human social complexity, and what possibly might be the next steps?

How to even pose that question properly could be learned from looking at societies of the past, van der Leeuw said. "What I expect we will learn is not a recipe for the past that we can apply to the present, but a way of thinking that will change our way of thinking about our society." ■

Watch Jerry Sabloff's interview at www.santafe.edu/states

Larry O'Hanlon is a science journalist, carpenter, tool collector, and geologist based in Placitas, New Mexico.

CLAY BOWL, INSIGHTFOTO