ART TO ZOO

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October 1991

# The Survival Game after Columbus: Pigs, Weeds, and Other Players

At the beginning of 1492, the Old World and the New had been cut off from each other for approximately 10,000 years. Now this separation was about to end.

For weeks, three small Spanish ships had been venturing farther from Europe into the uncharted waters of the western Atlantic, through unfamiliar winds and unknown currents. No one on board was even positive that there was land out there. Columbus himself, the leader of the expedition, had been deliberately under-reporting the distances traveled each day, in an effort to assuage his sailors' anxiety. Even so their fear of the unknown was bringing them to the edge of mutiny.

Then, on the evening of October 11, land was sighted—the Bahamas (though those on shipboard thought they were seeing Asia).

The next day, a party of Europeans stepped ashore onto American soil . . . establishing a contact between Old World and New that has continued to this day.

There was no way that these people could possibly have guessed what massive trains of cause and effect they were setting in motion—trains of cause and effect that today are still shaping our lives.

*What happens when living creatures from two worlds that have been evolving separately for 10,000 years are suddenly thrown together?*

It was as if the wall separating* two rooms stuffed full of living creatures had been torn open. Creatures from both rooms began to pour through the opening, bumping into each other, attacking, fighting back, competing, eating, being eaten, struggling to find food and living space and safety in a scheme of things that was suddenly completely different.

Even while the Europeans and the Indians were examining each other with amazement and struggling to exchange thoughts without a common language . . . biological exchanges were proceeding fast.

Microorganisms from European lungs were being breathed out into the New World air . . . and being sucked into Indian lungs. Seeds stuck to Spanish boots were being scraped off and ground into American soil. Soon American foods would be entering European stomachs, and Indians would be sampling European foods the Spaniards offered. European body wastes, along with the bacteria and parasites they contained, would be deposited on New World soil. Spaniards would be packing up samples of American plants and animals, and kidnapping some Indians, to show off back in Spain. . . .

And this was just the beginning of an endless stream of further arrivals from the Old World: human beings, dogs, pigs, horses, cattle, food plants, grape cuttings, fruit pits, olive trees . . . and more and more varieties of unwittingly carried seeds and spores and germs. . . .

But before going on with this story, let's leave this scene and set up an analogy that can help your students focus on some biological essentials of the upheavals that Columbus was setting in motion.

(Please stop here and read "The Game of Survival," on the Pull-Out Page. Then continue with this Teacher's Background.)

Since our space is limited, we can discuss only a few examples in this ART TO ZOO. We have chosen ones that suggest parallels that your students can discuss . . . and that illustrate ecological principles that have vital implications for us today.

*Actually, the separation was not total. More about this later.

Picture from *Florentine Codex*, photo by Isabella Sansoni, courtesy Biblioteca Medicea Laurenziana, Florence

Unloading Old World items onto New World soil. This ART TO ZOO describes what happened to some of the *living* freight—including hoofed livestock like the pigs, cattle, sheep, and horses in the foreground of this picture.

## Livestock Colonizers

Human beings and their livestock (pigs and cattle will be our main focus here) had been living close to each other and depending on each other for thousands of years in the Old World. People there led their herds to pasture, provided water and winter fodder, set shepherds to guard flocks against predators, and provided barnyard shelter when necessary.

For these human populations, taking care of their livestock was a move that paid off: the livestock played a vital role in helping the human beings survive. People ate their animals' meat, drank their milk, wrapped themselves in their hides, rode on their backs, and used their musclepower to haul their plows and carts and carriages. . . .

Naturally, when Europeans came to the New World, they brought livestock with them.

What happened to these Old World animals when they were set down in the New World—where the game had developed with different players, into a different set-up?

Most domesticated animals from the Old World did well in the New. They multiplied dramatically, spreading into more and more regions. Some ran off and flourished in the wild.

Pigs followed this pattern the soonest and fastest. They were ideal colonists—tough, omnivorous, and prolific. They gorged themselves on the abundant fruits and nuts of the Antilles, where they were first set down, and began producing three litters a year.

Soon more and more pigs were eating their way across more and more New World areas: gobbling nuts and fruits, gouging up roots, ripping out plants. . . .

Cattle too raised havoc in their new surroundings, as they ate and trampled their way through populations of native plants unadapted to abuse on this scale. It wasn't many years before herds had established themselves up and down the Americas.

When these and other Old World hoofed farm animals stepped onto New World soil after crossing the Atlantic, they were entering a world that had been proceeding along different lines from back home. These animals thrived in their new surroundings because, in the main, they found there ample food, few competitors, few predators, and few diseases to which they were susceptible.

The contrasting histories of the Old and New Worlds provide some clues to why this was so.

In the Old World, where hoofed grazers (both domesticated and wild) were numerous, whole networks of players had evolved together. The various species developed ways of surviving in each others' presence. . . and even of using each others' presence as their means of surviving. Germs and worms evolved that could use grazing mammals as hosts. Predators were drawn to places where livestock offered easy prey: wolves stole lambs from flocks; foxes stole chickens from barnyards. And plant species that evolved in ways that allowed them to survive and reproduce even after being trampled

Continued on page 2

*continued from page 1*

and gnawed gained a competitive edge.

The New World was a different story. American Indians were superb plant growers, but they had few domesticated animals: some dogs, guinea pigs; a few kinds of fowl; and, in the Andes, llamas and alpacas. Large *wild* herds of hoofed grazers were also uncommon in the parts of the New World where the Spanish settled early on.*

This situation made for different developments. Here in the New World, parasites were adapted to New World animals, not to the Old World grazers. Here, most plant populations were not particularly well equipped for surviving heavy onslaughts from animals, because until the spread of European livestock, to do so had offered no particular survival advantage. And here there were few predators able to prey on animals as large and tough as these European pigs and cattle.

This situation gave the Old World animals an opening in the game—and they were quick to take advantage of it. But winning moves by some players spell losses for others.

The proliferation of Old World livestock in the Americas made survival harder, or even impossible, for many of the native American plants and peoples. As Old World cattle, pigs, and horses spread across American landscapes, they packed down the soil with their hooves, crushed plants underfoot, gnawed down plants. . . . Result: in place after place, native plant populations were snuffed out.

The spread of Old World livestock made survival harder for native *people* too. Plant foods were the mainstay of most Indians' diets. As the herds grew, local humans found themselves competing with the livestock (especially with pigs) for wild plant foods that both ate. Meanwhile, the Europeans were turning more and more land into pasture. Often this meant that the Indians could not even count on harvesting the produce they planted in the gardens they were able to hold onto—because livestock from nearby, usually unfenced, pastureland were apt to wander in, trampling and consuming the crops.

But the game—the environment—never stands still. As the years passed, the livestock lost some of their initial advantages. Most important, these newcomer animals began in many places to eat their way through their food supply. The animals' initial population explosion usually lasted only a few decades in any area.

Take cattle in what is now Mexico, for example. They were introduced for breeding purposes in 1521. At first there were so few that killing any was forbidden. But within just a few years, the cattle were doing so well that cattle ranches were springing up all around. When the cattle spread into the rich grasslands in the northern part of the country, their rate of increase soared even higher. One writer noted in 1579 that a herd of 20,000 was considered small in these parts, and some ranches had as many as 150,000. (Back in Spain, herds of over 1,000 were rare.) Yet by the late 1500s, large areas of central Mexico had been so overgrazed that cattle in some places were starving to death. The great herds began to shrink.

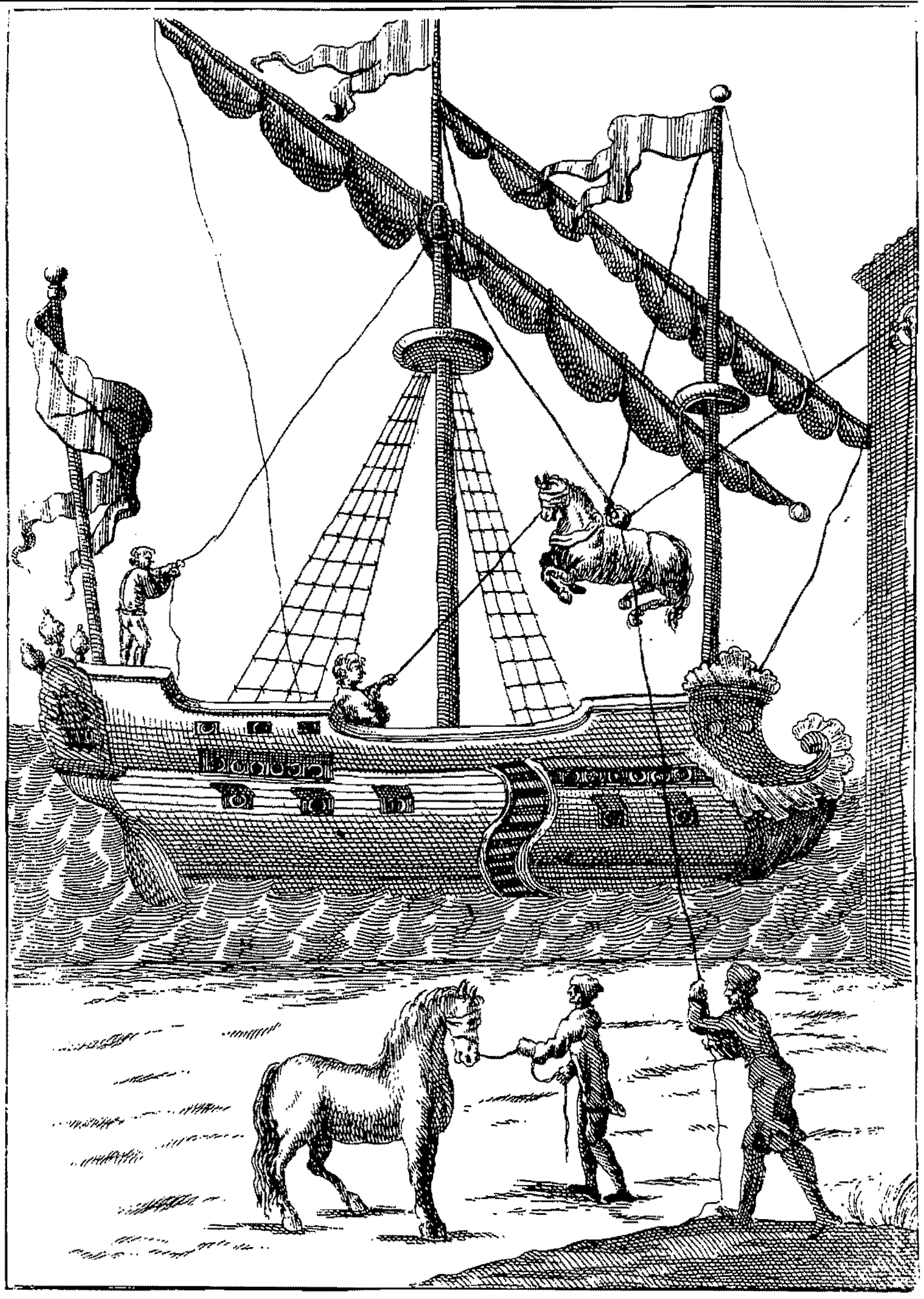
## Plant Colonizers

For Old World people and their animals, moving to the New World created opportunities to prosper. But they were not the only newcomers for whom the move was advantageous: Old World plants too were soon spreading over the Americas.

Some of these plants were brought over on purpose, as the livestock were, by Spanish colonists eager to have a local supply of the foods they were used to. The Americas offered variety enough in climates and soils so almost any European crop could find a place there to flourish. It wasn't long before Spaniards in the New World were eating bread made from American-grown wheat with olives from American-grown trees, washed down with wine pressed from American-grown grapes—even though none of these food plants had existed in the Americas before.

In addition to these and countless other Old World food plants that were brought over and cultivated, numerous *wild* Old World plants—weeds—came to the New World and flourished. When the European livestock munched and trampled populations of native plants out of existence, it was very often Old World plants that moved in to replace them. In the West Indies, Old World thistles, nettles, and sedges were proliferating by the early 1500s. In Peru, European clover spread so aggressively that it smothered out native crops in many areas. And by the end of the century, the weed population of central Mexico was made up mostly of Eurasian plants.

*Farther north, in what are now the United States and Canada, there were huge herds of buffalo.



Courtesy Bancroft Library, University of California, Berkeley

Horses being loaded for transport to the New World. On board ship, horses were often held in slings to keep them from falling. Nevertheless, as many as half died during the ocean crossing. In the New World, horses were slower to establish themselves than were pigs or cattle. The tropical lowlands where they were first introduced were not well suited to them. Once they reached temperate grassland areas, they multiplied rapidly.

Why was it that *Old* World plants—rather than indigenous New World ones—so often moved in when local plant populations were destroyed?

To get some inkling of possible reasons, it's necessary first to think about what weeds are.

*Weed* is not a scientific term. It's what people call plants they consider "useless" or don't want around. What is thought of as a weed in one place may be cultivated deliberately elsewhere. For instance, the clover that ran wild in parts of Peru, stifling indigenous competitors including Indian crops, in other times and places is raised to provide forage, prevent erosion, and put nutrients back into the soil.

Weeds grow exuberantly under what would seem to be the worst of conditions—in habitats that have been deeply disturbed: plowed up, burnt over, flooded out. Weeds can thrive in the scorching sunlight of stripped spaces. They grow fast. They propagate under conditions that kill off less aggressive species. Weeds often possess several ways of propagating: by means of shoots, for instance, bits of root, bulbs, runners that snake out over the ground, or seeds that can survive passage through an animal's digestive system and then invade a new territory by sprouting wherever they emerge.

Back in Europe, there were plenty of disturbed areas where these qualities were called for. For thousands of years there, herds of animals had been trampling and munching, and human beings had been plowing up fields, clearing forests, and building roads and towns. Where such conditions prevailed, it was the plants with weedy resilience that best survived . . . and by competing with each other over the centuries, they became even better at flourishing in adversity.

New World conditions were quite different. Fewer people, as well as fewer grazing mammals, lived there. Estimates of the total human population of the Americas at the beginning of 1492 vary widely, but around 100 million people would be in the reasonable range. At the same time, the Old World population was probably approaching 600 million.

In other words (since the Americas together cover half the area of Europe, Asia, and Africa together) the New World had on average one-third the Old World's population density*—one-third the number of people per square mile, on average, to tear up their surroundings. Moreover, New World people had lifestyles that tended to be less destructive of their environments than the lifestyles of Old World people.

American Indians, for example, used digging sticks and hoes—far less invasive agricultural tools than the European plows, which could churn up whole fields.

With the arrival of the Europeans, this changed. Wherever they settled, these human newcomers created upheavals in their surroundings. They burned and cut down forests, plowed up land, set loose livestock, dug mines. . . .

In short, they created just the kinds of conditions that Old World weeds were particularly well adapted to taking advantage of. Transported to the Americas, these plants moved quickly, making the most of a superb opening in the game.

*Throughout most of the New World's history, its population had been smaller and more widely scattered. But in the last thousand years or so before Columbus, thickly populated areas had been developing in parts of what are now Mexico and Peru, and to some degree in Central America. Teotihuacan, in Central Mexico, was by 500 A.D. probably the sixth largest city in the world, with about 200,000 inhabitants.

By 1492, well over half of the people in the Americas were clustered in these built-up areas; the rest were scattered thinly over the huge remaining portions of the American continents.

## Germ Colonizers

In the years after the two worlds came into contact, epidemic after epidemic of Old World diseases struck down staggering numbers of Indians. Over and over, on down into our own century, whenever formerly isolated New World populations have come into contact with Old World people, Old World diseases have taken heavy tolls.

These Old World diseases spread for many of the same reasons that Old World livestock and Old World weeds spread: thrust into the New World, they found themselves in surroundings that offered plenty of food and few enemies—surroundings suited to a different combination of players.

To understand why Old World diseases struck the way they did, it is necessary to think about the fact that germs (like livestock and weeds) are living creatures. Like all living creatures, *they* have to find the resources they need or they will die. They too play the game.

From people's point of view, the germs that infect them with a serious disease are a threat. But from the germs' point of view, the people are an opportunity—a place to live, an environment that can provide food and shelter.

For a population of germs and a population of hosts (people are the host species we are talking about here) to keep living in the same geographical area, they have to reach some kind of balance. Otherwise, one or both of the populations will die out:

*The antibodies that a baby can receive from its mother for a short while are an exception.

• If the people are too *resistant* to the germs, the germs won't be able to successfully take up residence . . . and will die out.

• If the people are so *vulnerable* that everyone who is infected immediately dies, then both populations will probably disappear: first the people will die of the disease; then the germs will die because there are no more hosts left to live in.

One way that human beings defend themselves against invasions by populations of germs is by producing *antibodies*—special molecules that destroy a particular species of germ.

Nowadays, inoculations can induce people to produce antibodies to diseases they have never encountered naturally. But this is a new development, and one limited to certain diseases. In the past, a person had to be naturally exposed to a disease—the germs producing that disease had to actually invade the person's body—before the person could produce antibodies to that disease.* If a particular kind of germ had never been around, then people had no antibodies to protect them against it.

From the germs' point of view, then, moving into a new geographical area can be an excellent move. When germs come across a human population without antibodies to them, it is like a burglar coming across a town without locks.

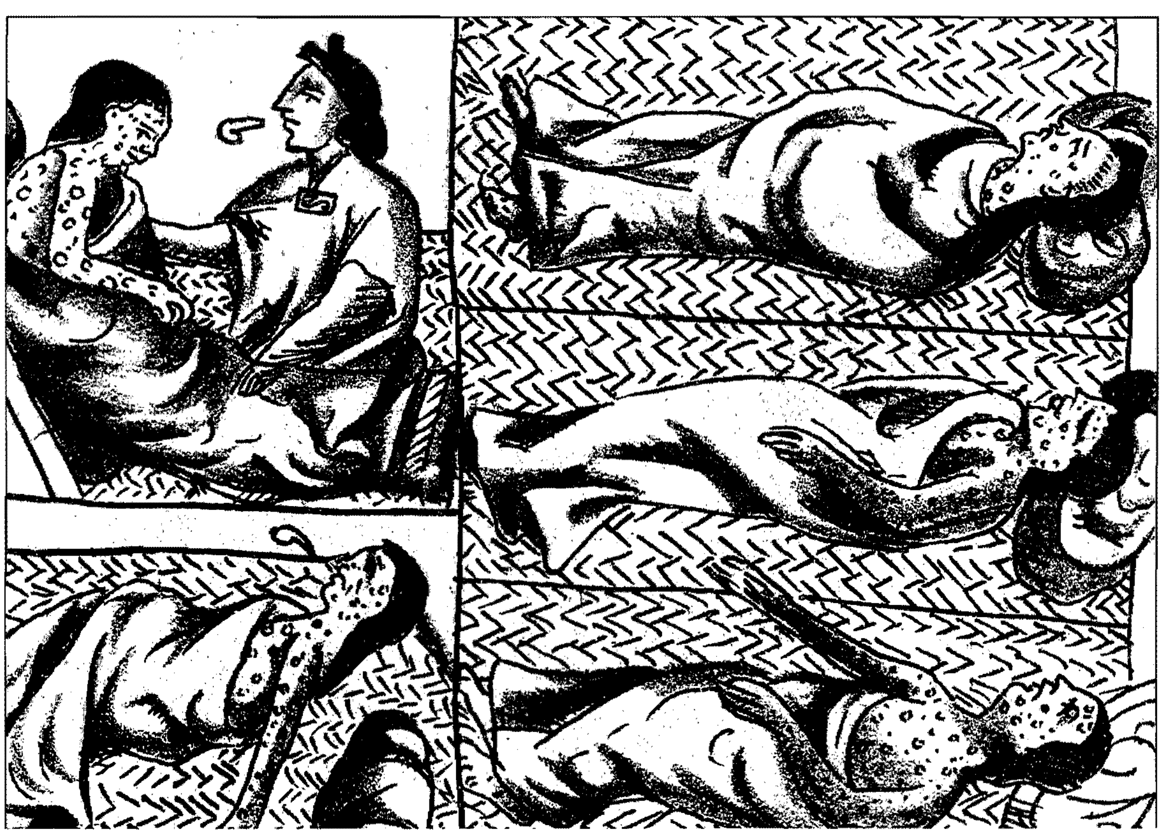
Of course, soon the townspeople will order locks and the people exposed to the germs will begin to produce antibodies to them. For this reason, the germs' move helps them most early on.

Now let's look at how this actually happened with one particular disease—smallpox.

***Smallpox.*** Smallpox was probably the first massive epidemic of an Old World disease to occur in the Americas. It arrived in 1518, when it landed on Hispaniola (the island that today comprises Haiti and the Dominican Republic) and wiped out all but a thousand of the Indians living there.

Then it advanced like fire across the Americas. Wherever the smallpox germs went, most Indians came down with the disease, and somewhere between one-third and one-half of those who caught it died. In Mexico, smallpox struck just as the Aztec Indians were preparing to attack the small band of Spanish invaders. In Peru a few years later, it killed off—among countless other victims—both the Inca leader and his successor within just a few hours, leaving the indigenous government in disarray.

The Spaniards, meanwhile, remained untouched. To both Spaniards and Indians, it must have seemed that heaven had turned its back on the native American peoples.



American Museum of Natural History

Smallpox was just one of the Old World diseases that took terrible tolls among New World people.

Diseases seemed to single out New World victims. They also seemed to travel from Old World to New, but seldom in the opposite direction.* Why? Once again, the very different circumstances in which Old and New World peoples had been living can help explain these contrasts.

***Old World.*** Long before Columbus, Europeans—especially city dwellers—had become immunologically cosmopolitan. With trade connections reaching all the way across Asia, through the Middle East, and into Africa, Europeans had for centuries been importing exotic germs along with exotic goods.

Even places that Europeans never visited directly could export germs—for a disease could spread from person to person along trade routes.

Diseases from all over the Old World thrived in Europe, especially in large ports, where crowding and poor sanitation created ideal conditions for the spread of illness. Smallpox, typhus, measles, and other diseases kept permanent residence in such places. Virtually all city dwellers who survived to adulthood had become immune. Yet the germs causing the illnesses did not die out, because there were always enough children being born so the germs could find vulnerable hosts.

***New World.*** Circumstances in the Americas right before Columbus were very different—and, unfortunately, perfectly suited to maximize the spread of imported diseases.

• *Isolation had prevented the development of immunities.* Since the Americas had been cut off from the rest of the world for about 10,000 years, the Indians had had no chance to develop immunities to foreign germs.

• *The Bering "decontamination chamber."* What about the germs that the original Americans brought with them when they crossed over from Asia? Didn't they bring Asian (Old World) germs?

Probably far fewer than if they had crossed into the Americas through a milder area. The cold in the Bering land bridge area probably killed off a lot of the germs that the immigrants carried. Their bodies had already produced antibodies, and only healthy people were likely to have survived the rigors of the trip. The first New World peoples probably entered the Americas relatively disease-free.

• *Low population density in past.* Moreover, during most of their history, New World peoples were spread out thinly, making large-scale epidemics unlikely. Where there are no nearby hosts to infect, populations of germs tend to die out.

• *Recent rises* in population density. However, as we have seen, areas of dense human population had developed during the last centuries before Columbus. The Indians in these regions had lost the protection of low population density; here there were plenty of people to fuel any epidemic that might start.

• *Absence of domesticated herds.* Some Old World germs that infected people passed part of their life cycle in animal hosts, particularly in the domesticated animals that were so common there. The relatively small number of domesticated species and the absence of large herds in the New World tended to make this an ineffective play in the New World.

# Lesson Plan

### Step 1: How Many Pigs?

Begin by having your students carry out the "How Many Pigs?" activity on the Pull-Out Page, as homework.

In class the next day, after the children have checked their answers, give them a chance to discuss the activity. Do they think the pig population would actually get this large in real life? Why not?

With your guidance, the children should be able to figure out for themselves many of the factors that would in reality keep the actual number of pigs far smaller. (Lack of food, of water, of space, of hiding places; competing species; attacks by predators; disease; etc.)

Finally, say that pigs were just one of many, many species of living creatures from Europe and Asia and Africa that were brought to the Americas after 1492. Among the other animals deliberately exported were cattle, horses, sheep, goats, and dogs. Inadvertent exports included Old World rats and many plant weed species.

### Step 2: Worlds Apart, Worlds Together

Provide each of your students with an outline map of the world. Have them write in the names of the continents. (Antarctica may be omitted.)

Then ask: Are there places where the continents are joined, or are they completely separate? The children can see for themselves that the inhabitable continents are clumped into three separate chunks:

• *Europe and Asia* are really part of the same huge land mass, which is joined to Africa by the part of Egypt where the Suez Canal is. These three continents together form the Old World.

• *North and South America* are joined, and together form the so-called *New World* (new, that is, to the Europeans who sailed there).

• *Australia* is by itself. (We won't be talking about it in this ART TO ZOO.)

Have the kids fill in the Old World and the New World on their maps, each with a different color, and label the two areas. Be sure the children understand clearly the meaning of the terms Old World and New World, since they will be used over and over in this ART TO ZOO.

Tell the class that *human beings* evolved in the Old World (probably in Africa). No one knows exactly when these first people arrived on the scene (the date depends also on which of our ancestors you count as people) . . . but humans could very likely have been living in the Old World well over a million years ago.

Meanwhile, during most of these million-plus years, there wasn't a single human being in the New World. There were lots of other living creatures there—whose ancestors had been alive when the continents were still joined into a single land mass. But the earliest human beings appeared after the continents had moved away from each other: they had no way to cross over to the New World.

Then, during the most recent Ice Age, the level of oceans dropped worldwide . . . and a land bridge between Asia and North America emerged at the Bering Straits. (Have your students locate and mark this place on their maps.)

Over this land bridge came people in search of food—the Asians whose descendants became the Eskimos and Indians of the New World.

Then, about 10,000 years ago, the Ice Age ended, the oceans rose, and once more the Bering Straits land bridge disappeared underwater (where it remains today). Once again, the Old World and the New were cut off from each other. They remained so for about 10,000 years.

This isolation was not total. Occasional ships—blown off-course during storms, for example—once in a while made their way from the Old World to the New. Some ships probably made the crossing intentionally. The Vikings even established a colony in North America in the 11th century. But it didn't last long. This and these other pre-Columbian contacts seem to have had no significant impact.

Not until Columbus arrived in 1492 was *ongoing* contact established.

### Step 3: The Game of Survival

What happened then, when living creatures that had been evolving in two separate worlds for thousands of years, came into ongoing contact? Before beginning to find out, your students should read "The Game of Survival," on the Pull-Out Page.

Then give them plenty of time to ask questions and discuss what they have read. Emphasize how *interrelated* every part of an environment is in this game: if one population makes a move, it changes the set-up of the game for other populations around it.

### Step 4: Animals, Plants, Germs

Now draw on the "Animal Colonizers," "Plant Colonizers," and "Germ Colonizers" sections of the Teacher's Background to describe some examples of biological consequences of the contact that Columbus initiated.

Guide the children to see the parallels between the animal, plant, and germ examples: In all three cases, when the newcomers that are described arrived in the New World, they found abundant sources of food . . . and environments where, at first, local species were not able to make the kind of moves that would slow the newcomers' spread.

*Continued on page 4*

*The only major human disease that may have traveled from New World to Old is syphilis, which first appeared in Europe around 1500. But there is no consensus about its origin.

continued from page 3

After the children have had plenty of opportunity for discussion, have them conclude this section by writing the "Weird Postcard" on the Pull-Out Page. You can end the Lesson Plan here if you are out of time. Or you can develop these ideas further by moving on to Step 5.

### Step 5: Human Population Growth

Now that your students have looked into several examples of fast-growing populations, you may want to have them conclude by turning to the human population, which began its dramatic upswing around 1650—in part because food plants of *New World* origin (most notably potatoes and corn) dramatically increased the food supply worldwide.

Here are some approximate world population figures

| | |
|---|---|
| 4000 B.C. | 15 million |
| 1 A.D. | 250 million |
| 1000 A.D. | 340 million |
| 1650 A.D. | 500 million |
| 1750 A.D. | 711 million |
| 1850 A.D. | 1,130 million |
| 1950 A.D. | 2,500 million |
| 1970 A.D. | 3,650 million |
| 1990 A.D. | 5,300 million |
| 2000 A.D. | 6,250 million (estimated) |

First, have your students make a graph of these figures. Then ask them to write a short story about what they think might happen in the future because of this human population growth. Ask them to create two or three alternative endings for their story, and to describe what events took place to cause these different outcomes.

National Air and Space Museum, Smithsonian Institution

Howard Hughes's airplane, in which he flew around the world in 1938. His trip took 4 days: the linkage of Old World and New had become much faster than in Columbus's time . . . and the population of both worlds much larger.

## Seeds of Change

The exhibition Seeds of Change, at the Smithsonian's National Museum of Natural History from October 26, 1991 until April 1, 1993, examines the exchange of plants and seeds between the Old and New Worlds following Columbus's arrival in the Americas in 1492. Themes include the effects of the introduction of potatoes and corn to the New World.

A traveling version of this show, organized by the Smithsonian Institution Traveling Exhibition Service (SITES), will be on display in cities around the United States.

For information, contact:

Office of Public Affairs
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## Other Smithsonian Quincentenary Activities

For information about other Smithsonian events commemorating the 500th anniversary of the landing of Christopher Columbus in the New World, contact:

Office of Quincentenary Programs
Smithsonian Institution
1100 Jefferson Drive, Suite 3123
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## National Metric Week

Over 95 percent of the world uses the metric system of measure, yet many Americans are still inching along with our traditional systems. Use of metrics is not mandatory in the United States, but more and more businesses are converting to stay competitive in international markets.

To obtain a kit of useful posters, handouts, cards, and explanatory materials to use with your students write to

Metric Program Office
U.S. Department of Commerce, Room 4845
Washington, D.C. 20230

. . . and celebrate National Metric Week, October 6–12, 1991!

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ART TO ZOO brings news from the Smithsonian Institution to teachers of grades three through eight. The purpose is to help you use museums, parks, libraries, zoos, and many other resources within your community to open up learning opportunities for your students.

Our reason for producing a publication dedicated to *promoting the use of community resources among students and teachers nationally* stems from a fundamental belief, shared by all of us here at the Smithsonian, in the *power of objects.* Working as we do with a vast collection of national treasures that literally contain the spectrum from "art" to "zoo," we believe that objects (be they works of art, natural history specimens, historical artifacts, or live animals) have a tremendous power to educate. We maintain that it is equally important for students to learn to use objects as research tools as it is for them to learn to use words and numbers—and you can find objects close at hand, by drawing on the resources of your own community.

Our idea, then, in producing ART TO ZOO is to share with you—and you with us—methods of working with students and objects that Smithsonian staff members have found successful.


Special thanks to the following people at the Smithsonian for their help in preparing this issue of ART TO ZOO:

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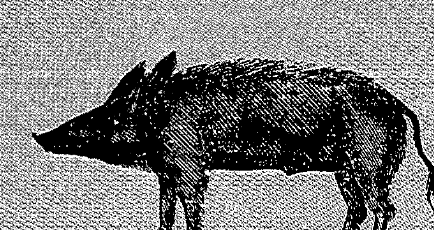


### What Does the Game of Survival Have to Do with Columbus?

Columbus's landing in 1492 was the beginning of a huge flow of living creatures from Old World to New. The arrival of these new species dramatically changed the state of the game in the New World.

When, in a game, someone makes a dramatic move like this, other players have to scramble to find new ways to respond. There is a period when a lot of changes take place. Soon the state of the game will look very different from before.

This is what happened in the years after Columbus put the two worlds in contact.

As we look at some examples of the new plays that occurred, we will be focusing on *populations* (a population is all the members of a species living in a particular place).

As a population plays the game, it may change drastically—for example, by getting bigger or smaller, or becoming extinct, or migrating.

For instance, if its food supply grows or its enemies die off, the population is likely to get bigger. But if its food supply shrinks, or more competitors for the same food arrive, or a killer epidemic strikes, then the population is likely to get smaller.

These are the kinds of biological follow-ups to 1492 that you will be learning about in this ART TO ZOO.

## Weird Postcard

Imagine that weeds, cattle, and smallpox germs can think . . . and even write!

Imagine too that it is about 100 years after Columbus's first trip, and you are one of these creatures, writing a postcard home. (The postcard too is a pretend situation, since there were no postcards back then.)

You want to describe what happened to your ancestors after they arrived in the New World. Because whatever you say has to fit on the postcard, you have to figure out what is absolutely essential about your ancestors' experiences.

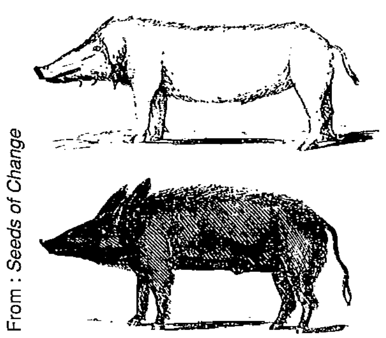
When you have figured it out, cut out the postcard and write your message, saying "*we* did this" and "*we* did that." Then draw a picture on the back of the postcard to illustrate what you are telling about.

**Post Card**

Place
Stamp
Here


**ART TO ZOO October 1991**
**News for Schools from the Smithsonian Institution**

# How Many Pigs?



From: Seeds of Change

In the years after 1492 (when Columbus arrived in America), European ships would often leave behind a pair of pigs on the islands they visited. They hoped that this pair would breed, so that when the ship came back to the island in the future, the descendants of this pair of pigs would be meat on the hoof.

How many pigs could they expect to find when they came back?

To make it possible to figure this out quite easily, imagine a *very* simplified situation (the reality would be far more complicated; later you will have a chance to discuss why):

- The ship leaves one pair of pigs, a male and a female.
- This pair produces three litters a year—one every 4 months.
- There are 5 males and 5 females in each litter.
- All females have a litter every 4 months.*
- No pigs die.

The ship comes back after 3 years. How many pigs do the sailors find?

Before figuring out the answer, make a guess:

My guess is that, in 3 years, there will be _______ pigs on the island.

*In reality, the females would not have any babies until they were about one year old. But to keep the math easy, we will imagine they become mothers at a younger age. This makes their population grow in almost the same way, but in our version the changes happen 4 months sooner. In other words, your answer at *32 months* is similar to the real pig population after *36 months* of unlimited growth.

**The first 3 months have been filled in, as examples.**

- *After 4 months:*
  The female of the pair gives birth to 10 babies—of which 5 are female.
  Now the total number of female pigs is: the 1 mother + 5 female babies = 6 female pigs.

- *After 8 months:*
  The 6 females all give birth, producing a total of 60 babies—of which 30 are female.
  Now the total number of female pigs is: the 6 mothers + the 30 female babies = 36 female pigs.

- *After 12 months:*
  The 36 females all give birth, producing a total of 360 babies—of which 180 are female.
  Now the total number of female pigs is: the 36 mothers + the 180 female babies = 216 females.

- *After 16 months:*
  The 216 females all give birth, producing a total of ______ babies—of which ______ are female.
  Now the total number of female pigs is: the ______ mothers + the ______ female babies = ______ females.

- *After 20 months:*
  The ______ females all give birth, producing a total of ______ babies—of which ______ are female.
  Now the total number of female pigs is: the ______ mothers + the ______ female babies = ______ females.

- *After 24 months:*
  The ______ females all give birth, producing a total of ______ babies—of which ______ are female.
  Now the total number of female pigs is: the ______ mothers + the ______ female babies = ______ females.

- *After 28 months:*
  The ______ females all give birth, producing a total of ______ babies—of which ______ are female.
  Now the total number of female pigs is: the ______ mothers + the ______ female babies = ______ females.

- *After 32 months:*
  The ______ females all give birth, producing a total of ______ babies—of which ______ are female.
  Now the total number of female pigs is: the ______ mothers + the ______ female babies = ______ females.

- *After 36 months:*
  The ______ females all give birth, producing a total of ______ babies—of which ______ are female.
  Now the total number of female pigs is: the ______ mothers + the ______ female babies = ______ females.

This is the number females at the end of 3 years. But remember, for each female there is a male . . . so double the number of females to find out the total number of pigs the sailors would find—according to our model—when they came back after 3 years.

________TOTAL NUMBER OF PIGS:
______ females + ______ males = ______ pigs.

# The Game of Survival

In a sense, every living animal and plant is engaged in a very complicated and serious game—the game of survival.

- ***Players.*** Every species—and every member of every species, whether microbe, plant, or animal—is a player in this game. They have no choice. If you are born, you play.
- ***Goal.*** The goal of the game is survival. There can be many winners, but not everyone can win.

For a species to survive, enough of its individual members have to survive, at least long enough to produce offspring . . . and enough of these offspring, in turn, have to survive to reproduce . . . and so on, generation after generation. . . .

As long as it does this, the species is still in the game.

- ***Resources.*** All players are surrounded by *nonliving physical conditions* (like terrain and climate) and other *living creatures* (of all kinds: microbes, plants, animals).

Together all this makes up the *environment* where each player plays the game.

To stay in the game, the player must succeed in finding in this environment the *resources* (food, shelter, safety from predators, etc.) that it needs to stay alive and reproduce.

- ***Moves.*** In this game, a living creature can make any moves of which it is capable. A move is any kind of behavior or the development of any new physical feature. As in chess, where each piece moves in a different way, in the game of survival, each species has a different set of moves. (Most birds can fly. Most fish can breathe underwater. A pufferfish can inflate its body to scare its enemies.)

How useful a move is depends on what's happening. If you are being chased through a desert by a predator, the ability to breathe underwater is no help . . . but the ability to fly may save you. On the other hand, if you come to a water hole, the ability to breathe underwater may allow you to escape even a flying enemy.

In other words, an adaptation (a move) isn't good or bad in an absolute way. It's good or bad in a particular set of circumstances. Evolution isn't a climb toward perfection, but a series of adaptations to an ever-changing environment. What works in one set of circumstances may not work in another.

Rothamsted Experimental Station

Example of a potato's move in the game of survival.

This type of wild potato from the Andes has developed on its leaves tiny hairs containing a sticky substance. When an aphid or other small insect walks across a leaf, the insect breaks open the hairs, releasing a sticky substance that glues it to the leaf.

The aphid in this picture will not get away to consume any more potato plants!

Though we human beings cannot eat this particular kind of potato, it may still turn out to be useful to us. Experimenters are breeding it with edible potatoes, to see if they can produce new types that can both defend themselves in this way and be eaten by people.

Countless little-known plants could turn out to be useful to us human beings as we play the survival game: crops that fight off pests, or that can grow where existing crops fail, or that may turn out to be sources of medicines able to save human lives.

Since the game is always changing, no one knows what moves we human beings may need in the future. Whenever species die off, fewer moves in the game are left—fewer of the choices that can mean our own survival.

### ¿Qué Tiene que Ver el Juego de la Sobrevivencia con Colón?

La llegada de Colón en 1492 fue el inicio de un enorme flujo de seres vivientes de el Viejo al Nuevo Mundo. La llegada de estas nuevas especies cambió dramaticamente la forma de el juego en el Nuevo Mundo.

Cuando en un juego, alguien hace una movida tan extrema como esta, los otros jugadores tienen que encontrar nuevas formas de responder. Se dá un periodo en en que se producen muchos cambios. Pronto la forma de el juego será muy diferente que la anterior.

Esto es lo que paso en los años que siguieron después que Colón puso ambos mundos en contacto.

Mientras vemos algunos de los ejemplos de las nuevas jugadas que ocurrieron, nos concentraremos en *poblaciones* (una población consiste en todos los miembros de una especie que viven en un lugar en particular).

En la medida en que una población participa en el juego, esta puede cambiar drasticamente—por ejemplo, volviendose mas grande o mas pequeña, o extinguiendose, o migrando.

Por ejemplo, si su fuente de comida crece o si sus enemigos mueren, es muy posible que la poblacion crezca. Pero si su fuente de comida disminuye, o mas competidores aparecen, o una epidemia se produce, entonces es muy posible que la población disminuya.

Estos son los tipos de seguimientos biologicos a partir de 1492 sobre los cuales aprenderas en este ARTE A ZOOLOGICO.

## Una Postal Rara

¡Imagínate que las malezas, ganado, y los germenes del sarampión pudiesen pensar...e incluso escribir!

Imagínate también que han pasado 100 anos después del primer viaje de Colón, y que tu eres una de esas criaturas, escribiendo una postal a casa. (La postal también es una situacion simulada, ya que entonces no habían postales).

Tu quieres describir lo que le pasó a tus antepasados después de su llegada al Nuevo Mundo. Dado que lo que vayas a decir debe poder caber en la postal, tienes que pensar que es lo absolutamente esencial acerca de las experiencias de tus antepasados.

Cuando lo hayas pensado, corta la postal y escribe tu mensaje, diciendo, "*nosotros* hicimos esto" y "*nosotros* hicimos lo otro". Luego haz un dibujo en la parte trasera de la postal ilustrando lo que estas contando.

**Postal**

Pon un sello aquí

______________________

______________________

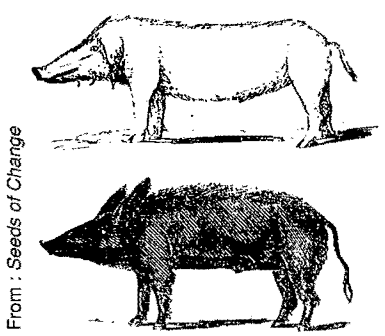
______________________

______________________


Del Arte al Zoologico Octubre 1991
Noticias para las escuelas del Instituto Smithsonian

# ¿Cuántos Cerdos?

En los años que le siguieron a 1492 (cuando Colón llegó a América), muchos barcos europeos acostumbraban dejar un par de cerdos en las islas que ellos visitaban. Los tripulantes de estos barcos esperaban que esta pareja de cerdos tuviesen crías, de tal forma que cuando el barco volviese a la isla en el futuro, los descendientes de estos cerdos pudiesen ser utilizados como ganado.



From : *Seeds of Change*

Cuántos cerdos podían esperar encontrar ellos cuando volviesen?

Para solucionar este problema facilmente, imagínate una situación simplificada (imaginarse la situacion real sería mucho mas complicado; luego tendrás la oportunidad de descubrir porque):

- El barco deja un par de cerdos,un macho y una hembra.
- Este par produce tres camadas al año—una cada 4 meses.
- En cada camada hay 5 machos y 5 hembras.
- Todas la hembras tienen una camada cada 4 meses.*
- Ninguno de los cerdos muere.

El barco regresa despues de tres años. ¿Cuántos cerdos encuentran los marineros?

Antes de calcular la respuesta, trata dé adivinar cuantos:

Yo pienso que, en tres años, habrán ____________ cerdos en la isla.

* En realidad, las hembras no hubiesen podido tener crías hasta que tuviesen la edad de un año. Pero para simplificar la operación, nos imaginaremos que ellas fueron madres a una edad mas temprana. Esto hace que la población de cerdos crezca de la misma forma, pero en nuestra versión los cambios suceden 4 meses antes. En otras palabras, tu respuesta a los *32 meses* es similar a la población real de cerdos despues de *36 meses* de crecimiento ilimitado.

Traducción de Maria del Rosario Basterra

**Los primeros 3 meses han sido calculados como ejemplos**

- *Después de 4 meses:*
  La hembra de la pareja inicial da a luz 10 cerditos de los cuales 5 son hembras.
  Ahora el número total de hembras es:la hembra madre + 5 cerditas = 6 hembras.

- *Después de 8 meses:*
  Las 6 hembras dan a luz,produciendo un total de 60 cerditos—de los cuales 30 son hembras.
  Ahora el número total de hembras es: las 6 madres + las 30 cerditas = 36 hembras.

- *Después de 12 meses:*
  Las 36 hembras dan a luz, produciendo un total de 360 cerditos—de los cuales 180 son hembras.
  Ahora el número total de hembras es: las 36 madres + las 180 cerditas = 216 hembras.

- *Después de 16 meses:*
  Las 216 hembras dan a luz, produciendo un total de ______ cerditos—de los cuales ______ son hembras.
  Ahora el número total de hembras es: las ______ madres + las ______ cerditas = ______ hembras.

- *Después de 20 meses:*
  Las ______ hembras dan a luz, produciendo un total de ______ cerditos—de los cuales______ son hembras.
  Ahora el número total de hembras es: las ______ madres + las ______ cerditas = ______ hembras.

- *Después de 24 meses:*
  Las ______ hembras dan a luz, produciendo un total de ______ cerditos—de los cuales ______ son hembras.
  Ahora el número total de hembras es: las ______ madres + las ______ cerditas = ______ hembras.

- *Después de 28 meses:*
  Las ______ hembras dan a luz, produciendo un total de ______ cerditos—de los cuales ______ son hembras.
  Ahora el número total de hembras es: las ______ madres + las ______ cerditas = ______ hembras.

- *Después de 32 meses:*
  Las ______ hembras dan a luz, produciendo un total de ______ cerditos—de los cuales ______ son hembras.
  Ahora el número total de hembras es: las ______ madres + las ______ cerditas = ______ hembras.

- *Después de 36 meses:*
  Las ______ hembras dan a luz, produciendo un total de ______ cerditos—de los cuales ______ son hembras.
  Ahora el número total de hembras es: las ______ madres + las ______ cerditas = ______ hembras.

Este es el número total de hembras al final de los tres años. Pero recuerda que por cada hembra hay un macho... asi es que duplica el número de hembras para encontrar el número total de cerdos que los marineros encontrarían—de acuerdo con nuestro modelo—cuando regresasen despues de los tres años.

Número total de cerdos: ______ hembras + ______ machos = ______ cerdos.

# El Juego de la Sobrevivencia

De una forma u otra cada ser vivo, animal o planta, está involucrado en un juego muy complicado y serio—el juego de la sobrevivencia.

- ***Jugadores.*** Cada especie—y cada miembro de cada especie, ya sea microbio, planta o animal—es un jugador en este juego. No tienen alternativa. Si naces, juegas.
- ***Meta.*** La meta de este juego es la sobrevivencia. Pueden haber muchos ganadores, pero no todo el mundo puede ganar.

Para que una especie pueda sobrevivir, un número suficiente de sus individuos tiene que lograr subsistir por lo menos el tiempo necesario como para reproducirse ...y un número suficiente de estos nuevos miembros, tambien deberá tener el mismo tiempo para reproducirse...y así una y otra vez de generación en generación...

Mientras esto suceda, la especie continúa en el juego.

- ***Recursos.*** Todos los jugadores están rodeados por *condiciones físicas inanimadas* (como el terreno y el clima) y otros *seres vivientes* (de todo tipo: microbios, plantas, animales).

Todos estos elementos representan el *medio ambiente* donde cada uno de los jugadores juega el juego.

Para permanecer en el juego, los jugadores deben lograr encontrar es su medio ambiente los *recursos* (comida, vivienda, refugio de sus agresores, etc.) que necesitan para permanecer vivos y reproducirse.

- ***Movimientos.*** En este juego, toda criatura viviente puede hacer cualquier movimiento que sea capaz de realizar. Un movimiento es cualquier tipo de comportamiento o el desarrollo de un nueva adquisición física. Como en el ajedrez, donde cada pieza se mueve de una forma diferente, en el juego de la sobrevivencia, cada especie tiene un conjunto de movimientos posibles. (La mayoría de los pájaros pueden volar, la mayoría de los peces pueden respirar debajo del agua. Un pez globo puede hincharse para espantar a sus enemigos).

Cuan útil es un movimiento esta en función de que es lo que está sucediendo. Si un animal terrestre te esta persiguiendo en el desierto, la habilidad de respirar bajo el agua no es gran ayuda...pero la habilidad para volar puede salvarte. De otro lado, si te encontrases con un estanque, la habilidad para respirar bajo el agua te podría permitir escapar aún de un enemigo volador.

En otras palabras, una adaptación (un movimiento) no es bueno o malo en términos absolutos. Es bueno o malo en un conjunto de determinadas circunstancias. La evolución no es un ascenso hacia la perfección, pero una serie de adaptaciones al medio ambiente. Lo que funciona en determinadas circunstancias puede que no funcione en otras.

Ejemplo de la movida de una papa en el juego de sobrevivencia.

Este tipo de papa salvaje de los Andes ha desarrollado unos pelitos delgados que contienen una substancia pegajosa en sus hojas. Cuando un áfido u otro insecto pequeño camina a través de la hoja, el insecto abre estos pelitos que desalojan una substancia pegajosa y que lo dejan pegado a la hoja .

¡El áfido en esta figura no podrá consumir mas plantas de papa!

Aunque los seres humanos no pueden consumir este tipo de papa, todavía esta puede sernos útil. Algunos especialistas estan haciendo injertos con este tipo de papa salvaje y papas comestibles, para ver si pueden producir nuevos tipos de papa que se puedan defender de esta forma y que a su vez puedan ser comidas por la gente.

Innumerables plantas que son poco conocidas pueden resultar valiosas para los seres humanos mientras jugamos el juego de la sobrevivencia: cosechas que combatan pestes o que prosperen donde otras cosechas fallan, o que puedan convertirse en la fuente de medicinas que puedan salvar vidas.

En tanto que el juego esta en constante cambio, uno nunca sabe que tipo de movidas necesitaremos los seres humanos en el futuro. A medida que especies desaparecen, las posibilidades de movidas en el juego disminuyen—dandose menos alternativas que pueden implicar nuestra propia sobrevivencia.