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Complex Whistles Found to Play Key Roles in Inca and Maya Life

Much more than toys, the whistles were genuine musical instruments.

By WILLIAM J. BROAD

EXPERTS are teasing thousand-year-old secrets from the clay whistles, ocarinas and flutes of the ancient Americas, discovering that these old musical instruments are surprisingly advanced in their construction and tonal qualities.

Once dismissed as toys, these objects are now seen as ancient American wind instruments that were vital to the life of the Inca and Maya peoples, including the ruling elite.

Recently in Belize, a rich lode of instruments was unearthed from a royal tomb, underscoring their importance.

The new appreciation of the pre-Columbian instruments is being fueled by recent discoveries of musical objects at archeological sites in Central and South America and by increasingly rigorous analysis of such instruments for their cultural significance and mechanical action.

Indeed, some are turning out to be so complex that they have no counterparts in modern instruments.

Army of Researchers

In the last few years, a small army of physicists, archeologists, anthropologists, musicians, ethnomusicologists and craftsmen have probed these ancient wind instruments with tools, X-rays, stethoscopes, stroboscopes, tape recorders, frequency meters and spectrum analyzers.

In one case, a tiny ocarina, which is generally more complex than a whistle and wider than a flute, generated much interest because it had an impressive ability to produce 17 notes. X-rays showed it to have three hidden chambers that gave it unusual versatility.

The earliest pre-Columbian clay instruments, found on the coast of present day Ecuador, date from thousands of years B.C. The art of instrument making flourished until the time of the Spanish conquest in the 16th century, and is still practiced, though with diminished skill, by descendants of the prehistoric Americans.

"People think of these objects as signaling devices or playthings," said Sue Carole DeVale, head of the systematic musicology program at the University of California at Los Angeles. "That's wrong. They were clearly musical instruments, used for ritual and pleasure."

Few written records were left by the peoples who made and played the ancient instruments, forcing modern experts to glean tantalizing clues about their use from the objects themselves, their sounds, Spanish accounts and ancient Indian murals. For centuries, pre-Columbian instruments were generally regarded as curiosities that were valued more for their shapes than for their ability to produce music. Every major museum had a few, although curators sometimes did not realize they were musical instruments or know how to make them come to life. Moreover, the instruments revealed little about the people who used them since the objects had often been removed from their cultural context by grave robbers and curio dealers.

"Because the remains of musical instruments have

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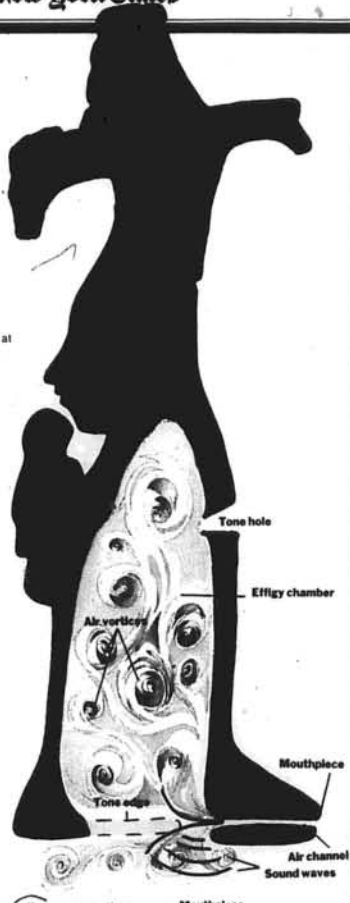
Anatomy Of a Whistle

Maya whistle, shown at left and in cutaway at right, was found in fragments in Belize.



Ancient Instrument's Voice

A stream of air is split by a wedge-shaped tone edge into swirling vortices that produce a tone. Covering the tone hole varies the pitch.

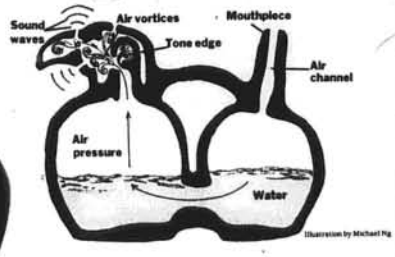


Illustration by Michael Pig

Incan Whistle Driven by Water

Sloshing water in this bottle drives air into the bird's head, where it is forced into a stream and split into sound-producing vortices.

Pictures of Maya whistle, courtesy of Paul Healy, anthropology department, Trent University

Temperature For World Rises Sharply In the 1980's

Some scientists maintain that they are finally seeing results of greenhouse effect.

By PHILIP SHABECOFF

Special to The New York Times

WASHINGTON, March 28 — Average global temperatures in the 1980's are the highest measured since reliable records were first kept over 130 years ago, according to reports now coming in from scientists around the world.

Temperatures have been rising more or less steadily for much of the last century. But, in the view of some scientists, a sharper rise detected in the 1980's is the most persuasive evidence yet that carbon dioxide and other industrial gases are trapping heat in the atmosphere and warming the earth as if it were a greenhouse.

In interviews, meteorologists and others engaged in plotting global climate trends were cautious about blaming the greenhouse effect for the recent sharp increase, saying mathematical models of the phenomenon project much sharper increases than have so far occurred.

But several agreed that if the pattern persisted into the next decade, it would almost certainly mean that an era of global warming, caused by humans and certain to affect them in major ways, has begun.

How hot is the world now? The scientists do not offer a straightforward response, saying that the vast amount of data is still being studied and that comparisons cannot be precise. But the data gathered by American, British and Soviet scientific teams generally show a faster warming so far in the 1980's than in the century before. And most of the readings agree that the three or four warmest years on record occurred in this decade.

One of the scientists, Dr. James E. Hansen of the National Aeronautics and Space Administration's Institute for Space Studies in Manhattan, said he used the 30-year period 1950-1980, when the average global temperature was 59 degrees Fahrenheit, as a base to determine temperature variations. He said his readings showed that the average global temperature rose about as much since the base period as it did from the 1880's to the base period — about half a degree in both cases. He stressed that these were estimates and that it would take millions of measurements to reach an accurate global average.

> New reports say the earth's warmest years on record occurred in this decade.

Mathematical models project that at the current rate of buildup of the gases thought to cause the greenhouse effect, the average global temperature will rise from the 59-degree base by 3 to 9 degrees Fahrenheit by about 2030, with increases substantially greater at higher latitudes but lower increases near the Equator.

Dr. Hansen said the temperature was increasing in this decade even as natural factors were keeping surface temperatures lower than they might have been. These factors, he said, are relatively low radiation from the sun and high volcanic activity, which produces particles that tend to filter out some solar radiation.

As the earth warms, experts predict major changes in climatic patterns and a gradual rise in sea levels as the warming oceans expand and polar ice melts. Coastal flooding, dust bowls, sharply reduced crops, and dying forests could result in some regions. On the other hand, *some relatively barren areas might become farmlands.*

Tom Wigley, director of the Climatic Research Unit at the University of East Anglia in Britain, said that his data, taken from stations on the ocean as well as on land,

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Study of Normal Mourning Process Illuminates Grief Gone Awry

Research describes the stages of the process from denial of death to acceptance.

By DANIEL GOLEMAN

MOURNING a loved one is always painful, but some people find the process more difficult than others, either becoming too distraught or holding too much emotion in. In studying these extreme reactions, researchers are coming to a sharper understanding of the normal course of mourning, and of the signs that it has gone awry.

The research is also spawning new psychological treatments for those who have trouble grieving. Most of the treatments focus on helping mourners follow the normal path, moving past a point where they might have become "frozen."

The death of a loved one "is the prototypical psychological catastrophe, a blow to the unconscious sense of personal invulnerability that most of us carry," said Dr. Mardi Horowitz, a psychiatrist at the University of California Medical School at San Francisco. Dr. Horowitz, who has long been a leader in research on mourning, has just completed a new study on grief. More than any other research to date it details the specific ways in which mourning can go off course.

Dr. Horowitz said that the issue was a pressing one because about of a third of those who come in for psychiatric therapy have had difficulties mourning a loss, often one suffered long ago. In many cases, it is not the difficulties themselves that bring the person to therapy, he said. Instead, the issue arises as therapy progresses.

The main signs of mourning, such as overwhelming sadness or anger, typically decrease noticeably after six to nine months, research suggests, and signals of the end of mourning come after a year or so. But researchers say that mourning for two or three years is not unusual, and in some people signs of grief can linger for years.

The question of when a mourner needs psychological treatment is best answered, according to Dr. Horowitz and others, by distinguishing between normal grief and extremes of intensity or duration. While a typical mourner may be deeply disturbed at various moments, that does not necessarily indicate the need for treatment. But some extremes indicate a freezing of the course of mourning, and therapists say that those who have not completed the mourning process may need help.

Some troubled mourning can approach the bizarre. One man kept his dead father's broken cameras hanging in his clothes closet for 14 years so he could glimpse them while he dressed in the morning. Another man had his

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Doug Keating

DANCE: A tribute in Boston for Plisetskaya, page C13./ **THEATER:** Broadway offering more to black theatergoers, page C13.

BOOKS: "Paris Fashion" explores clothes in culture, page C18./ **TV:** 2 shows for the young about homelessness, page C18.

Outbreaks of 2 Diseases in Coral Prompt Assessment of Caribbean's Reefs

An 'important marine resource' might be at risk.

By WALTER SULLIVAN

CRUZ BAY, V.I.

ALARMED by outbreaks of two diseases in coral, researchers are beginning ambitious programs to evaluate the condition of reefs throughout the Caribbean and neighboring waters.

The latest problem is white band disease, which girdles a coral, primarily of the elkhorn type, and can kill it. It has recently been found in many parts of the Caribbean, and the reefs of Buck Island Reef National Monument, off St. Croix in the Virgin Islands, have been severely affected.

Last year the most severe outbreak on record of another coral disease, bleaching disease, struck corals from Colombia and Venezuela as far north as the Florida coast near Palm Beach. Although much of the bleached coral appears to be recovering, the outbreaks have left scientists worried that some unknown, long-term factor is affecting the world's reefs.

'Important Marine Resource'

Until now little has been done to keep track of what is happening along the reefs. Yet, according to Dr. Judith C. Lang, who is coordinating what is probably the most extensive study, reefs are "one of the most important marine resources of the Tropics." Dr. Lang, who is curator of invertebrate zoology at the University of Texas's Memorial Museum in Austin, has reported that in Puerto Rico, 180 species of edible fish are found only on reefs.

Doug Keating

Brain coral in Virgin Islands, showing bleached area at upper left.

According to Dr. Caroline Rogers, biologist of the National Park here on the island of St. John, the bleaching disease chiefly attacks varieties of brain coral, named for their bulbous shape and labyrinthine markings, which resemble the brain. All told, however, specialists say 60 species of brain and other coral have been affected in the Caribbean, and a similar outbreak has infected 24 species in Australia.

While Dr. Rogers has found that many brain corals are recovering, a recent inspection of reefs in Great Lamsabur Bay, on the south side of St. John, has shown that another type, fire coral, which once covered 40 to 80 percent of the shallow reefs of the bay, has died off, leaving the reefs open to colonization by other species of corals and by other organisms and leading to basic changes in the reef habitat.

Corals are formed by polyps, small invertebrate animals that grow on the skeletons of former generations, gradually building up reefs in tropical waters. Coral reefs take centuries to grow; it is estimated that 1,000 years are needed to build a reef 40 feet high. For food corals depend in part on microscopic photosynthetic algae. When a coral or the algae are ailing, the dark algae leave the coral, "bleaching" it; the coral's white skeleton becomes visible through its transparent tissue. The coral can live only six to eight weeks without the algae.

White band disease has been found from the coast of Venezuela all the way to the Bahamas. Scientists do not know what causes it, how fast it spreads, how long it lasts or how it kills, according to Dr. John C. Ogden of the West Indies Laboratory, operated on St. Croix by Fairleigh Dickinson University in New Jersey.

An earlier outbreak, affecting staghorn corals, which, like the elkhorn species, resemble antlers, may have been caused by the same source, but little is known of either. The form attacking elkhorn corals first infects the base of the coral and then works upward.

Specialists say they cannot rule out the possibility that the two diseases or others might be threatening the existence of coral species. They note that corals near the northern limits of their range, off Florida and the Bahamas, are highly vulnerable to environmental changes, including pollution.

According to Dr. Rogers, some brain corals off St. John are now totally dead because of the bleaching disease. Parts of some others have died and become coated with another type of algae that lives only on dead surfaces. But many corals recover from loss of the photosynthetic algae. Successive photographs of the same corals have confirmed that they have thrown off the disease.

Role of Currents Doubted

According to Dr. Rogers, Billy D. Causey, manager of the Looe Key National Marine Sanctuary in the Florida Keys, found over the winter that many corals had recovered entirely, while others remained blanched.

Dr. Lang and Dr. Walter C. Jaap of the Florida Department of Natural Resources said the disease could not have been carried by ocean currents. The currents would take more than six months, for instance, to carry the disease from Panama to Florida, yet the ailment appeared all around the Caribbean about the same time, they said.

This contrasts with the gradual spread around the Caribbean of the disease that killed off most of the region's sea urchins, which live along coral reefs and elsewhere undersea, in 1983 and 1984.

Visits to half a dozen beaches here on St. John have shown that sea urchins have returned and some have grown very large. But they are by no means as abundant as they used to be. On neighboring St. Croix, according to the Newsletter of Fairleigh Dickinson's West Indies Laboratory, large algae have taken their place, "dominate many areas of the reef and are rarely eaten by herbivorous fish."

The favored explanation for the coral bleaching has been the unusually long period of high seawater temperature last year. Not until after Christmas did the water cool, Dr. Ogden says. A number of investigators believe this promoted the disease, but in what way they are not sure.

'Could Bode Very Ill'

Coral species recovered from each of the earlier outbreaks.

But Dr. Ogden said the early onset of warm water this year was "disturbing" and could mean that a new bleaching episode could occur before corals fully recover from the old one. "This," he said, "could bode very ill."

There are skeptics about the warm seawater theory, however. Among them is Dr. Donald K. Atwood of the Atlantic Oceanographic Laboratory, operated in Miami by the National Oceanographic and Atmospheric Administration. He noted that in the Pacific Ocean at least, coral bleaching has begun only when sea temperatures remained above 30 degrees Celsius (86 degrees Fahrenheit) for weeks. Dr. Rogers points out that the bleaching last year affected corals 100 feet deep or deeper, where the water is not likely to have stayed hot for extended periods.

In the reef study coordinated by Dr. Lang and financed by the National Science Foundation, questionnaires have been sent to scientists in 40 countries and on Caribbean islands, seeking past records of such factors as seawater temperature and urging new assessments of reef conditions through what are called standardized "transects."

In a transect, observations are made along a light-weight chain or tape laid across a reef and marked at intervals of 10 centimeters (4 inches) to aid in specifying where each feature is seen. Periodic transects across the same stretch of reef should indicate any changes.

The National Park Service has provided funds for monitoring reefs within National Parks in Biscayne Bay near Miami, in the Dry Tortugas islands off the end of the Florida Keys, on St. John and at Buck Island.

The United Nations Environment Program administers a "regional seas" program in the Caribbean. According to Dr. Ogden, its counterpart in the Mediterranean has been a "tremendous success," despite deep hostility among some countries bordering that sea. In the Caribbean, however, he said "nothing is happening" as far as reef monitoring is concerned. The program's focus, he said, is on oil spills and harbor pollution.

Fermat's Theorem Solved? Not This Time

By JAMES GLEICK

THE most notorious unsolved problem of mathematics, Fermat's Last Theorem, appears to have defeated yet another attack, put forward this month by a Japanese number theorist.

Experts who examined a draft manuscript by the number theorist, Yoichi Miyaoka at the Max Planck Institute in Bonn, have found gaps that seem serious, at least for now.

"It's looking rather poor," said Don Zagier, another number theorist at the institute. "There have been many objections, some easily handleable, but now several points have arisen which at the very least are quite worrying. Miyaoka himself is now not sure that his proof is correct."

Amateurs and professionals alike have struggled for 350 years with this deceptively simple conjecture about numbers, scribbled in the margin of a Latin mathematics text by the great 17th century mathematician Pierre de Fermat. He asserted that no combination of whole numbers, zeroes aside, could satisfy the equation $x^n + y^n = z^n$ for n greater than 2.

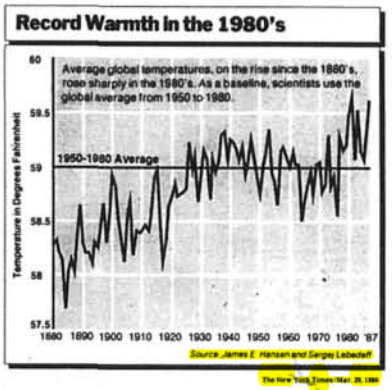
When n equals 2, there are infinitely many solutions: pairs of perfect squares whose sum equals a third perfect square, such as $3^2 + 4^2 = 5^2$. Fermat's contention was that for cubes and higher powers, no such sum would ever be found.

Dr. Miyaoka, who has been unwilling to comment publicly, tentatively proposed that he had proved a far more general result that, as a secondary byproduct, would have proved Fermat's Last Theorem as well — or almost proved it. One loophole would have remained, which mathematicians said might have been closed with some computer calculations.

The history of mathematics is littered with failed proofs of Fermat's Last Theorem, but, to many mathematicians, the problem is beginning to seem less unreachable than in the past. Dr. Miyaoka, a distinguished mathematician who has made important advances in number theory, is working to salvage his approach.

"It's not quite that he's retracted the proof or that all is lost," Dr. Zagier said. "But there's still work to be done, and it may be a lot of work."

Global Warming Trend Accelerates in 1980's



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found that 1987 was "the warmest year on record" and that the three warmest years in the record were 1987, 1983 and 1981.

He said in a telephone interview, that while some of his data supported the predictions of the greenhouse models, others did not. For one thing, he said, the temperature levels in the higher latitudes of the Northern Hemisphere did not rise as fast as the models predicted.

'Hard to Deny'

But he said that if "the next 10 years are as warm or warmer, it would be very hard to deny the greenhouse effect," adding, "It is very hard to deny now."

"Chances are the greenhouse effect is not as strong as some people say, but you can't say it isn't happening at all," he said.

Both Dr. Wigley and Dr. Hansen said temperatures taken by Soviet scientists were similar to theirs.

Temperatures in the United States in this century did not rise as fast as global temperatures; several explanations are possible, including a different climate circulation over the country and pollution particles that block solar radiation. Still, measurements by the National Climatic Data Center of the National Oceanic and Atmospheric Administration show that the last few years were substantially warmer than any year since the 1850's in the United States.

Thomas Karl, research meteorologist for the center, said that 1986 and 1987 "were both unusually warm" in this country with an average of 54 degrees Fahrenheit for both years.

"Our data are not inconsistent with the greenhouse effect," Mr. Karl said, but "I am more cautious than others. I found you can get in a heap of trouble if you look at a climate time series and draw an inference. You can get swings that last for 10 or 20 years."

Gradual Rise Since 1800's

Global temperatures had already shown a gradual rise since the late 1800's. The century-long warming trend is still considered a "real mystery," although the greenhouse effect is probably part of the answer, said Alan Hecht, director of the National Climate Program, a Federal office.

Dr. Hecht noted that the earth was now in the later stages of an interglacial period, meaning the temperatures should be growing cooler as a new ice age approached.

He said the amount of carbon dioxide in the atmosphere had risen from 280 parts per million to 340 parts per million over the last century, probably because of the burning of fossil fuels and the destruction of forests whose trees use carbon dioxide.

A Lag in Temperature Rise

Given that increase of carbon dioxide, global temperatures should have increased by almost 2 degrees Fahrenheit over the century, under the assumptions of most of the models. But in fact they increased only about 1 degree, said Michael E. Schlesinger, associate professor of atmospheric sciences at Oregon State University.

One possible explanation, he said, is that "the models are more sensitive than nature." A more likely explanation, however, is a lag between the emission of greenhouse gases and the greenhouse effect because much of the extra heat is stored in the oceans rather than moving immediately to the atmosphere.

> **Rise in temperature occurs despite factors that should be cooling the earth.**

Dr. Schlesinger said testing the greenhouse models required not just taking readings of global temperatures but also plotting their geographical distribution. He said that he and colleagues were doing that now and that the results were so far mixed.

Meanwhile, human activity is sending carbon dioxide and other gases that trap radiation from the sun, including chlorofluorocarbons, methane and nitrous oxides, into the atmosphere at faster rates. If the models are correct, that means that global temperatures will rise sharply. Chlorofluorocarbons are also believed to be destroying the stratospheric ozone that shields the earth's surface from ultraviolet radiation from the sun.

Michael Oppenheimer, an atmospheric physicist with the Environmental Defense Fund, a group based in New York, said, "If the last few years are taken seriously it means the world is now warming very rapidly and, at the beginning of the next century, the climate warming will be the major environmental problem of the globe."